ArevaEPRDCPEm Resource

From: WILLIFORD Dennis (AREVA) [Dennis.Williford@areva.com]
Sent: Thursday, April 11, 2013 4:34 PM
To: Snyder, Amy
Cc: Gleaves, Bill; DELANO Karen (AREVA); LEIGHLITER John (AREVA); ROMINE Judy (AREVA); RYAN Tom (AREVA); WILLS Tiffany (AREVA); HONMA George (EXTERNAL AREVA); KOWALSKI David (AREVA)
Subject: Response to U.S. EPR Design Certification Application FINAL RAI No. 569 (6945), FSAR Ch. 6, Supplement 1
Attachments: RAI 569 Supplement 1 Response US EPR DC.pdf

Importance: High

Amy,

AREVA NP Inc. provided a schedule for technically correct and complete responses to the four questions in RAI No. 569 on February 8, 2013. The attached file, "RAI 569 Supplement 1 Response US EPR DC.pdf," provides a technically correct and complete final response to the four questions.

Appended to this file are affected pages of the U.S. EPR Final Safety Analysis Report in redline-strikeout format which support the response to RAI 569 Questions 06.02.02-138 and 06.02.02-139.

The following table indicates the respective pages in the response document, "RAI 569 Supplement 1 Response US EPR DC.pdf," that contain AREVA NP's response to the subject questions.

Question #	Start Page	End Page
RAI 569 — 06.02.02-136	2	2
RAI 569 — 06.02.02-137	3	4
RAI 569 — 06.02.02-138	5	6
RAI 569 — 06.02.02-139	7	7

This concludes the formal AREVA NP response to RAI 569, and there are no questions from this RAI for which AREVA NP has not provided responses.

Sincerely,

Dennis Williford, P.E.
U.S. EPR Design Certification Licensing Manager
AREVA NP Inc.
7207 IBM Drive, Mail Code CLT 2B
Charlotte, NC 28262
Phone: 704-805-2223
Email: Dennis.Williford@areva.com

From: RYAN Tom (RS/NB)
Sent: Friday, February 08, 2013 2:18 PM
To: Snyder, Amy
Cc: DELANO Karen (RS/NB); LEIGHLITER John (RS/NB); ROMINE Judy (RS/NB); RYAN Tom (RS/NB); WILLS Tiffany

(CORP/QP); peter.hearn@nrc.gov; KOWALSKI David (RS/NB); LENTZ Tony (External RS/NB); WILLIFORD Dennis (RS/NB)
Subject: Response to U.S. EPR Design Certification Application FINAL RAI No. 569 (6945), FSAR Ch. 6

Amy,

Attached please find AREVA NP Inc.'s response to the subject request for additional information (RAI). The attached file, "RAI 569 Response US EPR DC," provides a schedule since a technically correct and complete response to the four Questions is not provided.

The following table indicates the respective pages in the response document, "RAI 569 Response US EPR DC," that contain AREVA NP's response to the subject question.

Question #	Start Page	End Page
RAI 569 — 06.02.02-136	2	2
RAI 569 — 06.02.02-137	3	3
RAI 569 — 06.02.02-138	4	4
RAI 569 — 06.02.02-139	5	5

The schedule for a technically correct and complete response to the four Questions is provided below.

Question #	Response Date
RAI 569 — 06.02.02-136	April 11, 2013
RAI 569 — 06.02.02-137	April 11, 2013
RAI 569 — 06.02.02-138	April 11, 2013
RAI 569 — 06.02.02-139	April 11, 2013

Sincerely,

Tom Ryan for
Dennis Williford, P.E.
U.S. EPR Design Certification Licensing Manager
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From: Snyder, Amy [mailto:Amy.Snyder@nrc.gov]
Sent: Wednesday, January 09, 2013 2:51 PM
To: ZZ-DL-A-USEPR-DL
Cc: Terao, David; Strnisha, James; Gleaves, Bill; Segala, John; GUCWA Len (External RS/NB); BALLARD Bob (EP/PE)
Subject: U.S. EPR Design Certification Application FINAL RAI No. 569 (6945), FSAR Ch. 6

Attached please find the subject request for additional information (RAI). A draft of the RAI was provided to you on December 7, 2012 and December 14, 2012 you informed us that the draft RAI is clear and no further clarification is needed and that the draft RAI does not contain proprietary information. As result, no change is made to the draft RAI.

The schedule we have established for review of your application assumes technically correct and complete responses within 30 days of receipt of RAIs. For any RAI question that cannot be answered within 30 days, it is expected that a date for receipt of this information will be provided to the staff within the 30-day period so that the staff can assess how this information will impact the published schedule.

Thank you.
Amy

Hearing Identifier: AREVA_EPR_DC_RAIs
Email Number: 4387

Mail Envelope Properties (554210743EFE354B8D5741BEB695E6561143E3)

Subject: Response to U.S. EPR Design Certification Application FINAL RAI No. 569 (6945), FSAR Ch. 6, Supplement 1
Sent Date: 4/11/2013 4:34:25 PM
Received Date: 4/11/2013 4:34:34 PM
From: WILLIFORD Dennis (AREVA)

Created By: Dennis.Williford@areva.com

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Tracking Status: None
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Files	**Size**	**Date & Time**
MESSAGE	4172	4/11/2013 4:34:34 PM
RAI 569 Supplement 1 Response US EPR DC.pdf		488483

Options
Priority: High
Return Notification: No
Reply Requested: No
Sensitivity: Normal
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Response to

Request for Additional Information No.569, Supplement 1

1/9/2013

U.S. EPR Standard Design Certification
AREVA NP Inc.
Docket No. 52-020
SRP Section: 06.02.02 – Containment Heat Removal Systems
Application Section: 6.2.2

Question 06.02.02-136:

Follow-up to RAI 498, Questions 6.2.2-113 and 6.2.2-116.

Technical Report ANP-10293, Appendix G, Revision 4 states that pumps and valves will be qualified using the guidance of QME-1-2007 as endorsed by RG 1.100 Revision 3. RG 1.100 Revision 3 states that when a licensee commits to the use of QME-1-2007 for its qualification of pumps and valves, then the criteria and procedures become part of the basis for the qualification program. Therefore, staff does not consider it acceptable to state that "pumps and valves will be qualified using the guidance of QME-1-2007." Staff expectation is that qualification of pumps and valves will be in accordance with QME-1-2007. (Note: "In accordance with" is consistent with the terminology used in DCD Section 3.9.6 for pump and valve qualification.) Staff requests AREVA to revise the applicable sections of Technical Report ANP-10293, Appendix G to state that pumps and valves will be qualified in accordance with QME-1-2007 as endorsed by RG 1.100.

Response to Question 06.02.02-136:

Technical Report ANP-10293, Section G.3, will be revised to state that pumps and valves will be qualified in accordance with QME-1-2007 as endorsed by Regulatory Guide 1.100.

Additionally, markups related to an NRC discussion on chemical effects evaluation are included in the enclosed for completeness.

FSAR Impact:

The U.S. EPR FSAR will not be changed as a result of this question.

Technical Report Impact:

ANP-10293, "U.S. EPR Design Features to Address GSI-191," will be revised as described in the response and indicated on the enclosed markup.

Question 06.02.02-137:

Technical Report ANP-10293, Table G.2-4 states that for latent debris the densities of the fiber and particulate (dirt and dust) are comparable (NEI 04-07) and that the settling velocity of fiber and particulate are the same (0.008 ft/sec). Technical Report ANP-10293, Table G.2-5 identifies latent particulates as 139 lbm of sand with a density of 169 lb/ft3. Since the density of latent particulate is much greater than the density of latent fiber, staff requests AREVA to provide justification for stating that the densities of latent fiber and particulate are comparable and provide justification for stating 0.008 ft/sec as the settling velocity of latent particulate.

Response to Question 06.02.02-137:

Technical Report ANP-10293, Section G.2.5 and Table G.2-4, will be revised to include an estimation of the terminal settling velocity for latent particulate. Since the settling velocities of latent fiber and particulate are less than the minimum velocities of the emergency core cooling system (ECCS) as identified in Technical Report ANP-10293, Section G.3.3.1, neither fiber nor particulate will settle in portions of the ECCS.

The terminal settling velocity of latent particulate was estimated using the Goncharov equation (Reference 1). The accuracy of this equation was validated by estimating the particulate settling velocity using two other independent equations, Rubey (Reference 2) and Ferguson and Church (Reference 3), as documented in the table below. All three equations estimate the settling velocity to be ≤ 0.66 ft/s.

These three equations are used for predicting settling velocities for “natural sediments” or “grain” particles such as sand or quartz (References 1 and 2); therefore, they are not applicable for estimating the settling velocities for coating particles (i.e., inorganic zinc and epoxy) listed in Table 4-2 of NEI 04-07. Settling velocities from Table 4-2 of NEI 04-07 were used in Table G.2-4 of Technical Report ANP-10293 for coating particles (i.e., inorganic zinc and epoxy).

	Terminal Settling Velocity (ft/s)		
	Goncharov (1962)	**Rubey (1933)**	**Ferguson and Church (2004)**
Latent Particulate	0.66	0.49	0.66

References:

1. Cheng, N.S. (1997), A Simplified Settling Velocity Formula for Sediment Particle, Journal of Hydraulic Engineering, ASCE, 123(2), 149-152.
2. W.W. Rubey (1933),Settling Velocities of Gravel, Sand, and Silt Particles, American Journal of Science by Stanford University’s HighWire Press.
3. A Simple Universal Equation for Grain Settling Velocity, Ferguson and Church, Journal of Sedimentary Research, 74 (6), p. 933.

FSAR Impact:

The U.S. EPR FSAR will not be changed as a result of this question.

Technical Report Impact:

ANP-10293, “U.S. EPR Design Features to Address GSI-191,” will be revised as described in the response and indicated on the enclosed markup.

Question 06.02.02-138:

Technical Report ANP-10293, Section G.3.3.2, “Wear Rate Evaluation for Valves, Orifices and Pipes,” describes the wear rate evaluation for valves, orifices and pipes during operation with post-LOCA fluids. In summary, Section G.3.3.2 states the following: The wear rate evaluation is performed using the post-LOCA fluid constituents listed in Technical Report ANP-10293, Table G.2.5 and the flow velocities listed in Technical Report ANP-10293, Table G.3-1. The vendor will provide tests and/or analysis to support acceptable wear rates of valves, pipes and orifices. In addition, an analysis will be provided to confirm that the overall system resistance/pressure drop across the ECCS is consistent with the safety analysis results for the 30 day mission time.

ITAAC 7.13 in DCD Tier 1, Table 2.2.3-3 provides confirmation that LHSI and MHSI system flow and wear rates are acceptable during operation with post-LOCA fluids. ITAAC 7.13 states, “A report concludes that pressure drop/ECCS is consistent with safety analysis results for 30 days of post-LOCA operation. A report concludes that wear rates are acceptable for 30 days of post-LOCA operation based on provided equipment specifications.”

Staff requests AREVA to further describe the how the analysis described in Technical Report ANP-10293, Section G.3.3.2 will provide verification of acceptable ECCS operation at the end of the 30 day mission time when all components and piping reach their maximum wear. Provide sufficient detail of how vendor provided wear data of valves, pipes and orifices is used in the analysis.

Also, ITAAC 7.13, “Inspection, Test, and Analysis,” states, “An analysis of plugging and wear of valves and orifices will be performed.” Staff would consider the analysis of the ECCS operation to address the wear of all components in the ECCS system including the piping, not only the valves and orifices. Staff requests AREVA to discuss why only the wear of valves and orifices are addressed in ITAAC 7.13 and not all components in the ECCS system.

Response to Question 06.02.02-138:

The general concern associated with erosive wear of pipes, orifices, and valves is increased system flow. Erosive wear may increase flow areas through the emergency core cooling system (ECCS); thus, reducing system resistance and increasing system flow. AREVA will provide equipment vendors with flow rates and debris profiles to perform testing and/or analysis to ascertain wear rate data for piping, valves, and orifices. Wear rate data provided by vendors will be conservatively used by AREVA to evaluate the potential increase in system flow caused by wear. This will demonstrate that ECCS flow rates remain within the maximum allowable system flow rate for at least 30 days of post-loss of coolant accident (LOCA) operation, as calculated in the hydraulic analyses performed in support of the FSAR Chapter 15 Safety Analyses.

U.S. EPR FSAR Tier 1, Table 2.2.3-3–Safety Injection System and Residual Heat Removal System ITAAC will be revised to include the following updated Inspections, Tests, Analyses for Item 7.13:

a. An analysis of pressure drop/overall system resistance across ECCS will be performed.

b. An analysis of plugging and wear rates of piping, valves, and orifices will be performed.

c. An analysis of plugging of ECCS instrument lines will be performed.

FSAR Impact:

U.S. EPR FSAR Tier 1, Table 2.2.3-3, will be revised as described in the response and indicated on the enclosed markup.

Technical Report Impact:

ANP-10293, “U.S. EPR Design Features to Address GSI-191,” will not be changed as a result of this question.

Question 06.02.02-139:

All the valves in Technical Report ANP-10293, Table G.2-1, Components in the ECCS Flow Path during an LBLOCA," do not appear to be listed in DCD Tier 1 Table 2.2.3-1, "SIS/RHR Equipment Mechanical Design." Since ITAAC 3.1 in DCD Tier 1 Table 2.2.3-3 concludes that ECCS pumps and valves in Tier 1 Table 2.2.3-1 are functionally designed and qualified under design basis accident conditions, then all pumps and valves in the ECCS flow path during SBLOCA and LBLOCA operations should be listed in the Tier 1 Table 2.2.3-1. Staff requests AREVA to ensure that all valves in the ECCS flow path are identified in Tier 1 Table 2.2.3-3 or provide justification why the valves should not identified in this table.

Response to Question 06.02.02-139:

U.S. EPR FSAR Tier 1, Table 2.2.3-1–SIS/RHRS Equipment Mechanical Design, and Table 2.2.2-1—IRWSTS Equipment Mechanical Design, will be revised to include valves listed in Technical Report ANP-10293, Table G.2-1, "Components in the ECCS Flow Path during a LBLOCA."

Some valves in the ECCS flow path listed in Technical Report ANP-10293, Table G.2-1, are part of the In-Containment Refueling Water Storage Tank System and are identified in U.S. EPR FSAR Tier 1, Table 2.2.2-1—IRWSTS Equipment Mechanical Design.

Conforming changes related to these valve additions will be made to U.S. EPR FSAR Tier 1, Section 2.2.2, Item 3.2, Table 2.2.2-3—In-Containment Refueling Water Storage Tank System ITAAC, Figure 2.2.2-1—In-Containment Refueling Water Storage Tank System Functional Arrangement, Figure 2.2.3-1—Safety Injection System and Residual Heat Removal System Functional Arrangement, and U.S. EPR FSAR Tier 2, Table 3.2.2-1—Classification Summary.

Technical Report ANP-10293, Table G.2-1– Components in the ECCS Flow Path during a LBLOCA, will also be revised to include ECCS valves not previously listed and also to correct a valve designation. These valves are listed in U.S. EPR FSAR Tier 1, Table 2.2.3-1.

FSAR Impact:

U.S. EPR FSAR Tier 1, Section 2.2.2, Item 3.2, Table 2.2.2-1, Table 2.2.2-3, Table 2.2.3-1, Figure 2.2.2-1, Figure 2.2.3-1, and U.S. EPR FSAR Tier 2, Table 3.2.2-1 will be revised as described in the response and indicated on the enclosed markup.

Technical Report Impact:

ANP-10293, "U.S. EPR Design Features to Address GSI-191," will be revised as described in the response and indicated on the enclosed markup.

U.S. EPR Final Safety Analysis Report Markups

2.2.2 In-Containment Refueling Water Storage Tank System

Design Description

1.0 System Description

The in-containment refueling water storage tank system (IRWSTS) is a safety-related system. The IRWSTS provides the following safety-related function:

- Borated water supply for the emergency core cooling systems.

The IRWSTS provides the following non-safety-related function:

- Borated water supply to the severe accident heat removal system (SAHRS) during a severe accident.

2.0 Arrangement

2.1 The functional arrangement of the IRWSTS is as described in the Design Description of Section 2.2.2, Tables 2.2.2-1—IRWSTS Equipment Mechanical Design and 2.2.2-2—IRWSTS Equipment I&C and Electrical Design, and as shown on Figure 2.2.2-1—In-Containment Refueling Water Storage Tank System Functional Arrangement.

2.2 Deleted.

2.3 Physical separation exists between divisions of the IRWSTS as shown on Figure 2.2.2-1.

3.0 Mechanical Design Features

3.1 Valves listed in Table 2.2.2-1 will be functionally designed and qualified such that each valve is capable of performing its intended function for a full range of system differential pressure and flow, ambient temperatures, and available voltage (as applicable) under design basis accident conditions.

3.2 Check valves listed in Table 2.2.2-1 will function to change position as listed in Table 2.2.2-1 under normal operating conditions.~~Deleted.~~

3.3 Equipment identified as Seismic Category I in Table 2.2.2-1 can withstand seismic design basis loads without a loss of the function listed in Table 2.2.2-1.

RAI 569, Q. 06.02.02-139

3.4 Deleted.

3.5 Deleted.

3.6 Deleted.

3.7 Deleted.

3.8 Deleted.

Table 2.2.2-1—IRWSTS Equipment Mechanical Design
Sheet 1 of 3

Description	Tag Number(1)	Location	ASME Code Section III	Function	Seismic Category
IRWST Three-way Isolation Valve for SIS Division 1	30JNK10AA001	Safeguard Building 1	Yes	open/close	I
IRWST Three-way Isolation Valve for SIS division 2	30JNK20AA001	Safeguard Building 2	Yes	open/close	I
IRWST Three-way Isolation valve for SIS Division 3	30JNK30AA001	Safeguard Building 3	Yes	open/close	I
IRWST Three-way Isolation Valve for SIS Division 4	30JNK40AA001	Safeguard Building 4	Yes	open/close	I
IRWST Isolation Valve for CVCS	30JNK10AA009	Safeguard Building 1	Yes	close	I
MHSI Miniflow Line Check Valve	30JNK10AA010	Reactor Building	Yes	open/close	I
MHSI Miniflow Line Check Valve	30JNK10AA011	Reactor Building	Yes	open/close	I
MHSI Miniflow Line Check Valve	30JNK11AA010	Reactor Building	Yes	open/close	I
MHSI Miniflow Line Check Valve	30JNK11AA011	Reactor Building	Yes	open/close	I
IRWST Isolation Valve for CVCS	30JNK10AA013	Safeguard Building 1	Yes	close	I
IRWST Isolation Valve for SAHRS	30JNK11AA009	Safeguard Building 4	Yes	open/close	I
SIS Division 1 Strainer Backflush Isolation Valve	30JNK10AA006	Reactor Building	N/A	close	II

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Table 2.2.2-3—In-Containment Refueling Water Storage Tank System ITAAC
Sheet 1 of 8

	Commitment Wording	Inspections, Tests, Analyses	Acceptance Criteria
2.1	The functional arrangement of the IRWSTS is as described in the Design Description of Section 2.2.2, Tables 2.2.2-1 and 2.2.2-2, and as shown on Figure 2.2.2-1.	An inspection of the as-built IRWSTS functional arrangement will be performed.	The IRWSTS conforms to the functional arrangement as described in the Design Description of Section 2.2.2, Tables 2.2.2-1 and 2.2.2-2, and as shown on Figure 2.2.2-1.
2.2	Deleted.	Deleted.	Deleted.
2.3	Physical separation exists between divisions of the IRWSTS as shown on Figure 2.2.2-1.	An inspection will be performed to verify that the as-built divisions of the IRWSTS are physically separated.	The divisions of the IRWSTS are physically separated in the Reactor Building as shown on Figure 2.2.2-1. The IRWSTS equipment in the Safeguard Buildings is located in separate Safeguard Buildings as listed in Table 2.2.2-1.
3.1	Valves listed in Table 2.2.2-1 will be functionally designed and qualified such that each valve is capable of performing its intended function for a full range of system differential pressure and flow, ambient temperatures, and available voltage (as applicable) under design basis accident conditions.	Tests or type tests of valves will be performed to demonstrate that the pumps and valves function under design basis accident conditions.	A report concludes that the valves listed in Table 2.2.2-1 are capable of performing their intended function for a full range of system differential pressure and flow, ambient temperatures, and available voltage (as applicable) under design basis accident conditions.
3.2	Check valves listed in Table 2.2.2-1 will function to change position as listed in Table 2.2.2-1 under normal operating conditions.Deleted.	Tests will be performed to verify the ability of check valves to change position under normal operating conditions.Deleted.	The check valves change position as listed in Table 2.2.2-1 under normal operating conditions.Deleted.

RAI 569,
Q. 06.02.02-139

Figure 2.2.2-1—In-Containment Refueling Water Storage Tank System Functional Arrangement
Sheet 1 of 3

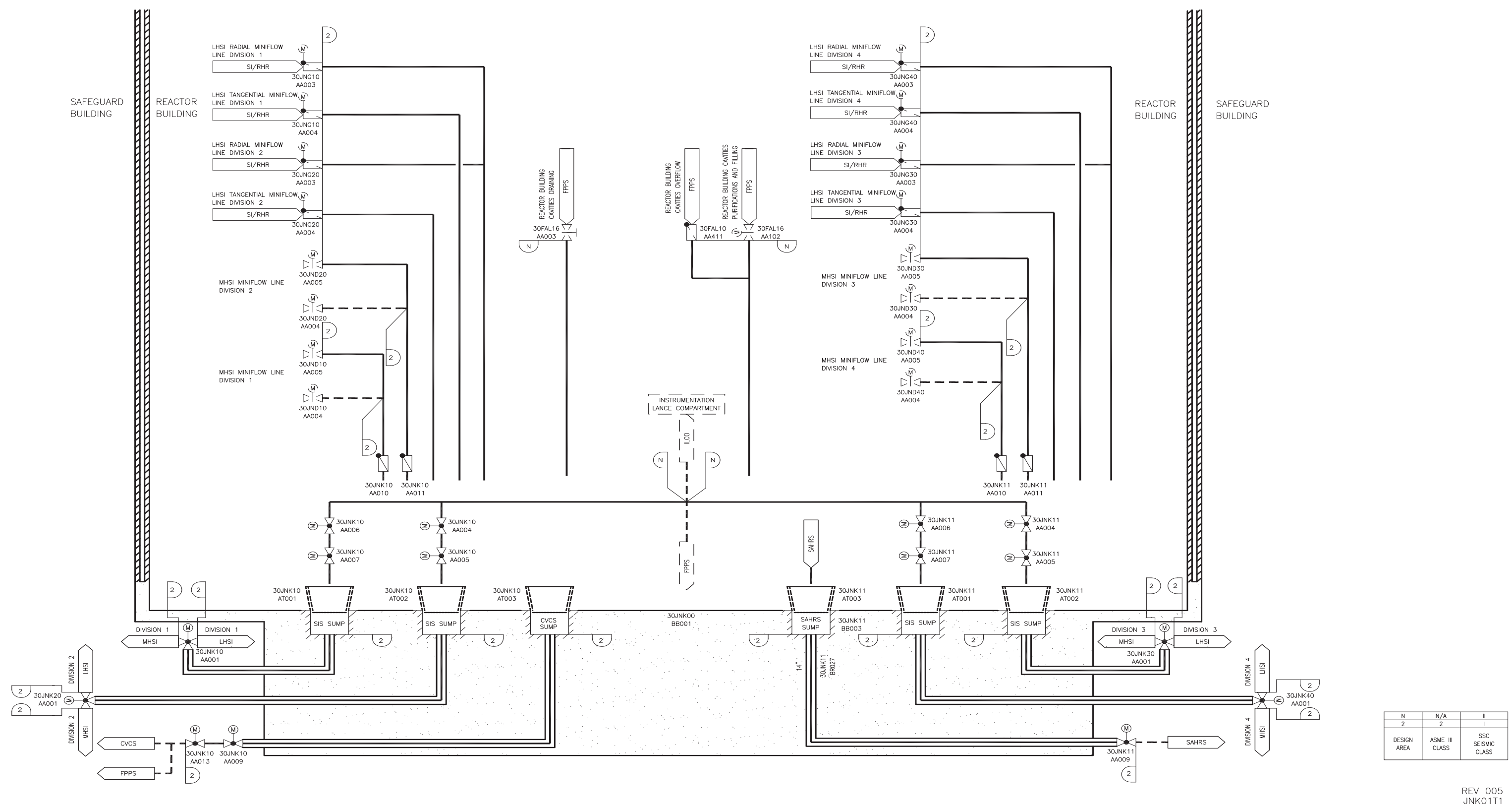

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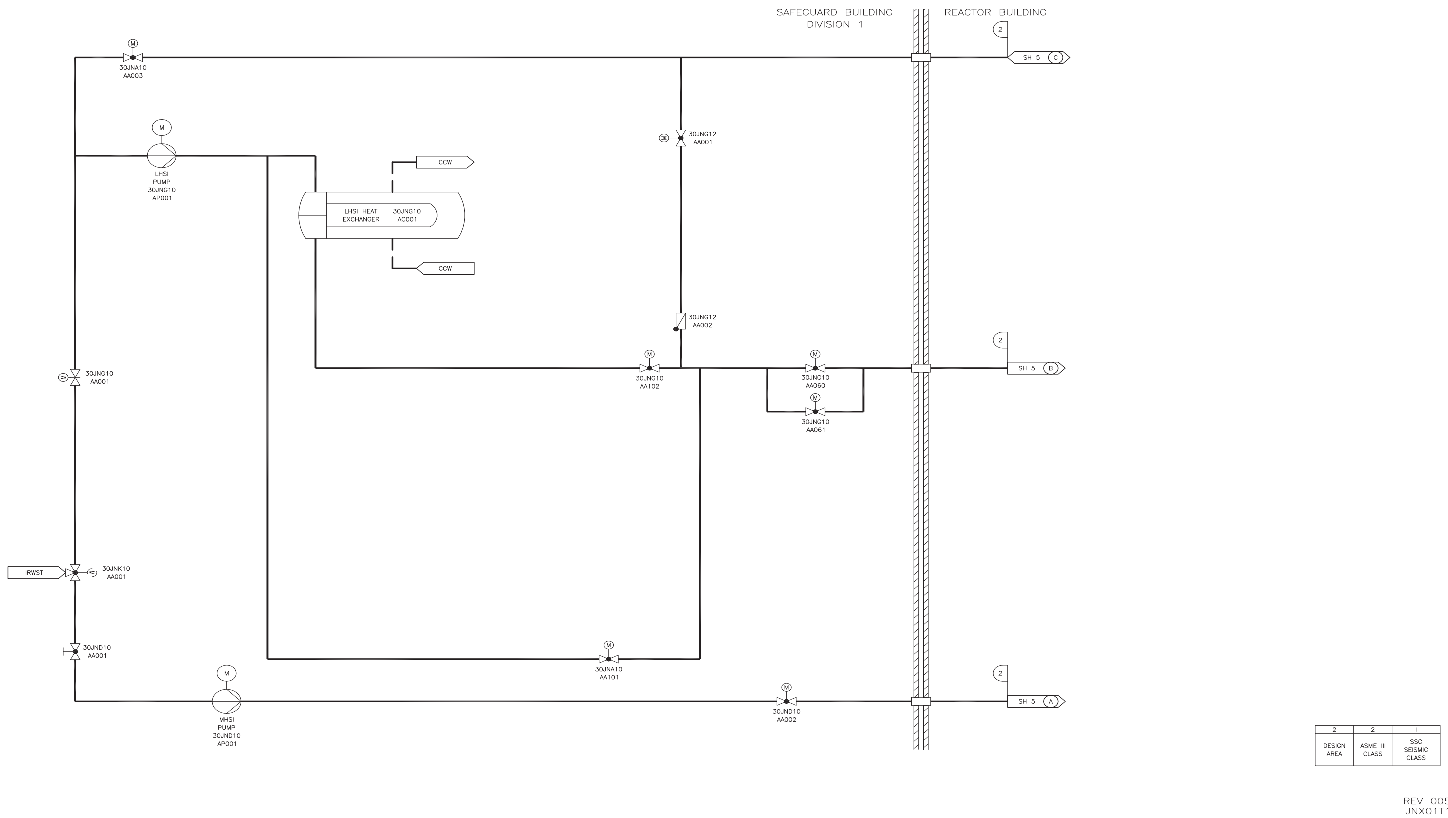
Table 2.2.3-1—SIS/RHRS Equipment Mechanical Design
Sheet 2 of 8

Description	Tag Number(1)	Location	ASME Code Section III	Function	Seismic Category
MHSI Pump Division 1 (Division 2, Division 3, Division 4)	30JND10AP001 (30JND20AP001) (30JND30AP001) (30JND40AP001)	Safeguard Building 1 (Safeguard Building 2) (Safeguard Building 3) (Safeguard Building 4)	Yes	Run	I
MHSI Suction Isolation Valve Division 1 (Division 2, Division 3, Division 4)	30JND10AA001 (30JND20AA001) (30JND30AA001) (30JND40AA001)	Safeguard Building 1 (Safeguard Building 2) (Safeguard Building 3) (Safeguard Building 4)	Yes	Open / Close	I
MHSI Outside Containment Isolation Valve Division 1 (Division 2, Division 3, Division 4)	30JND10AA002 (30JND20AA002) (30JND30AA002) (30JND40AA002)	Safeguard Building 1 (Safeguard Building 2) (Safeguard Building 3) (Safeguard Building 4)	Yes	Open / Close	I
MHSI 2nd RCPB Isolation Valve Division 1 (Division 2, Division 3, Division 4)	30JND10AA003 (30JND20AA003) (30JND30AA003) (30JND40AA003)	Reactor Building	Yes	Open / Close	I
MHSI Small Miniflow Line Isolation Valve Division 1 (Division 2, Division 3, Division 4)	30JND10AA004 (30JND20AA004) (30JND30AA004) (30JND40AA004)	Reactor Building	Yes	Open	I
MHSI Large Miniflow Line Isolation Valve Division 1 (Division 2, Division 3, Division 4)	30JND10AA005 (30JND20AA005) (30JND30AA005) (30JND40AA005)	Reactor Building	Yes	Open / Close	I

Table 2.2.3-3—Safety Injection System and Residual Heat Removal System ITAAC
Sheet 10 of 10

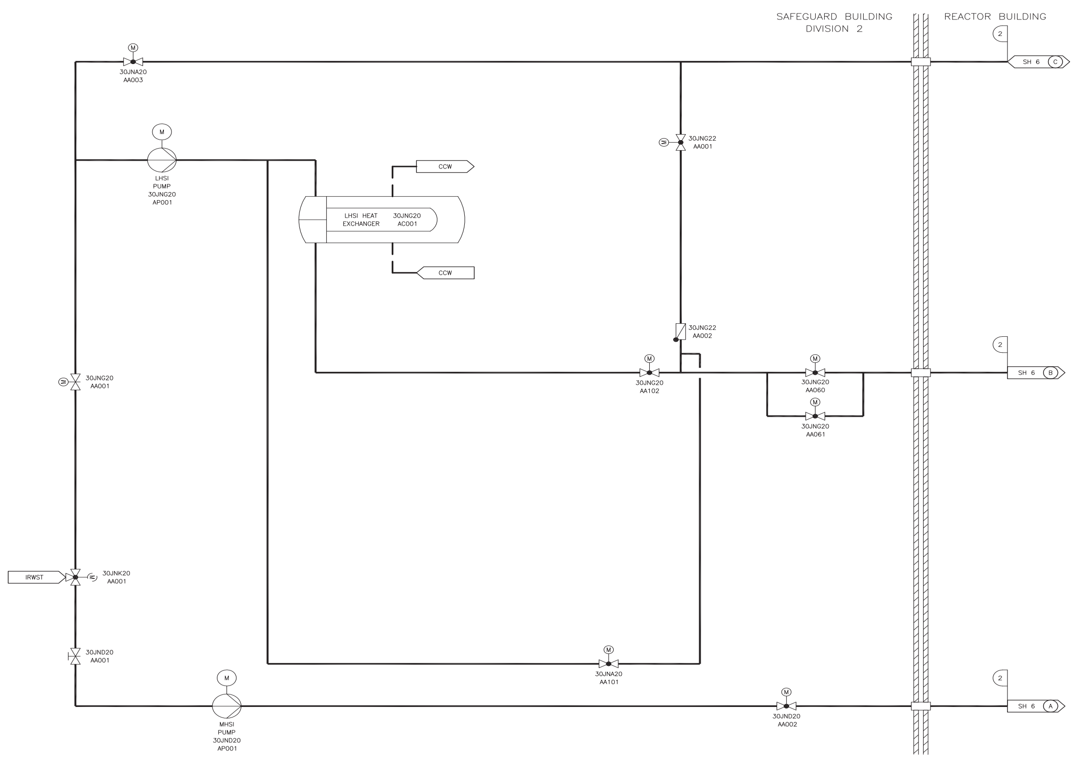
	Commitment Wording	Inspections, Tests, Analyses	Acceptance Criteria
7.13	LHSI and MHSI systems provide safety injection flow to the RCS during post-LOCA operation. RAI 569, Q. 06.02.02-138	a. An analysis of pressure drop/overall system resistance across ECCS will be performed. b. An analysis of plugging and wear rates of piping, valves, and orifices will be performed. c. An analysis of plugging of ECCS instrument lines will be performed	a. A report concludes that pressure drop/overall system resistance across ECCS is consistent with safety analysis results for 30 days of post-LOCA operation. b. A report concludes that wear rates are acceptable for 30 days of post-LOCA operation based on provided equipment specification. c. A report concludes that post-LOCA debris will not clog the ECCS instrument lines.
7.14	The SIS/RHRS includes high point vents to avoid gas accumulation in the SIS/RHRS.	An inspection will be performed to verify high point vents are installed in the as-built SIS/RHRS.	High point vents are installed in the SIS/RHRS.

Figure 2.2.3-1—Safety Injection System and Residual Heat Removal System Functional Arrangement
Sheet 1 of 8



RAI 569,
Q. 06.02.02-139

Figure 2.2.3-1—Safety Injection System and Residual Heat Removal System Functional Arrangement Sheet 2 of 8

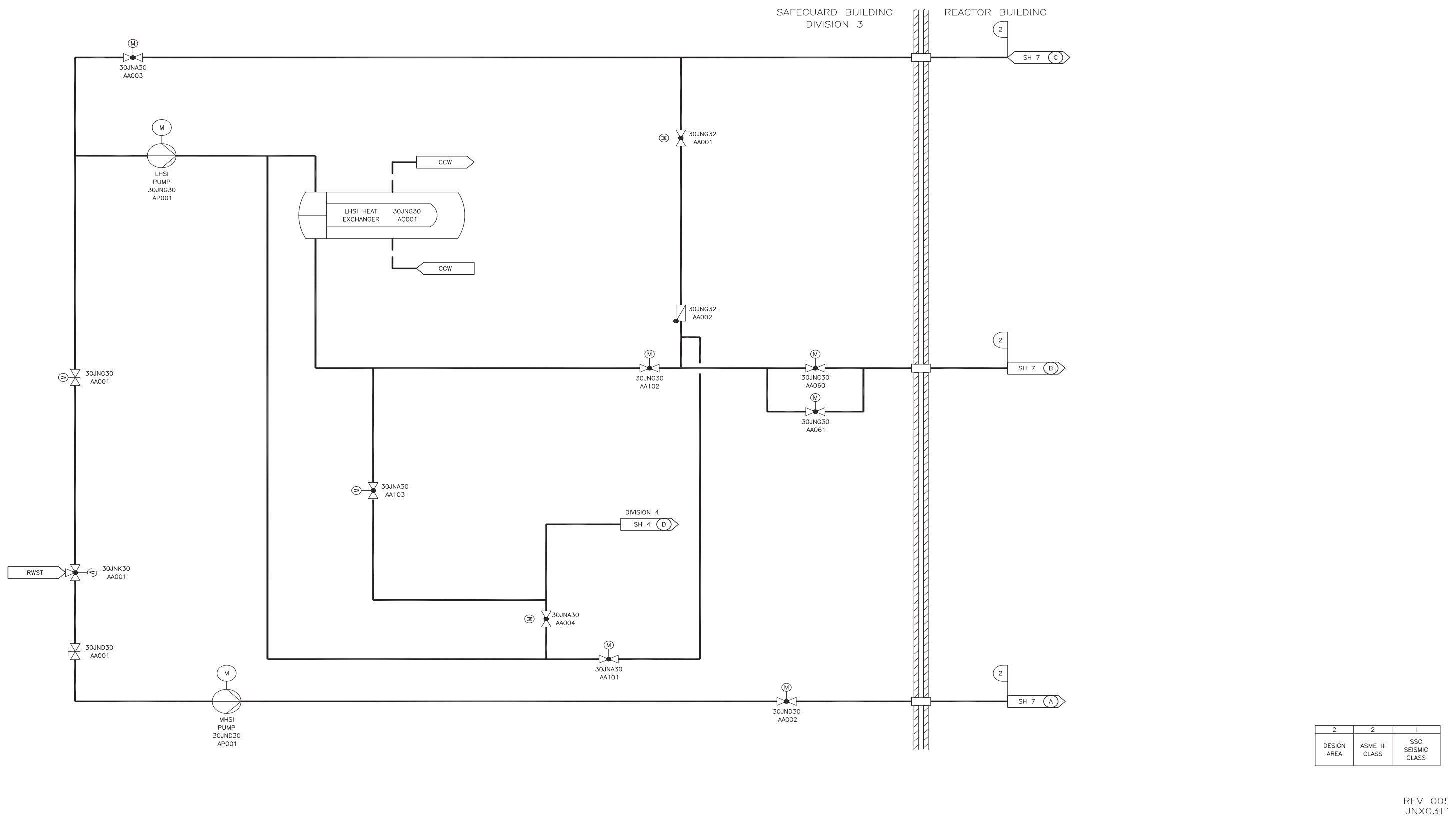


2	2	I
DESIGN AREA	ASME III CLASS	SSC SEISMIC CLASS

REV 005
JNX02T1

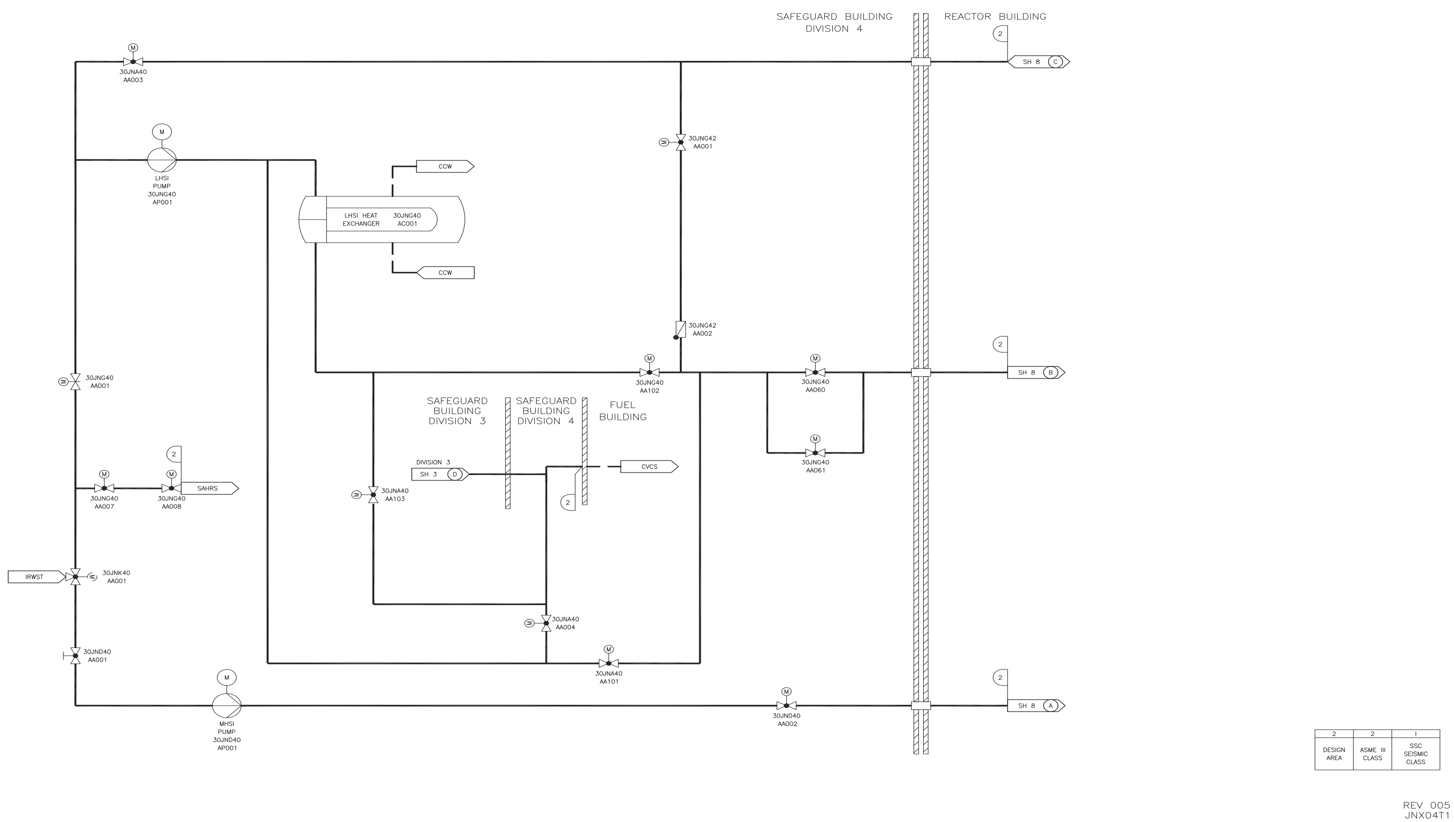
RAI 569,
Q. 06.02.02-139

Figure 2.2.3-1—Safety Injection System and Residual Heat Removal System Functional Arrangement
Sheet 3 of 8



RAI 569,
Q. 06.02.02-139

Figure 2.2.3-1—Safety Injection System and Residual Heat Removal System Functional Arrangement
Sheet 4 of 8



RAI 569,
Q. 06.02.02-139

Table 3.2.2-1—Classification Summary
Sheet 41 of 192

KKS System or Component Code	SSC Description	Safety Classification (Note 15)	Quality Group Classification	Seismic Category (Note 16)	10 CFR 50 Appendix B Program (Note 5)	Location (Note 17)	Comments/ Commercial Code
JNK	FPPS supply: Piping and Valve from FAL (30FAL16 AA102) to the IRWST	NS-AQ	D	II	Yes	UJA	ANSI/ASME B31.1[6]; Penetrates IRWST boundary
30JNK11 AA009	IRWST Isolation Valve for SAHRS	S	B	I	Yes	UJH	ASME Class 2[2]
30JNK10 AA009/013	IRWST Isolation Valves for CVCS and FPPS	S	B	I	Yes	UJH	ASME Class 2[2]
30JNK10 AA010/011 30JNK11 AA010/011	MHSI Miniflow Line Check Valve	S	B	I	Yes	UJA	ASME Class 2[2]
30JNK10/11 AT004/ 005	IRWST Retaining Baskets	S	N/A	I	Yes	UJA	ANSI/AISC N690-1994(R2004)s2 [13]
30JNK00 BB001	IRWST Tank	S	N/A	I	Yes	UJA	ACI 349R
30JNK10/20/30/40 AA001	IRWST Three-way Isolation Valves for SIS			I	Yes	UJH	ASME Class 2[2]
JNK	RCDT Overpressure Protection Line: Piping Downstream of RCDT to IRWST	S	C	I	Yes	UJA	ASME Class 3[3]

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MARKUPS

G.2.3 Components of Interest

Table G.2-1 lists the ECCS/RHRS/IRWST components in the downstream effects evaluation. These components are in the ECCS flow path during SBLOCA and LBLOCA operations.

Table G.2-1 Components in the ECCS Flow Path during an LBLOCA

Components	Description
PUMPS	
LHSI Pump (30JND10/20/30/40 AP001)	**Type**: Centrifugal **Arrangement**: Horizontal **Flow Rate**: ~441.6 lbm/s (maximum)
MHSI Pump (30JNG10/20/30/40 AP001)	**Type**: Centrifugal **Arrangement**: Horizontal **Flow Rate**: ~152.6 lbm/s (maximum)
HEAT EXCHANGERS	
LHSI Heat Exchanger (30JNG10/20/30/40 AC001)	**Type**: Shell and Tube, U-Tube, Horizontally Mounted **Number of Shell in Series**: 1 **Number of Tube Passes**: 2 **Tube Material**; Austenitic Steel **Flow rate**: ~392.4 lbm/s (during LBLOCA LHSI Injection)
VALVES AND ORIFICES	
Motor Operated Valves:	
30JNG10/20/30/40 AA102	**Function**: LHSI Heat Exchanger Control Valve **Size**: 8 inches **Type**: Globe Valve
30JNG10/20/30/40 AA060	**Function**: LHSI Discharge Valve **Size**: 8 inches **Type**: Globe Valve
30JNG10/20/30/40 AA061	**Function**: LHSI Discharge Valve **Size**: 4 inches **Type**: Globe Valve
30JNA10/20/30/40 AA002	**Function**: Hot Leg (RCPB) Isolation Valve **Size**: 10 inches **Type**: Globe Valve

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Components	Description
30JNG10/20/30/40 AA001	**Function**: LHSI Pump Suction from IRWST Isolation Valve **Size**: 14 inches **Type**: Gate Valve
30JNG12/22/32/42 AA001	**Function**: LHSI Hot Leg Injection Isolation Valve **Size**: 8 inches **Type**: Globe Valve
30JNK10/20/30/40 AA001	**Function**: IRWST 3-Way Isolation Valve **Size**: Inlet – 16 inches; MHSI Outlet – 10 inches; LHSI Outlet – 14 inches **Type**: 3-Way Globe Valve
30JND10/20/30/40 AA002	**Function**: MHSI Pump Discharge Valve **Size**: 6 inches **Type**: Globe Valve
30JND10/20/30/40 AA004	**Function**: MHSI Small Miniflow Line Isolation Valve **Size**: 2 inches **Type**: Globe Valve
30JNG10/20/30/40 AA004	**Function**: LHSI Tangential Miniflow Line Check Valve **Size**: 4 inches **Type**: Lift Check with Electric Motor
30JNA10/20/30/40 AA001	**Function**: Hot Leg (RCPB) Isolation Valve **Size**: 10 inches **Type**: Gate Valve
30JNG10/20/30/40 AA106	**Function**: LHSI Control Valve **Size**: 8 Inches **Type**: Globe Valve
30JND10/20/30/40 AA103	**Function**: MHSI Control Valve **Size**: 6 Inches **Type**: Globe Valve
Manual Valves:	
30JND10/20/30/40 AA001	**Function**: MHSI Suction Isolation Valve **Size**: 10 inches **Type**: Globe Valve
30JND10/20/30/40 AA003	**Function**: MHSI 2nd RCPB Isolation Valve **Size**: 6 inches **Type**: Globe/Check Valve

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Components	Description
30JNG10/20/30/40 AA006	**Function**: LHSI 2nd RCPB Isolation Valve **Size**: Inlet – 8 inches ; Outlet – 10 inches **Type**: Globe/Check Valve
Check valves:	
30JND10/20/30/40 AA007	**Function**: MHSI Check Valve **Size**: 6 inches **Type**: Swing Check Valve
30JNG12/22/32/42 AA002	**Function**: LHSI Hot Leg Injection Check Valve **Size**: 8 inches **Type**: Swing Check Valve
30JNG10/20/30/40 AA009	**Function**: LHSI Check Valve **Size**: 8 inches **Type**: Swing Check Valve
30JNG10/20/30/40 AA011	**Function**: LHSI Check Valve **Size**: 8 inches **Type**: Swing Check Valve
30JNG13/23/33/43 AA005	**Function**: Cold Leg Check Valve **Size**: 12 inches **Type**: Swing Check Valve
30JNK10 AA010/AA011 30JNK11 AA010/AA011 ~~30JNK10/20/30/40 AA010~~	**Function**: MHSI Check Valve **Size**: 4 inches **Type**: Swing Check Valve
Orifices:	
30JND10/20/30/40 BP003	**Function**: MHSI Discharge Orifice **Size**: 6 inches
30JND10/20/30/40 BP002	**Function**: MHSI Miniflow Orifice **Size**: 2 inches
30JNG12/22/32/42 BP001	**Function**: LHSI Hot Leg Injection/Suction Orifice **Size**: 8 inches
30JNG10/20/30/40 BP001	**Function**: LHSI Tangential Miniflow Orifice **Size**: 4 inches
30JNG10/20/30/40 BP061	**Function**: LHSI Outside Containment Bypass Line Orifice **Size**: 4 inches

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Bypass testing of the latent debris yielded a fiber bypass percentage of less than 70 percent (see Appendix E, Section E.7.3). This evaluation uses bounding bypass percentages of 100 percent for latent particulates (i.e., dust and dirt) and 70 percent for latent fiber.

Results of the NRC debris generation test documented in NUREG/CR-6808 show that RMI debris size distribution ranges from 0.25 inches to 6 inches. Transport testing performed by AREVA demonstrated that RMI debris pieces will sink in the retaining basket (See Appendix E, Section E.7.1). In the unlikely event that RMI debris bypasses the retaining baskets, RMI debris will not bypass the sump screens and enter the ECCS because the size of the RMI debris is greater then the mesh size of the sump screen. As a result, this evaluation assumes no RMI bypasses through the sump screen.

G.2.5 ECCS Flow Rate and Flow Velocity

To evaluate debris settlement and component wear during LBLOCA, this evaluation conservatively assumes ECCS flow rates ranging from shutoff head conditions to run-out conditions.

The LHSI and MHSI pumps provide minimum flow rates of 72.8 lbm/s (≈525 gpm) and 22.9 lbm/s (≈165 gpm), respectively, to provide pump operation at shutoff head conditions. These minimum flow rates are assumed for evaluating debris settlement in the ECCS.

In general, the velocity of the debris in the post-LOCA fluid is equal to the velocity of the fluid. If the ECCS fluid velocity is greater than the terminal settling velocity of the debris, the debris will not settle.

The debris settlement evaluation (Section G.3.3.1) compares the ECCS fluid velocities with the terminal settling velocities of the debris source materials listed in Table G.2-4. The terminal settling velocity of the debris source materials listed in Table G.2-4, excluding the latent debris, is derived from NEI 04-07, Volume 1. The terminal settling

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velocity of latent particulate is estimated using the following equation (cited by Cheng, NS (1987)):

$$w = 1.068\sqrt{\frac{(\rho_{sphere} - \rho_{fluid})gd}{\rho_{fluid}}} \quad \text{for } d > 0.06 \text{ in (Concharov, 1962)}$$

where:

w = terminal settling velocity of the particle (ft/s)

g = gravitational acceleration (32.2 ft/s^2)

d = Diameter of the particle (ft)

ρ_{sphere} = mass density of the particle (169 lbm/ft^3) (Table G.2.5)

ρ_{fluid} = mass density of the fluid (61.1 lbm/ft^3, density at 122°F)

Based on the equation, terminal settling velocity is expected to increase with the size of the particle (ρ_{sphere}). Therefore, the settling velocity of the coarse sand constituent of the latent particulate bounds the settling velocities of medium sand and fine sand. Thus, the settling velocity of the latent particulate is defined by the settling velocity of coarse sand.

The terminal settling velocity of the latent particulate is estimated as:

$$w = 1.068\sqrt{\frac{(169 - 61.1) \times 32.2 \times 0.08}{61.1 \times 12}} = 0.66 \text{ ft/s}$$

The settling velocity of the latent debris source material is estimated relative to the settling velocity of the latent particulate constituent, since the particulate settling velocity is greater than the latent fiber settling velocity of 0.008 ft/s (NEI 04-07, Volume 1).

The minimum flow rate of the LHSI and MHSI pumps at shutoff head conditions will be verified during component procurement.

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The ECCS is designed to limit maximum flow rates to 441.6 lbm/s (3220 gpm) and 152.6 lbm/s (1110 gpm) for the LHSI and MHSI pumps, respectively. Flow rates of 3520 gpm for the LHSI pumps and 1320 gpm for the MHSI pumps are conservatively assumed for component wear evaluation. The component wear rate evaluation is detailed in Section G.3.1.

Table G.2-4 Terminal Settling Velocity of Debris Source Materials

Debris Source Material	Terminal Settling Velocity (ft/sec)	Reference/Comments
Microtherm	N/A	Microtherm, a microporous insulation material similar to calcium silicate, is expected to dissolve in the post-LOCA fluid (NUREG/CR-6772).
Qualified Epoxy Coatings	0.15	NEI 04-07 (page 4-34, epoxy).
Qualified IOZ Coatings	0.000674	NEI 04-07 (page 4-34, inorganic zinc).
Unqualified Coatings	0.15	Estimated to the settling velocity of epoxy coatings.
Latent Debris	0.~~0~~66~~08~~	The terminal settling velocity of latent debris is estimated relative to the settling velocity of the constituent latent particulate estimated in Section G.2.5.~~The densities of loose fiber and latent particulates are comparable (NEI 04-07). Therefore, the settling velocity of the latent debris is estimated to the settling velocity of loose fiber.~~

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G.2.6 Summary of Assumptions and Conservatisms

Assumptions and conservatisms used in this evaluation are summarized as follows:

1. 100 percent of all particulates (i.e., microtherm, coating debris, latent particulates) and 70 percent of latent fiber are assumed to pass through the strainers and enter into the ECCS. RMI debris generated during an LBLOCA will be stopped by the retention basket.

Table G.2-5 Post-LOCA Fluid Constituents Downstream of ECCS Screen

Debris	Amount	Concentration (ppm)	Density (lb/ft^3)	Size Range (inches)	% by Mass
Microtherm	1.00 ft^3	3.6	12	0 – 0.08	100
Qualified Epoxy Coatings	126.30 lbm	38.4	94	0 – 0.08	100
Qualified IOZ Coatings	958.70 lbm	291	457	0 – 0.08	100
Unqualified Coatings	250.00 lbm	76	94	0 – 0.08	100
Latent Particulates	139.80 lbm	42.5	169		
Fine Sand				< 0.003	37.4
Medium Sand				0.003 – 0.02	35.3
Coarse Sand				0.02 – 0.08	27.3
Latent Fiber	15.75 lbm[b]	4.8	2.4[a]	< 4	100

a. As-fabricated density

b. Fiber amount is conservative

G.3 ECCS Component Evaluations

This section evaluates the ECCS pumps, heat exchangers, valves, instrument tubes, and piping regarding wear, blockage, and fouling (heat exchanger).

G.3.1 LHSI and MHSI Pump Evaluation

The LHSI and MHSI pumps are horizontally mounted, centrifugal pumps with single mechanical seals. The pumps are sized in safety injection mode to provide nominal flow rates.

Generally, particulates tend to accumulate and potentially affect flow through close clearances. The LHSI and MHSI pumps will be designed with increased clearances to support successful post-LOCA operations.

The LHSI and MHSI pumps and associated mechanical seals will be qualified to operate with the post-LOCA fluids for at least 30 days, ~~using the qualification guidance~~

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~~of~~in accordance with QME-1-2007 endorsed by RG1.100 Revision 3. As part of the qualification process, the pump vendor, at a minimum, will fulfill the following pump criteria:

1. Provide tests and/or analyses to confirm that the opening sizes and internal running clearances of the LHSI and MHSI pumps yield acceptable operation in post-LOCA fluids for at least 30 days. Also, provide a list of the opening sizes and internal running clearances in the qualification documentation.
2. Provide hydraulic performance test results and/or analyses to confirm that the LHSI and MHSI pumps can provide the required safety injection flow for at least 30 days of ECCS post-LOCA operation.
3. Provide tests and/or analyses to confirm that the wear rates of the LHSI and MHSI pump wetted surface materials (e.g., wear rings, pump internals, bearing, casing) provide acceptable operation in the post-LOCA fluids for at least 30 days. Also, provide a list of the wetted pump surfaces materials, hardness of each material, and verification of acceptable wear rates in the qualification documentation.
4. Provide mechanical performance (i.e., pump vibration, rotor dynamics, bearing load) test results and/or analyses to confirm that there will be no adverse changes in system vibration response or rotor dynamics performance during ECCS operation for at least 30 days. Also, provide relevant test results and/or analyses to confirm that any increases in internal bypass flow caused by impeller or casing wear will not decrease the performance of the pumps or cause accelerated internal wear for at least 30 days of post-LOCA operation.
5. Provide mechanical seal assembly performance test results and/or analyses to confirm that ECCS 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. If the cyclone separator or any filtering device could be impaired within 30 days of post-LOCA operation, the test results and/or analysis will show that the absence of a cyclone separator or any filtering device yields acceptable seal performance.

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7. The vendor will also identify any additional potential pump malfunctions, ~~per~~ in accordance with QME-1-2007 Section QP-7200.
8. The vendor will verify that the LHSI and MHSI pumps provide minimum flow rates of 72.8 lbm/s and 22.9 lbm/s, respectively, at shutoff head conditions.
9. The vendor will verify that LHSI and MHSI pumps provide flow rates at run-out conditions of less than 3520 gpm and 1320 gpm, respectively.

G.3.2 LHSI Heat Exchanger Evaluation

The LHSI heat exchangers are evaluated for potential susceptibility to tube plugging, fouling, and abrasive wear.

G.3.2.1 Heat Exchanger Tube Plugging

Post-LOCA debris will not plug the heat exchanger tubes if the tube inside diameter is greater than the expected particle size (based on the opening size of the sump screen). In addition, debris will not settle in the heat exchanger tubes if the fluid velocity in the tubes is greater than the terminal settling velocity of the debris (Table G.2-4).

The vendor will provide data to confirm that post-LOCA debris will not plug the heat exchanger tubes during the 30 day mission time. In addition, the vendor will perform one of the following:

The suction lines of the LHSI and MHSI pumps are the largest lines in the ECCS.

The LHSI pump suction line is a 14-inch Schedule 30 stainless steel pipe (inside diameter = 13.25 inches). The velocity in this line at the minimum flow rate is 1.23 ft/s. This velocity is greater than the terminal settling velocities of the post-LOCA debris materials (Table G.2-4). Therefore, settling will not occur in the LHSI flow path to the RCS.

The MHSI pump suction line is a 10-inch Schedule 40S stainless steel pipe (inside diameter = 10.02 inches). The velocity in this line at the minimum flow rate is 0.68 ft/s. This velocity is greater than the terminal settling velocities of the post-LOCA debris materials (Table G.2-4). Therefore, settling will not occur in the MHSI flow path to the RCS.

An analysis will be performed to confirm that post-LOCA debris will not clog the ECCS instrument lines during post-LOCA operation for at least 30 days.

G.3.3.2 *Wear Rate Evaluation for Valves, Orifices and Pipes*

Erosive wear is caused by particles that impinge on a component surface and remove material from the surface because of momentum effects. The wear rate of a material depends on the debris type, debris concentration, material hardness, flow velocity, and valve position.

Flow rates of 3520 (490 lbm/s) and 1320 gpm (184 lbm/s) for LHSI and MHSI, respectively, are conservatively assumed for the wear rate evaluation of the components listed in Table G.2-1.

The vendor will qualify the ECCS valves to operate with the post-LOCA fluids for at least 30 days, ~~using the qualification guidance of~~ in accordance with QME-1-2007 endorsed by RG1.100 Revision 3. As part of the qualification process, the vendor will provide data and/or analyses to support acceptable wear rates during operation in post-LOCA fluids (Table G.2-5) at the associated flow velocities listed in Table G.3-1.

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Table G.3-1 Flow Velocities for Component Wear Evaluation

Components	Inside Diameter (inches)	Designed ECCS Flow (lbm/s)	Assumed Flow Rate (lbm/s)	Assumed Velocity (ft/s)
Piping				
14” LHSI Pump Suction Line (SS Schedule 30)	13.25	441.6	490	8.27
8” LHSI Pump and Heat Exchanger Discharge (SS Schedule 80S)	7.625	441.6	490	24.73
10” MHSI Pump Suction Line (SS Schedule 40S)	10.02	152.6	184	5.37
6” MHSI Discharge Line (SS Schedule 40S)	6.065	152.6	184	14.66
10” RCS Cold Leg Discharge (SS Schedule 160)	8.5	< 594.2	674	27.37
8” Hot Leg Injection/Suction Line (SS Schedule 80S)	7.625	< 441.6	490	24.73
Orifice				
4” Orifice on LHSI valve/line bypass	-	< 441.6	490	-
8” Orifice on line between cold leg injection and hot leg injection/suction	-	< 441.6	490	-
6” Orifice on MHSI pump discharge line	-	152.6	184	-
2” Orifice on MHSI Miniflow Orifice	-	-	50	-

G.3.4 Chemical Effects Evaluation

Chemical precipitates (aluminum oxyhydroxide/hydroxide, calcium phosphate, and sodium aluminum silicate) are formed when concrete and LOCA-generated debris materials are exposed to the buffering materials in the IRWST. This reaction forms additional solid species that could potentially pass through the sump screen and degrade the performance of the ECCS.

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In-vessel fuel blockage tests performed using particulate, fiber and aluminum oxyhydroxide precipitate demonstrated that the flow resistance created by the chemical precipitate is significantly less than the pump head that is available in the ECCS piping system. Secondly, similar to the particulate and fiber debris materials, only chemical precipitates smaller than (or equal to) the strainer mesh size will be ingested by the ECCS. The diameter of the ECCS piping, orifices, valves and heat exchanger tubes are significantly larger than the size of the ingested chemical precipitates, and the velocity of the post-LOCA fluid is expected to be sufficient to avoid settling. Therefore, components downstream of the sump strainers are not expected to become clogged with chemical precipitates such that blockage of flow occurs.

In addition, the qualification of the ECCS pumps, performed with conservative amounts of post-LOCA debris (Table G.2-5), in accordance with QME-1-2007, will include confirmation that the internal running clearance of the ECCS pumps is sufficiently large enough to avoid clogging, and supports acceptable pump and seal operation during the 30-day post-LOCA mission time.

The chemical precipitates are also unlikely to reduce the efficiency of the heat exchanger because most precipitates will form later in the post-LOCA event when temperatures have decreased (NUREG/CR-6914 and NUREG/CR-6913) and the required heat transfer capacity of the ECCS heat exchangers has ample margin. Precipitates that form soon after the pipe break are only expected to form, at most, thin deposit films on the heat exchanger tubes. Deposit thicknesses are limited by scrubbing from particulate in the coolant as well as the relatively high flow rate and pressure differential associated with the ECCS. In addition, the LHSI heat exchangers are designed and specified with conservative fouling factors to maximize heat transfer efficiency and performance. Operating experience has also demonstrated that fouling is a long-term phenomenon and heat exchangers can still perform adequately with significant fouling. Therefore, the chemical precipitates are not expected to significantly impair the heat transfer capability of the ECCS heat exchangers.

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