## RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

**03/29/2013**

**US-APWR Design Certification**

**Mitsubishi Heavy Industries**

**Docket No. 52-021**

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| **RAI NO.:** | **NO. 496-3735 REVISION 0** |
| **SRP SECTION:** | **03.08.05 - Foundations** |
| **APPLICATION SECTION:** | **3.8.5** |
| **DATE OF RAI ISSUE:** | **12/01/2009** |

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**QUESTION NO. 03.08.05-31:**

In its response to Part (a) of Question 3.8.4-12, MHI describes the changes made to both DCD Tier 1 and DCD Tier 2 regarding the maximum differential settlement of 2 in. in the reactor building (R/B) complex basemat. MHI explains that the value of 2 in. was obtained considering a soft soil site (shear wave velocity of 1,000 fps), and that the maximum differential settlement represents 1/3 of the estimated maximum settlement of the R/B complex foundation. In the response for Part (b) of the question, MHI states that forces and moments resulting from differential settlement are not combined with other load cases. They explain that the 2 in. maximum differential settlement was intended for use in sizing gaps between adjacent buildings, and that stresses due to this differential settlement are not critical for the design of the foundation basemat.

The applicant is requested to provide the following information:

1. In the response for Part (a) of the question, MHI states that "The specified maximum differential settlement represents one third (1/3) of the estimated maximum settlement of the R/B complex foundation." MHI is requested to provide the technical rationale for choosing 1/3 of the estimated maximum settlement for the differential settlement. Also, in the response, MHI stated that a value of 27.6 lb/in$^3$ representing the stiffness of the soft soil generic subgrade is used in short term settlement calculation and one half of this value, 13.8 lb/in$^3$, is used in the long term settlement calculation. MHI is requested to provide technical information and rationale to support the use of one half the value of the stiffness used in the short term settlement to calculate the long term settlement. The staff also notices that the value of 27.6 lb/in3 used in the calculation of the short-term foundation settlement is taken from Table 2(c) given in the MHI's response to RAI 3.8.5-7 of this RAI, and that it represents the average of soil spring constant of the lump-mass model. As discussed in the evaluation of RAI 3.8.5-7, this average value is theoretically unsound, and is not accepted by the staff. The applicant is requested to address this issue.

MHI's response for Part (b) of the question is not acceptable. Even if the forces and moments due to the 2 in differential settlement are not critical to the design, these forces and moments need to be combined with the forces and moments due to other loads. The staff considers that foundation uplift and differential settlement are two additive events. MHI is

requested to consider these as additive events or to provide the rationale and justification for why these loads should not be combined in the analysis.

Reference: MHI response to RAI 340-2004, dated 7/3/2009, MHI Ref: UAP-HF-09363, ML091900557.

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**ANSWER:**

This answer revises and replaces the previous MHI answer that was transmitted by letter UAP-HF-10032 (ML100430770). The original response to this question transmitted by MHI letter UAP-HF 10032 (ML100430770) was supplemented by the response to follow-up RAI 657-5135 Question 03.08.05-40 transmitted by MHI letter UAP-HF-10351 (ML110040127). Further definition and details on calculation for differential settlements (and tilt) produced by short term and long term static loads are also provided in the response to RAI 855-6090, Question 03.08.05-42.

NRC questions are repeated below in italics and answered separately:

*Question 03.08.05-31(a)1:*

*In the response for Part (a) of the question, MHI states that "The specified maximum differential settlement represents one third (1/3) of the estimated maximum settlement of the R/B complex foundation". MHI is requested to provide the technical rationale for choosing 1/3 of the estimated maximum settlement for the differential settlement.*

Answer:

The settlements and differential settlements for the Standard Plant structures have been re-calculated as explained in the answer to RAI 340-2004, Question 03.08.05-13.

*Question 03.08.05-31(a)2:*

*Also, in the response, MHI stated that a value of 27.6 lb/in$^3$ representing the stiffness of the soft soil generic subgrade is used in short term settlement calculation and one half of this value, 13.8 lb/in$^3$, is used in the long term settlement calculation. MHI is requested to provide technical information and rationale to support the use of one half the value of the stiffness used in the short term settlement to calculate the long term settlement.*

Answer:

In the MHI Answer to RAI 340-2004, Question 3.8.5-12, "short term" and "long term" stiffness was intended to actually refer to stiffness corresponding to "short duration loads" - acting during the construction period, and "long duration loads" - acting during the entire life of the plant, respectively. Soil spring stiffness values are no longer used for calculation of settlements. Settlements and differential settlements due to short term and long term static loads are computed by means of three-dimensional finite element (FE) analysis of all Standard Plant structures simultaneously, placed on the subgrade, which is included in the FE model and represented by continuous FEs. This detailed FE representation accounts for the

flexibility of structures and of the subgrade. The settlement analysis method is presented in more detail in the answer to RAI 340-2004, Question 03.08.05-13. Subgrade stiffness is included in the model through the deformation moduli of various layers of the profile considered. Secant equivalent elastic deformation moduli that allow capturing both immediate and time dependent deformations are established as described in the answer to RAI 340-2004, Question 03.08.05-14. Only the most deformable subgrade is considered, and the resulting deformations envelope results for any other soil profile.

*Question 03.08.05-31(a)3:*

*The staff also notices that the value of 27.6 lb/in3 used in the calculation of the short-term foundation settlement is taken from Table 2(c) given in the MHI's response to RAI 3.8.5-7 of this RAI, and that it represents the average of soil spring constant of the lump-mass model. As discussed in the evaluation of RAI 3.8.5-7, this average value is theoretically unsound, and is not accepted by the staff. The Applicant is requested to address this issue.*

Answer:

Soil spring stiffness values are not used for calculation of settlement. Please refer to the response to Question 03.08.05-31(a)2 above for explanation of how soil stiffness is considered.

*Question 03.08.05-31(b)*

*MHI's response for Part (b) of the question is not acceptable. Even if the forces and moments due to the 2 in differential settlement are not critical to the design, these forces and moments need to be combined with the forces and moments due to other loads. The staff considers that foundation uplift and differential settlement are two additive events. MHI is requested to consider these as additive events or to provide the rationale and justification for why these loads should not be combined in the analysis.*

Answer:

The shear forces and bending moments generated in the mat by differential settlements produced during construction will be accounted for in a future revision of the basemat design calculations.

**Impact on DCD**

There is no impact on the DCD.

**Impact on R-COLA**

There is no impact on the R-COLA.

**Impact on S-COLA**

There is no impact on the S-COLA.

**Impact on PRA**

There is no impact on the PRA.

**Impact on Technical/Topical Report**

There is no impact on the Technical/Topical Report.

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This completes MHI's response to the NRC's question.