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1 INTRODUCTION

1.1 Purpose

This report contains the results of the assessment of the critical characteristics for ***SPINLINE 3*** Digital Safety I&C Platform, performed in accordance with EPRI TR-106439 (Reference 7). Section 3 shows a "critical characteristics matrix" that lists critical characteristics and provides references to acceptance criteria and the verification methods used in verifying them. The matrix covers each of the three categories of critical characteristics: physical characteristics, performance characteristics, and dependability characteristics.

This report also contains the results of the assessment of the ***SPINLINE 3*** Digital Safety I&C Platform, performed in accordance with EPRI TR-107330 (Reference 6). The assessment results in Section 4 documents a detailed compliance matrix demonstrating how the ***SPINLINE 3*** system complies (i.e., Requirement Not Applicable, Fully Complies, Exception Taken, or TR Discrepancy Noted) with each of the requirements specified in EPRI TR-107330.

This report supplements the information provided in the Rolls-Royce Dedication Report for the Generic ***SPINLINE 3*** Digital Safety I&C Platform (Reference 12), which was submitted to NRC by Rolls-Royce letter dated June 30, 2011.

1.2 Acronyms and Abbreviations

AC	Alternating Current
ANSI/NCSL	American National Standard Institute/National Conference of Standards Laboratories
ASME	American Society of Mechanical Engineers
ASOA	Application Software Objects Acceptance
BTP	Branch Technical Position
C	Centigrade
CB	Consistency Block
CD-ROM	Compact Disc Read Only Memory
CFR	Code of Federal Regulations
CNET	French National Centre for Telecommunication Studies
CPLD	Complex Programmable Logic Device
CPU	Central Processing Unit
CSS	Core System Software
DAS	Data Acquisition System
DC	Direct Current
dB	Decibel
EdF	Électricité de France
EEPROM	Electrically Erasable Programmable Read-Only Memory
EFT	Electrical Fast Transient

EMI	Electromagnetic Interference
EPRI	Electric Power Research Institute
ESD	Electrostatic Discharge
F	Fahrenheit
FMEA	Failure Modes and Effects Analysis
FPGA	Field Programmable Gate Array
HMI	Human Machine Interface
Hz	Hertz
I&C	Instrumentation and Controls
I/O	Input/Output
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronic Engineers
ISA	Instrument Society of America
ISG	Interim Staff Guidance
kV	Kilovolt
LCD	Liquid Crystal Display
LDU	Local Display Unit
LED	Light Emitting Diode
LSB	Least Significant Bit
LTR	Licensing Topical Report
mA	Milliampere
MIL-STD	Military Standard
MMU	Monitoring and Maintenance Unit
NRC	Nuclear Regulatory Commission
OBE	Operating Basis Earthquake
OSS	Operating System Software
PID	Proportional-Integral-Derivative
PLC	Programmable Logic Controller
PLD	Programmable Logic Device
PVC	Polyvinyl Chloride
PWR	Pressurized Water Reactor
QTS	Qualification Test Specimen
RAM	Random Access Memory
RFI	Radio Frequency Interference
RBMK	Russian High Power Channel-type Reactor
RRS	Required Response Spectrum
RTD	Resistance Temperature Detector
SCADE	Safety Critical Application Development Environment
SMQP	Software Modification Quality Plan

SOE	Sequence of Events
SQAP	Software Quality Assurance Plan
SQP	Software Quality Plan
SSE	Safe Shutdown Earthquake
SVVP	Software Verification and Validation Plan
TR	Topical Report
TSAP	Test Specimen Application Program
TTL	Transistor–Transistor Logic
V	Volt
V&V	Verification and Validation
VVER	Russian Pressurized Water Reactor

1.3 Background

SPINLINE 3 originally was designed, qualified, and manufactured to meet European nuclear safety and quality standards. In addition, ***SPINLINE 3*** systems have demonstrated compliance with the nuclear safety regulations in several nations outside of Europe. The ***SPINLINE 3*** Licensing Topical Report (LTR, Reference 9) describes the safety case that demonstrates that the ***SPINLINE 3*** safety I&C platform and the associated quality and software life cycle processes comply with U.S. nuclear safety requirements. Compliance is demonstrated via the following licensing approach:

- Dedicate the generic ***SPINLINE 3*** digital safety I&C platform, which was not originally developed under a 10 CFR Part 50 Appendix B (Reference 1) quality assurance program.
  - Consistent with the basic requirements for commercial dedication as defined in 10 CFR Part 21 (Reference 2), Rolls-Royce is employing the commercial dedication processes described in EPRI TR-107330 and EPRI TR-106439.
  - The suitability of ***SPINLINE 3*** for dedication is documented in the Design Analysis Report (Reference 13) and the Dedication Plan (Reference 11).
  - The generic ***SPINLINE 3*** platform is managed under a 10 CFR Part 50 Appendix B quality program during and after dedication.
- Qualify ***SPINLINE 3*** hardware to meet U.S. standards. The ***SPINLINE 3*** hardware will be qualified and maintained under the 10 CFR Part 50 Appendix B quality program. If new boards are developed or existing boards modified for obsolescence or other reasons, the new or modified hardware will be appropriately tested and/or analyzed to maintain equipment qualification to U.S. standards.
- Develop plant-specific application software in accordance with software life cycle plans that are compliant with NRC Branch Technical Position 7-14 (Reference 3)
- The non-Class 1E set of software tools, which are used as design aids and not as a replacement for verification and validation, are not dedicated but continue to be subject to a configuration management program.

The ***SPINLINE 3*** LTR is organized as follows:

- **Chapter 1, Introduction:** This chapter provides an overview of the report and identifies the numerous supporting documents that will be submitted for NRC review. This chapter also provides an overview of the quality program and the quality process employed to dedicate the generic ***SPINLINE 3*** platform software and hardware.

- **Chapter 2, *SPINLINE 3* Development and Operational History:** This chapter provides an overview of ***SPINLINE 3*** development and operational use in many French and international nuclear power plants where it is currently deployed in a variety of digital safety I&C applications. This historical information is intended to illustrate the substantial legacy of safety I&C developments that led to the ***SPINLINE 3*** digital safety I&C platform.

- **Chapter 3, Regulations, Codes and Standards:** This chapter provides summaries of ***SPINLINE 3*** compliance with the U.S. and international regulations, codes and standards listed or referenced in the NRC Standard Review Plan, Table 7-1, "Regulatory Requirements, Acceptance Criteria, and Guidelines for Instrumentation and Control Systems Important to Safety" (Reference 4) plus additional standards referenced in the report. Detailed compliance matrices for selected regulations, codes, and standards are provided in Appendix A of the LTR. This chapter and Appendix A serve as a compliance roadmap and include references to where additional compliance details are provided in the report or other supporting documents submitted by Rolls-Royce for NRC review.

- **Chapter 4, Description of the *SPINLINE 3* Digital Safety I&C Platform:** This chapter provides generic descriptions of the hardware and software that comprise the ***SPINLINE 3*** digital safety I&C platform. In addition, details are provided on how digital communications and testability are implemented in ***SPINLINE 3***. Data sheets for individual ***SPINLINE 3*** hardware items are provided in Appendix B of the LTR.

- **Chapter 5, Equipment Qualification and Analysis:** This chapter provides an overview of the generic equipment qualification program, which is described in detail in the Equipment Qualification Plan (Reference 14). The ***SPINLINE 3*** qualification "envelope" is generic and is intended to meet or exceed the environmental qualification requirements for nuclear power plants in the U.S. using the EPRI TR-107330 criteria. The Equipment Qualification Plan defines the Qualification Test Specimen and the specific test procedures and the resulting test reports for each test. This chapter also provides: (1) a summary of the board / device-level reliability analysis process and results reported separately, and (2) an overview of the setpoint analysis support information reported separately.

- **Chapter 6, Software Development Process for *SPINLINE 3* Platform Software and Application Software**: This chapter describes the development history and the software life cycle processes applicable to the ***SPINLINE 3*** platform software (i.e., the standard Operating System Software, the application-oriented library of re-usable software components, embedded software in the NERVIA+ board and ICTO Pulse Input board, and the CLARISSE System and Software Development Environment). The software life cycle processes used for the ***SPINLINE 3*** platform software were developed in the mid-1980s in connection with the development of digital safety I&C systems for the Électricité de France P4 and N4 fleets of plants. These software life cycle processes are examined in more detail in the Design Analysis Report. This chapter also describes the separate software life cycle processes for plant-specific application software.

- **Appendix A, Compliance Matrices:** This appendix contains the detailed regulatory compliance matrices referenced in Chapter 3 of the LTR.

- **Appendix B, *SPINLINE 3* Hardware Data Sheets:** This appendix contains the data sheets for ***SPINLINE 3*** standard hardware items described in Section 4.3 of the LTR.

1.4 Approach

The Rolls-Royce commercial grade dedication effort for the ***SPINLINE 3*** platform was performed using the NRC-approved guidance of EPRI TR-106439, which is based on the NRC-approved guidance in EPRI NP-5652 (Reference 8). This set of guidance provides the overall framework for the technical basis for acceptance and the specific methods used to establish acceptance. It is important to understand how this guidance relates to the use of testing in the acceptance review. Testing can be used to support acceptance in three distinct ways, each with its own set of rules.

Method 1 – EPRI NP-5652 Section 3.1.2 states that "Method 1 should be used when the purchaser desires to verify critical characteristics after the item is received." Method 1 testing is performed during the commercial grade dedication process. EPRI NP-5652 Section 2.5 specifies that this work must be performed in accordance with a 10 CFR Part 50, Appendix B program.

Method 2 - EPRI NP-5652 Section 3.2.2 states that "Method 2 should be used when the purchaser desires to accept commercial grade items based on the merits of a supplier's commercial quality controls. These controls may constitute quality programs, procedures, or practices." EPRI NP-5652 Section 3.2.3 states that "Two basic criteria must be met when conducting a commercial grade survey. The purchaser must confirm that the selected commercial grade item's critical characteristics are controlled under the scope of commercial quality system activities. The purchaser must also be reasonably assured that the commercial supplier's activities adequately control the commercial grade items supplied." EPRI NP-5652 Table 3-1 lists typical supplier controls that can be surveyed using Method 2, which includes testing. Similarly, EPRI TR-106439 Figure 3-2 shows a review of vendor testing as an element of the dedication process. EPRI NP-5652 Section 2.5 specifies that the review for acceptance of vendor testing must be performed in accordance with a 10 CFR Part 50, Appendix B program; however, the vendor testing itself is not performed in accordance with a 10 CFR Part 50, Appendix B program.

Method 3 - EPRI NP-5652 Section 3.3.1 states that "Method 3 involves the verification of critical characteristics by witnessing quality activities before releasing the item for shipment." EPRI NP-5652 Section 2.5 specifies that the verification for acceptance of vendor testing must be performed in accordance with a 10 CFR Part 50, Appendix B program; however, the vendor testing itself is not performed in accordance with a 10 CFR Part 50, Appendix B program.

Method 4 - EPRI NP-5652 Section 3.3.1 states that "Method 4 allows the purchaser to accept commercial grade items based upon a confidence in the supplied item achieved through proven performance of the item. It also allows the purchaser to take credit for item performance based upon historical verification gained from the successful utilization of Methods 1, 2, or 3 or pertinent industry-wide performance data."

NRC Generic Letter 89-02 (Reference 5) places two limitations of the use of EPRI NP-5652:

1. Acceptance Method 2, "Commercial-Grade Survey of Supplier", should not be employed as the basis for accepting items from suppliers with undocumented commercial quality control programs or with programs that do not effectively implement their own necessary controls. Likewise, Method 2 should not be employed as the basis for accepting items from distributors unless the survey includes the part manufacturer(s) and the survey confirms adequate controls by both the distributor and the part manufacturer(s).
2. Acceptance Method 4, "Acceptable Supplier/Item Performance Record," should not be employed alone unless:

a. The established historical record is based on industry-wide performance data that is directly applicable to the item's critical characteristics and the intended safety-related application; and

b. The manufacturer's measures for the control of design, process, and material changes have been adequately implemented as verified by audit (multi-licensee team audits are acceptable).

Rolls-Royce performed a review of the historical development records for the ***SPINLINE 3*** platform as part of the commercial grade dedication effort and made two broad conclusions. First, Rolls-Royce concluded that additional testing would be needed to satisfy the US regulatory requirements for hardware qualification. These hardware qualification tests represent Method 1 activities and are described in LTR Section 5.1. Second, Rolls-Royce concluded that the ***SPINLINE 3*** software and firmware development processes (including the original validation testing) were of acceptable based on the rigor of the development processes, quality of the development documentation, and the validity of the results obtained. The software validation tests were accepted by Method 2 and are described in LTR Sections 6.2 and 6.3.

Method 3 was not used by Rolls-Royce for the ***SPINLINE 3*** commercial grade dedication effort. A Method 3 process, if used, would be akin to a licensee observing a factory acceptance test for a system they purchased.

Method 4 was not used to compensate for shortcomings in legacy software nor was it used as a basis for establishing module failure rates. Rolls-Royce has only used the ***SPINLINE*** operating experience to demonstrate satisfactory performance with the performance platform technology.

2 METHODOLOGY AND RESULTS

Table A-1 in the Dedication Report for the Generic ***SPINLINE 3*** Digital Safety I&C Platform maps the dedication elements of EPRI TR-106439 to the applicable ***SPINLINE 3*** documentation. Section 3 shows a "critical characteristics matrix" that lists the three categories of critical characteristics (i.e., physical characteristics, performance characteristics, and dependability characteristics) and provides references to acceptance criteria and the verification methods that can be used in verifying them. The assessment results in Section 4 documents a detailed compliance matrix demonstrating how the ***SPINLINE 3*** system complies (i.e., Requirement Not Applicable, Complies, Partially Complies, Exception Taken, or TR Discrepancy Noted) with each of the requirements specified in EPRI TR-107330.

Additional information on the use of Methods 1, 2, and 4 are described below.

2.1 Method 1 Implementation

The ***SPINLINE 3*** Qualification Plan, which is based on EPRI TR-107330, identifies qualification testing to verify critical performance characteristics. These tests represent the Method 1 activities that are used in the commercial grade dedication process for the ***SPINLINE 3*** platform. The ***SPINLINE 3*** qualification program is summarized in LTR Section 5.1.

The high level critical performance characteristics for acceptance to be validated through the ***SPINLINE 3*** qualification testing are summarized below:

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

The ***SPINLINE 3*** Qualification Plan identifies the safety functions to be demonstrated by the qualification testing during normal and abnormal operating conditions as follows:

- Proper response of inputs to applied input signals,
- Proper response of outputs to application program control,
- Proper control of connected output devices,
- Proper operation of communication interfaces,
- Acceptable input/output accuracy,
- Acceptable response time,
- Proper response to momentary interruption of input power,
- Proper response to loss of input power,
- Proper response to input power quality (voltage and frequency) variations,
- Proper failover to redundant components.

The qualification tests inherently test the basic functionality of the ***SPINLINE 3*** OSS, TSAP, and NERVIA communication software and the component firmware and software operating within the QTS hardware environment.

The Operability Test Procedure (Reference 27) defines specific critical performance characteristics for acceptance that are verified for the various test sequences. These critical performance characteristics for acceptance are summarized below:

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

Operability Testing is performed at the following times during hardware qualification testing:

- At the completion of Radiation Exposure Withstand Testing
- At the completion of the high temperature, high humidity phase of Environmental Testing
- At the completion of the low temperature phase of Environmental Testing
- At the completion of the low humidity phase of Environmental Testing
- At the completion of Environmental Testing
- At the completion of Seismic Testing

The Prudency Test Procedure (Reference 28) also defines specific critical performance characteristics for acceptance that are verified for the various test sequences. These critical performance characteristics for acceptance are summarized below:

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

Prudency Testing is performed at the following times during hardware qualification testing:

- At the completion of Radiation Exposure Withstand Testing
- At the completion of the high temperature, high humidity phase of Environmental Testing
- At the completion of Seismic Testing
- During Performance Proof Testing

Other critical characteristics for acceptance for ***SPINLINE 3*** OSS, TSAP, and NERVIA communication software and the component firmware and software operating within the QTS hardware environment were specified as correct performance of the system. These verifications demonstrate correct operation of the ***SPINLINE 3*** software operation, as shown in LTR Figures

4.4-2 through 4.4-9. The critical characteristics for acceptance to demonstrate normal operation of the ***SPINLINE 3*** software include:

- Successful initialization
- Transition to cyclical mode
- Execution of self-diagnostic tests to detect and signal failures in the hardware environment
- Cycle time management maintaining a fixed cycle time (absence of halts due to cycle time being exceeded)
- Acquisition and data management of analog and discrete inputs, including inputs from NERVIA networks
- Execution of the application software
- Transmission of output data to analog and discrete outputs, including outputs to NERVIA networks

The critical characteristics for acceptance were verified as specified in the following test procedures:

- System Setup and Checkout Test Procedure (Reference 18)
  - Attachment 4, Normal Operating Performance Data Verification Checklist
- Environmental Test Procedure (Reference 20)
  - Attachment 3, Normal Operating Performance Data Verification Checklist
  - Attachment 4, Data Evaluation For Normal Operating Performance
- Seismic Test Procedure (Reference 21)
  - Attachment 3, Data Evaluation For Normal Operating Performance
  - Attachment 4, Normal Operating Performance Data Verification Checklist
- EMI/RFI Test Procedure (Reference 22)
  - Attachment 4, Data Evaluation For Normal Operating Performance
  - Attachment 5, Normal Operating Performance Data Verification Checklist
- Electrostatic Discharge (ESD) Test Procedure (Reference 23)
  - Attachment 3, Data Evaluation For Normal Operating Performance
  - Attachment 4, Normal Operating Performance Data Verification Checklist
- Electrical Fast Transient (EFT) Test Procedure (Reference 24)
  - Attachment 3, Data Evaluation For Normal Operating Performance
  - Attachment 4, Normal Operating Performance Data Verification Checklist
- Surge Withstand Test Procedure (Reference 25)
  - Attachment 3, Data Evaluation For Normal Operating Performance
  - Attachment 4, Normal Operating Performance Data Verification Checklist
- Operability Test Procedure (Reference 27)
  - Section 7- Failover Operability Test
    - Attachment 3, Normal Operating Performance Data Verification Checklist
  - Section 8 - Loss Of Power Test
    - Attachment 3, Normal Operating Performance Data Verification Checklist
    - Attachment 4, Data Verification Checklist After System Reset
    - Attachment 5, Resume Normal Operation Data Verification Checklist
    - Attachment 6, Loss Of Power Data Verification Checklist
    - Attachment 7, System Reset Data Verification Checklist
  - Section 9 - Power Interruption Test
    - Attachment 3, Normal Operating Performance Data Verification Checklist
  - Section 10 - Power Quality Tolerance Test
    - Attachment 3, Normal Operation Data Verification Checklist
    - Attachment 4, Normal Operation Data Verification Checklist
    - Attachment 5, Normal Operation Data Verification Checklist

- Attachment 6, Normal Operation Data Verification Checklist

The following documents exist (and have been submitted to NRC) that describe the ***SPINLINE 3*** qualification testing:

- Equipment Qualification Plan (Reference 14)
- System Setup and Checkout Test Procedure (Reference 18)
- Radiation Exposure Test Procedure (Reference 19)
- Environmental Test Procedure (Reference 20)
- Seismic Test Procedure (Reference 21)
- EMI / RFI Test Procedure (Reference 22)
- ESD Test Procedure (Reference 23)
- Electrical Fast Transient Test Procedure (Reference 24)
- Surge Withstand Test Procedure (Reference 25)
- Class 1E to Non-Class 1E Isolation Test Procedure (Reference 26)
- Operability Test Procedure (Reference 27)
- Prudency Test Procedure (Reference 28)

The results of the qualification testing will be documented in a various test reports described in the Equipment Qualification Plan.

All of these documents are maintained in the Rolls-Royce records management system.

2.2 Method 2 Implementation

Method 2 was applied to the ***SPINLINE 3*** technology in three broad parts. First, the ***SPINLINE 3*** software development process (based on International Electrotechnical Commission standard IEC 880-1986) was compared to the applicable NRC review guidance for safety system software development defined in NRC Branch Technical Position 7-14. Second, the ***SPINLINE 3*** development process was compared to the applicable US industry process standards applied to software development for safety systems. And third, the ***SPINLINE 3*** platform design characteristics were compared to the applicable US regulatory guidance.

As noted in EPRI NP-5652 Section 3.2.3 states that “Two basic criteria must be met when conducting a commercial grade survey. The purchaser must confirm that the selected commercial grade item's critical characteristics are controlled under the scope of commercial quality system activities. The purchaser must also be reasonably assured that the commercial supplier's activities adequately control the commercial grade items supplied.”

2.2.1 *SPINLINE 3* Software Development Process Evaluation

The results of the comparison of the ***SPINLINE 3*** software development process to Branch Technical Position 7-14 are documented in the following tables in LTR Appendix A:

- Table 3.10-1, IEC 880-1986 Appendix B Compliance Matrix
- Table 3.10-2, Comparison of IEC 880-1986 and NRC Branch Technical Position 7-14 Requirements

The results of the comparison of the ***SPINLINE 3*** development process to the applicable US industry process standards applied to hardware and software development for safety systems are documented in the following tables in LTR Appendix A:

- Table 3.1-1, Standard Review Plan Table 7-1 Compliance Summary
- Table 3.2-1, 10CFR50 Appendix B and ASME NQA-1-1994 Map to Corresponding I&C France QA Plans & Procedures
- Table 3.2-2, 10CFR50 Appendix B and ASME NQA-1-1994 Map to Corresponding I&C US QA Plans & Procedures
- Table 3.8-1, IEEE 7-4.3.2-2003 Compliance Matrix
- Table 3.8-3, Mapping ***SPINLINE 3*** SQP MC3 and Other Content to IEEE 730-1998 SQAP Content Guidance
- Table 3.8-4, Mapping ***SPINLINE 3*** SMQP and Other Content to IEEE 730-1998 SQAP Content Guidance
- Table 3.8-5, Mapping ***SPINLINE 3*** Application SQAP and Other Content to IEEE 730-1998 SQAP Content Guidance
- Table 3.8-6, Mapping ***SPINLINE 3*** SQP MC3 and Other Content to IEEE 828-1998 SCMP Content Guidance
- Table 3.8-7, Mapping ***SPINLINE 3*** Platform SCMP and Other Content to IEEE 828-1998 SCMP Content Guidance
- Table 3.8-8, Mapping ***SPINLINE 3*** Application SCMP and Other Content to IEEE 828-1998 SCMP Content Guidance
- Table 3.8-9, Mapping ***SPINLINE 3*** SQP MC3 and Other Content to IEEE 1012-1998 SVVP Content Guidance
- Table 3.8-10, Mapping ***SPINLINE 3*** SMQP and Other Content to IEEE 1012-1998 SVVP Content Guidance
- Table 3.8-11, Mapping ***SPINLINE 3*** Application SVVP and Other Content to IEEE 1012-1998 SVVP Content Guidance
- Table 3.8-12, Alignment of IEEE 1074-1995 Activities, ISG-06 Tier 3 Document Guidance, and ***SPINLINE 3*** Documents

These comparisons demonstrate that the Rolls-Royce processes used for ***SPINLINE 3*** software development provided adequately control of the software development."

2.2.2 *SPINLINE 3* System Design Evaluation

The ***SPINLINE 3*** development process comparison is supplemented with the information provided in Rolls-Royce document Map of ISG-06 Tier 3 Submittal Guidance to Generic ***SPINLINE 3*** Digital Safety I&C Platform Licensing Documents (Reference 10).

The results of the comparison of the ***SPINLINE 3*** platform design characteristics to the applicable US regulatory guidance are documented in the following tables in LTR Appendix A:

- Table 3.6-1, Responses to NUREG/CR-6082 Communications System Questions
- Table 3.7-1, Interim Staff Guide DI&C-ISG-04 Compliance Matrix
- Table 3.8-2, IEEE 603-1991 Compliance Matrix

These results demonstrate that the ***SPINLINE 3*** system developed with the Rolls-Royce processes meets the identified critical system characteristics.

The ***SPINLINE 3*** digital safety I&C platform has the following general attributes:

- Fail-safe: ***SPINLINE 3*** assures that, in case of detected failure, the outputs associated with a central processing Unit achieve a pre-defined safe position.
- Fault-tolerance: ***SPINLINE 3*** supports system architectures that meet the redundancy requirements of the single failure criterion. In addition, ***SPINLINE 3*** microprocessors can

automatically reconfigure their voting logic to accomplish the intended safety function with one or more divisions out of service.

- Diversity: ***SPINLINE 3*** supports system architectures that employ signal diversity to defend against common cause failures. ***SPINLINE 3*** also can be deployed as a diverse system as part of a plant-level defense-in-depth and diversity strategy.
- Functional isolation: ***SPINLINE 3*** equipment and communications design prevents propagation of failures between redundant equipment in separate divisions. In addition, communication paths to nonsafety I&C systems are electrically isolated with one-way communications from ***SPINLINE 3*** to the nonsafety I&C system. This prevents faults in a non-safety I&C system from affecting ***SPINLINE 3***.
- Determinism: For all processing, the same inputs produce the same outputs within a guaranteed response time.
- Ease of use: Operation and maintenance are simplified by automated on-line system supervision, fault detection, and self-diagnosis.
- Flexibility: Through carefully controlled processes, many system operating characteristics can be updated without hardware modification.
- Modularity: ***SPINLINE 3*** can be delivered either in standard chassis to be integrated into existing cabinets (for refurbishment purposes) or in new cabinets.
- Scalability: ***SPINLINE 3*** has been deployed internationally in a wide variety of safety I&C applications, including Reactor Trip System, Engineered Safety Feature Actuation System, Nuclear Instrumentation System, and diverse trip system applications.
- Secure development and operational environment: The software life cycle processes applied by Rolls-Royce establish a secure development and operational environment for managing the generic ***SPINLINE 3*** platform baseline and developing the plant-specific application software through the factory test phase. These processes protect against unauthorized, unintended, and unsafe modifications to the system, and support implementation of design requirements that promote integrity and reliability during operation and maintenance in the event of inadvertent operator actions or undesirable behavior of connected equipment

Twelve generic board-level Reliability and Predictive Safety Analysis reports were prepared to assess the failure modes and effects of the individual modules and provide reliability estimates for each board References 30 through 41). The reliability assessments for the ***SPINLINE 3*** hardware were summarized LTR Section 5.2. These reliability characteristics represent Method 2 dependability characteristics for acceptance.

2.2.3 *SPINLINE 3* OSS Design Evaluation

The ***SPINLINE 3*** OSS originally was designed and validated based on the requirements provided in IEC 880-1986, which provides technical and process requirements for the development of software in the safety systems of nuclear power plants. These requirements include the following:

- no interrupts
- no dynamic memory allocation
- no support for event driven multi-tasking
- be simple and include only the functions and components necessary for I&C safety functions
- be self-tested
- include defense-in-depth safety programming
- execution must be safety oriented (i.e., go to a safe position when a failure is detected)

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These requirements represent critical design performance characteristics that were verified and/or validated during the development process described in ***SPINLINE 3*** LTR Section 6.2. Of particular interest to NRC is the validation testing of the ***SPINLINE 3*** OSS. This testing was performed as part of the original software development. As such, it was assessed as part of the Method 2 effort. The critical dependability characteristics for acceptance include the following validation test documents:

- ***SPINLINE 3*** Technical Instruction V&V of software components (Reference 53) - This technical instruction sets the verification and validation rules for safety-classified software components.
- ***SPINLINE 3*** Safety of Processing Unit Software (Reference 54) – Section 2.5 describes the overall Test strategy for the ***SPINLINE 3*** OSS. The tests performed on the Class 1E OSS are:
  - Unit tests of each module - The unit tests are comprised of [[

    ]]
  - Integration tests - The purpose of integration tests is to ensure that mutual relations between software modules and relations between these modules and the target hardware are in accordance with the design.
  - Validation tests - The purpose of validation tests is to check that the software operates in accordance with the specification.
- ***SPINLINE 3*** / OSS / Software Validation Test Plan (Reference 49) - This document constitutes the OSS Validation Tests Analysis for safety class Units. This software is applicable to software developments for 1E-class Units which based on ***SPINLINE 3***-standard boards and are compatible with ***SPINLINE 3*** technology. It defines the strategy employed in the tests performed in order to check that the OSS operates in accordance with specified requirements. The document covers all of the functions indicated in the OSS System Requirements Specification (Reference 46) for safety class Units. Validation tests are defined in a [[

  ]] The critical design performance characteristics validated in the original development process are identified in Section 5 of the Software Validation Test Plan.
- ***SPINLINE 3*** / OSS / Software Validation Test Report (Reference 51) - This document contains the following information:
  - Section 2 provides information of the environment required for the execution of the tests, indicating the hardware, software, and test sets used.

- Section 3 describes the layout and content of the test forms and test reports.
- Section 4 contains all of the test forms corresponding to the tests identified in the Software Validation Test Plan (Reference 49). Each form sets out the test procedure together with the expected results of the tests. This section contains all of the test forms designed for this software, even including those which were not used in the most recent test run.
- Section 5 contains the test run reports for each version of the software,
- The appendices contain all non-conformity reports for each version of the software.

- ***SPINLINE 3*** / CSS / Software Integration Test Plan and Report (Reference 50) - This document contains the following information:
  - Section 2 outlines:
    - the test strategy,
    - the various stages of the integration process and the order in which these steps are performed.
  - Section 3 describes the test facilities required for the integration of the Core System Software (CSS), i.e.:
    - hardware requirements,
    - software requirements,
    - test configurations.
  - Section 4 describes implementation of the tests. This section includes:
    - a description of the test forms and test reports,
    - all procedures for tests and associated verifications. These procedures are referred to later in the test description (test forms).
  - Section 5 gives a detailed description of the tests to be performed at each stage of the integration process.
  - Section 6 relates to test coverage, i.e. the relationship between the modules and the tests for the various steps in the integration process.
  - Section 7 sets out the principles applied to determine which tests need to be run again if the software is upgraded (i.e. tests associated with the upgrade and regression tests).
  - Section 8 contains reports on the different tests performed and includes the following information for each version of the CSS:
    - description of characteristics for the various test sequences performed,
    - a table summarizing data for the test sequences performed,
    - conclusions arising from the test sequences performed.
  - Section 9 provides an index for the different test cases identified in section 2 and for the various test procedures and verifications specified in section 3.
  - Section 10 at the end of the document contains the appendices. There is an appendix for each version of the CSS, containing nonconformance reports covering the non-conformities detected during the different test sequences.

These results demonstrate that the ***SPINLINE 3*** software was appropriately tested with a rigorous validation process, that high quality test documentation was available to describe the testing performed and results obtained, and that the test results remain valid through the implementation of the Rolls-Royce design control and configuration management systems.

The assessment of the ***SPINLINE 3*** platform development process described in ***SPINLINE 3*** LTR Section 6.3 and Appendix A as well as Rolls-Royce document Map of ISG-06 represents the Method 2 data. These development process characteristics represent Method 2 dependability characteristics for acceptance. The ***SPINLINE 3*** Design Analysis Report (MPR Document No. MPR-3337, Revision 1) provides an independent assessment of documented evidence related to the ***SPINLINE 3*** platform software design and software life cycle processes and determine if there is an adequate technical basis for dedication of the platform software using the process defined in EPRI technical reports TR-107330 and TR-106439. MPR's favorable conclusions are documented

in the report. The MPR work builds on previous assessment work they had performed with EPRI on the ***SPINLINE 3*** technology.

All of these documents cited in the Tables in LTR Appendix A and Rolls-Royce document Map of ISG-06 are maintained in the Rolls-Royce records management system.

The use of Method 2 is appropriate to accept the original development test records, since the review for acceptance was done during the dedication period and the review was performed with a program in accordance with 10 CFR Part 50 Appendix B requirements whereas the original validation test was not.

The results of the Method 2 review of the validation testing were favorable. The review found that the development processes (including the original validation testing) were rigor and comparable to US nuclear safety standards, the development documentation was available and of high quality, and the design and test results remain valid.

EPRI TR-106439 envisioned the approach of using the historical development records as a basis for acceptance in a commercial grade dedication review.

EPRI TR-106439 notes on page 3-3 in the discussion on the equivalent assurance for commercial equipment that “Because the vendor does not have a 10 CFR Part 50 Appendix B quality assurance program, the process that was followed in development and verification of the product may not have included all of the elements of an Appendix B program, and documentation of the process may be lacking.” The Rolls-Royce review of the ***SPINLINE 3*** software development process found that it was comparable to an Appendix B program and that the full set of development documentation was available.

EPRI TR-106439 notes on page 3-4 that:

> Additional activities will be required by the dedicator to reach an adequate level of assurance for a commercial grade item. An example would be additional testing needed to supplement the vendor's tests and build confidence in the device and its functionality, or to examine its response to specific conditions or abnormal events. Additional reviews or analyses may be needed (e.g., review of the device design and analysis of its failure modes), depending on the extent of reviews and verifications performed by the vendor during product development. Additional documentation may need to be produced, for example, in areas where it is evident that some process steps were performed by the vendor but not adequately documented.

The Rolls-Royce review of the ***SPINLINE 3*** platform development process found that additional hardware qualification testing was needed to demonstrate performance in to response the specific conditions or abnormal events outlined in the EPRI TR-107330 regimen of Operability and Prudency tests. On the other hand, Rolls-Royce found that no additional activities were required to supplement the original software development process or validation testing.

EPRI TR-106439 notes on page 4-5 in the discussion on performance characteristics that:

> These include the functionality required of the device (the "must-do" functions) and performance related to this functionality (e.g., response time). They also include environmental requirements related to the needed performance (e.g., meeting accuracy requirements over a specified range of ambient temperatures). The acceptance criteria and verification methods for these again are similar to those for analog equipment. However, this category also includes characteristics related to

> failure management and "must-not-do" functions. For example, based on a failure analysis the utility may require specific behavior of the device under certain abnormal or faulted conditions. Acceptance criteria might include items such as detection of classes of failures, and "preferred" or fail-safe failure modes to be entered under prescribed circumstances (e.g., a specific output state required on loss of power or signal input). Verification methods include testing and design reviews, supported by failure analysis and reviews of operating history. These activities can involve Methods 1 (Tests and Inspections), 2 (Commercial Grade Survey), and 4 (Supplier/Item Performance Record) of EPRI NP-5652.

The Rolls-Royce review of the ***SPINLINE 3*** platform development process found that additional hardware qualification testing was needed to demonstrate performance in to response the performance and failure management conditions outlined in EPRI TR-107330 regimen of Operability and Prudency tests. On the other hand, Rolls-Royce found that no additional activities were required to supplement the original software development process or validation testing.

EPRI TR-106439 notes in Table 4-1 on the discussion of performance characteristics that:

> The dedicator typically reviews tests that were performed by the vendor or a third party, and runs supplementary tests as part of the dedication. Some characteristics may be verified through special stress or "challenge" testing performed by the vendor or dedicator (e.g., tests of performance under conditions of high data rates or calculation burden).

The Rolls-Royce review of the ***SPINLINE 3*** platform development process found that additional hardware qualification testing was needed to demonstrate performance in to response the challenge testing outlined in EPRI TR-107330 regimen of Operability and Prudency tests. On the other hand, Rolls-Royce found that no additional activities were required to supplement the original software development process or validation testing.

EPRI TR-106439 Table 4-2 provides an example on the assessment of "built-in quality" for commercial digital equipment that addresses the review of vendor testing:

Review of vendor testing	Functional and performance testing Environmental testing including EMI/RFI Extent of software verification testing (e.g., module, line, or branch coverage) Extent of validation testing (e.g., static, dynamic, random) Extent of challenge testing (e.g., tests specifically designed to uncover failure modes) Documentation of testing

The Rolls-Royce review of the ***SPINLINE 3*** platform development process found that additional hardware qualification testing was needed to demonstrate qualification to environmental, seismic, and EMI/RFI conditions and in to response the challenge testing outlined in EPRI TR-107330 regimen of Operability and Prudency tests. On the other hand, Rolls-Royce found that no additional activities were required to supplement the original software development process or validation testing. The validation tests were found to be comprehensive with regard to functional, performance, and fault management requirements.

2.2.4 *SPINLINE 3* Embedded Firmware Evaluation

The use of a structured design process for the firmware, the robust module type test program, and the integrated validation test with the ***SPINLINE 3*** UC25 N+ hardware and software form the basis for the commercial grade acceptance of the firmware on the 32ACT module, 16 E.ANA ISO module, 32ETOR TI SR module, and NERVIA+ Daughter Board.

These modules were designed to the I&C France Quality Assurance Program applicable to Class 1E hardware, as described in LTR Section 2.1. Roll-Royce established a development process (with associated design and validation instructions) to be used for FPGA development, due to the programmable capability of these components and to their ability to embed potentially complex functions.

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]] (References 97 and 98). The development process used for FPGA- and PLD-based components is briefly described in LTR Section 6.2.10.

The following development documents exist (in French) that describe the design and testing of the 32ACT firmware:

- 32ACT FPGA Requirements Specification (Reference 99)
- 32ACT FPGA Detailed Design Specification (Reference 100)
- 32ACT FPGA Detailed Design Report (Reference 101)
- 32ACT FPGA Test Program Specification (Reference 102)
- 32ACT FPGA Simulation Test Report (Reference 103)
- 32ACT FPGA Programming Instruction (Reference 104)

The following development documents exist (in French) that describe the design and testing of the 16 E.ANA ISO board firmware:

- 16 E.ANA ISO FPGA Requirements Specification (Reference 105)
- 16 E.ANA ISO FPGA Detailed Design Specification (Reference 106)
- 16 E.ANA ISO FPGA Detailed Design Report (Reference 107)
- 16 E.ANA ISO FPGA Test Program Specification (Reference 108)
- 16 E.ANA ISO FPGA Simulation Test Report (Reference 109)
- 16 E.ANA ISO FPGA Programming Instruction (Reference 110)

The following development documents (in French) exist that describe the design and testing of the NERVIA+ Daughter Board firmware:

- NERVIA+ CPLD Requirements Specification (Reference 111)
- NERVIA+ CPLD Detailed Design Specification (Reference 112)
- NERVIA+ CPLD Detailed Design Report (Reference 113)
- NERVIA+ CPLD Test Program Specification (Reference 114)
- NERVIA+ CPLD Simulation Test Report (Reference 115)
- NERVIA+ CPLD Programming Instruction (Reference 116)

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]] (Reference 97). The firmware for the 32ETOR TI SR module was developed in 1998. [[

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The following development documents exist (in French) that describe the design and testing of the 32ACT firmware:

- 5 100 435 511 A, Type Test Procedure for 32ETOR Board
- 5 100 435 512 B, Type Test Report for 32ETOR Board

The 32ACT module, 16 E.ANA ISO module, 32ETOR TI SR module, and NERVIA+ Daughter Board were also included in the validation testing of the ***SPINLINE 3*** OSS, a documented in ***SPINLINE 3*** / OSS / Software Validation Test Plan (Reference 49) and ***SPINLINE 3*** / OSS / Software Validation Test Report (Reference 51).

The 32ACT module, 16 E.ANA ISO module, 32ETOR TI SR module, and NERVIA+ Daughter Board firmware is controlled by the following configuration management procedures (in French):

- Product Identification and Traceability (Reference 117)
- Management of Electronic Board Embedding Programmable Components (Reference 118)
- Configuration Management during Electronic Development (Reference 119)
- Documentation Management of Electronic Sub-Assemblies (Reference 120)

2.2.5 *SPINLINE 3* Embedded Software Evaluation

The Class 1E software embedded in the ICTO Pulse Acquisition Board and the Class 1E software embedded in the NERVIA+ Daughter Board was developed according to the life cycle process, configuration management controls, and Quality Assurance Program applicable to Class 1E software that was used for the development of the ***SPINLINE 3*** OSS, as discussed in LTR Sections 6.2.1 through 6.2.8.

The use of a structured design process for the software and the integrated validation test with the ***SPINLINE 3*** UC25 N+ hardware and software form the basis for the commercial grade acceptance of the Class 1E software embedded in the ICTO Pulse Acquisition and NERVIA+ Daughter Boards. The following development documents exist (in French) that describe the design and testing of the ICTO Pulse Acquisition Board software:

- ICTO Software Requirements Specification (Reference 121)
- ICTO Software Design Description (Reference 122)
- ICTO Software Component Test File (Reference 123)
- ICTO Software Integration Test Plan (Reference 124)
- ICTO Software Integration Test Report (Reference 125)
- ICTO Software Validation Test Plan (Reference 126)
- ICTO Software Validation Test Report (Reference 127)

The following development documents (in French) exist that describe the design and testing of the NERVIA+ Daughter Board software:

- NERVIA+ Software Requirements Specification (Reference 128)
- NERVIA+ Software Preliminary Design Description: Volume 1 - Analysis of Architecture Solutions (Reference 129)
- NERVIA+ Software Preliminary Design Description: Volume 2 - Architecture Description (Reference 130)

- NERVIA+ Software Detailed Design Description: Volume 1 - Description of Functions (Reference 131)
- NERVIA+ Software Design Description (Reference 132)
- NERVIA+ Test Strategy Analysis (Reference 133)
- NERVIA+ Software Integration Test File (Reference 134)
- NERVIA+ Software Validation Test Analysis: Volume 1 - Top Level Document (Reference 135)
- NERVIA+ Software Validation Test Analysis: Volume 2 - RequisitePro Report (Reference 136)
- NERVIA+ Software Validation Test Report (Reference 137)

The ICTO Pulse Acquisition and NERVIA+ Daughter Boards were also included in the validation testing of the ***SPINLINE 3*** OSS, a documented in ***SPINLINE 3*** / OSS / Software Validation Test Plan (Reference 49) and ***SPINLINE 3*** / OSS / Software Validation Test Report (Reference 51). The use of a structured design process for the software and firmware, the robust module type test program, and the integrated validation test with the ***SPINLINE 3*** UC25 N+ hardware and software form the basis for the commercial grade acceptance of the ICTO Pulse Acquisition and NERVIA+ Daughter Boards.

2.3 Method 4 Implementation

Rolls-Royce has been designing and manufacturing safety I&C systems for nuclear power plants for more than 30 years. Rolls-Royce originally developed non-software-based analog safety I&C systems for the Électricité de France (EdF) fleet of 900 megawatt pressurized water reactors (PWRs). In the 1980s, Rolls-Royce designed and deployed two generations of software-based digital safety I&C systems for EdF's later fleet of P4 and N4 PWRs. ***SPINLINE 3*** is the next generation of Rolls-Royce digital safety I&C systems. This chapter provides an overview of ***SPINLINE 3*** development and operational use in the many French and international nuclear power plants where it is currently deployed in a variety of digital safety I&C applications. This historical information is intended to illustrate the substantial legacy of safety I&C developments that led to the ***SPINLINE 3*** digital safety I&C platform.

The operating experience summarized in ***SPINLINE 3*** LTR Section 2 and section 6.1 correlates to the Method 4 data that demonstrates that the ***SPINLINE 3*** technology has operated reliably in typical nuclear power plant environments.

EPRI TR-106349 and EPRI TR-107330 discuss the use of operating experience in support of the commercial grade dedication of a legacy digital system. In particular, operating experience can be used in the following ways:

- If the device has been applied previously (it is not the first of its kind), its operating experience may be reviewed to determine whether it has been satisfactory.
- The qualifier may compensate for shortcomings in legacy software by evaluating documented operating experience in applications similar to nuclear safety related applications, and by performing tests of legacy software to confirm conformance to requirements.
- If operating experience is used as a basis for establishing module failure rates, the PLC manufacturer must have a problem reporting and tracking program.

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From the beginning, Rolls-Royce hardware components and systems were designed, implemented, and qualified in compliance with European nuclear standards, including the International Atomic Energy Agency 50-C-QA code for quality assurance and the French national code RCC-E, which prescribes requirements for qualification of electrical equipment used in French-built nuclear power plants. This experience provided a strong foundation in nuclear safety system design requirements that provide the basis for the modular nature of the ***SPINLINE 3*** technology that provides the flexibility to meet customer performance requirement (e.g., functionality and reliability) and local regulatory requirements (e.g., redundancy, independence, and diversity).

The Rolls-Royce safety software evolved in stages to adapt to the introduction of new digital components and software methods and tools. These evolutionary stages started with software development "from scratch" using low-level manual coding and have now matured into processes based on high-level languages, including application-oriented languages, code re-use and automated code generation.

The P4 SPIN software was developed using life cycle processes targeted to produce "close to zero faults" software. The main features are:

- A "V" model software development cycle
- A top-down modular design
- Design and coding rules aimed at developing reliable software
- A Verification and Validation (V&V) team independent of the software design team
- The verification of all design documents and source code
- "White box" unit testing of all the software modules, achieving 100% branch coverage
- "Black box" validation testing performed at the processing unit level, channel/division/train level, and system level

This technology uses the Motorola 6800 microprocessor with unidirectional and asynchronous communication links for data exchange. A single P4 unit's SPIN system has 52 safety processing units distributed in a four-channel architecture. Today, 20 P4 SPIN systems are in operation with a total of 1,040 safety processing units. P4 SPIN systems have accumulated more than 500 reactor-years of operation.

The P4 SPIN software consists of about 40,000 instructions written in 6800 assembly code. This software includes the application software performing the processing of the safety functions, and

the OSS that performs data acquisition, actuator control, data communication, and hardware self-supervision functions.

This main software development effort took place during the years 1981 and 1982 and was performed according to the guidance in working drafts of the future IEC 880 standard, which was intended to significantly improve the reliability of software used for the implementing nuclear safety functions. The feedback of experience gained on the P4 project was a major input to this IEC 880 standard which was eventually issued in 1986. This experience provided a strong foundation in nuclear safety system software development.

The EdF N4 project deployed 1450 megawatt four-loop PWRs with a fully-computerized Main Control Room that implemented new I&C technologies. For the N4 nuclear power plants, Rolls-Royce developed a new generation of its software-based safety I&C system technology, called N4 SPIN, which is based on the Motorola (now Freescale) MC68000 family of microprocessors and on an Rolls-Royce proprietary high-speed deterministic communications network called NERVIA. The main improvements relative to the P4 SPIN technology were:

- A reduction in the number of separate functional processing units, from seven for P4 to five for N4, enabled by the greater processing power of the 68000 microprocessor;
- The NERVIA digital communications network, which allowed for a significant reduction of electronic boards and wiring; and
- The implementation of software-based voting units for both the Reactor Protection System and the Engineered Safety Feature Actuation System actuators.

A single N4 unit's SPIN system uses 40 safety processing units used in a four channel / two output train system architecture. Today, four N4 SPIN systems are in operation with a total of 160 safety processing units. The same digital safety I&C technology is also employed in the protection systems of 11 research reactors. The N4 SPIN has been in operational use since the first N4 plant commissioning tests in 1991 and has been in commercial operation since 1996. N4 SPIN systems have accumulated more than 50 reactor-years of operation.

The N4 SPIN software consists of about 200,000 instructions implemented in C language, most of them generated from 200 graphical views created using a proprietary Functional Block Diagram language named SAGA.

As for the P4 project, the N4 software was developed with the objective of producing "close to zero faults" software, using basically the same software life cycle processes, but with intensive use of software tools for the tasks that could be automated or assisted.

This main software development effort for the N4 project took place during the years 1988 and 1989 and was performed according to the guidance provided in IEC 880-1986. The basic processes for developing the N4 safety software have not changed since the P4 project. However, process changes were made to take into account the evolution in languages and tools used for the N4 project and evolution in software engineering processes not explicitly required in IEC 880-1986, such as requirements for dedicated software plans.

The ***SPINLINE 3*** platform was developed between 1993 and 1996, based on the N4 technology. It includes enhancements to the N4 hardware and the development of platform software and tools needed to produce an adaptable safety I&C platform suitable for use worldwide in refurbishment of existing nuclear power plant safety I&C systems and for new construction safety I&C systems. The main improvements relative to the N4 SPIN technology are:

- Hardware:
  - New EMC-proofed chassis, cabling, and terminal blocks

- Additional CPU, I/O, and communication boards
- Software:
  - Configurable OSS,
  - An enhanced software engineering tool set, including a platform-dedicated tool to configure and set the parameters for the processing Units and NERVIA networks
  - A non-proprietary version of the SAGA environment called the Safety Critical Application Development Environment (SCADE), developed and maintained by the software company Esterel Technologies.

The software for the ***SPINLINE 3*** platform also builds on N4 software design and experience. The following software was developed for the ***SPINLINE 3*** platform:

- A Class 1E standardized OSS, which creates the environment in which the ***SPINLINE 3*** application software runs
- A Class 1E application-oriented library of re-usable software components
- Class 1E software embedded in the communication board of the 10 megabits/second version of the NERVIA network
- A non-Class 1E set of tools integrated in a software development environment called CLARISSE, which is used for the configuration of the OSS and for the development of the application software for ***SPINLINE 3*** systems

SPINLINE 3 has been implemented successfully for the refurbishment of Class 1E I&C systems on several models of PWR nuclear power plants and on several Russian-designed nuclear power plants, including both VVER and RBMK. ***SPINLINE 3*** also is deployed in safety I&C systems on several new PWRs in the Republic of China. ***SPINLINE 3*** systems have accumulated more than 220 reactor-years of operation.

The life cycle processes for the ***SPINLINE 3*** platform software were established according to the guidance provided in IEC 880-1986 and were documented in dedicated software plans. The ***SPINLINE 3*** software life cycle processes also took into account additional process enhancements employed on the N4 project and ongoing standardization works for a supplement to IEC 880, which was issued in 2000. The experience gained at Rolls-Royce in developing several safety I&C systems using the ***SPINLINE 3*** digital I&C platform was an input to the revision of IEC 880-1986, which started in 2001 and was completed in 2006 as IEC 60880 Edition 2. The project leader for this revision was from Rolls-Royce.

The generic ***SPINLINE 3*** platform now is managed under a quality assurance program that complies with 10 CFR Part 50 Appendix B.

The base of ***SPINLINE*** nuclear operating experience validates performance and has provided opportunities to identify latent errors. As a consequence of the high quality software development, the feedback of experience gained from the P4, the N4, and the ***SPINLINE 3*** safety I&C systems is that no failure with software as a root cause has been detected during operation in installed Class 1E systems. In addition, operating experience with ***SPINLINE 3*** systems and the previous generations of Rolls-Royce digital safety I&C systems has shown no instances where the capability of the safety I&C system to perform its intended safety function(s) was compromised during an anticipated operational occurrence. Specifically, the ***SPINLINE 3*** systems have not experienced an unsafe condition in more than 220 reactor-years of operation as of December 2011.

Rolls-Royce has a problem reporting and tracking system as described in the Rolls-Royce Civil Nuclear SAS Instrumentation & Control Quality Manual (Reference 61). The applicable implementing procedures are identified in ***SPINLINE 3*** LTR Table 3.2-1 Item XV – Nonconforming Materials, Parts of Components and Item XVI – Corrective Action).

3 EPRI TR-106439 CRITICAL CHARACTERISTICS FOR ACCEPTANCE

Critical Characteristics for Acceptance	Acceptance Criteria	Methods of Verification	Application of Methods
Physical			
Product/part identification: • Model/part number • Firmware revision number • Software revision level • Hardware version (e.g., module or circuit board revision level)	Product/part identification for QTS must be identified, including both hardware and software.	Hardware part identifications are documented for the QTS and verified by inspection *(Method 1).* Firmware revision is directly linked to part number verification.	See References 16 and 70.
Physical characteristics of hardware, e.g.: • Size • Mounting Physical characteristics of device interfaces, e.g.: • Power • Signal • Data communications • Human-machine interfaces	Criteria for other physical and interface characteristics are defined for use in project-specific applications.	Physical and interface characteristics verified by review of original design documents *(Method 2).*	See Reference 9 Appendix B.

Critical Characteristics for Acceptance	Acceptance Criteria	Methods of Verification	Application of Methods
Performance Required functionality, e.g.; • Input processing • Specific functions or algorithms required • Output signal requirements • HMI functionality Test and diagnostic functions — on-line and off-line	Functional and performance criteria are defined for use in project-specific applications.	Functional and performance characteristics were verified by review of existing design documents *(Method 2).*	See discussion of input functionality in Section 4 (EPRI TR-107330 Section 4.3.2). See discussion of specific functions or algorithms in Section 4 (EPRI TR-107330 Sections 4.3.4, 4.3.5, and 4.4.1, 4.4.2, 4.4.3, 4.4.5, and 4.4.7). See discussion of output functionality in Section 4 (EPRI TR-107330 Section 4.3.3). See discussion of HMI functionality in Section 4 (EPRI TR-107330 Section 4.5). See discussion of test and diagnostic functions in Section 4 (EPRI TR-107330 Sections 4.2.3.6, 4.2.3.7, and 4.4.6.).

Critical Characteristics for Acceptance	Acceptance Criteria	Methods of Verification	Application of Methods
Performance (cont.)			
Performance requirements related to the required functionality, e.g.: • Response time • Accuracy • Range • Stability • Data throughput rate • Interfaces including the item power, signal and data communication	Performance requirements are defined in the Qualification Plan and the Operability and Prudency Test Procedures (References 27 and 28).	Performance characteristics were verified by testing *(Method 1)*.	See discussion of operability testing in Section 4 (EPRI TR-107330 Sections 5.3, 5.4, and 5.5). The use of a single QTS for the testing is acceptable, since the performance characteristics being verified are determined solely by the basic design.
Environmental conditions (harsh or mild) related to the required functionality and performance, e.g.: • Temperature • Humidity • Seismic • EMI/RFI susceptibility and emissions, and ESD	Performance requirements are defined in the Qualification Plan (Reference 14) and associated test procedures (References 18 through 28). Performance requirements for specific faults (e.g., loss of power) are defined in the Qualification Plan and the Operability and Prudency Test Procedures.	Functional and performance characteristics in the presence of defined environmental conditions were verified by testing *(Method 1)*. Performance characteristics were verified by testing *(Method 1)*.	See discussion of qualification functionality in Section 4 (EPRI TR-107330 Sections 4.3.6, 4.3.7, 4.3.8, and 4.3.9). The use of a single QTS for the testing is acceptable, since the performance characteristics being verified are determined solely by the basic design.

Critical Characteristics for Acceptance	Acceptance Criteria	Methods of Verification	Application of Methods
Performance (cont.) Normal operation of the ***SPINLINE 3*** software. • Successful initialization • Transition to cyclical mode • Execution of self-diagnostic tests to detect and signal failures in the hardware environment • Cycle time management maintaining a fixed cycle time (absence of halts due to cycle time being exceeded) • Acquisition and data management of analog and discrete inputs, including inputs from NERVIA networks • Execution of the application software Transmission of output data to analog and discrete outputs, including outputs to NERVIA networks	The critical characteristics for acceptance were specified in the following test procedures: • System Setup and Checkout Test Procedure (Reference 18) • Environmental Test Procedure (Reference 20) • Seismic Test Procedure (Reference 21) • EMI/RFI Test Procedure (Reference 22) • Electrostatic Discharge Test Procedure (Reference 23) • Electrical Fast Transient Test Procedure (Reference 24) • Surge Withstand Test Procedure (Reference 25) • Operability Test Procedure (Reference 27) Critical design performance characteristics for normal operation validated in the original development process are identified in Section 5 of ***SPINLINE 3*** / OSS / Software Validation Test Plan (Reference 49).	Normal operation of the ***SPINLINE 3*** software was verified by testing *(Method 1).* Functional and performance characteristics were verified by review of existing test documents *(Method 2).*	See Qualification Test Summary Report (Reference 29). The use of a single QTS for the testing is acceptable, since the performance characteristics being verified are determined solely by the basic design. See ***SPINLINE 3*** / OSS / Software Validation Test Report (Reference 51)

Critical Characteristics for Acceptance	Acceptance Criteria	Methods of Verification	Application of Methods
Performance (cont.) Behavior under specific abnormal or faulted conditions: • Response to specific abnormal conditions and events • Fail-safe characteristics	Critical design performance characteristics for abnormal and faulted conditions validated in the original development process are identified in Section 5 of ***SPINLINE 3*** / OSS / Software Validation Test Plan (Reference 49).	Functional and performance characteristics were verified by review of existing test documents *(Method 2).*	See discussion of qualification functionality in Section 4 (EPRI TR-107330 Sections 5.3.H through 5.3.K and 5.4.B). The use of a single QTS for the testing is acceptable, since the performance characteristics being verified are determined solely by the basic design. See ***SPINLINE 3*** / OSS / Software Validation Test Report (Reference 51).

Critical Characteristics for Acceptance	Acceptance Criteria	Methods of Verification	Application of Methods
Dependability			
Reliability related to the required functionality	Criteria for reliability are defined for use in project-specific applications.	Existing reliability calculations and results were reviewed for acceptance methods and results. Review and assess design. *(Method* 2) Operating history data was assessed for adverse performance data. *(Method* 4)	See discussion of reliability in Section 4 (EPRI TR-107330 Sections 4.2.3, 4.7.8.2, 8.6.3.K, 8.6.3.Q, and 8.6.4). See Reference 9 Section 5.2. See discussion in Section 2.3 of this report. See discussion of operating experience in Section 4 (EPRI TR-107330 Sections 4.2.3.8 and 7.6.2). See Reference 9 Sections 2 and 6.1.
Maintainability related to the required functionality	Criteria for maintainability are defined for use in project-specific applications.	Existing design features and documentation were reviewed for applicability to maintainability and testing criteria. *(Method* 2)	See discussion of maintenance in Section 4 (EPRI TR-107330 Sections 4.7). See Reference 9 Section 4.6.

Critical Characteristics for Acceptance	Acceptance Criteria	Methods of Verification	Application of Methods
Dependability (cont.) Built-in quality including: • Quality of design • Quality of manufacture • Failure management • Compatibility with human operators, maintainers	Basic criterion for built-in quality is equivalence to the quality of a device developed and applied under a 10 CFR Part 50 Appendix B program. • Design and design review processes, including software life cycle, V&V, etc. • Design documentation • Configuration management • QA program and practices • Software requirements definition and traceability • Consideration of failure modes and abnormal events in design and verification • Testing by the vendor or dedicator	Review of existing processes and documentation *(Method 2):* • Design, development and verification processes • Quality assurance program and practices • V&V program and practices Design reviews -- architecture review, code reviews, use of analytical techniques, etc. *(Method* 2) Failure analysis, at the component level to support assessment at project-specific system level. Comparison of device's failure modes to needs of the application. *(Method* 2)	See discussion in Section 2.2 of this report. See Reference 9, especially Sections 4, 5, and 6 and Appendix A. See development documentation summary in Reference 10.

Critical Characteristics for Acceptance	Acceptance Criteria	Methods of Verification	Application of Methods
Dependability (cont.) Built-in quality including: • Quality of design • Quality of manufacture • Failure management • Compatibility with human operators, maintainers	Basic criterion for built-in quality is equivalence to the quality of a device developed and applied under a 10 CFR Part 50 Appendix B program. • Product operating history	Review of product operating history *(Method 4):* • Documented (records, traceable) • Sufficient (units, years in service) • Successful (error tracking shows good performance and device including software is stable) • Relevant (same or similar hardware/software configuration, functions used, operated similarly, etc.)	See discussion in Section 2.3 of this report. See Reference 10 documentation summary. See Reference 9 Section 2 for listing of units in service at nuclear power plants. See Reference 9 Section 6.1 for perspective on software stability.

Critical Characteristics for Acceptance	Acceptance Criteria	Methods of Verification	Application of Methods
Dependability (cont.)			
Configuration control and traceability of: • Hardware • Software • Firmware (aspects of both hardware and software configuration control)	Basic criterion for configuration management is equivalence to the quality of a device developed and applied under a 10 CFR Part 50 Appendix B program.	Review existing configuration management program and practices. *(Method* 2).	See discussion of configuration management in Section 4 (EPRI TR-107330 Sections 4.4.4.C, 4.4.5.2, 7.7, and 8.4.N). See Reference 9 Sections 6.2 and 6.4.3 and Tables 3.1-1, 3.2-1, 3.2-2, 3.8-1, 3.8-6, 3.8-7, and 3.8-8,
Problem reporting	As a minimum, problem reporting must be sufficient to support use of product operating history and to allow dedicator to carry out 10 CFR Part 21 responsibilities. Specific criteria should be established (e.g., on coverage, timeliness, reporting to the right organization or department).	Review existing problem reporting procedures and practices. *(Method* 2)	See discussion of problem reporting in Section 4 (EPRI TR-107330 Sections 7.3, 7.8).

Rolls-Royce

4 EPRI TR-107330 REQUIREMENTS AND COMPLIANCE TRACEABILITY MATRIX

Section	Summary of EPRI TR-107330 Requirements [1]	Compliance [2]	Comments
1	Scope. Description of TR scope.	- - -	No requirements.
2	Definitions, Abbreviations, Acronyms. List of definitions, abbreviations, and acronyms used in the TR.	- - -	No requirements.
3	Reference Documents. List of documents referenced in the TR.	- - -	No requirements.
4	System Requirements. (section heading)	- - -	No requirements.
4.1	Overview of Performance Basis. Descriptive information.	- - -	No requirements.
4.2	Functional Requirements. (section heading)	- - -	No requirements.
4.2.1	General Functional Requirements. Descriptive information.	- - -	No requirements.

Section	Summary of EPRI TR-107330 Requirements [1]	Compliance [2]	Comments
4.2.1.A	Response Time. The overall response time from an analog or discrete input exceeding its trip condition to the resulting discrete outputs being set shall be 100 milliseconds or less. Response time shall include time required for input filtering, input module signal conversion, main processor input data acquisition, two scan times of an application program containing 2000 simple logic elements, main processor output data transmission, digital output module signal conversion, and performance of self-diagnostics and redundancy implementation.	Exception	See Reference 9 (Sections 4.2.6 and 4.5). [[ ]] ***SPINLINE 3*** response time varies with system configuration and application program size. For a project-specific application, the theoretical response time would be estimated and if it exceeded the requirement, then the architecture would be modified so that the response time fit in the required limits. The qualification program Operability Test Procedure (Reference 27) verified that the test specimen performed within the expected response times for the test system. See Reference 29 Appendices A, B, C, D, E, and K. See Reference 10 (Items 1.19 and 2.14) for the treatment of project-specific actions.

Section	Summary of EPRI TR-107330 Requirements [1]	Compliance [2]	Comments
4.2.1.B	Discrete I/O. The PLC shall have the capability to provide a total of at least 400 discrete I/O points.	Comply	The modular nature of the ***SPINLINE 3*** technology supports this system requirement using the I/O modules described in Reference 9 (Section 4.3).
4.2.1.C	Analog I/O. The PLC shall have the capability to provide a total of 100 analog I/O points.	Comply	
4.2.1.D	Combined I/O. The PLC shall have the capability to provide a total of 50 analog and 400 discrete I/O points.	Comply	
4.2.2	Control Function Requirements. The PLC shall provide a high-level language designed for control algorithms.	Comply	See Reference 9 (Sections 4.4.4 and 4.4.5).
4.2.3	Availability/Reliability and FMEA. (section heading)	- - -	No requirements.
4.2.3.1	Availability/Reliability Overview. Descriptive information.	- - -	No requirements.
4.2.3.2	Availability/Reliability and Basic Requirements. The overall availability goal of the PLC is 0.99.	Comply	See Reference 9 (Section 5.2) and References 30 – 41. The predicted hardware failure rates demonstrate that the reliability requirements for project-specific systems can be met with the typical redundant architectures used for nuclear power plant safety systems, as demonstrated by the operating experience with ***SPINLINE 3*** (see Reference 9 Section 2.2). See Reference 10 (Items 2.8 and 2.15) for the treatment of project-specific actions.
4.2.3.3	Availability/Reliability Calculation Requirements. An availability calculation shall be prepared which conforms to IEEE 352.	Comply	
4.2.3.3.1	Availability/Reliability Calculation Requirements Applicable to Redundant PLCs. For PLCs that include redundancy, the availability calculation shall address additional, redundancy-specific considerations.	Comply	
4.2.3.4	PLC Fault Tolerance Requirements. Fault tolerance capability shall be addressed in the availability calculation, and included as part of the qualification envelope definition.	Comply	

Section	Summary of EPRI TR-107330 Requirements [1]	Compliance [2]	Comments
4.2.3.5	Failure State/FMEA Requirements. An FMEA analysis shall be performed in accordance with IEEE 352. The analysis shall evaluate the effects of failures of components in the PLC modules on the PLC performance.	Comply	See Reference 9 (Section 5.2) and References 30 – 41. The hardware failure modes and effects were analyzed for each ***SPINLINE 3*** hardware module. The hardware failure modes and effects are used as input to the project-specific evaluation of a complete system. See Reference 10 (Items 2.8 and 2.15) for the treatment of project-specific actions.
4.2.3.6	Failure Detection Requirements. The PLC shall contain features to permit generating an alarm when the on-line fault detection detects a failure. Processor-to-processor communication for fault detection shall meet the given specific performance requirements.	Comply	See Reference 9 (Sections 4.2.9, 4.6.3, 4.6.4, and 4.6.10).
4.2.3.7	Recovery Capability Requirements. The PLC shall include a watchdog timer and power bus monitoring features. Output modules shall initialize to a known state.	Comply	See Reference 9 (Sections 4.2.8, 4.4.3.5.1, and 4.4.3.5.2).

Section	Summary of EPRI TR-107330 Requirements [1]	Compliance [2]	Comments
4.2.3.8	Requirements for Use of Operating Experience. If operating experience is used as a basis for establishing module failure rates, the PLC manufacturer must have a problem reporting and tracking program.	Comply	Rolls-Royce did not use operating experience as a basis for establishing module failure rates. Twelve generic board-level Reliability and Predictive Safety Analysis reports (References 30 – 41) were prepared to assess the failure modes and effects of the individual modules and provide reliability estimates for each board. The board failure rates were calculates using IEC 62380 predictive models rather than operating experience. Failure rates for all electronic components installed in the board were obtained from industry handbooks (e.g., IEC 62380 Reliability Data Handbook, CNET 1993 reliability data handbook RDF93, and CNET 2000 reliability data handbook UTEC80810, or MIL HDBK 217 F reliability data handbook notice 2). See Table Section 7.8 for reference to Rolls-Royce Problem Reporting and Tracking Program procedures.

Section	Summary of EPRI TR-107330 Requirements [1]	Compliance [2]	Comments
4.2.4	Setpoint Analysis Support Requirements. An analysis shall be prepared to provide the information needed to support an application specific setpoint analysis per ISA RP 67.04.	Comply	See References 9 (Section 5.2.2) and 42. See Reference 10 (Items 1.21 and 2.16) for the treatment of project-specific actions.
4.3	Hardware Requirements. (section heading)	- - -	No requirements.
4.3.1	General. (section heading)	- - -	No requirements.
4.3.1.1	Background. Descriptive information.	- - -	No requirements.
4.3.1.2	Requirements Common to All Modules. All modules shall meet or support the general requirements given in Section 4.2.1, and shall meet the range of environmental conditions given in Section 4.3.6. Special requirements apply to single module assemblies that include both inputs and outputs.	Comply	See Table Sections 4.2.1 and 4.3.6. No ***SPINLINE 3*** modules include both inputs and output points on the same module assembly.
4.3.1.3	External Device Requirements. External devices used to meet I/O module requirements shall meet the given specific requirements.	Comply	See specific requirements in applicable table sections.
4.3.1.4	General Redundancy Requirements. Redundant components may be included in the generic PLC platform.	Comply	See References 14, 15, and 27. The ***SPINLINE 3*** qualification test specimen verified proper failover to redundant power supply components.
4.3.2	Input Requirements. (section heading)	- - -	No requirements.

Section	Summary of EPRI TR-107330 Requirements [1]	Compliance [2]	Comments
4.3.2.1	Analog Input Requirements. The PLC shall include modules that provide analog inputs.	Comply	See Reference 9 (Section 4.3.4.2). 16E.ANA ISO board acquires up to 16 analog signals and performs the analog to digital conversion. See Reference 16 for ***SPINLINE 3*** analog input modules included in the qualification program.
4.3.2.1.A	Monotonicity. The analog inputs shall be monotonic to ±1/2 LSB.	Comply	The 16E.ANA ISO board is monotonic by design.
4.3.2.1.B	Number of Channels. Each analog input module shall provide a minimum of four input channels.	Comply	See Reference 9 (Section 4.3.4.2 and Appendix B). 16E.ANA ISO board acquires up to 16 analog signals.
4.3.2.1.C	Over Range. The converted value of each analog input module shall remain at its maximum value for over range inputs up to twice rated.	Exception	See References 9 (Appendix B) and 141. [[ ]]
4.3.2.1.D	Under Range. The converted value of each analog input module shall remain at its minimum value for low range inputs up to the negative of the rated input value.	Exception	See References 9 (Appendix B) and 141. [[ ]]
4.3.2.1.E	Out of Range Indication. Over and under range conditions shall be indicated in a manner available to the application program.	Comply	Data range is managed at Application software level. See References 9 (Sections 4.4.3.6.4 and 4.6.8.2.2 and Table 3.7.1 Item 12) and 141.
4.3.2.1.1	Voltage Input Requirements. (section heading)	- - -	No requirements.

Section	Summary of EPRI TR-107330 Requirements [1]	Compliance [2]	Comments
4.3.2.1.1.A	Analog Voltage Input Module Ranges. The PLC shall include analog voltage input modules with ranges of: 0 to 10 VDC, -10 to 10 VDC, and 0 to 5 VDC.	Partially Comply	See Reference 9 (Section 4.3.4.2 and Appendix B). Input voltage measuring ranges: -10/+10 V and -1/+1 V. ***SPINLINE 3*** analog voltage input modules do not specifically include 0 to 10 VDC and 0 to 5 VDC input ranges.
4.3.2.1.1.B	Analog Voltage Input Module Accuracies. Overall accuracies shall be ± 0.32% of the specified range.	Comply	See Reference 9 (Appendix B). Full scale error: ± 0.1% at 25°C.
4.3.2.1.1.C	Analog Voltage Input Module Resolution. The minimum resolution shall be 12 bits.	Comply	See References 9 (Appendix B) and 141. Analog to digital conversion on 15 bits + 1 bit sign.
4.3.2.1.1.D	Analog Voltage Input Module Common Mode Voltage. The common mode voltage capability shall be at least 10 volts with a common mode rejection ratio of at least 90 dB.	Partially Comply	A voltage criterion is met. Common mode rejection ratio is typically 96 dB but can be 80 dB minimum with unitary gain. External components, especially capacitors to frame ground on I.16EANA board, decrease it further. (References 141 and 142.
4.3.2.1.1.E	Analog Voltage Input Module Response Time. The overall response time of the analog voltage input modules must support the response time requirement given in Section 4.2.1.A.	Comply	See Table Section 4.2.1.A above. See References 9 (Appendix B) and 141.
4.3.2.1.1.F	Analog Voltage Input Module Group-to-Group Isolation. The group-to-group isolation shall be at least ± 30 volts peak.	Comply	Group to group isolation is 500 V_{eff} (Reference 141).
4.3.2.1.1.G	Analog Voltage Input Module Class 1E to Non-1E Isolation. The Class 1E to Non-1E isolation capability shall meet the requirements of Section 4.6.4.	N/A	Analog input modules are not intended for use as a Class 1E to Non-1E isolation device.

Section	Summary of EPRI TR-107330 Requirements [1]	Compliance [2]	Comments
4.3.2.1.1.H	Analog Voltage Input Module Surge Withstand. Surge withstand shall be as given in Section 4.6.2.	Comply	See Reference 25. Surge withstand capability meets IEC 61000-4-5 and IEC 61000-4-12. See Reference 29 Appendix H.
4.3.2.1.1.I	Analog Voltage Input Module Input Impedance. The input impedance shall be at least 1 megohm.	Comply	See Reference 141.
4.3.2.1.2	Current Input Requirements. (section heading)	- - -	No requirements.
4.3.2.1.2.A	Analog Current Input Module Ranges. The PLC shall include analog current input modules with ranges of: 4 to 20 mA and 10 to 50 mA or 0 to 50 mA.	Exception	See Reference 9 (Section 4.3.4.2 and Appendix B). Input current measuring range is ± 20 mA. ***SPINLINE 3*** analog current input modules do not specifically include 10 to 50 mA and 0 to 50 mA input ranges.
4.3.2.1.2.B	Analog Current Input Module Accuracies. Overall accuracies shall be ± 0.35% of the specified range.	Comply	See Reference 9 (Appendix B). Full scale error: ± 0.1% at 25°C.
4.3.2.1.2.C	Analog Current Input Module Resolution. The minimum resolution shall be 12 bits.	Comply	See References 9 (Appendix B) and 141. Analog to digital conversion on 15 bits + 1 bit sign.
4.3.2.1.2.D	Analog Current Input Module Common Mode Voltage. The common mode voltage capability shall be at least 10 volts.	Comply	References 141 and 142.
4.3.2.1.2.E	Analog Current Input Module Common Mode Rejection Ratio. The common mode rejection ratio shall be at least 90 dB.	Comply	References 141 and 142.
4.3.2.1.2.F	Analog Current Input Module Response Time. The overall response time of the analog current input modules must support the response time requirement given in Section 4.2.1.A.	Comply	See References 9 (Appendix B) and 141.
4.3.2.1.2.G	Analog Current Input Module Group-to-Group Isolation. The group-to-group isolation shall be at least ± 30 volts peak for 4 to 20 mA inputs.	Comply	Group to group isolation is 500 V_{eff} (Reference 141).

Section	Summary of EPRI TR-107330 Requirements [1]	Compliance [2]	Comments
4.3.2.1.2.H	Analog Current Input Module Class 1E to Non-1E Isolation. The Class 1E to Non-1E isolation capability shall meet the requirements of Section 4.6.4.	N/A	Analog input modules are not intended for use as a Class 1E to Non-1E isolation device.
4.3.2.1.2.I	Analog Current Input Module Surge Withstand. Surge withstand shall be as given in Section 4.6.2.	Comply	See Reference 25. Surge withstand capability meets IEC 61000-4-5 and IEC 61000-4-12. See Reference 29 Appendix H.
4.3.2.1.2.J	Analog Current Input Module Input Impedance. The input impedance shall be 250 ohms maximum.	Comply	Input impedance is 100 ohms (Reference 141).
4.3.2.1.3	RTD Input Requirements. (section heading)	- - -	No requirements.
4.3.2.1.3.A	RTD Input Module Types. The PLC shall include RTD input modules for use with 2, 3 or 4 wire European (DIN 43 760) or US standard 100 ohm RTDs.	Comply	See Reference 9 (Section 4.3.4.1 and Appendix B). 8PT100 conditioning board acquires and conditions 8 analog signals provided by PT100 platinum temperature sensors. See Reference 16 for ***SPINLINE 3*** RTD input module included in the qualification program.
4.3.2.1.3.B	RTD Input Module Ranges. The PLC shall include RTD input modules with a range of at least 0 to 800°C (32 to 1472°F).	Exception	See Reference 9 (Appendix B). The RTD input module range is 0 to 400°C (32 to 752°F).
4.3.2.1.3.C	RTD Input Module Accuracies. Overall accuracies shall be ± 2°C.	Comply	See Reference 9 (Appendix B). The RTD input module overall accuracy is Accuracy: 0.1% (0.52°C) at 25°C.
4.3.2.1.3.D	RTD Input Module Resolution. The minimum resolution shall be 0.1° or less for both °C or °F scaling.	Comply	See References 141, 146, and 155.

Section	Summary of EPRI TR-107330 Requirements [1]	Compliance [2]	Comments
4.3.2.1.3.E	RTD Input Module Common Mode Voltage. The common mode voltage capability shall be at least 10 volts.	Comply	See References 146, 147, and 155.
4.3.2.1.3.F	RTD Input Module Common Mode Rejection Ratio. The common mode rejection ratio shall be at least 90 dB.	Comply	See References 146, 147 and 155.

Section	Summary of EPRI TR-107330 Requirements [1]	Compliance [2]	Comments
4.3.2.1.3.G	RTD Input Module Response Time. The overall response time of the RTD input modules must support the response time requirement given in Section 4.2.1.A.	Exception	See Table Section 4.2.1.A above. RTD input signal conditioner response time characteristics are: • Time for propagation of the signal on the board (propagation time between input and output) for an input that increases at a rate of 1.5°C per second is less than 100 milliseconds and • Time for stabilization of the output, for an input step change of 400°C is less than 6 seconds. The RTD response time characteristics are long compared to the processor and unique to the RTD used. As such, they are not generic (i.e., not appropriate for platform qualification) and mask the processor response time. The response time to an RTD input was not measured in the qualification tests. The expected time response of a complete RTD channel would be verified for the project-specific application, consistent with applicable safety analysis requirements.
4.3.2.1.3.H	RTD Input Module Group-to-Group Isolation. The group-to-group isolation shall be at least ± 30 volts peak.	Comply	Group to group isolation is 500 V_{eff} (References 146 and 155).

Section	Summary of EPRI TR-107330 Requirements [1]	Compliance [2]	Comments
4.3.2.1.3.I	RTD Input Module Class 1E to Non-1E Isolation. The Class 1E to Non-1E isolation capability shall meet the requirements of Section 4.6.4.	N/A	RTD input modules are not intended for use as a Class 1E to Non-1E isolation device.
4.3.2.1.3.J	RTD Input Module Surge Withstand. Surge withstand shall be as given in Section 4.6.2.	Comply	See Reference 25. Surge withstand capability meets IEC 61000-4-5 and IEC 61000-4-12. See Reference 29 Appendix H.
4.3.2.1.3.K	RTD Input Module Input Impedance. The input impedance shall be 1 megohm minimum.	Comply	See Reference 146.
4.3.2.1.4	Thermocouple Input Requirements. Thermocouple (T/C) input modules must meet performance requirements with 1000 feet of 20 AWG extension wire connected to input.	Comply	This requirement is met by manufacturer product description documentation.
4.3.2.1.4.A	T/C Input Module Types. The PLC shall include T/C input modules for use with type B, E, J, K, N, R, S and T thermocouples over the specified temperature ranges.	N/A	The ***SPINLINE 3*** system does not include external thermocouple input signal conditioners.
4.3.2.1.4.B	T/C Input Module Accuracies. Overall accuracies shall be: Type E: ± 4.5°F, Type J: ± 6.3°F, Type K: ± 7.2°F, Type T: ± 4.5°F.	N/A	The ***SPINLINE 3*** system does not include external thermocouple input signal conditioners.
4.3.2.1.4.C	T/C Input Module Accuracies. Cold junction compensation shall support Section 4.3.2.1.4.B accuracies for the environmental temperature range given in Section 4.3.6.	N/A	The ***SPINLINE 3*** system does not include external thermocouple input signal conditioners.
4.3.2.1.4.D	T/C Input Module Resolution. The minimum resolution shall be 0.1° or less for both °C or °F scaling.	N/A	The ***SPINLINE 3*** system does not include external thermocouple input signal conditioners.
4.3.2.1.4.E	T/C Input Module Common Mode Voltage. The common mode voltage capability shall be at least 10 volts.	N/A	The ***SPINLINE 3*** system does not include external thermocouple input signal conditioners.

Section	Summary of EPRI TR-107330 Requirements [1]	Compliance [2]	Comments
4.3.2.1.4.F	T/C Input Module Common Mode Rejection Ratio. The common mode rejection ratio shall be at least 90 dB.	N/A	The ***SPINLINE 3*** system does not include external thermocouple input signal conditioners.
4.3.2.1.4.G	T/C Input Module Open Detection. The module shall provide open thermocouple detection.	N/A	The ***SPINLINE 3*** system does not include external thermocouple input signal conditioners.
4.3.2.1.4.H	T/C Input Module Response Time. The overall response time of the T/C input modules must support the response time requirement given in Section 4.2.1.A.	N/A	The ***SPINLINE 3*** system does not include external thermocouple input signal conditioners.
4.3.2.1.4.I	T/C Input Module Group-to-Group Isolation. The group-to-group isolation shall be at least ± 30 volts peak.	N/A	The ***SPINLINE 3*** system does not include external thermocouple input signal conditioners.
4.3.2.1.4.J	T/C Input Module Class 1E to Non-1E Isolation. The Class 1E to Non-1E isolation capability shall meet the requirements of Section 4.6.4.	N/A	The ***SPINLINE 3*** system does not include external thermocouple input signal conditioners.
4.3.2.1.4.K	T/C Input Module Surge Withstand. Surge withstand shall be as given in Section 4.6.2.	N/A	The ***SPINLINE 3*** system does not include external thermocouple input signal conditioners.
4.3.2.1.4.L	T/C Input Module Input Impedance. The input impedance shall be 1 megohm minimum.	N/A	The ***SPINLINE 3*** system does not include external thermocouple input signal conditioners.
4.3.2.2	Discrete Input Requirements. The PLC shall include modules that provide discrete inputs. Each module shall provide a minimum of 8 input channels and include indicators that show the ON/OFF status of each point.	Comply	See Reference 9 (Section 4.3.4.3 and Appendix B). 32ETOR TI SR discrete acquisition board performs the acquisition of 32 signals. See Reference 16 for ***SPINLINE 3*** discrete input modules included in the qualification program.

Section	Summary of EPRI TR-107330 Requirements [1]	Compliance [2]	Comments
4.3.2.2.1	Discrete AC Input Requirements. (section heading)	- - -	No requirements.
4.3.2.2.1.A	Discrete AC Input Module Types. The PLC shall include discrete AC input modules for nominal inputs of 120 VAC and 24 VAC.	N/A	The ***SPINLINE 3*** system does not include discrete AC input modules.
4.3.2.2.1.B	Discrete AC Input Module ON Transition. The input must transition to ON at 90 VAC max. (120 VAC input) or 20 VAC max. (24 VAC input).	N/A	The ***SPINLINE 3*** system does not include discrete AC input modules.
4.3.2.2.1.C	Discrete AC Input Module OFF Transition. The input must transition to OFF between 65 to 25 VAC (120 VAC input) or 15 to 6 VAC (24 VAC input).	N/A	The ***SPINLINE 3*** system does not include discrete AC input modules.
4.3.2.2.1.D	Discrete AC Input Module Operating Range. The module must operate for inputs up to at least 150 VAC (120 VAC input) or 40 VAC (24 VAC input).	N/A	The ***SPINLINE 3*** system does not include discrete AC input modules.
4.3.2.2.1.E	Discrete AC Input Module Response Time. The overall response time of the discrete AC input modules must support the response time requirement given in Section 4.2.1.A.	N/A	The ***SPINLINE 3*** system does not include discrete AC input modules.
4.3.2.2.1.F	Discrete AC Input Module Group-to-Group Isolation. The group-to-group isolation shall be at least 600 volts peak for 120 VAC inputs or 100 volts peak for 24 VAC inputs.	N/A	The ***SPINLINE 3*** system does not include discrete AC input modules.
4.3.2.2.1.G	Discrete AC Input Module Class 1E to Non-1E Isolation. The Class 1E to Non-1E isolation capability shall meet the requirements of Section 4.6.4.	N/A	The ***SPINLINE 3*** system does not include discrete AC input modules.
4.3.2.2.1.H	Discrete AC Input Module Surge Withstand. Surge withstand shall be as given in Section 4.6.2.	N/A	The ***SPINLINE 3*** system does not include discrete AC input modules.
4.3.2.2.2	Discrete DC Input Requirements. (section heading)	- - -	No requirements.

Section	Summary of EPRI TR-107330 Requirements [1]	Compliance [2]	Comments
4.3.2.2.2.A	Discrete DC Input Module Types. The PLC shall include discrete DC input modules for nominal inputs of 125 VDC, 24 VDC, 15 VDC and 12 VDC.	Partially Comply	See Reference 9 (Section 4.3.4.3 and Appendix B). 32ETOR TI SR discrete acquisition board performs the acquisition of 32 signals. See Reference 16 for ***SPINLINE 3*** discrete input modules included in the qualification program. ***SPINLINE 3*** discrete DC input modules do not include 12 or 15 VDC input ranges.
4.3.2.2.2.B	Discrete DC Input Module ON Transition. The input must transition to ON at 90 VDC max. (125 VDC input) or 20 VDC max. (24 VDC input).	Comply	The input transitions to ON at 30 VDC max. (125 VDC input) or 11 VDC max. (24 and 48 VDC input). See Reference 157.
4.3.2.2.2.C	Discrete DC Input Module OFF Transition. The input must transition to OFF between 65 to 25 VDC (125 VDC input) or 15 to 6 VDC (24 VDC input).	Comply	The input transitions to OFF between 30 to 25 VDC (125 VDC input) or 11 to 10 VDC (24 and 48 VDC input). See Reference 157.
4.3.2.2.2.D	Discrete DC Input Module Operating Range. The module must operate for inputs up to at least 150 VDC (125 VDC input) or 40 VDC (24 VDC input).	Comply	All system inputs ranges withstand up to 165 VDC. An overvoltage can be detected at 149 V (125 VDC input) or at 31 V (24 VDC input). These overvoltage signals are marked as invalid. See Reference 157.
4.3.2.2.2.E	Discrete DC Input Module Response Time. The overall response time of the discrete DC input modules must support the response time requirement given in Section 4.2.1.A.	Comply	See Table Section 4.2.1.A above. See Reference 90. Acquisition period: <1.15 millisecond.

Section	Summary of EPRI TR-107330 Requirements [1]	Compliance [2]	Comments
4.3.2.2.2.F	Discrete DC Input Module Group-to-Group Isolation. The group-to-group isolation shall be at least 600 volts peak for 125 VDC inputs or 40 volts peak for 24 VDC inputs.	Comply	Each input group is isolated for 2000 VAC from other galvanic groups and mechanical ground linked together. See Reference 157.
4.3.2.2.2.G	Discrete DC Input Module Class 1E to Non-1E Isolation. The Class 1E to Non-1E isolation capability shall meet the requirements of Section 4.6.4.	N/A	Discrete DC input modules are not intended for use as a Class 1E to Non-1E isolation device.
4.3.2.2.2.H	Discrete DC Input Module Surge Withstand. Surge withstand shall be as given in Section 4.6.2.	Comply	See Reference 25. Surge withstand capability meets IEC 61000-4-5 and IEC 61000-4-12. See Reference 29 Appendix H.
4.3.2.2.3	TTL Input Requirements. Requirements for TTL level input modules. Based on exception to this requirement, Sections 4.3.2.2.3.A through 4.3.2.2.3.G are not included in this table.	N/A	The ***SPINLINE 3*** system does not include TTL level input modules.
4.3.2.3	Other Inputs. (section heading)	- - -	No requirements.
4.3.2.3.1	Pulse Input Requirements. The PLC shall include modules that provide pulse inputs.	Comply	See Reference 9 (Section 4.3.4.4 and Appendix B). ICTO board performs the acquisition of two pulse signals. See Reference 16 for ***SPINLINE 3*** pulse input modules included in the qualification program.
4.3.2.3.1.A	Pulse Input Module Input Number. The module shall have at least two inputs.	Comply	See Reference 9 (Section 4.3.4.4 and Appendix B). ICTO board performs the acquisition of two pulse signals.

Section	Summary of EPRI TR-107330 Requirements [1]	Compliance [2]	Comments
4.3.2.3.1.B	Pulse Input Module Range. The module input count frequency range shall be at least 20 to 5000 Hz.	Comply	See Reference 9 (Section 4.3.4.4 and Appendix B). Count rate range: 1 pulse/second to 6.5 10^6 pulses/second.
4.3.2.3.1.C	Pulse Input Module Operation. The input must operate for a pulse range of at least 3 to 28 VDC and a duty cycle of at least 20 microseconds at 90%.	Exception	Voltage: 5 V pulse inputs (3.5 V ≤ Vih ≤ 5 V; 0 ≤ Vil ≤ 0.5 V) Time : pulse width : 20 to 200 nanoseconds See Reference 158.
4.3.2.3.1.D	Pulse Input Module Count Accuracy. The module shall have up and down count modes with a range of at least 9999. The accuracy of the count shall be ± 0.1%.	Exception	[[ ]] See Reference 158.
4.3.2.3.1.E	Pulse Input Module Frequency Accuracy. The module shall have a frequency mode with a range of at least 20 to 5000 Hz. The accuracy of the frequency measurement shall be ± 0.1%.	Comply	[[ ]] For generic precision, refer to Reference 158.

Section	Summary of EPRI TR-107330 Requirements [1]	Compliance [2]	Comments
4.3.2.3.1.F	Pulse Input Module Response Time. The overall response time of the pulse input module must support the response time requirement given in Section 4.2.1.A.	Exception	Reference 9 (Section 4.3.4.4) notes that the board operating modes. The module response time depends on the project-specific application and is defined by the operation mode and by the operating setpoints. According to TR-107330, section 4.2.1, item A, the ICTO board should not be included in the time response evaluation. The expected time response of a complete pulse count channel would be verified for the project-specific application, consistent with applicable safety analysis requirements. See Table Section 4.2.1.A above.
4.3.2.3.1.G	Pulse Input Module Group-to-Group Isolation. The group-to-group isolation shall be at least 40 VDC.	Comply	See Reference 158.
4.3.2.3.1.H	Pulse Input Module Class 1E to Non-1E Isolation. The Class 1E to Non-1E isolation capability shall meet the requirements of Section 4.6.4.	N/A	Pulse input modules are not intended for use as a Class 1E to Non-1E isolation device.
4.3.2.3.1.I	Pulse Input Module Surge Withstand. Surge withstand shall be as given in Section 4.6.2.	Comply	See Reference 25. Surge withstand capability meets IEC 61000-4-5 and IEC 61000-4-12. See Reference 29 Appendix H.
4.3.3	Output Requirements. (section heading)	- - -	No requirements.

Section	Summary of EPRI TR-107330 Requirements [1]	Compliance [2]	Comments
4.3.3.1	Analog Output Requirements. The PLC shall include modules that provide analog outputs.	Comply	See Reference 9 (Section 4.3.4.6 and Appendix B). 6SANA ISO board generates up to six analog signals. See Reference 16 for ***SPINLINE 3*** pulse input modules included in the qualification program.
4.3.3.1.A	Monotonicity. The analog outputs shall be monotonic to ±1/2 LSB.	Comply	The 6SANA ISO board is monotonic by design.
4.3.3.1.B	Number of Channels. Each analog output module shall provide a minimum of four output channels.	Comply	See Reference 9 (Section 4.3.4.6 and Appendix B). 6SANA ISO board generates up to six analog signals,
4.3.3.1.1	Analog Voltage Output Requirements. (section heading)	- - -	No requirements.
4.3.3.1.1.A	Analog Voltage Output Module Ranges. The PLC shall include analog voltage output modules with ranges of: 0 to 10 VDC, -10 to 10 VDC and 0 to 5 VDC. The PLC shall provide differential outputs for these ranges.	Partially Comply	See Reference 9 (Section 4.3.4.6 and Appendix B). 6SANA ISO provides two kinds of voltage output channels: 0/+10 V and or -10/+10 V. ***SPINLINE 3*** analog output modules do not include a 0 to 5 VDC output range.
4.3.3.1.1.B	Analog Voltage Output Module Accuracy. Overall accuracy shall be ± 0.32% of full range.	Exception	See Reference 9 (Section 4.3.4.6 and Appendix B). Full scale error: ± 0.1% at 25°C.
4.3.3.1.1.C	Analog Voltage Output Module Resolution. The minimum resolution shall be 12 bits.	Comply	See Reference 91.
4.3.3.1.1.D	Analog Voltage Output Module Load Impedance. The outputs shall support a load impedance of 1 kilo ohm or greater.	Comply	See Reference 91.

Section	Summary of EPRI TR-107330 Requirements [1]	Compliance [2]	Comments
4.3.3.1.1.E	Analog Voltage Output Module Response Time. The overall response time of the analog voltage output modules must support the response time requirement given in Section 4.2.1.A.	Comply	See Table Section 4.2.1.A above. See Reference 91. Acquisition period: <1 millisecond.
4.3.3.1.1.F	Analog Voltage Output Module Isolation. The group-to-group, module-to-module and module to backplane isolation shall meet the requirements of Section 4.6.4.	Comply	See Reference 26. Class 1E to Non-1E isolation capability meets IEEE 384-1981. See Reference 29 Appendix J.
4.3.3.1.1.G	Analog Voltage Output Module Surge Withstand. Surge withstand shall be as given in Section 4.6.2.	Comply	See Reference 25. Surge withstand capability meets IEC 61000-4-5 and IEC 61000-4-12. See Reference 29 Appendix H.
4.3.3.1.2	Current Output Requirements. (section heading)	- - -	No requirements.
4.3.3.1.2.A	Analog Current Output Module Ranges. The PLC shall include analog current output modules with ranges of: 4 to 20 mA or 0 to 20 mA, and 10 to 50 mA or 0 to 50 mA.	Partially Comply	See Reference 9 (Section 4.3.4.6 and Appendix B). 6SANA ISO provides one kind of current output channel: 4 to 20 mA. ***SPINLINE 3*** analog output modules do not include 0 to 20 mA, 10 to 50 mA or 0 to 50 mA output ranges.
4.3.3.1.2.B	Analog Current Output Module Accuracy. Overall accuracy shall be ± 0.32% of full range.	Comply	See Reference 9 (Section 4.3.4.6 and Appendix B). Full scale error: ± 0.1% at 25°C.
4.3.3.1.2.C	Analog Current Output Module Resolution. The minimum resolution shall be 12 bits.	Comply	See Reference 91.
4.3.3.1.2.D	Analog Current Output Module Load Impedance. The 4 to 20 mA outputs shall support a load impedance of 1 kilo ohm or less.	Comply	The load impedance supported is ~620 ohm. (See References 91, 148, 149, and 150)

Section	Summary of EPRI TR-107330 Requirements [1]	Compliance [2]	Comments
4.3.3.1.2.E	Analog Current Output Module Response Time. The overall response time of the analog current output modules must support the response time requirement given in Section 4.2.1.A.	Comply	See Table Section 4.2.1.A above. See Reference 91.
4.3.3.1.2.F	Analog Current Output Module Isolation. The group-to-group, module-to-module and module to backplane isolation shall meet the requirements of Section 4.6.4.	Comply	See Reference 26. Class 1E to Non-1E isolation capability meets IEEE 384-1981. See Reference 29 Appendix J.
4.3.3.1.2.G	Analog Current Output Module Surge Withstand. Surge withstand shall be as given in Section 4.6.2.	Comply	See Reference 25. Surge withstand capability meets IEC 61000-4-5 and IEC 61000-4-12. See Reference 29 Appendix H.
4.3.3.2	Discrete Output Requirements. The PLC shall include modules that provide discrete outputs.	Comply	See Reference 9 (Section 4.3.4.5 and Appendix B). 32ACT actuator drive board manages up to 32 discrete outputs. See Reference 19 for ***SPINLINE 3*** pulse input modules included in the qualification program.
4.3.3.2.A	Number of Channels. Each module shall provide a minimum of 8 output channels.	Comply	See Reference 9 (Section 4.3.4.5 and Appendix B). 32ACT actuator drive board manages up to 32 discrete outputs.

Section	Summary of EPRI TR-107330 Requirements [1]	Compliance [2]	Comments
4.3.3.2.B	Leakage Current. Leakage current in the OFF state of non-supervised (no internal ringback) modules shall be less than 80% of the minimum current needed to turn ON any digital input module.	Comply	For 32ACT: outputs are supervised and leakage current is 1.2 mA. When put in parallel (by the MV16), the maximum leakage current is then 2.4 mA. It is less than the maximum leakage current of 10 mA tolerated by the 8SRelay (type 1 or 2), which is the only module driven by the 32ACT. (See References 93, 143, and 156).
4.3.3.2.C	Output Circuit Interrupter. Outputs must include a circuit interrupter.	Exception	***SPINLINE 3*** system does not provide discrete output circuit interrupters.
4.3.3.2.D	Status Indication. Modules must include indicators that show the ON/OFF status of each point.	Exception	***SPINLINE 3*** system does not provide discrete output status indication.
4.3.3.2.1	Discrete AC Output Requirements. (section heading)	- - -	No requirements.
4.3.3.2.1.A	Discrete AC Output Module Types. The PLC shall include discrete AC output modules for nominal outputs of 120 VAC and 24 VAC.	N/A	The ***SPINLINE 3*** system does not include discrete AC input modules.
4.3.3.2.1.B	Discrete AC Output Module Output Current. The output must operate with an output current between 50 mA and 0.5 amps with an inrush capability of at least 2 amps.	N/A	The ***SPINLINE 3*** system does not include discrete AC input modules.
4.3.3.2.1.C	Discrete AC Output Module ON State Voltage Drop. The ON state voltage drop shall not exceed 2 VAC at 0.5 amps.	N/A	The ***SPINLINE 3*** system does not include discrete AC input modules.

Section	Summary of EPRI TR-107330 Requirements [1]	Compliance [2]	Comments
4.3.3.2.1.D	Discrete AC Output Module OFF State Leakage. The OFF state leakage current shall not exceed 2 mA.	N/A	The ***SPINLINE 3*** system does not include discrete AC input modules.
4.3.3.2.1.E	Discrete AC Output Module Operating Range. The modules must operate for point source inputs at 47 Hz to 63 Hz over the range 90 to 130 VAC min. (120 VAC output).	N/A	The ***SPINLINE 3*** system does not include discrete AC input modules.
4.3.3.2.1.F	Discrete AC Output Module Response Time. The overall response time of the discrete AC output modules must support the response time requirement given in Section 4.2.1.A.	N/A	The ***SPINLINE 3*** system does not include discrete AC input modules.
4.3.3.2.1.G	Discrete AC Output Module Group-to-Group Isolation. The group-to-group isolation shall be at least 600 volts peak for 120 VAC outputs.	N/A	The ***SPINLINE 3*** system does not include discrete AC input modules.
4.3.3.2.1.H	Discrete AC Output Module Class 1E to Non-1E Isolation. The Class 1E to Non-1E isolation capability shall meet the requirements of Section 4.6.4.	N/A	The ***SPINLINE 3*** system does not include discrete AC input modules.
4.3.3.2.1.I	Discrete AC Output Module Surge Withstand. Surge withstand shall be as given in Section 4.6.2.	N/A	The ***SPINLINE 3*** system does not include discrete AC input modules.
4.3.3.2.2	Discrete DC Output Requirements. (section heading)	- - -	No requirements.
4.3.3.2.2.A	Discrete DC Output Module Types. The PLC shall include discrete DC output modules for nominal outputs of 125 VDC, 48 VDC, 24 VDC, 15 VDC and 12 VDC.	Partially Comply	See Reference 9 (Section 4.3.4.5 and Appendix B). 32ACT actuator drive board manages up to 32 discrete outputs. See Reference 16 for ***SPINLINE 3*** pulse input modules included in the qualification program. ***SPINLINE 3*** discrete output modules do not include 125 VDC, 48 VDC, 15 VDC, and 12 VDC output ranges.

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Section	Summary of EPRI TR-107330 Requirements [1]	Compliance [2]	Comments
4.3.3.2.2.B	Discrete DC Output Module Output Current. The outputs must operate with an output current between 50 mA and 0.5 amps with an inrush capability of at least 2 amps.	Comply	See References 93, 144, and 145 for 32ACT. See Reference 143 for 8SRELAY.
4.3.3.2.2.C	Discrete DC Output Module ON State Voltage Drop. The ON state voltage drop shall not exceed 2 VDC at 0.5 amps.	Exception Comply	See References 93 and 156 for 32ACT. The voltage does not exceed 3.3 VDC at 0.5 amps. See Reference 143 for 8SRELAY.
4.3.3.2.2.D	Discrete DC Output Module OFF State Leakage. The OFF state leakage current shall not exceed 2 mA.	Partially Comply Comply	See References 93 and 156 for 32ACT. 1.2 mA at 24 VDC. Leakage current is roughly proportional to polarization voltage and stays under 2 mA until 40 VDC, while maximum polarization voltage is 60 VDC. Established by design for 8SRELAY.
4.3.3.2.2.E	Discrete DC Output Module Operating Range. The module points must operate for source inputs of 90 to 140 VDC min. (125 VDC output), 35 to 60 VDC min. (48 VDC output), and 20 to 28 VDC min. (24 VDC output).	Partially Comply Comply	See References 93 and 156 for 32ACT (24 VDC output only). See Reference 143 for 8SRELAY.
4.3.3.2.2.F	Discrete DC Output Module. The overall response time of the discrete DC output modules must support the response time requirement given in Section 4.2.1.A.	Comply	See Table Section 4.2.1.A above. See References 92 and 93. Acquisition period: < 0.1 millisecond.

Section	Summary of EPRI TR-107330 Requirements [1]	Compliance [2]	Comments
4.3.3.2.2.G	Discrete DC Output Module Group-to-Group Isolation. The group-to-group isolation shall be at least twice nominal output.	Comply	Group to group isolation is 500 VDC (References 93, 143, and 156).
4.3.3.2.2.H	Discrete DC Output Module Class 1E to Non-1E Isolation. The Class 1E to Non-1E isolation capability shall meet the requirements of Section 4.6.4.	Comply	See Reference 26. Class 1E to Non-1E isolation capability meets IEEE 384-1981. See Reference 29 Appendix J.
4.3.3.2.2.I	Discrete DC Output Module Surge Withstand. Surge withstand shall be as given in Section 4.6.2.	Comply	See Reference 25. Surge withstand capability meets IEC 61000-4-5 and IEC 61000-4-12. See Reference 29 Appendix H.
4.3.3.2.3	Relay Output Requirements. (section heading)	- - -	No requirements.
4.3.3.2.3.A	Relay Output Module Types. The PLC shall include relay output modules that provide normally open and normally closed contacts.	Comply	See Reference 9 (Section 4.3.4.5 and Appendix B). 8SRELAY1 and 8SRELAY2 relay output modules provide normally open and normally closed contacts. See Reference 16 for ***SPINLINE 3*** pulse input modules included in the qualification program.
4.3.3.2.3.B	Relay Output Module Output Current. The continuous current carrying capacity must be at least 2 amps with make and break switching capability of at least 750 VA for AC and 150 watts for DC.	Exception	Make and break switching capability of 1.4 A @ 220 VAC or VDC and L/R = 40 milliseconds (type 2 relays) with series connection of contacts. Make and break switching capability of 0.3 A @ 220 VAC or VDC and L/R = 40 milliseconds (type 1 relays). See References 143 and 159.

Section	Summary of EPRI TR-107330 Requirements [1]	Compliance [2]	Comments
4.3.3.2.3.C	Relay Output Module Contact Resistance. The contact resistance shall not exceed 2 ohms.	Comply Exception	See References 93, 144, and 145. See Reference 143 (30 milliohm maximum for FD470 and 250 milliohm maximum for F480) for 8SRELAY.
4.3.3.2.3.D	Relay Module Operating Range. The contacts must operate from a source of up to 30 VDC or 150 VAC.	Comply	See Reference 143.
4.3.3.2.3.E	Relay Output Module Response Time. The overall response time of the relay output module must support the response time requirement given in Section 4.2.1.A.	Comply	See Reference 9 (Appendix B). Response time is 15 milliseconds.
4.3.3.2.3.F	Relay Output Module Group-to-Group Isolation. The group-to-group isolation shall be at least 600 volts peak.	Comply	Isolation is 1.5 kV_{rms} or 2.1 kV DC (Reference 143).
4.3.3.2.3.G	Relay Output Module Class 1E to Non-1E Isolation. The Class 1E to Non-1E isolation capability shall meet the requirements of Section 4.6.4.	Comply	See Reference 26. Class 1E to Non-1E isolation capability meets IEEE 384-1981. See Reference 29 Appendix J.
4.3.3.2.3.H	Relay Output Module Surge Withstand. Surge withstand shall be as given in Section 4.6.2.	Comply	See Reference 25. Surge withstand capability meets IEC 61000-4-5 and IEC 61000-4-12. See Reference 29 Appendix H.
4.3.3.2.4	TTL Output Requirements. Requirements for TTL level output modules. Sections 4.3.3.2.4.A through 4.3.3.2.4.F are not included in this table.	N/A	The ***SPINLINE 3*** system does not include TTL level input modules.
4.3.4	Processor/Other System Component Requirements. (section heading)	- - -	No requirements.

Section	Summary of EPRI TR-107330 Requirements [1]	Compliance [2]	Comments
4.3.4.1	Processor Loop Time Requirements. Processor loop time shall support the response time requirement given in Section 4.2.1.A. Also, processor loop time shall be faster than the longer of the analog input conversion time or the period associated with 2.5 times the analog filter cutoff frequency.	Comply	See Table Section 4.2.1.A above. Analog input filter (first order): 75 Hz (See Reference 9 Appendix B). QTS cycle time: 20 milliseconds (See Reference 15).
4.3.4.2	Memory Capacity and Data Retention Capability Requirements. The memory capacity of the main processor shall provide sufficient memory to execute a single application program with the number of program elements given. The memory used to contain the program shall be capable of retaining the information for a minimum of 6 months with no power applied. Any memory used for field modifiable constants shall be capable of at least 100,000 write cycles.	Comply Comply Comply	See References 9 (Section 4.2.3), 160, and 161. 2 megabytes of read-only flash memory, 2 megabytes of write-protected RAM for operational system software and application software execution, 2 megabytes of RAM for data space, and 64 kilobytes of non-volatile EEPROM memory. EEPROM: Comply (100 year data retention; 100,000 write cycles) Flash : (20 year data retention; 1,000,000 write cycles)

Section	Summary of EPRI TR-107330 Requirements [1]	Compliance [2]	Comments
4.3.4.3	Data Acquisition Requirements. The PLC shall be capable of transferring information between the main processor and I/O modules mounted in the same or expansion chassis. The data transfer rate shall support the response time requirement given in Section 4.2.1.A.	Comply	See Reference 9 (Section 4.3.2.2). The BAP bus interconnects the UC25 N+ CPU board to the different I/O boards. The UC25 N+ CPU board controls the BAP bus with the ***SPINLINE 3*** Operational System Software (OSS) through an asynchronous protocol. The data transfer rate is included in the CPU cycle time. Refer to item 4.2.1.A See References 46 and 51 for generic validation testing of ***SPINLINE 3*** platform communication features. The qualification program Operability Test Procedure (Reference 27) verified that the test specimen performed within the expected response times for the test system. See Reference 29 Appendices A, B, C, D, E, and K.
4.3.4.3.A	Main Chassis Interconnect Device Operation. Devices used to interface remote or expansion chassis to the main chassis shall meet the range of environmental conditions given in Section 4.3.6. Failures of the chassis interconnect devices shall not defeat the ability to transfer data on the main chassis.	N/A	Expansion chassis are not used for ***SPINLINE 3***.

Section	Summary of EPRI TR-107330 Requirements [1]	Compliance [2]	Comments
4.3.4.3.B	Main Chassis Interconnect Device Failure. Failures of the chassis interconnect devices shall not affect memory capacity or main processor data retention.	N/A	Expansion chassis are not used for ***SPINLINE 3***.
4.3.4.3.C	Main Chassis Interconnect Device Loss of Power. Loss of power to chassis interconnect devices shall not defeat the ability to transfer data on the main chassis or I/O on any other chassis.	N/A	Expansion chassis are not used for ***SPINLINE 3***.
4.3.4.3.D	Main Chassis Interconnect Device Class 1E to Non-1E Isolation. The Class 1E to Non-1E isolation capability shall meet the requirements of Section 4.6.4.	N/A	Expansion chassis are not used for ***SPINLINE 3***.
4.3.4.3.E	Main Chassis Interconnect Device Surge Withstand. Surge withstand shall be as given in Section 4.6.2.	N/A	Expansion chassis are not used for ***SPINLINE 3***.
4.3.4.3.F	Main Chassis Interconnect Device Data Acquisition Time. Data acquisition time shall be deterministic or manufacturer shall provide information to establish timing effect.	N/A	Expansion chassis are not used for ***SPINLINE 3***.
4.3.4.3.G	Redundant Inter-Processor Data Acquisition Backplane Busses. Descriptive information.	- - -	No requirements.
4.3.4.3.G.1	Redundant Inter-Processor Data Acquisition Backplane Busses. Busses shall be at least dual redundant.	N/A	The ***SPINLINE 3*** system does not use redundant backplane busses.
4.3.4.3.G.2	Redundant Inter-Processor Data Acquisition Backplane Busses. Loss of one bus shall not cause misoperation.	N/A	The ***SPINLINE 3*** system does not use redundant backplane busses.
4.3.4.3.G.3	Redundant Inter-Processor Data Acquisition Backplane Busses. Loss of all busses shall not result in an indeterminate operation.	N/A	The ***SPINLINE 3*** system does not use redundant backplane busses.
4.3.4.3.G.4	Redundant Inter-Processor Data Acquisition Backplane Busses. External alarm shall be activated on loss of one bus.	N/A	The ***SPINLINE 3*** system does not use redundant backplane busses.
4.3.4.3.G.5	Redundant Inter-Processor Data Acquisition Backplane Busses. Data acquisition time shall be deterministic.	N/A	The ***SPINLINE 3*** system does not use redundant backplane busses.

Section	Summary of EPRI TR-107330 Requirements [1]	Compliance [2]	Comments
4.3.4.3.G.6	Redundant Inter-Processor Data Acquisition Backplane Busses. Operation of busses shall support the response time requirement given in Section 4.2.1.A.	N/A	The ***SPINLINE 3*** system does not use redundant backplane busses.
4.3.4.4	Communication Port Requirements. The main processor shall provide at least one communication port.	Comply	See Reference 9 (Sections 4.3.2.3, 4.3.3, 4.3.4.8 and Appendix B).
4.3.4.4.A	Communication Port Data Rate. The port shall support data rates up to 9600 baud.	Comply	See Reference 9 (Sections 4.2.3 and 4.3.4.8). High speed, deterministic Class 1E digital communications network: NERVIA is a 10 megabit per second, broadcast type network that implements a time-based token bus communications protocol.
4.3.4.4.B	Communication Port Interface. The port shall support RS-232, RS-422, RS-485 or other widely used protocol.	Comply	See Reference 9 (Sections 4.3.4.8, 4.5 and Table 3.6-1). The ***SPINLINE 3*** NERVIA communication protocol The protocol is a “time based token bus protocol. The software is proprietary software developed by Rolls-Royce. The medium is based on IEEE Standard 802.3.
4.3.4.4.C	Communication Port Connector. The port shall provide positive hold down of connectors.	Comply	See Reference 9 Appendix B.

Section	Summary of EPRI TR-107330 Requirements [1]	Compliance [2]	Comments
4.3.4.4.D	Communication Port Isolation. For multiple ports, the port-to-port isolation shall be at least 300 volts peak.	Comply	UC25N+: Ethernet port (front panel) ×1: 1500 VDC galvanic isolation. LSA – asynchronous serial link (front panel): 1500 VDC isolation. See Reference 162. I.NERVIA+: Each NERVIA network has galvanic insulation of 500 VDC. See Reference 163. Hubs galvanic isolation: 1500 VAC / 2250 VDC.
4.3.4.4.E	Communication Port Class 1E to Non-1E Isolation. The Class 1E to Non-1E isolation capability shall meet the requirements of Section 4.6.4.	N/A	Communication ports are not intended for use as a Class 1E to Non-1E isolation device.
4.3.4.4.F	Communication Port Surge Withstand. Surge withstand shall be as given in Section 4.6.2.	Comply	See Reference 25. Surge withstand capability meets IEC 61000-4-5 and IEC 61000-4-12. See Reference 29 Appendix H.
4.3.4.5	Coprocessor Module Requirements. Detailed requirements for coprocessors that may be installed in I/O slots but contain local processing capability independent of the main processor.	Comply	The ***SPINLINE 3*** system uses a coprocessor that is integral to the UC25+ CPU module. See Reference 9 (Sections 4.3.3 and 4.3.4.7 and Appendix B). Operation of ***SPINLINE 3*** coprocessors is invoked automatically during operation independent of any application software program. Coprocessor processing capability performance is inherently tested during all qualification tests..

Section	Summary of EPRI TR-107330 Requirements [1]	Compliance [2]	Comments
4.3.4.6	Chassis Requirements. Chassis must be suitable for mounting in a standard 19 inch rack, and must have adequate strength and provide positive hold down of modules sufficient to meet seismic withstand requirements.	Partially Comply	See Reference 9 (Section 4.3.2.1), 21, and 76. See Reference 29 Appendix E. Some seismic test deficiencies will be resolved by a second round of qualification testing.
4.3.4.7	Backup Devices/Redundancy Requirements. Descriptive information.	- - -	No requirements.
4.3.4.7.A	Redundant Device Requirements. Transfer to a redundant device shall occur within the larger of the main processor scan cycle or three data conversion cycles of the failed module.	Comply	See References 14, 15, and 27. The ***SPINLINE 3*** qualification test specimen verified proper failover to redundant power supply components. See Reference 29 Appendices A, B, C, D, E, and K.
4.3.4.7.B	Redundant Device Requirements. Undetected failures in redundant components shall be detectable during periodic surveillance.	Comply	For the case of DC/DC power supplies: they operate in parallel and deliver approximately each half of the power supply voltage. Both are continuously monitored with a relay device. Any required periodic testing of the relays will be specified on a project-specific basis in accordance with the generic plan to develop project-specific preventive maintenance recommendations (Reference 57).
4.3.4.7.C	Redundant Device Requirements. Diagnostics shall not result in indeterminate failure states and repetitive switching between redundant components.	Comply	See References 14, 15, and 14. The ***SPINLINE 3*** qualification test specimen verified proper failover to redundant power supply components.

Section	Summary of EPRI TR-107330 Requirements [1]	Compliance [2]	Comments
4.3.4.7.D	Redundant Device Requirements. Requirements for effect of transfer mechanism operation on input/output module operation.	Comply	See References 14, 15, and 14. The ***SPINLINE 3*** qualification test specimen verified proper failover to redundant power supply components.
4.3.5	Programming Terminal Requirements. Special programming terminal hardware or software shall meet the requirements of Sections 4.4.4, 7.7.2 and 7.5.2.	Comply	See Reference 9 (Sections 4.4.4, 6.2.9, and 6.2.10). The ***SPINLINE 3*** programming tools are not intended for use by the end user.
4.3.6	Environmental Requirements. (section heading)	- - -	No requirements.
4.3.6.1	Normal Environmental Basic Requirements. The normal PLC operating environment is: Temperature Range: 16 to 40ºC (60 to 104ºF). Humidity Range: 40 to 95% (non-condensing) Power Source Range: As given in Section 4.6.1.1 Radiation Exposure: Up to 1000 Rads	Comply	See References 19 and 20. Verified by radiation withstand and environmental qualification testing. See Reference 29 Appendices C and D.
4.3.6.2	Abnormal Environmental Basic Requirements. The abnormal PLC operating environment is: Temperature Range: 4 to 50ºC (40 to 120ºF). Humidity Range: 10 to 95% (non-condensing) Power Source Range: As given in Section 4.6.1.1 Radiation Exposure: Up to 1000 Rads	Comply	See References 19 and 20. Verified by radiation withstand and environmental qualification testing. See Reference 29 Appendices C and D.
4.3.6.3	Environmental Withstand Specific Requirements. PLC shall operate for the temperature/humidity profile given in TR Figure 4-4 with operability as given in Section 5.3. Evaluations may be used to establish radiation withstand capability.	Comply	See References 19 and 20. Verified by radiation withstand and environmental qualification testing. See Reference 29 Appendices C and D.

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4.3.7	EMI/RFI Withstand Requirements. The PLC shall withstand EMI/RFI levels given in EPRI TR-102323. When exposed to the radiated and conducted test levels, the PLC processors shall continue to function, I/O data transfer shall not be interrupted, discrete I/O shall not change state, analog I/O shall not vary more than 3%.	Comply	See References 22 and 24. Verified by EMC qualification testing. See Reference 29 Appendices F and G. Additional testing from 1 – 8 GHz will be performed in a second round of qualification testing, as recommended by Regulatory Guide 1.180, Revision 1.
4.3.8	Electrostatic Discharge (ESD) Withstand Requirements. The PLC shall withstand ESD levels given in EPRI TR-102323 (8 kV for direct contact discharge and 15 kV for air discharge).	Partially Comply	See Reference 23. Verified by ESD qualification testing. See Reference 29 Appendix I. ESD Testing of the ***SPINLINE 3*** QTS was performed to maximum ESD test levels of 8 kV for air discharges and 6 kV for contact discharges. These levels correspond to IEC 61000-4-2 Level 3 installations. Testing to contact discharges included the lower levels of 4 kV and 2 kV. Testing to air discharges included the lower levels of 4 kV and 2 kV.
4.3.9	Seismic Withstand Requirements. PLC shall be suitable for qualification as a Category 1 Seismic device. The PLC shall meet performance requirements during and after exposure to OBE and SSE levels shown in TR Figure 4-5. Relay contacts of relay output modules shall not chatter.	Partially Comply	See Reference 21. Verified by seismic qualification testing. See Reference 29 Appendix E. Some seismic test deficiencies will be resolved by a second round of qualification testing.
4.4	Software/Firmware. (section heading)	- - -	No requirements.
4.4.1	Executive. (section heading)	- - -	No requirements.

Section	Summary of EPRI TR-107330 Requirements [1]	Compliance [2]	Comments
4.4.1.1	Background. Descriptive information.	- - -	No requirements.
4.4.1.2	Main Processor Executive Capability Requirements. The main processor executive shall: A. Acquire inputs from the modules. B. Implement the application program in a continuous loop. C. Load outputs to the modules. D. Perform power-up and run time diagnostics. E. Manage communications. F. Upload application programs. G. Support on-line diagnostics, maint. and troubleshooting. H. Implement the application program functions. I. Perform power-up initialize functions. J. Implement redundancy functions.	Comply	See References 9 (Sections 4.2.6, 4.4.4, 4.4.5, and 4.5), 46, and 48.
4.4.1.3	Program Flow Control Requirements. Requirements for PLCs where scanning of the inputs and application program execution are performed in parallel. The use of application program interrupts shall be restricted. The use of interrupts that result in non-deterministic application program execution should not be permitted. Requirements for PLCs that implement interrupts that could result in non-deterministic application program execution.	N/A Comply Comply	See References 9 (Sections 4.2.6, 4.4.3.1, 4.4.3.2, and 4.4.5.1 and Table 3.10-1 Item B2e), 46, and 48. ***SPINLINE 3*** software operates deterministically. Software units run cyclically and sequentially. A fixed-duration unit cycle is always composed of the following steps: • Self-monitoring • Cycle time management • Data acquisition • Application processing • Data output • Local terminal management

Section	Summary of EPRI TR-107330 Requirements [1]	Compliance [2]	Comments
4.4.1.4	Unintended/Unused Function Isolation Requirements. Descriptive information.	- - -	No requirements.
4.4.1.5	Coprocessor Executive Capability. (section heading)	- - -	No requirements.
4.4.1.5.1	Coprocessor Executive Capability Background. Descriptive information.	- - -	No requirements.
4.4.1.5.2	Coprocessor Executive Capability Requirements. Requirements for coprocessor resident executives or invoked utilities.	Comply	he ***SPINLINE 3*** system uses a coprocessor that is integral to the UC25+ CPU module. See Reference 9 (Sections 4.3.3 and 4.3.4.7 and Appendix B). ***SPINLINE 3*** coprocessors are not user programmable. ***SPINLINE 3*** executive software includes coding for control and operation of embedded coprocessors.
4.4.2	Media Requirements. Software media provided by the manufacturer shall be high quality and new. CD-ROMS or 3-1/2 inch floppy disks are acceptable. Packaging shall preclude damage during shipping. Media shall be clearly labeled including revision and serial number. Media shall include electronic identification.	Comply	The ***SPINLINE 3*** software is provided on EEPROMs and can be provided on CD-ROMs. See References 94 and 95.
4.4.3	Ladder Logic Requirements. Descriptive information.	- - -	No requirements.
4.4.3.A	Standard Functions. Simple normally inactive and normally active paths.	Comply	See References 81 and 82.
4.4.3.B	Standard Functions. Transition ON/OFF (one-shot) paths.	Comply	See References 81 and 82.
4.4.3.C	Standard Functions. Simulate break before make and make before break contact actions.	Comply	See References 81 and 82.
4.4.3.D	Standard Functions. Coils that change paths from normal to alternate states when energized.	Comply	See References 81 and 82.

Section	Summary of EPRI TR-107330 Requirements [1]	Compliance [2]	Comments
4.4.3.E	Standard Functions. Coils that change paths from normal to alternate states when energized and remain there until the coils are de-energized and a reset signal is applied.	Comply	See References 81 and 82.
4.4.3.F	Standard Functions. Timing functions that can be set from 0.1 seconds to 2 hours.	Comply	See References 81 and 82.
4.4.3.G	Standard Functions. Counters that perform up or down counting from at least 1 to 9999.	Comply	See References 81 and 82.
4.4.3.H	Standard Functions. Methods to perform less than, equal to and greater than numeric comparisons.	Comply	See References 81 and 82.
4.4.3.I	Standard Functions. Addition, subtraction, multiplication, and division functions for integer and floating point numbers. Out of range and error on division by zero.	Comply	See References 81 and 82.
4.4.3.J	Standard Functions. Square root, exponentiation and logarithm functions. Out of range indications.	Comply	See References 81 and 82.
4.4.3.K	Standard Functions. A PID algorithm with 5 to 500% proportional band, 1% resolution, 0 to 100 repeats per minute integral action, 1 repeat per second resolution, anti-reset windup, 0 to 100 minutes rate action, 1 second resolution, output limiting, out of range indication, bumpless transfer to external switch activated manual control, cascade control.	N/A	The ***SPINLINE 3*** system application software does not include specific PID functions.
4.4.3.L	Standard Functions. A dynamic compensation function. Lead/lag ratio of 0 to 10, minimum resolution of 0.05, 0.01 to 100 minute lag time, minimum 1 second resolution, lead action filter.	N/A	The ***SPINLINE 3*** system application software does not include specific lead/lag functions.
4.4.3.M	Standard Functions. Capability to put limits on values.	Comply	See References 81 and 82.
4.4.3.N	Standard Functions. Implement a function generator with at least five slopes.	N/A	The ***SPINLINE 3*** system application software does not include a function generator function.

Section	Summary of EPRI TR-107330 Requirements [1]	Compliance [2]	Comments
4.4.3.O	Standard Functions. Support Section 4.9.1 communications requirements.	Comply	See References 83 and 84.
4.4.3.P	Standard Functions. Functions to capture results of self-tests.	Comply	See References 83 and 84.
4.4.3.Q	Standard Functions. Functions to implement sequence of events requirements in Section 4.4.9.	N/A	The ***SPINLINE 3*** system application software does not include sequence of events functions.
4.4.3.R	Standard Functions. AND, OR and XOR bit manipulation functions.	Comply	See References 81 and 82.
4.4.3.S	Standard Functions. Functions to store results in buffer type memory, 10 instances of 50 values. Facilities to transmit this data over a serial port.	Comply	Parameter data used in the application software layer can be exported to the plant computer via a gateway (See Reference 9 Section 4.5.7). Alarm and diagnostic data is exported to the MMU (See Reference 9 Section 4.6.10). Individual parameter values can be viewed by request using the LDU (See Reference 9 Section 4.4.3.5.5). The LDU interface uses a serial port. The gateway and MMU interface use the NERVIA+ communication protocol.
4.4.3.T	Standard Functions. Functions to implement requirements of Section 4.4.7.2.	Comply	See References 83 and 84.
4.4.3.U	Standard Functions. Capability to attach comments to ladder logic rungs.	Comply	See References 83 and 84.
4.4.4	Software Tools Requirements. A tool shall be provided for programming, debugging and documentation.	Comply	See References 81, 82, 83, 84, 85, 86, and 87.

Section	Summary of EPRI TR-107330 Requirements [1]	Compliance [2]	Comments
4.4.4.A	Software Tools Requirements. Ability to use a host device to enter a program in the PLC.	Comply	See References 83 and 84.
4.4.4.A.1	Software Tools Requirements. Ability to attach explanatory comments to program steps.	Comply	See References 83 and 84.
4.4.4.A.2	Software Tools Requirements. Ability to store programs on removable magnetic media.	Comply	See References 83 and 84.
4.4.4.A.3	Software Tools Requirements. Ability to perform bit by bit comparison of program contained in PLC and program contained in programming device.	Comply	See References 83 and 84.
4.4.4.A.4	Software Tools Requirements. Ability to print the program contained in the PLC or programming device in a fashion similar in appearance to programming device display. Include supplemental prints of programming values.	Comply	See References 83 and 84.
4.4.4.A.5	Software Tools Requirements. Features to aid in I/O mapping and memory management of the PLC.	Comply	See References 83 and 84.
4.4.4.A.6	Software Tools Requirements. System security requirements similar to Section 4.9.2.	Comply	See References 83 and 84.
4.4.4.B	Debugging Aids. Descriptive information.	- - -	No requirements.
4.4.4.B.1	Debugging Aids. Ability to highlight all discrete elements not in their normal state.	Comply	See References 83 and 84.
4.4.4.B.2	Debugging Aids. Ability to display input, output and intermediate program values.	Comply	See References 83 and 84.
4.4.4.B.3	Debugging Aids. Ability to set constants and variables to arbitrary values, including values outside normal range.	Comply	See References 83 and 84.
4.4.4.B.4	Debugging Aids. Ability to force outputs.	Comply	See References 83 and 84.
4.4.4.B.5	Debugging Aids. Ability to single step through a program.	Comply	See References 83 and 84.

Section	Summary of EPRI TR-107330 Requirements [1]	Compliance [2]	Comments
4.4.4.B.6	Debugging Aids. Ability to view the status of memory where error codes and other status information is stored.	Comply	See References 83 and 84.
4.4.4.C	Software Tools Requirements. Apply Configuration management requirements per Section 7.7.3.	Comply	See Reference 52.
4.4.4.D	Software Tools Requirements. Meet requirements of Sections 4.4.5.2 and 4.4.7.2.	Comply	See Reference 52.
4.4.4.E	Software Tools Requirements. Software Verification and Validation requirements of Section 7.4 shall be applied to the software tools.	Comply	See Reference 43.
4.4.4.F	Software Tools Requirements. Provide features to aid in detecting faults in redundant components which are not detectable by self-diagnostics.	Comply	See References 81, 82, 83, 84, 85, 86, and 87.
4.4.5	Configuration Identification. (section heading)	- - -	No requirements.
4.4.5.1	Configuration Identification Background. Descriptive information.	- - -	No requirements.
4.4.5.2	Configuration Management Aids Requirements. Descriptive information.	- - -	No requirements.
4.4.5.2.A	Configuration Management. The PLC executive shall include a retrievable, embedded electronic revision level.	N/A	See References 9 (Sections 4.4.3.5.5 and 4.4.4.3) and 58 (Section 4.5).
4.4.5.2.B	Configuration Management. Configuration information of configurable modules shall be retrievable in the field.	N/A	The ***SPINLINE 3*** system does not use software configurable modules.
4.4.5.2.C	Configuration Management. Software tools for modifying device configurations shall provide measures to prevent unauthorized access.	Comply	See References 9 (Sections 4.4.3.5.5 and 4.4.4.3 and Table 3.7.-1 Item 10, and Table 3.8-2 Item 5.9), 58, and 59.
4.4.5.2.D	Configuration Management. PLC and support tools shall provide capability to extract and record database information, including program constants.	Comply	See References 9 (Sections 4.4.3.5.5 and 4.4.4.3), 83, and 84.

Section	Summary of EPRI TR-107330 Requirements [1]	Compliance [2]	Comments
4.4.5.2.E	Configuration Management. All PLC devices that include firmware shall be marked with an identifier that includes revision level.	Comply	See Reference 88.
4.4.5.2.F	Configuration Management. For PLCs with redundancy, tools shall provide capability to confirm that configurations are consistent.	Comply	See References 81, 82, 83, 84, 85, 86, and 87.
4.4.6	Diagnostics Requirements. (section heading)	- - -	No requirements.
4.4.6.1	General Diagnostic Requirements. PLC must have sufficient diagnostics and test capability to detect all failures that could prevent the PLC from performing its intended safety function. Items 4.4.6.1.1 through 4.4.6.1.6 must be covered by on-line self test. Items 4.4.6.1.7 and 4.4.6.1.8 must be covered in power-up tests. Short term diagnostics changes in module outputs shall be 2 milliseconds or less for DC outputs and 1/2 cycle or less for AC outputs. Capability to disable these diagnostics shall be provided.	Comply Comply N/A	See Reference 9 (Sections 4.4.3 and 4.6). The ***SPINLINE 3*** system does not implement diagnostic changes in module outputs.
4.4.6.1.1	Processor Stall. For PLCs with redundant processors, the PLC shall detect processor stall and halt operation of the failed processor.	Comply	The ***SPINLINE 3*** UC25+ processor uses a watchdog timer function (See Reference 9 (Sections 4.4.3 and 4.6). ***SPINLINE 3*** does not use redundant processors.
4.4.6.1.2	Executive Program Error. Check of executive firmware integrity using a checksum or similar test.	Comply	See Reference 9 (Sections 4.4.3 and 4.6).
4.4.6.1.3	Application Program Error. Check of application program integrity using a checksum or similar test.	Comply	See Reference 9 (Sections 4.4.3 and 4.6).
4.4.6.1.4	Variable Memory Error. Read/Write memory test by writing and reading back bit patterns that test both states of all bits, or similar test.	Comply	See Reference 9 (Sections 4.4.3 and 4.6).

Section	Summary of EPRI TR-107330 Requirements [1]	Compliance [2]	Comments
4.4.6.1.5	Module Communication Error. Check of communication data integrity.	Comply	See Reference 9 (Sections 4.4.3, 4.5, and 4.6).
4.4.6.1.6	Memory Battery Low. Check of memory battery capacity.	N/A	The ***SPINLINE 3*** system does not use memory batteries.
4.4.6.1.7	Module Loss of Configuration. For software configurable modules, validate configuration.	N/A	The ***SPINLINE 3*** system does not use software configurable modules.
4.4.6.1.8	Failure of Watchdog Timer. Check of operation of watchdog timer.	Comply	See Reference 9 (Sections 4.4.3 and 4.6).
4.4.6.1.9	Application not Executing. Failure to complete application program scan.	Comply	See Reference 9 (Sections 4.4.3 and 4.6).
4.4.6.1.10	Analog Output not Following. Failure of analog output to follow commanded value.	Comply	See Reference 9 (Sections 4.4.3, 4.5, and 4.6).
4.4.6.1.11	Analog Input not Responding. Failure of analog input to respond to input signal.	Comply	See Reference 9 (Sections 4.4.3, 4.5, and 4.6).
4.4.6.1.12	Discrete Input/Output not Responding. Failure of discrete input/output to operate correctly.	Comply	See Reference 9 (Sections 4.4.3, 4.5, and 4.6).
4.4.6.1.13	Analog I/O out of Calibration. Analog input or output point out of calibration.	Comply	See Reference 9 (Sections 4.4.3, 4.5, and 4.6).
4.4.6.1.14	Power Supply out of Tolerance. Power supply to PLC is interrupted or a chassis power supply module fails.	Comply	See Reference 9 (Sections 4.3.4.9 and 4.6.10).
4.4.6.2	On-Line Self-Test Requirements. On-line self-tests shall cover at least items 4.4.6.1.1 through 4.4.6.1.6 above. Results shall be made available to the application program.	Comply	See Reference 9 (Sections 4.4.3 and 4.6).

Section	Summary of EPRI TR-107330 Requirements [1]	Compliance [2]	Comments
4.4.6.3	Power Up Diagnostics Requirements. Power up diagnostics shall include all on-line self tests, configuration verification, and test of failure to complete a scan. Application program execution shall be inhibited if power up diagnostics detect a failure.	Comply	See Reference 9 (Sections 4.4.3 and 4.6).
4.4.7	Data and Data Base. (section heading)	- - -	No requirements.
4.4.7.1	Data and Data Base Overview. Descriptive information.	- - -	No requirements.
4.4.7.2	Data and Data Base Requirements. Descriptive information.	- - -	No requirements.
4.4.7.2.A	Data and Data Base Requirements. PLC shall support use of user-defined program constants that are contained in non-volatile memory. Features shall confirm that constants in redundant processors are the same.	Comply	See References 9 (Sections 4.4.3 and 4.5 and Table 3.7.-1 Items 7 and 12), 46, and 47 for Consistency Blocks. See References 9 (Sections 4.4.3.5.5 and 4.4.4.3 and Table 3.7.-1 Item 10) for Changeable Parameters. ***SPINLINE 3*** does not use redundant processors.
4.4.7.2.B	Data and Data Base Requirements. PLC shall provide functions to read and modify data base constants. Features shall confirm that modified constants are consistent between redundant processors.	Comply	See References 9 (Sections 4.4.3 and 4.5 and Table 3.7.-1 Items 7 and 12), 46, and 47 for Consistency Blocks. See Reference 9 (Sections 4.4.3.5.5 and 4.4.4.3 and Table 3.7.-1 Item 10) for Changeable Parameters. ***SPINLINE 3*** does not use redundant processors.

Section	Summary of EPRI TR-107330 Requirements [1]	Compliance [2]	Comments
4.4.7.2.C	Data and Data Base Requirements. PLC shall provide features to prevent modifications to data base constants over connected communication paths.	Comply	See References 9 (Sections 4.4.3 and 4.5 and Table 3.7.-1 Items 7 and 12), 46, and 47 for Consistency Blocks. See Reference 9 (Sections 4.4.3.5.5 and 4.4.4.3 and Table 3.7.-1 Item 10) for Changeable Parameters.
4.4.7.2.D	Data and Data Base Requirements. PLC shall provide features to permit transmitting input, outputs and calculated values to other devices over a serial port.	Comply	See References 9 (Sections 4.4.3 and 4.5 and Table 3.7.-1 Items 7 and 12), 46, and 47 for Consistency Blocks. See Reference 9 (Sections 4.4.3.5.5 and 4.4.4.3 and Table 3.7.-1 Item 10) for Changeable Parameters. Also see 4.4.3.S above.
4.4.8	Other Non-Ladder Logic Programming Languages. (section heading)	- - -	No requirements.
4.4.8.1	Requirements for Sequential Logic Languages. Sequential logic language other than ladder logic may be used. Language shall provide capabilities given in Section 4.4.3. Language must support tools with features given in Section 4.4.4.	Comply	See Reference 9 (Sections 4.4.4, 6.2.9, and 6.2.10). The ***SPINLINE 3*** programming tools are not intended for use by the end user.
4.4.8.2	Standard High Level Languages. (section heading)	- - -	No requirements.
4.4.8.2.1	Overview of Standard High Level Languages. Descriptive information.	- - -	No requirements.

Section	Summary of EPRI TR-107330 Requirements [1]	Compliance [2]	Comments
4.4.8.2.2	Requirements for Standard High Level Languages. Required capabilities of supported standard high level programming languages.	Comply	See Reference 9 (Sections 4.4.4, 6.2.9, and 6.2.10). The ***SPINLINE 3*** programming tools are not intended for use by the end user.
4.4.9	Sequence of Events Processing Requirements. Descriptive information.	- - -	No requirements.
4.4.9.A	Sequence of Events. Shall permit application program to capture, store and time tag up to 20 transitions of up to 50 different discrete events of inputs or application objects.	Exception	***SPINLINE 3*** status and alarm data is sent to the MMU for processing and display See Reference 9 (Section 4. 6.10).
4.4.9.B	Sequence of Events. Shall permit starting and stopping the event recording.	N/A	***SPINLINE 3*** status and alarm data is sent to the MMU for processing and display See Reference 9 (Section 4. 6.10).
4.4.9.C	Sequence of Events. Shall permit transmitting the data to an external device using a PLC communication port.	Comply	See Reference 9 (Section 4.5.7).
4.4.9.D	Sequence of Events. Relative accuracy of time tags shall be one scan cycle ± 50 msecs.	N/A	***SPINLINE 3*** status and alarm data is sent to the MMU for processing and display See Reference 9 (Section 4. 6.10).

Section	Summary of EPRI TR-107330 Requirements [1]	Compliance [2]	Comments
4.4.10	System Integration Requirements. An appropriate level of system integration and integration testing shall be applied to the test specimen and TSAP.	Comply	See Reference 9 (Sections 6.2 and 6.4). See References 46 and 51 for generic platform integration testing. See References 53 and 56 for project specific integration testing requirements. See References 64 and 69 for TSAP integration testing.
4.5	Human/Machine Interface (HMI). (section heading)	- - -	No requirements.
4.5.1	Human/Machine Interface (HMI) Background. Descriptive information.	- - -	No requirements.
4.5.2	Requirements for Human/Machine Interface Functions. Descriptive information.	- - -	No requirements.
4.5.2.A	HMI Functions. PLC shall support switching a loop controller between manual and automatic via switch inputs. For control loops with integral action, auto/manual tracking shall be provided.	N/A	The ***SPINLINE 3*** system does not provide operator workstations for loop controllers.
4.5.2.B	HMI Functions. PLC shall support setpoint adjustments via switch inputs. Adjustments shall include increase, decrease, and rate of change of setpoint.	N/A	The ***SPINLINE 3*** system does not provide operator workstations for controller setpoint adjustments. .
4.5.2.C	HMI Functions. PLC shall support manual initiation of equipment via switch inputs. PLC shall support detection of manually initiated equipment.	Comply	See Reference 9 (Section 4.2.4.2). Manual initiation of protection functions is a project-specific system design issue. The ***SPINLINE 3*** system supports completion of protective actions for manual initiation signals.

Section	Summary of EPRI TR-107330 Requirements [1]	Compliance [2]	Comments
4.5.2.D	HMI Functions. PLC shall support display of status of discrete and continuous value parameters via connected devices.	Comply	See Reference 9 (Section 4.2.4.2). Display of safety parameters is a project-specific system design issue. The ***SPINLINE 3*** system supports display of safety parameters.
4.5.2.E	HMI Functions. PLC shall support sending information to a serial port device. Information sent shall include input, output and internal variable values, on-line diagnostics, sequence of events (SOE) data, and results of calculations, comparisons and bit manipulations.	Comply	See References 9 (Section 4.5.7) and 15.
4.5.3	Requirements for Interactive Features. The PLC shall provide mechanisms to prevent unauthorized access to or inadvertent use of on-line functions. Interactive features shall be available through a programming, maintenance and debugging port. PLC shall operate with no connection to this port. PLC shall mask interactive commands during run mode.	Comply Comply Comply	See References 1 (Sections 4.4.3.5.5 and 4.4.4.3 and Table 3.7.-1 Item 10, and Table 3.8-2 Item 5.9), 58, and 59.
4.5.4	Requirements for Operator Action System Response Times. For any operator action that requires PLC confirmation, the PLC shall include features to enable confirmation within 0.5 seconds.	N/A	The ***SPINLINE 3*** system does not provide operator workstations for loop controllers.
4.5.5	Display Requirements. LEDs are acceptable for any status displays.	Comply	See Reference 9 (Appendix B). Displays on modules are provided by LCDs and LEDs.
4.5.6	Alarm Processing Requirements. Descriptive information.	- - -	No requirements.
4.5.6.A	Alarm Processing. PLC shall have ability to compare inputs or derived parameters to setpoints.	Comply	See References 9 (Section 4.6.10), 81, and 82.

Section	Summary of EPRI TR-107330 Requirements [1]	Compliance [2]	Comments
4.5.6.B	Alarm Processing. PLC shall have ability to latch an alarm condition and reset based on alarm reset condition.	Comply	See References 81 and 82. Alarms require interface with plant alarm system.
4.5.6.C	Alarm Processing. PLC shall have ability to blink an output indicator.	Partially Comply	See References 81 and 82. Alarms require interface with plant alarm system for blink capability.
4.5.6.D	Alarm Processing. PLC shall have ability to acknowledge an alarm.	Partially Comply	See References 81 and 82. Alarms require interface with plant alarm system for actuation and reset controls.
4.5.6.E	Alarm Processing. Application program shall have ability to capture results of self-diagnostics.	Comply	See Reference 9 (Section 4.6.10).
4.5.6.F	Alarm Processing. Application program shall have ability to store results of items A through E in a buffer and transmit the data via a communication port.	Comply	See Reference 9 (Section 4.5.7).
4.5.7	Hard Manual Backup. Descriptive information.	- - -	No requirements.
4.6	Electrical. (section header)	- - -	No requirements.
4.6.1	Power Supply Requirements. (section heading)	- - -	No requirements.
4.6.1.1	PLC Power Sources and Power Supply Requirements. Descriptive information.	- - -	No requirements.
4.6.1.1.A	Power Sources. AC sources shall operate from at least 90 VAC to 150 VAC and 57 to 63 Hz. AC sources shall operate at the temperature and humidity range given in Section 4.3.6.	Comply	See References 14, 15, 27. and 29 Appendix D.

Section	Summary of EPRI TR-107330 Requirements [1]	Compliance [2]	Comments
4.6.1.1.B	Power Sources. DC sources shall operate from at least 20.4 VDC to 27.6 VDC. DC sources shall operate at the temperature and humidity range given in Section 4.3.6.	Exception	See References 14, 15, 27, and 29 Appendix D. ALIM 48 V / 5 V - 24 V power supply board powered by internal power supplies connected to 120 VAC. See Table Item 4.6.1.1.A above.
4.6.1.1.C	Power Sources. DC sources shall operate for seven days from a 30 VDC source.	Exception	See References 14, 15, 27. and 29. ALIM 48 V / 5 V - 24 V power supply board powered by internal power supplies connected to 120 VAC. See Table Item 4.6.1.1.A above. Duration of overvoltage conditions as specified in the test procedures.
4.6.1.1.D	Power Sources. Sources shall be capable of supplying 1.2 times bus loading for a fully loaded main chassis.	Exception	The power capacity will be checked against the calculated power consumption for the project-specific application, consistent with applicable safety analysis requirements.
4.6.1.1.E	Power Sources. Sources shall be capable of supplying 1.2 times bus loading for a fully loaded expansion chassis.	N/A	Expansion chassis are not used for ***SPINLINE 3***.
4.6.1.1.F	Power Sources. Hold up time for AC supplied power sources shall be 40 msec.	Comply	See Reference 27. Verified by qualification program Operability Test Procedure. See Reference 29 Appendices A, B, C, D, E, and K.

Section	Summary of EPRI TR-107330 Requirements [1]	Compliance [2]	Comments
4.6.1.1.G	Power Sources. Sources shall meet the EMI/RFI, surge withstand and ESD requirements of Sections 4.3.7, 4.6.2 and 4.3.8. Sources shall meet the grounding requirements of Section 4.6.8.	Comply Comply	See Reference 25. Surge withstand capability meets IEC 61000-4-5 and IEC 61000-4-12. See Reference 22. Verified by EMI/RFI, Surge withstand, and ESD qualification testing. See Reference 29 Appendices F, G, and I. Grounding of the QTS and test system is in accordance with the manufacturer recommendations (Reference 96). This grounding configuration met MIL-STD-461E and IEC 61000 requirements.
4.6.1.1.H	Power Sources. Requirements for fan cooled power sources.	Comply	See References 9 (Section 4.3.4.3) and 15.
4.6.1.1.I	Power Sources. Faults in redundant power sources shall not prevent operation of the alternate supply.	Comply	See References 9 (Section 4.3.4.9), 27, and 29 Appendices A, B, C, D, E, and K.
4.6.1.2	Loop Power Supply Requirements. Power supply modules shall be provided for external devices. Modules shall provide at least 500 mA at 24 VDC. The modules shall meet requirements A, B, C, F. G and H above.	Partially Comply	The power capacity will be checked against the calculated power consumption for the project-specific application, consistent with applicable safety analysis requirements. Loop power supplies are provided by the same power converters as discussed in 4.6.1.1 above.

Section	Summary of EPRI TR-107330 Requirements [1]	Compliance [2]	Comments
4.6.2	Surge Withstand Capability Requirements. PLC platform shall withstand IEEE C62.41 ring wave and combination wave, 3000 volt peak surges. Withstand capability applies to power sources, analog and discrete I/O interfaces, and communication port interfaces. Per Section 6.3.5, surge testing shall be conducted per IEEE C62.45.	Comply	See Reference 25. Surge withstand capability meets IEC 61000-4-5 and IEC 61000-4-12. See Reference 29 Appendix H.
4.6.3	Separation. Descriptive information.	- - -	No requirements.
4.6.4	Class 1E/Non-1E Isolation Requirements. The PLC modules shall provide isolation of at least 600 VAC and 250 VDC applied for 30 seconds. Isolation features shall conform to IEEE 384. Isolation testing shall be performed on the modules.	Comply	See Reference 26. Class 1E to Non-1E isolation capability meets IEEE 384-1981. See Reference 29 Appendix J.
4.6.5	Cable/Wiring Requirements. Manufacturer shall supply all PLC hardware interconnecting cabling. All cabling shall be suitable for UL Class 2 service. Specifically, withstand rating shall be larger of 3 times the signal level voltage or 150 volts. Temperature rating shall be 60ºC or greater. Vendor shall identify the quantities of PVC type wire and cable used in the system.	Exception	The requirements for each power plant can vary and must be verified for the project-specific application, consistent with applicable safety analysis requirements.
4.6.6	Termination Requirements. Modules shall be able to be removed without disconnecting field wiring. Features shall be provided to substitute test signals or monitoring instruments for field connections. Connectors to the PLC shall have positive hold down mechanisms. Connectors and terminations to the PLC shall be qualified with the generic PLC.	Comply Comply Comply	See References 9 (Section 4.3 and Appendix B), 15, and 16.
4.6.7	Backup Power. Descriptive information.	- - -	No requirements.

Section	Summary of EPRI TR-107330 Requirements [1]	Compliance [2]	Comments
4.6.8	Grounding/Shielding Requirements. The PLC equipment shall meet IEEE 1050 and EPRI TR-102323 grounding requirements. This includes supporting connection to single point, multi-point and floating ground systems, and providing separate ground connection points on each chassis for AC ground, DC ground, and signal ground. The PLC equipment shall meet IEEE 1050 and EPRI TR-102323 shielding requirements. This includes providing shielding connection points for the I/O module field terminations.	Comply	See Reference 96.
4.7	Maintenance. (section heading)	- - -	No requirements.
4.7.1	Maintenance Background. Descriptive information.	- - -	No requirements.
4.7.2	Diagnosis/Built-in Testability Requirements. Descriptive information.	- - -	No requirements.
4.7.3	Module Replacement Requirements. The PLC shall contain features to aid in module replacement. The maintenance manual shall contain a description of any hardware configuration item for each module. The module hold downs shall be easily accessible and provide ease of removal and reinstallation.	Comply	See Reference 57 for generic template to prepare this information for each project.
4.7.4	Preventive Maintenance Requirements. Equipment manuals shall contain preventive maintenance information. Preventive maintenance shall also include components identified in Section 4.7.8.2.	Comply	See Reference 57 for generic template to prepare this information for each project. See also Table Section 4.7.8.2.

Section	Summary of EPRI TR-107330 Requirements [1]	Compliance [2]	Comments
4.7.5	Surveillance Testing Requirements. The PLC shall support IEEE 338 surveillance testing through: - Ability to read input, intermediate and output values. - Ability to force output values. - Ability to make connections to all I/O signals. - Ability to program I/O operations. Features and procedures shall be provided that permit detection of failures of all redundant components if those failures are not detectable by self-diagnostics or are masked by redundant channel behavior.	Comply Comply	See Reference 9 (Section 4.6).
4.7.6	Output Bypass/Control Devices. Descriptive information.	- - -	No requirements.
4.7.7	Hot Repair Capability. The PLC shall support installing I/O modules with backplane power applied. Low power modules shall support removal with field power applied. When output modules are removed from the backplane, the state of the outputs should be known.	N/A	The ***SPINLINE 3*** system does not support on-line removal or installation of components.
4.7.8	Manufacturer System Life Cycle Maintenance. (section heading)	- - -	No requirement.
4.7.8.1	Parts Replacement Life Cycle Requirements. The baseline configuration of the qualified PLC shall be established. Records shall be maintained for revision history and changes. Records shall be maintained for tracking failures. Testing shall be performed as necessary to maintain a qualified platform based on future revisions or replacements.	Comply	See Reference 16. See Reference 9 (Table 3.2-1 Items III – Design Control). See Table Section 7.8.

Section	Summary of EPRI TR-107330 Requirements [1]	Compliance [2]	Comments
4.7.8.2	Component Aging Analysis Requirements. A periodic surveillance and maintenance interval shall be determined per IEEE 323 to account for any significant aging mechanisms.	Comply	See Reference 9 Section 5.2 and References 30 – 41 demonstrate that the predicted reliability for ***SPINLINE 3*** modules are greater than the typical nuclear plant surveillance intervals used to detect failures, Reference 57 contains the generic plan to develop project-specific preventive maintenance recommendations for any components with limited life (e.g., batteries, air filters, or electrolytic capacitors). Regulatory Position C.1 of NRC Regulatory Guide 1.209 does not require the age conditioning in IEEE Std. 323-2003 Section 6.2.1.2 to be applicable because of the absence of significant aging mechanisms on microprocessor-based modules.
4.7.9	Maintenance Human Factors. Descriptive information.	- - -	No requirements.
4.7.9.A	Special PLC Manufacturer Equipment. The manufacturer shall provide documentation for PLC support equipment.	Comply	See Reference 57 for generic template for project-specific operating and maintenance documentation.
4.7.9.B	Test Equipment Connections. Test equipment connections shall be supported by documentation and hardware, including interconnection devices. The manufacturer shall provide any special instruction for use of test equipment connections.	Comply	See Reference 57 for generic template for project-specific operating and maintenance documentation.

Section	Summary of EPRI TR-107330 Requirements [1]	Compliance [2]	Comments
4.7.9.C	Job Aids. Aids for operating the PLC equipment shall be provided.	Comply	See Reference 57 for generic template for project-specific operating and maintenance documentation.
4.7.9.D	Help Screens. Help screens for software used to support maintenance shall be provided.	Comply	See Reference 57 for generic template for project-specific operating and maintenance documentation.
4.8	Requirements for Third Party/Sub-Vendor Items. All items provided by sub-vendors or third parties shall be subjected to all applicable requirements and tests. Compatibility of operation with the PLC shall be demonstrated through tests.	Comply	See References 9 (Section 4.3 and Appendix B), 14, 15, and 16.
4.9	Other. (section heading)	- - -	No requirements.
4.9.1	Data Handling and Communication Interface Overview. Descriptive information.	- - -	No requirements.
4.9.1.1	Peripheral Communication Requirements. The PLC executive and/or application software tools shall provide features to prevent loss of serial communication from degrading the application program. Communication overhead time shall be deterministic. Peripheral communications shall support at least 1000 character communication buffers. (Note: 1 character = 1 byte. A real variable uses 8 bytes or eight characters). Serial communications shall support checksum (or equivalent) data quality checks. Requirements for redundant communication hardware.	Comply	See References 9 (Sections 4.4 and 4.5 and Table 3.7.-1), 46, 48, 50, and 51.
4.9.1.1.1	Software Isolation Requirements. Descriptive information.	- - -	No requirements.
4.9.1.1.1.A	Software Isolation. Features shall be provided to permit sending serial port data with no hardware or software handshaking.	Comply	See References 9 (Sections 4.4 and 4.5 and Table 3.7.-1), 46, 48, 50, and 51.

Section	Summary of EPRI TR-107330 Requirements [1]	Compliance [2]	Comments
4.9.1.1.1.B	Software Isolation. Features shall be provided to permit the application program to ignore communication port incoming data.	Comply	See References 9 (Sections 4.4 and 4.5 and Table 3.7.-1), 46, 48, 50, and 51.
4.9.1.1.1.C	Software Isolation. Software shall permit use of the send data functions with the receive data functions disabled.	Comply	See References 9 (Sections 4.4 and 4.5 and Table 3.7.-1), 46, 48, 50, and 51.
4.9.1.1.1.D	Software Isolation. Features shall be provided to disable interrupts caused by full serial port receive buffers.	Comply	See References 9 (Sections 4.4 and 4.5 and Table 3.7.-1), 46, 48, 50, and 51.
4.9.1.2	PLC Peer-to-Peer Communication Requirements. Peer-to-peer link shall meet requirements of Section 4.3.4.4, except item B. Communication time shall be deterministic. Communication errors shall not affect other portions of the application program or inhibit the PLC scan cycle. Queues for communicated data shall be supported and queue status shall be available to the communication program. Loss of communication shall be detected and made available to the application program. Use of the peer-to-peer communication link shall support the response time requirement given in Section 4.2.1.A.	Comply	See References 9 (Sections 4.4 and 4.5 and Table 3.7.-1), 46, 48, 50, and 51.
4.9.2	Overall System Security Requirements. Switching the main processor from RUN mode to other modes shall be by keylock switch. Features shall ensure that redundant components operate in the same mode, and that program changes are loaded into all redundant processors. Provisions shall prevent modification of the application program and operating system while the PLC in on-line.	N/A N/A Comply	See References (Sections 4.4.3.5.5 and 4.4.4.3 and Table 3.7.-1 Item 10, and Table 3.8-2 Item 5.9), 58, and 59. The ***SPINLINE 3*** system does not utilize key switches to change the operating mode of the processors. (See Reference 9 Section 4.4.3.4). ***SPINLINE 3*** does not use redundant processors.

Section	Summary of EPRI TR-107330 Requirements [1]	Compliance [2]	Comments
4.9.3	Heartbeat Requirements. The PLC shall provide capability to activate a "heartbeat" external to the PLC.	Comply	See Reference 66. On each cycle, TSAP1 increments by 1 the value of counter and sends it to TSAP2 and DAS via network connections. Each cycle, TSAP1 receives a counter from TSAP2 (which has been incremented by 8) and sends it for information to DAS via the network. Each cycle, TSAP1 checks the validity of data received from TSAP2 and elaborates one global invalidity indicator for the network connection if there is at least one invalid datum. This information can be used to diagnose any network problem identified through NERVIA self-tests (i.e., the Consistency Block refreshment indicator).
4.9.4	Hazardous Materials Requirements. Material data sheets shall be provided for all hazardous materials associated with the PLC.	N/A	No hazardous materials associated with the ***SPINLINE 3*** systems.
4.10	Shipping and Handling Requirements. Packaging and shipping shall be in accordance with ANSI N45.2.2.	Comply	See References 62, 78, and 79.
4.10.1	Packaging Requirements. Descriptive information.	- - -	No requirements.
4.10.1.A	Items Shipped. Shall be packaged to avoid damage or degradation due to various environmental and handling factors which may be encountered during shipping and storage.	Comply	See References 62, 78, and 79.
4.10.1.B	Items Shipped. Packaging shall include desiccant materials as required.	Comply	See References 62, 78, and 79.

Section	Summary of EPRI TR-107330 Requirements [1]	Compliance [2]	Comments
4.10.1.C	Items Shipped. Items shall be inspected for cleanliness prior to packaging. Items not immediately packaged shall be protected from contamination.	Comply	See References 62, 78, and 79.
4.10.1.D	Items Shipped. Cushioning shall be provided to protect against shock and vibration.	Comply	See References 62, 78, and 79
4.10.1.E	Items Shipped. Items and containers shall be marked with appropriate identification.	Comply	See References 62, 78, and 79
4.10.1.F	Items Shipped. Copies of packing lists shall be included with each carton shipped.	Comply	See References 62, 78, and 79
4.10.1.G	Items Shipped. ESD sensitive items shall be appropriately packaged, handled and marked.	Comply	See References 62, 78, and 79
4.10.1.H	Items Shipped. Packaging shall be suitable for movement using hand trucks.	Comply	See References 62, 78, and 79
4.10.1.I	Items Shipped. Special handling or storage requirements shall be marked on the containers.	Comply	See References 62, 78, and 79
4.10.1.J	Items Shipped. See Section 4.4.2 for requirements for software storage media.	N/A	The ***SPINLINE 3*** systems do not provide software media for utility use.
4.10.2	Shipping Requirements. Requirements for mode of shipping, use of fully enclosed vehicles, special handling and stacking instructions as necessary, and container markings and protective covers.	Comply	See References 62, 78, and 79
4.10.3	Storage Requirements. Storage and shelf life requirements shall be provided for all PLC items.	Comply	See References 62, 78, and 79
5	Acceptance/Operability Testing. Descriptive information.	- - -	No requirements.
5.1	Acceptance/Operability Testing Overview. The development, design and performance of acceptance testing shall use the documentation requirements of Section 8.14.	Comply	See References 14 and 17 - 28.

Section	Summary of EPRI TR-107330 Requirements [1]	Compliance [2]	Comments
5.2	Pre-Qualification Acceptance Test Requirements. Descriptive information.	- - -	No requirements.
5.2.A	Application Objects Testing. Testing of the software objects in the PLC library shall be performed. This testing shall be in addition to any testing performed by the manufacturer.	Exception	Reference 9 (Section 6.2.9) and References 43 and 45. The qualification of the application objects (SCADE Function Blocks) was based on the software development process (including independent verification and validation) of the Function Blocks.
5.2.B	Initial PLC Calibration. The generic qualification sample PLC shall be calibrated to NIST traceable sources.	Comply	See References 14, 17, 18, and 29.
5.2.C	System Integration. System integration testing portion of TSAP V&V shall be performed during acceptance testing.	Comply	See Reference 69.
5.2.D	Operability Tests. The Operability Test shall be performed during acceptance testing.	Comply	See References 14, 17, 27, and 29 Appendix A.
5.2.E	Prudency Tests. The Prudency Test shall be performed during acceptance testing.	Comply	See References 14, 17, 28, and 29 Appendix A.

Section	Summary of EPRI TR-107330 Requirements [1]	Compliance [2]	Comments
5.2.F	Burn-In Test. A minimum 352 hour burn-in test shall be performed during acceptance testing.	Exception	See Reference 14. The sequence of testing does not include Burn-In Testing. The ***SPINLINE 3*** platform manufacturing process includes routine burn-in of platform hardware. In addition to the routine burn-in during the manufacturing process, the QTS was subjected to the Factory Acceptance Test and the Pre-Qualification Acceptance Testing, as described in Reference 29. The Pre-Qualification Acceptance Testing sequence included both Operability and Prudency Testing. This testing was performed prior to transportation of QTS to the qualification test facility and represents additional burn-in time for the test specimen. It meets the intent of this requirement to detect early life failures during Pre-Qualification Testing through performance of Burn-In Testing.
5.3	Operability Test Requirements. Descriptive information.	- - -	No requirements.
5.3.A	Accuracy. Accuracy checks shall be performed on the analog input/output modules.	Comply	See References 27 and 29 Appendices A, B, C, D, E, and K. Verified by qualification program Operability Test Procedure.

Section	Summary of EPRI TR-107330 Requirements [1]	Compliance [2]	Comments
5.3.B	Response Time. Response time of analog input to digital output and digital input to digital output sequences shall be measured. For baseline (acceptance) testing, the acceptance criteria is that the measured response time shall not vary more than 20% from the value calculated from manufacturer's data. For all subsequent testing, the measured value shall not vary more than 10% from the baseline.	Comply	The qualification program Operability Test Procedure (Reference 27) verified that the test specimen performed within the expected response times for the test system (Reference 29 Appendices A, B, C, D, E, and K). See Table Section 4.2.1.A above.
5.3.C	Discrete Input Operability. Discrete inputs shall be tested for capability to detect changes in the inputs.	Comply	See Reference 27. Verified by qualification program Operability Test Procedure (Reference 29 Appendices A, B, C, D, E, and K).
5.3.D	Discrete Output Operability. Discrete outputs shall be tested for ability to operate within rated voltages and currents.	Comply	See Reference 27. Verified by qualification program Operability Test Procedure (Reference 29 Appendices A, B, C, D, E, and K).

Section	Summary of EPRI TR-107330 Requirements [1]	Compliance [2]	Comments
5.3.E	Communication Operability. If any communication functions are included in the qualification envelope, then operability of the ports shall be tested. Tests shall look for degradation in bit rates, signal levels and pulse shapes of communication protocol.	Exception	The communication Operability tests described in EPRI TR-107330, Section 5.3.E are not applicable to this fiber optic communication interface. Instead, the NERVIA+ fiber optic communication interface will be connected and exercised continuously by the TSAP throughout prequalification and qualification testing. Data transmitted through the interface will be monitored continuously during testing and checked for consistency with the operation of the TSAP. Any failures of the NERVIA+ fiber optic communication interface will be immediately indicated by the test system data acquisition system. See Reference 29 Appendices A, B, C, D, E, and K.

Section	Summary of EPRI TR-107330 Requirements [1]	Compliance [2]	Comments
5.3.F	Coprocessor Operability. If any coprocessors are included in the qualification envelope, then tests shall be performed specifically on these coprocessors.	Comply	The ***SPINLINE 3*** system uses a coprocessor that is integral to the UC25+ CPU module. See Reference 9 (Sections 4.3.3 and 4.3.4.7 and Appendix B). Coprocessor processing capability performance is inherently tested during all qualification tests. Separate coprocessor qualification tests are not required.
5.3.G	Timer Tests. Accuracy of timer functions shall be tested.	N/A	See Reference 27. Verified by qualification program Operability Test Procedure. See Reference 29 Appendices A, B, C, D, E, and K.

Section	Summary of EPRI TR-107330 Requirements [1]	Compliance [2]	Comments
5.3.H	Test of Failure to Complete Scan Detection. The function of the mechanism to detect failure to complete a scan shall be tested. The power up testing of this feature may be used to establish its operability.	Comply	The functions of the QTS mechanisms to detect a failure to complete a scan (the watchdog timers) are checked during hardware diagnostics performed on power-up of the QTS. If a failure of a watchdog timer mechanism is detected, the test specimen power-up will stop and a diagnostic fault indication will be generated. Therefore, successful restart on restoration of power indicates proper functioning of the QTS watchdog timer mechanisms. The QTS is powered down and restarted at several points throughout Operability testing. Therefore, this procedure does not include a separate test of the watchdog timer mechanism function.
5.3.I	Failover Operability Tests. If redundancy with automatic transfer to a redundant device is used, tests shall be performed to establish operability of the failover hardware.	Comply	See References 14, 15, and 27. The ***SPINLINE 3*** qualification test specimen verified proper failover to redundant power supply components. See Reference 29 Appendices A, B, C, D, E, and K.
5.3.J	Loss of Power Test. The AC and DC power sources shall be shut off for at least 30 seconds and reapplied.	Comply	See Reference 27. Verified by qualification program Operability Test Procedure. See Reference 29 Appendices A, B, C, D, E, and K.

Section	Summary of EPRI TR-107330 Requirements [1]	Compliance [2]	Comments
5.3.K	Power Interrupt Test. The AC power sources shall be interrupted for a 40 millisecond hold-up time.	Comply	See Reference 27. Verified by qualification program Operability Test Procedure. See Reference 29 Appendices A, B, C, D, E, and K.
5.4	Prudency Testing Requirements. The Prudency tests shall be performed with the power supply sources at the minimum values specified in Section 4.6.1.1.	Comply	See Reference 28. Verified by qualification program Prudency Test Procedure. See Reference 29 Appendices A, B, C, D, E, and K.
5.4.A	Burst of Events Test. Tests shall be performed to verify operation of the PLC under highly dynamic input/output variation conditions.	Comply	See Reference 28. Verified by qualification program Prudency Test Procedure. See Reference 29 Appendices A, B, C, D, E, and K.

Section	Summary of EPRI TR-107330 Requirements [1]	Compliance [2]	Comments
5.4.B	Failure of Serial Port Receiver Test. The receiving device connected to the main processor serial communication port shall be simulated to fail in various modes. PLC response time shall be verified to not degrade unacceptably.	Comply	The QTS includes fiber-optic communication ports for connection to external safety related or non-safety related communication devices. These connections inherently provide electrical isolation between the Class 1E and non-Class 1E communication circuits because the fiber optic cables are incapable of transmitting electrical faults. Further, the fiber optic cables do not include separate transmit and receive data lines. Therefore, the test approach described in EPRI TR-107330 is not applicable. To meet the intent of EPRI TR-107330, Prudency testing of the QTS will include a test that demonstrates that the QTS response time is not degraded due to a simulated failure of the QTS fiber optic communication connection to the external test system communication device (momentary disconnection from the non-Class 1E receiving device).

Section	Summary of EPRI TR-107330 Requirements [1]	Compliance [2]	Comments
5.4.C	Serial Port Noise Test. The transmit line to the main processor serial communication port shall be subjected to white noise. PLC response time shall be verified to not degrade unacceptably.	N/A	As described above, the QTS includes only fiber optic communication line connections to external communication devices. These lines are not capable of impressing a low level white noise voltage on the QTS communication port. Therefore, this test is not applicable to the design and configuration of the QTS.
5.4.D	Fault Simulation. For PLC's that include redundancy, failures in redundant elements shall be simulated.	Exception	This testing is identical to the fault simulation testing performed as part of Operability testing (Reference 27). Because Operability testing is performed each time Prudency testing is performed, this testing will not be repeated during Prudency testing.

Section	Summary of EPRI TR-107330 Requirements [1]	Compliance [2]	Comments
5.5	Operability/Prudency Testing Applicability Requirements. As a minimum, Operability and Prudency tests shall be performed: - During acceptance testing: Operability – All, Prudency – All - During environmental testing: Operability – All, Prudency – All at end of high temperature/relative humidity - During seismic testing: Operability – All, Prudency – All - After seismic testing: Operability – All, Prudency – None - During EMI/RFI testing: Operability – All except analog I/O checks, Prudency – Only burst of events test - After ESD testing: Operability – All, Prudency - None	Exception	See References 14, 21, 27, and 28. [[ ]]

Section	Summary of EPRI TR-107330 Requirements [1]	Compliance [2]	Comments
			[[ ]]
5.6	Application Software Objects Acceptance (ASOA) Testing. Requirements for ASOA testing. Based on exception to ASOA testing, Section 5.6 requirements are not included in this table.	N/A	See Table Section 5.2.A
6	Qualification Testing and Analysis. Descriptive information.	- - -	No requirements.

Section	Summary of EPRI TR-107330 Requirements [1]	Compliance [2]	Comments
6.1	Qualification Process Overview. Descriptive information.	- - -	No requirements.
6.1.1	PLC System Qualification Overview. Descriptive information.	- - -	No requirements.
6.2	PLC System Test Configuration Requirements. Descriptive information.	- - -	No requirements.
6.2.1	Test Specimen Hardware Configuration Requirements. Hardware configuration shall be developed and documented consistent with the requirements of Sections 6.5 and 8.2.	Comply	See References 9 and 64.
6.2.1.A	Module Types. The test specimen shall include at least one type of module needed to encompass the requirements of Section 4.3. Multiple samples of configurable modules shall be included to cover the different configurations. For T/C modules, only one T/C type needs to be tested unless different types use different signal conditioning.	Comply	See Reference 9 (Appendix B), and References 14, 15, and 16.
6.2.1.B	Module Types. The test specimen shall include modules needed to support Operability testing.	Comply	See Reference 9 (Appendix B), and References 14, 15, and 16.
6.2.1.C	Ancillary Devices. The test specimen shall include at least one of each type of ancillary device needed to meet the TR requirements.	Comply	See Reference 9 (Appendix B), and References 14, 15, and 16.
6.2.1.D	Chassis Types. The test specimen shall include at least one of each type of chassis needed to meet the TR requirements. Connections between chassis shall use maximum permissible cable lengths.	Comply	See Reference 9 (Appendix B), and References 14, 15, and 16.
6.2.1.E	Power Supplies. The test specimen shall include the power supplies needed to meet the TR requirements. Additional resistive loads shall be placed on each power supply output so that the power supply operates at rated conditions.	Comply	See Reference 9 (Appendix B), and References 14, 15, and 16.
6.2.1.F	Dummy Modules. Dummy modules shall be used to fill all remaining slots in the main chassis and at least one expansion chassis. The dummy modules shall provide a power supply and weight load approximately equal to an eight point discrete input module.	Comply	See References 14, 15, and 16.

Section	Summary of EPRI TR-107330 Requirements [1]	Compliance [2]	Comments
6.2.1.G	Termination Devices. The test specimen shall include at least one of each type of termination device and associated cabling used to provide field connections.	Comply	See Reference 9 (Appendix B), and References 14, 15, and 16.
6.2.1.H	Redundant Devices. The test specimen shall include any devices needed to implement any redundancy included in the qualification envelope.	Comply	See Reference 9 (Appendix B), and References 14, 15, and 16.
6.2.1.I	Additional Modules. The test specimen shall include any additional modules needed to support Operability and Prudency testing and to support module arrangement variations.	Comply	See Reference 9 (Appendix B), and References 14, 15, and 16.
6.2.1.1	Test Specimen Hardware Arrangement Requirements. Descriptive information.	- - -	No requirements.
6.2.1.1.A	Seismic Testing. Hardware shall be arrangement to maximize stress on the chassis and mountings.	Comply	See References 14, 15, and 16.
6.2.1.1.B	Environmental Testing. Modules shall be arranged to simulate maximum expected temperature rise across the chassis.	Comply	See References 14, 15, and 16.
6.2.2.	Test Specimen Application Program (TSAP) Configuration Requirements. Descriptive information.	- - -	No requirements.
6.2.2.A	TSAP Communication Commands. TSAP shall include a serial communication output sequence.	Comply	See Reference 15.
6.2.2.B	TSAP Programming. TSAP shall include program sequences to support Operability and Prudency testing.	Comply	See Reference 15.

Section	Summary of EPRI TR-107330 Requirements [1]	Compliance [2]	Comments
6.2.2.C	TSAP Programming. TSAP shall include a program sequence to change the state of an output once each cycle.	Comply	See Reference 66. On each cycle, TSAP1 increments by 1 the value of counter and sends it to TSAP2 and DAS via network connections. Each cycle, TSAP1 receives a counter from TSAP2 (which has been incremented by 8) and sends it for information to DAS via the network. Each cycle, TSAP1 checks the validity of data received from TSAP2 and elaborates one global invalidity indicator for the network connection if there is at least one invalid datum. This information can be used to diagnose any network problem identified through NERVIA self-tests (i.e., the Consistency Block refreshment indicator).
6.2.2.D	TSAP Programming. TSAP shall include any functions needed to support redundancy, and fault detection and failover.	Comply	See Reference 15.

Section	Summary of EPRI TR-107330 Requirements [1]	Compliance [2]	Comments
6.2.2.1	Coprocessor TSAP Requirements. If a coprocessor uses a high-level language, then it shall have its own TSAP which implements the given functions.	N/A	The ***SPINLINE 3*** system uses a coprocessor that is integral to the UC25+ CPU module. See Reference 9 (Sections 4.3.3 and 4.3.4.7 and Appendix B). Operation of ***SPINLINE 3*** coprocessors is invoked automatically during operation independent of any application software program. Coprocessor processing capability performance is inherently tested during all qualification tests.
6.2.3	Test Support Equipment Requirements. Test equipment to support Acceptance and Operability testing shall be provided.	Comply	See References 14, 15, and 17 - 28. This requirement is met by a documented qualification plan, specification, and procedures.
6.2.3.A	Test Support Equipment. Equipment shall include panels for connecting and simulating inputs and outputs.	Comply	See References 14, 15, and 17 - 28. This requirement is met by a documented qualification plan, specification, and procedures.
6.2.3.B	Test Support Equipment. Equipment shall include test and measurement equipment with required accuracy.	Comply	See References 14, 15, and 17 - 28. This requirement is met by a documented qualification plan, specification, and procedures.
6.2.3.C	Test Support Equipment. Equipment shall include special tools and devices needed to support testing.	Comply	See References 14, 15, and 17 - 28. This requirement is met by a documented qualification plan, specification, and procedures.

Section	Summary of EPRI TR-107330 Requirements [1]	Compliance [2]	Comments
6.2.3.D	Test Support Equipment. All test equipment shall be controlled per IEEE 498.	Comply	See References 14 and 18. Intent of IEEE 498 requirements for test equipment calibration control met by requiring compliance with ANSI/NCSL Z540-1-1994, "Calibration Laboratories and Measuring and Test Equipment, General Requirements."
6.3	Qualification Tests and Analysis Requirements. All PLC testing shall be performed on a calibrated system with all user setpoint values adjusted to default values.	Comply	See Reference 18. Verified by qualification program System Setup and Checkout Test Procedure. See Reference 29 Appendices A, B, C, D, E, F and K.
6.3.1	Aging Requirements. Testing shall include environmental, electrostatic discharge (ESD), seismic, EMI/RFI and surge withstand testing. Environmental testing shall be performed first.	Comply	See Reference 27. Established by the qualification program test sequence. See Reference 29 Appendices D, F, G, H and I.

Section	Summary of EPRI TR-107330 Requirements [1]	Compliance [2]	Comments
6.3.2	EMI/RFI Test Requirements. EMI/RFI testing to be performed as described in Section 4.3.7. Susceptibility tests to be performed at 25%, 50% and 75% of specified levels in addition to the specified levels.	Comply Exception	See References 22 and 29. Established by the qualification program EMI/RFI Test Procedure. Additional testing from 1 – 8 GHz will be performed in a second round of qualification testing, as recommended by Regulatory Guide 1.180, Revision 1. [[ ]]

Section	Summary of EPRI TR-107330 Requirements [1]	Compliance [2]	Comments
6.3.2.1	EMI/RFI Mounting Requirements. Test specimen shall be mounted on a non-metallic surface six feet above floor with no secondary enclosure. PLC shall be grounded per manufacturer's recommendations.	Exception	See References 21 and 29. QTS was mounted in one open mounting frame. [[ ]] Grounding of the QTS and test system is in accordance with the manufacturer recommendations (Reference 96). This grounding configuration met MIL-STD-461E and IEC 61000 requirements.

Section	Summary of EPRI TR-107330 Requirements [1]	Compliance [2]	Comments
6.3.3	Environmental Testing Requirements. Testing shall be performed using the temperature and relative humidity profile given in TR Figure 4-4. Margin shall be applied to maximum and minimum specified temperatures and humidities. Power sources shall be set to maximize heat dissipation. PLC shall be energized with TSAP operating. One-half of all discrete and relay outputs shall be on and energized to rated current. All analog outputs shall be set to one-half to two-thirds full scale output.	Comply	See References 14, 20, and 29.
6.3.3.1	Environmental Test Mounting Requirements. PLC shall be mounted on a simple structure. Air temperature at bottom of chassis shall be monitored. No additional cooling fans shall be included.	Comply	See References 14, 20, and 29.
6.3.4	Seismic Test Requirements. PLC shall be vibration aged using five OBEs with the RRS as shown in TR Figure 4-5 followed by an SSE with the RRS shown in TR Figure 4-5. Testing shall conform to IEEE 344. Tri-axial, random, multi-frequency tests shall be used. Repairs during testing shall conform to IEEE 344.	Comply	See References 14, 15, 21, and 29.
6.3.4.1	Seismic Test Mounting Requirements. Test specimen shall be mounted per manufacturer's recommendations. Mounting structure shall have no resonances below 100 Hz. Most susceptible mounting configuration shall be tested. All mounting screws shall be torqued to known values.	Comply	See References 14, 15, 21, and 29.
6.3.4.2	Seismic Test Measurement Requirements. Relay contacts shall be monitored for chatter. One half of the relays shall be energized and one half de-energized. One quarter of the relays shall transition from ON to OFF and one quarter from OFF to ON during the tests. The PLC shall be powered with the TSAP operating. One half of the digital outputs shall be ON and loaded to their rated current. Power sources shall be at lower voltage and frequency limits. One or more response accelerometers shall be mounted on each chassis.	Comply	See References 14, 15, 21, and 29.
6.3.4.3	Seismic Test Performance Requirements. Seismic test shall include a resonance search, five OBEs, one SSE and an Operability test.	Comply	See References 14, 15, 21, and 29.

Section	Summary of EPRI TR-107330 Requirements [1]	Compliance [2]	Comments
6.3.4.4	Seismic Test Spectrum Analysis Requirements. The test response spectrum from the control and specimen response accelerometers shall be reported at 1/2, 1, 2, 3 and 5% damping.	Comply	See Reference 140. NTS performed an analysis at 1/2, 1, 2, 3, and 5% damping on the control accelerometers for at least one OBE and the SSE runs.
6.3.5	Surge Withstand Capability Testing. Surge testing shall be conducted per Section 4.6.2 and IEEE C62.45.	Comply	See Reference 25. Surge withstand capability meets IEC 61000-4-5 and IEC 61000-4-12. See Reference 29 Appendix H.
6.3.5.1	Surge Withstand Test Mounting Requirements. Test specimen shall be mounted on a non-metallic surface six feet above floor with no secondary enclosure. PLC shall be grounded per manufacturer's recommendations.	Exception	See Reference 25. Surge withstand capability meets IEC 61000-4-5 and IEC 61000-4-12. QTS was mounted in one open mounting frame. [[ ]] See Reference 29 Appendix H.

Section	Summary of EPRI TR-107330 Requirements [1]	Compliance [2]	Comments
6.3.6	Class 1E to Non-1E Isolation Testing. Test specimen shall be mounted on a non-metallic surface six feet above floor with no secondary enclosure. PLC shall be grounded per manufacturer's recommendations.	Exception	See Reference 26. Class 1E to Non-1E isolation capability meets IEEE 384-1981. [[ ]] See Reference 29 Appendix J.
6.4	Other Tests and Analysis. (section heading)	- - -	No requirements.
6.4.1	FMEA. An FMEA analysis of the PLC shall be performed.	Partially Comply	See Reference 9 Section 5.2 and References 30 – 41. The hardware failure modes and effects were analyzed for each ***SPINLINE 3*** hardware module. The hardware failure modes and effects are used as input to the project-specific evaluation of a complete system See Reference 10 entries for Items 2.8 and 2.15 for the treatment of project-specific actions.
6.4.2	Electrostatic Discharge (ESD) Testing Requirements. ESD testing of the PLC shall be performed per EPRI TR-102323.	Comply	See Reference 23. Verified by ESD qualification testing. See Reference 29 Appendix I.

Section	Summary of EPRI TR-107330 Requirements [1]	Compliance [2]	Comments
6.4.3	Power Quality Tolerance Requirements. Power quality tolerance testing shall be performed during acceptance testing, at the end of the elevated temperature test while still at high temperature and following seismic tests. The same AC source shall be connected to redundant power supplies during testing.	Comply	See References 14, 17, 20, 21, 27, and 29 Appendices A, B, C, D, E, and K.
6.4.4	Requirements for Compliance to Specifications. Test instrumentation measurement accuracy shall be considered. Compliance to specifications shall be considered for each module or grouping of modules.	Comply	See References 14, 18, and 29.
6.4.4.A	Environmental Test Compliance. Environmental Operability test results shall be evaluated for compliance to specifications.	Comply	See References 14, 18, 20, 27, and 29 Appendix D.
6.4.4.B	Seismic Test Compliance. The seismic levels achieved during testing shall be used as the seismic withstand response spectrum.	Partially Comply	See References 14, 18, 21, 27, and 29 Appendix E. Some seismic test deficiencies will be resolved by a second round of qualification testing.
6.4.4.C	Class 1E to Non-1E Test Compliance. Test levels shall be checked for compliance to Section 4.6.4 specifications.	Comply	See References 14, 26 and 29 Appendix J. Class 1E to Non-1E isolation capability meets IEEE 384-1981.
6.4.4.D	Surge Withstand Test Compliance. Test levels shall be checked for compliance to Section 4.6.2 specifications.	Partially Comply	See References 25 and 29 Appendix H. Surge withstand capability meets IEC 61000-4-5 and IEC 61000-4-12.

Section	Summary of EPRI TR-107330 Requirements [1]	Compliance [2]	Comments
6.4.4.E	EMI/RFI Test Compliance. PLC performance shall be checked for compliance to Section 4.3.7 specifications.	Comply	See References 22, 24, and 29 Appendices F and G. Verified by EMC qualification testing. Additional testing from 1 – 8 GHz will be performed in a second round of qualification testing, as recommended by Regulatory Guide 1.180, Revision 1.
6.4.4.F	Power Quality Test Compliance. Results shall be evaluated for compliance to Sections 4.6.1 and 4.2.3.7 specifications.	Comply	See References 14, 17, 20, 21, 27, and 29 Appendices A, B, C, D, E, and K. Verified by Operability qualification testing.
6.4.4.G	ASOA Test Compliance. Results shall be evaluated for compliance to Section 5.6 requirements.	N/A	See Table Section 5.2.A.
6.4.4.H	Quality Assurance Program Compliance. Results of audits of manufacturer's QA Program shall be checked for compliance to Section 7 requirements.	Comply	See Reference 62. Global Quality Assurance Audit Report dated February 3, 2009. Audit Date: January 19 — 23, 2009. Products/Scope: Design and Manufacture of Safety Instrumentation and Controls Systems.
6.4.5	Human Factors. Descriptive Information.	- - -	No requirements.

Section	Summary of EPRI TR-107330 Requirements [1]	Compliance [2]	Comments
6.5	Quality Assurance Measures Applied to Qualification Testing. Test program TSAP development, hardware procurement, test specimen chain of custody, and tests and data analysis shall meet the requirements of 10 CFR Part 50, Appendix B.	Comply	See References 9 (Section 1.4 and Table 3.2-1), 14, and 64. This requirement is met by a documented Qualification Program Quality Assurance Plan that references applicable 10 CFR Part 50, Appendix B Quality Assurance Program procedures.
7	Quality Assurance. Descriptive information.	- - -	No requirements.
7.1	QA Overview. Descriptive information.	- - -	No requirements.
7.2	10 CFR Part 50, Appendix B Requirements for Safety-Related Systems. Descriptive information.	- - -	No requirements.
7.2.A	10 CFR Part 50, Applicability. Regulations apply to all qualification activities.	Comply	See References 9 (Section 1.4 and Table 3.2-1) and 14. This requirement is met by a documented Qualification Program Quality Assurance Plan that references applicable 10 CFR Part 50, Appendix B Quality Assurance Program procedures.
7.2.B	10 CFR Part 50, Applicability. Regulations apply to application specific activities.	Comply	See Reference 9 (Section 1.4 and Table 3.2-1). This requirement is met by a documented Qualification Program Quality Assurance Plan that references applicable 10 CFR Part 50, Appendix B Quality Assurance Program procedures.

Section	Summary of EPRI TR-107330 Requirements [1]	Compliance [2]	Comments
7.2.C	10 CFR Part 50, Applicability. Regulations apply to PLC dedication activities.	Comply	See Reference 9 (Section 1.4). If necessary, this requirement is met by a documented Qualification Program Quality Assurance Plan that references applicable 10 CFR Part 50, Appendix B Quality Assurance Program procedures.
7.2.D	10 CFR Part 50 Compliance. Quality processes other than 10 CFR Part 50 shall be shown to be commensurate with 10 CFR Part 50.	Comply	See References 9 (Sections 1 and 6.3 and Table 3.10-2) and 13. Rolls-Royce concluded that the ***SPINLINE 3*** platform software life cycle process (based on IEC 880) achieves equivalent results to those that would be attained using BTP 7-14.
7.2.E	10 CFR Part 50 Compliance. Qualifier shall perform audits to confirm that manufacturer's quality process has been applied to the PLC product.	Comply	See Reference 9 (Table 3.2-1 Item XVIII – Audits).
7.2.F	10 CFR Part 50 Compliance. Audits performed against manufacturer programs other than 10 CFR Part 50 shall demonstrate that the program process is commensurate with 10 CFR Part 50.	N/A	Rolls-Royce will manufacture the ***SPINLINE 3*** systems under a 10 CFR Part 50, Appendix B program.
7.2.G	V&V Program Evaluation. Qualifier shall evaluate the manufacturer's V&V program to the criteria in Section 7.4.	Comply	See References 9 (Sections 1 and 6.3 and Table 3.10-2) and 13. Rolls-Royce concluded that the ***SPINLINE 3*** platform software life cycle process (based on IEC 880) achieves equivalent results to those that would be attained using BTP 7-14.

Section	Summary of EPRI TR-107330 Requirements [1]	Compliance [2]	Comments
7.2.H	Qualification Test Witnessing. The qualifier shall have the right to witness qualification tests.	N/A	Rolls-Royce is the manufacturer and qualifier.
7.3	10 CFR Part 21 Compliance Requirements. Section lists 10 CFR Part 21 compliance requirements of a utility which applies the PLC in a safety-related application. PLC manufacturer shall support problem reporting and tracking.	Comply	See References 9 (Sections 1.4 and 4.1.2) and 13. This requirement is met by a documented Qualification Program Quality Assurance Plan that references applicable 10 CFR Part 50, Appendix B Quality Assurance Program procedures.
7.4	Verification and Validation Requirements. Qualifier shall evaluate the manufacturer's V&V process for software, firmware and software tools against IEEE 7-4.3.2 and IEEE 1012. The qualifier shall confirm the following basic requirements are met: a) there is a V&V Plan for the PLC product, b) software development shall be done in accordance with a life cycle approach (see IEEE Std 1074-1995), and c) the software requirements document shall be reviewable. If the manufacturer V&V processes do not meet requirements applicable to Nuclear Power Plants, then compensatory measures shall be implemented.	Comply N/A	See References 9 (Sections 1, 6.3, and 6.4 and Tables 3.8.1, 3.8.9 through 3.8.11), 10, and 13. Rolls-Royce concluded that the ***SPINLINE 3*** platform software life cycle process (based on IEC 880) achieves equivalent results to those that would be attained using BTP 7-14.
7.5	Manufacturer Qualification Maintenance Throughout Product Life Cycle. (section heading)	- - -	No requirements.
7.5.1	Overview of Manufacturer Qualification Maintenance Throughout Product Life Cycle. Descriptive information.	- - -	No requirements.

Section	Summary of EPRI TR-107330 Requirements [1]	Compliance [2]	Comments
7.5.2	Requirements for Manufacturer Qualification Maintenance Throughout Product Life Cycle. The qualifier shall obtain documentation confirming that the PLC manufacturer will ensure upward compatibility, maintain rigor of processes, commit to at least five year support for the qualified PLC configuration, and commit to six months notice before withdrawing product support.	Comply	Rolls-Royce is the manufacturer and qualifier. The development and qualification processes to be used in the future are described in Reference 9 (Sections 1, 5, and 6).
7.5.3	Life Cycle Support for Tools Requirement. PLC manufacturer shall ensure continued access to the same versions of application software development tools, or capability to reconstruct functionality with using revised tools.	Comply	Rolls-Royce is the manufacturer and qualifier. The development tools to be used in the future are described in Reference 9 (Section 4.4.4).
7.6	Compensatory Quality Activities for Legacy Software. (section heading)	- - -	No requirements.
7.6.1	Overview of Compensatory Quality Activities for Legacy Software. Descriptive information.	- - -	No requirements.

Section	Summary of EPRI TR-107330 Requirements [1]	Compliance [2]	Comments
7.6.2	Requirements for Compensatory Quality Activities for Legacy Software. The qualifier may compensate for shortcomings in legacy software by evaluating documented operating experience in applications similar to nuclear safety related applications, and by performing tests of legacy software to confirm conformance to requirements. The manufacturer shall place legacy software under configuration control once baselined.	N/A	Rolls-Royce did not use ***SPINLINE*** operating experience to compensate for shortcomings in legacy software. The development process for the ***SPINLINE 3*** system was found to be both robust and consistent with applicable US regulatory guidance. The ***SPINLINE 3*** software development process had a rigorous verification and validation program to confirm conformance to requirements. In addition, the ***SPINLINE 3*** system has considerable deployment experience in nuclear power plants and has operated reliably in systems and environments comparable to those in U.S. nuclear power plants. See Reference 9 (Sections 2 and 6.1) described the operational experience that supplements the software development processes described in Reference 9 (Sections 6.2 and 6.4). Reference 9 (Sections 6.2.6 and 6.4.3 and Tables 3.8.6 through 3.8.8) describe the ***SPINLINE 3*** configuration management system.
7.7	Configuration Management. (section heading)	- - -	No requirements.

Section	Summary of EPRI TR-107330 Requirements [1]	Compliance [2]	Comments
7.7.1	Configuration Management Overview. Descriptive information.	- - -	No requirements.
7.7.2	Hardware Configuration Management Requirements. The scope shall include revisions to module design, module component configuration, compatibility of revised modules with existing hardware, and manufacturer documentation.	Comply	See Reference 9 (Table 3.2-1 Items III – Design Control, VII - Control of Purchased Materials, Equipment and Services, VIII – Identification and Control of Materials, Parts and Components, and IX - Control of Special Processes).
7.7.2.A	Hardware Configuration Management Review. Utility (and Qualifier) shall evaluate the manufacturer configuration management process for design revisions to NQA-1.	Comply	See Reference 9 (Table 3.2-1 Items III – Design Control and VII - Control of Purchased Materials, Equipment and Services).
7.7.2.B	Hardware Configuration Management Review. Utility (and Qualifier) shall evaluate the manufacturer configuration management process for methods of identification of each constituent component within the PLC modules to NQA-1.	Comply	See Reference 9 (Table 3.2-1 Items III – Design Control, VII - Control of Purchased Materials, Equipment and Services, VIII – Identification and Control of Materials, Parts and Components, and IX - Control of Special Processes).
7.7.2.C	Hardware Configuration Management Review. Utility (and Qualifier) shall evaluate the manufacturer configuration management process for methods of document control to NQA-1.	Comply	See Reference 9 (Table 3.2-1 Items V - Instructions, Procedures and Drawings, VI – Document Control, VII - Control of Purchased Materials, Equipment and Services, and XVII - Quality Assurance Records).

Section	Summary of EPRI TR-107330 Requirements [1]	Compliance [2]	Comments
7.7.3	Software Configuration Management Requirements. The scope of software configuration management includes creation and revision of firmware, runtime software libraries, software engineering tools, and documentation.	Comply	See Reference 9 (Sections 6.2.6 and 6.4.3 and Tables 3.8.6 through 3.8.8) for a description of the ***SPINLINE 3*** configuration management system. See Reference 10 entries for Item 1.10 for the ***SPINLINE 3*** configuration management implementation documents.
7.7.3.A	Software Configuration Management Review. Utility (and Qualifier) shall evaluate the manufacturer software configuration management process for definition of organization and responsibilities to Reg. Guide 1.169, Section C.	Comply	See Reference 9 (Sections 6.2.6 and 6.4.3 and Tables 3.8.6 through 3.8.8) for a description of the ***SPINLINE 3*** configuration management system. See Reference 10 entries for Item 1.10 for the ***SPINLINE 3*** configuration management implementation documents.
7.7.3.B	Software Configuration Management Review. Utility (and Qualifier) shall evaluate the manufacturer software configuration management process for methods of configuration identification, control, status and audits to Reg. Guide 1.169, Section C.	Comply	See Reference 9 (Sections 6.2.6 and 6.4.3 and Tables 3.8.6 through 3.8.8) for a description of the ***SPINLINE 3*** configuration management system. See Reference 10 entries for Item 1.10 for the ***SPINLINE 3*** configuration management implementation documents.

Section	Summary of EPRI TR-107330 Requirements [1]	Compliance [2]	Comments
7.7.3.C	Software Configuration Management Review. Utility (and Qualifier) shall evaluate the manufacturer configuration management process to ensure sub-tier suppliers maintain comparable levels of configuration management per Reg. Guide 1.169, Section C.	Comply	See Reference 9 (Sections 6.2.6 and 6.4.3 and Tables 3.8.6 through 3.8.8) for a description of the ***SPINLINE 3*** configuration management system. See Reference 10 entries for Item 1.10 for the ***SPINLINE 3*** configuration management implementation documents.
7.8	Problem Reporting/Tracking Requirements. PLC manufacturer shall maintain a problem reporting and tracking system that includes classification of problems, description of problems, identification of affected hardware, type of application, description of configuration, name of reporting site and means to contact site, type of site, and cumulative operating time of PLC when problem occurred. Manufacturer shall provide a mechanism for making this information available to all nuclear utility users.	Comply	This requirement is met by a documented Quality Assurance Plan that references applicable 10 CFR Part 50, Appendix B Quality Assurance Program procedures. See References 9 (Table 3.2-1 Item XV – Nonconforming Materials, Parts of Components and Item XVI – Corrective Action) and 61.
8	Documentation. Descriptive information.	- - -	No requirements.
8.1	Equipment General Overview Document Requirements. Descriptive information.	- - -	No requirements.
8.1.A	Manufacturer Documentation. Documentation shall include a description of the PLC.	Comply	See Reference 9 (Section 4 and Appendix B).
8.1.B	Manufacturer Documentation. Documentation shall include a description of the chassis interconnections.	Comply	See Reference 9 (Section 4 and Appendix B).
8.1.C	Manufacturer Documentation. Documentation shall include a module overview and selection guide.	Comply	See Reference 9 (Section 4 and Appendix B).

Section	Summary of EPRI TR-107330 Requirements [1]	Compliance [2]	Comments
8.1.D	Manufacturer Documentation. Documentation shall include a description of the overall I/O capacity and processing speeds.	Comply	See Reference 9 (Section 4 and Appendix B).
8.1.E	Manufacturer Documentation. Documentation shall include installation information.	Comply	See References 75 and 96.
8.1.F	Manufacturer Documentation. Documentation shall include handling and storage requirements.	Comply	See Reference 62 and 78.
8.1.G	Manufacturer Documentation. Documentation shall include a description of the self-diagnostics and redundancy features.	Comply	See Reference 9 (Section 4).
8.2	Equipment General Specifications Requirements. Manufacturer documentation shall provide general specifications for the PLC.	Comply	See Reference 9.
8.3	Operator's Manual Requirements. Manufacturer documentation shall include information on operation of the PLC.	Comply	See Reference 9 (Section 4).
8.4	Programmer's Manual Requirements. Manufacturer shall provide detailed information on the use of the functions available in the PLC processors.	Comply	See References 81, 82, 83, and 84.
8.4.A	Programmer's Manual Requirements. Manual shall include a summary and brief description of available functions.	Comply	See References 81, 82, 83, and 84.
8.4.B	Programmer's Manual Requirements. Manual shall include a detailed description of each function.	Comply	See References 81, 82, 83, and 84.
8.4.C	Programmer's Manual Requirements. Manual shall include examples of complex functions.	Comply	See References 81, 82, 83, and 84.
8.4.D	Programmer's Manual Requirements. Manual shall include limitations on use of functions.	Comply	See References 81, 82, 83, and 84.
8.4.E	Programmer's Manual Requirements. Manual shall include methods for resource management.	Comply	See References 81, 82, 83, and 84.
8.4.F	Programmer's Manual Requirements. Manual shall include a user manual for programming and debugging tools, and for any programming terminal.	Comply	See References 81, 82, 83, and 84.

Section	Summary of EPRI TR-107330 Requirements [1]	Compliance [2]	Comments
8.4.G	Programmer's Manual Requirements. Manual shall include detailed information for creating user defined functions.	Comply	See References 53 and 60. The ***SPINLINE 3*** programming tools are not intended for use by the end user.
8.4.H	Programmer's Manual Requirements. Manual shall include a detailed description of operation of conditional statements.	Comply	See References 81 and 82.
8.4.I	Programmer's Manual Requirements. Manual shall include a description of limitations of PID and lead/lag functions.	N/A	The ***SPINLINE 3*** system application software does not include specific PID or lead/lag functions.
8.4.J	Programmer's Manual Requirements. Manual shall include a description of interaction between main processor and I/O modules.	Comply	See References 83 and 84.
8.4.K	Programmer's Manual Requirements. Manual shall include a detailed description of interaction between the application program and redundancy features.	Comply	See References 83 and 84.
8.4.L	Programmer's Manual Requirements. Manual shall include any software build procedures and software tools.	Comply	See References 81, 82, 83, and 84.
8.4.M	Programmer's Manual Requirements. Manual shall include a description of the operation of the executive.	Comply	See References 83 and 84.
8.4.N	Programmer's Manual Requirements. Manual shall include a description of data, data base and configuration management.	Comply	See References 83 and 84.
8.4.O	Programmer's Manual Requirements. Manual shall include a description of operation and use of self-diagnostics.	Comply	See References 83 and 84.

Section	Summary of EPRI TR-107330 Requirements [1]	Compliance [2]	Comments
8.4.P	Programmer's Manual Requirements. Manual shall include a manual for coprocessor programming.	N/A	The ***SPINLINE 3*** system uses a coprocessor that is integral to the UC25+ CPU module. See Reference 9 (Sections 4.3.3 and 4.3.4.7 and Appendix B). ***SPINLINE 3*** coprocessors are not user programmable. ***SPINLINE 3*** executive software includes coding for control and operation of embedded coprocessors.
8.5	Equipment Maintenance Manual Requirements. Manufacturer documentation shall contain information for calibration, trouble shooting, maintenance, required special tools or software, and communication protocols. Manufacturer documentation shall include results of component aging analysis.	Comply	See Reference 57 for generic template to prepare this information for each project.
8.6	Qualification Documentation Requirements. Qualifier shall provide and submit all qualification documentation to customer utility for review and approval.	Comply	See References 14 - 29.
8.6.1	Programmatic Documentation Requirements. Descriptive information.	- - -	No requirements.
8.6.1.A	Programmatic Documentation. A test plan shall be prepared which includes test plans for environmental, seismic, surge, Class 1E to Non-1E, EMI/RFI, availability/reliability, FMEA and ASOA qualification activities.	Comply	See References 14 - 29.
8.6.1.B	Programmatic Documentation. Test specifications shall be prepared which include equipment identifications, interfaces and service conditions.	Comply	See References 14 - 29.
8.6.1.C	Programmatic Documentation. Procedures shall be prepared for qualification testing.	Comply	See References 14 - 29.

Section	Summary of EPRI TR-107330 Requirements [1]	Compliance [2]	Comments
8.6.1.D	Programmatic Documentation. Test reports shall be prepared for each qualification test performed.	Comply	See Reference 29. (To be updated after completion of second round of qualification testing.)
8.6.1.E	Programmatic Documentation. Reports on audits performed on the manufacturer shall be prepared.	Comply	This requirement is met by performing audits in accordance with the Rolls-Royce Quality Assurance Manual (Reference 61).
8.6.1.F	Programmatic Documentation. Reports on design evaluations shall be prepared.	Comply	See References 151 - 154 for examples.
8.6.2	Technical Items and Acceptance Criteria Documentation Requirements. Descriptive information.	- - -	No requirements.
8.6.2.A	Technical Items Documentation. Documentation shall include test specimen requirements.	Comply	See References 14, 15, 16, and 29.
8.6.2.B	Technical Items Documentation. Documentation shall include test specimen purchasing records.	N/A	See Reference 70 for QTS End of Manufacturing Report (certificate of conformance).
8.6.2.C	Technical Items Documentation. Documentation shall include TSAP development documentation.	Comply	See Reference 71 for list of QTS TSAP documents.
8.6.2.D	Technical Items Documentation. See Sections 8.8, 8.9, 8.10, 8.12 and 8.13.	- - -	No requirements.
8.6.2.E	Technical Items Documentation. See Section 8.14.	- - -	No requirements.
8.6.3	Application Guide Documentation Requirements. A qualification summary document shall be provided.	Comply	See Reference 29. (To be updated after completion of second round of qualification testing.)

Section	Summary of EPRI TR-107330 Requirements [1]	Compliance [2]	Comments
8.6.3.A	Application Guide. Guide shall include results of environmental Operability testing to support each specific safety related application.	Comply	See Reference 29.
8.6.3.B	Application Guide. Guide shall include results of seismic testing including seismic withstand capability for all damping values used in test data analysis.	Comply	See Reference 29. (To be updated after completion of second round of qualification testing.)
8.6.3.C	Application Guide. Guide shall include results of Class 1E to Non-1E isolation testing.	Comply	See Reference 29.
8.6.3.D	Application Guide. Guide shall include results of surge withstand testing.	Comply	See Reference 29.
8.6.3.E	Application Guide. Guide shall include results of EMI/RFI testing.	Comply	See Reference 29. (To be updated after completion of second round of qualification testing.)
8.6.3.F	Application Guide. Guide shall include results of power quality testing.	Comply	See Reference 29.
8.6.3.G	Application Guide. Guide shall describe any combination of software objects or special purpose objects created to support testing.	N/A	No software objects or special purpose objects used in testing.
8.6.3.H	Application Guide. Guide shall include a description of the as-tested PLC configuration.	Comply	See Reference 29.
8.6.3.I	Application Guide. Guide shall include a description of the executive software and software tools revision levels included in qualification.	Comply	See References 16 and 89.
8.6.3.J	Application Guide. Guide shall include a description of the as-tested PLC configuration.	Comply	See Reference 29.

Section	Summary of EPRI TR-107330 Requirements [1]	Compliance [2]	Comments
8.6.3.K	Application Guide. Guide shall include a summary of the FMEA and availability analysis.	Comply	See Reference 9 Section 5.2 and References 30 – 41. The predicted hardware failure rates demonstrate that the reliability requirements for project-specific systems can be met with the typical redundant architectures used for nuclear power plant safety systems, as demonstrated by the operating experience with ***SPINLINE 3*** (see Reference 9 Section 2.2.). The hardware failure modes and effects were analyzed for each ***SPINLINE 3*** hardware module. The hardware failure modes and effects are used as input to the project-specific evaluation of a complete system. See Reference 10 entries for Items 2.8 and 2.15 for the treatment of project-specific actions.
8.6.3.L	Application Guide. Guide shall include the setpoint analysis support document.	Comply	See Reference 9 Section 5.2.2 and Reference 42. See Reference 10 entries for Items 1.21 and 2.16 for the treatment of project-specific actions.
8.6.3.M	Application Guide. Guide shall include information from manufacturer audits and surveys applicable to future purchasing.	Comply	See References 88 and 164.

Section	Summary of EPRI TR-107330 Requirements [1]	Compliance [2]	Comments
8.6.3.N	Application Guide. Guide shall include a description of the redundancy features include in qualification.	Comply	See Reference 29.
8.6.3.O	Application Guide. Guide shall include a description of external devices included in qualification.	Comply	See Reference 29.
8.6.3.P	Application Guide. Guide shall include a description of the PLC configuration management methods.	Comply	See Table Section 7.7 above.
8.6.3.Q	Application Guide. Guide shall include a summary of the component aging analysis.	Comply	See Reference 9 Section 5.2 and References 30 – 41 demonstrate that the predicted reliability for ***SPINLINE 3*** modules are greater than the typical nuclear plant surveillance intervals used to detect failures, Reference 57 contains the generic plan to develop project-specific preventive maintenance recommendations for any components with limited life (e.g., batteries, air filters, or electrolytic capacitors). Regulatory Position C.1 of NRC Regulatory Guide 1.209 does not require the age conditioning in IEEE Std. 323-2003 Section 6.2.1.2 to be applicable because of the absence of significant aging mechanisms on microprocessor-based modules.

Section	Summary of EPRI TR-107330 Requirements [1]	Compliance [2]	Comments
8.6.3.R	Application Guide. Guide shall include a description of seismic mounting methods.	Comply	See Reference 29. (To be updated after completion of second round of qualification testing.)
8.6.3.S	Application Guide. Guide shall include a description of qualification envelopes for specific modules if different from the overall envelope.	Comply	See Reference 29. (To be updated after completion of second round of qualification testing.)
8.6.3.T	Application Guide. Guide shall include a description of any application hardware or software features that are assumed in order to meet qualification requirements.	Comply	See Reference 29.

Section	Summary of EPRI TR-107330 Requirements [1]	Compliance [2]	Comments
8.6.4	Supporting Analyses Documentation Requirements. Documentation shall be provided of the FMEA and Availability/Reliability Analyses.	Partially Comply	See Reference 9 Section 5.2 and References 30 – 41. The predicted hardware failure rates demonstrate that the reliability requirements for project-specific systems can be met with the typical redundant architectures used for nuclear power plant safety systems, as demonstrated by the operating experience with ***SPINLINE 3*** (see Reference 9 Section 2.2). The hardware failure modes and effects were analyzed for each ***SPINLINE 3*** hardware module. The hardware failure modes and effects are used as input to the project-specific evaluation of a complete system. See Reference 10 entries for Items 2.8 and 2.15 for the treatment of project-specific actions.
8.6.5	Class 1E to Non-1E Isolation Test Plan. A Class 1E to Non-1E Isolation test plan and report shall be provided. The test plan shall be reviewed and approved by the utility.	Comply	See Reference 26. Class 1E to Non-1E isolation capability meets IEEE 384-1981. See Reference 29 Appendix J.
8.7	V&V Documentation Requirements. Descriptive information.	- - -	No requirements.
8.7.A	V&V Documentation. Documentation shall include a software quality assurance plan.	Comply	See Reference 64.

Section	Summary of EPRI TR-107330 Requirements [1]	Compliance [2]	Comments
8.7.B	V&V Documentation. Documentation shall include a software requirements specification.	Comply	See References 15 and 66.
8.7.C	V&V Documentation. Documentation shall include a software design description.	Comply	See References 67 and 68.
8.7.D	V&V Documentation. Documentation shall include a software V&V plan.	Comply	See Reference 69.
8.7.E	V&V Documentation. Documentation shall include a software V&V report.	Comply	See Reference 69.
8.7.F	V&V Documentation. Documentation shall include software user documentation.	N/A	There is no software user manual for TSAP, since the operator does not interact with it. Reference 72 is the DAS software user manual.
8.7.G	V&V Documentation. Documentation shall include a software configuration management plan.	Comply	See Reference 65.
8.8	System Description Requirements. A test specimen hardware and software description document shall be provided.	Comply	See Reference 15, 67, and 68..
8.9	Critical Characteristics Listing Requirement. A critical characteristics listing document shall be provided.	- - -	See Section 3 of this report.
8.10	System Drawing Requirements. A set of test specimen hardware, software and configuration drawings shall be provided.	Comply	See References 67, 68, 73, and 74.
8.10.A	System Drawing Requirements. Drawings shall include a functional description of the test specimen.	Comply	See Reference 15.
8.10.B	System Drawing Requirements. Drawings shall include a schematic of the test specimen.	Comply	See Reference 73.
8.10.C	System Drawing Requirements. Drawings shall include diagrams that define the TSAP.	Comply	See References 67 and 68.
8.10.D	System Drawing Requirements. Drawings shall show test specimen wiring, power distribution and grounding.	Comply	See Reference 74.

Section	Summary of EPRI TR-107330 Requirements [1]	Compliance [2]	Comments
8.10.E	System Drawing Requirements. Drawings shall show layout of test specimen chassis, modules and qualification test fixtures.	Comply	See References 73, 74, and 77.
8.10.F	System Drawing Requirements. Drawings shall show test specimen mounting and mounting fixtures, including special installation requirements.	Comply	See References 75 and 76.
8.11	System Software/Hardware Configuration Document Requirements. Software and hardware configuration used for qualification testing shall be documented, including identification and revision of executive software, module firmware, software tools, downloadable PLC executive packages, and the TSAP (including printout). The identification, revision level and serial number of hardware shall be documented.	Comply	See References 16, 67, and 68.
8.12	System Database Documentation Requirements. The TSAP database used for qualification testing shall be documented.	Comply	The ***SPINLINE 3*** system does not use a database. Project documents are generated by CLARISSE for a given software version and are archived as the Controlled Baseline of the software in the Dimensions configuration management tool. See Reference 65.
8.13	System Setup/Calibration/Checkout Procedure Requirements. All setup, calibration and checkout procedures used during qualification shall be documented.	Comply	See References 14, 18, and 29.
8.14	System Test Documentation Requirements. A test plan and test report shall be provided covering qualification Operability testing. The documents shall include test requirements, acceptance criteria, sequence of testing, data recording methods, test equipment requirements and a test data summary.	Comply	See References 14 - 29.

Section	Summary of EPRI TR-107330 Requirements [1]	Compliance [2]	Comments
8.15	Manufacturer's Quality Documentation Requirements. The manufacturer shall provide its Quality Assurance Plan.	Comply	See References 9 (Section 1.4 and Table 3.2-1), 14, and 64. This requirement is met by a documented Qualification Program Quality Assurance Plan that references applicable 10 CFR Part 50, Appendix B Quality Assurance Program procedures.
8.16	Manufacturer's Certifications Requirements. Manufacturer shall provide certificates of conformance for all test specimen hardware.	Comply	See Reference 80 for generic procedure. See Reference 70 for QTS End of Manufacturing Report (certificate of conformance).

Table Notes:

1. The requirement summaries are intended to paraphrase the basic hardware, software, or programmatic requirements, and may not include all of the detailed requirement text given in the corresponding section of EPRI TR-107330. The statement of compliance for each requirement given in the table pertains to the detailed requirements as given in the corresponding section of EPRI TR-107330.
2. Definition of Compliance Terms:

- - -	The referenced EPRI TR-107330 section does not include any specific PLC requirements. No statement of compliance is necessary.
N/A	The EPRI TR-107330 requirement is not applicable to the specific design of the ***SPINLINE 3*** system. No statement of compliance is necessary. The Comments column provides a basis for the requirement being not applicable.
Comply	The ***SPINLINE 3*** system design fully complies with the corresponding requirement as given in the applicable section of EPRI TR-107330.
Partially Comply	The ***SPINLINE 3*** system design complies with given in the applicable section of EPRI TR-107330 but additional plant-specific work is required or not all range options are provided, or the intent of the requirement is met when SPINLINE 3 design differences are considered.

Exception	The ***SPINLINE 3*** system design does not fully comply with the corresponding requirement as given in the applicable section of EPRI TR-107330. The Comments column provides a disposition of the compliance exception.
TR Discrepancy	The requirement as given in EPRI TR-107330 cannot be met. The Comments column provides a discussion and disposition of the identified EPRI TR-107330 discrepancy.

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5 REFERENCES

NRC Documents

1. 10 CFR Part 50 Appendix B, “Quality Assurances Requirements for Nuclear Power Plants and Fuel Reprocessing Plants.”
2. 10 CFR Part 21, “Reporting of Defects and Noncompliance.”
3. NRC Branch Technical Position 7-14, Revision 5, “Guidance on Software Reviews for Digital Computer Based Instrumentation and Control Systems.”
4. NUREG-0800, NRC Standard Review Plan, Table 7-1, “Regulatory Requirements, Acceptance Criteria, and Guidelines for Instrumentation and Control Systems Important to Safety,” Revision 5.
5. NRC Generic Letter 89-02, “Actions to Improve the Detection of Counterfeit and Fraudulently Marketed Products.”

Industry Documents

6. EPRI TR-107330, “Generic Requirements Specification for Qualifying a Commercially Available PLC for Safety-Related Applications in Nuclear Power Plants,” Final Report dated December 1996.
7. EPRI TR-106439, “Guideline on Evaluation and Acceptance of Commercial Grade Digital Equipment for Nuclear Safety Applications,” Final Report dated October 1996.
8. EPRI NP-5652, "Guideline for the Utilization of Commercial-Grade Items in Nuclear Safety-Related Applications (NCIG-07)," June 1988

Rolls-Royce Documents Submitted to NRC

9. Rolls-Royce Document 3 008 503 C, *“**SPINLINE 3** Licensing Topical Report.”*
10. Rolls-Royce Document 3 011 552 B, “Map of ISG-06 to ***SPINLINE 3*** Licensing Documents.”
11. Rolls-Royce Document 3 010 794 A, “***SPINLINE 3*** Platform Dedication Plan.”
12. Rolls-Royce Document 3 010 795 A, “Dedication Report for the Generic ***SPINLINE 3*** Digital Safety I&C Platform.”
13. “***SPINLINE 3*** Design Analysis Report,” Document No. MPR-3337, Revision 1, MPR Associates, Inc., June 2009
14. Rolls-Royce Document 3 006 501 D, “Equipment Qualification Plan.”
15. Rolls-Royce Document 3 006 404 E, “***SPINLINE 3*** Qualification Test System Specification.”
16. Rolls-Royce Document 3 010 612 D, ***“SPINLINE 3*** Qualification Test System Master Configuration List.”
17. Rolls-Royce Document 3 010 783 A, “Factory Acceptance Test Procedure.”
18. Rolls-Royce Document 3 010 294 B, “System Setup and Checkout Test Procedure.”
19. Rolls-Royce Document 3 010 286 B, “Radiation Exposure Test Procedure.”
20. Rolls-Royce Document 3 010 287 B, “Environmental Test Procedure.”
21. Rolls-Royce Document 3 010 288 B, “Seismic Test Procedure.”
22. Rolls-Royce Document 3 010 289 A, “EMI / RFI Test Procedure.”

23. Rolls-Royce Document 3 010 292 A, “Electrostatic Discharge Test Procedure.”
24. Rolls-Royce Document 3 010 290 B, “Electrical Fast Transient Test Procedure.”
25. Rolls-Royce Document 3 010 291 A, “Surge Withstand Test Procedure.”
26. Rolls-Royce Document 3 010 293 A, “Class 1E to Non-Class 1E Isolation Test Procedure.”
27. Rolls-Royce Document 3 010 295 B, “Operability Test Procedure.”
28. Rolls-Royce Document 3 010 296 B, “Prudency Test Procedure.”
29. Rolls-Royce Document 3 014 545 A, ***“SPINLINE 3*** Summary Equipment Qualification Test Report.”
30. Rolls-Royce Document 5 100 436 882 C, “Reliability Analysis and Predictive Safety Analysis - RTD conditioning board: 8PT100 and I.8PT100 Interface board.”
31. Rolls-Royce Document 5 100 436 348 C, “Reliability Analysis and Predictive Safety Analysis - Analog input board: 16E.ANA ISO and I.16EANA interface board.”
32. Rolls-Royce Document 5 100 435 707 C, “Reliability Analysis and Predictive Safety Analysis - Digital isolated input board: 32ETOR TI SR and I.32ETOR TI interface board.”
33. Rolls-Royce Document 1 479 513 C, “Reliability Analysis and Predictive Safety Analysis - Calibrated pulse acquisition board: ICTO and I.ICTO interface board.”
34. Rolls-Royce Document 5 100 437 019 C, “Reliability Analysis and Predictive Safety Analysis - Actuator drive board: 32ACT and I.32ACT interface board.”
35. Rolls-Royce Document 3 008 651 B, “Reliability Analysis and Predictive Safety Analysis - Analog output board: 6SANA ISO and I.6SANA interface board.”
36. Rolls-Royce Document 6 648 805 D, “Reliability Analysis and Predictive Safety Analysis - CPU board: UC25N+.”
37. Rolls-Royce Document 1 208 933 C, “Reliability Analysis and Predictive Safety Analysis - NERVIA+ daughter board and I.NERVIA+ interface board.”
38. Rolls-Royce Document 3 000 180 C, “Reliability Analysis and Predictive Safety Analysis - ALIM 48V/5V-24V power supply board and I.ALIM 48 interface board.”
39. Rolls-Royce Document 5 100 436 936 C, “Reliability Analysis and Predictive Safety (Analysis - Actuation voting module: MV16.”
40. Rolls-Royce Document 5 100 436 935 C, “Reliability Analysis and Predictive Safety Analysis - Output relays terminal block: 8SRELAY1 & 8SRELAY2.”
41. Rolls-Royce Document 3 008 991 B, “Reliability Analysis and Predictive Safety Analysis - 32ETOR input terminal block.”
42. Rolls-Royce Document 3 009 397 A. ***“SPINLINE 3*** Setpoint Analysis Support.”
43. Rolls-Royce Document 1 208 686 B, “Software Modification Quality Plan for **SPINLINE 3** Software.”
44. Rolls-Royce Document 1 208 356 B, “Software Quality Plan / SCADE Operator Library.”
45. Rolls-Royce Document 1 208 878 E, “Software Configuration Management Plan for ***SPINLINE 3*** Software.”
46. Rolls-Royce Document 1 207 108 J, ***“SPINLINE 3*** / OSS / Software Requirement Specification.”
47. Rolls-Royce Document 1 207 110 J, ***“SPINLINE 3*** / Interface Specifications.”
48. Rolls-Royce Document 1 207 141 H, ***“SPINLINE 3 /*** CSS / Software Preliminary Design.”

49. Rolls-Royce Document 1 207 146 G, “Software Validation Test Plan (SVTP) – Operational System Software for Safety Class Units.”
50. Rolls-Royce Document 1 207 204 E, ***“SPINLINE 3*** / CSS / Software Integration Test Plan and Report.”
51. Rolls-Royce Document 1 207 232 F, ***“SPINLINE 3*** / OSS / Software Validation Test Report.”
52. Rolls-Royce Document 1 207 875 G, “Configuration Management Process Procedure.”
53. Rolls-Royce Document 1 207 107 D, “Rules for Verification and Validation of Software Components.”
54. Rolls-Royce Document 1 207 228 H, “***SPINLINE 3*** Safety of Processing Unit Software.”
55. Rolls-Royce Document 8 307 210 B. ***“SPINLINE 3*** Project-Specific Software Verification and Validation Plan - US Template.”
56. Rolls-Royce Document 8 307 245 A, ***“SPINLINE 3*** Project-Specific System Integration and Factory Test Plan - US Template.”
57. Rolls-Royce Document 8 307 244 A, “***SPINLINE 3*** System Operations and Maintenance Plan - US Template.”
58. Rolls-Royce Document 3 013 962 A, ***“SPINLINE 3*** Secure Development and Operational Environment.”
59. Rolls-Royce Document 3 014 543 A, "***SPINLINE 3*** Secure Development and Operational Environment - Vulnerability Assessment.”
60. Rolls-Royce Document 8 307 208 B, ***“SPINLINE 3*** Project-Specific Software Quality Assurance Plan - US Template.”
61. Royce Document 8 303 186 P, “Rolls-Royce Civil Nuclear SAS Instrumentation & Control Quality Manual.”
62. Global Quality Assurance Audit Report dated February 3, 2009

Rolls-Royce Documents Not Submitted to NRC (Available for Audit)

63. Rolls-Royce Document 3 010 897 A, “QTS Response Time Analysis.”
64. Rolls-Royce Document 3 007 964 B. “TSAP Software Quality Assurance Plan.”
65. Rolls-Royce Document 3 007 966 B, “TSAP Software Configuration Management Plan.”
66. Rolls-Royce Document 3 008 127 B, “Software Requirements Specification QTS/TSAP - ***SPINLINE 3*** NRC Qualification.”
67. Rolls-Royce Document 3 008 676 A, “Software Design Document TSAP1.”
68. Rolls-Royce Document 3 008 677 A, “Software Design Document TSAP2.”
69. Rolls-Royce Document 3 008 773 A, “Software Validation Test Plan and Report TSAP.”
70. Rolls-Royce Document 4 501 529 B, “QTS End of Manufacturing Report.”
71. Rolls-Royce Document 3 009 280 A, “List of Software Documents QTS / DAS – ***SPINLINE 3*** NRC Qualification.”
72. Rolls-Royce Document 3 009 283 A, “DAS Software User Manual.”
73. Rolls-Royce Document 3 007 837 F, “QTS Principle Schematics.”
74. Rolls-Royce Document 3 008 630 E, “QTS Wiring Diagrams.”
75. Rolls-Royce Document 3 011 606 A, “Instruction for QTS Mounting and Set-up.”

76. Rolls-Royce Document 3 009 634 C, “Equipment Mounting Details for Seismic Testing.”
77. Rolls-Royce Document 3 010 520 E, “Table of Connections to QTS-DAS.”
78. Rolls-Royce Document 8 303 226, “Handling, Packing and Storage Procedure.”
79. Rolls-Royce Document 8 303 326, “Shipping Procedure.”
80. Rolls-Royce Document 8 303 228, “Establishment of Factory Reports Procedure.”
81. “SCADE Language Reference Manual,” Version 3.1
82. “***SPINLINE 3*** - SCADE Operators Library User Manual,” Version 0200.
83. Rolls-Royce Document 3 002 582 B, ***“SPINLINE 3*** - Clarisse Workshop - Reference Manual.”
84. Rolls-Royce Document 3 002 800 C, ***“SPINLINE 3*** - Clarisse Workshop – User’s Guide.”
85. Rolls-Royce Document 3 002 593 A, ***“SPINLINE 3*** / Software User Document of Verif_CMU tool.”
86. Rolls-Royce Document 3 002 594 A, ***“SPINLINE 3*** / Software User Document of Verif_ASA tool.”
87. Rolls-Royce Document 3 003 769 A, “VERIF_COMP Software User Document.”
88. Rolls-Royce Document 1 203 540 E, “Self-testing Programmable Hardware Components and Identification Rules Instruction.”
89. Rolls-Royce Document 3 008 562 A, “List of Tools and Libraries Used for Software Development.”
90. Rolls-Royce Document 5 100 435 513 B, “32ETOR TI Board – User’s Sheet.”
91. Rolls-Royce Document 1 479 165 B, “6SANA Board – User’s Sheet.”
92. Rolls-Royce Document 5 100 436 541 B, “32ACT FPGA Design Requirement.”
93. Rolls-Royce Document 5 100 436 366 B, “32ACT Board - User’s Sheet.”
94. Rolls-Royce Document 1 613 969 G, “General Procedure for Programming.”
95. Rolls-Royce Document 1 207 861 B, “Documentation Guide - The Software Manufacturing File - Programming Instruction.”
96. Rolls-Royce Document 3 011 458 A, “***SPINLINE 3*** Cabling and Grounding.”
97. Rolls-Royce Document 8 303 349 E, “Design Control of Electronic Equipment Procedure.”
98. Rolls-Royce Document 8 303 687 A, “Design Process of Programmable Components Procedure.”
99. Rolls-Royce Document 5 100 436 536 B, “32ACT FPGA Requirements Specification.”
100. Rolls-Royce Document 5 100 436 537 A, “32ACT FPGA Detailed Design Specification.”
101. Rolls-Royce Document 5 100 436 538 B, “32ACT FPGA Detailed Design Report.”
102. Rolls-Royce Document 5 100 436 539 A, “32ACT FPGA Test Program Specification.”
103. Rolls-Royce Document 5 100 436 540 A, “32ACT FPGA Simulation Test Report.”
104. Rolls-Royce Document 5 100 436 541 B, “32ACT FPGA Programming Instruction.”
105. Rolls-Royce Document 5 100 435 971 B, “16 E.ANA ISO FPGA Requirements Specification.”

106. Rolls-Royce Document 5 100 435 972 B, “16 E.ANA ISO FPGA Detailed Design Specification.”
107. Rolls-Royce Document 5 100 435 992 B, “16 E.ANA ISO FPGA Detailed Design Report.”
108. Rolls-Royce Document 5 100 435 979 A, “16 E.ANA ISO FPGA Test Program Specification.”
109. Rolls-Royce Document 5 100 436 011 B, “16 E.ANA ISO FPGA Simulation Test Report.”
110. Rolls-Royce Document 5 100 436 319 B, “16 E.ANA ISO FPGA Programming Instruction.”
111. Rolls-Royce Document 5 100 436 611 B, “NERVIA+ CPLD Requirements Specification.”
112. Rolls-Royce Document 5 100 436 612 B, “NERVIA+ CPLD Detailed Design Specification.”
113. Rolls-Royce Document 5 100 436 613 B, “NERVIA+ CPLD Detailed Design Report.”
114. Rolls-Royce Document 5 100 436 614 B, “NERVIA+ CPLD Test Program Specification.”
115. Rolls-Royce Document 5 100 436 615 A, “NERVIA+ CPLD Simulation Test Report.”
116. Rolls-Royce Document 5 100 436 209 B, “NERVIA+ CPLD Programming Instruction.”
117. Rolls-Royce Document 8 303 221 H, “Product Identification and Traceability Procedure.”
118. Rolls-Royce Document 8 303 436 C, “Management of Electronic Board Embedding Programmable Components Procedure.”
119. Rolls-Royce Document 8 303 711 B, “Configuration Management during Electronic Development Procedure.”
120. Rolls-Royce Document 8 303 675 F, “Documentation Management of Electronic Sub-Assemblies Procedure.”
121. Rolls-Royce Document 1 202 646 D, “ICTO Software Requirements Specification.”
122. Rolls-Royce Document 1 202 715 C, “ICTO Software Design Description.”
123. Rolls-Royce Document 1 202 856 C, “ICTO Software Component Test File.”
124. Rolls-Royce Document 1 202 812 B, “ICTO Software Integration Test Plan.”
125. Rolls-Royce Document 1 203 102 B, “ICTO Software Integration Test Report.”
126. Rolls-Royce Document 1 202 855 B, “ICTO Software Validation Test Plan.”
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129. Rolls-Royce Document 1 208 763 A, “NERVIA+ Software Preliminary Design Description: Volume 1 - Analysis of Architecture Solutions.”
130. Rolls-Royce Document 1 208 961 A, “NERVIA+ Software Preliminary Design Description: Volume 2 - Architecture Description.”
131. Rolls-Royce Document 1 208 928 A, “NERVIA+ Software Detailed Design Description: Volume 1 - Description of Functions.”
132. Rolls-Royce Document 1 208 963 B, “NERVIA+ Software Design Description.”

133. Rolls-Royce Document 1 208 879 A, “NERVIA+ Test Strategy Analysis.”
134. Rolls-Royce Document 1 208 992 B, “NERVIA+ Software Integration Test File.”
135. Rolls-Royce Document 1 208 910 A, “NERVIA+ Software Validation Test Analysis: Volume 1 - Top Level Document.”
136. Rolls-Royce Document 1 208 956 A, “NERVIA+ Software Validation Test Analysis: Volume 2 - RequisitePro Report.”
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149. Rolls-Royce Document 32466651RM, Vp0808b datasheet.
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152. Rolls-Royce Document MPD-08.4249, “***SPINLINE 3*** QTS System Specification Plan Review.”
153. Rolls-Royce Document MPD-08.4134bis, “***SPINLINE 3*** QTS Qualification Plan Review.”
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