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.:	**25-7844**
SRP Section:	**06.02.02 - Containment Heat Removal Systems**
Application Section:	**6.2.2**
Date of RAI Issued:	**06/11/2015**

Question No. 06.02.02-3

General Design Criterion (GDC) 38 requires, in part, that the containment heat removal system perform in a manner consistent with the function of other systems. It also requires that the system have suitable redundancy in components and features and suitable interconnections…[that] the system safety function can be accomplished in the event of a single failure.

As the safety related source of water for both the safety injection and containment spray system, the in-containment refueling water storage tank (IRWST) is required to function in concert with the containment heat removal system to ensure that core and containment cooling are achieved. The In-containment refueling water storage tank (IRWST) contains spargers for the pilotoperated safety relief valves (POSRVs), pressurizer vent valves, and reactor head vent valves.

A. The spargers do not appear in any of the line diagrams in relation to the rest of the IRWST. Update the design control document (DCD) to include the spargers and associated piping within the IRWST, particularly with respect to their elevation and spatial relationship to the strainers. The staff needs this information in order to have a full understanding of the system to make a safety finding that the system will function under all postulated accident conditions.

B. The effect of steam release from the spargers while submerged is discussed in the DCD; however, the effect of fluid release from the spargers while not fully submerged is not explored. Are there any postulated accidents (for example, involving feed and bleed or release from the reactor head vent) where the spargers are uncovered or partially uncovered during release? If so, discuss and explain in detail in the DCD the effects of uncovered release from the spargers on the spargers themselves, the IRWST, and associated structures.

Response

A. The spargers are installed at the end of the discharging piping of the POSRV and at the end of the venting piping of the pressurizer and the reactor vessel closure head which are the reactor coolant gas vent system (RCGVS) to reduce the discharge or source pressure for the air clearing phase and the steam phase, by discharging a portion of the air and steam before the end of the sparger.

The RCGVS flow diagram (DCD Figure 5.4.12-1) currently shows piping and spargers in the IRWST. The POSRV flow diagram is shown in DCD Figure 5.1.2-3, and will be revised to indicate the spargers and associated piping.

To identify the spatial relationship of the spargers to the strainers located on the IRWST sump, sparger locations in the IRWST are provided in Figure 1. The IRWST and HVT plan view in DCD Figure 6.8-1 will be replaced with Figure 1, as shown in Attachment 3, to show the RCGVS and POSRV spargers.

The typical arrangement of header piping and spargers in the IRWST is provided in Figure 2 and will be included in the DCD as Figure 6.8-7. Proposed Figure 6.8-7, “Typical Header Piping and Sparger in IRWST” is included in this response as Attachment 4.

In addition, Section 6.8.4.3 of the DCD will be revised to include discussion of the aforementioned figures. The proposed revision is provided as Attachment 2 to this response.

B. In a postulated RCS pressure increase accident resulting in the POSRVs opening, the submerged sparger holes may be expected to uncover above the IRWST pool surface due to water trap in the containment building when safety injection (SI) and/or containment spray (CS) pumps are actuated.

In the APR1400, there are no postulated accidents that cause the sparger holes to be uncovered above the IRWST pool surface during steam release through the POSRVs. Figure 2 shows that the top most holes of the spargers are submerged 1' 4.4"(1.37') below the minimum water level of the IRWST.

In the case that SI pumps are only actuated with feed and bleed operation during total loss of feedwater or reactor head vent valve opening, most of the injected water to the RCS is returned to the IRWST without significant loss of water, thus the IRWST water level is hardly affected by the SI pumps actuation and the sparger holes are maintained to be submerged.

A feedwater line break can be taken into account as an RCS heat removal decrease accident causing the CS pumps actuation by containment high pressure. In this accident, the POSRVs will be opened due to the RCS pressure increase. However, the POSRVs remain opened only within a short period of time (less than about 60 seconds after accident initiation as shown in DCD Figure 15.2.8-8). The POSRVs are closed before the IRWST water level begins to decrease by the actuation of CS pumps. The time required for the top most holes to be exposed above the IRWST pool surface is greater than about 450 seconds, when considering that both CS pumps are operating.

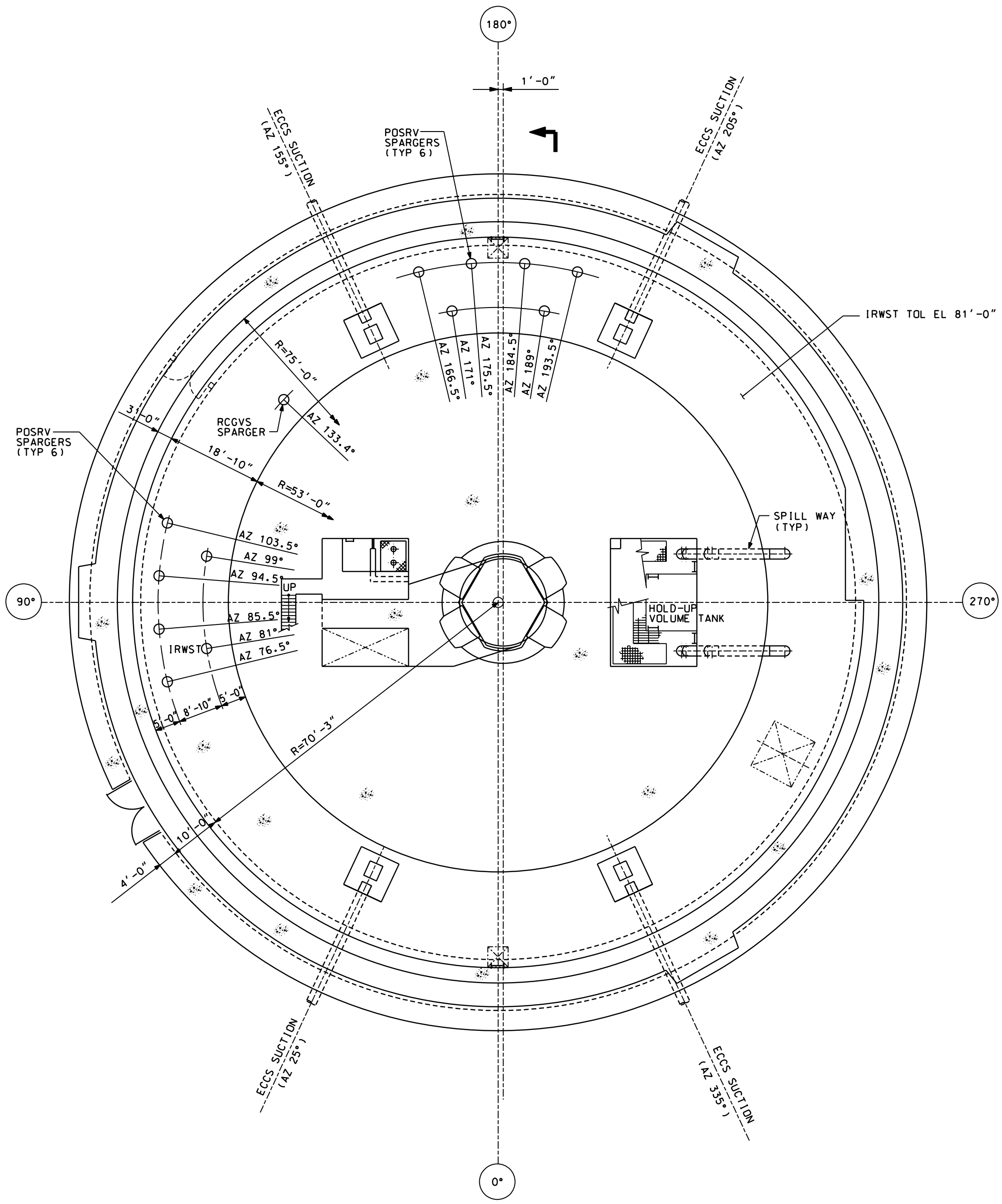

Figure 1 Sparger Locations within the IRWST

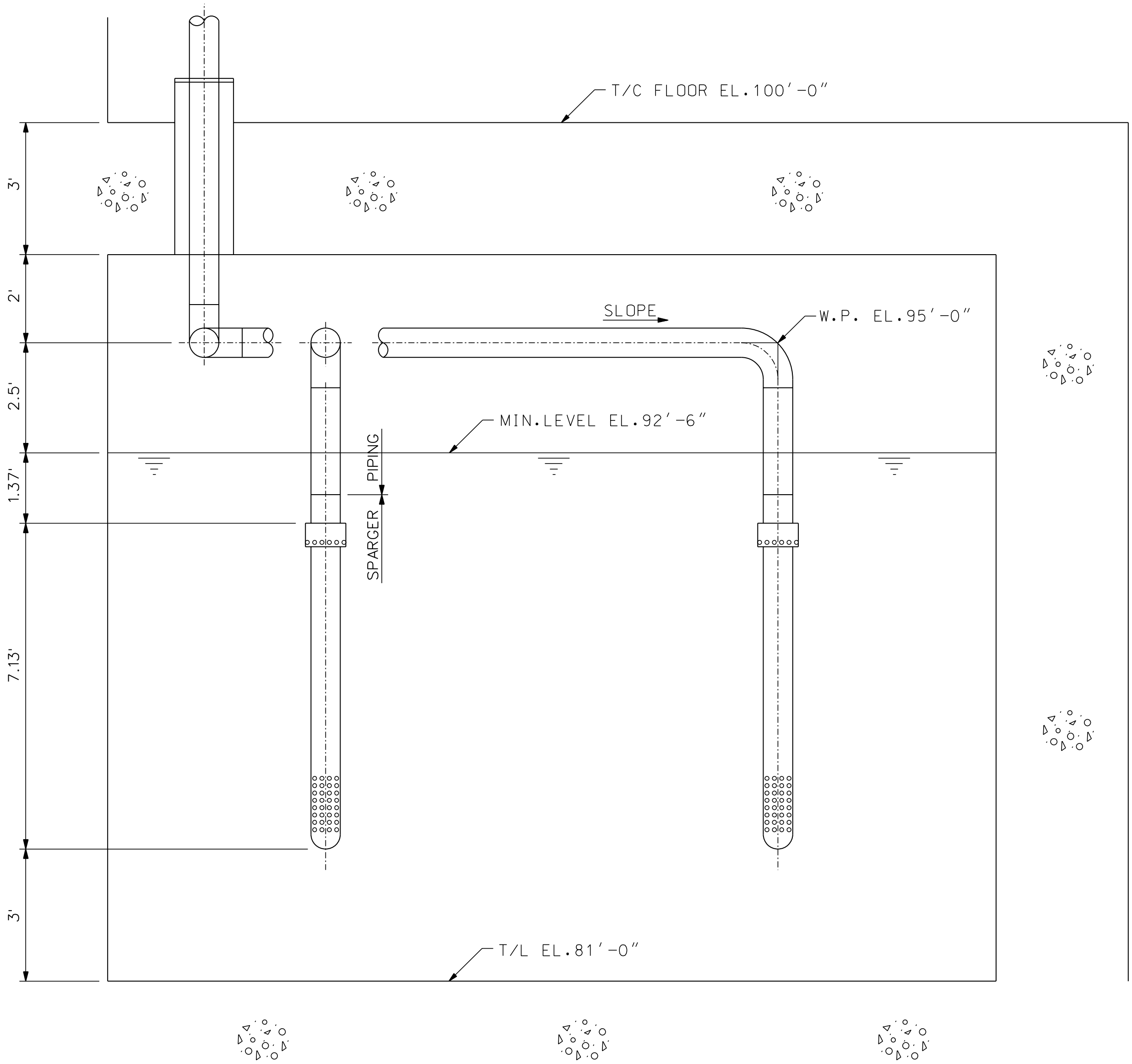

Figure 2. Typical header piping and spargers in IRWST

Impact on DCD

DCD Figure 5.1.2-3 will be revised as shown in Attachment 1.
DCD Section 6.8.4.3 will be revised as shown in Attachment 2.
DCD Figure 6.8-1 will be revised as shown in Attachment 3.
DCD Figure 6.8-7 will be added as shown in Attachment 4.

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.

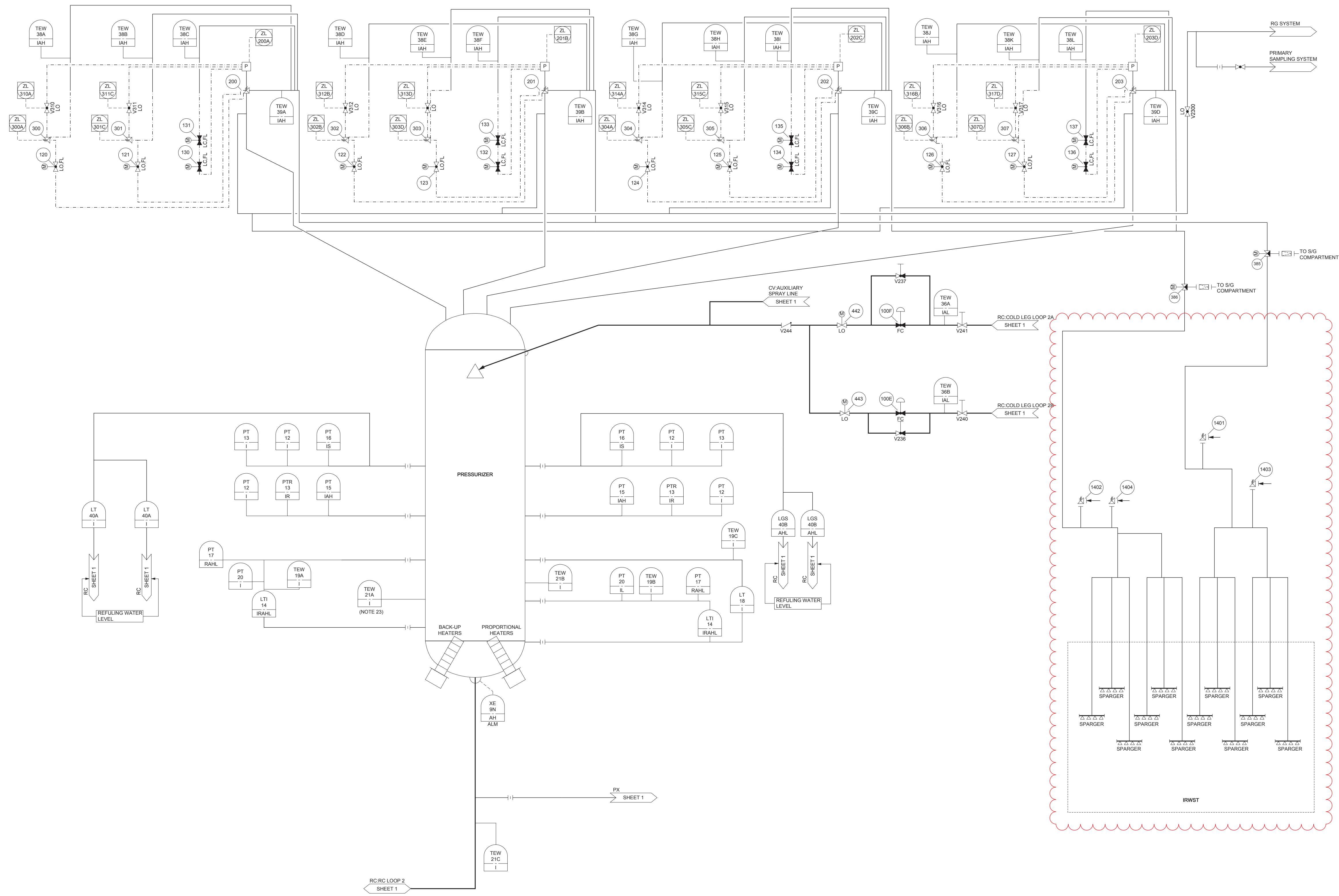

Figure 5.1.2-3 Pressurizer and POSRV Flow Diagram

source pressure of the air bubble are developed based on the boiling water reactor (BWR) test results. Pressure calculations are performed based on a source pressure of 1.49 kg/cm^{2}D (21.2 psid). The dominant bubble frequency is scaled as range of 4 to 14 Hz. Predictions include the effect of the asymmetry in the sparger location relative to the boundaries of the IRWST.

6.8.4.4 Pool Temperature of IRWST

The spargers are designed to effectively condense the steam and to minimize the loads on the structure. However, if the pool temperature of the IRWST increases, significantly high loads on the IRWST structure may occur due to unstable steam condensation. Therefore, for the APR1400 design, the following regulatory requirement has been selected, so the limited pool temperature of each type of sparger in the IRWST is specified to prevent unstable steam condensation phenomena and as the most conservative pool temperature condition in the condensation sump of the BWR: "The local suppression pool temperature should not exceed 93.3 °C (200 °F)" (ASME Section XI).

In the event of the inadvertent operation of the POSRV as the DBA, the analyses of average and local pool temperature are performed. The analysis of the average pool temperature is conducted using analytical calculations, and the local pool temperature analysis is conducted using the ANSYS-CFX code (Reference 5). According to the results, both of average and local pool temperature in the IRWST are maintained less than 93.3 °C (200 °F). The local pool temperature is set as the temperature of the node above the spargers, corresponding to the definition of local pool temperature in NUREG-0783 (Reference 6).

6.8.4.5 Performance of the IRWST Sump Strainer

The performance evaluation of IRWST sump strainer during a LOCA and long-term post-LOCA related to Generic Safety Issue (GSI)-191 is described in Reference 4 in accordance with NRC RG 1.82 (Reference 3). The following subsections are the summary of key information to address GSI-191.

The flow diagrams for the POSRV and reactor coolant gas vent system (RCGVS) with the spargers are provided in Figure 5.1.2-3 and Figure 5.4.12-1, respectively. The location of spargers for POSRV and RCGVS is shown in Figure 6.8-1 and elevation section for the typical header piping and sparger in the IRWST is shown in Figure 6.8-7.

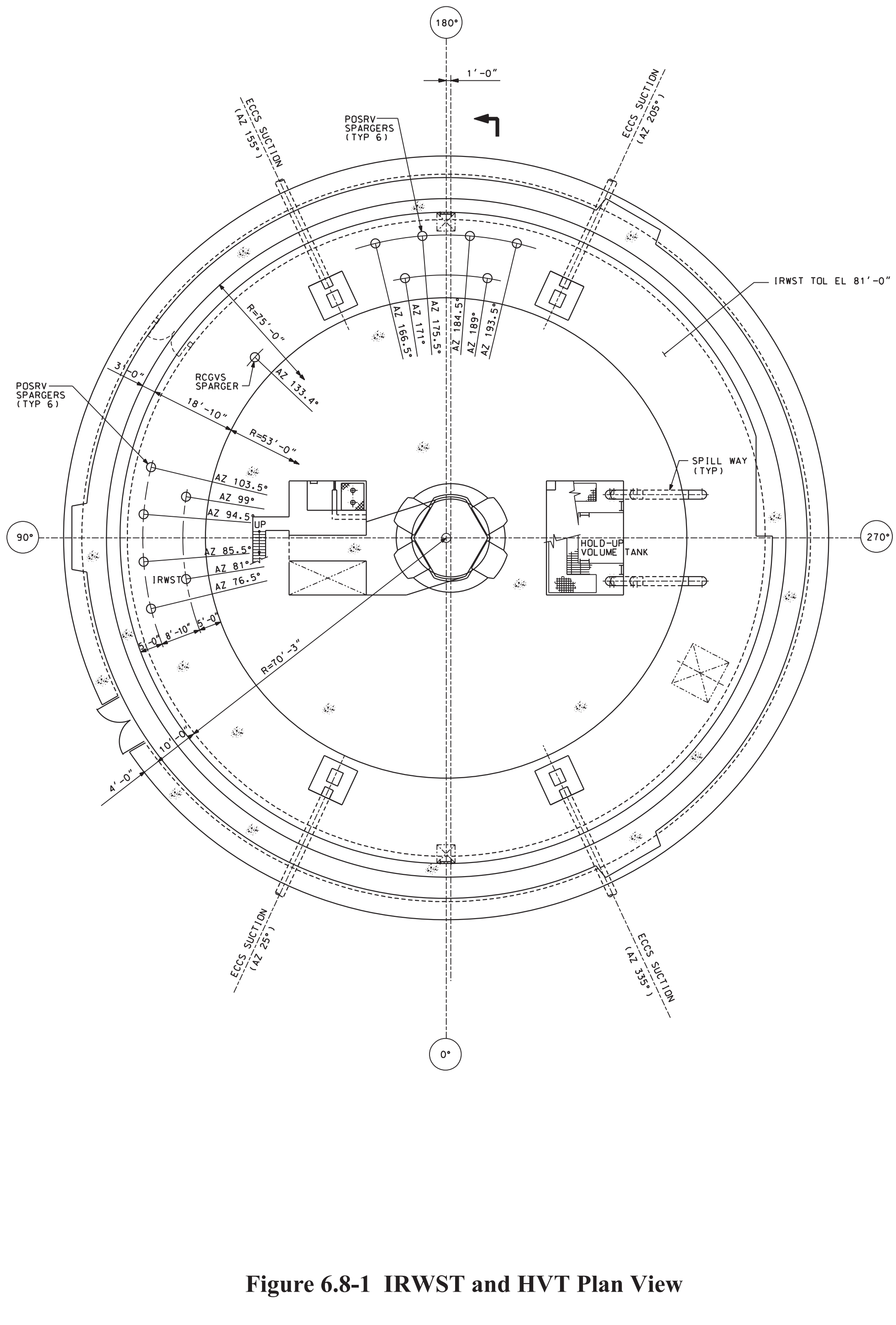

Figure 6.8-1 IRWST and HVT Plan View

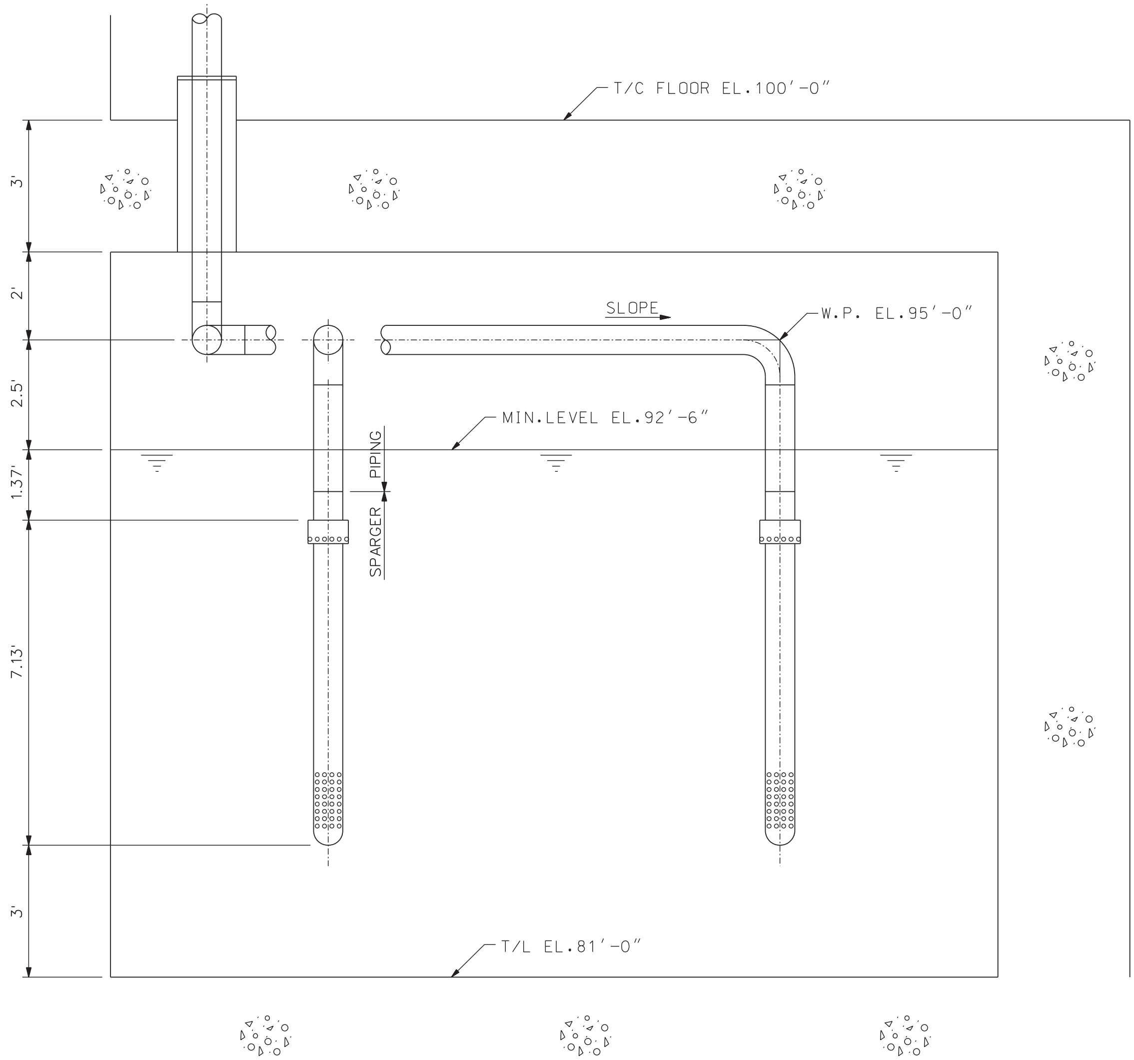

Figure 6.8-7 Typical Header Piping and Sparger in IRWST

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Question No. 06.02.02-4

General Design Criterion (GDC) 38 requires, in part, that the containment heat removal system perform in a manner consistent with the function of other systems. It also requires that the system have suitable redundancy in components and features and suitable interconnections… [that] the system safety function can be accomplished in the event of a single failure.

No discussion is included in the design control document (DCD) with regards to voiding in the CSS system, which provides a means for common-cause single failure. Explain in the DCD the provisions taken to mitigate against the effect of voiding (such as high point venting).

Response

With regards to voiding in the containment spray (CS) system, DCD Section 6.2.2.3 states that the design of the CSS piping and spray nozzle headers considers the effects of water hammer which can be caused by voiding. However, to provide the provisions taken to mitigate against the effect of voiding, the DCD will be revised as indicated on the attached markup.

Impact on DCD

DCD Section 6.2.2.3 will be revised as indicated on the attached markup.

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.

~~The design of the CSS piping and spray nozzle headers considers the effects of water hammer.~~

Piping from the CS pump up to the containment isolation check valves (V1007, V1008) is routed not to exceed 9.144 m (30 ft) vertically from the IRWST minimum water level in order to prevent water column separation which may induce a water hammer. In addition, the CS system is designed to minimize the potential for water hammer by providing means for adequate filling and high point venting.

6.2.2.2.4 Containment Spray Nozzles

The spray nozzles are attached to and become part of the spray nozzle headers located in the upper portion of the containment building and below the operating floor. The nozzles disperse the spray solution throughout the containment in the form of droplets to increase the heat transfer surface. The main spray nozzle headers with main spray nozzles are arranged to provide the maximum effective coverage of the containment volume.

The auxiliary spray nozzle headers with main and auxiliary spray nozzles are installed below the operating floor to provide post-accident containment atmosphere mixing to prevent high local hydrogen concentration in the containment.

The spray nozzles are nonclogging and produce a hollow cone spray pattern. The orifice sizes of the main and auxiliary spray nozzles are 13.1 mm (0.516 in) and 5.60 mm (0.220 in), respectively.

The nozzles provide a drop size distribution that is determined by testing and found to be suitable for the fission product removal function. The CSS provides a nozzle pressure differential of 2.81 kg/cm^{2}D (40 psid), which is the nozzle design condition for the drop size distribution. The mass mean drop size produced at this differential pressure is shown in the Table 6.2.2-5. The mean drop size distributions emitted from the nozzle are obtained by testing based on the method described in ASTM E799 (Reference 22).

Figure 6.2.2-2 shows spray nozzle orientation on the spray nozzle headers. Nozzles are oriented to spray downward at 0, 45, 75, or 90 degrees from the vertical. Figure 6.2.2-3 shows spray profiles for the main spray nozzle types at several fall distances. Figure 6.2.2-4 shows the sectional view of the containment providing the main spray nozzle header elevations. Figure 6.2.2-5 provides the containment plan view showing the developed spray patterns on the operating floor at elevation 156 ft during post-LOCA conditions.

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Question No. 06.02.02-5

SRP section 6.2.2 stipulates that the spray drop size spectrum as a function of pressure be provided in order to provide the staff reasonable assurance that the test program for the spray nozzles shows the droplets to reasonably be bounded by the values specified in the DCD. Although a mean droplet size as a function of pressure and a maximum droplet size to be used in analyses is specified, no such spectrum of drop sizes is identified. Provide, in the DCD, the range of droplet sizes produced by the spray nozzles.

Response

The drop size spectrums for the main spray nozzles and auxiliary spray nozzles produced at the nozzle design condition of 2.81 kg/cm^{2}D(40 psid) are shown in Figure 1 and 2, respectively. These spectrums were obtained by testing as described in DCD Section 6.2.2.4. The testing was conducted by the SVC Inc. in Korea.

Based on the drop size spectrums shown below, the range of drop sizes will be incorporated in DCD Section 6.2.2.2.4.

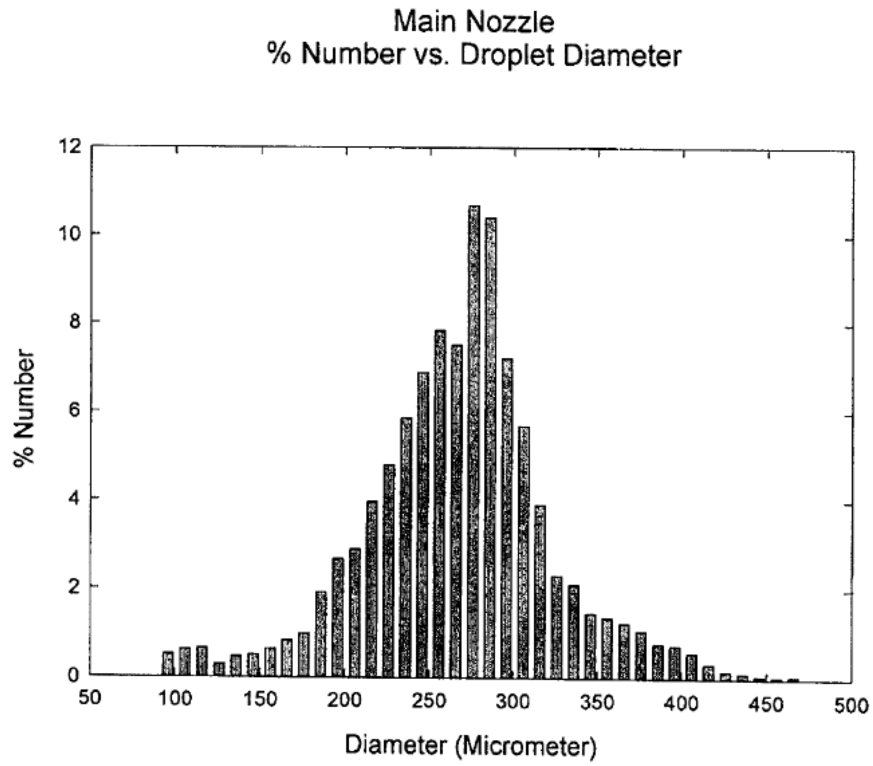

Figure 1. Drop size spectrum for main spray nozzle

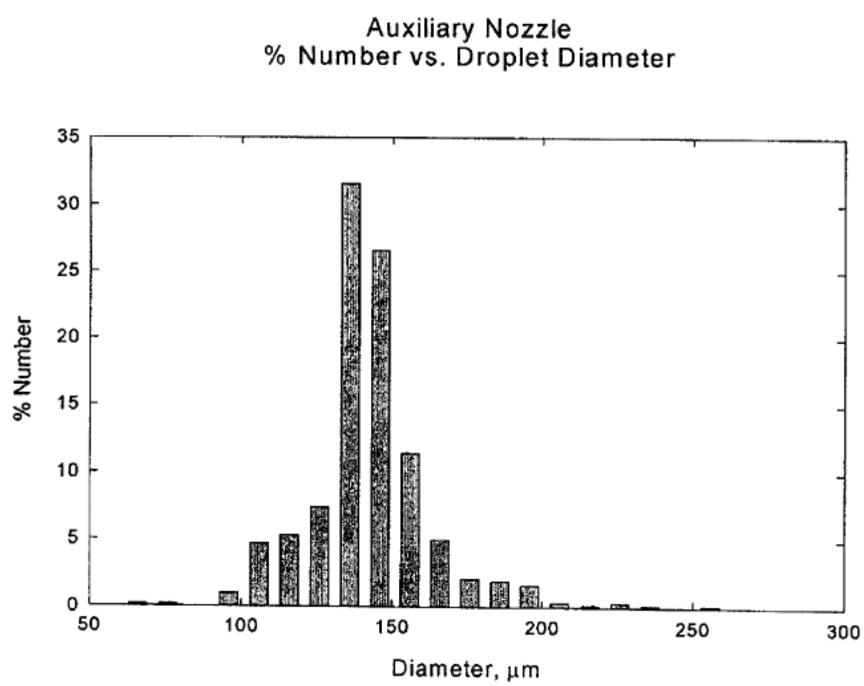

Figure 2. Drop size spectrum for auxiliary spray nozzle

Impact on DCD

DCD Section 6.2.2.2.4 will be revised as indicated on the attached markup.

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.

The design of the CSS piping and spray nozzle headers considers the effects of water hammer.

6.2.2.2.4 Containment Spray Nozzles

The spray nozzles are attached to and become part of the spray nozzle headers located in the upper portion of the containment building and below the operating floor. The nozzles disperse the spray solution throughout the containment in the form of droplets to increase the heat transfer surface. The main spray nozzle headers with main spray nozzles are arranged to provide the maximum effective coverage of the containment volume.

The auxiliary spray nozzle headers with main and auxiliary spray nozzles are installed below the operating floor to provide post-accident containment atmosphere mixing to prevent high local hydrogen concentration in the containment.

The spray nozzles are nonclogging and produce a hollow cone spray pattern. The orifice sizes of the main and auxiliary spray nozzles are 13.1 mm (0.516 in) and 5.60 mm (0.220 in), respectively.

The nozzles provide a drop size distribution that is determined by testing and found to be suitable for the fission product removal function. The CSS provides a nozzle pressure differential of 2.81 kg/cm^{2}D (40 psid), which is the nozzle design condition for the drop size distribution. The mass mean drop size produced at this differential pressure is shown in the Table 6.2.2-5. The mean drop size distributions emitted from the nozzle are obtained by testing based on the method described in ASTM E799 (Reference 22).

Figure 6.2.2-2 shows spray nozzle orientation on the spray nozzle headers. Nozzles are oriented to spray downward at 0, 45, 75, or 90 degrees from the vertical. Figure 6.2.2-3 shows spray profiles for the main spray nozzle types at several fall distances. Figure 6.2.2-4 shows the sectional view of the containment providing the main spray nozzle header elevations. Figure 6.2.2-5 provides the containment plan view showing the developed spray patterns on the operating floor at elevation 156 ft during post-LOCA conditions.

The main spray nozzle drop size ranges from 90 microns to 490 microns, and the auxiliary spray nozzle drop size ranges from 60 microns to 260 microns, at the nozzle design condition of 2.81 kg/cm^{2}D (40 psid).

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Question No. 06.02.02-7

General Design Criterion (GDC) 38 requires, in part, that the containment heat removal system be capable of rapidly reducing the containment pressure and temperature following a LOCA and to maintain these parameters at acceptably low levels. In the APR1400, in order for the staff to reach a finding that GDC 38 is satisfied, additional information about the containment spray system (CSS) heat exchangers is required.

1. SRP section 6.2.2 states that a discussion on the surface fouling used for heat exchangers used to assure containment heat removal capability shall be provided. While the design control document (DCD) references a fouling value for the containment spray (CS) heat exchangers, no such discussion is provided. In the DCD, describe how the value provided in Table 6.2.2-2 is arrived at, including whether the value bounds the fouling values expected over the life of the plant.
2. In a response, describe how the CS heat exchangers are modeled in the analyses presented in Section 6.2 of the DCD. The staff requires this information to complete the following:
   - make a safety finding that the heat exchangers will perform their function over the life of the plant
   - perform a confirmatory analysis

Response

1. The fouling resistances for the containment spray (CS) heat exchangers listed in DCD Table 6.2.2-2 were selected based on the Tubular Exchanger Manufacturer Association (TEMA) Standards. The fouling resistance value stated will bound the fouling value expected over the design life of the plant since the water chemistry is maintained by administrative controls and the design UA for the CS heat exchanger is established

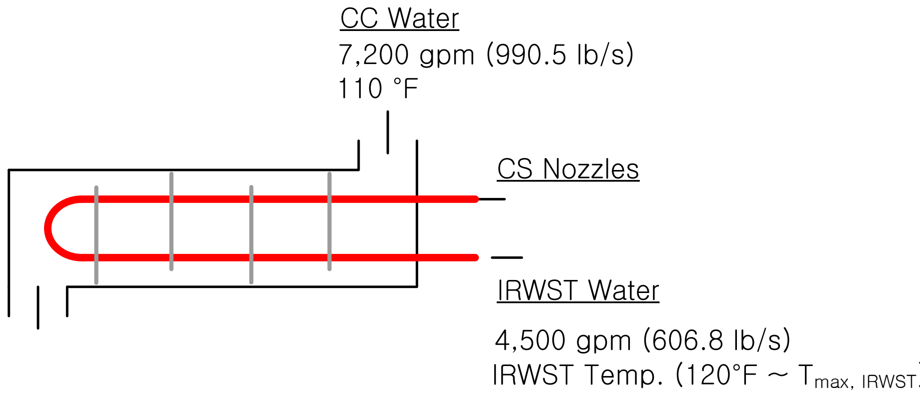
considering the fouling resistance. This information will be incorporated in DCD Section 6.2.2.2.2.

2. The CS heat exchanger used for the APR1400 containment P/T analysis is modeled using a GOTHIC heat exchanger component. The CS heat exchanger model uses a design heat transfer coefficient (UA) and CS heat exchanger input data which are developed from the design specification sheets, summarized in Table 1. Figure 1 shows the schematic diagram of the CS heat exchanger modeled in the GOTHIC containment analysis.

Table 1. CS heat exchanger Design / Analysis data

Component	Description	Unit	Design Value	Value used for Containment P/T Analyses
CS system	No. of trains (1)	EA	2	1
	CSP flow/train	gpm	5,000	4,500 (2)
		m^3/s (ft^3/s)	0.315 (11.14)	0.284 (10.026)
CS heat exchanger Design Spec.	No. of units (1)	EA	2	1
	Heat transfer area	m^2/unit (ft^2/unit)	500.2 (5,382)	500.2 (5,382)
	Overall heat transfer coeff.	Kcal/m^2-hr-°C (Btu/ft^2-hr-°F)	2690.4 (551.04)	1619.8 (331.76) (3)
CS heat exchanger (tube side)	Temperature, tube inlet	°C (°F)	98.9 (210)	IRWST Temp.(4)
	Volume flow rate/line	gpm	5,000	4,500 (2)
	Mass flow rate @210°F	kgm/s (lbm/s)	303.9 (670)	273.5 (603)
CS heat exchanger (shell side)	Temperature, shell inlet (5)	°C (°F)	43.3 (110)	43.3 (110)
	Flow rate/line (shell), CCW	gpm	8,000	7,200 (2)
	Mass flow rate @110°F	kgm/s (lbm/s)	499.0 (1,100)	449.1 (990) (2)

(1) Single failure of the CSS is assumed for both LOCA and MSLB(Loss of a CSS) accidents.
(2) Conservatively, the CS flow and the component cooling water flow in analysis are assumed to be 90 % of their design flow.
(3) The overall heat transfer coefficient reflects the fouling effects.
(4) The temperature of the CS heat exchanger tube side inlet flow varies with the IRWST water temperature.
(5) The component cooling water heat exchanger is not modeled. Instead, the highest expected component cooling water heat exchanger post-accident cooling water temperature (110 °F) is used for the CS heat exchanger shell side inlet temperature.



Heat transfer area: 5381.76 ft²

Tube thickness: 0.049 in

Heat transfer rate: 331.76 btu/ft²-hr-°F (fouling condition)

Figure 1. CS heat exchanger Modeling for Containment P/T analysis

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Impact on DCD

DCD Section 6.2.2.2.2 will be revised as indicated on the attached markup.

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.

A flow restrictor is provided to minimize the loss of fluid in the event of a gross seal failure. Vent and drain connections are provided. An internal drain to the pump suction is provided in the pump casing. The pump is designed to be completely drained and flushed prior to maintenance, thus reducing radiation levels and doses to plant personnel.

The pressure-retaining portions of the pumps are stainless steel, meeting ASME Section III, Class 2 requirements. The material for all other parts is reviewed for compatibility with its intended service and is approved prior to release for manufacture.

Two CSPs automatically start on a SIAS or a CSAS, and the containment spray header isolation valves automatically open on a CSAS, thus initiating flow to the CSS spray nozzle headers. Initiating signals and controls is described in Chapter 7. Electric power supplies are discussed in Chapter 8.

6.2.2.2.2 Containment Spray Heat Exchangers

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 CSHX parameters are given in Table 6.2.2-2.

The CSHXs are used as a backup to the shutdown cooling heat exchangers for IRWST cooling during post-accident operations when the SIS and the pressurizer POSRVs are used for feed-and-bleed cooling of the RCS.

6.2.2.2.3 Containment Spray Piping

Each IRWST suction valve is normally open to provide a reliable water source to the CSPs and to provide reasonable assurance of water full suction piping.

During normal power operation, the CSS piping is water solid up to the IRWST 100 percent water level at elevation 28.3 m (93 ft). A 110-second delay is conservatively assumed between the system initiation and the spray flow through the spray nozzles. The delay time is described further in Subsection 6.2.1.1.3.

The fouling resistances for the CSHXs are selected based on the Tubular Exchanger Manufacturer Association (TEMA) Standards. The fouling resistance value stated will bound the fouling value expected over the design life of the plant since the water chemistry is maintained by administrative controls and the design UA for the CSHXs is established considering the fouling resistances.

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Question No. 06.02.02-8

General Design Criterion (GDC) 38 requires, in part, that the containment heat removal system perform in a manner consistent with the function of other systems. It also requires that the system have suitable redundancy in components and features and suitable interconnections… [that] the system safety function can be accomplished in the event of a single failure.

The holdup volume tank (HVT) flooding valves are described as having the ability to be operated either separately or simultaneously. Explain, in the DCD, the impact of having these valves opened inadvertently at the same time (provide a failure mode and effects analysis for these components), or provide details on the interlocks in place to prevent such an occurrence from taking place. The staff requires this information to ensure that the in-containment refueling water storage tank (IRWST) will perform its safety function for all postulated accidents.

Response

As described in the third paragraph of DCD Section 6.8.2.1.2, the HVT flooding valves (IW-0001, IW-0002) and the reactor cavity flooding valves (IW-0003, IW-0004) are motor operated valves which are normally closed, de-energized, and remotely opened by operator action from the main control room (MCR). So these valves do not open inadvertently at the same without any operator actions.

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

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

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Question No. 06.02.02-9

In order for the staff to reach a safety conclusion regarding adequate net positive suction head, additional clarity is required in the DCD with respect to break selection. Specifically, revise the explanation used for selection of break criteria in section 6.8.4.5.1 of the DCD in accordance with the NEI 04-07 guidance (the break selection should maximize the head loss across the strainers), as is already mentioned in the DCD.

Response

The description of selection of break criteria will be revised to indicate that the postulated break location is based on the break size and location which results in debris generation that produces the maximum head loss across the IRWST sumps strainer in accordance with the guidance in NEI 04-07 and the associated Safety Evaluation for NEI 04-07.

Impact on DCD

DCD Section 6.8.4.5.1 will be revised as indicated on the attached markup.

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.

6.8.4.5.1 Break Selection

The design basis accidents (DBAs) requiring engineered safety features (ESF) system action result in full ESF initiation, which initiates four safety injection pumps (SIPs), and two containment spray pumps (CSPs). The shutdown cooling pumps (SCPs) may be initiated when the CSP is not available.

The design basis accidents that result in debris generation are categorized as 3 scenarios, Large Break loss-of-coolant accident (LBLOCA), Small Break loss-of-coolant accident (SBLOCA), and other high-energy-line break (HELB).

~~Break location is selected considering the determination of the size and location of HELBs that produce debris and potentially challenge the performance of the IRWST sump strainers. Based on the pipe break sizes and locations which are determined as a result of the above reviews of the accident analysis and operational procedures that require the ECCS and CSS to take suction from the IRWST sumps, the postulated break location is selected by considering the guidance recommended in NEI 04-07 (Reference 7) and Safety Evaluation (SE) for NEI 04-07 (Reference 8).~~

The selection of the postulated break location is based on the break size and location which results in debris generation that produces the maximum head loss across the IRWST sumps strainer in accordance with the guidance in NEI 04-07 (Reference 7) and the associated Safety Evaluation (SE) for NEI 04-07 (Reference 8).

Based on the break criteria above ~~in SE for NEI 04-07~~, the junction of the RCS HL pipe (42 in) and SG included in LBLOCA was selected as the postulated limiting break location. This selection for break location is reasonable because the SGs have a larger volume of insulation applied to them than does RCS piping and most of the primary system piping is located in this compartment. The larger amount of insulation presents and volume of debris are transported to the IRWST sump strainer comparing to other scenarios. This results in the maximum head loss across the IRWST sump strainer.

6.8.4.5.2 Debris Generation

The sources of debris in the APR1400 are insulation debris, coating debris, and latent debris. For the insulation debris, the Reflective Metal Insulation (RMI) is considered as a potential debris source following a HELB.

In estimating the debris generation, the spherical ZOI is used. All significant debris sources (e.g., insulation, fixed debris) within the ZOI were evaluated. For insulation (RMI)

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APR1400 Design Certification

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

Docket No. 52-046

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Application Section:	**6.2.2**
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Question No. 06.02.02-10

In order for the staff to make a finding regarding the suitability of the strainer system and that adequate net positive suction head is available as required by 10 CFR 50.46(b)(5) for long term decay heat removal, additional information regarding the calculation of sump approach flow velocity is required. Explain how the value of 0.088 m/s in Section 3.4 of technical report APR1400-E-N-NR-14001-P, "Design Features to Address GSI-191," was calculated, including available strainer flow areas and system conditions.

Response

All RMI fine debris is assumed to be transported to the IRWST throughout the containment bottom floor (El. 100 ft) and HVT. However, the debris will not be transported to the IRWST sump strainers because the sump approach flow velocity at the IRWST is expected to be 0.088m/sec (0.29 ft/s) which is lower than the terminal velocity (0.113 m/s (0.37 ft/s)) and lift over curb velocity (0.256 m/s (0.84 ft/s)) of RMI fine debris addressed in Table 4-2 of NEI 04-07.

The sump approach flow velocity of 0.088 m/sec (0.29 ft/s) at the IRWST is calculated by dividing the sump suction maximum flowrate of 0.56 m^3/sec (8,858 gpm) by the sump cross-sectional area of 6.323m^2 (68.063 ft^2). This approach is reasonable for the following reasons:

- The point where the flow velocity is the highest in the IRWST is at the IRWST sump suction since the IRWST is a torus and there is no blockage.
- The sump suction maximum flowrate of 0.56 m^3/sec (8,858 gpm) is the sum of the CS pump flowrate (5,425 gpm) and the SI pump flowrate (1,235 gpm) with sufficient margin of 33%. Even though these flowrates are not actually the design maximum flowrates, it is conservatively assumed to be the maximum flowrate to be suctioned in one sump.
- The top cross-sectional area of 6.323m^2 (68.063 ft^2) is considered to be the smallest flow pass area on the flow path into the IRWST sump. The cross-sectional area is much less than the effective surface area of 46.452 m^2 (500 ft^2) which is actually flow pass area.

Technical Report APR1400-E-N-NR-14001-P will be revised to correct the debris transport location to the IRWST.

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

The technical report APR1400-E-N-NR-14001-P will be revised as indicated on the attached markup.

3.4 Debris Transport

Debris transport quantifies debris that transports to the sump strainer. The amount of debris generation and the characteristics of the debris transport are used to determine debris accumulation.

The blockage of the strainers and its effect on the net positive suction head (NPSH) of the pumps are considered conservatively when the accumulation has reached its maximum.

In accordance with the guidance provided in Subsection 3.6.1 of NEI 04-07 (Reference [3-2]), the following four major debris transport modes are considered.

1) Blowdown transport - Horizontal and vertical transport of debris by the break jet. All debris by the break jet is transported to the containment floor. No debris is transported upwards to the containment dome.

2) Washdown (containment spray) transport - Vertical transport of debris by the containment sprays/break flow. Since all debris is modeled as transporting to the containment floor during blowdown, there is no washdown transport.

3) Pool fill-up transport - Horizontal transport of the debris by break and CS flows to active and inactive areas of the basement pool. All debris are transported out of the SG D-rings to the holdup volume tank (HVT) and assumed to be transported to the IRWST. The large piece of RMI insulation is not transported to IRWST sump strainers located in the IRWST because of sufficient density (Table 3.3-2) and slow flow rates. No transport to inactive volumes is modeled.

4) Recirculation transport - Horizontal transport of the debris in the active portions of the basement pool by the recirculation flow through the ECCS/CSS. All latent debris and failed coating are conservatively assumed to be collected in the HVT and transported to the IRWST sump strainers by recirculating water. The only small amount of RMI debris is assumed to be transported to the HVT and the IRWST in the APR1400. The sump approach flow velocity (i.e., 0.088 m/s (0.29 ft/s)) at ~~containment bottom floor (El. 100 ft)~~ the IRWST is lower than the terminal settling velocity (i.e., 0.113 m/s (0.37 ft/s)) and lift over curb velocity (i.e., 0.256 m/s (0.84 ft/s)) of the RMI fine debris addressed in Table 4-2 of NEI 04-07 (Reference [3-2]). Therefore, RMI debris transported in the IRWST settles on the IWRST floor around the sump and does not rise to the strainer surface.

All particulate and coating debris is assumed to be fine enough to remain in suspension due to turbulence and to be transported to the IRWST sump strainers. This assumption provides the most conservative upper limit for the debris transport evaluation and includes the debris breaking down to its minimum size initially so no further particle size reduction occurs during transport.

Latent debris is categorized as fiber and particulates and is assumed to be uniformly distributed. All latent fiber is assumed to have the same fiber diameter as NUKON insulation.

The APR1400 design has four ECCS/CS trains with an independent strainer for each train. The design requires a minimum of three trains in operation assuming that the fourth train has a single failure. Therefore, transported debris in the IRWST is assumed to be distributed to three sumps. However, the APR1400 design assumes that all of break-generated coating, latent debris, and chemical precipitates are transported directly to a single sump for conservatism for the strainer head loss evaluation and the NPSH evaluation. For the bypass debris fraction, the number of available sumps maximizes the amount of bypass debris (i.e., assumes four operating sumps). No credit is taken for debris settlement on the floor or entrapment in ineffective pool.