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Subject: **Response to Portion of NRC Request for Additional Information Letter No. 360 - Related To ESBWR Design Certification Application - RAI Number 14.2-101**

The purpose of this letter is to submit the GE Hitachi Nuclear Energy (GEH) response to the U.S. Nuclear Regulatory Commission (NRC) Request for Additional Information (RAI) sent by the Reference 1 NRC letter. GEH response to RAI Number 14.2-101 is addressed in Enclosures 1 and 2.

If you have any questions or require additional information, please contact me.

Sincerely,

Richard E. Kingston

Richard E. Kingston
Vice President, ESBWR Licensing

References:

1. MFN 09-260, Letter from U.S. Nuclear Regulatory Commission to Jerald G. Head, *Request For Additional Information Letter No. 360 Related To ESBWR Design Certification Application*, dated April 13, 2009.

Enclosures:

1. MFN 09-249 – Revised Response to Portion of NRC Request for Additional Information Letter No. 360 - Related To ESBWR Design Certification Application – RAI Number 14.2-101
2. MFN 09-249 – Revised Response to Portion of NRC Request for Additional Information Letter No. 360 - Related To ESBWR Design Certification Application – RAI Number 14.2-101 – DCD Markups

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Enclosure 1

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Response to Portion of NRC Request for

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NRC RAI 14.2-101

Tier 2 designation.*

The staff requests that the entire section 14.2.8.2.35, ESBWR First-of-a-Kind Tests is identified as Tier 2 information.*

GEH Response

GEH understands the request and provides a markup of Subsection 14.2.8.2.35 identified as Tier 2* (enclosed with square brackets with a star (*) at the end). In addition, the First-Of-A-Kind (FOAK) portion of Subsection 14.2.8.2.7 Core Performance is also identified as Tier 2* information.

During the review of this request, it was noted that Subsection 14.2.8.2.11 'Reactor Internals Vibration Test (Initial Startup Flow-Induced Vibration Testing)' referred to Appendix 3L instead of Subsection 3.9.2.4 which describes the Initial Startup Flow Induced Vibration Testing of Reactor Internals requirements. Also Subsection 3.9.2.4 refers to COL 3.9.9-1-H which specifies the responsibility of the holder to outline the reactor vessel internal testing program based on Regulatory Guide 1.20 requirements. The Subsection was updated to refer to Subsection 3.9.2.4 rather than Appendix 3L.

Also, during the review of this request, it was noted that the reference to Subsections 14.2.8.2.7 and 14.2.8.2.11 in Subsection 14.2.8.2.35 is confusing and adds no value. Therefore this sentence was removed.

DCD Impact

DCD Tier 2, Subsections 14.2.8.2.7, 14.2.8.2.11, and 14.2.8.2.35, will be revised as noted in the markups in Enclosure 2.

Enclosure 2

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DCD Markups

[*A First Of A Kind (FOAK) test will be conducted for observation of reactor stability. The objective of this test is to characterize the stability performance during power ascension, where chimney partition may experience flow-regime-transition-induced flow oscillation. The test will begin at 20% thermal power and the first time the reactor achieves a new 5% power increment above that point. The test will collect pertinent LPRM data to identify stability performance characteristics and determine a decay ratio during the ascension to rated reactor power. The monitored LPRM signals are filtered to remove noise components with frequencies above the range of stability related power oscillation. This data will be collected at sufficient instances to capture the development of instability pattern (if any) that may occur during in the ascent to rated power.*]*

Criteria

Technical Specification and license condition requirements involving core thermal limits, maximum power level, and any observed reactivity anomalies or core instabilities shall be met.

Text sections that are bracketed and italicized with an asterisk following the brackets are designated as Tier 2. Prior NRC approval is required to change.

14.2.8.2.8 Nuclear Boiler Process Monitoring Test

Purpose

The objectives of this test are to:

- Verify proper operation of various nuclear boiler process instrumentation;
- Collect pertinent data from such instrumentation at various plant operating conditions; and
- Verify the test instruments to measure the flow-induced vibration of reactor internals have been installed and calibrated in order to validate design assumptions and identify any operational limitations that may exist.

Prerequisites

The applicable preoperational testing has been completed and plant management has reviewed the test procedure(s) and approved the initiation of testing. For each scheduled testing iteration, the plant shall be in the appropriate operational configuration with specified prerequisite testing complete. Additionally, system and test instrumentation shall have been installed and calibrated. The internals, test instrumentation and instrumentation lead wires for measurement of flow-induced vibration of reactor internals are installed in the reactor vessel head and it is water leak tight. The proper operation and calibration of the test instrumentation and recording equipment is verified during the leak testing of the RPV.

Description

After all in-vessel work has been completed and the RPV head has been secured, a hydrostatic pressure test is required before nuclear heatup. The RPV must be heated to a minimum temperature before it can be hydrotested; refer to the pressure-temperature curve for the RPV. The feedwater system in conjunction with the RWCU/SDC System shall be used to meet this temperature requirement and demonstrate their capability.

Specific piping systems may be added to the vibration test program based on the results of the preoperational walkdown.

Description

Vibration testing during the power ascension phase is limited to those systems that could not be adequately tested during the preoperational phase. Systems within the scope of this testing are therefore the same as mentioned in Subsection 14.2.8.1.42. However, the systems that remain to be tested are primarily of those exposed to and affected by steam flow and high rates of core flow. Because of the potentially high levels of radiation present during power operation, the testing is performed using remote monitoring instrumentation. Displacement, acceleration, and strain data is collected at various critical steady-state operating conditions and during a significant AOO such as turbine or generator trip, main steamline isolation, and SRV actuation.

Criteria

Criteria are calculated for those points monitored for vibration for both steady state and AOO cases. Two levels of criteria are generated, one level for predicted vibration and one level based on acceptable values of displacement and acceleration and the associated stress to assure that there are no failures from fatigue over the life of the plant. Failure to remain within the predicted levels of vibration shall be investigated but do not necessarily preclude the continuation of further testing. However, failure to meet the criteria based on stress limits requires prompt investigation and resolution while the plant or affected system is placed in a safe condition.

14.2.8.2.11 Reactor Internals Vibration Test (Initial Startup Flow-Induced Vibration Testing)

Purpose

The objective of this test is to collect information needed to verify the adequacy of the design, manufacture, and assembly of reactor vessel internals with respect to the potential affects of flow-induced vibration. Instrumentation of major components and the flow tests and remote inspections provide assurance that excessive vibration amplitudes, if they exist, are detected at the earliest possible time. The data collected also helps establish the margin to safety associated with steady state and AOO conditions and helps confirm the pretest analytical vibration calculations. This testing fulfills the initial startup test requirements of Regulatory Guide 1.20 for a vibration measurement and inspection program for prototype reactor internals. A complete description of the reactor internals vibration test program is provided in Subsection 3.9.2.4.

Prerequisites

The applicable preoperational phase testing is complete and plant management has reviewed the test procedure(s) and approved the initiation of testing. The initial vibration analysis computations and specifications of acceptance criteria shall be complete. These results shall be utilized to define final inspection and measurement programs. Reactor vessel components and structures shall be installed and secured as designed in expectation of being subjected to rated volumetric core flow. This includes the steam separator and dryer assembly and reactor vessel head. The assembly and disassembly of vessel internals shall be choreographed such that structures and components requiring remote inspections are accessible at the proper times. The required sensors shall be installed and calibrated prior to the flow testing. All other systems, components and structures shall be available, as required, to support the reactor internals

14.2.8.2.35 [*ESBWR First of a Kind Tests*

The ESBWR is an evolutionary design in the BWR family. As such, it has some systems or applications that are new or are increased in size such that these systems or applications are subjected to "First of a Kind" testing to confirm proper operation of the new design or to confirm that testing of prior smaller application is valid. ~~Two such augmented tests are discussed in Subsections 14.2.8.2.7 Core Performance and 14.2.8.2.11 Reactor Internal Vibration (Initial Startup Flow-Induced Vibration).~~ The tests in the following subsections are created for testing the first ESBWR to be commissioned and are only required on the first ESBWR.

14.2.8.2.35.1 *Reactor Pre Critical Heatup With RWCU/SDC*

Purpose

The objective of this test is to demonstrate an effective method of ESBWR non-nuclear heatup exists and can be used when decay heat levels are low. The test measures and records the vertical profile of the reactor metal temperature during non-nuclear heat up prior to beginning control rod withdrawal for the purpose of achieving criticality. The primary purpose of the test is to:

- *Confirm the uniform heatup of the reactor vessel metal temperature; and*
- *Determine the time to achieve the minimum temperatures necessary to begin control rod withdrawal in accordance with the Technical Specification surveillance requirement 3.4.4.2 and the Pressure and Temperature Limits Report (PTLR) DCD Tier 2 Chapter 16 Subsection 5.6.4.*

Prerequisites

The applicable preoperational tests have been completed and plant management has reviewed the test procedure(s) and approved the initiation of testing. For each scheduled testing iteration, the plant is in the appropriate operational configuration with specified prerequisite testing complete. All applicable instrumentation is checked and calibrated, as appropriate. Temporary instrumentation is installed on the exterior of the RPV to measure the vertical temperature profile during this test. This instrumentation consists of at least eight vertical strings, spaced at 45-degree increments around the vessel. Each of these strings consists of a defined number of temperature elements located from near the flange down to the bottom head. The temperature elements are mounted directly on the RPV under the vessel insulation and the signals are brought outside the primary containment and recorded during the testing. The temperature elements are abandoned in place at the conclusion of the startup program.

Description

The ESBWR non-nuclear heatup is accomplished by operating the RWCU system in a manner to remove water from the lower region of the vessel and reject to the main condenser while the vessel is fed from a heated feedwater source. Data collection is conducted during the non-nuclear heatup of the reactor coolant and metal. This data will be used to verify achievement of the desired temperature to begin control rod withdrawal. Data collection is continued during rod withdrawal and after criticality as reactor heat up is continued to the point of boiling and establishment of natural core circulation due to boiling and convection.

Criteria

The criteria for this test are met when sufficient data is collected to demonstrate the following:

- *An effective procedural method for vessel heatup without decay heat is provided;*
- *Plant heat up is established using feedwater heated with non-nuclear steam in conjunction with operation of the RWCU system;*
- *The heatup method and hardware provides uniform heating around the vessel; and*
- *A heat up can be established to meet the minimum Pressure/Temperature requirements to begin control rod withdrawal for criticality in a timely manner.*

14.2.8.2.35.2 ***ICS Heatup and Steady State Operation***

Purpose

The objective of this test is to confirm proper startup, operation and shutdown of one Isolation Condenser System train. Proper operation is determined by:

- *Measurement of vibration, displacement and strain on the ICS heat exchanger (Isolation Condenser) piping and tubing;*
- *Measurement of steam inlet and condensate flow return to the reactor;*
- *Change in bulk pool temperature and temperature profiles within the pool; and*
- *Level changes in the IC/PCCS system pools.*

The measurement of all parameters is made and recorded as the ICS train transitions from standby into normal operation and then back into standby. The testing for this subsection is to be performed during the 14.2.8.2.34 Isolation Condenser Performance Test.

Prerequisites

The applicable preoperational tests have been completed and plant management has reviewed the test procedure(s) and approved the initiation of testing. For each scheduled testing iteration, the plant is in the appropriate operational configuration with specified prerequisite testing complete. All applicable instrumentation is checked and calibrated, as appropriate. One of the four trains of ICS and the associated IC/PCCS pool has temporary instrumentation installed for this test. This instrumentation consists of:

- *Displacement transducers attached to predefined locations on the Isolation Condenser tubes and locations on the steam supply and condensate return piping;*
- *Strain gages attached to predefined locations on the Isolation Condenser tubes and locations on the steam supply and condensate return piping;*
- *Temperature elements to measure the vertical temperature profile of the water in at least two locations in the selected pool; and*
- *Supplemental flow instrumentation mounted as low as possible on the condensate return piping to monitor and record the value and stability of the flow rate of condensate returning to the reactor.*

Description

Data collection is accomplished during the ICS Performance Test. A single train of the ICS is placed into service and operated until steady state operation is achieved. After a period of steady state operation and data collection, the operating ICS train is secured and returned to standby.

During the return to standby, the time for the condensate return piping to re-fill with condensate to the top of the piping is measured. This point determines when the system has fully returned to the standby state or condition.

Criteria

The criteria for this test are met when sufficient data is collected to demonstrate the following:

- *The displacement and strain produced in the rapid startup of the Isolation Condenser remains within design limits;*
- *The temperature profile changes as the pool is heated by the Isolation Condenser is consistent with engineering design calculations;*
- *IC/PCCS pool level control is per design;*
- *Isolation Condenser startup and shutdown transients are smooth, as indicated by flow, displacement and vibration measurements that do not indicate evidence of water hammer or steam collapse; and*
- *Variations in steam and condensate return flow measurements observed and recorded during the startup and shutdown transients which do not challenge set points for leak detection isolation.*

14.2.8.2.35.3 ***Power Maneuvering In the FW Temperature Operating Domain***

Purpose

The objective of this test is to maneuver reactor power at high power using plant-operating procedures to demonstrate effective and stable reactor power control is achieved by varying temperature of final feedwater fed into the reactor.

Prerequisites

The applicable preoperational tests have been completed and plant management has reviewed the test procedure(s) and approved the initiation of testing. For each scheduled testing iteration, the plant is in the appropriate operational configuration with specified prerequisite testing complete. All applicable instrumentation is checked and calibrated. Data necessary to limit operation within the bounds of the permissible operating domain have been inserted into the ATLM system. All initial startup tests for the low and mid power plateaus are satisfactorily completed. The startup-testing program has been authorized to proceed into testing in the high power region.

Description

In the ESBWR, one method used to change reactor power is achieved by controlling final feedwater temperature. This is accomplished by adjustment of steam flow to the shell of the

seventh stage feedwater heater or by adjusting the amount of feedwater bypassing high pressure feedwater heaters as discussed in DCD Tier 2 in Subsections 7.7.3 and 10.4.7.2.2.3. This test collects data sufficient to demonstrate that reactor and core performance characteristics remain within design limits and expectations for the operational conditions the plant is expected to encounter. The testing maneuvers the plant through the acceptable regions of the Power-Feedwater Temperature Operating Domain (Figure 4.4-1). Data is taken at a number of specifically identified points on this map to ensure complete coverage of the operational area. The data is sufficient to determine:

- *The axial and radial core power distributions;*
- *Compliance with core thermal limits;*
- *Consistency with predicted core reactivity; and*
- *Stability and core flow versus core power.*

Criteria

The criteria for this test are met when sufficient data is collected to demonstrate the following:

- *Power maneuvering via adjustment of feedwater temperature is an effective method for power control;*
- *Power maneuvering procedures are fully functional; and*
- *Operation of the reactor within the envelope of the Power-Feedwater Temperature Operating Domain is shown to be acceptable for core thermal limits and stability.*

14.2.8.2.35.4 ***Load Maneuvering Capability***

Automatic load maneuvering testing is included in the First-of-a-Kind tests to demonstrate automatic maneuvering characteristics of the first plant commissioned meets the ESBWR design basis. Any future testing of this feature is to be conducted by utilities that plan on using this mode of operation. Therefore this testing is not considered a fixed requirement for the follow-on plants.

Purpose

The objectives of this test are to verify the power plant can execute automated load maneuvering to a pre-programmed profile (or trajectory) without operator intervention. During this demonstration of automatic maneuvering, all plant parameters remain within the plant's design and administrative limits.

Prerequisites

The applicable preoperational and startup tests have been completed and plant management has reviewed the testing procedure and approved the initiation of testing. Affected systems and equipment, including lower level control systems such as RC&IS, feedwater level and temperature control, turbine control, as well as monitoring and predicting functions of the PAS (PGCS/APR) and/or N-DCIS, have been adequately tested under actual operating conditions during the startup test program. A pre-programmed power profile is loaded into the plant's PAS to operate under full automatic mode for the purpose of this testing. The power profile is created to test the plant's ability to achieve, but not exceed, the power rate-of-change contained in the

unit's design specification. This profile is consistent with the ESBWR load maneuvering capability described in Subsection 10.2.1.3.3.

Description

This test consists of a single period of plant operation when the power operation follows a specific generator electric output profile. The test profile includes a power reduction from 100% to 50% in two hours, a hold at 50% of at least one hour followed by a two-hour return to full power. The balance of the 24-hour period will be fixed 100% operation. This testing includes power reduction and increase rates based on the ESBWR design requirements for load following. During the entire period, enhanced monitoring of the plant systems and the reactor core is conducted to ensure the proper plant operation is being maintained.

Criteria

Throughout the planned automatic load following test interval, PAS and other features and functions of plant automation and control performs in accordance with the applicable design and operational specifications. Core thermal power and generator electrical output are within the allowable limits of the programmed profile. Automatic maneuvering characteristics of plant and systems meets the appropriate response and stability requirements. Safety and protection features perform at all times to be consistent with safety analysis assumptions and predictions. Plant parameters do not reach or exceed plant technical or administrative limits, nor require operator action to avoid exceeding them.

14.2.8.2.35.5 ***Defense-In-Depth Stability Solution Evaluation Test***

Purpose

The objective of this test is to evaluate and confirm the proper operation and setpoints of the defense-in-depth stability solution. As initially installed this subsystem will function to provide alarm functions only. Specifically the portion of the subsystem allowing the Oscillation Power Range Monitor (OPRM) channel to signal the associated RPS channel to generate a reactor scram request is not enabled. This test will be conducted during the entire first cycle of plant operation. A secondary objective of this testing is to allow an opportunity to adjust trip and alarm setpoint if test evaluations determine the setpoints are too conservative or too near the operating values and nuisance alarms/trips are being observed.

Prerequisites

The applicable preoperational tests have been completed and plant management has reviewed the test procedure(s) and approved the initiation of testing. During the preoperational testing confirmation has been made that simulation of an OPRM channel trip does not cause the associated RPS channel to trip, however all alarm functions of the OPRM are functional.

Description

Data collection will be accomplished during the defense-in-depth stability solution Test consists of monitoring OPRM performance during all modes where the defense-in-depth stability solution subsystem is armed (>25% thermal power). This data is to be sufficient to evaluate the performance of the three algorithms Period Based Detection Algorithm (PBDA), Amplitude Based Algorithm (ABA), and Growth Rate Algorithm (GRA) used in the subsystem. The data collections include the margin to trip of the monitored signals to the subsystem setpoints.

Collection is made during both steady-state operation and transient events created in the startup test program.

Criteria

Data collected in the performance of the entire startup test program period show the defense-in-depth stability solution subsystem to provide effective protection against power oscillations without creation of unnecessary alarms or scram requests.]*

Text sections that are bracketed and italicized with an asterisk following the brackets are designated as Tier 2. Prior NRC approval is required to change.

14.2.9 Site-Specific Preoperational and Start up Tests

The preceding discussion of preoperational and startup tests was limited to those systems and components within, or directly related to, the ESBWR. Other testing, with respect to site-specific aspects of the plant, is necessary.

The COL Applicant will define any required site specific preoperational and startup testing. See Subsection 14.2.10 for COL Information item 14.2-5-A. Testing of such systems and components should be adequate to demonstrate conformance to such requirements as defined throughout the specific chapters of the Standard Safety Analysis Report (SSAR). Below are systems that may require such testing:

- Electrical switchyard and equipment;
- Station Water System;
- Personnel monitors and radiation survey instruments; and
- The automatic dispatcher control system (if applicable).

If site-specific preoperational or startup tests are identified as necessary, the appropriate procedures will be prepared by the same method and to the same standard as discussed in Subsection 14.2.2.2. Approved test procedures satisfying the commitments of this chapter are to be made available to the NRC approximately 60 days prior to their intended use for preoperational tests and not less than 60 days prior to scheduled fuel loading for power ascension tests. See Subsection 14.2.10 COL Information item 14.2-6-H.

14.2.9.1 Site-Specific Preoperational Tests

System tests as appropriate.

14.2.9.2 Site Specific Startup Tests

System tests as appropriate.