ArevaEPRDCPEm Resource

From:	Pederson Ronda M (AREVA NP INC) [Ronda.Pederson@areva.com]
Sent:	Thursday, July 16, 2009 2:52 PM
To:	Tesfaye, Getachew
Cc:	BENNETT Kathy A (OFR) (AREVA NP INC); DELANO Karen V (AREVA NP INC); BEELMAN Ronald J (AREVA NP INC)
Subject:	Response to U.S. EPR Design Certification Application RAI No. 212, FSAR Ch. 6, Supplement 1
Attachments:	RAI 212 Supplement 1 Response US EPR DC.pdf

Getachew,

AREVA NP Inc. (AREVA NP) provided responses to 6 of the 13 questions of RAI No. 212 on May 13, 2009. The attached file, “RAI 212 Supplement 1 Response US EPR DC.pdf” provides technically correct and complete responses to the remaining 7 questions, as committed.

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 212 Questions 06.02.02-23, 06.02.02-26, 06.02.02-27, and 06.02.02-28.

The following table indicates the respective pages in the response document, “RAI 212 Supplement 1 Response US EPR DC.pdf,” that contain AREVA NP’s responses to the subject questions.

Question #	Start Page	End Page
RAI 212 — 06.02.02-23	2	3
RAI 212 — 06.02.02-24	4	4
RAI 212 — 06.02.02-25	5	5
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RAI 212 — 06.02.02-27	7	7
RAI 212 — 06.02.02-28	8	9
RAI 212 — 06.03-9	10	10

This concludes the formal AREVA NP response to RAI 212, and there are no questions from this RAI for which AREVA NP has not provided responses.

Sincerely,

Ronda Pederson
ronda.pederson@areva.com
Licensing Manager, U.S. EPR Design Certification
AREVA NP Inc.
An AREVA and Siemens company
3315 Old Forest Road
Lynchburg, VA 24506-0935
Phone: 434-832-3694
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From: Pederson Ronda M (AREVA NP INC)
Sent: Wednesday, May 13, 2009 5:19 PM

To: 'Getachew Tesfaye'
Cc: BENNETT Kathy A (OFR) (AREVA NP INC); DELANO Karen V (AREVA NP INC); BEELMAN Ronald J (AREVA NP INC)
Subject: Response to U.S. EPR Design Certification Application RAI No. 212, FSAR Ch. 6

Getachew,

Attached please find AREVA NP Inc.'s response to the subject request for additional information (RAI). The attached file, "RAI 212 Response US EPR DC.pdf" provides technically correct and complete responses to 6 of the 13 questions.

The following table indicates the respective pages in the response document, "RAI 212 Response US EPR DC.pdf," that contain AREVA NP's response to the subject questions.

Question #	Start Page	End Page
RAI 212 — 06.02.02-23	2	2
RAI 212 — 06.02.02-24	3	3
RAI 212 — 06.02.02-25	4	4
RAI 212 — 06.02.02-26	5	5
RAI 212 — 06.02.02-27	6	6
RAI 212 — 06.02.02-28	7	7
RAI 212 — 06.03-5	8	8
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RAI 212 — 06.03-7	12	12
RAI 212 — 06.03-8	13	13
RAI 212 — 06.03-9	14	14
RAI 212 — 06.03-10	15	15
RAI 212 — 06.03-11	16	16

A complete answer is not provided for 7 of the 13 questions. The schedule for a technically correct and complete response to these questions is provided below.

Question #	Response Date
RAI 212 — 06.02.02-23	July 17, 2009
RAI 212 — 06.02.02-24	July 17, 2009
RAI 212 — 06.02.02-25	July 17, 2009
RAI 212 — 06.02.02-26	July 17, 2009
RAI 212 — 06.02.02-27	July 17, 2009
RAI 212 — 06.02.02-28	July 17, 2009
RAI 212 — 06.03-9	July 17, 2009

Sincerely,

Ronda Pederson

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From: Getachew Tesfaye [mailto:Getachew.Tesfaye@nrc.gov]
Sent: Tuesday, April 14, 2009 5:12 PM
To: ZZ-DL-A-USEPR-DL
Cc: Clinton Ashley; Christopher Jackson; Thomas Scarbrough; David Terao; John Budzynski; Shanlai Lu; Joseph Donoghue; Jason Carneal; Michael Miernicki; Joseph Colaccino; ArevaEPRDCPEm Resource
Subject: U.S. EPR Design Certification Application RAI No. 212 (2452, 2461,2421), FSAR Ch. 6

Attached please find the subject requests for additional information (RAI). A draft of the RAI was provided to you on April 7, 2009, and on April 14, 2009, you informed us that the RAI is clear and no further clarification is needed. As a result, no change is made to the draft RAI with the exception of referenced RAI numbering clarification. 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 RAIs 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.

Thanks,
Getachew Tesfaye
Sr. Project Manager
NRO/DNRL/NARP
(301) 415-3361

Hearing Identifier: AREVA_EPR_DC_RAIs
Email Number: 668

Mail Envelope Properties (5CEC4184E98FFE49A383961FAD402D310110FB28)

Subject: Response to U.S. EPR Design Certification Application RAI No. 212, FSAR Ch. 6, Supplement 1
Sent Date: 7/16/2009 2:51:59 PM
Received Date: 7/16/2009 2:52:05 PM
From: Pederson Ronda M (AREVA NP INC)

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Post Office: AUSLYNCMX02.adom.ad.corp

Files	**Size**	**Date & Time**
MESSAGE	4753	7/16/2009 2:52:05 PM
RAI 212 Supplement 1 Response US EPR DC.pdf	304423	

Options
Priority: Standard
Return Notification: No
Reply Requested: No
Sensitivity: Normal
Expiration Date:
Recipients Received:

Response to

Request for Additional Information No. 212, Supplement 1

4/14/2009

U. S. EPR Standard Design Certification
AREVA NP Inc.
Docket No. 52-020
SRP Section: 06.02.02 - Containment Heat Removal Systems
SRP Section: 06.03 - Emergency Core Cooling System

Application FSAR Ch 6

QUESTIONS for Containment and Ventilation Branch 1 (AP1000/EPR Projects) (SPCV)
QUESTIONS for Component Integrity, Performance, and Testing Branch 1 (AP1000/EPR Projects) (CIB1)
QUESTIONS for Reactor System, Nuclear Performance and Code Review (SRSB)

Question 06.02.02-23:

Information provided in response to RAI 111, Question No. 06.02.02-8.K.15 requires follow-up. Additional information is needed to determine how the IRWST safety function is assured when applying single failure criteria per §52.47 and §50 Appendix A, General Design Criteria. Based upon RAI 111, Question No. 06.02.02-8.K.15 and RAI 6, Question No. 19-103 (Figure 19-103-1) responses, it appears that it may be necessary to isolate the flow path connecting the IRWST to the core spreading area upon inadvertent (spurious) opening of the 'passive flooding device' in order to ensure the IRWST can perform its safety function (core cooling).

Therefore, describe the design of the passive flooding lines (two) that connect the IRWST to the Core Spreading Area and how the IRWST core cooling function is accomplished assuming a single failure – active and/or passive - of the components in the passive flooding line. Discuss the basis for assuming component failure (spurious opening) associated with the normally closed 'passive flooding valve' and when this is postulated to occur. Discuss if inadvertent (spurious) opening of a "passive flooding valve(s)" is consequential to the IRWST safety function and describe the analysis inputs and assumptions that support the conclusion. Discuss what, if any, automatic or manual actions are necessary to ensure the IRWST can perform its core cooling safety function assuming an inadvertent (spurious) opening of a "passive flooding valve(s)"

Response to Question 06.02.02-23:

The design of the passive flooding lines has been revised. The following design changes will be incorporated into the U.S. EPR FSAR in accordance with the attached mark-up.

The original design of the passive flooding lines described in RAI 6, Question 19-103 (see Figure 19-103-1) called for two normally open isolation valves per passive flooding line connecting the in-containment refueling water storage tank (IRWST) to the spreading area; these valves are located in compartments separating the IRWST from the spreading area. Each passive flooding line draws suction from a strainer in the IRWST directing gravity-driven emergency core coolant (ECC) flow through a flow limiter upstream of the two motorized isolation valves. Downstream of the motorized isolation valves is a normally closed passive flooding device held closed by a cable. Within the spreading compartment, the cable is attached to a thermal actuator. When the thermal actuator melts from contact with molten debris, the tension in the cable is released and the spring-loaded passive flooding device opens, initiating the gravity-driven ECC flow from the IRWST into the spreading compartment.

In order to address the safety related function of protecting the IRWST water inventory and to provide sufficient net positive suction head (NPSH) for the safety injection system and residual heat removal pumps, the following changes have been made to the design of the passive flooding lines:

1. One of the motorized isolation valves in each of the passive flooding lines was removed.

2. The normal operating position of the remaining motorized isolation valves was changed from "normal open" to "normal closed" position.

3. The motorized isolation in each remaining passive flooding line is powered from separate divisions (Division 1 and Division 4) and backed by 12-hour uninterruptible

power supply. The valves are deactivated during normal operation with their electrical supply breakers open to remove electrical power.

Based on the above changes, the isolation valves are normally closed and disconnected from the power system to maintain a condition in which a single failure can not result in the loss of a safety function. This is accomplished by opening the isolation valves' electrical supply breaker (not powered) to prevent spurious opening of these valves. In case of a severe accident, once the core outlet temperature reaches 650°C, the operator will have an action to close the breaker to allow the valves to be powered and operated in the open position (see NUREG-0800, BTP 8-4 for more information regarding control on the circuit breaker). With the passive flooding device normally closed and the power removed from the motorized isolation valves, no single failure can result in the loss of the safety function to maintain the water level of the IRWST at an appropriate level for emergency core cooling system pump NPSH.

FSAR Impact:

U.S. EPR FSAR, Tier 1, Section 2.3.3.1, Table 2.3.3-1 and Figure 2.3.3-1 will be revised as described in the response and indicated on the enclosed markup.

U.S. EPR FSAR, Tier 2, Section 1.2.3.3.4, Section 19.2.3.3.3.1, Table 3.2.2-1 and Figure 19.2-2 will be revised as described in the response and indicated on the enclosed markup.

Question 06.02.02-24:

Define the IRWST water level (elevation) if the passive flooding device inadvertently opened and no action was taken to stop water flow. [Follow-up question for RAI 111, Question No. 06.02.02-8.K.15; related to RAI 212, Question 06.02.02-23 above]

Response to Question 06.02.02-24:

The water level for the in-containment refueling water storage tank (IRWST) during normal operation following an inadvertent opening of the passive flooding valve can be approximated by assuming the minimum required water volume for normal operation of the IRWST to be approximately 66,886 ft^3, and subtracting the approximate volume of the spreading room. The water level can be determined by dividing the remaining IRWST volume by the floor area of the IRWST. The spreading room volume is conservatively determined to be 24,197 ft^3, while the floor area of the IRWST is approximately 5,866 ft^2. Therefore, the water level in the IRWST is approximately 7.3 ft. The water level elevation can be determined using the bottom elevation of the IRWST. The IRWST bottom floor elevation is -20.2 ft. Adding the water level to the elevation, the IRWST water level elevation is approximately -12.9 ft. By comparison, the spreading compartment ceiling level is at -12.14 ft. Allowing for conservatisms based on this approximation, the hydrostatic equilibrium level between IRWST and the spreading compartment is at approximately the ceiling level of the spreading compartment following an inadvertent opening of the passive flooding valve.

The design of the passive flooding line has been modified as described in the Response to Question 06.02.02-23. An inadvertent opening of the passive flooding device will not affect the water level of the IRWST. The elevation of the water level in the IRWST will remain unchanged during an inadvertent opening of the passive flooding device.

FSAR Impact:

The FSAR will not be changed as a result of this response.

Question 06.02.02-25:

Define the lowest IRWST water level (elevation) necessary to support the worst case design basis accident. Follow-up question for RAI 111, Question No. 06.02.02-8.K.15; related to RAI 212, Question 06.02.02-23 above]

Response to Question 06.02.02-25:

The lowest in-containment refueling water storage tank (IRWST) water level (elevation) was conservatively assumed to be -10.2 ft. Refer to the Response to Question 06.03-6 for more details.

FSAR Impact:

The FSAR will not be changed as a result of this response.

Question 06.02.02-26:

In accordance with RG 1.206 C.I.6.3.2.1, provide a simplified drawing depicting all components in the flow path from the IRWST to the spreading area using the passive flooding line. This simplified drawing should be depicted in the FSAR. [Follow-up question for RAI 111, Question No. 06.02.02-8.K.15; related to RAI 212, Question 06.02.02-23 above]

Response to Question 06.02.02-26:

The design of the passive flooding lines has been revised (see Response to Question 06.02.02-23). U.S. EPR FSAR, Tier 1, Figure 2.3.3-1 — Severe Accident Heat Removal System Functional Arrangement, and U.S. EPR FSAR, Tier 2, Figure 19.2.2 — Severe Accident Heat Removal System, will be changed according to the attached markup to reflect the design change.

FSAR Impact:

U.S. EPR FSAR, Tier 1, Figure 2.3.3-1 will be revised as described in the response and indicated on the enclosed markup.

U.S. EPR FSAR, Tier 2, Figure 19.2-2 will be revised as described in the response and indicated on the enclosed markup.

Question 06.02.02-27:

In response to an RAI on EPR FSAR Section 6.3.2.2, Areva stated that there are two connections from the In-Containment Refueling Water Storage Tank (IRWST) to the core spreading area for the EPR design. Each connection has two motor-operated valves (MOVs) and one passive flooding valve between the IRWST and the core spreading area. The normal position for the passive flooding valves is closed and the normal position for the MOVs is open. Areva stated that the MOVs can be closed if a passive flooding valve fails open. The NRC staff requests that Areva provide the following information regarding the MOVs in the IRWST system that are used to isolate the passive flooding valves: (1) provide their identification numbers; (2) specify their safety classification; (3) discuss their normal and safety functions; (4) discuss their functional design, qualification, and inservice testing; and (5) discuss their automatic and manual operation, and the justification for any manual reactor operator action associated with these MOVs.

Response to Question 06.02.02-27:

The motor-operated valves (MOVs) are part of the severe accident heat removal system (SAHRS), not part of the in-containment refueling water storage tank (IRWST) system. The design of the passive flooding lines has been revised as described in Response to Question 06.02.02-23 and as reflected in the attached markup. The following information is based on the revised design:

1. The SAHRS flooding line isolation MOV identification numbers are 30JMQ42 AA004 and 30JMQ42 AA006.

2. The MOVs are safety-related and Seismic Category I.

3. The MOVs are normally closed and support the safety related function of the IRWST by protecting the water volume in the IRWST from inadvertent draining.

4. The MOVs are part of the U.S. EPR environmental qualification program for seismically and dynamically qualified mechanical equipment (U.S. EPR FSAR, Tier 2, Table 3.10-1) and part of the in-service testing program. Since the actuators are normally deactivated and are not required to perform a safety function, they will not be listed in U.S. EPR FSAR, Tier 2, Table 3.11-1.

5. The MOVs are normally closed and deactivated and do not have to be operated to perform their safety function. No operator action is required to perform their safety function in case of an inadvertent opening of the passive flooding devices. Manual operator action is only required in case of a severe accident, in which case the breaker will have to be reset and the valves activated to open.

FSAR Impact:

U.S. EPR FSAR, Tier 2, Table 3.10-1 will be revised as described in the response and indicated on the enclosed markup.

Question 06.02.02-28:

The NRC staff requests the following additional information regarding the passive flooding valves in the IRWST system for the EPR design: (1) provide their identification numbers; (2) specify their safety classification; (3) describe their design and operating mechanism; (4) discuss their normal and safety functions; (5) discuss their functional design, qualification and inservice testing; and (6) discuss their position indication system, and the provisions to alert the reactor operators to an incorrect valve position.

Response to Question 06.02.02-28:

The passive flooding valves are part of the severe accident heat removal system (SAHRS), not part of the in-containment refueling water storage tank (IRWST) system. The design of the passive flooding lines has been revised as described in Response to Question 06.02.02-23 and as reflected in the attached markup. The following information is based on the revised design:

1. The SAHRS passive flooding valve identification numbers are 30JMQ42 AA003 and 30JMQ42 AA005.

2. The passive flooding valves identified above are non-safety augmented quality and Seismic Category II.

3. Details of the passive flooding valve design require vendor input and will be developed later in the design process. The design is described in the U.S. EPR FSAR, Tier 2, Section 19.2.3.3.3.1, Core Melt Stabilization System. The spring-loaded valve is held closed by a cable and pulley system. The cable is attached to the thermal actuator in the sacrificial concrete of the spreading compartment. The tension in the cable offsets the force of the spring and keeps the valve from opening. In case of a core melt with subsequent corium spreading, the thermal actuator is destroyed, releasing the tension in the cable. The spring then opens the valve and allows water to flow from the IRWST to the spreading compartment.

4. The passive flooding valves are normally closed and do not perform a safety-related function. The valves are only used in case of a severe accident.

5. The passive flooding valves will be part of the U.S. EPR environmental qualification program for seismically and dynamically qualified mechanical equipment (U.S. EPR FSAR, Tier 2, Table 3.10-1). However, since these valves are used only to mitigate beyond design basis accidents, they do not have to meet the stringent requirements for quality assurance requirements of 10 CFR Part 50, Appendix B or the redundancy/ diversity requirements of 10 CFR Part 50, Appendix A.

6. Position indication will be provided for each passive flooding valve providing Open/Close indication in the control room. In addition, flow measurements will be provided downstream of the passive flooding valves to further assist the operator in determining an opening of the passive flooding valves.

FSAR Impact:

U.S. EPR FSAR, Tier 2, Table 3.10-1 will be revised as described in the response and indicated on the enclosed markup.

Question 06.03-9:

Spurious Actuation of a SAHRS Flooding Valve

GDC 35 requires that the ECCS accomplish its safety functions assuming a single failure. During design basis accidents, opening of a valve could potentially deplete the IRWST level below the level required for NPSH for the safety injection pumps.

The failure mode and effect analysis of the ECCS did not address opening of a flooding valve. A mechanical failure of either the initiator or the actuator of one of the flooding valves would be a single passive failure. Opening of the valve could deplete the water level in the IRWST, which could affect all four LHSI pumps in the long term cooling mode.

a. What would be the consequence of inadvertent opening of a flooding valve during a design-basis accident?

b. Why was this failure mode not addressed in the single passive failure evaluation?

Response to Question 06.03-9:

a. The inadvertent opening of a passive flooding valve during a design-basis accident requires operator action to isolate in the design configuration described in Revision 0 of U.S. EPR FSAR. As indicated in Response to Question 06.02.02-24, the liquid elevation level of the in-containment refueling water storage tank (IRWST) after an inadvertent opening of the passive flooding valve is -12.9 ft. As indicated in Response to Question 06.03-6, the liquid elevation level used for net positive suction head (NPSH) calculations for the medium head safety injection (MHSI) and low head safety injection (LHSI) pumps is -10.2 ft. This results in a deficiency of 2.7 ft relative to the NPSH requirements of the pumps without operator action.

   Assuming 30 minutes of no operator action and a conservative flow rate of 2.65 ft^3/second (one and a half times the flow rate of the passive outflow reducer) through the passive flooding line, the volume lost from the IRWST to the spreading room would be approximately 4770 ft^3. This translates into a liquid elevation level in the IRWST of -9.6 ft. This water level supports the NPSH requirements of the MHSI and LHSI pumps.

   Instrumentation and control (I&C) sensors are provided to give indication in the main control room on the position of the passive flooding valves, flow downstream of the passive flooding valve and the IRWST water level itself. The IRWST water level is monitored by safety grade I&C while the passive flooding valve position and downstream flow indication are non-safety grade I&C.

b. The exclusion of this failure mode from the failure mode and effects analysis for the emergency core cooling system is addressed by the design modification in Response to Question 06.02.02-23. Based on this design change, an inadvertent opening of the passive flooding valve no longer negatively impacts the performance of the MHSI or LHSI pumps.

FSAR Impact:

The FSAR will not be changed as a result of this response.

U.S. EPR Final Safety Analysis Report Markups

2.3.3 Severe Accident Heat Removal System

1.0 Description

The severe accident heat removal system (SAHRS) is a dedicated cooling water system for the primary containment to support mitigation of beyond design basis events (BDBEs). The system does not operate during normal plant operations or design basis accidents.

The SAHRS provides the following safety related functions:

- Containment isolation.
- Provides integrity of the IRWST boundary.

06.02.02-23

The SAHRS provides the following non-safety related functions:

- Passive cooling of the core melt stabilization system (CMSS).
- Active spray for environmental control of the containment atmosphere.
- Active recirculation cooling of the CMSS and containment.

2.0 Arrangement

2.1 The functional arrangement of the SAHRS is as shown in Figure 2.3.3-1—SAHRS Functional Arrangement.

2.2 The location of the SAHRS equipment is as listed in Table 2.3.3-1—SAHRS Equipment Mechanical Design.

3.0 Mechanical Design Features

3.1 Equipment listed in Table 2.3.3-1 as ASME Code Section III is designed, welded, and hydrostatically tested in accordance with ASME Code Section III.

3.2 Check valves listed in Table 2.3.3-1 will function as listed in Table 2.3.3-1.

3.3 Deleted.

3.4 Components identified as Seismic Category I in Table 2.3.3-1 can withstand seismic design basis loads without a loss of the function listed in Table 2.3.3-1. ~~Equipment identified as Seismic Category I in Table 2.3.3-1 can withstand seismic design basis loads without loss of safety function as listed in Table 2.3.3-1.~~

3.5 Deleted.

3.6 Deleted.

3.7 Deleted.

Table 2.3.3-1—SAHRS Equipment Mechanical Design (2 Sheets)

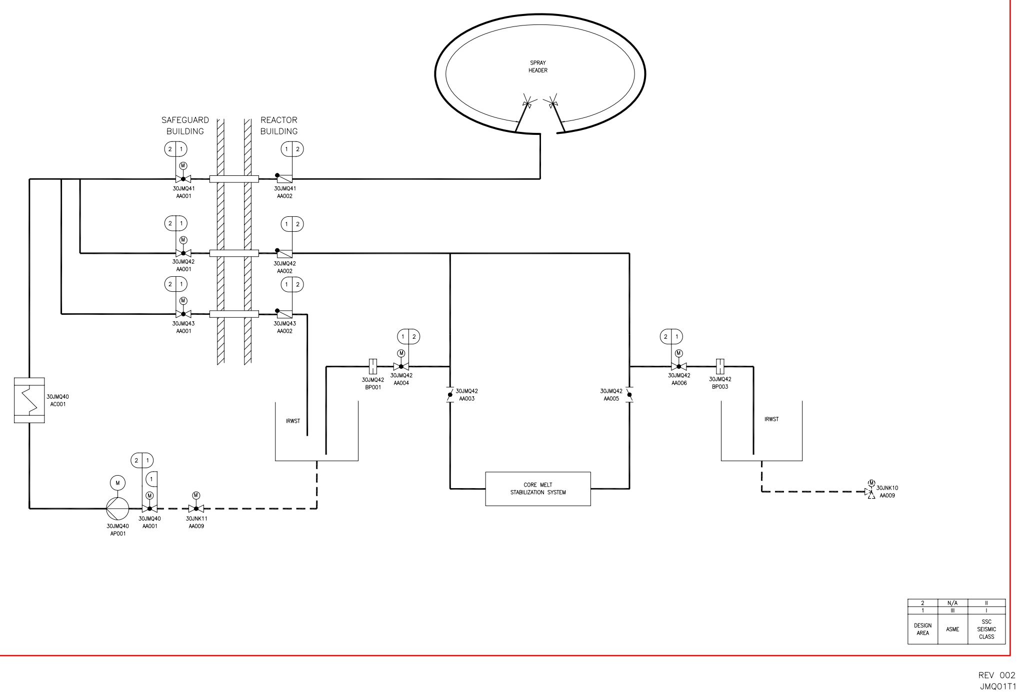
Equipment Description	Equipment Tag Number [1]	Equipment Location	ASME Code Section III	Function	Seismic Category
Passive Cooling Function Flow Reducer	30JMQ42BP001	Reactor Building	Yes	N/A	I
Passive Cooling Function Flow Reducer	30JMQ42BP003	Reactor Building	Yes	N/A	I
Passive Flooding Line Isolation Valve	30JMQ42AA003	Reactor Building	No	Open (Corium Cooling)	II
Passive Flooding Line Motorized Isolation Valve	30JMQ42AA004	Reactor Building	Yes	Open (Corium Cooling)	I
Passive Flooding Line Isolation Valve	30JMQ42AA005	Reactor Building	No	Open (Corium Cooling)	II
Passive Flooding Line Motorized Isolation Valve	30JMQ42AA006	Reactor Building	Yes	Open (Corium Cooling)	I

1) Equipment tag numbers are provided for information only and are not part of the certified design.

06.02.02-23

Figure 2.3.3-1—Severe Accident Heat Removal System Functional Arrangement

06.02.02-23 and
06.02.02-26



Next File

The SIS/RHRS is described in further detail in Sections 6.3 and 5.4.7.

1.2.3.3.2 In-Containment Refueling Water Storage Tank

The function of the IRWST is to hold an amount of borated water sufficient to flood the refueling cavity for normal refueling. The tank maintains this water at a homogeneous concentration and temperature. The IRWST is also the safety-related source of water for emergency core cooling in the event of a LOCA; it is also a source of water for containment cooling and core melt cooling in the event of a severe accident. During a LOCA, the IRWST collects the discharge from the RCS, allowing it to be recirculated by the SIS.

The IRWST is described in further detail in Section 6.3.

1.2.3.3.3 Emergency Feedwater System

The EFWS supplies water to the SGs to maintain water level and remove decay heat following the loss of normal feedwater resulting from design basis events. The EFWS removes heat from the RCS, which is initially transferred to the secondary side via the SGs and then discharged as steam via the main steam relief train (MSRT).

The EFWS is described in further detail in Section 10.4.9.

1.2.3.3.4 Core Melt Stabilization System

The U.S. EPR is equipped with a dedicated core melt stabilization system (CMSS) for molten core debris up to and including the total inventory of the core, internals, and lower RPV head. The functional principle of the CMSS is to spread the molten core debris over a large area and stabilize it by quenching it with water. Spreading increases the surface-to-volume ratio of the melt to promote fast and effective cooling and limit further release of radionuclides into the containment atmosphere. ~~These~~This ~~features~~ allows ~~a passive~~for transformation~~, without operator action,~~ of the molten core into a coolable configuration.

06.02.02-23

The U.S. EPR core melt stabilization concept has two main phases:

1. Temporary retention and accumulation of the molten fuel mixture in the reactor cavity.

2. Flooding, quenching, and long-term cooling of melt in the lateral spreading compartment.

The relocation of the melt from the reactor cavity into the spreading area is initiated by the opening of a retention gate centered in the lower portion of the cavity. This gate, which isolates the reactor cavity from the spreading compartment, consists of a steel framework enclosed by an aluminum outer layer and covered with a layer of sacrificial concrete. The concrete gate cover is an integral part of the sacrificial layer in the cavity and has approximately the same thickness as the rest of the layer. The retention time in the pit is primarily driven by the thickness of this concrete cover and not by the delay-to-failure time of the gate after melt contact.

The spreading compartment is a dead-end room which is isolated from the rest of the containment. It is also protected from sprays, leaks, or other kinds of spillage. Because there is no direct water inflow into this compartment, the spreading area is dry at the time of the melt arrival.

The molten core debris is ultimately retained in a shallow crucible. The bottom and sides of the crucible are assembled from individual elements of a cast iron cooling structure. The cooling structure is covered with a layer of sacrificial concrete, which provides protection against thermal loads resulting from melt spreading as well as a sufficient delay to allow the cooling elements to be flooded prior to the initial contact between the molten core debris and the metallic cooling structure.

06.02.02-23

Prior to core melt, the motorized isolation valves of the passive flooding lines have to be opened. The passive melt stabilization process ~~in the spreading area~~ is then enabled. ~~passively actuated.~~ When the melt enters into the spreading area, spring-loaded valves are opened by a thermal actuator, initiating a controlled gravity-driven flow of water from the IRWST. The incoming water fills a central supply duct underneath the spreading area where it enters the system of parallel channels formed by finned cooling structure elements. The water continues to rise along the sidewall of the cooling structure and pours onto the surface of the melt from the circumference. Water overflow continues until the spreading room and IRWST are balanced, resulting in the submersion of the spreading area and transfer channel as well as a portion of the reactor cavity, thereby stabilizing any residual core debris in those areas.

The CMSS is described in further detail in Section 19.2.

1.2.3.3.5 Severe Accident Heat Removal System

The SAHRS is used in the event of a severe accident to control the containment pressure and achieve long-term cooling of the IRWST and the molten corium in the spreading compartment. The SAHRS performs the following functions:

- Provides containment spray function to rapidly control containment pressure and temperature following passive melt stabilization.
- Provides long-term containment pressure and temperature control through operation in the recirculation mode.
- Transfers residual heat from the containment atmosphere to the IRWST during a severe accident to control the containment pressure and temperature.

Table 3.2.2-1—Classification Summary
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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
30JMQ42 BR005/007	Passive Flooding line up to and including MOV (JMQ42 AA00~~7~~4/00~~9~~6)	S	B	I	Yes	UJA	ASME Class 2[2]
30JMQ41 BR004	Piping - Spray Header and Nozzles	NS-AQ	D	II	Yes	UJA	ANSI/ASME B31.1[6]; Located above safety-related piping and equipment
30JMQ40	Piping and associated equipment in Safeguards Building	NS	D	NSC	No	UJH	ANSI/ASME B31.1[6]
30JMQ41/43	Piping and associated equipment inside Containment	NS-AQ	D	II	Yes	UJA	ANSI/ASME B31.1[6]; Located in close proximity to safety-related piping and equipment
30JMQ42	Piping and associated equipment inside Containment (except Passive Flooding Line)	NS-AQ	D	II	Yes	UJA	ANSI/ASME B31.1[6]; Located in close proximity to safety-related piping and equipment

Table 3.10-1 List of Seismically and Dynamically Qualified Mechanical and Electrical Equipment
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Name Tag (Equipment Description)	Tag Number	Local Area KKS ID (Room Location)	EQ Environment (Note 1)	Radiation Environment Zone (Note 2)	EQ Designated Function (Note 3)	Safety Class (Note 4)	EQ Program Designation (Note 5)
DRAIN VALVE	30FAL16AA402	30UJA11021	H	H	SI	S C/NM	Y(4) Y(5)
DRAIN VALVE	30FAL16AA403	30UJA11021	H	H	SI	S C/NM	Y(4) Y(5)
RB POOL TO IRWST DRAIN VALVE	30FAL16AA003	30UJA11021	H	H	SI	S C/NM	Y(4) Y(5)
Demineralized Water Distribution System (DWDS)							
DEMIN WATER LLRT CONN VALVE	30GHC74AA251	30UFA21045	M	H	ES SI	S C/NM	Y (3) Y (5)
DEMIN WATER THERMAL RELIEF VALVE	30GHC74AA192	30UFA21046	M	H	ES SI	S C/NM	Y (3) Y (5)
DEMIENALIZED WATER OUTER COTAINMENT ISOL	30GHC74AA001	30UFA21045	M	H	ES SI	S C/NM	Y (3) Y (5)
DEMIENALIZED WATER INNER COTAINMENT ISOL	30GHC74AA002	30UJA18013	H	H	ES SI	S C/NM	Y (4) Y (5)
Leak-Off System (LOS)							
CIDS INSIDE CI VALVE	30JMM10AA006	30UJA23013	H	H	ES SI	S C/NM	Y (4) Y (5)
CIDS OUTSIDE CI VALVE	30JMM10AA007	30UFA24095	M	H	ES SI	S C/NM	Y (3) Y (5)
CIDS LLRT Test Valve	30JMM10AA252	30UJA23013	H	H	ES SI	S C/NM	Y (4) Y (5)
CLES CI VALVE: LOCATED INSIDE RB (UJA)	30JMM23AA001	30UJA11016	H	H	ES SI	S C/NM	Y (4) Y (5)
CLES CI VALVE: LOCATED INSIDE ANNULUS (U	30JMM23AA002	30UJB05002	M	M	ES SI	S C/NM	Y (5)
CLES LLRT Test Valve	30JMM23AA252	30UJA11016	H	H	ES SI	S C/NM	Y (4) Y (5)
CLTS INSIDE CI VALVE (NON MOTORIZED)	30JMM30AA001	30UJA29015	H	H	ES SI	S C/NM	Y (4) Y (5)
CLTS OUTSIDE CI VALVE (NON MOTORIZED)	30JMM30AA003	33UJH10002	M	H	ES SI	S	Y (5)
CLTS LLRT Test Valve	30JMM30AA252	30UJA29015	H	H	ES SI	S C/NM	Y (4) Y (5)
Severe Accident Heat Removal System (SAHRS)							
SUCTION LINE FROM IRWST OUTER CI VALVE	30JMQ40AA001	34UJH01010	M	H	ES SI	S C/NM	Y (3) Y (5)
SPRAYING LINE OUTER CI VALVE	30JMQ41AA001	34UJH05007	M	H	ES SI	S C/NM	Y (3) Y (5)
SPRAYING LINE INSIDE CI CHECK VALVE	30JMQ41AA002	30UJA07015	H	H	ES SI	S C/NM	Y (4) Y (5)
SPRAYING LINE FROM IRWST LLRT CONN VALVE	30JMQ41AA008	30UJA07015	H	H	ES SI	S C/NM	Y (4) Y (5)
ACTIVE RECIRCULATION LINE OUTER CI VALVE	30JMQ42AA001	34UJH05007	M	H	ES SI	S C/NM	Y (3) Y (5)
ACTIVE RECIRCULATION LINE INSIDE CI CHEC	30JMQ42AA002	30UJA07015	H	H	ES SI	S C/NM	Y (4) Y (5)
ACTIVE RECIRCULATION LINE LLRT CONN VALVE	30JMQ42AA008	30UJA07015	H	H	ES SI	S C/NM	Y (4) Y (5)
BACKFLUSHING LINE OUTER CI VALVE	30JMQ43AA001	34UJH05007	M	H	ES SI	S C/NM	Y (3) Y (5)
BACKFLUSHING LINE INSIDE CI CHECK VALVE	30JMQ43AA002	30UJA07015	H	H	ES SI	S C/NM	Y (4) Y (5)
BACKFLUSHING LINE LLRT CONN VALVE	30JMQ43AA008	30UJA07015	H	H	ES SI	S C/NM	Y (4) Y (5)
Passive Flooding Motorized Iso. Valve	30JMQ42AA004	30UJA04005	H	H	ES SI	S C/NM	Y (4) Y (5)
Passive Flooding Motorized Iso. Valve	30JMQ42AA006	30UJA04006	H	H	ES SI	S C/NM	Y (4) Y (5)
Passive Flooding Isolation Valve	30JMQ42AA003	30UJA04005	H	H	SII	NS-AQ C/NM	Y (4) Y (5)

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Table 3.10-1 List of Seismically and Dynamically Qualified Mechanical and Electrical Equipment
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Name Tag (Equipment Description)	Tag Number	Local Area KKS ID (Room Location)	EQ Environment (Note 1)	Radiation Environment Zone (Note 2)	EQ Designated Function (Note 3)	Safety Class (Note 4)	EQ Program Designation (Note 5)
Passive Flooding Isolation Valve	30JMQ42AA005	30UJA04006	H	H	SII	NS-AQ C/NM	Y (4) Y (5)
Gaseous Waste Processing System (GWPS)							
Containment Isolation Valve (UFA Side)	30KPL84AA002	30UFA06095	M	H	ES SI	S C/NM	Y (3) Y (5)
Containment Isolation Valve (UJA side)	30KPL84AA003	30UJA07016	H	H	ES SI	S C/NM	Y (4) Y (5)
Containment Isolation Valve (UJA side)	30KPL85AA003	30UJA07016	H	H	ES SI	S C/NM	Y (4) Y (5)
Containment Isolation Valve (UFA side)	30KPL85AA004	30UFA06095	M	H	ES SI	S C/NM	Y (3) Y (5)
TEST CONNECTION ISOLATION VALVE	30KPL85AA202	30UJA07016	H	H	ES SI	S C/NM	Y (4) Y (5)
Condensate (Inside Containment) System (CS)							
Condensate C I-V	30LCA90AA003	32UJE34003	M	M	ES SI	S C/NM	Y (5)
Condensate containment I-V	30LCA90AA004	30UJA34014	H	H	ES SI	S C/NM	Y (4) Y (5)
Condensate C I-V	30LCA90AA005	30UJA34014	H	H	ES SI	S C/NM	Y (4) Y (5)
Condensate C I-V	30LCA90AA006	32UJE34003	M	M	ES SI	S C/NM	Y (5)
Condensate BD cooler I-V	30LCA90AA009	30UJA07018	H	H	SII	NS-AQ C/NM	Y (4) Y (5)
Condensate BD cooler I-V	30LCA90AA015	30UJA07018	H	H	SII	NS-AQ C/NM	Y (4) Y (5)
Condensate BD cooler I-V	30LCA90AA016	30UJA07018	H	H	SII	NS-AQ C/NM	Y (4) Y (5)
Condensate BD cooler I-V	30LCA90AA017	30UJA07018	H	H	SII	NS-AQ C/NM	Y (4) Y (5)
Condensate BD cooler bypass I-V	30LCA90AA030	30UJA07018	H	H	SII	NS-AQ C/NM	Y (4) Y (5)
Condensate BD cooler bypass I-V	30LCA90AA031	30UJA07018	H	H	SII	NS-AQ C/NM	Y (4) Y (5)
BD cooler shell relief valve	30LCA90AA182	30UJA07018	H	H	SII	NS-AQ C/NM	Y (4) Y (5)
BD cooler shell relief valve	30LCA90AA184	30UJA07018	H	H	SII	NS-AQ C/NM	Y (4) Y (5)
BD cooler bypass relief valve	30LCA90AA186	30UJA07018	H	H	SII	NS-AQ C/NM	Y (4) Y (5)
Condensate relief valve by BD cooler	30LCA90AA188	30UJA07018	H	H	SII	NS-AQ C/NM	Y (4) Y (5)
Condensate relief valve by BD cooler	30LCA90AA191	30UJA07018	H	H	SII	NS-AQ C/NM	Y (4) Y (5)
CondensateContainmentPenetration relief	30LCA90AA195	30UJA34014	H	H	ES SI	S C/NM	Y (4) Y (5)
condensate BD cooler press instr I-V	30LCA90AA310	30UJA07018	H	H	SII	NS-AQ C/NM	Y (4) Y (5)
condensate BD cooler press instr I-V	30LCA90AA320	30UJA07018	H	H	SII	NS-AQ C/NM	Y (4) Y (5)
condensate BD cooler press instr I-V	30LCA90AA330	30UJA07018	H	H	SII	NS-AQ C/NM	Y (4) Y (5)
Condensate drain I-V	30LCA90AA401	30UJA07018	H	H	SII	NS-AQ C/NM	Y (4) Y (5)
Condensate drain I-V	30LCA90AA402	30UJA07018	H	H	SII	NS-AQ C/NM	Y (4) Y (5)
BD cooler drain valve	30LCA90AA406	30UJA07018	H	H	SII	NS-AQ C/NM	Y (4) Y (5)
condensate drain valve	30LCA90AA410	30UJA07018	H	H	SII	NS-AQ C/NM	Y (4) Y (5)
BD cooler vent valve	30LCA90AA501	30UJA07018	H	H	SII	NS-AQ C/NM	Y (4) Y (5)
BD cooler vent valve	30LCA90AA502	30UJA07018	H	H	SII	NS-AQ C/NM	Y (4) Y (5)
BD cooler vent valve	30LCA90AA511	30UJA07018	H	H	SII	NS-AQ C/NM	Y (4) Y (5)

elements that line the floor and side walls of the spreading compartment. To enhance heat transfer, the horizontal and vertical plates have fins that form rectangular cooling channels. The sacrificial concrete layer protects the cooling structure against thermal loads resulting from melt spreading. It also delays melt contact with the metallic cooling structure so that the cooling elements will be flooded with water from the IRWST prior to the initial contact between them and the molten debris. The structural elements are joined using flexible connections so that the cooling structure withstands expansion and deformation.

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Prior to core melt, the normally closed, de-energized motor operated isolation valves of the passive flooding lines will be manually opened by the operator. The arrival of the melt into the spreading compartment triggers the opening of spring-loaded valves that initiate the gravity-driven flow of water from the IRWST into the spreading compartment. Initially, a cable holds each spring-loaded valve closed. Within the spreading compartment the cable is attached to a thermally sensitive initiator, consisting of a material of low melting point. When the initiator is destroyed during contact with molten debris, the cable will allow the spring-loaded actuator to open the flooding valve and allow water to flow from the IRWST.

The water first fills the central supply duct underneath the spreading area. From there, it enters the horizontal cooling channels and then fills the space behind the sidewall cooling structure. Finally, the water pours onto the surface of the melt and overflow will continue until the hydrostatic pressure in the IRWST and the spreading room is equal. Both the spreading room and the IRWST are open to the containment atmosphere with sufficient area of communication so there is no buildup of pressure as steam is generated in the spreading room. In parallel with the inflow of water, the melt interacts with the sacrificial concrete covering the horizontal and vertical cooling plates. The resulting delay allows the walls of the cooling structure to be cooled on the outside prior to the first contact with the molten corium.

19.2.3.3.3.2 Severe Accident Heat Removal System

The SAHRS works along with the CMSS to cool the molten debris. The SAHRS is a dedicated thermal-fluid system used to remove the heat generated in the containment during a severe accident. The SAHRS has four modes of operation, each playing a role in containment heat removal and controlling the environmental conditions within the containment so that its fission product retention function is maintained. These modes of SAHRS operation include:

- Passive cooling of molten debris.
- Active spray for environmental control of the containment atmosphere.
- Active recirculation cooling of the molten debris and containment atmosphere.

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Figure 19.2-2—Severe Accident Heat Removal System