RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

APR1400 Design Certification

Korea Electric Power Corporation / Korea Hydro & Nuclear Power Co., LTD

Docket No. 52-046

RAI No.:	**221-8248**
SRP Section:	**05.04.07 – Residual Heat Removal (RHR) System**
Application Section:	**5.4.7**
Date of RAI Issue:	**09/23/2015**

Question No. 05.04.07-2

SCP and CSP Net Positive Suction Head (NPSH) During Shutdown Cooling

10 CFR Part 50, Appendix A, GDC 34 requires the capability to transfer decay heat and other residual heat from the reactor such that fuel and pressure boundary design limits are not exceeded. BTP 5-4 provides an acceptable approach to ensure compliance with GDC 34 with regard to accomplishing the RHR system safety functions assuming a single failure.

As discussed in subsection 5.4.7.1.2, "Functional Design Bases," the shutdown cooling system (SCS) and containment spray system (CSS) pumps are interchangeable to provide flexibility to backup each system when a pump is out of service. For shutdown cooling, the applicant must demonstrate that the net positive suction head (NPSH) is sufficient when the CSS pump is connected to the shutdown cooling system since the piping configuration is different. Also, it must be shown that the NPSH available exceeds the NPSH required for both SCS and CSS one/two pumps in shutdown cooling mode under all operational conditions of which the pumps will be operated to ensure the flow paths for normal decay heat removal is not impacted by other shutdown cooling operations such as flow to chemical and volume control system for purification, transfer of refueling water to the IRWST, and cooling of the IRWST that may be initiated during shutdown cooling.

The applicant provided limited discussion related to SCS NPSH design calculations and the impact of the other SCS functions on heat removal capability. In DCD Table 5.4.7-1, NPSH (available, 19 ft @ 5,425 gpm) exceeded NPSH (required, 18 ft @ 5,425 gpm) by 1 ft; however, no NPSH information was found in DCD Sections 5.4.7 or 6.2 related to NPSH when CSP is substituted for SCP during shutdown cooling.

Therefore, in order to complete SCS NPSH technical evaluation, please provide the NPSH calculations for both a SCS and a CSS pump(s) in the shutdown cooling configuration including line losses and the elevation drawings.

Response

The available NPSH is calculated using the following general equation:

$$NPSHa = h_{atm} + h_{static} - h_{loss} - h_{vp}$$

Where:

h_{atm} : Head on the liquid surface resulting from the pressure in the atmosphere above the water source

h_{static} : Head resulting from the difference in elevation between the liquid surface and centerline of pump suction

h_{loss} : Head loss resulting from fluid friction and fittings in the flow path to the pump suction flange

h_{vp} : Head equivalent to the vapor pressure of the water at the water temperature

The NPSHa calculation results for the SCP and the CSP during the shutdown cooling and containment spray operations are as follows;

Pump	Operation	h_{atm} (ft-water)	h_{static} (ft-water)	h_{loss} (ft-water)	h_{vp} (ft-water)	Cal. NPSHa (ft-water)	Min. NPSHa (ft-water)	NPSHr (ft-water)	Margin (ft-water)
SCP 1	Shutdown Cooling	35.4	61.5	17.5	35.4	44.0	19	18	26.0
	Containment Spray	35.4	30.2	10.8	35.4	19.4	19	18	1.4
SCP 2	Shutdown Cooling	35.4	61.5	18.2	35.4	43.3	19	18	25.3
	Containment Spray	35.4	30.2	10.8	35.4	19.4	19	18	1.4
CSP 1	Shutdown Cooling	35.4	61.5	19.3	35.4	42.2	-	17.5	24.7
	Containment Spray	35.4	30.2	9.7	35.4	20.5	-	17.5	3.0
CSP 2	Shutdown Cooling	35.4	61.5	19.3	35.4	42.2	-	17.5	24.7
	Containment Spray	35.4	30.2	9.7	35.4	20.5	-	17.5	3.0

As shown in above table, the margin of NPSH for SCP and CSP for shutdown cooling are 24 thru 26.

In addition, when the SCPs are substituted for the containment spray operation, the IRWST water is used to supply water for containment spray for a design basis accident. The suction line starts IRWST and ends at the suction of the SCPs. The piping length is estimated to be 287 feet with variable piping diameter ranging from 24” down to 16”, with the IRWST sump strainer and number of fittings as follows: gate valves (3), check valve (1), reducers (3, 24” to 20”, 20” to 18”,

18” to 16”), tee-run (3), tee-branch (1), and 90° elbow (15). The IRWST minimum water level is at 86 feet elevation, and the inlet line at pump suction is at 55.8 feet elevation.

The above information is based on reference plant design (SKN 3&4), since the detailed piping design has not been established in APR1400 DC.

Impact on DCD

DCD Tier 2 Table 5.4.7-1 will be revised as indicated in the Attachment.

Impact on PRA

There is no impact on the PRA.

Impact on Technical Specifications

There is no impact on the Technical Specifications.

Impact on Technical/Topical/Environmental Reports

There is no impact on any Technical, Topical, or Environmental Report.

Table 5.4.7-1 (2 of 3)

Parameter	Value
Component Design Parameters (cont.)	
At 96 hours after shutdown Tube side: Flow, kg/hr (lb/hr) Inlet temperature, °C (°F) Outlet temperature, °C (°F)	 1.08×10^6 (2.38×10^6) 48.9 (120) 40.2 (104.4)
Shell side: Flow, million kg/hr (lb/hr) Inlet temperature, °C (°F) Outlet temperature, °C (°F) Heat transfer rate, W (Btu/hr)	 2.49×10^6 (5.48×10^6) 35 (95) 38.8 (101.8) 11.0×10^6 (37.4×10^6)
Shutdown cooling pump: Quantity Type Safety classification Code Design pressure, kg/cm^2 (psig) Design temperature, °C (°F) Design flow rate, L/min (gpm) Design head, m (ft) Materials Seals Brake power, kW (HP) NPSH Available NPSH Required	 2 Single stage, vertical, centrifugal 2 ASME Section III, NC 63.2 (900) 204.4 (400) 20,536 (5,425) (3) 140.2 (460) Stainless steel type 304,316 Mechanical 746 (1,000) 5.79 m at 20,536 L/min (19 ft at 5,425 gpm) (3) 5.49 m at 20,536 L/min (18 ft at 5,425 gpm) (3)
Shutdown cooling miniflow heat exchanger: Quantity Type Service transfer rate, kcal/hr-m^2-°C (Btu/hr-ft^2-°F) Effective heat transfer area, m^2/HX (ft^2/HX)	 2 Shell and tube, horizontal U-tube 1831.4 (375.1) 14.0 (150.2)

Minimum NPSH Available