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Sous-ensemble *Subassembly*		
Classé 1E ou équiv. *Safety classification*	X	**1E**

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1 Purpose

This document provides a summary of the equipment qualification (EQ) testing performed in accordance with the EQ Test Plan (Reference 1) on the Rolls-Royce ***SPINLINE 3*** Qualification Test Specimen (QTS, Reference 2). The ***SPINLINE 3*** QTS includes all of the generic safety-related components of the Rolls-Royce ***SPINLINE 3*** digital safety instrumentation and control (I&C) platform described in the ***SPINLINE 3*** Licensing Topical Report (LTR, Reference 3). The generic ***SPINLINE 3*** platform is intended for use in mild environments as defined in the LTR and the EQ Test Plan.

This document is the summary report of EQ test results required by the U.S. Nuclear Regulatory Commission (NRC) Interim Staff Guide DI&C-ISG-06 (Reference 4), item 2.12, including the QTS factory acceptance test (FAT) results, which correspond to DI&C-ISG-06 items 2.5 and 2.6.

The test results reported herein define the as-tested EQ envelope within which the hardware and software of the generic ***SPINLINE 3*** digital safety I&C platform are expected to be able to perform intended safety functions without experiencing environmentally induced common-cause failures during normal environmental conditions and anticipated operational occurrences.

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

A	Ampere
AC	Alternating Current
AI	Analog Input
AIOTB	Analo Input Output Terminal Block
ANSI	American National Standards Institute
AO	Analog Output
ASOA	Application Software Objects Acceptance
C	Celsius
CFAS	Cooling Fan Assembly System
CFR	Code of Federal Regulations
DAS	Data Acquisition System
dB	Decibel
DC	Direct Current
DI	Digital Input
DITB	Digital Input Terminal Block
DO	Digital Output
EFT	Electrical Fast Transient
EMC	Electromagnetic Compatibility
EMI	Electromagnetic Interference
EPRI	Electric Power Research Institute
EQ	Equipment qualification
ESD	Electrostatic Discharge

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F	Fahrenheit
FAT	Factory Acceptance Test
g	Gravity
G1 to G5	Converters DC/DC located in the PS1 rack
GHz	Gigahertz
HCAS	Hubs and Converters Assembly System
hPa	Hectopascal
Hz	Hertz
HMI	Human-Machine Interface
I&C	Instrumentation and Control
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
ICTO	Count rate Interface Board
I/O	Input/Output
ISG	Interim Staff Guidance
ISO	International Standards Organization
kA	Kiloampere
kHz	Kilohertz
kV	Kilovolt
LDU	Local Display Unit
LTR	Licensing Topical Report
M	meter
M&TE	Measurement and Test Equipment
mA	Milliamp
MCL	Master Configuration List
MHz	Megahertz
MIL-STD	Military Standard
msec	Millisecond
mV	Millivolt
NCSL	National Conference of Standards Laboratories
NERVIA+ Daughter	UC25 N+ daughter board (constitutes the NERVIA+ network electronic part)
NET	Network
NIST	National Institute of Standards and Technology
NRC	Nuclear Regulatory Commission
NTS	National Technical Systems
OBE	Operating Basis Earthquake
PC	Personal Computer
PLC	Programmable Logic Controller
PS1	Power Supply rack type 1 (48VDC/24VDC)
PS2	Power Supply rack type 2 (120VAC/24VDC)
PSAS	Power Supply Assembly System
PSI	Pounds per Square Inch
PTVAS	Periodic Test and Vote Modules Assembly System
QA	Quality Assurance
QTS	Qualification Test Specimen
Rad	Radiation Absorbed Dose
RFI	Radio-Frequency Interference

RG	Regulatory Guide
RH	Relative Humidity
RTD	Resistance Temperature Detector
RMS	Root Mean Square
RO	Relay Output
Rolls-Royce	Rolls-Royce Civil Nuclear SAS (Société Anonyme Simplifié)
ROTB	Relay Output Terminal Block
RRS	Required Response Spectrum
SER	Safety Evaluation Report
S/N	Serial Number
SSE	Safe Shutdown Earthquake
Temp	Temperature
TP/FL	Copper link to Optical fiber link
TR	Technical Report
TSAP	Test Specimen Application Program
UC25 N+	Board that leads processing and control unit function
VI	Voltage Input
V	Volt
ZPA	Zero Period Acceleration
µV	Microvolt
16E.ANA ISO	Analog signals acquisition and analog to digital conversion board
32ACT	Actuator Drive Board
32ETOR	Digital Input isolated acquisition board

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3 Scope of EQ Testing

The EQ testing of the ***SPINLINE 3*** QTS was performed in accordance with the requirements of Regulatory Guide (RG) 1.89 (Reference 5) and requirements of Institute of Electrical and Electronics Engineers (IEEE) Standard 323-2003 (Reference 6). This standard is subject to the enhancements and exceptions listed in Section C, "Regulatory Position" of RG 1.209 (Reference 7).

The environmental qualification testing of the ***SPINLINE 3*** QTS also was performed in accordance with the requirements for qualifying digital computers in IEEE Standard 7-4.3.2-2003 (Reference 8) and RG 1.152, Revision 3 (Reference 9).

Electric Power Research Institute (EPRI) Technical Report TR-107330 (Reference 10) describes an approach for generically qualifying commercial Programmable Logic Controllers (PLCs) for safety-related applications. This approach was found acceptable by the NRC as documented in its Safety Evaluation Report (SER) Letter dated July 30, 1998 to Mr. J. Naser of the EPRI (Reference 11). The generic hardware qualification testing approach described in the EQ Plan uses guidance from EPRI TR-107330 as applicable to meet the requirements of IEEE Standard 323-2003 and other NRC guidance.

RG 1.180, Revision 1 (Reference 12) describes methods acceptable to the NRC 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 I&C systems. The qualification testing approach described in the EQ Plan uses guidance from RG 1.180, Revision 1 as applicable to meet the requirements of IEEE Standard 323-2003.

RG 1.100, Revision 2 (Reference 13) states that the procedures described in IEEE Standard 344-1987 (Reference 14) are acceptable to the NRC 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 the EQ Plan uses guidance from EPRI TR-107330 to meet the requirements of RG 1.100 and IEEE Standard 344-1987.

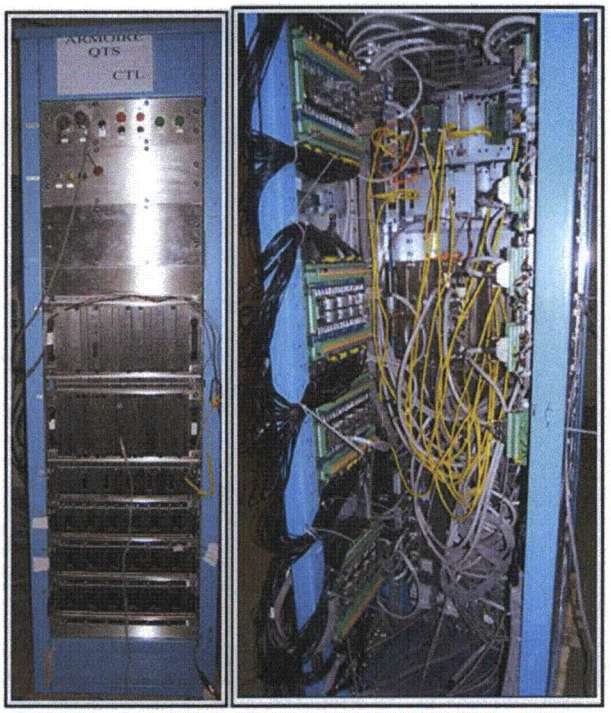
The EQ Plan appendices are the test design specifications for EQ testing required by DI&C-ISG-06, Item 2.4.

4 Equipment Tested

The equipment under test was known as the ***SPINLINE 3*** QTS. In accordance with EPRI TR-107330, the equipment tested included a representative sample of the ***SPINLINE 3*** platform components. The QTS was comprised of the following types of hardware modules and components:

- Chassis (PU1and PU2)
- Power Supply Modules (PS1, PS2/1 to PS2/3)
- Digital Processing Modules (PTVAS)
- Communication Modules (HCAS)
- Signal Input Modules
- Signal Output Modules
- Signal Conditioning Modules
- Terminal Blocks (DITB, AIOTB and ROTB)
- Cable and Wire Sets
- Fan Cooling Hardware (CFAS)
- Power Distribution Hardware (PSAS)

A detailed description of the ***SPINLINE 3*** QTS is provided in the document, "System Specification for the Qualification Test Specimen and Data Acquisition System". Test specimen and test system arrangement and wiring drawings (References 15 to 18) provide additional hardware configuration information. The Master Configuration List (MCL, Reference 19) provides detailed ***SPINLINE 3*** QTS configuration information such as component serial numbers and software version numbers. The QTS is shown in Figure 1.



QTS (front view) **QTS (rear view)**

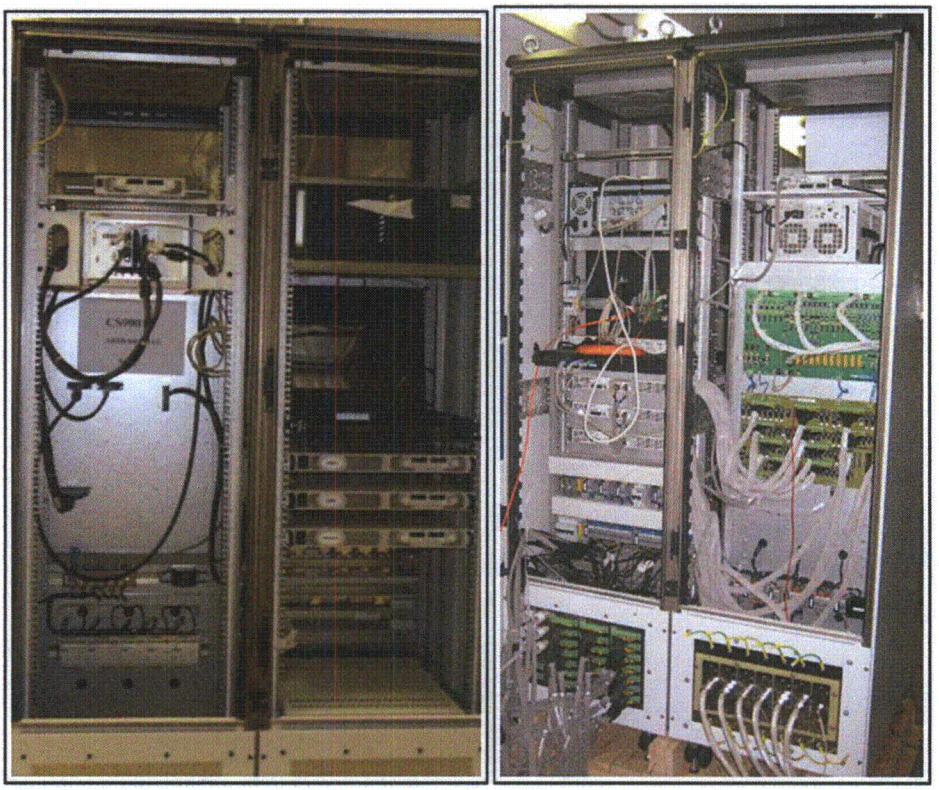
Figure 1: Qualification Test Specimen

5 Test System

The QTS was exercised during qualification testing by a test system comprised of an industrial-grade data acquisition system (DAS) and a test specimen application program (TSAP), both of which are described in the "System Specification for the Qualification Test Specimen and Data Acquisition System". This test system is a non-qualified system whose sole purposes were 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 demonstrate the predictable behavior of ***SPINLINE 3*** hardware during normal and abnormal plant operating conditions. The DAS is shown in Figure 2.

The DAS is composed of the following equipment:

- • A cabinet, with terminal blocks
- • Power supplies
- • Hubs and Fiber optic converter
- • Conditioning boards, which provide protection to digital and analog inputs
- • the DAS-PC,
- • the DAS-RT (Real Time), including a PXI (PCI bus eXtended for Instrumentation) system



DAS (front view) **DAS (Rear view)**

Figure 2: Data Acquisition System

6 Test Requirements and Acceptance Criteria

As discussed in Section 3, the generic hardware qualification testing approach defined in the EQ Plan used guidance from EPRI TR-107330 to meet the requirements of IEEE Standard 323-2003, IEEE Standard 7-4.3.2-2003, and other NRC guidance applicable to qualifying safety-related digital I&C systems intended for installation in a mild plant environment.

The basic test acceptance criteria applied to the ***SPINLINE 3*** QTS are the following:

- The ***SPINLINE 3*** QTS will continue to function correctly during and/or after exposure to abnormal environmental conditions (incident gamma radiation, temperature, and humidity).
- The ***SPINLINE 3*** QTS will continue to function correctly during and after exposure to Operating Basis Earthquake (OBE) and Safe Shutdown Earthquake (SSE) seismic events.
- The ***SPINLINE 3*** QTS will continue to function correctly during and after exposure to EMI/RFI, voltage surges, electrical fast transients, and electrostatic discharges.
- The ***SPINLINE 3*** QTS will continue to function correctly during and after exposure to electrical faults applied to selected external interface points.

Correct functioning of the ***SPINLINE 3*** QTS during normal and abnormal plant operating conditions was determined by the behavior or the performance of operational parameters identified in the respective test procedures. Correct functioning 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 (I/O) 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 Plan and Test Procedures

The EQ Plan defines the qualification testing program for the generic ***SPINLINE 3*** digital safety I&C platform. As listed in Table 7-1, Appendices A through M of the EQ Plan are the detailed Test Plans for each of the tests performed on the ***SPINLINE 3*** QTS. These individual Test Plans constitute the qualification test design specifications required by DI&C-ISG-06, Item 2.4.

Table 7-1. *SPINLINE 3* EQ Test Plans

EQ Test Plan	Reference 1 Appendix
Factory Acceptance Test Plan	Appendix A
Pre-qualification Acceptance Test Plan	Appendix B
Radiation Exposure Test Plan	Appendix C
Environmental Test Plan	Appendix D
Seismic Test Plan	Appendix E
EMI / RFI Test Plan	Appendix F
Electrical Fast Transient Test Plan	Appendix G
Surge Withstand Test Plan	Appendix H
Electrostatic Discharge Test Plan	Appendix I
Class 1E to Non-Class 1E Isolation Plan	Appendix J
System Setup and Checkout Test Plan	Appendix K
Operability Test Plan	Appendix L
Prudency Test Plan	Appendix M

Each individual Test Plan addresses the specific test approach, equipment tested, sequence of testing, test procedures, test specimen mounting, service conditions, test levels, performance monitoring, acceptance criteria and documentation. The Test Plans provide references to the specific qualification test requirements and guidance obtained from IEEE Standard 323-2003 , IEEE Standard 344-1987, IEEE Standard 7-4.3.2-2003, EPRI TR-107330, RG 1.100 Revision 2, RG 1.152 Revision 3, RG 1.180 Revision 1, and RG 1.209.

The Test Plans are implemented by the following set of test procedures that are executed as defined in the Test Plans.

Table 7-2. *SPINLINE 3* EQ Test Procedures

EQ Test Procedures	Document #	Reference
Factory Acceptance Test Procedure and Report	3 010 783 B	20
System Setup and Checkout Test Procedure	3 010 294 C	21
Radiation Exposure Test Procedure	3 010 286 C	22
Environmental Test Procedure	3 010 287 C	23
Seismic Test Procedure	3 010 288 C	24
EMI / RFI Test Procedure	3 010 289 A	25
Electrical Fast Transient Test Procedure	3 010 290 B	26
Surge Withstand Test Procedure	3 010 291 A	27
Electrostatic Discharge Test Procedure	3 010 292 A	28
Class 1E to Non-Class 1E Isolation Test Procedure	3 010 293 A	29
Operability Test Procedure	3 010 295 C	30
Prudency Test Procedure	3 010 296 B	31

These test procedures are the detailed qualification test methodologies required by DI&C-ISG-06, Item 2.11. The completed test procedures are the "completed test procedures and reports" required by DI&C-ISG-06, Item 3.5.

8 Test Responsibilities

Rolls-Royce is both the manufacturer and the qualifier of the generic ***SPINLINE 3*** platform, as those terms are defined in Section 1.3 of EPRI TR-107330.

In Section 7.2 of EPRI TR-107330, there is a requirement that generic qualification activities shall be performed under a 10 CFR Part 50 Appendix B (Reference 32) compliant Quality Assurance (QA) Program. The qualification testing and analyses activities summarized in this report were performed in accordance with the Rolls-Royce Quality Manual (Reference 33), which defines a nuclear quality program that is in compliance with 10 CFR Part 50 Appendix B. Procurement, receipt and acceptance of the test laboratory services was done in accordance with Rolls-Royce quality procedures for procurement, receipt and acceptance of nuclear grade services, including preparation of a services procurement specification.

Rolls-Royce subcontracted with the test laboratory NTS (National Technical Systems) located in Acton, Massachusetts to provide qualification testing services in 2011. Laboratory testing services were performed in accordance with the Rolls-Royce procurement specification, which invoked the NTS QA Program, which is in compliance with 10 CFR Part 50 Appendix B. Rolls-Royce subcontracted with Wyle laboratory located in Huntsville, Alabama to provide qualification testing services in 2010. Laboratory testing services were performed in accordance with the Rolls-Royce procurement specification, which invoked the Wyle QA Program, which is in compliance with 10 CFR Part 50 Appendix B.

Appendices A through K of this report 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.

9 Test Control

Rolls-Royce personnel were present to perform test setup and oversee all hardware qualification testing performed by the test laboratory. Rolls-Royce activities were performed according to the quality procedures for test control. All testing activities performed by Rolls-Royce and the test laboratory were accomplished according to Rolls-Royce test procedures.

Rolls-Royce completed the procedures, recorded any deviation relating to the sequence of testing, the test specimen mounting, service conditions, test levels, test results and any exception, deficiency or field change which occurred during these tests. The results are summarized in the following appendixes A to K.

It should be noted that the laboratory reports are not all yet available, and the consequence is that some slight changes may have to be brought in the future, to assertions regarding, for example, the laboratory test specimen mounting or the exact levels applied. Any such changes should not change the results presented here.

All test exceptions, deficiencies, and field changes resulting from discrepancies or deficiencies in test documentation or unacceptable test specimen hardware or software performance during qualification testing are identified in Appendices A through K of this summary report and are being processed in accordance with Rolls-Royce quality procedures.

10 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 were calibrated to the requirements of American National Standards Institute / National Conference of Standards Laboratories (ANSI/NCSL) Z540-1 (Reference 34) and/or International Standards Organization (ISO) 10012-1 (Reference 35). Standards used for calibration were traceable to the National Institute of Standards and Technology (NIST).

Rolls-Royce provided all required M&TE for simulating inputs to and monitoring performance of the test specimen during hardware qualification testing. Calibration of this equipment was done by Rolls-Royce approved suppliers.

NTS provided 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 specified, procured, and programmed a software based data acquisition system for use during pre-qualification and qualification testing. The data acquisition system was calibrated for use in the qualification project. Calibration was performed by a Rolls-Royce approved supplier.

11 Test Schedule

The originally planned sequence of testing is defined in Figure 1 of the EQ Plan. The actual testing sequence is summarized in Table 11-1. The basis for making changes to the original test sequence is included as comments in Table 11-1.

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Table 11-1: Sequence of *SPINLINE 3* EQ Testing

Originally-Planned Test Sequence		Actual Test Sequence		Test Start Date	Test End Date	Comments
FACTORY ACCEPTANCE TESTING						
1	Test Specimen and Test System Factory Acceptance Testing, including Operability and Prudency Testing			03/10/10	04/20/10	
PRE-QUALIFICATION ACCEPTANCE TESTING						
2	Pre-Qualification Testing System Setup and Checkout Testing			04/21/10	04/21/10	
3	Pre-Qualification Testing Operability Testing			04/22/10	04/27/10	
4	Pre-Qualification Testing Prudency Testing			04/26/10	04/26/10	
QUALIFICATION TESTING						
5	Radiation Exposure Withstand Testing		Group 1 (2010 campaign)	05/19/10	05/19/10	QTS parts
			Group 2 (2011 campaign)	03/17/11	03/22/11	Spare parts
6	Environmental Testing System Setup and Checkout Testing		(2010 campaign)	06/05/2010	06/07/2010	
			(2011 campaign)	03/27/11	03/28/11	
7	Post-Radiation Exposure Testing Operability Testing		(2010 campaign)	06/07/2010	06/09/2010	
			(2011 campaign)	03/29/11	03/30/11	
8	Post-Radiation Exposure Prudency Testing		(2010 campaign)	06/09/2010	06/09/2010	
			(2011 campaign)	03/30/11	03/30/11	
9	Environmental Testing		(2010 campaign)	06/11/2010	06/13/2010	
			(2011 campaign)	03/29/11	04/07/11	
10	Operability Testing at High Temperature (Temp)/Relative Humidity (RH), Low Temp/RH and Ambient Temp/RH			04/03/11	04/07/11	
11	Prudency Testing at High Temp/RH			04/03/11	04/03/11	
12	Seismic Testing System Setup and Checkout Testing		First Stage	04/18/11	04/27/11	Configuration 1 and 2
13	Seismic Testing		First Stage	04/18/11	05/03/11	Configuration 1 and 2
			Second Stage	06/21/11	06/23/11	Configuration 1

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Originally-Planned Test Sequence		Actual Test Sequence		Test Start Date	Test End Date	Comments
14	Post Seismic Operability Testing			05/02/11	05/03/11	Note: For the second Stage the Performance Proof Tests series was used.
15	Post Seismic Prudency Testing			05/03/11	05/03/11	Note: For the second Stage the Performance Proof Tests series was used.
16	EMI/RFI Testing System Setup and Checkout Testing			05/09/11	05/09/11	
17	EMI/RFI Emissions Testing			05/19/11	05/23/11	
18	EMI/RFI Susceptibility Testing			05/13/11	06/14/11	
19	Electrical Fast Transient Testing			05/12/11	05/13/11	
20	Surge Withstand Testing			06/07/11	06/10/11	
21	Electrostatic Discharge Testing			05/10/11	05/11/11	
22	Class 1E to Non-1E Isolation Testing			06/15/11	06/23/11	
	Post EMC Operability Testing			06/16/11	06/17/11	Note: Added based on addition of second stage seismic test.
	Post EMC Prudency Testing			06/17/11	06/17/11	Note: Added based on addition of second stage seismic test.
PERFORMANCE PROOF TESTING						
23	Performance Proof Testing System Setup and Checkout Testing			06/24/11	06/24/11	
24	Performance Proof Testing Operability Testing			06/24/11	06/24/11	
25	Performance Proof Testing Prudency Testing			06/24/11	06/24/11	

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12 Test Documentation

This document is the summary report of EQ test results required by the NRC Interim Staff Guide DI&C-ISG-06, item 2.12, including the QTS FAT results associated with DI&C-ISG-06 items 2.5 and 2.6.

Appendices A through K of this summary report provide a synopsis of each test and identify the supporting documentation that serves as the detailed record of the qualification testing and analysis of the ***SPINLINE 3*** QTS.

The Test Summaries describe the results obtained from the implementation of the test procedures that were executed in accordance with the Test Plans.

The following terminology is used in the Appendices to describe the results of the qualification testing:

- **Passed** – Test acceptance criteria were met and no events encountered during testing.
- **Satisfactory** – Test acceptance criteria were met. However; some events encountered were encountered during testing that did not affect qualification.
- **Unsatisfactory** – Some test acceptance criteria were not met and required additional technical evaluation or analysis to demonstrate qualification.
- **Failed** - Some test acceptance criteria were not met and additional testing will be required to demonstrate qualification.

13 As-tested Equipment Qualification Envelope

Successful execution of the EQ tests defined in the Test Plans is intended to qualify the generic ***SPINLINE 3*** digital safety I&C platform for a qualification envelope substantiated by the actual test levels. The as-tested equipment qualification envelope is summarized in Table 13-1.

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Table 13-1. As-tested Generic Qualification Envelope for the *SPINLINE 3* Digital Safety I&C Platform

Equipment Qualification Category	EQ Plan Appendix	Regulatory Requirements	Source of Qualification Test Specification	As-tested Qualification Envelope	Qualification Test Acceptance Criteria
Radiation Exposure	Appendix C	RG 1.89 and IEEE Standard 323-2003	Section 4.3.6 of EPRI TR-107330	[[ ]]	Section 4.3.6 of EPRI TR-107330
Environmental (Temperature & Humidity)	Appendix D	RG 1.89 and IEEE 323, subject to enhancements and exceptions listed in Section C of RG 1.209.	Section 4.3.6 of EPRI TR-107330, modified	[[ ]]	Section 4.3.6 of EPRI TR-107330
Seismic	Appendix E	RG 1.100 and IEEE Standard 344	Section 4.3.9 of EPRI TR-107330. 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.	[[ ]]	Section 4.3.9 of EPRI TR-107330.
				[[ ]]	
				[[ ]]	
EMI/RFI	Appendix F	RG 1.180, Revision 1	**EMI/RFI Emissions Tests**		
			MIL-461E, CE101 (Reference 38): Conducted Emissions, Low Frequency, AC and DC Power Leads	[[ ]]	Section 4.3.7 of EPRI TR-107330 and RG 1.180, Revision 1 Emission limit: RG 1.180, Revision 1: Figure 3-1
			MIL-461E, CE102 (Reference 38): Conducted Emissions, High Frequency, AC and DC Power Leads	[[ ]]	Section 4.3.7 of EPRI TR-107330 and RG 1.180, Revision 1 Emission limit: RG 1.180, Revision 1: Figure 3-2
			MIL-461E, RE101 (Reference 38): Radiated Emissions, Magnetic Field, QTS Surfaces and Leads	[[ ]]	Section 4.3.7 of EPRI TR-107330 and RG 1.180, Revision 1 Emission limit: RG 1.180, Revision 1: Figure 3-3
			MIL-461E, RE102 (Reference 38): Radiated Emissions, Electric Field,	[[ ]]	Section 4.3.7 of EPRI TR-107330 and RG 1.180, Revision 1

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Table 13-1. As-tested Generic Qualification Envelope for the *SPINLINE 3* Digital Safety I&C Platform					
Equipment Qualification Category	**EQ Plan Appendix**	**Regulatory Requirements**	**Source of Qualification Test Specification**	**As-tested Qualification Envelope**	**Qualification Test Acceptance Criteria**
			Antenna Measurement		Emission limit: RG 1.180, Revision 1: Figure 3-4
			EMI/RFI Susceptibility Tests		
			IEC 61000-4-6 (Reference 39): Conducted Susceptibility, Induced RF Fields, Power/Signal Leads	[[ ]]	Section 4.3.7 of EPRI TR-107330 and RG 1.180, Revision 1 Susceptibility test level - power leads: 140 dBµV
					Section 4.3.7 of EPRI TR-107330 and RG 1.180, Revision 1 Susceptibility test level - signal leads: 130 dBµV
			IEC 61000-4-13 (Reference 40): Conducted Susceptibility, Harmonics/Interharmonics, Power Leads	[[ ]]	Section 4.3.7 of EPRI TR-107330 and RG 1.180, Revision 1 Susceptibility test level: RG 1.180: Table 10
			IEC 61000-4-16 (Reference 41): Conducted Susceptibility, Common Mode Disturbance, Power/Signal Leads	[[	Section 4.3.7 of EPRI TR-107330 and RG 1.180, Revision 1 Susceptibility test level - power leads: RG 1.180: Table 11
				]]	Section 4.3.7 of EPRI TR-107330 and RG 1.180, Revision 1 Susceptibility test level - signal leads: RG 1.180: Table 15
			IEC 61000-4-8 (Reference 42): Radiated Susceptibility, Magnetic Field, Helmholtz Coil Exposure	[[ ]]	Section 4.3.7 of EPRI TR-107330 and RG 1.180, Revision 1 Susceptibility test level - continuous: 30 A/m
					Section 4.3.7 of EPRI TR-107330 and RG 1.180, Revision 1 Susceptibility test level - short

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Table 13-1. As-tested Generic Qualification Envelope for the *SPINLINE 3* Digital Safety I&C Platform					
Equipment Qualification Category	**EQ Plan Appendix**	**Regulatory Requirements**	**Source of Qualification Test Specification**	**As-tested Qualification Envelope**	**Qualification Test Acceptance Criteria**
					duration: 300 A/m
			IEC 61000-4-9 (Reference 43): Radiated Susceptibility, Magnetic Field, Pulsed	[[ ]]	Section 4.3.7 of EPRI TR-107330 and RG 1.180, Revision 1 Susceptibility test level: 300 A/m
			IEC 61000-4-10 (Reference 44): Radiated Susceptibility, Magnetic Field, Damped Oscillatory	[[ ]]	Section 4.3.7 of EPRI TR-107330 and RG 1.180, Revision 1 Susceptibility test level: 30 A/m
			IEC 61000-4-3 (Reference 45): Radiated Susceptibility, High Frequency, Antenna Exposure	[[ ]]	Section 4.3.7 of EPRI TR-107330 and RG 1.180, Revision 1 Susceptibility test level: 10 V/m
Electrical Fast Transient (EFT)	Appendix G	RG 1.180, Revision 1	IEC 61000-4-4, "Electromagnetic Compatibility (EMC), Part 4-4: Testing and Measurement Techniques, Electrical Fast Transient/Burst Immunity Test," (Reference 47)	[[ ]] [[ ]]	Sections 4.6.2 and 4.3.7 of EPRI TR-107330 and RG 1.180, Revision 1
Surge Withstand	Appendix H	RG 1.180, Revision 1	Table 22 of RG 1.180, Revision 1 defines the IEC 61000-4-12 Ring Wave and IEC 61000 4-5 Combination Wave surge withstand levels for power supplies	[[	Section 4.6.2 of EPRI TR-107330 and RG 1.180, Revision 1.

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Table 13-1. As-tested Generic Qualification Envelope for the *SPINLINE 3* Digital Safety I&C Platform					
Equipment Qualification Category	**EQ Plan Appendix**	**Regulatory Requirements**	**Source of Qualification Test Specification**	**As-tested Qualification Envelope**	**Qualification Test Acceptance Criteria**
			installed in Category B locations with surge waveform Low Exposure levels		
			Table 15 of RG 1.180, Revision 1 defines the IEC 61000-4-12 Ring Wave and IEC 61000 4-5 Combination Wave 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," (Reference 48)	[[	
			IEC 61000-4-12, "Electromagnetic Compatibility (EMC), Part 4-12: Testing and Measurement Techniques, Oscillatory Waves Immunity Test," (Reference 49).	]]	
Electrostatic Discharge (ESD)	Appendix I	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, Revision 1 (Reference 37). RG 1.180, Revision 1 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" (Reference 50).	[[ ]]	Sections 4.3.8 of EPRI TR-107330
Class 1E to Non-Class 1E Isolation	Appendix J	IEEE Standard 384 (Reference 51). EPRI TR-107330, Section 6.3.6, requires that the test specimen under qualification be tested for Class 1E to non-Class 1E isolation capability in	Sections 4.6.4 of EPRI TR-107330	[[ ]]	Sections 4.6.4 of EPRI TR-107330

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Table 13-1. As-tested Generic Qualification Envelope for the *SPINLINE 3* Digital Safety I&C Platform					
Equipment Qualification Category	**EQ Plan Appendix**	**Regulatory Requirements**	**Source of Qualification Test Specification**	**As-tested Qualification Envelope**	**Qualification Test Acceptance Criteria**
		accordance with the requirements of EPRI TR-107330, Section 4.6.4		[[ ]]	

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14 References

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5. Regulatory Guide 1.89, "Environmental Qualification of Certain Electric Equipment Important to Safety for Nuclear Power Plants", June 1984
6. IEEE Standard 323-2003, "Standard for Qualifying Class 1E Equipment for Nuclear Power Generating Stations," Institute of Electrical and Electronics Engineers
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11. NRC Letter dated July 30, 1998 to Mr. J. Naser (EPRI), "Safety Evaluation by the Office of Nuclear Reactor Regulation Electric Power Research Institute Topical Report, TR-107330, Final Report, "Generic Requirements Specification for Qualifying a Commercially Available PLC for Safety-Related Applications in Nuclear Power Plants".
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13. Regulatory Guide 1.100, Revision 2, "Seismic Qualification of Electric and Mechanical Equipment for Nuclear Power Plants", June 1988
14. IEEE Standard 344-1987 "Recommended Practice for Seismic Qualification of Class 1E Equipment for Nuclear Power Generating Stations," Institute of Electrical and Electronics Engineers
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17. Equipment Mounting Details for Seismic Testing, 3 009 634 C, Rolls-Royce
18. Interconnection of Qualification Test Specimen and Data Acquisition System, 3 010 520 E, Rolls-Royce
19. QTS Master Configuration List, 3 010 612 F, Rolls-Royce, June 2010
20. Factory Acceptance Test Procedure and Report, 3 010 783 B Rolls-Royce
21. System Setup and Checkout Test Procedure, 3 010 294 C, Rolls-Royce
22. Radiation Exposure Test Procedure, 3 010 286 C, Rolls-Royce
23. Environmental Test Procedure, 3 010 287 C, Rolls-Royce
24. Seismic Test Procedure, 3 010 288 C, Rolls-Royce
25. EMI / RFI Test Procedure, 3 010 289 A, Rolls-Royce
26. Electrical Fast Transient Test Procedure, 3 010 290 B, Rolls-Royce
27. Surge Withstand Test Procedure, 3 010 291, A Rolls-Royce
28. Electrostatic Discharge Test Procedure, 3 010 292 A, Rolls-Royce

29. Class 1E to Non-Class 1E Isolation Test Procedure, 3 010 293 A, Rolls-Royce
30. Operability Test Procedure, 3 010 295 C, Rolls-Royce
31. Prudency Test Procedure, 3 010 296 B, Rolls-Royce
32. Title 10 to the Code of Federal Regulation, Part 50, Appendix B, "Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants".
33. "Rolls-Royce Civil Nuclear SAS Quality Manual", Document No. 8 303 186 Revision P.
34. ANSI / NCSL Z540.1-1994 (R2002) - Calibration & Measurement & Test Equipment - General Requirements, American National Standards Institute,
35. ISO 10012-1-1992: Quality Assurance Requirements for Measuring Equipment, International Organization for Standardization
36. EPRI TR-100516, "Nuclear Power Plant Equipment Qualification Reference Manual", 1992.
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39. IEC 61000-4-6, "Testing and Measurement Techniques, Immunity to Conducted Disturbances Induced by Radio-Frequency Fields," May 2006.
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42. IEC 61000-4-8, "Testing and Measurement Techniques, Power Frequency Magnetic Field Immunity Test," March 2001.
43. IEC 61000-4-9, "Testing and Measurement Techniques, Pulse Magnetic Field Immunity Test," March 2001.
44. IEC 61000-4-10, "Testing and Measurement Techniques, Damped Oscillatory Magnetic Field Immunity Test," March 2001.
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46. IEEE Standard 1050-1989, "Guide for Instrumentation and Control Equipment Grounding in Generating Stations."
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48. IEC 61000-4-5, "Testing and Measurement Techniques, Section 5: Surge Immunity Test," November 2005.
49. IEC 61000-4-12, "Testing and Measurement Techniques, Section 12: Oscillatory Waves Immunity Tests," September 2006.
50. IEC 61000-4-2, "Testing and Measurement Techniques, Section 2: Electrostatic Discharge Immunity Test," April 2001.
51. IEEE Standard 384-1981, "Standard Criteria for Independence of Class 1E Equipment and Circuits."

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Appendix A: Factory Acceptance Test Summary

A.1 Purpose

This test summary describes the FAT of the ***SPINLINE 3*** QTS and Test System and presents the results of this test.

A.2 Objective

FAT was 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".

A.3 Equipment Tested

The equipment tested were the ***SPINLINE 3*** QTS (hardware and software) and the Test System. The MCL identifies the specific hardware and firmware items that are part of the QTS.

A.4 Sequence of Testing

The FAT is the first test performed on the QTS and Test System. The FAT was performed at the Rolls-Royce facilities in Grenoble, France.

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A.5 Procedures

The applicable test procedure is, "Factory Acceptance Test Procedure and Report", which includes instructions and checklists for performing the following tests:

1. Perform the system startup tests
   a. Power startup of DAS hardware test
   b. Power startup of QTS hardware test
   c. Inputs / Outputs Addressing Tests (to confirm the correct interface between DAS and QTS hardwired inputs / outputs)
2. Perform FAT functional tests
   a. Perform system setup and checkout tests
   b. Perform the Operability Test, including
      i. Analog Input And Output Accuracy Test
      ii. Response Time Test
      iii. Discrete Input Operation Tests
      iv. Discrete Output Operation Test
      v. Timer Function Accuracy Test
      vi. Failover Performance Test
      vii. Loss of Power Performance Test
      viii. Power Interrupt Performance Test
      ix. Power Quality Tolerance Test
   c. Perform the Prudency Test
   d. Perform environmental mode test
   e. Perform seismic mode test
   f. Perform hardware failure tests (from the normal state configuration, a hardware failure is generated manually. The verification of the correct detection and reporting is made via the HMI of the DAS)

A.6 Test Specimen Mounting

The ***SPINLINE 3*** QTS was mounted in open mounting frames for the FAT. The configuration of the ***SPINLINE 3*** QTS components and interconnecting cabling was similar to the configuration if the hardware were installed in a cabinet. The QTS cooling fans were installed on the open mounting frames and provided cooling to the other ***SPINLINE 3*** QTS components.

A.7 Service Conditions

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A.8 Test Results

The test results are reported in the completed copy of the "Factory Acceptance Test Procedure and Report" and are summarized below.

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Appendix B: Pre-Qualification Acceptance Test Summary

B.1 Purpose

This test summary describes the Pre-Qualification Acceptance Testing of the Rolls-Royce ***SPINLINE 3*** QTS and presents the results of this test. Pre Qualification Acceptance Testing of the ***SPINLINE 3*** QTS was performed as part of qualification testing to demonstrate compliance with the applicable Pre-Qualification Acceptance Tests requirements of EPRI TR-107330, Section 5.2.

B.2 Objective

The Pre-Qualification Acceptance Testing was performed to demonstrate that the ***SPINLINE 3*** QTS hardware and the TSAP operated 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 Tested

The MCL documents the ***SPINLINE 3*** QTS hardware and firmware that was tested.

B.4 Sequence of Testing

Pre-Qualification Acceptance Testing was performed after FAT of the ***SPINLINE 3*** QTS and Test System, and prior to the start of the qualification testing. The Pre-Qualification Acceptance Testing was performed at the Rolls-Royce facilities in Grenoble, France. 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.

The sequence of testing did not include Application Software Objects Acceptance (ASOA) Testing, as listed in Section 5.2.A of EPRI TR-107330. As described in LTR, Section 6.2.9, the generic ***SPINLINE 3*** platform software includes an application-oriented library of re-usable software components that has been subject to verification and validation and is available for use in developing future application software for ***SPINLINE 3*** plant-specific systems. The equipment qualification testing program was not intended to qualify application software.

The sequence of testing did 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 sufficient 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.

B.5 Procedures

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

a) System Setup and Checkout Test Procedure: Through this procedure, initial ***SPINLINE 3*** QTS calibration was addressed and the correct operation of the ***SPINLINE 3*** QTS and test system was verified.

b) Operability Test Procedure: This procedure includes a series of tests defined in Section 5.3 of EPRI TR-107330 that verified 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 established 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 included a series of tests defined in Section 5.4 of EPRI TR-107330 that verified 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 established baseline performance of the ***SPINLINE 3*** QTS for use in performance of the Prudency Test Procedure throughout qualification testing.

All procedures above include instructions and checklists for performing the Pre-Qualification Acceptance Test as follows:

a. Perform system setup and checkout tests
b. Perform the Operability Test , including
    i. Analog Input And Output Accuracy Test
    ii. Response Time Test
    iii. Discrete Input Operation Tests
    iv. Discrete Output Operation Test
    v. Timer Function Accuracy Test
    vi. Failover Performance Test
    vii. Loss of Power Performance Test
    viii. Power Interrupt Performance Test
    ix. Power Quality Tolerance Test
c. Perform the Prudency Test

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 was mounted in open mounting frame(s) for Pre-Qualification Acceptance Testing. The configuration of the ***SPINLINE 3*** QTS components and interconnecting cabling is similar to expected in-cabinet applications. The test specimen cooling fans were installed on the open mounting frames and operated in such a manner that they provided 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 was powered with the I/Os operating under control of the TSAP and the connected test system simulation devices.

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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 were maintained within the normal operating range of the ***SPINLINE 3*** QTS.

EPRI TR-107330 provides no requirements or guidance for configuration of the test PLC power supply sources during Pre-Qualification Acceptance Testing. [[

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B.8 Test Levels

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

B.11 Documentation

The following records were 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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B.12Test Results

The test results are reported in the completed copies of the following procedures:

- the "System Setup and Checkout Test Procedure"
- the "Operability Test Procedure"
- the "Prudency Test Procedure"

The results are summarized below.

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Appendix C: Radiation Exposure Withstand Test Summary

C.1 Purpose

This test summary describes the Radiation Exposure Withstand Testing of the Rolls-Royce ***SPINLINE 3*** QTS. Radiation Exposure Withstand Testing of the QTS was performed as part of qualification testing to demonstrate compliance with the applicable environmental requirements of EPRI TR-107330, Section 4.3.6.

C.2 Objective

The objective of Radiation Exposure Withstand Testing was to demonstrate the ***SPINLINE 3*** QTS did not experience failures or unacceptable degradation due to expected radiation exposure arising from normal and abnormal service conditions as required by RG 1.89 and IEEE 323-2003. 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). [[

]]

C.3 Equipment tested

The MCL documents the ***SPINLINE 3*** QTS hardware and firmware that was tested.

C.4 Sequence of Testing

As stated in Table 11-1, Radiation Exposure Withstand Testing was performed in two groups after completion of the Pre-Qualification Testing Baseline Operability and Prudency Test runs. The QTS was irradiated in one group and the spare parts were irradiated in a second group. The test for the first group was performed by Wyle and the Southwest Research Institute in San Antonio, Texas.

The test for the second group was performed by NTS and University of Massachusetts Lowell Radiation Laboratory in Lowell, Massachusetts.

C.5 Procedures

The following procedure was used during Radiation Exposure Withstand Testing:

a) Radiation Exposure Withstand Test Procedure: Through this procedure, the ***SPINLINE 3*** QTS was configured in the test chamber for irradiation, and the condition of the ***SPINLINE 3*** QTS was determined on completion of testing.
This procedure has been performed two times: one for ***SPINLINE 3*** QTS components and another one for ***SPINLINE 3*** QTS spare parts.

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C.6 Test Specimen Mounting

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

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C.7 Service Conditions

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

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

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C.8 Test Levels

As stated in Section 4.1 of EPRI TR-107330, the normal and abnormal environmental radiation exposure levels (1000 Rads) 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 (Reference 36), provides a basis for the specified 1000 Rads radiation exposure level. Section 6.3 further defines the 1000 Rads exposure as the gamma 40-year dose from normal/abnormal service (related to approximately 2.9 millirems per hour).

RG 1.209 identifies that one significant difference between digital and analog equipment is the radiation tolerance. The radiation exposure level (1000 Rads) as required in EPRI TR-107330 is compliant with the sensitivity of digital equipment as discussed in section B of RG 1.209.

IEEE Standard 323-2003 imposes an additional margin of 10% on the qualification test level.

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C.9 Performance Monitoring

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

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]] Also, the ***SPINLINE 3*** QTS was visually inspected for exterior damage or degradation following Radiation Exposure Withstand Testing.

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C.10 Acceptance Criteria

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

a) The ***SPINLINE 3*** QTS components and ***SPINLINE 3*** QTS spare parts 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. Subsequently, this criteria shall be met by all spare parts which are used to replace any ***SPINLINE 3*** QTS components

C.11 Documentation

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

1. Two Radiation Exposure Withstand Test Procedures (Completed with Attachments): One filled during the first campaign in 2010 (***SPINLINE 3*** QTS components and additional components) and another one for the second campaign in 2011 (***SPINLINE 3*** QTS spare parts)
2. Two Post Radiation Exposure Withstand Testing Operability Test Procedures (Completed with Attachments): One was performed after subjecting ***SPINLINE 3*** QTS components and additional components to the Radiation Exposure and another one was performed after subjecting ***SPINLINE 3*** QTS spare parts to the Radiation Exposure.
3. Two Post Radiation Exposure Withstand Testing Prudency Test Procedures (Completed with Attachments): One was performed after subjecting ***SPINLINE 3*** QTS components and additional components to the Radiation Exposure and another one was performed after subjecting ***SPINLINE 3*** QTS spare parts to the Radiation Exposure.
4. Two Rolls-Royce Radiation Exposure Withstand Test Reports: One linked to the campaign 2010 and another one linked to the campaign 2011.

The following records were prepared by NTS to document the results of Radiation Exposure Withstand Testing:

1. Test Facility Radiation Exposure Withstand Testing Report (Wyle facilities for campaign 2010)
2. Test Facility Radiation Exposure Withstand Testing Report (NTS facilities for campaign 2011)

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C.12Test Results

The test results are reported in the completed copies of the following procedures (two copies for each procedure):

- "System Setup and Checkout Test Procedure"
- "Operability Test Procedure"
- "Prudency Test Procedure"

The results are summarized below.

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C.13 Resolution of Test Discrepancies

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Appendix D: Environmental Test Summary

D.1 Purpose

This test summary describes the Environmental Testing of the Rolls-Royce ***SPINLINE 3*** QTS. Environmental Testing of the ***SPINLINE 3*** QTS was 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.

D.2 Objective

The objective of Environmental Testing was to demonstrate the ***SPINLINE 3*** QTS did not experience failures due to abnormal service conditions of temperature and humidity, as required by RG 1.89 and IEEE 323-2003, subject to enhancements and exceptions listed in Section C of RG 1.209. 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). [[

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D.3 Equipment tested

The MCL documents the ***SPINLINE 3*** QTS hardware and firmware that was tested.

D.4 Sequence of Testing

During the first ***SPINLINE 3*** qualification campaign in 2010, environmental testing was performed at the Wyle laboratory in Huntsville, Alabama. This campaign was stopped before finishing the planned testing due to problems at the test facility. All results from this testing were reported in the first Rolls-Royce Environmental Test Report Reference Number 3 013 309 A

The ***SPINLINE 3*** qualification campaign was restarted in 2011 at the NTS laboratories in Boxborough, Massachusetts.

As shown in Table 11-1, Environmental Testing was performed after completion of Radiation Exposure Withstand Testing and included performance of the post Radiation Exposure Withstand Testing Operability and Prudency Tests. Environmental Testing Operability and Prudency Testing were performed at the times identified in the Environmental Testing procedures.

D.5 Procedures

The following procedures were used during Environmental Testing:

a) System Setup and Checkout Test Procedure: Through this procedure, the ***SPINLINE 3*** QTS was configured in the test chamber for Environmental Testing and the correct operation of the ***SPINLINE 3*** QTS and test system was verified.

b) Environmental Test Procedure: Through this procedure, the ***SPINLINE 3*** QTS received additional configuration in the test chamber for Environmental Testing. The performance of the ***SPINLINE 3*** QTS was monitored throughout application of the Environmental Test conditions.

c) Operability Test Procedure: This procedure included a series of tests defined in Section 5.3 of EPRI TR-107330 that verified acceptable performance of the ***SPINLINE 3*** QTS in accordance with the manufacturer's specifications and with baseline performance for the ***SPINLINE 3*** platform. The Post Radiation Exposure Withstand Testing run of this procedure was performed following completion of the Setup and Checkout Test procedure and prior to application of the Environmental Test conditions. This procedure was 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 included a series of tests defined in Section 5.4 of EPRI TR-107330 that verified 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 was performed following completion of the Setup and Checkout Test procedure and prior to application of the Environmental Test conditions. This procedure was also performed one time during application of the Environmental Test conditions, as listed in Table 5-1 of EPRI TR-107330.

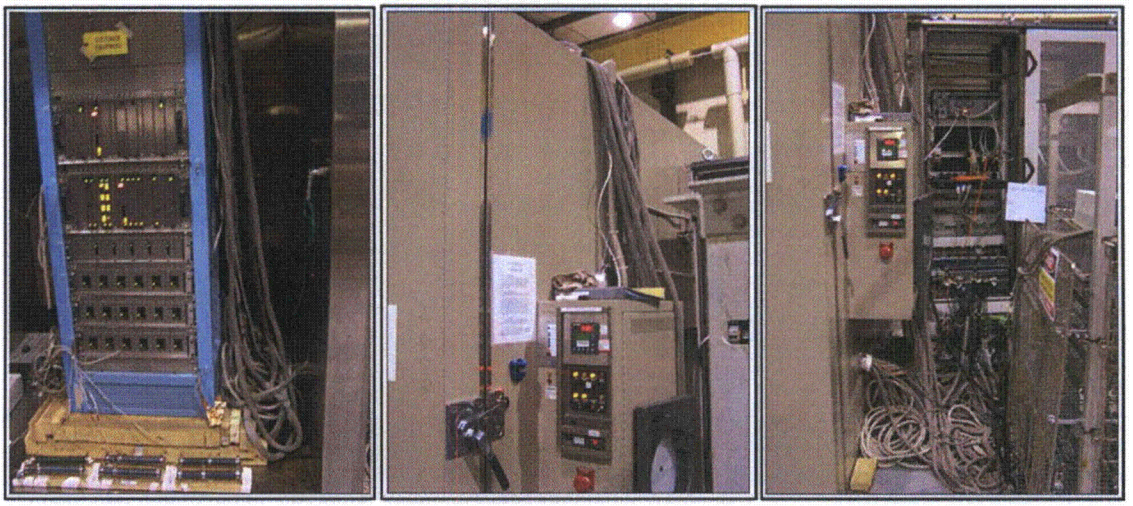
D.6 Test Specimen Mounting

As required by EPRI TR-107330, Section 6.3.3.1, the test specimen was mounted on a simple structure that does not enclose the test specimen chassis during Environmental Testing. 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 was 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 fans which would 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 fans were installed on the ***SPINLINE 3*** QTS mounting frame and operated in such a manner that they provided cooling of the other ***SPINLINE 3*** QTS components. The cabinet cooling fans were powered from the output of the ***SPINLINE 3*** QTS cabinet power supply assembly.

EPRI TR-107330, Section 6.2.1.1 required 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 were arranged to meet the intent of this requirement.

The QTS and DAS arrangements during the environmental testing are shown in Figure D-1.



QTS inside the chamber - Cables from QTS to DAS DAS outside the chamber

Figure D-1: Equipment Arrangements During Environmental Testing

D.7 Service Conditions

As required by EPRI TR-107330, Section 6.3.3, the test specimen was powered with its TSAP operating during Environmental Testing, with one half of the discrete and relay outputs on and loaded to their rated current. In addition, all analog outputs were set to between one half and two thirds of full scale.

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EPRI TR-107330, Section 6.3.3, required that Environmental Testing be performed with the power supply sources set to values that maximize heat dissipation in the test specimen. [[

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EPRI TR-107330, Section 6.2.1, required 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 required that these additional resistive loads be placed in the Environmental Test chamber. [[

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EPRI TR-107330, Section 6.2.1, required 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 required that these additional resistive loads be placed in the Environmental Test chamber. [[

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Figure D-2: Equipment Layout in Environmental Test Chamber (NTS)

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D.8 Test Levels

EPRI TR-107330, Section 4.3.6, required 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 versus 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).

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Figure D-3: Actual Test Conditions for Temperature and Humidity Versus Time.

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D.9 Performance Monitoring

EPRI TR-107330, Section 6.3.3.1, required 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. [[

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EPRI TR-107330, Section 4.3.6.3, required 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. [[

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D.10 Acceptance Criteria

The following Environmental Test acceptance criteria were 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 were 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

Rolls-Royce

The following records were prepared by the test facility to document the results of Environmental Testing:

1. Test Facility Environmental Test Report (Wyle facilities for campaign 2010)
2. Test Facility Environmental Test Report (NTS facilities for campaign 2011)

D.12Test Results

The test results are reported and summarized below:

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D.13 Resolution of Test Discrepancies

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Rolls-Royce

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Rolls-Royce

Appendix E: Seismic Test Summary

E.1 Purpose

This test summary describes the Seismic Testing of the Rolls-Royce ***SPINLINE 3*** QTS. Seismic Testing of the ***SPINLINE 3*** QTS was performed as part of qualification testing to demonstrate compliance with RG 1.100 and IEEE Standard 344-1987. It used guidance from EPRI TR-107330 which is compliant with these requirements.

E.2 Objective

The objective of Seismic Testing was 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 RG 1.100 and IEEE 344 - 1987 . 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 established the qualification envelope for ***SPINLINE 3*** seismic withstand.

E.3 Equipment tested

The MCL documents the ***SPINLINE 3*** QTS hardware and firmware to be tested. The first configuration tested included all of the ***SPINLINE 3*** QTS equipment. The second configuration testing included all of the ***SPINLINE 3*** QTS equipment except the subassembly containing the four Hubs.

E.4 Sequence of Testing

As shown in Table 11-1, Seismic Testing was performed in two parts after completion of the Resonance Search Testing. This test was performed in NTS facilities in Acton, Massachusetts. The first sequence was performed to the specified SSE test levels (for the second configuration – see below) and was performed after the completion of Environmental Testing. Post Seismic Testing Operability and Prudency Testing were performed after the SSE test sequence (for the second configuration – see below). The second sequence was performed to the specified SSE test levels (for the first configuration – see below) and was performed prior to the Performance Proof Testing. The Performance Proof Testing served as the Post Seismic Testing Operability and Prudency Testing for SSE test sequence (for the first configuration – see below).

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The equipment layout for the seismic testing is shown in Figure E-1.

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Figure E-1: Equipment Layout in Seismic Test Room

Rolls-Royce

E.5 Procedures

The following procedures were used during Seismic Testing:

a) System Setup and Checkout Test Procedure: Through this procedure, the ***SPINLINE 3*** QTS was configured on the test table for Seismic Testing, and the correct operation of the ***SPINLINE 3*** QTS and test system was verified.

b) Seismic Test Procedure: Through this procedure, the ***SPINLINE 3*** QTS was subjected to resonance search testing and received additional configuration on the test table for Seismic Testing. This procedure required monitoring the performance of the ***SPINLINE 3*** QTS throughout application of the Seismic Test conditions.

c) Operability Test Procedure: This procedure included a series of tests defined in Section 5.3 of EPRI TR-107330 that verified acceptable performance of the ***SPINLINE 3*** QTS in accordance with the manufacturer's specifications for the ***SPINLINE 3*** platform. This procedure was 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 included a series of tests defined in Section 5.4 of EPRI TR-107330 that verified 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 was performed at the completion of Seismic Testing. [[Due

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E.6 Test Specimen Mounting

As required by EPRI TR-107330, Section 6.3.4.1, the test specimen should be mounted on a structure whose configuration meets the manufacturer's mounting requirements during Seismic Testing. The seismic tests were performed with the test specimen mounting most susceptible to seismic vibrations. The mounting used manufacturer required hardware. All threaded fasteners used for mounting were tightened with a torque wrench and the torque values recorded.

The ***SPINLINE 3*** QTS was mounted to the Seismic Test table in accordance with Rolls-Royce specified mounting instructions for seismic applications. The Seismic Test mounting simulated a typical 19" rack mount configuration using standard Rolls-Royce chassis mounting brackets and fastener hardware. Resonance search testing was performed to demonstrate that the simulated mounting configuration was stiff enough to ensure that there were no resonances below 100 Hz. The first analysis of the NTS report indicates that the fixture had two resonance frequencies below 100 Hz (74 Hz side-to-side and 43 Hz front-to-back). The impact of these resonances on the test results continues to be assessed.

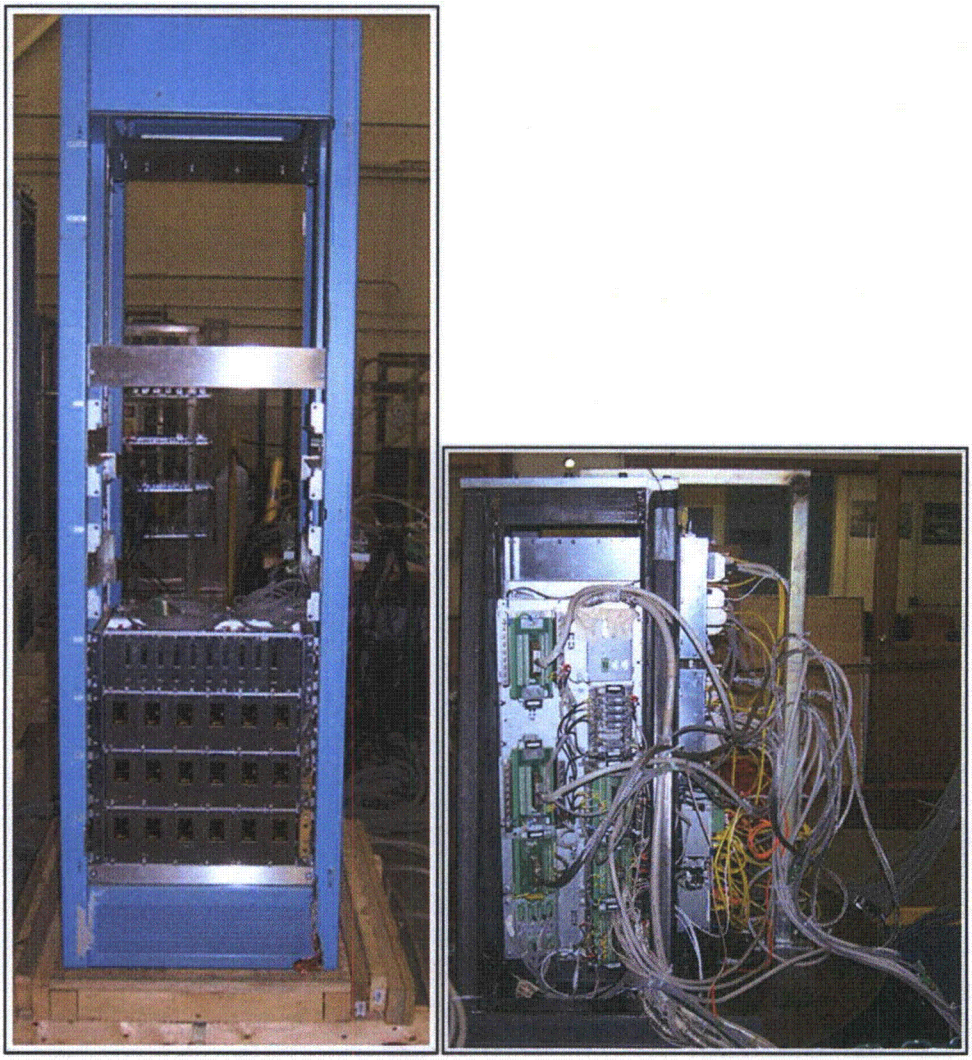
All mounting hardware fasteners were tightened using calibrated tightening torque devices, and torque values were recorded.

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. Dummy weights were added.

The ***SPINLINE 3*** QTS was 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. For more details about where the dummy loads were added, please refer to the Rolls-Royce document "Instruction for QTS mounting and setup" Reference 3 011 606A.

Several modules installed in the ***SPINLINE 3*** QTS main chassis were located as close together as the chassis design allows to demonstrate interaction effects during the Seismic Testing.

The equipment arrangement for seismic test configuration 1 is shown in Figure E-2.



Part of QTS not mounted on the test fixture – Parts on the test fixture (Configuration 1)

Figure E-2: Equipment Arrangement for Seismic Test Configuration 1

E.7 Service Conditions

As required by EPRI TR-107330, Section 6.3.4.2, the test specimen was powered with its TSAP operating during Seismic Testing, with one half of its solid-state discrete outputs ON and loaded to their rated current, one half of its relay outputs ON, and one half of its relay outputs OFF. In addition, one quarter of its relay outputs transitioned from OFF to ON and one quarter transitioned from ON to OFF during the OBE and SSE tests.

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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.

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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. [[

]]

E.8 Test Levels

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

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]] Figures E-3 through E-5 show the results for the OBE testing. Figures E-6 through E-8 show the results for SSE testing.

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E.9 Performance Monitoring

As required by EPRI TR-107330, Section 6.3.4.1, the test specimen should be mounted on a structure whose configuration meets the manufacturer's mounting requirements during Seismic Testing. Resonance search testing was performed to demonstrate that the simulated mounting configuration was stiff enough to ensure that there were no resonances below 100 Hz. The first analysis of the NTS report indicates that the fixture had two resonance frequencies below 100 Hz (74 Hz side-to-side and 43 Hz front-to-back). The impact of these resonances on the test results continues to be assessed.

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

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EPRI TR-107330, Section 4.3.9, required 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.

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

E.10 Acceptance Criteria

The following Seismic Test acceptance criteria were 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 are being prepared by Rolls-Royce to document the results of Seismic Testing:

1. Seismic OBE Testing Setup and Checkout Test Procedure (Completed with Attachments)
2. Seismic OBE Testing Procedure (Completed with Attachments)

3. Post Seismic OBE Testing Operability Test Procedure (Completed with Attachments)
4. Post Seismic OBE Testing Prudency Test Procedure (Completed with Attachments)
5. Seismic SSE Testing Setup and Checkout Test Procedure (Completed with Attachments)
6. Seismic SSE Testing Procedure (Completed with Attachments)
7. Performance Proof Testing (Post Seismic SSE Testing) Operability Test Procedure (Completed with Attachments)
8. Performance Proof Testing (Post Seismic SSE Testing) Prudency Test Procedure (Completed with Attachments)
9. Rolls-Royce Seismic Test Report

The following record was prepared by NTS to document the results of Seismic Testing:

1. Test Facility Seismic Test Report

E.12 Test Results

The test results are reported and summarized below:

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Rolls-Royce

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E.13 Resolution of Test Discrepancies

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Rolls-Royce

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Rolls-Royce

Appendix F: EMI/RFI Test Summary

F.1 Purpose

This test summary describes the EMI/RFI Testing performed on the Rolls-Royce ***SPINLINE 3*** QTS. EMI/RFI Testing of the ***SPINLINE 3*** QTS was performed as part of qualification testing to demonstrate compliance with the applicable EMI/RFI emissions and susceptibility requirements of RG 1.180, Revision 1 and EPRI TR-107330 .

F.2 Objective

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

EMI/RFI Emissions Tests

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

EMI/RFI Susceptibility Tests

- IEC 61000-4-6: Conducted Susceptibility, Induced RF Fields, Power/Signal Leads
- IEC 61000-4-13: Conducted Susceptibility, Harmonics/Interharmonics, Power Leads
- IEC 61000-4-16: Conducted Susceptibility, Common Mode Disturbance, Power/Signal Leads
- IEC 61000-4-8: Radiated Susceptibility, Magnetic Field, Helmholtz Coil Exposure
- IEC 61000-4-9: Radiated Susceptibility, Magnetic Field, Pulsed
- IEC 61000-4-10: Radiated Susceptibility, Magnetic Field, Damped Oscillatory
- IEC 61000-4-3: Radiated Susceptibility, High Frequency, Antenna Exposure

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

F.3 Equipment tested

The MCL documents the ***SPINLINE 3*** QTS hardware and firmware that was tested.

F.4 Sequence of Testing

As shown in Table 11-1, EMI/RFI Testing was performed after completion of the ESD and EFT Testing.

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F.5 Procedures

The following procedures were used during EMI/RFI Testing:

a) System Setup and Checkout Test Procedure: Through this procedure, the ***SPINLINE 3*** QTS was configured in the EMI/RFI test chamber for EMI/RFI Testing, and the correct operation of the ***SPINLINE 3*** QTS and test system was verified.

b) EMI/RFI Test Procedure: Through this procedure, the ***SPINLINE 3*** QTS received additional configuration in the EMI/RFI test chamber for EMI/RFI Testing, and the performance of the ***SPINLINE 3*** QTS was 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 received additional configuration and instrumentation in the EMI/RFI test chamber for EMI/RFI Testing, and the specified EMI/RFI Test conditions were 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 (Reference 46) and EPRI TR-102323, Revision 1.

The ***SPINLINE 3*** QTS was installed in the EMI/RFI test chamber mounted in metal frame instrument cabinets 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 could not practicably be met. The test specimen mounting frames were mounted on non-conductive (i.e., wooden) supports approximately 4 inches above the floor of the test chamber. This was done to prevent the EMI/RFI Test results from being affected by beneficial ground paths that might exist through the test specimen mounting frames. [[

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

Emissions Tests (CE101, CE102, RE101 and RE102) and some Susceptibility Tests (IEC 61000-4-6, IEC 61000-4-16 and IEC 61000-4-3) were performed inside the EMC Chamber.

The arrangement of the QTS in the EMC Test Chamber is shown in Figure F-1.

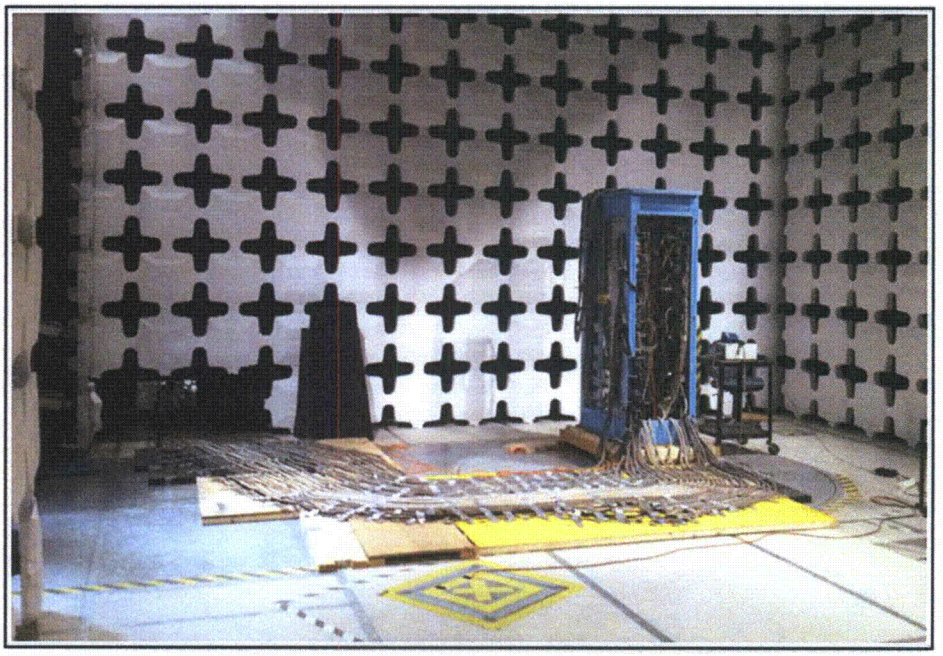

Figure F-1: Arrangement of QTS in EMC Test Chamber

F.7 Service Conditions

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

Rolls-Royce

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Figure F-2: Approach to Cabling Through the Penetration Plate

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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 used required 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. [[

]] The equipment layout in the EMC test chamber is shown in Figure F-3.

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Figure F-3: Equipment Layout in the EMC Test Chamber

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F.8 Test Levels

EMI/RFI Testing of the ***SPINLINE 3*** QTS were performed inside a shielded (anechoic or semi-anechoic) test chamber. The following table summarizes the specific EMI/RFI emissions and susceptibility testing accomplished per RG 1.180, Revision 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
Conducted Emissions, Low Frequency, AC and DC Power Leads	MIL-461E, CE101	[[ ]]
Conducted Emissions, High Frequency, AC and DC Power Leads	MIL-461E, CE102	[[ ]]
Radiated Emissions, Magnetic Field, Surfaces and Leads	MIL-461E, RE101	[[ ]]
Radiated Emissions, Electric Field, Antenna Measurement	MIL-461E, RE102	[[ ]]
Conducted Susceptibility, Disturbances Induced by Radio-Frequency Fields	IEC 61000-4-6	[[ ]]
Conducted Susceptibility, Harmonics/Interharmonics, Power Leads	IEC 61000-4-13	[[ ]]
Conducted Susceptibility., Common Mode Disturbances, Power/Signal Leads	IEC 61000-4-16	[[ ]]
Radiated Susceptibility, Magnetic Field, Helmholtz Coil Exposure	IEC 61000-4-8	[[ ]]
Radiated Susceptibility, Magnetic Field, Pulsed	IEC 61000-4-9	[[ ]]
Radiated Susceptibility, Magnetic Field, Damped Oscillatory	IEC 61000-4-10	[[ ]]
Radiated Susceptibility, High Frequency, Antenna Exposure	IEC 61000-4-3	[[ ]]

[[

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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).

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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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F.10 Acceptance Criteria

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F.11 Documentation

The following records were 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 was prepared by the test facility to document the results of EMI/RFI Testing:

1. Test Facility EMI/RFI Test Report

Rolls-Royce

F.12 Test Results

The test results are reported and summarized below:

[[

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Rolls-Royce

F.13 Resolution of Test Discrepancies

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Rolls-Royce

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Rolls-Royce

Appendix G: Electrical Fast Transient Test Summary

G.1 Purpose

This test summary describes the EFT Testing performed on the Rolls-Royce ***SPINLINE 3*** QTS. EFT Testing of the ***SPINLINE 3*** QTS was performed as part of qualification testing to demonstrate compliance with the applicable EFT susceptibility requirements of RG 1.180, Revision 1.

G.2 Objective

The objective of EFT testing was 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 was performed in accordance with RG 1.180, Revision 1, using additional guidance from EPRI TR-107330, as applicable. The specific EFT test performed was IEC 61000-4-4, "Electromagnetic Compatibility (EMC), Part 4-4: Testing and Measurement Techniques, Electrical Fast Transient/Burst Immunity Test". This test established the qualification envelope for ***SPINLINE 3*** for EFT susceptibility.

G.3 Equipment tested

The MCL documents the ***SPINLINE 3*** QTS hardware and firmware that was tested.

G.4 Sequence of Testing

As shown in Table 11-1, EFT Testing was performed after completion of ESD Testing and uses the same ***SPINLINE 3*** QTS and test system setup as the EMI/RFI Testing. The EFT test was performed in the EMC chamber at the NTS facilities in Boxborough, Massachusetts.

G.5 Procedures

The following procedures were used during EFT Testing:

a) EFT Test Procedure: Through this procedure, the ***SPINLINE 3*** QTS received additional configuration in the test chamber for EFT Testing, and the performance of the ***SPINLINE 3*** QTS was monitored throughout application of the EFT Test conditions.

b) Test Facility EFT Test Procedure: Through this procedure, the ***SPINLINE 3*** QTS received additional configuration and instrumentation in the test chamber for EFT Testing, and the specified EFT Test conditions were applied to the ***SPINLINE 3*** QTS and monitored.

Rolls-Royce

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 and EPRI TR-102323, Revision 1.

For EFT Testing, the ***SPINLINE 3*** QTS was installed in the EMI/RFI test chamber mounted in metal frame instrument cabinets 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 could not practicably be met. The ***SPINLINE 3*** QTS mounting frames were mounted on non-conductive (i.e., wooden) supports approximately 4 inches above the floor of the test chamber. This was done to prevent the EFT Test results from being affected by beneficial ground paths that might exist through the ***SPINLINE 3*** QTS mounting frames if the frames were placed directly on the floor of the EMI/RFI test chamber. [[

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Grounding of the ***SPINLINE 3*** QTS was in accordance with the manufacturer's recommendations. The ***SPINLINE 3*** QTS grounds passed across the gap created by the mounting frame non-conductive supports and bonded to the EMI/RFI test chamber floor. This grounding configuration met 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. [[

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

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

]] Neither EPRI TR-107330 nor the industry EFT test standard 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. [[

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G.8 Test Levels

Table 22 of RG 1.180, Revision 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. [[

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Table 15 of RG 1.180, Revision 1 defines the IEC 61000-4-4 EFT withstand levels for the signal leads of safety related instrumentation installed in various plant locations. [[

]]

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 was 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).

Rolls-Royce

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

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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 were based on Sections 4.3.7 and 4.6.2 of EPRI TR-107330 and RG 1.180, Revision 1.

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Rolls-Royce

G.11 Documentation

The following records were 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 was prepared by NTS to document the results of EFT Testing:

1. Test Facility EFT Test Report

G.12 Test Results

The test results are reported and summarized below:

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G.13 Resolution of Test Discrepancies

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Rolls-Royce

Appendix H: Surge Withstand Test Summary

H.1 Purpose

This test summary describes the Surge Withstand Testing performed on the Rolls-Royce ***SPINLINE 3*** QTS. Surge Withstand Testing of the ***SPINLINE 3*** QTS was performed as part of qualification testing to demonstrate compliance with the applicable Surge Withstand requirements of RG (RG) 1.180, Revision 1.

H.2 Objective

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

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

This test established the qualification envelope for ***SPINLINE 3*** Surge Withstand.

H.3 Equipment tested

The MCL documents the ***SPINLINE 3*** QTS hardware and firmware that was tested.

H.4 Sequence of Testing

As shown in Table 11-1, Surge Withstand 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. The Surge Withstand Tests were performed at the NTS facilities in Boxborough, Massachusetts.

H.5 Procedures

The following procedures were used during Surge Withstand Testing:

a) Surge Withstand Test Procedure: Through this procedure, the ***SPINLINE 3*** QTS received additional configuration in the test chamber for Surge Withstand Testing, and the performance of the ***SPINLINE 3*** QTS was monitored throughout application of the Surge Withstand Test conditions.

b) Test Facility Surge Withstand Test Procedure: This procedure was prepared and implemented by NTS (qualification test facility). Through this procedure, the ***SPINLINE 3*** QTS received additional

configuration and instrumentation in the test chamber for Surge Withstand Testing and the specified Surge Withstand Test conditions were 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 and EPRI TR-102323, Revision 1.

For Surge Withstand Testing, the ***SPINLINE 3*** QTS was installed in the EMI/RFI test chamber mounted in metal frame instrument cabinets 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 could not practicably be met. The ***SPINLINE 3*** QTS mounting frames were mounted on non-conductive (i.e., wooden) supports approximately 4 inches above the floor of the test chamber. This was done to prevent the Surge Withstand Test results from being affected by beneficial ground paths that might exist through the ***SPINLINE 3*** QTS mounting frames if the frames were placed directly on the floor of the EMI/RFI test chamber. [[

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Grounding of the ***SPINLINE 3*** QTS was in accordance with the manufacturer's recommendations. The ***SPINLINE 3*** QTS grounds passed across the gap created by the mounting frame non-conductive supports and bonded to the EMI/RFI test chamber floor. This grounding configuration met 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. [[

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

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

]] Neither EPRI TR-107330 nor the industry Surge Withstand test standards 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. [[

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H.8 Test Levels

Table 22 of RG 1.180, Revision 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. [[

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Table 15 of RG 1.180, Revision 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. [[

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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). [[

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the relatively large number of components being qualified as part of the ***SPINLINE 3*** QTS qualification t

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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. [[

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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 I/O module. [[

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

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H.10 Acceptance Criteria

The following Surge Withstand Test acceptance criteria were based on Section 4.6.2 of EPRI TR-107330 and RG 1.180, Revision 1. [[

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H.11 Documentation

The following records were 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 was prepared by NTS to document the results of Surge Withstand Testing:

1. Test Facility Surge Withstand Test Report

H.12 Test Results

The test results are reported and summarized below:

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H.13 Resolution of Test Discrepancies

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Appendix I: Electrostatic Discharge Test Summary

I.1 Purpose

This test summary describes the Electrostatic Discharge (ESD) Testing performed on the Rolls-Royce ***SPINLINE 3*** QTS. ESD Testing of the ***SPINLINE 3*** QTS was performed as part of qualification testing to demonstrate compliance with the applicable ESD requirements of EPRI TR-107330, Section 4.3.8.

I.2 Objective

The objective of ESD testing was 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, Revision 1. In accordance with EPRI TR-102323, Revision 1, 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". This test will establish the qualification envelope for ***SPINLINE 3*** ESD withstand. RG 1.180, Revision 1 provides no guidance for ESD Testing.

I.3 Equipment tested

The MCL documents the ***SPINLINE 3*** QTS hardware and firmware that was tested.

I.4 Sequence of Testing

As shown in Table 11-1, ESD Testing was performed after completion of Seismic OBE Testing and uses the same ***SPINLINE 3*** QTS and test system setup as the EMI/RFI Testing. The ESD Testing was performed in the EMC chamber at the NTS facilities in Boxborough, Massachusetts.

I.5 Procedures

The following procedures were used during ESD Testing:

a) Electrostatic Discharge Test Procedure: Through this procedure, the ***SPINLINE 3*** QTS received additional configuration in the test chamber for ESD Testing, and the performance of the ***SPINLINE 3*** QTS was monitored throughout application of the ESD Test conditions.

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

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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 and EPRI TR-102323, Revision 1.

For ESD Testing, the ***SPINLINE 3*** QTS was installed in the EMI/RFI test chamber mounted in metal frame instrument cabinets 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 could not practicably be met. The ***SPINLINE 3*** QTS mounting frames were mounted on non-conductive (i.e., wooden) supports approximately 4 inches above the floor of the test chamber. This was done to prevent the ESD Test results from being affected by beneficial ground paths that might exist through the test specimen mounting frames if the frames were placed directly on the floor of the EMI/RFI test chamber. [[

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Grounding of the ***SPINLINE 3*** QTS was in accordance with the manufacturer's recommendations. The ***SPINLINE 3*** QTS grounds were passed across the gap created by the mounting frame non-conductive supports and bonded to the EMI/RFI test chamber floor. This grounding configuration met 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. [[

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

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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 were energized during ESD Testing. The AC sources to the ***SPINLINE 3*** QTS

cabinet power supply assembly were 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. [[

]] Neither EPRI TR-107330 nor the industry ESD test standard 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. [[

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I.8 Test Levels

Appendix B, Section 3.5 of EPRI TR-102323, Revision 1 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.

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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.

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I.10 Acceptance Criteria

The following ESD Test acceptance criteria were based on Section 4.3.8 of EPRI TR-107330. [[

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I.11 Documentation

The following records were 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 was prepared by NTS to document the results of ESD Testing:

1. Test Facility Electrostatic Discharge Test Report

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I.12 Test Results

The test results are reported and summarized below:
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I.13 Resolution of Test Discrepancies

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Rolls-Royce

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

J.1 Purpose

This test summary describes the Class 1E to Non-1E Isolation Testing performed on the Rolls-Royce ***SPINLINE 3*** QTS. Class 1E to Non-1E Isolation Testing of the ***SPINLINE 3*** QTS was 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 .

J.2 Objective

The objective of Class 1E to Non-1E Isolation Testing was 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. 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 established the qualification envelope for ***SPINLINE 3*** Class 1E to Non-1E Isolation

J.3 Equipment tested

The MCL documents the ***SPINLINE 3*** QTS hardware and firmware that was tested.

J.4 Sequence of Testing

As shown in Table 11-1, Class 1E to Non-1E Isolation Testing was performed after completion of the last EMI/RFI Test and used the same ***SPINLINE 3*** QTS and test system setup as the Surge Withstand Testing. The Class 1E to Non-1E Isolation Testing was performed at the NTS facilities in Acton, Massachusetts.

J.5 Procedures

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

a) Class 1E to Non-1E Isolation Test Procedure: Through this procedure, the ***SPINLINE 3*** QTS received additional configuration in the test chamber for Class 1E to Non-1E Isolation Testing, and the performance of the ***SPINLINE 3*** QTS was 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 NTS. Through this procedure, the NTS Test Equipment was connected to ***SPINLINE 3*** QTS for Class 1E to Non-1E Isolation Testing, and the specified Class 1E to Non-1E Isolation Test conditions were applied to the ***SPINLINE 3*** QTS and monitored.

This Test was performed outside the EMC Chamber.

J.6 Test Specimen Mounting

As required by EPRI TR-107330, Section 6.3.6, the Class 1E to Non-1E Isolation test specimen was 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 was connected to a ground bus located at the base of the mounting surface using the manufacturer's recommended grounding conductor. Grounding and shielding met the requirements of IEEE Standard 1050 and EPRI TR-102323, Revision 1.

For Class 1E to Non-1E Isolation Testing, the ***SPINLINE 3*** QTS was 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 could not practicably be met. The ***SPINLINE 3*** QTS mounting frames were mounted on non-conductive (i.e., wooden) supports approximately 4 inches above the floor of the test chamber. This was 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 frames if the frames were placed directly on the floor of the EMI/RFI test chamber. [[

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Grounding of the ***SPINLINE 3*** QTS was done in accordance with the manufacturer's recommendations. The ***SPINLINE 3*** QTS grounds were passed across the gap created by the mounting frame non-conductive supports and bonded to the EMI/RFI test chamber floor. This grounding configuration met 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 was powered with the Test Specimen

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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 were maintained within the normal

operating range of the ***SPINLINE 3*** QTS. The test chamber barometric pressure was 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. [[

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

]] EPRI TR-107330 does not require the relay output points to be operating at rated currents during Class 1E to Non-1E Isolation Testing.

As required by EPRI TR-107330, Section 6.2.1, additional resistive loads were placed on each ***SPINLINE 3*** QTS loop power supply output so that nominal current draws at nominal power supply output voltages were equal to the power supply rating. [[

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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 .

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.

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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 determined the minimum voltage level that the device must withstand across the Non-1E side terminals and between the Non-1E terminals and ground. [[

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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

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Rolls-Royce

J.10 Acceptance Criteria

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

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J.11 Documentation

The following records were 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 was prepared by NTS 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

J.12 Test Results

The test results are reported and summarized below:
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J.13 Resolution of Test Discrepancies

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Rolls-Royce

Appendix K: Performance Proof Test Summary

K.1 Purpose

This test summary describes the Performance Proof Testing that was performed on the Rolls-Royce ***SPINLINE 3*** QTS. Performance Proof Testing of the ***SPINLINE 3*** QTS was performed as part of qualification testing to meet the intent of the applicable requirements of EPRI TR-107330, Section 5.5.

K.2 Objective

The objective of Performance Proof Testing was 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 included 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 tested

The MCL documents the ***SPINLINE 3*** QTS hardware and firmware to be tested.

K.4 Sequence of Testing

The Performance Proof Testing sequence was:

- Perform system setup and checkout tests
- Perform the Operability Test , including
  - Analog Input And Output Accuracy Test
  - Response Time Test
  - Discrete Input Operation Tests
  - Discrete Output Operation Test
  - Timer Function Accuracy Test
  - Failover Performance Test
  - Loss of Power Performance Test
  - Power Interrupt Performance Test
  - Power Quality Tolerance Test
- Perform the Prudency Test

As shown in Table 11-1, Performance Proof Testing was performed after completion of Seismic SSE Testing (Configuration 1 Stage 2). The Performance Proof Testing was performed at the NTS facilities in Acton, Massachusetts.

Rolls-Royce

K.5 Procedures

The following procedures were used during Performance Proof Testing:

a) System Setup and Checkout Test Procedure: Through this procedure, the ***SPINLINE 3*** QTS was configured for Performance Proof Testing, and the correct operation of the ***SPINLINE 3*** QTS and test system was verified.

b) Operability Test Procedure: This procedure included a series of tests defined in Section 5.3 of EPRI TR-107330 that verified 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 demonstrated performance of the ***SPINLINE 3*** QTS at the completion of all hardware qualification testing.

c) Prudency Test Procedure: This procedure included a series of tests defined in Section 5.4 of EPRI TR-107330 that verified 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 demonstrated 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 was mounted in open mounting frame(s) for Performance Proof Testing. The configuration of the ***SPINLINE 3*** QTS components and interconnecting cabling was similar to expected in-cabinet applications. The ***SPINLINE 3*** QTS cooling fans were installed on the open mounting frame(s) and operated to 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. [[

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

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EPRI TR-107330 provides no requirements or guidance for configuration of the test specimen power supply sources during Performance Proof Testing. [[

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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 were as specified 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 was performed as specified 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 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 were 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

K.12Test Results

The test results are reported and summarized below:
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K.13Resolution of Test Discrepancies

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