## 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. 855-6090 REVISION 3** |
| **SRP SECTION:** | **03.08.05 – Foundations** |
| **APPLICATION SECTION:** | **3.8.5** |
| **DATE OF RAI ISSUE:** | **10/24/2011** |

**QUESTION NO. 03.08.05-42:**

In Sections 2.1 and 2.2 of MUAP-11007(R0), the applicant stated that the effects of differential settlement will be considered in the calculation of seismic gap between buildings but did not provide any details of how the differential settlement will be calculated. The applicant is requested to specifically explain its definition of "differential settlement" and describe how the effects of differential settlement are addressed in the standard design. Also describe how differential settlement and tilt settlement have been considered in the specification of seismic gaps between adjacent buildings.

**ANSWER:**

The definition and details on calculation for differential settlements and tilt produced by short term and long term static loads are provided below. Two types of differential settlement are addressed:

1. Differential settlements within the same structure, representing the maximum difference (in vertical direction) between settlements of any two points of the basemat. This is typically the difference between settlements at two opposite corners. This type of differential settlement is due to: (1) rigid body motion of the structure – this affects tilt and may result in reduced gaps between structures; and (2) flexibility of the structure at mat level – this induces additional stresses in the mat, but generally does not reduce gaps between structures because it typically induces inward angular deformations. The tilt induced by differential settlement, used for calculating gap closure due to static loads, is a rigid body rotation conservatively calculated as the maximum differential settlement within the same structure divided by the distance between the points on the basemat where this differential settlement occurs. Maximum tilt is used to assess functionality of sensitive equipment. Tilt used for assessing possible gap reduction is calculated separately for the North and South walls and for the East and West walls.

2. Differential settlements between adjacent structures, representing the maximum difference between settlements of any two neighboring points on the basemats, each of them on one of the adjacent structures.

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 finite elements. This detailed FE representation accounts for the flexibility of structures and of the subgrade. Subgrade stiffness is included in the model through the deformation moduli of various layers of the profile considered. Only the most deformable subgrade (generalized layered soil profile 270-500 as identified in Design Control Document (DCD) Table 3.7.1-6) is considered, and the resulting deformations envelope results for any other soil profile. Moreover, to capture a large palette of time-dependent deformations, two types of subgrade are considered in the settlement analysis: predominantly sand soils and predominantly clay soils. More details regarding the settlement analysis method are presented in the answers to RAI 340-2004, Questions 03.08.05-13 and 03.08.05-14.

Actual total and differential settlements are dependent on site-specific conditions such as lateral soil variability, construction sequence, loading conditions, excavation plans and dewatering plans. It is expected that all immediate settlements and most of the time dependent settlements will occur by the time of completion of construction, and that most of these settlements can be compensated during construction. While the effects of soil variability in a horizontal plane can only be addressed on a site specific basis, all the other factors governing settlements and differential settlements are addressed in the settlement analysis of the Standard Plant, and the most conservative assumptions are used when verifying the integrity of gaps between structures. In this respect, tilt between adjacent buildings due to static loads is calculated assuming a relatively short construction time, and neglecting any compensation of differential settlement during construction.

All standard plant seismic category I structures are on a common basemat. The turbine building (T/B) is located approximately 16 in. away from the safety related reactor building (R/B) complex, as shown in DCD Figure 1.2-4. The access building (AC/B) and tank house are located adjacent to the auxiliary building (A/B) (placed on the R/B complex common basemat), with 16 in. gaps in between. These gaps are verified by adding the closure due to static loads to the seismic induced gap closure (wall bending, sliding).

Differential settlements between adjacent structures are important for critical connections between buildings and commodities and their supports and tunnels. As completion of these connections can be delayed until completion of infrastructure construction and major equipment installation, only the differential settlements developed during operational life of the plant and those due to backfill loads are relevant. The calculated values range between 0.1 in. and 0.4 in. These values are less than the 0.5 in. limit specified in Table 2.0-1, Tier 2 and Table 2.1-1 of Tier 1 of the DCD for maximum differential settlement between buildings.

**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.