July 6, 2015

Mr. Robert W. Schrauder
Vice President, Licensing
US ABWR Projects & Technologies
3545 Whitehall Park Drive
Suite 500
Charlotte, NC 28273

SUBJECT: REQUEST FOR ADDITIONAL INFORMATION FOR "LICENSING TOPICAL REPORT FOR TOSHIBA NRW [NON RE-WRITABLE]-FPGA [FIELD PROGRAMMABLE GATE ARRAY]-BASED INSTRUMENTATION AND CONTROL SYSTEM FOR SAFETY-RELATED APPLICATION," UTLA 0020P, REVISION 0 (TAC NO. ME9861)

Dear Mr. Schrauder:

By letter dated February 23, 2015, Toshiba Corporation submitted Revision 2 "Licensing Topical Report For Toshiba NRW-FPGA-Based Instrumentation And Control System For Safety-Related Application" (Agencywide Documents Access and Management System Accession No. ML15062A183). Upon review of the information provided, the U.S. Nuclear Regulatory Commission (NRC) staff has determined that additional information is needed to complete the review.

During a May 28, 2015, meeting with Toshiba representatives it was agreed that the NRC staff will receive your response to the enclosed Request for Additional Information (RAI) questions by August 30, 2015.

If you have any questions regarding the enclosed RAI, please contact me at 301-415-7297 or Joseph.Holonich@nrc.gov.

Sincerely,

/RA/

Joseph J. Holonich, Sr. Project Manager
Licensing Processes Branch
Division of Policy and Rulemaking
Office of Nuclear Reactor Regulation

Project No. 729

Enclosure:
RAI questions

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Vice President, Licensing
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REQUEST FOR ADDITIONAL INFORMATION "LICENSING TOPICAL REPORT FOR TOSHIBA NRW [NON RE-WRITABLE]-FPGA [FIELD PROGRAMMABLE GATE ARRAY]-BASED INSTRUMENTATION AND CONTROL SYSTEM FOR SAFETY-RELATED APPLICATION," UTLA 0020P, REVISION 0 (TAC NO. ME9861)

Documents to be Docketed

1. Please docket the documents identified below

Power Range Monitoring (PRM) System

- Equipment Requirement Specification (ERS) (FPG-RQS-C51-0001)
- Qualification Plan for the PRM System (FPG-PLN-C51-0003)
- Preliminary Technical Evaluation Report (PTER) (FPG-DRT-C51-0001)
- Acceptance Plan for the PRM System (FPG-PLN-C51-0008, FPG-PLN-C51-0010, and FPG-PLN-C51-0025)
- Compliance to Electric Power Research Institute (EPRI) NP-5652 and EPRI Technical Report (TR)-106439 (IM-2014-001234)
- Master Test Plan (MTP) (FPG-PLN-C51-0005)
- Final Technical Evaluation Report (FTER) for PRM System (FPG-DRT-C51-0102)
- Qualification Test Summary Report (FPG-TRT-C51-0101)
- Software Quality Assurance Plan (FPG-PLN-C51-0002)
- Verification and Validation Plan (FPG-PLN-C51-0006)
- Failure Mode and Effects Analysis (FMEA) (FPG-DRT-C51-0018)
- Availability/Reliability Analysis Report (FPG-TRT-C51-0018)
- Setpoint Support Analysis Report (FPG-TRT-C51-0003)

Oscillation Power Range Monitoring (OPRM) Unit

- Equipment Design Specification (EDS) (FC51-3002-1000)
- Commercial Grade Dedication (CGD) Plan for OPRM unit (FA32-7021-1000)
- Commercial Dedication Instruction (CDI) for the OPRM unit (9B8K0046, 9B8K0047, 9B8K0048 Rev.3, 9B8K0049, 9B8K0050, 9B8K0051, 9B8K0053, 9B8K0054, 9B8K0055, 9B8K0056, 9B8K0057)
- Preliminary Technical Evaluation
- Equipment Qualification (EQ) Test Plan (FC51-7012-1000)
- EMC Test Plan (FC51-7012-1001)
- Final Technical Evaluation Report for the OPRM Unit (FC51-1505-1001)
- Software Quality Assurance Plan (FA32-3701-1001)
- Verification and Validation Plan (FA32-3709-1000)
- FMEA (C51-3704-1101)
- Availability/Reliability Analysis Report (C51-3809-1000)
- Setpoint Support Analysis Report (FC51-1505-0002)
- Dynamic Qualification Report for Safety-Related OPRM (FC51-7513-1003)
- EQ Report for Safety-Related OPRM (FC51-7513-1000)
- EMC Qualification Report for Safety-Related OPRM (FC51-7513-1001)
- Aging Analysis Report for Safety-Related OPRM (FC51-1505-0001)
- Software Safety Analysis Report (FC51-3704-1101)

Commercial Grade Dedication

2. The PTER (FPG-DRT-C51-0001) comments about the critical characteristics for design (CCD) and critical characteristics for acceptance (CCA). In particular, Section 4.2.2 describes the process for selecting CCDs and CCAs. Section 4.2 refers to Appendix A where a "summary for CCDs and CCAs for the test specimen" is provided.

   Because Appendix A includes all the system requirements from the ERS, it is not clear if the entire information in Appendix A refers to all critical characteristics of the system. The problem with Appendix A is that it identifies all requirements from EPRI TR-107330 without distinguishing the type of critical characteristics for each requirement.

   This is acceptable for critical characteristics associated with physical and performance characteristics, but not for dependability characteristics. Dependability characteristics address process attributes to build the system, which are not identified in EPRI TR-107330, "Generic Requirements Specification for Qualifying a Commercially Available PLC for Safety-Related Applications in Nuclear Power Plants."

   In addition, the Acceptance Plan (FPG-PLN-C51-0008) documents the critical characteristics of the PRM system. However, it is not clear how the critical characteristics in the Acceptance Plan relate to those identified in Appendix A of the PTER.

   Based on this information, the staff has identified the following requests:

   a. Please identify the critical characteristics for the PRM system and OPRM unit.
   b. Please explain the relationship between the requirements in Appendix A of the PTER and the critical characteristics identified in the Acceptance Plan. Also, please identify what characteristics are considered CCD or CCA.
   c. Table 1-1 of the PTER lists the sources to identify critical characteristics. However, this table lists the PTER itself as a source. It is not clear how the PTER can be a source. Please clarify this circular reference.

Design Process

3. Topical Report (TR) Table II-B-1 identifies Toshiba modules for the PRM system and the OPRM unit. Please identify which modules were developed using the original process and which were developed using the current process. Also, identify what modules have not been developed and manufactured yet, if any.

4. Please provide figures illustrating the relationship between the different design documents and the system lifecycle for the PRM system and the OPRM unit.

5. It is the staff's understanding the Preliminary Technical Evaluation Report (FPG-DRT-C51-0001) was prepared in accordance with the ERS (FPG-RQS-C51-0001). However, the relationship between the PTER and the EDS (FC51-3002-1000) and the relationship between the ERS and EDS are not clear.

   Furthermore, the EDS defines the system design requirements for the neutron monitoring system (RS-5155709) for the Advanced Boiling Water Reactor (ABWR). Therefore, the EDS is not related with the PRM system for the BWR-5 (which is the

scope of the staff's review). Please explain the scope and relationships among the following documents: ERS, EDS, and PTER.

6. The ERS does not identify the requirements associated with system communication. Please explain what document or section(s) of the ERS identifies these requirements.

Power Supply

7. The TR, Section II-2.2.5.2, describes the power supply redundancy for the Neutron Monitoring System (NMS). In addition, TR, Section II-2.2.2.5.1, item (2) Average Power Range Monitor (APRM), (d.) Discrete Output Interfaces, states the discrete output interface of the APRM unit requires external power supply. The scope of the NRC review only covers the PRM system and OPRM unit; it does not include the NMS. As a consequence, this section does not describe the power supply to be provided for the PRM system and OPRM unit. Please describe how power will be provided and distributed to the modules in the system. Also, please describe what component will provide the power necessary for the APRM output interface.

8. Section 5.1.6 of the ERS defines a requirement to monitor the voltage of the High Voltage Power Supply (HVPS). However, the document does not mention anything else about the HVPS. Furthermore, the TR does not describe this component for neither the PRM system nor the OPRM unit. Please describe the HVPS and how it is used in the system.

System Description

9. The TR does not explain if the system includes cooling fans or if it will use natural circulation to cool the components. Please describe the system cooling capabilities.

10. The TR, Section II-A.2.7 states modules with Electrically Erasable Programmable Read-Only Memory (EEPROM) will verify the setpoint values using parity bits or dual storage. The TR does not provide enough information about EEPROM and Erasable Programmable Read Only Memory (EPROM). Please provide the following information:
    a. Identify modules that contain EEPROM and/or EPROM.
    b. Describe how data stored in the EEPROM or EPROM is verified.

11. The TR, Appendix II-B, describes the modules included in the PRM system and OPRM unit. Several module descriptions talk about "rotary switches" and "push buttons." The figures illustrating these modules indicate where the push buttons are, but they don't indicate where the rotary switches are located. Please identify where the rotary switches are located. Also, please describe the functions these rotary switches perform and how they are used.

12. The EDS (FC51-3002-1000) states one division of the PRM system includes one Relay Unit. The ERS (FPG-RQS-C51-0001) states the PRM system includes the trip auxiliary unit. Finally, the PTER states the PRM system includes the trip auxiliary unit. Please confirm the trip auxiliary unit and relay unit are not in the scope of review for the PRM system and OPRM unit.

13. The TR, Section II-2.2.2.1, states: "the Local Power Range Monitor (LPRM) monitors local neutron flux in the power range between 1 % and 125 % of the rated power." However, Section 4.2 of the ERS states: "the LPRM detectors provide measurement of

core local power from 1% to above 100% of the rated power." and, Section 5.1.1 of the ERS states: "The PRM System shall be designed to provide adequate flux monitoring information from one percent through 125% reactor power." Please explain the correct range of operation for the LRM detectors.

14. Section 1 of the EDS (FC51-3002-1000) states: The scope of this EDS is to specify requirements for the equipment design of the LPRM, APRM and OPRM comprising the Power Range Neutron Monitor (PRNM), which is a part of the NMS. Toshiba identified this document to provide the requirements for the OPRM unit (which is the only part to be reviewed by the staff). However, the requirements for the OPRM in this document are not clearly identified, since it identifies all requirements for a PRNM system. Please identify the requirements relevant to just the OPRM unit, since the requirements in the EDS associated with the LPRM and APRM are out of the scope of the NRC evaluation (because they apply to the ABWR design).

15. The TR, Section II-2 describes the FPGA-based system. In particular, Section II-2.1.3 describes the units, which consists of a chassis where modules are mounted. However, this section does not provide sufficient information about the chassis configuration. Therefore, please describe the following:

    a. How the chassis is configured.
    b. How the system recognizes the correct module is inserted.
    c. If the position of the module in the chassis is pre-defined, and specific in the backplane.

System Communication

16. The TR, Part IV, Section IV-5, Conformance with Interim Staff Guidance (ISG)-04, Staff Position 1.2, notes the system uses parity check to verify errors in the PRM system, for which Toshiba performed the qualification test. In this item Toshiba added a comment saying it would update the FPGA logic to use Cyclic Redundancy Check (CRC) to identify data corruption. Please explain if Toshiba has modified the FPGA logic to use CRC instead of parity check.

17. The TR is not consistent with the terms used to describe communication. Specifically, the following terms are used: fiber optic links, serial link, point-to-point copper serial communication link, three-wire electrical communication link, and hardwired connections. Please clarify what the terms listed previously refer to and for which of the following data transmission type they correspond to:

    - Data transmission between modules,
    - Data transmission on the middle plane, and
    - Data transmission between FPGAs.

18. Section 3.3.4 of the Nuclear Instrumentation and Control Systems Department's (NICSD's) Critical Digital Review Report (FPG-DRT-C51-0005) and Section 5.2.3.3 of the ERS describe how the APRM module receives data from the LPRM modules. In these descriptions, Toshiba uses the following sentence: "The dual electrical communication links are used in the data transmission from the TRN and RCV modules." The use of this sentence in these descriptions is not clear. Therefore, please clarify the following:

a. Are the dual electrical communication links the same fiber optic link described in Section II-2.1.4.3 of the TR?
b. Are the dual electrical communication links only used for communication between the TRN in the LPRM unit and the RCV module in the APRM/LPRM unit? Also, confirm these links are not used to transfer data from the LPRM modules mounted in the same LPRM/APRM unit through the TRN module.

19. The TR and the NICSD's Critical Digital Review Report (FPG-DRT-C51-0005) do not provide sufficient information about data transmission. Specifically, the staff needs clarification on the following items:

    a. Descriptions of where the clock signal and load pulse for transmitting data are generated and how they are used.
    b. Communication mechanism for analog input or output modules.
    c. Description of how data is transferred from the hardwired discrete input or output.

20. The TR does not provide clear information on how data is transferred through the TRN and RCV modules. Instead, the information seems to be scattered throughout supporting documents (e.g., TRN module design specification) with no clear connections. In addition, the translation seems to be confusing and unclear about data format, messages, FPGAs, etc.

    Therefore, please provide clear and detailed information for the staff to evaluate system communication in accordance with ISG-04. Below are some examples of insufficient information provided in the TR. Note these are just a few examples, and there are more items that require clear description for the staff to evaluate the system communication:

    a. Section 3 of the TRN module design specification (5G8HC108) describes two operation modes for the TRN module. But this section seems to describe at least three modes. Then the NICSD's Critical Digital Review Report describes three operation modes. In addition, Section 3 of this design specification describes the type of signal that will be received for different Unit types (1, 2, or 3) depending on the operation mode. However, this document does not describe what these unit types are, the operation modes, and how they relate. Therefore, it is not clear how many operation modes there are, what they do, and why communication changes based on the unit type.
    b. Section 5.1 of the TRN module design specification (5G8HC108) describes the input signals. Then Section 5.2 describes the output signals. However, based on information provided in this document, data received is modified and then transferred to other modules (i.e., block diagram in Figure 3.1). This document does not describe how the input signals are modified and transmitted as output signals.
    c. Section 5.1 of the TRN module design specification (5G8HC108) describes the input signals. This document does not describe what type of input signal is used in the OPRM unit.
    d. According to the description provided in the TRN and RCV module design specifications (5G8HC108 and 5G8HC109, respectively), the TRN and RCV modules includes a primary and a secondary communication link. However, these documents do not explain how the module switches from one link to the other, when one link fails. Also, it is not clear what happens if both links fail.
    e. According to the description in Section II-2.1.4.3 of the TR and Section 3.2.1, item (1), of the NICSD's Critical Digital Review Report, if successive data frames with corrupted data are sent, the RCV would reject the message. On the other hand, the

RCV module design specifications (5G8HC109) describes correct data should be received several times for the RCV module to accept it and the module will stop if data is not received in the pre-defined period. It is not clear if data should be received several times before it is accepted as correct or marked as invalid data.

Surveillance Testing and Diagnostics

21. The TR, Section II-A-2.8 describes system features associated with surveillance testing. Specifically, this section states the Toshiba system can be designed to provide the capabilities necessary for surveillance testing. However, this section does not describe the principles and the methodology to be used to perform surveillance tests in order to verify the capability of safety systems to perform their functions in accordance with the design and safety requirements. Please provide the following information:

    a. The principles and the methodology used to perform surveillance tests.
    b. The TR, Section II-A-2.8 states Toshiba concluded that a surveillance frequency of once a month is reasonable. Please explain how Toshiba determined this frequency to be reasonable.