REQUEST FOR ADDITIONAL INFORMATION 597-4590 REVISION 2

6/8/2010

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No. 52-021

SRP Section: 06.03 - Emergency Core Cooling System
Application Section: DCD Chap 6.3

QUESTIONS for Reactor System, Nuclear Performance and Code Review (SRSB)

06.03-84

On March 8, 2010 at the MNES Arlington location, the NRC staff performed an audit of the NPSH calculations for the USAPWR. One of the areas of concern expressed during the audit was the determination of the end location for the NPSHa calculation.

Net positive suction head is the term that is usually used to describe the absolute pressure of a fluid at the inlet to a pump minus the vapor pressure of the liquid. The resultant value is known as the Net Positive Suction Head available (NPSHa).

Different pumps will have different NPSH requirements (NPSHr) dependent on the impeller design, impeller diameter, inlet type, flow rate, pump speed and other factors. A pump performance curve will usually include a NPSH requirement graph expressed in meters or feet head so that the NPSHr for the operating condition can be established. The fluid pressure at a pump inlet will be determined by the pressure on the fluid surface, the frictional losses in the suction piping and any pressure loses within the suction piping system associated with elbows, valves, orifices and any other obstructions to flow.

The CSS and SI pumps are estimated to be 6 feet tall and the midpoint of the pump is 3 feet below the inlet of the pump. The inlet and outlet of the pumps are on top of the pump. When the staff reviewed the diagram of the pump, it appeared that the flow of water goes through the pump suction inlet at the top of the pump and travels to the centerline before it enters the impeller. MHI assumes that the NPSH requirement should be applied at the center of the pump. The distance from the pump inlet to the centerline is 3 feet and applying MHI's assumption that the NPSHr is measured at the centerline adds 3 feet to the NPSHa calculated value. Based on staff experience, many NPSHa calculations are performed at the pump suction, which, for the case of the USAPWR CSS and SI pumps, is 3 feet above the centerline of the pump. If the NPSHr is measured at the pump inlet, MHI's NPSHa calculation could be in error.

The staff request that MHI's provide information from the vender of the pump that states specifically where the NPSHr is measured, i.e., at the pump suction or at the pump centerline.

06.03-85

The US-APWR design has four 50% safety injection (SI) pumps that will be required to mitigate a very large range of small and large break LOCAs. The FSAR states that the design flow of each pump is 1540 gpm and the minimum flow is 265 gpm through the pump minimum-flow loop. Therefore, the pumps will be required to operate at flows significantly less than their best efficiency flow condition. When the pumps automatically actuate following a LOCA occurrence, they will run at these lesser flow conditions for a significant period of time before system pressure drops sufficiently to allow flow closer to best efficiency operation. Even with only one pump running, the smallest break LOCAs would result in flows significantly less than best efficiency flow. The pumps are presumed to be “high suction energy” pumps, as defined by Hydraulic Institute standards ANSI/HI 9.6.1-1998 and ANSI/HI 9.6.3-1997, and would encounter recirculation cavitation at flows significantly less than the best efficiency flow. Recirculation cavitation is known to cause significant vibration and can damage pump impellers, wear rings, seals, shafts, and bearings within a short time period. The staff understands that the specific pump models have not been selected at this time. However, the staff requests that MHI provide (1) the range of possible values of suction energy (as defined by ANSI/HI 9.6.1-1998 and ANSI/HI 9.6.3-1997) for the SI pumps, (2) the required pump operating flows relative to the best efficiency flow conditions, and (3) the potential impact of recirculation cavitation on the pump internals that is predicted to occur for the range of small- and large-break LOCAs especially at low-flow conditions. Provide a description of the pump functional qualification and testing that will demonstrate the design-basis capability of the pumps for their required mission times under recirculation cavitation conditions that might occur for the range of small- and large-break LOCAs.
Similarly, the US-APWR design has four 50% residual heat removal/containment spray (RHR/CS) pumps. Each pump has a design flow of 3000 gpm and a minimum flow of 355 gpm through the pump minimum-flow loop. These pumps are required to operate at the minimum-flow condition until normally closed valves are opened to initiate CS flow following a LOCA. Similar to the SI pumps above, provide (1) the range of possible values of suction energy for the RHR/CS pumps, (2) the required pump operating flows relative to the best efficiency flow conditions, and (3) the impact of the resulting recirculation cavitation that is predicted to occur for the range of small- and large-break LOCAs especially at low-flow conditions. Provide a description of the pump functional qualification and testing that will demonstrate the design-basis capability of the pumps for their required mission times under recirculation cavitation conditions that might occur for the range of small- and large-break LOCAs.

06.03-86

Testing and operational experience for centrifugal pumps indicates that the greatest amount of cavitation-induced erosion of pump internal parts may occur with available net positive suction head (NPSH) significantly greater than that typically required for a 3% total head drop (approximately 1.1 to 1.6 times the NPSH values for a 3% total head drop). The staff understands that the specific SI and RHR/CS pump models have not been selected at this time. However, the staff requests that MHI provide (1) the expected range of available NPSH values and associated operating times relative to the NPSH required for a 3% total head drop and (2) the time periods where the pumps will be expected to operate with high-cavitation erosion. Provide a description of the pump

functional qualification and testing that will demonstrate that the resulting cavitation-induced erosion wear of the various pump parts occurring for the range of small- and large-break LOCAs will not result in unacceptable degradation of the SI and RHR/CS pump internal materials, structural integrity, or performance over the required pump mission times.