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TABLE DES MATIERES

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1 Purpose

This document describes the approach for generic nuclear safety-related qualification testing of the Rolls-Royce ***SPINLINE 3*** Qualification Test Specimen (QTS) for application in a mild environment.

The ***SPINLINE 3*** QTS is assembled from the safety-related components of the Rolls-Royce ***SPINLINE 3*** Digital Safety Instrumentation and Control (I&C) Platform.

The qualification testing described in this document is intended to demonstrate with reasonable assurance that the ***SPINLINE 3*** QTS hardware and software can perform their intended safety functions without experiencing environmentally induced common-cause failures during normal environmental conditions and anticipated operational occurrences.

The document has been updated to take into account the additional qualification testing that must be performed to complete the resolution of the test deficiencies as reported in the Summary Equipment Qualification Report (Ref. 37),

The content of this additional qualification testing is detailed on the section §13 (Figure 2).

In this document, double brackets ("[[ ]]") denote proprietary information. In the proprietary document, the two brackets denoting the end of a proprietary segment may appear one or more pages following the bracket indicating the start of the proprietary segment. In the nonproprietary edition of this document, the material within the brackets is removed.

2 Abbreviations and Acronyms

AC	Alternating Current
ANSI	American National Standards Institute
ASOA	Application Software Objects Acceptance
CDR	Critical Digital Review
CFR	Code of Federal Regulations
DC	Direct Current
EFT	Electrical Fast Transient
EMC	Electromagnetic Compatibility
EMI	Electromagnetic Interference
EPRI	Electric Power Research Institute
ESD	Electrostatic Discharge
HCAS	Hubs and Converters Assembly System
I&C	Instrumentation and Control
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
I/O	Input/Output
ISA	Instrumentation, Systems and Automation
ISO	International Standards Organization
M&TE	Measurement and Test Equipment
MCL	Master Configuration List
MIL-STD	Military Standard
NCSL	National Conference of Standards Laboratories
NIST	National Institute of Standards and Technology

NUREG	Nuclear Regulation
OBE	Operating Basis Earthquake
PLC	Programmable Logic Controller
PU1	Processing Unit 1
QA	Quality Assurance
QTS	Qualification Test Specimen
RFI	Radio-Frequency Interference
RG	Regulatory Guide
RMS	Root Mean Square
RP	Recommended Practice
Rolls-Royce	Rolls-Royce Civil Nuclear SAS (Société Anonyme Simplifié)
RRS	Required Response Spectrum
SER	Safety Evaluation Report
SSE	Safe Shutdown Earthquake
TR	Technical Report
TSAP	Test Specimen Application Program
USNRC	United States Nuclear Regulatory Commission
ZPA	Zero Period Acceleration

3 Scope

The environmental qualification testing of the ***SPINLINE 3*** Qualification Test Specimen (QTS) is performed in accordance with the requirements of U.S. Nuclear Regulatory Commission (USNRC) Regulatory Guide (RG) 1.89, "Environmental Qualification of Certain Electric Equipment Important to Safety for Nuclear Power Plants", (Ref. 1) and requirements of Institute of Electrical and Electronics Engineers (IEEE) Standard 323-2003, "IEEE Standard for Qualifying Class 1E Equipment for Nuclear Power Stations" (Ref. 2). This standard is subject to the enhancements and exceptions listed in Section C, "Regulatory Position" of USNRC RG 1.209, "Guidelines for Environmental Qualification of Safety Related Computer-Based Instrumentation and Control Systems in Nuclear Power Plants" (Ref. 3).

The environmental qualification testing of the ***SPINLINE 3*** QTS is also performed in accordance with the requirements for qualifying digital computers IEEE Standard 7-4.3.2-2003, "Standard Criteria for Digital Computers in Safety Systems of Nuclear Power Generating Stations" (Ref. 4) and USNRC RG 1.152, Revision 2 (Ref. 32).

Electric Power Research Institute (EPRI) Technical Report (TR) 107330, "Generic Requirements Specification for Qualifying a Commercially Available PLC for Safety-Related Applications in Nuclear Power Plants" (Ref. 5), describes an approach for generically qualifying commercial Programmable Logic Controllers (PLCs) for safety-related applications. This approach was found acceptable by the USNRC as documented in USNRC Safety Evaluation Report (SER) Letter dated July 30, 1998 to Mr. J. Naser of the EPRI (Ref. 6). The generic qualification testing approach described in this Equipment Qualification Plan uses guidance from EPRI TR-107330 as applicable to meet the requirements of IEEE Standard 323-2003 and other USNRC guidance.

Section 1.2.1 of EPRI TR-107330 defines the following steps involved in completing a generic qualification effort:

a. Select a PLC product line that supports the EPRI TR-107330 requirements specification and the required functionality of nuclear-safety related applications.
b. Evaluate the manufacturer's hardware and software Quality Assurance (QA) programs applied to the PLC product line to determine if they are adequate to support nuclear safety-related applications with a reasonable set of supplementary activities.
c. Procure a set of modules and any required supporting devices and software from the PLC manufacturer to be used as the qualification test specimen.
d. Define and produce a Test Specimen Application Program (TSAP). The TSAP is a synthetic application designed to aid in the qualification tests and Operability testing.
e. Combine the test specimen hardware and TSAP into a suitable test configuration and perform a set of acceptance tests on the test specimen.
f. Specify the set of qualification tests to be performed on the test specimen, including defining a set of Operability tests to be performed at suitable times in the qualification process.
g. Perform the qualification tests and document the results.

Although not listed in Section 1.2.1, the EPRI TR-107330 generic qualification approach includes the following additional step:

h. Perform other technical evaluations as needed to demonstrate compliance with regulatory requirements and other technical requirements in EPRI TR-107330.

The scope of this Equipment Qualification Plan addresses the activities described in Items d) through h) listed above. The software qualification activities addressed by the performance of item b) and h) will be addressed separately in the ***SPINLINE 3*** Design Analysis Report (DAR, Ref. 34).

USNRC RG 1.180, Rev. 1, "Guidelines for Evaluating Electromagnetic and Radio-Frequency Interference in Safety-Related Instrumentation and Control Systems" (Ref. 7) describes methods acceptable to the USNRC for complying with regulations on testing practices to address the effects of electromagnetic and radio-frequency interference (EMI/RFI) and power surges on safety-related instrumentation and control (I&C) systems. The qualification testing approach described in this Equipment Qualification Plan uses guidance from RG 1.180, Rev. 1 as applicable to meet the requirements of IEEE Standard 323-2003.

USNRC RG 1.100, Rev. 2, "Seismic Qualification of Electric and Mechanical Equipment for Nuclear Power Plants" (Ref. 33) states that the procedures described in IEEE Standard 344-1987 "Recommended Practice for Seismic Qualification of Class 1E Equipment for Nuclear Power Generating Stations" (Ref. 15) are acceptable to the USNRC for complying with regulations on testing practices to address the effects of seismic qualification of electric equipment. Seismic testing based on EPRI TR-107330 guidance is performed in accordance with IEEE Standard 344-1987. The qualification testing approach described in this Equipment Qualification Plan uses guidance from EPRI TR-107330 to meet the requirements of USNRC RG 1.100 and IEEE Standard 344-1987.

4 Equipment to be Tested

The equipment to be tested is the Rolls-Royce ***SPINLINE 3*** Qualification Test Specimen (QTS). In accordance with EPRI TR-107330 (Ref. 5), a representative sampling of the Rolls-Royce ***SPINLINE 3*** platform components are identified for evaluation and qualification testing.

The assembled components of the ***SPINLINE 3*** QTS include the following types of hardware modules and components:

- Chassis
- Power Supply Modules
- Digital Processing Modules
- Communication Modules
- Signal Input Modules
- Signal Output Modules
- Signal Conditionin g Modules
- Terminal Blocks
- Cable and Wire Sets
- Fan Cooling Hardware
- Power Distribution Hardware

The Rolls-Royce "System Specification for the Qualification Test Specimen and Data Acquisition System" (Ref. 8) provides a detailed description of the ***SPINLINE 3*** QTS. Test specimen and test system arrangement and wiring drawings will be prepared to provide additional hardware configuration information. The Master Configuration List (Ref. 38), to be prepared as part of the ***SPINLINE 3*** Qualification Project, will provide detailed ***SPINLINE 3*** QTS configuration information such as component serial numbers and software version numbers.

Additional Qualification Testing required a new Qualification Test Specimen. Therefore, it was manufactured for 2012 tests and its description is provided in the Master Configuration List (Ref. 38)

5 Test System

The QTS will be exercised during qualification testing by a test system comprised of an industrial-grade data acquisition system (DAS) and a test specimen application program (TSAP), which are described in "System Specification for the Qualification Test Specimen and Data Acquisition System" (Ref. 8). This test system is a non-qualified system whose sole purposes are to: (1) generate a series of known inputs to the QTS, and (2) monitor the corresponding outputs of the QTS. Correct correspondence between input and output during and after qualification tests and lack of spurious behavior are the key results that will demonstrate the predictable behavior of SPINLINE 3 hardware during normal and abnormal plant operating conditions.

6 Safety Functions to be Demonstrated

The ***SPINLINE 3*** QTS safety functions to be demonstrated by the qualification testing described in this document include:

- Correct function during normal and abnormal plant operating conditions. Correct function includes:
  - Proper response of inputs to applied input signals,
  - Proper response of outputs to application program control,
  - Proper control of connected output devices,
  - Proper operation of communication interfaces,
  - Acceptable input/output accuracy,
  - Acceptable response time,

- Proper response to momentary interruption of input power,
- Proper response to loss of input power,
- Proper response to input power quality (voltage and frequency) variations,
- Proper failover to redundant components.

7 Test Requirements

EPRI TR-107330 identifies qualification and acceptance testing which meets the requirements of IEEE Standard 323 and IEEE Standard 7-4.3.2 for safety-related digital I&C systems installed in a mild plant environment. The following summarizes the qualification and acceptance testing to be applied to the ***SPINLINE 3*** QTS to meet the intent of testing identified in EPRI TR-107330:

- The ***SPINLINE 3*** QTS will continue to function correctly during and/or after exposure to abnormal environmental conditions (incident gamma radiation, temperature and humidity). Correct function of the ***SPINLINE 3*** QTS includes some or all of the performance or operational parameters listed in Section 5.0 above, to be identified in the controlling test procedures.
- The ***SPINLINE 3*** QTS will continue to function correctly during and after exposure to Operating Basis and Safe Shutdown Earthquake seismic events. Correct function of the ***SPINLINE 3*** QTS includes some or all of the performance or operational parameters listed in Section 5.0 above, to be identified in the controlling test procedure.
- The ***SPINLINE 3*** QTS will continue to function correctly during and after exposure to Electromagnetic Interference/Radio-Frequency Interference (EMI/RFI), voltage surges, electrical fast transients and electrostatic discharges. Correct function includes some or all of the performance or operational parameters listed in Section 5.0 above, to be identified in the controlling test procedures.
- The ***SPINLINE 3*** QTS will continue to function correctly during and after exposure to electrical faults applied to selected external interface points. Correct function includes some or all of the performance or operational parameters listed in Section 5.0 above, to be identified in the controlling test procedures.

The following outlines the qualification and acceptance testing scope and sequence described above for the ***SPINLINE 3*** QTS. The testing scope and sequence is shown in Figure 1 of this Equipment Qualification Plan.

<u>Pre-Qualification Acceptance Testing</u>

- Pre-Qualification Testing System Setup and Checkout Testing
- Pre-Qualification Testing Operability Testing
- Pre-Qualification Testing Prudency Testing

<u>Qualification Testing</u>

- Radiation Exposure Withstand Testing
- Environmental Testing System Setup and Checkout Testing
- Post Radiation Exposure Operability Testing
- Post Radiation Exposure Prudency Testing
- Environmental Testing including:
    - High Temperature and High Humidity Operability Testing
    - High Temperature and High Humidity Prudency Testing
    - Low Temperature and Low Humidity Operability Testing
    - Ambient Temperature and Ambient Humidity Operability Testing

- Seismic Testing System Setup and Checkout Testing
- Seismic Testing
- Post Seismic Operability Testing
- Post Seismic Prudency Testing
- EMI/RFI System Setup and Checkout Testing
- EMI/RFI Emissions Testing
- EMI/RFI Susceptibility Testing
- Electrical Fast Transient Testing
- Surge Withstand Testing
- Electrostatic Discharge Testing
- Class 1E to Non-1E Isolation Testing

Performance Proof Testing

- Performance Proof Testing System Setup and Checkout Testing
- Performance Proof Testing Operability Testing
- Performance Proof Testing Prudency Testing

The following outlines the supplemental qualification and acceptance testing scope and sequence for Test Program 2012 which will achieve the first Test Program. These supplemental qualification tests are required because of failures or insufficient testing as reported in the Summary Equipment Qualification Report (Ref. 37)

The testing scope and sequence is shown in Figure 2 of this Equipment Qualification Plan.

Pre-Qualification Acceptance Testing

- Pre-Qualification Testing System Setup and Checkout Testing
- Pre-Qualification Testing Operability Testing
- Pre-Qualification Testing Prudency Testing

Qualification Testing

- Seismic Testing System Setup and Checkout Testing
- Seismic Testing (for two subassemblies: PU1 and HCAS)
- Post Seismic Operability Testing
- Post Seismic Prudency Testing
- EMI/RFI System Setup and Checkout Testing
- EMI/RFI Susceptibility Testing

Performance Proof Testing

- Performance Proof Testing System Setup and Checkout Testing
- Performance Proof Testing Operability Testing
- Performance Proof Testing Prudency Testing

8 Test Plans

Appendices A through M of this Equipment Qualification Plan provide the detailed Test Plans for each of the ***SPINLINE 3*** QTS tests identified in Section 7.0. Each Test Plan addresses the specific test approach, equipment to be tested, sequence of testing, test procedures, test specimen mounting, service conditions, test levels, performance monitoring, acceptance criteria and documentation.

Appendixes N and O of this Equipment Qualification Plan provide the detailed supplemental Test Plans for Seismic and EMI-RFI tests which failed or which were incomplete in the first Test Program as reported in the Summary Equipment Qualification Report (Ref. 37).

The Test Plans provide reference to the specific qualification test requirements and guidance obtained from IEEE Standard 323-2003 (Ref. 2), IEEE Standard 344-1987 (Ref. 15), IEEE Standard 7-4.3.2-2003 (Ref. 4), EPRI TR-107330 (Ref. 5), USNRC RG 1.100 Rev. 2 (Ref. 33), USNRC RG 1.152 Rev. 2 (Ref. 32), USNRC RG 1.180 Rev. 1 (Ref. 7) and USNRC 1.209 (Ref. 3).

Successful execution of the testing described in these Test Plans is intended to qualify the generic ***SPINLINE 3*** digital safety I&C platform for the qualification envelope summarized in Table 1-1.

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Table 1. Generic Qualification Envelope for the *SPINLINE 3* Digital Safety I&C Platform

Equipment Qualification Category	EQ Plan Section	Regulatory Requirements	Source of Qualification Test Specification	Qualification Envelop	Qualification Test Acceptance Criteria
Radiation Exposure	Appendix C	Regulatory Guide 1.89 (Ref. 1) and IEEE Standard 323-2003 (Ref. 2)	Section 4.3.6 of EPRI TR-107330 (Ref. 5)	[[1000 Rad]]	Section 4.3.6 of EPRI TR-107330
Environmental (Temperature & Humidity)	Appendix D	Regulatory Guide 1.89 (Ref. 1) and IEEE 323 (Ref. 2), subject to enhancements and exceptions listed in Section C of Regulatory Guide 1.209 (Ref. 3).	Section 4.3.6 of EPRI TR 107330 (Ref. 5), modified	[[41°F (5°C) to 122°F (50°C) and 10% to 95% relative humidity(non condensing)]]	Section 4.3.6 of EPRI TR 107330
Seismic	Appendix E	Regulatory Guide 1.100 (Ref. 33) and IEEE Standard 344 (Ref. 15)	Section 4.3.9 of EPRI TR 107330 (Ref. 5). The OBE and SSE tests shall follow the RRS curve given as Figure 4-5 in EPRI TR-107330 (Ref. 5) within the limits of the seismic test table, with the exception that the minimum ZPA requirements are met.	[[Resonance search as described in Section 7.1.4 of IEEE Standard 344.]]	Section 4.3.9 of EPRI TR 107330.
				[[Five triaxial Operating Basis Earthquake (OBEs) tests with a minimum Zero Period Acceleration (ZPA) of 4.9 g]]	
				[[One triaxial Safe Shutdown Earthquake (SSE) test with a minimum ZPA of 7 g]]	
	Appendix N	Regulatory Guide 1.100 (Ref. 33) and IEEE Standard 344 (Ref. 15)	Section 4.3.9 of EPRI TR 107330 (Ref. 5). The OBE and SSE tests shall follow the RRS curve given as Figure 4-5 in EPRI TR-107330 (Ref. 5) within the limits of the seismic test table, with the exception that the minimum ZPA requirements are met.	[[Resonance search as described in Section 7.1.4 of IEEE Standard 344.]]	Section 4.3.9 of EPRI TR 107330.
				[[Five triaxial Operating Basis Earthquake (OBEs) tests with a minimum Zero Period Acceleration (ZPA) of 3.5 g]]	
				[[One triaxial Safe Shutdown Earthquake (SSE) test with a minimum ZPA of 4.9 g]]	
				[[One triaxial Safe Shutdown Earthquake (SSE) test with a minimum ZPA of 7 g]]	

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Table 1. Generic Qualification Envelope for the *SPINLINE 3* Digital Safety I&C Platform

Equipment Qualification Category	EQ Plan Section	Regulatory Requirements	Source of Qualification Test Specification	Qualification Envelop	Qualification Test Acceptance Criteria
EMI/RFI (continued)	Appendix F	USNRC Regulatory Guide 1.180, Revision 1 (Ref. 7)	**EMI/RFI Emissions Tests**		
			MIL-461E, CE101 (Ref. 17): Conducted Emissions, Low Frequency, AC and DC Power Leads	[[30 Hz to 10 kHz]]	Section 4.3.7 of EPRI TR 107330 and USNRC RG 1.180, Rev. 1 [[Emission limit: RG 1.180, Rev. 1: Figure 3-1]]
			MIL-461E, CE102 (Ref. 17): Conducted Emissions, High Frequency, AC and DC Power Leads	[[10 kHz to 2 MHz]]	Section 4.3.7 of EPRI TR 107330 and USNRC RG 1.180, Rev. 1 [[Emission limit: RG 1.180, Rev. 1: Figure 3-2]]
			MIL-461E, RE101 (Ref. 17): Radiated Emissions, Magnetic Field, QTS Surfaces and Leads	[[30 Hz to 100 kHz]]	Section 4.3.7 of EPRI TR 107330 and USNRC RG 1.180, Rev. 1 [[Emission limit: RG 1.180, Rev. 1: Figure 3-3]]
			MIL-461E, RE102 (Ref. 17): Radiated Emissions, Electric Field, Antenna Measurement	[[2 MHz to 1 GHz]]	Section 4.3.7 of EPRI TR 107330 and USNRC RG 1.180, Rev. 1 [[Emission limit: RG 1.180, Rev. 1: Figure 3-4]]
			EMI/RFI Susceptibility Tests		
			IEC 61000-4-6 (Ref. 18): Conducted Susceptibility, Induced RF Fields, Power/Signal Leads	[[150 kHz to 80 MHz]]	Section 4.3.7 of EPRI TR 107330 and USNRC RG 1.180, Rev. 1 [[Susceptibility test level - power leads: 140 dBµV]]
					Section 4.3.7 of EPRI TR 107330 and USNRC RG 1.180, Rev. 1 [[Susceptibility test level - signal leads: 130 dBµV]]
			IEC 61000-4-13 (Ref. 19): Conducted Susceptibility, Harmonics/Interharmonics, Power Leads	[[16 Hz to 2.4 kHz]]	Section 4.3.7 of EPRI TR 107330 and USNRC RG 1.180, Rev. 1 [[Susceptibility test level: RG 1.180: Table 10]]

Table 1. Generic Qualification Envelope for the *SPINLINE 3* Digital Safety I&C Platform

Equipment Qualification Category	EQ Plan Section	Regulatory Requirements	Source of Qualification Test Specification	Qualification Envelop	Qualification Test Acceptance Criteria
EMI/RFI (continued)	Appendix F (continued)	USNRC Regulatory Guide 1.180, Revision 1 (Ref. 7)	IEC 61000-4-16 (Ref. 20): Conducted Susceptibility, Common Mode Disturbance, Power/Signal Leads	[[15 Hz to 150 kHz]]	Section 4.3.7 of EPRI TR 107330 and USNRC RG 1.180, Rev. 1 [[Susceptibility test level - power leads: RG 1.180: Table 11]]
					Section 4.3.7 of EPRI TR 107330 and USNRC RG 1.180, Rev. 1 [[Susceptibility test level - signal leads: RG 1.180: Table 15]]
			IEC 61000-4-8 (Ref. 21): Radiated Susceptibility, Magnetic Field, Helmholtz Coil Exposure	[[60 Hz]]	Section 4.3.7 of EPRI TR 107330 and USNRC RG 1.180, Rev. 1 [[Susceptibility test level - continuous: 30 A/m]]
					Section 4.3.7 of EPRI TR 107330 and USNRC RG 1.180, Rev. 1 [[Susceptibility test level - short duration: 300 A/m]]
			IEC 61000-4-9 (Ref. 22): Radiated Susceptibility, Magnetic Field, Pulsed	[[Pulsed]]	Section 4.3.7 of EPRI TR 107330 and USNRC RG 1.180, Rev. 1 [[Susceptibility test level: 300 A/m]]
			IEC 61000-4-10 (Ref. 23): Radiated Susceptibility, Magnetic Field, Damped Oscillatory	[[100 kHz and 1 MHz]]	Section 4.3.7 of EPRI TR 107330 and USNRC RG 1.180, Rev. 1 [[Susceptibility test level: 30 A/m]]
			IEC 61000-4-3 (Ref. 24): Radiated Susceptibility, High Frequency, Antenna Exposure	[[26 MHz to 1 GHz]]	Section 4.3.7 of EPRI TR 107330 and USNRC RG 1.180, Rev. 1 [[Susceptibility test level: 10 V/m]]

Table 1. Generic Qualification Envelope for the *SPINLINE 3* Digital Safety I&C Platform

Equipment Qualification Category	EQ Plan Section	Regulatory Requirements	Source of Qualification Test Specification	Qualification Envelop	Qualification Test Acceptance Criteria
EMI/RFI (continued)	Appendix O	USNRC Regulatory Guide 1.180, Revision 1 (Ref. 7)	MIL-STD 461-E, RS103 (Ref. 17): Radiated Susceptibility, High Frequency, Antenna Exposure	[[1 GHz to 8 GHz]]	Section 4.3.7 of EPRI TR 107330 and USNRC RG 1.180, Rev. 1 [[Susceptibility test level: 10 V/m]]
			IEC 61000-4-16 (Ref. 20): Conducted Susceptibility, Common Mode Disturbance, Signal Leads	[[DC test on the Digital Inputs]]	Section 4.3.7 of EPRI TR 107330 and USNRC RG 1.180, Rev. 1 [[Susceptibility test level - signal leads: RG 1.180: Table 15]]
Electrical Fast Transient (EFT)	Appendix G	USNRC Regulatory Guide 1.180, Rev. 1 (Ref. 7)	IEC 61000-4-4, "Electromagnetic Compatibility (EMC), Part 4-4: Testing and Measurement Techniques, Electrical Fast Transient/Burst Immunity Test," (Ref. 26)	[[Power Leads, Level 3 Test Voltage Level: 2 kV max]] [[Signal Leads, Level 3 Test Voltage Level: 1 kV max]]	Sections 4.6.2 and 4.3.7 of EPRI TR 107330 and USNRC Regulatory Guide 1.180, Rev. 1

Table 1. Generic Qualification Envelope for the *SPINLINE 3* Digital Safety I&C Platform

Equipment Qualification Category	EQ Plan Section	Regulatory Requirements	Source of Qualification Test Specification	Qualification Envelop	Qualification Test Acceptance Criteria
Surge Withstand	Appendix H	USNRC Regulatory Guide 1.180, Rev. 1 (Ref. 7)	Table 22 of USNRC RG 1.180, Rev. 1 (Ref. 7) defines the IEC 61000-4-12 Ring Wave (Ref. 29) and IEC 61000 4-5 Combination Wave (Ref. 28) surge withstand levels for power supplies installed in Category B locations with surge waveform Low Exposure levels	[[For power supplies installed in Category B locations with surge waveform Low Exposure levels, the corresponding Ring Wave surge withstand level is 2 kV and the corresponding Combination Wave surge withstand level is 2 kV open circuit and 1 kA short circuit]]	Section 4.6.2 of EPRI TR 107330 and USNRC Regulatory Guide 1.180, Rev. 1.
			Table 15 of USNRC RG 1.180, Rev. 1 (Ref. 7) defines the IEC 61000-4-12 Ring Wave (Ref. 29) and IEC 61000 4-5 Combination Wave (Ref. 28) surge withstand levels for signal leads in Low Exposure locations with Level 2 surge waveforms.		
			IEC 61000-4-5, "Electromagnetic Compatibility (EMC), Part 4-5: Testing and Measurement Techniques, Surge Immunity Test," (Ref. 28)	[[For signal leads in Low Exposure locations with Level 2 surge waveforms, the corresponding Ring Wave surge withstand level is 1 kV and the corresponding Combination Wave surge withstand level is 1 kV open circuit and 0.5 kA short circuit .]]	
			IEC 61000-4-12, "Electromagnetic Compatibility (EMC), Part 4-12: Testing and Measurement Techniques, Oscillatory Waves Immunity Test," (Ref. 29).		
Electrostatic Discharge (ESD)	Appendix I	EPRI TR 107330, Section 4.3.8 (Ref. 5), requires that the test specimen under qualification be tested for ESD withstand capability in accordance with the requirements of EPRI TR-102323-R1. USNRC Regulatory Guide 1.180, Revision 1 (Ref. 7) provides no guidance or requirements for ESD Testing.	IEC 61000-4-2 "Electromagnetic Compatibility (EMC), Part 4-2: Testing and Measurement Techniques, Electrostatic Discharge Immunity Test," (Ref. 30).	[[Maximum test levels of 8 kV for air discharges and 6 kV for contact discharges, corresponding to IEC 61000-4-2 Level 3. Testing to contact discharges will include the lower levels of 4 kV and 2 kV. Testing to air discharges will include the lower levels of 4 kV and 2 kV.]]	Sections 4.3.8 of EPRI TR 107330

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Table 1. Generic Qualification Envelope for the *SPINLINE 3* Digital Safety I&C Platform					
Equipment Qualification Category	**EQ Plan Section**	**Regulatory Requirements**	**Source of Qualification Test Specification**	**Qualification Envelop**	**Qualification Test Acceptance Criteria**
Class 1E to Non-Class 1E Isolation	Appendix J	IEEE Standard 384 (Ref. 31). EPRI TR 107330, Section 6.3.6 (Ref. 5), requires that the test specimen under qualification be tested for Class 1E to non-Class 1E isolation capability in accordance with the requirements of EPRI TR-107330, Section 4.6.4 (Ref. 5)	Sections 4.6.4 of EPRI TR 107330 (Ref. 5)	[[Analog output module Class 1E to Non-1E isolation point is tested for a maximum isolation capability of 250 VAC and 250 VDC at a maximum 10 amps applied for 30 seconds.]] [[Relay output module is tested to the full EPRI TR-107330 voltage levels of 600 VAC and 250 VDC for 30 sec. The applied currents will be limited to 25 amps (600 VAC) and 10 amps (250 VDC)]]	Sections 4.6.4 of EPRI TR 107330

9 Test Responsibilities

Rolls-Royce is both the manufacturer and the qualifier of the ***SPINLINE 3*** platform, as those terms are defined in Section 1.3 of EPRI TR-107330. Rolls-Royce will subcontract with a national test laboratory to provide qualification testing services.

Appendices A through M of this Equipment Qualification Plan identify the division of responsibilities between each organization for performance and documentation of the qualification testing and analysis activities. This division of responsibilities is identified by the indicated preparers of the qualification testing procedures and the test documentation.

10 Test Control

Section 7.2 of EPRI TR-107330 states that any activities performed to provide generic qualification of a PLC product shall be performed under a 10CFR50 Appendix B compliant Quality Assurance (QA) Program.

The qualification testing and analyses described in this Equipment Qualification Plan will be performed in accordance with the requirements of the Rolls-Royce Quality Assurance (QA) Program (Ref. 11), which is in compliance with the requirements of the Code of Federal Regulations, Title 10, Part 50, Appendix B (10CFR50, Appendix B, Ref. 13). Rolls-Royce Project Quality Plan (Ref. 12) identifies the task specific QA requirements applicable to the ***SPINLINE 3*** Qualification Project, and describe how those requirements will be satisfied.

As part of this project, Rolls-Royce will subcontract with and oversee hardware qualification testing by a test laboratory with a 10CFR50, Appendix B compliant Quality Assurance Program. Procurement, receipt and acceptance of the test laboratory services will be in accordance with Rolls-Royce QA Manual procedures for procurement, receipt and acceptance of nuclear grade services, including preparation of a services procurement specification. Laboratory testing services will be performed in accordance with the requirements of the procurement specification for such services, which shall invoke the test laboratory Appendix B QA Program. Rolls-Royce personnel appropriately certified to Rolls-Royce QA Manual procedures for certification of inspection, examination and test personnel will be present during and oversee all hardware qualification testing performed by the test laboratory.

As part of this project, Rolls-Royce personnel will participate in performing certain qualification testing activities. All Rolls-Royce personnel test activities will be performed according to the requirements of Rolls-Royce QA Manual procedures for test control. All testing activities performed by Rolls-Royce and the test laboratory will be accomplished according to documented test procedures prepared in accordance with Rolls-Royce QA Manual procedures for task-specific instructions and procedures.

All test exceptions, deficiencies, or field changes resulting from discrepancies or deficiencies in test documentation or unacceptable test specimen hardware or software performance during qualification testing will be set up in accordance with the Rolls-Royce Project Quality Plan (Ref. 12).

11 Test Documentation

Appendices A through M of this Equipment Qualification Plan identify the documentation to be prepared as a record of the qualification testing and analysis of the ***SPINLINE 3*** QTS.

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12 Measurement and Test Equipment

All measurement and test equipment (M&TE) used in the ***SPINLINE 3*** QTS Qualification Testing project to acquire data according to the qualification test procedures will be calibrated to the requirements of American National Standards Institute / National Conference of Standards Laboratories (ANSI/NCSL) Z540-1 (Ref. 35) and/or International Standards Organization (ISO) 10012-1 (Ref. 36). Standards used for calibration will be traceable to the National Institute of Standards and Technology (NIST).

Rolls-Royce will provide all required M&TE for simulating inputs to and monitoring performance of the test specimen during hardware qualification testing. Calibration of this equipment will be through Rolls-Royce approved suppliers. The selected qualification test laboratory will provide all required calibrated M&TE for monitoring the applied qualification test conditions and for recording the ***SPINLINE 3*** QTS response to the applied test conditions.

As part of the ***SPINLINE 3*** QTS Qualification Testing project, Rolls-Royce will specify, procure and program software based data acquisition system for use during Pre Qualification and Qualification Testing. The data acquisition system will be calibrated for use in the qualification project. Calibration shall be performed through a Rolls-Royce approved supplier.

13 References

1. U.S. Nuclear Regulatory Commission Regulatory Guide 1.89, "Environmental Qualification of Certain Electric Equipment Important to Safety for Nuclear Power Plants", June 1984
2. IEEE Standard 323-2003, "Standard for Qualifying Class 1E Equipment for Nuclear Power Generating Stations."
3. U.S. Nuclear Regulatory Commission Regulatory Guide 1.209, "Guidelines for Environmental Qualification of Safety-Related Computer-Based Instrumentation and Control Systems in Nuclear Power Plants," March 2007.
4. IEEE Standard 7-4.3.2-2003, "Standard Criteria for Digital Computers in Safety Systems of Nuclear Power Generating Stations."
5. EPRI TR-107330, "Generic Requirements Specification for Qualifying a Commercially Available PLC for Safety-Related Applications in Nuclear Power Plants," December 1996.
6. USNRC Letter dated July 30, 1998 to Mr. J. Naser (EPRI), "Safety Evaluation by the Office of Nuclear Reactor Regulation Electric Power Research Institute (EPRI) Topical Report, TR-107330, Final Report, "Generic Requirements Specification for Qualifying a Commercially Available PLC for Safety-Related Applications in Nuclear Power Plants."
7. U.S. Nuclear Regulatory Commission Regulatory Guide 1.180, Revision 1, "Guidelines for Evaluating Electromagnetic and Radio-Frequency Interference in Safety-Related Instrumentation and Control System," October 2003.
8. "System Specification of the Qualification Test Specimen and Data Acquisition System," Document No. 3 006 404E, Rolls-Royce Civil Nuclear SAS.
9. NUREG 0800, Standard Review Plan, Chapter 7.0, "Instrumentation and Controls - Overview of Review Process," Rev. 5, March 2007.
10. ISA RP 67.04.02-2000, "Methodologies for the Determination of Setpoints for Nuclear Safety-Related Instrumentation."
11. "Rolls-Royce Civil Nuclear SAS Quality Manual," Document No. 8 303 186 Rev. P.
12. "***SPINLINE 3*** NRC Qualification Project Quality Plan," Document No. 3 006 499A, Rolls-Royce Civil Nuclear SAS.
13. Title 10 to the Code of Federal Regulation, Part 50, Appendix B, "Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants."
14. EPRI TR-100516, "Nuclear Power Plant Equipment Qualification Reference Manual," 1992.

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15. IEEE Standard 344-1987, "Recommended Practice for Seismic Qualification of Class 1E Equipment for Nuclear Power Generating Stations."
16. EPRI TR-102323-R1, "Guidelines for Electromagnetic Interference Testing in Power Plants," January 1997.
17. Military Standard 461E, "Requirements for the Control of Electromagnetic Interference Characteristics of Subsystems and Equipment," August 20, 1999.
18. IEC 61000-4-6, "Testing and Measurement Techniques, Immunity to Conducted Disturbances Induced by Radio-Frequency Fields," May 2006.
19. IEC 61000-4-13, "Testing and Measurement Techniques, Harmonics and Interharmonics Including Mains Signaling at A.C. Power Ports, Low Frequency Immunity Tests," March 2002.
20. IEC 61000-4-16, "Testing and Measurement Techniques, Tests for Immunity to Conducted, Common Mode Disturbances in the Frequency Range 0 Hz to 150 kHz," July 2002.
21. IEC 61000-4-8, "Testing and Measurement Techniques, Power Frequency Magnetic Field Immunity Test," March 2001.
22. IEC 61000-4-9, "Testing and Measurement Techniques, Pulse Magnetic Field Immunity Test," March 2001.
23. IEC 61000-4-10, "Testing and Measurement Techniques, Damped Oscillatory Magnetic Field Immunity Test," March 2001.
24. IEC 61000-4-3, "Testing and Measurement Techniques, Radiated, Radio-Frequency, Electromagnetic Field Immunity Test," February 2006.
25. IEEE Standard 1050-1989, "Guide for Instrumentation and Control Equipment Grounding in Generating Stations."
26. IEC 61000-4-4, "Testing and Measurement Techniques, Section 4: Electrical Fast Transient/Burst Immunity Test," July 2004.
27. IEEE Standard C62.41-1991, "IEEE Recommended Practice on Surge Voltages in Low-Voltage AC Power Circuits," 1991, Reaffirmed 1995.
28. IEC 61000-4-5, "Testing and Measurement Techniques, Section 5: Surge Immunity Test," November 2005.
29. IEC 61000-4-12, "Testing and Measurement Techniques, Section 12: Oscillatory Waves Immunity Tests," September 2006.
30. IEC 61000-4-2, "Testing and Measurement Techniques, Section 2: Electrostatic Discharge Immunity Test," April 2001.
31. IEEE Standard 384-1981, "Standard Criteria for Independence of Class 1E Equipment and Circuits."
32. USNRC Regulatory Guide 1.152, Revision 2, "Criteria for Use of Computers in Safety Systems of Nuclear Power Plants," January 2006.
33. USNRC Regulatory Guide 1.100, Revision 2, "Seismic Qualification of Electric and Mechanical Equipment for Nuclear Power Plants", June 1988
34. ***SPINLINE 3*** Design Analysis Report (DAR), Document No. MPR-3337, MPR Associates, Inc., June 2009
35. ANSI / NCSL Z540.1-1994 (R2002) - Calibration & Measurement & Test Equipment - General Requirements, American National Standards Institute,
36. ISO 10012-1-1992: Quality Assurance Requirements for Measuring Equipment, International Organization for Standardization
37. "***SPINLINE 3*** NRC Qualification Project Summary Equipment Qualification Test Report," Document No. 3 014 545B, Rolls-Royce Civil Nuclear SAS.
38. "***SPINLINE 3*** NRC Qualification Project Master Configuration List," Document No. 3 010 612G, Rolls-Royce Civil Nuclear SAS.

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2010/2011 ***SPINLINE 3*** QTS QUALIFICATION SEQUENCE

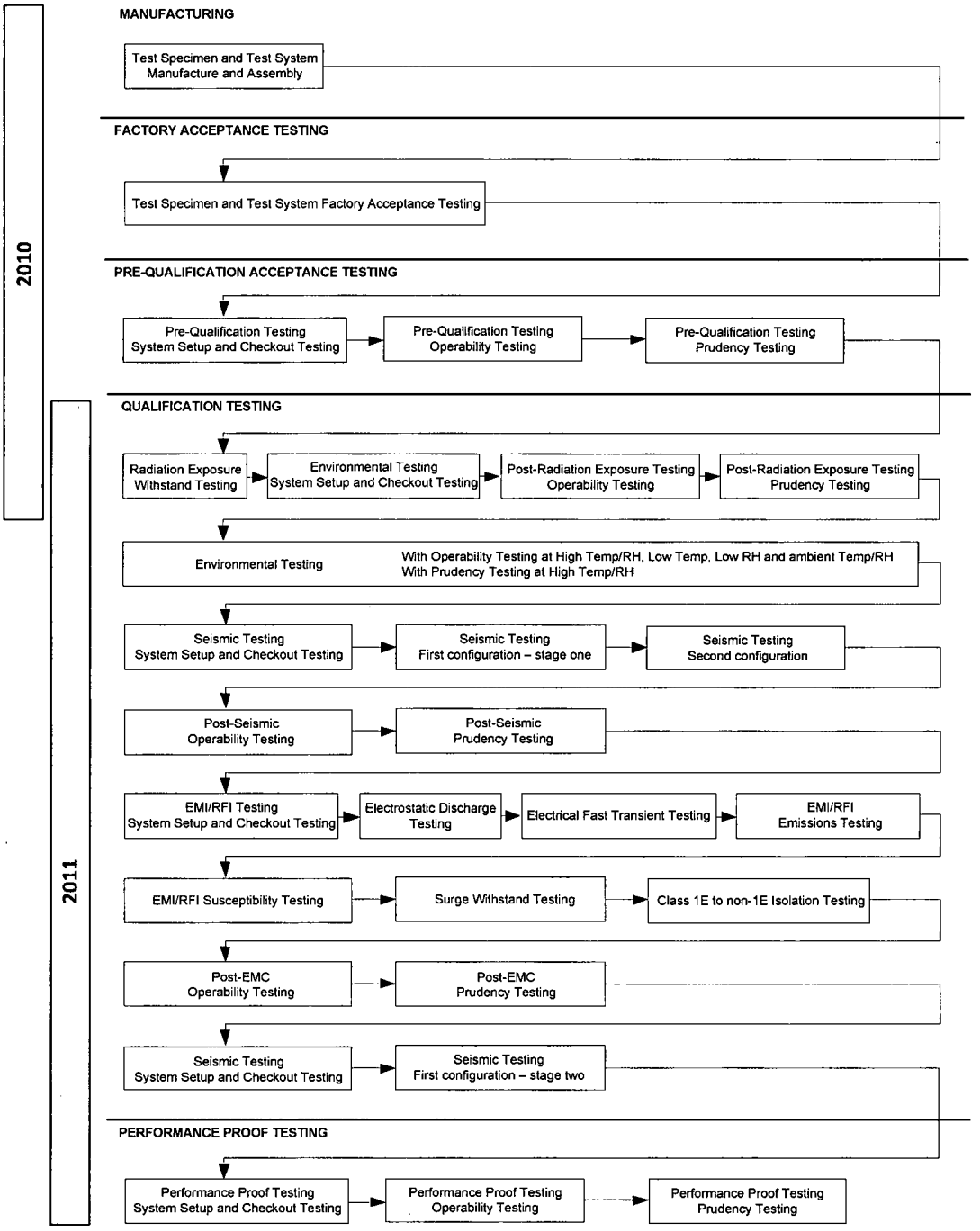

Figure 1 : 2010/2011 *SPINLINE 3* QTS Qualification Testing Sequence

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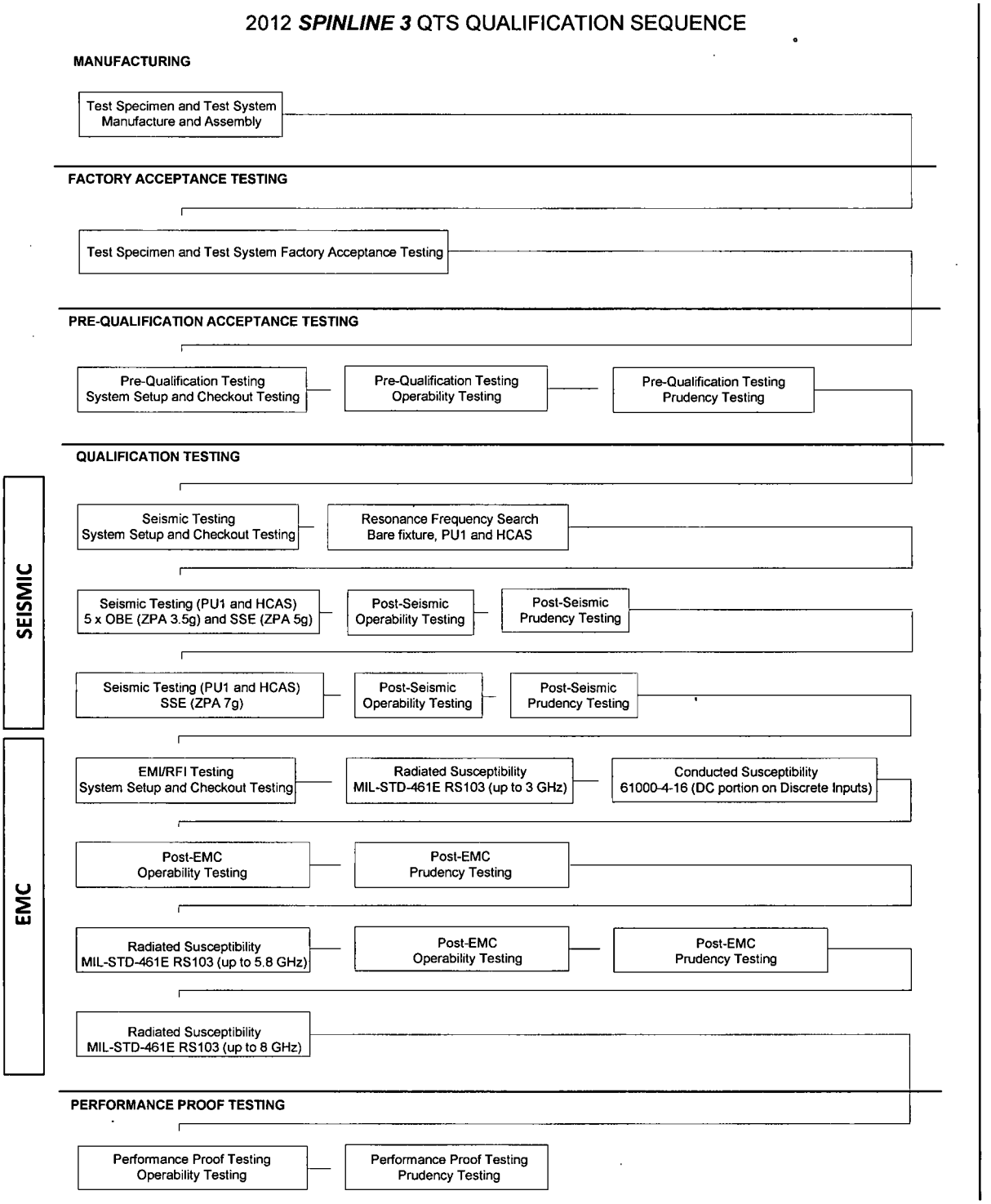

Figure 2 : 2012 *SPINLINE 3* QTS Qualification Testing Sequence

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14 Appendix – Summary Table

Tests	Appendix	Performed in
Factory Acceptance Test	A	2010 and 2012
Pre-Qualification Acceptance Testing	B	2010 and 2012
Radiation Exposure Testing	C	2010 and 2011 (spare parts)
Environmental Testing	D	2011
Seismic Testing	E	2011
EMI/RFI Testing	F	2011
Electrical Fast Transient Testing	G	2011
Surge Withstand Testing	H	2011
Electrostatic Discharge Testing	I	2011
Class 1^E to non-1^E Isolation Testing	J	2011
Performance Proof Testing	K	2011 and 2012
Operability Testing	L	2010, 2011 and 2012
Prudency Testing	M	2010, 2011 and 2012
Additional Seismic Testing	N	2012
Additional EMI/RFI Testing	O	2012

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Appendix A : Factory Acceptance Test Plan

A.1 Purpose

This test plan describes the approach for Factory Acceptance Testing of the Rolls-Royce ***SPINLINE 3*** Qualification Test Specimen (QTS) and Test System.

A.2 Objective

As part of the Rolls-Royce manufacturing process, hardware and software are developed and tested individually according to a "V" cycle:

- The ***SPINLINE 3*** QTS hardware undergo tests further to its manufacture and assembly, including:
  - visual inspection
  - ground continuity
  - insulation resistance
  - dielectric test
  - electrical consumption
  - functional tests first step (The TSAP is not yet installed in the QTS. The LACRAL test software is used instead, it enables verification of data acquisition and data transmission of the QTS).
- The ***SPINLINE 3*** QTS software is validated according to its Software Test Plan (the validation tests are performed on processing racks identical to the QTS processing racks)
- The Test System hardware undergo tests further to its manufacture and assembly
- The software of the Data Acquisition System is validated according to its Software Test Plan

Factory Acceptance Testing is performed at the end of the manufacturing and assembly phase to demonstrate compliance of the ***SPINLINE 3*** QTS and Test System with "System Specification of the Qualification Test Specimen and Data Acquisition System" (Ref. 8).

A.3 Equipment to be Tested

Equipment to be tested includes the ***SPINLINE 3*** QTS (hardware and software) and the Test System.

The Master Configuration List (Ref. 38), to be prepared by Rolls-Royce as part of the ***SPINLINE 3*** Qualification Project, will document the ***SPINLINE 3*** QTS hardware and firmware to be tested.

A Configuration List will also be prepared by Rolls-Royce for the Test System as part of the ***SPINLINE 3*** Qualification Project

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A.4 Sequence of Testing

As shown in Figure 1, Factory Acceptance Testing is performed after manufacture and assembly of the ***SPINLINE 3*** QTS and development of the TSAP, and prior to the start of the Pre-Qualification testing. The following describes the Acceptance Testing sequence:

1. Assemble the ***SPINLINE 3*** QTS and test system.
2. Install the TSAP on the QTS (the programmed components are placed on the corresponding processing unit).
3. Perform the Factory Acceptance Test.

A.5 Procedures

The following procedures are used during Factory Acceptance Testing:

a) Factory Acceptance Test Procedure: This procedure is written and implemented by Rolls-Royce. Through this procedure, correct operation of the ***SPINLINE 3*** QTS and test system is verified for all their operating modes.

A.6 Test Specimen Mounting

EPRI TR-107330 provides no requirements or guidance for mounting of the test specimen during Factory Acceptance Testing. The ***SPINLINE 3*** QTS will be mounted in open mounting frame(s) for Factory Acceptance Testing. The configuration of the ***SPINLINE 3*** QTS components and interconnecting cabling will be similar to expected in cabinet applications. The test specimen cooling fan(s) will be installed on the open mounting frame(s) and operating in such a manner that they provide cooling to the other ***SPINLINE 3*** QTS components.

A.7 Service Conditions

[[During Factory Acceptance Testing, the ***SPINLINE 3*** QTS will be powered with the input/outputs operating under control of the TSAP and the connected test system simulation devices. The input/output field circuits will be configured with loads representative of the types intended for connection to the corresponding input/output module points, and other devices required for monitoring of the circuit operations.

During Factory Acceptance Testing, the test space conditions of temperature and humidity shall be maintained within the normal operating range of the ***SPINLINE 3*** QTS.

During Factory Acceptance Testing, the power sources to the ***SPINLINE 3*** QTS cabinet power supply assembly will be set as follows:

a) Both of the test system power supply circuits to the ***SPINLINE 3*** QTS cabinet power supply assembly will be energized during Factory Acceptance Testing.

b) The power source to the ***SPINLINE 3*** QTS cabinet power supply assembly will be set to the manufacturer's specified nominal source voltage and frequency ratings for the cabinet power supply assembly inputs.]]

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A.8 Test Levels

The test levels (supply power and input/output signal and load levels) applied to the ***SPINLINE 3*** QTS during Factory Acceptance Testing will be as specified separately in the Factory Acceptance Test procedures.

A.9 Performance Monitoring

Performance monitoring of the ***SPINLINE 3*** QTS during Factory Acceptance Testing will be as specified separately in the Factory Acceptance Test procedure.

A.10 Acceptance Criteria

Acceptance criteria for performance monitoring of the ***SPINLINE 3*** QTS during Factory Acceptance Testing will be as specified separately in the Factory Acceptance Test procedure.

A.11 Documentation

The following records will be prepared by Rolls-Royce to document the results of Factory Acceptance Testing:

1. Factory Acceptance Test Procedure (Completed with Attachments)
2. Factory Acceptance Testing Report

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Appendix B : Pre-Qualification Acceptance Test Plan

B.1 Purpose

This test plan describes the approach for Pre-Qualification Acceptance Testing of the Rolls-Royce ***SPINLINE 3*** Qualification Test Specimen (QTS). Pre Qualification Acceptance Testing of the ***SPINLINE 3*** QTS is performed as part of qualification testing to demonstrate compliance with the applicable Pre-Qualification Acceptance Tests requirements of EPRI TR-107330, Section 5.2 (Ref. 5).

B.2 Objective

The objective of Pre-Qualification Acceptance Testing is to demonstrate that the ***SPINLINE 3*** QTS hardware and the Test Specimen Application Program (TSAP) operate as intended prior to start of qualification testing, and to provide baseline acceptance data for qualification testing implementation of the Operability and Prudency Tests. Section 5.2 of EPRI TR 107330 provides guidance for implementation of Pre-Qualification Acceptance Testing.

B.3 Equipment to be Tested

The Master Configuration List (Ref. 38), to be prepared by Rolls-Royce as part of the ***SPINLINE 3*** Qualification Project, will document the ***SPINLINE 3*** QTS hardware and firmware to be tested. Due to the complexity of the hardware and the scope of the required qualification testing, only one ***SPINLINE 3*** QTS will be used during qualification testing.

B.4 Sequence of Testing

As shown in Figure 1, Pre-Qualification Acceptance Testing is performed after Factory Acceptance Testing of the ***SPINLINE 3*** QTS and Test System, and prior to the start of the qualification testing. The following describes the Pre-Qualification Acceptance Testing sequence:

1. Perform the Pre-Qualification Acceptance Testing System Setup and Checkout Test.
2. Perform Pre-Qualification Acceptance (baseline) Operability Testing.
3. Perform Pre-Qualification Acceptance (baseline) Prudency Testing.
4. Disassemble the ***SPINLINE 3*** QTS and test system for transport to the qualification test facility[1].

The sequence of testing does not include Application Software Objects Acceptance (ASOA) Testing as listed in Section 5.2.A of EPRI TR-107330. ASOA is part of the software qualification activities, which are addressed by the Design Analysis Report (DAR).

The sequence of testing does not include Burn-In Testing as listed in Section 5.2.F of EPRI TR 107330. The Rolls-Royce ***SPINLINE 3*** platform manufacturing process includes routine burn-in of ***SPINLINE 3*** platform hardware. This process is documented in Rolls-Royce manufacturing procedures. Manufacturing burn-in of the ***SPINLINE 3*** QTS hardware is considered to meet the intent of the EPRI TR 107330 requirement to detect early life failures during Pre-Qualification Testing through performance of Burn-In Testing.

[1] The 2012 Pre-Qualification Testing of the ***SPINLINE 3*** QTS is performed at the qualification test facility.

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B.5 Procedures

The following procedures are used during Pre-Qualification Acceptance Testing:

a) System Setup and Checkout Test Procedure: This procedure is drafted by MPR Associates, finalized by Rolls-Royce, and implemented by Rolls-Royce. Through this procedure, initial ***SPINLINE 3*** QTS calibration is addressed and the correct operation of the ***SPINLINE 3*** QTS and test system is verified.

b) Operability Test Procedure: This procedure is drafted by MPR Associates, finalized by Rolls-Royce, and implemented by Rolls-Royce. This procedure includes a series of tests defined in Section 5.3 of EPRI TR-107330 that verify acceptable performance of the ***SPINLINE 3*** QTS in accordance with the manufacturer's specifications for the ***SPINLINE 3*** platform. The Pre Qualification Testing run of this procedure establishes baseline performance of the ***SPINLINE 3*** QTS for use in performance of the Operability Test Procedure throughout qualification testing.

c) Prudency Test Procedure: This procedure is drafted by MPR Associates, finalized by Rolls-Royce, and implemented by Rolls-Royce. This procedure includes a series of tests defined in Section 5.4 of EPRI TR-107330 that verify acceptable performance of the ***SPINLINE 3*** QTS in accordance with the manufacturer's specifications for the ***SPINLINE 3*** platform. The Pre-Qualification Testing run of this procedure establishes baseline performance of the ***SPINLINE 3*** QTS for use in performance of the Prudency Test Procedure throughout qualification testing.

B.6 Test Specimen Mounting

EPRI TR-107330 provides no requirements or guidance for mounting of the test specimen during Pre Qualification Acceptance Testing.

The ***SPINLINE 3*** QTS will be mounted in open mounting frame(s) for Pre-Qualification Acceptance Testing. The configuration of the ***SPINLINE 3*** QTS components and interconnecting cabling will be similar to expected in cabinet applications. The test specimen cooling fan(s) will be installed on the open mounting frame(s) and operating in such a manner that they provide cooling to the other ***SPINLINE 3*** QTS components.

B.7 Service Conditions

EPRI TR-107330 provides no requirements or guidance for operation of the test specimen during Pre-Qualification Acceptance Testing. During Pre-Qualification Acceptance Testing, the ***SPINLINE 3*** QTS will be powered with the input/outputs operating under control of the TSAP and the connected test system simulation devices

[[The input/output field circuits will be configured with loads representative of the types intended for connection to the corresponding input/output module points, and other devices required for monitoring of the circuit operations.]]

EPRI TR-107330 provides no requirements or guidance for control of ambient conditions (temperature, pressure and humidity) during Pre-Qualification Acceptance Testing. [[During Pre Qualification Acceptance Testing, the test space conditions of temperature and humidity shall be maintained within the normal operating range of the ***SPINLINE 3*** QTS.]]

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EPRI TR-107330 provides no requirements or guidance for configuration of the test PLC power supply sources during Pre-Qualification Acceptance Testing. [[During Pre-Qualification Acceptance Testing, the power sources to the ***SPINLINE 3*** QTS cabinet power supply assembly will be set as follows:

a) Both of the test system power supply circuits to the ***SPINLINE 3*** QTS cabinet power supply assembly will be energized during Pre-Qualification Acceptance Testing.

b) The power sources to the energized ***SPINLINE 3*** QTS cabinet power supply assembly will be set to the manufacturer's specified nominal source voltage and frequency ratings for the cabinet power supply assembly inputs.]]

B.8 Test Levels

The test levels (supply power and input/output signal and load levels) applied to the ***SPINLINE 3*** QTS during Pre-Qualification Acceptance Testing will be as specified separately in the System Setup and Checkout, Operability and Prudency Test procedures.

B.9 Performance Monitoring

Performance monitoring of the ***SPINLINE 3*** QTS during Pre-Qualification Acceptance Testing will be as specified separately in the System Setup and Checkout, Operability and Prudency Test procedures.

B.10 Acceptance Criteria

Acceptance criteria for performance monitoring of the ***SPINLINE 3*** QTS during Pre Qualification Acceptance Testing will be as specified separately in the System Setup and Checkout, Operability and Prudency Test procedures

B.11 Documentation

The following records will be prepared by Rolls-Royce to document the results of Pre-Qualification Acceptance Testing:

1. Pre-Qualification Testing System Setup and Checkout Test Procedure (Completed with Attachments)
2. Pre-Qualification Acceptance Testing Operability Test Procedure (Completed with Attachments)
3. Pre-Qualification Acceptance Testing Prudency Test Procedure (Completed with Attachments)
4 Pre-Qualification Acceptance Testing Report

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Appendix C : Radiation Exposure Withstand Test Plan

C.1 Purpose

This test plan describes the approach for Radiation Exposure Withstand Testing of the Rolls-Royce ***SPINLINE 3*** Qualification Test Specimen (QTS). Radiation Exposure Withstand Testing of the QTS is performed as part of qualification testing to demonstrate compliance with the applicable environmental requirements of EPRI TR 107330, Section 4.3.6 (Ref. 5).

C.2 Objective

The objective of Radiation Exposure Withstand Testing is to demonstrate the ***SPINLINE 3*** QTS will not experience failures or unacceptable degradation due to expected radiation exposure arising from normal and abnormal service conditions as required by Regulatory Guide 1.89 (Ref. 1) and IEEE 323-2003 (Ref. 2). Section 4.3.6 of EPRI TR 107330 defines the normal and abnormal radiation exposure levels the test specimen must withstand (i.e., the test specimen must continue to meet the manufacturer specified performance levels). [[The radiation qualification envelope for ***SPINLINE 3*** is intended to be 1000 Rad.]]

C.3 Equipment to be Tested

The Master Configuration List (Ref. 38), to be prepared by Rolls-Royce as part of the ***SPINLINE 3*** Qualification Project, will document the ***SPINLINE 3*** QTS hardware and firmware to be tested. Due to the complexity of the hardware and the scope of the required qualification testing, only one ***SPINLINE 3*** QTS will be used during qualification testing.

C.4 Sequence of Testing

As shown in Figure 1, Radiation Exposure Withstand Testing is performed after completion of the Pre-Qualification Testing Baseline Operability and Prudency Test runs. The following describes the Radiation Exposure Withstand Test sequence:

1. Disassemble the ***SPINLINE 3*** QTS for Radiation Exposure Withstand Testing.
2. Transport the ***SPINLINE 3*** QTS to the Radiation Exposure Withstand Testing facility.
3. Position the ***SPINLINE 3*** QTS components to be irradiated in the test chamber.
4. Irradiate the ***SPINLINE 3*** QTS components per the Radiation Exposure Withstand test procedures.
5. If required per the Radiation Exposure Withstand test procedures, reposition the ***SPINLINE 3*** QTS components to be irradiated and repeat Step 4.
6. Remove the irradiated ***SPINLINE 3*** QTS components from the test chamber.
7. Repeat Steps 3 through 6 for the remaining ***SPINLINE 3*** QTS components to be irradiated.

8. Transport the ***SPINLINE 3*** QTS to the Environmental Testing facility.
9. Per the Environmental Test procedure, reassemble the ***SPINLINE 3*** QTS, perform System Setup and Checkout Testing, and perform the post Radiation Exposure Withstand Testing Operability and Prudency Testing.

C.5 Procedures

The following procedure is used during Radiation Exposure Withstand Testing:

a) Radiation Exposure Withstand Test Procedure: This procedure is drafted by MPR Associates, finalized by Rolls-Royce, and implemented by Rolls-Royce. Through this procedure, the ***SPINLINE 3*** QTS is configured in the test chamber for irradiation, and the condition of the ***SPINLINE 3*** QTS is determined on completion of testing.

C.6 Test Specimen Mounting

EPRI TR-107330 provides no requirements or guidance for mounting of the test specimen during Radiation Exposure Withstand Testing.

The exposed ***SPINLINE 3*** QTS components for each irradiation test run will be positioned on a bench top located in front of the gamma radiation source window. [[Tests will be run with both the front and rear faces of each of the larger test specimen components oriented towards the gamma radiation source. During each test run, no additional hardware or shielding material will be located inside the test chamber. During each test run, all other parts of the ***SPINLINE 3*** QTS not under test will be located outside the test chamber.]]

C.7 Service Conditions

EPRI TR-107330 provides no requirements or guidance for operation of the test specimen during Radiation Exposure Withstand Testing.

[[Radiation induced degradation or damage at the exposure levels specified by EPRI TR-107330 is not expected to be influenced by the operating state of the ***SPINLINE 3*** QTS. In particular, the specified test exposure levels and exposure rates will not cause any significant heating of the ***SPINLINE 3*** QTS that might exaggerate the normal operating heat buildup. Therefore, the ***SPINLINE 3*** QTS will not be energized during Radiation Exposure Withstand Testing.]]

EPRI TR-107330 provides no requirements or guidance for control of ambient conditions (temperature, pressure and humidity) during Radiation Exposure Withstand Testing. [[The irradiation test chamber ambient conditions of temperature and humidity shall be maintained within the normal operating range of the ***SPINLINE 3*** QTS.]]

C.8 Test Levels

As stated in Section 4.1 of EPRI TR-107330, the normal and abnormal environmental radiation exposure levels (1000 RAD) given in Section 4.3.6 of the TR are characteristic of "mild" plant operating environments (i.e., plant environments that are not exposed to harsh environmental conditions during design basis events).

Section 6.3 (Table 6.6) of EPRI TR 100516, Nuclear Power Plant Equipment Qualification Reference Manual (Ref. 14), provides a basis for the specified 1000 RAD radiation exposure level. Section 6.3 further defines the 1000 RAD exposure as the gamma 40-year dose from normal/abnormal service (approximately 2.9 millirem per hour).

USNRC RG 1.209, "Guidelines for Environmental Qualification of Safety Related Computer-Based Instrumentation and Control Systems in Nuclear Power Plants" (Ref. 3) identifies that one significant difference between digital and analog equipment is the radiation tolerance. The radiation exposure level (1000 RAD) as required in EPRI TR-107330 is compliant with the sensitivity of digital equipment as discussed in section B of USNRC RG 1.209.

IEEE Standard 323-2003, "Standard for Qualifying Class 1E Equipment for Nuclear Power Generating Stations," (Ref. 2) imposes an additional margin of 10% on the qualification test level.

[[The ***SPINLINE 3*** QTS will be exposed to a total accumulated external surface dose of 1100 RAD (plus 100 RAD or minus 0 RAD) using a ^{60}Co gamma ray source. A typical plant installation will have the ***SPINLINE 3*** platform chassis stacked and housed in metal instrument cabinets. The cabinets will provide some shielding of the enclosed hardware from incident radiation. It is expected that in the installed configuration, the front and rear faces of each chassis will receive the least cabinet shielding from incident radiation, and will provide the least shielding for further penetration of the incident radiation to components inside the chassis. Therefore, the front and rear face of each test specimen chassis will be separately oriented towards the gamma radiation source during Radiation Exposure Withstand Testing.

Accelerated exposure rate testing will be performed to achieve a practical total test time. The exposure rate shall result in delivery of the required total dose over a minimum 2 hour and maximum 4 hour exposure period.]]

C.9 Performance Monitoring

EPRI TR-107330 provides no requirements or guidance for performance monitoring of the test specimen during Radiation Exposure Withstand Testing.

[[As described in Section C.7, the ***SPINLINE 3*** QTS will be de-energized during Radiation Exposure Withstand Testing. Therefore, operation of the ***SPINLINE 3*** QTS will not be monitored during testing. Successful completion of the Radiation Exposure Withstand Tests is based on satisfactory results of the Operability and Prudency Tests to be performed following completion of the Radiation Exposure Withstand Testing.]] Also, the ***SPINLINE 3*** QTS will be visually inspected for exterior damage or degradation following Radiation Exposure Withstand Testing

C.10 Acceptance Criteria

The following Radiation Exposure Withstand Test acceptance criteria are based on Section 4.3.6 of EPRI TR-107330.

a) The ***SPINLINE 3*** QTS components shall not exhibit any exterior damage or degradation as a result of gamma radiation exposure based on visual examinations performed following Radiation Exposure Withstand Testing.

b) The ***SPINLINE 3*** QTS shall meet all acceptance criteria of the Operability and Prudency Tests to be performed following Radiation Exposure Withstand Testing.

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C.11 Documentation

The following records will be prepared by Rolls-Royce to document the results of Radiation Exposure Withstand Testing:

1. Radiation Exposure Withstand Test Procedure (Completed with Attachments)
2. Post Radiation Exposure Withstand Testing Operability Test Procedure (Completed with Attachments)
3. Post Radiation Exposure Withstand Testing Prudency Test Procedure (Completed with Attachments)
4. Rolls-Royce Radiation Exposure Withstand Test Report

The following record will be prepared by the test facility to document the results of Radiation Exposure Withstand Testing:

1. Test Facility Radiation Exposure Withstand Test Report

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Appendix D : Environmental Test Plan

D.1 Purpose

This test plan describes the approach for Environmental Testing of the Rolls-Royce ***SPINLINE 3*** Qualification Test Specimen (QTS). Environmental Testing of the ***SPINLINE 3*** QTS is performed as part of qualification testing to demonstrate compliance with the applicable environmental requirements of EPRI TR 107330, Sections 4.3.6 and 6.4.4 (Ref. 5).

D.2 Objective

The objective of Environmental Testing is to demonstrate the ***SPINLINE 3*** QTS will not experience failures due to abnormal service conditions of temperature and humidity as required by Regulatory Guide 1.89 (Ref. 1) and IEEE 323-2003 (Ref. 2), subject to enhancements and exceptions listed in Section C of Regulatory Guide 1.209 (Ref. 3).. Section 4.3.6 of EPRI TR 107330 defines the recommended normal and abnormal temperature and humidity exposure levels the test specimen must withstand (i.e., the test specimen must continue to meet the manufacturer specified performance levels). [[The temperature and humidity environmental qualification envelope for ***SPINLINE 3*** is intended to be from 41°F (5°C) to 122°F (50°C) and 5% to 90% relative humidity (non-condensing).]]

D.3 Equipment to be Tested

The Master Configuration List (Ref. 38), to be prepared by Rolls-Royce as part of the ***SPINLINE 3*** Qualification Project, will document the ***SPINLINE 3*** QTS hardware and firmware to be tested. Due to the complexity of the hardware and the scope of the required qualification testing, only one ***SPINLINE 3*** QTS will be used during qualification testing.

D.4 Sequence of Testing

As shown in Figure 1, Environmental Testing is performed after completion of Radiation Exposure Withstand Testing, and includes performance of the post Radiation Exposure Withstand Testing Operability and Prudency Tests. The following describes the Environmental Testing sequence:

1. Assemble the ***SPINLINE 3*** QTS in the Environmental Test chamber.
2. Perform the Pre-Environmental Testing System Setup and Checkout Test.
3. Perform the Post Radiation Exposure Withstand Testing Operability and Prudency Testing.
4. Expose the ***SPINLINE 3*** QTS to varying temperature and humidity conditions according to the Environmental Testing procedures.

5. Perform Environmental Testing Operability and Prudency Testing at the times identified in the Environmental Testing procedures.
6. Remove the ***SPINLINE 3*** QTS from the Environmental Test chamber.

D.5 Procedures

The following procedures are used during Environmental Testing:

a) System Setup and Checkout Test Procedure: This procedure is drafted by MPR Associates, finalized by Rolls-Royce, and implemented by Rolls-Royce. Through this procedure, the ***SPINLINE 3*** QTS is configured in the test chamber for Environmental Testing, and the correct operation of the ***SPINLINE 3*** QTS and test system is verified.

b) Environmental Test Procedure: This procedure is drafted by MPR Associates, finalized by Rolls-Royce, and implemented by Rolls-Royce. Through this procedure, the ***SPINLINE 3*** QTS receives additional configuration in the test chamber for Environmental Testing, and the performance of the ***SPINLINE 3*** QTS is monitored throughout application of the Environmental Test conditions.

c) Operability Test Procedure: This procedure is drafted by MPR Associates, finalized by Rolls-Royce, and implemented by Rolls-Royce. This procedure includes a series of tests defined in Section 5.3 of EPRI TR-107330 that verify acceptable performance of the ***SPINLINE 3*** QTS in accordance with the manufacturer's specifications for the ***SPINLINE 3*** platform. The Post Radiation Exposure Withstand Testing run of this procedure is performed following completion of the Setup and Checkout Test procedure and prior to application of the Environmental Test conditions. This procedure is also performed at various times during application of the Environmental Test conditions as listed in Table 5-1 of EPRI TR-107330.

d) Prudency Test Procedure: This procedure is drafted by MPR Associates, finalized by Rolls-Royce, and implemented by Rolls-Royce. This procedure includes a series of tests defined in Section 5.4 of EPRI TR-107330 that verify acceptable performance of the ***SPINLINE 3*** QTS in accordance with the manufacturer's specifications for the ***SPINLINE 3*** platform. The Post Radiation Exposure Withstand Testing run of this procedure is performed following completion of the Setup and Checkout Test procedure and prior to application of the Environmental Test conditions. This procedure is also performed one time during application of the Environmental Test conditions as listed in Table 5-1 of EPRI TR-107330.

D.6 Test Specimen Mounting

EPRI TR-107330, Section 6.3.3.1 requires that during Environmental Testing the test specimen be mounted on a simple structure that does not enclose the test specimen chassis. No additional cooling fans shall be included in the Environmental Test chamber other than those normally included with the ***SPINLINE 3*** QTS.

The ***SPINLINE 3*** QTS will be installed in the environmental test chamber in accordance with the requirements of EPRI TR-107330, Section 6.3.3.1. The ***SPINLINE 3*** QTS includes cabinet cooling fan(s) which will be a part of actual plant applications and therefore are subject to qualification testing. During environmental qualification of the ***SPINLINE 3*** QTS, the cabinet cooling fan(s) will be installed on the ***SPINLINE 3*** QTS mounting frame and operating in such a manner that they provide cooling of the other ***SPINLINE 3*** QTS components. The cabinet cooling fans are powered from the output of the ***SPINLINE 3*** QTS cabinet power supply assembly.

EPRI TR-107330, Section 6.2.1.1 requires that during Environmental Testing the test specimen modules be arranged to simulate the maximum expected temperature rise across the test specimen chassis for any reasonable arrangement of the modules included for qualification. The ***SPINLINE 3*** QTS modules will be arranged to meet the intent of this requirement.

D.7 Service Conditions

EPRI TR-107330, Section 6.3.3, requires that the test specimen be powered with its TSAP operating during Environmental Testing, with 1/2 of the discrete and relay outputs ON and loaded to their rated current. In addition, all analog outputs shall be set to between 1/2 and 2/3 of full scale.

[[The ***SPINLINE 3*** QTS includes only relay outputs. During Environmental Testing, the ***SPINLINE 3*** QTS will be powered with the TSAP operating. In accordance with the TSAP, more than 1/2 of the output points on each relay output module will be constantly ON. The field circuits for these relay output points will be configured with resistive loads which result in the approximate rated current through the output points at the nominal rated output point voltage. These resistive loads will be located outside the Environmental Test chamber.

During Environmental Testing, the ***SPINLINE 3*** QTS Test Specimen Application Program (TSAP) will be set such that all analog outputs operate continuously at between 50% and 75% of full scale (where 50% full scale is taken to be 10 mA for a 4 to 20 mA output). This operation bounds the EPRI TR-107330 requirement for operation of the analog outputs between 50% and 67%.]]

EPRI TR-107330, Section 6.3.3, requires that Environmental Testing be performed with the power supply sources set to values that maximize heat dissipation in the test specimen. [[The QTS is powered by the cabinet power supply assembly. This assembly includes three cabinet power supply chassis. Each chassis includes two separate power converter groups. The test system provides two separate 120 VAC power supply circuits (AC-1 and AC-2) to the cabinet power supply assembly. One circuit provides power to each of three power converter groups, one in each cabinet power supply chassis. The other circuit provides power to each of the other three power converter groups, one in each cabinet power supply chassis. Although all of the cabinet power supply assembly power converter groups would normally be powered during system operation, only half of the power converter groups (those fed from either AC-1 or AC-2) are required to fully power the QTS. The other half of the power converter groups provides redundant and non-interruptible backup power in case of failure or loss of power to the primary power converter groups. During Environmental Testing, the power sources to the ***SPINLINE 3*** QTS cabinet power supply assembly will be set as follows:

a) One of the two test system power supply circuits will be de-energized during Environmental Testing. This will place the full test specimen load on only one of the two cabinet power supply assembly power converter groups. This configuration is expected to result in greater heat dissipation than operating both of the cabinet power supply assembly power converter groups at significantly lower loadings.

b) The power source to the energized cabinet power supply assembly power converter group will be set to the manufacturer's minimum allowable source voltage and frequency settings. This is expected to result in greater current draw by the energized cabinet power supply assembly power converter group, which will result in increased heat dissipation.]]

EPRI TR-107330, Section 6.2.1, requires that additional resistive loads be placed on each test specimen main power supply output so that nominal current draws at nominal power supply output voltages are equal to the power supply rating. Section 6.3.3.1 requires that these additional resistive loads be placed in the Environmental Test chamber. [[During Environmental Testing, additional resistive loads will be placed on the output of the energized ***SPINLINE 3*** QTS cabinet power supply assembly power converter group such that the nominal (at rated input voltage and frequency) current draw of the power converter group at nominal output voltage is equal to the power converter group rating. The additional resistive loads will be placed in the Environmental Test chamber during testing.]]

EPRI TR-107330, Section 6.2.1, requires that additional resistive loads be placed on each test specimen loop power supply output so that nominal current draws at nominal power supply output voltages are equal to the power supply rating. Section 6.3.3.1 requires that these additional resistive loads be placed in the Environmental Test chamber. [[During Environmental Testing, additional resistive loads will be placed on the output(s) of the ***SPINLINE 3*** QTS auxiliary power supply module(s) such that the nominal (at rated input voltage) current draws of the auxiliary power supply module(s) at nominal output voltage are equal to the auxiliary power supply module ratings. The additional resistive loads will be placed in the Environmental Test chamber during testing.]]

D.8 Test Levels

EPRI TR-107330, Section 4.3.6, requires that the test specimen meet its performance requirements during and following exposure to abnormal environmental conditions of 40°F (4.4°C) to 120°F (48.9°C) and 10% to 95% relative humidity (non-condensing). Figure 4-4 of EPRI TR-107330 shows a profile of temperature and humidity vs. time which can be used during Environmental Testing to demonstrate the environmental withstand requirements. The profile includes margin on maximum temperature to address potential increased temperature effects of in-cabinet installations. The Figure 4-4 minimum and maximum conditions of temperature and humidity are 40°F (4.4°C) to 140°F (60°C) and 5% to 90% relative humidity (non-condensing).

[[Environmental Testing of the ***SPINLINE 3*** QTS will be performed using an environmental test chamber. A temperature and humidity vs. time profile similar to Figure 4-4 of EPRI TR-107330 will be applied during testing. Additional low temperature and high humidity margin will be included to address uncertainties in test measurements and final in-plant application conditions. The minimum and maximum conditions of temperature and humidity to be applied during testing are 35°F (1.7°C) to 140°F (60°C) and 5% to 95% relative humidity (non condensing).]]

Some environmental test chambers can not simultaneously achieve conditions of low temperature (35°F) and low relative humidity (5%). Low temperature and low relative humidity testing can be performed separately as described in Note 1 of EPRI TR-107330 Figure 4-4. The maximum temperature obtained during low relative humidity testing shall not exceed 140°F.

D.9 Performance Monitoring

EPRI TR-107330, Section 6.3.3.1, requires that air temperature be monitored near the fan inlet if any test specimen power supply contains fans, or at the bottom of each test specimen chassis, for test specimens that use natural circulation cooling. [[The ***SPINLINE 3*** QTS cabinet power supply assembly does not include cooling fans. The ***SPINLINE 3*** QTS cooling fans are provided as a separate cabinet cooling fan assembly that would be located at the top of a ***SPINLINE 3*** cabinet. The cabinet cooling fan assembly draws cooling air up through each ***SPINLINE 3*** component. This cooling configuration more closely resembles the natural circulation cooling configuration described in EPRI TR-107330. Therefore, one thermocouple will be mounted at the bottom of each ***SPINLINE 3*** QTS component or component assembly to monitor air temperature during testing. An additional thermocouple will be located at the inlet of one ***SPINLINE 3*** QTS cabinet cooling fan assembly to monitor air temperature during testing.]]

EPRI TR-107330, Section 4.3.6.3, requires that the test specimen operate as intended during and following exposure to the temperature and humidity profile given in Figure 4-4 of EPRI TR 107330. [[During Environmental Testing, operation of the ***SPINLINE 3*** QTS will be continuously monitored and recorded by the test system data logging instrumentation. The recorded data will be evaluated for time periods both during and after the test. The data evaluations will consider operation (per the TSAP) of at least one input or output point on each I/O module installed in the ***SPINLINE 3*** QTS, and operation of all connected NERVIA communication interfaces.]]

D.10 Acceptance Criteria

The following Environmental Test acceptance criteria are based on Section 4.3.6 of EPRI TR 107330.

a) The ***SPINLINE 3*** QTS shall operate as intended during and after exposure to the Environmental Test conditions given in Section C.8. Evaluation of normal operating performance data (inputs, outputs and fault/diagnostic indicators) collected during testing shall demonstrate operation as intended.

b) The ***SPINLINE 3*** QTS shall meet the applicable acceptance criteria of the Operability Tests performed during Environmental Testing.

c) The ***SPINLINE 3*** QTS shall meet the applicable acceptance criteria of the Prudency Test performed during Environmental Testing.

D.11 Documentation

The following records will be prepared by Rolls-Royce to document the results of Environmental Testing:

1. Environmental Testing System Setup and Checkout Test Procedure (Completed with Attachments)
2. Environmental Testing Procedure (Completed with Attachments)
3. High Temperature, High Humidity Environmental Testing Operability Test Procedure (Completed with Attachments)
4. Low Temperature Environmental Testing Operability Test Procedure (Completed with Attachments)
5. Low Humidity Environmental Testing Operability Test Procedure (Completed with Attachments)
6. Ambient Temperature, Ambient Humidity Environmental Testing Operability Test Procedure (Completed with Attachments)
7. High Temperature, High Humidity Environmental Testing Prudency Test Procedure (Completed with Attachments)
8. Rolls-Royce Environmental Test Report

The following record will be prepared by the test facility to document the results of Environmental Testing:

1. Test Facility Environmental Test Report

Rolls-Royce

Appendix E : Seismic Test Plan

E.1 Purpose

This test plan describes the approach for Seismic Testing of the Rolls-Royce ***SPINLINE 3*** Qualification Test Specimen (QTS). Seismic Testing of the ***SPINLINE 3*** QTS is performed as part of qualification testing to demonstrate compliance with USNRC RG 1.100 (Ref. 33) and IEEE Standard 344-1987 (Ref. 15). It uses guidance from EPRI TR-107330 which is compliant with these requirements.

E.2 Objective

The objective of Seismic Testing is to demonstrate the suitability of the ***SPINLINE 3*** platform for qualification as a Category 1 seismic device based on seismic withstand testing performed on the ***SPINLINE 3*** QTS in accordance with Regulatory Guide 1.100 (Ref. 33) and IEEE 344--1987 (Ref. 15). Section 4.3.9 of EPRI TR 107330 defines the recommended seismic test levels the test specimen is expected to withstand (i.e., the test specimen must continue to meet the manufacturer specified performance levels). These tests will establish the qualification envelope for ***SPINLINE 3*** seismic withstand.

E.3 Equipment to be Tested

The Master Configuration List (Ref. 38), to be prepared by Rolls-Royce as part of the ***SPINLINE 3*** Qualification Project, will document the ***SPINLINE 3*** QTS hardware and firmware to be tested. Due to the complexity of the hardware and the scope of the required qualification testing, only one ***SPINLINE 3*** QTS will be used during qualification testing.

E.4 Sequence of Testing

As shown in Figure 1, Seismic Testing is performed after completion of Environmental Testing.

The following describes the Seismic Testing sequence:

1. Perform Resonance Search testing on the ***SPINLINE 3*** QTS components.
2. Setup the ***SPINLINE 3*** QTS on the Seismic Test table.
3. Perform the Pre-Seismic Testing System Setup and Checkout Test.
4. Perform five seismic tests to the specified Operating Basis Earthquake (OBE) test levels.
5. Perform one seismic test to the specified Safe Shutdown Earthquake (SSE) test level.
6. Perform Post Seismic Testing Operability and Prudency Testing.
7. Remove the ***SPINLINE 3*** QTS from the Seismic Test table.

E.5 Procedures

The following procedures are used during Seismic Testing:

a) System Setup and Checkout Test Procedure: This procedure is drafted by MPR Associates, finalized by Rolls-Royce, and implemented by Rolls-Royce. Through this procedure, the ***SPINLINE 3*** QTS is configured on the test table for Seismic Testing, and the correct operation of the ***SPINLINE 3*** QTS and test system is verified.

b) Seismic Test Procedure This procedure is drafted by MPR Associates, finalized by Rolls-Royce, and implemented by Rolls-Royce. Through this procedure, the ***SPINLINE 3*** QTS is subjected to resonance search testing and receives additional configuration on the test table for Seismic Testing. This procedure requires monitoring the performance of the ***SPINLINE 3*** QTS throughout application of the Seismic Test conditions.

c) Operability Test Procedure: This procedure is drafted by MPR Associates, finalized by Rolls-Royce, and implemented by Rolls-Royce. This procedure includes a series of tests defined in Section 5.3 of EPRI TR-107330 that verify acceptable performance of the ***SPINLINE 3*** QTS in accordance with the manufacturer's specifications for the ***SPINLINE 3*** platform. This procedure is performed at the completion of Seismic Testing as listed in Table 5-1 of EPRI TR-107330. [[Due to the short duration of the Seismic Test runs (approximately 30 seconds each), the Operability Test (which takes several hours to complete) can not be performed during Seismic Testing as indicated in Table 5-1 of EPRI TR-107330.]]

d) Prudency Test Procedure: This procedure is drafted by MPR Associates, finalized by Rolls-Royce, and implemented by Rolls-Royce. This procedure includes a series of tests defined in Section 5.4 of EPRI TR-107330 that verify acceptable performance of the ***SPINLINE 3*** QTS in accordance with the manufacturer's specifications for the ***SPINLINE 3*** platform. Although not required by Table 5-1 of EPRI TR-107330, this procedure is performed at the completion of Seismic Testing. [[Due to the short duration of the Seismic Test runs (approximately 30 seconds each), the Prudency Test (which takes several hours to complete) can not be performed during Seismic Testing as indicated in Table 5-1 of EPRI TR-107330.]]

E.6 Test Specimen Mounting

EPRI TR-107330, Section 6.3.4.1 requires the test specimen to be mounted on a structure whose configuration meets the manufacturer's mounting requirements during Seismic Testing. The structure shall be stiff enough so there are no resonances below 100 Hz. The seismic tests shall be performed with the test specimen mounting most susceptible to seismic vibrations. The mounting shall use manufacturer required hardware. All threaded fasteners used for mounting shall be tightened with a torque wrench and the torque values recorded.

The ***SPINLINE 3*** QTS will be mounted to the Seismic Test table in accordance with Rolls-Royce specified mounting instructions for seismic applications. The Seismic Test mounting will simulate a typical 19" rack mount configuration using standard Rolls-Royce chassis mounting brackets and fastener hardware. Resonance search testing will demonstrate that the simulated mounting configuration is stiff enough so that there are no resonances below 100 Hz. All mounting hardware fasteners will be tightened using calibrated torquing devices, and torque values will be recorded.

EPRI TR-107330, Section 6.2.1.1 requires that during Seismic Testing the test specimen modules and associated cabling be arranged to cause a total stress on the chassis and its mounting hardware that is equal to the maximum that could result from any reasonable arrangement of the modules, cabling, and any other devices included in the qualification program. If necessary, dummy weights may be added.

The ***SPINLINE 3*** QTS will be configured, mounted, and equipped with dummy weight loadings as necessary to meet these requirements within the confines of the manufacturer's instructions for configuration and mounting for seismic applications. Several modules installed in the ***SPINLINE 3*** QTS main chassis will be located as close together as the chassis design allows to demonstrate interaction effects during the Seismic Testing.

E.7 Service Conditions

EPRI TR-107330, Section 6.3.4.2, requires that the test specimen be powered with its Test Specimen Application Program (TSAP) operating during Seismic Testing, 1/2 of its solid-state discrete outputs shall be ON and loaded to their rated current, 1/2 of its relay outputs shall be ON, and 1/2 of its relay outputs shall be OFF. In addition, 1/4 of its relay outputs shall transition from OFF to ON and 1/4 shall transition from ON to OFF during the OBE and SSE tests.

[[During Seismic Testing, the ***SPINLINE 3*** QTS will be powered with the TSAP operating. The ***SPINLINE 3*** QTS does not include solid-state discrete outputs. Because there are no solid-state discrete outputs, several of the relay output points are required to operate under control of the TSAP differently than the fixed ON and OFF operation described above in order to support such measurements as time response during Seismic Testing. Therefore, in accordance with the TSAP, at any point during operation only 1/2 of a portion of the relay output points on the relay output modules will be held ON and 1/2 of a portion of the relay output points will be held OFF. Every 5 seconds, approximately 1/4 of the relay output points that were held ON will transition from ON to OFF, and another approximately 1/4 of the relay output points that were held OFF will transition from OFF to ON. In this manner, at any point during the tests, 1/2 of a portion of the relay output points will be held ON and 1/2 of a portion will be held OFF. Approximately 1/4 of the points held OFF will be shown to transition from OFF to ON, and approximately 1/4 of the points held ON will be shown to transition from ON to OFF. The field circuits of a representative portion of the relay output points will be configured with resistive loads which result in the approximate rated current through the output points at the nominal rated output point voltage.]]

EPRI TR-107330, Section 6.3.4.2, requires that Seismic Testing be performed with the power sources to the test specimen power supply modules set to operate at the following minimum AC and DC source voltages and frequencies given in Section 4.6.1.1 of the EPRI TR:

a) Power supply modules fed from AC sources shall remain operable at a minimum source voltage of 90 VAC and a minimum source frequency of 57 Hz.

b) Power supply modules fed from DC sources shall remain operable at a minimum source voltage of 20.4 VDC.

[[The ***SPINLINE 3*** QTS does not include cabinet power supply modules fed from external DC sources. During Seismic Testing, the energized AC power sources to the ***SPINLINE 3*** QTS cabinet power supply assembly will be set to 90 VAC and 57 Hz.]]

EPRI TR-107330, Section 6.2.1, requires that additional resistive loads be placed on each test specimen main power supply output so that nominal current draws at nominal power supply output voltages are equal to the power supply rating. [[During Seismic Testing, one of the two test system power supply circuits to the ***SPINLINE 3*** QTS will be de-energized. This will place the full test specimen load on only one of the two cabinet power supply assembly power converter groups. Additional resistive loads will be placed on the output of the energized power converter group such that the nominal (at rated input voltage and frequency) current draw of the power converter group at nominal output voltage is equal to the power converter group rating. The additional resistive loads will be located off of the Seismic Test table during testing.]]

EPRI TR-107330, Section 6.2.1, requires that additional resistive loads be placed on each test specimen loop power supply output so that nominal current draws at nominal power supply output voltages are equal to the power supply rating. [[During Seismic Testing, additional resistive loads will be placed on the output(s) of the ***SPINLINE 3*** QTS auxiliary power supply module(s) such that the nominal (at rated input voltage) current draws of the auxiliary power supply module(s) at nominal output voltage are equal to the auxiliary power supply module ratings. The additional resistive loads will be located off of the Seismic Test table during testing.]]

E.8 Test Levels

EPRI TR-107330, Sections 4.3.9 and 6.3.4, require that the test specimen be seismically tested in accordance with IEEE Standard 344 (Ref. 15). The testing shall include a resonance search followed by five simulated Operating Basis Earthquakes (OBEs) to the level shown in Figure 4 5 of EPRI TR-107330, and one simulated Safe Shutdown Earthquake (SSE) to the level shown in Figure 4 5 of EPRI TR-107330. The test vibrations shall be applied triaxially (in three orthogonal directions), and shall be random and multifrequency in content. The maximum SSE and OBE levels shown in Figure 4-5 are (maximum acceleration) 14 g and 9.75 g respectively, based on 5% damping.

[[Seismic Testing of the ***SPINLINE 3*** QTS will be performed using a resonance search test table and a triaxial seismic test table. Seismic Testing will be performed in the following order:

1) Resonance search as described in Section 7.1.4 of IEEE Standard 344.
2) Five triaxial Operating Basis Earthquake (OBEs) tests with a minimum Zero Period Acceleration (ZPA) of 4.9 g.
3) One triaxial Safe Shutdown Earthquake (SSE) test with a minimum ZPA of 7 g.

The resonance search tests shall include a low-level of acceleration (approximately 0.2 g) single-axis sine sweep from 1 to 100 Hz, or the Required Response Spectrum (RRS) cutoff frequency, whichever is higher, in each of the three orthogonal axes to determine major resonances. The resonance search sweep rate shall be set to two octaves per minute or less to ensure resonance build-up.

The OBE and SSE tests shall follow the RRS curve given as Figure 4-5 in EPRI TR-107330 within the limits of the seismic test table, with the exception that the minimum ZPA requirements are met. Testing will be performed and analyzed at 5% damping. Inability to meet the RRS at any specific vibration frequencies during OBE or SSE testing as a result of seismic table limitations will be documented in the seismic test report.]]

E.9 Performance Monitoring

EPRI TR-107330, Section 6.3.4.1, requires that the test specimen Seismic Table mounting fixtures be stiff enough so that there are no resonances below 100 Hz, which is verified by resonance search testing. During resonance search testing, the test facility will instrument the test table and the test specimen in order to detect resonances below 100 Hz.

EPRI TR-107330, Section 6.3.4.2, requires that the Seismic Test table be instrumented with a control accelerometer and that each chassis of the test specimen be instrumented with one or more response accelerometers located to establish maximum chassis accelerations.

[[During Seismic Testing, control accelerometers will be mounted on the Seismic Test table near the base of the ***SPINLINE 3*** QTS mounting fixtures. Additionally, three response accelerometers will be mounted on each of the ***SPINLINE 3*** QTS racks (one triaxial location per rack).

Additional response accelerometers will also be mounted on selected ***SPINLINE 3*** QTS components during each series of OBE and SSE tests (one triaxial location per selected component). The locations of these accelerometers will be selected to indicate the maximum response motion of the ***SPINLINE 3*** QTS components.]]

EPRI TR-107330, Section 4.3.9, requires that the test specimen operate as intended during and following the application of an SSE, all connections and parts remain intact and in place, and relay output contacts not chatter. Relay contact chatter is defined as a spurious change of state that exceeds 2 milliseconds in duration.

[[During application of the OBE and SSE vibrations, operation of the ***SPINLINE 3*** QTS will be continuously monitored and recorded by the test system data logging instrumentation. The recorded data will be evaluated for time periods both during and after the test. The data evaluations will consider operation (per the TSAP) of at least one input or output point on each I/O module installed in the ***SPINLINE 3*** QTS, and operation of all connected NERVIA communication interfaces. The data evaluations will also consider

operation of all points on the relay output modules, looking specifically for chattering in both the OFF and ON states.

Following each simulated OBE and SSE test, the ***SPINLINE 3*** QTS components mounted on the Seismic Test table will be inspected for damage or degradation.]]

E.10 Acceptance Criteria

The following Seismic Test acceptance criteria are based on Section 4.3.9 of EPRI TR 107330.

a) The ***SPINLINE 3*** QTS mounting fixtures shall be stiff enough so that there are no resonances below 100 Hz detected during resonance search testing.

b) The ***SPINLINE 3*** QTS shall operate as intended during and after application of the OBE and SSE vibrations given in Section E.8. Evaluation of normal operating performance data (inputs, outputs and fault/diagnostic indicators) collected during testing shall demonstrate operation as intended.

c) During and after application of the OBE and SSE vibrations:
   - All connections on the ***SPINLINE 3*** QTS shall remain intact,
   - All modules installed in the ***SPINLINE 3*** QTS shall remain fully inserted,
   - No functional or non-functional parts of the ***SPINLINE 3*** QTS shall fall off.

d) During application of the OBE and SSE vibrations, the relay output module contacts shall be demonstrated to change state from energized to de-energized and de-energized to energized in accordance with execution of the TSAP.

e) During application of the OBE and SSE vibrations, any spurious change of state of the relay output module contacts shall not exceed 2 milliseconds in duration for both energized and de-energized contact states.

f) The ***SPINLINE 3*** QTS shall meet the applicable acceptance criteria of the Operability Tests performed on completion of Seismic Testing.

g) The ***SPINLINE 3*** QTS shall meet the applicable acceptance criteria of the Prudency Test performed on completion of Seismic Testing.

E.11 Documentation

The following records will be prepared by Rolls-Royce to document the results of Seismic Testing:

1. Seismic Testing Setup and Checkout Test Procedure (Completed with Attachments)
2. Seismic Testing Procedure (Completed with Attachments)
3. Post Seismic Testing Operability Test Procedure (Completed with Attachments)
4. Post Seismic Testing Prudency Test Procedure (Completed with Attachments)
5. Rolls-Royce Seismic Test Report

The following record will be prepared by the test facility to document the results of Seismic Testing:

1. Test Facility Seismic Test Report

Rolls-Royce

Appendix F : EMI/RFI Test Plan

F.1 Purpose

This test plan describes the approach for Electromagnetic Interference / Radiofrequency Interference (EMI/RFI) Testing of the Rolls-Royce ***SPINLINE 3*** Qualification Test Specimen (QTS). EMI/RFI Testing of the ***SPINLINE 3*** QTS is performed as part of qualification testing to demonstrate compliance with the applicable EMI/RFI emissions and susceptibility requirements of USNRC Regulatory Guide (RG) 1.180, Rev. 1 (Ref. 7) and EPRI TR-107330 (Ref. 5).

F.2 Objective

The objective of EMI/RFI testing is to demonstrate the suitability of the ***SPINLINE 3*** platform for qualification as a safety-related device with respect to EMI/RFI emissions and susceptibility levels. EMI/RFI testing of the ***SPINLINE 3*** QTS will be performed in accordance with USNRC RG 1.180, Revision 1, using additional guidance from EPRI TR-107330 as applicable. The specific EMI/RFI tests to be performed include:

EMI/RFI Emissions Tests

- MIL-461E, CE101 (Ref. 17): Conducted Emissions, Low Frequency, AC and DC Power Leads
- MIL-461E, CE102 (Ref. 17): Conducted Emissions, High Frequency, AC and DC Power Leads
- MIL-461E, RE101 (Ref. 17): Radiated Emissions, Magnetic Field, QTS Surfaces and Leads
- MIL-461E, RE102 (Ref. 17): Radiated Emissions, Electric Field, Antenna Measurement

EMI/RFI Susceptibility Tests

- IEC 61000-4-6 (Ref. 18): Conducted Susceptibility, Induced RF Fields, Power/Signal Leads
- IEC 61000-4-13 (Ref. 19): Conducted Susceptibility, Harmonics/Interharmonics, Power Leads
- IEC 61000-4-16 (Ref. 20): Conducted Susceptibility, Common Mode Disturbance, Power/Signal Leads
- IEC 61000-4-8 (Ref. 21): Radiated Susceptibility, Magnetic Field, Helmholtz Coil Exposure
- IEC 61000-4-9 (Ref. 22): Radiated Susceptibility, Magnetic Field, Pulsed
- IEC 61000-4-10 (Ref. 23): Radiated Susceptibility, Magnetic Field, Damped Oscillatory
- IEC 61000-4-3 (Ref. 24): Radiated Susceptibility, High Frequency, Antenna Exposure

These tests will establish the qualification envelope for ***SPINLINE 3*** EMI/RFI emissions and susceptibility.

F.3 Equipment to be Tested

The Master Configuration List (Ref. 38), to be prepared by Rolls-Royce as part of the ***SPINLINE 3*** Qualification Project, will document the ***SPINLINE 3*** QTS hardware and firmware to be tested. Due to the complexity of the hardware and the scope of the required qualification testing, only one ***SPINLINE 3*** QTS will be used during qualification testing.

F.4 Sequence of Testing

As shown in Figure 1, EMI/RFI Testing is performed after completion of Seismic Testing. The following describes the EMI/RFI Testing sequence:

1. Setup the ***SPINLINE 3*** QTS in the EMI/RFI test chamber.
2. Perform the Pre-EMI/RFI Testing System Setup and Checkout Test.
3. Perform EMI/RFI Emissions Testing.
4. Perform EMI/RFI Susceptibility Testing.

F.5 Procedures

The following procedures are used during EMI/RFI Testing:

a) System Setup and Checkout Test Procedure: This procedure is drafted by MPR Associates, finalized by Rolls-Royce, and implemented by Rolls-Royce. Through this procedure, the ***SPINLINE 3*** QTS is configured in the EMI/RFI test chamber for EMI/RFI Testing, and the correct operation of the ***SPINLINE 3*** QTS and test system is verified.

b) EMI/RFI Test Procedure: This procedure is drafted by MPR Associates, finalized by Rolls-Royce, and implemented by Rolls-Royce. Through this procedure, the ***SPINLINE 3*** QTS receives additional configuration in the EMI/RFI test chamber for EMI/RFI Testing, and the performance of the ***SPINLINE 3*** QTS is monitored throughout application of the EMI/RFI Test conditions.

c) Test Facility EMI/RFI Test Procedure: This procedure is prepared and implemented by the selected qualification test facility. Through this procedure, the ***SPINLINE 3*** QTS receives additional configuration and instrumentation in the EMI/RFI test chamber for EMI/RFI Testing, and the specified EMI/RFI Test conditions are applied to the ***SPINLINE 3*** QTS and monitored.

F.6 Test Specimen Mounting

EPRI TR-107330, Section 6.3.2.1 requires that the test specimen be mounted on a non-metallic vertical surface at a height of at least six feet to the bottom of the test specimen chassis, with no secondary enclosure. The test specimen shall be connected to a ground bus located at the base of the mounting surface using the manufacturer's recommended grounding conductor. Grounding and shielding shall meet the requirements of IEEE Standard 1050 (Ref. 25) and EPRI TR 102323-R1.

The ***SPINLINE 3*** QTS will be installed in the EMI/RFI test chamber mounted in metal frame instrument cabinet(s) with all sides removed. Due to restraints imposed by the size of the ***SPINLINE 3*** QTS, the requirement to mount the test specimen six feet above the floor of the test chamber can not practicably be met. The test specimen mounting frame(s) will be mounted on non-conductive (i.e., wooden) supports approximately 4 inches above the floor of the test chamber. This is done to prevent the EMI/RFI Test results from being affected by beneficial ground paths that might exist through the test specimen mounting frame(s) if the frame(s) were placed directly on the floor of the EMI/RFI test chamber, which acts as a ground plane for the entire test chamber. [[The test system power distribution panel will also be located inside the test chamber. This panel is not part of the equipment under test, however, the panel grounding configuration shall be specified and documented by Rolls-Royce. All other test system equipment will be located outside the EMI/RFI test chamber.]]

Grounding of the ***SPINLINE 3*** QTS will be in accordance with the manufacturer's recommendations. The ***SPINLINE 3*** QTS grounds will be passed across the gap created by the mounting frame non-conductive supports and bonded to the EMI/RFI test chamber floor. This grounding configuration meets the applicable EPRI TR 107330 requirements for grounding during EMI/RFI Testing.

F.7 Service Conditions

EPRI TR-107330 does not include specific requirements for operation of the test specimen during EMI/RFI Testing. [[During EMI/RFI Testing, the ***SPINLINE 3*** QTS will be powered with the Test Specimen Application Program (TSAP) operating in a mode which will cycle all but one of the relay output circuits on timed ON/OFF cycles. The TSAP operating mode will also cycle a number of the analog output circuits through stair-stepping output values on repeating cycles, and exercise the NERVIA communication interfaces. The test system simulators (or jumpered connections) will operate a number of the discrete input circuits on timed ON/OFF cycles, and operate a number of the analog and RTD inputs through stair-stepping output values on repeating cycles.

The data acquisition system (DAS) which is part of the test system consists of a real time input/output chassis that performs signal generation and acquisition, and a part that performs the data processing. The communication between these two parts of the DAS is achieved with fiber optic. In order to minimize transmission of outside EMI/RFI sources into the EMI/RFI test chamber, the real time input/output chassis is embedded in a shielded cabinet that is installed in the test chamber. Most of the test system signal and communication wiring entering or exiting the shielded cabinet will pass through PI filters mounted on the shielded cabinet.

In order to limit the number of required signal wire pass-through filters, the normal ***SPINLINE 3*** QTS and test system configurations will be altered for EMI/RFI Testing. The number of signal wires passing from the ***SPINLINE 3*** QTS to the test system data recording and simulation system will be limited to approximately one circuit per test specimen input/output module. All other normally interconnected signal wires will be disconnected and input/output point jumpers installed as necessary.]]

EPRI TR-107330 provides no requirements or guidance for control of ambient conditions (temperature, pressure and humidity) during EMI/RFI Testing. [[During EMI/RFI Testing, the EMI/RFI test chamber conditions of temperature and humidity will be maintained within the normal operating range of the ***SPINLINE 3*** QTS and in accordance with the specific EMI/RFI test standards being performed. The EMI/RFI test chamber barometric pressure will be allowed to assume the barometric pressure conditions local to the test facility.]]

EPRI TR-107330 does not include specific requirements for configuration of the test specimen power supplies during EMI/RFI Testing. [[Both of the test system power supply circuits to the ***SPINLINE 3*** QTS cabinet power supply assembly will be energized during EMI/RFI Testing. The AC sources to the ***SPINLINE 3*** QTS cabinet power supply assembly will be set at nominal source voltage and frequency conditions during the EMI/RFI Testing.]] EPRI TR-107330, Section 6.2.1, requires that additional resistive loads be placed on each test specimen main power supply output so that nominal current draws at nominal power supply output voltages are equal to the power supply rating. [[This power supply loading is not realistic for a ***SPINLINE 3*** platform with redundant active cabinet power supply assembly supply circuits. During EMI/RFI Testing, additional resistive loads will be placed on the redundant outputs of the cabinet power supply assembly such that the nominal (at rated input voltage and frequency) current draws of each redundant output at nominal output voltage is equal to 1/2 the output ratings.

In order to minimize transmission of outside EMI/RFI sources into the EMI/RFI test chamber, all test system power supply cables entering the EMI/RFI test chamber must pass through filter capacitors (provided by the test facility) located in the chamber walls. The power supply feeds to the ***SPINLINE 3*** QTS cabinet power supply assembly must also pass through line impedance stabilization networks (LISNs, provided by the test facility) located inside the EMI/RFI test chamber.

The relay output point load resistors connected during Seismic and Environmental Testing will be disconnected during EMI/RFI Testing.]] Neither EPRI TR-107330 nor the industry EMI/RFI test standards to be used require the relay output points to be operating at rated currents during EMI/RFI Testing.

EPRI TR-107330, Section 6.2.1, requires that additional resistive loads be placed on each test specimen loop power supply output so that nominal current draws at nominal power supply output voltages are equal to the power supply rating. [[During EMI/RFI Testing, additional resistive loads will be placed on the output(s) of the ***SPINLINE 3*** QTS auxiliary power supply module(s) such that the nominal (at rated input voltage) current draws of the auxiliary power supply module(s) at nominal output voltage are equal to the auxiliary power supply module ratings.]]

F.8 Test Levels

EMI/RFI Testing of the ***SPINLINE 3*** QTS will be performed inside a shielded (anechoic or semi-anechoic) test chamber. The following table summarizes the specific EMI/RFI emissions and susceptibility testing to be accomplished per USNRC RG 1.180, Rev. 1, and the specified test levels (frequency ranges) to be used. Test acceptance criteria, including applied susceptibility test levels (dBmV, %V, Vrms, A/m, and V/m) are listed in Section F.10 of this Appendix).

Test Type	Test Method	[[Frequency Range]]
Cond. Emissions, Low Frequency, AC and DC Power Leads	MIL-461E, CE101	[[30 Hz to 10 kHz]]
Cond. Emissions, High Frequency, AC and DC Power Leads	MIL-461E, CE102	[[10 kHz to 2 MHz]]
Rad. Emissions, Magnetic Field, TUT Surfaces and Leads	MIL-461E, RE101	[[30 Hz to 100 kHz]]
Rad. Emissions, Electric Field, Antenna Measurement	MIL-461E, RE102	[[2 MHz to 1 GHz (1)]]
Cond. Susceptibility, Induced RF Fields, Power/Signal Leads	IEC 61000-4-6	[[150 kHz to 80 MHz]]
Cond. Susceptibility, Harmonics/Interharmonics, Power Leads	IEC 61000-4-13	[[16 Hz to 2.4 kHz]]
Cond. Suscept., Common Mode Disturbs., Power/Signal Leads	IEC 61000-4-16	[[15 Hz to 150 kHz]]
Rad. Susceptibility, Magnetic Field, Helmholtz Coil Exposure	IEC 61000-4-8	[[60 Hz]]
Rad. Susceptibility, Magnetic Field, Pulsed	IEC 61000-4-9	[[Pulsed]]
Rad. Susceptibility, Magnetic Field, Damped Oscillatory	IEC 61000-4-10	[[100 kHz and 1 MHz]]
Rad. Susceptibility, High Frequency, Antenna Exposure	IEC 61000-4-3	[[26 MHz to 1 GHz]]

[[(1) The listed frequency range assumes the highest intentionally generated frequency within the ***SPINLINE 3*** QTS is less than 100 MHz. 1 GHz is ten times this highest assumed intentionally generated internal frequency.]]

F.9 Performance Monitoring

EPRI TR-107330, Section 4.3.7, requires that the test specimen under qualification withstand the applied EMI/RFI susceptibility test levels.

Specifically, when subjected to the EMI/RFI test levels, the test specimen modules shall perform as follows:

a) The main processors and coprocessors shall continue to function.

b) The transfer of I/O data shall not be interrupted.

c) The emissions shall not cause the discrete I/O to change state.

d) Analog I/O levels shall not vary more than 3% (of full scale).

In addition, EPRI TR-107330 requires that a portion of the Operability and Prudency Tests be performed during the EMI/RFI testing.

[[During EMI/RFI emissions testing, the test facility will be responsible for measuring and recording emissions data and comparing the recorded data to the emissions acceptance criteria given in Section 3 of USNRC RG 1.180, Rev. 1. During emissions testing, Rolls-Royce will be responsible for ensuring proper operation of the ***SPINLINE 3*** QTS.

During EMI/RFI susceptibility testing, the test facility will be responsible for generating and exposing the ***SPINLINE 3*** QTS to the required levels of EMI/RFI given in Section 4 of USNRC RG 1.180, Rev. 1. During susceptibility testing, Rolls-Royce will be responsible for monitoring operation of the ***SPINLINE 3*** QTS and determining the susceptibility of the ***SPINLINE 3*** QTS to the applied levels of EMI/RFI.

During EMI/RFI Testing, operation of the ***SPINLINE 3*** QTS will be monitored and recorded by the test system data logging instrumentation. The recorded data will be evaluated for time periods before, during and after each EMI/RFI Test. The data evaluations will consider operation (per the TSAP) of at least one input or output point on each I/O module installed in the ***SPINLINE 3*** QTS, and operation of the NERVIA communication interfaces. The data recorded during EMI/RFI Testing will be sufficient to demonstrate the EPRI TR-107330 performance criteria listed above.

The SPINLINE 3 QTS and test system as configured for EMI/RFI Testing does not support Operability or Prudency Testing. This configuration (as necessitated by the constraints of installation in EMI/RFI test chamber) will be maintained throughout performance of the EFT, Surge Withstand, ESD and Class 1E to Non-1E Isolation testing to be done after EMI/RFI Testing. For these reasons it is not practical to perform the Operability and Prudency Tests either during or immediately following the EMI/RFI Tests. The data recorded during the EMI/RFI Tests will demonstrate acceptable system performance during EMI/RFI exposure. The Operability and Prudency Tests run at the completion of all qualification testing will demonstrate acceptable system performance following all electrical stress testing.]]

F.10 Acceptance Criteria

The following EMI/RFI Test acceptance criteria are based on Section 4.3.7 of EPRI TR 107330 and USNRC RG 1.180, Rev. 1.

[[

a) The SPINLINE 3 QTS shall meet allowable equipment emission limits as specified in USNRC RG 1.180, Rev. 1 for the following MIL-STD-461E test methods:

MIL-STD Test Method	Emission Limits
CE101 – Conducted Emissions, 30 Hz to 10 kHz	RG 1.180, Rev. 1: Figure 3-1
CE102 – Conducted Emissions, 10 kHz to 2 MHz	RG 1.180, Rev. 1: Figure 3-2
RE101 – Radiated Emissions, 30 Hz to 100 kHz	RG 1.180, Rev. 1: Figure 3-3
RE102 – Radiated Emissions, 2 MHz to 1 GHz	RG 1.180, Rev. 1: Figure 3-4

b) The SPINLINE 3 QTS shall operate as intended during and after application of the EMI/RFI test levels specified in USNRC RG 1.180, Rev. 1 for the following IEC 61000 series test methods:

IEC Test Method	Susceptibility Test Level
61000-4-6 – Cond. Suscept., Power Leads, 150 kHz to 80 MHz	140 dBµV
61000-4-6 – Cond. Suscept., Signal Leads, 150 kHz to 80 MHz	130 dBµV
61000-4-13 – Conducted Susceptibility, 16 Hz to 2.4 kHz	RG 1.180: Table 10
61000-4-16 – Cond. Suscept., Power Leads, 15 Hz to 150 kHz	RG 1.180: Table 11
61000-4-16 – Cond. Suscept., Signal Leads, 15 Hz to 150 kHz	RG 1.180: Table 15
61000-4-8 – Radiated Susceptibility, Continuous, 60 Hz	30 A/m
61000-4-8 – Radiated Susceptibility, Short Duration, 60 Hz	300 A/m
61000-4-9 – Radiated Susceptibility, Pulsed	300 A/m
61000-4-10 – Radiated Susceptibility, 100 kHz to 1 MHz	30 A/m
61000-4-3 – Radiated Susceptibility, 26 MHz to 1 GHz	10 V/m

Evaluation of normal operating performance data (inputs, outputs and fault/diagnostic indicators) shall demonstrate operation as intended, including the following specific operational performance from Section 4.3.7 of EPRI TR-107330:

a) The main processors and coprocessors shall continue to function.
b) The transfer of I/O data shall not be interrupted.
c) The emissions shall not cause the discrete I/O to change state.
d) Analog I/O levels shall not vary more than 3% (of full scale).

]]

F.11 Documentation

The following records will be prepared by Rolls-Royce to document the results of EMI/RFI Testing:

1. EMI/RFI Testing Setup and Checkout Test Procedure (Completed with Attachments)
2. EMI/RFI Testing Procedure (Completed with Attachments)
3. Rolls-Royce EMI/RFI Test Report

The following record will be prepared by the test facility to document the results of EMI/RFI Testing:

1. Test Facility EMI/RFI Test Report

Appendix G : Electrical Fast Transient Test Plan

G.1 Purpose

This test plan describes the approach for Electrical Fast Transient (EFT) Testing of the Rolls-Royce ***SPINLINE 3*** Qualification Test Specimen (QTS). EFT Testing of the ***SPINLINE 3*** QTS is performed as part of qualification testing to demonstrate compliance with the applicable EFT susceptibility requirements of USNRC Regulatory Guide (RG) 1.180, Rev. 1 (Ref. 7).

G.2 Objective

The objective of EFT testing is to demonstrate the suitability of the ***SPINLINE 3*** platform for qualification as a safety-related device with respect to EFT susceptibility levels. EFT testing of the ***SPINLINE 3*** QTS will be performed in accordance with USNRC RG 1.180, Rev. 1, using additional guidance from EPRI TR-107330 as applicable. The specific EFT test to be performed is IEC 61000-4-4, "Electromagnetic Compatibility (EMC), Part 4-4: Testing and Measurement Techniques, Electrical Fast Transient/Burst Immunity Test," (Ref. 26). This test will establish the qualification envelope for ***SPINLINE 3*** for EFT susceptibility.

G.3 Equipment to be Tested

The Master Configuration List (Ref. 38), to be prepared by Rolls-Royce as part of the ***SPINLINE 3*** Qualification Project, will document the ***SPINLINE 3*** QTS hardware and firmware to be tested. Due to the complexity of the hardware and the scope of the required qualification testing, only one ***SPINLINE 3*** QTS will be used during qualification testing.

G.4 Sequence of Testing

As shown in Figure 1, EFT Testing is performed after completion of EMI/RFI Testing and uses the same ***SPINLINE 3*** QTS and test system setup as the EMI/RFI Testing.

G.5 Procedures

The following procedures are used during EFT Testing:

a) EFT Test Procedure: This procedure is drafted by MPR Associates, finalized by Rolls-Royce, and implemented by Rolls-Royce. Through this procedure, the ***SPINLINE 3*** QTS receives additional configuration in the test chamber for EFT Testing, and the performance of the ***SPINLINE 3*** QTS is monitored throughout application of the EFT Test conditions.

b) Test Facility EFT Test Procedure: This procedure is prepared and implemented by the selected qualification test facility. Through this procedure, the ***SPINLINE 3*** QTS receives additional configuration and instrumentation in the test chamber for EFT Testing, and the specified EFT Test conditions are applied to the ***SPINLINE 3*** QTS and monitored.

G.6 Test Specimen Mounting

EPRI TR-107330, Section 6.3.2.1 requires that during EMI/RFI testing the test specimen be mounted on a non-metallic vertical surface at a height of at least six feet to the bottom of the test specimen chassis, with no secondary enclosure. The test specimen shall be connected to a ground bus located at the base of the mounting surface using the manufacturer's recommended grounding conductor. Grounding and shielding shall meet the requirements of IEEE Standard 1050 (Ref. 25) and EPRI TR-102323-R1.

For EFT Testing, the ***SPINLINE 3*** QTS will be installed in the EMI/RFI test chamber mounted in metal frame instrument cabinet(s) with all sides removed. Due to restraints imposed by the size of the ***SPINLINE 3*** QTS, the requirement to mount the ***SPINLINE 3*** QTS six feet above the floor of the test chamber can not practicably be met. The ***SPINLINE 3*** QTS mounting frame(s) will be mounted on non-conductive (i.e., wooden) supports approximately 4 inches above the floor of the test chamber. This is done to prevent the EFT Test results from being affected by beneficial ground paths that might exist through the ***SPINLINE 3*** QTS mounting frame(s) if the frame(s) were placed directly on the floor of the EMI/RFI test chamber, which acts as a ground plane for the entire test chamber. [[The test system power distribution panel will also be located inside the test chamber. This panel is not part of the equipment under test, however, the panel grounding configuration shall be specified and documented by Rolls-Royce. All other test system equipment will be located outside the EMI/RFI test chamber.]]

Grounding of the ***SPINLINE 3*** QTS will be in accordance with the manufacturer's recommendations. The ***SPINLINE 3*** QTS grounds will be passed across the gap created by the mounting frame non-conductive supports and bonded to the EMI/RFI test chamber floor. This grounding configuration meets the applicable EPRI TR 107330 requirements for grounding during EMI/RFI Testing.

G.7 Service Conditions

EPRI TR-107330 does not include specific requirements for operation of the test specimen during EFT Testing. [[During EFT Testing, the ***SPINLINE 3*** QTS will be powered with the Test Specimen Application Program (TSAP) operating in a mode which will cycle all but one of the relay output circuits on timed ON/OFF cycles. The TSAP operating mode will also cycle a number of the analog output circuits through stair-stepping output values on repeating cycles, and exercise the NERVIA communication interfaces. The test system simulators (or jumpered connections) will operate a number of the discrete input circuits on timed ON/OFF cycles, and operate a number of the analog and RTD inputs through stair-stepping output values on repeating cycles.

The data acquisition system (DAS) which is part of the test system consists of a real time input/output chassis that performs signal generation and acquisition, and a part that performs the data processing. The communication between these two parts of the DAS is achieved with fiber optic. In order to minimize transmission of applied EFT disturbances outside the EMI/RFI test chamber, the real time input/output chassis is embedded in a shielded cabinet that is installed in the test chamber. Most of the test system signal and communication wiring entering or exiting the shielded cabinet will pass through PI filters mounted on the shielded cabinet.

In order to limit the number of required signal wire pass-through filters, the normal ***SPINLINE 3*** QTS and test system configurations will be altered for EFT Testing. The number of signal wires passing from the ***SPINLINE 3*** QTS to the test system data recording and simulation system will be limited to approximately one circuit per ***SPINLINE 3*** QTS input/output module, using the same configuration as implemented for EMI/RFI Testing. All other normally interconnected signal wires will be disconnected and input/output point jumpers installed as necessary.]]

EPRI TR-107330 provides no requirements or guidance for control of ambient conditions (temperature, pressure and humidity) during EFT Testing. [[During EFT Testing, the test chamber conditions of temperature and humidity will be maintained within the normal operating range of the ***SPINLINE 3*** QTS and in accordance with the specific EFT test standard being performed. The test chamber barometric pressure will be allowed to assume the barometric pressure conditions local to the test facility.]]

EPRI TR-107330 does not include specific requirements for configuration of the test specimen power supplies during EFT Testing. [[Both of the test system power supply circuits to the ***SPINLINE 3*** QTS cabinet power supply assembly will be energized during EFT Testing. The AC sources to the ***SPINLINE 3*** QTS cabinet power supply assembly will be set at nominal source voltage and frequency conditions during the EFT Testing.]] EPRI TR-107330, Section 6.2.1, requires that additional resistive loads be placed on each test specimen main power supply output so that nominal current draws at nominal power supply output voltages are equal to the power supply rating. [[This power supply loading is not realistic for a ***SPINLINE 3*** platform with redundant active cabinet power supply assembly supply circuits. During EFT Testing, additional resistive loads will be placed on the redundant outputs of the cabinet power supply assembly such that the nominal (at rated input voltage and frequency) current draws of each redundant output at nominal output voltage is equal to 1/2 the output ratings.

In order to minimize transmission of applied EFT disturbances outside the EMI/RFI test chamber, all test system power supply cables entering the EMI/RFI test chamber must pass through filter capacitors (provided by the test facility) located in the chamber walls. The power supply feeds to the ***SPINLINE 3*** QTS cabinet power supply assembly must also pass through line impedance stabilization networks (LISNs, provided by the test facility) located inside the EMI/RFI test chamber.

The relay output point load resistors connected during Seismic and Environmental Testing will be disconnected during EFT Testing.]] Neither EPRI TR-107330 nor the industry EFT test standard to be used require the relay output points to be operating at rated currents during EFT Testing.

EPRI TR-107330, Section 6.2.1, requires that additional resistive loads be placed on each test specimen loop power supply output so that nominal current draws at nominal power supply output voltages are equal to the power supply rating. [[During EFT Testing, additional resistive loads will be placed on the output(s) of the ***SPINLINE 3*** QTS auxiliary power supply module(s) such that the nominal (at rated input voltage) current draws of the auxiliary power supply module(s) at nominal output voltage are equal to the auxiliary power supply module ratings.]]

G.8 Test Levels

Table 22 of USNRC RG 1.180, Rev. 1 defines the IEC 61000-4-4 EFT withstand levels for the AC and DC power supplies of safety related instrumentation installed in various plant locations. [[Based on the discussion in Section 5.3 of USNRC RG 1.180, Rev. 1, the AC power supplies of a ***SPINLINE 3*** platform are expected to be installed in Category B locations with EFT Low Exposure levels. The corresponding EFT withstand level is 2 kV.]]

Table 15 of USNRC RG 1.180, Rev. 1 defines the IEC 61000-4-4 EFT withstand levels for the signal leads of safety related instrumentation installed in various plant locations. [[Based on the discussion in Section 4.2 of USNRC RG 1.180, Rev. 1, the signal circuits of a ***SPINLINE 3*** platform are expected to be installed in Category B locations with EFT Low Exposure levels. The corresponding EFT Withstand level is 1 kV.

The applied EFT test levels will be stepped up from 0.5 kV to the maximum specified test voltage in 0.5 kV increments.]]

G.9 Performance Monitoring

EPRI TR-107330, Section 4.3.7, discusses performance of the test specimen under qualification during EMI/RFI Testing. This discussion is assumed to apply to EFT Testing as well. EPRI TR 107330, Section 4.3.7, requires that the test specimen under qualification withstand the applied EMI/RFI susceptibility test levels. Specifically, when subjected to the EMI/RFI test levels, the test specimen modules shall perform as follows:

a) The main processors and coprocessors shall continue to function.
b) The transfer of I/O data shall not be interrupted.
c) The emissions shall not cause the discrete I/O to change state.
d) Analog I/O levels shall not vary more than 3% (of full scale).

In addition, the EPRI TR requires that a portion of the Operability and Prudency Tests be performed during the EMI/RFI testing.

[[During EFT Testing, the test facility will be responsible for generating and exposing the ***SPINLINE 3*** QTS to the required levels of EFT disturbances given in Sections 4.2 and 5.3 of USNRC RG 1.180, Rev. 1. During EFT Testing, Rolls-Royce will be responsible for monitoring operation of the ***SPINLINE 3*** QTS and determining the susceptibility of the ***SPINLINE 3*** QTS to the applied levels of EFT.

During EFT Testing, operation of the ***SPINLINE 3*** QTS will be monitored and recorded by the test system data logging instrumentation. The recorded data will be evaluated for time periods before, during and after each EFT Test. The data evaluations will consider operation (per the TSAP) of at least one input or output point on each I/O module installed in the ***SPINLINE 3*** QTS, and operation of the NERVIA communication interfaces. The data recorded during EFT Testing will be sufficient to demonstrate the EPRI TR-107330 performance criteria listed above.

The ***SPINLINE 3*** QTS and test system as configured for EFT Testing does not support Operability or Prudency Testing. This configuration will be maintained throughout performance of the Surge Withstand, ESD and Class 1E to Non-1E Isolation testing to be done after EFT Testing. For these reasons it is not practical to perform the Operability and Prudency Tests either during or immediately following the EFT Tests. The data recorded during the EFT Tests will demonstrate acceptable system performance during EFT exposure. The Operability and Prudency Tests run at the completion of all qualification testing will demonstrate acceptable system performance following all electrical stress testing.]]

G.10 Acceptance Criteria

Section 4.3.7 of EPRI TR-107330 discusses the acceptance criteria for EMI/RFI Testing of the test specimen under qualification. Section 4.6.2 of EPRI TR-107330 discusses the acceptance criteria for Surge Withstand Testing of the test specimen under qualification. These discussions are assumed to apply to EFT Testing as well.

The following EFT Test acceptance criteria are based on Sections 4.3.7 and 4.6.2 of EPRI TR 107330 and USNRC RG 1.180, Rev. 1.

[[

a) Applying the EFT Test voltages to the specified ***SPINLINE 3*** QTS interfaces will 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.

b) The ***SPINLINE 3*** QTS shall operate as intended during and after application of the IEC 61000-4-4 EFT test levels specified in Sections 4.2 and 5.3 of NRC RG 1.180, Rev. 1 for low exposure applications. Specifically:

IEC 61000-4-4: Power Leads, Level 3 Test Voltage Level: 2 kV max.

IEC 61000-4-4: Signal Leads, Level 3 Test Voltage Level: 1 kV max.

Evaluation of normal operating performance data (inputs, outputs and fault/diagnostic indicators) shall demonstrate operation as intended, including the following specific operational performance from Section 4.3.7 of EPRI TR-107330:

a) The main processors and coprocessors shall continue to function.

b) The transfer of I/O data shall not be interrupted.

c) The applied EFT disturbances shall not cause the discrete I/O to change state.

d) Analog I/O levels shall not vary more than 3% (of full scale).

]]

G.11 Documentation

The following records will be prepared by Rolls-Royce to document the results of EFT Testing:

1. EFT Testing Procedure (Completed with Attachments)
2. Rolls-Royce EFT Test Report

The following record will be prepared by the test facility to document the results of EFT Testing:

1. Test Facility EFT Test Report

Rolls-Royce

Appendix H : Surge Withstand Test Plan

H.1 Purpose

This test plan describes the approach for Surge Withstand Testing of the Rolls-Royce ***SPINLINE 3*** Qualification Test Specimen (QTS). Surge Withstand Testing of the ***SPINLINE 3*** QTS is performed as part of qualification testing to demonstrate compliance with the applicable Surge Withstand requirements of USNRC Regulatory Guide (RG) 1.180, Rev. 1 (Ref. 7).

H.2 Objective

The objective of Surge Withstand Testing is to demonstrate the suitability of the ***SPINLINE 3*** platform for qualification as a safety-related device with respect to Surge Withstand levels. Surge withstand testing of the ***SPINLINE 3*** QTS will be performed in accordance with USNRC RG 1.180, Rev. 1, using additional guidance from EPRI TR-107330 as applicable. The specific Surge Withstand Tests to be performed include:

- IEC 61000-4-5, "Electromagnetic Compatibility (EMC), Part 4-5: Testing and Measurement Techniques, Surge Immunity Test," (Ref. 28), and,
- IEC 61000-4-12, "Electromagnetic Compatibility (EMC), Part 4-12: Testing and Measurement Techniques, Oscillatory Waves Immunity Test," (Ref. 29).

This test will establish the qualification envelope for ***SPINLINE 3*** surge withstand.

H.3 Equipment to be Tested

The Master Configuration List (Ref. 38), to be prepared by Rolls-Royce as part of the ***SPINLINE 3*** Qualification Project, will document the ***SPINLINE 3*** QTS hardware and firmware to be tested. Due to the complexity of the hardware and the scope of the required qualification testing, only one ***SPINLINE 3*** QTS will be used during qualification testing.

H.4 Sequence of Testing

As shown in Figure 1, Surge Withstand Testing is performed after completion of EFT Testing and uses the same ***SPINLINE 3*** QTS and test system setup as the EFT Testing.

H.5 Procedures

The following procedures are used during Surge Withstand Testing:

a) Surge Withstand Test Procedure: This procedure is drafted by MPR Associates, finalized by Rolls-Royce, and implemented by Rolls-Royce. Through this procedure, the ***SPINLINE 3*** QTS receives additional configuration in the test chamber for Surge Withstand Testing, and the performance of the ***SPINLINE 3*** QTS is monitored throughout application of the Surge Withstand Test conditions.

b) Test Facility Surge Withstand Test Procedure: This procedure is prepared and implemented by the selected qualification test facility. Through this procedure, the ***SPINLINE 3*** QTS receives additional configuration and instrumentation in the test chamber for Surge Withstand Testing, and the specified Surge Withstand Test conditions are applied to the ***SPINLINE 3*** QTS and monitored.

H.6 Test Specimen Mounting

EPRI TR-107330, Section 6.3.5.1 requires that during Surge Withstand testing the test specimen be mounted on a non-metallic vertical surface at a height of at least six feet to the bottom of the test specimen chassis, with no secondary enclosure. The test specimen shall be connected to a ground bus located at the base of the mounting surface using the manufacturer's recommended grounding conductor. Grounding and shielding shall meet the requirements of IEEE Standard 1050 (Ref. 25) and EPRI TR 102323-R1.

For Surge Withstand Testing, the ***SPINLINE 3*** QTS will be installed in the EMI/RFI test chamber mounted in metal frame instrument cabinet(s) with all sides removed. Due to restraints imposed by the size of the ***SPINLINE 3*** QTS, the requirement to mount the ***SPINLINE 3*** QTS six feet above the floor of the test chamber can not practicably be met. The ***SPINLINE 3*** QTS mounting frame(s) will be mounted on non-conductive (i.e., wooden) supports approximately 4 inches above the floor of the test chamber. This is done to prevent the Surge Withstand Test results from being affected by beneficial ground paths that might exist through the ***SPINLINE 3*** QTS mounting frame(s) if the frame(s) were placed directly on the floor of the EMI/RFI test chamber, which acts as a ground plane for the entire test chamber. [[The test system power distribution panel will also be located inside the test chamber. This panel is not part of the equipment under test, however, the panel grounding configuration shall be specified and documented by Rolls-Royce. All other test system equipment will be located outside the EMI/RFI test chamber.]]

Grounding of the ***SPINLINE 3*** QTS will be in accordance with the manufacturer's recommendations. The ***SPINLINE 3*** QTS grounds will be passed across the gap created by the mounting frame non-conductive supports and bonded to the EMI/RFI test chamber floor. This grounding configuration meets the applicable EPRI TR 107330 requirements for grounding during Surge Withstand Testing.

H.7 Service Conditions

EPRI TR-107330 does not include specific requirements for operation of the test specimen during Surge Withstand Testing. [[During Surge Withstand Testing, the ***SPINLINE 3*** QTS will be powered with the Test Specimen Application Program (TSAP) operating in a mode which will cycle all but one of the relay output circuits on timed ON/OFF cycles. The TSAP operating mode will also cycle a number of the analog output circuits through stair-stepping output values on repeating cycles, and exercise the NERVIA communication interfaces. The test system simulators (or jumpered connections) will operate a number of the discrete input circuits on timed ON/OFF cycles, and operate a number of the analog and RTD inputs through stair-stepping output values on repeating cycles.

The data acquisition system (DAS) which is part of the test system consists of a real time input/output chassis that performs signal generation and acquisition, and a part that performs the data processing. The communication between these two parts of the DAS is achieved with fiber optic. In order to minimize transmission of applied Surge Withstand disturbances outside the EMI/RFI test chamber, the real time input/output chassis is embedded in a shielded cabinet that is installed in the test chamber. Most of the test system signal and communication wiring entering or exiting the shielded cabinet will pass through PI filters mounted on the shielded cabinet.

In order to limit the number of required signal wire pass-through filters, the normal ***SPINLINE 3*** QTS and test system configurations will be altered for Surge Withstand Testing. The number of signal wires passing from the ***SPINLINE 3*** QTS to the test system data recording and simulation system will be limited to approximately one circuit per ***SPINLINE 3*** QTS input/output module, using the same configuration as implemented for EMI/RFI Testing. All other normally interconnected signal wires will be disconnected and input/output point jumpers installed as necessary.]]

EPRI TR-107330 provides no requirements or guidance for control of ambient conditions (temperature, pressure and humidity) during Surge Withstand Testing. [[During Surge Withstand Testing, the test chamber conditions of temperature and humidity will be maintained within the normal operating range of the ***SPINLINE 3*** QTS and in accordance with the specific Surge Withstand test standards being performed. The test chamber barometric pressure will be allowed to assume the barometric pressure conditions local to the test facility.]]

EPRI TR-107330 does not include specific requirements for configuration of the test specimen power supplies during Surge Withstand Testing. [[Both of the test system power supply circuits to the ***SPINLINE 3*** QTS cabinet power supply assembly will be energized during Surge Withstand Testing. The AC sources to the ***SPINLINE 3*** QTS cabinet power supply assembly will be set at nominal source voltage and frequency conditions during the Surge Withstand Testing.]] EPRI TR-107330, Section 6.2.1, requires that additional resistive loads be placed on each test specimen main power supply output so that nominal current draws at nominal power supply output voltages are equal to the power supply rating. [[This power supply loading is not realistic for a ***SPINLINE 3*** platform with redundant active cabinet power supply assembly supply circuits. During Surge Withstand Testing, additional resistive loads will be placed on the redundant outputs of the cabinet power supply assembly such that the nominal (at rated input voltage and frequency) current draws of each redundant output at nominal output voltage is equal to 1/2 the output ratings.

In order to minimize transmission of applied Surge Withstand disturbances outside the EMI/RFI test chamber, all test system power supply cables entering the EMI/RFI test chamber must pass through filter capacitors (provided by the test facility) located in the chamber walls. The power supply feeds to the ***SPINLINE 3*** QTS cabinet power supply assembly must also pass through line impedance stabilization networks (LISNs, provided by the test facility) located inside the EMI/RFI test chamber.

The relay output point load resistors connected during Seismic and Environmental Testing will be disconnected during Surge Withstand Testing.]] Neither EPRI TR-107330 nor the industry Surge Withstand test standards to be used require the relay output points to be operating at rated currents during Surge Withstand Testing.

EPRI TR-107330, Section 6.2.1, requires that additional resistive loads be placed on each test specimen loop power supply output so that nominal current draws at nominal power supply output voltages are equal to the power supply rating. [[During Surge Withstand Testing, additional resistive loads will be placed on the output(s) of the ***SPINLINE 3*** QTS auxiliary power supply module(s) such that the nominal (at rated input voltage) current draws of the auxiliary power supply module(s) at nominal output voltage are equal to the auxiliary power supply module ratings.]]

H.8 Test Levels

Table 22 of USNRC RG 1.180, Rev. 1 defines the IEC 61000-4-12 Ring Wave and IEC 61000 4-5 Combination Wave surge withstand levels for the power supplies of safety related instrumentation installed in various plant locations. [[Based on the discussion in Section 5 of USNRC RG 1.180, Rev. 1, the power supplies of a ***SPINLINE 3*** platform are expected to be installed in Category B locations with surge waveform Low Exposure levels. The corresponding Ring Wave surge withstand level is 2 kV and the corresponding Combination Wave surge withstand level is 2 kV open circuit and 1 kA short circuit. For AC source power supplies, the surge pulses are applied across the power supply line to neutral, line to ground, neutral to ground, and line and neutral to ground.]]

Table 15 of USNRC RG 1.180, Rev. 1 defines the IEC 61000-4-12 Ring Wave and IEC 61000 4-5 Combination Wave surge withstand levels for the signal leads of safety related instrumentation installed in various plant locations. [[Based on the discussion in Section 4.2 of USNRC RG 1.180, Rev. 1, the signal circuits of a ***SPINLINE 3*** platform are expected to be installed in Low Exposure locations with Level 2 surge waveforms. The corresponding Ring Wave surge withstand level is 1 kV and the corresponding Combination Wave surge withstand level is 1 kV open circuit and 0.5 kA short circuit.]]

Section 5 of IEC 61000-4-5 states that all voltages of the lower tests levels shall be satisfied (i.e., the surge voltage should be applied as a series of steps from a lower range value up to the maximum required test value). For equipment that contains surge protective devices, this approach can reveal "blind spots" in the equipment (applied surge test voltage levels where the protective devices perform less effectively than at higher test voltage levels). [[Due to the design of the ***SPINLINE 3*** QTS, there are no transitions from one protective device to another within the circuits, so stepped surge testing is not required. In addition, due to the relatively large number of components being qualified as part of the ***SPINLINE 3*** QTS qualification testing, stepped surge testing to the maximum required 2 kV peak test voltage is not practicable.

The Combination Wave and Ring Wave surge voltages will be applied to the ***SPINLINE 3*** QTS input/output ports in accordance with IEC 61000-4-5 and IEC 61000-4-12, as supplemented by the applicable parts of Section 4.6.2 of EPRI TR-107330.]]

EPRI TR-107330, Section 4.3.4.3, Item E requires Surge Withstand Testing of any devices required for connecting the main chassis to other types of chassis. [[The ***SPINLINE 3*** platform uses only one type of chassis. If a particular application requires more than one chassis, the chassis are connected via the NERVIA communication links. Only fiber-optic links would be used to interconnect chassis housed in different instrument cabinets (where such interconnects would be susceptible to applied surges). Because electrical transients can not be transmitted through the fiber optic cables, Surge Withstand Testing of these connections is not required.]]

Section 6.3.5 of EPRI TR-107330 states that Surge Withstand Testing should be performed on a representative sample of points for each type of input/output module. [[This procedure implements Surge Withstand Testing of one point at a time on each ***SPINLINE 3*** QTS input and output module. Each tested relay output point will be tested twice for each surge test connection, once in the ON state and once in the OFF state, which verifies surge withstand capability with the relay output point contacts open and closed.]]

H.9 Performance Monitoring

EPRI TR-107330, Section 4.6.2, requires that the test specimen under qualification continue to operate following application of the Surge Withstand Test voltages.

Applying the specified level of surge to the specified points:

a) Shall not damage any other module or device in the test specimen.
b) Shall not cause a disruption of the specimen backplane signals that could result in a loss of the ability to generate a trip.
c) Shall not cause a disruption of any other data acquisition signals that could result in a loss of the ability to generate a trip.

During Surge Withstand Testing, the test facility will be responsible for generating and exposing the ***SPINLINE 3*** QTS to the required levels of surge voltages given in Tables 15 and 22 of USNRC RG 1.180, Rev. 1. During Surge Withstand Testing, Rolls-Royce will be responsible for monitoring operation of the ***SPINLINE 3*** QTS and determining the ***SPINLINE 3*** QTS surge withstand capability.

[[During Surge Withstand Testing, operation of the ***SPINLINE 3*** QTS will be monitored and recorded by the test system data logging instrumentation. The recorded data will be evaluated for time periods before, during and after each Surge Withstand test. The data evaluations will consider operation (per the TSAP) of at least one input or output point on each I/O module installed in the ***SPINLINE 3*** QTS, and operation of the NERVIA communication interfaces. The data recorded during Surge Withstand Testing will be sufficient to demonstrate the EPRI TR-107330 performance criteria listed above.

The ***SPINLINE 3*** QTS and test system as configured for Surge Withstand Testing does not support Operability or Prudency Testing. This configuration will be maintained throughout performance of the ESD and Class 1E to Non-1E Isolation testing to be done after Surge Withstand Testing. For these reasons it is not practical to perform the Operability and Prudency Tests either during or immediately following the Surge Withstand Tests. The data recorded during the Surge Withstand Tests will demonstrate acceptable system performance during surge voltage exposure. The Operability and Prudency Tests run at the completion of all qualification testing will demonstrate acceptable system performance following Surge Withstand Testing.]]

H.10Acceptance Criteria

The following Surge Withstand Test acceptance criteria are based on Section 4.6.2 of EPRI TR 107330 and USNRC RG 1.180, Rev. 1. [[

a) Applying the surge test voltages specified in Tables 15 and 22 of USNRC RG 1.180, Rev. 1 to the specified ***SPINLINE 3*** QTS test points shall not damage any other module or device in the test specimen, or cause disruption of the operation of the ***SPINLINE 3*** QTS backplane signals or any other data acquisition signals that could result in a loss of the ability to generate a trip.

b) Evaluation of normal operating performance data (inputs, outputs, fault/diagnostic indicators and NERVIA communication links) shall demonstrate satisfactory operation of the ***SPINLINE 3*** QTS following application of the surge test voltage. The data evaluations shall demonstrate the following:

1. Application of the surge test voltages to the inputs of the cabinet power supply assembly shall not result in damage to any other modules installed in the ***SPINLINE 3*** QTS.
2. Application of the surge test voltages to the inputs of the cabinet power supply assembly shall not result in permanent disruption of the operation of the ***SPINLINE 3*** QTS, including the ability to correctly acquire input signals and generate output signals.
3. Application of the surge test voltages to an input/output module point shall not result in damage to any modules installed in the ***SPINLINE 3*** QTS.
4. Application of the surge test voltages to an input/output module point shall not result in permanent disruption of the operation of the ***SPINLINE 3*** QTS, including the ability to acquire the input signals from any other input module points correctly, and to generate the output signals associated with any other output module points.

c) Per Section 6.3.5 of EPRI TR-107330, failures of one or more redundant devices are acceptable so long as the failures do not result in the inability of the ***SPINLINE 3*** QTS to operate as intended. Faults or failures of redundant devices which occur during Surge Withstand Testing will be evaluated for effect on the ***SPINLINE 3*** QTS operation.]]

H.11 Documentation

The following records will be prepared by Rolls-Royce to document the results of Surge Withstand Testing:

1. Surge Withstand Testing Procedure (Completed with Attachments)
2. Rolls-Royce Surge Withstand Test Report

The following record will be prepared by the test facility to document the results of Surge Withstand Testing:

1. Test Facility Surge Withstand Test Report

Rolls-Royce

Appendix I : Electrostatic Discharge Test Plan

I.1 Purpose

This test plan describes the approach for Electrostatic Discharge (ESD) Testing of the Rolls-Royce ***SPINLINE 3*** Qualification Test Specimen (QTS). ESD Testing of the ***SPINLINE 3*** QTS is performed as part of qualification testing to demonstrate compliance with the applicable ESD requirements of EPRI TR-107330, Section 4.3.8 (Ref. 5).

I.2 Objective

The objective of ESD testing is to demonstrate the suitability of the ***SPINLINE 3*** platform for qualification as a safety-related device with respect to ESD withstand levels. EPRI TR 107330, Section 4.3.8, requires that the test specimen under qualification be tested for ESD withstand capability in accordance with the requirements of EPRI TR-102323-R1 (Ref. 16). In accordance with EPRI TR-102323-R1, the specific ESD Test to be performed is IEC 61000-4-2 "Electromagnetic Compatibility (EMC), Part 4-2: Testing and Measurement Techniques, Electrostatic Discharge Immunity Test," (Ref. 30). This test will establish the qualification envelope for ***SPINLINE 3*** ESD withstand. USNRC RG 1.180, Revision 1 (Ref. 7) provides no guidance for ESD Testing.

I.3 Equipment to be Tested

The Master Configuration List (Ref. 38), to be prepared by Rolls-Royce as part of the ***SPINLINE 3*** Qualification Project, will document the ***SPINLINE 3*** QTS hardware and firmware to be tested. Due to the complexity of the hardware and the scope of the required qualification testing, only one ***SPINLINE 3*** QTS will be used during qualification testing.

I.4 Sequence of Testing

As shown in Figure 1, ESD Testing is performed after completion of Surge Withstand Testing and uses the same ***SPINLINE 3*** QTS and test system setup as the Surge Withstand Testing.

I.5 Procedures

The following procedures are used during ESD Testing:

a) Electrostatic Discharge Test Procedure: This procedure is drafted by MPR Associates, finalized by Rolls-Royce, and implemented by Rolls-Royce. Through this procedure, the ***SPINLINE 3*** QTS receives additional configuration in the test chamber for ESD Testing, and the performance of the ***SPINLINE 3*** QTS is monitored throughout application of the ESD Test conditions.

b) Test Facility Electrostatic Discharge Test Procedure: This procedure is prepared and implemented by the selected qualification test facility. Through this procedure, the ***SPINLINE 3*** QTS receives additional configuration and instrumentation in the test chamber for ESD Testing, and the specified ESD Test conditions are applied to the ***SPINLINE 3*** QTS and monitored.

I.6 Test Specimen Mounting

EPRI TR-107330, Section 6.3.2.1 requires that during EMI/RFI testing the test specimen be mounted on a non-metallic vertical surface at a height of at least six feet to the bottom of the test specimen chassis, with no secondary enclosure. The test specimen shall be connected to a ground bus located at the base of the mounting surface using the manufacturer's recommended grounding conductor. Grounding and shielding shall meet the requirements of IEEE Standard 1050 (Ref. 25) and EPRI TR-102323-R1.

For ESD Testing, the ***SPINLINE 3*** QTS will be installed in the EMI/RFI test chamber mounted in metal frame instrument cabinet(s) with all sides removed. Due to restraints imposed by the size of the ***SPINLINE 3*** QTS, the requirement to mount the ***SPINLINE 3*** QTS six feet above the floor of the test chamber can not practicably be met. The ***SPINLINE 3*** QTS mounting frame(s) will be mounted on non-conductive (i.e., wooden) supports approximately 4 inches above the floor of the test chamber. This is done to prevent the ESD Test results from being affected by beneficial ground paths that might exist through the test specimen mounting frame(s) if the frame(s) were placed directly on the floor of the EMI/RFI test chamber, which acts as a ground plane for the entire test chamber. [[The test system power distribution panel will also be located inside the test chamber. This panel is not part of the equipment under test, however, the panel grounding configuration shall be specified and documented by Rolls-Royce. All other test system equipment will be located outside the EMI/RFI test chamber.]]

Grounding of the ***SPINLINE 3*** QTS will be in accordance with the manufacturer's recommendations. The ***SPINLINE 3*** QTS grounds will be passed across the gap created by the mounting frame non-conductive supports and bonded to the EMI/RFI test chamber floor. This grounding configuration meets the applicable EPRI TR 107330 requirements for grounding during EMI/RFI Testing.

I.7 Service Conditions

EPRI TR-107330 does not include specific requirements for operation of the test specimen during ESD Testing. [[During ESD Testing, the ***SPINLINE 3*** QTS will be powered with the Test Specimen Application Program (TSAP) operating in a mode which will cycle all but one of the relay output circuits on timed ON/OFF cycles. The TSAP operating mode will also cycle a number of the analog output circuits through stair-stepping output values on repeating cycles, and exercise the NERVIA communication interfaces. The test system simulators (or jumpered connections) will operate a number of the discrete input circuits on timed ON/OFF cycles, and operate a number of the analog and RTD inputs through stair-stepping output values on repeating cycles.

The data acquisition system (DAS) which is part of the test system consists of a real time input/output chassis that performs signal generation and acquisition, and a part that performs the data processing. The communication between these two parts of the DAS is achieved with fiber optic. In order to minimize transmission of applied ESD disturbances outside the EMI/RFI test chamber, the real time input/output chassis is embedded in a shielded cabinet that is installed in the test chamber. Most of the test system signal and communication wiring entering or exiting the shielded cabinet will pass through PI filters mounted on the shielded cabinet. The entering and exiting signal and communication wiring will be spliced onto the chamber wall filters.

In order to limit the number of required signal wire pass-through filters, the normal ***SPINLINE 3*** QTS and test system configurations will be altered for ESD Testing. The number of signal wires passing from the ***SPINLINE 3*** QTS to the test system data recording and simulation system will be limited to approximately one circuit per ***SPINLINE 3*** QTS input/output module, using the same configuration as implemented for EMI/RFI Testing. All other normally interconnected signal wires will be disconnected and input/output point jumpers installed as necessary.]]

EPRI TR-107330 provides no requirements or guidance for control of ambient conditions (temperature, pressure and humidity) during ESD Testing. [[During ESD Testing, the test chamber conditions of temperature and humidity will be maintained within the normal operating range of the ***SPINLINE 3*** QTS and in accordance with the specific ESD test standard being performed. The test chamber barometric pressure will be allowed to assume the barometric pressure conditions local to the test facility.]]

EPRI TR-107330 does not include specific requirements for configuration of the test specimen power supplies during ESD Testing. [[Both of the test system power supply circuits to the ***SPINLINE 3*** QTS cabinet power supply assembly will be energized during ESD Testing. The AC sources to the ***SPINLINE 3*** QTS cabinet power supply assembly will be set at nominal source voltage and frequency conditions during the ESD Testing.]] EPRI TR-107330, Section 6.2.1, requires that additional resistive loads be placed on each test specimen main power supply output so that nominal current draws at nominal power supply output voltages are equal to the power supply rating. [[This power supply loading is not realistic for a ***SPINLINE 3*** platform with redundant active cabinet power supply assembly supply circuits. During ESD Testing, additional resistive loads will be placed on the redundant outputs of the cabinet power supply assembly such that the nominal (at rated input voltage and frequency) current draws of each redundant output at nominal output voltage is equal to 1/2 the output ratings.

In order to minimize transmission of applied ESD disturbances outside the EMI/RFI test chamber, all test system power supply cables entering the EMI/RFI test chamber must pass through filter capacitors (provided by the test facility) located in the chamber walls. The power supply feeds to the ***SPINLINE 3*** QTS cabinet power supply assembly must also pass through line impedance stabilization networks (LISNs, provided by the test facility) located inside the EMI/RFI test chamber.

The relay output point load resistors connected during Seismic and Environmental Testing will be disconnected during ESD Testing.]] Neither EPRI TR-107330 nor the industry ESD test standard to be used require the relay output points to be operating at rated currents during ESD Testing.

EPRI TR-107330, Section 6.2.1, requires that additional resistive loads be placed on each test specimen loop power supply output so that nominal current draws at nominal power supply output voltages are equal to the power supply rating. [[During ESD Testing, additional resistive loads will be placed on the output(s) of the ***SPINLINE 3*** QTS auxiliary power supply module(s) such that the nominal (at rated input voltage) current draws of the auxiliary power supply module(s) at nominal output voltage are equal to the auxiliary power supply module ratings.]]

I.8 Test Levels

Appendix B, Section 3.5 of EPRI TR-102323-R1 recommends maximum ESD test levels of 15 kV for air discharges and 8 kV for contact discharges for safety-related instrumentation to be installed in a nuclear plant control room. These levels correspond to IEC 61000-4-2 Level 4 installations. Section 5 of IEC 61000-4-2 further requires that ESD testing of instrumentation at a specific test level also satisfy all lower levels.

[[ESD Testing of the ***SPINLINE 3*** QTS will be performed to maximum ESD test levels of 8 kV for air discharges and 6 kV for contact discharges. It corresponds to IEC 61000-4-2 Level 3 installations. Testing to contact discharges will include the lower levels of 4 kV and 2 kV. Testing to air discharges will include the lower levels of 4 kV and 2 kV.

The points specified for application of electrostatic discharges to the ***SPINLINE 3*** QTS will be selected to meet the criteria for direct application of electrostatic discharges to the equipment under test as stated in Section 8.3.1 of IEC 61000-4-2. In addition, electrostatic discharges will be applied to horizontal and vertical edges of coupling planes setup in proximity to the ***SPINLINE 3*** QTS in accordance with Sections 8.3.2.1 and 8.3.2.2 of IEC 61000 4-2.]]

I.9 Performance Monitoring

EPRI TR-107330, Section 4.3.8, requires that the test specimen under qualification continue to operate following application of the ESD Test voltages. Applying the specified level of electrostatic discharges to the specified points:

1. Shall not disrupt operation of the test specimen.
2. Shall not cause a disruption of the test specimen backplane signals that could result in a loss of the ability to generate a trip.
3. Shall not cause a disruption of any other data acquisition signals that could result in a loss of the ability to generate a trip.
4. Shall not cause damage to or failure of any components of the test specimen. This criterion does not apply to redundant components given that the test specimen continues to operate as intended following damage to or failure of a redundant component.

[[During ESD Testing, the test facility will be responsible for generating and exposing the ***SPINLINE 3*** QTS to the required electrostatic discharge voltages given in Section 3.5 of EPRI TR-102323-R1. During ESD Testing, Rolls-Royce will be responsible for monitoring operation of the ***SPINLINE 3*** QTS and determining the ***SPINLINE 3*** QTS ESD withstand capability.

During ESD Testing, operation of the ***SPINLINE 3*** QTS will be monitored and recorded by the test system data logging instrumentation. The recorded data will be evaluated for time periods before, during and after each ESD test. The data evaluations will consider operation (per the TSAP) of at least one input or output point on each I/O module installed in the ***SPINLINE 3*** QTS, and operation of the NERVIA communication interfaces. The set of monitored input and output points does not include points which will be subjected directly to the applied ESD test voltages. The data recorded during ESD Testing will be sufficient to demonstrate the EPRI TR 107330 performance criteria listed above.

The ***SPINLINE 3*** QTS and test system as configured for ESD Testing does not support Operability or Prudency Testing. This configuration will be maintained throughout performance of the Class 1E to Non-1E Isolation testing to be done after ESD Testing. For these reasons it is not practical to perform the Operability and Prudency Tests either during or immediately following the ESD Tests. The data recorded during the ESD Tests will demonstrate acceptable system performance during ESD exposure. The Operability and Prudency Tests run at the completion of all qualification testing will demonstrate acceptable system performance following ESD Testing.]]

Rolls-Royce

I.10 Acceptance Criteria

The following ESD Test acceptance criteria are based on Section 4.3.8 of EPRI TR 107330.

[[

a) Applying the ESD test voltages specified in Section H.8 above to the specified ***SPINLINE 3*** QTS test points shall not damage any component in the test specimen (see below for exception for redundant components), or cause disruption of the operation of the test specimen backplane signals or any other data acquisition signals that could result in a loss of the ability to generate a trip.

   Evaluation of normal operating performance data (inputs, outputs, fault/diagnostic indicators and NERVIA communications) shall demonstrate satisfactory operation of the ***SPINLINE 3*** QTS following application of the ESD test voltages.

b) Per Section 4.3.8 of EPRI TR-107330, failures of one or more redundant devices due to application of ESD test voltages are acceptable so long as the failures do not result in the inability of the ***SPINLINE 3*** QTS to operate as intended. Faults or failures of redundant devices which occur during ESD Testing will be evaluated for effect on the ***SPINLINE 3*** QTS operation. Evaluation of normal operating performance data (inputs, outputs, fault/diagnostic indicators and NERVIA communications) shall demonstrate intended operation of the ***SPINLINE 3*** QTS.]]

I.11 Documentation

The following records will be prepared by Rolls-Royce to document the results of ESD Testing:

1. Electrostatic Discharge Testing Procedure (Completed with Attachments)
2. Rolls-Royce Electrostatic Discharge Test Report

The following record will be prepared by the test facility to document the results of ESD Testing:

1. Test Facility Electrostatic Discharge Test Report

Appendix J : Class 1E to Non-1E Isolation Test Plan

J.1 Purpose

This test plan describes the approach for Class 1E to Non-1E Isolation Testing of the Rolls-Royce ***SPINLINE 3*** Qualification Test Specimen (QTS). Class 1E to Non-1E Isolation Testing of the ***SPINLINE 3*** QTS is performed as part of qualification testing to demonstrate compliance with the applicable Class 1E to Non-1E Isolation requirements of EPRI TR-107330, Section 6.3.6 (Ref. 5).

J.2 Objective

The objective of Class 1E to Non-1E Isolation Testing is to demonstrate the suitability of the ***SPINLINE 3*** platform for qualification as a safety-related device with respect to providing electrical isolation at Non-1E field connections, as required by IEEE 384 (Ref. 31). EPRI TR 107330, Section 6.3.6, requires that the test specimen under qualification be tested for Class 1E to Non-1E Isolation capability in accordance with the requirements of EPRI TR-107330, Section 4.6.4. This test will establish the qualification envelope for ***SPINLINE 3*** Class 1E to Non-1E Isolation

J.3 Equipment to be Tested

The Master Configuration List (Ref. 38), to be prepared by Rolls-Royce as part of the ***SPINLINE 3*** Qualification Project, will document the ***SPINLINE 3*** QTS hardware and firmware to be tested. Due to the complexity of the hardware and the scope of the required qualification testing, only one ***SPINLINE 3*** QTS will be used during qualification testing.

J.4 Sequence of Testing

As shown in Figure 1, Class 1E to Non-1E Isolation Testing is performed after completion of Electrostatic Discharge (ESD) Testing and uses the same ***SPINLINE 3*** QTS and test system setup as the ESD Testing.

J.5 Procedures

The following procedures are used during Class 1E to Non-1E Isolation Testing:

a) Class 1E to Non-1E Isolation Test Procedure: This procedure is drafted by MPR Associates, finalized by Rolls-Royce, and implemented by Rolls-Royce. Through this procedure, the ***SPINLINE 3*** QTS receives additional configuration in the test chamber for Class 1E to Non-1E Isolation Testing, and the performance of the ***SPINLINE 3*** QTS is monitored throughout application of the Class 1E to Non-1E Isolation Test conditions.

b) Test Facility Class 1E to Non-1E Isolation Test Procedure: This procedure is prepared and implemented by the selected qualification test facility. Through this procedure, the ***SPINLINE 3*** QTS receives additional configuration and instrumentation in the test chamber for Class 1E to Non-1E Isolation Testing, and the specified Class 1E to Non-1E Isolation Test conditions are applied to the ***SPINLINE 3*** QTS and monitored.

J.6 Test Specimen Mounting

EPRI TR-107330, Section 6.3.6 requires that during Class 1E to Non-1E Isolation Testing the test specimen be mounted on a non-metallic vertical surface at a height of at least six feet to the bottom of the test specimen chassis, with no secondary enclosure. The test specimen shall be connected to a ground bus located at the base of the mounting surface using the manufacturer's recommended grounding conductor. Grounding and shielding shall meet the requirements of IEEE Standard 1050 (Ref. 25) and EPRI TR-102323-R1.

For Class 1E to Non-1E Isolation Testing, the ***SPINLINE 3*** QTS will be installed in the EMI/RFI test chamber mounted in metal frame instrument cabinet(s) with all sides removed. Due to restraints imposed by the size of the ***SPINLINE 3*** QTS, the requirement to mount the ***SPINLINE 3*** QTS six feet above the floor of the test chamber can not practicably be met. The ***SPINLINE 3*** QTS mounting frame(s) will be mounted on non-conductive (i.e., wooden) supports approximately 4 inches above the floor of the test chamber. This is done to prevent the Class 1E to Non-1E Isolation Test results from being affected by beneficial ground paths that might exist through the ***SPINLINE 3*** QTS mounting frame(s) if the frame(s) were placed directly on the floor of the EMI/RFI test chamber, which acts as a ground plane for the entire test chamber. [[The test system power distribution panel will also be located inside the test chamber. This panel is not part of the equipment under test, however, the panel grounding configuration shall be specified and documented by Rolls-Royce. All other test system equipment will be located outside the EMI/RFI test chamber.]]

Grounding of the ***SPINLINE 3*** QTS will be in accordance with the manufacturer's recommendations. The ***SPINLINE 3*** QTS grounds will be passed across the gap created by the mounting frame non-conductive supports and bonded to the EMI/RFI test chamber floor. This grounding configuration meets the applicable EPRI TR 107330 requirements for grounding during Class 1E to Non-1E Isolation Testing.

J.7 Service Conditions

EPRI TR-107330 does not include specific requirements for operation of the test specimen during Class 1E to Non-1E Isolation Testing. [[During Class 1E to Non-1E Isolation Testing, the ***SPINLINE 3*** QTS will be powered with the Test Specimen Application Program (TSAP) operating in a mode which will cycle all but one of the relay output circuits on timed ON/OFF cycles. The TSAP operating mode will also cycle a number of the analog output circuits through stair-stepping output values on repeating cycles, and exercise the NERVIA communication interfaces. The test system simulators (or jumpered connections) will operate a

number of the discrete input circuits on timed ON/OFF cycles, and operate a number of the analog and RTD inputs through stair-stepping output values on repeating cycles.

The data acquisition system (DAS) which is part of the test system consists of a real time input/output chassis that performs signal generation and acquisition, and a part that performs the data processing. The communication between these two parts of the DAS is achieved with fiber optic. In order to minimize transmission of applied Class 1E to Non-1E Isolation disturbances outside the EMI/RFI test chamber, the real time input/output chassis is embedded in a shielded cabinet that is installed in the test chamber. Most of the test system signal and communication wiring entering or exiting the shielded cabinet will pass through PI filters mounted on the shielded cabinet.

In order to limit the number of required signal wire pass-through filters, the normal ***SPINLINE 3*** QTS and test system configurations will be altered for Class 1E to Non-1E Isolation Testing. The number of signal wires passing from the ***SPINLINE 3*** QTS to the test system data recording and simulation system will be limited to approximately one circuit per ***SPINLINE 3*** QTS input/output module, using the same configuration as implemented for EMI/RFI Testing. All other normally interconnected signal wires will be disconnected and input/output point jumpers installed as necessary.]]

EPRI TR-107330 provides no requirements or guidance for control of ambient conditions (temperature, pressure and humidity) during Class 1E to Non-1E Isolation Testing. [[During Class 1E to Non-1E Isolation Testing, the test chamber conditions of temperature and humidity will be maintained within the normal operating range of the ***SPINLINE 3*** QTS. The test chamber barometric pressure will be allowed to assume the barometric pressure conditions local to the test facility.]]

EPRI TR-107330 does not include specific requirements for configuration of the test specimen power supplies during Class 1E to Non-1E Isolation Testing. [[Both of the test system power supply circuits to the ***SPINLINE 3*** QTS cabinet power supply assembly will be energized during Class 1E to Non-1E Isolation Testing. The AC sources to the ***SPINLINE 3*** QTS cabinet power supply assembly will be set at nominal source voltage and frequency conditions during the Class 1E to Non-1E Isolation Testing.]] EPRI TR-107330, Section 6.2.1, requires that additional resistive loads be placed on each test specimen main power supply output so that nominal current draws at nominal power supply output voltages are equal to the power supply rating. [[This power supply loading is not realistic for a ***SPINLINE 3*** platform with redundant active cabinet power supply assembly supply circuits. During Class 1E to Non-1E Isolation Testing, additional resistive loads will be placed on the redundant outputs of the cabinet power supply assembly such that the nominal (at rated input voltage and frequency) current draws of each redundant output at nominal output voltage is equal to 1/2 the output ratings.

In order to minimize transmission of applied Class 1E to Non-1E Isolation disturbances outside the EMI/RFI test chamber, all test system power supply cables entering the EMI/RFI test chamber must pass through filter capacitors (provided by the test facility) located in the chamber walls. The power supply feeds to the ***SPINLINE 3*** QTS cabinet power supply assembly must also pass through line impedance stabilization networks (LISNs, provided by the test facility) located inside the EMI/RFI test chamber.

The relay output point load resistors connected during Seismic and Environmental Testing will be disconnected during Class 1E to Non-1E Isolation Testing.]] EPRI TR-107330 does not require the relay output points to be operating at rated currents during Class 1E to Non-1E Isolation Testing.

EPRI TR-107330, Section 6.2.1, requires that additional resistive loads be placed on each ***SPINLINE 3*** QTS loop power supply output so that nominal current draws at nominal power supply output voltages are equal to the power supply rating. [[During Class 1E to Non-1E Isolation Testing, additional resistive loads will be placed on the output(s) of the ***SPINLINE 3*** QTS auxiliary power supply module(s) such that the nominal (at rated input voltage) current draws of the auxiliary power supply module(s) at nominal output voltage are equal to the auxiliary power supply module ratings.]]

J.8 Test Levels

EPRI TR-107330, Section 4.6.4, specifies that Class 1E to Non-1E Isolation Testing of the test specimen under qualification demonstrate that the isolation features conform to the instrumentation and control requirements for Class 1E to Non-1E connections given in IEEE Standard 384-1981 (Ref. 31).

Section 7.2.2.1 of IEEE Standard 384 requires that:

a) The isolation device prevents shorts, grounds and open circuits on the Non-1E side from degrading unacceptably the operation of the circuits on the 1E side and,

b) The isolation device prevents application of the maximum credible voltage on the Non-1E side from degrading unacceptably the operation of the circuits on the 1E side.

[[This Class 1E to Non-1E Isolation Test procedure will address the item (a) and (b) isolation requirements for the ***SPINLINE 3*** QTS analog and relay output modules. Per Section 7.2.2.1 of IEEE Standard 384, the maximum credible voltage is applied across the Non-1E side terminals (line-to-line representing a short circuit) and across the Non-1E side terminals (lines) and ground (representing a short to ground).]]

EPRI TR-107330, Section 4.6.4, requires that the test specimen modules under qualification provide electrical isolation capability of at least 600 VAC and 250 VDC applied for 30 seconds. Per Section 7.2.2.1 of IEEE Standard 384, the highest voltage to which an isolation device Non 1E side is exposed shall determine the minimum voltage level that the device shall withstand across the Non-1E side terminals, and between the Non-1E terminals and ground. [[The cables connected to the ***SPINLINE 3*** platform analog output modules are expected to be routed separately from high voltage (greater than 120 VAC) cables. A line-to-line short to a three conductor 120 VAC cable could result in a maximum possible voltage exposure of 240 VAC RMS. Therefore, the analog output module Class 1E to Non-1E isolation point is tested for a maximum isolation capability of 250 VAC and 250 VDC applied for 30 seconds. The test voltages will be applied across the line leads of the analog output module point (to simulate a line-to-line fault exposure), and across the line leads and AC ground (to simulate a line to ground fault). The applied current will be limited to 10 amps. Higher fault currents would be expected to be automatically cleared by installed plant circuit protection devices.The ***SPINLINE 3*** QTS relay output module is tested to the full EPRI TR-107330 voltage levels of 600 VAC and 250 VDC as listed above. The test voltages will be applied across the line leads of one relay output point on the module for both the ON and OFF states of the point, and across the line leads and AC ground of one relay output point on the module for both the ON and OFF states of the point. The applied currents will be limited to 25 amps (600 VAC) and 10 amps (250 VDC).

The Class 1E to Non-1E isolation levels used in testing as given above will be reported as the electrical isolation qualification values in accordance with Section 8.6.3 of EPRI TR-107330.

The qualification of the ***SPINLINE 3*** QTS is based on a system design which may include interfaces to Non-1E communication equipment. These interfaces are made through fiber-optic cable connections to the ***SPINLINE 3*** NERVIA communications module. These connections inherently provide electrical isolation from the Non-1E input/output circuits because the fiber optic cables are incapable of transmitting electrical faults. Therefore, Class 1E to Non-1E Isolation Testing is not required on the NERVIA fiber-optic cable connections to Non-1E communication equipment.]]

J.9 Performance Monitoring

Per EPRI TR-107330, Section 4.6.4, applying the specified levels of Class 1E to Non-1E Isolation Test voltage to relay output module points shall not disrupt the operation of any other modules in the test specimen, or cause disruption of the test specimen backplane signals. Per EPRI TR-107330, Section 4.6.4, applying the specified levels of Class 1E to Non-1E Isolation Test voltage to analog output module points shall not cause more than a 5% change to any other channel on the module, disrupt the operation of any other modules in the test specimen, or cause disruption of the test specimen backplane signals

[[During Class 1E to Non-1E Isolation Testing, the test facility will be responsible for generating and exposing the ***SPINLINE 3*** QTS to the required test voltages and currents given in Section I.8 above. During Class 1E to Non-1E Isolation Testing, Rolls-Royce will be responsible for monitoring operation of the ***SPINLINE 3*** QTS and determining the ***SPINLINE 3*** QTS Class 1E to Non-1E Isolation capability.

During Class 1E to Non-1E Isolation Testing, operation of the ***SPINLINE 3*** QTS will be monitored and recorded by the test system data logging instrumentation. The recorded data will be evaluated for time periods before, during and after each Class 1E to Non-1E Isolation test. The data evaluations will consider operation (per the TSAP) of at least one input or output point on each I/O module installed in the ***SPINLINE 3*** QTS, and operation of the NERVIA communication interfaces. The test will not apply Class 1E to Non-1E Isolation test voltages to any monitored input or output point. The data recorded during Class 1E to Non-1E Isolation Testing will be sufficient to demonstrate the EPRI TR-107330 performance criteria listed above.

The ***SPINLINE 3*** QTS and test system as configured for Class 1E to Non-1E Isolation Testing does not support Operability or Prudency Testing. For this reason it is not practical to perform the Operability and Prudency Tests during the Class 1E to Non-1E Isolation Tests. The data recorded during the Class 1E to Non-1E Isolation Tests will demonstrate acceptable system performance during Class 1E to Non-1E Isolation Test voltage exposure. The Operability and Prudency Tests run at the completion of all qualification testing will demonstrate acceptable system performance following Class 1E to Non-1E Isolation Testing.]]

J.10 Acceptance Criteria

The following Class 1E to Non-1E Isolation Test acceptance criteria are based on Section 4.6.4 of EPRI TR-107330.

[[

a) Applying the Class 1E to Non-1E Isolation test voltages specified in Section I.8 above for the required time to the specified ***SPINLINE 3*** QTS test points shall not disrupt the operation of any other module in the ***SPINLINE 3*** QTS, or cause disruption of the ***SPINLINE 3*** QTS backplane signals.

   Evaluation of normal operating performance data (inputs, outputs, fault/diagnostic indicators and NERVIA communications) shall demonstrate satisfactory operation of the ***SPINLINE 3*** QTS during and after application of the Class 1E to Non-1E Isolation Test voltages.

b) Applying the Class 1E to Non-1E Isolation Test voltages specified in Section I.8 above for the required time to the specified ***SPINLINE 3*** QTS analog output module test point shall not cause more than a 5% change to any other monitored point on the module.

c) Per Section 6.3.6 of EPRI TR-107330, failures of one or more redundant devices due to application of Class 1E to Non-1E Isolation Test voltages are acceptable so long as the failures do not result in the inability of the ***SPINLINE 3*** QTS to operate as intended. Faults or failures of redundant devices which occur during Class 1E to Non-1E Isolation Testing will be evaluated for effect on the ***SPINLINE 3*** QTS operation. Evaluation of normal operating performance data (inputs, outputs, fault/diagnostic indicators and NERVIA communications) shall demonstrate intended operation of the ***SPINLINE 3*** QTS.]]

Rolls-Royce

J.11 Documentation

The following records will be prepared by Rolls-Royce to document the results of Class 1E to Non-1E Isolation Testing:

1. Class 1E to Non-1E Isolation Testing Procedure (Completed with Attachments)
2. Rolls-Royce Class 1E to Non-1E Isolation Test Report

The following record will be prepared by the test facility to document the results of Class 1E to Non-1E Isolation Testing:

1. Test Facility Class 1E to Non-1E Isolation Test Report

Rolls-Royce

Appendix K : Performance Proof Test Plan

K.1 Purpose

This test plan describes the approach for Performance Proof Testing of the Rolls-Royce ***SPINLINE 3*** Qualification Test Specimen (QTS). Performance Proof Testing of the ***SPINLINE 3*** QTS is performed as part of qualification testing to meet the intent of the applicable requirements of EPRI TR-107330, Section 5.5 (Ref. 5).

K.2 Objective

The objective of Performance Proof Testing is to demonstrate the continuing acceptable operation and performance of the ***SPINLINE 3*** QTS following completion of all hardware qualification testing. EPRI TR 107330, Section 5.5 requires a final performance of the Operability Test procedure on completion of Electrostatic Discharge Testing. As an alternative to this requirement, Performance Proof Testing will include a final performance of both the Operability and Prudency Test procedures following completion of all hardware qualification testing, and comparison of the test results to the results for all previous performances of the Operability and Prudency Test procedures.

K.3 Equipment to be Tested

The Master Configuration List (Ref. 38), to be prepared by Rolls-Royce as part of the ***SPINLINE 3*** Qualification Project, will document the ***SPINLINE 3*** QTS hardware and firmware to be tested. Due to the complexity of the hardware and the scope of the required qualification testing, only one ***SPINLINE 3*** QTS will be used during qualification testing.

K.4 Sequence of Testing

As shown in Figure 1, Performance Proof Testing is performed after completion of Class 1E to Non-1E Testing. The following describes the Performance Proof Testing sequence:

1. Remove the ***SPINLINE 3*** QTS and test system from the EMI/RFI test chamber.
2. Reassemble the ***SPINLINE 3*** QTS and test system
3. Perform the Performance Proof Testing System Setup and Checkout Test.
4. Perform Performance Proof Testing Operability Testing.
5. Perform Performance Proof Testing Prudency Testing.

As shown in Figure 2, Performance Proof Testing is performed after completion of EMI/RFI Testing. The following describes the Performance Proof Testing sequence:

6. Perform the Performance Proof Testing System Setup and Checkout Test.
7. Perform Performance Proof Testing Operability Testing.
8. Perform Performance Proof Testing Prudency Testing.

K.5 Procedures

The following procedures are used during Performance Proof Testing:

a) System Setup and Checkout Test Procedure: This procedure was drafted by MPR Associates, finalized by Rolls-Royce, and implemented by Rolls-Royce. Through this procedure, the ***SPINLINE 3*** QTS is configured for Performance Proof Testing, and the correct operation of the ***SPINLINE 3*** QTS and test system is verified.

b) Operability Test Procedure: This procedure was drafted by MPR Associates, finalized by Rolls-Royce, and implemented by Rolls-Royce. This procedure includes a series of tests defined in Section 5.3 of EPRI TR-107330 that verify acceptable performance of the ***SPINLINE 3*** QTS in accordance with the manufacturer's specifications for the ***SPINLINE 3*** platform. The Performance Proof Testing run of this procedure demonstrates performance of the ***SPINLINE 3*** QTS at the completion of all hardware qualification testing.

c) Prudency Test Procedure: This procedure was drafted by MPR Associates, finalized by Rolls-Royce, and implemented by Rolls-Royce. This procedure includes a series of tests defined in Section 5.4 of EPRI TR-107330 that verify acceptable performance of the ***SPINLINE 3*** QTS in accordance with the manufacturer's specifications for the ***SPINLINE 3*** platform. The Performance Proof Testing run of this procedure demonstrates performance of the ***SPINLINE 3*** QTS at the completion of all hardware qualification testing.

K.6 Test Specimen Mounting

EPRI TR-107330 provides no requirements or guidance for mounting of the test specimen during Performance Proof Testing. The ***SPINLINE 3*** QTS will be mounted in open mounting frame(s) for Performance Proof Testing. The configuration of the ***SPINLINE 3*** QTS components and interconnecting cabling will be similar to expected in-cabinet applications. The ***SPINLINE 3*** QTS cooling fan(s) will be installed on the open mounting frame(s) and operating in such a manner that they provide cooling of the other ***SPINLINE 3*** QTS components.

K.7 Service Conditions

EPRI TR-107330 provides no requirements or guidance for operation of the test specimen during Performance Proof Testing. [[During Performance Proof Testing, the ***SPINLINE 3*** QTS will be powered with the input and outputs operating under control of the Test Specimen Application Program (TSAP) and the connected test system simulation devices. The input and output field circuits will be configured with loads representative of the types intended for connection to the corresponding input and output module points, and other devices required for monitoring of the circuit operations.]]

EPRI TR-107330 provides no requirements or guidance for control of ambient conditions (temperature, pressure and humidity) during Performance Proof Testing. [[During Performance Proof Testing, the test space conditions of temperature and humidity shall be maintained within the normal operating range of the ***SPINLINE 3*** QTS.]]

EPRI TR-107330 provides no requirements or guidance for configuration of the test specimen power supply sources during Performance Proof Testing. [[During Performance Proof Testing, the power sources to the ***SPINLINE 3*** QTS cabinet power supply assembly will be set as follows:

a) Both of the test system power supply circuits to the ***SPINLINE 3*** QTS cabinet power supply assembly will be energized during Performance Proof Testing.

b) The power source to the ***SPINLINE 3*** QTS cabinet power supply assembly will be set to the manufacturer's specified nominal source voltage and frequency ratings for the cabinet power supply assembly inputs.]]

K.8 Test Levels

The test levels (supply power, input signals, output signals and loads) applied to the ***SPINLINE 3*** QTS during Performance Proof Testing will be as specified separately in the System Setup and Checkout, Operability and Prudency Test procedures.

K.9 Performance Monitoring

Performance monitoring of the ***SPINLINE 3*** QTS during Performance Proof Testing will be as specified separately in the System Setup and Checkout, Operability and Prudency Test procedures.

K.10 Acceptance Criteria

Acceptance criteria for performance monitoring of the ***SPINLINE 3*** QTS during Performance Proof Testing will be as specified separately in the System Setup and Checkout, Operability and Prudency Test procedures. In addition, comparison of the Performance Proof Testing Operability and Prudency Test data to all other Operability and Prudency test data shall not indicate an unacceptable change in performance of the ***SPINLINE 3*** QTS hardware.

K.11 Documentation

The following records will be prepared by Rolls-Royce to document the results of Performance Proof Testing:

1. Performance Proof Testing System Setup and Checkout Test Procedure (Completed with Attachments)
2. Performance Proof Testing Operability Test Procedure (Completed with Attachments)
3. Performance Proof Testing Prudency Test Procedure (Completed with Attachments)
4. Performance Proof Testing Report

Rolls-Royce

Appendix L : Operability Test Plan

L.1 Purpose

This test plan describes the approach for Operability Testing of the Rolls-Royce ***SPINLINE 3*** Qualification Test Specimen (QTS). Operability Testing of the ***SPINLINE 3*** QTS is performed as part of qualification testing to meet the intent of the applicable requirements of EPRI TR-107330, Section 5.5 (Ref. 5).

L.2 Objective

The objective of Operability Testing is to demonstrate the continuing correct function and performance of the ***SPINLINE 3*** QTS throughout qualification testing. Section 5.3 of EPRI TR 107330 describes the specific functional and performance tests to be performed as part of Operability Testing. These tests will be implemented in the ***SPINLINE 3*** QTS Operability Test Procedure as they are applicable to the ***SPINLINE 3*** QTS design (see Section L.5 below). Section 5.5 of EPRI TR-107330 identifies the points at which the Operability Tests should be performed during hardware qualification testing. The Operability Tests will be performed at the points identified in the individual hardware qualification test plans and Section L.4 below, based on the accessibility and configuration of the ***SPINLINE 3*** QTS during those tests.

L.3 Equipment to be Tested

The Master Configuration List (Ref. 38), to be prepared by Rolls-Royce as part of the ***SPINLINE 3*** Qualification Project, will document the ***SPINLINE 3*** QTS hardware and firmware to be tested. Due to the complexity of the hardware and the scope of the required qualification testing, only one ***SPINLINE 3*** QTS will be used during qualification testing.

L.4 Sequence of Testing

As shown in Figure 1, Operability Testing was performed at the following times during 2010-2011 hardware qualification testing.

1. During Pre-Qualification Acceptance Testing
2. At the completion of Radiation Exposure Withstand Testing
3. At the completion of the high temperature, high humidity phase of Environmental Testing
4. At the completion of the low temperature phase of Environmental Testing
5. At the completion of the low humidity phase of Environmental Testing
6. At the completion of Environmental Testing
7. At the completion of Seismic Testing
8. During Performance Proof Testing

As shown in Figure 2, Operability Testing is performed at the following times during 2012 hardware qualification testing.

1. During Pre-Qualification Acceptance Testing
2. At the completion of Seismic Testing for SSE level at 9.75 g
3. At the completion of Seismic Testing for SSE level at 14 g
4. At the completion of Radiated Susceptibility from 1 GHz to [[3]] GHz
5. At the completion of Radiated Susceptibility from [[3 GHz to 5.8]] GHz
6. During Performance Proof Testing

L.5 Procedures

The following procedure is used during Operability Testing:

a) Operability Test Procedure: This procedure was drafted by MPR Associates, finalized by Rolls-Royce, and implemented by Rolls-Royce. This procedure includes a series of tests defined in Sections 5.3 and 6.4.3 of EPRI TR-107330 that verify acceptable performance of the ***SPINLINE 3*** QTS in accordance with the manufacturer's specifications for the ***SPINLINE 3*** platform. These tests include:

b) [[

- Analog Input and Output Accuracy, to demonstrate no degradation in the accuracy of analog input and analog output circuits.
- Response Time, to demonstrate no degradation in the response time of the digital hardware, as indicated by a change in outputs in response to a change in inputs.
- Discrete Input Operation, to demonstrate no degradation in discrete input circuit voltage switching levels.
- Discrete Output Operation, to demonstrate no degradation in operation and load capability of relay output circuits.
- Timer Function Accuracy, to demonstrate no degradation in hardware implementation of software timer functions.
- Failover Performance, to demonstrate no degradation in automatic failover to redundant components.
- Loss of Power performance, to demonstrate no degradation in capability to fail to a known state on loss of power.
- Power Interrupt Performance, to demonstrate no degradation in capability to operate through momentary input power interruptions.
- Power Quality Tolerance, to demonstrate no degradation in capability to operate under degraded input power voltage and frequency conditions.]]

L.6 Test Specimen Mounting

EPRI TR-107330 provides no requirements or guidance for mounting of the test specimen during Operability Testing. The ***SPINLINE 3*** QTS mounting during Operability Testing is as specified in the individual hardware qualification test plans included in this document.

L.7 Service Conditions

EPRI TR-107330 provides no requirements or guidance for operation of the test specimen during Operability Testing. The ***SPINLINE 3*** QTS operation at the start of Operability Testing is as specified in the individual hardware qualification test plans included in this document. Performance of the Operability Tests may require temporarily modification of the ***SPINLINE 3*** QTS mode of operation.

EPRI TR-107330 provides no requirements or guidance for control of ambient conditions (temperature, pressure and humidity) during Operability Testing. During Operability Testing, the test space conditions of temperature and humidity will be as specified in the individual hardware qualification test plans included in this document.

EPRI TR-107330 provides no requirements or guidance for configuration of the test specimen power supply sources during Operability Testing. At the start of Operability Testing, the ***SPINLINE 3*** QTS power supplies will be configured as specified in the individual hardware qualification test plans included in this document. Performance of the Operability Tests may require temporarily modification of the ***SPINLINE 3*** QTS power supply configuration.

L.8 Test Levels

The test levels (supply power, input signals, output signals and loads) applied to the ***SPINLINE 3*** QTS at the start of Operability Testing will be as specified in the individual hardware qualification test plans included in this document. Performance of the Operability Tests may require temporarily modification of the test levels applied to the ***SPINLINE 3*** QTS.

L.9 Performance Monitoring

Performance monitoring of the ***SPINLINE 3*** QTS during Operability Testing will be as specified in the individual sections of the Operability Test procedure.

L.10 Acceptance Criteria

Acceptance criteria for performance monitoring of the ***SPINLINE 3*** QTS during Operability Testing will be as specified in the individual sections of the Operability Test procedure.

Rolls-Royce

L.11 Documentation

The following records will be prepared by Rolls-Royce to document the results of Operability Testing:

For 2010, 2011 and 2012 campaign,

1. Pre-Qualification Testing Operability Test Procedure (Completed with Attachments)
2. Performance Proof Testing Operability Test Procedure (Completed with Attachments)

For 2010-2011 campaign,

3. Post Radiation Exposure Withstand Testing Operability Test Procedure (Completed with Attachments)
4. High Temperature, High Humidity Environmental Testing Operability Test Procedure (Completed with Attachments)
5. Low Temperature Environmental Testing Operability Test Procedure (Completed with Attachments)
6. Low Humidity Environmental Testing Operability Test Procedure (Completed with Attachments)
7. Ambient Temperature, Ambient Humidity Environmental Testing Operability Test Procedure (Completed with Attachments)
8. Post Seismic Testing Operability Test Procedure (Completed with Attachments)
9. Post EMI-RFI Testing Operability Test Procedure (Completed with Attachments)

For 2012 campaign,

10. Post SSE ZPA 4.9 g Seismic Testing Operability Test Procedure (Completed with Attachments)
11. Post SSE ZPA 7 g Seismic Testing Operability Test Procedure (Completed with Attachments)
12. Post RS103 [[ ]] GHz EMI/RFI Testing Operability Test Procedure (Completed with Attachments)
13. Post RS103 [[ ]] GHz EMI/RFI Testing Operability Test Procedure (Completed with Attachments)

Rolls-Royce

Appendix M : Prudency Test Plan

M.1 Purpose

This test plan describes the approach for Prudency Testing of the Rolls-Royce ***SPINLINE 3*** Qualification Test Specimen (QTS). Prudency Testing of the ***SPINLINE 3*** QTS is performed as part of qualification testing to meet the intent of the applicable requirements of EPRI TR-107330, Section 5.5 (Ref. 5).

M.2 Objective

The objective of Prudency Testing is to demonstrate the continuing correct function and performance of the ***SPINLINE 3*** QTS throughout qualification testing. Section 5.4 of EPRI TR 107330 describes the specific functional and performance tests to be performed as part of Prudency Testing. These tests will be implemented in the ***SPINLINE 3*** QTS Prudency Test Procedure as they are applicable to the ***SPINLINE 3*** QTS design (see Section L.5 below). Section 5.5 of EPRI TR-107330 identifies the points at which the Prudency Tests should be performed during hardware qualification testing. The Prudency Tests will be performed at the points identified in the individual hardware qualification test plans and Section L.4 below, based on the accessibility and configuration of the ***SPINLINE 3*** QTS during those tests.

M.3 Equipment to be Tested

The Master Configuration List (Ref. 38), to be prepared as part of the ***SPINLINE 3*** Qualification Project, will document the ***SPINLINE 3*** QTS hardware and firmware to be tested. Due to the complexity of the hardware and the scope of the required qualification testing, only one ***SPINLINE 3*** QTS will be used during qualification testing.

M.4 Sequence of Testing

As shown in Figure 1, Prudency Testing is performed at the following times during 2010-2011 hardware qualification testing.

1. During Pre-Qualification Acceptance Testing
2. At the completion of Radiation Exposure Withstand Testing
3. At the completion of the high temperature, high humidity phase of Environmental Testing
4. At the completion of Seismic Testing
5. During Performance Proof Testing

As shown in Figure 2, Prudency Testing is performed at the following times during 2012 hardware qualification testing.

1. During Pre-Qualification Acceptance Testing
2. At the completion of Seismic Testing for SSE level at 9.75 g
3. At the completion of Seismic Testing for SSE level at 14 g
4. At the completion of Radiated Susceptibility from 1 GHz to [[3]] GHz
5. At the completion of Radiated Susceptibility from [[3 GHz to 5.8]] GHz
6. During Performance Proof Testing

M.5 Procedures

The following procedure is used during Prudency Testing:

a) Prudency Test Procedure: This procedure is drafted by MPR Associates, finalized by Rolls-Royce, and implemented by Rolls-Royce. This procedure includes a series of tests defined in Section 5.4 of EPRI TR-107330 that verify acceptable performance of the ***SPINLINE 3*** QTS in accordance with the manufacturer's specifications for the ***SPINLINE 3*** platform. These tests include: [[

- Burst of Events Performance, to demonstrate no degradation in capability to process rapidly changing inputs.
- Communication Port Failure Performance, to demonstrate no degradation in performance during conditions of simulated electrical faults on connected communication ports.]]

M.6 Test Specimen Mounting

EPRI TR-107330 provides no requirements or guidance for mounting of the test specimen during Prudency Testing. The ***SPINLINE 3*** QTS mounting during Prudency Testing is as specified in the individual hardware qualification test plans included in this document.

M.7 Service Conditions

EPRI TR-107330 provides no requirements or guidance for operation of the test specimen during Prudency Testing. The ***SPINLINE 3*** QTS operation at the start of Prudency Testing is as specified in the individual hardware qualification test plans included in this document. Performance of the Prudency Tests may require temporarily modification of the ***SPINLINE 3*** QTS mode of operation.

EPRI TR-107330 provides no requirements or guidance for control of ambient conditions (temperature, pressure and humidity) during Prudency Testing. During Prudency Testing, the test space conditions of temperature and humidity will be as specified in the individual hardware qualification test plans included in this document.

EPRI TR-107330, Section 5.4 includes requirements for configuration of the test specimen power supply sources during Prudency Testing. At the start of Prudency Testing, the ***SPINLINE 3*** QTS power supplies will be configured as specified in the individual hardware qualification test plans included in this document. Performance of the Prudency Tests will require temporarily modification of the ***SPINLINE 3*** QTS power supply configuration to meet the requirements of EPRI TR 107330, Section 5.4.

M.8 Test Levels

The test levels (supply power, input signals, output signals and loads) applied to the ***SPINLINE 3*** QTS at the start of Prudency Testing will be as specified in the individual hardware qualification test plans included in this document. Performance of the Prudency Tests may require temporarily modification of the test levels applied to the ***SPINLINE 3*** QTS.

M.9 Performance Monitoring

Performance monitoring of the ***SPINLINE 3*** QTS during Prudency Testing will be as specified in the individual sections of the Prudency Test procedure.

M.10 Acceptance Criteria

Acceptance criteria for performance monitoring of the ***SPINLINE 3*** QTS during Prudency Testing will be as specified in the individual sections of the Prudency Test procedure.

M.11 Documentation

The following records will be prepared by Rolls-Royce to document the results of Prudency Testing:

For 2010, 2011 and 2012 campaign,

1. Pre-Qualification Testing Prudency Test Procedure (Completed with Attachments)
2. Performance Proof Testing Prudency Test Procedure (Completed with Attachments)

For 2010-2011 campaign,

3. Post Radiation Exposure Withstand Testing Prudency Test Procedure (Completed with Attachments)
4. High Temperature, High Humidity Environmental Testing Prudency Test Procedure (Completed with Attachments)
5. Post Seismic Testing Prudency Test Procedure (Completed with Attachments)
6. Post EMI-RFI Testing Prudency Test Procedure (Completed with Attachments)

For 2012 campaign,

7. Post SSE ZPA 4.9 g Seismic Testing Prudency Test Procedure (Completed with Attachments)
8. Post SSE ZPA 7 g Seismic Testing Prudency Test Procedure (Completed with Attachments)
9. Post RS103 [[ ]] GHz EMI/RFI Testing Prudency Test Procedure (Completed with Attachments)
10. Post RS103 [[ ]] GHz EMI/RFI Testing Prudency Test Procedure (Completed with Attachments)

Rolls-Royce

Appendix N : Additional Seismic Test Plan (2012)

N.1 Purpose

This test plan describes the approach for additional Seismic Testing of the Rolls-Royce ***SPINLINE 3*** QTS performed in 2012. Seismic Testing of the ***SPINLINE 3*** QTS is performed as part of qualification testing to demonstrate compliance with USNRC RG 1.100 (Ref. 33) and IEEE Standard 344-1987 (Ref. 15). It uses guidance from EPRI TR-107330 which is compliant with these requirements.

N.2 Objective

The objective of this supplemental Seismic Testing is to achieve the demonstration of the suitability of the ***SPINLINE 3*** platform for qualification as a Category 1 seismic device based on seismic withstand testing performed on the ***SPINLINE 3*** QTS in accordance with Regulatory Guide 1.100 (Ref. 33) and IEEE 344--1987 (Ref. 15). Section 4.3.9 of EPRI TR 107330 defines the recommended seismic test levels the test specimen is expected to withstand (i.e., the test specimen must continue to meet the manufacturer specified performance levels).

However, based on the licensing precedents, we will perform the seismic tests with a reduce level for OBE:

- Conduct five OBEs at maximal acceleration of 7 g (rather than 9.75 g),
- Conduct one SSE at maximal acceleration of 9.75 g (rather than 14 g), and
- Conduct one additional SSE at maximal acceleration of 14 g.

These tests will establish the qualification envelope for ***SPINLINE 3*** seismic withstand.

N.3 Equipment to be Tested

According to the 2011 tests results reported in the Summary Equipment Qualification Report (Ref. 37), two subassemblies (PU1 and HCAS) need to be tested in 2012 to demonstrate the compliance of ***SPINLINE 3*** Platform with standards mentioned above. Due to the complexity of the hardware and the scope of the required qualification testing, only one ***SPINLINE 3*** QTS will be used during qualification testing.

N.4 Sequence of Testing

As shown in Figure 2, Seismic Testing is performed after completion of Pre-Qualification Acceptance Testing.

The following describes the Seismic Testing sequence for each subassembly:

1. Perform Resonance Search testing on the ***SPINLINE 3*** QTS components.
2. Setup the ***SPINLINE 3*** QTS subassemblies on the Seismic Test table (PU1 and HCAS).
3. Perform the Pre-Seismic Testing System Setup and Checkout Test.
4. Perform five seismic tests to the specified OBE (with ZPA at 3.5 g) test levels.
5. Perform one seismic test to the specified SSE (with ZPA at 4.9 g) test level.
6. Perform Post Seismic Testing Operability and Prudency Testing
7. Perform one seismic test to the specified SSE (with ZPA at 7 g) test level.
8. Perform Post Seismic Testing Operability and Prudency Testing.
9. Remove the ***SPINLINE 3*** QTS subassemblies from the Seismic Test table.

N.5 Procedures

The following procedures are used during Seismic Testing:

a) System Setup and Checkout Test Procedure: This procedure was drafted by MPR Associates, finalized by Rolls-Royce, and implemented by Rolls-Royce. Through this procedure, the ***SPINLINE 3 QTS*** is configured on the test table for Seismic Testing, and the correct operation of the ***SPINLINE 3*** QTS and test system is verified.

b) Seismic Test Procedure This procedure was drafted by MPR Associates, finalized by Rolls-Royce, and implemented by Rolls-Royce. Through this procedure, the ***SPINLINE 3*** QTS is subjected to resonance search testing and receives additional configuration on the test table for Seismic Testing. This procedure requires monitoring the performance of the ***SPINLINE 3*** QTS throughout application of the Seismic Test conditions.

c) Operability Test Procedure: This procedure was drafted by MPR Associates, finalized by Rolls-Royce, and implemented by Rolls-Royce. This procedure includes a series of tests defined in Section 5.3 of EPRI TR-107330 that verify acceptable performance of the ***SPINLINE 3*** QTS in accordance with the manufacturer's specifications for the ***SPINLINE 3*** platform. This procedure is performed at the completion of Seismic Testing as listed in Table 5-1 of EPRI TR-107330. [[

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d) Prudency Test Procedure: This procedure was drafted by MPR Associates, finalized by Rolls-Royce, and implemented by Rolls-Royce. This procedure includes a series of tests defined in Section 5.4 of EPRI TR-107330 that verify acceptable performance of the ***SPINLINE 3*** QTS in accordance with the manufacturer's specifications for the ***SPINLINE 3*** platform. Although not required by Table 5-1 of EPRI TR-107330, this procedure is performed at the completion of Seismic Testing. [[

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N.6 Test Specimen Mounting

EPRI TR-107330, Section 6.3.4.1 requires the test specimen to be mounted on a structure whose configuration meets the manufacturer's mounting requirements during Seismic Testing. The structure shall be stiff enough so there are no resonances below 100 Hz. The seismic tests shall be performed with the test specimen mounting most susceptible to seismic vibrations. The mounting shall use manufacturer required hardware. All threaded fasteners used for mounting shall be tightened with a torque wrench and the torque values recorded.

The ***SPINLINE 3*** QTS will be mounted to the Seismic Test table in accordance with Rolls-Royce specified mounting instructions for seismic applications. The Seismic Test mounting will simulate a typical 19" rack

mount configuration using standard Rolls-Royce chassis mounting brackets and fastener hardware. Resonance search testing will demonstrate that the simulated mounting configuration is stiff enough so that there are no resonances below 100 Hz. All mounting hardware fasteners will be tightened using calibrated torquing devices, and torque values will be recorded.

EPRI TR-107330, Section 6.2.1.1 requires that during Seismic Testing the test specimen modules and associated cabling be arranged to cause a total stress on the chassis and its mounting hardware that is equal to the maximum that could result from any reasonable arrangement of the modules, cabling, and any other devices included in the qualification program. If necessary, dummy weights may be added.

The ***SPINLINE 3*** QTS will be configured, mounted, and equipped with dummy weight loadings as necessary to meet these requirements within the confines of the manufacturer's instructions for configuration and mounting for seismic applications. Several modules installed in the ***SPINLINE 3*** QTS main chassis will be located as close together as the chassis design allows to demonstrate interaction effects during the Seismic Testing.

N.7 Service Conditions

EPRI TR-107330, Section 6.3.4.2, requires that the test specimen be powered with its Test Specimen Application Program (TSAP) operating during Seismic Testing, 1/2 of its solid-state discrete outputs shall be ON and loaded to their rated current, 1/2 of its relay outputs shall be ON, and 1/2 of its relay outputs shall be OFF. In addition, 1/4 of its relay outputs shall transition from OFF to ON and 1/4 shall transition from ON to OFF during the OBE and SSE tests.

[[During Seismic Testing, the ***SPINLINE 3*** QTS will be powered with the TSAP operating. The ***SPINLINE 3*** QTS does not include solid-state discrete outputs. Because there are no solid-state discrete outputs, several of the relay output points are required to operate under control of the TSAP differently than the fixed ON and OFF operation described above in order to support such measurements as time response during Seismic Testing. Therefore, in accordance with the TSAP, at any point during operation only 1/2 of a portion of the relay output points on the relay output modules will be held ON and 1/2 of a portion of the relay output points will be held OFF. Every 5 seconds, approximately 1/4 of the relay output points that were held ON will transition from ON to OFF, and another approximately 1/4 of the relay output points that were held OFF will transition from OFF to ON. In this manner, at any point during the tests, 1/2 of a portion of the relay output points will be held ON and 1/2 of a portion will be held OFF. Approximately 1/4 of the points held OFF will be shown to transition from OFF to ON, and approximately 1/4 of the points held ON will be shown to transition from ON to OFF. The field circuits of a representative portion of the relay output points will be configured with resistive loads which result in the approximate rated current through the output points at the nominal rated output point voltage.]]

EPRI TR-107330, Section 6.3.4.2, requires that Seismic Testing be performed with the power sources to the test specimen power supply modules set to operate at the following minimum AC and DC source voltages and frequencies given in Section 4.6.1.1 of the EPRI TR:

a) Power supply modules fed from AC sources shall remain operable at a minimum source voltage of 90 VAC and a minimum source frequency of 57 Hz.

b) Power supply modules fed from DC sources shall remain operable at a minimum source voltage of 20.4 VDC.

[[The ***SPINLINE 3*** QTS does not include cabinet power supply modules fed from external DC sources. During Seismic Testing, the energized AC power sources to the ***SPINLINE 3*** QTS cabinet power supply assembly will be set to 90 VAC and 57 Hz.]]

EPRI TR-107330, Section 6.2.1, requires that additional resistive loads be placed on each test specimen main power supply output so that nominal current draws at nominal power supply output voltages are equal to the power supply rating. [[

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EPRI TR-107330, Section 6.2.1, requires that additional resistive loads be placed on each test specimen loop power supply output so that nominal current draws at nominal power supply output voltages are equal to the power supply rating. [[

]]

N.8 Test Levels

EPRI TR-107330, Sections 4.3.9 and 6.3.4, require that the test specimen be seismically tested in accordance with IEEE Standard 344 (Ref. 15). The testing shall include a resonance search followed by five simulated Operating Basis Earthquakes (OBEs) to the level shown in Figure 4 5 of EPRI TR-107330, and one simulated Safe Shutdown Earthquake (SSE) to the level shown in Figure 4 5 of EPRI TR-107330. The test vibrations shall be applied triaxially (in three orthogonal directions), and shall be random and multifrequency in content.

[[

Seismic Testing will be performed in the following order:

1) Resonance search as described in Section 7.1.4 of IEEE Standard 344.
2) Five triaxial Operating Basis Earthquake (OBEs) tests with a minimum Zero Period Acceleration (ZPA) of 3.5 g.
3) One triaxial Safe Shutdown Earthquake (SSE) test with a minimum ZPA of 4.9 g.
4) One triaxial Safe Shutdown Earthquake (SSE) test with a minimum ZPA of 7 g.

The resonance search tests shall include a low-level of acceleration (approximately 0.2 g) single-axis sine sweep from 1 to 100 Hz, or the RRS cutoff frequency, whichever is higher, in each of the three orthogonal axes to determine major resonances. The resonance search sweep rate shall be set to two octaves per minute or less to ensure resonance build-up.

The OBE and SSE tests shall follow the RRS curve given as Figure 4-5 in EPRI TR-107330 within the limits of the seismic test table, with the exception mentioned above about OBE and SSE levels (see Figure 3). Testing will be performed and analyzed at 5% damping. Inability to meet the RRS at any specific vibration frequencies during OBE or SSE testing as a result of seismic table limitations will be documented in the seismic test report.]]

N.9 Performance Monitoring

EPRI TR-107330, Section 6.3.4.1, requires that the test specimen Seismic Table mounting fixtures be stiff enough so that there are no resonances below 100 Hz, which is verified by resonance search testing. During resonance search testing, the test facility will instrument the test table and the test specimen in order to detect resonances below 100 Hz.

EPRI TR-107330, Section 6.3.4.2, requires that the Seismic Test table be instrumented with a control accelerometer and that each chassis of the test specimen be instrumented with one or more response accelerometers located to establish maximum chassis accelerations.

[[During Seismic Testing, control accelerometers will be mounted on the Seismic Test table near the base of the ***SPINLINE 3*** QTS mounting fixtures. Additionally, three response accelerometers will be mounted on each of the ***SPINLINE 3*** QTS racks (one triaxial location per rack).

Additional response accelerometers will also be mounted on selected ***SPINLINE 3*** QTS components during each series of OBE and SSE tests (one triaxial location per selected component). The locations of these accelerometers will be selected to indicate the maximum response motion of the ***SPINLINE 3*** QTS components.]]

EPRI TR-107330, Section 4.3.9, requires that the test specimen operate as intended during and following the application of an SSE, all connections and parts remain intact and in place, and relay output contacts not chatter. Relay contact chatter is defined as a spurious change of state that exceeds 2 milliseconds in duration.

[[During application of the OBE and SSE vibrations, operation of the ***SPINLINE 3*** QTS will be continuously monitored and recorded by the test system data logging instrumentation. The recorded data will be evaluated for time periods both during and after the test. The data evaluations will consider operation (per the TSAP) of at least one input or output point on each I/O module installed in the ***SPINLINE 3*** QTS, and operation of all connected NERVIA communication interfaces. The data evaluations will also consider operation of all points on the relay output modules, looking specifically for chattering in both the OFF and ON states.

Following each simulated OBE and SSE test, the ***SPINLINE 3*** QTS components mounted on the Seismic Test table will be inspected for damage or degradation.]]

N.10 Acceptance Criteria

The following Seismic Test acceptance criteria are based on Section 4.3.9 of EPRI TR 107330.

a) The ***SPINLINE 3*** QTS mounting fixtures shall be stiff enough so that there are no resonances below 100 Hz detected during resonance search testing.

b) The ***SPINLINE 3*** QTS shall operate as intended during and after application of the OBE and SSE vibrations given in Section E.8. Evaluation of normal operating performance data (inputs, outputs, and fault/diagnostic indicators) collected during testing shall demonstrate operation as intended.

c) During and after application of the OBE and SSE vibrations:
   - All connections on the ***SPINLINE 3*** QTS shall remain intact,
   - All modules installed in the ***SPINLINE 3*** QTS shall remain fully inserted,
   - No functional or non-functional parts of the ***SPINLINE 3*** QTS shall fall off.

d) During application of the OBE and SSE vibrations, the relay output module contacts shall be demonstrated to change state from energized to de-energized and de-energized to energized in accordance with execution of the TSAP.

e) During application of the OBE and SSE vibrations, any spurious change of state of the relay output module contacts shall not exceed 2 milliseconds in duration for both energized and de-energized contact states.

f) The ***SPINLINE 3*** QTS shall meet the applicable acceptance criteria of the Operability Tests performed on completion of Seismic Testing.

g) The ***SPINLINE 3*** QTS shall meet the applicable acceptance criteria of the Prudency Test performed on completion of Seismic Testing.

N.11 Documentation

The following records will be prepared by Rolls-Royce to document the results of Seismic Testing:

1. Seismic Testing Setup and Checkout Test Procedure (Completed with Attachments)
2. Seismic Testing Procedure (Completed with Attachments)
3. Post SSE ZPA 4.9 g Seismic Testing Operability Test Procedure (Completed with Attachments)
4. Post SSE ZPA 4.9 g Seismic Testing Prudency Test Procedure (Completed with Attachments)
5. Post SSE ZPA 7 g Seismic Testing Operability Test Procedure (Completed with Attachments)
6. Post SSE ZPA 7 g Seismic Testing Prudency Test Procedure (Completed with Attachments)
7. Rolls-Royce Seismic Test Report

The following record will be prepared by the test facility to document the results of Seismic Testing:

1. Test Facility Seismic Test Report

Rolls-Royce

Appendix O: Additional EMI/RFI Test Plan (2012)

O.1 Purpose

This test plan describes the approach for additional EMI/RFI Testing of the Rolls-Royce ***SPINLINE 3*** QTS performed in 2012. EMI/RFI Testing of the ***SPINLINE 3*** QTS is performed as part of qualification testing to demonstrate compliance with the applicable EMI/RFI emissions and susceptibility requirements of USNRC RG 1.180, Rev. 1 (Ref. 7) and EPRI TR-107330 (Ref. 5).

O.2 Objective

The objective of supplemental EMI/RFI testing is to demonstrate the suitability of the ***SPINLINE 3*** platform for qualification as a safety-related device with respect to EMI/RFI susceptibility levels. EMI/RFI testing of the ***SPINLINE 3*** QTS will be performed in accordance with USNRC RG 1.180, Revision 1, using additional guidance from EPRI TR-107330 as applicable. The specific EMI/RFI tests to be performed include:

EMI/RFI Susceptibility Tests

- IEC 61000-4-16 (Ref. 20): Conducted Susceptibility, Common Mode Disturbance, Signal Leads – DC portion on Digital Inputs.
- MIL-STD 461 E – RS103 (Ref. 17): Radiated Susceptibility, High Frequency, Antenna Exposure (from 1 GHz to [[

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O.3 Equipment to be Tested

The Master Configuration List (Ref. 38), to be prepared by Rolls-Royce as part of the ***SPINLINE 3*** Qualification Project, will document the ***SPINLINE 3*** QTS hardware and firmware to be tested. Due to the complexity of the hardware and the scope of the required qualification testing, only one ***SPINLINE 3*** QTS will be used during qualification testing.

O.4 Sequence of Testing

As shown in Figure 2, EMI/RFI Testing is performed after completion of Seismic Testing. The following describes the EMI/RFI Testing sequence:

1. Setup the ***SPINLINE 3*** QTS in the EMI/RFI test chamber.
2. Perform the Pre-EMI/RFI Testing System Setup and Checkout Test.

3. Perform EMI/RFI Susceptibility Testing

   a. Radiated Susceptibility from 1 GHz to [[ ]] GHz
   b. Conducted Susceptibility for QTS Digital Inputs in DC mode
   c. Perform Post EMI/RFI Testing Operability and Prudency Testing
   d. Radiated Susceptibility from [[ ]]
   e. Perform Post EMI/RFI Testing Operability and Prudency Testing
   f. Radiated Susceptibility from [[ ]]

O.5 Procedures

The following procedures are used during EMI/RFI Testing:

a) System Setup and Checkout Test Procedure: This procedure was drafted by MPR Associates, finalized by Rolls-Royce, and implemented by Rolls-Royce. Through this procedure, the ***SPINLINE 3*** QTS is configured in the EMI/RFI test chamber for EMI/RFI Testing, and the correct operation of the ***SPINLINE 3*** QTS and test system is verified.

b) EMI/RFI Test Procedure: This procedure was drafted by MPR Associates, finalized by Rolls-Royce, and implemented by Rolls-Royce. Through this procedure, the ***SPINLINE 3*** QTS receives additional configuration in the EMI/RFI test chamber for EMI/RFI Testing, and the performance of the ***SPINLINE 3*** QTS is monitored throughout application of the EMI/RFI Test conditions.

c) Test Facility EMI/RFI Test Procedure: This procedure is prepared and implemented by the selected qualification test facility. Through this procedure, the ***SPINLINE 3*** QTS receives additional configuration and instrumentation in the EMI/RFI test chamber for EMI/RFI Testing, and the specified EMI/RFI Test conditions are applied to the ***SPINLINE 3*** QTS and monitored.

O.6 Test Specimen Mounting

EPRI TR-107330, Section 6.3.2.1 requires that the test specimen be mounted on a non-metallic vertical surface at a height of at least six feet to the bottom of the test specimen chassis, with no secondary enclosure. The test specimen shall be connected to a ground bus located at the base of the mounting surface using the manufacturer's recommended grounding conductor. Grounding and shielding shall meet the requirements of IEEE Standard 1050 (Ref. 25) and EPRI TR 102323-R1.

The ***SPINLINE 3*** QTS will be installed in the EMI/RFI test chamber mounted in metal frame instrument cabinet(s) with all sides removed. Due to restraints imposed by the size of the ***SPINLINE 3*** QTS, the requirement to mount the test specimen six feet above the floor of the test chamber cannot practicably be met. The test specimen mounting frame(s) will be mounted on non-conductive (i.e., wooden) supports approximately 4 inches above the floor of the test chamber. This is done to prevent the EMI/RFI Test results from being affected by beneficial ground paths that might exist through the test specimen mounting frame(s) if the frame(s) were placed directly on the floor of the EMI/RFI test chamber, which acts as a ground plane for the entire test chamber. [[

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Grounding of the ***SPINLINE 3*** QTS will be in accordance with the manufacturer's recommendations. The ***SPINLINE 3*** QTS grounds will be passed across the gap created by the mounting frame non-conductive supports and bonded to the EMI/RFI test chamber floor. This grounding configuration meets the applicable EPRI TR 107330 requirements for grounding during EMI/RFI Testing.

O.7 Service Conditions

EPRI TR-107330 does not include specific requirements for operation of the test specimen during EMI/RFI Testing. [[

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EPRI TR-107330 provides no requirements or guidance for control of ambient conditions (temperature, pressure, and humidity) during EMI/RFI Testing. [[

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EPRI TR-107330 does not include specific requirements for configuration of the test specimen power supplies during EMI/RFI Testing. [[

]] EPRI TR-107330, Section 6.2.1, requires that additional resistive loads be placed on each test specimen main power supply output so that nominal current draws at nominal power supply output voltages are equal to the power supply rating. [[

]] Neither EPRI TR-107330 nor the industry EMI/RFI test standards to be used require the relay output points to be operating at rated currents during EMI/RFI Testing.

EPRI TR-107330, Section 6.2.1, requires that additional resistive loads be placed on each test specimen loop power supply output so that nominal current draws at nominal power supply output voltages are equal to the power supply rating. [[

]]

O.8 Test Levels

EMI/RFI Testing of the ***SPINLINE 3*** QTS will be performed inside a shielded (anechoic or semi-anechoic) test chamber. The following table summarizes the specific EMI/RFI emissions and susceptibility testing to be accomplished per USNRC RG 1.180, Rev. 1, and the specified test levels (frequency ranges) to be used. Test acceptance criteria, including applied susceptibility test levels (dBmV, %V, Vrms, A/m, and V/m) are listed in Section O.10 of this Appendix).

Test Type	Test Method	[[ ]]
Cond. Suscept., Common Mode Disturbs., Power/Signal Leads	IEC 61000-4-16	[[ ]]
Rad. Susceptibility, High Frequency, Antenna Exposure	MIL-STD 461-E, RS103	[[ ]]

[[ ]]

O.9 Performance Monitoring

EPRI TR-107330, Section 4.3.7, requires that the test specimen under qualification withstand the applied EMI/RFI susceptibility test levels.

Specifically, when subjected to the EMI/RFI test levels, the test specimen modules shall perform as follows:

a) The main processors and coprocessors shall continue to function.
b) The transfer of I/O data shall not be interrupted.
c) The emissions shall not cause the discrete I/O to change state.
d) Analog I/O levels shall not vary more than 3% (of full scale).

In addition, EPRI TR-107330 requires that a portion of the Operability and Prudency Tests be performed during the EMI/RFI testing.

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O.10 Acceptance Criteria

The following EMI/RFI Test acceptance criteria are based on Section 4.3.7 of EPRI TR 107330 and USNRC RG 1.180, Rev. 1.

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O.11 Documentation

The following records will be prepared by Rolls-Royce to document the results of EMI/RFI Testing:

1. EMI/RFI Testing Setup and Checkout Test Procedure (Completed with Attachments)
2. EMI/RFI Testing Procedure (Completed with Attachments)
3. Post RS103 [[ ]] GHz EMI/RFI Testing Operability Test Procedure (Completed with Attachments)
4. Post RS103 [[ ]] GHz EMI/RFI Testing Prudency Test Procedure (Completed with Attachments)
5. Post RS103 [[ ]] GHz EMI/RFI Testing Operability Test Procedure (Completed with Attachments)
6. Post RS103 [[ ]] GHz EMI/RFI Testing Prudency Test Procedure (Completed with Attachments)
7. Rolls-Royce EMI/RFI Test Report

The following record will be prepared by the test facility to document the results of EMI/RFI Testing:

1. Test Facility EMI/RFI Test Report