ENCLOSURE 5

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Commercial Grade Dedication Plan for FPGA-based Safety-Related Systems

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NRW-FPGA-Based I&C System Qualification Project

Commercial Grade Dedication Plan

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1 Introduction

1.1 Purpose

The purpose of this Commercial Grade Dedication Plan (CGD Plan) is to describe the dedication plan for commercial grade items comprising the Non-Rewritable (NRW) Field Programmable Gate Array (FPGA)-based safety-related systems for use as basic components in US nuclear power plants. This plan documents methods for safety classification of system, and describes the activities required for the dedication of Commercial Grade Items (CGIs) and Commercial Grade Services (CGSs) used for this project.

1.2 Background

Nuclear Instrumentation & Control Systems Department (NICSD) procures modules from a commercial supplier, Power Platform Development Department (PPDD), through the NICSD CGD process. PPDD designs and manufactures modules under a commercial QA program. For typical CGD processes, a commercial product is produced and then CGD is performed to qualify the commercial product for use in a safety-related application. However, since FPGA development follows a typical software life cycle, waiting for a completed product to perform CGD is inappropriate for verification of software dependability. NICSD performs necessary activities in each life cycle phase that support a final CGD of the completed modules. NICSD oversees PPDD activities during each life cycle phase with PPDD involvement. This ensures that the FPGA development is acceptable as it proceeds through the life cycle. A module's CGD can only be completed when the completed module is delivered to and accepted by NICSD.

The NICSD CGD process complies with EPRI NP-5652 (Reference (3)), which has been endorsed by the USNRC. NICSD developed its own commercial grade acceptance process based on the process described in EPRI TR-102260 (Reference (4)), EPRI TR-106439 (Reference (5)) in development of the evaluation and CGD process for FPGA Instrumentation and Control (I&C) systems.

NICSD also procures unit chassis, cables, and other equipment that do not include FPGA or software from commercial suppliers, through the NICSD CGD process.

1.3 Scope

This CGD Plan applies to the dedication activities of each project for FPGA-based safety-related system. This CGD Plan applies to the dedication activities to be followed by NICSD. This CGD Plan complies with the following sections of the NICSD Software Management Plan (Reference (22)):

- Section 8.1.2, Software Development Tool Control
- Section 11, Use of Previously Developed or Purchased Software
- Section 13, Software Development Plan

This CGD Plan does not cover planning of Equipment Qualification (EQ) and Electromagnetic Compatibility (EMC) testing that is described in separate plans.

Existing Nuclear Energy Systems & Services Division (NED) AS standards and NICSD Nuclear Quality (NQ) standards are used for preparation of this CGD Plan and dedication activities to the extent described in the followings.

(1) AS-200A-110 (Reference (7))

This standard is applicable for documentation of technical evaluations at the system or sub-system level and acceptance activities. The CGD Plan is called a dedication plan in this standard.

The procedures prescribed in Paragraph 3.1 are applied for CGD planning, Paragraph 3.2.1 for developing a Preliminary Technical Evaluation Report (PTER), Paragraph 3.2.4 for developing a Final Technical Evaluation Report (FTER), and Paragraph 4.1 for preparing a CGD package.

In this CGD Plan methods to identify system safety functions and design requirements, to classify component functions, and to determine CGIs and CGSs are described. System safety classification, component function classification and CGI/CGS identification are documented in a concrete form in the PTER.

(2) NQ-4001 (Reference (16))

This standard is applicable for preparing a Commercial Dedication Instruction (CDI) to document a CGD process for each individual item procured. This standard is also applicable for preparing a CGD report to document a result of acceptance activities for each item.

(3) AS-200A111 (Reference (8))

This standard is used as a guide in developing a CGI acceptance policy. If a CDI is prepared, an Acceptance Plan for CGD (see Exhibit-1 attached therein) needs not be prepared. As a format of Source Verification Check Sheet, Exhibit-3 is applied. Other formats attached are not to be applied.

(4) AS-200A-112 (Reference (9))

This standard is used as a guide in developing an acceptance policy for commercial grade services. If a CDI is prepared, an Acceptance Plan for CGD (see Exhibit-1 attached therein) needs not be prepared. As a format of Source Verification Check Sheet, Exhibit-3 is applied. Other formats attached are not to be applied.

2 Definitions and Abbreviations

2.1 Definitions

Basic component: (1)(i) When applied to nuclear power plants licensed under 10 CFR part 50 or part 52 of this chapter, basic component means a structure, system, or component, or part thereof that affects its safety function necessary to assure:

(A) The integrity of the reactor coolant pressure boundary;

(B) The capability to shut down the reactor and maintain it in a safe shutdown condition; or

(C) The capability to prevent or mitigate the consequences of accidents which could result in potential offsite exposures comparable to those referred to in § 50.34(a)(1), § 50.67(b)(2), or § 100.11 of this chapter, as applicable.

(ii) Basic components are items designed and manufactured under a quality assurance program

complying with appendix B to part 50 of this chapter, or commercial grade items which have successfully completed the dedication process.

(Definitions (2) and (3) are omitted.)

(4) In all cases, basic component includes safety-related design, analysis, inspection, testing, fabrication, replacement of parts, or consulting services that are associated with the component hardware, design certification, design approval, or information in support of an early site permit application under part 52 of this chapter, whether these services are performed by the component supplier or others.

[This definition is extracted from 10 CFR 21 (Reference (1)).]

Commercial grade item: (1) When applied to nuclear power plants licensed pursuant to 10 CFR Part 30, 40, 50, 60, commercial grade item means a structure, system, or component, or part thereof that affects its safety function, that was not designed and manufactured as a basic component. Commercial grade items do not include items where the design and manufacturing process require in-process inspections and verifications to ensure that defects or failures to comply are identified and corrected (i.e., one or more critical characteristics of the item cannot be verified). (Definition (2) is omitted.)
[This definition is extracted from 10 CFR 21 (Reference (1)).]

(3) For the purpose of this procedure, commercial grade item also means a commercial service that was not intended to be relied upon as an activity affecting quality, or was not considered part of a basic component (e.g., safety-related design, analysis, inspection, testing, or fabrication that is associated with a basic component). (This is a definition of commercial grade service)

[This definition is extracted from NQ-4001 (Reference (16)).]

Commercial-Off-The-Shelf (COTS): This term (COTS) is defined to be software purchased from a vendor, which is not modified to support plant requirements, but may be configured to support plant requirements. This definition does not vary for safety or nonsafety life cycles.
[This definition is extracted from the NICSD SMP (Reference (22))]

In this plan, the Functional Elements (FEs) are treated as previously developed COTS software.

Functional Element (FE): A Functional Element is a component of digital logic that is completely verified and validated through full pattern testing, i.e. tests that are performed for all possible input combinations. An FE is written in Very High Speed Integrated Circuit Hardware Description Language (VHDL). All VHDL source codes for the NRW-FPGA-based System solely consist of FEs and interconnect between FEs.
[This definition is extracted from the NICSD SMP (Reference (22))]

Module: A part of a unit. Each module consists of one or more printed circuit boards, on which the FPGAs and other circuitry are mounted, and a front panel.
[This definition is extracted from the NICSD SMP (Reference (22))]

Previously Developed Software (PDS): This term (PDS) is defined to be software that a vendor wrote, or purchased from another vendor, at an earlier date, which might be used as-is, or more likely will be modified to support plant requirements. This definition does not vary for safety or nonsafety life cycles.
[This definition is extracted from the NICSD SMP (Reference (22))]

In this plan, FPGA logic is treated as PDS.

Unit: A major component of FPGA-based equipment. A unit is a chassis that has front slots and back slots to mount modules. Each unit consists of several modules. There is a vertical middle plane between the front and back slots in each unit. This plane consists of two circuit boards. These circuit boards provide backplanes for the front and rear modules. Modules plug into the backplanes using connectors. Once a module is plugged into the appropriate

connector, it exchanges data with other modules in the unit, connects to other units and any external field equipment, and is powered.
[This definition is extracted from the NICSD SMP (Reference (22))]

2.2 Abbreviations

CC	Critical Characteristic
CCA	Critical Characteristics for Acceptance
CCD	Critical Characteristics for Design
CDI	Commercial Dedication Instruction
CDR	Critical Digital Review
CFR	Code of Federal Regulations
CGD	Commercial Grade Dedication
CG	Commercial Grade
CGI	Commercial Grade Item
CGS	Commercial Grade Service
C of C	Certificate of Conformance
COTS	Commercial-Off-The-Shelf
DDS	Detailed Design Specification
DRM	Design Review Meeting
ECWD	Elementary Control Wiring Diagram
EDS	Equipment Design Specification
EMC	Electromagnetic Compatibility
EPRI	Electrical Power Research Institute
EQ	Equipment Qualification
FE	Functional Element
FTER	Final Technical Evaluation Report
FMEA	Failure Mode Effect Analysis
FPGA	Field Programmable Gate Array
I&C	Instrumentation and Control
IV&V	Independent Verification and Validation
MCL	Master Configuration List
NED	Nuclear Energy Systems & Services Division
NICSD	Toshiba Fuchu-PS, Nuclear Instrumentation & Control Systems Department
NICS-QA	Quality Assurance Group for Nuclear Instrumentation & Control Systems
NICS-QC	Quality Control Group for Nuclear Instrumentation & Control Systems
NQ	Nuclear Quality
NRW	Non-Rewritable
PDS	Previously Developed Software
PPDD	Power Platform Development Department
PPS	Procurement Planning Sheet
PTER	Preliminary Technical Evaluation Report
QA	Quality Assurance
QC	Quality Control
SDD	System Design Description
SD Team	Software Development Team
SMP	Software Management Plan
SQA	Software Quality Assurance
SS Team	Software Safety Team
SVR	Source Verification Report
TDMS	Toshiba Design and Manufacturing Service Corporation

USNRC	United States Nuclear Regulatory Commission
V&V	Verification and Validation
VHDL	Very High Speed Integrated Circuit Hardware Definition Language

3 References

(1) USNRC 10CFR21
"Reporting of Defects and Noncompliance."

(2) USNRC Generic Letter 89-02
"Actions to Improve the Detection of Counterfeit And Fraudulently Marked Products"

(3) EPRI NP-5652"Utilization of Commercial Grade Items in Nuclear Safety Related Applications," March 1988

(4) EPRI TR-102260, "Supplement Guidance for the Application of EPRI Report NP-5652 on the Utilization of Commercial Grade Items," March 1994

(5) EPRI TR-106439, "Guideline on Evaluation and Acceptance of Commercial Grade Digital Equipment for Nuclear Safety Applications," October 1996

(6) Toshiba Nuclear Energy Systems and Service Division AS-200A008
"Procurement Planning Procedure"

(7) Toshiba Nuclear Energy Systems and Service Division AS-200A110
"Procedure for commercial grade items and services"

(8) Toshiba Nuclear Energy Systems and Service Division AS-200A111
"Acceptance Procedure for Commercial Grade Items"

(9) Toshiba Nuclear Energy Systems and Service Division AS-200A112
"Acceptance Procedure for Commercial Grade Services"

(10)Toshiba Nuclear Energy Systems and Service Division AS-300A003
"Procedure for Source Verification"

(11)Toshiba Nuclear Energy Systems and Service Division AS-300A005
"Preparation Procedure for Source Verification"

(12)Toshiba Nuclear Instrumentation & Control Systems Department NQ-2025
"Preparation Procedure for Procurement Document for CG Items & Services"

(13)Toshiba Nuclear Instrumentation & Control Systems Department NQ-2026
"Control Procedure of supplier generated documents"

(14)Toshiba Nuclear Instrumentation & Control Systems Department NQ-3005
"Procedure for Evaluation of Suppliers"

(15)Toshiba Nuclear Instrumentation & Control Systems Department NQ-3024
"Receiving Inspection Procedure"

(16)Toshiba Nuclear Instrumentation & Control Systems Department NQ-4001
"Commercial Grade Dedication"

(17)Toshiba Power Platform Development Department E-68016
"PPDD Procedural Standard for FPGA Products Development"

(18)Toshiba Power Platform Development Department E-68017
"PPDD Procedural Standard for FPGA Device Development"

(19)Toshiba Power Platform Development Department E-68018
"PPDD Procedural Standard for Functional Element Development"

(20)Toshiba Power Platform Development Department E-68019
"PPDD Procedural Standard for FPGA Configuration Management"

(21)Toshiba Power Platform Development Department E-68020
"PPDD Procedural Standard for Control of Software Tools for FPGA-based Systems"

(22)Toshiba Project Document Number FA32-3702-1000
"Nuclear Instrumentation & Control Systems Department Software Management Plan for FPGA-based Safety-Related Systems" Rev.0

Notice: When NED, NICSD and other Toshiba internal standards listed above are applied, the latest version of them shall be used.

4 Organizations and Responsibilities

4.1 Organizations

Figure 5-1 of the NICSD SMP (Reference (22)) shows organizations responsible for development of FPGA-based systems software design. NICSD is responsible for detailed design of the FPGA based system, procures modules for the FPGA based equipment from the Power Platform Development Department (PPDD), and assembles the FPGA based equipment from the modules. PPDD designs the modules, and tests the FPGAs and the modules. PPDD procures a service for manufacturing the designed modules from Toshiba Design and Manufacturing Service Corporation (TDMS). NICSD oversees PPDD activities.

4.2 Responsibilities

General responsibilities of each organization performing safety-related software lifecycle activities are described in Section 5.2 of the NICSD SMP (Reference (22)). This section describes responsibilities of the organizations regarding to dedication activities.

The NICSD Software Development (SD) Team shall be responsible for technical evaluation of FPGA logic and FEs, and shall prepare the following dedication documents:

- CGD Plan
- Preliminary Technical Evaluation Report (PTER)
- Procurement Planning Sheet (PPS)
- Commercial Dedication Instruction (CDI)
- Procurement Document
- Critical Digital Review (CDR) Report
- CGD Report
- Final Technical Evaluation Report (FTER)
- CGD Package

The NICSD SD Team shall be responsible for determining the acceptance methods and criteria for CGIs and CGSs. Quality Assurance Group for Nuclear Instrumentation & Control Systems (NICS-QA) shall conduct a Commercial Grade Survey (CG Survey) when required by the NICSD SD Team, and prepare a CG Survey Report. Quality Control Group for Nuclear Instrumentation & Control Systems (NICS-QC) is responsible for conducting source verification

of supplier (Method 3), receiving inspection of CGIs, and special inspection and test (Method1) in accordance with the instruction specified by the NICSD SD Team.

The NICSD SD Team and the NICSD Independent Verification and Validation (IV&V) Team with support from the NICSD Software Quality Assurance (SQA) Team shall perform evaluations of FPGA logic and FEs. The NICSD Software Safety (SS) Team shall participate in the evaluations. The NICSD SD Team, NICSD IV&V Team, and NICSD SS Team shall ensure completion, documentation, and maintenance of these evaluations.

The NICSD IV&V Team is responsible for reviewing supplier's design and test documents.

The NICSD SS Team is responsible for safety analysis activities for module and FPGA design, VHDL source code, FPGA and module testing in accordance with Sections 11.2.1, 14.4, 14.5 and 14.6 of the NICSD SMP (Reference (22)), and document the result of the analysis in the NICSD Software Safety Analysis Reports.

Table-A of the NICSD SMP lists the types of documents generated by NICSD throughout the life cycle phases for the FPGA-based systems.

5 Method to Identify Safety Functions and Design Requirements

5.1 Safety Functions and Safety Classification of System

The NICSD SD Team shall identify documents describing safety functions and design requirements at the system or sub-system level (i.e., parent components) such as technical requirements that are attached to a purchase order issued by customer or the System Design Description (SDD) issued by Nuclear Energy Systems & Services Division (NED), and list those documents in the PTER in order to identify the safety functions and design requirements therein.

5.2 Design Requirements for System

The NICSD SD Team shall identify documents describing design requirements at the system or sub-system level (i.e., parent components) such as technical requirements that are attached to a purchase order issued by customer or the System Design Description (SDD) issued by NED, and list those documents in the PTER in order to identify the design requirements therein.

The NICSD SD Team shall identify the Equipment Design Specification describing equipment specifications at the component level determined based on parent component design requirements, and list the specification in the PTER in order to identify the equipment specifications therein.

5.3 Environmental Considerations

Environmental qualification requirements including Equipment Qualification (EQ) and EMC qualification requirements are design conditions to be considered, since those requirements are necessary to determine Critical Characteristics (CCs), which are derived for satisfying them. Those qualification requirements are, however, not CCs in themselves.

The NICSD SD Team shall identify documents describing environmental qualification requirements such as technical requirements that are attached to a purchase order issued by

customer or the System Design Description (SDD) issued by NED, and list those documents in the PTER in order to identify the environmental requirements therein.

The NICSD SD Team shall identify the Equipment Design Specification describing qualification test requirements for equipment, and list the specification in PTER in order to identify the qualification test requirements for equipment therein.

6 Method to Identify CGI and CGS

This section describes methods for functional classification of items and services.

The NICSD SD Team shall classify the each component comprising target system and relevant services into the following classes, and document the functional classification in PTER.

(1) Having a safety function

(2) Having an effect on performance of the system safety function

(3) Other than (1) and (2) (non-safety)

The NICSD SD Team shall identify whether the items and services that have safety functions conform to the definition of commercial grade item (Refer to Section 2.1) or not, and document the CGI and CGS identification in PTER

7 Commercial Grade Dedication Process

Figure 13-1 of NICSD SMP (Reference (22)) shows a simplified diagram of the process flow throughout the life cycle phases for the FPGA-based systems. After NICSD receives design inputs from NED, NICSD performs activities of the Project Planning and Concept Definition Phase and Requirements Definition Phase under the NICSD Appendix-B QA program (Sections 7.3 and 7.4). During the Requirements Definition Phase, NICSD conducts a vendor evaluation before ordering from PPDD (Section 7.4.5). NICSD oversees the PPDD activities from Design Phase through Module Validation Testing Phase. NICSD involvement with PPDD activities in detail is described in the subsections in Section 7.5. After NICSD receives the modules from PPDD, NICSD integrates FPGA-based systems and conducts System Validation Testing (Section 7.6).

The Figure 7-1 shows the overview of dedication steps and relation of CGD documentation.

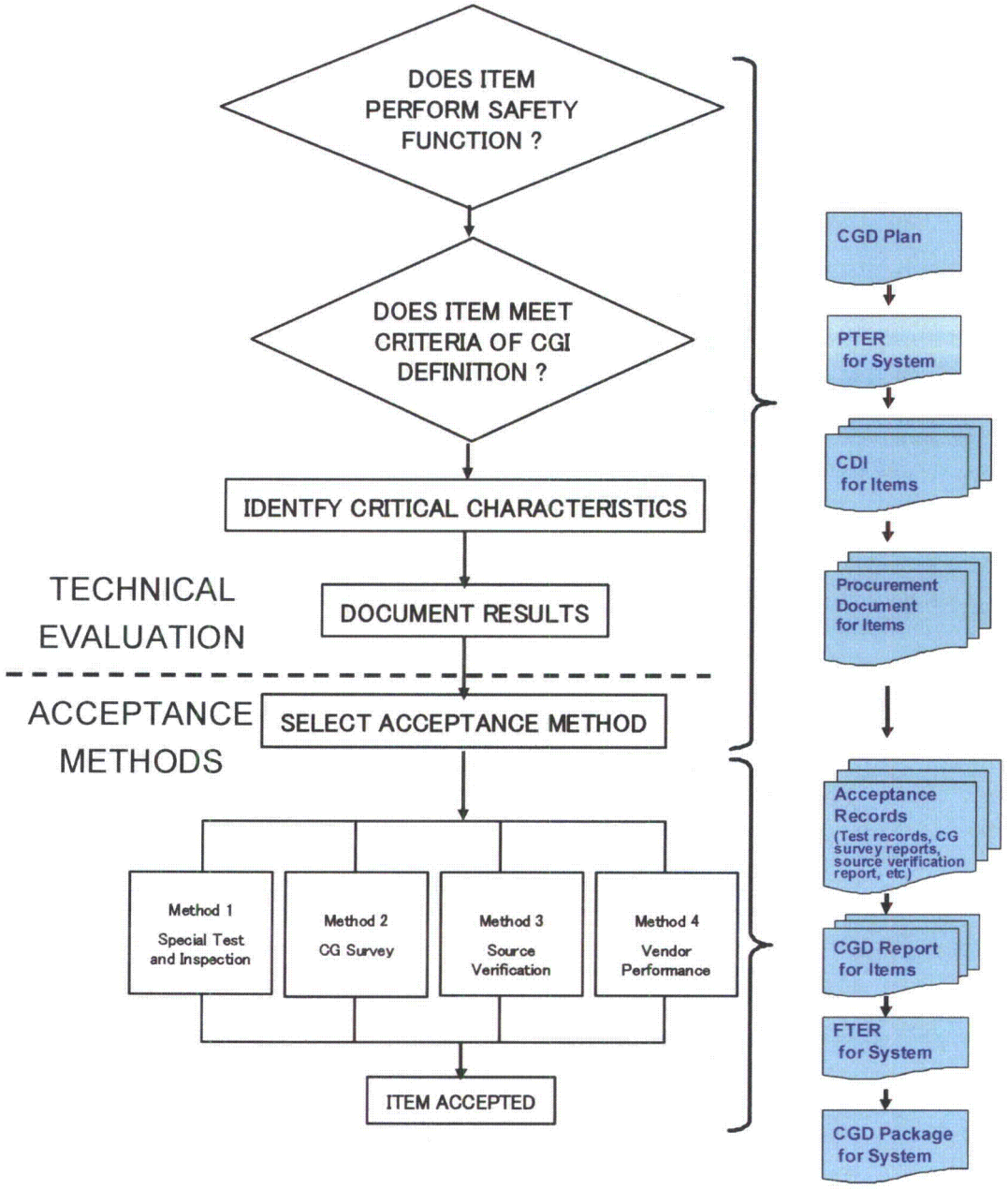

Figure 7-1 Overview of Dedication Steps and Relation of CGD Documentation.

7.1 Explanation of Acceptance Methods

(1) Method 1: Special Test and Inspection

The special tests and inspections can be conducted during or after receipt of an item to verify CCs. If the NICSD SD Team defines in the CDIs that a special test and inspection is one of the acceptance method, the NICSD SD Team shall issue a special test specification before special testing. NICS-QC shall conduct the special test in accordance with the special test specification, and prepare the special test record as an acceptance record.

(2) Method 2: Commercial Grade Survey of Supplier (Vendor Survey)

Per Generic Letter 89-02 (Reference (2)), Methods 2 shall not be employed as the basis for accepting items from suppliers with undocumented commercial quality control programs or with programs that do not effectively implement their own necessary controls. Likewise, Method 2 shall not be employed as the basis for accepting items from distributors unless the survey includes the part manufacturer(s) and the survey confirms adequate controls by both the distributor and the part manufacturer(s).

The survey is a means by which the purchase can take credit for the commercial controls that the supplier exercises on a given item. If the NICSD SD Team defines in the CDIs that a CG Survey is one of the acceptance method, NICS-QA shall conduct a CG Survey and prepare a CG Survey Report in accordance with NQ-3005 (Reference (14)).

(3) Method 3: Source Verification

Method 3 involves the verification of CCs by witnessing quality activities before releasing the item for shipment. The NICSD QC inspector conducts source verification in accordance with AS-300A003 "Procedure for Source Verification" (Reference (10)). The NICSD SD Team shall define acceptance criteria for source verification in the CDIs. The results of the source verification are documented in a Source Verification Report (SVR) in accordance with AS-300A005, "Preparation Procedure for Source Verification" (Reference (11)) and Exhibit-3 of AS-200A111 (Reference (8)).

(4) Method 4: Acceptable Supplier/Item Performance (Vendor Performance)

Method4 allows the purchaser to accept CGIs based upon a confidence in the supplied item achieved through proven performance of the item. Per Generic Letter 89-02 (Reference (2)), Method 4 shall not be employed alone. Necessary documentation requirements when applying Method 4 is described in NQ-4001 (Reference (16)).

7.2 Dedication of FPGA-based Module

Special consideration shall be given to the following two items regarding dedication of FPGA-based modules:

(1) Dependability of FPGA-based Module

Since an FPGA-based module is developed through a lifecycle process equivalent to that of software development, dependability shall be considered for dedication of FPGA-based modules. Sections 7.4.5 and 7.5.1 describe CGD processes to effectively verify dependability of FPGA-based modules.

More detailed description of an acceptance process to verify dependability of FPGA-based modules is provided in PTER. PTER also includes documentation of results from a preliminary vendor evaluation. PTER is updated to incorporate additional evaluation results as needed.

(2) Evaluation of FPGA Supply Chain

In order to supplement the verification of FPGA-based module dependability, the supply chain of FPGA devices, which are critical parts to implement safety functions, shall be thoroughly evaluated. FPGAs to be used for Toshiba FPGA-based systems are from Microsemi (Actel)'s SX-A series. More detailed methods of an evaluation of FPGA supply chain is provided in PTER.

The following sections describe dedication activities for FPGA-based safety-related systems. The phases identified are consistent with the FPGA-based system life cycle defined in Table 13-1 of the NICSD SMP (Reference (22)).

7.3 Project Planning and Concept Definition Phase

7.3.1 Equipment Design Specification (EDS)

Based on a System Design Description (SDD) and other technical requirements provided by NED, the NICSD SD Team prepares an EDS that breaks down system level requirements into equipment design requirements.

7.3.2 CGD Plan

The NICSD SD Team prepares a CGD Plan (this document) for FPGA based system to describe a dedication plan for commercial grade items and services.

7.3.3 Preliminary Technical Evaluation Report (PTER)

The NICSD SD Team prepares a PTER for each FPGA-based system to document safety classification of system, and identify Critical Characteristics for Design (CCD) typically applicable to components comprising system (i.e. whole component) in accordance with AS-200A110 (Reference (7)). The PTER also identifies Critical Characteristics for Acceptance (CCA), and acceptance methods as an acceptance plan that provides acceptance process typically applicable to components comprising system.

7.3.4 Procurement Planning Sheet (PPS)

The NICSD SD Team shall prepare PPS to schedule procurement and vendor evaluation activities in accordance with AS-200A008 "Procurement Planning Procedure" (Reference (6))

7.4 Requirements Definition Phase

7.4.1 Unit Detailed Design Specification (Unit DDS)

The NICSD SD Team prepares a Unit DDSs for each unit comprising the FPGA-based system. The Unit DDSs provides design requirements for each module and unit chassis comprising a unit.

7.4.2 Equipment Schematic

The NICSD SD Team designs hardware connections for test system based on the EDS and Unit DDSs. The NICSD SD Team prepares an Elementary Control Wiring Diagram (ECWD) to define detailed hardware connections of system and design requirements for cables and other equipment comprising the FPGA-based system.

7.4.3 Commercial Dedication Instruction (CDI)

The NICSD SD Team shall prepare a CDI for each CGIs and CGSs used for project in accordance with NQ-4001 (Reference (16)). The CDI identifies Critical Characteristics, acceptance plan that includes acceptance criteria, and methods. The NICSD SD Team performs an Failure Mode Effect Analysis (FMEA) to determine their critical characteristics.

As for dedication of FPGA-based modules, the NICSD SD Team evaluates a design package for each module that is controlled by PPDD. The design package includes a list of design documents, manufacturing documents, a parts list, a FPGA Control Sheet and so on. The NICSD SD Team evaluates Module Design Specifications, manufacturing drawings and test results, and assesses if the module design has a potential to perform its intended functions set forth in the Unit DDS.

The NICSD SD Team documents these evaluations into a CDI and identifies in the CDI those requirements for item design modification, additional documents and additional quality, if any.

7.4.4 Procurement Document

The NICSD SD Team shall prepare a procurement documents for each CGIs and CGSs used for project in accordance with NQ-2025, "Preparation Procedure for Procurement Document for CG Items & Services" (Reference (12)). The procurement document includes technical requirements and QA requirements. The technical requirements are applicable design requirements for commercial grade items derived from the Unit DDS or equipment schematics. The QA requirements identify applicable quality assurance requirements for commercial grade items and services.

The followings shall be taken into account in preparing a procurement document to be provided to PPDD.

The procurement document to PPDD shall identify procedures to be followed by PPDD for building software. PPDD has the following development procedures for commercial grade item development. An applicable revision of the following procedures identified through the vendor evaluation described in Section 7.4.5 shall be specified in the procurement document to be provided to PPDD.

- "PPDD Procedural Standard for FPGA Products Development," E-68016 (Reference (17));
- "PPDD Procedural Standard for FPGA Device Development," E-68017 (Reference (18));
- "PPDD Procedural Standard for Functional Element Development," E-68018 (Reference (19));
- "PPDD Procedural Standard for FPGA Configuration Management," E-68019 (Reference (20)); and
- "PPDD Procedural Standard for Control of Software Tools for FPGA-based Systems," E-68020 (Reference (21)).

In the procurement documents, a necessary right of access shall be requested.

7.4.5 Vendor Evaluation

The NICS-QA shall conduct a vendor evaluation for commercial suppliers as scheduled in the PPSs in accordance with NQ-3005 (Reference (14)).

The followings shall be taken into account in conducting a vendor evaluation to PPDD.

The NICSD SD Team shall perform an evaluation of FPGA logic as a part of technical

evaluation activities described in Section 11.2.1 of the NICSD SMP (Reference (22)). The NICSD SD Team shall perform an evaluation of FEs as a part of technical evaluation activities described in Section 11.2.2 of the NICSD SMP. The NICSD SD Team shall review a document of software coding conventions and guidelines provided by PPDD as a part of technical evaluation activities described in Section 11.3 of the NICSD SMP.

As described in Section 13.8 of the NICSD SMP, the NICSD SD Team shall conduct a vendor evaluation for PPDD and Actel (Microsemi) with support from the NICSD IV&V Team, SQA Team, SS Team and NICS-QA. The evaluation shall be conducted before issuing a Job Order to PPDD.

The followings shall be evaluated at a minimum.

- PPDD's control over critical characteristics identified in the PTER, or CDIs.
- Evaluation of software development tools as described in Section 8.1.2 of the NICSD SMP.
- Evaluation of FPGA logic as described in Section 11.2.1 of the NICSD SMP.
- Evaluation of PPDD procedures for using a Libero tool ensuring that only approved codes are included in fusemap, and FPGA logic does not contain any undocumented code or configuration as described in Section 13.4.10 of the NICSD SMP.
- PPDD's control over personnel qualification for FPGA development and testing.

In addition, if NICSD considers necessary from a technical point of view, the NICSD SD Team will perform a CDR of the Actel (Microsemi) toolset and Actel development practices before applying software tools to actual design works, with support from NED.

7.5 Design Phase through Module Validation Testing Phase

7.5.1 Procurement Activities for PPDD

(1) Job Order to PPDD

The NICSD SD Team issues a Job Order to procure modules from PPDD in accordance with NQ-2025 (Reference (12)). In the Job Order to PPDD, the NICSD SD Team shall specify a version of software tools that can be used for FPGA products.

(2) Document Review

The NICSD IV&V Team shall perform independent review for the following PPDD documents. After the independent review is completed successfully, the NICSD SD Team shall approve the PPDD documents in accordance with NQ-2026 (Reference (13)).

- Module Design Specification
- FPGA Design Specification
- FPGA Test Procedure
- FPGA Test Report
- Module Test Procedure

(3) Design Review Meeting (DRM) Oversight

NICSD verifies that PPDD follows their software development process correctly, and confirms the status of PPDD activities through the oversight of DRMs convened by PPDD. NICSD performs an oversight to following DRMs.

- DRM for module design review by PPDD

- DRM for FPGA design review by PPDD
- DRM for FPGA test planning and specification review by PPDD
- DRM for FPGA test activity result review by PPDD
- DRM for module test planning and specification review by PPDD
- DRM for module testing activity result review by PPDD

The NICSD SD Team shall define detailed methods for DRM oversight in CDI.

(4) Software Coding Readiness Review

The NICSD SD Team performs a software coding readiness review during the oversight of DRM for FPGA design review as described in Section 13.3.8 of the NICSD SMP (Reference (22)). The review result shall be documented in a PTER. The NICSD SD Team shall update the PTER.

(5) Software Coding and Coding Review (VHDL Source Code)

The NICSD IV&V Team performs a VHDL source code review and issues a source code review sheet.

(6) Witness of FPGA Implementation

After the FPGA Test Report is reviewed and approved by NICSD and FPGA baseline is established, the NICSD SD Team sends an FPGA Logic Implementation Request/Record Sheet and approved FPGA logic (fusemap) to TDMS via PPDD to implement an FPGA logic into FPGA chip.

The NICSD QC inspector shall witness the FPGA logic implementation into the FPGA by TDMS, and NICSD QC inspector shall check whether the FPGA logic implementation has been carried out correctly by checking a specific checksum indicated on the programming tool. The NICSD SD Team shall define acceptance criteria for witness of FPGA implementation in CDI.

(7) Oversight of Vendor Testing Activities

In order to oversee testing activities and check if those activities are appropriately performed, the NICSD IV&V Team conducts the oversight of FPGA Testing and Module Validation Testing. An oversight method is described in Software Test Plan.

(8) Receiving of Modules

After the Module Test Report is approved by NICSD, PPDD shall prepare a PPDD Certificate of Conformance (C of C) and deliver the modules to NICSD. PPDD shall update and submit a PPDD Module Master Configuration List (MCL) to NICSD as their software release report.

The NICSD receiving inspectors shall perform receiving inspections for modules in accordance with NQ-3024, "Receiving Inspection Procedure" (Reference (15)). The NICSD receiving inspectors shall check and receive a module, and PPDD C of C including necessary documentation required by the NICSD SD Team.

If the NICSD SD Team defines in the CDIs that a special test at receiving inspection is one of the acceptance method, the NICSD SD Team shall issue a special test specification before

special testing. NICS-QC shall conduct the special test in accordance with the special test specification, and prepare the special test record as an acceptance record.

After the successful completion of receiving inspection, NICS-QC shall prepare the receiving inspection reports as an acceptance record.

7.5.2 Procurement Activities for Commercial Supplier (Other than PPDD)

(1) Purchase Order to Commercial Suppliers

The procurement group issues purchase orders to procure a unit chassis, cable and other equipment comprising system from commercial suppliers. In addition, the procurement group issues a purchase order for M&TE calibration services from commercial suppliers. The NICSD SD Team, NICS-QA and NICS-QC shall conduct acceptance activities specified in the CDI for each CGI and CGS.

(2) Acceptance Actives before Receiving Items and Services

Acceptance activities set forth in the CDI such as witness inspection and document review are performed if any. An additional CG survey is performed if needed.

(3) Receiving of Commercial Grade Items

The NICSD receiving inspectors performs receiving inspections for a unit chassis, cable and other equipment in accordance with NQ-3024, "Receiving Inspection Procedure" (Reference (15)). A special test/inspection is performed if prescribed in the CDI.

7.6 System Validation Testing Phase

In this phase the NICSD assembles system using the received modules, unit chassis, cables, and other equipment, and tests the system under their Appendix-B QA program.

7.6.1 CGD Report

The NICSD SD Team shall prepare a CGD Report for each CGIs and CGSs used for project in accordance with NQ-4001 (Reference (16)). This report contains a list of documents used for dedication activities and acceptance records.

7.6.2 Final Technical Evaluation Report (FTER)

The NICSD SD Team shall prepare a Final Technical Evaluation Report (FTER) for each FPGA-based system in accordance with AS-200A110 (Reference (7)). This report will summarize the results of CGD activities.

7.6.3 CGD Package

The NICSD SD Team shall prepare a CGD Package in accordance with AS-200A110 (Reference (7)). This package contains a list of documents used for dedication planning, FTER, CDIs, and CGD Reports. The PTER, FTER and any other applicable documentation, including plans,

reviews, and other documentation associated with re-engineering, shall be included in the CGD Package.

8 Environmental Conditions Qualification

8.1 Qualification Testing and Completion of Dedication

Environmental qualification requirements including Equipment Qualification (EQ) and EMC qualification requirements are design conditions to be considered, since those requirements are necessary to determine CCs, which are derived for satisfying them. Those qualification requirements are, however, not CCs in themselves.

Qualification tests are performed in a type test using test specimen that is a part of design verification activities. If an item is procured for the first time before qualification testing, a qualification test report may not yet be identified in the CDI at the time of issuance of purchase order. Dedication activities for each component will be complete basically at the time of receiving inspection, and if necessary a special test will be performed following a receiving inspection.

Afterwards, qualification testing is performed using test specimen. If any modification is made to an item as the result of testing, the change control shall be performed so that the same modification is reflected to an item to be purchased subsequently; the identity of configuration between the item that has undergone a type test and a newly purchased item shall be ensured. Any changes to an item after receiving shall be performed in accordance with configuration management procedures of a project.

The NICSD SD Team shall identify a test report in the CDI after qualification test, which shows successful compliance with qualification test requirements. If any changes are made to a configuration as the result of qualification test, the NICSD SD Team shall identify a baseline after change in the CDI. The NICSD SD Team evaluates any changes to an item that are made after baseline establishment, determines the need for an additional qualification test, and documents the evaluation result in the CDI. In order to continuously purchase items with same configuration, the configuration management of supplier shall be verified as a CC.

8.2 Test System Procurement for Qualification Testing

Qualification tests are performed using a test system consisting of test specimen and test equipment.

8.2.1 Test Specimen

Since it is necessary to use a test specimen for qualification testing that has a configuration same as that of a product and are manufactured through a manufacturing process to be applied to the product, CGD is to be applied for purchasing a test specimen. The test specimen, however, is not to be shipped as a product.

8.2.2 Test Equipment

Test equipment includes cables for testing, a test rack for seismic testing, a test rack for EMC

testing, measuring equipment and a test bench. The test bench may include "Hardware Test Tools" and "Software Test Tools." The "Hardware Test Tools" include items such as a detector current signal simulator, a current-voltage converter for detector current monitor or a discrete signal I/O display simulator (Auxiliary relay circuit simulator). The "Software Test Tools" may include items such as a transmission data acquisition tool, an optical data transmitter or a detector output signal simulator. These test equipment are not provided to nuclear power plants as part of products. Therefore, any items which have safety functions do not belong to the test equipment. CGD is not applied to test equipment that is classified as non-safety.