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.: **266-8338**

SRP Section: **06.02.02 - Containment Heat Removal Systems**

Application Section:

Date of RAI Issue: **10/22/2015**

Question No. 06.02.02-31

NRC regulation 10 CFR 50.46(b)(5) requires that after initiation of the Emergency Core Cooling System (ECCS), the core temperature shall be maintained at an acceptably low value and decay heat shall be removed for the extended period of time required by the long-lived radioactivity remaining in the core. In order for this requirement to be met satisfactorily, the effects of debris generation by the loss-of-coolant (LOCA) on downstream equipment should be evaluated. Regulatory Guide 1.82 provides the relevant guidance and SRP Section 6.2.2 provides the review criteria related to this subject.

This RAI is a supplement to RAI 63-7983, Question Number 06.02.02-13. In response to RAI 63-7983, Question Number 06.02.02-13, dated August 10, 2015, the applicant committed to add the containment spray (CS) pump miniflow heat exchangers (CS-HE02A/02B) to Table 4.2-1, “Components in the Flow Path during an LBLOCA,” in Technical Report (TR) APR1400-E-N-NR-14001, "Design Features to Address GSI-191," currently revision 0. However, Section 4.2.3.2, “Heat Exchanger Evaluation,” and the applicable subsections of the TR do not provide an evaluation of the effects of post-LOCA debris for heat exchangers CS-HE02A/02B. The applicant is requested to describe the evaluation of the effects of post-LOCA debris for heat exchangers CS-HE02A/02B, including revising the TR as appropriate.

Response

The evaluation of the effects of post-LOCA debris for heat exchangers CS-HE02A/02B will be provided in Section 4.2.3.2 and the applicable subsections of the TR.

Impact on DCD

There is no impact on the DCD.

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

Technical report APR1400-E-N-NR-14001-P/NP, Section 4.2.3.2, 4.2.3.2.1 and 4.2.3.2.2 will be revised, as shown in the attachment associated with this response.

operation with post-LOCA fluids will not impair seal performance, or cause seal failure, or significantly degrade seal leakage during the 30 day post-LOCA mission time.

6) Provide test and/or analysis to confirm:

- that the cyclone separator or any filtering device designed to protect the mechanical seal, if applicable, is not susceptible to clogging or impairment by fiber or other particulates;

- that there is no adverse impact on pump performance or reliability, for at least 30 days of operation with post-LOCA fluids.

7) The vendor will also identify any additional potential pump malfunctions, per ASME QME-1-2007.

8) The vendor will verify that the SI and CS pumps provide minimum flow rates of 397 L/min (105 gpm) and 1,817 L/min (480 gpm), respectively, at shutoff head conditions.

9) The vendor will verify that SI and CS pumps provide flow rates at run-out conditions of less than 4,675 L/min (1,235 gpm) and 24,605 L/min (6,500 gpm), respectively.

4.2.3.2 Heat Exchanger Evaluation

The CSHXs are used to remove heat from the containment atmosphere during and after an accident. The units are designed to reduce the containment atmosphere pressure in 24 hours after an accident to half of the calculated peak pressure. The CS miniflow heat exchangers are used to remove heat generated by running the CS pump when operating at miniflow (i.e., against a closed main discharge path or against a back pressure that is higher than the sum of the pump suction pressure and total developed pump head).

The CS heat exchangers and CS miniflow heat exchangers ~~The CS/RHR heat exchangers~~ are specified as shell and U-tube units. ~~The heat exchangers~~ The CS heat exchangers are composed of 31.75 mm (1.25 inch) OD, Birmingham Wire Gauge (BWG) 18 (1.24 mm (0.049 inch)), 304 SS tubes. ~~A single unit is provided in each of the two CSS divisions.~~ The CS miniflow heat exchangers are composed of 22.23 mm (0.875 inch) OD, Birmingham Wire Gauge (BWG) 18 (1.24 mm (0.049 inch)), 304 SS tubes.

The heat exchanger plugging, fouling and wear evaluation are done in the context of the equipment specification. For velocity, a maximum tube velocity of 4.57 m/s (15 ft/s) is assumed. A nominal design and operating heat exchanger velocity range is 0.91 to 3.05 m/s (3 to 10 ft/s). Therefore the use of 4.57 m/s (15 ft/s) is conservative from a heat exchanger design perspective and bounds the heat exchanger design and procurement specification(s).

4.2.3.2.1 Heat Exchanger Plugging

The ~~heat exchanger~~ CS heat exchanger tubes are 31.75 mm (1.25 inch) OD, 29.26 mm (1.152 inch) ID, BWG 18 (1.24 mm (0.049 inch)). The CS miniflow heat exchanger tubes are 22.23 mm (0.875 inch) OD, 19.74 mm (0.777 inch) ID, BWG 18 (1.24 mm (0.049 inch)). The perforated plate hole size of the IRWST sump strainers is 2.38 mm (0.094 inch). The heat exchanger tubes are significantly larger than the largest expected particle size. Therefore, a heat exchanger tube will not be plugged or blocked by post-LOCA debris. The flow velocity within a heat exchanger tube is significantly greater than the terminal settling velocity of the debris (Table 4.2-4). Therefore, the debris will not settle in the heat exchanger tubes.

These conclusions are consistent with the referenced NRC Safety Evaluation on WCAP-16406-P

(Reference [4-3]).

4.2.3.2.2 Heat Exchanger Performance and Wear

The CS heat exchangers and CS miniflow heat exchangers are

~~The CS heat exchange is~~ sized and designed with a fouling factor of 0.000088 m^2-K/W (0.0005 hr-ft^2-°F/Btu) to maximize heat transfer efficiency and performance. The post-LOCA fluid could potentially cause particulate fouling of the heat exchanger tubes if the fluid velocity is less than the terminal settling velocity of the debris. However, fouling is considered a long-term phenomenon. In addition, the heat load of the CS heat exchangers is greatest at the start of the event and decreases rapidly over the first 24 hours. Heat removal capacity is not degraded over this short period. Any potential reduction in capability over the 30 day mission time is gradual and well within the nominal heat exchanger design.

The CS heat exchangers' and CS miniflow heat exchangers'

~~The CS heat exchanger~~ tubes are specified to be constructed of 304 stainless steel. Stainless steel is appropriate for use as heat exchanger tubing and is standard for use in mildly abrasive applications. The tube material will not significantly degrade considering operation with post-LOCA fluid over an intended mission time of 30 days.

The CS heat exchangers and CS miniflow heat exchangers

Therefore, ~~the CS heat exchanges~~ are fully capable of performing their intended function using post-LOCA fluid as the process fluid.

The vendor will also provide test and/or analysis to confirm that the heat exchanger tube material will not degrade significantly (i.e., “eroded” tube thickness > minimum tube thickness required to retain pressure) in post-LOCA fluid over the 30 day mission time.

4.2.3.3 Evaluation of Valves, Orifices and Pipes

4.2.3.3.1 Blockage and Debris Settling Evaluation for Valves, Orifices and Pipes

The strainer hole size is 2.38 mm (0.094 inch). Therefore, when the gap of the components is 2.38 mm (0.094 inch) + 0.238 mm (0.0094 inch) (10%) or 2.62 mm (0.103 inch) or less than this value, the flow-path or component may be blocked. This is consistent with Reference [4-3]. Components that are in the flow-paths during accidents are listed in Table 4.2-1.

<u>Piping</u>

Fluid velocity decreases with an increase in pipe diameter. Therefore, the lowest velocity in the ECCS occurs in the region with the largest pipe diameter/flow area. Flow velocities in all piping except several cases (24 inch, 20 inch, and 10 inch SI Pump suction lines and 12 inch SI pump discharge line) are above the settling velocities of the post-LOCA fluid. Refer to Table 4.2-6.