TOSHIBA

PSNN-2018-0209

UTLR-0020NP Part IV Rev.3
October 2018

Topical Report

Licensing Topical Report for Toshiba NRW-FPGA-based
Instrumentation and Control System for Safety-Related Application

Part IV
Compliance to the Codes and Standards

Approved by
Electrical System Design & Engineering Dept.

H. Takeda

Toshiba Energy Systems & Solutions Corporation
Nuclear Energy Systems & Services Division

Table of Contents

List of Tables

Note for Acronyms and References

All acronyms and references are listed in the separate Acronym and Reference Part, which is part of this LTR.

IV-1 Introduction

This is Part IV of the Licensing Topical Report (LTR) for the Toshiba Non-Rewitable Field Programmable Gate Array (NRW-FPGA-based) Instrumentation and Control (I&C) Systems for Safety-Related Applications. This part describes the compliance to Codes and Standards.

IV-1.1 Background

Toshiba has extensive experience in supplying nuclear safety-grade Instrumentation and Control (I&C) systems in Japan. This experience ranges from supplying digital I&C systems, such as power range neutron monitors for individual plants, up to designing and manufacturing the world's first fully integrated digital CPU-based I&C system for Advanced Boiling Water Reactor (ABWR)s. These systems were first installed at Kashiwazaki-Kariwa Unit 6, and are in use at Kashiwazaki-Kariwa Unit 6 and Hamaoka Unit 5.

Following the installation of the CPU-based BWR digital system, Toshiba started development of I&C technology based on Non-Rewritable (NRW) Field Programmable Gate Arrays (FPGAs) and supplied the NRW-FPGA-based I&C products to Japanese Nuclear Power Plants under Toshiba's ISO 9001 program. NRW-FPGA-based products have been installed in 11 nuclear power plants including 254 NRW-FPGA-based units for non-safety-related systems, 91 units for safety-related process radiation monitors, and 60 units for safety-related neutron monitoring systems.

Toshiba also established a 10 CFR 50 Appendix B (Reference (a2)) Quality Assurance (QA) process to permit the use of Toshiba FPGA-based system in the US for safety-related applications in nuclear power plants. Toshiba implemented Appendix B QA processes in a phased approach as follows to ensure a smooth transition of the processes at the affected organizations.

- Original Process:
  Initial establishment of the Appendix B QA process in the system engineering organization, this process was applied to the development and the qualification of the Power Range Monitor (PRM) for a Boiling Water Reactor (BWR)-5. This process is referred to as the "Original Process" in this topical report.

- Current Process:
  Toshiba improved the Original Process by extending the Appendix B QA process into the design organization and closer to the manufacturing organizations where other Toshiba NRW-FPGA-based I&C products are developed. This process is referred to as the "Current Process"

in this LTR. All future work will be under this process, including modifications to equipment produced under the original process.

Toshiba has used the Original Process to develop and qualify a NRW-FPGA-based PRM for a BWR-5. Toshiba used the Current Process to develop and qualify the Oscillation Power Range Monitor (OPRM) for ABWR.

This LTR uses the term "PRM," to mean PRM for BWR-5 and uses the term "OPRM," to mean OPRM for ABWR.

This LTR consists of the following six parts:

Part I describes software lifecycle and development processes.

Part II provides the design descriptions for the PRM and the OPRM and includes an application guide.

Part III describes the qualification results for the PRM and the OPRM.

Part IV provides the compliance tables for Toshiba processes to important Codes and Standards.

Part V provides the BWR-5 PRM V&V report.

Part VI provides the ABWR OPRM V&V report.

The Acronym and Reference Part lists all the acronyms and references used in the all Parts except Part V and VI of the LTR. Part V and Part VI have their own acronym and reference lists because they are the existing actual V&V reports for the PRM and the OPRM.

IV-1.2 Purpose

This document is Part IV of the LTR. This part of the LTR describes the compliance of Toshiba NRW-FPGA-based Safety-Related PRM and OPRM Systems to the codes and standards.

IV-1.3 Scope

This LTR, including Part IV, is being submitted to the USNRC for review and approval of the Toshiba NRW-FPGA-based Safety-Related PRM and OPRM.

The Part IV of the LTR describes the compliance of the Toshiba NRW-FPGA-based Safety-Related

PRM and OPRM to the following codes and standards:

- IEEE Std 603-1991 (Reference (a36))
- IEEE Std 7-4.3.2-2003 (Reference (a30))
- EPRI TR-107330 (Reference (a46))
- DI&C ISG-04 (Reference (a22))
- DI&C ISG-06 (Reference (a23))

This report includes the following information:

- Section IV-1 provides introductory material, including the report purpose and scope,
- Section IV-2 describes compliance with IEEE Std 603-1991.
- Section IV-3 describes compliance with IEEE Std 7-4.3.2-2003.
- Section IV-4 describes compliance with EPRI TR-107330.
- Section IV-5 describes compliance with DI&C ISG-04.
- Section IV-6 describes how this LTR maps to DI&C ISG-06.

IV-2 Compliance with IEEE Std 603-1991

Table IV-2-1 documents conformance of the PRM and OPRM to IEEE Std 603-1991 (Reference (a36)). All Toshiba safety systems will comply with the requirements of IEEE Std 603-1991, as required by US regulation.

Appendix 7.1-C of the USNRC Standard Review Plan (SRP), NUREG-0800 (Reference (a4)) provides guidance for evaluation of conformance to IEEE Std 603-1991. Table IV-2-1 is prepared considering Appendix 7.1-C of the SRP.

Figure 2 of the IEEE Std 603-1991 illustrates the scope of the standard. Some parts of this standard are out of the scope of the FPGA-based safety-related I&C systems in this LTR, as the features apply to the installed system with a plant-specific context. For example, Toshiba cannot include the manual control features defined in Clause 7.2 of IEEE Std 603-1991 "Execute Features" in the FPGA-based safety-related I&C systems. Rather, such features will be included in a plant-specific design. Toshiba's equipment includes design features to support plant applications, including compliance with the manual control features to the extent that a PRM or OPRM requires manual control features.

The IEEE clauses are summarized in the table below. Toshiba evaluates system and plant-specific designs against the standard itself, to avoid issues with interpretation that result from changes in the IEEE standard.

Notes:

- "Comply" means the Toshiba safety system comply with the corresponding IEEE Std 603 requirement.
- "---" means there is no requirement in the IEEE Std 603.
- "N/A" means the IEEE Std 603 requirement is applied at the plant level, when the systems described in this LTR are integrated with the plant, including the plant human-system interface.

Table IV-2-1 PRM and OPRM Conformance with IEEE Std 603-1991

IEEE Std 603-1991		Compliance	Comments
Clause	Requirements Summary		
1	Scope. Description of IEEE scope.	---	No requirements.
2	Definitions. List of definitions used in the standard.	---	No requirements.
3	Reference. List of documents referenced in the standard.	---	No requirements.

IEEE Std 603-1991		Compliance	Comments
Clause	Requirements Summary		
4	A safety system design basis shall be established.	Comply	Toshiba established a specific design basis for each safety system design in each engineering process. The engineering processes are described in the following LTR sections. Section I-2 describes QA programs used in establishing design bases and performing work in the current process. Section I-A-3 describes QA programs used in establishing design bases and performing work in the original process. Section I-3.3.1 describes how the base requirements for the FPGA-based I&C system are established in the Project Planning and Concept Definition Phase in the current process. Section I-A-4.2.1 describes how the base requirements for the PRM were established in the Project Planning and Concept Definition Phase in the original process.
4.1	The design basis events applicable to each operation mode.	Comply	Section I-3.3.1.1 states that plant specific documents, regulations, and applicable industry codes and standards are inputs to the Project Planning and Concept Definition Phase in current process. Section I-A-2 states that plant specific documents, regulations, and applicable industry codes and standards are inputs to the Project Planning and Concept Definition Phase in the original process. The design basis events are included in the plant specific documents and regulations.
4.2	The safety functions and corresponding protective actions of the execute features.	N/A	The PRM and OPRM in this LTR monitor the core and provide safety functions (trips or data to block rod withdrawal or insertion) to protect the core, which supports the protective actions of the reactor trip system and the rod block monitor.
4.3	The permissive conditions for each operating bypass capability.	Comply	Section I-3.3.1.3 states that the SDD and IBD are prepared for each FPGA-based system and Section I-3.3.1.7 states that an EDS is prepared for each FPGA-based system in the current process. Section I-A-4.2.1 states that the ERS was prepared for the PRM in the original process. These documents and drawings document the permissive conditions for each operating bypass capability.
4.4	The variables or combinations of variables, or both, to be monitored; the analytical limit associated with each variable, the ranges; and the rates of change of these variables.	Comply	Section I-3.3.1.3 states that the SDD and IED are prepared for each FPGA-based system and Section I-3.3.1.7 states EDS is prepared for each FPGA-based system in the current process. Section I-A-4.2.1 describes that the ERS was prepared for the PRM in the original process. These documents and drawings document the monitored variables, as well as system response times, ranges, and the rates of the change of the variables with the value required from the plant specific document for the analytical limit.
4.5	Minimum criteria for each possible manual action.	---	The PRM and OPRM are automatic systems, providing automatic initiation function corresponding to protective actions, not requiring any safety action by manual means.

IEEE Std 603-1991		Compliance	Comments
Clause	Requirements Summary		
4.6	For those spatially dependent variables in 4.4, the minimum number and locations of sensors required for protective purposes.	Comply	The location and number of neutron flux detectors in the reactor core is not part of this LTR. This LTR expects that appropriate numbers and locations of detectors are defined, and that the allocation of detectors to channels has been performed in a manner that will protect the core. The PRM and OPRM systems are typical systems that use spatially dependent variables.
4.7	The environmental conditions throughout which the safety system shall perform.	Comply	Section II-A-4.2 describes how the PRM and OPRM are evaluated for compliance with the environmental conditions given in EPRI TR-107330, RG 1.180 Rev.1, and other nuclear standards.
4.8	The conditions which may cause degradation and for which provisions are needed to retain the capability for performing the safety functions.	Comply	Toshiba qualified the PRM and OPRM using the guidance of RG 1.180, Revision 1; RG 1.209, Revision 0; EPRI TR-107330, and IEEE Std 323-2003 as appropriate. Toshiba considers that the stressors applied during equipment qualification are sufficient for installation in a mild environment.
4.9	The methods of the reliability analysis determine that the reliability is sufficient for the safety systems.	Comply	Section I-3.3 Software Development Plan and Section I-3.10 Software V&V Plan describe methods Toshiba uses to enhance the software reliability in the current process, ensuring the requirements in the top level design documents are implemented. Section I-A-4.2 Software Development Planning and Practice and Section I-A-4.8 Software V&V Planning and Practice describes methods Toshiba used to enhance the software reliability of the PRM, ensuring the requirements in the top level design documents are implemented. For qualitative hardware reliability, Section III-3.2.1 describes the Availability/Reliability analysis for the PRM system and Section III-6.2.1 describes the Availability/Reliability analysis for the OPRM system. These analyses are used to establish conservative hardware reliability figures. Toshiba uses the hardware reliability numbers to ensure the hardware has sufficient reliability to meet typical utility and PRA requirements and expectations.
4.10	The critical points in time or the plant conditions including:	Comply	Section II-2.2.3.3 discusses determinism, stating that analyses are performed to satisfy the design timing requirements set forth in Clause 4.10 of IEEE Std 603. Section I-3.3.1.3 states that the SDD and IBD are prepared for each FPGA-based system and Section I-3.3.1.7 states EDS is prepared for it in the current process. Section I-A-4.2.1 describes that the ERS was prepared for the PRM in the original process. These documents and drawings document the critical points in time and plant conditions for the initiation, completion, and control of the protective actions, and the conditions that allow returning the safety systems to normal.
4.10.1	For the protective actions of the safety system shall be initiated.		
4.10.2	For the completion of the safety function.		
4.10.3	Requiring automatic control of protective actions.		
4.10.4	Allowing returning a safety system to normal.		

IEEE Std 603-1991		Compliance	Comments
Clause	Requirements Summary		
4.11	The equipment protective provisions that prevent the safety systems from accomplishing their safety functions.	Comply	FMEA in the qualification and the hazard analysis report documents potential faults and failures, which Toshiba attempts to eliminate or at least mitigate in the system design (Section III-3.2.2 for the PRM and Section III-6.2.2 for the OPRM). The system behavior then provides a basis on which plant faults and failures can be evaluated (Section III-4.1.3 for the PRM and Section III-7.1.3 for the OPRM). For plant systems, Toshiba will perform safety analyses as necessary.
4.12	Any other special design basis.	Comply	Section II-2.2.3.3 discusses determinism, and Section II-2.2.3.5 discusses simplicity.
5	The safety systems shall maintain plant parameters within acceptable limits.	Comply	Section I-3.3.1.3 states that the SDD and IED are prepared for each FPGA-based system and Section I-3.3.1.7 states EDS is prepared for each FPGA-based system and in the current process. Section I-A-4.2.1 states that the ERS is prepared for each FPGA-based system in the original process. These documents and drawings document how the safety systems with precision and reliability maintain required specific plant parameters within acceptable limits established for the required design basis event.
5.1	Single-failure criterion.	Comply	Section II-2.2.2.3 describes that the PRM and OPRM systems can generate a trip signal leading to a scram signal generated by the RPS, under permissible bypass conditions, meeting the Single Failure Criterion.
5.2	Completion of protective action. The safety systems shall be designed to complete the protective actions.	N/A	Neither PRM nor OPRM complete the protective actions by itself, because they are part of the safety systems that complete the protective actions. Toshiba expects that the RPS will be designed to ensure that an initiated trip carries through to completion, once sufficient PRM or OPRM have provided votes to trip to the RPS.
5.3	Quality. Safety system equipment shall be designed, manufactured, inspected, installed, tested, operated, and maintained in accordance with a prescribed quality assurance program (ANSI/ASME NQA-1-1989).	Comply	Section I-2.1 describes the QA program in the current process. Section I-A-3 describes the QA program in the original process. These sections also describe how the complete software / programmable logic life cycle program (including the software quality assurance program) operates under Toshiba's NQA-1 compliant nuclear QA program used for the FPGA-based safety-related I&C systems. Section I-3 describes Software/Hardware development process in the current process. Section I-A-4 describes Software/Hardware development process in the original process. Section I-2.2.3 and Section I-A-3.2.3 describes the methods Toshiba uses to accept commercial grade items.

IEEE Std 603-1991		Compliance	Comments
Clause	Requirements Summary		
5.4	Equipment qualification. Safety system equipment shall be qualified by type test, previous operating experience, or analysis, or any combination of these three methods.	Comply	Part III of this LTR describes Toshiba's Qualification Test program and Test Results. Toshiba qualifies the FPGA-based I&C system by type test, using EPRI TR-107330, IEEE Std 323-1983, and Reg. Guide 1.209. Reg. Guide 1.180 Revision 1 is used for EMI qualification.
5.5	System integrity. The safety systems shall be designed to accomplish their safety functions under the full range of applicable conditions enumerated in the design basis.	Comply	The qualification test and the V&V efforts provide adequate confidence that system integrity is maintained under the full range of applicable conditions defined enumerated in the specific plant design basis. Section I-3 addresses the software/hardware development process in the current process, and Section I-A-4 addresses the software/hardware development process in the original process. The software/hardware development process ensures software and hardware integrity in the FPGA-based I&C systems. Software safety analysis in the current process is described in Section I-3.9; software safety analysis in the original process is described in Section I-A-4.7. Appendix 7.1-C of the SRP states that real-time performance is a special concern of system integrity. Section II-2.2.2.2.1 addresses the response time requirements of the PRM. Section II-2.2.2.2.2 addresses the response time requirements of the OPRM.
5.6	Independence.	---	Clause Title
5.6.1	Redundant portions of a safety system shall be independent and physically separated.	Comply	Section II-2.2.3.2.1 describes that each of the divisions of the PRM and OPRM are physically and electrically separated. Section II-2.2.3.2 describes that only votes to trip and status information are provided across divisional boundaries into the RPS, providing communications independence. As described in Section II-2.1.4.5, for BWR-3, data is shared across division in a controlled manner to ensure that sufficient data is provided to protect the fuel integrity, in a manner approved and licensed in the US BWR fleet for existing PRM and OPRM applications. For other BWRs no data are shared across the divisions.
5.6.2	Safety system equipment shall be independent of, and physically separated from, the effects of the design basin event. Equipment qualification in accordance with 5.4 is one method that can be used.	Comply	Toshiba qualifies FPGA-based I&C systems using methods compliant to Clause 5.4 of this IEEE.

IEEE Std 603-1991		Compliance	Comments
Clause	Requirements Summary		
5.6.3	The safety system shall be designed not to suffer from credible failures in and consequential actions by other systems, in meeting the requirements of this standard.	Comply	Section II-2.2.3 describes FPGA application principles including redundancy and independence. Redundant power supplies are provided on separate circuits. Section II-2.2.3.2.1 describes that qualified electrical isolation devices are provided between redundant Class 1E divisions and between non-Class 1E and Class 1E circuits. Section II-2.1.4.3 describes data and communication independence. Each division has uni-directional fiber optic communication links, providing fixed data sets between divisions as well as fixed data sets from each safety-related division individually to external, non-safety-related systems, through Class 1E to non-Class 1E isolation. All equipment and programmable logic physically located within safety systems is classified as safety-related. Appropriate data, communication, and electrical isolation are provided between channels/divisions as well as from safety to non-safety.
5.6.3.1	Interconnected equipment. (1) Classification. Equipment that is used for both safety and non-safety functions shall be classified as part of the safety systems. Isolation devices used to effect a safety system boundary shall be classified as part of the safety system.	Comply	
	(2) Isolation. No credible failure on the non-safety side of an isolation device shall prevent any portion of a safety system from meeting its minimum performance requirements.	Comply	
5.6.3.2	Equipment in proximity. (1) Separation. Other systems equipment placed proximity to safety system equipment shall be physically separated from the safety system equipment. The separation of Clans 1E equipment shall be in accordance with the requirements of IEEE Std 384-1981.	Comply	Section II-2.2.3.2.1 states that each of the divisions of the PRM and OPRM is physically separated from the other redundant divisions, following the guidance of Regulatory Guide 1.75 which endorses IEEE Std 384. Each plant-specific design will ensure that adequate separation and/or barriers are provided between systems and wiring as necessary.
	(2) Barrier. Physical barriers used to effect a safety system boundary shall meet the requirements of 5.3, 5.4 and 5.5.	Comply	
5.6.3.3	Effects of a single random failure. The safety system shall perform the safety functions even it is degraded by any separate single failure in a non-safety system.	Comply	Section II-2.2.3.2 describes physical, data, and communications independence of the PRM and OPRM, and ensures that they do not suffer from failures in any non-safety system. Single random failures in the safety systems are dealt with through divisional redundancy. Detected failures are annunciated. There are no identified interfaces with non-safety-related equipment that could degrade the operation of the PRM or OPRM.
5.6.4	Detailed criteria. IEEE Std 384-1981 provides detailed criteria for the independence of Class 1E equipment and circuits.	Comply	Section II-2.2.3.2.1 addresses physical and electrical independence; Section II-2.2.3.2.2 addresses communication and data independence. Toshiba has designed the FPGA-based systems to comply with the likely independence requirements in plant-specific systems.

IEEE Std 603-1991		Compliance	Comments
Clause	Requirements Summary		
5.7	Capability for testing and calibration. Safety system equipment shall provide testing and calibration capability during power operation, retaining the safety functions. Testing of Class 1E systems shall be in accordance with the requirements of IEEE Std 338-1987. Exceptions are allowed where this capability cannot be provided without adversely affecting the safety or operability of the generating station.	Comply	Section II-2.2.3.1.2 describes how the PRM and OPRM configurations are redundant, and the PRM and OPRM generate divisional votes to trip leading to a scram signal generated in the RPS, under permissible bypass conditions. Section II-2.2.3.2.2 describes the PRM and OPRM self-diagnostic functions that continuously verify proper FPGA and communications performance. The PRM and OPRM are also designed for surveillance testing and maintenance. The PRM and OPRM also meet the Single Failure Criterion even when one division is bypassed for maintenance. Section II-A-2.7 describes self-diagnostics capabilities.. Toshiba notes that the sensors themselves are likely to require outages for more extensive maintenance, surveillance, or replacement activities, but that the FPGA-based equipment is designed to support on-line maintenance, to the extent practicable.
5.8	Information Displays.	---	Clause Title
5.8.1	Displays for manually controlled actions. The display instrumentation provided for safety manually controlled actions shall be part of the safety systems.	N/A	The requirements for the information display are issues of plant design, and the PRM and OPRM alone cannot satisfy the requirements. Basically, the PRM and OPRM are designed to accomplish their safety actions without any manual action. However, the PRM and the OPRM have features to support information display and indication of bypasses in the Main Control Room. Toshiba does not include a video display unit or soft controls in this LTR.
5.8.2	System status Indication. Display instrumentation shall provide accurate, complete, and timely information pertinent to safety system status.	Comply	
5.8.3	Indication of bypasses. Bypass status except an operating bypass shall be provided in the control room.	Comply	
5.8.4	Location. Information displays shall be located accessible to the operator.	Comply	

IEEE Std 603-1991		Compliance	Comments
Clause	Requirements Summary		
5.9	Control of access. The access to the safety system equipment shall be administratively controlled.	Comply	Provisions for controlling access through administrative means is provided in all Toshiba safety system designs. Implementation of such administrative controls is plant-specific. The PRM and OPRM have some support features to meet this requirement.
5.10	Repair. The safety systems shall allow timely recognition, location, replacement, repair, and adjustment of malfunctioning equipment.	Comply	The PRM and OPRM systems have self diagnostics for early detection of a fault, and their modular design eases the replacement of failed components. Section II-A-2.7 describes self-diagnostic capabilities. Section II-2.2.3.3 describes how the FPGA-based system designs use multiple FPGAs on modules, in which data is passed from the first FPGA through the remaining FPGAs, and a watchdog timer on each module alarms if all signal processing FPGAs do not finish passing data as well as a means of annunciating the failure locally and remotely to the main control room operators.
5.11	Identification. The following identification requirements shall be met: Safety system equipment shall be identified for each redundant portion of safety system. Components identified as being in a single redundant portion do not require identification. Safety system identification shall be distinguishable from other identification. Identification shall not require frequent use of reference material. The associated documentation shall be identified.	Comply	Toshiba will meet the identification requirements with some elements being plant specific and not within the scope of this LTR. Toshiba's QA program requires identification of safety-related documents , including (but not limited to) plans, procedures, instructions, design documents, drawings, VHDL code, V&V reports, safety analysis reports, and test documentation. Section I-3.12 discusses software configuration management in the current process that includes activities maintaining the identification and version of FPGA logic. Section I-A-4.9 discusses software configuration management for PRM in the original process that includes activities maintaining the identification and version of FPGA logic.
5.12	Auxiliary features.	Comply	Auxiliary supporting features and other auxiliary features are provided through plant designs, and these are not in the scope of this LTR. The power supplies for the PRM and OPRM is also an auxiliary feature. Section II-2.2.3.2.1 describes the qualified electrical isolation devices that are provided in the design.
5.13	Multi-unit stations. The sharing of structures, systems, and components between units at multi-unit generating stations shall be capable of simultaneous performance of the safety functions.	N/A	Neither PRM nor OPRM will be shared between units at multi-unit generating stations.

IEEE Std 603-1991		Compliance	Comments
Clause	Requirements Summary		
5.14	Human factors considerations. Human factors shall be considered at the initial stages and throughout the design process.	N/A	Human factors compliance will be verified by plant-specific implementation. Toshiba considers that the human interfaces on the equipment are sufficient for use by trained operators and maintainers.
5.15	Reliability. Appropriate analysis of the design shall be performed.	Comply	As described for Clause 5.3, Toshiba develops FPGA-based safety-related I&C systems in a high quality development process to achieve an internally set reliability goal. Section I-3 describes the Software/Hardware development process of the current process. Section I-A-4 describes the Software/Hardware development process in the original process. Section III-3 describes qualification analyses including FMEA for the PRM. Section III-6 describes qualification analyses including FMEA for the OPRM. System and software safety activities, including FMEA, are performed throughout the life cycle to detect and eliminate, or at least mitigate, potential unsafe conditions, and ensure that the unsafe conditions are reviewed and tested during the programmable logic, hardware, and integration life cycle processes.
6	Sense and Command Features The following requirements shall apply:	---	Requirements are in the subclauses.
6.1	Automatic initiation and control of all protective actions shall be provided.	Comply	Section II-2.2.2 describes PRM and OPRM that will initiate automatic protective actions. There are no manual protective actions applicable to this system. Since the PRM and OPRM are digital systems, functional requirements need to be appropriately allocated into hardware and software requirements. Section I-3.3.1.3 states that a System Design Description (SDD) is prepared, documenting functions, comprehensive system design description in the current process. Based on the SDD, an Equipment Design Specification was prepared that defines functional requirements, hardware and software design requirements in the current process. Section I-A-4.2.1 states that the ERS is prepared to document system design and functional requirements in the original process. Section I-3.10 describes how Toshiba traces requirements throughout the life cycle in the current process. For the PRM, Part V documents the V&V activities including the requirements traceability efforts.
6.2	Manual control.	---	Clause Title

IEEE Std 603-1991		Compliance	Comments
Clause	Requirements Summary		
6.2.1	Division level manual action means shall be provided in the control room to initiate protective actions that are initiated automatically.	N/A	The PRM and OPRM will initiate automatic protective actions through the RPS. When integrated with a plant design, appropriate manual capabilities will be supplied to meet regulatory requirements and licensing commitments through the RPS. The Main Control Room HSI will provide manual means for protective actions through the RPS.
6.2.2	Manual control means shall be provided in the control room to initiate protective actions that are not initiated automatically.	N/A	The PRM and OPRM will initiate automatic protective actions through the RPS. When integrated with a plant design, appropriate manual capabilities will be supplied to meet regulatory requirements and licensing commitments through the RPS. The Main Control Room HSI will provide manual means for protective actions.
6.2.3	Manual control means to maintain safe conditions shall be provided.	N/A	The PRM and OPRM will initiate automatic protective actions through the RPS. When integrated with a plant design, appropriate manual capabilities will be supplied to meet regulatory requirements and licensing commitments through the RPS. The Main Control Room HSI will provide manual means for protective actions.
6.3	Interaction between the sense and command features and other systems.	---	No Requirements.

IEEE Std 603-1991		Compliance	Comments
Clause	Requirements Summary		
6.3.1	Where a single credible event can cause a non-safety system action that result in a condition requiring protective action and can concurrently prevent the protective action and command feature channels providing protection against the condition, one of the following requirements shall be met: (1) Alternate channels shall be provided to limit the consequences. Alternate channels shall be selected from the following: (a) Channels that sense a set of variables different from the principal channels. (b) Channels that use equipment different from that of the principal channels to sense the same variable. (c) Channels that sense a set of variables different from those of the principal channels using equipment different from that of the principal channels. (2) Equipment not subject to failure caused by the same single credible event shall be provided to detect the event and limit the consequences to a value specified by the design bases. Such equipment is considered a part of the safety system.	N/A	In plant application, Toshiba will perform safety analyses, and design and implement FPGA-based safety-related I&C systems so that isolation is ensured between: • safety systems in the different channels • safety systems and non-safety systems The analyses, design, and implementation will depend on the plant-specific design, which Toshiba and the utility will incorporate appropriately. Section II-2.2.2.3 describes the PRM system configuration arranged in multiple divisions. Section II-2.2.3.2.2 describes communication and data independence including use of uni-directional communication from a safety system to a non-safety system. Diversity and defense-in-depth (D3) is a plant-specific design activity that will be undertaken with each plant licensing and design basis as well as between the utility, Toshiba, and NRC staff.
6.3.2	Provisions shall be included so that the requirements in 6.3.1 can be met in conjunction with the requirements of 6.7 if a channel is in maintenance bypass.	Comply	The PRM and OPRM are configured to meet the single failure criterion even if one channel is bypassed. Section II-2.2.2.3 describes that the PRM and OPRM configuration is redundant, and the APRM and OPRM generate votes to trip leading to a scram signal generated in the RPS, under permissible bypass conditions, meeting the Single Failure Criterion. This clause will be considered in the plant-specific D3 analysis and design activities.
6.4	Derivation of system inputs. Sense and command feature inputs shall be derived from signals that are direct measures of the desired variables as specified in the design basis.	Comply	The PRM and OPRM use in-core detector signals that are representative of neutron flux and core flow. Toshiba complies with this requirement.
6.5	Capability for testing and calibration.	---	Clause Title

IEEE Std 603-1991		Compliance	Comments
Clause	Requirements Summary		
6.5.1	Checking the operational availability. Means shall be provided for checking, the operational availability of each sense and command feature input sensor required for a safety function during reactor operation.	Comply	The PRM and OPRM are configured in redundant channels. Each PRM/OPRM channel has its own set of sensors. Cross-comparison of the sensor readings of different channels provides checking of the operational availability. These cross-checks are performed in an external non-safety-related system or by the operators. Section II-2.2.2.3 describes that the PRM and OPRM configuration. Toshiba requires the utility to install and operate cross-channel comparisons. A manual means would be performed by plant operators. An automated means would be in external, non-safety-related equipment, to avoid complexity in the safety systems.
6.5.2	Assuring the operational availability.	N/A	Toshiba has designed equipment with high availability and reliability. Self-diagnostics enhance operational availability. Equipment qualification ensures that the equipment is capable of continued operation in a mild environment.
6.6	Operating bypasses.	Comply	Section II-A-6.4 states that the OPRM is bypassed when the APRM level is less than the setpoint, or when the Core Flow Level is more than the setpoint. The OPRM is only armed when within the potentially unstable region of the core power-flow map. The PRM is operationally bypassed by the operator when the plant is operating at power levels below the equipment's design capability.
6.7	Maintenance bypass. Capability of a safety system to accomplish its safety function shall be retained while sense and command features equipment is in maintenance bypass.	Comply	Toshiba will design I&C systems including the PRM and OPRM so that their maintenance bypasses becomes active if and only if the applicable permissive conditions are met, with consideration of faults and failures and not being able to bypass more than one division at a time. Section II-2.2.2.3 describes the PRM and OPRM configuration that allows individual LPRM bypass and channel bypass for maintenance.
6.8	Setpoints.	---	Clause Title
6.8.1	The allowance for uncertainties between the process analytical limit and the device setpoint shall be determined using a documented methodology. Refer to ISA S67.04-1987	Comply	Data for entry into a utility's setpoint analysis methodology is provided by Toshiba, as described in Section III-3.2.3 Setpoint Support Analysis for the PRM and Section III-6-2.3 for the OPRM.
6.8.2	Where multiple setpoints are required, the design shall provide means to use the more restrictive setpoint when required.	Comply	Data for entry into a utility's setpoint analysis methodology is provided by Toshiba, as described in Section III-3.2.3 Setpoint Support Analysis for the PRM and Section III-6.2.3 for the OPRM.

IEEE Std 603-1991		Compliance	Comments
Clause	Requirements Summary		
7	Execute features—functional and design requirements. The following requirements shall apply to the execute features.	---	No requirement
7.1	Automatic Control. Execute features shall receive and act upon automatic control signals from the sense and command features.	N/A	The PRM and OPRM described in this LTR do not include execute features, but the systems provide automatic control signals to the execute features. Plant-specific designs will include manual control of the execute features in the RPS, with the manual signals injected at a point beyond where common cause failure of the programming language could inhibit manual control.
7.2	Manual Control. The additional design features in the execute features for manual control shall not defeat the requirements of 5.1 and 6.2. Capability shall be provided in the execute features to receive and act upon manual control signals.	N/A	The PRM and OPRM described in this LTR do not include the any manual control of execute features. Plant-specific designs will include manual control of the execute features in the RPS, with the manual signals injected at a point beyond where common cause failure of the programming language could inhibit manual control.
7.3	Completion of Protective Action. The design of the execute features shall be such that once initiated, the protective actions of the execute features shall go to completion.	N/A	The PRM and OPRM described in this LTR do not include the execute features. Plant-specific designs will include manual control of the execute features in the RPS, with the manual signals injected at a point beyond where common cause failure of the programming language could inhibit manual control. The RPS design shall ensure that the required plant scram goes to completion.
7.4	Operating Bypass. Operational bypass shall be active if and only if applicable permissible conditions are met, and if the conditions changes: Remove the bypass, Restore the plant conditions, or Initiate the appropriate safety functions.	N/A	The PRM and OPRM comply with the operating bypass requirements in Clause 6.6 in this IEEE standard.
7.5	Maintenance Bypass. The capability of a safety system to accomplish its safety function shall be retained while execute features equipment is in maintenance bypass.	N/A	The PRM and OPRM comply with the maintenance bypass requirements in Clause 6.7 in this IEEE standard
8	Power source requirements.	---	Clause Title

IEEE Std 603-1991		Compliance	Comments
Clause	Requirements Summary		
8.1	Electrical Power Sources. Those portions of the Class 1E power system required to provide the power to the safety system are a portion of the safety systems.	N/A	This requirement is mostly addressed in plant-specific designs. The low voltage power supplies inside the equipment are safety related, Class 1E. This LTR does not address this requirement for external power, but the systems are designed to support installation in electrical systems compliant to this requirement.
8.2	Non-electrical Power Sources. Non-electrical power sources, such as control-air systems, bottled-gas systems, and hydraulic systems, required to provide the power to the safety systems are a portion of the safety systems.	N/A	The FPGA-based Safety-Related Instrumentation and Control Systems do not require any non-electrical power source.
8.3	Maintenance Bypass. The capability of the safety systems to accomplish their safety functions shall be retained while power sources are in maintenance bypass.	N/A	This is a requirement for the plant electrical design. Each plant-specific design will ensure that power is supplied to the safety systems when normal power supplies are in maintenance bypass, to allow the PRM and OPRM to accomplish their safety functions.

IV-3 Compliance with IEEE Std 7-4.3.2-2003

Table IV-3-1 documents conformance of the PRM and OPRM to IEEE Std 7-4.3.2-2003 (Reference (a30)). All Toshiba safety systems will comply with the requirements of IEEE Std 7-4.3.2-2003.

Appendix 7.1-D of the SRP (Reference (a4)) provides guidance for evaluation of conformance to IEEE Std 7-4.3.2-2003, including "Cyber Security Criteria" added in Reg. Guide 1.152 Revision 2. Table IV-3-1 is prepared considering the point of views in Appendix 7.1-D of the SRP, except using Regulatory Guide 1.152 Revision 3 instead of Revision 2.

In the table, the IEEE clauses are summarized. Toshiba evaluates system and plant-specific designs against the standard itself, to avoid issues with interpretation that result from changing the IEEE standard wording.

Notes:
- "Comply" means the Toshiba safety system comply with the corresponding IEEE Std 7-4.3.2 requirement.
- "---" means there is no requirement in the IEEE Std7-4.3.2.
- "N/A" means the IEEE Std7-4.3.2 requirement is not applicable.

Table IV-3-1 Conformance with IEEE Std 7-4.3.2-2003

IEEE Std 7-4.3.2-2003		Compliance	Comments
Clause	Requirements Summary		
1	Scope. Amplifying criteria in IEEE Std 603-1998	---	No requirements.
2	Reference	---	No requirements.
3	Definitions and abbreviations	---	No requirements.
4	Safety System design basics No requirements beyond those defined in IEEE Std 603.	---	No requirements beyond this Clause in IEEE Std 603.
5	Safety system criteria	---	Requirements are in the subclauses
5.1	Single-failure criterion No requirements beyond those defined in IEEE Std 603.	---	No requirements beyond this Clause in IEEE Std 603.
5.2	Completion of Protective Action No requirements beyond those defined in IEEE Std 603.	---	No requirements beyond this Clause in IEEE Std 603.

IEEE Std 7-4.3.2-2003		Compliance	Comments
Clause	Requirements Summary		
5.3	Quality	----	The Toshiba life cycle processes incorporate both hardware and programmable logic, as the two are heavily interconnected, including the process for integrating programmable logic and hardware and commercial grade dedication of hardware components and assembly.
5.3.1	Software Development	Comply	Section I-3 describes the Software/Hardware development process in the current process, and Section I-A-4 describes Software/Hardware development process in the original process. Both the original and current processes conform to BTP 7-14. Section I-3.3 describes the software development plan in the current process, and Section I-A-4.2 describes the software development planning and practice in the original process.
5.3.1.1	Software quality metrics	Comply	Toshiba uses several metrics in the process. Section I-3.2.6 describes that the Toshiba Project Managers are responsible for metrics in the current process. Section I-3.11 describes how the V&V reports and evaluates metrics in the current process. Section I-A-4.1.2 describes software quality metrics for the original process.
5.3.2	Software tools	Comply	Section I-2.2.2 and Section I-A.3.2.2 describe that Toshiba surveyed tool vendors and implemented Critical Digital Reviews of the software tools and vendor software processes, including acceptance of software tools from their sub-vendors. Sections I-3.12.2 and I-A-4.9 describe the software tools are configuration items and controlled under the appropriate processes. The Netlist Viewer and ModelSim tools are used to detect design errors in the VHDL logic. Part V includes use of the software tools in the V&V in the current process, and Part VI includes use of the software tools in V&V in the original process.
5.3.3	Verification and validation	Comply	Sections I-3.10 and I-A-4.8 describes that the V&V Plans in the current process and the original process cover the requirements of IEEE Std 1012 as endorsed in USNRC Reg. Guide 1.168.
5.3.4	Independent V&V (IV&V) requirements	Comply	Toshiba performs IV&V activities, with at least as much independence as is required in this clause. Section I-3.2.1 discusses the organization including the IV&V Team in the current process. Section I-A-1.1 discusses the organization including the V&V team in the original process. Sections I-3.2.3.4 describes the independence of the IV&V Leads in the current process. Section I-A-4.1.1 describes the independence of the V&V team in the original process. Section I-3.10 describes the V&V Plan in the current process. Section I-A-4.8 describes the V&V Plan in the original process.

IEEE Std 7-4.3.2-2003		Compliance	Comments
Clause	Requirements Summary		
5.3.5	Software configuration Management	Comply	Toshiba performs software configuration management in compliance with USNRC RG 1.169 and the endorsed IEEE Std 828-1990 and ANSI/IEEE Std 1042-1987. Section I-3.12 describes the software configuration management plan in the current process. Section I-A-4.9 describes the configuration management plan in the original process.
5.3.6	Software Project Risk Management	Comply	Section I-3.2.5 states that the NED PM is responsible for risk management of the entire project including schedule, budget, resources, and technical issues, and must take appropriate actions to minimize project risks in the current process. Section I-A-4.1.2 states that NED Group Manager shall perform risk management in the original process.
5.4	Equipment qualification	---	Requirements are in the subclauses.
5.4.1	Computer system testing	Comply	Section I-3.13 describes the Software Test Plan, which describes FPGA testing, Module Validation Testing, and System Validation Testing in the current process Section I-A-4.10 describes the Software Test Planning and Practice in the original process. Section III-2 describes the PRM Qualification Test . Section III-5 describes the OPRM Qualification Test.
5.4.2 and subclauses	Qualification of existing commercial computers Including: Preliminary phase of the COTS dedication process Detailed phase of the COTS dedication process Maintenance of commercial dedication	Comply	Toshiba established a CGD process to procure FPGA-based safety-related I&C systems. Section I-2.2 describes the CGD process in the current process. Section I-A-3.2 describes CGD process in the original process.
5.5	System integrity	---	The requirements are described in the subclauses.
5.5.1	Design for computer integrity The computer shall be designed to perform its safety function when subjected to conditions, external or internal, that have significant potential for defeating the safety function.	Comply	The FPGA-based safety-related I&C systems are designed to have integrity. Section I-3 addresses the software/hardware development processes that ensure the software and hardware integrity of the FPGA-based I&C systems in the current process. The process includes software safety analysis as described in Section I-3.9. Section I-3.9.3.3 states that potential hazards associated with design are adequately resolved to eliminate or at least mitigate possible safety concerns in the current process. Section I-A-4.2 describes software development planning and practice and Section I-A-4.7 describes software safety planning and practices including hazard analysis in the original process.

IEEE Std 7-4.3.2-2003		Compliance	Comments
Clause	Requirements Summary		
5.5.2	Design for test and calibration Test and calibration function shall not adversely affect the ability of the computer to perform its safety function. Appropriate bypass of one redundant channel is not considered an adverse effect in this context. It shall be verified that the test and calibration function does not affect any computer function not included in a calibration change.	Comply	Toshiba designs the PRM and OPRM so that test and calibration functions do not adversely affect the safety functions. Section II-2.2.2.3 describes that the PRM and OPRM configuration is redundant, and the PRM and OPRM can generate a trip signal leading to a scram signal generated in the RPS, under permissible bypass conditions.
	V&V, configuration management, and QA • shall be required for test and calibration computer providing sole verification of test and calibration data. • shall be required for the test and calibration function of the safety system. • are not required when the test and calibration function on a separate computer does not provide the sole verification of test and calibration data.	N/A	Toshiba does not incorporate a test and calibration computer in the PRM or OPRM.
5.5.3	Fault detection and self diagnostics. Self-diagnostics are one means that can be used to assist in detecting failures. If reliability requirements warrant self-diagnostics, then computer programs shall incorporate functions todetect and report computer system faults and failures in a timely manner. Self-diagnostic functionsshall not adversely affect the ability of the computer system to perform its safety function, or causespurious actuations of the safety function.	Comply	Section II-2.2.3.2.2 describes how the PRM and OPRM include self-diagnostic functions that continuously verify proper FPGA and communications performance. Section II-A-2.7 describes self-diagnostic capabilities

IEEE Std 7-4.3.2-2003		Compliance	Comments
Clause	Requirements Summary		
5.6	Independence	Comply	Toshiba complies with the guidance provided in Digital Instrumentation and Controls Interim Staff Guidance 4, Revision 1. Section II-2.1.4.3 and II-2.2.3.2.2 describe communication and data independence. Each division has uni-directional fiber optic communication link, providing fixed data sets from each safety-related division individually to the non-safety-related, providing Class 1E to non-1E isolation. No engineering unit data passes between divisions.
5.7	Capability for test and calibration No requirements beyond those of IEEE Std 603.	Comply	No requirements beyond this Clause in IEEE Std 603.
5.8	Information displays No requirements beyond those of IEEE Std 603.	N/A	No requirements beyond this Clause in IEEE Std 603. This LTR does not contain any information Display for Plant Operation.
5.9	Control of access No requirements beyond those of IEEE Std 603.	Comply	No requirements beyond this Clause in IEEE Std 603.
5.10	Repair No requirements beyond those of IEEE Std 603.	Comply	No requirements beyond this Clause in IEEE Std 603.
5.11	Identification	Comply	The PC board fabricator installs logic in the FPGA, and the logic cannot be changed later. The correct programmable logic is verified by the commercial grade dedication process and by module testing under Toshiba's NQA-1 compliant NQA program. Section I-3.12 explains software configuration management used to ensure that correct logic is installed in each FPGA in the current process. Section I-A-4.9 describes configuration management in the original process. The configuration management covers the module supplier.
5.12	Auxiliary features No requirements beyond those of IEEE Std 603.	Comply	No requirements beyond this Clause in IEEE Std 603.
5.13	Multi-unit stations No requirements beyond those of IEEE Std 603.	Comply	No requirements beyond this Clause in IEEE Std 603.
5.14	Human factors considerations No requirements beyond those of IEEE Std 603.	Comply	No requirements beyond this Clause in IEEE Std 603.
5.15	Reliability When reliability goals are identified, the proof of meeting the goals shall include the software.	Comply	No requirements beyond this Clause in IEEE Std 603.

IEEE Std 7-4.3.2-2003		Compliance	Comments
Clause	Requirements Summary		
6	Sense and command features—functional and design requirements No requirements beyond those of IEEE Std 603.	Comply	No requirements beyond this Clause in IEEE Std 603.
7	Execute features—functional and design requirements No requirements beyond those of IEEE Std 603.	N/A	No requirements beyond this Clause in IEEE Std 603. Neither PRM nor OPRM has any execute features.
8	Power source requirements No requirements beyond those of IEEE Std 603.	N/A	No requirements beyond this Clause in IEEE Std 603. No requirement for this LTR.
	SDOE Appendix 7.1-D of the SRP describes "Cyber Security Criteria" in addition to IEEE Std 7-4.3.2 in accordance with Reg. Guide 1.152, Revision 2. Reg. Guide 1.152 was revised to Revision 3, and "Cyber Security" was changed to "SDOE."	Comply	Section I-3.14 describes SDOE in the current process. Toshiba's SDOE program complies with RG 1.152, Revision 3, Regulatory Positions 2.1 through 2.5. Toshiba's implementation of SDOE provides sufficient capabilities in the system design to support a utility in evaluation of the system against USNRC Regulatory Guide (RG) 5.71, "Cyber Security Programs for Nuclear Facilities." Section I-A-5 describes Cyber Security in the original process.

IV-4 Conformance with EPRI TR-107330

Table IV-4-1 documents conformance of PRM and OPRM to EPRI TR-107330 (Reference (a46)). Table IV-4-1 shows the mapping of EPRI TR-107330 requirements to the PRM and OPRM. Table IV-4-2 through Table IV-4-10 are attached to provide supplemental information to Table IV-4-1.

Notes:

- "Comply" means the Toshiba NRW-FPGA-based Safety-Related I&C Systems comply with corresponding EPRI TR-107330 requirement.
- "N/A" means the EPRI TR-107330 requirement is not applicable to Toshiba NRW-FPGA-based Safety-Related I&C Systems.
- "Application Specific Requirements" means Toshiba NRW-FPGA-based Safety-Related I&C systems has its own application specific requirements which originates from system specific requirements for PRM and OPRM.
- "Comply with limited scope and/or condition" means that the systems could not be tested against full scope of the profile requirement of the specific test due to the limitation of the test facility or the system needed additional conditions to pass the specific test.
- "Exception" means Toshiba takes an exception to the corresponding EPRI TR-107330 requirement for the NRW-FPGA-based Safety-Related I&C system.

Table IV-4-1 Conformance with EPRI TR-107330

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

Section No	Summary of EPRI TR-107330 Requirements	Compliance with EPRI TR-107330 Requirements (or N/A)
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.	Application Specific Requirements. The generic PLC requirement was converted to the following application specific requirements which are documented in Section II-2.2.2.2. Section 5.1.3.1 of ERS and Section 5.1.4 item 6 of EDS further describe the response time requirements for PRM and OPRM respectively. The PRM and the OPRM comply with these requirements. PRM (1) APRM Upscale (High-High) The PRM response time, which is measured as the total delay time from a step change of the LPRM input current to the change of the APRM trip auxiliary unit output, shall be equal to or less than 40 milliseconds. (2) Simulated Thermal Power Upscale Method 2 step 1 within 40 ms Method 2 step 2 within 6.0±0.5 s OPRM A) The OPRM trip response time of the PRNM system from the core oscillation initiation detected by LPRM detector through LPRM subsystem to the OPRM trip function initiation from Relay unit shall not exceed[ ][a,c] ms. B) The OPRM trip response time of the OPRM unit from when the core oscillation initiation is detected by LPRM detector is input to the OPRM unit and thus to the OPRM trip function initiation by the OPRM unit shall not exceed [ ][a,c] ms.
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.	Application Specific Requirements. The I/O configuration of the Toshiba NRW-FPGA-based PRM and OPRM hardware is application specific. Therefore, the system configurations are known and fixed for each system.
4.2.1.C	Analog I/O. The PLC shall have the capability to provide a total of 100 analog I/O points.	Application Specific Requirements. The I/O configuration of the Toshiba NRW-FPGA-based PRM and OPRM hardware is application specific. Therefore, the system configurations are known and fixed for each system. For the PRM, 172 analog inputs are provided for the Local Power Range Monitors, with additional inputs for reactor flow. For the OPRM, the digitized data from the LPRM and flow inputs are used.
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.	Application Specific Requirements. The I/O configuration of the Toshiba NRW-FPGA-based PRM and OPRM hardware is application specific. Therefore the system configurations are known and fixed for each system.
4.2.2	Control Function Requirements. The PLC shall provide a high-level language designed for control algorithms.	Application Specific Requirements. The Toshiba NRW-FPGA-based PRM and OPRM hardware systems are application specific. The control function configuration (i.e., logic) is known and fixed for each system. The VHDL code employed is appropriate for the system functionality.

Section No	Summary of EPRI TR-107330 Requirements	Compliance with EPRI TR-107330 Requirements (or N/A)
4.2.3	Availability/Reliability and FMEA. (section heading)	No requirement
4.2.3.1	Availability/Reliability Overview. Descriptive information.	No requirement
4.2.3.2	Availability/Reliability and Basic Requirements. The overall availability goal of the PLC is 0.99.	Comply. The hardware-based availability of the full PRM system for a BWR-5 is more than 0.99 (see Section III-3.2.1). The hardware-based availability of the OPRM equipment is more than 0.99 (see Section III-6.2.1).
4.2.3.3	Availability/Reliability Calculation Requirements. An availability calculation shall be prepared which conforms to IEEE Std 352.	Comply with limited scope and/or condition based on application specific usage of the system . An availability calculation is prepared in a manner that conforms to IEEE Std 352-1987. Twenty-four hour MTTR is used. The surveillance interval and the environmental stress are considered. Specific IO changes are not considered.
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.	N/A. The Toshiba PRM or OPRM system does not include redundant components for signal processing. Redundancy is applied at the channel or division level. Toshiba interprets that the redundant LVPSs and fiber optic communication are not for redundant PLC.
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. An Availability/Reliability Analysis for the PRM system is documented in Section III-3.2.1, and Availability/Reliability Analysis for the OPRM system is documented in Section III-6.2.1.
4.2.3.5	Failure State/FMEA Requirements. An FMEA analysis shall be performed in accordance with IEEE Std 352. The analysis shall evaluate the effects of failures of components in the PLC modules on the PLC performance.	Comply. A Failure Modes and Effects Analysis (FMEA) for the PRM is documented in Section III-3.2.2, and an FMEA for the OPRM is documented in Section III-6.2.2.

Section No	Summary of EPRI TR-107330 Requirements	Compliance with EPRI TR-107330 Requirements (or N/A)
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. The following diagnostic functions are provided: (a) Monitoring of the Low Voltage Power Supply module The Low Voltage Power Supply (LVPS) module shall monitor its output voltage. If the voltage of the LVPS becomes lower than the setpoint in either of the LVPS module, the STATUS module front panel shall provide the indication and generate discrete output for annunciation in the MCR. (b) Monitoring Low Voltage Supply for each module The LPRM, APRM, SQ-ROOT, FLOW, TRN, RCV, STATUS, CELL, DAT/ST, AGRD, and PBD modules shall monitor the input voltage from the LVPS modules. If the input voltage becomes lower than the setpoint, the module shall be reset, which generates a discrete output for annunciation in the MCR. (c) Monitoring of the FPGAs with a watchdog A watchdog timer shall monitor each FPGA that operates periodically as documented in Section II-2.2.3.3. (d) Checking data transmission between units through fiber optic cables The module receiving data from the other unit shall verify the periodic occurrence of the data transmissions, and the validity of transmitted data between units over fiber optic cables. The validity of data shall be verified by Cyclic Redundancy Check (CRC) in the transmitted data. Note: Parity check was used as the method for error checking in the PRM system, for which Toshiba performed the qualification test. Toshiba updated the FPGA logic to use CRC and qualified the modified transmit and receive modules in the OPRM qualification. PRM and OPRM products will have the TRN and RCV modules that support CRC.

Section No	Summary of EPRI TR-107330 Requirements	Compliance with EPRI TR-107330 Requirements (or N/A)
4.2.3.6 (continued)	(continued)	(e) Checking data transmission from the modules in a same unit The APRM module and CELL module shall check the periodic transmission of the data frame from the TRN modules and the RCV modules. If a timeout error occurs, a Minor Failure signal shall be generated. The Minor Failure generates a discrete output for annunciation in the MCR. (f) Checking constants stored in Rewritable ROM Every Rewritable ROM storing constants used for the signal processing shall protect its stored values with parity bits or dual storage of each value. If an error is detected, a Minor Failure alarm shall be generated. The Minor Failure generates a discrete output for annunciation in the MCR. (g) Checking the voltage of the LPRM High Voltage Power Supply on each LPRM module. Each LPRM module shall monitor the voltage of the High Voltage Power Supply on that module. If the voltage becomes lower than the setpoint, the LPRM shall be inoperable. A single inoperable LPRM module does not affect the Safety-Related function, but a Minor Alarm will be generated to initiate replacement of the faulted module. (h) Checking the input value of the SQ-ROOT module The SQ-ROOT module shall perform range check for the input current value after digital conversion. If the input current value becomes lower than setpoint, the SQ-ROOT module shall output failure signal. The Minor Failure generates a discrete output for annunciation in the MCR. (i) Checking [ ][a,c] on PBD module and AGRD module The PBD module and AGRD module shall perform check for the [ ][a,c] If [ ][a,c] is detected the PBD module and AGRD module shall output failure signal. The failure signal generates a discrete output for inoperable trip. (j) Checking [ ][a,c] on CELL module, PBD module and AGRD module The CELL module, PBD module and AGRD module shall perform check for the [ ][a,c] If [ ][a,c] is detected the PBD module and AGRD module shall output failure signal. The failure signal generates a discrete output for inoperable trip.
4.2.3.7.A	Recovery Capability Requirements. The PLC shall include a watchdog timer.	(See Item 4.2.3.6 in this table)

Section No	Summary of EPRI TR-107330 Requirements	Compliance with EPRI TR-107330 Requirements (or N/A)
4.2.3.7.B	Recovery Capability Requirements. The PLC processor shall contain power bus monitoring features to assure that the processor successfully completes any memory writes and goes into a reset state when the supply voltage is outside of the range.	N/A. The CELL, PBD, module AGRD modules of the OPRM use SRAMs for safety functions. The values of the SRAMs will be cleared to zero if the power supply fails. Because these modules apply a time average filter on the data, any data stored in the SRAM before the reset and re-initialization is useless and is discarded appropriately on power restoration. The PRM does not perform any memory writes during normal operation. Should the plant power supply fail or go out of range, the affected PRM Unit will reinitialize upon restoration of power.
4.2.3.7.C	Recovery Capability Requirements. Output modules shall initialize to a known state.	Comply. Whenever power is applied to the PRM or OPRM equipment, the equipment is initialized by the power-on reset function. All trip and alarm outputs remain tripped until the initialization process has completed (about 470 ms). After initialization, the trip and alarm outputs assume the states indicated by calculations and bypass settings. The power on reset function also is executed when the power supply low voltage is detected. The modules that have FPGAs are provided with a power supply monitoring IC, which provides about 150 ms or 470 ms reset action and initial startup of FPGA at the time when the module is energized. In addition, it executes a reset action when the power supply voltage lowers, i.e., if the power supply voltage continues to be low, the module remains in initialization state, and keeps all trip and alarm outputs in the tripped state. Note: The TRN module has about 470 ms reset time while other modules have about 150 ms reset time. The PRM and OPRM System perform run time diagnostics.
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.	N/A. Operating experience is not used as a basis for establishing module failure rates of the PRM or OPRM system.
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. The PRM and OPRM trip setpoints can be adjustable by a technician during equipment maintenance or an operator during periodical surveillance service. The PRM and OPRM System support setpoint adjustments of equipment on the front panel of each module. Toshiba supplies sufficient data to support a utility's setpoint program. Section III-3.2.3 provides setpoint support analysis for the PRM and Section III-6.2.3 provides setpoint support analysis for the OPRM.
4.3	Hardware Requirements. (section heading)	No requirement
4.3.1	General. (section heading)	No requirement

Section No	Summary of EPRI TR-107330 Requirements	Compliance with EPRI TR-107330 Requirements (or N/A)
4.3.1.1	Background. Descriptive information.	No requirement
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.	(Compliance documented in Items 4.2.1 and 4.3.6 in this table.)
4.3.1.3	External Device Requirements. External devices used to meet I/O module requirements shall meet the given specific requirements.	N/A. The PRM and OPRM do not require external devices, other than sensors and transmitters which are not part of this LTR.
4.3.1.4	General Redundancy Requirements. Redundant components may be included in the generic PLC platform.	N/A. The PRM or OPRM System does not include redundant components for signal processing. Toshiba interprets that the redundant LVPSs and fiber optic communication are not for redundant PLC.
4.3.2	Input Requirements. (section heading)	No requirement.
4.3.2.1	Analog Input Requirements. The PLC shall include modules that provide analog inputs.	Comply. The PRM analog inputs are designed to interface with industry standard LPRM detectors and Flow transmitters. The required analog input design specifications are, therefore, known and satisfied. The OPRM has no analog inputs.
4.3.2.1.A	Monotonicity. The analog inputs shall be monotonic to ±1/2 LSB.	Comply. The PRM analog inputs have defined monotonicity, based on the design choice of analog-to-digital converter made for each specific module. Both modules are monotonic to ±1/2 LSB. The OPRM has no analog inputs.
4.3.2.1.B	Number of Channels. Each analog input module shall provide a minimum of four input channels.	Application Specific Requirements. The LPRM and SQ-ROOT modules include analog inputs. The LPRM module has one analog input channel and the SQ-ROOT module has one analog input channel. Those are based on the application specific requirements of the PRM
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.	Application Specific Requirements. The LPRM and SQ-ROOT modules take specific, appropriate actions when presented with an over range condition.
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.	Application Specific Requirements. The LPRM and SQ-ROOT modules take specific, appropriate actions when presented with an under range condition.

Section No	Summary of EPRI TR-107330 Requirements	Compliance with EPRI TR-107330 Requirements (or N/A)
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.	Application Specific Requirements. The LPRM and SQ-ROOT modules take appropriate action when presented with these conditions.
4.3.2.1.1	Voltage Input Requirements.	N/A. There are no analog voltage inputs in the PRM or OPRM system.
4.3.2.1.2	Current Input Requirements. (section heading)	No requirement
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.	Application Specific Requirement. The PRM FLOW analog input range of 4 to 20 mA is designed to interface with industry standard Flow transmitters. The LPRM input range of 0 to 3 mA is designed to interface with the conventional standard LPRM detectors. The required application-specific analog input design specifications are, therefore, known and satisfied.
4.3.2.1.2.B	Analog Current Input Module Accuracies. Overall accuracies shall be ± 0.35% of the specified range.	Application Specific Requirements. The PRM analog inputs are designed to interface with industry standard LPRM detectors and Flow transmitters, with accuracies appropriate for the specific application. The required analog input design specifications are, therefore, known and satisfied. Please note the generic PLC requirement was converted to PRM application specific requirements. ERS section 5.1.4 addresses PRM system accuracy for example. LPRM input to output through by AO module 2.5% (2.0% of FS 0-125%) FLOW 3.75% (3.0 % of FS 0-125% for 0 to 50% FLOW) 2.5% (2.0 % of FS 0-125% for 50 to 125% FLOW) The OPRM does not have an AO module. Please see Item 4.3.3.1.1.B for more details.
4.3.2.1.2.C	Analog Current Input Module Resolution. The minimum resolution shall be 12 bits.	Comply. The analog inputs are designed to interface with industry standard LPRM detectors and Flow transmitters. The LPRM and FLOW modules convert analog input signals to 12 bits data. The required analog input design specifications are, therefore, known and satisfied.
4.3.2.1.2.D	Analog Current Input Module Common Mode Voltage. The common mode voltage capability shall be at least 10 volts.	N/A. The PRM analog inputs do not have differential voltage inputs with external current to voltage conversion. The PRM individual analog inputs are appropriately isolated, and self-powered.

Section No	Summary of EPRI TR-107330 Requirements	Compliance with EPRI TR-107330 Requirements (or N/A)
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.	N/A. The PRM analog inputs do not have differential voltage inputs with external current to voltage conversion.
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.	(See Item 4.2.1.A Response Time in this table.)
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. The FLOW analog current inputs are grouped by unit. The unit to unit isolation is assured by fiber optic cable.
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. Since there is no system-specific requirement to accept non-safety analog data into the PRM or OPRM safety systems, the analog input modules do not need to perform Class 1E to Non-Class-1E isolation.
4.3.2.1.2.I	Analog Current Input Module Surge Withstand. Surge withstand shall be as given in Section 4.6.2.	(See Item 4.6.2 Surge in this table.)
4.3.2.1.2.J	Analog Current Input Module Input Impedance. The input impedance shall be 250 ohms maximum.	Application Specific Requirements. The PRM analog inputs are designed to interface with industry standard LPRM detectors and Flow transmitters.
4.3.2.1.3	RTD Input Requirements.	N/A. There is no RTD input in the PRM or OPRM system.
4.3.2.1.4	Thermocouple Input Requirements.	N/A. There is no Thermocouple input in the Toshiba NRW-FPGA -based PRM or OPRM system.
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.	Application Specific Requirements. The Toshiba designs provide 4 ch inputs on the DIO module that is sufficient discrete input capabilities to meet the specific system needs. The DIO module does not include input channel status ON/OFF indicators for each point. However, the ON/OFF status of the important connected input channels is displayed in functionally translated manner on the front panel of another module to meet the system specific needs.
4.3.2.2.1	Discrete AC Input Requirements.	N/A. The PRM or OPRM hardware does not include Discrete AC input.
4.3.2.2.2	Discrete DC Input Requirements. (section heading)	No requirement

Section No	Summary of EPRI TR-107330 Requirements	Compliance with EPRI TR-107330 Requirements (or N/A)
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.	Comply. The DIO are capable of operating with 24 VDC. Qualified relays will be used to interface to plant inputs when the input voltages do not match the DIO capabilities.
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).	Application Specific Requirements. The associated specification of the DIO module is based on the system specific requirements to be used to interface to plant inputs. Qualified relays will be used to interface to plant inputs when the input voltages do not match the DIO capabilities.
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).	Application Specific Requirements. The associated specification of the DIO module is based on the system specific requirements to be used to interface to plant inputs. Qualified relays will be used to interface to plant inputs when the input voltages do not match the DIO capabilities.
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. The associated specification of the DIO module is based on the system specific requirements to be used to interface to plant inputs. Qualified relays will be used to interface to plant inputs when the input voltages do not match the DIO capabilities. The DIO Module can operate for input up to 40 VDC for 24 VDC input.
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.	(See Item 4.2.1.A, Response Time in this table)
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. Discrete inputs are grouped by unit. The unit to unit isolation is assured by fiber optic cable.
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.	(See Item 4.6.4, Class 1E to Non-1E Isolation in this table.)
4.3.2.2.2.H	Discrete DC Input Module Surge Withstand. Surge withstand shall be as given in Section 4.6.2.	(See Item 4.6.2, Surge in this table.)
4.3.2.2.3	TTL Input Requirements.	N/A. There are no TTL inputs in the PRM or OPRM.

Section No	Summary of EPRI TR-107330 Requirements	Compliance with EPRI TR-107330 Requirements (or N/A)
4.3.2.3	Other Inputs. (section heading)	No requirement
4.3.2.3.1	Pulse Input Requirements.	N/A. There are no pulse inputs in the PRM or OPRM.
4.3.3	Output Requirements. (section heading)	No requirement
4.3.3.1	Analog Output Requirements. The PLC shall include modules that provide analog outputs.	Comply. The PRM System analog outputs are to the plant data recorders and computer. The analog outputs are provided through qualified 1E to non-1E isolators. The PRM system can also provide communication links with a richer data stream, eliminating the requirement for calibration of these extra analog outputs.
4.3.3.1.A	Monotonicity. The analog outputs shall be monotonic to ±1/2 LSB.	Comply. The AO modules outputs are monotonic to ±1/2 LSB.
4.3.3.1.B	Number of Channels. Each analog output module shall provide a minimum of four output channels.	Comply. The AO module has sixteen output ports.
4.3.3.1.1	Analog Voltage Output Requirements. (section heading)	No requirement
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.	Application Specific Requirements. The voltage output type AO module ranges are 0 to 5 volts, 0 to 1 volt, 1 to 5 volts, and 0 to 160 millivolts as appropriate based on the system specific requirements to match the requirements of the plant-specific interface.
4.3.3.1.1.B	Analog Voltage Output Module Accuracy. Overall accuracy shall be ± 0.3% of full range.	Application Specific Requirements. The Toshiba designs provide appropriate accuracy to meet the specific system needs. The required analog output design specifications are, therefore, known and satisfied. The analog output accuracy of the PRM system are as follows: 1. LPRM function a. The LPRM drift over a period of two weeks does not exceed ±1.0 % full scale (FS) at control room environmental conditions. b. The LPRM input-and-output linearity (inaccuracy) is within ±2.0 % FS, at control room environmental conditions. Note: 1. FS is from 0% to 125% reactor power. 2. The LPRM drift and linearity are measured from the LPRM input current to the LPRM output through the AO module.

Section No	Summary of EPRI TR-107330 Requirements	Compliance with EPRI TR-107330 Requirements (or N/A)
4.3.3.1.1.B (continued)	(continued)	2. APRM function a. The APRM drift over a period of two weeks does not exceed ±1.0 %FS at control room conditions. b. The APRM input-and-output linearity (inaccuracy) is within ±2.0 % FS. c. The APRM function is designed such that, at control room environmental conditions, trip accuracy is as follows: Scram signal: Within ±2.0 % FS Rod withdrawal signals: Within ±3.0 % FS (FLOW: 0 to 50 %) Within ±2.0 % FS (FLOW: 50 to 125 %) d. The trip reset point is –1.25 % below trip set point. Note: 1. FS is from 0% to 125% reactor power. 2. The APRM drift, linearity, and trip accuracy are measured from the LPRM input current to the APRM output through the AO module. 3. FLOW function a. The FLOW function is designed such that, at control room environmental conditions, the drift over a period of two weeks shall not exceed ±1.0 %FS. b. The FLOW function is designed such that the input-and-output linearity (inaccuracy) and the trip accuracy at control room environmental conditions is as follows. Within ±3.0 % FS (FLOW: 0 to 50 %) Within ±2.0 % FS (FLOW: 50 to 125 %) c. The trip reset point is –1.25 % below trip set point. Note: 1. FS is from 0% to 125% recirculation flow. 2. The FLOW drift and linearity are measured from the FLOW unit input current to the FLOW output through the AO module. The drift is conservatively evaluated in the overall accuracy from the input to the output through the AO module. 4. The OPRM has no analog output.
4.3.3.1.1.C	Analog Voltage Output Module Resolution. The minimum resolution shall be 12 bits.	Comply. The Toshiba NRW-FPGA-based PRM analog outputs are designed to have 12 bits resolution to interface with the plant-specific data recorders and computer. The required analog output design specifications are, therefore, known and satisfied.

Section No	Summary of EPRI TR-107330 Requirements	Compliance with EPRI TR-107330 Requirements (or N/A)
4.3.3.1.1.D	Analog Voltage Output Module Load Impedance. The outputs shall support a load impedance of 1 Kohm or less.	Application Specific Requirements. The Toshiba NRW-FPGA-based PRM analog outputs are designed to interface with to the plant-specific data recorders and computer. The output impedance is 1M ohm. The required analog output design specifications are, therefore, known and satisfied.
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.	(See Item 4.2.1.A, Response Time in this table.)
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. Analog voltage outputs are not grouped in the modules. The AO module outputs are isolated from the unit middle plane using photo couplers and a DC/DC converter.
4.3.3.1.1.G	Analog Voltage Output Module Surge Withstand. Surge withstand shall be as given in Section 4.6.2.	(See Item 4.6.2, Surge in this table.)
4.3.3.1.2	Current Output Requirements.	N/A. The AO module design does not include current output.
4.3.3.2	Discrete Output Requirements. The PLC shall include modules that provide discrete outputs.	Comply. The discrete input and output module receives discrete signals from external equipment and provides discrete outputs to external equipment. Signals are routed through the unit middle plane in the unit
4.3.3.2.A	Number of Channels. Each module shall provide a minimum of 8 output channels.	Comply. The discrete input and output module has 16 output ports.
4.3.3.2.B	Leakage Current. Leakage current in the OFF state of non-supervised (no internal ring back) modules shall be less than 80% of the minimum current needed to turn ON any digital input module.	Comply. The DIO modules in PRM or OPRM are used to drive a qualified relay that is selected to meet the specific plant application needs. Leakage current is less than 80 % of the minimum required relay coil current.
4.3.3.2.C	Output Circuit Interrupter. Outputs must include a circuit interrupter.	Comply. The DIO modules do not include output circuit interrupters. Toshiba will provide appropriate external interrupters when installed, as required by the customer.
4.3.3.2.D	Status Indication. Modules must include indicators that show the ON/OFF status of each point.	Application Specific Requirements. The DIO module does not include output channel status ON/OFF indicators for each point. However, on/off status of the output of the DIO module is monitored by other I&C systems.

Section No	Summary of EPRI TR-107330 Requirements	Compliance with EPRI TR-107330 Requirements (or N/A)
4.3.3.2.1	Discrete AC Output Requirements.	N/A. There is no discrete AC output in the PRM or OPRM. AC outputs can be created through use of the existing DC outputs through a qualified relay, selected to meet the specific plant application needs.
4.3.3.2.2	Discrete DC Output Requirements. (section heading)	No requirement
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.	Comply. The DIO modules in the PRM or OPRM are used to drive a qualified relay that is selected to meet the specific plant application needs (e.g., voltage). The DIO module provides 24VDC outputs.
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.	Application Specific Requirements. The DIO modules in PRM or OPRM are used to drive a qualified relay that is selected to meet the specific plant application needs (e.g., current). The DIO module minimum output current is 100 mA and maximum load current is[ ]a,c A.
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.	Comply. The DIO modules in PRM or OPRM are used to drive a qualified relay that is selected to meet the specific plant application needs (e.g., voltage). The on resistance of each DIO module output is[ ]a,c Ohm max. So the voltage drop will be[ ]a,c V max at 0.5A.
4.3.3.2.2.D	Discrete DC Output Module OFF State Leakage. The OFF state leakage current shall not exceed 2 mA.	Comply. The DIO modules in PRM or OPRM are used to drive a qualified relay that is selected to meet the specific plant application needs. Off state leakage is[ ]a,c μA.
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).	Comply. The DIO modules in PRM or OPRM are used to drive a qualified relay that is selected to meet the specific plant application needs. The DIO module operates at[ ]a,c VDC for 24 VDC output.
4.3.3.2.2.F	Discrete DC Output Module Response Time. The overall response time of the discrete DC output modules must support the response time requirement given in Section 4.2.1.A.	(See Item 4.2.1.A, Response Time in this table.)
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. Each PRM or OPRM System Discrete DC output module (DIO module) is designed to provide isolation from other modules.

Section No	Summary of EPRI TR-107330 Requirements	Compliance with EPRI TR-107330 Requirements (or N/A)
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. Qualified relays will be used to meet the isolation requirements. (See Item 4.6.4, Class 1E to Non-1E Isolation in this table.) DIO has[ ][a,c] KVAC isolation in the DIO module design. However, the credited Class 1E to Non-Class 1E isolation is provided by external relays mounted in the same cabinet with the PRM and OPRM.
4.3.3.2.2.I	Discrete DC Output Module Surge Withstand. Surge withstand shall be as given in Section 4.6.2.	(See Item 4.6.2, Surge Withstand Capability in this table.)
4.3.3.2.3	Relay Output Requirements.	N/A. Toshiba will use commercially available qualified relays in the plants.
4.3.3.2.4	TTL Output Requirements.	N/A. There is no TTL output module in the Toshiba NRW-FPGA-based PRM or OPRM system.
4.3.4	Processor/Other System Component Requirements. (section heading)	No requirement
4.3.4.1	Processor Loop Time Requirements. Processor loop time shall support the response time requirement given in Section 4.2.1.A.	(See Item 4.2.1.A. Response Time in this table.)
	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. The FPGA signal processing time is designed to provide much faster signal processing time than the time addressed here.
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.	Comply. PRM and OPRM are application specific systems including the necessary logic in the FPGAs, and have sufficient data retention capacity in the FPGAs, EPROMs, EEPROMs, and SRAMs.
	The memory used to contain the program shall be capable of retaining the information for a minimum of 6 months with no power applied.	Comply. The NRW-FPGA anti-fuse programmable logic is sufficient to hold the logic required for each FPGA for the life of the FPGA.
	Any memory used for field modifiable constants shall be capable of at least 100,000 write cycles.	Comply. Any EEPROM used for field modifiable constants is capable of at least 100,000 write cycles.
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. Each unit of the PRM or OPRM is capable of transferring information between modules in the same unit or other units in short time sufficient to support the response time requirements.

Section No	Summary of EPRI TR-107330 Requirements	Compliance with EPRI TR-107330 Requirements (or N/A)
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.	Comply. The PRM or OPRM system operates not only within the normal environmental condition in the located area, but also within the abnormal environmental conditions of anticipated transients and accidents, in order to preserve the safety system functions. This includes the fiber optic cables used to couple units together, using transmit and receive modules in the units. The fiber optic cables and modules were included in the qualification. The PRM or OPRM units will be located in a mild environment such as the main control room, so only mild environmental conditions are considered. Thus the fiber optic cables and the middle plane, which Toshiba interprets as are the Main Chassis Interconnect Device from the context of the requirements, meet these environmental conditions. Details are provided in Section 4.3.6. Failures of one or more units shall not defeat any other unit's capability to transfer data.
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.	Comply. The NRW-FPGA anti-fuse programmable logic is sufficient to hold the logic required for each FPGA. Any memory devices in the PRM or OPRM modules are not directly connected to the Main Chassis Interconnect devices, which Toshiba interprets as fiber optic cables and the middle planes from the context of the requirements. Thus, the memory devices are not affected by the failures of other units. Failure of other units does not affect the FPGA logic.
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.	Comply. Loss of power to one unit does not defeat the capability of other unit. In addition, loss of power to one module does not defeat the capability of other modules in the same unit.
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.	Comply. Fiber optic cable inherently provides Class 1E to Non-Class 1E isolation. Data isolation is provided by one-way transmission from safety to non-safety. The AO module has isolation devices to separate Class 1E from Non-Class 1E. The DIO is provided with external relays for isolation of Class 1E from Non-Class 1E.
4.3.4.3.E	Main Chassis Interconnect Device Surge Withstand. Surge withstand shall be as given in Section 4.6.2.	Comply. Fiber optic cable inherently provides surge protection.
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.	Comply. Data acquisition of the LPRM module and Flow module in each associated units and the transfer to other units are deterministic, cyclic, and sequential, thus the data acquisition time of the PRM or OPRM system is consistent with the overall system response time.
4.3.4.3.G	Redundant Inter-Processor Data Acquisition Backplane Busses. Descriptive information.	N/A. The PRM or OPRM hardware does not need redundant backplane busses and uses redundancy in fiber optic communication for LPRM data communication in the PRM and for APRM data input to the OPRM unit.

Section No	Summary of EPRI TR-107330 Requirements	Compliance with EPRI TR-107330 Requirements (or N/A)
4.3.4.4	Communication Port Requirements. The main processor shall provide at least one communication port.	N/A. Special purpose communication links can be provided as necessary in a separate module to meet system requirements.
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.	N/A. There is no Coprocessor in the Toshiba NRW-FPGA-based PRM or OPRM system.
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.	Comply Chassis that are used as the enclosure of the units are suitable for mounting in a standard 19 inch rack, have adequate strength for seismic conditions, and provide positive hold down for the modules. The chassis were qualified while mounted in a 19 inch rack. The chassis meets seismic requirements. The PRM Chassis are qualified using a test profile with a maximum 9.8g acceleration. The OPRM chassis was qualified using a test profile with a maximum 15.4g acceleration
4.3.4.7	Backup Devices/Redundancy Requirements. Descriptive information.	No requirement
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. Each PRM or OPRM unit has two redundant LVPS modules that operate in parallel. Each LVPS module has enough capacity to supply power to all modules mounted in the chassis. There are redundant optical communications for LPRM data communication in the PRM and for APRM data input to the OPRM unit. The link is diagnosed as failed if errors are detected in three consecutive communication cycles.
4.3.4.7.B	Redundant Device Requirements. Undetected failures in redundant components shall be detectable during periodic surveillance.	N/A. Failures of one of redundant LVPS module as well as failure of one of redundant optical communication link between units are indicated in the STATUS module. Such failures are annunciated to the MCR. There are no identified undetected failures that cause the loss of functionality in redundant components.
4.3.4.7.C	Redundant Device Requirements. Diagnostics shall not result in indeterminate failure states and repetitive switching between redundant components.	N/A. The redundant LVPS modules and the redundant optical communication between units operate in parallel. The design does not provide any features that would result repetitive switching between redundant LVPS modules or between redundant optical communications links.
4.3.4.7.D	Redundant Device Requirements. Requirements for effect of transfer mechanism operation on input/output module operation.	Comply. Any failure of a redundant LVPS modules or the failure of a redundant optical communications between units causes no change in the analog input and output signals, which is well within the 5% requirement in EPRI TR-107330.
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.	N/A. The Toshiba NRW-FPGA-based systems do not require end user programming terminal hardware or software.

Section No	Summary of EPRI TR-107330 Requirements	Compliance with EPRI TR-107330 Requirements (or N/A)
4.3.6	Environmental Requirements. (section heading)	No requirement
4.3.6.1	Normal Environmental Basic Requirements. The normal PLC operating environment is:	Comply with limited scope and/or condition. Requirements are set as follows complying with this section. Qualification test results meet the requirement with limited scope. See Section 6.3.3 for the results. Normal Environmental Requirements (PRM, OPRM) Temperature Range 16 to 40°C Humidity Range 40 to 95% non-condensing Radiation Exposure Up to 10 Gy
4.3.6.2	Abnormal Environmental Basic Requirements. The abnormal PLC operating environment is:	Comply with limited scope and/or condition. Requirements are set as follows complying with this section. Qualification test results meet the requirement with limited scope. See Section 6.3.3 for the results. Abnormal Environmental Requirements (PRM, OPRM) Temperature Range 4 to 50°C Humidity Range 10 to 95% non-condensing Radiation Exposure Up to 10 Gy

Section No	Summary of EPRI TR-107330 Requirements	Compliance with EPRI TR-107330 Requirements (or N/A)
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. The PRM and OPRM systems were qualified as follows, based on EPRI TR-107330 Figure 4-4 and Section 4.3.6: PRM: a. High Temperature and Humidity: 140 °F and 95% relative humidity, which meets EPRI TR-107330 Section 4.3.6 and Figure 4-4 requirements (Toshiba notes that adding 5% margin to the relative humidity would most likely induce condensation, which is not included in Toshiba's qualification envelope). b. Low Temperature and Humidity: 35 °F and 10% relative humidity, which meets EPRI TR-107330 Section 4.3.6 requirements (Figure 4-4 requirements for humidity could not be met in this chamber, even with relaxation for non-simultaneous temperature and humidity, and Toshiba notes that the OPRM is constructed of similar components and had no issues at 40 °F and 5% relative humidity which could be achieved in the environmental test chamber use for the OPRM testing). OPRM: a. High Temperature and Humidity: 140 °F and 90% relative humidity, which meets EPRI TR-107330 Figure 4-4 requirements (Section 4.3.6 requirements for humidity were met in separate testing at Toshiba, see Note below). b. Low Temperature and Humidity: 40 °F and 5% relative humidity, which meets EPRI TR-107330 Section 4.3.6 and Figure 4-4 requirements. Note: OPRM testing with 140 °F and 95% relative humidity profile was successfully met in the factory test which was performed under Toshiba's ISO 9001 program separately from the EQ test.

Section No	Summary of EPRI TR-107330 Requirements	Compliance with EPRI TR-107330 Requirements (or N/A)
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 with limited scope and/or condition. The PRM and OPRM units are designed to minimize susceptibility to and generation of electromagnetic interference (EMI) and radio frequency interference (RFI). The PRM and OPRM units were subjected to test for EMI/RFI conditions that conform to the guidelines given in RG 1.180, Revision 1. The results of the susceptibility testing showed that the PRM and OPRM units continued to function correctly throughout all test exposure levels. For the emissions tests, the PRM and OPRM units were found to comply with the allowable equipment emissions levels. The PRM and the OPRM pass the test with the modifications described below. The first EMI Susceptibility Test failed. The hardware was re-designed to resolve the test failure. Therefore, for the second EMI/RFI, Surge Withstand Capability, EFT/B, ESD, and Class 1E to Non-1E Isolation tests, the new LPRM module and the new AO modules were replaced with the failed LPRM module and the failed AO modules. The re-designed LPRM and AO modules had additional capacitors to enhance electric-noise-withstand-capability and passed the test. For Low-Frequency Conducted Emissions (CE101), the addition of the additional inductance (coils) was needed in the PRM to pass the test. For the OPRM, the power factor corrector (PCF) was developed and added to the test specimen, which passed the CE101 test. For radiated susceptibility (RS103), Toshiba did not perform the test for the frequencies above 1 GHz for the PRM, and thus accepts that either a utility employing this equipment must preclude the use of cell phones and radios near this equipment or accept an open issue from the USNRC in the SER requiring an evaluation by the utility. RS103 test for the OPRM was conducted for the frequency up to 10 GHz.
4.3.8	Electrostatic Discharge (ESD) Withstand Requirements. The PLC shall withstand ESD levels given in EPRI TR-102323.	Comply. ESD testing in the PRM showed that the rear panels were susceptible. The back panels in the units are accessible only when locked cabinet doors are opened. Thus, the back panels are not normally exposed to ESD. In normal use at a US plant, the cabinet doors are unlocked and opened only when work is to be done on the panels, such as maintenance or calibration, which is done with unit bypassed. Toshiba's application guide will be revised to state that the equipment past the plane of the door on the back panels should not be touched unless the technician or engineer is wearing a grounded ESD wriststrap. No susceptibility was observed in the ESD test for the OPRM. Note: The climatic conditions during the ESD tests are 58 % (day 1) and 51 % (day 2) in the PRM tests, 40 % (day 1) and 42 % (day 2) in the OPRM tests, which is within the required range of 30 to 60 % relative humidity.

Section No	Summary of EPRI TR-107330 Requirements	Compliance with EPRI TR-107330 Requirements (or N/A)
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.	Comply with limited scope and/or condition. It was found that Figure 4-5 of a later version of EPRI TR-107330 available on the EPRI website is slightly different from Figure 4-5 in the original October 1997 version which is the basis for the Toshiba RRS. The later version (available from the EPRI website) provides Figure 4-5 with a narrow peak spectral band. Specifically, the 5% damped SSE response spectrum control points of Figure 4-5 of the later version of EPRI TR-107330 are (1 Hz, 0.42 g); (4.5 Hz, 14 g); (16 Hz, 14 g); (33 Hz,6.13 g); and (100 Hz, 6.13 g). The original version of Figure 4-5 includes a broader frequency. Specifically, the 5 % damped SSE response spectrum break points of this version of Figure 4-5 are (0.5 Hz, 0.1 g); (1 Hz, 0.8 g); (3 Hz, 14 g); (33 Hz, 14 g); (40 Hz, 7 g); and (100Hz, 7 g). The discussion here refers to the version of EPRI TR-107330 Figure 4-5 of the later version of EPRI TR-107330 as the "narrow" spectrum, and the original version of EPRI TR-107330 Figure 4-5 as the "broad" spectrum. Because of test table limitation of 9.8 g, Toshiba has had to take exception to the EPRI TR-107330 requirement of 14 g in the PRM testing. The PRM testing was conducted at a laboratory where the table could not satisfy the EPRI TR-107330 peak spectral limits. Specifically, the table could only satisfy a peak spectral demand of 9.8 g. PRM test results show that the "narrow" spectrum demand is satisfied with the following exceptions. • The 14 g peak in the narrow spectrum was above the table capacity. The table capacity produced a peak that exceeded 9.8 g. • Exceedances in the frequency lower than 3.5 Hz are acceptable based on Clause 8.6.3.1(j) of IEEE Std. 344-2004 since there are clearly no resonances below 5 Hz. • An additional exception to the "broad" EPRI TR-107330 spectrum demand would have to be taken for the exceedance at the peak above 30 Hz. Seismic testing for OPRM was conducted at a different facility several years after the PRM testing. The OPRM testing was conducted with the RRS in Figure II-A-4-5 that is based on the "broad" EPRI TR-107330 spectrum to ensure the test table could meet the seismic demand. The test results exceeded the requirements of the broad spectrum with the exception that exceedances in the frequency lower than 3.5 Hz are acceptable based on Clause 8.6.3.1(j) of IEEE Std. 344-2004 since there are clearly no resonances below 5 Hz. Accordingly, Toshiba believes that the OPRM system satisfies EPRI TR-107330 requirements for the "broad" spectrum with the noted exception.
4.4	Software/Firmware. (section heading)	No requirement
4.4.1	Executive. (section heading)	No requirement
4.4.1.1	Background. Descriptive information.	No requirement

Section No	Summary of EPRI TR-107330 Requirements	Compliance with EPRI TR-107330 Requirements (or N/A)
4.4.1.2	Main Processor Executive Capability Requirements. The main processor executive shall: (section Heading)	No requirement This requirement is made for microprocessor based platforms that uses an executive. The FPGA implementation of the PRM and OPRM meets requirements "A" through "J" without using any executive.
4.4.1.2.A	A. Acquire inputs from the modules.	Comply. FPGA acquires inputs from the modules.
4.4.1.2.B	B. Implement the application program in a continuous loop.	Comply. FPGA implements the signal processing in a continuous cycle.
4.4.1.2.C	C. Load outputs to the modules.	Comply. FPGA provides signal outputs.
4.4.1.2.D	D. Perform power-up and run time diagnostics.	Comply. Whenever power is applied to the PRM or OPRM module, the equipment is initialized by the internal power on reset function. All trip and alarm outputs remain de-energized and thus tripped until the initialization process has completed (about 470 ms). After initialization, the trip and alarm outputs assume the states indicated by calculations and bypass settings. The power on reset function also is executed when the output of both LVPS power supplies is low, and low voltage is detected. The modules that have FPGAs are provided with a power supply monitoring IC, which provides about 150 ms or 470 ms reset action and initial startup of FPGA at the time when the module is energized. In addition, it executes a reset action when the power supply voltage lowers, i.e., if the power supply voltage continues to be low, the module remains in initialization state, and keeps all trip and alarm outputs in the tripped state. Note: The TRN module has about 470 ms reset time while other modules have about 150 ms reset time. The PRM and OPRM perform run time diagnostics. (See Item 4.4.6 in this table.)
4.4.1.2.E	E. Manage communications.	Comply. The PRM and OPRM include dedicated function communication links to provide data to external systems.
4.4.1.2.F	F. Upload application programs.	N/A The FPGA used in the PRM and OPRM use non-rewritable FPGAs and therefore this requirement does not apply.
4.4.1.2.G	G. Support on-line diagnostics, maintenance, and troubleshooting.	(See Items 4.4.6 and 4.7 in this table.)
4.4.1.2.H	H. Implement the application program functions.	N/A. Application logic is implemented in FPGAs on the PRM or OPRM modules.
4.4.1.2.I	I. Perform power-up initialize functions.	(See Section 4.4.1.2.D in this table.)

Section No	Summary of EPRI TR-107330 Requirements	Compliance with EPRI TR-107330 Requirements (or N/A)
4.4.1.2.J	J. Implement redundancy functions.	Comply. The Toshiba NRW-FPGA-based PRM system does not use redundant I/O. Redundant power feeds and power supplies are provided. Redundant fiber optic links are provided for LPRM data communication in the PRM and for APRM data input to the OPRM.
4.4.1.3	Program Flow Control Requirements.	Comply. Each execution of the PRM or OPRM application logic is preceded by an input module data request. The FPGA logic does not use interrupts.
4.4.1.4	Unintended/Unused Function Isolation Requirements. Descriptive information.	No requirement. Only functions that are used and documented are incorporated in the PRM and OPRM documentation on FPGAs. The Software/Hardware development process (see Section I) through software life cycle assures the integrity against Unintended/Unused Function isolation.
4.4.1.5	Coprocessor Executive Capability.	N/A. The PRM and OPRM do not use any 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.	N/A. Logic (or software) for on the PRM and OPRM is shipped in the FPGAs on the modules and is not shipped separately from the modules. Toshiba uses the Non-Rewritable (NRW)-FPGA, so Toshiba does not provide software media to utilities.
4.4.3	Ladder Logic Requirements.	N/A. The PRM and OPRM application logic is written in VHDL hardware programming language.
4.4.4	Software Tools Requirements. A tool shall be provided for programming, debugging, and documentation.	N/A. The PRM and OPRM are provided with permanently installed application specific logic, which means the utilities do not need any software tools for programming, debugging, documentation, or maintenance. Toshiba does not provide utilities with software tools for changing programs.
4.4.5	Configuration Identification. (section heading)	No requirement
4.4.5.1	Configuration Identification Background. Descriptive information.	No requirement
4.4.5.2	Configuration Management Aids Requirements. Descriptive information.	No requirement
4.4.5.2.A	Configuration Management. The PLC executive shall include a retrievable, embedded electronic revision level.	Comply. The PRM or OPRM modules do not have an equivalent of a PLC executive. Toshiba provides an equivalent configuration management capability since each module type number defines the programmable logic version installed in that module. Changes to the programmable logic will generate a new, unique module type number.

Section No	Summary of EPRI TR-107330 Requirements	Compliance with EPRI TR-107330 Requirements (or N/A)
4.4.5.2.B	Configuration Management. Configuration information of configurable modules shall be retrievable in the field.	N/A. The PRM and OPRM system reconfigurations are only accomplished through mechanical devices (switches or pushbuttons) provided on the hardware chasses. The only configuration updated and provided externally is the gain adjustment factors for LPRMs.
4.4.5.2.C	Configuration Management. Software tools for modifying device configurations shall provide measures to prevent unauthorized access.	N/A. The PRM and OPRM system configuration cannot be modified by any software tool.
4.4.5.2.D	Configuration Management. PLC and support tools shall provide capability to extract and record database information, including program constants.	N/A. The PRM and OPRM systems do not need to implement data bases and modifiable program constants. The only configuration provided externally is the gain adjustment factors for LPRMs, which are set from an external core monitoring system.
4.4.5.2.E	Configuration Management. All PLC devices that include firmware shall be marked with an identifier that includes revision level.	Comply. All modules and units of PRM and OPRM are marked with an identifier that includes revision level, which Toshiba tracks.
4.4.5.2.F	Configuration Management. For PLCs with redundancy, tools shall provide capability to confirm that configurations are consistent.	Comply. The PRM and OPRM do not employ internal redundancy except for LVPS modules with each unit and redundant communication links for LPRM data communication in the PRM and for APRM data input to the OPRM. The Master Configuration List is the tool to manage the configuration items for consistency.
4.4.6	Diagnostics Requirements. (section heading)	No requirement
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.	Comply. The PRM and OPRM have diagnostic functions to detect failures that could prevent the FPGA equipment 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.	(See Items 4.4.6.1.1 through 4.4.6.1.8 in this table.)
	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.	N/A. The output modules of PRM and OPRM do not use output short term changes of state for self-tests or diagnosis.
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.	N/A. The PRM and OPRM do not include redundant processors. However, failure of any FPGA to complete its required computations is detected and annunciated in the MCR.
4.4.6.1.2	Executive Program Error. Check of executive firmware integrity using a checksum or similar test.	N/A. The PRM and OPRM do not use executive firmware.

Section No	Summary of EPRI TR-107330 Requirements	Compliance with EPRI TR-107330 Requirements (or N/A)
4.4.6.1.3	Application Program Error. Check of application program integrity using a checksum or similar test.	N/A. A checksum is verified during FPGA fusemap implementation. After programming, no additional checksums are possible, based on the FPGA internal configuration.
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. The PRM does not use read/write memory, and the application cannot be modified. The AGRD and PBD modules of OPRM have a small SRAM to retain a small amount of processed temporal data. The values in the SRAM are protected by error correcting code (ECC). Toshiba considers that the ECC works in compliance with the intention of this requirement
4.4.6.1.5	Module Communication Error. Check of communication data integrity.	Comply. The TRN and RCV modules implement data transmission checks, between units, through fiber optic cables The module receiving data from the other unit shall verify the periodic occurrence of the data transmissions, and the validity of transmitted data between units over fiber optic cables. The data is protected by CRC included with the data. Checking data transmission from the modules in a same unit: The APRM module in the PRM and the CELL module in the OPRM check the periodic transmission of the data frame from the TRN and the RCV modules in the same unit. The AGRD and PBD modules of the OPRM check the periodic transmission of the data frame from the CELL module. If a timeout error occurs, a Minor Failure alarm is generated.
4.4.6.1.6	Memory Battery Low. Check of memory battery capacity.	N/A. The PRM or OPRM system does not use any battery-backed memory.
4.4.6.1.7	Module Loss of Configuration. For software configurable modules, validate configuration.	N/A. The PRM or OPRM system does not use software configurable modules.
4.4.6.1.8	Failure of Watchdog Timer. Check of operation of watchdog timer.	Comply. Each module that has one or more FPGAs has one or two watchdog timers. Each watchdog timer can be checked for correct operation by the removal of a jumper. Watchdog timer time outs are detected and annunciated in the MCR.
4.4.6.1.9	Application not Executing. Failure to complete application program scan.	Comply. If a signal processing FPGA halts, the module containing the FPGA generates an inoperable signal. Failures of the Human Machine Interface (HMI) FPGAs do not generate an inoperable signal, but do generate a Minor Failure Alarm, except for the LPRM module. The watchdog timers are external, not built into the FPGA logic, and do not depend on the clock signal used by the FPGA. (See Item 4.4.6.1.8 in this table.)
4.4.6.1.10	Analog Output not Following. Failure of analog output to follow commanded value.	Comply. Failure of an analog output can be detected by an upscale or downscale alarm in the receiving equipment. The capability to support surveillance test is provided.

Section No	Summary of EPRI TR-107330 Requirements	Compliance with EPRI TR-107330 Requirements (or N/A)
4.4.6.1.11	Analog Input not Responding. Failure of analog input to respond to input signal.	Comply. Gross failure of one analog input can be detected by upscale or downscale alarm in the receiving equipment. Failure of a single LPRM to a stuck value does not adversely affect operation of the power averages in the redundant PRM units or oscillation detection logic in the redundant OPRM units. The capability to support surveillance test is provided.
4.4.6.1.12	Discrete Input/Output not Responding. Failure of discrete input/output to operate correctly.	Comply. The PRM or OPRM systems do not have functions to detect the failure of discrete inputs or outputs. The capability to support surveillance test is provided.
4.4.6.1.13	Analog I/O out of Calibration. Analog input or output point out of calibration.	Comply. For PRM System, range check of analog input value is conducted. Analog output calibration would be part of periodic surveillance.
4.4.6.1.14	Power Supply out of Tolerance. Power supply to PLC is interrupted or a chassis power supply module fails.	Comply. The Low Voltage Power Supply (LVPS) module monitors its output voltage. If the voltage of the LVPS becomes lower than the setpoint –10%±5% in either of the LVPS module, the STATUS module (PRM) or the DAT/ST module (OPRM) front panel provides the indication.
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.	(See Items 4.4.6.1.1 through 4.4.6.1.6 in this table.)
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. Whenever power is applied to the PRM or OPRM module, the equipment is initialized by the power on reset function. All trip and alarm outputs remain de-energized and thus tripped until the initialization process has completed (about 470 ms). After initialization, the trip and alarm outputs assume the states indicated by calculations and bypass settings. Power on reset function is also executed when the power supply low voltage is detected. The modules that have FPGAs are provided with a power supply monitoring IC, which provides about 150 ms or 470 ms reset action and initial startup of FPGA at the time when the module is energized. In addition, it executes a reset action when the power supply voltage lowers, i.e., if the power supply voltage continues to be low, the module remains in initialization state, and keeps all trip and alarm outputs in the tripped state. Note: The TRN module has about 470 ms reset time while other modules have about 150 ms reset time. The PRM System is capable of performing run time diagnostics.
4.4.7	Data and Data Base. (section heading)	No requirement.

Section No	Summary of EPRI TR-107330 Requirements	Compliance with EPRI TR-107330 Requirements (or N/A)
4.4.7.1	The data base resident in a PLC are those items necessary to cause the application program to operate as designed or to establish the configuration and/or types of I/O modules connected to the PLC.	N/A. The Toshiba NRW-FPGA -based PRM or OPRM do not have a resident data base for the application program.
4.4.7.2 A	The PLC shall support usage of user-defined program constants that are contained in non-volatile memory. For redundant systems, features shall be provided to confirm that the constants in redundant processors are the same.	Comply. The PRM and OPRM have non-volatile memory to store constants. The PRM and OPRM do not have redundant processors.
4.4.7.2 B	The PLC shall provide functions to permit reading and modifying the constants in the application program. For redundant systems, features shall be included to assure that the modification of constants is consistent between the redundant processors.	Comply. The FPGA logic used in the PRM and OPRM has functions to read and modify constants such as gain constants and setpoints from the front panel or by the rotary switch in the module. The PRM and OPRM do not have redundant processors.
4.4.7.2 C	The PLC shall provide features to prevent modifications to the local data table over peer-to-peer communication paths and any other on-line communication paths.	Comply. In the PRM and OPRM, constants stored in non-volatile memory cannot be modified over any kind of on-line communication path, and the communication paths do not support any messages other than the pre-defined data transfer messages, which are not programmed or designed to modify constants.
4.4.7.2 D	The PLC shall provide features to permit transmitting inputs, outputs, and calculated values to other devices over a serial port.	Comply. The PRM and OPRM can transmit inputs, outputs, status, and calculated values to other devices over a (serial) fiber optic communication link.
4.4.8	Other Non-Ladder Logic Programming Languages.	N/A. The PRM and OPRM application logic will be designed in VHDL, which is a specific hardware programming language. No other languages are supported.
4.4.9	Sequence of Events Processing Requirements.	N/A. The PRM and OPRM are provided with an application specific logic. Sequence of events logic is not provided in the PRM or OPRM, but can be created in external systems based on data sent by the PRM and OPRM.
4.4.10	System Integration Requirements. An appropriate level of system integration and integration testing shall be applied to the test specimen and TSAP.	(See Item 5.2.C in this table.)
4.5	Human/Machine Interface (HMI). (section heading)	No requirement

Section No	Summary of EPRI TR-107330 Requirements	Compliance with EPRI TR-107330 Requirements (or N/A)
4.5.1	Human/Machine Interface (HMI) Background. Descriptive information.	No requirement
4.5.2	Requirements for Human/Machine Interface Functions. Descriptive information.	No requirement
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 PRM and OPRM applications do not include loop controllers logics.
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.	Comply. The PRM and OPRM setpoints are adjustable by a technician during equipment maintenance or an operator during periodical surveillance service. The PRM and OPRM support setpoint adjustments through the front panel. Adjustments include increasing and decreasing the selected setpoint.
4.5.2.C	HMI Functions. PLC shall support manual initiation of equipment via switch inputs. PLC shall support detection of manually initiated equipment.	N/A. The PRM or OPRM functions do not require manual initiation of equipment.
4.5.2.D	HMI Functions. PLC shall support display of status of discrete and continuous value parameters via connected devices.	Comply. Status of discrete and continuous value parameters are shown on the front panel indication on each module.
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. The PRM or OPRM does not support sending information to a serial port device. Instead, the PRM and OPRM can provide fiber optic communication ports, running a defined protocol, sending defined datasets to external safety or non-safety systems.
4.5.3	Requirements for Interactive Features. The PLC shall provide mechanisms to prevent unauthorized access to or inadvertent use of on-line functions.	N/A. The PRM and OPRM are provided with an application specific logic that cannot be modified. This feature is not required. A keylock switch is provided for each module to prevent inadvertent setpoint changes.
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.	Comply. Operator action that requires FPGA processing is executed sequentially with rapid response to operator action. For operator actions that require confirmation, the HMI FPGAs in each module providing the required processing ensures quick response.

Section No	Summary of EPRI TR-107330 Requirements	Compliance with EPRI TR-107330 Requirements (or N/A)
4.5.5	Display Requirements. Status shall be easily visible.	Comply. Status of each function is shown on the indicators on the front panel of each module.
4.5.6	Alarm Processing Requirements. Descriptive information.	No requirement
4.5.6.A	Alarm Processing. PLC shall have ability to compare inputs or derived parameters to setpoints.	Comply. The PRM and OPRM have ability to compare the signal input and calculated values to appropriate setpoints, and generate alarms or trip signals.
4.5.6.B	Alarm Processing. PLC shall have ability to latch an alarm condition and reset based on alarm reset condition.	Comply. The PRM and OPRM have ability to latch alarm conditions and reset based on alarm reset conditions. The module front panels of the PRM and OPRM provide a manual reset button to perform this action.
4.5.6.C	Alarm Processing. PLC shall have ability to blink an output indicator.	Application Specific Requirement. The PRM and OPRM have the ability to provide an alarm signal to the plant annunciator which has the capability to flash an annunciator. The front panel HMI LEDs on the PRM and OPRM modules do not blink. The alarm status can be communicated to external systems where the alarm status can be recorded and integratedly displayed with blink as needed.
4.5.6.D	Alarm Processing. PLC shall have ability to acknowledge an alarm.	Application Specific Requirement. The PRM and OPRM provide alarm signals that lock in until the alarm condition clears and is reset. All alarm acknowledgements is performed by the external, annunciator system and not by the Toshiba safety equipment.
4.5.6.E	Alarm Processing. Application program shall have ability to capture results of self-diagnostics.	Application Specific Requirement. The PRM or OPRM does not use an application program to capture results of self-diagnostics. When a failure is detected, an inoperable signal or minor failure alarm is generated, which is latched by the detected condition, and indicated on the module detecting the self-diagnostic failure. The alarm status can be communicated to external systems where the alarm status can be recorded.
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.	Application Specific Requirement. Alarms and internal conditions are transmitted on the fiber optic output link to external safety or non-safety systems where the status of the alarms is stored.
4.5.7	Hard Manual Backup. Descriptive information.	No requirement
4.6	Electrical. (section header)	No requirement
4.6.1	Power Supply Requirements. (section heading)	No requirement
4.6.1.1	PLC Power Sources and Power Supply Requirements. Descriptive information.	No requirement

Section No	Summary of EPRI TR-107330 Requirements	Compliance with EPRI TR-107330 Requirements (or N/A)
4.6.1.1.A	Power supplies. 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. The PRM and OPRM operate on an AC source range of 90 to 150 VAC and frequency range of 57 to 63 Hz (EPRI TR-107330 Section 4.6.1). Each LVPS module is capable of supplying 1.2 times the bus loading in a fully loaded main chassis. The LVPS modules operate under the qualified temperature and humidity of the main control room as demonstrated during EQ testing.
4.6.1.1.B	Power supplies. 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.	N/A. The PRM or OPRM configuration does not have and is not qualified with a low voltage DC power source.
4.6.1.1.C	Power supplies. DC sources shall operate for seven days from a 30VDC source.	N/A. The PRM or OPRM configuration does not have and is not qualified with a low voltage DC power source.
4.6.1.1.D	Power supplies. Power supplies shall be capable of supplying 1.2 times bus loading for a fully loaded main chassis.	Comply. The PRM and OPRM operate on an AC source range of 90 to 150 VAC and frequency range of 57 to 63 Hz (EPRI TR-107330 Section 4.6.1). Each LVPS module is capable of supplying 1.2 times the bus loading in a fully loaded main chassis.
4.6.1.1.E	Power supplies. Power supplies shall be capable of supplying 1.2 times bus loading for a fully loaded expansion chassis.	N/A. The PRM or OPRM do not have or require an expansion chassis.
4.6.1.1.F	Power Sources. Hold up time for AC sourced power supplies shall be 40 ms.	Comply. During Hold up time for AC power sources (40 ms), discrete I/O values do not change and analog I/O values do not change, which is within the EPRI TR-107330 requirement for less than a 5% of full scale change.
4.6.1.1.G	Power supplies. Power supplies shall meet the EMI/RFI, surge withstand and ESD requirements of Sections 4.3.7, 4.6.2 and 4.3.8.	(See Item 4.3.7 EMI/RFI in this table.) (See Item 4.6.2 Surge in this table.) (See Item 4.3.8 ESD in this table.)
	Sources shall meet the grounding requirements of Section 4.6.8.	(See Section 4.6.8 in this table.)
4.6.1.1.H	Power supplies. Requirements for fan cooled power supplies.	N/A. The PRM and OPRM system does not require or provide forced air cooling for the power supplies or for the units.
4.6.1.1.I	Power supplies. Faults in redundant power sources shall not prevent operation of the alternate supply.	Comply. The failure of one of the redundant power supplies does not cause the discrete I/O values to change state, and the analog I/O values do not change which is within the EPRI TR-107330 requirements for less than 5% of full scale change.

Section No	Summary of EPRI TR-107330 Requirements	Compliance with EPRI TR-107330 Requirements (or N/A)
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.	N/A. The PRM and OPRM do not provide or require Loop Power Supplies. The FLOW inputs are powered from external sources.
4.6.2	Surge Withstand Capability Requirements. PLC platform shall withstand IEEE Std 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 in accordance IEEE Std C62.45.	Comply with limited scope and/or condition. Power sources meet surge withstand criteria. IEEE Std C62.45 does not address surge testing of I/O and communications circuits. External communications are on fiber optic links, which do not require surge withstand testing, as they are nonconductive. These circuits were tested in accordance with RG 1.180 Revision 1, IEC 61000-4-5, and IEC 61000-4-12. For the PRM testing the repetition time of the ring wave is [ ]a,c seconds which is longer than the 1 second requirement. However, since the period of the ring wave (30 μs) is very short compared to the required 1-second repetition rate, the effect of the transient can be considered over and the longer [ ]a,c second rate will, therefore, not affect the conclusion of the test. For the PRM, the ring wave test was expected to be performed with 12 Ω coupling impedance. This is the default setting of the test equipment and the most likely scenario. However, this is not described in the test procedures or test record and it cannot be confirmed that the test was performed with 12 Ω, not 30 Ω. If the possibility that the test was performed with 30 Ω cannot be fully denied, in this possibility, the test results may not reflect the requirement for 12 Ω, which provides more energy to the test specimen. In the OPRM testing, the repetition time of the ring wave was [ ]a,c seconds. The OPRM ring wave test was performed with 12 Ω coupling impedance
4.6.3	Separation. Descriptive information.	No requirement
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 Std 384. Isolation testing shall be performed on the modules.	Comply. Isolation capability of Class 1E to Non-Class 1E was tested with 600 VAC and 250 VDC applied for 30 seconds. Test level voltages were applied to the test points and the test specimen of the PRM unit operated normally during and after the application. There are no additional Class 1E to non-Class 1E isolators for the OPRM.

Section No	Summary of EPRI TR-107330 Requirements	Compliance with EPRI TR-107330 Requirements (or N/A)
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 60°C or greater. Vendor shall identify the quantities of PVC type wire and cable used in the system.	Comply. 1. The PRM and OPRM include all cabling and wiring necessary to connect and operate the units (and the system). 2. All cables and connectors do not contain any polyvinylchloride (PVC). 3. All cables are suitable for UL Class 2 service. Specifically, the provided cables shall have a withstand rating of more than 3 times the signal level voltage or at least 150 volts. 4. All cables have a temperature rating of 60°C or greater.
4.6.6	Termination Requirements. Modules shall be able to be removed without disconnecting field wiring.	Comply. Modules can 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.	Comply. Test signals or monitoring instruments can be connected with PRM and OPRM units by connectors for field connections. Connectors to the modules have positive hold down mechanisms.
	Connectors and terminations to the PLC shall be qualified with the generic PLC.	Comply. Any connectors and terminations to the units are included in qualification testing.
4.6.7	Backup Power. Descriptive information.	No requirement
4.6.8	Grounding/Shielding Requirements. The PLC equipment shall meet IEEE Std 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.	Comply. The PRM and OPRM meet IEEE Std 1050 and EPRI TR-102323 grounding requirements. This includes supporting connection to single point, multi-point, and floating ground systems, and providing a ground connection point on each chassis.
	The PLC equipment shall meet IEEE Std 1050 and EPRI TR-102323 shielding requirements. This includes providing shielding connection points for the I/O module field terminations.	Comply. The PRM and OPRM meet IEEE Std 1050 and RG 1.180 Revision 1 shielding requirements. This includes providing shielding connection points for the I/O module field terminations.
4.7	Maintenance. (section heading)	No requirement
4.7.1	Maintenance Background. Descriptive information.	No requirement

Section No	Summary of EPRI TR-107330 Requirements	Compliance with EPRI TR-107330 Requirements (or N/A)
4.7.2	Diagnosis/Built-in Testability Requirements. Descriptive information.	No requirement
4.7.3	Module Replacement Requirements. The PLC shall contain features to aid in module replacement.	Comply. Each module is designed for easy access of removal and installation as documented in Section II-2.1.3.
	The maintenance manual shall contain a description of any hardware configuration item for each module.	Comply. The Instructions for the LPRM Unit (Reference (d45)), Instructions for the LPRM/APRM Unit (Reference (c46)), Instructions for the FLOW Unit (Reference (d47)), and the OPRM Unit User's Manual (Reference (c27)) include each hardware configuration item for each unit.
	The module hold downs shall be easily accessible and provide ease of removal and reinstallation.	Comply. The module is designed for easy access for removal and installation as documented in Section II-2.1.3.
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. The Instructions for the LPRM Unit (Reference (d45)), Instructions for the LPRM/APRM Unit (Reference (d46)), Instructions for the FLOW Unit (Reference (d47)), and the OPRM Unit User's Manual (Reference (c27)) include information for preventive maintenance, including air filter cleanliness, termination checks, power supply checks, and instrument ground checks.
4.7.5	Surveillance Testing Requirements. The PLC shall support IEEE Std 338 surveillance testing.	Application Specific Requirement. Although the Toshiba NRW-FPGA-based PRM and OPRM do not support all the recommendations in the EPRI TR, the hardware does support the applicable requirements of IEEE Std 338 Surveillance Testing, including Channel Checks, Calibration Verification, Functional Tests, Time Response Tests, and Analog Trip Signal Tests. Section II-A-2.8 discusses surveillance capabilities of the PRM and OPRM.
4.7.6	Output Bypass/Control Devices. Descriptive information.	No requirement.
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.	Exception. Since Toshiba's engineers concluded that the additional hardware required to support hot-swap will increase the module complexity unnecessarily, the PRM or OPRM does not support powered removal or installation of components with power applied.
4.7.8	Manufacturer System Life Cycle Maintenance. (section heading)	No requirement.

Section No	Summary of EPRI TR-107330 Requirements	Compliance with EPRI TR-107330 Requirements (or N/A)
4.7.8.1	Parts Replacement Life Cycle Requirements. The baseline configuration of the qualified PLC shall be established.	Comply. Configuration management is conducted in accordance with internal Toshiba procedures as documented in Section I-3.12 for the current process and Section I-A-4.9 for the original process. The design baseline of the qualified units is maintained in Toshiba's configuration management system. The Instructions for the LPRM Unit (Reference (d45)), Instructions for the LPRM/APRM Unit (Reference (d46)), Instructions for the FLOW Unit (Reference (d47)), and the OPRM Unit User's Manual (Reference (c27)) contain information on parts replacement, consistent with information in Toshiba's configuration management system.
	Records shall be maintained for revision history and changes.	Comply. Each module has a type number as shown in Table II-2-6 in Section II-2.2.4. When there is a design change, the module type number is changed. The type number and all applicable configuration item data is maintained in configuration management.
	Records shall be maintained for tracking failures.	Comply. Failures are controlled as nonconformance under the Toshiba QA program and are recorded and tracked.
	Testing shall be performed as necessary to maintain a qualified platform based on future revisions or replacements.	Comply. Toshiba will perform testing as necessary to maintain a qualified platform based on future hardware or FPGA programmable logic revisions or component replacements.
	The information necessary fulfill these task shall be obtained from manufacturer.	Comply. The information necessary to fulfill these tasks shall be maintained and provided by Toshiba.
4.7.8.2	Component Aging Analysis Requirements. A periodic surveillance and maintenance interval shall be determined per IEEE Std 323 to account for any significant aging mechanisms.	Comply. System specific periodic surveillance and maintenance intervals will be determined. There are no significant aging mechanisms, based on an evaluation of IEEE Std 323. The maintenance frequency is discussed in Section II-A-2.8.
4.7.9	Maintenance Human Factors. Descriptive information.	No requirement
4.7.9.A	Special PLC Manufacturer Equipment. The manufacturer shall provide documentation for PLC support equipment.	N/A. No special tools are required for routine maintenance of the PRM system.
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. The Instructions for the LPRM Unit (Reference (d45)), Instructions for the LPRM/APRM Unit (Reference (d46)), Instructions for the FLOW Unit (Reference (d47)), and the OPRM Unit User's Manual (Reference (c27)) include information for maintenance, including requirements for measuring and test equipment and connection of M&TE.
4.7.9.C	Job Aids. Aids for operating the PLC equipment shall be provided.	Comply. The Instructions for the LPRM Unit (Reference (d45)), Instructions for the LPRM/APRM Unit (Reference (d46)), Instructions for the FLOW Unit (Reference (d47)), and the OPRM Unit User's Manual (Reference (c27)) include necessary information for operation, maintenance, surveillance, and calibration of the PRM system.

Section No	Summary of EPRI TR-107330 Requirements	Compliance with EPRI TR-107330 Requirements (or N/A)
4.7.9.D	Help Screens. Help screens for software used to support maintenance shall be provided.	N/A. In the future, Toshiba may determine that supplying a software tool for validation of certain ROM content would be appropriate, in which case, Toshiba will supply a software tool for such validation to customers. Such a software tool would include any required help screens. This software tool is not part of the current Topical Report.
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. All items provided by sub-vendors or third parties are subjected to all applicable Toshiba requirements and tests performed by Toshiba. Compatibility of operation with the FPGA-based unit is demonstrated through tests. Toshiba performed CG survey and CDR for Third Party/Sub-Vendors as documented in Section I-2.2.2 and Section I-A-3.2.2.
4.9	Other. (section heading)	No requirement
4.9.1	Data Handling and Communication Interface Overview. Descriptive information.	No requirement
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.	N/A. This requirement does not apply since the PRM and OPRM do not require or use a PLC and their peripheral communication port. If serial communication is provided to an external system, the loss or degradation of that serial communication link will not degrade the operability of the safety function.

Section No	Summary of EPRI TR-107330 Requirements	Compliance with EPRI TR-107330 Requirements (or N/A)
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. Communication on fiber optic communication links between units is documented in Section II-2.1.4.3.
4.9.2	Overall System Security Requirements. Switching the main processor from RUN mode to other modes shall be by key lock switch.	Comply. Since no portion of the application program can be changed at the utility, the PRM application cannot be changed from the front panel. Switches and keylocks are used to change configuration parameters including constants as documented elsewhere (Item 4.4.7.2.B) in these responses. The configuration, including adjustable parameters, is protected by keylock switches. Toshiba implements an SDOE-compliant process for the design, development, manufacturing, review, and testing of these systems.
	Features shall ensure that redundant components operate in the same mode, and that program changes are loaded into all redundant processors.	N/A. The PRM or OPRM does not use redundant processors.
	Provisions shall prevent modification of the application program and operating system while the PLC in on-line.	N/A. The application logic of the PRM and OPRM is installed in the NRW-FPGAs, and cannot be modified in the field.
4.9.3	Heartbeat Requirements. The PLC shall provide capability to activate a "heartbeat" external to the PLC.	Application Specific Requirement. The Toshiba PRM hardware does not include an available output point to operate an external "heartbeat" indicator. Rather, each module includes separate internal hardware to verify that each module completes its programmable logic program within the expected time frame. Each module receiving data from a separate FPGA module verifies that the module transmitting data sends the data in a timely manner. Thus, Toshiba provides an equivalent implementation of this requirement using internal hardware separate from the programmable logic.
4.9.4	Hazardous Materials Requirements. Material data sheets shall be provided for all hazardous materials associated with the PLC.	Comply. There are no hazardous materials in the PRM or OPRM.

Section No	Summary of EPRI TR-107330 Requirements	Compliance with EPRI TR-107330 Requirements (or N/A)
4.10	Shipping and Handling Requirements. Packaging and shipping shall be in accordance with ANSI N45.2.2.	Comply. Packaging and shipping will be in accordance with ANSI N45.2.2 Level A when shipped to the plant.
4.10.1	Packaging Requirements. Descriptive information.	No requirement
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. Items will be packaged to avoid damage or degradation due to various environmental and handling factors which may be encountered during shipping and storage when shipped to the plant, including maintenance of cyber security.
4.10.1.B	Items Shipped. Packaging shall include desiccant materials as required.	Comply. Packaging will include desiccant materials as required by the customer.
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. Items will be inspected for cleanliness prior to packaging when shipped to the plant. Items not immediately packaged will be protected from contamination when shipped to the plant.
4.10.1.D	Items Shipped. Cushioning shall be provided to protect against shock and vibration.	Comply. Cushioning will be provided to protect against shock and vibration when shipped to the plant.
4.10.1.E	Items Shipped. Items and containers shall be marked with appropriate identification.	Comply. Items and containers will be marked with appropriate identification when shipped to the plant.
4.10.1.F	Items Shipped. Copies of packing lists shall be included with each carton shipped.	Comply. Copies of packing lists will be included with each carton shipped when shipped to the plant.
4.10.1.G	Items Shipped. ESD sensitive items shall be appropriately packaged, handled and marked.	Comply. ESD sensitive items will be appropriately packaged, handled, and marked when shipped to the plant. This will include all modules having integrated circuits.
4.10.1.H	Items Shipped. Packaging shall be suitable for movement using hand trucks.	Comply. Packaging will be suitable for movement using hand trucks when shipped to the plant.
4.10.1.I	Items Shipped. Special handling or storage requirements shall be marked on the containers.	Comply. Special handling or storage requirements will be marked on the containers when shipped to the plant.
4.10.1.J	Items Shipped. See Section 4.4.2 for requirements for software storage media.	N/A. The PRM or OPRM do not provide software media to utilities. The NRW-FPGA is not rewritable, so no media is necessary, as the program is permanently embedded in the FPGA antifuse memory.
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. Shipping requirements will be specified when shipped to the plant. Requirements will include use of fully enclosed vehicles, special handling and stacking instructions as necessary, and container markings and protective covers.

Section No	Summary of EPRI TR-107330 Requirements	Compliance with EPRI TR-107330 Requirements (or N/A)
4.10.3	Storage Requirements. Storage and shelf life requirements shall be provided for all PLC items.	Comply. Storage requirements will be provided for all items. Requirements for storage will include temperature, humidity, and any static control requirements.
5	Acceptance/Operability Testing. Descriptive information.	No requirement
5.1	Acceptance/Operability Testing Overview. The development, design and performance of acceptance testing shall use the documentation requirements of Section 8.14.	(See Item 8.14 in this table.)
5.2	Pre-Qualification Acceptance Test Requirements. Descriptive information.	No requirement
5.2.A	Application Software 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.	Comply. All FPGA application programs are developed using Functional Elements (FEs) as documented in Part V (VVR of PRM) and Part VI (VVR of OPRM) of this LTR. FEs are similar to Application Software Objects (ASOs). FEs are written by Toshiba and are completely tested using pattern test methods. The pattern tests are considered to be comparable to application software objects acceptance (ASOA) tests.
5.2.B	Initial PLC Calibration. The generic qualification sample PLC shall be calibrated to NIST traceable sources. The acceptance criteria are that the analog I/O modules meet the manufacturer's specifications	Comply. The test specimens were tested using test equipment calibrated to sources traceable to the National Metrology Institute of Japan (NMIJ). NMIJ is a signatory to the Bureau International des Poids et Mesures (BIPM), as is the National Institute of Standard and Technology (NIST). Test facility's calibrations are thus traceable to NIST. The acceptance criteria are that the equipment accuracy meets the requirements specified in Section 5.1.4 of the ERS.
5.2.C	System Integration. System integration testing portion of TSAP V&V shall be performed during acceptance testing.	Comply. The system integration testing portion of the V&V phase in the digital system life cycle is performed during system validation testing as documented in Part V (VVR of PRM) and Part VI (VVR of OPRM) of this LTR.
5.2.D	Operability Tests. The Operability Test shall be performed during acceptance testing.	Comply. The operability test is performed during pre-qualification testing, and during qualification testing as documented in Section III-2.1.1 and Section III-2.2 for the PRM qualification test, and in Section III-5.1.1 and Section III-5.2 for the OPRM qualification test.
5.2.E	Prudency Tests. The Prudency Test shall be performed during acceptance testing.	Comply. The prudency test is performed during pre-qualification testing, and during qualification testing as documented in Section III-2.1.1 and Section III-2.2 for PRM qualification test, and in Section III-5.1.1 and Section III-5.2 for the OPRM qualification test.
5.2.F	Burn-In Test. A minimum 352 hour burn-in test shall be performed during acceptance testing.	Comply. Toshiba's 352 hour burn-in test was performed on the PRM units as documented in Section III-2.1.1. For OPRM unit, the 352 hours burn-in occurred during system validation test.
5.3	Operability Test Requirements. Descriptive information.	No requirement

Section No	Summary of EPRI TR-107330 Requirements	Compliance with EPRI TR-107330 Requirements (or N/A)
5.3.A	Accuracy. Accuracy checks shall be performed on the analog input/output modules.	Comply. Accuracy checks were performed for PRM safety-related functions for analog inputs and outputs in the operability test during the PRM qualification testing. Test results for the PRM qualification testing are documented in Section III-2. The acceptance criteria for the PRM are described in the ERS Section 7.2.2.A as follows" Accuracy checks shall be performed for PRM safety-related functions defined in Section 4.1.2 for analog inputs and outputs. Minimum five point linearity checks shall be made on the analog inputs and outputs. The test shall be performed on at least one channel of each type of analog inputs and /outputs in the qualification envelope. For the OPRM, there are no analog inputs or outputs, and thus this does not apply, as documented in Section 5.1.5.3 of the EDS (Reference (c28)).
5.3.B	Response Time. Response time of analog input to discrete output and discrete input to discrete output sequences shall be measured. For baseline (acceptance) testing, the acceptance criteria are 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. For PRM, the response time between receiving an analog input and generating a discrete output for safety-related functions and the response time between receiving a discrete input and generating a discrete output for those safety-related functions defined in ERS Section 4.1.2 is measured in such a way that repeatable results can be obtained. The acceptance criteria are that the measured response time for the baseline testing shall be equal to or less than the response time given in Section 5.1.3.1 of the ERS. The acceptance criteria for the response time shown in Item 4.2.1A of the EPRI TR-107330 do not include the variance threshold for the response time. The criteria only require the measured values should be less than the required value. This is based on the system requirements. Toshiba's evaluation is based on the properties of an FPGA system, where signal processing is done by hardware not by sequentially executed software like in a PLC. In the operability tests conducted during the qualification tests, Toshiba only performed a limited number of the tests conducted in the pre-qualification test. For details please see Table IV-4-2 Toshiba evaluated the variance per the NRC question and confirmed the variance is within requirements. For the OPRM, there are no analog inputs or outputs. The requirement for the response time of the OPRM unit is defined in EDS Section 5.1.4 item 6B which does not include the variance threshold for the response time. The criteria only require the measured values should be less than the required value. This is based on the system requirements. The response time test was conducted in the System Validation Testing. The results of the response time test for OPRM are documented in the Part VI of this LTR.

Section No	Summary of EPRI TR-107330 Requirements	Compliance with EPRI TR-107330 Requirements (or N/A)
5.3.C	Discrete Input Operability. Discrete inputs shall be tested for capability to detect changes in the inputs.	Application Specific Requirement. For the PRM and OPRM, the discrete inputs were tested for their ability to detect changes for safety-related functions in operability test during qualification testing. For the PRM, Section 7.2.2 C of the ERS states as follows: The discrete inputs shall be tested for their ability to detect changes for safety-related functions defined in Section 4.1.2. These tests shall be performed on at least one channel of each type of discrete input module. The acceptance criteria is that the operational modes of safety-related functions shown in Section 4.1.2 shall be changed according to discrete input within the unit and module requirements given in Sections 5.2.2.2 and 5.2.2.3. The DIO module is responsible for setting the operation mode of the PRM. Toshiba tested that the operational mode was set correctly. The DIO module was fully tested in the factory against manufacturing specification. The Reference to the test results are as follows: Changes of the safety-related setpoint by DI status were tested in accordance with the Operability Test Procedure (FPG-TPRC-C51-1009 Rev.5). The results of the Operability Tests were recorded in the Operability Test Record (FPG-06-ETR-001-03), the Pre-Operation Test Record (FPG-06-ETR-002-02), the Environmental Test Record (FPG-06-ETR-002-04a), the Seismic Test Record (FPG-06-ETR-002-05), the Preparation for EMC Test Record (FPG-06-ETR-002-6a), the Post Qualification Tests (Before re-exchange of modules) Record (FPG-06-ETR-002-11), and the Post Qualification Tests (After re-exchange of modules) Record (FPG-06-ETR-002-13). For the OPRM Section 5.2.1 of the OPRM Unit Detailed Design Specification (OPRM Unit DDS) (Reference (C29)) discusses Filtering Initialization Circuit and Algorithm Initialization Function when APRM Bypass Input is cancelled (APRM Bypass turns to disable from enable.) The Reference to the test results are as follows: APRM bypass discrete input was tested in the operability test in accordance with Operability Test Procedure (FC51-7021-1003 Rev.1) Section 6.4. The results of the Operability Tests were recorded in the Performance Proof (Pre-Qualification for EQ Test) Test Record (FC51-7021-1011), the Environmental Qualification Test Record (FC51-7021-1012), the Seismic Test Record (FC51-7021-1014), the Performance Proof (Post-Qualification for EQ Test) Test Record (FC51-7021-1015), the Performance Proof (Pre-Qualification for EMC Test) Test Record (FC51-7021-1026), and the Performance Proof (Post-Qualification for EMC Test) Test Record (FC51-7021-1027).

Section No	Summary of EPRI TR-107330 Requirements	Compliance with EPRI TR-107330 Requirements (or N/A)
5.3.D	Discrete Output Operability. Discrete outputs shall be tested for ability to operate within rated voltages and currents.	Application Specific Requirement. For the PRM and OPRM, the discrete outputs for safety-related functions were tested for their ability to perform their safety related functions in operability test during qualification testing. For the PRM, ERS Section 7.2.2 D states as follows: The discrete output for safety-related functions defined in Section 4.1.2 shall be tested for their ability. The test shall be performed on at least one channel of each type of discrete output in the qualification envelope. The acceptance criteria are that the discrete output of safety-related function which is shown in Section 4.1.2 shall be changed within the unit and module requirements given in Sections 5.2.2.1, 5.2.2.2, and 5.2.2.3. Toshiba confirmed that the DIO modules perform the required safety functions. The DIO modules are designed to operate in the environmental conditions, and nothing tested would change the voltage or current capabilities of the output points. Since the outputs are either votes to trip or annunciation points, there is no requirement to drive high power or high current loads. The testing provided was appropriate for inputs to reactor trip systems and annunciators. The monitoring of the output of DIO module was performed through relays which are driven by the DIO module. These relays are parts of the test equipment and provide isolation. For the OPRM, Section 5.2.2.3.5 of the EDS defines the requirement for trip and alarm generation. Tests were conducted in accordance with Operability Test procedure (FC51-7021-1003 Rev.1) Sections 6.3, 6.5, and 6.7. For documentation of the test record, please see Item 5.3 C in this table.
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.	Application Specific Requirement. No acceptance criterion is defined in the PRM ERS and the OPRM EDS, because Toshiba considered this to be a requirement for copper-based electronic serial communication ports, which the PRM and the OPRM do not have. The PRM does not have a fiber optic receiver for data outside the PRM. The OPRM only receives data from the LPRM and APRM units. The PRM and the OPRM do have fiber optic communication for internal communication, which Toshiba tested in the factory by intentionally degrading the light intensity by inserting the attenuator in the fiber communication line, and also tested in the qualification test by monitoring the alarms. This EPRI TR-107330 requirement to check degradation in bit rates, signal levels, and pulse shapes of communication protocol is not appropriate to fiber optic communication. The PRM and the OPRM bit rate is immaterial, within reasonable bounds, as the fiber optic signal is self-clocking. To implement this during EQ test would require Toshiba to place modules or extenders to hook up instruments, which is not the actual operational state of the unit and would not provide EQ testing results consistent with the intended in-plant configuration. Thus Toshiba relied on communications alarms to detect faults and failures in the fiber optic communication. The intentional attenuation of light intensity in internal data links within the PRM and the PRM was one of the test items during factory module tests.

Section No	Summary of EPRI TR-107330 Requirements	Compliance with EPRI TR-107330 Requirements (or N/A)
5.3.F	Coprocessor Operability. If any coprocessors are included in the qualification envelope, then tests shall be performed specifically on these coprocessors.	N/A. The PRM or OPRM does not use coprocessors.
5.3.G	Timer Tests. Accuracy of timer functions shall be tested.	N/A. The PRM or OPRM does not provide any separate timer functions. The EPRI TR provides generic requirements for qualifying a general purpose PLC. For the PRM and OPRM functions, the specific timing functions required are hardcoded into the logic, and then verified and validated during the software lifecycle, culminating in system validation testing.
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 PRM or OPRM does not need separate scan failure detection. Each module includes separate hardware to verify that each module completes its programmed logic within the expected time frame. Each module receiving data from a separate FPGA module verifies that the module transmitting data sends the data in a timely manner. Thus, Toshiba provides an equivalent implementation of this requirement using internal hardware and programmed logic. The logic is implemented in a parallel implementation, and detection of failure to complete an FPGA-specific function is detected and alarmed by hardware watchdog timers external to the FPGAs. If the logic is not completing in an acceptable time, the watchdog time expires, which triggers the INOP alarm which Toshiba monitored during all testing.
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. For the PRM and OPRM, failover to the redundant AC power source test was performed during operability testing during qualification testing. For the PRM and OPRM, Toshiba performed tests in which the voltage of one of the two redundant Low Voltage Power Supplies (LVPSs) outputs of each unit were lowered to the level at which Fail signal status occurred to the LVPS module, and confirmed that each redundant power supply operated correctly without generating "Fail" signal. The tests were performed during the Pre and Post Qualification Testing. The DIO module that has safety functions was monitored and the recorded officially in the PRM and the OPRM. For the PRM, the monitoring of the analog output (AO) module that has non-safety function is not included in the acceptance criteria and the results are not included in the official test records. However, Toshiba confirmed that a recorder monitored the output of the analog output module, reviewed the results, and confirmed that the results were acceptable. The OPRM does not have an AO module. For the documentation of test record, please see Item 5.3 C in this table.

Section No	Summary of EPRI TR-107330 Requirements	Compliance with EPRI TR-107330 Requirements (or N/A)
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. The AC power source was shut off for at more than 30 seconds and then reapplied. For the PRM and OPRM, the loss of power tests were performed during operability testing during qualification testing. The DIO module that has safety functions was monitored and was used to demonstrate power fail and recovery during the PRM testing and during the OPRM testing. For the PRM, the monitoring of the AO module that has no safety function is not included in the acceptance criteria and the results are not described in the official test records. However, Toshiba confirmed that a recorder monitored the output of the AO, reviewed the results, and confirmed that the results were acceptable. The OPRM does not have AO module. For the documentation of test record, please see Item 5.3 C in this table.
5.3.K	Power Interrupt Test. The AC power sources shall be interrupted for a 40 millisecond hold-up time.	Comply. The AC power source is interrupted for 40 ms. For the PRM and OPRM, the power interruption tests were performed during the operability testing during qualification testing. Power to both of the redundant power supplies was interrupted. The DIO that has safety functions was monitored and the recorded officially in the PRM and the OPRM, For the PRM, the monitoring of analog output module that has not safety function is not included in the acceptance criteria and the results are not included in the official test records. However, Toshiba confirmed that a recorder monitored the output of the AO module, reviewed the results, and confirmed that the results were acceptable. The OPRM does not have AO module. For the documentation of test record, please see Item 5.3 C in this table.
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. Failure of one of the redundant LVPS modules is simulated in the fault simulation test. The PRM and OPRM system successfully detected the failure and continued normal operation with power from the other LVPS module in the prudency test during qualification testing. For the documentation of test record, please see Item 5.3 C in this table.

Section No	Summary of EPRI TR-107330 Requirements	Compliance with EPRI TR-107330 Requirements (or N/A)
5.4.A	Burst of Events Test. Tests shall be performed to verify operation of the PLC under highly dynamic input/output variation conditions.	Application Specific Requirement. For the PRM: The Burst of Events test is designed to ensure that a programmable logic controller (PLC) can cope with a burst of discrete input (DI) changes occurring simultaneously without causing increased scan processing time. This effect does not happen in FPGAs with parallel logic. For the PRM and OPRM, there is no general purpose DI. However, Toshiba did demonstrate that the special purpose DIs operate correctly within the requirements. Each logic element can work in parallel with synchronization of the clock signals, which are far shorter than the response time. The timeout of the signal processing is monitored by the watchdog timer. For Discrete Input (DI) toggling, all DIs (Reactor Operational Mode, APRM Bypass, and FLOW Bypass) are toggled. The acceptance criterion is that APRM High-High Trip occurs within 40 milliseconds after the Reactor Operational Mode DI is changed to OFF. In this DI toggling, the APRM High-High Trip is the only safety related output which changes its status with DI toggling. Accordingly, Toshiba considers that this test satisfies the requirements in Section 5.4A of EPRI TR-107330. For Analog Input (AI) toggling, all AIs (LPRM inputs and Flow inputs) are toggled. The acceptance criterion is that APRM High-High Trip occurs within[ ]a,c milliseconds after the APRM AO outputs exceed 120.0% level. In this AI toggling, the APRM High-High Trip is the only safety related output that changes its status with DI toggling. The accuracy was verified in the operability test. Toshiba considers that this test satisfies the requirements of Section 5.4A of EPRI TR-107330. To test the output and communication against the EPRI TR-107330 requirements, the test specimen would require different FPGA logic. In keeping with Equipment Qualification testing requirements, Toshiba considered it is more appropriate to perform type testing with the real PRM logic rather than create and test with FPGA logic with significant differences. For the OPRM: The PRM Bypass signal toggling test, LPRM Level Toggling test, and APRM Level and Core Flow Level Toggling tests were performed in accordance with Prudency Test Procedure (FC51-7021-1003) Section 6.2, Burst of Events. For the documentation of test record, please see Item 5.3 C in this table.

Section No	Summary of EPRI TR-107330 Requirements	Compliance with EPRI TR-107330 Requirements (or N/A)
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.	Application Specific Requirement. There is no Serial Port Receiver for the PRM. The Failure of Serial Port Receiver Test was performed for the OPRM optical serial transmission port during the OPRM prudency test. Toshiba conducted room temperature factory product tests using an attenuator in each of the fiber optic links. Toshiba confirmed that the fiber optic links remained operable with about[ ]a,c dbm light intensity and that no alarms were generated. Toshiba then confirmed that further decrease of the optical intensity does generate alarms by further attenuating the light intensity. This test confirmed that alarms are generated and that monitoring in the operability test is sufficient to detect and alarm when degraded fiber optic communication links occur. Toshiba does not interpret the requirements in TR-107330 as such that intentional degradation of the communication is required in the qualification testing. However, through the discussion with the NRC, Toshiba understood that the real intent of the questions is to confirm if Toshiba found any impacts on the response time by intentionally degrading the external fiber optic communication. Degrading the fiber optic communications has no adverse effects on time response as long as communication is still occurring. The PRM and the OPRM does not have any receiving port for external communication. The PRM has only transmit (TRN) modules to send data to external systems. The TRN module has only transmission ports and no receiving ports. There are no receiving modules for external data in the PRM and the OPRM. The PRM and the OPRM are not designed to accommodate any RCV modules for external communication. The installation of such an RCV module is not allowed and is impossible by the design of the programmable logic. Because the PRM and the OPRM do not have any external receiving ports, Toshiba did not conduct a failure of the serial port receiver test during equipment qualification testing. Toshiba views the tests performed at the factory sufficient demonstration for the PRM. Since the back panel and chassis design is unique to the PRM, the general serial communication boards that can be used in PLC cannot be used in the PRM. Regarding the RCV module and TRN module used for internal communication within the PRM, Toshiba conducted the factory test and operability/prudency test as stated earlier in this response. Please note that Failure of Serial Port Receiver Test was performed for the OPRM optical serial transmission port during the OPRM prudency test by plugging out the other end of the fiber optic cable connected the test equipment that works for sending the LPRM data. For the documentation of test record, please see Item 5.3 C in this table.
5.4.C	Serial Port Noise Test. The transmit line to the main processor serial communication shall be subject to white noise. PLC response time shall be verified to not degrade unacceptably.	Application Specific Requirement. Please see Item 5.4.B in this table.

Section No	Summary of EPRI TR-107330 Requirements	Compliance with EPRI TR-107330 Requirements (or N/A)
5.4.D	Fault Simulation. For PLCs that include redundancy, failures in redundant elements shall be simulated.	Comply. For the PRM and OPRM, failure of one of the redundant LVPS modules was simulated in prudency test during qualification testing. The PRM and OPRM system successfully detected the failure (using self-diagnosis) and transferred to the other LVPS module. The PRM and continued normal operation without suffering any degraded operation. Please see Item 5.3. I in this table. For the documentation of test record, please see Item 5.3 C in this table.
5.5	Operability/Prudency Testing Applicability Requirements. As a minimum, Operability and Prudency tests shall be performed:	Comply. For the PRM and OPRM, operability and prudency tests were performed at the Pre-qualification test, the Environmental test, Post SSE test, and Performance Proof test during qualification test. Test results for the PRM qualification testing are documented in Section III-2, and test results for the OPRM qualification are documented in Section III-5. For the documentation of test record, please see Item 5.3 C in this table.
	- During acceptance testing: Operability – All, Prudency – All - During environ. testing: Operability – All, Prudency – All - 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	Comply with limited scope and/or condition. Due to the short duration of seismic SSE tests, and special set-up required for the EMI/RFI tests, complete Operability and Prudency Tests cannot be performed during the seismic event or during EMI/RFI testing. Toshiba chose to monitor the equipment operation during the test and perform the operability and prudency tests before and after the tests to ensure that the PRM and OPRM remained operable during and after the seismic event and EMI/RFI testing. Separate Table IV-4-3 and Table IV-4-4 provide the test details of the PRM Operability/Prudency testing. Separate Table IV-4-8 and Table IV-4-9 provide the test details of the OPRM Operability/Prudency testing.
5.6	Application Software Objects Acceptance (ASOA) Testing. Requirements for ASOA testing.	(See Item 5.2.A in this table.) All ASOA testing was performed under the 10CFR50 Appendix B program during Verification and Validation.
6	Qualification Testing and Analysis. Descriptive information.	No requirement
6.1	Qualification Process Overview. Descriptive information.	No requirement
6.1.1	PLC System Qualification Overview. Descriptive information.	No requirement

Section No	Summary of EPRI TR-107330 Requirements	Compliance with EPRI TR-107330 Requirements (or N/A)
6.2	PLC System Test Configuration Requirements. Descriptive information.	No requirement
6.2.1	Test Specimen Hardware Configuration Requirements. Hardware configuration shall be developed and documented consistent with the requirements of Sections 6.5 and 8.6.2.	(See Items 6.5 and 8.6.2 in this table.)
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. The test specimens for the qualification testing of the PRM and OPRM includes all modules needed to encompass the system requirements for one division. Section II-A-3 provides the Unit/Module configuration qualified for the PRM and for the OPRM.
6.2.1.B	Module Types. The test specimen shall include modules needed to support Operability testing.	Comply. The PRM and OPRM test specimens for the qualification testing included all modules needed to support system testing. Section II-A-3 provides the Unit/Module configuration qualified for the PRM and for the OPRM.
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. The test specimens for the qualification testing of the PRM and OPRM includes all equipment needed to meet the system specific requirements. Section II-A-3 provides the Unit/Module configuration qualified for the PRM and for the OPRM.
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. The test specimens for the qualification testing of the PRM and OPRM includes all required unit chassis needed to meet the system requirements. Section II-A-3 provides the Unit/Module configuration qualified for the PRM and for the OPRM.
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. The test specimens for the qualification testing of the PRM and OPRM includes the LVPS modules needed to meet the system requirements. Section II-A-3 provides the Unit/Module configuration qualified for the PRM and for the OPRM.

Section No	Summary of EPRI TR-107330 Requirements	Compliance with EPRI TR-107330 Requirements (or N/A)
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. The PRM and OPRM test specimens for the qualification testing included dummy modules to fill all remaining slots in each unit chassis. Section II-A-3 provides the Unit/Module configuration qualified for the PRM and for the OPRM.
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. The PRM and OPRM test specimens for the qualification testing included all required connectors in the modules. Section II-A-3 provides the Unit/Module configuration qualified for the PRM and for the OPRM.
6.2.1.H	Redundant Devices. The test specimen shall include any devices needed to implement any redundancy included in the qualification envelope.	Comply. The test specimens for the qualification testing for the PRM and OPRM include redundant LVPS modules. Redundant fiber optic cables were provided for LPRM data communication in the PRM. Section II-A-3 provides the Unit/Module configuration qualified for the PRM and for the OPRM.
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. The test specimens for the qualification testing for the PRM and OPRM includes all required modules needed to support Operability and Prudency testing. Section II-A-3 provides the Unit/Module configuration qualified for the PRM and for the OPRM.
6.2.1.1	Test Specimen Hardware Arrangement Requirements.	Comply. The hardware configuration of the Test Specimen is the qualified PRM or OPRM system. The Test Specimen for PRM qualification included one LPRM/APRM unit, one LPRM unit, and one FLOW unit. An additional FLOW unit was provided as test equipment, along with test equipment to simulate LPRM and FLOW unit inputs. The Test Specimen for OPRM qualification includes one OPRM unit and test equipment to provide test data to the OPRM. Section II-A-3 provides the Unit/Module configuration qualified for the PRM and for the OPRM.
6.2.2	Test Specimen Application Program (TSAP) Configuration Requirements.	Comply. The Toshiba NRW-FPGA-based PRM and OPRM systems were manufactured with the application specific logic required for each system. Rather than creating a TSAP, Toshiba used a BWR-5 specific PRM program. The Operability and Prudency testing were tailored to that application logic.
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 Toshiba NRW-FPGA-based PRM or OPRM systems do not use coprocessors.

Section No	Summary of EPRI TR-107330 Requirements	Compliance with EPRI TR-107330 Requirements (or N/A)
6.2.3	Test Support Equipment Requirements. Test equipment to support Acceptance and Operability testing shall be provided.	Comply. The test support equipment was documented for the PRM and OPRM qualification testing. Test support equipment for PRM qualification is documented in the Preliminary Technical Evaluation Report (PTER) (Reference (d38)). Test support equipment for OPRM qualification is documented in the Environmental Qualification Report (Reference (c20)), EMC Qualification Report (Reference (c21)), and Dynamic Qualification Report (Reference (c22)).
6.2.3.A	Test Support Equipment. Equipment shall include panels for connecting and simulating inputs and outputs.	Comply. Panels for connecting to the inputs and outputs and equipment for simulating inputs and monitoring outputs were provided for the PRM and QPRM qualification test. Test support equipment for PRM qualification is documented in the Preliminary Technical Evaluation Report (PTER) (Reference (d38)). Test support equipment for the OPRM qualification is documented in the EQ Test Plan (Reference (c10)) and EMC Test Plan (Reference (c11)).
6.2.3.B	Test Support Equipment. Equipment shall include test and measurement equipment with required accuracy.	Comply. Test and measurement equipment with required accuracy was provided for the PRM and OPRM qualification tests. Test support equipment for the PRM qualification tests is documented in the Preliminary Technical Evaluation Report (PTER) (Reference (d38)). Test support equipment for the OPRM qualification tests is documented in the EQ Test Plan (Reference (c10)) and EMC Test Plan (Reference (c11)).
6.2.3.C	Test Support Equipment. Equipment shall include special tools and devices needed to support testing.	Comply. Tools and devices needed to support testing were provided for the PRM and OPRM qualification test. Test support equipment for the PRM qualification tests is documented in the Preliminary Technical Evaluation Report (PTER) (Reference (d38)). Test support equipment for the OPRM qualification tests is documented in the EQ Test Plan (Reference (c10)) and EMC Test Plan (Reference (c11)).
6.2.3.D	Test Support Equipment. All test equipment shall be controlled per IEEE Std 498.	Comply. All test equipment used in the PRM and OPRM qualification testing were controlled per IEEE Std 498.
6.3	Qualification Tests and Analysis Requirements. All testing shall be performed on a calibrated system with all user setpoint values adjusted to default values.	Comply. All tests were performed on the calibrated PRM and OPRM systems with setpoint values adjusted to the values defined in the test procedures.
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. For convenience in testing, environmental testing for the PRM and OPRM qualification tests were performed before the other tests. Test results for the PRM qualification testing are documented in Section III-2. Test results for the OPRM are documented in Section III-5.

Section No	Summary of EPRI TR-107330 Requirements	Compliance with EPRI TR-107330 Requirements (or N/A)
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.	Exception. The EMI/RFI tests for the PRM and OPRM qualification tests were performed at the maximum levels and the equipment passed, so no further threshold testing was required. Test results for the PRM qualification testing are documented in Section III-2. Test results for the OPRM qualification testing are documented in Section III-5.
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.	Comply with limited scope and/or condition. Due to space limitations in the test facility's EMI/RFI chamber, the PRM and OPRM test specimens were not mounted six feet above the floor. The test specimens were mounted on an open metal rack that provided no significant shielding within the restrictions of the test chamber. Test specimen mounting for the EMI/RFI testing for the PRM qualification testing is documented in the Qualification Summary Test Report (Reference (d16)). Test mounting for the EMI/RFI testing for the OPRM qualification testing is documented in the EMC Qualification Report (Reference (c21)).
	EMI/RFI Mounting Requirements. PLC shall be grounded per manufacturer's recommendations.	Comply. The PRM and OPRM test specimens were connected to ground. The grounding used for these tests meets the grounding and shielding requirements documented in the Application Guide. Test specimen mounting for the EMI/RFI testing in the PRM qualification testing is documented in the Qualification Summary Test Report (Reference (d16)). The mounting for the EMI/RFI testing for the OPRM qualification testing is documented in the EMC Qualification Report (Reference (c21)).

Section No	Summary of EPRI TR-107330 Requirements	Compliance with EPRI TR-107330 Requirements (or N/A)
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 humidifies. 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 with limited scope and/or condition. Environmental testing was performed to the environmental withstand requirements documented in EPRI TR-107330 to assure that the PRM and OPRM systems do not fail due to temperature and humidity stressors. Environmental tests were performed with power supply conditions that resulted in maximum heat dissipation into the PRM and OPRM systems. Test results for the PRM environmental tests are documented in the Qualification Test Summary Report (Reference (d16)) Test results for the OPRM environmental tests are documented in the Environmental Qualification Report (Reference (c20)). The PRM and the OPRM systems were qualified as follows, based on EPRI TR-107330 Figure 4-4 and Section 4.3.6: PRM: a. High Temperature and Humidity: 140 °F and 95% relative humidity, which meets EPRI TR-107330 Section 4.3.6 and Figure 4-4 requirements (Toshiba notes that adding 5% margin to the relative humidity would most likely induce condensation, which is not included in Toshiba's qualification envelope). b. Low Temperature and Humidity: 35 °F and 10% relative humidity, which meets EPRI TR-107330 Section 4.3.6 requirements (Figure 4-4 requirements for humidity could not be met in this chamber, even with relaxation for non-simultaneous temperature and humidity, and Toshiba notes that the OPRM is constructed of similar components and had no issues at 40 °F and 5% relative humidity which could be achieved in the environmental test chamber used for testing the OPRM). OPRM: a. High Temperature and Humidity: 140 °F and 90% relative humidity, which meets EPRI TR-107330 Figure 4-4 requirements (Section 4.3.6 requirements for humidity were met in separate testing at Toshiba, see Note below). b. Low Temperature and Humidity: 40 °F and 5% relative humidity, which meets EPRI TR-107330 Section 4.3.6 and Figure 4-4 requirements. Note: OPRM testing with 140 °F and 95% relative humidity profile was successfully met in the factory test which was performed under Toshiba's ISO 9001 program separately from the EQ test.

Section No	Summary of EPRI TR-107330 Requirements	Compliance with EPRI TR-107330 Requirements (or N/A)
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. The PRM and OPRM test specimens were mounted in the environmental chamber on a simple structured rack that does not enclose the chassis. Air temperature was monitored at the bottom of the chassis. No additional cooling fan was included in the chamber. Test specimen mounting for the environment testing in the PRM qualification testing is documented in the Qualification Summary Test Report (Reference (d16)). Test specimen mounting for the OPRM qualification testing is documented in the Environmental Qualification Report (Reference (c20)).
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 Std 344. Tri-axial, random, multi-frequency tests shall be used. Repairs during testing shall conform to IEEE Std 344.	Comply with limited scope and/or condition. Seismic testing uses five OBEs with the Required Response Spectrum (RRS) as shown in EPRI TR-107330 followed by an SSE in both the PRM and OPRM qualification testing. Test results of the PRM qualification testing are documented in Section III-2. Test results for the OPRM qualification are documented in Section III-5. Due to the limitations of the Test facilities, the SSE profile in the ERS requirement could not be achieved in the PRM test. Achieved responses will be provided in the Qualification Test Summary Report Revision 2 that has the seismic qualification profile for the PRM. The OPRM achieved the desired seismic test profile for 5% dumping SSE. See Item 4.3.9 for more details.
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. The PRM and OPRM test specimens were mounted on a structure that is stiff enough so that there are no resonances below 100Hz with the test specimen mounted on the test structure and the shake table. A resonance search was performed to verify this requirement for both PRM and OPRM. Test specimen mounting for the seismic test for the PRM qualification testing is documented in the Qualification Summary Test Report (Reference (d16)). The mounting for the seismic test for the OPRM qualification testing is documented in the Dynamic Qualification Report (Reference (c22)).

Section No	Summary of EPRI TR-107330 Requirements	Compliance with EPRI TR-107330 Requirements (or N/A)
6.3.4.2	Seismic Test Measurement Requirements. Relay contacts shall be monitored for chatter. One half of the relays shall be energized and on 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 discrete 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.	N/A. Relay contacts were not included in the PRM and OPRM qualification tests.
6.3.4.3	Seismic Test Performance Requirements. Seismic test shall include a resonance search, five OBE's, one SSE and an Operability test.	Comply. The following tests were performed in the order shown for both the PRM and the OPRM qualification: (1) Resonance Search (2) Five tri-axial OBEs (3) One tri-axial SSE (4) Operability Test Test results for the PRM qualification testing are documented in Section III-2. Test results for the OPRM qualification testing are documented in Section III-5.
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. The test response spectrum from the control and specimen response accelerometers provided 1/2, 1, 2, 3 and 5% damping for the PRM and the OPRM qualification testing. Test results for the PRM qualification testing are documented in Section III-2. Test results for the OPRM qualification are documented in Section III-5.
6.3.5	Surge Withstand Capability Testing. Surge testing shall be conducted per Section 4.6.2 and IEEE Std C62.45.	N/A. See Item 4.6.2 in this table for a description of the testing performed.
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.	Comply with limited scope and/or condition. Due to space limitations in the test facility's EMI/RFI chamber, the PRM and OPRM test specimens were not mounted six feet above the floor while performing this test. The test specimens were mounted on an open metal rack that provided no significant shielding. The test specimens were grounded to meet Toshiba's requirements. Test specimen mounting for the Surge Withstand testing for the PRM qualification testing is documented in the Qualification Summary Test Report (Reference (d16)). The mounting for the OPRM qualification testing is documented in the EMC Qualification Report (Reference (c21)).

Section No	Summary of EPRI TR-107330 Requirements	Compliance with EPRI TR-107330 Requirements (or N/A)
6.3.6	Class 1E to Non-Class 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.	Comply with limited scope and/or condition. Due to space limitations in the test facility's EMI/RFI chamber, the PRM test specimen was not mounted exactly six feet above the floor while performing this test. The PRM test specimen was mounted on an open metal rack that provided no significant shielding. The PRM test specimen was grounded based on Toshiba's requirements. For OPRM, Class 1E to Non-Class 1E isolation testing was not performed. Test specimen mounting for the PRM for Class 1E to Non-Class 1E testing for the PRM qualification testing is documented in the Qualification Summary Test Report (Reference (d16)).
6.4	Other Tests and Analysis. (section heading)	No requirement
6.4.1	FMEA. An FMEA analysis of the PLC shall be performed.	Comply. Separate Failure Modes and Effects Analysis (FMEA) were performed for the PRM and OPRM in accordance with IEEE Std 352-1987. For each component in each module, the analysis evaluates the component failure modes and effects on the PRM and OPRM units' performance. The FMEA for PRM is discussed in Section III-3.2.2. The FMEA for the OPRM is discussed in Section III-6.2.2.
6.4.2	Electrostatic Discharge (ESD) Testing Requirements. ESD testing of the PLC shall be performed per EPRI TR-102323.	Comply. ESD tests were performed to assure that the PRM and OPRM test specimen do not fail due to service condition for an ESD event level at a severity of Level 4, as specified in IEC 61000-4-2. (EPRI TR-107330 Section 4.3.8. and EPRI TR-102323, Appendix B, Section 3.5). ESD testing in the PRM showed that the rear panels were susceptible. The back panels in the units are accessible only when locked cabinet doors are opened. Thus, the back panels are not normally exposed to ESD. In normal use at a US plant, the cabinet doors are unlocked and opened only when work is to be done on the panels, such as maintenance or calibration, which is done with unit bypassed. Toshiba's application guide will be revised to state that the equipment past the plane of the door on the back panels should not be touched unless the technician or engineer is wearing a grounded ESD wriststrap. Please see Item 4.3.8 in this table.
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. Power Quality Tolerance tests to the input voltage range were performed in operability tests during qualification testing for both the PRM and OPRM. The redundant power supply modules were tested with the same AC power supply connected to both modules during the test. For the documentation of test record, please see Item 5.3 C in this table.

Section No	Summary of EPRI TR-107330 Requirements	Compliance with EPRI TR-107330 Requirements (or N/A)
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. The Master Test Plan (Reference (d19)) defines the acceptance criteria for the PRM qualification testing, conforming to the requirements in Section 6.4.4 of EPRI TR-107330. The EQ Test Plan (Reference (c10)) and the EMC Qualification Test Plan (Reference (c11)) define the acceptance criteria for the OPRM qualification testing.
6.4.4.A	Environmental Test Compliance. Environmental Operability test results shall be evaluated for compliance to specifications.	Comply. Environmental Operability test results were evaluated for compliance to the specification for both PRM and OPRM qualification testing. Test results for the PRM environmental tests are documented in the Qualification Test Summary Report (Reference (d16)). Test results for the OPRM environmental tests are documented in the Environmental Qualification Report (Reference (c20)).
6.4.4.B	Seismic Test Compliance. The seismic levels achieved during testing shall be used as the seismic withstand response spectrum.	Comply with limited scope and/or condition. The seismic levels achieved during testing were used as the seismic withstand response spectrum in qualification testing for both the PRM and the OPRM. Due to the limitations of the Test facilities, the SSE profile in the ERS requirement could not be achieved in the PRM test. Achieved responses will be provided in the Qualification Test Summary Report Revision 2 that has the seismic qualification profile for the PRM. The OPRM achieved the desired seismic test profile. See Item 4.3.9 for more details.
6.4.4.C	Class 1E to Non-Class 1E Test Compliance. Test levels shall be checked for compliance to Section 4.6.4 specifications.	Comply. Test levels were checked for compliance to the specifications in the PRM qualification testing. The result of the PRM qualification testing is documented in Section III-2. For OPRM, Class 1E to Non-Class 1E isolation testing was not performed, as there are no non-Class 1E elements.
6.4.4.D	Surge Withstand Test Compliance. Test levels shall be checked for compliance to Section 4.6.2 specifications.	Comply. Test levels were checked for compliance to the specifications in qualification testing for both the PRM and the OPRM. Test results for the PRM qualification testing are documented in Section III-2. Test results for the OPRM qualification testing are documented in Section III-5.

Section No	Summary of EPRI TR-107330 Requirements	Compliance with EPRI TR-107330 Requirements (or N/A)
6.4.4.E	EMI/RFI Test Compliance. PLC performance shall be checked for compliance to Section 4.3.7 specifications.	Comply with limited scope and/or condition. The performance of the PRM units was checked for compliance to the specifications in qualification testing for both the PRM and the OPRM. Test results for the PRM qualification testing are documented in Section III-2, and test results for the OPRM qualification testing are documented in Section III-5. The PRM and the OPRM pass the test with the modifications described below. The first EMI Susceptibility Test failed. The hardware was re-designed to resolve the test failure. Therefore, for the second EMI/RFI, Surge Withstand Capability, EFT/B, ESD and Class 1E to Non-1E Isolation tests, the new LPRM module and the new AO modules replaced the failed LPRM module and the failed AO modules. The re-designed LPRM and AO modules had additional capacitors to enhance electric-noise-withstand-capability and passed the test. For the Low-Frequency Conducted Emissions (CE101), additional inductance (coils) was needed in the PRM power leads to pass the test. For the OPRM, the PCF was developed and added to the test specimen, which passed CE101 test.
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. Power quality tests were performed during operability testing during qualification testing for both the PRM and OPRM. For the documentation of test record, please see Item 5.3 C in this table.
6.4.4.G	ASOA Test Compliance. Results shall be evaluated for compliance to Section 5.6 requirements.	(See Item 5.2.A in this table.)
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. Quality Assurance Program Compliance. Results of annual internal audits of QA Programs were checked. Toshiba concluded that the QA program was implemented effectively.
6.4.5	Human Factors. Descriptive Information.	No requirement
6.5	Quality Assurance Measures Applied to Qualification Testing. (Section Heading)	No requirement
6.5.A	Quality Assurance Measures Applied to Qualification Testing. Test program TSAP development shall meet the requirements of 10 CFR 50, Appendix B.	Comply. The FPGA logic lifecycle meets the requirements of 10 CFR 50, Appendix B, as documented in various USNRC Regulatory Guides and in the Standard Review Plan, Chapter 7, BTP 7-14. Section I-2.1 describes the QA programs in the current process. Section I-A-3 describes the QA process in the original process.

Section No	Summary of EPRI TR-107330 Requirements	Compliance with EPRI TR-107330 Requirements (or N/A)
6.5.B	Quality Assurance Measures Applied to Qualification Testing. Hardware procurement shall meet the requirements of 10 CFR 50, Appendix B.	Comply. The hardware used for the qualification tests meets the requirements of 10 CFR 50, Appendix B. The procurement process in the current process is documented in Section I-2.2.3. The procurement process in the original process is documented in Section I-A-3.2.3.
6.5.C	Quality Assurance Measures Applied to Qualification Testing. Test specimen chain of custody shall meet the requirements of 10 CFR 50, Appendix B.	Comply. The PRM and OPRM test specimens were controlled in accordance with the Toshiba QA program, which complies with 10 CFR 50 Appendix B Program. Section I-2 describes the QA program used in the current process. Section I-A-3.1 describes the QA program used in the original process.
6.5.D	Quality Assurance Measures Applied to Qualification Testing. Tests and data analysis shall meet the requirements of 10 CFR 50, Appendix B.	Comply. Tests and data analysis were conducted in accordance with the Toshiba QA program, which complies with 10 CFR 50 Appendix B Program. Section I-2 describes the QA program used in the current process. Section I-A-3.1 describes the QA program used in the original process.
7	Quality Assurance. Descriptive information.	No requirement
7.1	QA Overview. Descriptive information.	No requirement
7.2	10 CFR 50 Appendix B Requirements for Safety-Related Systems. Descriptive information.	No requirement
7.2.A	10 CFR 50 Applicability. Regulations apply to all qualification activities.	Comply. The PRM and OPRM system qualification activities were performed in accordance with the requirements of the US Nuclear Regulations (including 10 CFR 50, Appendix B) and the Toshiba Corporation, Power Systems Company, Nuclear Energy (PSNE) QA Program. Section I-2 describes the QA program used in the current process. Section I-A-3.1 describes the QA program used in the original process.
7.2.B	10 CFR 50 Applicability. Regulations apply to application specific activities.	Comply. The PRM and OPRM system specific activities were performed in accordance with the requirements of the US Nuclear Regulations (including 10 CFR 50, Appendix B) and the Toshiba Corporation, Power Systems Company, Nuclear Energy (PSNE) QA Program. Section I-2 describes the QA program used in the current process. Section I-A-3.1 describes the QA program used in the original process.

Section No	Summary of EPRI TR-107330 Requirements	Compliance with EPRI TR-107330 Requirements (or N/A)
7.2.C	10 CFR 50 Applicability. Regulations apply to any application-specific activities for dedication activities.	Comply. The commercial grade dedication activities for the PRM and OPRM were performed in accordance with the requirements of the US Nuclear Regulations (including 10 CFR 50, Appendix B) and the Toshiba Corporation, Power Systems Company, Nuclear Energy (PSNE) QA Program. Section I-2.2 describes the commercial grade dedication (CGD) process and activities performed under the current process. Section I-A-3.2 describes the commercial grade dedication process and activities performed under the original process.
7.2.D	10 CFR 50 Compliance. Manufacture's quality processes other than 10 CFR 50 shall be shown to be commensurate with 10 CFR 50.	Comply. For the PRM, NED used its CGD processes in procurement of the PRM from NICSD, and the manufacturer worked under its ISO 9001 quality program at that time. NED evaluated the process of NICSD and other suppliers, and issued a Job Order indicating QA program requirements to improve their process as described in Section I-A-3.2.2. For the OPRM, NICSD used its CGD processes in procurement of the OPRM modules from the module supplier. NICSD performed supplier evaluation as described in Section I-2.2.2.
7.2.E	10 CFR 50 Compliance. The qualifier shall perform audits to confirm that the manufacturer's quality process has been applied to the PLC product.	Comply. Audits were conducted to confirm that various quality programs in different Toshiba divisions were applied to the PRM and OPRM qualification activities.
7.2.F	10 CFR 50 Compliance. Audits performed against manufacturer programs other than 10 CFR 50 shall demonstrate that the program process is commensurate with 10 CFR 50.	Comply. Toshiba has integrated 10 CFR 50, Appendix B into their nuclear quality assurance program. The activities performed under ISO 9001 quality programs used work products that were commercial grade dedicated successfully under Toshiba's commercial grade dedication program.
7.2.G	V&V Program Evaluation. The qualifier shall evaluate the manufacturer's V&V program to the criteria in Section 7.4.	Comply. The V&V efforts for the PRM and OPRM were conducted under Toshiba's nuclear QA program, which complies with 10 CFR 50 Appendix B Program. Sections I-3.10 and I-3.11 describe software V&V as applied under the current process. Section I-A-4.8 describes software V&V as applied under the original process.
7.2.H	Qualification Test Witnessing. The Qualifier shall have the right to witness qualification tests.	N/A. The PRM and OPRM qualification tests were conducted under the Toshiba's nuclear QA program, which complies with 10 CFR 50 Appendix B Program. Section I-2 describes the QA program as applied under the current process. Section I-A-3.1 describes the QA program as applied under the original process.

Section No	Summary of EPRI TR-107330 Requirements	Compliance with EPRI TR-107330 Requirements (or N/A)
7.3	10 CFR 21 Compliance Requirements. Section lists 10 CFR 21 compliance requirements of a utility which applies the PLC in a safety-related application. The PLC manufacturer shall support problem reporting and tracking as described in Section 7.8.	N/A. The requirements are for the utility. Toshiba will support problem reporting and tracking as the manufacturer. For Toshiba's compliance with problem reporting and tracking, see the response to Item 7.8 in this table, which states "As described in Section I-3.3.7, Toshiba will address any problem that occurs in the Operation and Maintenance phases of the system lifecycle."
7.4	Verification and Validation Requirements. Qualifier shall evaluate the manufacturer's V&V process for software, firmware and software tools against IEEE Std 7-4.3.2 and IEEE Std 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.	Comply. The V&V efforts for the PRM and OPRM were conducted under Toshiba's nuclear QA program, which complies with 10 CFR 50 Appendix B Program. Section I-3.10 and Section I-3.11 describes software V&V as applied under the current process. Section I-A-4.8 describes software V&V as applied under the original process.
7.5	Manufacturer Qualification Maintenance Throughout Product Life Cycle. (section heading)	No requirement (Requirements are described in subsections.)
7.5.1	Overview of Manufacturer Qualification Maintenance Throughout Product Life Cycle (descriptive information)	No requirement
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. Toshiba, including the module supplier described in Section I-1.5.1, will ensure upward compatibility, maintain processes of, commit to at least five years support for the qualified configuration, and commit to six months notice before withdrawing product support.

Section No	Summary of EPRI TR-107330 Requirements	Compliance with EPRI TR-107330 Requirements (or N/A)
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. Both PRM and OPRM do not need any engineering tool for operation. For potential needs for the FPGA logic modification, Toshiba will maintain the same versions of software tools, or capability to reconstruct the same functionality with the newer versions of software tools under the configuration management documented in Section I-3.12.2.1.
7.6	Compensatory Quality Activities for Legacy Software. (section heading)	No requirement
7.6.1	Overview of Compensatory Quality Activities for Legacy Software. (descriptive information)	No Requirement
7.6.2	Requirements for Compensatory Quality Activities for Legacy Software. Using the guidance of EPRI TR-106439, the qualifier may compensate for shortcomings of 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.	Comply. Toshiba treats functional elements (FEs) as legacy software. Control of FEs is documented in Section I-2.2. New FEs will be processed under Toshiba's current Appendix B program.
7.7	Configuration Management. (section heading)	No requirement
7.7.1	Configuration Management Overview. Descriptive information.	No requirement
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. Configuration Management includes the module type number which identifies the FPGA version, module design, and module component configuration. Configuration management is documented in Section I-3.12 for the current process and in Section I-A-4.9 for the original process.
7.7.2.A	Hardware Configuration Management Review. The utility (and the Qualifier) shall evaluate the manufacturer configuration management process for design revisions to NQA-1.	Comply. Toshiba, as the Qualifier, reviews the configuration management. Configuration management is documented in Section I-3.12 for the current process and in Section I-A-4.9 for the original process.

Section No	Summary of EPRI TR-107330 Requirements	Compliance with EPRI TR-107330 Requirements (or N/A)
7.7.2.B	Hardware Configuration Management Review. The utility (and the Qualifier) shall evaluate the manufacturer configuration management process for methods of identification of each constituent component within the PLC modules to NQA-1.	Comply. Toshiba, as the Qualifier, reviews the configuration management. Configuration management is documented in Section I-3.12 for the current process and in Section I-A-4.9 for the original process.
7.7.2.C	Hardware Configuration Management Review. The utility (and the Qualifier) shall evaluate the manufacturer configuration management process for methods of document control to NQA-1.	Comply. Toshiba, as the Qualifier, reviews the configuration management. Configuration management is documented in Section I-3.12 for the current process and in Section I-A-4.9 for the original process.
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. Configuration Management includes each module type number which identifies the FPGA version, module design, and module component configuration. Configuration management is documented in Section I-3.12 for the current process and in Section I-A-4.9 for the original process.
7.7.3.A	Software Configuration Management Review. The utility (and the Qualifier) shall evaluate the manufacturer software configuration management process for definition of organization and responsibilities using Reg. Guide 1.169, Section C.	Comply. Toshiba, as the Qualifier, reviews the configuration management. Configuration management is documented in Section I-3.12 for the current process and in Section I-A-4.9 for original process.
7.7.3.B	Software Configuration Management Review. The utility (and the Qualifier) shall evaluate the manufacturer software configuration management process for methods of configuration identification, control, status and audits using Reg. Guide 1.169, Section C.	Comply. Toshiba, as the Qualifier, reviews the configuration management. Configuration management is documented in Section I-3.12 for current process and in Section I-A-4.9 for original process.
7.7.3.C	Software Configuration Management Review. The utility (and the Qualifier) shall evaluate the manufacturer configuration management process to ensure sub-tier suppliers maintain comparable levels of configuration management using Reg. Guide 1.169, Section C.	Comply. Toshiba, as the Qualifier, reviews the configuration management. Configuration management is documented in Section I-3.12 for the current process and in Section I-A-4.9 for the original process.

Section No	Summary of EPRI TR-107330 Requirements	Compliance with EPRI TR-107330 Requirements (or N/A)
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. As described in Section I-3.3.7, Toshiba will address any problem that occurs in the Operation and Maintenance plant lifecycle phases. .
8	Documentation. Descriptive information.	No requirement
8.1	Equipment General Overview Document Requirements. Descriptive information.	No requirement
8.1.A	Manufacturer Documentation. Documentation shall include a description of the PLC.	Comply. Description of each unit, chassis, module, and FPGA is documented in design documents as documented in Section I-3.3.2 and I-3.3.3 for the current process and I-A-4.2 for the original process.
8.1.B	Manufacturer Documentation. Documentation shall include a description of the chassis interconnections.	Comply. The PRM and OPRM system unit interconnections are documented in Section II-A-7 (Application Guide).
8.1.C	Manufacturer Documentation. Documentation shall include a module overview and selection guide.	Comply. Appendix II-B, Module Summary Description, of this LTR provides a complete module overview for PRM and OPRM. For the PRM and OPRM, Toshiba selects the appropriate modules and generates the plant specific configuration and programmable logic applications.
8.1.D	Manufacturer Documentation. Documentation shall include a description of the overall I/O capacity and processing speeds.	Comply. Appendix II-A provides the system configuration including the number of the I/Os. Section II-2.2.2.2 provides the response time. ERS of FPGA based Units (Reference (d36)) and EDS for PRNM (Reference (c28)) provide more detailed information.
8.1.E	Manufacturer Documentation. Documentation shall include installation information.	Comply. Toshiba will provide necessary information including the Instructions for the LPRM Unit (Reference (d45)), Instructions for the LPRM/APRM Unit (Reference (d46)), Instructions for the FLOW Unit (Reference (d47)), and the OPRM Unit User's Manual (Reference (c27)) document the installation information.
8.1.F	Manufacturer Documentation. Documentation shall include handling and storage requirements.	Comply. The Instructions for the LPRM Unit (Reference (d45)), Instructions for the LPRM/APRM Unit (Reference (d46)), Instructions for the FLOW Unit (Reference (d47)), and the OPRM Unit User's Manual (Reference (c27)) include handling and storage requirements.

Section No	Summary of EPRI TR-107330 Requirements	Compliance with EPRI TR-107330 Requirements (or N/A)
8.1.G	Manufacturer Documentation. Documentation shall include a description of the self-diagnostics and redundancy features.	Comply. Appendix II-B, Module Summary Description, of this LTR includes a summary of the self-diagnostics. Further details are documented in the LPRM Unit EDS (Reference (d42)), the LPRM/APRM Unit EDS (Reference (d43)), the FLOW monitoring Unit EDS (Reference (d44)), and the OPRM Unit Detailed Design Specification (Reference (c29)).
8.2	Equipment General Specifications Requirements. Manufacturer documentation shall provide general specifications for the PLC.	Comply. ERS of FPGA based Units (Reference (d36)) and EDS for PRNM (Reference (c28)) provide general specifications. In addition, the FPGA Design Specification provides general specification of for the FPGA as documented in Section I-3.3.1 for the current process and Section I-A-4.2 for the original process. Design specifications and the system descriptions provide specific requirements for the PRM and OPRM.
8.3	Operator's Manual Requirements. Manufacturer documentation shall include information on operation of the PLC.	Comply. Instructions for the LPRM Unit (Reference (d45)), Instructions for the LPRM/APRM Unit (Reference (d46)), Instructions for the FLOW Unit (Reference (d47)), and the OPRM Unit User's Manual (Reference (c27)) include information on operation of the PRM and OPRM.
8.4	Programmer's Manual Requirements. Manufacturer shall provide detailed information on the use of the functions available in the PLC processors.	N/A. Based on the NRW-FPGA technology, utilities cannot change the programmable logic in the FPGAs. Therefore, Toshiba does not provide the utility with a Programmer's Manual for the NRW-FPGA-based PRM or OPRM system.
8.5	Equipment Maintenance Manual Requirements. Manufacturer documentation shall contain information for calibration, trouble shooting, maintenance, required special tools or software, and communication protocols.	Comply. Instructions for the LPRM Unit (Reference (d45)), Instructions for the LPRM/APRM Unit (Reference (d46)), Instructions for the FLOW Unit (Reference (d47)), and the OPRM Unit User's Manual (Reference (c27)) provide guidance for troubleshooting, calibration, surveillance, and other utility functions during the Operation and Maintenance plant system lifecycle.
	Manufacturer documentation shall include results of component aging analysis.	N/A. Aging analysis is not necessary where equipment is qualified for use only in mild environments (RG 1.209). Toshiba also notes there are no significant aging mechanisms in this FPGA-based equipment.
8.6	Qualification Documentation Requirements. The qualifier shall provide all documentation supporting the qualification of the generic PLC platform. The qualifier shall submit all such documentation to the customer(s) for review and approval.	Comply. Toshiba, the qualifier, will provide all documents which support the qualification of the PRM and OPRM to the NRC and to customers.
8.6.1	Programmatic Documentation Requirements. (descriptive information)	No requirement

Section No	Summary of EPRI TR-107330 Requirements	Compliance with EPRI TR-107330 Requirements (or N/A)
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. The Master Test Plan (Reference (d19)) for the PRM qualification testing as well as the EQ Test Plan (Reference (c10)) and EMC Qualification Test plan (Reference (c11)) for the OPRM qualification testing were prepared. These include test plans for radiation exposure, environmental (temperature and humidity), seismic, EMI/RFI, surge, EFT/B, ESD, and Class 1E to Non-Class 1E testing.
8.6.1.B	Programmatic Documentation. Test specifications shall be prepared which include equipment identifications, interfaces and service conditions.	Comply. The Master Test Plan (Reference (d19)) for the PRM qualification testing as well as the EQ Test Plan (Reference (c10)) and EMC Qualification Test plan (Reference (c11)) for the OPRM qualification testing were prepared. These include documentation of the required equipment identification, interfaces, and conditions.
8.6.1.C	Programmatic Documentation. Procedures shall be prepared for qualification testing.	Comply. Test procedures for the PRM Qualifications testing (Reference (d20) – (d29)) and the test procedures for OPRM qualification testing (Reference (c12) – (c19)) were prepared to direct the performance, evaluation, and data recording for each qualification test.
8.6.1.D	Programmatic Documentation. Test reports shall be prepared for each qualification test performed.	Comply. The Qualification Test Summary Report (Reference (d16)) was prepared for PRM qualification testing. The EQ Report (Reference (c20)), EMC Qualification Report (Reference (c21)), and Dynamic Qualification Report (Reference (c22)) were prepared for the OPRM qualification testing.
8.6.1.E	Programmatic Documentation. Reports on audits performed on the manufacturer shall be prepared.	Comply. Toshiba prepares and retains audit reports for each audit (Reference (d3) – (d6)).
8.6.1.F	Programmatic Documentation. Reports on design evaluations shall be prepared.	Comply. The Final Technical Evaluation Report (Reference (d39)) was prepared for design evaluation of the PRM. The Final Technical Evaluation Report (Reference (c26)) was prepared for design evaluation of the OPRM. Section II-A-2.4 describes "Failure Analysis" and Section II-A-2.6 describes "Setpoint Support Analysis."
8.6.2	Technical Items and Acceptance Criteria Documentation Requirements. (descriptive information)	No requirement
8.6.2.A	Technical Items Documentation. Documentation shall include test specimen requirements.	Comply. The Preliminary Technical Evaluation Report (PTER) (Reference (d38)) includes test specimen requirements for the PRM qualification testing. The EQ Test Plan (Reference (c10)) and EMC Qualification Test plan (Reference (c11)) include test specimen requirements for the OPRM qualification testing.
8.6.2.B	Technical Items Documentation. Documentation shall include test specimen purchasing records.	Comply. The Job Order includes purchasing activities for the test specimen as documented in Section I-3.3.1.5 for current process and in Section I-A-4.2.1 for the original process.

Section No	Summary of EPRI TR-107330 Requirements	Compliance with EPRI TR-107330 Requirements (or N/A)
8.6.2.C	Technical Items Documentation. Documentation shall include TSAP development documentation.	Comply. In the PRM and OPRM system qualification project, the equipment being qualified had the actual PRM and OPRM system logic embedded in the FPGAs. This approach meets the intent of this requirement (TSAP development documentation), which is used to test the range of possible PLC program features that may be employed when the PLC is programmed for a specific application to ensure that the system-level test is meaningful.
8.6.2.D	Technical Items Documentation per Sections 8.8, 8.9, 8.10, 8.12 and 8.13.	(See Items 8.8, 8.9, 8.10, 8.12 and 8.13 in this table.)
8.6.2.E	Technical Items Documentation. See Section 8.14.	(See Item 8.14 in this table.)
8.6.3	Application Guide Documentation Requirements. A qualification summary document shall be provided. The document shall describe the qualification envelope and provide the configuration information.	Comply. Section II-A-4 (Application Guide) of this LTR describes the summaries for the PRM and OPRM qualification testing. More details are documented in Qualification Test Summary Report (Reference (d16)) for the PRM, and Environmental Qualification Report for OPRM (Reference (c20)), EMC Qualification Report for OPRM (Reference (c21)), and Dynamic Qualification Report for OPRM (Reference (c22)) for the OPRM.
8.6.3.A	Application Guide. Guide shall include results of environmental Operability testing to support each specific safety related application.	Comply. Test results for the PRM and OPRM environmental operability tests are documented in Section II-A-4 (Application Guide).
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. Test results for the PRM and OPRM seismic tests are documented in Section II-A-4 (Application Guide). The Application Guide includes the torque requirements for screws and fasteners.
8.6.3.C	Application Guide. Guide shall include results of Class 1E to Non-1E isolation testing.	Comply. Test results for the PRM Class 1E to Non-Class 1E isolation testing are documented in Section II-A-4. For the OPRM, Class 1E to Non-1E isolation testing was not required, and was thus not conducted.
8.6.3.D	Application Guide. Guide shall include results of surge withstand testing.	Comply. Test results for the PRM and OPRM surge withstand testing are documented in Section II-A-4 (Application Guide).
8.6.3.E	Application Guide. Guide shall include results of EMI/RFI testing.	Comply. Test results for the PRM and OPRM EMI/RFI testing are documented in Section II-A-4 (Application Guide).
8.6.3.F	Application Guide. Guide shall include results of power quality testing.	Comply. The power quality testing was conducted during the operability test in the PRM and OPRM qualification testing. The results of the PRM and OPRM qualification testing are documented in Section II-A-4 (Application Guide).
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 are used in testing. Toshiba uses the final, shippable application for all qualification testing.

Section No	Summary of EPRI TR-107330 Requirements	Compliance with EPRI TR-107330 Requirements (or N/A)
8.6.3.H	Application Guide. Guide shall include a description of the as-tested PLC configuration.	Comply. The unit, module, wiring, support equipment, and interconnection configuration of the PRM and OPRM qualification testing is documented in Section II-A-3 (Application Guide).
8.6.3.I	Application Guide. Guide shall include a description of the executive software and software tools revision levels included in qualification.	N/A. The PRM and OPRM do not include executive software, and thus did not require any software tools for the qualification.
8.6.3.J	Application Guide. Guide shall include a description of the as-tested PLC configuration.	Comply. The unit, module, wiring, support equipment, and interconnection configuration of the PRM and OPRM qualification testing is documented in Section II-A-3 (Application Guide).
8.6.3.K	Application Guide. Guide shall include a summary of the FMEA and availability analysis.	Comply. The FMEA and availability analysis are documented in Section III-3.2.2 for the PRM and in Section III-6.2.2 for the OPRM.
8.6.3.L	Application Guide. Guide shall include the setpoint analysis support document.	Comply. The setpoint support analysis is documented in Section III-3.2.3 for PRM and in Section III-6.2.3 for OPRM.
8.6.3.M	Application Guide. Guide shall include information from manufacturer audits and surveys applicable to future purchasing.	N/A. Since Toshiba performed commercial grade dedication on commercial products, this data is not required in the Application Guide.
8.6.3.N	Application Guide. Guide shall include a description of the redundancy features included in qualification.	Comply. The Application Guide Section II-A-3 provides the PRM and OPRM tested system configurations including redundant LVPSs and dual communication lines.
8.6.3.O	Application Guide. Guide shall include a description of external devices included in qualification.	Comply. .The Application Guide Section II-A-3 describes Power Factor Correction modules (PFCs) as external modules to the units and included in the OPRM qualification.
8.6.3.P	Application Guide. Guide shall include a description of the PLC configuration management methods.	Comply. The Application Guide includes the configuration data (module numbers) applicable to a given installation. The plant-specific portion of the Application Guide will be revised for each utility if changes are required to modules, which results in new module numbers.
8.6.3.Q	Application Guide. Guide shall include a summary of the component aging analysis.	N/A. Aging analysis is not necessary where equipment is qualified for use only in mild environments. USNRC RG 1.209 does not require equipment aging for mild environment. Toshiba also notes there are no significant aging mechanisms in this FPGA-based equipment.
8.6.3.R	Application Guide. Guide shall include a description of the mounting methods used in seismic qualification	Comply. The mounting methods used in the PRM and OPRM qualification testing is documented in Sections III-2.2.2 and III-5.2.2.

Section No	Summary of EPRI TR-107330 Requirements	Compliance with EPRI TR-107330 Requirements (or N/A)
8.6.3.S	Application Guide. Guide shall include a description of qualification envelopes for specific modules if different from the overall envelope.	Comply. The PRM and OPRM qualification used the same qualification envelopes for all modules except the seismic qualification for the PRM. The envelopes for the PRM and OPRM qualification testing is documented in Section II-A-4 (Application Guide).
8.6.3.T	Application Guide. Guide shall include a description of any application level hardware or software features that are assumed in order to meet qualification requirements.	Comply. LTR application guide section II-A-4.5.3 EMI/RFI Test for BWR-5 PRM System says: "specific exceedance was found during CE101 in the power leads. From approximately 100 Hz to 700 Hz, emissions exceed the limit shown in Regulatory Guide 1.180 Revision 1. This excess comes from the waveform distortion due to the AC/DC power supply (i.e. LVPS module) in the PRM system. To suppress this emission, Toshiba inserted a filter into the AC power line to the LVPS module, and confirmed that the test results satisfy the requirement with this corrective measure as shown in Table II-A-4-5. Systems supplied for use in the US would either use this power line filter or the PFC module used for the OPRM type testing. Either approach would successfully mitigate the LVPS emissions peaks."
8.6.4	Supporting Analyses Documentation Requirements. Documentation shall be provided of the FMEA and Availability/Reliability Analyses.	Comply. The FMEA and availability analyses are documented in Section III-3.2.2 for PRM and in Section III-6.2.2 for OPRM. These LTR sections will be supplied with the Application Guide.
8.6.5	Class 1E to Non-Class 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. The Master Test Plan (Reference (d19)) provides the test plan for Class 1E to Non-1E Isolation Test. Toshiba will provide the plan to utilities. The Qualification Test Summary Report (Reference (d16)) provides the report for Class 1E to Non-Class 1E Isolation test. A summary of the results is documented in the Application Guide. For OPRM, Class 1E to Non-Class 1E Isolation Test is not required, and was thus not conducted.
8.7	V&V Documentation Requirements. (section heading)	No requirement
8.7.A	V&V Documentation. Documentation shall include a software quality assurance plan.	Comply. The systems are implemented under a programmable logic life cycle that includes a Software Quality Assurance Plan as documented in Section I-3.4 for the current process in Section I-A-4.3 for the original process. The Verification and Validation Plan for PRM (Reference (d41)) and Verification and Validation Plan for OPRM (Reference (c6)) were also prepared. Documentation is generated to document the activities and findings from independent V&V.
8.7.B	V&V Documentation. Documentation shall include a software requirements specification.	Comply. The systems are implemented under a programmable logic life cycle that includes unit design specification documents describing software requirement specifications as documented in Section I-3.3.2 for the current process and in Section I-A-4.2.2 for the original process.

Section No	Summary of EPRI TR-107330 Requirements	Compliance with EPRI TR-107330 Requirements (or N/A)
8.7.C	V&V Documentation. Documentation shall include a software design description.	Comply. The systems are implemented under a programmable logic life cycle that includes appropriate FPGA design descriptions as documented in Section I-3.3.3 for the current process and in Section I-A-4.2.3 for the original process.
8.7.D	V&V Documentation. Documentation shall include a software V&V plan.	Comply. The systems are implemented under a programmable logic life cycle that includes a Software V&V Plan as well as appropriate V&V documentation as documented in Section I-3.10 for the current process and in Section I-A-4.8 for the original process.
8.7.E	V&V Documentation. Documentation shall include a software V&V report.	Comply. The systems are implemented under a programmable logic life cycle that includes appropriate V&V phase summary reports and a final summary report as documented in Section I-3.11 for the current process and in Section I-A-4.8 for the original process.
8.7.F	V&V Documentation. Documentation shall include software user documentation.	Comply. The systems are implemented under a programmable logic life cycle that includes appropriate user documentation as documented in Section I-3.3.2.3 for the current process and in Section 3.2 of Attachment-5 of Part V for the original process.
8.7.G	V&V Documentation. Documentation shall include a software configuration management plan.	Comply. The systems are implemented under a programmable logic life cycle that includes a Software Configuration Management Plan as documented in Section I-3.12 for the current process and in Section I-A-4.9 for the original process.
8.8	System Description Requirements. A test specimen hardware and software description document shall be provided.	Comply. Hardware and software documents for the PRM and OPRM test specimen were prepared in accordance with the software/hardware development lifecycle documented in Section I-3.3 for PRM and documented in Section I-A-4.2 for the OPRM. The Application Guide Section II-A-3 provides the PRM and OPRM tested system configurations.
8.9	Critical Characteristics Listing Requirement. A critical characteristics listing document shall be provided.	Comply. The Final Technical Evaluation Report for the PRM (Reference (d39)) and the Final Technical Evaluation Report for the OPRM (Reference (c26)) list the Critical Characteristics.
8.10	System Drawing Requirements. (Section Heading)	No requirement (Requirements are described in subsections.)
8.10.A	System Drawing Requirements. Documents shall include a functional description of the test specimen.	Comply. The Preliminary Technical Evaluation Report (PTER) (Reference (d38)) includes test specimen requirements for the PRM qualification testing. The EQ Test Plan (Reference (c10)) and EMC Qualification Test plan (Reference (c11)) include test specimen requirements for the OPRM qualification testing.
8.10.B	System Drawing Requirements. Documents shall include a schematic of the test specimen.	Comply. The Preliminary Technical Evaluation Report (PTER) (Reference (d38)) includes test specimen schematics for the PRM qualification testing. The EQ Test Plan (Reference (c10)) and EMC Qualification Test plan (Reference (c11)) include test specimen schematics for the OPRM qualification testing. Both sets of schematics include all test equipment and wiring for the test equipment.

Section No	Summary of EPRI TR-107330 Requirements	Compliance with EPRI TR-107330 Requirements (or N/A)
8.10.C	System Drawing Requirements. Documents shall include diagrams that define the TSAP.	(See Item 8.6.2.C in this table.)
8.10.D	System Drawing Requirements. Drawings shall show test specimen wiring, power distribution and grounding.	Comply. The Preliminary Technical Evaluation Report (PTER) (Reference (d38)) includes test specimen internal and external wiring, power distribution and grounding for the PRM qualification testing. The EQ Test Plan (Reference (c10)) and EMC Qualification Test plan (Reference (c11)) include test specimen internal and external wiring, power distribution, and grounding for the OPRM qualification testing. Test documents include the test specimen internal and external wiring, power distribution and grounding.
8.10.E	System Drawing Requirements. Drawings shall show layout of test specimen chassis, modules and qualification test fixtures.	Comply. The Preliminary Technical Evaluation Report (PTER) (Reference (d38)) includes a description of the layout of the test specimen chassis, modules, internal and external wiring, and qualification test fixtures for the PRM qualification testing. The EQ Test Plan (Reference (c10)) and EMC Qualification Test plan (Reference (c11)) include description for layout of the test specimen chassis, modules, internal and external wiring, and qualification test fixtures for the OPRM qualification testing.
8.10.F	System Drawing Requirements. Drawings shall show test specimen mounting and mounting fixtures, including special installation requirements.	Comply. The Master Test Plan for PRM (Reference (d19)) includes the description of the test specimen mounting and mounting fixtures, including special installation requirements. The EQ Test Plan (Reference (c10)) and EMC Qualification Test Plan (Reference (c11)) for the OPRM includes a description of the test specimen mounting and mounting fixtures, including special installation requirements.
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. The Master Configuration List for the PRM (Reference (d48)) and the Master Configuration List for the OPRM (Reference (c30)) document all module type numbers.
8.12	System Database Documentation Requirements. The TSAP database used for qualification testing shall be documented.	(See Item 8.6.2.C in this table.)
8.13	System Setup/Calibration/Checkout Procedure Requirements. All setup, calibration and checkout procedures used during qualification shall be documented.	Comply. All setup, calibration, and checkout procedures used during qualification are documented in the System Set-Up and Check-out Test Procedure for the PRM (Reference (d20)) and the Setup and Check-out Test Procedure for the OPRM (Reference (c12)).

Section No	Summary of EPRI TR-107330 Requirements	Compliance with EPRI TR-107330 Requirements (or N/A)
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. The Master Test Plan (Reference (d19)) provides the test plan for Operability Testing and .the Qualification Test Summary Report (Reference (d16)) provides the report for Operability Testing for the PRM. The EQ Test Plan (Reference (c10)) and EMC Qualification test Plan (Reference (c11)) provide the test plan for Operability Testing and the EQ report (Reference (c20)), EMC Qualification Report (Reference (c21)), and Dynamic Qualification Report (Reference (c22)) provides the report for Operability Testing for the OPRM.
8.15	Manufacturer's Quality Documentation Requirements. The manufacturer shall provide its Quality Assurance Plan.	Comply. The systems are implemented under a programmable logic life cycle that includes a Software Quality Assurance Plan. Section I-3.4.1 describes the software quality assurance plan in the current process and Section I-A-4.3 describes the software quality assurance plan in the original process. As described in I-2.2.2.1, NICSD surveyed or evaluated the module supplier's quality system.
8.16	Manufacturer's Certifications Requirements. Manufacturer shall provide certificates of conformance for all test specimen hardware.	Comply. The Final Technical Evaluation Report document conformance for all test specimen hardware. The activity in the current process is documented in Section I-2.2.3, and the activity in the original process is documented in Section I-A-3.2.3.

Table IV-4-2 Response Time Operability Test Results

		A3.1(Ical= 40 μA)			A3.3(Ical= 2,400 μA)			A3.2(Ical= 400 μA)		
		APRM High High (ms)	TPM High(0s) (ms)	TPM High(6s) (s)	APRM High High (ms)	TPM High(0s) (ms)	TPM High(6s) (s)	APRM High High (ms)	TPM High(0s) (ms)	TPM High(6s) (s)
Pre-Qualification Test (Base Line)										a,c
Radiation Exp										
Environmental Test	Before High Temperature and High Humidity Exposure									
	During High Temperature and High Humidity Exposure									
	After(End of) *)High Temperature and High Humidity Exposure									
	During Low Humidity Exposure									
	After (End of) *) Low Humidity Exposure									
	After *) all Environmental									
Exchange of Modules (LPRM Modules was exchanged for HNS013 from HNS011. AO Modules was exchanged for HNS515/516/517/518 from HNS511/512/513/514.										
	Before EMC Test									a,c
	During EMC Test									
	After EMC Test									

Isolation Test(Class 1E to Non 1E Test)	[ ]a,c
Post Qualification Test(Before re-exchange of modules)	
Re-Exchange of Modules (LPRM Modules was exchanged for HNS011 from HNS013. AO Modules was exchanged for HNS511/512/513/514 from HNS515/516/517/518.	
Post-Qualification Test(After re-exchange of modules)	[ ]a,c

*) Note for Clarification: The Operability Tests were performed at the end of each environment test run and again after all the environmental tests were complete.

Table IV-4-3 Mapping of PRM Operability Tests to Table-5-1 in EPRI TR-107330

Test Condition(Toshiba qualification tests)		Description of TR-107330 Table 5-1 Operability Tests (Section 5.3)		Operability Test for PRM	
		Scope	Test Item	Performed Tests (See Note A at the end of Table)	Justification/Explanation
Pre-Qualification Test(Base Line)		"All"	A. Accuracy	(1), (2), (3), (7)	
			B. Response time	(4), (5), (6)	
			C. Discrete input operability	(9)	
			D. Discrete output operability	(4), (5), (6), (8)	
			E. Communication operability	Confirm no communication alarms occurred	
			F. Coprocessor operability	N/A	The PRM does not use coprocessors.
			G. Timer Tests	N/A	The PRM does not provide any separate timer functions.
			H. Test of failure to complete scan detection	(13), (14), (15)	
			I. Failover Operability Tests	(10), (11), (12), (16)	
			J. Loss of power test	(17)	
			K. Power Interrupt Test.	(18)	
Radiation Exposure		No Description			
Environmental Test	Before High Temperature and High Humidity Exposure	No Description	A. Accuracy	(2), (7)	See Note B (i)
			B. Response time	(5) Response time measurement of TPM H, in which the TPM time constant is set to [ ] a,c second was not performed	See Note B (ii)
			C. Discrete input operability	(9)	

Test Condition(Toshiba qualification tests)		Description of TR-107330 Table 5-1 Operability Tests (Section 5.3)		Operability Test for PRM	
		Scope	Test Item	Performed Tests (See Note A at the end of Table)	Justification/Explanation
			D. Discrete output operability	(5)	See Note B (v)
			E. Communication operability	Confirm no communication alarms occurred.	
			F. Coprocessor operability	N/A	The PRM does not use coprocessors.
			G. Timer Tests	N/A	The PRM does not provide any separate timer function.
			H. Test of failure to complete scan detection	Test Items (13), (14), and (15) were not performed.	See Note B (iii)
			I. Failover Operability Tests	(16) Test Items (10), (11), and (12) were not performed.	See Note B (iv)
			J. Loss of power test	(17)	
			K. Power Interrupt Test.	(18)	
	During High Temperature and High Humidity Exposure	No Description			Toshiba monitored the equipment operation during the tests. Table IV-4-6 in this attachment shows the acceptance criteria for the output signals.
	After (End of) High Temperature and High Humidity Exposure	"ALL" at the point per Figure 4-4	A. Accuracy	(2), (7)	See Note B (i)
			B. Response time	(5) Response time measurement of TPM H, in which the TPM time constant is set to [ ] a,c second was not performed	See Note B (ii)
			C. Discrete input operability	(9)	

Test Condition(Toshiba qualification tests)	Description of TR-107330 Table 5-1 Operability Tests (Section 5.3)		Operability Test for PRM	
	Scope	Test Item	Performed Tests (See Note A at the end of Table)	Justification/Explanation
		D. Discrete output operability	(5)	See Note B (v)
		E. Communication operability	Confirmed no communication alarms occurred.	
		F. Coprocessor operability	N/A	The PRM does not use coprocessors.
		G. Timer Tests	N/A	The PRM does not provide any separate timer function.
		H. Test of failure to complete scan detection	Test Item (13), (14), and (15) were not performed.	See Note B (iii)
		I. Failover Operability Tests	(16) Test Items (10), (11), and (12) were not performed.	See Note B (iv)
		J. Loss of power test	(17)	
		K. Power Interrupt Test.	(18)	
During Low Temperature Exposure	No Description			Toshiba monitored the equipment operation during the tests. Table IV-4-6 in this attachment shows the acceptance criteria for the output signals.
After (End of) Low Temperature Exposure	"ALL" at the point per Figure 4-4	A. Accuracy	(2), (7)	See Note B (i)
		B. Response time	(5) Response time measurement of TPM H, in which the TPM time constant is set to [ ][a,c] second was not performed	See Note B (ii)
		C. Discrete input operability	(9)	
		D. Discrete output operability	(5)	See Note B (v)

Test Condition(Toshiba qualification tests)	Description of TR-107330 Table 5-1 Operability Tests (Section 5.3)		Operability Test for PRM	
	Scope	Test Item	Performed Tests (See Note A at the end of Table)	Justification/Explanation
		E. Communication operability	Confirmed no communication alarms occurred.	
		F. Coprocessor operability	N/A	The PRM does not use coprocessors.
		G. Timer Tests	N/A	The PRM does not provide any separate timer functions.
		H. Test of failure to complete scan detection	Test Items (13), (14), and (15) were not performed.	See Note B (iii)
		I. Failover Operability Tests	(16) Test Items (10), (11), and (12) were not performed.	See Note B (iv)
		J. Loss of power test	(17)	
		K. Power Interrupt Test.	(18)	
During Low Humidity Exposure	No Description			Toshiba monitored the equipment operation during the tests. Table IV-4-6 in this attachment shows the acceptance criteria for the output signals.
After (End of) Low Humidity Exposure	"ALL" at the point per Figure 4-4	A. Accuracy	(2), (7)	See Note B (i)
		B. Response time	(5) Response time measurement of TPM H, in which the TPM time constant is set to [ ] a,c second was not performed	See Note B (ii)
		C. Discrete input operability	(9)	
		D. Discrete output operability	(5)	See Note B (v)
		E. Communication operability	Confirmed no communication alarms occurred.	
		F. Coprocessor operability	N/A	
		G. Timer Tests	N/A	

Test Condition(Toshiba qualification tests)		Description of TR-107330 Table 5-1 Operability Tests (Section 5.3)		Operability Test for PRM	
		Scope	Test Item	Performed Tests (See Note A at the end of Table)	Justification/Explanation
			H. Test of failure to complete scan detection	Test Items (13), (14), and (15) were not performed.	See Note B (iii)
			I. Failover Operability Tests	(16) Test Items (10), (11), and (12) were not performed.	See Note B (iv)
			J. Loss of power test	(17)	
			K. Power Interrupt Test.	(18)	
	After all Environmental	"ALL" at the point per Figure 4-4	A. Accuracy	(2), (7)	See Note B (i)
			B. Response time	(5) Response time measurement of TPM H, in which the TPM time constant is set to [ ] [a,c] second was not performed	See Note B (ii)
			C. Discrete input operability	(9)	
			D. Discrete output operability	(5)	See Note B (v)
			E. Communication operability	Confirmed no communication alarms occurred.	
			F. Coprocessor operability	N/A	The PRM does not use coprocessors.
			G. Timer Tests	N/A	The PRM does not provide any separate timer functions.
			H. Test of failure to complete scan detection	Test Items (13), (14), and (15) were not performed.	See Note B (iii)
			I. Failover Operability Tests	(16) Test Items (10), (11), and (12) were not performed.	See Note B (iv)
			J. Loss of power test	(17)	
			K. Power Interrupt Test.	(18)	

Test Condition(Toshiba qualification tests)		Description of TR-107330 Table 5-1 Operability Tests (Section 5.3)		Operability Test for PRM	
		Scope	Test Item	Performed Tests (See Note A at the end of Table)	Justification/Explanation
Seismic Test	Before Seismic Test	No Description			
	During Seismic Test	"All"	A. Accuracy	No operability test was performed but output signals are monitored.	Due to the short duration of the seismic tests, Operability Tests cannot be performed during the seismic event. Toshiba chose to monitor the equipment operation during the test and performed the operability tests before and after the tests to ensure that the PRM remained operable during and after the seismic event. The acceptance criteria during the Seismic test is described in the Seismic test procedure. The analog outputs and discrete outputs of each unit are set as shown in Table IV-4-5 in this attachment with their acceptance criteria.
			B. Response time		
			C. Discrete input operability		
			D. Discrete output operability		
			E. Communication operability		
			F. Coprocessor operability		
			G. Timer Tests		
			H. Test of failure to complete scan detection		
			I. Failover Operability Tests		
			J. Loss of power test		
			K. Power Interrupt Test.		
	After Seismic Test	"All"	A. Accuracy	(1), (2), (3), (7)	
			B. Response time	(4),(5),(6)	
			C. Discrete input operability	(9)	
			D. Discrete output operability	(4),(5),(6),(8)	
			E. Communication operability	Confirm no communication alarms occurred	
			F. Coprocessor operability	N/A	The PRM does not use coprocessors.
			G. Timer Tests	N/A	The PRM does not provide any separate timer functions.
			H. Test of failure to complete scan detection	(13), (14), (15)	
			I. Failover Operability Tests	(10), (11), (12), (16)	
			J. Loss of power test	(17)	
			K. Power Interrupt Test.	(18)	

Test Condition(Toshiba qualification tests)		Description of TR-107330 Table 5-1 Operability Tests (Section 5.3)		Operability Test for PRM	
		Scope	Test Item	Performed Tests (See Note A at the end of Table)	Justification/Explanation
Exchange of Modules (LPRM Modules was exchanged for HNS013 from HNS011. AO Modules was exchanged for HNS515/516/517/518 from HNS511/512/513/514.					
EMC Test	Before EMC Test	No Description	A. Accuracy	(1), (7) Test Items (2) and (3) were not performed.	The LPRM and AO modules were modified to enhance immunity against EMC. As a test after modification, accuracy was tested using worst case configuration for the LPRM modules.
			B. Response time	(4) Test Items (5) and (6) were not performed.	The LPRM and AO modules were modified to enhance immunity against EMC. As a test after modification, accuracy was tested using worst case configuration for the LPRM modules.
			C. Discrete input operability	(9)	
			D. Discrete output operability	(4), (8) Test Items (5) and (6) were not performed.	Because modification to the LPRM and AO modules does not influence discrete outputs, Tests (4) and (8) are sufficient.
			E. Communication operability	Confirmed no communication alarms occurred	
			F. Coprocessor operability	N/A	The PRM does not use coprocessors.
			G. Timer Tests	N/A	The PRM does not provide any separate timer functions.
			H. Test of failure to complete scan detection	(13), (14) Test Item (15) was not performed. Test Items (13) and (14) were only performed for the LPRM module.	Because the LPRM module was the only module that was modified and contained FPGAs.
			I. Failover Operability Tests	(10), (11), (12) Test (16) was not performed.	Because the LPRM module and AO modules were only modules that were modified.
			J. Loss of power test	(17)	
			K. Power Interrupt Test.	(18)	

Test Condition(Toshiba qualification tests)	Description of TR-107330 Table 5-1 Operability Tests (Section 5.3)		Operability Test for PRM	
	Scope	Test Item	Performed Tests (See Note A at the end of Table)	Justification/Explanation
During EMC Test	"All except A"	A. Accuracy		Due to the special set-up required for the EMC tests, Operability Tests cannot be performed during EMC testing. Toshiba chose to monitor the equipment operation during the test and perform the operability tests before and after the tests to ensure that the PRM remained operable during and after the EMC testing. Table IV-4-7 in this attachment shows the acceptance criteria for the output signals.
		B. Response time	The operability tests were not performed.	
		C. Discrete input operability	The operability tests were not performed.	
		D. Discrete output operability	The operability tests were not performed.	
		E. Communication operability	Confirmed no communication alarms occurred	
		F. Coprocessor operability	N/A	
		G. Timer Tests	N/A	
		H. Test of failure to complete scan detection	The operability tests were not performed.	
		I. Failover Operability Tests	The operability tests were not performed.	
		J. Loss of power test	The operability tests were not performed.	
		K. Power Interrupt Test.	The operability tests were not performed.	
After EMC Test	"All"	A. Accuracy	The operability tests were not performed.	Tests were carried out as Post Qualification Tests (After re-exchange of modules).
		B. Response time		
		C. Discrete input operability		
		D. Discrete output operability		
		E. Communication operability		
		F. Coprocessor operability		
		G. Timer Tests		
		H. Test of failure to complete scan detection		
		I. Failover Operability Tests		
		J. Loss of power test		
		K. Power Interrupt Test.		

Test Condition(Toshiba qualification tests)	Description of TR-107330 Table 5-1 Operability Tests (Section 5.3)		Operability Test for PRM	
	Scope	Test Item	Performed Tests (See Note A at the end of Table)	Justification/Explanation
Isolation Test(Class 1E to Non Class 1E Isolation Test)	No Description		Note: Toshiba conducted Class 1E to Non Class 1E Isolation Test	
Post Qualification Test(Before re-exchange of modules)	No Description	A. Accuracy	(1), (7) Tests (2) and (3) were not performed.	The LPRM and AO modules were modified to enhance immunity against EMC. As a test after modification, accuracy was tested using worst case configuration for the LPRM modules.
		B. Response time	(4) Test Items (5) and (6) were not performed.	The LPRM and AO modules were modified to enhance immunity against EMC. As a test after modification, accuracy was tested using worst case configuration for the LPRM modules.
		C. Discrete input operability	(9)	
		D. Discrete output operability	(4), (8) Test Items (5) and (6) were not performed.	Because modification to the LPRM and AO modules does not influence discrete outputs, Tests (4) and (8) are sufficient.
		E. Communication operability	Confirmed no communication alarms occurred	
		F. Coprocessor operability	N/A	The PRM does not use coprocessors.
		G. Timer Tests	N/A	The PRM does not provide any separate timer functions.
		H. Test of failure to complete scan detection	(13), (14) Test Item (15) was not performed. Test Items (13) and (14) were performed only on LPRM module.	Because the LPRM module was the only module that was modified and contained FPGAs.
		I. Failover Operability Tests	(10), (11), (12) Test Item (16) was not performed.	Because the LPRM module and AO modules were only modules that were modified.
		J. Loss of power test	(17)	
		K. Power Interrupt Test.	(18)	

Test Condition(Toshiba qualification tests)	Description of TR-107330 Table 5-1 Operability Tests (Section 5.3)		Operability Test for PRM	
	Scope	Test Item	Performed Tests (See Note A at the end of Table)	Justification/Explanation
Re-Exchange of Modules (LPRM Modules was exchanged for HNS011 from HNS013. AO Modules was exchanged for HNS511/512/513/514 from HNS515/516/517/518.				
Post-Qualification Test(After re-exchange of modules)	No Description	A. Accuracy	(1), (2), (3), (7)	
		B. Response time	(4), (5), (6)	
		C. Discrete input operability	(9)	
		D. Discrete output operability	(4), (5), (6), (8)	
		E. Communication operability	Confirmed no communication alarms occurred	
		F. Coprocessor operability	N/A	The PRM does not use coprocessors.
		G. Timer Tests	N/A	The PRM does not provide any separate timer functions.
		H. Test of failure to complete scan detection	(13), (14), (15)	
		I. Failover Operability Tests	(10), (11), (12), (16)	
		J. Loss of power test	(17)	
		K. Power Interrupt Test.	(18)	

Note A
(1) Linearity test for APRM level, TPM level, and LPRM level at the LPRM gains 40 μA/100%
(2) Linearity test for APRM level, TPM level, and LPRM level at the LPRM gains 400 μA/100%
(3) Linearity test for APRM level, TPM level, and LPRM level at the LPRM gains 2400 μA/100%
(4) APRM Upscale (High-High) trip and TPM Upscale trip response time test at the LPRM gains 40 μA/100%
(5) APRM Upscale (High-High) trip and TPM Upscale trip response time test at the LPRM gains 400 μA/100%
(6) APRM Upscale (High-High) trip and TPM Upscale trip response time test at the LPRM gains 2400 μA/100%
(7) Linearity test for FLOW level
(8) APRM Inoperable trip function test
(9) DI function test
(10) Low voltage power supply failure test for the LPRM unit
(11) Low voltage power supply failure test for the LPRM/APRM unit
(12) Low voltage power supply failure test for the FLOW unit
(13) Watchdog function test for the LPRM unit
(14) Watchdog function test for the LPRM/APRM unit
(15) Watchdog function test for the FLOW unit

(16) Current value test of the Square Root module in the FLOW unit
(17) Loss of power test
(18) Power interruption test

Note B
(i) Test Items (1) and (3) were not performed, because the LPRM gain or the Ical setting change can be made only by manual operation on the front panel, which was not accessible while the PRM was in the chamber.

Fresh LPRM detectors send over 400 μA signals to the LPRM module, and the signal level decreases by aging in the core. Toshiba selected 400 μA setting as the Ical value, which is generated to simulate the LPRM detectors signal for testing. The LPRM module is calibrated using data from a Traversing In-core Probe (TIP) in actual plants.

The Ical setting is implemented by selecting one resistor from a resistor array in the input of each LPRM module. Since all three selectable resistors are in the same resistor array and all selectable resistors were tested in the factory test, Toshiba selected the 400 μA setting that is the most commonly used in actual operation due to the limitation mentioned above.
Toshiba chose to confirm the accuracy of the PRM for all Ical settings in the Post qualification testing. Toshiba did not observe any degradation in accuracy for all Ical settings,

(ii) Test (4) and (5) with the TPM time constant □ [a,c] second were not performed, because the TPM time constant can be changed only by manual operation on the front panel of the PRM module, which was not accessible while the PRM was in the chamber. Toshiba set the TPM time constant to 6 seconds, which is consistent with Toshiba recommendations for the initial value in the plant.

(iii) Test (13), (14), and (15) were not performed, because the watchdog function test requires intentionally expiring the watchdog timer by removing a jumper pin on the PC board of the test specimen and stop the reset signals from FPGAs to the watchdog timer. This was not possible while the PRM was in the chamber. Instead, Toshiba monitored the equipment operation during the tests. An alarm was generated by the watchdog timer when the jumper pin was removed.

(iv) Test (10), (11), and (12) were not performed, because the output voltage of the LVPS module, which is in the chamber, can be changed only by manual operation on the front panel of the LVPS module.
Toshiba monitored the equipment operation during the tests. An alarm is generated when the voltage of LVPS module was lowered.

(v) Tests (4) and (6) were not performed, because the LPRM gain or the Ical setting change can be made only by manual operation on the front panel, which was not accessible while the PRM was in the chamber. Since the Ical value does not influence discrete output operability, Test (5) is sufficient to ensure discrete output operability.
Test (8) was not performed, because the APRM Inoperable trip is generated only by manual operation on the front panel of the APRM or LPRM modules. The operation changes the mode of the APRM or LPRM module to other than "OP," and makes the number of the operable LPRM modules, i.e., LPRM modules in the "OP" mode, less than the "minimum number of operable LPRM modules" set value. Toshiba monitored the equipment operation during the tests. An inoperable signal is generated when the mode of the APRM module and LPRM modules were changed.

Table IV-4-4 Mapping of PRM Prudency Tests to Table-5-1 in EPRI TR-107330

Test Condition(Toshiba qualification tests)		Description of TR-107330 Table 5-1 Prudency Tests(Section5.4)		Prudency Test	
		Test Point	Item	What is done(refer to note)	Justification/Explanation
Pre-Qualification Test(Base Line)		"All"	A. Burst of events test.	(19), (20)	
			B. Failure of serial port receiver test.	N/A	There is no serial port receiver in the PRM.
			C. Serial port noise test.	N/A	The Toshiba NRW-FPGA-based PRM uses fiber optic links.
			D. Fault simulation.	(21)	The test was performed during the operability test. (Note A (10), (11), and (12)) Failure simulation test is to disconnect the one AC Power source for LVPS1 module of each test specimen unit.
Radiation Exposure		No Description			
Environmental Test	Before High Temperature and High Humidity Exposure	No Description			
	During High Temperature and High Humidity Exposure	No Description			
	After(End of) *)High Temperature and High Humidity Exposure	"ALL at end of high temp/RH only"	A. Burst of events test.	(19), (20)	
			B. Failure of serial port receiver test.	N/A	There is no serial port receiver in the PRM.
			C. Serial port noise test.	N/A	The Toshiba NRW-FPGA-based PRM uses fiber optic links.

Test Condition(Toshiba qualification tests)		Description of TR-107330 Table 5-1 Prudency Tests(Section5.4)		Prudency Test	
		Test Point	Item	What is done(refer to note)	Justification/Explanation
			D. Fault simulation.	The tests were not performed.	Test (21) was not performed because the AC Power of the test specimen in the chamber could not be disconnected. Toshiba chose to monitor the equipment operation during the test. Table IV-4-6 in this attachment shows the acceptance criteria for the output signals. An alarm is generated when the voltage was lowered.
	During Low Temperature Exposure	No Description			
	After (End of) *) Low Temperature Exposure	No Description			
	During Low Humidity Exposure	No Description			
	After (End of) *) Low Humidity Exposure	No Description			
	After *) all Environmental	No Description			
Seismic Test	Before Seismic Test	No Description			
	During Seismic Test	"All"	A. Burst of events test. B. Failure of serial port receiver test. C. Serial port noise test. D. Fault simulation.	The all Prudency tests were not performed.	Due to the short duration of the seismic tests, Prudency Tests cannot be performed during the seismic event. Toshiba chose to monitor the equipment operation during the test.
	After Seismic Test	"None"			
Exchange of Modules (LPRM Modules was exchanged for HNS013 from HNS011. AO Modules was exchanged for HNS515/516/517/518 from HNS511/512/513/514.					
EMC Test	Before EMC Test	No Description			

Test Condition(Toshiba qualification tests)		Description of TR-107330 Table 5-1 Prudency Tests(Section5.4)		Prudency Test	
		Test Point	Item	What is done(refer to note)	Justification/Explanation
	During EMC Test	"A only"	A. Burst of events test.	The tests were not performed.	Due to the special set-up required for the EMC tests, Prudency Tests cannot be performed during EMC testing. Toshiba chose to monitor the equipment operation during the test and perform the operability tests before and after the tests to ensure that the PRM remained operable during and after the EMC testing. Table IV-4-7 in this attachment shows the acceptance criteria for the output signals.
	After EMC Test	"None"			
Isolation Test(Class 1E to Non 1E Test)		No Description			
Post Qualification Test(Before re-exchange of modules)		No Description			
Re-Exchange of Modules (LPRM Modules was exchanged for HNS011 from HNS013. AO Modules was exchanged for HNS511/512/513/514 from HNS515/516/517/518.					
Post-Qualification Test(After re-exchange of modules)		No Description	A. Burst of events test.	(19), (20)	
			B. Failure of serial port receiver test.	N/A	There is no serial port receiver in the PRM.
			C. Serial port noise test.	N/A	The Toshiba NRW-FPGA-based PRM uses fiber optic links.
			D. Fault simulation.	(21)	The test was performed during the operability test. (Note A (10), (11), and (12)) Failure simulation test is to disconnect the one AC Power source for LVPS1 module of each test specimen unit.

Note: Prudency Test item
(19) DI Toggling test
(20) AI Toggling test
(21) Failure simulation test

Table IV-4-5 Acceptance Criteria for Output Signals Monitored during Seismic Test

Signals		Target Value (For analog outputs, input signals were adjusted so that the value of each analog output signal became as the target value shown below)	Acceptance Criteria (For analog outputs, acceptable deviation from the target value)
Analog output	LPRM #1 in LPRM/APRM unit	[	]a,c
	APRM in LPRM/APRM unit		
	TPM in LPRM/APRM unit		
	FLOW in LPRM/APRM unit		
	LPRM #1 in LPRM unit		
	Loop a FLOW in FLOW unit		
	FLOW in FLOW unit		
Discrete output	APRM FAIL in LPRM/APRM unit	Occurred*	Not change
	APRM INOP in LPRM/APRM unit	Not Occurred	Not change
	APRM High-High in LPRM/APRM unit	Not Occurred	Not change
	TPM High in LPRM/APRM unit	Not Occurred	Not change

* To simulate the APRM Fail during seismic test, removed the[ ]a,c from the LPRM/APRM Unit during the seismic test. The[ ]a,c from the FLOW Unit.

Table IV-4-6 Acceptance Criteria for Output Signals Monitored during Environmental Test

	Input		Expected Output (Acceptance criteria)						
Time (min)	LPRM Input Current (μA)	FLOW Input Current (mA)	LPRM Output (Computer) (mV)	APRM/TPM[1] Output (Computer) (mV)	FLOW Output (Computer) (mV)	TPM High Set point (Computer) (mV)	APRM High-High Trip Discrete Output	TPM High Trip Discrete Output	APRM INOP Discrete Output
0-15						[a]	Not Occur[2]	Not Occur[3]	Not Occur
15-30							Not Occur	Not Occur	Not Occur
30-45							Occur[2]	Occur[3]	Not Occur
45-60							Occur	Occur	Not Occur

Note:
1) TPM Output is a first order lag of APRM Output with 6 seconds time constant.
2) APRM High-High trip occurs about 40 ms after the change of LPRM Signal.
3) TPM High trip occurs about 40 ms after the TPM Output change.

Table IV-4-7 Acceptance Criteria for Output Signals Monitored during EMC Test

	Input		Expected Output (Acceptance Criteria)						
Time (s)	LPRM (μA)	FLOW (mA)	HNS511/ HNS515 LPRM (V) a,c	HNS514/ HNS518 LPRM (mV) a,c	HNS512/ HNS516 APRM (V) a,c	HNS514/ HNS518 APRM (mV) a,c	HNS512/ HNS516 FLOW (V)	HNS513/ HNS517 FLOW (V)	APRM High-High Trip Discrete Output
0								a,c	
1									
2									
3									Not Occur
4									
5									
6									
7									
8									
9									
10									
11									
12									
13									
14									Occur
15									
16									
17									
18									
19									

	Input		Expected Output (Acceptance Criteria)						
Time (s)	LPRM (μA)	FLOW (mA)	HNS511/ HNS515 LPRM (V) (±0.136)	HNS514/ HNS518 LPRM (mV) (±5.504)	HNS512/ HNS516 APRM (V) (±0.034)	HNS514/ HNS518 APRM (mV) (±5.504)	HNS512/ HNS516 FLOW (V)	HNS513/ HNS517 FLOW (V)	APRM High-High Trip Discrete Output
20								a,c	
21									Ocur
22									
23									
24									
25									
26									
27									Not Occur
28									
29									
30									

Table IV-4-8 Mapping of OPRM Operability Tests to Table-5-1 in EPRI TR-107330

Test Condition (Toshiba qualification tests)		Description of TR-107330 Table 5-1 Operability Tests (Section 5.3)		Operability Test for OPRM	
		Scope	Test Item	Performed Tests (See Note at the end of Table)	Justification/Explanation
Performance Proof Test (Pre-Qualification Test for EQ test (Base Line))		"All"	A. Accuracy	N/A	The OPRM does not have analog input and output.
			B. Response time	N/A	The OPRM does not have analog input.
			C. Discrete input operability	(7)	
			D. Discrete output operability	(3),(4),(5),(6)	
			E. Communication operability	(1),(2)	
			F. Coprocessor operability	N/A	The OPRM does not use coprocessors.
			G. Timer Tests	N/A	The OPRM does not provide any separate timer function.
			H. Test of failure to complete scan detection	Confirmed no watchdog time alarms occurred	
			I. Failover Operability Tests	(8)	
			J. Loss of power test	(10)	
			K. Power Interrupt Test.	(11)	
Environmental Test	Wear Aging Test	No Description			
	After the Wear Aging test	No Description	A. Accuracy	N/A	The OPRM does not have analog input and output.
			B. Response time	N/A	The OPRM does not have analog input.
			C. Discrete input operability	(7)	
			D. Discrete output operability	(3),(4),(5),(6)	
			E. Communication operability	(1),(2)	
			F. Coprocessor operability	N/A	The OPRM does not use coprocessors.
			G. Timer Tests	N/A	The OPRM does not provide any separate timer function.
			H. Test of failure to complete scan detection	Confirmed no watchdog time alarms occurred	
			I. Failover Operability Tests	(8)	
			J. Loss of power test	(10)	
			K. Power Interrupt Test.	(11)	

Test Condition (Toshiba qualification tests)		Description of TR-107330 Table 5-1 Operability Tests (Section 5.3)		Operability Test for OPRM	
		Scope	Test Item	Performed Tests (See Note at the end of Table)	Justification/Explanation
	Preparation of Temperature and Humidity Environment Test	No Description			
	During High Temperature and High Humidity Environment Test	No Description			
	After (End of) High Temperature and High Humidity Environment Test	"ALL" at the point per Figure 4-4	A. Accuracy	N/A	The OPRM does not have analog input and output.
			B. Response time	N/A	The OPRM does not have analog input.
			C. Discrete input operability	(7)	
			D. Discrete output operability	(3),(4),(5),(6)	
			E. Communication operability	(1),(2)	
			F. Coprocessor operability	N/A	The OPRM does not use coprocessors.
			G. Timer Tests	N/A	The OPRM does not provide any separate timer function.
			H. Test of failure to complete scan detection	Confirm no watchdog time alarms occurred	
			I. Failover Operability Tests	(8)	Tests numbered from (8-4) to (8-12) were not performed. The key switch is on the front panel of the module, which was not accessible while the OPRM was in the chamber.
			J. Loss of power test	(10)	
			K. Power Interrupt Test.	(11)	
	During Low Temperature Environment Test	No Description			
	After (End of) Low Temperature Environment Test	"ALL" at the point per Figure 4-4	A. Accuracy	N/A	The OPRM does not have analog input and output.
			B. Response time	N/A	The OPRM does not have analog input.
			C. Discrete input operability	(7)	
			D. Discrete output operability	(3),(4),(5),(6)	
			E. Communication operability	(1),(2)	
			F. Coprocessor operability	N/A	The OPRM does not use coprocessors.

Test Condition (Toshiba qualification tests)		Description of TR-107330 Table 5-1 Operability Tests (Section 5.3)		Operability Test for OPRM	
		Scope	Test Item	Performed Tests (See Note at the end of Table)	Justification/Explanation
			G. Timer Tests	N/A	The OPRM does not provide any separate timer function.
			H. Test of failure to complete scan detection	Confirmed no watchdog time alarms occurred	
			I. Failover Operability Tests	(8)	Test numbered from (8-4) to (8-12) were not performed. The key switch is on the front panel of the module, which was not accessible while the OPRM was in the chamber.
			J. Loss of power test	(10)	
			K. Power Interrupt Test.	(11)	
	During Low Humidity Environment Test	No Description			
	After (End of) Low Humidity Environment Test	"ALL" at the point per Figure 4-4	A. Accuracy	N/A	The OPRM does not have analog input and output.
			B. Response time	N/A	The OPRM does not have analog input.
			C. Discrete input operability	(7)	
			D. Discrete output operability	(3),(4),(5),(6)	
			E. Communication operability	(1),(2)	
			F. Coprocessor operability	N/A	The OPRM does not use coprocessors.
			G. Timer Tests	N/A	The OPRM does not provide any separate timer function.
			H. Test of failure to complete scan detection	Confirmed no watchdog time alarms occurred	
			I. Failover Operability Tests	(8)	Test numbered from (8-4) to (8-12) were not performed. The key switch is on the front panel of the module, which was not accessible while the OPRM was in the chamber.
			J. Loss of power test	(10)	
			K. Power Interrupt Test.	(11)	
	Translation to Ambient Environmental Condition	No Description			
	After All Environmental	"ALL" at the pointper Figure	A. Accuracy	N/A	The OPRM does not have analog input and output.
			B. Response time	N/A	The OPRM does not have analog input.

Test Condition (Toshiba qualification tests)		Description of TR-107330 Table 5-1 Operability Tests (Section 5.3)		Operability Test for OPRM	
		Scope	Test Item	Performed Tests (See Note at the end of Table)	Justification/Explanation
	Test	4-4	C. Discrete input operability	(7)	
			D. Discrete output operability	(3),(4),(5),(6)	
			E. Communication operability	(1),(2)	
			F. Coprocessor operability	N/A	The OPRM does not use coprocessors.
			G. Timer Tests	N/A	The OPRM does not provide any separate timer function.
			H. Test of failure to complete scan detection	Confirmed no watchdog time alarms occurred	
			I. Failover Operability Tests	(8)	
			J. Loss of power test	(10)	
			K. Power Interrupt Test.	(11)	
Post-Shipment Performance Proof Test. Note: Seismic Tests were performed after EMC Tests. Post-Shipment Performance Proof Test was performed at the Seismic Test site after the shipment of the test specimen and the test equipment from the EMC Test site to the Seismic Test site.		"All"	A. Accuracy	N/A	The OPRM does not have analog input and output.
			B. Response time	N/A	The OPRM does not have analog input.
			C. Discrete input operability	(7)	
			D. Discrete output operability	(3),(4),(5),(6)	
			E. Communication operability	(1),(2)	
			F. Coprocessor operability	N/A	The OPRM does not use coprocessors.
			G. Timer Tests	N/A	The OPRM does not provide any separate timer function.
			H. Test of failure to complete scan detection	Confirmed no watchdog time alarms occurred	
			I. Failover Operability Tests	(8)	
			J. Loss of power test	(10)	
			K. Power Interrupt Test.	(11)	
Seismic Test	Preparation Seismic Test	No Description			
	During Seismic Test(OBEs and SSE)	"All"	A. Accuracy	No operability test was performed but output signals are monitored.	Due to the short duration of the seismic tests, Operability Tests cannot be performed during the seismic event. Toshiba chose to monitor the Equipment operation during the test and performed the operability tests before and after the tests to ensure that the OPRM remained operable during and after the seismic event. The acceptance criteria
			B. Response time		
			C. Discrete input operability		
			D. Discrete output operability		
			E. Communication operability		

Test Condition (Toshiba qualification tests)		Description of TR-107330 Table 5-1 Operability Tests (Section 5.3)		Operability Test for OPRM	
		Scope	Test Item	Performed Tests (See Note at the end of Table)	Justification/Explanation
			F. Coprocessor operability		during the Seismic test are described in the Seismic test procedure. The discrete outputs and optical outputs are set as shown in Table IV-4-10 in this attachment with their acceptance criteria.
			G. Timer Tests		
			H. Test of failure to complete scan detection		
			I. Failover Operability Tests		
			J. Loss of power test		
			K. Power Interrupt Test.		
	After Seismic Test	"All"	A. Accuracy	N/A	The OPRM does not have analog input and output.
			B. Response time	N/A	The OPRM does not have analog input.
			C. Discrete input operability	(7)	
			D. Discrete output operability	(6)	
			E. Communication operability	Confirmed no communication alarms occurred	
			F. Coprocessor operability	N/A	The OPRM does not use coprocessors.
			G. Timer Tests	N/A	The OPRM does not provide any separate timer function.
			H. Test of failure to complete scan detection	Confirmed no watchdog time alarms occurred	
			I. Failover Operability Tests	(8)	Test numbered from (8-4) to (8-12) were not performed. The key switch is on the front panel of the module, which was not accessible while the OPRM was on the Vibration table.
			J. Loss of power test	Confirmed at the performance proof test (Pre—Qualification for EMC Test)	
			K. Power Interrupt Test.	Confirmed at the performance proof test (Pre—Qualification for EMC Test)	

Test Condition (Toshiba qualification tests)		Description of TR-107330 Table 5-1 Operability Tests (Section 5.3)		Operability Test for OPRM	
		Scope	Test Item	Performed Tests (See Note at the end of Table)	Justification/Explanation
Performance Proof Test(Pre-Qualification for EMC Test)		No Description	A. Accuracy	N/A	The OPRM does not have analog input and output.
			B. Response time	N/A	The OPRM does not have analog input.
			C. Discrete input operability	(7)	
			D. Discrete output operability	(3),(4),(5),(6)	
			E. Communication operability	(1),(2)	
			F. Coprocessor operability	N/A	The OPRM does not use coprocessors.
			G. Timer Tests	N/A	The OPRM does not provide any separate timer function.
			H. Test of failure to complete scan detection	Confirmed no watchdog time alarms occurred	
			I. Failover Operability Tests	(8)	
			J. Loss of power test	(10)	
			K. Power Interrupt Test.	(11)	
EMC Test	During EMC Test	"All except A"	A. Accuracy	No operability test was performed but output signals are monitored.	Due to the special set-up required for the EMC tests, Operability Tests cannot be performed during EMC testing. Toshiba chose to monitor the equipment operation during the test and perform the operability tests before and after the tests to ensure that the OPRM remained operable during and after the EMC testing. The acceptance criteria during the EMC test is described in the EMI/RFI test procedure. The discrete outputs and optical outputs are set as shown in Table IV-4-10 in this attachment with their acceptance criteria.
			B. Response time		
			C. Discrete input operability		
			D. Discrete output operability		
			E. Communication operability		
			F. Coprocessor operability		
			G. Timer Tests		
			H. Test of failure to complete scan detection		
			I. Failover Operability Tests		
			J. Loss of power test		
			K. Power Interrupt Test.		
Performance Proof Test(Post-Qualification Test for EMC Test)		No Description	A. Accuracy	N/A	The OPRM does not have analog input and output.
			B. Response time	N/A	The OPRM does not have analog input.
			C. Discrete input operability	(7)	
			D. Discrete output operability	(3),(4),(5),(6)	
			E. Communication operability	(1),(2)	
			F. Coprocessor operability	N/A	The OPRM does not use coprocessors.

Test Condition (Toshiba qualification tests)	Description of TR-107330 Table 5-1 Operability Tests (Section 5.3)		Operability Test for OPRM	
	Scope	Test Item	Performed Tests (See Note at the end of Table)	Justification/Explanation
		G. Timer Tests	N/A	The OPRM does not provide any separate timer function.
		H. Test of failure to complete scan detection	Confirmed no watchdog time alarms occurred	
		I. Failover Operability Tests	(8)	
		J. Loss of power test	(10)	
		K. Power Interrupt Test.	(11)	
Performance Proof Test (Post-Qualification Test for EQ Test)	No Description	A. Accuracy	N/A	The OPRM does not have analog input and output.
		B. Response time	N/A	The OPRM does not have analog input.
		C. Discrete input operability	(7)	
		D. Discrete output operability	(3),(4),(5),(6)	
		E. Communication operability	(1),(2)	
		F. Coprocessor operability	N/A	The OPRM does not use coprocessors.
		G. Timer Tests	N/A	The OPRM does not provide any separate timer function.
		H. Test of failure to complete scan detection	Confirmed no watchdog time alarms occurred	
		I. Failover Operability Tests	(8)	
		J. Loss of power test	(10)	
		K. Power Interrupt Test.	(11)	

Note: Operability Test item
(1) APRM/FLOW level input and output Function Test
(2) LPRM Ch-data input and output Function Test
(3) Amplitude Based detection Algorithm (ABA) Trip Function Test
(4) Growth Rate detection Algorithm (GRA) Trip Function Test
(5) Period Based Detection Algorithm (PBDA) Trip Function Test
(6) OPRM Automatic Bypass Function Test
(7) OPRM Function Change by APRM Bypass Signal Test
(8) Failure Detection and Self-Diagnosis Test
(8-1) Start the test pattern (APRM Inoperative occurs).
(8-2) Start the test pattern (APRM Unit Data 1 and 2 error).
(8-3) Start the APRM data (All LPRM levels are 50 % at OPRM Region).
(8-4) Turn the key switch of the CELL module to "STANDBY" position.

(8-5) Turn the key switch of the CELL module to "CAL" position.
(8-6) Turn the key switch of the CELL module to "OP" position.
(8-7) Turn the key switch of the AGRD module to "STANDBY" position.
(8-8) Turn the key switch of the AGRD module to "CAL" position.
(8-9) Turn the key switch of the AGRD module to "OP" position.
(8-10) Turn the key switch of the PBD module to "STANDBY" position.
(8-11) Turn the key switch of the PBD module to "CAL" position.
(8-12) Turn the key switch of the PBD module to "OP" position.
(8-13) Start the test pattern (Number of Active OPRM Cell is lower than the setpoint).
(8-14) Start the test pattern (All LPRM levels are 50 % at OPRM Region).

(9) Power Quality Tolerance Test
(10) Loss of Power Test
(11) Power Interruption Test

Table IV-4-9 Mapping of OPRM Prudency Tests to Table-5-1 in EPRI TR-107330

Test Condition (Toshiba qualification tests)		Description of TR-107330 Table 5-1 Prudency Tests(Section5.4)		Prudency Test for OPRM	
		Test Point	Item	What is done(See Note at the end of Table)	Justification/Explanation
Performance Proof Test (Pre-Qualification Test for EQ test (Base Line))		"All"	A. Burst of events test.	(12), (13), (14)	
			B. Failure of serial port receiver test.	(15), (16), (17)	
			C. Serial port noise test.	N/A	The OPRM uses fiber optic links.
			D. Fault simulation.	(18)	
Environmental Test	Wear Aging Test	No Description			
	After the Wear Aging test	No Description			
	Preparation of Temperature and Humidity Environment Test	No Description			
	During High Temperature and High Humidity Environment Test	No Description			
	After (End of) High Temperature and High Humidity Environment Test	"ALL at end of high temp/RH only"	A. Burst of events test.	(12), (13), (14)	
			B. Failure of serial port receiver test.	(15), (16), (17)	
			C. Serial port noise test.	N/A	The OPRM uses fiber optic links.
			D. Fault simulation.	The tests were not performed.	Test (18) was not performed because the AC Power switches of the test specimen in the chamber could not be turned off. Toshiba chose to monitor the equipment operation during the test. An alarm is generated when one of the AC power sources is shut off.
	During Low Temperature Environment Test	No Description			

Test Condition (Toshiba qualification tests)		Description of TR-107330 Table 5-1 Prudency Tests(Section5.4)		Prudency Test for OPRM	
		Test Point	Item	What is done(See Note at the end of Table)	Justification/Explanation
	After (End of) Low Temperature Environment Test	No Description			
	During Low Humidity Environment Test	No Description			
	After (End of) Low Humidity Environment Test	No Description			
	During High Temperature and High Humidity Environment Test	No Description			
	Translation to Ambient Environmental Condition	No Description			
	After All Environmental Test	No Description			
Post-Shipment Performance Proof Test. Note: Seismic Tests were performed after EMC Tests. Post-Shipment Performance Proof Test was performed at the Seismic Test site after the shipment of the test specimen and the test equipment from the EMC Test site to the Seismic Test site.		"All"	A. Burst of events test.	(12), (13), (14)	
			B. Failure of serial port receiver test.	(15), (16), (17)	
			C. Serial port noise test.	N/A	The OPRM uses fiber optic links.
			D. Fault simulation.	(18)	

Test Condition (Toshiba qualification tests)		Description of TR-107330 Table 5-1 Prudency Tests(Section5.4)		Prudency Test for OPRM	
		Test Point	Item	What is done(See Note at the end of Table)	Justification/Explanation
Seismic Test	Preparation Seismic Test	No Description			
	During Seismic Test (OBEs and SSE)	"All"	A. Burst of events test. B. Failure of serial port receiver test. C. Serial port noise test. D. Fault simulation.	The all Prudency tests were not performed.	Due to the short duration of the seismic tests, Prudency Tests cannot be performed during the seismic event. Toshiba chose to monitor the equipment operation during the test. The acceptance criteria during the EMC test is described in the EMI/RFI test procedure. The discrete outputs and optical outputs are set as shown in Table IV-4-10 in this attachment with their acceptance criteria.
	After Seismic Test	"None"			
Performance Proof Test (Pre-Qualification for EMC Test)		No Description	A. Burst of events test.	(12), (13), (14)	
			B. Failure of serial port receiver test.	(15), (16), (17)	
			C. Serial port noise test.	N/A	The OPRM uses fiber optic links.
			D. Fault simulation.	(18)	
EMC Test	During EMC Test	"A only"	A. Burst of events test.	The tests were not performed.	Due to the special set-up required for the EMC tests, Prudency Tests cannot be performed during EMC testing. Toshiba chose to monitor the equipment operation during the test and perform the Prudency tests before and after the tests to ensure that the OPRM remained operable during and after the EMC testing. The acceptance criteria during the EMC test is described in the EMI/RFI test procedure. The discrete outputs and optical outputs are set as shown in Table IV-4-10 in this attachment with their acceptance criteria.

Test Condition (Toshiba qualification tests)	Description of TR-107330 Table 5-1 Prudency Tests(Section5.4)		Prudency Test for OPRM	
	Test Point	Item	What is done(See Note at the end of Table)	Justification/Explanation
Performance Proof Test(Post-Qualification Test for EMC Test)	No Description	A. Burst of events test.	(12), (13), (14)	
		B. Failure of serial port receiver test.	(15), (16), (17)	
		C. Serial port noise test.	N/A	The OPRM uses fiber optic links.
		D. Fault simulation.	(18)	
Performance Proof Test(Post-Qualification Test for EQ Test)	No Description	A. Burst of events test.	(12), (13), (14)	
		B. Failure of serial port receiver test.	(15), (16), (17)	
		C. Serial port noise test.	N/A	The OPRM uses fiber optic links.
		D. Fault simulation.	(18)	

Note: Prudency Test item
(12) Bypass Signal Toggling test
(13) LPRM Level Toggling test
(14) APRM Level and Core Flow Level Toggling test
(15) Parity Error in the Optical Transmission Input Signals test
(16) All LPRM Signals Loss test
(17) One Side of the Redundant APRM Signals Loss Test
(18) Fault Simulation Test

Table IV-4-10 Acceptance Criteria for Output Signals Monitored during Seismic Test and EMC Test for OPRM

Signals		Target Value	Acceptance Criteria
Discrete output	SCRAM	-	Occurred
	PBDA_TRIP	-	Not occurred
	GRA_TRIP	-	Occurred
	ABA_TRIP	-	Not occurred
	OPRM_INOP	-	Not occurred
	OPRM_FAIL	-	Not occurred
	OPRM_AT_BYP	-	Not occurred
	Trip Interval time (Tcyc)	[ ]a,c s	+/-[ ]a,c s
	Trip Interval time (Tga)	s	+/- s
	Trip Interval time (Tap)	s	+/- s
	Trip Interval time (Tpp)	s	+/- s
Optical output (ELCS/ PICS data)	SCRAM	-	Occurred
	PBDA_TRIP	-	Not occurred
	GRA_TRIP	-	Occurred
	ABA_TRIP	-	Not occurred
	OPRM_INOP	-	Not occurred
	OPRM_FAIL	-	Not occurred
	OPRM_AT_BYP	-	Not occurred
	Trip Interval time (Tcyc)	[ ]a,c s	+/-[ ]a,c s
	Trip Interval time (Tga)	s	+/- s
	Trip Interval time (Tap)	s	+/- s
	Trip Interval time (Tpp)	s	+/- s

ELCS: Engineering Safety Features Logic & Control System
PICS: Plant Information and Control System

IV-5 Compliance to DI&C ISG-04 "Highly-Integrated Control Rooms—Communications Issues (HICRc)"

Table IV-5-1 documents conformance of a typical Toshiba safety system to DI&C ISG-04 (Reference (a22)).

Notes:
- "Comply" means the corresponding section in the ERS comply with corresponding DI&C ISG-04 requirement.
- "---" means there is no requirement in the ISG-04.

Table IV-5-1 Conformance with ISG-04

NRC Guidance ISG-04	Compliance	Comments
1. Inter Divisional Communications	---	Section title
Staff Position 1.1 A safety channel should not be dependent upon any information or resource originating or residing outside its own safety division to accomplish its safety function. This is a fundamental consequence of the independence requirements of IEEE-603. It is recognized that division voting logic must receive inputs from multiple safety divisions.	Comply	The PRM or OPRM does not require data from any other safety systems residing outside its own safety division or external to its own safety division except PRM application to small core BWR-3s where the limited number of LPRM detectors forces data sharing between specific APRM units in different division in order to have sufficient data to perform the APRM and OPRM functions. This arrangement is documented in existing licensing basis for US BWR-3 plants. Section II-2.2 explains the application of Toshiba FPGA-Based Safety-Related I&C Systems including the PRM and OPRM. Section II-2.2.3 explains FPGA application principles. For PRM and OPRM, functional, physical, electrical, and communication independence exists between redundant safety-related divisions, between each safety-related division and other divisions in other safety-related systems, and between safety-related systems and non-safety-related systems; data independence is exhibited in PRM and OPRM. Data transmission within the PRM and OPRM is documented in detail in the Application Guide (See Part II, Appendix A). Section II-2.2.3.2 describes the independence that exists in PRM and OPRM.

NRC Guidance ISG-04	Compliance	Comments
Staff Position 1.2 The safety function of each safety channel should be protected from adverse influence from outside the division of which that channel is a member. Information and signals originating outside the division must not be able to inhibit or delay the safety function. This protection must be implemented within the affected division (rather than in the sources outside the division), and must not itself be affected by any condition or information from outside the affected division. This protection must be sustained despite any operation, malfunction, design error, communication error, or software error or corruption existing or originating outside the division.	Comply	The PRM and OPRM use uni-directional fiber optic links for interdivisional communication to protect the safety function of each safety channel from adverse influence from outside the division of which that channel is a member. Section II-2.2.3.2 and II-2.2.3 3 describe independence, an FPGA application principle. Each division of PRM or OPRM can accomplish its safety function regardless of the operability or adverse impact of other redundant divisions or other systems. Each division of PRM or OPRM independently performs its safety function without requiring data from other divisions except PRM application to small core BWR-3s where the limited number of LPRM detectors forces data sharing between specific APRM units in different division in order to have sufficient data to perform the APRM and OPRM functions This arrangement is documented in existing licensing basis for US BWR-3 plants. The data links information is transmitted in packets with a fixed length, fixed content, and predefined format. Failures in the communication links do not adversely affect operation of the divisions receiving malformed, incorrect, or inappropriate data messages. Section II-2.2.3.2.1 explains physical and electrical independence between the divisions. Section II-2.1.4.3 explains error detection in the fiber optic communication. To detect failures, the fiber optic link is always operating, using a self-clock of each module. The data link uses Manchester encoding to send zeros and ones. Each message includes Cyclic Redundancy Check (CRC), which detects data corruption. When data needs to be transferred, a special pattern is sent to indicate the start of a data packet. The fixed length data packet is sent. Note: Toshiba has updated the FPGA logic to use CRC in addition to parity check used in the old FPGA logic. The transmitting module is configured to send all required data from the unit to external equipment. The serial communication link to the outside world is electrically isolated using uni-directional fiber optic communication.

NRC Guidance ISG-04	Compliance	Comments
Staff Position 1.3 A safety channel should not receive any communication from outside its own safety division unless that communication supports or enhances the performance of the safety function. Receipt of information that does not support or enhance the safety function would involve the performance of functions that are not directly related to the safety function. Safety systems should be as simple as possible. Functions that are not necessary for safety, even if they enhance reliability, should be executed outside the safety system. A safety system designed to perform functions not directly related to the safety function would be more complex than a system that performs the same safety function, but is not designed to perform other functions. The more complex system would increase the likelihood of failures and software errors. Such a complex design, therefore, should be avoided within the safety system. For example, comparison of readings from sensors in different divisions may provide useful information concerning the behavior of the sensors (for example, On-Line Monitoring). Such a function executed within a safety system, however, could also result in unacceptable influence of one division over another, or could involve functions not directly related to the safety functions, and should not be executed within the safety system. Receipt of information from outside the division, and the performance of functions not directly related to the safety function, if used, should be justified. It should be demonstrated that the added system/software complexity associated with the performance of functions not directly related to the safety function and with the receipt of information in support of those functions does not significantly increase the likelihood of software specification or coding errors, including errors that would affect more than one division. The applicant should justify the definition of "significantly" used in the demonstration.	Comply	The PRM and OPRM are designed to ensure the independence of each safety channel. Section II-2.2.3.2 describes the independence that exists in PRM and OPRM.

NRC Guidance ISG-04	Compliance	Comments
Staff Position 1.4 The communication process itself should be carried out by a communications processor separate from the processor that executes the safety function, so that communications errors and malfunctions will not interfere with the execution of the safety function. The communication and function processors should operate asynchronously, sharing information only by means of dual-ported memory or some other shared memory resource that is dedicated exclusively to this exchange of information. The function processor, the communications processor, and the shared memory, along with all supporting circuits and software, are all considered to be safety-related, and must be designed, qualified, fabricated, etc., in accordance with 10 C.F.R. Part 50, Appendix A and B. Access to the shared memory should be controlled in such a manner that the function processor has priority access to the shared memory to complete the safety function in a deterministic manner. For example, if the communication processor is accessing the shared memory at a time when the function processor needs to access it, the function processor should gain access within a timeframe that does not impact the loop cycle time assumed in the plant safety analyses. If the shared memory cannot support unrestricted simultaneous access by both processors, then the access controls should be configured such that the function processor always has precedence. The safety function circuits and program logic should ensure that the safety function will be performed within the timeframe established in the safety analysis, and will be completed successfully without data from the shared memory in the event that the function processor is unable to gain access to the shared memory.	Comply except the difference of the FPGA-based I&C systems from CPU-based systems.	Section II-2.1.4.3 describes communication on fiber optic link. The PRM and OPRM use two types of communication modules, TRN (transmitter) modules and RCV (receiver) modules. These modules implement the communication process separation between units required by Staff Position 1.4. Communication within the unit is not part of this discussion. Each TRN module talks to one or more RCV modules that receive data through a uni-directional, point-to-point communication link. The TRN and RCV modules are separated from safety functions performed by safety-function modules, such as the APRM module. In safety function modules, the PRM or OPRM handles data in a different way from microprocessor based systems. Section II-2.2.3.5 describes that the FPGA circuits are constructed of discrete logic blocks that are similar to older, analog and discrete relay circuits in existing operating plants. The PRM or OPRM implements the required functionality in fixed gates, in dedicated FPGAs for necessary functions. Therefore, the PRM and OPRM achieve the separation of safety functions from communications and the prioritization of the safety functions over communication in a finer granularity than CPU-based systems. Staff Position 1.4 discusses a concern of the communication processor is accessing the shared memory at a time when the function processor should gain access. The RCV module checks for the periodic data transmission through each fiber optic cable. If the RCV module fails to receive data packets three times in row, the RCV module issues an alarm, the RCV module marks the link failed. The RCV module conducts CRC in the received data. Failure of data to arrive is detected and will be alarmed.
Staff Position 1.5 The cycle time for the safety function processor should be determined in consideration of the longest possible completion time for each access to the shared memory. This longest-possible completion time should include the response time of the memory itself and of the circuits associated with it, and should also include the longest possible delay in access to the memory by the function processor assuming worst-case conditions for the transfer of access from the communications processor to the function processor. Failure of the system to meet the limiting cycle time should be detected and alarmed.	Comply except the difference of the FPGA-based I&C systems from CPU-based systems.	The PRM and OPRM uses multiple FPGAs that operate in sequence in a deterministic time as documented in Section II-2.2.3.3. Since the cycle is fixed, the PRM and OPRM always operate on exactly the same cycle.

NRC Guidance ISG-04	Compliance	Comments
Staff Position 1.6 The safety function processor should perform no communication handshaking and should not accept interrupts from outside its own safety division.	Comply	The communication data link provided in each division is over a point-to-point, uni-directional communication links using the TRN and RCV modules. The link has no physical or logic provisions for communication handshaking.
Staff Position 1.7 Only predefined data sets should be used by the receiving system. Unrecognized messages and data should be identified and dispositioned by the receiving system in accordance with the pre-specified design requirements. Data from unrecognized messages must not be used within the safety logic executed by the safety function processor. Message format and protocol should be pre-determined. Every message should have the same message field structure and sequence, including message identification, status information, data bits, etc. in the same locations in every message. Every datum should be included in every transmit cycle, whether it has changed since the previous transmission or not, to ensure deterministic system behavior.	Comply	Section II-2.1.4 describes three types of communication links. All communication within the PRM or OPRM uses pre-defined, fixed length, fixed format, fixed content messages. Sections II-2.2.3.2 and II-2.2.3.3 describes the communication protocols as using pre-defined, fixed length, fixed format, and fixed content, as well as being generated only at specific times in the FPGA logic execution. The transmitted data is encapsulated in a data packet consisting of a fixed number of data fields. Headers and CRC are added to this frame to detect the start of the frame and determine if bit errors have occurred within the frame. To detect failures, all fiber optic links are always operating, using a self-clocking data signal. Each message includes CRC. When data needs to be transferred, a special pattern is sent to indicate the start of a data packet.
Staff Position 1.8 Data exchanged between redundant safety divisions or between safety and non-safety divisions should be processed in a manner that does not adversely affect the safety function of the sending divisions, the receiving divisions, or any other independent divisions.	Comply	The PRM and OPRM are designed to preserve the safety function of the safety divisions, the receiving divisions, or any other independent divisions by the use of dedicated function, point-to-point, uni-directional fiber optic communication. Section II-2.2.3.2.1 describes physical and electrical independence. Section II-2.2.3.2.2 describes communication independence.
Staff Position 1.9 Incoming message data should be stored in fixed predetermined locations in the shared memory and in the memory associated with the function processor. These memory locations should not be used for any other purpose. The memory locations should be allocated such that input data and output data are segregated from each other in separate memory devices or in separate pre-specified physical areas within a memory device.	Comply	Section II-2.2.3.2.2 describes that each communication links has its own independent communication buffer. Each dedicated function communication buffer is designed in a manner to preclude buffer overflow from having any effect.

NRC Guidance ISG-04	Compliance	Comments
Staff Position 1.10 Safety division software should be protected from alteration while the safety division is in operation. On-line changes to safety system software should be prevented by hardwired interlocks or by physical disconnection of maintenance and monitoring equipment. A workstation (e.g. engineer or programmer station) may alter addressable constants, setpoints, parameters, and other settings associated with a safety function only by way of the dual-processor / shared-memory scheme described in this guidance, or when the associated channel is inoperable. Such a workstation should be physically restricted from making changes in more than one division at a time. The restriction should be by means of physical cable disconnect, or by means of keylock switch that either physically opens the data transmission circuit or interrupts the connection by means of hardwired logic. "Hardwired logic" as used here refers to circuitry that physically interrupts the flow of information, such as an electronic AND gate circuit (that does not use software or firmware) with one input controlled by the hardware switch and the other connected to the information source: the information appears at the output of the gate only when the switch is in a position that applies a "TRUE" or "1" at the input to which it is connected. Provisions that rely on software to effect the disconnection are not acceptable. It is noted that software may be used in the safety system or in the workstation to accommodate the effects of the open circuit or for status logging or other purposes.	Comply	The FPGA-based system uses antifuse FPGA architecture that is non-volatile and non-rewritable. Once safety functions are programmed into the FPGA, there is no method to change the logic, i.e., the logic is protected from alteration. Section II-A-2.7 describes how an attached EEPROM is used to store setpoint values for the PRM. Section II-A-2.7 describes use of an attached one-time programmable EPROM .
Staff Position 1.11 Provisions for interdivisional communication should explicitly preclude the ability to send software instructions to a safety function processor unless all safety functions associated with that processor are either bypassed or otherwise not in service. The progress of a safety function processor through its instruction sequence should not be affected by any message from outside its division. For example, a received message should not be able to direct the processor to execute a subroutine or branch to a new instruction sequence.	Comply	The FPGA-based system uses antifuse FPGA architecture that is non-volatile and non-rewritable. Once safety functions are programmed into the FPGA, there is no method to change the logic, i.e., the logic is protected from alteration. Changing the instructions requires unsoldering the FPGA from the module, replacing the original with an updated FPGA, and soldering the physically updated FPGA back onto the module.

NRC Guidance ISG-04	Compliance	Comments
Staff Position 1.12 Communication faults should not adversely affect the performance of required safety functions in any way. Faults, including communication faults, originating in non-safety equipment, do not constitute "single failures" as described in the single failure criterion of 10 C.F.R. Part 50, Appendix A. Examples of credible communication faults include, but are not limited to, the following:	Comply	The Response provided for Staff Position 1.9 is also applicable to Staff Position 1.12. The PRM or OPRM does not receive data from non-safety equipment. The PRM and OPRM provide data to non-safety equipment through unidirectional fiber optic communication links. Therefore communication faults cannot adversely affect safety functions in the Toshiba design.
• Messages may be corrupted due to errors in communications processors, errors introduced in buffer interfaces, errors introduced in the transmission media, or from interference or electrical noise.	Comply	The data packet consists of fixed fields or channels. RCV modules check for periodic arrival of data packets, in addition to data corruption checks using CRC. The RCV module checks the received data. If the RCV module finds an error in a frame, the frame is discarded. EMC qualification was performed for the PRM and the OPRM. The results are documented in Part III
• Messages may be repeated at an incorrect point in time.	Comply	Communication between the TRN and RCV modules is point-to-point, and uni-directional. Optical receivers of the RCV module detect the frame preambles of the messages even if the message was sent at an incorrect point in time, and stores the accepted data in a buffer. However, the remaining FPGAs in the receiver train operate cyclically in a pre-determined time interval. The messages do not affect adversely to the RCV module, and the other modules using the data.
• Messages may be sent in the incorrect sequence.	Comply	The data communication over the fiber optic link uses only one type of data packet on each link. The TRN (transmitter) and RCV (receiver) modules are used for the fiber optic links, using only one type of fixed data packet. In PRM or OPRM, a sender module may send a large data to a destination module residing in another unit through a pair of TRN and RCV modules. In this case, the sender module divides the data set into more than one message with sequence numbers attached to each message, and sends the messages through the TRN module in the same unit. The RCV modules deliver the messages to the target module in the same unit, without regard to the order of the sequence numbers. The target module checks the sequence numbers of the message, and if the target module detect an incorrect sequence of messages, the whole set of messages is discarded.
• Messages may be lost, which includes both failures to receive an uncorrupted message or to acknowledge receipt of a message.	Comply	RCV modules check for periodic arrival of data packets. If the RCV module fails to receive data packets three times in row, the RCV module issues an alarm. RCV modules have dedicated FPGAs for error detection.
• Messages may be delayed beyond their permitted arrival time window for several reasons, including errors in the transmission medium, congested transmission lines, interference, or by delay in sending buffered messages.	Comply	The RCV modules checks for corruption of data packets by CRC and/or Parity. If the RCV module fails to receive data packets three times in row, the RCV module issues an alarm. RCV modules have dedicated FPGAs for error detection.

NRC Guidance ISG-04	Compliance	Comments
• Messages may be inserted into the communication medium from unexpected or unknown sources.	Comply	The communication of the PRM and OPRM are point-to-point through the fiber optic link. It is unlikely to receive messages from unexpected or unknown sources. Additionally, the fiber optic cables must be maintained in vital plant areas, to ensure that the fiber optic cables are protected.
• Messages may be sent to the wrong destination, which could treat the message as a valid message.	Comply	The communications of the PRM and OPRM are point-to-point through the fiber optic link. It is unlikely to send messages to a wrong destination. In addition, the RCV module checks the source of the data packet. It is possible that fiber optic connections will be confused during installation or maintenance activities. The source, unit type, and unit number detect such errors and generate appropriate external notification of the error.
• Messages may be longer than the receiving buffer, resulting in buffer overflow and memory corruption.	Comply	The RCV module is designed to receive messages of pre-defined lengths. If a message is longer than the defined length, the RCV module will discard the excess. If a message is shorter than the defined length, the RCV module will detect a message corruption error. The PRM and OPRM have no problem with buffer overflow or memory corruption since all messages are stored in pre-defined, pre-allocated registers and there is no possibility of storing data beyond the end of the pre-defined, pre-allocated register length.
• Messages may contain data that is outside the expected range.	Comply	If the cause is due to message corruption, the corruption will be detected by CRC; otherwise the redundant portion of the PRM and OPRM will perform the required safety functions.
• Messages may appear valid, but data may be placed in incorrect locations within the message.	Comply	This would require faults or failures in the programmable logic in the transmitter or receiver with multiple cross-connections, which is unlikely. It is more likely that data would not be inserted from single hardware faults and failures. Even if this kind of random failures happened, the remainder of the redundant system would continue to function and perform the safety functions that the failed unit can no longer perform.
• Messages may occur at a high rate that degrades or causes the system to fail (i.e., broadcast storm).	Comply	Because the PRM and OPRM exchanges messages over point-to-point data links, there can be no broadcast storm. Data packages are sent based on pre-determined, fixed rate clocks generated in the FPGA logic and based on hardware timing signals.
• Message headers or addresses may be corrupted.	Comply	The data packet in the PRM and OPRM has a field that identifies the TRN module at the opposite end of the communication link. The field is protected by CRC. The RCV module checks the identification numbers to identify the message source. If headers or addresses are corrupted, the message will be rejected, as the header or the source would not be as expected.

NRC Guidance ISG-04	Compliance	Comments
Staff Position 1.13 Vital communications, such as the sharing of channel trip decisions for the purpose of voting, should include provisions for ensuring that received messages are correct and are correctly understood. Such communications should employ error-detecting or error-correcting coding along with means for dealing with corrupt, invalid, untimely, or otherwise questionable data. The effectiveness of error detection / correction should be demonstrated in the design and proof testing of the associated codes, but once demonstrated is not subject to periodic testing. Error-correcting methods, if used, should be shown to always reconstruct the original message exactly or to designate the message as unrecoverable. None of this activity should affect the operation of the safety-function processor.	Comply	Data transmission from the TRN module to the RCV module has features (CRC and source checking) to detect communication faults. For this discussion, Toshiba assumes that proof testing is a combination of verification and validation tests and equipment qualification type tests. As documented in Part VI of this LTR, verification and validation tests demonstrated CRC function in communication links.
Staff Position 1.14 Vital communications should be point-to-point by means of a dedicated medium (copper or optical cable). In this context, "point-to-point" means that the message is passed directly from the sending node to the receiving node without the involvement of equipment outside the division of the sending or receiving node. Implementation of other communication strategies should provide the same reliability and should be justified.	Comply	As documented in Section II- 2.2.3.2.2, and shown in Figure II-2-13, communications in the PRM and OPRM are point-to-point over fiber optic cables.
Staff Position 1.15 Communication for safety functions should communicate a fixed set of data (called the "state") at regular intervals, whether data in the set has changed or not.	Comply	As documented in Section II-2.2.3.3, the communication protocols are pre-defined, fixed length, fixed format, generated at specific times in the FPGA logic execution, and always contain all data required to be communicated.
Staff Position 1.16 Network connectivity, liveness, and real-time properties essential to the safety application should be verified in the protocol. Liveness, in particular, is taken to mean that no connection to any network outside the division can cause an RPS/ESFAS communication protocol to stall, either deadlock or livelock. (Note: This is also required by the independence criteria of: (1) 10 C.F.R. Part 50, Appendix A, General Design Criteria ("GDC") 24, which states, "interconnection of the protection and control systems shall be limited so as to assure that safety is not significantly impaired."; and (2) IEEE Std 603-1991, IEEE Standard Criteria for Safety Systems for Nuclear Power Generating Stations.) (Source: NUREG/CR-6082, 3.4.3)	Comply	As documented in Section II-2.2.3.3, the communication protocols are pre-defined, fixed length, fixed format, and generated at specific times in the FPGA logic execution. The communication links that perform safety functions include data, data checking, and time out error checking. The communication protocols and logic in the communication receivers include self-diagnostics that will generate module failure signals upon detection of communication failures, taking conservative actions, and alerting operators. Communication with other safety and non-safety related systems each use different implementations of the programmable logic and separate TRN/RCV modules to avoid the possibility of communication errors on any link affecting any other link or the safety function.

NRC Guidance ISG-04	Compliance	Comments
Staff Position 1.17 Pursuant to 10 C.F.R. § 50.49, the medium used in a vital communications channel should be qualified for the anticipated normal and post-accident environments. For example, some optical fibers and components may be subject to gradual degradation as a result of prolonged exposure to radiation or to heat. In addition, new digital systems may need susceptibility testing for EMI/RFI and power surges, if the environments are significant to the equipment being qualified.	Comply	Toshiba fiber optic and copper cables for the equipment in this LTR are all installed in mild environments, and have been demonstrated to work effectively in the expected radiation fields, even with prompt dose exposure rates. For harsh environments, which are not part of this LTR, Toshiba uses qualified cables. Section III-2.2.3 describes electromagnetic compatibility (EMC) test including EMI/RFI, Surge Withstand Capability (SWC), EFT, ESD, and Class-1E to Non Class-1E Isolation Tests of PRM. Section III-5.2.3 describes electromagnetic compatibility (EMC) test including EMI/RFI, Power Surge, EFT/B, and ESD tests of OPRM. The applicability of the RG 1.180, Revision 1, test levels will need to be evaluated for plant applications significantly different from the light water reactors surveyed to generate the levels in the regulatory guide. This activity would be a joint responsibility of Toshiba and the utility.
Staff Position 1.18 Provisions for communications should be analyzed for hazards and performance deficits posed by unneeded functionality and complication.	Comply	Section I-3.9 describes Software Safety Analysis, which includes hazard analyses. Toshiba analyzes communication hazards in the analysis. Section III-3.2.2 describes the FMEA performed for the PRM system. Section III-6.2.2 describes the FMEA performed for the OPRM system.
Staff Position 1.19 If data rates exceed the capacity of a communications link or the ability of nodes to handle traffic, the system will suffer congestion. All links and nodes should have sufficient capacity to support all functions. The applicant should identify the true data rate, including overhead, to ensure that communication bandwidth is sufficient to ensure proper performance of all safety functions. Communications throughput thresholds and safety system sensitivity to communications throughput issues should be confirmed by testing.	Comply	As documented in Section II-2.2.3.2.2, the FPGA-based system uses fiber optic links; and as documented in Section II-2.2.3.3, fixed length data packets are generated at specific times. Therefore, the fixed, designed, computed data rate cannot exceed the capacity of the links, and will not suffer congestion, since all data is transmitted in each message. The data links run at the same communication loading at all times. Operation of the links is tested continuously at the same loading, without regard to the plant conditions. This loading is tested during V&V activities, equipment qualification testing, Factory Acceptance Test, and continuously while the system operates, or is maintained.

NRC Guidance ISG-04	Compliance	Comments
Staff Position 1.20 The safety system response time calculations should assume a data error rate that is greater than or equal to the design basis error rate and is supported by the error rate observed in design and qualification testing.	Comply	The FPGA-based I&C systems uses fiber optic links for communications. According to the data sheet of the optic device, the error rate of data transmission is less than [ ]a,c The rate of occurring a single packet error is calculated as follows based on the design that the FPGA-based systems transmit [ ]a,c bits packet every [ ]a,c milliseconds: [ ]a,c (sec^{-1}) The rate of occurring successive packet error is calculated as follows: [ ]a,c (sec^{-1}) = [ ]a,c $(year^{-1})$ From this, it is unlikely that successive errors will occur. As documented in Section 3.3.6 of the NICSD's CDR Report, data packets are sent from a TRN module to a RCV module in fixed interval in such a way that the error detection time does not affect the compliance to the response time requirement. If a data error occurs in a packet, the RCV module discards the packet, and waits for the next packet. Therefore, occurrence of a recurring error can delay the issuance of a trip of one safety channel no more than three of the 1.016 millisecond periods. Since this failure is likely a hardware failure, the remaining channels should not be affected by it and would still operate without delay. The FPGA-based module vendor tested the optic transmission of the modules, and confirmed that no error was observed during a half day run.
2. Command Prioritization	---	---
Staff Positions 2.1 through 2.10	N/A	Does not apply to this LTR, since a priority logic module is not included in the PRM and OPRM. Neither the PRM nor the OPRM directly initiate equipment in the plant.
3. Multidivisional Control and Display Stations, including • **3.1, Independence and Isolation;** • **3.2, Human Factors Considerations; and** • **3.3 Diversity and Defense-in-Depth (D3) Considerations**	---	Does not apply to this LTR, since human-system interfaces in the operator consoles in the main control room are not included in this topical report.

IV-6 Document Mapping with DI&C ISG-06

Table IV-6-1 provides the mapping from the Digital Instrumentation and Controls Interim Staff Guidance (DI&C ISG)-06 (Reference (a23)) to the reference documents in this LTR. Toshiba concludes that the original process and the current process both comply with DI&C ISG-06 expectations. The Reference provided points to the section of the LTR that contains a summary of the item required by ISG-06. In that summary, references are usually provided to Toshiba documents containing more detailed information.

Table IV-6-1 Document Mapping with DI&C ISG-06

Items required by DI&C ISG-06 for LAR		Reference in the Current Process	Reference in the Original Process
1.1	Hardware Architecture Descriptions	Section II-2 FPGA System Description	Same as the current process.
1.2	Quality Assurance Plan for Digital Hardware	Section I-2.1 QA Program and Section I-3 Software/Hardware Development Process	Section I-A-3 QA Program in the original process and Section I-A-4 Software/Hardware Development in the original Process.
1.3	Software Architecture Description	Section II-2.1 FPGA Platform	Same as the current process.
1.4	Software Management Plan	Section I-3.2 Software Management Plan.	Section I-A-4.1 Software Management Planning and Practice.
1.5	Software Development Plan	Section I-3.3 Software Development Plan	Section I-A-4.2 Software Development Planning and Practice.
1.6	Software QA Plan	Section I-3.4 Software Quality Assurance Plan	Section I-A-4.3 Software Quality Assurance Planning and Practice.
1.7	Software Integration Plan	Section I-3.5 Software Integration Plan	Section I-A-4.4 Software Integration Planning and Practice.
1.8	Software Safety Plan	Section I-3.9 Software Safety Analysis	Section I-A-4.7 Software Safety Planning and Practice.
1.9	Software V&V Plan	Section I-3.10 Software V&V Plan	Section I-A-4.8 Software V&V Planning and Practice.
1.10	Software Configuration Management Plan	Section I-3.12 Software Configuration Management Plan	Section I-A-4.9 Configuration Management Planning and Practice.

Items required by DI&C ISG-06 for LAR		Reference in the Current Process	Reference in the Original Process
1.11	Software Test Plan	Section I-3.13 Software Test Plan	Section I-A-4.10 Software Test Planning and Practice.
1.12	Software Requirement Specification	To be addressed in the design specification documents. See Section I-3.3.2.	To be addressed in the design specification documents. See Section I-A-4.2.2.
1.13	Software Design Specification	See Section I-3.3.3.2 Module Design Specification (MDS) and Section I-3.3.3.3 FPGA Design Specification.	See Section I-A-4.2.2 Requirements Definition Phase and Section I-A-4.2.3 Design Phase.
1.14	Equipment Qualification Testing Plans (including EMI, Temperature, Humidity, and Seismic)	Section III-5 Qualification Test of OPRM.	Section III-2 Qualification Test of PRM.
1.15	D3 Analysis	Out of scope of the LTR, and addressed in the licensee's LAR See Section II-2.2.3.4 Diversity	Same as the current process.
1.16	Design Analysis Reports	Section III-6.2.1 Availability/Reliability Analysis of OPRM System of this LTR. Section III-6.2.2 FMEA for OPRM System of this LTR. Section III-6.2.3 Setpoint Support Analysis for OPRM System Section 6.3.1 of EPRI TR-107330 requires performing aging analysis. However, aging analysis is not necessary where equipment is qualified for use only in mild environments, where USNRC RG 1.209 (Reference (16a)) does not require equipment aging. Toshiba states that there are no significant aging mechanisms in this FPGA-based equipment.	Section III-3.2.1 Availability/Reliability Analysis of PRM System of this LTR. Section III-3.2.2 FMEA for PRM System of this LTR. Section III-3.2.3 Setpoint Support Analysis for PRM System. Section 6.3.1 of EPRI TR-107330 requires performing aging analysis. However, aging analysis is not necessary where equipment is qualified for use only in mild environments, where USNRC RG 1.209 (Reference (16a)) does not require equipment aging. Toshiba states that there are no significant aging mechanisms in this FPGA-based equipment.
1.17	System Description (To block diagram level)	Section II-2 FPGA System Description	Same as the current process.

Items required by DI&C ISG-06 for LAR		Reference in the Current Process	Reference in the Original Process
1.18	Design Report on Computer integrity, Test and Calibration, and Fault Detection	This item is addressed in the design specification documents and confirmed in the test plans/procedures and test reports which were verified in the V&V reports. Toshiba does not write a separate design report for these functions, as the functions are defined completely in existing documents, including the User's Manuals. Basically, these are same as the original process.	For each phase, NED prepared a V&V report to document that phase's V&V activities. The V&V report for the System Validation Testing Phase summarizes all V&V activities. Each V&V report contains the following information: Results of reviews of design, planning, review, and test documents. Results of RTM efforts. Results of reviews of hazard analyses. Summary of validation test results, as applicable. Problem reporting and corrective action, if any.
1.19	System Response Time Analysis Report	This item is addressed in the design specification documents.	The unit design specification specifies the performance.
1.20	Theory of Operation Description	This item is documented in the design specification documents and User's Manuals.	Theory of Operation Description is documented in the design specification documents and Users Manuals.
1.21	Setpoint Methodology	The setpoint analysis result is documented in Section III-6.2.3 Qualification Analysis of OPRM.	The setpoint analysis result is documented in Section III-3.2.3 Qualification Analysis of PRM.

Items required by DI&C ISG-06 for LAR		Reference in the Current Process	Reference in the Original Process
1.22	Vendor Software Plan	Toshiba has a complete set of software plans, customized to fit FPGA development. Those plans are outlined in Sections I-3 of this LTR. In accordance with IEEE Std 7-4.3.2, Clause 5.3.1, software quality assurance is incorporated in the Toshiba plans, procedures, and instructions. • Nuclear Energy Systems and Services Division FA32-3702-0005 "Nuclear Energy Systems and Services Division FPGA-based Safety-Related Systems Software Management Plan" (Reference (c2)) • Nuclear Instrumentation & Control Systems Department FA32-3702-1000 "Nuclear Instrumentation & Control Systems Department Software Management Plan for FPGA-based Safety-Related Systems" (Reference (c3)). See also Section I-3.2 Software Management Plan and Section I-3.4 Software Quality Assurance Plan.	The SQAP (Reference (d40)) addresses the plan for software quality assurance for the following activities. Also, V&V activities covered to review and approve vendor software Plan, and assure vendor's V&V activities include evaluation of: • Developing the logic for implementing functions for FPGAs. • Using a software tool suite to translate the VHDL code written by NICSD design engineers into fuse maps, to test the logic, and to embed the logic onto the FPGA chips. • Using software tool to test the FPGA chips. • Using commercially available software programs for the test equipment (e.g., data acquisition, signal generators, etc.) for: • Unit/Module Validation testing • System Validation and acceptance testing For these activities, the SQAP provides the following information: • A description of the project software Quality Assurance (QA) planning measures to be used to demonstrate how the project requirements are met. This description is provided for NED's basic approach in the SQAP. • A description of the required interactions between NED and NICSD and subcontractors. This description is provided in the SQAP where special provisions must be made to define an interaction or division of responsibilities between NED and NICSD. • A determination of the Software Integrity Level for the types of software covered by the SQAP. See Appendix A of this SQAP for the Software Integrity Levels to be used for the various types of software covered by the SQAP.

Items required by DI&C ISG-06 for LAR		Reference in the Current Process	Reference in the Original Process
1.23	Software Tool Verification Program	Nuclear Instrumentation & Control Systems Department FA32-3702-1000 "Nuclear Instrumentation & Control Systems Department Software Management Plan for FPGA-based Safety-Related Systems" (Reference (c3)). See also Section I-3.2 Software Management Plan. When Toshiba established the NQA-1 program, Toshiba performed a Critical Digital Review of Actel, to evaluate the Actel software tool life cycle and the Actel acceptance process for purchased software tools. The Toshiba V&V process was informed by the Actel evaluation. The current process and the original process are based on the same processes and evaluations.	NICSD engineers followed the NICSD standard when they use software tools in the design activities. In addition, NICSD performed necessary activities to ensure the reliability of the software tools. The activities include the following items: • Confirming that the software tools used are applicable to the project objectives. • Establishing the software tool Software Integrity Level based on the significance of the system where the tool will be used. • Establishing the software tool acceptance criteria, and determining if the software tool meets the criteria. • Establishing the software tool update criteria and the version control methods based on the criteria in accordance with the configuration management. • Establishing procedures to use the software tool, including the methods to record and resolve any errors in accordance with the configuration management. • Training and recording the personnel to use the software tool. NED V&V activities assure above NICSD activities.
1.24	Software Project Risk Management Program	Section I-3.2 Software Management Plan.	Section I-A-4.1 Software Management Planning and Practice.
1.25	Commercial Grade Dedication Plan	Section I-2.2 CGD in the current process.	Section I-A-3.2 CGD in the original process.
1.26	Vulnerability Assessment	This item was addressed in the V&V Report.	This item was addressed in V&V Report.
1.27	Secure Development and Operational Environment Control	Section I-3.14 Secure Development and Operational Environment (SDOE).	Section I-A-5 Cyber Security.
2.1	Safety Analysis	This item is addressed in the Software Safety Analysis Report. See also Section I-3.9 Software Safety Analysis.	This item is addressed in the Hazard Analysis Report. See also Section I-A-4.7 Software Safety Planning and Practices.
2.2	V&V Report	This item is addressed in the V&V reports. See also Section I-3.11 Software V&V Report and OPRM V&V report (Part VI).	This item is addressed in the V&V reports. See also Section I-A-4.8 Software V&V Planning and PRM V&V report (Part V).

Items required by DI&C ISG-06 for LAR		Reference in the Current Process	Reference in the Original Process
2.3	As-Manufactured, System Configuration Documentation	This item is addressed in the Master Configuration List. See also Section I-3.3.1.11 Configuration Management.	This item is addressed in the Master Configuration List. See also Section I-A-9 Configuration Management Planning and Practice.
2.4	Test Design Specification	This item was addressed in test plan, test procedures, and test reports.	This item was addressed in the test plan, test procedures, and test reports.
2.5	Summary Test Reports (Including FAT)	This item is addressed in test plan, test procedures, and test reports. FAT is out of scope for this project.	This item was addressed in the test plan, test procedures, and test reports. Summary V&V Reports, incorporating the Test Reports and Test Results, are provided for the PRM in Part V. FAT is out of scope for this project.
2.6	Summary of Test Results (Including FAT)	This item is addressed in test plans, test procedures, and test reports. FAT is out of scope for this project.	This item was addressed in the test plans, test procedures, and test reports. Summary V&V Reports, incorporating the Test Reports and Test Results, are provided for the PRM in Part V. FAT is out of scope for this project.
2.7	Requirement Traceability Matrix	This item is included in the Requirement Traceability Matrix (RTM) for each software lifecycle phase	This item was addressed in the RTM reports for each phase.
2.8	FMEA	This item is addressed in the FMEA report. See also Section III-6.2.2.	This item is addressed in the FMEA report. See also Section III-3.2.2.
2.9	System Build Documents	This item is listed in the OPRM Master Configuration List (Reference (c30)).	This item is listed in the PRM Master Configuration List (Reference (d48)).
2.10	This raw is left blank in the ISG-06 Enclosure B		
2.11	Qualification Test Methodologies	This item is addressed in the OPRM test plan. See also Section III-5 Qualification Test.	This item is addressed in the PRM test plan. See also Section III-2 Qualification Test.
2.12	Summary of Digital EMI, Temp., Humidity, and Seismic Testing Results	This item is addressed in the OPRM test report. See also Section III-5.2.	This item is addressed in the PRM test report. See also Section III-2.2.
2.13	As Manufactured Logic Diagrams	As-manufactured logic diagrams are available through the Netlist Viewer using the electronic files maintained in Toshiba's configuration management system.	Same as the current process.

Items required by DI&C ISG-06 for LAR		Reference in the Current Process	Reference in the Original Process
2.14	System Response Time Confirmation Report	The response time test was conducted in the software validation test. The result of the response time test is documented in Part VI.	The response time test was conducted in the Unit/Module Validation Testing. The result of the response time test is documented in Part V.
2.15	Reliability Analysis	This item is addressed in the OPRM reliability analysis report. See also Section III-6.2.1.	This item is addressed in the PRM reliability analysis report. See also Section III-3.2.1.
2.16	Setpoint Calculations	This item is addressed in the OPRM setpoint support analysis. See also Section III-6.2.3.	This item is addressed in the PRM setpoint support analysis. See also Section III-3.2.3.
2.17	Software Tool Analysis Report	When Toshiba established their NQA-1 program, Toshiba performed a Critical Digital Review (CDR) of Actel, to evaluate the Actel software tool life cycle and the Actel acceptance process for purchased software tools. See also Section I-2.2.2.	The FPGA software tools used in the project were reviewed using the CDR technique and a commercial grade survey of Actel (now Microsemi) for acceptance early in the project. See also Section I-A-3.2.2. In the Implementation & Integration (Implementation) Phase, the NICSD V&V team confirmed the control of the software tools used in the design and V&V activities. The NED V&V team reviewed the results of the activities and determined that NICSD controlled the tools appropriately throughout their use.
	Commercial Grade Dedication Report(s)	This item is addressed in the OPRM Commercial Grade Dedication (CGD) package, discussed in Section I-2.2.3.	This item was addressed in the PRM CGD package, discussed in Section I-A-3.2.3.
3.1	Software Integration Report	Since the programmable logic is installed in the FPGAs as part of the manufacturing process, the Commercial Grade Dedication discussion in Section I-2.2 of this LTR applies. The test reports and V&V reports issued for each testing provide the data normally expected in the software integration report. See also Section I-3.6 Software Integration Report.	Since the programmable logic is installed in the FPGAs as part of the manufacturing process, the Commercial Grade Dedication discussion in Section I-A-3.2 applies. The test reports and V&V reports issued for each testing provide the data normally expected in the software integration report.
3.2	Individual V&V Problem Report up to FAT	This item is addressed in the V&V reports (Part V of this LTR). See also Section I-3.11 Software V&V Report.	This item is addressed in the V&V reports (Part VI of this LTR). See also Section I-A-4.8 Software V&V Planning and Practice.
3.3	Configuration Management Report	This item is addressed in the OPRM Master Configuration List and the OPRM Baseline Review Report, which are discussed in Section I-3.12.	This item is addressed in the PRM Master Configuration List, which is discussed in Section I-A-4.9.

Items required by DI&C ISG-06 for LAR		Reference in the Current Process	Reference in the Original Process
3.4	Test Procedure Specification	This item is addressed in the test procedures, which are discussed in Section I-3-13.	This item is addressed in the test procedures, which are discussed in Section I-A-4.10.
3.5	Completed Test Procedure and Reports	This item is addressed in test procedures and test reports, which are discussed in Section I-3-13.	This item is addressed in the test procedure and test report, which are discussed in Section I-A-4.10.
3.6	Test Incident Reports	This item is addressed in the test reports, which are discussed in Section I-3-13.	This item is addressed in the test reports, which are discussed in Section I-A-4.10.
3.7	Code Listing	VHDL Code is discussed in Section I-3.3.4 of the LTR. The code is maintained electronically, and is available for inspection at the Fuchu Complex.	VHDL Code is discussed in Section I-A.4.2.4 of the LTR. The code is maintained electronically, and is available for inspection at the Fuchu Complex.
3.8	Software Project Risk Management Report	See Section I-3.2.5 Risk Management of this LTR. When the PM identifies any risks that may have considerable impacts on the project, the PM reports the risks to the customer in a timely manner.	See Section I-A-4.1.2 Project Management.
3.9	Circuit Schematics	This item is addressed in unit/module circuit diagrams, which are available for inspection at the Fuchu Complex.	Same as the current process.
3.10	Detailed System and Hardware Drawings	This item is addressed in equipment design specification documents.	Same as the current process.
4.1	Software Installation Plan	See Section I-3.5 Software Integration Plan. FPGA Software is installed in the Implementation and Integration Phase. Programmable logic is installed during the manufacturing process, with nuclear Quality Assurance oversight of the embedding process. The embedding process is part of the Commercial Grade Dedication program.	See Section I-A-4.4 Software Integration Planning and Practice.

Items required by DI&C ISG-06 for LAR		Reference in the Current Process	Reference in the Original Process
4.2	Software Maintenance Plan	NED has overall responsibility for maintenance, including deciding when a design change is necessary. NICSD is responsible to provide to NED any required or suggested changes identified by NICSD. If NED decides to change the design, NED requests NICSD to perform the change activity. Modifications and/or enhancements to FEs and FPGAs require that the NICSD design group follow the lifecycle process that focus on the design and development of the required or desired changes. After installation in a nuclear power plant, any modifications are tested at Toshiba and then installed and tested at the plant. Maintenance activities are as follows: • Identify software improvement needs. • Implement problem reporting method. • Reapply software lifecycle. • Update the design baseline. See also Section I-3.7.	Same as the current process. See also Section I-A-4.5.
4.3	Software Training Plan	Nuclear Energy Systems and Services Division FA32-3702-0005 "Nuclear Energy Systems and Services Division FPGA-based Safety-Related Systems Software Management Plan" (Reference (c2)) Nuclear Instrumentation & Control Systems Department FA32-3702-1000 "Nuclear Instrumentation & Control Systems Department Software Management Plan for FPGA-based Safety-Related Systems" (Reference (c3)). See also Section I-3.8 Software Training Plan. Customer training requirements will be designed on a plant-specific basis.	All Toshiba personnel involved in this project were trained based on requirements established in Toshiba plans, procedures, and instructions, and shall be trained based on the work each does, and their roles and responsibilities in the Toshiba organization. Training and training documentation by NED for the PRM system complied with the requirements documented in the NED Procedure for Indoctrination and Training. Training and training documentation by NICSD for the PRM System complied with the requirements documented in the NICSD Procedure for FPGA Products Development. See also Section I-A-4.6.
4.4	Software Operations Plan	Recommendations and requirements for operation and maintenance of the equipment are provided in the OPRM Unit User's Manual (Reference (c27)) which establishes methods to be used in applying the equipment.	Recommendations and requirements for operation and maintenance of the equipment are provided Instructions for the LPRM Unit (Reference (d45)), Instructions for the LPRM/APRM Unit (Reference (d46)), and Instructions for the FLOW Unit (Reference (d47)), which establish methods to be used in applying the equipment.

Items required by DI&C ISG-06 for LAR		Reference in the Current Process	Reference in the Original Process
4.5	Site Test Documentation	Site acceptance documentation will be prepared	Same as current process.
4.6	Operations Manual	This item is addressed in the OPRM Unit User's Manual (Reference (c27)).	This item is addressed in the Instructions for the LPRM Unit (Reference (d45)), Instructions for the LPRM/APRM Unit (Reference (d46)), and Instructions for the FLOW Unit (Reference (d47)).
4.7	Software Maintenance Manuals	See Section I-3.7 Software Maintenance Plan. Since utilities are not modifying the FPGA programmable logic, software maintenance activities are not performed by utility engineers.	Same as current process. See also Section I-A-4.5.
4.8	Software Training Manuals	Nuclear Energy Systems and Services Division FA32-3702-0005 "Nuclear Energy Systems and Services Division FPGA-based Safety-Related Systems Software Management Plan" (Reference (c2)) Nuclear Instrumentation & Control Systems Department FA32-3702-1000 "Nuclear Instrumentation & Control Systems Department Software Management Plan for FPGA-based Safety-Related Systems" (Reference (c3)). See also Section I-3.8 Software Training Plan. In addition, the User's Manuals will contain instructions for system-specific utility training activities for each system. Since utilities are not supplied with the programmable logic, software maintenance activities are not performed by utility engineers and training for such activities is not required.	All Toshiba personnel involved in this project was trained based on requirements established in Toshiba plans, procedures, and instructions, and were trained based on the work each does, and their roles and responsibilities in the Toshiba organization. Training and training documentation by NED for the PRM system complied with the requirements documented in NED Procedure for Indoctrination and Training. Training and training documentation by NICSD for the PRM System complied with the requirements documented in NICSD Procedure for FPGA Products Development. See also Section I-A-4.6.
4.9	Installation Configuration Tables	This item is listed in the system specific Master Configuration List. See also Section I-3.12.	This item is listed in the system specific Master Configuration List. See also Section I-A-4.9.

IV-7 Correspondence of Toshiba Process to RG 1.152

Table IV-7-1 documents correspondence of Toshiba process to RG 1.152 (Reference (a11)).

Table IV-7-1 Correspondence of Toshiba Process to RG 1.152

RG 1.152	Toshiba Process
2.1 Concepts Phase	This Concept Phase corresponds to the Project Planning and Concept Definition Phase in the Toshiba process. Section I-3.3.1 describes the Project Planning and Concept Definition Phase in the current process. Section I-A-4.2.1 describes the Project Planning and Concept Definition Phase in the original process. In the security review in the Project Planning and Concept Definition Phase, NICSD evaluated access control to design deliverables in servers and security of PCs (see also Part VI of this LTR).
2.2 Requirements Phase	This Requirements Phase corresponds to the Requirements Definition Phase in the Toshiba process. Section I-3.3.2 describes the Requirements Definition Phase in the current process. Section I-A-4.2.2 describes the Requirement Definition Phase in the original process.
2.2.1 System Features	Toshiba defines the security requirements for the external interfaces, the physical system, the functional system, and the programmable logic. The requirements are based on the requirements defined in the previous phase, which ensures that a secure operational environment will exist in the finished system. Communication links are carefully considered in the system designs, with the preference for uni-directional communication out of the safety system being designed and into other systems. Toshiba does not embed commercial products or products developed by others in the Toshiba-designed programmable logic, so Toshiba is completely aware of the capabilities or vulnerabilities of each item used in the system.
2.2.2 Development Activities	All requirements are subject to the V&V activities including independent reviews, traceability analyses, and validation testing throughout the software lifecycle phases. Requirements Traceability Matrices (RTMs) are maintained to ensure that only requirements defined in the upstream documents are implemented in the final system, which helps prevent the introduction of unnecessary or extraneous requirements in the Requirements Definition Phase. Section I-3.14.2 describes the RTM activities in the current process. Part V documents the V&V activities for the PRM.
2.3 Design Phase	This Design Phase corresponds to the Design Phase in the Toshiba process. Section I-3.3.3 describes the Design Phase in the current process. Section I-A-4.2.3 describes the Design Phase in the original process.

RG 1.152	Toshiba Process
2.3.1 System Features	The security requirements defined in the Requirements Definition Phase are translated into designs for both modules and FPGAs. The concepts and requirements for a secure operational environment are incorporated into the Toshiba design. Section I-3.14 describes the secure operation environment in the current process. Section I-A-5 describes the secure operation environment in the original process. In the Project Planning and Concept Definition Phase, the security assessment evaluates the absence of remote access and use of uni-directional communication. The RTM ensures that the design reflects the result of the security assessment. Section I-3.9.2 describes requirement management activities in the current process. Part V documents the V&V activities for the PRM.
2.3.2 Development Activities	The RTM ensures that the design reflects the result of the security assessment. Section I-3.14.2 describes requirement management activities in the current process. Part V documents the V&V activities for the PRM.
2.4 Implementation Phase	This Implementation Phase corresponds to the Implementation and Integration Phase in the Toshiba process. Section I-3.3.4 describes the Implementation and Integration Phase in the current process. Section I-A-4.2.4 describes the Implementation and Integration Phase in the original process.
2.4.1 System Features	The FPGA design is translated into programmable logic. The NICSD V&V Team verifies the translation. Section I-3.3.4 describes the activities in the current process. Section I-A-4.2.4 describes the activities in the original process.
2.4.2 Development Activities	The NICSD V&V Team conducts security reviews to identify any potential susceptibilities to inadvertent access from external sources, by searching for hidden functions or vulnerable features embedded in the code. If any vulnerable feature found, the feature is modified, removed, or appropriate mitigation measures are taken. Based on the tested nature of Functional Elements and the requirement that all code be implemented using only 100% tested Functional Elements, the basic building blocks of the programmable logic are verified and validated to be free of unnecessary and inappropriate coding. Section I-3.10.2 describes the activities in the current process. Part V documents the activities for the PRM.
2.5 Test Phase	This Test Phase corresponds to the Module Validation Testing and the System Validation Testing Phases in the Toshiba process. Testing is performed on modules with integrated FPGAs, on units (i.e., chassis) with the required modules, and on the complete, integrated system. Section I-3.3.5 describes the Module Validation Testing Phase and Section I-3.3.6 describes the System Validation Testing Phase in the current process. Section I-A-4.2.5 describes the Unit/Module Validation Testing Phase and Section I-A-4.2.6 describes the System Validation Testing Phase in the original process.
2.5.1 System Features	Toshiba performs the Module Validation Testing and the System Validation Testing for all requirements including security requirements and for the integrated system. Section I-3.3.5 describes the Module Validation Testing Phase and Section I-3.3.6 describes the System Validation Testing Phase in the current process. Section I-A-4.2.5 describes the Unit/Module Validation Testing Phase and Section I-A-4.2.6 describes the System Validation Testing Phase in the original process.

RG 1.152	Toshiba Process
2.5.2 Development Activities	In the Module Validation Testing and the System Validation Testing Phases, Toshiba tests communication links between the TRN and RCV modules. The result of the Unit/Module Validation Testing and the System Validation Testing of PRM are documented in Part V of this LTR. The result of the Module Validation Testing and the System Validation Testing of OPRM are documented in Part VI of this LTR.