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Document Control Desk
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

Attention: Mr. Jeffery A. Ciocco

Docket No. 52-021
MHI Ref: UAP-HF-10088

Subject: MHI's Response to US-APWR DCD RAI No. 538-4320

Reference: 1) "Request for Additional Information No. 538-4320 Revision 2, SRP Section: 03.07.04 – Seismic Instrumentation," dated 3/02/2010.

With this letter, Mitsubishi Heavy Industries, Ltd. ("MHI") transmits to the U.S. Nuclear Regulatory Commission ("NRC") a document entitled "Response to Request for Additional Information No. 538-4320, Revision 2."

Enclosed is the response to 1 RAI contained within Reference 1. This transmittal completes the response to this RAI.

Please contact Dr. C. Keith Paulson, Senior Technical Manager, Mitsubishi Nuclear Energy Systems, Inc. if the NRC has questions concerning any aspect of this submittal. His contact information is provided below.

Sincerely,

Y. Ogata

Yoshiki Ogata,
General Manager- APWR Promoting Department
Mitsubishi Heavy Industries, LTD.

Enclosure:

1. Response to Request for Additional Information No. 538-4320, Revision 2

CC: J. A. Ciocco
C. K. Paulson

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Docket No. 52-021
MHI Ref: UAP-HF-10088

Enclosure 1

UAP-HF-10088
Docket No. 52-021

Response to Request for Additional Information No. 538-4320,
Revision 2

March, 2010

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

3/30/2010

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No. 52-021

RAI NO.: NO. 538-4320 REVISION 2
SRP SECTION: 03.07.04 - Seismic Instrumentation
APPLICATION SECTION: 03.07.04
DATE OF RAI ISSUE: 3/2/10

QUESTION NO. RAI 03.07.04-03:

Section 3.7.4.1 of the DCD states that seismic instrumentation for monitoring the free-field ground motion is not specifically required since both the site-independent and site-specific design are based on control motions that are defined at the bottom of the basemats. Section 3.7.4.1 of the DCD further states that the response spectra of the free-field ground motion are not directly relevant to the design of the US-APWR standard plant nor are directly comparable to the design input ground motion as defined by the CSDRS and FIRS in Subsection 3.7.1.1. In lieu of a free field seismic instrument, you propose that the OBE exceedance checks be performed using ground motions obtained from seismic instrumentation installed at five plant locations (i.e. two basemat locations and three upper level locations as described in Subsection 3.7.4.2). You further state that the use of five instrument locations is more conservative than the interim OBE exceedance guidelines given in Appendix A of RG 1.166 (Reference 3.7-41), which allow basemat level only instrumental checks.

RG 1.12 specifies that a seismic instrument be located in the free-field and RG 1.166 states that the evaluation to determine whether the OBE has been exceeded should be performed using the ground motion recorded from a free-field seismic instrument. In addition, the purpose of Appendix A, as noted in RG 1.166, is to provide interim OBE exceedance guidelines in the case that the installed seismic instrumentation or data processing equipment is inoperable.

With regards to Section 3.7.4 of the DCD, please provide the following information:

1. Explain how the proposed US-APWR design is consistent with the regulation, as well as the guidance in RG 1.12 and RG 1.166, which specify that COL applicants install a free-field instrument to determine OBE exceedance.
2. Please clarify the OBE exceedance criteria in subsection 3.7.4.1, which states that, "the shutdown of the plant is required only if all three of the above conditions are met." RG 1.166 states that the OBE exceedance occurs if the response spectrum check and the CAV check are exceeded. The OBE response spectrum is exceeded if the spectral acceleration or spectral velocity criteria are exceeded.
3. Subsection 3.7.4.1 states that "the measured response spectra at each of the instrumentation locations in Subsection 3.7.4.2 are compared against the corresponding site-specific OBE instructure acceleration and velocity response spectra." Please explain how the in-structure acceleration and velocity response spectra are developed. Specifically, clarify whether the site-specific instructure OBE spectra would necessitate

that applicants perform a soil-structure-interaction (SSI), if they elect not to have a free-field seismic instrument to determine OBE exceedance.

ANSWER:

1. Regulation [10CFR50 Appendix S (a)(1)(i)] requires that the SSE must be characterized by free-field ground motion response spectra at the free ground surface. The certified seismic design response spectra (CSDRS) described in the Design Control Document (DCD) for the standard plant is a free-field motion and is applied at the base of the foundations. The relationship between free-field ground surface motion and the motion at the foundation bases cannot be determined without knowing site-specific information. For purposes of generic design the DCD assumes that the CSDRS and the free-field motion at the ground surface are the same. Therefore, the proposed US-APWR design is consistent with the regulation.

The DCD adopts an operating-basis earthquake (OBE) value that is 1/3 of the safe-shutdown earthquake (SSE) for purposes of standard plant design. For shutdown purposes, the 1/3 value of SSE is conservative with respect to previous historical values of OBE which were typically set at 1/2 SSE. The OBE is set on a site-specific basis by the COL Applicant. Setting OBE at 1/3 SSE [as permitted by 10 CFR 50 Appendix S IV(2)(i)(A)] is conservative with respect to setting the level for required shutdown, because it would result in shutdown at a lower level of ground motion than permitted by Appendix S IV(2)(i)(B).

The DCD requires each applicant to confirm that the foundation input response spectra (FIRS) are enveloped by the CSDRS, which is the input motion for design at the base of foundation. As discussed in DCD Subsection 3.7.4.1, since both the site-independent and site-specific design are based on control motions that are defined at the bottom of the basemats, the response spectra of the free-field ground motion are not directly relevant to the design of the US-APWR standard plant nor are directly comparable to the design input ground motion as defined by the CSDRS and FIRS in Subsection 3.7.1.1. Therefore, the US-APWR DCD provides an option for COL Applicants to utilize seismic instrumentation provided within the standard plant structures only for purposes of shutdown consideration, instead of installing a free-field instrument as specified in RG 1.12 and RG 1.166. Use of this option is dependent on conditions and requirements specific to the site. The COL Applicant is to verify the site-specific applicability of the standard plant monitors described in DCD Subsection 3.7.4.2 and determine if there is a need for the free-field instrumentation as required by COL Item 3.7(16). If free-field instrumentation is not used, then the cumulative absolute velocity (CAV) exceedance criteria are not applicable and it is automatically assumed that they are exceeded. This is conservative and meets RG 1.166 Criteria 5.1.

The use of FIRS in plant analyses as described above enables direct comparison of the input motion with measured motion. Comparison of the measured in-structure response spectra (ISRS) to the design ISRS for plant structures, based on the FIRS, may be a more accurate way to determine OBE exceedances for certain sites. Propagation of ground motion typically results in the free-field ground surface motion being greater than that at the foundation control point. Therefore, the trigger set point for instrumentation in the plant may be more conservative than a shutdown trigger based on free-field surface motion for certain sites.

During the NRC/Industry Meeting sponsored by NEI on May 31, 2007, during the Bob Whorton presentation, the NRC indicated it would consider on an applicant-by-applicant basis the recommendation of EPRI NP-5930 to locate ground motion sensors at the foundation of containment if the NPP is founded on rock or stiff soil as an option instead of having to locate the instrument at the ground surface in the free field. Less desirable aspects and difficulties in implementing the instrument at free-field locations were discussed in this meeting including:

- The fact that the ground motion response spectra (GMRS) (used in developing the design ground motion for design of the NPP SSCs) is specified on an outcrop or hypothetical outcrop that will exist after excavation where as soil layers representing the free field may be completely excavated to expose competent material and replaced with alternate material not actually representative of a free field condition.
 - Due to changes in subsurface conditions with distance from the plant, a location for the sensors may not be available such that the effects associated with surface features, buildings, and components on the recorded motion will be insignificant.
 - The free field location may also be a significant distance away from the NPP requiring additional difficulties to connect to the NPP, maintenance, and security to protect over the long term, when a location at the foundation of containment would meet the suitable requirement for instrumentation of 10 CFR 50, Appendix S and meet the objective of the sensor location to ensure that earthquake motions recorded are consistent with the plant design.
2. It is agreed that RG 1.166 defines OBE exceedance to occur if the response spectrum check and the CAV check are exceeded. It is also agreed that the logic for determining if the OBE response spectrum is exceeded is based on exceedance of the spectral acceleration or spectral velocity criteria. Therefore, when free-field instrumentation is chosen to be implemented by the COL Applicant for shutdown determination, the guidance of RG 1.166 Sections 4.1 and 4.2 are to be used for OBE exceedance checks. When in-structure instrumentation only is chosen by the COL Applicant for shutdown determination, it is proposed that the OBE exceedance criteria of RG 1.166 Appendix A be used for all five plant instrumentation locations. As stated in DCD Subsection 3.7.4.4, the use of the five instrument locations is more conservative than basemat-level only instrumental checks. The related paragraphs in Subsection 3.7.4.1 will be changed to correct the logic and to clarify the proposed shutdown conditions as shown below in "Impact on DCD".
 3. Subsection 3.7.4.1 of the DCD states that "the measured response spectra at each of the instrumentation locations in Subsection 3.7.4.2 are compared against the corresponding site-specific OBE instructure acceleration and velocity response spectra."

ISRS acceleration and velocity response spectra are developed in accordance with Section 3.7.2.5 of the DCD from seismic input motion at the base of the foundation referred to as FIRS. The instrument locations correspond to locations in the model for which ISRS are developed.

COL Applicants must perform soil-structure-interaction (SSI) analyses as described in DCD Subsection 3.7.2 and in the response to RAI 495-3980, regardless of whether free-field instrumentation is utilized. The SSI analyses are used to generate the site-specific in-structure OBE response spectra to be used for purposes of shutdown evaluation by comparison to measured vibratory ground motion.

Impact on DCD

See the attached mark-up of DCD Tier 2, Subsection 3.7.4, changes to be incorporated.

- Replace the fifth and sixth paragraphs with the following:

"Acceleration and velocity spectra can be calculated from the measurement of free-field ground motion in order to set additional conditions for OBE exceedance in addition to the CAV check. When free-field instrumentation is used, the site-specific OBE is exceeded and plant shutdown is required in accordance with the criteria of RG 1.166 (Reference 3.7-41), if the first of the following three conditions in combination with either the second or third conditions are met:

1. Any calculation of CAV described above yields a value that is greater than 0.16 g-second.
2. 5% damping ARS generated by free-field ground motion ARS are higher than 0.2 g at frequencies between 2 and 10 Hz, or higher than the site-specific OBE ARS between 2 and 10 Hz, whichever is greater.
3. 5% damping velocity response spectra generated by free-field ground motion are higher than 6 in./sec at frequencies between 1 and 2 Hz, or higher than the site-specific OBE velocity response spectra between 1 and 2 Hz, whichever is greater.

If free-field instrumentation is not used, the criteria of RG 1.166 Appendix A are used for OBE exceedance checks, it is assumed that the checks of CAV and free field ground spectra are exceeded, and shutdown of the plant is required if the 5% damping spectra are exceeded at any of the in-structure instrumentation."

Impact on COLA

There is no impact on the COLA.

Impact on PRA

There is no impact on the PRA.

This completes MHI's responses to the NRC's questions.

is different than that recommended by EPRI. In accordance with RG 1.166 (Reference 3.7-41), for each component of the free-field ground motion, the CAV should be calculated as follows: (1) the absolute acceleration (g units) time-history is divided into 1-second intervals, (2) each 1-second interval that has at least 1 exceedance of 0.025 g is integrated over time, (3) all the integrated values are summed together to arrive at the CAV. The approaches in EPRI Report NP-5930 (Reference 3.7-43) and EPRI Report TR-100082 (Reference 3.7-42) provide additional guidance on determining the CAV.

Acceleration and velocity spectra can be calculated from the measurement of free-field ground motion in order to set additional conditions for OBE exceedance in addition to the CAV check. When free-field instrumentation is used, the site-specific OBE is exceeded and plant shutdown is required in accordance with the criteria of RG 1.166 (Reference 3.7-41), if the first of the following three conditions in combination with either the second or third conditions are met.~~The site-specific OBE is exceeded only if all of the following three conditions identified in RG 1.166 (Reference 3.7-41) are met:~~

1. Any calculation of CAV described above yields a value that is greater than 0.16 g-second.
2. 5% damping ARS generated by free-field ground motion ARS are higher than 0.2 g at frequencies between 2 and 10 Hz, or higher than the site-specific OBE ARS between 2 and 10 Hz, whichever is greater.
3. 5% damping velocity response spectra generated by free-field ground motion are higher than 6 in./sec at frequencies between 1 and 2 Hz, or higher than the site-specific OBE velocity response spectra between 1 and 2 Hz, whichever is greater.

If free-field instrumentation is not used, the criteria of RG 1.166 Appendix A are used for OBE exceedance checks, it is assumed that the checks of CAV and free field ground spectra are exceeded, and shutdown of the plant is required if the 5% damping spectra are exceeded at any of the in-structure instrumentation.~~The shutdown of the plant is required only if all three of the above conditions are met and any of the 5% damping ARS obtained from the measurements of the instructure accelerations exceed the OBE spectra at the corresponding location. If the free field ground motion is not measured, it is conservatively assumed that the checks of CAV and free field ground accelerations and velocities are exceeded.~~

Additionally, low-level seismic effects would be included in the design of certain equipment potentially sensitive to a number of such events, based on a percentage of the responses calculated for the SSE.

3.7.4.2 Location and Description of Instrumentation

Consistent with the guidance of RG 1.12 (Reference 3.7-40), the seismic instrumentation for the US-APWR standard plant is solid-state multi-channel digital instrumentation with computerized recording and playback capability that allows the processing of data at the plant site within 4 hours of a seismic or other dynamic event.

- The US-APWR triaxial time-history accelerograph consists of a centralized digital time history analyzer/recorder with multi-channel capability, which is located in a panel in a