REQUEST FOR ADDITIONAL INFORMATION 207-1577 REVISION 0

2/25/2009

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No. 52-021

SRP Section: 03.09.02 - Dynamic Testing and Analysis of Systems Structures and Components
Application Section: 3.9.2.5

QUESTIONS for Engineering Mechanics Branch 1 (AP1000/EPR Projects) (EMB1)

03.09.02-23

RAI 3.9.2-50

The applicant stated in DCD Tier 2, Subsection 3.9.2.5.1, that the mathematical model for dynamic system analysis includes representation of reactor vessel (RV) support system, inlet and outlet piping nozzles, control rod drive mechanism (CRDM) system, integrated head support system, in-core instrumentation support system, and fuel assembly nozzles and grids. The applicant further stated that fluid-structure interaction effects were accounted for by matrices developed for that purpose.

The staff reviewed Subsection 3.9.2.5 and found that the applicant did not provide sufficient details. Section 3.9.2 of the SRP states that mathematical model used for dynamic system analysis for LOCA in combination with SSE effects should include fluid-structure effects when applicable. Also, typical diagrams and modeling basis should be described. The applicant is requested to provide the details to explain how the fluid-structure effects are accounted for in the modeling of the reactor internals and dynamically related piping, pipe supports, and components. Alternately, provide a reference document that describes the mathematical models used for the dynamic system analysis for LOCA in combination with SSE. The staff needs this information to assure conformance with GDC 2, 4, 14, and 15. Revise the DCD to include the requested information or provide a reference where this information is available.

03.09.02-24

RAI 3.9.2-51

In Subsection 3.9.2.5.2 of the DCD the applicant stated that the pipe rupture analysis methodology is similar to the seismic analysis methodology. The reactor internals are represented in the model by beam elements; and the connectivity of the reactor internals and interfacing structures, is represented by mass inertia effect, stiffness and hydrodynamic matrices, springs, and/or impact elements including gap and damping. Dominant frequencies are identified by comparing the frequency response of the reactor internals with the response based on experience and measurements.

The staff's review of Subsection 3.9.2.5 of the DCD indicated that the applicant did not provide any discussion regarding system structural partitioning and directional decoupling employed in the model. Section 3.9.2 of the SRP states that mathematical model used for dynamic system analysis of reactor internals should include a justification regarding any system structural partitioning and directional decoupling employed in the model. The applicant is requested to provide a discussion and justification for any system structural partitioning and directional decoupling employed in the dynamic system modeling of the reactor internals and the reactor pressure vessel. The staff needs this information to assure conformance with GDC 2, 4, 14, and 15. Revise the DCD to include the requested information.

03.09.02-25

RAI 3.9.2-52

The applicant stated in DCD Tier 2, Subsection 3.9.2.5.2, that the mathematical model for dynamic system analysis includes such structural characteristics as the flexibility, mass inertia effect, geometric configuration, and damping (including possible coexistence of viscous and Coulomb damping).

However, the staff found that the applicant did not include any justification that the model is representative of the system structural characteristics, or provide a reference document where such information is available. Section 3.9.2 of the SRP states that mathematical model used for dynamic system analysis of reactor internals under faulted conditions should typify such system structural characteristics as flexibility, mass inertia effect, geometry geometric configuration, and damping (including possible coexistence of viscous and Coulomb damping). The applicant is requested to provide a discussion to justify that the dynamic reactor internals models are representative of system structural characteristics, such as the flexibility, mass inertia effect, geometric configuration, and damping (including possible coexistence of viscous and Coulomb damping). Alternately, provide a reference document where this information is available. The staff needs this information to assure conformance with GDC 2, 4, 14, and 15. Revise the DCD to include the requested information or provide a reference where this information is available.

03.09.02-26

RAI 3.9.2 -53

The applicant stated in DCD Tier 2, Subsection 3.9.2.5.2, that the mathematical model for dynamic system analysis includes such structural characteristics as the flexibility, mass inertia effect, geometric configuration, and damping (including possible coexistence of viscous and Coulomb damping). In addition, the effects of flow upon the mass and flexibility properties of the system are accounted for in the model.

The staff reviewed the DCD and found that the applicant did not provide sufficient details regarding the mathematical model. Section 3.9.2 of the SRP states that mathematical model used for dynamic system analysis for LOCA in combination with SSE effects should address the effects of flow upon the lumped-mass and flexibility properties of the system. The applicant is therefore requested to provide the details to explain how the effects of flow upon the lumped-mass and flexibility properties of the system are accounted for in the LOCA dynamic system analysis model. Alternately, provide a reference document where this information is available. The requested information is needed to complete the review of the mathematical model for dynamic system analysis and to assure conformance with GDC 2, 4, 14, and 15. Revise the DCD to include the requested information or provide a reference where this information is available.

03.09.02-27

RAI 3.9.2-54

The applicant stated in DCD Tier 2, Subsection 3.9.2.5.2 that the design input for the dynamic system analyses is defined by postulated pipe rupture, as discussed in Subsection 3.6.2 of the DCD. The time-history forcing function on the reactor internals is determined from pipe rupture events that are enveloped by the most limiting blow-down hydraulic loads.

The DCD, however, does not provide any discussion regarding the basis for developing the forcing function. Section 3.9.2 of the SRP states that evaluation of the dynamic effects on reactor internals associated with postulated pipe rupture should include a description of the governing hydrodynamic equations and the assumptions used for flow path geometries, tests for determining flow coefficients, and any semi-empirical formulations and scaled model testing for determining pressure differentials or velocity distributions. Typical diagrams and the basis for postulating the LOCA-induced forcing function should also be provided. The applicant is requested to provide (a) typical diagrams and the basis for postulating the pipe break-induced forcing function, including a description of the governing hydrodynamic equations and the assumptions used for flow path geometries, and (b) tests to determine flow coefficients, and any semi-empirical formulations and scaled model tests to determine pressure differentials or velocity distributions. The staff needs this information to assure conformance with GDC 2, 4, 14, and 15. Revise the DCD to include the requested information.

03.09.02-28

RAI 3.9.2-55

In Subsection 3.9.2.5.2 of the DCD the applicant stated that methods and procedures used for the LOCA dynamic system analysis are based on the computer code used in the LOCA analysis. The computer code incorporates the governing equations of motion and the computational scheme for deriving results. Asymmetric LOCA loads for the reactor internals are considered for the LOCA dynamic system analysis.

However, staff's review indicated that the DCD did not provide sufficient details. Section 3.9.2 of the SRP states that evaluation of the dynamic effects on reactor internals associated with postulated pipe rupture should include a description of the methods and procedures for dynamic system analyses, including the governing equations of motion and the computational scheme for deriving results. The applicant is requested to describe in detail the methods and procedures used for dynamic system analyses including the governing equations of motion and the computational scheme used for deriving results. Alternately, provide a reference document where this information is available. The staff needs this information to assure conformance with GDC 2, 4, 14, and 15. Revise the DCD to include the requested information or provide a reference where this information is available.

03.09.02-29

RAI 3.9.2-56

The applicant stated in Subsection 3.9.2.5.2 of the DCD that methods and procedures used for the LOCA dynamic system analysis are based on the computer code used in the LOCA analysis. The computer code incorporates the governing equations of motion and the computational scheme for deriving results. Asymmetric LOCA loads for the reactor internals are considered for the LOCA dynamic system analysis.

The applicant did not include a discussion to assure that there is no significant dynamic amplification of the load on reactor internals as a result of the oscillatory nature of the blow-down forces during a postulated LOCA. Section 3.9.2 of the SRP states that evaluation of the dynamic effects on reactor internals associated with postulated pipe rupture should include a description of the methods and procedures for dynamic system analyses, including the governing equations of motion and the computational scheme for deriving results. The applicant is requested to provide the analytical results to demonstrate that there is no significant amplification of the loads on reactor internals and core support structures as a result of postulated pipe rupture. The staff needs this information to assure conformance with GDC 2, 4, 14, and 15. Revise the DCD to include the requested information.

03.09.02-30

RAI 3.9.2-57

The applicant stated in Subsections 3.9.2.5.2 and 3.9.2.5.3 of the DCD that the maximum stress intensities and displacements obtained from the LOCA dynamic system analyses are compared with the ASME Code, Section III, stress limits, and the allowable interface load and displacement limits given in Table 3.9-2 of the DCD. The applicant further stated that the LOCA dynamic system analyses results confirm that the structural design adequacy of the reactor internals can withstand the dynamic loadings of the most severe LOCA in combination with the SSE.

The staff’s review of the DCD showed that the applicant did not provide any details regarding the dynamic systems analyses. Section 3.9.2 of the SRP states that the dynamic system analyses should confirm the design adequacy of the reactor internals and unbroken loops of the reactor coolant piping, to withstand the dynamic loadings of the most severe LOCA in combination with SSE. The applicant is requested to identify the locations in the reactor internals where the stress deformation and fatigue are determined to be the highest. Also identify the corresponding loading combination. The staff needs this information to assure conformance with GDC 2, 4, 14, and 15. Revise the DCD to include the requested information.

03.09.02-31

RAI 3.9.2-59

The applicant stated in DCD Tier 2, Subsections 3.9.2.5.3, that the pipe break sizes of current 4-loop plants were based on the largest LOCA loads that resulted from either a 0.093 m^2 (1.0 ft^2) single-ended cold leg break or a double-ended hot leg break, whereas, the leak before break (LBB) criteria is applied to determine the break condition for the US-APWR design input. The magnitude of blow-down hydraulic loads applying LBB is smaller than either the loads for the large cold leg or hot leg breaks. Thus, maximum stresses and displacements of the reactor internals under faulted conditions meet the ASME Code Section III Subsection NG stress and deflection limits.

The staff's review indicated that the DCD did not provide sufficient details. The applicant is requested to:

(a) Confirm that to eliminate the dynamic effects of pipe rupture from the design basis, leak before break (LBB) evaluation was performed in accordance with SRP Section 3.6.3 to demonstrate that the probability of pipe rupture is extremely low for the applied loading resulting from normal conditions, anticipated transients, and postulated SSE.
(b) Identify the piping systems that were included in the evaluations.
(c) What were the nominal pipe diameter and postulated pipe break flow area for the limiting design basis pipe size used to determine the pipe rupture dynamic response.

The staff needs this information to assure conformance with GDC 2, 4, 14, and 15. Revise the DCD to include the requested information.

03.09.02-32

RAI 3.9.2-58

In Subsections 3.9.2.5.2 and 3.9.2.5.3 of the DCD the applicant stated that the maximum stress intensities and displacements obtained from the LOCA dynamic system analyses are compared with the ASME Code, Section III, stress limits, and the allowable interface load and displacement limits given in Table 3.9-2 of the DCD. In addition, the functional requirements that need to be met include the following:

(a) Allowable horizontal load of the guide tube should not impede insertion of the control rod after a LOCA,
(b) Upper core barrel displacement is not to impede the down comer emergency core cooling flow after a LOCA,
(c) Reaction loads at the RV connections are not to exceed allowable values of the interface load,
(d) Maximum vertical displacement of the upper core plate relative to the upper support plate should preclude buckling of the guide tube, and

(e) Upper core barrel permanent displacement should not prevent loss of function of the control rod assembly by radial inwardly deforming the upper guide tube.

The staff reviewed the DCD and found that the applicant did not address the stability of the core barrel in compression. Section 3.9.2 of the SRP states that the dynamic system analyses of the reactor internals under pipe rupture loadings should investigate the stability of the elements in compression such as the core barrel and control rod guide tubes. The applicant is requested to describe how the stability of the elements in compression such as the core barrel and control rod guide tubes, under pipe rupture loadings, was investigated. The staff needs this information to assure conformance with GDC 2, 4, 14, and 15. Revise the DCD to include the requested information.