## ArevaEPRDCPEm Resource

**From:** Pederson Ronda M (AREVA NP INC) [Ronda.Pederson@areva.com]
**Sent:** Thursday, April 23, 2009 5:54 PM
**To:** Getachew Tesfaye
**Cc:** BENNETT Kathy A (OFR) (AREVA NP INC); DELANO Karen V (AREVA NP INC); KOWALSKI David J (AREVA NP INC)
**Subject:** Response to U.S. EPR Design Certification Application RAI No. 83, FSAR Ch 10, Supplement 4
**Attachments:** RAI 83 Supplement 4 Response US EPR DC.pdf

Getachew,

AREVA NP Inc. provided responses to 12 of the 17 questions of RAI No. 83 on November 10, 2008. Supplement 1 response to RAI No. 83 was sent on December 29, 2008 to address 2 of the remaining questions. Supplement 2 response to RAI No. 83 was sent on January 8, 2009 to address 1 of the remaining questions. Supplement 3 response to RAI No. 83 was sent on February 20, 2009 to address the remaining 2 questions.

On April 8, 2009, AREVA NP apprised the NRC of an error in the Supplement 3 response regarding a seismic category 1 fire protection system. The response has been corrected to refer to the "fire water distribution system is designed to remain functional following a safe shutdown earthquake."

The attached file, "RAI 83 Supplement 4 Response US EPR DC.pdf" provides technically correct and complete responses to the subject 2 questions, as committed, and supersedes the submittal dated February 20, 2009, in its entirety.

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 83 Questions 10.04.09-5 and 10.04.09-9.

The following table indicates the respective pages in the response document, "RAI 83 Supplement 4 Response US EPR DC.pdf," that contain AREVA NP's response to the subject questions.

| Question # | Start Page | End Page |
|---|---|---|
| RAI 83 — 10.04.09-5 | 2 | 3 |
| RAI 83 — 10.04.09-9 | 4 | 4 |

This concludes the formal AREVA NP response to RAI 83, 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
Cell: 434-841-8788

**From:** Pederson Ronda M (AREVA NP INC)
**Sent:** Friday, February 20, 2009 4:02 PM
**To:** 'Getachew Tesfaye'
**Cc:** BENNETT Kathy A (OFR) (AREVA NP INC); DELANO Karen V (AREVA NP INC); KOWALSKI David J (AREVA NP INC)
**Subject:** Response to U.S. EPR Design Certification Application RAI No. 83, Supplement 3
Getachew,

AREVA NP Inc. (AREVA NP) provided responses to 12 of the 17 questions of RAI No. 83 on November 10, 2008. AREVA NP submitted Supplement 1 on December 29, 2008 to address 2 of the remaining questions. AREVA NP submitted Supplement 2 on January 8, 2009 to address 1 of the remaining questions.

The attached file, "RAI 83 Supplement 3 Response US EPR DC.pdf" provides technically correct and complete responses to the remaining 2 questions, as committed.

Appended to this file are affected pages of the U.S. EPR Final Safety Analysis Report in redline-strikeout format which supports the response to RAI 83 Questions 10.04.09-5 and 10.04.09-9.

The following table indicates the respective pages in the response document, "RAI 83 Supplement 3 Response US EPR DC.pdf," that contain AREVA NP's response to the subject questions.

| Question # | Start Page | End Page |
|---|---|---|
| RAI 83 — 10.04.09-5 | 2 | 3 |
| RAI 83 — 10.04.09-9 | 4 | 4 |

This concludes the formal AREVA NP response to RAI 83, 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
Cell: 434-841-8788


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**From:** Pederson Ronda M (AREVA NP INC)
**Sent:** Thursday, January 08, 2009 6:04 PM
**To:** 'Getachew Tesfaye'
**Cc:** BENNETT Kathy A (OFR) (AREVA US); DELANO Karen V (AREVA NP INC); VAN NOY Mark (EXT); KOWALSKI David J (AREVA NP INC)
**Subject:** Response to U.S. EPR Design Certification Application RAI No. 83, FSAR Ch 10, Supplement 2

Getachew,

AREVA NP Inc. provided responses to 12 of the 17 questions of RAI No. 83 on November 10, 2008. Supplement 1 response to RAI No. 83 was sent on December 29, 2008 to address 2 of the remaining 5 questions. The attached file, "RAI 83 Supplement 2 Response US EPR DC.pdf" provides technically correct and complete responses to 1 of the remaining 3 questions, as committed.

The following table indicates the respective pages in the response document, “RAI 83 Supplement 2 Response US EPR DC.pdf,” that contain AREVA NP’s response to the subject questions.

| Question # | Start Page | End Page |
|---|---|---|
| RAI 83 — 10.04.07-2 | 2 | 2 |

The schedule for technically correct and complete responses to the remaining 2 questions is unchanged and provided below:

| Question # | Response Date |
|---|---|
| RAI 83 — 10.04.09-5 | February 20, 2009 |
| RAI 83 — 10.04.09-9 | February 20, 2009 |

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
Cell: 434-841-8788

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**From:** WELLS Russell D (AREVA NP INC)
**Sent:** Monday, December 29, 2008 1:53 PM
**To:** 'Getachew Tesfaye'
**Cc:** 'John Rycyna'; Pederson Ronda M (AREVA NP INC); BENNETT Kathy A (OFR) (AREVA NP INC); DELANO Karen V (AREVA NP INC)
**Subject:** Response to U.S. EPR Design Certification Application RAI No. 83, FSAR Ch 10, Supplement 1

Getachew,

AREVA NP Inc. (AREVA NP) provided responses to 12 of the 17 questions of RAI No. 83 on November 10, 2008. The attached file, “RAI 83 Supplement 1 Response US EPR DC.pdf” provides technically correct and complete responses to 2 of the remaining 5 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 83 Supplement 1 Questions 10.04.09-1 and 10.04.09-10.

The following table indicates the respective pages in the response document, “RAI 83 Supplement 1 Response US EPR DC.pdf” that contain AREVA NP’s response to the subject questions.

| Question # | Start Page | End Page |
|---|---|---|
| RAI 83 — 10.04.09-1 | 2 | 3 |
| RAI 83 — 10.04.09-10 | 4 | 4 |

The schedule for technically correct and complete responses to the remaining 3 questions is unchanged and is provided below:

| Question # | Response Date |
|---|---|
| RAI 83 — 10.04.09-5 | February 20, 2009 |
| RAI 83 — 10.04.09-9 | February 20, 2009 |
| RAI 83 — 10.04.07-2 | January 9, 2009 |

Sincerely,

(Russ Wells on behalf of)
*Ronda Pederson*
ronda.pederson@areva.com
Licensing Manager, U.S. EPR Design Certification
New Plants Deployment
**AREVA NP, Inc.**
An AREVA and Siemens company
3315 Old Forest Road
Lynchburg, VA 24506-0935
Phone: 434-832-3694
Cell: 434-841-8788

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**From:** WELLS Russell D (AREVA NP INC)
**Sent:** Monday, November 10, 2008 5:03 PM
**To:** 'Getachew Tesfaye'
**Cc:** 'John Rycyna'; Pederson Ronda M (AREVA NP INC); BENNETT Kathy A (OFR) (AREVA NP INC); DELANO Karen V (AREVA NP INC)
**Subject:** Response to U.S. EPR Design Certification Application RAI No. 83, FSAR Ch 10

Getachew,

Attached please find AREVA NP Inc.'s response to the subject request for additional information (RAI). The attached file, "RAI 83 Response US EPR DC.pdf" provides technically correct and complete responses to 12 of the 17 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 83 Questions 10.04.09-2, 10.04.09-3, 10.04.09-6, 10.04.09-7, 10.04.09-8, 10.04.09-11, 10.04.07-1, 10.04.07-3, 10.04.05-1, 10.04.02-1 and 10.04.01-1.

The following table indicates the respective pages in the response document, "RAI 83 Response US EPR DC.pdf," that contain AREVA NP's response to the subject questions.

| Question # | Start Page | End Page |
|---|---|---|
| RAI 83 — 10.04.09-1 | 2 | 2 |
| RAI 83 — 10.04.09-2 | 3 | 3 |
| RAI 83 — 10.04.09-3 | 4 | 5 |
| RAI 83 — 10.04.09-4 | 6 | 8 |
| RAI 83 — 10.04.09-5 | 9 | 9 |
| RAI 83 — 10.04.09-6 | 10 | 10 |
| RAI 83 — 10.04.09-7 | 11 | 11 |
| RAI 83 — 10.04.09-8 | 12 | 12 |
| RAI 83 — 10.04.09-9 | 13 | 13 |
| RAI 83 — 10.04.09-10 | 14 | 14 |

| | | |
|---|---|---|
| RAI 83 — 10.04.09-11 | 15 | 15 |
| RAI 83 — 10.04.07-1 | 16 | 16 |
| RAI 83 — 10.04.07-2 | 17 | 17 |
| RAI 83 — 10.04.07-3 | 18 | 19 |
| RAI 83 — 10.04.05-1 | 20 | 21 |
| RAI 83 — 10.04.02-1 | 22 | 23 |
| RAI 83 — 10.04.01-1 | 24 | 24 |

A complete answer is not provided for 5 of the 17 questions. The schedule for a technically correct and complete response to these questions is provided below.

| Question # | Response Date |
|---|---|
| RAI 83 — 10.04.09-1 | December 31, 2008 |
| RAI 83 — 10.04.09-5 | February 20, 2009 |
| RAI 83 — 10.04.09-9 | February 20, 2009 |
| RAI 83 — 10.04.09-10 | December 31, 2008 |
| RAI 83 — 10.04.07-2 | January 9, 2009 |

Sincerely,

(Russ Wells on behalf of)

*Ronda Pederson*
ronda.pederson@areva.com
Licensing Manager, U.S. EPR Design Certification
New Plants Deployment
**AREVA NP, Inc.**
An AREVA and Siemens company
3315 Old Forest Road
Lynchburg, VA 24506-0935
Phone: 434-832-3694
Cell: 434-841-8788

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**From:** Getachew Tesfaye [mailto:Getachew.Tesfaye@nrc.gov]
**Sent:** Thursday, October 09, 2008 3:36 PM
**To:** ZZ-DL-A-USEPR-DL
**Cc:** Angelo Stubbs; Devender Reddy; John Segala; Peter Hearn; Joseph Colaccino; John Rycyna
**Subject:** U.S. EPR Design Certification Application RAI No. 83(1230,1132,1233,1234,976), FSAR Ch 10

Attached please find the subject requests for additional information (RAI). A draft of the RAI was provided to you on September 16, 2008, and on October 7, 2008, 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. 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:** 426

**Mail Envelope Properties** (5CEC4184E98FFE49A383961FAD402D31D9ACDA)

**Subject:** Response to U.S. EPR Design Certification Application RAI No. 83, FSAR Ch 10, Supplement 4
**Sent Date:** 4/23/2009 5:53:37 PM
**Received Date:** 4/23/2009 5:53:41 PM
**From:** Pederson Ronda M (AREVA NP INC)

**Created By:** Ronda.Pederson@areva.com

**Recipients:**
"BENNETT Kathy A (OFR) (AREVA NP INC)" <Kathy.Bennett@areva.com>
Tracking Status: None
"DELANO Karen V (AREVA NP INC)" <Karen.Delano@areva.com>
Tracking Status: None
"KOWALSKI David J (AREVA NP INC)" <David.Kowalski@areva.com>
Tracking Status: None
"Getachew Tesfaye" <Getachew.Tesfaye@nrc.gov>
Tracking Status: None

**Post Office:** AUSLYNCMX02.adom.ad.corp

| **Files** | **Size** | **Date & Time** |
|---|---|---|
| MESSAGE | 10735 | 4/23/2009 5:53:41 PM |
| RAI 83 Supplement 4 Response US EPR DC.pdf | | 384642 |

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

**Response to**

**Request for Additional Information No. 83 Supplement 4**
**(1230,1132,1233,1234,976)**

**10/9/2008**

**U. S. EPR Standard Design Certification**
**AREVA NP Inc.**
**Docket No. 52-020**
**SRP Section: 10.04.09 - Auxiliary Feedwater System (PWR)**
**SRP Section: 10.04.07 - Condensate and Feedwater System**
**SRP Section: 10.04.05 - Circulating Water System**
**SRP Section: 10.04.02 - Main Condenser Evacuation System**
**SRP Section: 10.04.01 - Main Condensers**
**Application Section: FSAR Ch. 10**
**SBPA Branch**

**Question 10.04.09-5:**

In FSAR Section 10.4.9.3, the minimum required water inventory for the bounding cases with or without offsite power is given as less than $1.14 \times 10^6$ L (300,000 gallons). The applicant states that this inventory is sufficient to remove heat over the entire range of reactor operation and cool the plant to the residual heat removal (RHR) system cut-in temperature assuming a single active failure with a loss of offsite power. During its review the staff was unable to find sufficient information for the basis to calculate the required water inventory necessary for cooldown. Provide in the FSAR the basis for using the $1.14 \times 10^6$ L (300,000 gallons) as the minimum required water volume to be able to provide a sufficient supply of water to the steam generators under all conditions.

**Response to Question 10.04.09-5:**

The analyses performed to determine the bounding Branch Technical Position (BTP) 5-4 cooldown and the minimum required emergency feedwater (EFW) water inventory (300,000 gallons) were based on natural circulation cases where all four steam generators (SG) were fed. These analyses were shown to be bounding due to the water required to return the SGs to normal level.

It has since been determined that scenarios including a single failure that results in an unfed SG are more limiting. While the original analyses considered head voiding during a natural circulation cooldown, the impact on depressurization created by the flashing of the water in the stagnant RCS loop piping and surges in pressurizer level, for SGs not fed by the emergency feedwater system (EFWS), was not modeled. During a review of industry operating experience, it was identified that relative to the thermal hydraulic effects of stagnant loops, a slower cooldown and depressurization were needed to provide acceptable pressurizer conditions; and also required the EFWS water inventory to be significantly increased. Similarly, it was determined that the presence of a stagnant reactor coolant system (RCS) loop affects the U.S. EPR cooldown analyses and required EFW inventory.

The following two additional analysis cases were performed for BTP 5-4 scenarios resulting in conditions similar to those described above:

- Case 1 considered the failure of an EFW level control valve (LCV) in the closed position which results in the inability to feed that SG. A cooldown rate of 25 degrees/hour and a core exit subcooling margin of 50 degrees were used to control the pressurizer level surges during depressurization. The required EFWS inventory for this case is approximately 365,000 gallons.

- Case 2 considered a failed main steam relief control valve (MSRCV) in the closed position assuming the main steam isolation valves (MSIV) are closed. This case also results in a stagnant RCS loop, in addition to the inability to cool or depressurize the SG with the failed MSRCV. Analysis results are improved if the cooling and depressurization of the hot SG is initiated at the start of the RCS cooldown allowing the four SGs to be fed and steamed. The operationally preferred method to cool and depressurize the SG is to credit the non-safety passive main steam (MS) piping and use the 22 inch turbine bypass lines and 40 inch turbine bypass header to cross-tie the MS lines which allows use of the other main steam relief trains (MSRT). In the unlikely event there is a break in the downstream MS piping, the MSIVs would be closed and the cooldown and depressurization of the SG controlled by using the 6 inch safety-related MSIV warm-up/bypass valves. This capability, if needed, fulfils BTP 5-4 requirements. The required EFW water inventory to support this 50 degrees/hour cooldown is approximately 300,000 gallons.

The non-safety demineralized water distribution system, with more than 260,000 gallons of water available, provides the normal make-up supply for the EFW storage pools. If needed, the fire water distribution system (FWDS) can be used to provide approximately 280,000 gallons of additional make-up water to the EFW storage pools from standpipes located in each Safeguard Building. The FWDS is designed to remain functional following a safe shutdown earthquake.

As a result of performing new cooldown analyses, the following changes were made to the U.S. EPR FSAR:

- U.S. EPR FSAR Tier 2, Section 5.4.7.3.3 has been revised to include a description of the new cooldown analyses. This included the addition of six new figures, U.S. EPR FSAR Tier 2, Figure 5.4-13 through Figure 5.4-18.

- U.S. EPR FSAR Tier 2, Section 10.4.9.3 has been revised to remove the existing description of cooldown details, describe the exception to BTP 5-4 functional requirements and capabilities provided for make-up to the EFW storage pools, and reference U.S. EPR FSAR Tier 2, Section 5.4.7.3.3 for a description of the bounding BTP 5-4 cooldown analyses. U.S. EPR FSAR Tier 2, Table 10.4.9-2—Emergency Feedwater System Failure Analysis has been revised to reflect the above noted changes.

- U.S. EPR FSAR Tier 2, Section 15.0.4 has been revised to remove the existing description of cooldown details and analytical results, limit the details to Chapter 15 events, provide clarification of cooldown following Chapter 15 events, and reference U.S. EPR FSAR Tier 2, Section 5.4.7.3.3 for a description of the bounding BTP 5-4 cooldown analyses. This included the deletion of existing U.S. EPR FSAR Tier 2, Figure 15.0-13 through Figure 15.0-18.

- U.S. EPR FSAR Tier 1, Table 2.2.4-3—EFWS ITAAC Item 7.3 has been revised to reflect the change in the minimum required EFW storage pool volume to 365,000 gallons.

**FSAR Impact:**

U.S. EPR FSAR Tier 2, Section 5.4.7.3.3, Section 10.4.9.3, Table 10.4.9-2, Section 15.0.4, and U.S. EPR FSAR Tier 1, Table 2.2.4-3 will be revised as described in the response and indicated on the enclosed markup.

**Question 10.04.09-9:**

The storage pool design function is to provide a water source to the EFW pumps. The applicable EFW Storage Pools' LCO is provided in Tier 2 Section 16; LCO 3.7.6. The LCO includes two action levels for the following conditions:

1) One EFW Storage Pool inoperable (Immediately verify usable volume in three remaining pools ≥ 300,000 gallons, and declare associated EFW train inoperable). In its review the staff noticed that all of the storage pool suction sources are aligned to a common header.

   The staff requests the applicant to explain in the FSAR the methodology used to determine the specific EFW train, which is connected to a common header, associated with the inoperable storage pool .

2) Two or more EFW storage pools inoperable, or usable volume in EFW SPs < 300,000 gallons (be in Mode 3 in 6 hours and Mode 4 in 24 hours without reliance on SGs for heat removal).

If there is not sufficient storage pool volume available in MODE 1, 2, or 3, the unit is in a seriously degraded condition with no safety related means for conducting a cooldown. In such a condition, the unit should not be perturbed by any action, including a power change that might result in a trip. The seriousness of this condition should require action similar to what is required for EFW System LCO 3.7.5.D.1. That is, the OPERABLE status of the storage pool should be restored immediately. The staff requests the applicant to provide in the FSAR a justification/basis for action specified for this LCO.

**Response to Question 10.04.09-9:**

As described in the Response to Question 10.04.09-5, the required emergency feedwater (EFW) storage pool inventory has been increased to 365,000 gallons. As a result, all four EFW storage pools are required to be operable.

U.S. EPR FSAR Tier 2, Chapter 16, Technical Specifications, Limiting Condition for Operation (LCO) 3.7.6, Surveillance Requirement (SR) 3.7.6.1, and Technical Specifications Bases 3.7.6 will be revised to include this increase in the EFW storage pool inventory and reflect the bounding Branch Technical Position (BTP) 5-4 natural circulation cooldown that provides the basis for the required EFW storage pool inventory. The revised LCO 3.7.6 more closely follows the required actions in the Standard Technical Specifications for Westinghouse Plants (NUREG-1431).

**FSAR Impact:**

U.S. EPR FSAR Tier 2, Chapter 16, Technical Specifications Section 3.7.6 will be revised as described in the response and indicated on the enclosed markup.

# U.S. EPR Final Safety Analysis Report Markups

letdown line, while the steam generators levels are controlled by the startup and shutdown system.

In the analysis performed, two RCPs are tripped when the RCS temperature decreases to 250°F, another RCP is tripped when the RCS temperature decreases to 158°F, and the last RCP is tripped when the RCS temperature decreases to 122°F.

Two trains of the SIS/RHRS are normally placed in service for residual heat removal when the RCS pressure and temperature decreases below approximately 390 psia and 250°F. The remaining two trains are placed in service after the RCS temperature has been further reduced to approximately 212°F.

Performance curve showing the calculated cooldown rates for four trains operation is shown in Figure 5.4-3—RCS Cooldown for Four Train SIS/RHRS Shutdown Cooling Operation From Figure 5.4-3, the time required to cool the plant down to approximately 250°F is around 7.3 hours after reactor trip, while the time required to cool the RCS temperature down to approximately 131°F (using all four LHSI heat exchangers in the sequence explained) is another 7.7 hours. The total time to cool the plant down to 131°F (for refueling) is approximately 15 hours after reactor trip. This total time attained is much shorter than the required time of 40 hours, as specified in Section 5.4.7.1.

### 5.4.7.3.2 Performance Evaluation Assuming the Most Limiting Single Failure and Offsite Power Available

For the most limiting single failure scenario, two SIS/RHRS trains are available to remove residual heat, assuming one train is unavailable due to system maintenance and a second train is lost due to the single failure. Offsite power is available; therefore, all auxiliary functions described in Section 5.4.7.3.1 to bring the reactor down to SIS/RHRS connection conditions are available.

Performance curve showing the most limiting single failure and offsite power available is shown in Figure 5.4-4—RCS Cooldown for Two Train SIS/RHRS Shutdown Cooling Operation (with Offsite Power Available). In Figure 5.4-4, two RHR trains (with full flow through the LHSI HXs) are able to cool the plant down from approximately 250°F to 200°F in around ~~10~~2.7 hours. This cooldown time is achieved with the normal RCP shutdown sequence explained in Section 5.4.7.3.1.

10.04.09-5

### 5.4.7.3.3 Performance Evaluation Assuming the Most Limiting Single Failure and Only Onsite Power Available (Bounding Branch Technical Position 5-4 Cooldown)

System(s) that can be used for heat removal, including depressurization, flow circulation, and reactivity control to take the reactor from normal operating

10.04.09-5

conditions to cold shutdown should satisfy the general functional requirements of Branch Technical Position (BTP) 5-4.

The U.S. EPR meets the requirements of BTP 5-4 with the following exception:

> Cases where an EFW pump is unavailable due to single failure or maintenance, action outside of the control room may be required to re-align the manual supply header valves to provide access to the inventory from all four storage pools. Sufficient water inventory is available for six to eight hours of EFWS operation before this action is necessary.

### 5.4.7.3.3.1 Cooldown Analyses

Cooldown analyses were performed using the RELAP5 computer code for several single failure scenarios with and without offsite power available. The bounding case, with respect to EFWS inventory usage, is a natural circulation cooldown following the loss of offsite power with a failed closed EFW SG level control valve (LCV). This failure results in an unfed SG and associated stagnant RCS loop. The stagnant RCS loop conditions require a slow and controlled cooldown and depressurization to SIS/RHR entry conditions.

### 5.4.7.3.3.2 Cooldown Scenario

For the most limiting single failure scenario, with only onsite power available, the cooldown to cold shutdown condition is achieved with use of only safety-related equipment. The LOOP results in immediate RCP coastdown and termination of the main feedwater supply. Cooldown prior to SIS/RHRS connection is achieved by natural circulation using the main steam relief trains (MSRT), while the steam generators levels are controlled by the emergency feedwater (EFW) system; the EFW system begins operation once the EFW pumps are automatically loaded onto the emergency diesel generators. During cooldown, boron concentration is adjusted as necessary through the use of the extra borating system (EBS). RCS make-up is accomplished by using the medium head safety injection (MHSI) pumps taking suction from the IRWST and by EBS injection flow from the EBS tanks.

The following provides the detailed scenario:

- Reactor and turbine are tripped at 2000 seconds.
- MSRT trains are available all the time.
- EFW Trains 1, 2 and 3 are available all the time. EFW LCV on Train 4 fails closed at the beginning of the transient and stays closed for the duration of the transient. SG 4 has no EFW flow during the transient; however, it can be steamed via its MSRT.

10.04.09-5

- Reactor Coolant Pumps (RCPs) are tripped at the beginning of the transient and stay tripped for the rest of the transient.
- Pressurizer (PZR) heaters, normal spray, and auxiliary spray systems are not available during the transient.
- PZR makeup/letdown system is not available during the transient. PZR makeup can be performed using the medium head safety injection (MHSI) system and two trains of extra borating system (EBS).
- Turbine bypass system (TBS) is not available and stays closed during the transient.
- Main feedwater (MFW) system trains are not available during the transient.
- MSIVs stay closed during the transient.
- Cooldown is initiated at 17,000 seconds or 15,000 seconds (4.17 hours) after reactor trip (RT). This allows the RCS to remain at the hot standby condition for more than four hours. The cooldown rate is 25°F/hr.
- During cooldown, the RCS pressure is manually controlled by the operator through the safety-related PZR safety relief valve (PSRV). A minimum core exit subcooled margin of 50°F is maintained.
- SIS/RHR entry conditions are achieved when the hot leg fluid temperatures at each non-stagnant loop and the saturation temperature at the stagnant loop is equal to or less than 350°F, which is the highest allowed for connection of the SIS/RHRS to perform its residual heat removal function.
- The SIS/RHR system is then aligned and the RCS is cooled to cold shutdown conditions.

### 5.4.7.3.3.3 Cooldown Analysis Results

The analysis starts with a RT from hot full power condition, at which time a LOOP is assumed to occur and de-energize the RCPs. The plant is assumed to maintain hot standby conditions for the first 15,000 seconds, at which time the operator initiates a RCS cooldown.

RCS pressure increases after RT and turbine trip as SG secondary pressure increases to the MSRT setpoint. Shortly afterwards, the pressure stabilizes at hot standby conditions. The pressure then drops after about 30 minutes when EFW is actuated on low SG level followed by an increase and then stabilizes. At approximately 5,000 seconds, SGs 1, 2, and 3 are returned to normal level and EFW level control becomes active, except for SG 4 which has boiled dry.

At 15,000 seconds, a 25°F/hr cooldown is initiated using the MSRTs to reduce secondary side pressure and the PSRV is manually cycled to decrease RCS pressure while maintaining the core exit subcooling margin between 50 and 75°F.

When the RCS pressure is decreased to the saturation pressure of the hot water in the stagnant RCS loop, some surging of pressurizer level occurs; however, the level stays within scale and there is no discharge of liquid water from the PSRV.

SIS/RHR operation entry conditions are met when primary temperature is below 350°F and primary pressure is below 400 psia at about 62,400 seconds after RT, or 47,400 seconds after the initiation of the cooldown. Curves showing pertinent information for the cooldown to RHR entry conditions information are provided in Figures 5.4-13 through 5.4-18.

Figure 5.4-5—RCS Cooldown for Two Train SIS/RHRS Shutdown Cooling Operation (with Only Onsite Power Available) conservatively shows the cooldown time for an SIS/RHRS connection at a much earlier entry time of between approximately three to five hours. The cooldown time, with full flow through the LHSI heat exchangers, from approximately 350°F to 200°F (cold shutdown condition) is around three hours.

### 5.4.7.3.3.4 Conclusion

The cooldown analysis demonstrates that the plant can be cooled to cold shutdown conditions in a reasonable time following the BTP 5-4 functional requirements. The bounding EFW water inventory required to reach SIS/RHR entry conditions is approximately 365,000 gallons.

Cold shutdown conditions are reached at approximately 20.3 hours after reactor trip.~~For the most limiting single failure scenario, with only onsite power available, the cooldown to cold shutdown condition is achieved with use of only safety-related equipment. The LOOP results in immediate RCP coastdown and termination of the main feedwater supply.~~

~~Cooldown prior to SIS/RHRS connection is achieved by natural circulation using the main steam relief trains (MSRT), while the steam generators levels are controlled by the emergency feedwater (EFW) system; the EFW system begins operation once the EFW pumps are automatically loaded onto the emergency diesel generators. During cooldown, boron concentration is adjusted as necessary through the use of the extra borating system (EBS). RCS make-up is accomplished by using the medium head safety injection (MHSI) pumps taking suction from the IRWST and by EBS injection flow from the EBS tanks.~~

~~In the cooldown phase prior to SIS/RHRS connection, analyses are performed where the RCS cooldown rate is limited to both 50°F/hr (refer to Section 10.4.9.3) and 90°F/hr~~

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~~(refer to Section ). The primary pressure is manually controlled by the operator through the pressurizer safety relief valves during the transient.~~

~~Based on the cooldown rate specified, the total time to cool the reactor using natural circulation from reactor trip to SIS/RHRS connection temperature of below 356°F is between approximately 7 to 10 hours. The RCS temperature of 356°F is the highest allowed for connection of the SIS/RHRS to perform its residual heat removal function.~~

~~Figure 5.4-5—RCS Cooldown for Two Train SIS/RHRS Shutdown Cooling Operation (with Only Onsite Power Available) conservatively shows the cooldown time for an SIS/RHRS connection at a much earlier entry time of between approximately 3 to 5 hours. The cooldown time, with full flow through the LHSI HXs, from approximately 356°F to 200°F (cold shutdown condition) is around 3 hours.~~

### 5.4.7.4 Inspection and Testing Requirements

Refer to Section 14.2 (Test #016, Test #017 and Test #161) for initial plant testing.

The installation and design of the SIS/RHRS provides accessibility for periodic testing and in-service inspection. Section 3.9.6, Section 5.2.4 and Section 6.6 address the preservice and in-service testing and inspection programs for the SIS/RHRS.

### 5.4.7.5 Instrumentation Requirements

Controls for the major electrical equipment that is required to establish and initiate, control and terminate the shutdown cooling function of the SIS/RHRS are available in the MCR. Indications required for operation of the shutdown cooling function of the SIS/RHRS, such as flow, pressure, and temperature, are displayed in the MCR.

Automatic protection (shutdown or isolation) of the affected SIS/RHRS train or equipment occurs, unless an initiation signal from the protection system (indicating accident conditions) is present, in the event of such adverse conditions as a break in an RHR train outside containment, or low loop level or low delta-$P_{sat}$ during RHR. Operator intervention to protect the affected SIS/RHRS equipment is required in the event that alarms indicate unacceptable parameters such as high bearing oil, motor winding, or motor air temperatures. These indications are available in the MCR.

No automatic features other than parametric range controls, such as temperature dependent HX bypass flow control, and equipment protection interlocks, such as the low suction pressure trip for the LHSI pumps, are incorporated for operation of the shutdown cooling function for the SIS/RHRS. The shutdown cooling function of the SIS/RHRS must be initiated and terminated by deliberate manual action. Operation of the SIS/RHRS is performed from the MCR for all operating conditions. Refer to Section 6.3 for details of the automatic and manual actions associated with the LHSI function of the SIS/RHRS.

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Figure 5.4-13—Core Exit Temperature

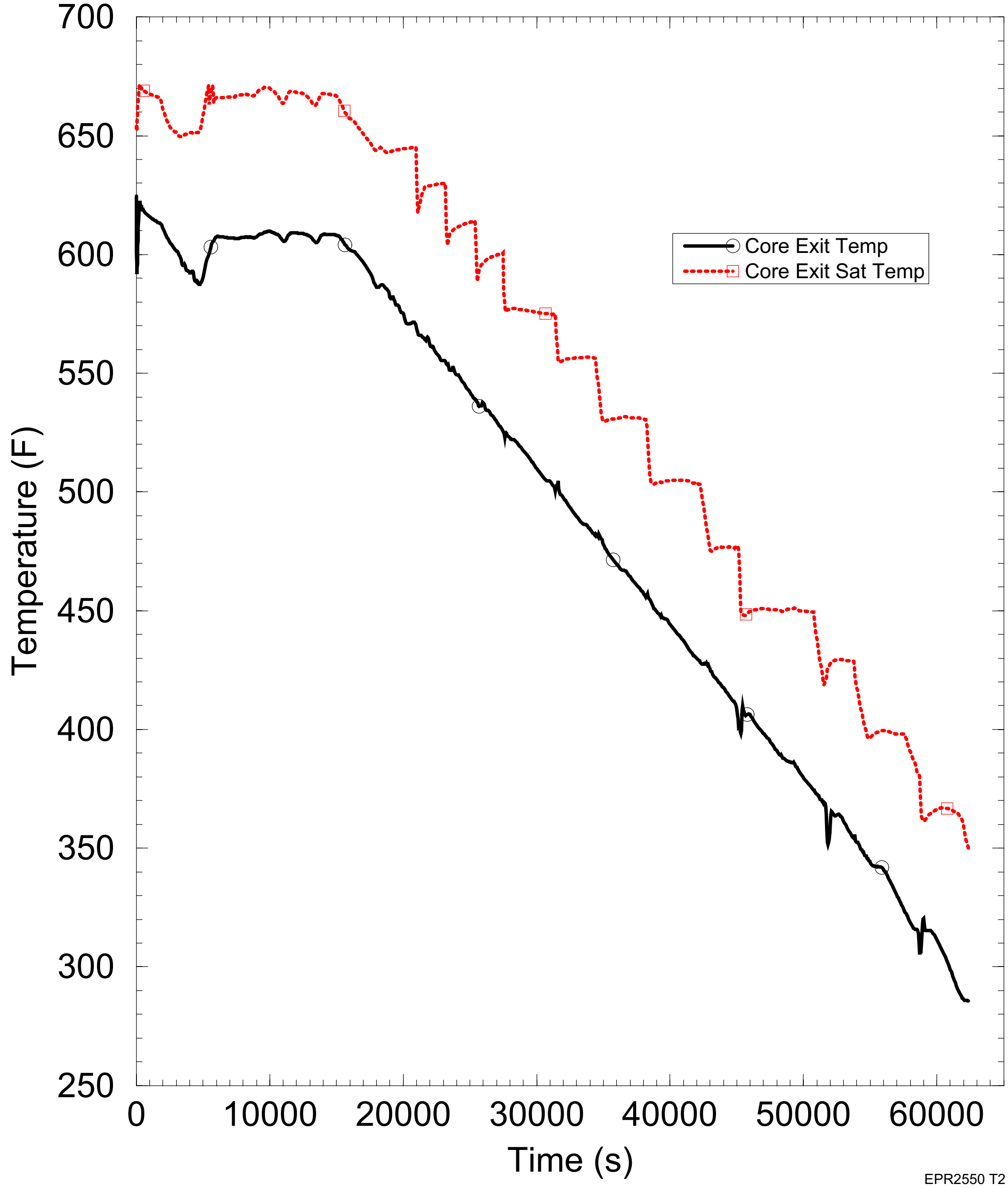

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**Figure 5.4-14—EFW Usage**

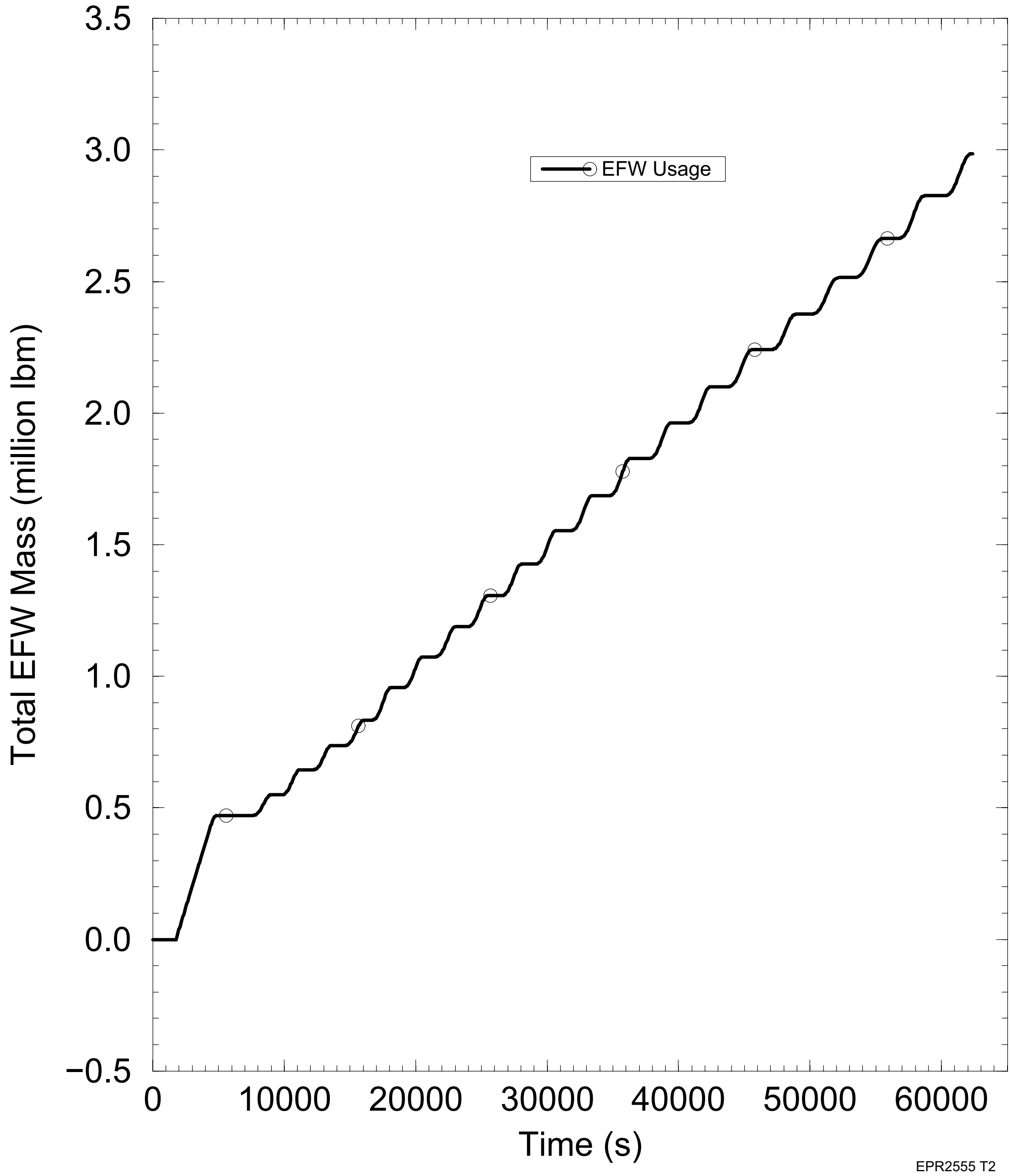

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Figure 5.4-15—Primary Temperatures

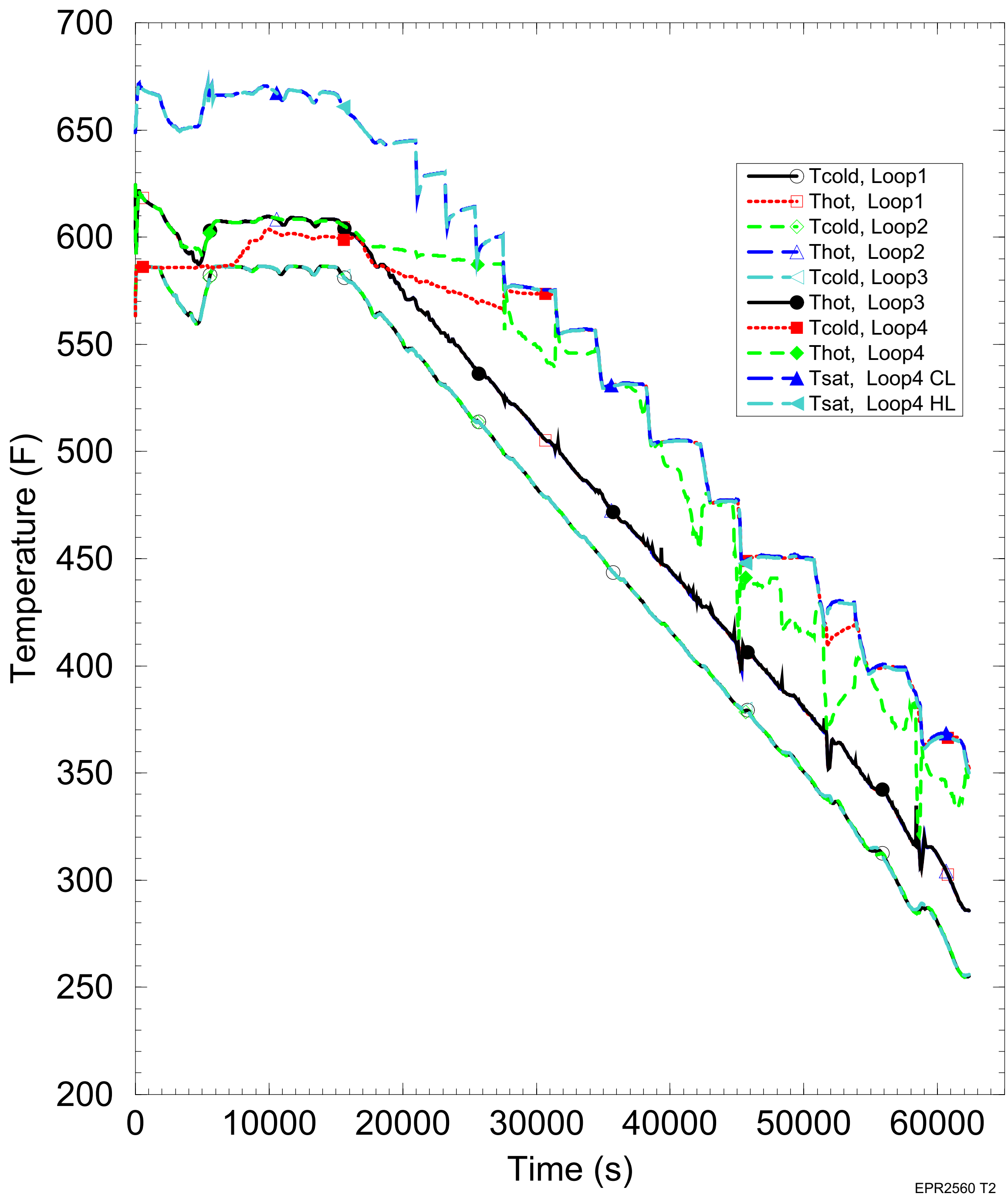

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**Figure 5.4-16—Pressurizer Level**

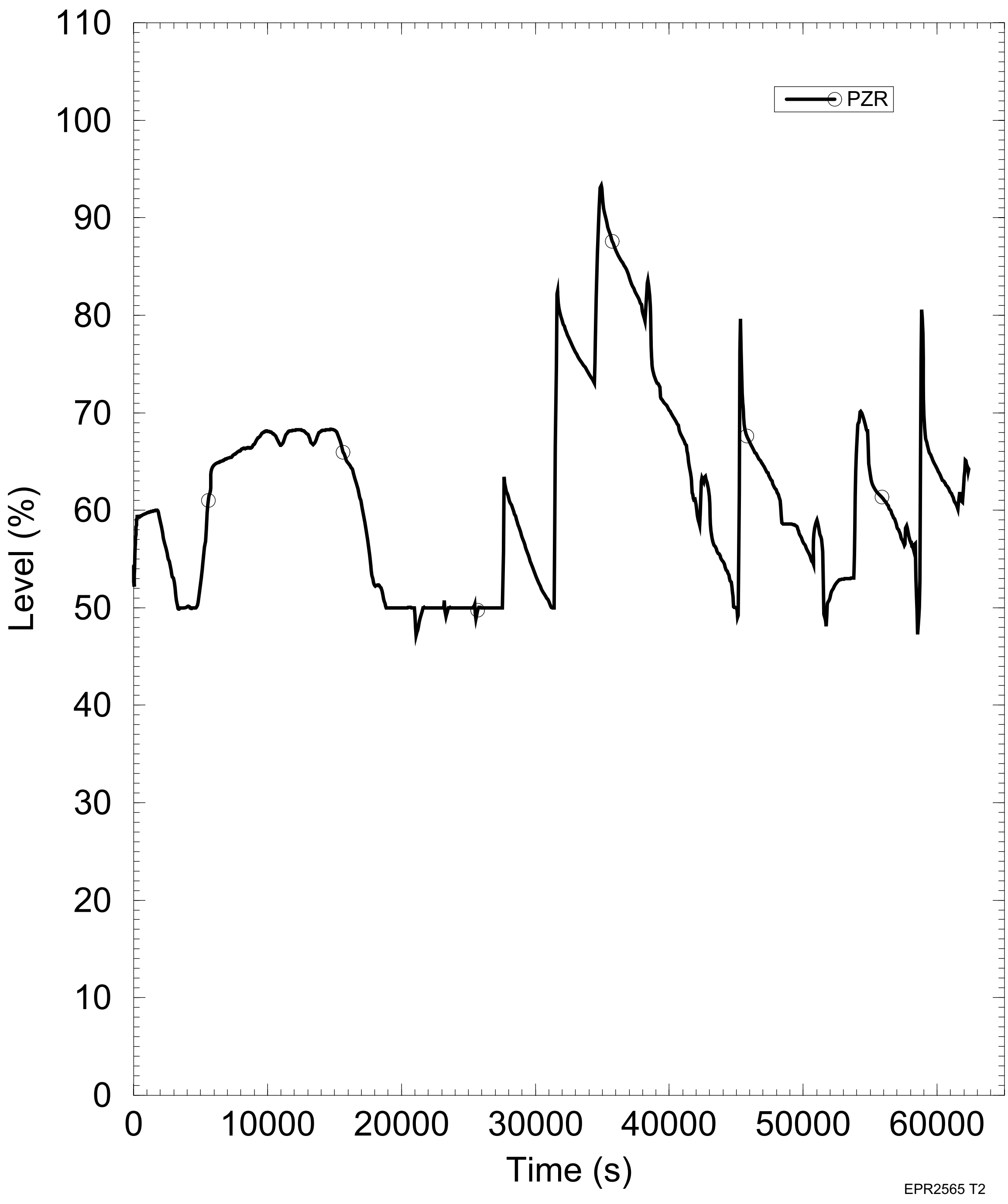

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**Figure 5.4-17—RCS Pressures**

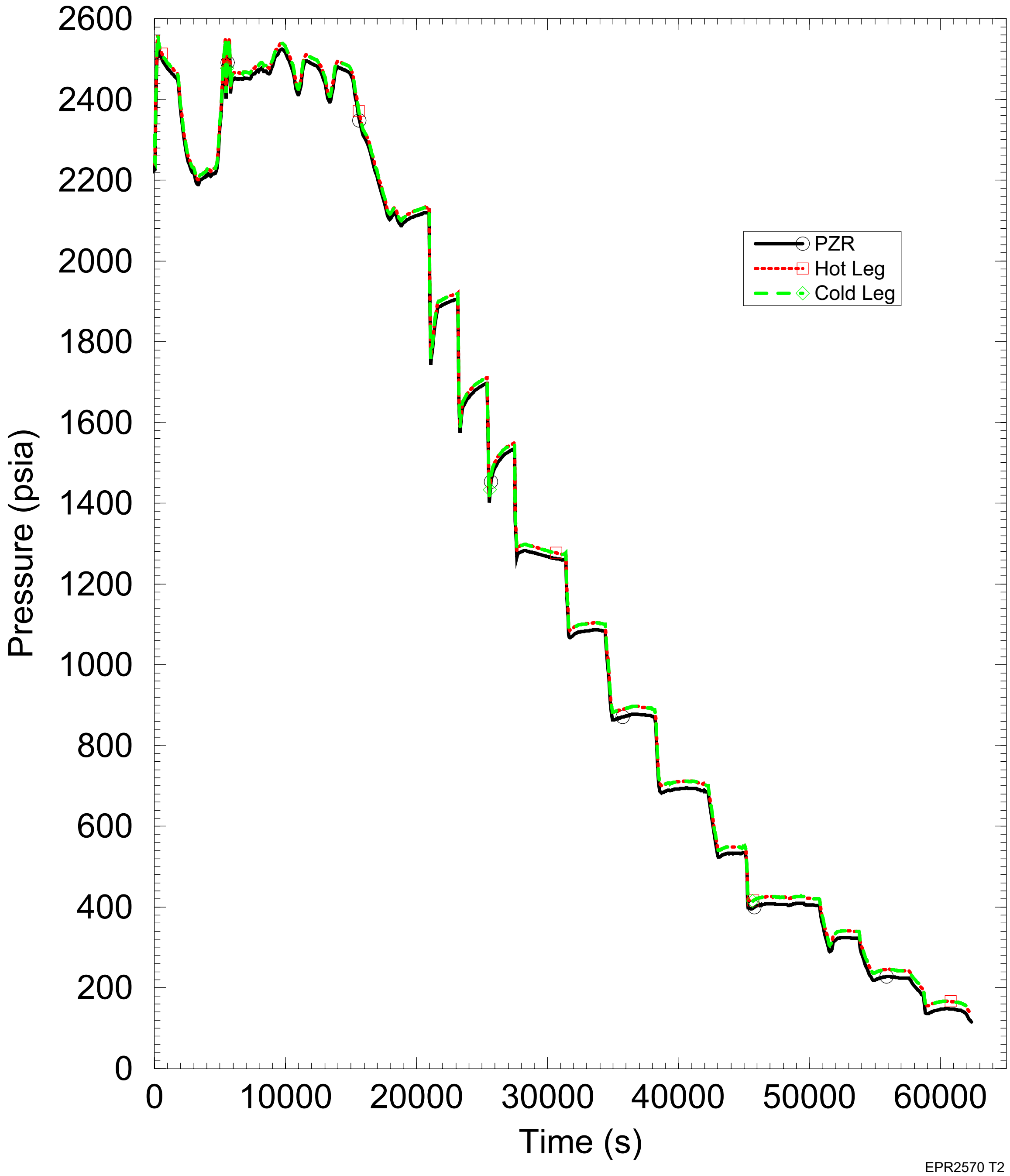

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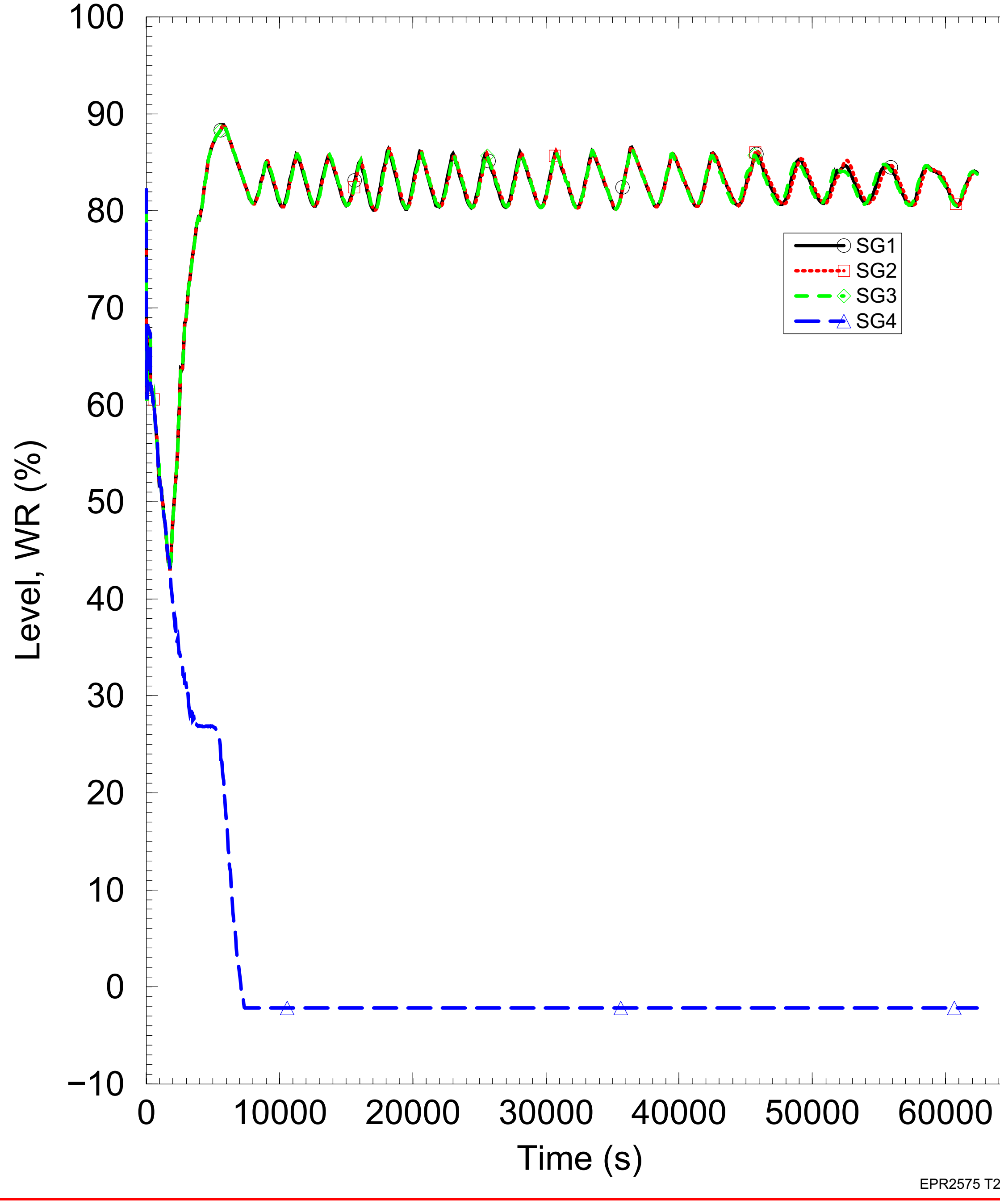
**Figure 5.4-18—SG Levels**



100,000 lbm of Hypalon jacket and 4000 lbm of PVC cable jacketing. The $H^+$ time history is provided in Table 15.0-55—$H^+$ Added to IRWST and the mass of TSP versus pH is provided in Table 15.0-56—Mass of TSP vs. pH at 30 Days.

### 15.0.3.13 Control Room Radiological Habitability

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The MCR and TSC radiological habitability evaluation is included in Section 15.0.3.11.

## 15.0.4 Plant Cooldown

### 15.0.4.1 Post Chapter 15 Events Cooldown

The analysis of Chapter 15 events are generally terminated when the plant achieves a stable, controlled condition (i.e., the reactor is subcritical and remains subcritical, the core is covered, decay heat is being removed from the RCS, and secondary inventory levels are sufficient to maintain RCS temperatures). Subsequent actions, including cooldown, will be addressed in plant specific Emergency Operating Procedures (EOPs). ~~Events are analyzed until the plant achieves a stable, controlled condition, i.e., the reactor is subcritical and remains subcritical, the core is covered, decay heat is being removed from the RCS and secondary inventory levels are sufficient to maintain RCS temperatures. The U.S. EPR is designed to achieve cold shutdown, RHR entry, using only safety-related equipment. This section presents the results of an analysis demonstrating that RHR entry conditions can be achieved in a timely manner using only safety-related equipment.~~

### ~~15.0.4.2 Analysis~~

~~The majority of Chapter 15 non-LOCA events result in an RT. The specific initiator for RT does not have a significant impact on the long term cooling analysis. Two cases are presented to demonstrate that the plant can be cooled down to RHR entry point after these events.~~

#### ~~15.0.4.1.1 Case 1 Scenario~~

~~Case 1 demonstrates the postaccident cooldown from hot full power (HFP) conditions with the use of the RCPs. The analysis includes the following assumptions:~~

- ~~Reactor and turbine are tripped at time zero.~~
- ~~MSRTs 1 and 2 are available. MSRTs 3 and 4 are not available.~~
- ~~EFW trains 1, 2, and 3 are available. EFW train 4 is not available during the transient. All EFW discharge header valves are open during the transient enabling EFW trains 1, 2, and 3 to feed all four SGs.~~
- ~~All four RCPs are operating during the transient.~~

- The PZR heaters, normal spray, and auxiliary spray systems are not available.
- RCS pressure is controlled manually by operator using the PZR safety valve (PSRV).
- CVCS is not available. PZR makeup is accomplished using MHSI system and two trains of EBS.
- Turbine bypass is not available and remains closed.
- MFW is unavailable during the transient because it is a non-safety-related system.
- The cooldown is initiated by the operator at 15,000 seconds (4.17 hours) after RT. This allows the RCS to remain at hot shutdown (HSD) for more than four hours (BTP 5-4 requirement, Reference 1). The SG cooldown rate is 90°F/hr.
- The transient ends when hot leg temperatures in all loops are at or below 340°F, which is less than the hot leg temperature requirement of 356°F for RHR entry.

**Results for Case 1**

The analysis starts with an RT from HFP condition. All 4 RCPs are assumed to remain in operation. The plant is assumed to maintain hot standby conditions for the first 15,000 seconds, at which time, the operator initiates an SG cooldown at 90°F/hr using the MSRTs to reduce secondary side pressure.

RCS pressure (Figure 15.0-13—Case 1—RCS Pressures) increases after RT and TT as SG secondary pressure increases to the MSRT setpoint. Shortly afterwards, the pressure stabilizes at hot standby conditions. In addition to starting the SG cooldown at 15,000 seconds, the operator begins manually cycling a PSRV to decrease RCS pressure while maintain subcooling margin in the RCS loops between 25°F and 50°F. The sudden drop in RCS pressure when the PSRV first is opened is due to the large initial subcooling margin of about 70°F. Afterwards, the pressure decreases are smaller with each PSRV cycle.

Figure 15.0-14—Case 1—SG Pressures shows the SG pressures during the transient. Turbine stop valves are closed at RT. Since the turbine bypass system is assumed not to be available, the SG pressures increase. MSRTs control the secondary side pressure to 1384.7 psia in SGs 1 and 2. MSRTs are assumed not to be operable in SGs 3 and 4. At 15,000 seconds, the operator initiates a 90°F/h cooldown using the MSRTs in SGs 1 and 2. Figure 15.0-15—Case 1—Primary Side Temperatures shows the primary side temperatures follow the secondary side.

The operator is able to enter RHR operation when primary temperature is below 356°F and primary pressure is below 400 psia at about 24,000 seconds, 9000 seconds after the initiation of the SG cooldown.

### 15.0.4.1.2 Case 2 Scenario

Case 2 is the same as Case 1 except that the RCPs are assumed not to be available after RT.

**Results for Case 2**

The analysis starts with an RT from HFP condition, at which time LOOP is assumed to occur and de-energize the RCPs. The plant is assumed to maintain hot standby conditions for the first 15,000 seconds, at which time the operator initiates an SG cooldown at 90°F/hr using the MSRTs to reduce secondary side pressure.

RCS pressure (see Figure 15.0-16—Case 2 - RCS Pressures) increases after RT and TT as SG secondary pressure increases to the MSRT setpoint. Shortly afterwards, the pressure stabilizes at hot standby conditions. The pressure then drops at about 30 minutes when EFW is actuated on low SG level. It continues to fluctuate as EFW cycles between low level and high level PS setpoints. In addition to starting the SG cooldown at 15,000 seconds, the operator begins manually cycling a PSRV to decrease RCS pressure while maintain subcooling margin in the RCS loops between 25°F and 50°F. As for Case 1, the sudden drop in RCS pressure when the PSRV first is opened is due to the large initial subcooling margin of about 70°F. Afterwards, the pressure decreases are smaller with each PSRV cycle.

Figure 15.0-17—Case 2 - SG Pressures shows the SG pressures during the transient. Turbine stop valves are closed at RT. Since the turbine bypass system is assumed not to be available, the SG pressures increase. MSRTs control the secondary side pressure to 1384.7 psia in SGs 1 and 2. MSRTs are assumed not to be operable in SGs 3 and 4. The drop in secondary pressure a few minutes later is due to the initiation of EFW on low SG level. At 15,000 seconds, the operator initiates a 90°F/h cooldown using the MSRTs in SGs 1 and 2. Figure 15.0-18—Case 2 - Primary Side Temperatures shows the primary side temperatures follow the secondary side.

The operator is able to enter RHR operation when primary temperature is below 356°F and primary pressure is below 400 psia at about 26,000 seconds, 11,000 seconds after the initiation of the SG cooldown.

### 15.0.4.2 Conclusion

The cooldown analyses demonstrate that the plant can be cooled to RHR entry conditions following postulated events using only safety-related equipment. The analyses also demonstrate that three of the four EFW pools provide adequate inventory of feedwater to achieve RHR entry following Chapter 15 events.

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~~Figure 15.0-13—Case 1 - RCS Pressures~~

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~~Figure 15.0-14—Case 1 - SG Pressures~~

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~~Figure 15.0-15—Case 1 - Primary Side Temperatures~~

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~~Figure 15.0-16—Case 2 - RCS Pressures~~

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~~Figure 15.0-17—Case 2 - SG Pressures~~

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~~Figure 15.0-18—Case 2 - Primary Side Temperatures~~

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single internal hazard. The EFWS components are located in the Safeguard Buildings (SBs) and the Reactor Building (RB). No piping has been identified which could result in internally generated missiles, pipe whip, or jet impingement forces that could impact operation of the EFWS. Refer to U.S. EPR FSAR Tier 2, Section 3.6.1 for information regarding the plant design for protection against postulated piping failures in fluid systems outside of containment.

- Each EFWS train, including the storage pools, is located within a Safeguard Building which is Seismic Category I and provides protection from external missiles. External missiles are addressed in U.S. EPR FSAR Tier 2, Section 3.5.

- EFWS components located within the Reactor Building are qualified for accident environmental conditions (radiation, temperature, pressure, and humidity). EFWS components located in the Safeguard Buildings are qualified for accident environmental radiation conditions. The Safeguard Building heating, ventilation and air conditioning (HVAC) system maintains acceptable environmental conditions for operation of the active EFWS equipment. Refer to U.S. EPR FSAR Tier 2, Section 3.11 for equipment qualification.

The design of the safety-related portions of the EFWS satisfies GDC 5 regarding sharing of systems. The EFWS is not shared among nuclear power units.

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The design of the safety-related portions of the EFWS satisfies GDC 19 and Reference 1 regarding the capability to support RCS cooldown from the MCR using only safety grade equipment and assuming any single active failure.

- ~~The water inventory of all four storage pools is available to any available EFWS pump train. The required EFWS water inventory was determined in conformance with Reference 1. Cooldown analyses were performed that included cases with and without offsite power available. Only safety related and Seismic Category I equipment is used to perform the cooldown and required operator actions are performed from the MCR. The exception is that all four RCPs were conservatively assumed (i.e., additional heat load) to be running for the cases with offsite power available. Hot standby conditions were maintained for four hours before initiating the cooldown for all cases. A cooldown rate of 50°F/hr was used for the bounding loss of offsite power case, rather than the normal 90°F/hr rate.~~

  - ~~The 50°F/hr rate increases the EFWS water usage and is considered a rate that plant operators can readily manage for this natural cooldown case with the restrictions applied by Reference 1.~~

  - ~~A hot leg subcooling margin of 50 to 25°F is maintained during the cooldown.~~

  - ~~The total EFWS water used for the bounding cases, with or without offsite power, is less than 300,000 gallons.~~

  - ~~The combined available water inventory of three storage pools is sufficient to support the bounding cooldown cases.~~

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- The water inventory of the four EFW storage pools can be aligned to any available EFWS pump train. The total credited inventory of the four EFW storage pools is 411,200 gallons. This volume is greater than the 365,000 gallons required to perform the bounding BTP 5-4 cooldown described in Section 5.4.7.3.3.

  The non-safety demineralized water distribution system with more than 260,000 gallons of water available provides the normal make-up supply for the EFW storage pools. If needed, the fire water distribution system can be used to provide approximately 280,000 gallons of additional make-up water to the EFW storage pools from standpipes located in each Safeguard Building.

The design of the safety-related portions of the EFWS satisfies GDC 34 and 44 regarding having sufficient flow capacity so that the system can remove residual heat over the entire range of reactor operation and cool the plant to the decay heat removal system cut-in temperature coincident with a single active failure and loss of offsite power.

- The EFWS has the capability to remove the full range of decay heat from the RCS during design basis transient and accident conditions. The system has suitable redundancy, as demonstrated by a failure modes and effects analysis (FMEA) to withstand a high-energy pipe break, a single active failure, and LOOP and still perform its safety functions. Refer to Table 10.4.9-2—Emergency Feedwater System Failure Analysis.

- The EFWS automatically initiates upon a system actuation signal. The EFWS also satisfies the recommendations of RG 1.62 regarding the capability of manual initiation of protective actions.

- The EFWS meets the recommendations of NUREG-0611 (Reference 2) and NUREG-0635 (Reference 3). TMI Action Plan item II.E.1.1 of NUREG 0737 (Reference 4) and 10 CFR 50.34(f)(1)(ii) for applicants subject to 10 CFR 50.34(f) require an AFWS reliability analysis. An acceptable AFWS should have unreliability in the range of $10^{-4}$ to $10^{-5}$ per demand exclusive of station blackout scenarios. The results of the EFWS reliability analysis is provided in Table 10.4.9-4—EFWS Unreliability Results.

The design of the EFWS is consistent with BTP 10-1, except that the power sources are redundant but not diverse. Incorporating a non-electric EFWS pump into the U.S. EPR plant design for diversity is not expected to significantly improve the EFWS reliability or the plant core damage frequency (CDF). The following EFWS design features provide a highly reliable means of cooling the RCS:

- There are four complete trains, each normally aligned to a separate SG. The supply and discharge headers can be configured to allow the pumps to feed any combination of SG.

- Each EFWS train receives power from a separate Class 1E emergency power system. In the event of loss of normal onsite and offsite power, power is supplied

**Table 10.4.9-2—Emergency Feedwater System Failure Analysis**
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| Component | Component Function | Failure Mode | Failure Mechanism | Failure Symptoms/ Effect | Can EFWS Satisfy Mission Success Criteria? |
|---|---|---|---|---|---|
| Minimum Flow Check Valve<br>30LAR11 AA002<br>30LAR21 AA002<br>30LAR31 AA002<br>30LAR41 AA002 | Pump Protection | (a) Injection path fails closed | Mechanical Failure | No flow to SG | Yes, only affects one EFW pump.<br><br>If feeding faulted SG – no impact<br>If feeding an intact SG, isolation of flow and cross-connection of the pump feeding the faulted SG to the intact SG of the train in maintenance is required |
| | | (b) Injection path fails open | Mechanical Failure | No back flow prevention | Yes, backflow prevention function of valve would not apply during SG injection.<br><br>Temperature alarms are provided to alert the operators of back flow during normal plant operation. Procedures will call for appropriate actions to be taken. |
| | | (c) Recirculation path fails closed | Mechanical Failure | Pump failure due to over heating | Same as (a) |
| | | (d) Recirculation path fails open | Mechanical Failure | Inadequate flow to SG | Isolation of flow and cross-connection of the pump feeding the faulted SG to the intact SG of the train in maintenance is required. |
| Level Control Valve<br>30LAR11 AA105<br>30LAR21 AA105<br>30LAR31 AA105<br>30LAR41 AA105 | Controls SG Level and Isolation of EFW Flow to SG | (a) Fails open | Electrical/Mechanical/ I&C Failure | Loss of level control and cannot be used to isolate SG | Yes, if feeding the faulted SG, the SGIV can be used to isolate the SG, or if the failure also prevents the closure of the SGIV.<br><br>If feeding an intact SG, isolation of flow per above and cross-connection of the pump feeding the faulted SG to the intact SG of the train in maintenance is required. RCS cooldown must consider stagnant loop conditions. |
| | | (b) Fails closed | Electrical/Mechanical/ I&C Failure | No flow to SG | Yes, if feeding faulted SG – no impact.<br><br>If feeding an intact SG, isolation of flow and cross-connection of the pump feeding the faulted SG to the SG of the train in maintenance is required. RCS cooldown must consider stagnant loop conditions. |
| SG Isolation Valve<br>30LAR11 AA006<br>30LAR21 AA006<br>30LAR31 AA006<br>30LAR41 AA006 | Isolation of EFW Flow to SG | (a) Fails to close | Electrical/Mechanical/ I&C Failure | Cannot be used to isolate flow to SG | Yes, if feeding the faulted SG, the LCV can be used to isolate the SG.<br>If feeding an intact SG – no impact. |
| | | (b) Fails to stay closed | Mechanical/I&C Failure | Same as (a) | Yes, same as (a). |
| | | (c) Fails closed | Mechanical/I&C Failure | No flow to SG | Yes, if feeding faulted SG – no impact.<br><br>If feeding an intact SG, isolation of flow and cross-connection of the pump feeding the faulted SG to the intact SG of the train in maintenance is required. RCS cooldown must consider stagnant loop conditions. |

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Table 10.4.9-2—Emergency Feedwater System Failure Analysis
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| Component | Component Function | Failure Mode | Failure Mechanism | Failure Symptoms/ Effect | Can EFWS Satisfy Mission Success Criteria? |
|---|---|---|---|---|---|
| DC Bus Failure<br>BUC31<br>BUC32<br>BUC33<br>BUC34 | Provide start and run capability to associated EDG and supply power to associated EUPS<br>Provides start-stop control power for associated EFW pump<br>Provides motive power for associated LCV, SGIV, and DCCV.<br>(Assumes LOOP) | (a) Failure to provide power | Electrical/Mechanical Failure | Loss of power and control to the associated EFW train and MSRT train | Yes, only affects one EFW train.<br>If feeding faulted SG – no impact<br>If feeding an intact SG, isolation of flow and cross-connection of the pump feeding the faulted SG to an intact SG is required.<br>SG overfill protection is provided from the MCR by closure of the LCV, SGIV, or by tripping the EFW pump. |
| DC Bus Failure – in alternate feed mode<br>BUC31<br>BUC32<br>BUC33<br>BUC34 | Provide start and run capability to associated EDG and supply power to associated EUPS<br>Provides start-stop control power for associated EFW pump<br>Provides motive power for associated LCV, SGIV, and DCCV.<br>(Assumes LOOP) | (a) Failure to provide power | Electrical/Mechanical Failure | Immediate loss of power and control to the associated EFW train and MSRT train. In addition, loss of power and control to the equipment in the EFW train being alternate fed that is not powered by the EUPS.<br>At two hours, loss of the LCVs, SGIVs , and DCCVs, of the EFW train receiving the alternate feed; and the associated MSRT. | Yes, taking credit for the following actions:<br>Time (0-30 minutes)<br>• 1 intact train of EFW and MSRT is available<br>• 1 EFW train feeding the faulted SG for 30 minutes<br>• 2 EFW trains are unavailable (Single Failure and Maintenance)<br>Time (30 -120 minutes)<br>• 1 intact train of EFW and MSRT is available<br>• Manual isolation from the MCR of the affected SG<br>• Manual re-alignment from the MCR of the EFW train feeding the faulted SG to the SG associated with the EFW train out for maintenance (using EUPS power for valves)<br>• From the MCR, manually open the MSRCV and EFW LCV of the train receiving the cross feed (while EUPS power is available)<br>Time (120 minutes to RHR Cut-in)<br>• From the MCR, throttle the DCCV of the EFW train providing the cross feed, as needed, to control SG level<br>At RHR cut-in, manually isolate, from the MCR, the MSRIV of the SG being manually fed and shut down EFW trains.<br>SG overfill protection is provided from the MCR by closure of the LCV, SGIV, or by tripping the EFW pump. |
| I&C Protection System (ESFAS EFW actuations) | Initiate automatic EFWS actuations | (a) No automatic actuation signal | I&C signal failure | Loss of EFW low level actuation, SIS with LOOP actuation, and EFW trip during EDG sequencing following a LOOP | Yes, only affects one EFW train.<br>If feeding faulted SG – no impact<br>If feeding an intact SG, cross-connection of the pump feeding the faulted SG to the SG of the train in maintenance is required. |
| MSRCV during all modes<br>30LBA13 AA101<br>30LBA23 AA101<br>30LBA33 AA101<br>30LBA43 AA101 | MSRT Pressure Control/ Isolation (supports EFW decay heat removal function) | Fails closed | Electrical/Mechanical/ I&C Failure | Loose pressure control of SG | Yes, only affects one SG<br>The MSRV will close and control power will still be available to two MSRTs for the duration of event.<br>Assumes LOOP<br>Actions are required to depressurize and cool the SG at the initiation of the RCS cooldown. |

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**Table 10.4.9-2—Emergency Feedwater System Failure Analysis**
**Sheet 5 of 5**

| Component | Component Function | Failure Mode | Failure Mechanism | Failure Symptoms/ Effect | Can EFWS Satisfy Mission Success Criteria? |
|---|---|---|---|---|---|
| MSRCV during alternate feed mode<br>30LBA13 AA101<br>30LBA23 AA101<br>30LBA33 AA101<br>30LBA43 AA101 | MSRT Pressure Control/ Isolation (supports EFW decay heat removal function) | (a) Fails closed | Electrical/Mechanical/ I&C Failure | Loss of MSRT of SG | Yes, only affects one SG<br>If faulted SG, no impact<br>If intact SG, control power will still be available to two MSRTs for the duration of event |
| | | (b) Fails open | Electrical/Mechanical/ I&C Failure | Loose pressure control of SG | Yes, only affects one SG<br>The MSRIV will close and control power will still be available to two MSRTs for the duration of event |
| | | (c) Fails as-is | Electrical | Bounded by above | Bounded by above |
| MSRIV during all modes<br>30LBA13 AA001<br>30LBA23 AA001<br>30LBA33 AA001<br>30LBA43 AA001 | MSRT Pressure Relief (supports EFW decay heat removal function) | (a) All | All | None | Yes, actuation of the valve is ensured by the single failure proof design provided by the four solenoids. Closure is ensured by the valve's passive (spring loaded) design. |
| SBVSE Recirculation Cooling Units<br>30SAC61 AC001<br>30SAC62 AC001<br>30SAC63 AC001<br>30SAC64 AC001 | Provide Cooling to EFW Pump Rooms | (a) Failure to start | Electrical/Mechanical/ I&C Failure | Failure of EFW Pump, FCV, or LCV | Yes, only affects one EFW train.<br>If feeding faulted SG – no impact<br>If feeding an intact SG, cross-connection of the pump feeding the faulted SG to the SG of the train in maintenance is required. |
| | | (b) Failure to run | Electrical/Mechanical/ I&C Failure | Bounded by (a) | Bounded by (a) |
| | | (c) Failure to cool (SCWS) | Electrical/Mechanical/ I&C Failure | Bounded by (a) | Bounded by (a) |
| SBVS Recirculation Cooling Units<br>30KLC51 AC002<br>30KLC52 AC002<br>30KLC53 AC002<br>30KLC54 AC002 | Provide Cooling to Safeguard Building Penetration Room | (a) Failure to Start | Electrical/Mechanical/ I&C Failure | Increased temperature in Penetration Room containing the SGIV | Yes, only affects one EFW train.<br>If feeding faulted SG – no impact<br>If feeding an intact SG, cross-connection of the pump feeding the faulted SG to the SG of the train in maintenance is required. |
| | | (b) Failure to Run | Electrical/Mechanical/ I&C Failure | Bounded by (a) | Bounded by above |
| | | (c) Failure to cool | Electrical/Mechanical/ I&C Failure | Bounded by (a) | Bounded by (a) |

**Notes:**

1. A MFLB results in RCS heat-up with a faulted SG and is considered the bounding accident/transient with respect to single failure.
2. Mission success requires:
   - The EFWS to operate until the plant is cooled down sufficiently (emergency cut-in point) to permit operation of the residual heat removal (RHR) system.
   - The need for successful operation of two EFW pumps feeding ~~two~~all available SGs, including their main steam relief trans (MSRT). 10.04.09-5
3. One EFW train is assumed to be in maintenance with the following components out of service: EFW pump, flow control valve, and minimum flow check valve. In addition, the associated division's EDG can be out for maintenance.

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**Table 2.2.4-3—EFWS ~~Inspections, Tests, Analyses, and Acceptance Criteria~~ITAAC (~~5~~ 7 Sheets)**

| | Commitment Wording | Inspections, Tests, ~~or Analysis~~Analyses | Acceptance Criteria |
|---|---|---|---|
| 7.2 | The EFWS delivers water to the steam generators at the required flowrate to restore and maintain SG water level and remove decay heat following the loss of normal feedwater supply due to design basis events. | Analysis will be performed to determine the EFWS delivery flowrate to the steam generators for design conditions. | The EFWS delivers the following design flowrate to the SGs for design conditions: Minimum flow of 198,416 $lb_m$/hr (or 399.4 gpm at 122°F) at pressures up to 1426.1 psia and linearly ramping to 61,906 $lb_m$/hr (or 124.6 gpm at 122°F) at 1568.2 psia |
| 7.3 | The EFWS combined storage pool volume is sufficient to achieve a cold shutdown condition for design basis conditions. | Inspection and analysis will be performed to determine the EFWS storage pool volume required to achieve a cold shutdown condition for design basis conditions. | The following EFWS combined storage pool volume is sufficient to achieve a cold shutdown condition for design basis conditions: Minimum ~~300,000~~365,000 gallons (total for 4 pools). 10.04.09-5 |
| 7.4 | The EFWS provides for a maximum flow rate to a depressurized steam generator. | Analysis will be performed to verify the EFWS provides a maximum flow rate to a depressurized steam generator. | The EFWS provides the following maximum flow rate to a depressurized steam generator: Maximum 490 gpm. |
| 7.5 | EFWS cross-connections allow alignment of EFWS pump suction on all EFWS storage pools and pump discharge alignment with any SG. | Testing will be performed to demonstrate the EFWS cross-connections allow alignment of EFWS pump suction on all EFWS storage pools and pump discharge alignment with any SG. | The EFWS cross-connections allow the following system alignments: 1. EFWS pump suction to all EFWS storage pools. 2. EFWS pump discharge with any SG. |
| 7.6 | ~~Alignment of the EFWS pumps with any SG can be accomplished from the main control room~~Deleted. | ~~Testing will be performed to demonstrate that alignment of the EFWS pumps with any SG can be accomplished from the main control room~~Deleted. | ~~The EFWS pumps can be aligned with any SG from the main control room~~Deleted. |

## 3.7 PLANT SYSTEMS

### 3.7.6 Emergency Feedwater (EFW) Storage Pools

LCO 3.7.6 Four EFW Storage Pools shall be OPERABLE.

APPLICABILITY: MODES 1, 2, and 3,
MODE 4 when steam generator is relied upon for heat removal.

10.04.09-9

ACTIONS

| CONDITION | REQUIRED ACTION | COMPLETION TIME |
|---|---|---|
| A. One or more EFW Storage Pools inoperable. | A.1 Declare associated EFW train inoperable.<br><br>AND<br><br>A.2 Verify by administrative means, the operability of the back-up water supplies.<br><br>AND<br><br>A.3 Restore EFW storage pools to operable status.<br>~~the usable volume in the three remaining EFW Storage Pools is ≥ 300,000 gal.~~<br>~~AND~~<br>~~A.2 Declare associated EFW train inoperable.~~ | Immediately<br><br>4 hours<br><br>AND<br><br>Once per twelve hours thereafter.~~Immediately~~<br><br>7 days |
| B. Required action and associated completion time not met.~~Two or more EFW Storage Pools inoperable.~~<br><br>~~OR~~ | B.1 Be in MODE 3.<br><br>AND<br><br>B.2 Be in MODE 4, without reliance on steam generator for heat removal. | 6 hours<br><br><br><br>24 hours |

SURVEILLANCE REQUIREMENTS

10.04.09-9

| SURVEILLANCE | | FREQUENCY |
|---|---|---|
| SR 3.7.6.1 | Verify the EFW Storage Pools contain a usable volume ≥ ~~300,000~~ 365,000 gal. | 24 hours |
| SR 3.7.6.2 | Verify each EFW Storage Pool supply cross connect valve is ~~locked open~~closed. | 31 days |

B 3.7 PLANT SYSTEMS

B 3.7.6 Emergency Feedwater (EFW) Storage Pools

BASES

BACKGROUND

The EFW pumps take suction through separate suction lines from their respective EFW storage pool (SP) and normally pump to their respective steam generator secondary side via separate and independent connections. The steam generators function as a heat sink for core decay heat. The heat load is dissipated by releasing steam to the atmosphere from the steam generators via the ~~main steam safety valves (MSSVs) (LCO 3.7.1) or~~ main steam relief trains (MSRTs) (LCO 3.7.4) or the main steam safety valves (MSSV) (LCO 3.7.1). If the main condenser is available, steam may be released via the steam bypass valves.

10.04.09-9

The EFW System consists of four motor driven EFW pumps and four EFW SPs configured into four separate trains. The inventory of the four EFW SPs ~~is available~~can be aligned to all EFW pumps through the common supply header.

Because the SPs are principal components in removing residual heat from the Reactor Coolant System (RCS), they are designed to withstand earthquakes and other natural phenomena, including missiles that might be generated by natural phenomena. The SPs are designed to Seismic Category I to ensure availability of the emergency feedwater supply. A description of the SPs is found in FSAR Section 10.4.9 (Ref. 1).

10.04.09-9

The demineralized water distribution system (DWDS), with more than 260,000 gallons available, provides the normal make-up supply to the EFW storage pools. The DWDS can be aligned to the EFW storage pools from the MCR. If needed, the fire water distribution system can be used to provide approximately 280,000 gallons of additional make-up water to the EFW storage pools from standpipes located in each Safeguard Building.

APPLICABLE SAFETY ANALYSES

The EFW SPs provide cooling water to remove decay heat and to cool down the unit following the loss of normal feedwater supplies due to anticipated operational occurrences and accidents addressed in FSAR Section 15 (Ref. 3).~~all events in the accident analysis as discussed in Chapters 6 and 15 (Ref. 2 and 3, respectively). For anticipated operational occurrences and accidents that do not affect the OPERABILITY of the steam generators, the analysis assumption is generally four hours at MODE 3, steaming through the MSSVs and MSRVs~~ MSRTs ~~followed by a cooldown to residual heat removal (RHR) entry conditions at the design cooldown rate or a lower cooldown rate if offsite power is not available.~~

~~The limiting accident for the EFW SPs is a Main Feedwater Line Break (MFWLB) with a natural circulation cooldown.~~The limiting case for sizing of the EFW storage pools is a natural circulation cooldown following a LOOP in accordance with BTP 5-4 requirements. A failed closed EFW level control valve is the assumed single failure that results in an unfed SG and stagnant RCS loop.

10.04.09-9

The EFW SPs satisfy the requirements of Criterion 2 and 3 of 10 CFR 50.36(~~d~~c)(2)(ii).

BASES

LCO

10.04.09-9

To satisfy accident analysis assumptions, the EFW SPs must contain sufficient water to remove decay heat for four hours following a reactor trip from 102% RTP and then to cool down the RCS to RHR entry conditions, assuming a coincident loss of offsite power and the most adverse single failure. In doing this, it must retain sufficient water to ensure adequate net positive suction head for the EFW pumps during cooldown or before isolating EFW to a faulted steam generator.

The EFW SP required usable volume of 300,000365,000 gallons is based on a cooldown to RHR entry conditions at 50°F/hour, with all four reactor coolant pumps in service for the bounding BTP 5-4 natural circulation cooldown described in FSAR Section 5.4.7.3.3.1 (Ref. 2). This basis is established in Reference 1 and exceeds the volume required by the accident analysis.

The OPERABILITY of the EFW SPs is determined by summing the available tank volumes. The volume in an SP is considered usable when it is aligned to its respective EFW pumpthe common supply header.

APPLICABILITY

In MODES 1, 2, and 3, and in MODE 4, when a steam generator is being relied upon for heat removal, the EFW SPs are required to be OPERABLE to support EFW System operability.

In MODE 5 or 6, the EFW SPs are not required because the EFW System is not required.

ACTIONS

A.1 and A.2

10.04.09-9

With one or more of the EFW SPs inoperable in MODE 1, 2, or 3, or MODE 4, when a steam generator is being relied upon for heat removal, action must be taken to verify the usable volume in the remaining SPs is ≥ 300,000 gal. and to declare the associated EFW train inoperable and verify the operability of the back-up water supplies.

B.1 and B.2

With two or more EFW SPs inoperable or the usable volume of the available SPs is < 300,000 gal., If the required action and associated completion times are not met, the unit must be placed in a MODE in which the LCO does not apply. To achieve this status, the unit must be placed in at least MODE 3 within 6 hours and in MODE 4, without reliance on a steam generator for heat removal, within 24 hours. The allowed Completion Times are reasonable, based on operating experience, to reach the required unit conditions from full power conditions in an orderly manner, and without challenging unit systems.

BASES

SURVEILLANCE REQUIREMENTS

SR 3.7.6.1

This SR verifies that the EFW Storage Pools contain the required volume of cooling water. The 24 hour Frequency is based on operating experience and are not used by other systems and that the SPs have no other function thant to supply water to the EFW trains. Also, the 24 hour Frequency is considered adequate in view of other indications in the control room, including alarms, to alert the operator to abnormal deviations in the SP levels.

SR 3.7.6.2

This SR verifies every 31 days that the EFW storage pool supply cross connect valves are locked openclosed. This verification ensures that the usable volume in the SPs are is available to all its EFW trainss to ensure EFW train separation through the supply cross connect header and ensures timely discovery if a valve should be not locked open. If an EFW supply cross connect valve is not open, the usable volume of the SP is not available to each of the four EFW trains as assumed in the safety analysis. This Frequency is considered reasonable in view of other administrative controls that ensure a mispositioned EFW supply cross connect valve is unlikely.

REFERENCES

1. FSAR Section 10.4.9.
2. FSAR Chapter 6.Section 5.4.7.3.3.

10.04.09-9

3. FSAR Chapter 15.