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Subject: **Response to Portion of NRC Request for Additional Information - NRC Letter 76 - Related to ESBWR Design Certification Application – DCD Sections 7.1, 7.2, 7.5, 7.6 – RAI Numbers 7.1-7, 7.1-36, 7.2-21, 7.2-22, 7.2-23, 7.2-24, 7.2-25, 7.2-26, 7.2-27, 7.2-29, 7.2-39, 7.5-5, 7.5-6, 7.6-1, and 7.6-2**

Enclosure 1 contains GE's response to the subject NRC RAIs transmitted via Reference 1.

If you have any questions or require additional information regarding the information provided here, please contact me.

Sincerely,

Kathy Sedney for

James C. Kinsey
Project Manager, ESBWR Licensing

D068

Reference:

1. MFN 06-388 - Letter from U.S. Nuclear Regulatory Commission to David Hinds, "*Request for Additional Information Letter No. 76, Related to ESBWR Design Certification Application*", dated October 11, 2006

Enclosure:

1. MFN 07-163 - Response to NRC Request for Additional Information Related to ESBWR Design Certification Application – DCD Sections 7.1, 7.2, 7.5, 7.6 – RAI Numbers 7.1-7, 7.1-36, 7.2-21, 7.2-22, 7.2-23, 7.2-24, 7.2-25, 7.2-26, 7.2-27, 7.2-29, 7.2-39, 7.5-5, 7.5-6, 7.6-1, and 7.6-2

cc: AE Cubbage USNRC (with enclosures)
BE Brown GE/Wilmington (with enclosures)
GB Stramback GE/San Jose (with enclosures)

eDRF	**RAI**
0000-0060-0280	7.1-1
0000-0061-0936	7.1-36
0000-0061-0839	7.2-21
0000-0061-0839	7.2-22
0000-0061-0839	7.2-23
0000-0061-0839	7.2-24
0000-0061-0939	7.2-25
0000-0061-0839	7.2-26
0000-0061-0839	7.2-27
0000-0066-9039	7.2-29
0000-0060-4051	7.2-39
0000-0060-6456	7.5-5
0000-0065-7878	7.5-6
0000-0064-4647	7.6-1
0000-0060-4316	7.6-2

MFN 07-163

Enclosure 1

Response to NRC Request for Additional Information Related to ESBWR Design Certification Application DCD Sections 7.1, 7.2, 7.5, 7.6

RAI Numbers
7.1-7, 7.1-36, 7.2-21, 7.2-22, 7.2-23, 7.2-24, 7.2-25, 7.2-26, 7.2-27, 7.2-29, 7.2-39, 7.5-5, 7.5-6, 7.6-1, and 7.6-2

NRC RAI 7.1-7

Some of information on DCD, Tier 2, Revision 1, Table 7.1-1 needs to be updated. For example: 50.55a(h) should refer to IEEE-603-1991, Regulatory Guide (RG) 1.97, Revision 4, should refer to IEEE-497-2002. Applicable RGs should include RG 1.180-1/2000, "Guidelines for Evaluating Electromagnetic and Radio-frequency Interference in Safety-related I&C Systems" and RG 1.204-11/2005, "Guidelines for Lightning Protection of Nuclear Power Plants."

GE Response

DCD Tier 2, Revision 3, Table 7.1-1 and referenced subsections, have been updated in response to NRC RAI 7.1-7. Revisions to the table include incorporation of RG 1.180 and 1.204. In addition, the referenced regulations, industry standards, and other guidance documents have been revised within the table to reflect the text in Chapter 7. Subsections within Chapter 7 have been revised to reflect the changes in the table. Notes have been revised and added to the table for clarification. The table also reflects the association of the named subsystems with the Q-DCIS, the N-DCIS, or both DCISs. DCD Tier 2, Revision 3, Chapter 1, has been revised to reflect the use of IEEE Std. 603-1991, IEEE Std. 497-2002, and RG 1.97 R4 by the ESBWR, specifically in response to NRC RAI 7.1-7.

DCD/LTR Impact

There are no additional changes to any DCD Tier required by this response.

NRC RAI 7.1-36

DCD, Tier 2, Revision 1, Section 7.9.2.2 provided the Non-essential Distributed Control and Information System (NE-DCIS) system description. There is a statement that the communication from nonsafety-related systems to the Essential Distributed Control and Information System (E-DCIS) is limited to communication from the 3D Monicore function of the NE-DCIS to the PRNM (LPRM and APRM) function of the Neutron Monitoring System. This is not consistent with the E-DCIS design that only allows one-way communication from divisional E-DCIS network to the NE-DCIS. Please explain this exception.

GE Response

The NMS Communication Interface Module (CIM) has 2-way fiber optic communication data links. The GE Licensing Topical Report NEDO-33288, "Application of Nuclear Measurement Analysis and Control (NUMAC) for the ESBWR Reactor Trip System," which describes the CIM function, communication data link and data flow in the NMS application, explains in Section 5.2.3.3.3 how the nonsafety-related to safety-related information interface is provided for specific functions. This Topical Report, Section 4.2.8.6, also describes how this interface meets the independence requirements of IEEE-603, Section 5.6. This LTR was submitted in letter MFN 07-160.

DCD/LTR Impact

There are no changes to any DCD Tier required by this response.

NRC RAI 7.2-21

DCD, Tier 2, Revision 1, Section 7A.1.2 makes a statement, "With their simple operating principles, gamma thermometers (GTs) have a very low failure rate (Reference 7A-1). The historical failure data of the similarly installed GTs in nuclear power plants is limited. Provide basis for this statement with regard to the limited similar plant operational data. What is the criteria for replacing GT/LPRM (Local Power Range Monitor) assembly i.e. failure of two or more sensors?

GE Response

The gamma thermometer LTR NEDE-33197P, Gamma Thermometer System for LPRM Calibration and Power Shape Monitoring, provides information on previous tests and sensor reliability. Sensor performance was determined to be sufficiently reliable to be "used in place of a TIP system for both LPRM calibration and power shape monitoring."

AFIP sensor data is postulated to be adequate with up to four of seven sensors failed depending upon the locations of the failed sensors within the LPRM assembly. AFIP sensor failures within a LPRM assembly will remain in-place until the LPRM can be replaced (typically during a refueling outage).

DCD, Tier 2, Appendix 7A was deleted in Revision 3. Information contained in Appendix 7A related to the Automated Fixed In-core Probe (AFIP) subsystem and GTs is addressed in DCD, Tier 2, Section 7.7.6 and in NEDE-33197P, by reference.

DCD/LTR Impact

No changes to any DCD Tier are required by this response. No changes to LTR NEDE-33197P are required by this response.

NRC RAI 7.2-22

DCD, Tier 2, Revision 1, Section 7A: What is the expected life of GTs and how does it compare with the qualified life of local power range monitors (LPRMs)?

GE Response

Lifetime of AFIP sensors is a commercial consideration in that failure of this non-safety-related sub-system has no safety impact. Gamma thermometers have been demonstrated to operate adequately for at least four years.

DCD, Tier 2, Appendix 7A was deleted in Revision 3. Information contained in Appendix 7A related to the Automated Fixed In-core Probe (AFIP) subsystem and GTs is addressed in DCD, Tier 2, Section 7.7.6 and in NEDE-33197P, by reference.

DCD/LTR Impact

No changes to any DCD Tier are required by this response. A revision to LTR NEDE-33197P, Gamma Thermometer System for LPRM Calibration and Power Shape Monitoring, will provide the end-of-life criteria.

NRC RAI 7.2-23

DCD, Tier 2, Revision 1, Section 7A.2.1 states, "the range in gamma heating rate should be 0.0 to 2.4 W/g for typical BWR." What is the corresponding range for fission density/thermal power.

GE Response

The figure of 2.4 Watts/gram (W/g), not including peaking factors, is for Tokai 2 (reference below), which operates at an average power density of 50 Watts/cubic centimeter (W/cc). Given a power density in the fuel assemblies of 50 watts/cc, the gamma heating in the gap between fuel assemblies will be about 19 watts/cc. Since steel has a density of 7.8 g/cc, the gamma heating in the steel rod is 19/7.8 = 2.4 watts/gram.

The ESBWR design is expected to have an average power density of up to 54.33 W/cc. Assuming a total radial and axial peaking factor of 2.1, the maximum power density would be 114 W/cc resulting in a gamma heating rate in the gap of 5.5 W/gram. The W/cc number is the commonly used reactor power density term.

Reference: MFN-05-079, GE Licensing Topical Report NEDE-33197P, "Gamma Thermometer System for LPRM Calibration and Power Shape Monitoring," September 2005.

DCD, Tier 2, Appendix 7A was deleted in Revision 3. Information contained in Appendix 7A related to the Automated Fixed In-core Probe (AFIP) subsystem and GTs is addressed in DCD, Tier 2, Section 7.7.6 and in NEDE-33197P, by reference.

DCD/LTR Impact

No changes to any DCD Tier are required by this response. No changes to LTR NEDE-33197P are required by this response.

NRC RAI 7.2-24

DCD, Tier 2, Revision 1, Section 7A: The GT sensitivity varies significantly with the age of the sensor. Since LPRM calibration is based on the calibration corrected GT data, what is the recommended calibration interval for new GT sensors and the interval after the first refueling outage? Provide the basis for the recommended duration.

GE Response

A description of the method used to determine recommended calibration intervals is located in LTR NEDE-33197P, Gamma Thermometer System for LPRM Calibration and Power Shape Monitoring, Section 9.2.1. One way of developing the intervals is outlined in Section 4.4 of this LTR. GTs should be calibrated before, but as close as practical to, the initiation of LPRM calibration until longer calibration intervals are justified as demonstrated by the model. For gamma thermometer AFIP sensors, a correction factor is applied to the LPRMs via an automated calibration system based upon sensor performance.

DCD, Tier 2, Appendix 7A was deleted in Revision 3. Information contained in Appendix 7A related to the Automated Fixed In-core Probe (AFIP) subsystem and GTs is addressed in DCD, Tier 2, Section 7.7.6 and in NEDE-33197P, by reference.

DCD/LTR Impact

No changes to any DCD Tier are required by this response. No changes to LTR NEDE-33197P are required by this response.

NRC RAI 7.2-25

DCD, Tier 2, Revision 1, Section 7A: GT neutron monitoring system is passing calibration data to the safety related LPRM system. GT neutron monitoring system is not a safety related system but the LPRM system is. Does the communication between the two systems meet the IEEE-603-1991 Section 5.6.3.(1) criterion: Equipment that is used for both safety and non-safety functions shall be classified as part of the safety system. Isolation devices used to effect a safety system boundary shall be classified as part of the safety system. (The term "equipment" should include both software and hardware of the digital systems.) Please describe how this criterion for communication between the two systems is met?

GE Response

Data from the gamma thermometers (GTs) is provided to the 3D Monicore system, which in turn calculates gain calibration factors for the LPRMs. These calibration factors from the nonsafety-related 3D Monicore system are then provided to the PRMS under operator control.
The application of this nonsafety-related to safety-related interface is described in detail in the GE Licensing Topical Report NEDO-33288, "Application of Nuclear Measurement Analysis and Control (NUMAC) for the ESBWR Reactor Trip System," Section 5.2.3.3.3. This Topical Report, Section 4.2.8.6, also describes how this interface meets the independence requirements of IEEE-603, Section 5.6. The Neutron Monitoring System (NMS) Communications Interface Module (CIM), which is part of the safety-related portion of the NMS, has 2-way fiber optic communication data links and provides electrical isolation when passing data from nonsafety-related subsystems to safety-related systems. This LTR was submitted in letter MFN 07-160.

DCD, Tier 2, Appendix 7A was deleted in Revision 3. Information contained in Appendix 7A related to the Automated Fixed In-core Probe (AFIP) subsystem and GTs is addressed in DCD, Tier 2, Section 7.7.6 and in NEDE-33197P, by reference.

DCD/LTR Impact

No changes to any DCD Tier are required by this response.

NRC RAI 7.2-26

DCD, Tier 2, Revision 1, Section 7A: GT signals, associated with GT strings that are being calibrated are blocked from transmittal to the 3D simulator (or are otherwise marked unusable). Are these totally excluded from the 3D simulation model or is the last good value substituted in its place. Provide response with rationale for the option used. How many signals can be placed in a blocked mode at any given time?

GE Response

In accordance with the present design, no AFIP value is sent to 3D Monicore when an AFIP sensor is out of service and 3D MONICORE will exclude that sensor and not use a replacement. The adaptation to a missing or rejected sensor will be replaced with the planar average values of the shape function for the remaining strings at each axial location or the user can use the information from a symmetric sensor if deemed appropriate by analysis. [Reference: NEDE-31307P-Y, 3D MONICORE - Monitor and Predictor, Revision 25, Section 2.3.2]

As noted in Section 2.3.2.3 of NEDE-31307P-Y, "as many as 1/3 of the measured readings can be unavailable or rejected without substantially altering the results." This includes blocked signals.

DCD/LTR Impact

No changes to any DCD Tier are required by this response. No changes to LTR NEDE-31307P-Y are required by this response.

NRC RAI 7.2-27

DCD, Tier 2, Revision 1, Section 7A: The GT calibration sensitivity is based on the time for which the GT has been in use. From the data provided it appears that sensitivity increases at first and then decreases over time. Will it settle to a fixed value? Is there a long term plan to check and confirm the changes in sensitivity of the GTs? The current data provided in NEDE-33179P regarding sensitivity is limited to a duration of less then 4.6 years.

GE Response

GT sensitivity is irrelevant if a GT calibration is performed prior to but as close as practical to a LPRM calibration. NEDE-33197P, Gamma Thermometer System for LPRM Calibration and Power Shape Monitoring, Section 4.4, states that once the fill gas comes to equilibrium with the diffused gas no further changes in sensitivity are expected. NEDE-33197P, Section 7.2.3, states that the physical reasons for changes in GT sensitivity are not precisely known and that internal calibration adjusts for the effect.

Lifetime of AFIP sensors is a commercial consideration in that failure of this non-safety related sub-system has no safety impact. Gamma thermometers have been demonstrated to operate adequately for at least four years.

DCD, Tier 2, Appendix 7A was deleted in Revision 3. Information contained in Appendix 7A related to the Automated Fixed In-core Probe (AFIP) subsystem and GTs is addressed in DCD, Tier 2, Section 7.7.6 and in NEDE-33197P, by reference.

DCD/LTR Impact

No changes to any DCD Tier are required by this response. No changes to LTR NEDE-33197P are required by this response.

NRC RAI 7.2-29

During July 26 and 27, 2006 I&C meeting, the applicant presented the NUMAC E-DCIS Platform Family. The RPS instrumentation and control architecture is significantly different from the architecture presented in DCD, Tier 2, Revision 1, Figure 7.2-1. The staff considers this a major design change of the RPS. This new proposed design, that involves the inter-division communication, may not meet the IEEE-603-1991 requirements. The applicant should provide a topical report describing the detailed hardware configuration that will implement the instrumentation and control architecture for the ESBWR reactor trip system (RPS). The report should address how the ESBWR reactor trip system design is in conformance with IEEE Std 603 requirements.

GE Response:

The GE NUMAC Licensing Topical Report NEDO-33288, "Application of Nuclear Measurement Analysis and Control (NUMAC) for the ESBWR Reactor Trip System" describing the detailed hardware and software configuration of the instrumentation and control architecture for the ESBWR Reactor Protection System (RPS) has been written to address compliance with IEEE Std 603 requirements. This LTR was submitted under MFN 07-160.

Following discussion with NRC in November at Wilmington, GE decided to revert to original point-to-point communication between divisions instead of the NUMAC ring architecture presented during July 26, 2006 I&C meeting.

DCD/LTR Impact

There are no additional changes to the DCD, beyond those described in MFN 07-160, required by this response.

NRC RAI 7.2-39

DCD, Tier 2, Revision 1, Section 7.2.1.2.4.2 stated that many process systems provide outputs to the reactor protection system (RPS) through the Essential Distributed Control and Information System (E-DCIS). Provide detailed discussion with drawings to address how the E-DCIS design satisfies the IEEE-603 criterion 5.6 (and IEEE 7-4.3.2) requirements. The response should also demonstrate that data communication between safety channels or between safety and nonsafety system shall not inhibit the performance of the safety function, and shall be in conformance with IEEE-603 criterion 5.6 requirements.

GE Response

DCD Tier 2, Revision 3, Subsection 7.1.3.3, 7.1.6.6.1.7, and Table 7.1-2 has been revised to add a detailed description of the safety-related distributed control and instrumentation system (Q-DCIS) including conformance with IEEE Std. 603, Section 5.6. The commitment to develop software in conformance with IEEE Std. 7-4.3.2 has been described in Subsection 7.1.6.4. as part of the statement of conformance with RG 1.152. The description of how the communication between Q-DCIS and N-DCIS conforms with IEEE Std. 603, Section 5.6, is described in Subsection 7.1.3.3.

DCD/LTR Impact

There are no additional changes to any DCD Tier required by this response.

NRC RAI 7.5-5

Update DCD, Tier 2, Revision 1, Section 7.5.2.3, "Safety Evaluation," to describe how the ESBWR design provides instrumentation adequate for monitoring plant conditions following an accident that includes core damage.

GE Response

DCD Tier 2 Revision 3 subsection 7.5.2.3.6 "TMI Action Plan Requirements" discusses 10CFR 50.34 (f)(2) (xix), TMI Item II.F.3 and references Table 1A-1 "TMI Action Plan Items." Table 1A-1 Item II.F.3 states that the ESBWR is designed in accordance with the most recent revision of Regulatory Guide 1.97 and references DCD Tier 2 Section 7.5.1.

A detailed assessment of the RG is found in DCD Tier 2, Revision 3, Subsection 7.5.1.3.1.4 "Regulatory Guides." Specific RG 1.97 variables required for the Containment Monitoring System are determined using the process discussed in subsection 7.5.1.3.1.4. The results of this process will be incorporated in the Post Accident Monitoring (PAM) Variable List described in subsection 7.5.1.3.1.4. Therefore no update of subsection 7.5.2.3 "Safety Evaluation" is planned at this time.

DCD/LTR Impact

There is no change to the DCD required for this RAI response.

NRC RAI 7.5-6

During the July 26 and 27 I&C meeting, the applicant presented the ESBWR I&C Network discussion and provided an ESBWR Network Diagram (draft). The staff found that the diagram is very helpful to understand the overall design of the ESBWR I&C systems. This diagram should be included in the DCD, Tier 2, Section 7.5. A description of major components on the network should be provided.

GE Response

It was decided that Section 7.5 was not an appropriate location in the DCD, Tier 2 to cover the proposed *ESBWR Network Diagram*, as proposed in this RAI. Instead, the *ESBWR Network Diagram* has been incorporated as Figure 7.1-2, *ESBWR Distributed Control and Information System (DCIS) Functional Network Diagram*, in DCD Tier 2, Revision 3. This diagram is a functional representation of the current DCIS network design, which consists of a safety-related DCIS (Q-DCIS) and a nonsafety-related DCIS (N-DCIS).

Supporting discussions are found in the following subsections of DCD Tier 2, Revision 3:

- Subsection 7.1.1 – contains a brief description of the ESBWR DCIS network in general.
- Subsections 7.1.2 and 7.1.3 – contain both general and specific descriptions of Q-DCIS network, including its major components.
- Subsections 7.1.4 and 7.1.5 – contain both general and specific descriptions of N-DCIS network, including its major components.

Therefore, this RAI has been addressed in DCD Tier 2, Revision 3 Section 7.1 and Figure 7.1-2.

DCD/LTR Impact

No other changes will be made to the DCD in response to this RAI.

NRC RAI 7.6-1 Question:

DCD, Tier 2, Revision 1, Section 7.6 described two types of interlock functions: (1) high pressure/ low pressure interlock, and (2) interlocks to isolate safety-related systems from nonsafety-related systems. HP/LP interlock functions include (a) RWCU to FAPCS, and (b) GDCS design pressure to GDCS pool. DCD, Tier 2, Section 7.6 should contain information related to interlock systems important to safety. For example, in DCD Section 7.3.1.2.2, DGCS system description stated that to operate the GDCS valves, the manual logic is interlocked with a low reactor pressure signal. For the deluge valves, the manual control is interlocked with a high drywell pressure signal. Many squib valves initiation are controlled by time delay logic. All interlock systems important to safety should be addressed in DCD, Tier 2, Section 7.6.

GE Response:

SRP 7.6 identifies the scope of the required "interlock systems important to safety." Furthermore, DG-1145, Section C.I.7.6 is also consistent with the SRP in specifying the scope of interlocks to be addressed.

As described in ESBWR DCD subsection 7.6, the only interlocks meeting the scope of SRP 7.6 are related to the High Pressure/Low pressure (HP/LP) systems interconnection, which are not addressed in other subsections of DCD 7.0

The RAI example related to DCD Section 7.3.1.2.2, and the GDCS system logic interlocks with a low reactor pressure signal is described in DCD 7.6.1.1 and is presented as not being a required HP/LP interlock. All other actuation logics (including associated interlocks) for operation of safety-related and nonsafety-related systems are within the scope of other subsections of DCD Chapter 7.

The action summarized from the November 17, 2006 I&C Audit, which is reflected in NRC Summary dated January 16, 2007 (ML063600377), to provide a table of interlocks in DCD 7.6 has been evaluated as not necessary. The single interlock within the scope of Section 7.6 is adequately presented without inclusion of a Table listing this single item.

DCD/LTR Impact

No other changes will be made to the DCD in response to this RAI.

NRC RAI 7.6-2 Question:

There is no interlock to isolate safety-related systems from non-safety-related systems identified in DCD, Tier 2, Revision 1, Section 7.6. Discuss the arrangement between the safety-related protection system functions and the nonsafety-related diverse actuation functions described in DCD, Tier 2, Revision 1, Section 7.8.

GE Response:

There are no interlocks to isolate safety-related systems from nonsafety-related systems. The function and operation of Diverse Protection System (DPS) in conjunction with safety-related systems (Reactor Protection System, Anticipated Transient Without Scram, etc.) are described in DCD Revision 3, Subsection 7.8 and Licensing Topical Report No. NEDO-33251 "Defense in Depth and Diversity Report"

In general the DPS system has its own sensors and actuating devices for operation of final elements, for example separate solenoid valve for controlling the air to valve actuator and separate igniter for operation of Squib valve. The DPS components are designed to ensure the reliability goals and system requirements are met. The DPS sensors and actuation devices, which interface directly with safety-related SSCs are designed to ensure the reliability goals and system requirements are met. Consistent with IEEE 603 and 384, the nonsafety-related DPS is also designed to avoid adverse interaction with the protection systems with which DPS interfaces. Since the DPS logic does not communicate with the RPS logic, credible DPS failure modes do not prevent the RPS from performing a reactor trip and the DPS cannot cause the RPS to initiate a trip prematurely. Credible DPS failure modes cannot prevent the ESF actuation system from initiating ECCS and/or performing barrier isolation functions. Additionally, credible failure modes cannot result in premature operation of these protection systems.

DCD/LTR Impact

No changes will be made to the DCD in response to this RAI.