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.: **543-8734**

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

Application Section:

Date of RAI Issue: **04/06/2017**

Question No. 06.02.02-46

This is a supplement to RAI 63-7983, Question 06.02.02-22.

In RAI 06.02.02-22, the NRC staff requested the applicant to provide technical justification that debris settling will not occur or affect system operation in piping and any associated valves where the flow velocity for latent debris (dust, dirt, sand) is less than the terminal settling velocity. In response to RAI 06.02.02-22, the applicant stated that settling of latent debris may occur at several locations in the CS spray ring line and the SI pump suction and discharge piping (including valves) where the flow velocity is less than the terminal settling velocity. In the RAI response the applicant explained that the following conservatisms were used when calculating the settling velocity of the latent debris.

- The pump shutoff flow rates (minimum flow rates) at which pump cavitation is likely to occur, rather than the design flow rates, are used to calculate the flow velocities. This lowers the flow velocities for additional conservatism for the debris settling evaluation.
- All particle sizes used for terminal settling velocity of the latent particle debris are assumed to be the strainer hole size of 0.094 inch, which is considerably large compared to Table V-2 of SE for NEI 04-07. This maximizes the terminal settling velocity.

Based on the conservatisms above, the applicant stated that particle debris settling may rarely occur at piping and associated valves with lower assumed flow velocity than the debris settling velocity. The applicant also stated that since the flow cross sectional area decreases as particles settle down and reduction of flow cross sectional area increases the flow velocity, the particle settling may occur no longer after the flow velocity equals the terminal settling velocity. Therefore, the applicant concluded that the piping and associated valves are not blocked and the effect on system operation is negligible.

The NRC staff agrees that conservatisms are incorporated into the settling evaluation such as the pump shutoff flow rates (minimum flow rates) and the assumption that all latent debris is the strainer hole size of 0.094 inch. However, the staff does not consider the licensee's discussion in its RAI response to be sufficient to conclude that settling of latent debris will have a negligible effect on system operation. To support a regulatory finding under GDC 4, the applicant is requested to provide additional information to support its assessment that the settling of latent debris will have a negligible effect on system operation. For example, the applicant is requested to address (1) the fluid flow velocities based on expected pump operation in the applicable systems, (2) the range of particle sizes and their applicable settling velocities to determine the percentage of material that will continue to be transported through the applicable systems without settling; and (3) the remaining material that will settle and its impact on the performance of components in the applicable systems.

Response

Debris settling evaluations are performed by calculating the flow velocity based on the pump shutoff flow rates (minimum flow rates). The evaluation results are listed in Table 4.2-6 of technical report APR1400-E-N-NR-14001-P/NP. A detailed evaluation is performed based on expected pump operation for piping where the lower flow velocity is less than the terminal settling velocity of 0.7ft/sec. The evaluation results are listed in Table below.

Piping	Associated valves	Description	Flow velocity (ft/sec)
4" CS spray ring line	None	NA	7.12
24" SI pump suction line	None	NA	5.84
20" SI pump suction line	SI-V-304/305/308/309	Gate (MOV), 20 inch	8.44
10" SI pump suction line	SI-V-130/131/402/470	Gate (Manual), 10 inch	5.30
12" SI pump discharge line	SI-V-123/143/217/227/ 237/ 247/541/543	Swing Check, 12 inch	4.50
18" CS pump suction line	SI-V-347/348 SI-V-157/158	Gate(MOV), 18 inch Swing Check, 18 inch	8.51

The results show that the debris will not settle because the calculated flow velocity is much higher than the terminal settling velocity of 0.7ft/sec under the expected pump operating conditions, even though settling may occur based on the pump shutoff flow rate. Therefore, there will be no impact of the latent debris on the system operation under expected pump operating conditions.

There is no information of the latent particle debris for the range of particle sizes analyzed. Therefore, debris settling evaluation by particle size and its impact on the performance of components in the applicable systems cannot be provided. Instead, the effective flow sectional area not settled by debris is calculated for only information using the assumption that all latent debris of particulates and fiber settle evenly at the shortest horizontal region of each piping at the lower flow velocity. The effective flow sectional area ratio is a function of the piping inner diameter and the horizontal piping length. The calculation results are listed in Table below.

Piping	Associated valves	Description	Effective sectional area ratio (%)
4" CS spray ring line	None	NA	NA
24" SI pump suction line	None	NA	96.4
20" SI pump suction line	SI-V-304/305/308/309	Gate (MOV), 20 inch	95.8
10" SI pump suction line	SI-V-130/131/402/470	Gate (Manual), 10 inch	96.4
12" SI pump discharge line	SI-V-123/143/217/227/ 237/ 247/541/543	Swing Check, 12 inch	83.8
18" CS pump suction line	SI-V-347/348 SI-V-157/158	Gate(MOV), 18 inch Swing Check, 18 inch	98.7

The 12 inch SI discharge piping has the minimum effective flow sectional area ratio of 83.8% and all other piping are above 83.8%. Therefore, the effect on system operation by the debris settling is considered to be negligible.

Technical Report APR1400-E-N-NR-14001-P/NP, Section 4.2.3.3.1 and Table 4.2-9 will be revised to address the fluid flow velocities based on expected pump operation.

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 4.2.3.3.1 and Table 4.2-9 will be revised as shown in the Attachment to this response.

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conservatism is thus provided for the debris settling evaluation.

Because debris settling is a longer term phenomenon, there is no short term impact on the flow velocities over the time period of interest. This fact, combined with the conservatism in the flow velocities and the latent particle debris terminal settling velocity make the probability of blockages in piping extremely low.

Based on the above considerations, debris settling will not occur or affect system operation in piping and any associated valves where the flow velocity for latent debris is less than the terminal settling velocity.

Table 4.2-9

The piping and associated valves with lower assumed flow velocity than the debris settling velocity are listed in ~~Table 4-9.~~ In the listed piping and associated valves, ~~the particle settling may rarely occur. However, since the flow cross sectional area decreases as particles settle down and reduction of flow cross sectional area increases the flow velocity, the particle settling may occur no longer after the flow velocity equals the terminal settling velocity. Therefore, the piping and associated valves are not blocked and the effect on system operation is negligible.~~

Valves

The valve types that are used in the flow-path during an accident are gate, check, globe and butterfly valves, see Table 4.2-1.

the fluid flow velocities are calculated based on the expected pump operation. The results show that the debris will not settle because the calculated fluid flow velocities are much higher than the terminal settling velocity of 0.7 ft/sec under the expected pump operating conditions. Therefore, there will be no impact of the latent debris on the system operation under expected pump operating conditions.

1) Gate valves

Gate valves are used full-open or full-close. The gate valve sizes are above 101.6 mm (4 inch) (see Table 4.2-1). Flow velocities in all cases are above the settling velocities of the post-LOCA fluid (refer to Table 4.2-6). NUREG/CR-6902 (Reference [4-4]) states that valve openings significantly larger than the debris size will not clog. The strainer hole size is 2.38 mm (0.094 inch). The 101.6 mm (4 inch) valve opening is considerably larger than any expected particle passing through the sump strainer. Therefore, the valves do not clog due to post-LOCA insulation debris.

2) Check valves

Check valves are used with sufficient flow rate, and check valve sizes are above 101.6 mm (4 inch) (see Table 4.2-6). Flow velocities in all cases are above the settling velocities of the post-LOCA fluid (refer to Table 4.2-6). Reference [4-4] states that valve openings significantly larger than the debris size will not be clogged. The strainer hole size is 2.38 mm (0.094 inch). The 101.6 mm (4 inch) valve opening is considerably larger than any expected particle passing through the sump strainer. Therefore, the valves do not clog due to post-LOCA insulation debris.

3) Globe valves

ECCS and CSS flow is controlled though a combination of orifices and throttled valves. Globe valves normally are full open but may be used for throttling system flow. ECCS and CSS pressure and flow are monitored in the MCR. In general, if a globe valve is in a throttled position and it begins to clog, system flow will decrease. Operator action may be taken to open the valve, thus clearing the potential clog. In the APR1400, globe valve sizes are above 101.6 mm (4 inch) (see Table 4.2-1). Flow velocities in all cases are above the settling velocities of the post-LOCA fluid (refer to Table 4.2-6). Reference [4-4] states that valve openings significantly larger than the debris size will not be clogged. The strainer hole size is 2.38 mm (0.094 inch). Throttle valves are expected to be throttled to a minimum of 50.8 mm (2 inch) open between the valve disc and seat. The 50.8 mm (2 inch) valve opening is considerably larger than any expected particle passing through the sump strainer. Therefore the valves do not clog due to post-LOCA insulation debris.

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Table 4.2-9 Piping and Associated Valves with Lower Assumed Flow Velocity than Settling Velocity

Piping	Associated valves	Description	flow velocity (ft/sec) (1)
4" CS spray ring line	None		7.12
24" SI pump suction line	None		5.84
20" SI pump suction line	SI-V-304/305/308/309	Gate (MOV), 20 inch	8.44
10" SI pump suction line	SI-V-130/131/402/470	Gate (Manual), 10 inch	5.30
12" SI pump discharge line	SI-V-123/143/217/227/237/ 247/541/543	Swing Check, 12 inch	4.50
18" CS pump suction line	SI-V-347/348 SI-V-157/158	Gate(MOV), 18 inch Swing Check, 18 inch	8.51

Note:
(1) The fluid flow velocity is based on the expected pump operation and much higher than the terminal settling velocity of 0.7 ft/sec.