ArevaEPRDCPEm Resource

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Sent: Saturday, May 04, 2013 10:49 PM
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Subject: Submittal of ANP-10329, "U.S. EPR Mitigation Strategies for Extended Loss of AC Power Event Technical Report"
Attachments: nrc13020.pdf; ANP-10329 Rev 0.pdf

Amy,

AREVA NP Inc. letter NRC:13:020 dated May 4, 2013 (attached) transmitted to NRC Technical Report ANP-10329, " U.S. EPR Mitigation Strategies for Extended Loss of AC Power Event Technical Report". In RAI 563, the NRC provided a request for additional information regarding the U.S. EPR Design Certification application as it relates to implementation of the Fukushima Near-Term task Force Recommendations, as presented in SECY-12-0025, "Proposed Orders and Requests for Information in Response to Lessons Learned from Japan's March 11, 2011, Great Tohoku Earthquake and Tsunami", dated February 12, 2012. This RAI specifically addresses Recommendation 4.2 on Mitigating Strategies.

Enclosed with the letter (and attached to this e-mail) is the document ANP-10329, "U.S. EPR Mitigation Strategies for Extended Loss of AC Power Event Technical Report," containing detailed information in support of AREVA NP Inc.'s (AREVA NP) response to this request.

AREVA NP has incorporated this report by reference in the U.S. EPR Final Safety Analysis Report (FSAR). The conforming changes to the U.S. EPR FSAR will be included with AREVA NP's response to RAI 563. AREVA NP requests that the NRC incorporate the review of this report into the assessment of the safety evaluation report for the U.S. EPR FSAR in a manner consistent with other reports which are incorporated by reference in the U.S. EPR FSAR.

Sincerely,

Dennis Williford, P.E.
U.S. EPR Design Certification Licensing Manager
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AREVA

May 4, 2013
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Submittal of ANP-10329, "U.S. EPR Mitigation Strategies for Extended Loss of AC Power Event Technical Report"

Ref. 1: E-mail, Amy Snyder (NRC) to Dennis Williford, et al. (AREVA NP Inc.), "U.S. EPR Design Certification Application RAI No. 563 (6890), FSAR Ch. 19 - NEW PHASE 4 RAI - Fukushima," November 30, 2012.

In Reference 1, the NRC provided a request for additional information (RAI) regarding the U.S. EPR Design Certification application (i.e., RAI No. 563) as it relates to implementation of the Fukushima Near-Term Task Force Recommendations, as presented in SECY-12-0025, "Proposed Orders and Requests for Information in Response to Lessons Learned from Japan's March 11, 2011, Great Tohoku Earthquake and Tsunami," dated February 12, 2012. This request for additional information specifically addresses Recommendation 4.2 on Mitigating Strategies.

Enclosed with this letter is the document ANP-10329, "U.S. EPR Mitigation Strategies for Extended Loss of AC Power Event Technical Report," containing detailed information in support of AREVA NP Inc.'s (AREVA NP) response to this request.

AREVA NP has incorporated this report by reference in the U.S. EPR Final Safety Analysis Report (FSAR). The conforming changes to the U.S. EPR FSAR will be included with AREVA NP's response to Reference 1. AREVA NP requests that the NRC incorporate the review of this report into the assessment of the safety evaluation report for the U.S. EPR FSAR in a manner consistent with other reports which are incorporated by reference in the U.S. EPR FSAR.

There are no new commitments contained within this correspondence.

If you have any questions related to this information, please contact Len Gucwa by telephone at (434) 832-3466, or by e-mail at len.gucwa.ext@areva.com.

Sincerely,

Pedro Salas, Director
Regulatory Affairs
AREVA NP Inc.

Enclosures:

1. ANP-10329, "U.S. EPR Mitigation Strategies for Extended Loss of AC Power Event Technical Report"

cc: A. M. Snyder
Docket 52-020

U.S. EPR Mitigation Strategies for Extended Loss of AC Power Event

ANP-10329
Revision 0

Technical Report

May 2013

AREVA NP Inc.

Nature of Changes

Item	Section(s) or Page(s)	Description and Justification
000		Initial Issue

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Nomenclature

Acronym	Definition
AC	Alternating Current
ANPR	Advance Notice of Proposed Rulemaking
BDBE	Beyond Design Basis Event
BDBEE	Beyond Design Basis External Event
BPE-LGT	Battery Pack Emergency Lighting
BWR	Boiling Water Reactor
CAS	Compressed Air System
COM	Communication System
DC	Direct Current
EBS	Extra Borating System
EDG	Emergency Diesel Generator
EFW	Emergency Feedwater
ELAP	Extended Loss of AC Power
E-LGT	Emergency Lighting
EOP	Emergency Operating Procedures
EP	Emergency Preparedness
EPR	Evolutionary Power Reactor
EPSS	Emergency Power Supply System
ERDS	Emergency Response Data System
ESF	Engineered Safety Feature
ESR-LGT	Escape Route-Egress Battery Pack Lighting
EUPS	Class 1E Uninterruptible Power Supply
FB	Fuel Building
FLEX	Diverse and Flexible Coping Strategies
FSAR	Final Safety Analysis Report
GOTHIC	Generation of Thermal-Hydraulic Information for Containments
HSI	Human-System Interface
HVAC	Heating, Ventilation, and Air Conditioning
I&C	Instrumentation and Control
IRWST	In-Containment Refueling Water Storage Tank
ISG	Interim Staff Guidance
LOOP	Loss of Offsite Power
MCC	Motor Control Center
MCR	Main Control Room
MHSI	Medium Head Safety Injection
MS	Main Steam
MSRCV	Main Steam Relief Control Valve
MSRIV	Main Steam Relief Isolation Valve
MSRT	Main Steam Relief Train
NEI	Nuclear Energy Institute

Acronym	Definition
NPSH	Net Positive Suction Head
NRC	U.S. Nuclear Regulatory Commission
NTTF	Near-Term Task Force
PA	Public Address
PRA	Probabilistic Risk Assessment
PSRV	Pressurizer Safety Relief Valve
PWR	Pressurized Water Reactor
PZR	Pressurizer
RCP	Reactor Coolant Pump
RCS	Reactor Coolant System
RFI	Request for Information
RSS	Remote Shutdown Station
SAHRS	Severe Accident Heat Removal System
SAS	Safety Automation System
SB	Safeguard Building
SBLOCA	Small Break Loss of Coolant Accident
SBO	Station Blackout (event)
SBVSE	Electrical Division of Safeguard Building Ventilation System
SE-LGT	Special Emergency Lighting
SFP	Spent Fuel Pool
SFPS	Spent Fuel Pool Spray
SG	Steam Generator
SICS	Safety Information and Control System
SSC	Structures, Systems, and Components
SSE	Safe Shutdown Earthquake
SSSS	Standstill Seal System
UHS	Ultimate Heat Sink

ABSTRACT

After the March 2011 accident at the Fukushima Daiichi Nuclear Power Plant in Japan, the U.S. Nuclear Regulatory Commission (NRC) took specific regulatory actions in areas of nuclear power plant design and emergency planning to improve the availability and reliability of plant safety systems to mitigate a beyond design basis event from external hazards. The NRC issued Order EA-12-049, "Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events," (Reference 1) on March 12, 2012, which requires Licensees to develop, implement, and maintain guidance and strategies to sustain or restore core cooling, containment integrity, and spent fuel pool (SFP) cooling capabilities following a beyond design basis external event. The beyond design basis external event (BDBEE) discussed in Order EA-12-049 is assumed to cause a simultaneous loss of all alternating current (AC) power and loss of normal access to the ultimate heat sink (UHS) that can occur in any operating mode. The NRC also issued Order EA-12-051, "Order Modifying Licenses with Regard to Reliable Spent Fuel Pool Instrumentation," (Reference 2) on March 12, 2012, which requires Licensees to provide sufficiently reliable instrumentation to monitor SFP water level and be capable of withstanding design-basis natural phenomena.

This technical report addresses the actions taken by the U.S. EPR (Evolutionary Power Reactor) to improve nuclear safety in response to the Fukushima Daiichi Nuclear Power Plant accident. For the U.S. EPR, the BDBEE evaluated is an extended loss of AC power (ELAP) event, which assumes a simultaneous loss of all AC power (LOOP, plus loss of EDGs, plus loss of alternate AC source) plus loss of normal access to the UHS. It also demonstrates the way in which the U.S. EPR provides baseline coping capability with installed equipment, describes permanent plant connections, and identifies performance requirements for portable equipment to support long-term event mitigation (interface provisions for Phase 2 and 3 actions). Critical operator actions and timing are also provided.

The U.S. EPR mitigation strategies are diverse and flexible to accommodate a wide range of possible conditions and have been verified to be acceptable by analytical methods and evaluations.

1.0 INTRODUCTION

The purpose of this technical report is to provide the U.S. EPR diverse and flexible mitigation strategies that reduce the risks associated with mitigation of BDBEEs. The BDBEE evaluated is an ELAP event, which assumes a simultaneous loss of all AC power (LOOP, plus loss of EDGs, plus loss of alternate AC source) plus loss of normal access to the UHS.

This technical report focuses primarily on Near-Term Task Force (NTTF) Recommendation 4.2. NTTF Recommendation 4.2 resulted in NRC Order EA-12-049 (Reference 1), which requires Licensees to develop, implement, and maintain guidance and strategies to maintain or restore core cooling, containment integrity, and SFP cooling capabilities following a BDBEE. These strategies must be capable of mitigating a simultaneous loss of all AC power and loss of normal access to the UHS and must be applicable in all operating modes. Reasonable protection for mitigating equipment must be provided. This technical report addresses the Nuclear Energy Institute (NEI) 12-06, “Diverse and Flexible Coping Strategies (FLEX) Implementation Guide” (Reference 3), which addresses FLEX Phase 1 event mitigation (installed equipment), describes permanent plant connections as needed, and identifies performance requirements for portable equipment to support long-term event mitigation (interface provisions for Phase 2 and 3 actions).

1.1 *Description of Fukushima Daiichi Accident*

On March 11, 2011, the Fukushima Daiichi plant in northern Japan was subjected to two BDBEEs:

1. An earthquake with peak ground accelerations at the site in the 0.5g - 0.6g range.
2. A tsunami, triggered by the earthquake, that struck the plant about one hour later with an approximately 36-foot high wave, which is approximately 10 ft above plant grade level.

Units 1, 2 and 3 were in operation at the time of the earthquake, while Units 4, 5 and 6 were shut down for routine refueling and maintenance activities. The beyond design basis earthquake resulted in a loss of offsite power (LOOP), a reactor trip, and an automatic startup of the emergency diesel generators (EDGs). The beyond design basis tsunami resulted in a total loss of heat sink, due to debris, on all units, a total loss of AC emergency power, due to flooding, on most units, and a total loss of DC emergency power, due to flooding, on one unit. As a result of the loss of emergency power for an extended period of time, Units 1, 2 and 3 experienced some core damage with radiological releases and hydrogen gas explosions. Releases of combustible gases from adjacent units into Unit 4 resulted in an explosion in Unit 4 as well. Units 5 and 6 remained shut down without any fuel damage.

1.2 *Purpose*

This technical report addresses the applicable Tier 1 and Tier 2 Near-Term Task Force (NTTF) recommendations.

Section 2.0 provides an overview of the applicable regulatory criteria and bases.

Section 3.0 provides a brief synopsis of the method that the U.S. EPR uses to address each of the applicable Tier 1 and Tier 2 NTTF Recommendations.

Section 4.1 summarizes the U.S. EPR mitigation strategy for NTTF Recommendation 4.2 (mitigation of beyond design basis external hazards).

Section 4.2 summarizes the U.S. EPR mitigation strategy for NTTF Recommendation 7 (enhancing SFP makeup and SFP instrumentation).

Section 4.3 summarizes the U.S. EPR mitigation strategy for NTTF Recommendation 9.3 (enhanced emergency preparedness staffing and communications).

In conclusion, the U.S. EPR mitigation strategies are diverse and flexible to accommodate a wide range of possible conditions and have been verified to be acceptable by analytical methods and evaluations.

2.0 REGULATORY OVERVIEW

This section describes the regulatory criteria and regulatory basis for the U.S. EPR design certification post-Fukushima Daiichi mitigation strategy. These NRC orders and NEI guidance documents were utilized to form the mitigation strategy.

Following the events at the Fukushima Daiichi Nuclear Power Plant on March 11, 2011, the NTTF was established as a senior-level agency task force. The NTTF was tasked with conducting a systematic and methodical review of the NRC regulations and processes, and then determining whether the agency should make additional improvements to these programs considering the events at Fukushima Daiichi. The NTTF provided these recommendations in the NRC Report, "Recommendations for Enhancing Reactor Safety in the 21st Century." The recommendations were further documented in SECY-11-0093, "Near-Term Report and Recommendations for Agency Actions Following the Events in Japan," (Reference 4).

The NRC identified a subset of the NTTF recommendations that should be undertaken without unnecessary delay in SECY-11-0124, "Recommended Actions to be Taken without Delay from the Near-Term Task Force Report," (Reference 5).

Subsequently, the NRC issued SECY-11-0137, "Prioritization of Recommended Actions to be taken in Response to Fukushima Lessons Learned" (Reference 6). As a result of the prioritization and assessment process of the Staff, the NTTF recommendations were prioritized into the following three tiers:

- Tier 1 consists of the NTTF recommendations that the Staff determined should be started without unnecessary delay, and for which there exists sufficient resource flexibility, including availability of critical skill sets.
- Tier 2 consists of the NTTF recommendations that cannot be initiated in the near term due to factors that include the need for further technical assessment and alignment, dependence on Tier 1 issues, or availability of critical skill sets. These

actions do not require long-term study and can be initiated when sufficient technical information and applicable resources become available.

- Tier 3 consists of the NTTF recommendations that require further Staff study to support a regulatory action, and that have an associated shorter-term action that needs to be completed to inform the longer-term action, that are dependent on the availability of critical skill sets, or that are dependent on the resolution of NTTF Recommendation 1 (Reference 9).

In SECY-12-0025, “Proposed Orders and Requests for Information in response to Lessons Learned from Japan’s March 11, 2011, Great Tohoku Earthquake and Tsunami” (Reference 7), the NRC described its process to disposition:

- The six additional recommendations described in SECY-11-0137.
- Other issues that continue to arise as part of ongoing Staff deliberations, stakeholder interactions, and interactions with the Advisory Committee on Reactor Safeguards (ACRS).

In SECY-12-0095, “Tier 3 Program Plans and 6-Month Status Update in Response to Lessons Learned from Japan’s March 11, 2011, Great Tohoku Earthquake and Subsequent Tsunami” (Reference 8), the NRC provided an updated list of recommendations that are being addressed under the Japan lessons learned project.

The NRC has issued two orders and a 10 CFR 50.54(f) letter to pressurized water reactor (PWR) operating plant licensees and Combined License holders:

- EA-12-049, “Mitigation Strategies for Beyond Design Basis External Hazards,” (Reference 1).
- EA-12-051, “Reliable Spent Fuel Pool Instrumentation,” (Reference 2)
- 10 CFR 50.54(f) letter requesting additional information, Recommendations 2.1, 2.3 and 9.3.

In SECY-13-0020, "Third 6-Month Status Update on Response to Lessons Learned from Japan's March 11, 2011, Great Tohoku Earthquake and Subsequent Tsunami," (Reference 9), the NRC provided an updated list of recommendations that are being addressed under the Japan lessons learned project. These actions are listed in Table 2-1.

2.1 *NRC Order EA-12-049, Interim Staff Guidance JLD-ISG-2012-01, and NEI 12-06, Revision 0*

In response to NTTF Recommendation 4.2, NRC Order EA-12-049, "Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events" (Reference 1) was issued on March 12, 2012. The Order requires guidance and strategies to be available to prevent fuel damage in the reactor and SFP if all units at a site simultaneously experience a loss of power, motive force, and normal access to the UHS.

NRC Order EA-12-049 requires a three-phase approach for mitigating BDBEEs. The initial phase, referred to as Phase 1, requires the use of installed equipment and resources to maintain or to restore core cooling, containment integrity and SFP cooling capabilities. The transition phase, referred to as Phase 2, requires that sufficient, portable, onsite equipment and consumables be available to maintain or restore these functions until they can be achieved with resources brought from offsite. The final phase, referred to as Phase 3, requires that sufficient offsite resources sustain Phase 1 and Phase 2 functions indefinitely.

The NRC issued Interim Staff Guidance (ISG) JLD-ISG-2012-01, "Compliance with Order EA-12-049, Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events," (Reference 11). This ISG endorses, with clarifications, the methodologies described in the industry guidance document, NEI 12-06 (Reference 3).

NEI 12-06 provides diverse and flexible coping strategies (FLEX) to establish an indefinite coping capability to prevent damage to the fuel in the reactor and SFPs, and to maintain the containment function by using installed equipment, onsite portable equipment, and prestaged offsite resources. This coping capability is based on strategies that focus on an assumed simultaneous extended loss of AC power (ELAP) and loss of normal access to the UHS condition caused by unspecified events. The ELAP event assumes a simultaneous loss of all AC power (LOOP plus loss of EDGs plus loss of alternate AC source) plus loss of normal access to the UHS. These mitigating strategies must be implemented for all modes.

Permanent plant equipment contained in structures with designs that are robust with respect to seismic events, floods, high winds and associated missiles, and extreme temperatures are assumed to be available. Onsite portable or prestaged mitigating equipment must also be reasonably protected from external events.

The U.S. EPR conforms to NRC Order EA-12-049 (Reference 1), NRC JLD-ISG-2012-01 (Reference 11), and NEI 12-06, Revision 0 (Reference 3) with the following clarifications:

1. JLD-ISG-2012-01 and NEI 12-06 do not specify an acceptance criterion for containment pressure control. For containment pressure, the U.S. EPR mitigation strategy has established an acceptance criterion that containment pressure remains below the containment ultimate pressure capacity limit.

2. The U.S. EPR mitigation strategy relies on secondary side feed and bleed cooling for Phase 1 event mitigation in Modes 1 through 5. This results in a period of steam generator (SG) depressurization and dryout until RCS temperature lowers allowing the low head diesel-driven fire pump to re-establish SG level, as described in Section 4.1.5.2.

3. The U.S. EPR mitigation strategy relies on secondary side feed and bleed cooling for Phase 1 event mitigation in Modes 1 through 5. During a short time period of Mode 5 operation (i.e., transition to and from Mode 6), the

FLEX mitigation method of primary feed and bleed may be ineffective, as described in Section 4.1.5.2.

2.2 *NRC Order EA-12-051, Interim Staff Guidance JLD-ISG-2012-03, and NEI 12-02, Revision 1*

In response to NTTF Recommendation 7.1, NRC Order EA-12-051, “Issuance of Order to Modify Licenses with Regard to Reliable Spent Fuel Pool Instrumentation” (Reference 2) was issued on March 12, 2012. This order stated that Licensees must provide sufficiently reliable instrumentation to monitor SFP water level that is capable of withstanding design-basis natural phenomena.

Attachment 2 to EA-12-051 (Reference 2) requires reliable water level instrumentation in associated spent fuel storage pools that is capable of supporting identification by trained personnel of the following pool water level conditions:

- A level that is adequate to support operation of the normal fuel pool cooling system.
- A level that is adequate to provide substantial radiation shielding for a person standing on the SFP operating deck.
- A level at which fuel remains covered and actions to implement the addition of makeup water addition should no longer be deferred.

The NRC issued ISG JLD-ISG-2012-03, “Compliance with Order EA-12-051, Reliable Spent Fuel Pool Instrumentation” (Reference 12) on August 29, 2012. This ISG endorses, with exceptions and clarifications, the methodologies described in the industry guidance document NEI 12-02, “Industry Guidance for Compliance with NRC Order EA-12-051, “To Modify Licenses with Regard to Reliable Spent Fuel Pool Instrumentation”, (Reference 2).

The U.S. EPR conforms to NRC Order EA-12-051 (Reference 2), NRC JLD-ISG-2012-03 (Reference 12) and NEI 12-02, Revision 1 (Reference 13).

Table 2-1—Status Summary of Japan Lessons Learned Activities (February 2013)

Identifier or Background Source	Regulatory Approach	Description	Status / Schedule
		Tier 1	
NTTF 2.1	Request for information (RFI)	Reevaluate seismic and flooding hazards against current requirements and guidance and update the design basis. Take appropriate regulatory action to resolve issues associated with updated site-specific hazards.	✓ RFI (03/12/2012) ✓ JLD-ISG-2012-04 (11/16/2012) ✓ JLD-ISG-2012-05 (11/30/2012) ✓ JLD-ISG-2012-06 (01/04/2013)
NTTF 2.3	RFI	Perform seismic and flood protection walkdowns and address plant-specific vulnerabilities. Take appropriate regulatory action to resolve issues associated with updated site-specific hazards.	✓ RFI (03/12/2012) ✓ TI 2515/187 (06/27/2012) ✓ TI 2515/188 (07/06/2012) ✓ Walkdown reports (11/30/2012)
NTTF 3 (partial)	Plan	Develop a plan to prepare a probabilistic risk assessment (PRA) methodology for seismic-induced fires and floods.	✓ PRA plan (06/07/2012)
NTTF 4.1	Rulemaking	Enhance the capability to maintain plant safety throughout a prolonged station blackout (SBO).	✓ ANPR (03/20/2012) ✓ COMSECY-13-0002 (01/25/2013)

Identifier or Background Source	Regulatory Approach	Description	Status / Schedule
NTTF 4.2	Order	Provide a three-phase approach for mitigating beyond design-basis external hazards.	✓ Order (03/12/2012) ✓ JLD-ISG-2012-01 (08/29/2012) • Integrated plans (02/28/2013)
NTTF 5.1	Order	Provide a reliable hardened containment vent system for boiling water reactor (BWR) Mark I and II containments.	✓ Order (03/12/2012) ✓ JLD-ISG-2012-02 (08/29/2012) • Integrated plans (02/28/2013)
NTTF 7.1	Order	Provide a reliable indication of water level in spent fuel storage pools.	✓ Order (03/12/2012) ✓ JLD-ISG-2012-03 (08/29/2012) • Integrated plans (02/28/2013)
NTTF 8	Rulemaking	Require integration of onsite emergency response processes, procedures, training, and exercises.	✓ ANPR (04/18/2012) ✓ Draft Regulatory Basis (01/08/2013)

Identifier or Background Source	Regulatory Approach	Description	Status / Schedule
NTTF 9.3 (partial)	RFI	Perform a staffing study for responding to multiunit events, evaluate enhancements that would be needed to power communications equipment throughout a prolonged SBO, and inform the NRC of the results.	✓ RFI (03/12/2012) ✓ Phase 1 Communications response (10/31/2012) • Phase 1 Staffing response (04/30/2013) • Phase 2 Communications and Staffing response (4 months before 2nd refueling outage)
NTTF 9.4	Voluntary initiative	Complete the Emergency Response Data System (ERDS) modernization initiative by June 2012 to provide multiunit site monitoring capability.	✓ (June 2012)
SECY-12-0025, Enclosure 2	Under Commission consideration	Related to Near-Team Task Force (NTTF) 5.1. Assess filtration and additional performance requirements for reliable hardened containment vent systems for BWR Mark I and II.	✓ SECY-12-0157 (11/26/2012)
SECY-12-0025, Enclosure 2	Orders and RFI	Related to NTTF 2.1, 2.3, 4.1, and 4.2. Include UHS systems in hazard reevaluations and walkdowns, loss of UHS as a design assumption in conjunction with strategies for dealing with prolonged SBO, and address loss of access to normal UHS in conjunction with measures taken to deal with beyond design basis external hazards.	✓ Subsumed within Orders and RFI (03/12/2012)
Tier 2			
NTTF 7.2-7.5	Rulemaking	Require licensees to provide reliable SFP makeup capabilities.	✓ COMSECY-13-0002 (01/25/2013)

Identifier or Background Source	Regulatory Approach	Description	Status / Schedule
NTTF 9.3 (partial)	Approach under evaluation	Require a revision to the emergency plan to address multiunit dose assessments, periodic training and exercises for multiunit and prolonged SBO scenarios, and drills on identification and acquisition of offsite resources, and ensuring sufficient emergency preparedness (EP) resources for multiunit and prolonged SBO scenarios.	• Under staff evaluation for path forward
SECY-12-0025, Enclosure 3	RFI	Reevaluate other natural external hazards against current requirements and guidance and update the design basis. Take appropriate regulatory action to resolve issues associated with updated site-specific hazards.	• Initiate as resources are available
Tier 3			
NTTF 2.2	Rulemaking	Periodic confirmation of seismic and flooding hazards.	• SECY-12-0095 Program Plan
NTTF 3 (partial)	Long-term evaluation	Potential enhancements to the capability to prevent or mitigate seismically-induced fires and floods.	• SECY-12-0095 Program Plan
NTTF 5.2	Long-term evaluation	Reliable hardened vents for other containment designs.	• SECY-12-0095 Program Plan
NTTF 6	Long-term evaluation	Hydrogen control and mitigation inside containment or in other buildings.	• SECY-12-0095 Program Plan
NTTF 9.1, 9.2	Critical skills availability	EP enhancements for prolonged SBO and multiunit events.	• SECY-12-0095 Program Plan
NTTF 9.3 (partial)	Dependent on NTTF 10	ERDS capability.	• SECY-12-0095 Program Plan
NTTF 10	Long-term evaluation	Additional EP topics for prolonged SBO and multiunit events.	• SECY-12-0095 Program Plan

Identifier or Background Source	Regulatory Approach	Description	Status / Schedule
NTTF 11	Long-term evaluation	EP topics for decision making, radiation monitoring, and public education.	• SECY-12-0095 Program Plan
NTTF 12.1	Dependent on NTTF 1	Reactor Oversight Process modifications to reflect the recommended defense-in-depth framework.	• SECY-12-0095 Program Plan
NTTF 12.2	Dependent on NTTF 8	Staff training on severe accidents and resident inspector training on severe accident management guidelines.	• SECY-12-0095 Program Plan
SECY-12-0025, Enclosure 2	Long-term evaluation	Basis of emergency planning zone size.	• SECY-12-0095 Program Plan
SECY-12-0025, Enclosure 2	Long-term evaluation	Prestaging of potassium iodide beyond 10 miles.	• SECY-12-0095 Program Plan
SECY-12-0025, Enclosure 2	Long-term evaluation	Transfer of spent fuel to dry cask storage.	• SECY-12-0095 Program Plan
SECY-12-0025, Enclosure 2	Long-term evaluation	Reactor and containment instrumentation withstanding beyond-design-basis conditions.	• SECY-12-0095 Program Plan

3.0 APPLICABLE TIER 1 AND TIER 2 RECOMMENDATIONS

The NRC issued a letter, “Implementation of Fukushima Near-Term Task Force Recommendations,” to AREVA NP Inc. (AREVA NP) on April 25, 2012 (Reference 14), which indicated that AREVA NP would be requested to provide information related to the Fukushima Tier 1 Recommendations in SECY-12-0025 (Reference 7) and SRM-12-0025, “Proposed Orders and Requests for Information in Response to Lessons Learned from Japan’s March 11, 2011, Great Tohoku Earthquake and Tsunami,” (Reference 15) that are applicable to the U.S. EPR. The four recommendations identified in the letter were:

- Recommendation 2.1—Seismic Hazards Analysis.
- Recommendation 4.2—Protection of Equipment from External Hazards.
- Recommendation 7.1—Spent Fuel Pool Instrumentation.
- Recommendation 9.3—Enhanced Emergency Preparedness.

Because the NRC letter of April 25, 2012 only addressed Fukushima Tier 1 recommendations, AREVA NP proposed a plan to the NRC at a September 19, 2012 public meeting to address all Tier 1 and Tier 2 Fukushima recommendations. This plan concluded that only a subset of the Tier 1 and Tier 2 Fukushima recommendations are applicable to the U.S. EPR.

The following subsections summarize the closure by AREVA NP of the applicable Fukushima Tier 1 and Tier 2 recommendations.

3.1 *NTTF Recommendation 2.1, Tier 1*

NTTF Recommendation 2.1 is a Tier 1 recommendation that requests Licensees reevaluate the seismic and flooding hazards at their sites against current NRC requirements and guidance, and, if necessary, that they update the design basis of structures, systems and components (SSC) important to safety to protect against the updated hazards.

Subsequent to the April 25, 2012 letter (Reference 14), the NRC Staff determined that this recommendation would be addressed by Licensees. No further action on this recommendation is required for the U.S. EPR.

3.2 *SECY-12-0025, Enclosure 3 Recommendation, Tier 2*

The recommendation from Enclosure 3 of SECY-12-0025 (Reference 7) is a Tier 2 recommendation that requests the reevaluation of other natural external hazards against current regulatory requirements and guidance, and that the design basis be updated accordingly.

The U.S. EPR satisfies current regulatory requirements and guidance. U.S. EPR FSAR Tier 2, Section 2.1 discusses the U.S. EPR site characteristics design parameters. AREVA NP considers that the U.S. EPR satisfies this recommendation, and that no further action on this recommendation is required for the U.S. EPR.

3.3 *NTTF Recommendation 4.1, Tier 1*

NTTF Recommendation 4.1 is a Tier 1 recommendation that resulted in an advance notice of proposed rulemaking (ANPR). The ANPR requests that Licensees strengthen their SBO mitigation capability (10 CFR 50.63) under conditions involving significant natural disasters.

The timeline for completing the SBO rulemaking is expected to occur after the schedule for completing rulemaking for the U.S. EPR. Given the synergies between the NTTF 4.1 rulemaking actions and the NTTF 4.2 order, AREVA NP will address the U.S. EPR design features for SBO as part of the response to NTTF Recommendation 4.2 in Section 4.1.

3.4 *NTTF Recommendation 4.2, Tier 1*

Recommendation 4.2 is a Tier 1 recommendation that resulted in the issuance of NRC Order EA-12-049 (Reference 1), which requires Licensees to enhance SBO mitigation capabilities for beyond design basis external hazards.

The U.S. EPR mitigation strategy for this recommendation is addressed in Section 4.1.

3.5 *SECY-12-0025, Enclosure 2 Recommendation, Tier 1*

Recommendation from SECY-12-0025 (Reference 7), Enclosure 2 is a Tier 1 recommendation that is related to NTTF 2.1, 2.3, 4.1, and 4.2. This recommendation requests that the Licensee include the loss of normal access to the UHS as a design assumption, in conjunction with strategies for dealing with prolonged SBO, and address loss of access to normal UHS in conjunction with measures taken to deal with BDBEE.

The U.S. EPR mitigation strategy for this recommendation is addressed in Section 4.1 as part the of mitigation strategy for NTTF 4.2.

3.6 *NTTF Recommendation 7.1, Tier 1*

Recommendation 7.1 is a Tier 1 recommendation that resulted in the issuance of NRC Order EA-12-051 (Reference 2). This Order stated that Licensees must provide sufficiently reliable instrumentation to monitor SFP water level and be capable of withstanding design basis natural phenomena.

The U.S. EPR mitigation strategy for this recommendation is discussed in Section 4.2.1.

3.7 *NTTF Recommendation 7.2, Tier 2*

Recommendation 7.2 is a Tier 2 recommendation that requests that Licensees provide safety-related AC electrical power for SFP makeup.

The U.S. EPR design, as described in U.S. EPR FSAR Tier 2, Section 9.1.3.2.4, includes the capability to provide safety-related SFP makeup powered by emergency AC electrical power. AREVA NP considers that the U.S. EPR design satisfies this recommendation, and that no further action on this recommendation is required for the U.S. EPR.

3.8 *NTTF Recommendation 7.3, Tier 2*

Recommendation 7.3 is a Tier 2 recommendation that requests that Plant Technical Specifications require one train of emergency onsite electrical power to be operable for SFP makeup/instrumentation when there is irradiated fuel in the SFP, regardless of plant operating mode.

The U.S. EPR mitigation strategy for this recommendation is discussed in Section 4.2.2.

3.9 *NTTF Recommendation 7.4, Tier 2*

Recommendation 7.4 is a Tier 2 recommendation that requests that the Licensee provide a seismically qualified means to spray water into SFPs, including an easily accessible connection to supply water, such as using a portable pump or pumper truck, at grade outside of the building.

The U.S. EPR mitigation strategy for this recommendation is discussed in Section 4.2.3.

3.10 *NTTF Recommendation 8, Tier 1*

Recommendation 8 is a Tier 1 recommendation that will result in an ANPR. Recommendation 8 requests that Licensees strengthen and better integrate Emergency Operating Procedures (EOPs), Severe Accident Management Guidelines (SAMGs) and Extensive Damage Mitigation Guidelines (EDMGs). As stated in SECY-12-0025 (Reference 7), the ANPR activities are in progress within the NRC, but the ANPR has not been issued.

The U.S. EPR FSAR Tier 2, Sections 13.5 and 19.2.5 include guidance for EOPs, SAMGs and EDMGs. U.S. EPR FSAR Tier 2, Section 13.5 discusses the U.S. EPR requirements for use of site-specific information for administrative, operating, emergency, maintenance, and other operating procedures. U.S. EPR FSAR Tier 2, Section 19.2.5 discusses the U.S. EPR Operating Strategies for Severe Accidents methodology and requirements for development and implementation of severe accident management guidelines prior to fuel loading using this methodology. No further action on this recommendation is required for the U.S. EPR.

3.11 *NTTF Recommendation 9.3, Tier 1*

A portion of Recommendation 9.3 is a Tier 1 recommendation that requires Licensees to provide enhanced emergency preparedness staffing and communications.

The U.S. EPR mitigation strategy for this recommendation is discussed in Section 4.3.

3.12 *NTTF Recommendation 9.3, Tier 2*

The remaining portion of Recommendation 9.3 is a Tier 2 recommendation that requires Licensees to enhance their Emergency Plan (e.g., multiunit dose assessments, periodic training).

U.S. EPR FSAR Tier 2, Section 13.3 discusses the U.S. EPR requirements for development of an Emergency Plan in accordance with 10 CFR 50.47 and 10 CFR 50, Appendix E. No further action is required on this recommendation for the U.S. EPR.

4.0 MITIGATION ASSESSMENT

4.1 *NTTF 4.2, Mitigation of Beyond Design Basis External Events*

4.1.1 Overview

In NTTF Recommendation 4.2 and NRC Order EA-12-049 (Reference 1), it is postulated that a BDBEE can deterministically result in a simultaneous ELAP and loss of normal access to the UHS. An ELAP event assumes a simultaneous loss of AC power (LOOP plus loss of EDGs plus loss of alternate AC source) for an indefinite period. An evaluation of an ELAP event caused by BDBEE performed for the U.S.EPR design. Mitigation strategies for the ELAP event have been developed based on the guidance of NEI 12-06 (Reference 3). This FLEX guidance has been endorsed by the NRC, with certain clarifications, provided in NRC JLD-ISG-2012-01 (Reference 11).

For new plant designs, the scope of the EA-12-049 (Reference 1) Order spans both the Design Certification and the Combined License. Accordingly, Section 4.1 focuses on providing a baseline coping capability with installed equipment (Phase 1), providing permanent plant connections, and identifying performance requirements for portable equipment to support long-term event mitigation (interface provisions for Phase 2 and 3 actions).

The scope of Section 4.1 is divided into the following subsections:

- Section 4.1.2 summarizes the acceptance criteria for core cooling, containment integrity and spent fuel cooling.

- Section 4.1.3 describes the analytical codes and methods, key assumptions and results of the analyses performed.

- Section 4.1.4 summarizes the reasonable protection requirements of installed and portable equipment.

- From the analytical bases provided in Section 4.1.3 and the reasonable protection requirements in Section 4.1.4, the mitigation strategies for core cooling, containment integrity and SFP cooling capabilities following an ELAP event are provided in Section 4.1.5.
- Section 4.1.6 then summarizes the sequence of events and critical operator actions.
- Section 4.1.7 summarizes the performance requirements for portable equipment.

4.1.2 Acceptance Criteria

The acceptance criteria for the Fukushima mitigation strategy are summarized in Table 4-1.

Table 4-1—Mitigation Strategy Acceptance Criteria

Function	Acceptance Criteria
Core Cooling	Fuel in core remains covered – no fuel damage Criticality – maintain core subcritical throughout the event
Spent Fuel Cooling	Fuel in SFP remains covered – no fuel damage
Containment Integrity	Containment pressure remains below containment ultimate pressure capacity limits

Adequate core cooling is provided by maintaining the liquid level in the reactor vessel above the top of the fuel in the core, and the reactor remains subcritical throughout the event.

Adequate cooling for fuel assemblies in the SFP is provided by keeping the fuel covered with water.

Adequate containment integrity occurs when the containment pressure is maintained below the Reactor Containment Building ultimate pressure capacity. As described in U.S. EPR FSAR Tier 2, Section 3.8.1.4.11 and Table 3.8-6, the construction opening closure is the limiting component in determining the Reactor Containment Building ultimate pressure capacity limits. The ultimate capacity buckling pressure is 118.5 psig.

4.1.3 Analytical Bases

This section provides information about the analyses performed that provide a basis for the ELAP event mitigation strategies, including codes and methods used, key assumptions, and the results of the analyses.

4.1.3.1 Core Cooling in Modes 1 through 5 - Secondary Side Feed and Bleed

Analytical Methods

The analysis of the core response for an ELAP event initiated in Modes 1 through 5 was performed using S-RELAP5. S-RELAP5 is a thermal hydraulic simulation code that utilizes a two-fluid (plus non-condensables) model with conservation equations for mass, energy, and momentum transfer. The reactor core is modeled with heat generation rates determined from reactor kinetics equations (point kinetics) with reactivity feedback, and with actinide and decay heating.

The two-fluid formulation uses a separate set of conservation equations and constitutive relations for each phase. The effects of one phase on another are accounted for by interfacial friction and heat and mass transfer interaction terms in the conservation equations. The conservation equations have the same form for each phase; only the constitutive relations and physical properties differ.

The modeling of plant components is performed by following guidelines developed to provide accurate accounting for physical dimensions and the dominant phenomena expected during the transient. The basic building blocks for modeling are the hydraulic volumes for fluid paths and the heat structures for heat transfer surfaces. In addition, special purpose components exist to represent specific components such as the pumps or the SG separators. Plant geometry is modeled at the resolution necessary to resolve the flow field and the phenomena being modeled within practical computational limitations.

Because the ELAP scenario is characterized by slow, but continuous reactor coolant system (RCS) inventory leakage through the reactor coolant pump (RCP) seals and core cooling occurs via natural circulation in Modes 1 through 5, the S-RELAP5 small break loss of coolant analysis (SBLOCA) methodology was chosen to perform this analysis. ANP-10263(P) (A), “Codes and Methods Applicability Report for the U.S. EPR” (Reference 16), EMF-2328(P) (A), “PWR Small Break LOCA Evaluation Model, S-RELAP5 Based” (Reference 17), and BAW-10240(P) (A), “Incorporation of M5™ Properties in Framatome ANP Approved Methods” (Reference 18) are the topical reports that justify application of the S-RELAP5 SBLOCA methodology to the U.S. EPR.

Key Assumptions

The analysis of core cooling for ELAP events that rely on the SGs for heat removal was performed using the following key assumptions:

- The S-RELAP5 SBLOCA model was used with the following best-estimate (or conservative) assumptions:
  - Non-safety system capabilities (such as fire water system) are included in the model, as appropriate.
  - End of cycle core reactor kinetics – conservative assumption.
  - Best-estimate core decay heat.
  - No stuck control rods.
  - No single failures.
  - No equipment out of service.

- The ELAP event assumes a simultaneous loss of all AC power sources (LOOP, loss of all EDGs and loss of all Alternate AC sources) in combination with a loss of normal access to the UHS.
- The initiating ELAP event was assumed to occur when the plant is operating normally at 100%, hot full power.
- The ELAP event causes an immediate loss of power to the RCPs and MFW pumps, followed by a reactor trip on low RCP speed, and a turbine trip on reactor trip.
- RCS leakage was assumed from the following two sources:
  - Allowable RCS leakage per Plant Technical Specifications (11 gpm).
  - RCP seal leakage. RCP seal leakage was modeled consistent with the SBO analysis described in U.S. EPR FSAR Tier 2, Section 8.4.
- Core decay heat is removed by means of secondary side feed and bleed cooling. This consists of depressurizing the secondary side of the SGs using the main steam relief trains (MSRTs) and feeding the SGs using the diesel-driven fire water pump(s).
- RCS makeup is provided passively by means of accumulator injection.

Results

For an ELAP event initiated in Modes 1 through 5, the Phase 1 mitigation strategy is to provide natural circulation core cooling by depressurizing the SGs using the MSRTs so that the low head, diesel-driven fire water pump(s) can supply water to the SGs via the emergency feedwater (EFW) header. The RCP standstill seal system (SSSS) is credited with limiting RCP seal leakage until a portable pump can be used to provide borated RCS makeup during Phase 2. The accumulators provide an additional source of borated RCS makeup water, but they cannot inject until the RCS pressure decreases below the accumulator nitrogen cover gas pressure.

A series of five S-RELAP5 cases were run to characterize the RCS response, timing of operator actions, and latitude in potential FLEX mitigating strategies. An overview of each case is provided as follows.

An initial case was run with no SG resupply and no SG depressurization to examine transient phenomena timing with no operator action. SG dryout occurred at approximately two hours after the start of the event. Core boiling began at approximately two and a half hours, and by approximately three hours, the core liquid level was significantly degraded.

These results indicate that the SG inventory is exhausted in about two hours if the MSRTs remain at their normal post-trip setpoints. Once SG dryout occurs, the RCS cannot be cooled unless the SGs are resupplied with water. Therefore, to make best use of the available SG inventory, the SG depressurization should start as early as possible (that is to say as soon as the plant operators recognize that they are in an ELAP scenario).

Case 2 was run to examine the extent to which the RCS can be cooled using only the inventory that existed in the SGs at the start of the transient. Case 2 was run with no SG resupply and with a controlled SG depressurization of 180 °F/hr that was initiated at 1800 seconds after the start of the event.

The results indicated that SG dryout occurs at approximately one hour fifteen minutes, and that the RCS primary can be cooled to approximately 485 °F by the controlled SG depressurization and boil off of the residual post-trip SG inventory.

Case 3 was run to demonstrate secondary side feed and bleed when all four SGs and MSRTs are available and the SGs are resupplied. In this case, a controlled SG depressurization at 180 °F/hr was initiated at 1800 seconds using all four SGs. Ten minutes after SG dryout occurred, the operators were assumed to stop the controlled SG depressurization and quickly lower the SG pressure to 180 psia. When the SG pressure reached the 180 psia setpoint (about 86 minutes into the event), flow from the diesel-driven fire pump(s) was delivered to all four SGs at a rate of 100 gpm per SG. Accumulator injection began at about two and a half hours. SG levels began to recover at about 3.7 hours. All core cooling acceptance criteria (refer to Section 4.1.2) were met for this case.

Case 4 was run to demonstrate secondary side feed and bleed when only two SGs and MSRTs are available and the SGs are resupplied. This case provides the analytical basis for the selected mitigation strategy for an ELAP event initiated in Modes 1 through 5. The key transient highlights for this case are as follows:

- A controlled depressurization of SGs 1 and 2 (equivalent to 90 °F/hr primary temperature) is initiated at 1800 seconds. SG dryout occurs at approximately 4000 seconds. At 4010 seconds, the operators stop the controlled SG depressurization and quickly lower the SG pressure to 100 psia. At 4105 seconds, the pressure in SGs 1 and 2 is ≤100 psia.
- At or before 4060 seconds, the operators start the diesel-driven fire water pump(s) and deliver water to SGs 1 and 2 at a rate of 300 gpm to each SG when SG pressure is ≤100 psia. During this evolution, the RCS primary is unaffected because SG heat transfer is not interrupted.
- At approximately 8970 seconds, the RCS pressure decreases below the accumulator pressure. Accumulator flows begin to slowly enter the cold legs to help maintain RCS inventory and reduce the rate of RCS depressurization.
- At 10,590 seconds, SGs 1 and 2 are above 5% level which indicates that SG inventory is being restored.
- At 14,400 seconds, flow from the diesel-driven fire water pump(s) is reduced to 150 gpm to SGs 1 and 2 since SG levels have been restored to normal.
- At 28,800 seconds, the SG flow is further reduced to 100 gpm to SGs 1 and 2.
- At 42,000 seconds, additional insurge flow from the accumulators has restored primary inventory, refilling the RV upper head and the pressurizer surge line.

- The S-RELAP5 run was ended at the 24-hour mark.

The results of Case 4 are depicted in Figure 4-1 through Figure 4-9. Based on these results and the analyses performed, the following insights can be drawn:

- A coping strategy and success path exists for the ELAP event when only two SGs and two MSRTs are available. In particular, Case 4 satisfies the core cooling acceptance criteria given in Section 4.1.2:
  - The nuclear fuel in the core remains covered with coolant water (refer to Figure 4-7).
  - No fuel damage—Fuel centerline temperatures remain safely below the melting point, and cladding temperatures remain safely below 2200 °F. Because the core remains covered with liquid at all times, the fuel and cladding temperature limits are not approached and fuel damage is never at risk.
  - Criticality—Because the core is maintained subcritical throughout the event (refer to Figure 4-8), a return to critical reactivity conditions due to overcooling is not a concern.
- A fire water supply rate of 300 gpm per SG is adequate to initiate and maintain natural circulation core cooling and restore SG levels. After SG levels are restored to normal post-trip ranges, the operators would throttle fire water flow rate to match core decay heat. Flow reductions from 300 gpm to 150 gpm per SG at four hours, and from 150 gpm to 100 gpm per SG at eight hours were used in the analysis.
- Based on the fire water flow rates applied in the analysis, the fire water storage tank would need to be replenished at around 17 hours following the start of the event.
- The pressurizer safety relief valves (PSRVs) do not lift, and the PSRVs are not needed for RCS pressure reduction.

- Boron precipitation is not a concern. The RCS temperature of ~350 °F is too high for this phenomenon to be of concern.
- Pumped RCS makeup would not be required for at least 24 hours. After 24 hours, an RCS makeup pump sized for 50 gpm at 500 psi would be needed to offset RCS leakage and/or manage core reactivity.

Figure 4-1—Case 4 Pressurizer Pressure

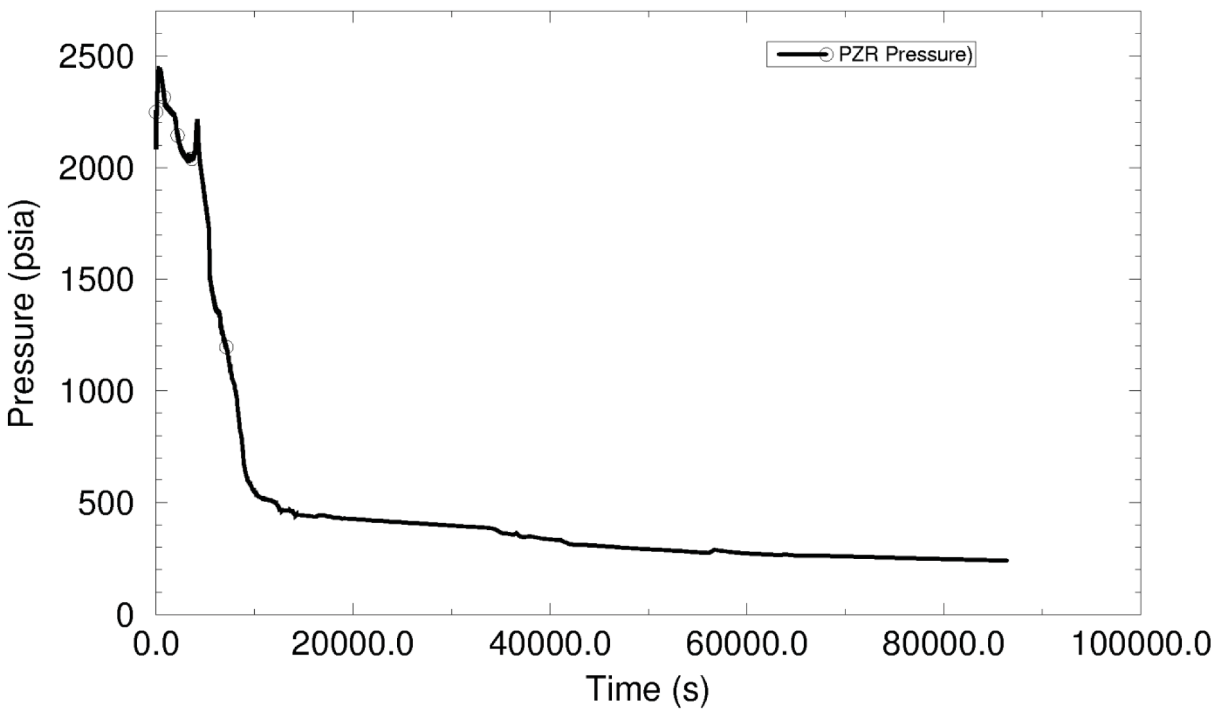


Figure 4-2—Case 4 Pressurizer Level

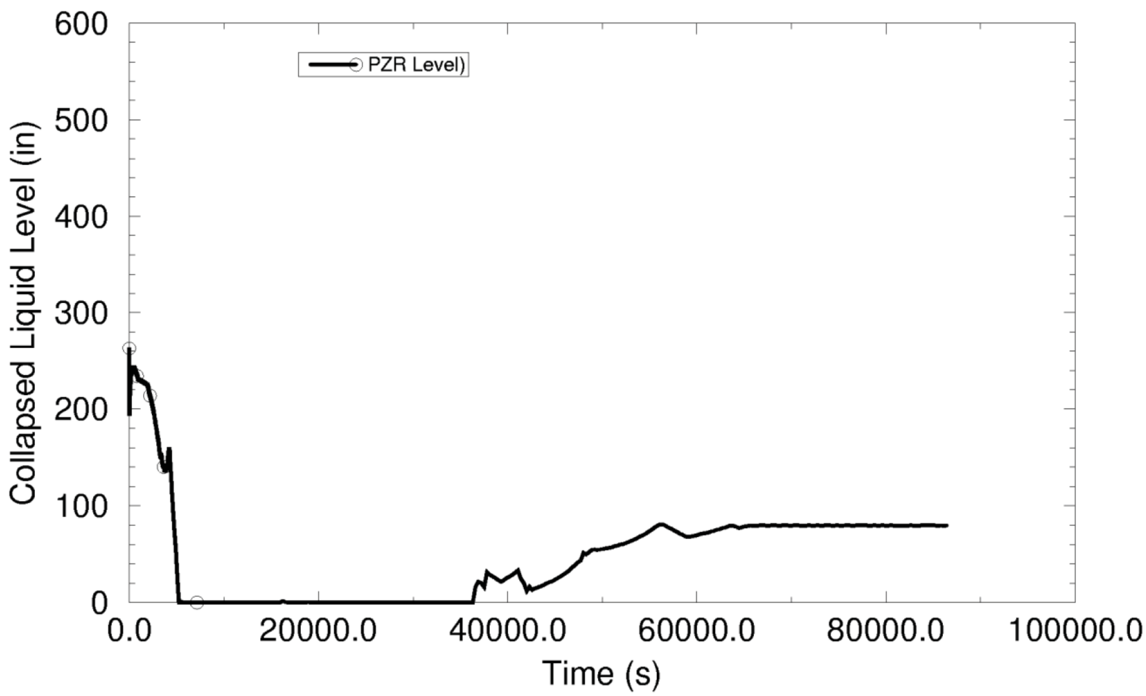


Figure 4-3—Case 4 RC Hot Leg and RV Upper Head Temperatures

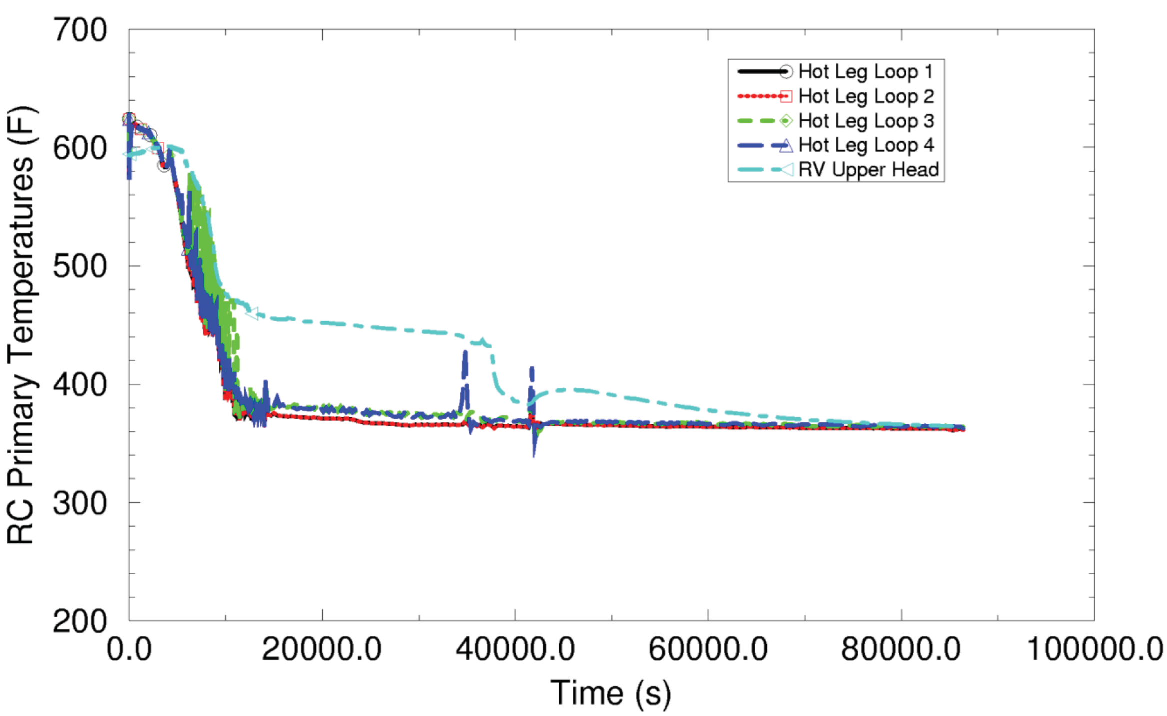


Figure 4-4—Case 4 RC Cold Leg and RV Upper Head Temperatures

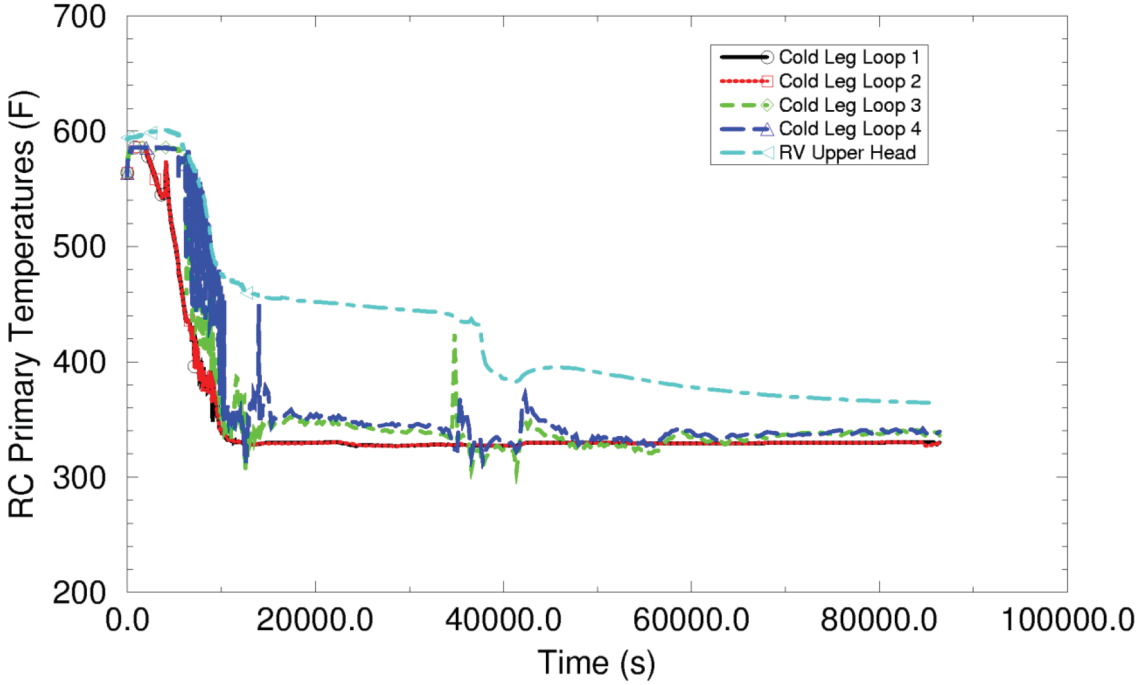


Figure 4-5—Case 4 SG Pressures

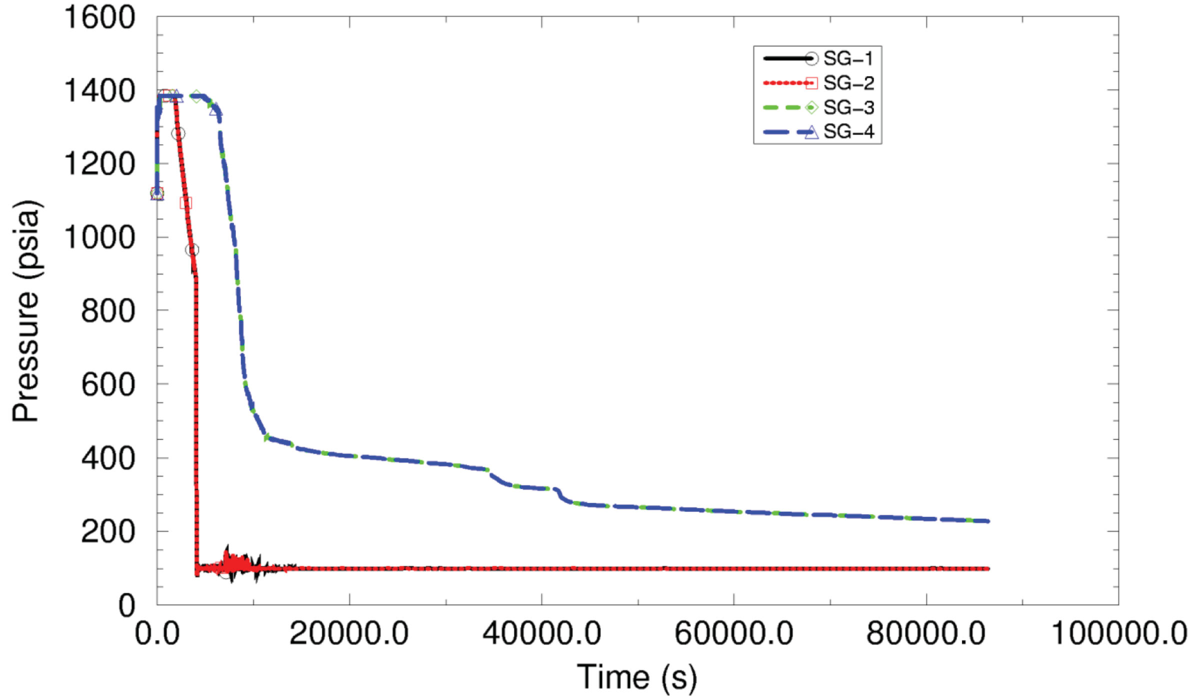


Figure 4-6—Case 4 SG Liquid Mass

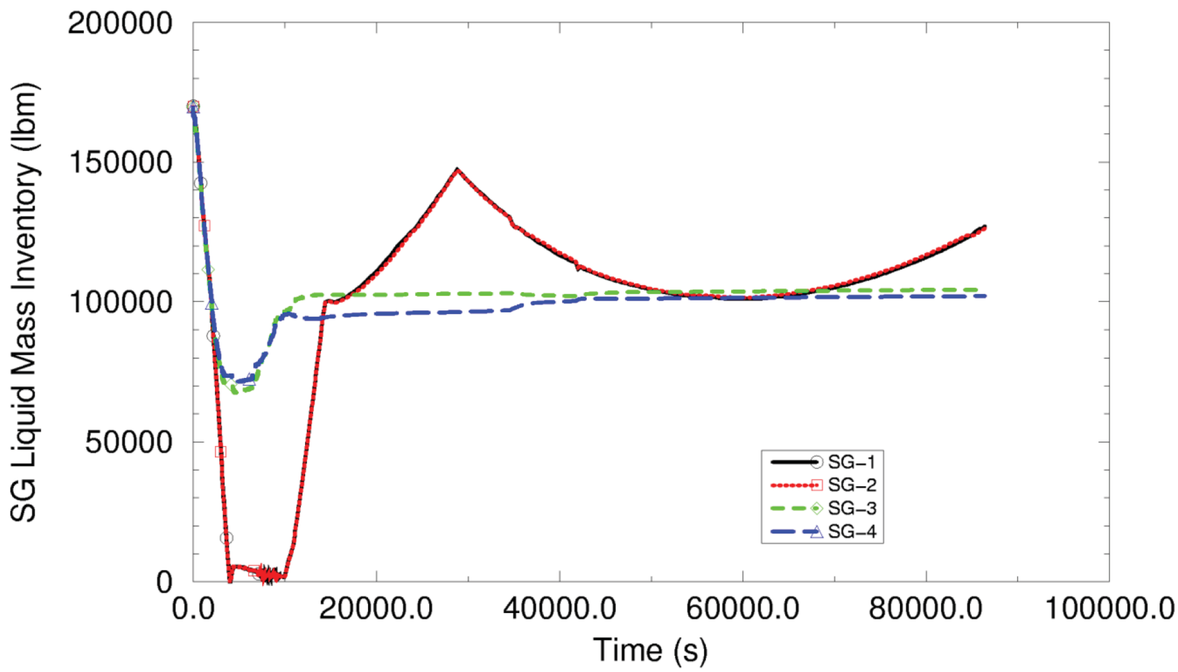


Figure 4-7—Case 4 Core Liquid Levels

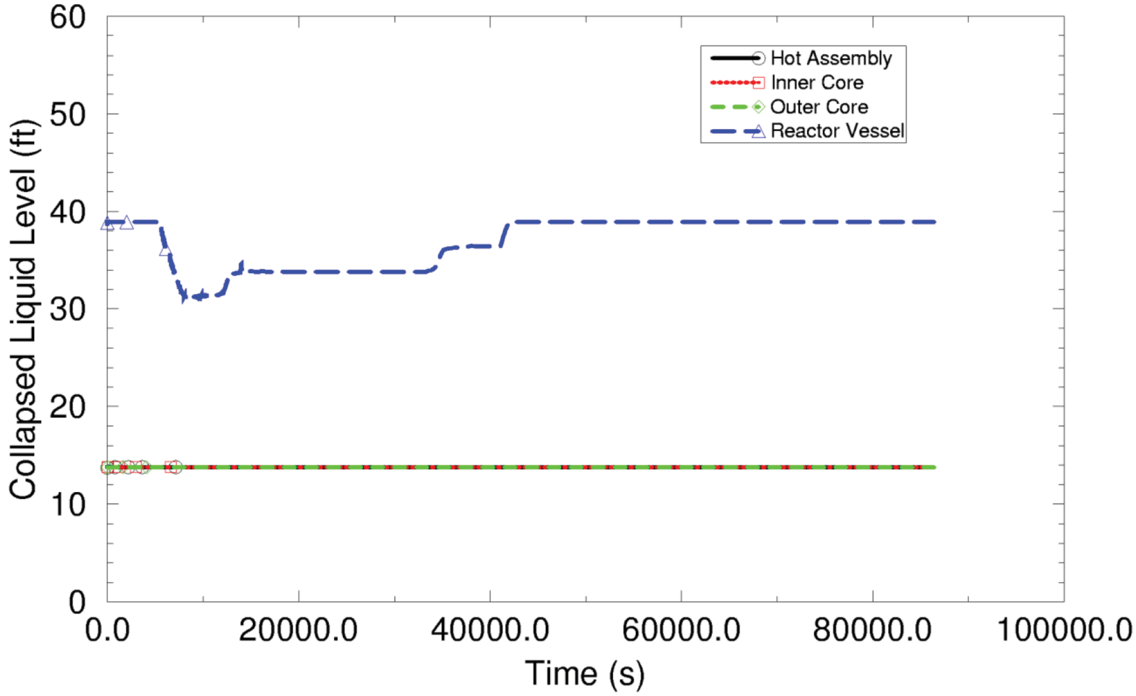


Figure 4-8—Case 4 Reactivity

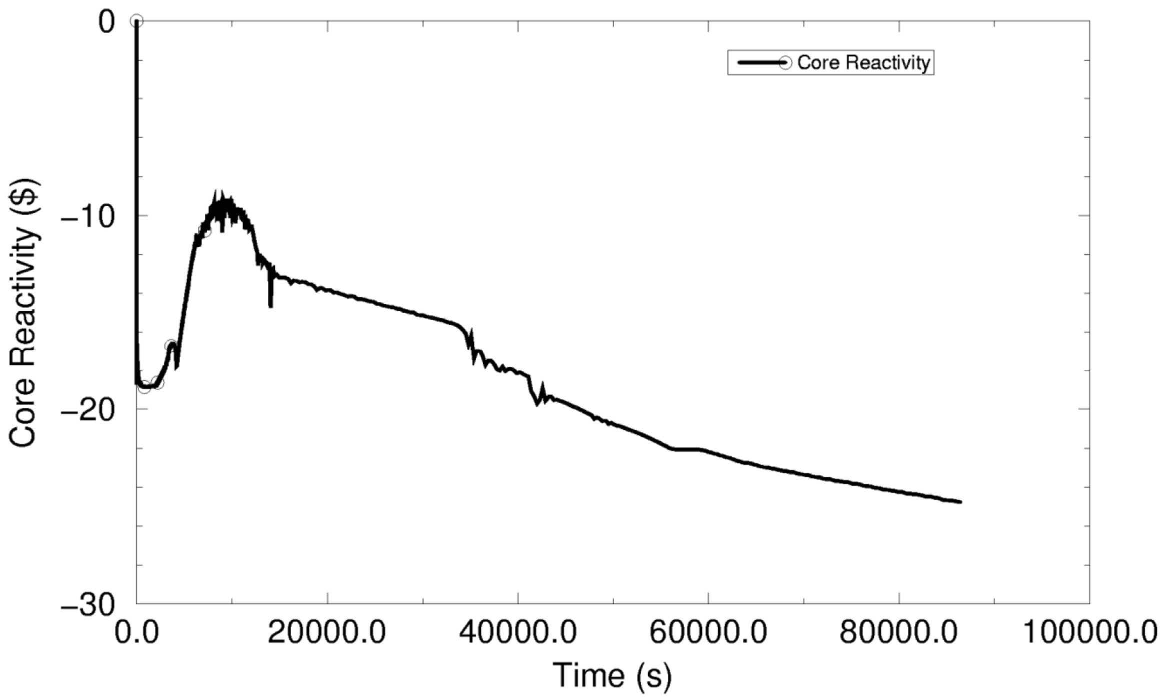
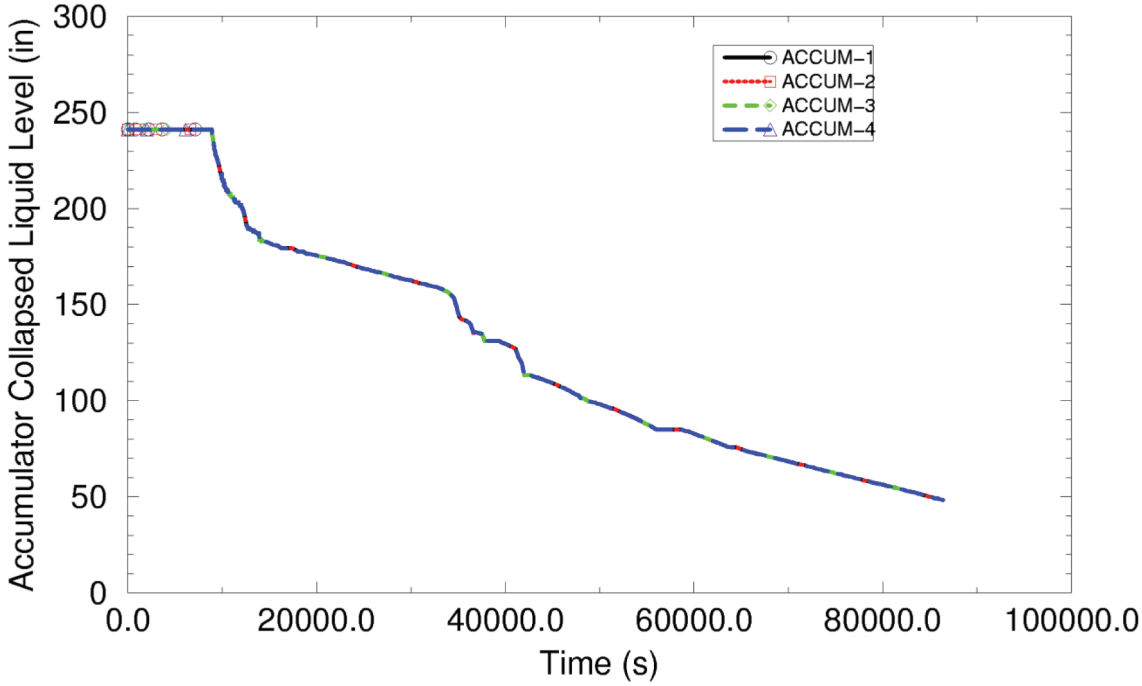


Figure 4-9—Case 4 Accumulator Liquid Levels



Case 5 was run to demonstrate secondary side feed and bleed when only two SGs and MSRTs are available and an operational decision is made to fully open the MSRTs and permit the SGs to blow down to near atmospheric pressure. In this case, the two MSRTs are fully opened at 1800 seconds and the SGs are resupplied. Fire water is delivered to the active SGs as soon as SG pressure permits (i.e., when SG pressure is below the delivery head of the fire water pump). In this analysis, fire water flow was initiated at the rate of 300 gpm per SG at 2340 seconds. All core cooling acceptance criteria (refer to Section 4.1.2) were met for this case.

4.1.3.2 Core Cooling in Mode 6 and Boron Precipitation Analysis

For an ELAP event initiated in Mode 6, primary side feed and bleed cooling is used as the method to remove core decay heat. With this core cooling method, two types of analyses were performed:

- Core cooling analyses to determine heat removal requirements and timing constraints for short-term accident mitigation.

- Boron precipitation analyses to determine long-term core cooling requirements to prevent boron precipitation.

Key Assumptions

The analysis of core cooling for an ELAP event initiated in Mode 6 was performed using the following key assumptions:

- The initial conditions span the conditions for Modes 5 and 6; an RCS pressure between 14.7 psia and 370 psia, and an RCS temperature ≤ 200 ºF.
- The RCS is adequately vented to remove core decay heat in the primary feed and bleed mode. Removal of the reactor vessel head in Mode 6 provides an adequate vent path.
- Boiling in the core is acceptable for core cooling, provided the core remains covered with liquid (refer to Section 4.1.2).
- Best estimate decay heat.
- The earliest time to enter Mode 5 following a normal plant shutdown is 16.67 hours. This conservative time establishes the maximum amount of core decay heat that must be removed in Mode 6.
- RCS level was assumed to be at the reactor vessel flange.
- It was conservatively assumed that only the volumes located within the core region are available to support the time to boil.

The analysis of boron precipitation for an ELAP event initiated in Mode 6 was performed using the following key assumptions:

- The earliest time to enter Mode 5 following a normal plant shutdown is approximately 16.67 hours. This conservatively establishes the maximum amount of core decay heat that must be removed.
- RCS makeup flow in excess of boil off refills the RCS, and conservatively, only once the cold-side is refilled, increases the mixing volume.

- The following additional assumptions were made consistent with U.S. EPR FSAR Tier 2, Chapter 15 LOCA boron precipitation analysis:
  - The boron solubility limit is 38,500 ppm.
  - The boil-off rate is based on the ANS 1973 decay heat standard with 20% uncertainty.
  - There is no credit for inlet subcooling.

Results

For short-term core cooling in Mode 6, analyses and evaluations were performed to determine injection flow requirements and estimated time to boil.

The injection flow requirements to replace boil off are determined using:

$Q = W (h_o – h_i)$

where,

Q = Decay heat.

W = Injection flow rate.

h_o = Core exit enthalpy (this corresponds to the enthalpy of saturated steam at 212 °F).

h_i = Injection flow enthalpy corresponding to the injection flow temperature.

The calculated injection flow required to replace boil off at 17 hours after shutdown was approximately 230 gpm.

The time to boil was estimated using:

Time to Saturation = $(Cp) (T_{sat} - T_{Initial})/(Q)$

where,

Cp = Specific heat, including credited metal mass and water volumes, BTU/lbm°F.

T_{sat} = Saturation temperature at atmospheric pressure, 212 °F.

$T_{Initial}$ = Initial temperature of the RCS.

Q = Best-estimate decay heat, in BTU/hr.

The estimated time to boil at 16.67 hours after shutdown with an initial temperature of 140° was 3.4 minutes (3 minutes 24 seconds).

Based on these results, the following insights can be drawn:

- A coping strategy and success path exists for the ELAP event in Mode 6 using primary side feed and bleed cooling. In particular, the core cooling acceptance criteria given in Section 4.1.2 can be met as follows:
  - The nuclear fuel in the core remains covered with coolant.
  - When RCS inventory addition is initiated, borated water is used as makeup to maintain the core subcritical.
- RCS makeup should be restored as quickly as practicable. At a minimum, a continuous RCS injection rate of 230 gpm is needed to maintain adequate inventory above the top of the fuel and remove core decay heat. Borated makeup water should be used as the injection source. The boron concentration should be equivalent to the concentration of the IRWST to ensure long-term subcriticality.

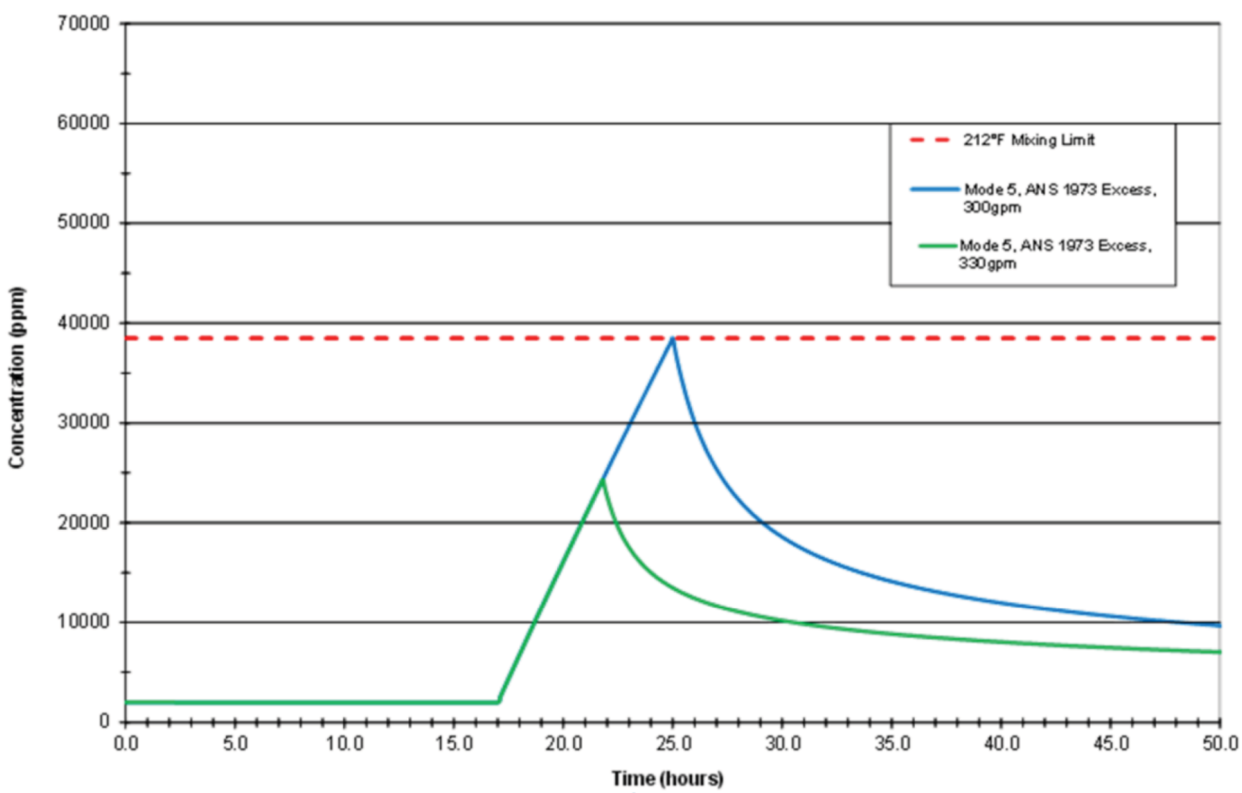
In Mode 6, core cooling is maintained in the long term by pumped flow from the IRWST or from a portable source with an equivalent boron concentration. The borated water from the IRWST provides a means for the core to remain subcritical, but causes a boron precipitation concern because of an increase in concentration from the decay heat boil off. An analysis was performed based on the U.S. EPR FSAR Tier 2, Chapter 15 LOCA boron precipitation methodology to determine the minimum injection flow rate needed to preclude boron precipitation.

The minimum flow rate to reach the solubility limit was determined. Sensitivity studies were also performed with different flow rates and a best estimate decay heat model.

Summary results of these analyses are presented in Figure 4-10. Based on these results and the analyses performed, the following insights can be drawn:

- Even with conservative decay heat assumptions, boron solubility limits are not approached for at least eight hours from the start of the ELAP event.
- A minimum RCS makeup flow rate of 300 gpm is sufficient to remove core decay heat and preclude boron precipitation using the conservative assumptions of this analysis.
- A minimum RCS makeup flow rate of 330 gpm provides substantial margin to remove core decay heat and preclude boron precipitation, and is recommended for long-term event mitigation.

Figure 4-10—Boron Precipitation Analysis Results



Minimum Injection Flow Rate, $\dot{V}_{inj} = 300gpm$

10% Increased Injection Flow Rate, $\dot{V}_{inj} = 330gpm$

4.1.3.3 RCP Seal Leakage

Following a BDBEE that results in an ELAP event, the normal methods of cooling the RCP seals with the RCP thermal barrier coolers and RCP seal injection are lost. The ELAP transient is similar to the SBO event that has been evaluated in U.S. EPR FSAR Tier 2, Section 8.4. In the U.S. EPR SBO mitigation strategy, the RCP SSSS is relied upon to close to limit RCP seal leakage. A similar strategy can be applied to the ELAP transient provided the plant parameters are maintained within the RCP SSSS qualification envelope.

For SBO mitigation, qualification testing was performed to demonstrate that the RCP SSSS would limit seal leakage to less than 0.5 gpm per pump for 24 hours. During the qualification tests, the RCP SSSS was subjected to the temperature and pressure profile representative of an SBO event.

Based on the qualification test results, an evaluation was performed to confirm that the SBO qualification testing envelope bounded the ELAP secondary feed and bleed cooling transient in Modes 1 through 5 during the initial 24-hour time period. For the Case 4 results of the S-RELAP5 analysis of secondary feed and bleed cooling (refer to Section 4.1.3.1), the evaluation concluded that the integrity and leak rate of the RCP SSSS is bounded by the SBO qualification tests results for the first 24 hours after loss of seal cooling.

For long-term ELAP event mitigation (i.e., beyond 24 hours), additional loss of RCP seal cooling tests are required for the standstill seal and the lower three RCP shaft seal stages. Test conditions will be selected based on the following considerations:

- Test conditions bound the full range of RCS conditions (temperature and pressure) that are expected for long-term mitigation of an ELAP event initiated in Modes 1 through 5.
- Test conditions bound the temperature range that may cause RCP seal degradation.

The purpose of this qualification testing is to validate the RCP shaft seal leak rate and integrity of the shaft seals when exposed to ELAP conditions on a long term basis.

4.1.3.4 Containment Pressure Control (Integrity)

Analytical Methods

Containment pressure control was evaluated using the GOTHIC (Generation of Thermal-Hydraulic Information for Containments) computer code. GOTHIC is a general purpose thermal-hydraulics software package for design, licensing, safety and operating analysis of nuclear power plant containments and other confinement buildings. Appropriate heat transfer and fluid flow correlations are used depending on fluid state. Special process models are used for components such as doors, valves, heat structures and break junctions. GOTHIC solves the conservation equations for mass, momentum and energy for multi-component, multi-phase flow. The phase balance equations are coupled by mechanistic models for interface mass, energy and momentum transfer that cover the entire flow regime from bubbly flow to film/drop flow, as well as single phase flows. The interface models allow for the possibility of thermal non-equilibrium between phases and unequal phase velocities.

GOTHIC has previously been used to analyze the containment response as discussed in U.S. EPR FSAR Tier 2, Section 6.2. BAW-10252PA-00, “Analysis of Containment Response to Pipe Ruptures using GOTHIC” (Reference 19), and ANP-10299P Revision 2, “Applicability of AREVA NP Containment Response Evaluation Methodology to the U.S. EPR™ for Large Break LOCA Analysis Technical Report” (Reference 20) are topical reports that justify application of the GOTHIC methodology to the U.S. EPR. Because the ELAP scenario is characterized by slow, but continuous containment pressurization, the GOTHIC containment response methodology is an appropriate choice for this ELAP analysis.

Key Assumptions

The GOTHIC analysis of containment response was performed using the following key assumptions and inputs:

- The GOTHIC subdivided multi-node EPR containment model was used as the base model.
- ELAP events were assumed to occur in either Modes 1 through 5, or Mode 6. Mass and energy releases from RCS leakage were modeled, along with sensible energy from the primary side and secondary side. Mass and energy releases from RCS leakage were based on the pertinent core cooling analysis in Modes 1 through 5 (refer to Section 4.1.3.1) or in Mode 6 (refer to Section 4.1.3.2).

Results

GOTHIC analyses were performed to determine the general timing of containment pressurization, the limiting mode for the ELAP event accident initiation relative to containment response, and the overall feasibility of containment spray and containment venting options to manage containment pressure response. Based on these analyses, the following insights can be drawn:

- For an ELAP event initiated in Modes 1 through 5, the GOTHIC analysis was run to 24 hours with no operator action. The maximum containment pressure at 24 hours was 20.1 psia. The projected time to reach the containment ultimate design pressure was 14.76 days (refer to Section 4.1.2).
- For an ELAP event initiated in Mode 6, the GOTHIC analysis was run to 24 hours with no operator action. During Mode 5 primary feed and bleed (which conservatively bounds Mode 6), a maximum containment pressure of 100.7 psia (86 psig) was reached at 24 hours, which is safely below the containment ultimate design pressure (refer to Section 4.1.2) of 133.2 psia (118.5 psig)
- The ELAP event initiated in Mode 6 was the limiting case because of the primary side heat rejection via primary feed and bleed cooling into the containment. The leakage flow rate and the leakage enthalpy are significantly higher with primary feed and bleed than with secondary heat removal.
- The feasibility of using a containment spray strategy for Phase 2 and 3 event mitigation was evaluated using the severe accident heat removal system

(SAHRS) spray header. A spray flow of 88.2 lbm/sec was assumed at 24 hours. For the limiting primary feed and bleed case, containment pressure immediately began to decrease following spray injection, as shown in Figure 4-11.

- The feasibility of using a containment venting strategy for Phases 2 and 3 event mitigation was also evaluated. The vent path chosen was the containment low flow purge line through a filter bank bypass line. For the limiting primary feed and bleed case, the low flow purge vent path was opened at five hours into the transient at a containment pressure of 39.3 psia (24.6 psig). Containment pressure immediately began to decrease and remained below 30 psia for the duration of the event as shown in Figure 4-12.
- The GOTHIC containment analyses demonstrated that containment pressurization following an ELAP event is a slow transient that provides ample time for operator action. Containment venting or containment sprays are both viable mitigation strategies to maintain containment integrity.

Figure 4-11—Containment Analysis Results – Containment Spray at 24 hours

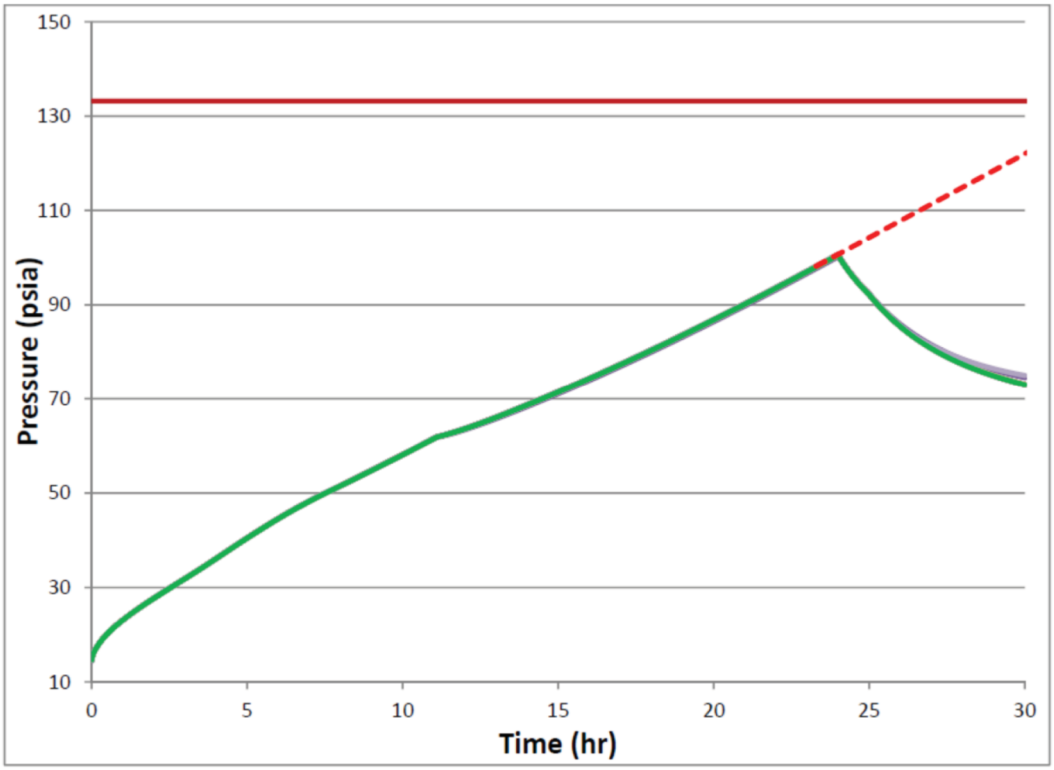
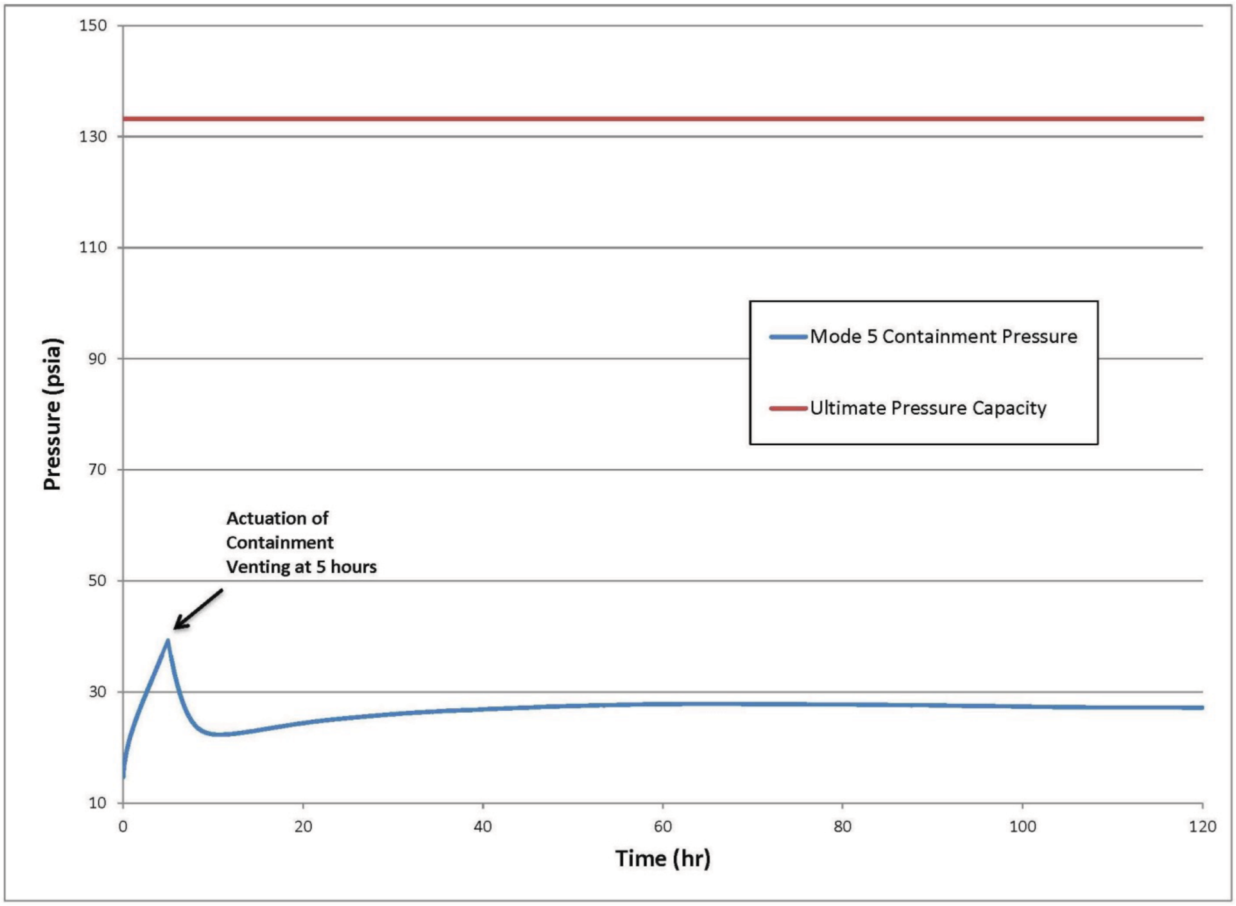


Figure 4-12—Containment Analysis Results – Containment Venting at Less than 40 psia



4.1.3.5 Safeguard Building Heatup Analysis

Analytical Methods

The GOTHIC computer code was used to evaluate heatup of the Safeguard Buildings (SBs) following a loss of all forced ventilation resulting from an ELAP event SB 2 was modeled by dividing the building into 12 homogeneous temperature regions (control volumes), which were evaluated individually with heat transfer to adjoining regions being considered. Areas with insignificant heat loads that were not expected to challenge equipment operability limit were grouped together into a single control volume for model simplification. Heat loads were modeled as heaters within each control volume.

Key Assumptions

The GOTHIC analysis of SB 2 response was performed using the following key assumptions and inputs:

- Room temperatures begin at the maximum normal temperature and 60% humidity.
- Air flow between rooms is not modeled, with the exception of flow between switchgear room 2UJK18029 and another control volume consisting of the other switchgear room and the hall. The door to switchgear room (2UJK18029) contains a two-foot-by-four-foot grating in it to allow airflow.
- Radiation heat transfer is neglected.
- Ambient temperature is 100 °F, consistent with Section 4.1.4.
- Five specified doors on the + 26'-7" elevation of the SB 2 are opened at 30 minutes after event initiation.
- Forced ventilation to SB 2 is restored at seven hours after event initiation.

Results

The results of the analysis indicated that all areas of SB 2 were maintained less than 130 °F. The most limiting room was the I&C cabinet room (2UJK18005), which reached a temperature of 121 °F. After initiation of forced flow at seven hours, the temperatures in all areas of SB 2 were maintained less than approximately 115°F.

4.1.3.6 Main Control Room Heatup Analysis

Analytical Methods

The GOTHIC computer code was used to conduct a parametric study of heatup of the MCR following a loss of forced ventilation. Refer to Section 4.1.3.4 for a description of the GOTHIC code. The MCR was modeled as a single node, with a single heat structure, comprised of concrete with a painted surface. The concrete surfaces of the room, as well as the free volume of air, served as heat sinks. The heat load was modeled as a heater. The parametric study examined changes in free volume, heat source, and concrete surface area.

Key Assumptions

The GOTHIC analysis of MCR response was performed using the following key assumptions and inputs:

- The MCR and the shift room were assumed to constitute a single, homogeneous, free volume with concrete walls, ceiling and floor.
- The MCR was assumed to have a drop ceiling which reduced the available free volume and concrete surface area. Additionally, the free volume of the MCR was further reduced for conservatism.
- The thickness of the concrete walls, floor, and ceiling was conservatively assumed to be half the thickness. The wall was conservatively treated as an insulated boundary, which thermally isolated the MCR from the surrounding rooms.
- The surface area of the walls, floor, and ceiling was reduced for conservatism.
- The concrete surface was assumed to be painted, with the thickness and properties of the coating typical for painted surfaces.
- The initial room temperature was conservatively assumed to be 80 °F.

Results

The parametric study demonstrated that if ventilation or cooling is not restored to the MCR for at least seven hours following an ELAP event, then:

- The MCR temperature would not exceed 110 °F for at least seven hours during an ELAP event with a heat load not more than 10 BTU/sec and an initial temperature not more than 80 °F.
- The MCR temperature would not exceed 95.1 °F if the heat load is not more than 5 BTU/sec.

4.1.3.7 Main Control Room Portable Cooler Sizing Evaluation

Analytical Methods

An evaluation was performed to determine the total heat input to the U.S. EPR MCR following an ELAP event to determine the minimum performance requirements for a portable cooler (air conditioner) for the MCR. The evaluation considered the heat loads from personnel and MCR equipment energized during an ELAP event to determine the total MCR heat load. This total MCR heat load was then compared against the GOTHIC parametric study results described in Section 4.1.3.6 to confirm that heatup of the MCR was acceptable. Additionally, this total MCR heat load was used to size a portable cooler for the MCR.

Key Assumptions

- Five operators were assumed in the MCR with heat input from each operator assumed to be 475 BTU/hr.
- Heat input to the MCR from emergency lighting is 1.5 kW.
- Heat input from the Safety Information And Control System (SICS) cabinets in the MCR is assumed to 2.4 kW.

Results

The evaluation determined that the MCR heat input rate was 4.36 BTU/sec, or about 16,000 BTU/hr. Examination of the results of the MCR heatup parametric study described in Section 4.1.3.6 indicated that with a heat load of 5.0 BTU/sec, the MCR temperature will rise at most to 95.1 °F within seven hours. Based on these results, the minimum portable cooler sizing was conservatively set at 32,000 BTU/hr (i.e., twice the expected heat load) to provide the capability to cool down the MCR. The portable MCR cooler would need to be placed in service within seven hours of the ELAP initiating event.

4.1.3.8 Spent Fuel Pool Time to Boil and Makeup Analysis

Key Assumptions

The SFP time to boil and makeup analysis was performed using the following key assumptions and inputs:

- During an ELAP event, spent fuel cooling by the spent fuel pool cooling system (SFPCS) heat exchangers is lost. Heatup of the SFP and boiling can be credited to cool the spent fuel, provided the water level is maintained above the top of the spent fuel (refer to Section 4.1.2). This spent fuel cooling strategy is consistent with NRC Staff guidance given in Question 5.8.4 in NUREG-1628, "Staff Responses to Frequently Asked Questions Concerning Decommissioning of Nuclear Power Reactors" (Reference 25).
- A conservative number of rack spaces is assumed with all rack spaces filled (22 years of fuel storage).
- The maximum SFP heat load was assumed at 130 hours after reactor trip based on a full core off-load. This SFP heat load conservatively assumes at least 15% excess margin.
- Heat losses from the SFP are conservatively neglected.

Results

The SFP time to boil and makeup analysis was performed to determine the bulk SFP heatup time and boil-off rate.

The SFP bulk heat-up time is conservatively calculated using $\Delta t = MCp\Delta T/Q$,

where,

M (lbm) is the mass of water in the SFP.

Cp (BTU/lbm°F) is the specific heat.

ΔT (°F) is the temperature rise.

Δt (hrs) is the time to complete the temperature rise.

Q (BTU/hr) is the heat added to the SFP from the spent fuel stored in the pool.

The boil-off rate is calculated using:

Boil off Rate = Q / h_{fg},

where,

Q (BTU/hr) is the heat added to the SFP from the spent fuel stored in the pool.

h_{fg} (BTU/lbm) is the latent heat of evaporation.

Based on these analyses, the following insights can be drawn:

- During a full core offload refueling condition, the time to reach SFP bulk boiling following the loss of all SFP cooling is approximately 4.3 hours. The initial boil-off rate is 140 gpm. The boil-off rate decreases over time as the spent fuel decay heat decreases.
- If spent fuel cooling is not restored, then an additional 30.5 hours is available to boil-off the pool inventory, while maintaining the level above the top of the spent fuel racks (refer to Section 4.1.2). Therefore, the total time to uncover the spent fuel (from a temperature of 140 °F) is approximately 4.3 + 30.5 hours = 34.8 hours.
- Since the operators have approximately 35 hours to restore cooling and/or makeup to the SFP, boiling of the SFP can be credited as the Phase 1 event mitigation method, and cooling and/or makeup to the SFP can be credited for Phases 2 and 3 event mitigation.

4.1.3.9 DC Load Shedding

Analytical Methods

To determine how long the Class 1E uninterruptible power supply (EUPS) system battery capacity can be extended, the following process was used:

- The loads on the EUPS battery were identified based on the design basis accident EUPS battery sizing calculation and the Electrical Load List.
- Loads required for ELAP Phase 1 scenario mitigation were identified and their operation defined.
- Loads to be shed from the EUPS battery for an ELAP event were identified.
- The time elapsed before ELAP load shedding takes place was identified.
- The ELAP EUPS duty cycle was defined by applying by the ELAP Phase 1 equipment operation and load shedding sequence to the loads supplied by the EUPS battery.
- The margins to apply for the EUPS batteries during an ELAP event were determined.
- The duration of battery discharge availability until the minimum acceptable cell voltage is reached was determined using the EUPS battery cell type, the ELAP EUPS duty cycle, and the ELAP margins.

Key Assumptions

The DC load shedding analysis was performed using the following key assumptions and inputs:

- No additional accidents or failures are assumed to occur immediately prior to or during the event, other than those causing the ELAP event.
- Reasonably protected installed electrical distribution equipment, including inverters and cabling, is assumed to remain available.

- ELAP event is identified at 10 minutes after initiation of the event after offsite power is lost, all EDGs fail to start or load, and all SBO diesel generators fail to start or load.
- DC load shedding is assumed to take 60 minutes to complete and is completed by 70 minutes after ELAP event initiation.
- Only those containment isolation valves identified in the U.S. EPR SBO coping strategy (refer to Section 8.4 of the U.S. EPR FSAR) and the primary coolant injection pump containment isolation valve (30JND11AA012) are assumed to be operated for the ELAP event.
- A minimum acceptable battery output of 210 Vdc is assumed.
- A 5% design margin is included in the cell size to account for less than optimum operating conditions of the battery. An aging factor of 1.25 is applied to the cell capacity to provide reasonable assurance that the battery is capable of meeting its design loads throughout its service life. A temperature correction factor of 1.11 (60 °F) is applied to the cell capacity.

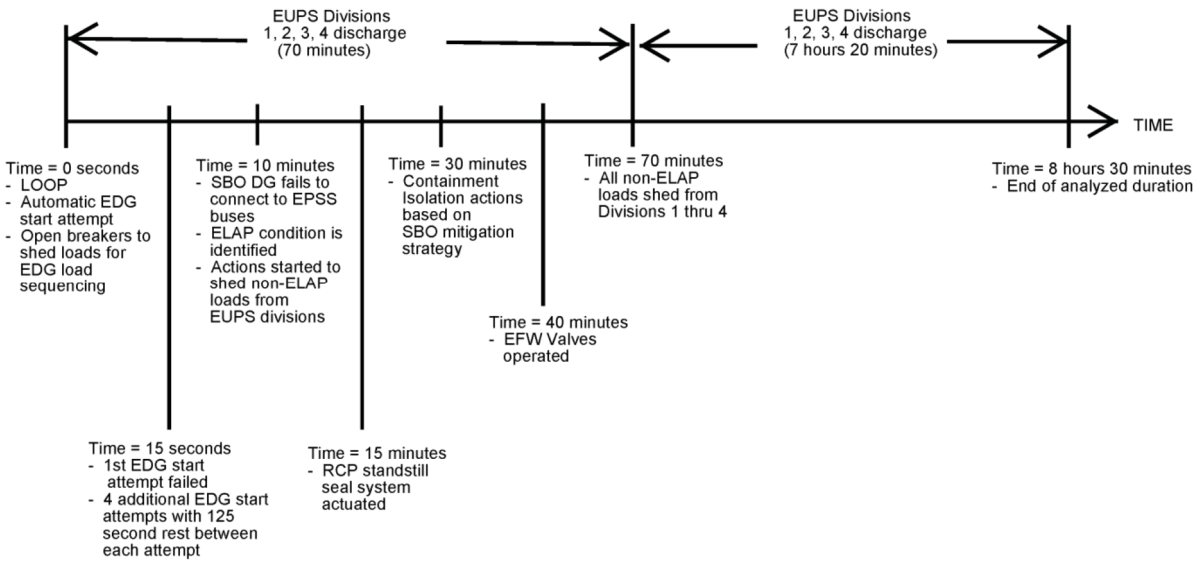
Results

Based on this analysis, it was determined that the EUPS battery discharge duration can be extended from two hours to eight hours and 30 minutes. The overall timeline for DC load shedding is provided in Figure 4-13. To extend the EUPS battery capacity to this duration, the following operator actions are required:

- Identify the ELAP event and begin DC load shedding in all four divisions of the EUPS within 10 minutes after initiation of the ELAP event.
- Complete shedding of non-ELAP loads in all four divisions of the EUPS within 70 minutes after initiation of the ELAP event.

- Before the EUPS divisions are depleted at eight hours and 30 minutes, re-energize credited EUPS Divisions 1 and 2 for long-term event mitigation in Phases 2 and 3.

Figure 4-13—ELAP Battery Discharge Duration



4.1.4 Reasonable Protection of Installed and Portable Equipment

The term “reasonable protection,” within the context of this technical report, means that the design of the SSC it is describing either meets the U.S. EPR design basis for the applicable external hazards, or has been shown by analysis or test to meet or exceed the U.S. EPR design basis. This definition is consistent with the definition of “robust” in NEI 12-06 (Reference 3).

Additionally, NEI 12-06 (Reference 3) provides the following guidance:

Section 3.2 Performance Attributes states:

> “…installed equipment that is designed to be robust with respect to DBEE is assumed to be fully available”.

Section 3.2.1.3 Initial Conditions, (6) states:

> "Permanent plant equipment that is contained in structures with designs that are robust with respect to seismic events, floods and high winds and associated missiles are available."

Section 3.2.1.3 (8) states:

> "Installed electrical distribution systems…remain available provided they are protected…"

The non-safety-related SSC (for example, diesel-driven fire water pump, discharge piping, portable equipment, Fire Protection Building, and the fire water storage tanks) that are relied upon to mitigate an ELAP event are designed to meet the FLEX reasonable protection standards. The following subsections comprise a list of external hazards defined in Section 2 of NEI 12-06 (Reference 3) and a description of the way in which the non-safety-related SSC, including the FLEX equipment, portable equipment, and Fire Protection Building, meet the FLEX reasonable protection requirements.

NEI 12-06 (Reference 3) provides the following guidance:

Section 2.3 states:

> "Considering the external hazards applicable to the site, the FLEX mitigation equipment should be stored in a location or locations such that it is reasonably protected such that no one external event can reasonably fail the site FLEX capability. Reasonable protection can be provided for example, through provision of multiple sets of portable on-site equipment stored in diverse locations or through storage in structures designed to reasonably protect from applicable external events."

Seismic

The Fire Protection Building and the fire water storage tanks are the only non-safety-related structures that are credited for Phase 1 event mitigation of an ELAP event. The Fire Protection Building and the fire water storage tanks are designed to meet or exceed ASCE 7-10, "Minimum Design Loads for Buildings and Other Structures" (Reference 22), consistent with the FLEX guidance.

Equipment that is credited for Fukushima event mitigation is either Seismic Category I, or is non-safety-related equipment that is installed in Seismic Category I, Seismic Category II and Conventional Seismic structures with the following clarification:

> To provide adequate functionality following a safe shutdown earthquake (SSE), the following supplemental seismic requirements are imposed:
>
> - For valves and piping – ANSI/ASME B31.1 (Reference 24). For example, this includes the non-safety-related piping and valves from the diesel-driven fire water pumps to the Emergency Feedwater system.
> - For other SSC – ASCE 43-05, "Seismic Design Criteria for Structures, Systems, and Components in Nuclear Facilities" (Reference 23). For example, this includes the ELAP diesel generator.

This seismic qualification strategy for equipment is consistent with the seismic qualification strategy used for the non-safety-related Fire Protection System as described in U.S. EPR FSAR Tier 2, Section 9.5.1.

Flooding

The U.S. EPR is designed as a "dry site" location, which means the plant grade level is located one foot above the flood elevation. This refers to the Seismic Category I safety-related structures. The Fire Protection Building and the fire water storage tanks are the only non-safety-related structures that are credited for Phase 1 event mitigation of an ELAP event. Taking this into account, the Fire Protection Building and the fire water storage tanks are designed and constructed at least one foot above the flood elevation.

Severe Storms with High Winds / Missile Protection

The Fire Protection Building and fire water storage tanks are designed to meet or exceed ASCE 7-10 (Reference 22). In accordance with NEI 12-06 FLEX requirements, the Fire Protection Building and the fire water storage tanks are missile protected. Missile protection of the Fire Protection Building and fire water storage tanks is provided for a hurricane wind speed of 230 mph per Regulatory Guide 1.221 (Reference 19). Selection of this hurricane wind speed is consistent with U.S. EPR FSAR Tier 2, Section 3.3.2.1.

Snow, Ice, and Extreme Cold

The Fire Protection Building and fire water storage tanks are designed to meet or exceed ASCE 7-10 (Reference 22), consistent with the FLEX guidance. Minimum temperatures for design of non-safety systems in the U.S. EPR are based on a best-estimate, 1% exceedance value of -10 °F. Because of the beyond design basis nature of the ELAP event, design evaluations of equipment performance (safety-related or non-safety-related) are similarly based on a best-estimate, 1% exceedance value of -10 °F.

High Temperatures

In accordance with NEI 12-06 (Reference 11), equipment should be maintained at a temperature within a range to support its likely function when called upon. Maximum temperatures for design of non-safety systems are based on a best-estimate, 1% exceedance value of 100 °F dry bulb / 77 °F wet bulb coincident. Because of the beyond design basis nature of the ELAP event, design evaluations of equipment performance (safety-related or non-safety-related) are similarly based on a best-estimate, 1% exceedance value of 100 °F dry bulb / 77 °F wet bulb coincident.

Table 4-2 provides a summary of reasonable protection.

Table 4-2—Reasonable Protection of ELAP Event Mitigation Equipment

Hazard	Applicability	General Approach
Seismic	Structure	Seismic Category I or ASCE 7-10 for Seismic Category II and Conventional Seismic structures.
	Systems and Components	Seismic Category I or reasonable protection of non-safety-related installed equipment in Seismic Category I, Seismic Category II and Conventional Seismic structures. Reasonable protection of non-safety-related equipment installed in Seismic Category I, Seismic Category II and Conventional Seismic structures includes: • ASME B31.1 – piping, valves and supports. • ASCE 43-05 – other equipment (e.g., pumps, diesels, electrical).
Flooding	Structure	Seismic Category I or Seismic Category II and Conventional Seismic structures located at same elevation as Seismic Category I structures. Note: U.S. EPR uses a “dry site” concept for Seismic Category I structures.
High Wind	Structure	Seismic Category I or ASCE 7-10 for Seismic Category II and Conventional Seismic structures with wind speeds based on Regulatory Guide 1.221.
Snow, Ice and Cold Temperatures	Structure	Seismic Category I or ASCE 7-10 for Seismic Category II and Conventional Seismic structures.
	Systems and Components	Equipment (safety-related or non-safety-related) evaluated for 1% exceedance temperatures (-10 °F).
High Temperatures	Structure	Seismic Category I or ASCE 7-10 for Seismic Category II and Conventional Seismic structures.
	Systems and Components	Equipment (safety-related or non-safety-related) evaluated for 1% exceedance temperatures (100 °F dry bulb/77 °F wet bulb coincident).

4.1.5 Mitigation Strategies

Based on the analytical bases provided in Section 4.1.3 and the reasonable protection requirements provided in Section 4.1.4, mitigation strategies were developed to satisfy the overall acceptance criteria given in Section 4.1.2. In particular, mitigation strategies were grouped as follows:

- AC and DC Power (Section 4.1.5.1).
- Core Cooling in Modes 1 through 5 (Secondary Side Feed and Bleed) (Section 4.1.5.2).
- Core Cooling in Mode 6 with the Reactor Vessel Head Removed (Section 4.1.5.3).
- Containment Pressure Control (Integrity) (Section 4.1.5.4).
- Spent Fuel Cooling (Section 4.1.5.5).
- Instrumentation and Controls (Section 4.1.5.6).
- Support Functions (Section 4.1.5.7).

Details of the mitigation strategy for each of these groupings are provided in the following subsections.

4.1.5.1 AC and DC Power

During an ELAP event, DC power is required for operation of electrical switchgear and I&C systems and for operation of essential AC motor-operated valves that are battery backed. The only power sources available during Phase 1 event mitigation are the two-hour batteries and their associated EUPS busses. Actions are required to extend the period of time that this power is available.

In the U.S. EPR EUPS design, each of the 250 VDC two-hour batteries (31/32/33/34BTD01) is connected to a 250 VDC switchboard (31/32/33/34BUC). One of two redundant battery chargers (31/32/33/34BTP01 or 31/32/33/34BTP02) is connected to each 250 VDC switchboard. The EUPS battery chargers BTP01 and BTP02 are normally supplied 480 VAC input power by the emergency power supply system (EPSS). Battery charger BTP01 is supplied by EPSS load center BMC in Divisions 1 and 4 and by EPSS motor control center (MCC) BNA02 in Divisions 2 and 3. Battery charger BTP02 is supplied by EPSS load center BMB in all four divisions. The battery chargers rectify the 480 VAC power to 250 VDC power and furnish electrical energy for the steady-state operation of loads connected to 250 VDC switchboards, while returning its battery to a full state of charge or maintaining its battery in a fully charged state.

Each 250 VDC switchboard provides input power to an inverter. The inverter is used to transform the DC power to three phase AC power to the EUPS busses.

For the mitigation of an ELAP event, all non-essential loads with the exception of the I&C cabinets are segregated from essential loads on separate AC and DC busses, referred to as “load shed busses.” Refer to U.S. EPR FSAR Tier 2, Figure 8.3-5. Each load shed bus is connected to the associated EUPS bus or 250 VDC switchboard by an isolation device that can be remotely operated from the Main Control Room (MCR). An ELAP condition is identified shortly after it has been determined that the EPSS buses cannot be energized from the EDGs or the SBO diesel generators. All load shed bus infeed isolation devices are opened from the MCR within 60 minutes after determination that an ELAP is in progress to conserve the stored energy in the batteries. Nine SAS cabinets in Divisions 1 and 4, six safety automation system (SAS) cabinets in Divisions 2 and 3, and one SICS remote shutdown station (RSS) workstation cabinet in Divisions 1 and 4 are de-energized locally by opening isolation devices at the cabinets. These actions extend battery availability to eight hours and 30 minutes as discussed in Section 4.1.3.9.

Prior to depletion of the batteries, the batteries in Divisions 1 and 2 are recharged from a prestaged, permanently installed dedicated diesel generator using the Divisions 1 and 2 battery chargers. The diesel generator is located in the Fire Protection Building and is referred to as the ELAP diesel generator. The ELAP diesel generator is independent from the plant and is also used to power permanently-installed plant equipment that is credited for Phase 2 and 3 event mitigation (for example, the primary coolant injection pump). This ELAP diesel generator is provided with a diesel fuel storage tank with a minimum capacity corresponding to eight hours of fully loaded operation. The ELAP diesel fuel storage tank is provided with external fill connections to allow replenishment in Phases 2 and 3. The ELAP diesel generator has a minimum load capability of 650 kw.

The ELAP diesel generator is a 480 VAC generator with a transformer to step up the voltage to 6.9 kV. The power is transmitted from the Fire Protection Building to the SB at 6.9 kV, and stepped down to 480V using a 6.9 kV to 480V step-down transformer. The 6.9 kV to 480V step-down transformer is located in SB 2 to meet FLEX reasonable protection requirements.

The feed from the ELAP diesel generator is routed to two transfer switches. Refer to Figure 4-14. One switch is located in the Division 1 feed from 6.9 kV switchgear 31BDB to EPSS 480V load center 31BMB, and the other is located in the Division 2 feed from 6.9 kV switchgear 32BDB to EPSS 480V load center 32BMB. The transfer switches are located in SBs 1 and 2, which meet the FLEX reasonable protection requirements.

Two additional transfer switches are provided that allow connection of 480V portable generators, which are provided by the COL applicant. One of the transfer switches is capable of providing power from either the ELAP diesel generator or a portable generator to the transfer switches feeding both 31BMB and 32BMB. The other transfer switch is only capable of providing power from either the ELAP DG or a portable generator to the transfer switch feeding 32BMB. Temporary connections to each of these transfer switches is provided from easily accessible electrical connections located at grade level inside the SBs. The transfer switches are arranged to allow the portable diesel generator at each connection to feed one EPSS 480V load center, or a larger portable generator connected to the transfer switch capable of providing power to both

31BMB and 32BMB to feed both EPSS 480V load centers. This provides the COL applicant the option of providing one larger, or two smaller portable diesel generators.

This AC and DC repowering mitigation strategy reflects the following considerations:

- At least two 250 VDC switchboards (Divisions 1 and 2) and their associated EUPS busses must be powered from the ELAP diesel generator because all systems are not four-division or four-train redundant, and certain equipment requires power from a minimum of two EUPS divisions to be operable. The main steam relief isolation valves (MSRIVs) require two EUPS divisions to be operable. The communications equipment and special emergency lighting is not four-division or four-train redundant either.
- The Division 3 and Division 4 250 VDC switchboards and their associated EUPS busses are de-energized by eight hours and 30 minutes after initiation of the event prior to depletion of their associated batteries. All loads are stripped from the Division 3 and Division 4 250 VDC switchboards and EUPS busses, and then the associated battery isolation device is opened. These actions are performed for equipment protection of the batteries, and are not required for event mitigation.
- The plant operators have ample time (eight hours and 30 minutes after initiation of the event) to repower the EUPS Divisions 1 and 2. As a result, the ELAP event can be mitigated in the short term (Phase 1) and long term (Phases 2 and 3) using only Division 1 and 2 equipment without power interruption.

The sequence of actions and required completion times for re-energizing Divisions 1 and 2 differ depending upon the plant mode at event initiation.

<u>Modes 1 through 5</u>

If the ELAP event is initiated in Modes 1 through 5, action is required to place the ELAP diesel generator in service within seven hours after event initiation to allow operation of Division 1 and Division 2 supply and exhaust ventilation fans of the electrical division of the safeguard building ventilation system (SBVSE). All loads are stripped from EPSS 480V load centers 31BMB and 32BMB and the four transfer switches are aligned to supply power from the ELAP diesel generator to the 480V load centers. The ELAP diesel generator is then started and its output breaker is closed, energizing 31BMB and 32BMB. All loads are stripped from 480V MCC 31BNB01 and 32BNB01, and the MCCs are energized by closing the feeder breakers from EPSS 480V load center 31BMB and 32BMB. The load breakers on 31BNB01 and 32BNB01 for the SBVSE Trains 1 and 2 supply, exhaust, and battery room fans are then closed.

The breakers on EPSS 480V load center 31BMB for battery charger 31BTP02 and on 480V load center 32BMB for battery charger 32BTP02 are closed prior to depletion of the Division 1 and Division 2 batteries at eight hours and 30 minutes after event initiation.

Mode 6 with the Reactor Vessel Head Removed

If the ELAP event is initiated in Mode 6 with the reactor vessel head removed, repowering of Divisions 1 and 2 is performed in three phases to minimize the time required to place the primary coolant injection pump in service.

In the first phase, the primary coolant injection pump is required to be placed in service within two hours after event initiation, prior to exhaustion of the accumulator inventory (refer to Section 4.1.3.2). For this phase, only 31BMB and 31BNB01 are re-energized to provide power to the pump. In the second phase, 32BMB and 32BNB01 are energized to allow operation of Division 2 SBVSE supply and exhaust ventilation fans. In the third phase the Divisions 1 and 2 EUPS 250 VDC switchboards and busses are powered from the ELAP diesel generator.

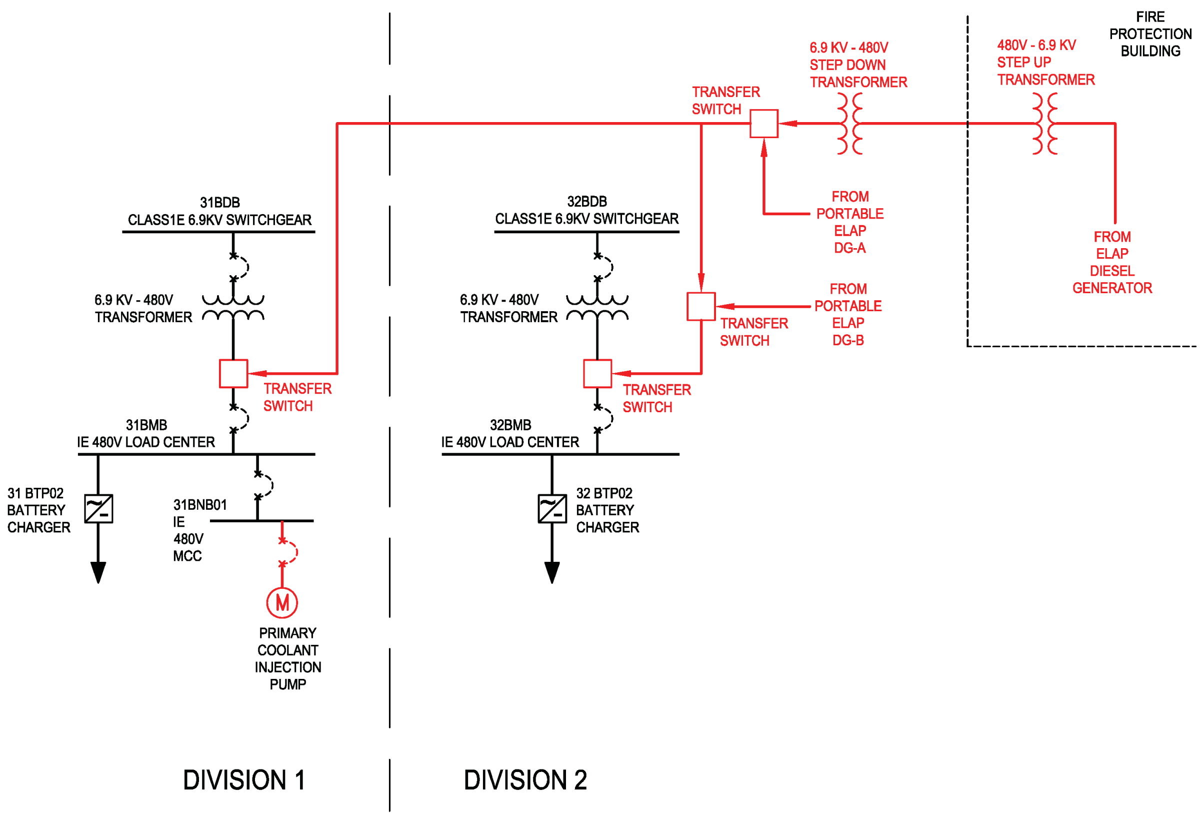
To implement the first phase, two transfer switches are positioned to align the output of the ELAP diesel generator to EPSS 480V load center 31BMB. All loads are stripped from EPSS 480V load center 31BMB and 480V MCC 31BNB01. The ELAP diesel generator is started and its output breaker is closed, restoring electrical power to EPSS

480V load center 31BMB. EPSS 480V MCC 31BNB01 is energized by closing its feeder breaker from EPSS 480V load center 31BMB.

In the second phase, action is required to power EPSS 480V MCC 32BNB01 to allow operation of Division 2 SBVSE supply and exhaust ventilation fans within seven hours after event initiation. All loads are stripped from EPSS 480V load center 32BMB and 480V MCC 32BNB01. Two transfer switches are positioned to align the output of the ELAP diesel generator to EPSS 480V load center 32BMB. EPSS 480V MCC 32BNB01 is energized by closing the feeder breaker on EPSS 480V load center 32BMB. EPSS 480V MCC 31BNB01, which supplies the SBVSE Train 1 fans, was energized in the first phase. The load breakers on 31BNB01 and 32BNB01 for the SBVSE Trains 1 and 2 supply, exhaust, and battery room fans are then closed.

In the third phase, action is required to power the Division 1 and Division 2 250 VDC switchboards and EUPS busses from the ELAP diesel generator prior to depletion of the Division 1 and Division 2 batteries. To accomplish this, the breakers on EPSS 480V load center 31BMB for battery charger 31BTP02 and on 480V load center 32BMB for battery charger 32BTP02 are closed prior to eight hours and 30 minutes after event initiation.

Figure 4-14—Simplified Diagram of Repowering EUPS



4.1.5.2 Core Cooling in Modes 1 through 5 (Secondary Side Feed and Bleed)

Three main functional objectives must be satisfied to effectively provide core cooling in Modes 1 through 4 using secondary side feed and bleed:

- RCS inventory control.
- Primary heat removal.
- Reactivity control.

The U.S. EPR strategy is to utilize secondary feed and bleed cooling when the RCS is intact and the SGs are available. If the ELAP event occurs in Mode 5 and the SGs are available for use, the RCS is allowed to heat up into Mode 4 and secondary side feed and bleed cooling will be used for core cooling.

For primary heat removal, Table D-1 of NEI 12-06 provides a summary of performance attributes for PWR core cooling functions. For core cooling and heat removal in Modes 5 and 6 with SGs not available, it establishes the following method:

> “All Plants Provide Means to Provide Borated RCS Makeup**
>
> ** Note: There may be short periods of time during Modes 5 & 6 where plant configuration may preclude use of this strategy.”

For the U.S. EPR, a condition exists during short periods of Mode 5 operation where the plant configuration precludes using borated RCS makeup to provide core cooling. During the transition to and from Mode 6, a condition exists when the SGs are not available for heat removal and the reator vessel head is not removed. If the reactor vessel head is not removed, there is insufficient venting of the RCS to support primary feed and bleed cooling. The duration of this condition is limited in nature (e.g., two to three days of total time each fuel cycle).

The risk associated with operating in this condition, following a BDBEE is low because:

- The exposure time period is short.
- The frequency of a BDBEE occurring during such a short exposure time period is very low, particularly a BDBEE of sufficient magnitude to result in a LOOP, common cause failure of the EDGs and common cause failure of the SBO diesel generators.

An assessment of the plant risk during these BDBEE conditions is described in U.S. EPR FSAR Tier 2, Section 19.1.5.4.

An overview of the mitigation strategies for these functional objectives is provided in Table 4-3. Details of the mitigation strategies for each of these functional objectives are provided in the following subsections.

Table 4-3—FLEX Capability – Core Cooling Summary – Modes 1 through 5

Safety Function		Method	Phase 1	Phase 2 and 3
Core Cooling	Reactor Core Cooling and Heat Removal (Modes 1 through 5 SGs available)	• Secondary side feed and bleed with diesel-driven fire pump to feed SGs via EFW header. • Depressurize SGs for secondary makeup. • Sustained source of makeup water.	• Permanent piping from seismically qualified diesel-driven fire pump to EFW header. • SGs are depressurized using MSRTs. • SG makeup sufficient to restore SG level with installed equipment following SG dryout. • Fire water storage tanks and building are reasonably protected.	• Permanent connections (primary and alternate) for portable, self-powered, SG makeup pump. • Portable means to refill fire water storage tank to extend baseline coping. • Portable means to refill fire pump diesel tanks and lube oil to extend baseline coping.
	RCS Inventory Control/Long-Term Subcriticality	• Low leakage RCP seals and/or borated high pressure RCS makeup required.	• RCP SSSS limits RCP seal leakage during initial event mitigation. • Accumulator volume initially maintains RCS inventory and borates the RCS.	• Permanent connections (primary and alternate) for portable, self-powered, high pressure RCS makeup pump. • Borated water source is portable tank mixed on site, off-site source, IRWST, or extra borating system (EBS) tanks.
	Key Reactor Parameters	• SG level. • SG pressure. • RCS pressure. • RCS temperature.	• Instruments powered by Class 1E DC bus. • DC load shedding used to extend baseline coping.	• Power Divisions 1 and 2 Class 1E batteries using either the ELAP diesel generator in the Fire Protection Building or by portable generators.

4.1.5.2.1 RCS Inventory Control

Adequate core cooling is provided by maintaining the liquid level in the reactor vessel above the top of the fuel in the core (refer to Section 4.1.2). RCS inventory control is challenged during an ELAP event by the loss of all AC powered RCS injection sources and by the potential for increased RCP seal leakage resulting from overheating of the RCP seals. Mitigation of the challenge to core cooling requires a source of makeup to the RCS, as well as minimization of RCS inventory losses.

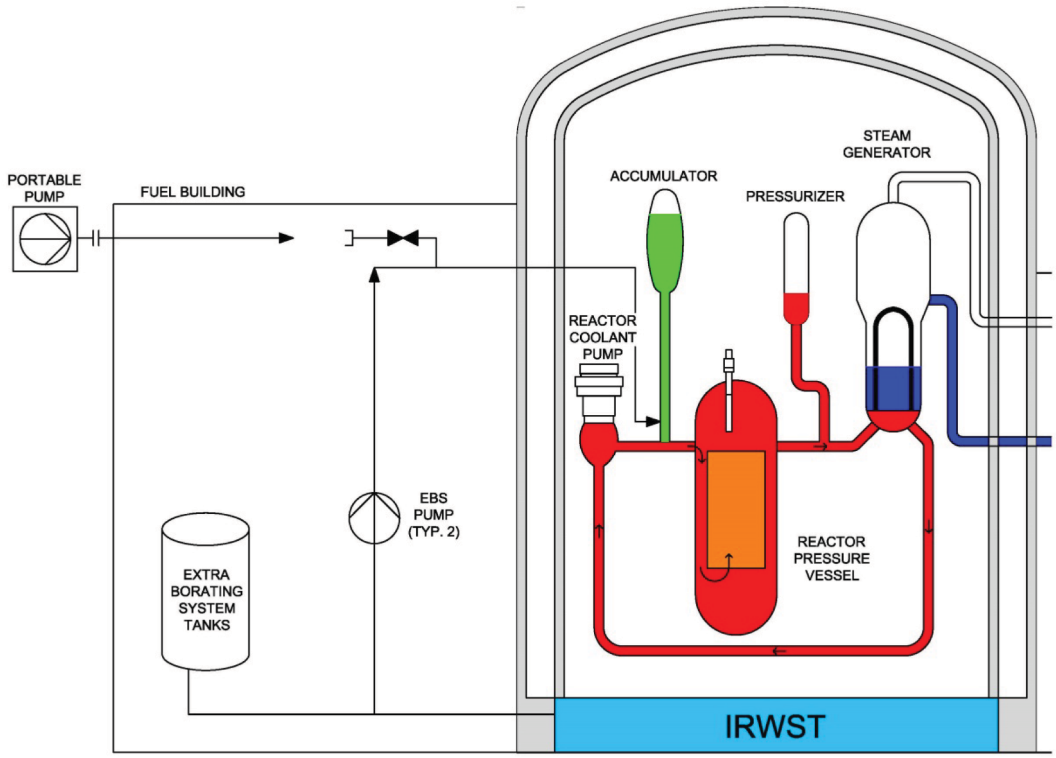
4.1.5.2.1.1 RCS Makeup

The reduction in RCS pressure resulting from primary to secondary heat transfer during SG depressurization enables the accumulators to inject borated water for RCS inventory makeup and reactivity control. Approximately 37,000 gallons of accumulator inventory is available to make up for RCS contraction and leakage until pumped injection can be placed into service.

In Section 4.1.3.1, analyses were performed to characterize the RCS response to an ELAP event initiated in Modes 1 through 5. These results indicated that accumulator injection began at approximately two and a half hours into the event and continued until approximately 24 hours without exhausting the accumulator inventory. These results indicate that adequate time exists for installation and alignment of a source of pumped injection for RCS makeup in Phase 2 (refer to simplified Figure 4-15).

An alternate supply source can be connected to the EBS discharge piping using a portable pump. The suction source to the portable pump may be a portable borated water supply or the IRWST. The U.S. EPR uses enriched boron. The equivalent boron concentration of the portable borated water supply is in the range of 1700 ppm enriched boron to 1900 ppm enriched boron. These values correspond to the minimum and maximum Technical Specification limits for the IRWST and accumulators.

Figure 4-15—RCS Makeup in Modes 1 through 5 Simplified Diagram



Two connections are provided on the EBS discharge lines to allow installation of a portable self-powered RCS makeup pump for Phase 2 event mitigation. The connection points are two EBS vent lines (valves 30JDH10AA506 and 30JDH40AA506). The two valves satisfy the FLEX N+1 criterion because the Fuel Building (FB) is protected, and the two valves are located in different zones of the FB. Refer to U.S. EPR FSAR Tier 2, Figure 6.8-1.

The core cooling analysis described in Section 4.1.3.1 indicated that the RCS pressure at the time pumped makeup would be required was approximately 400 psia. RCS leakage at this time was assumed to be 13 gpm. A calculation was performed to establish the minimum pump performance required. The results of this calculation show that the pump must be able to provide 50 gpm (to provide margin for possible increased RCS leakage) with a head rise across the pump of 1242 ft. The required net positive suction head (NPSH) for the pump must be less than 23.79 ft. The maximum expected pump discharge pressure under these conditions was calculated to be 548.4 psia. The EBS vent valve lines used as connection points are sized at two inches to accommodate the 50 gpm makeup flow rate.

If EBS Division 1 is used, the portable pump is connected to 30JDH10AA506. EBS Train 1 containment isolation valve (30JDH10AA006) is opened, and either EBS Train 1 RCS isolation valve (30JDH10AA015) or EBS Train 2 RCS isolation valve (30JDH20AA015) is opened to provide a flow path to the RCS. All of the valves required to be aligned to provide a flow path to the RCS are powered from their respective divisional EUPS busses.

Operators open EBS Division 4 containment isolation valve (30JDH40AA006) and either EBS Division 3 RCS isolation valve (30JDH30AA015) or EBS Train 4 RCS isolation valve (30JDH40AA015) from the MCR prior to Division 3 and Division 4 battery depletion at eight hours and 30 minutes. All of the valves are powered from their respective divisional EUPS busses. This action is performed even if the plan is to use EBS Division 1, because Division 3 and Division 4 EBS RCS isolation valves are located inside the containment and must be opened to create a viable RCS makeup path from EBS Division 4 to maintain N+1 capability. If EBS Division 4 is used, the portable pump is connected to 30JDH40AA506, and the EBS Division 4 containment isolation valve (30JDH40AA006) and either EBS Division 3 RCS isolation valve (30JDH30AA015) or EBS Division 4 RCS isolation valve (30JDH40AA015) provide a flow path to the RCS.

4.1.5.2.1.2 Minimizing RCS Inventory Losses

Following an ELAP event initiated in Modes 1 through 4, RCS inventory loss can occur through three pathways:

- RCS letdown.
- Pressurizer continuous degasification line.
- RCP seals.

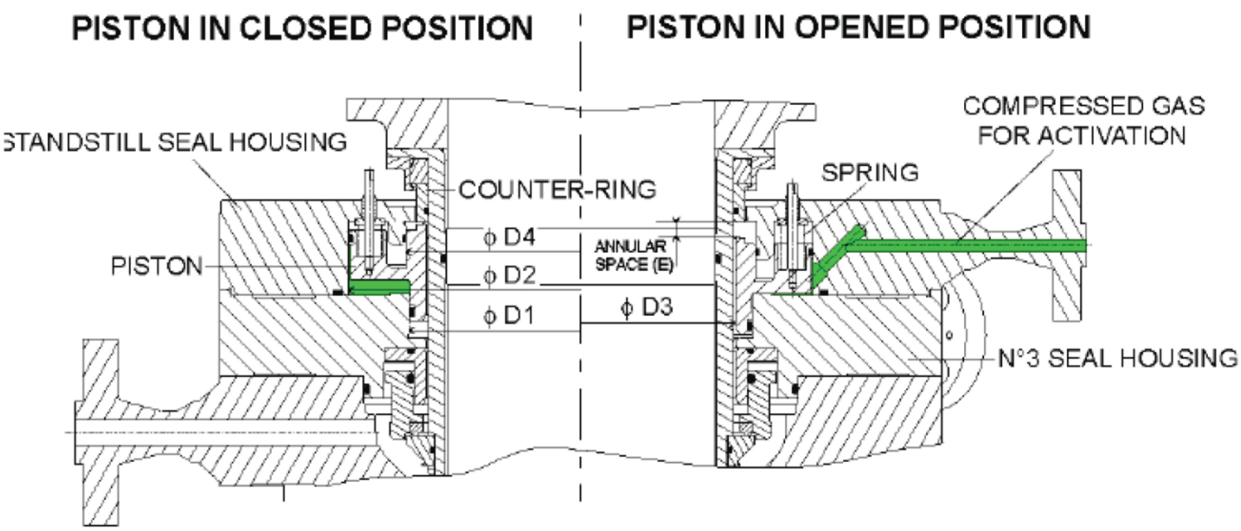
The letdown line isolation valve (30KBA10AA001) is automatically closed upon detection of low EDG bus voltage in all four electrical divisions for greater than 30 seconds. The letdown line isolation valve is powered from the Division 1 EUPS (31BRA) and fails as-is upon a loss of power after isolation.

The flow through the pressurizer continuous degasification line is limited by a flow restriction to approximately 0.004 lbm/sec. The pressurizer continuous degasification isolation valves (30JEF10AA503 and 30JEF10AA504) are closed by the operator when time is available. The pressurizer continuous degasification isolation valves are powered from the Division 1 and Division 4 EUPS busses (31BRA and 34BRA) and fail as-is upon a loss of power after isolation.

The RCPs are provided with an SSSS to limit RCP seal leakage during loss of seal cooling events (refer to Figure 4-16). The SSSS is a static seal located above the Number 3 seal, between the Number 3 seal housing and the pump coupling sleeve. It consists of a ring piston surrounding the pump shaft, which moves up under nitrogen pressure to land on the counter-ring of the shaft (closing annular space “E” in Figure 4-16). When the static seal is open, the piston is located on the bottom side of the Number 3 seal housing. To engage the SSSS, the piston is raised by injecting nitrogen under the piston until it comes into contact with the counter-ring. The leak tightness is created by metal to metal contact. The static seal is equipped with springs between the top of the piston and the end of the static seal housing. These springs are designed to return the piston to the down position when there is no actuation pressure and no pressure downstream of the Number 3 seal. Static sealing between the components (for example, piston and housing) is provided by O-rings designed for high temperatures.

The operators will remotely close the SSSS and all three seal leak-off isolation valves on each RCP within 15 minutes after the RCPs have tripped. All of the valves required to change position for SSSS closure and seal return isolation are powered from the EUPS two-hour batteries and fail as-is upon a loss of power after actuation. Closure of the SSSS and seal return isolation valves on all four RCPs limits total RCP seal leakage to less than or equal to 2 gpm.

Figure 4-16—RCP SSSS



4.1.5.2.2 Primary Heat Removal

Primary heat removal is required to remove the decay heat transferred from the core to the RCS. Additional primary heat removal, above core decay heat, is required to depressurize the RCS to allow low pressure makeup sources (accumulators, portable pumps) to be used for core cooling during an ELAP event. The mitigation strategy for an ELAP event initiated when SGs are available in Modes 1 through 5 utilizes primary to secondary heat transfer for primary heat removal. Primary to secondary heat transfer requires a source of feedwater to the SGs and a path to relieve steam from the SGs. Refer to simplified Figure 4-17.

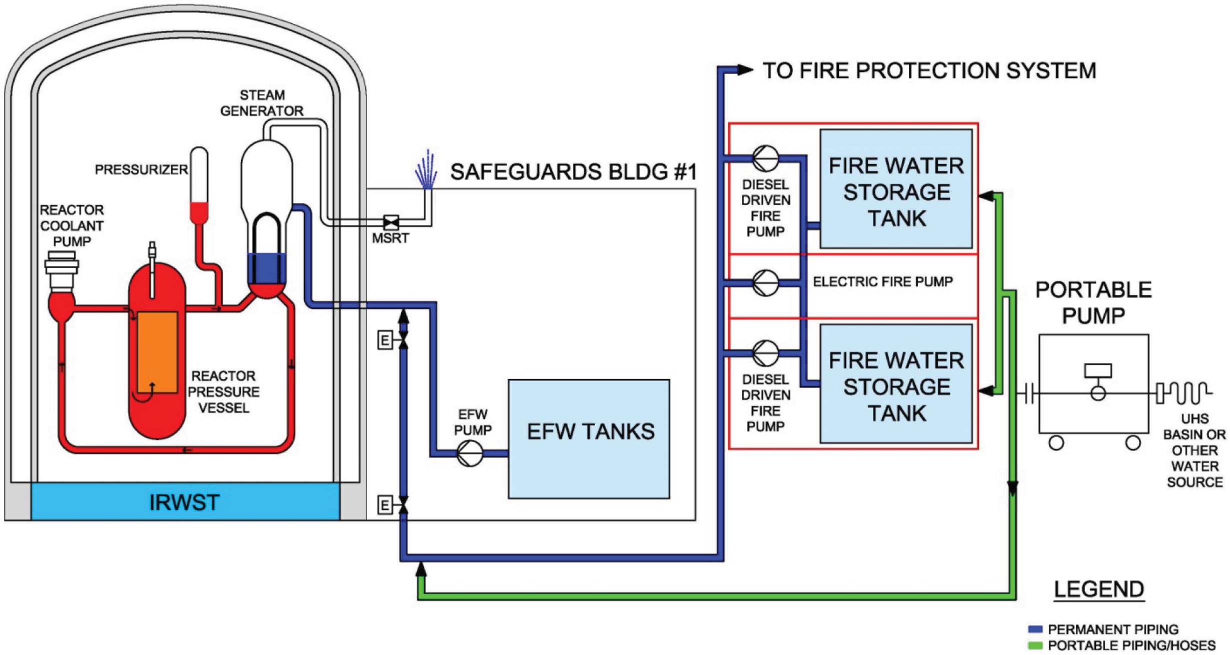
4.1.5.2.2.1 Feedwater Supply to SGs

The fire water storage tanks are used as a source of feedwater to the SGs during Phase 1 of the event. Two 300,000 gallon steel lined concrete storage tanks are provided (Tank 1 is assumed to be available for supplying a feedwater source, while Tank 2 is assumed to be available for firefighting). These tanks meet the NEI FLEX standards for reasonable protection. Each tank is provided with a six-inch seismically qualified connection to allow the tanks to be refilled using a portable self-powered pump during Phase 2 and Phase 3 event mitigation.

The diesel-driven fire pumps are used to pump fire water to the EFW discharge cross-connect header to supply feed to the SGs during event mitigation. Refer to U.S. EPR FSAR Tier 2, Figure 9.5.1-1. The diesel-driven fire pumps take suction on the fire water storage tanks. These diesel-driven fire pumps and their associated diesel fuel storage tanks are located in the Fire Protection Building. The Fire Protection Building meets the FLEX standards for reasonable protection. The diesel fuel storage tanks for the fire pumps are provided with external fill connections to allow fuel replenishment during Phases 2 and 3 of event mitigation.

A permanently installed, seismically qualified six-inch pipe is provided between the fire pump discharge header and the EFW discharge cross-connect header. This piping includes a manual isolation valve (30SGA01AA091) inside the Fire Protection Building. The line is routed underground into SB 1, which provides reasonable protection of the underground line. Two motor-operated isolation valves (30LAR55AA005 and 30LAR55AA002) are provided on this line inside the SB. Both motor-operated isolation valves are powered from EUPS Train 1 bus 31BRA. A check valve (30LAR55AA001) is also provided between the downstream motor-operated valve and the EFW discharge cross-connect header.

Figure 4-17—Secondary Side Feed and Bleed Simplified Diagram



The EFW discharge cross-connect valves (30LAR14/24/34/44 AA001) are closed during normal operation. These valves are opened to align flow from the cross-connect header to all EFW trains. The valves are powered from their respective divisional EUPS busses. The valves can be manually positioned locally if power is not available.

The EFW SG level control valves (30LAR11/21/31/41 AA105) are opened to allow flow to the respective SG. These valves are maintained open during normal operation and fail as-is when power is lost to the valves as a result of DC load shedding.

The SG isolation valves (30LAR11/21/31/41 AA006) are opened to allow flow to the respective SG. These valves are maintained open during normal operation, and fail as-is when power is lost to the valves as a result of DC load shedding.

A hose connection is provided on a four-inch vent valve (30LAR54AA501) on the EFW discharge cross-connect header in SB 4. This connection provides additional defense-in- depth by allowing the fire protection system in Safeguard Building 4 to supply feed to the SGs by manually connecting a hose between the fire system and the EFW discharge header vent.

Provisions are included for installation of a portable self-powered pump to supply SG feed water during Phases 2 and 3. Two connections (N+1) are provided for the portable pump discharge on the line connecting the fire pump discharge header to the EFW discharge cross-connect header. One of these connections is located at the Fire Protection Building and the other is located at the exterior of SB 1. A connection is also provided on the fire water storage tanks outlet cross-connect line to provide suction to the portable pump from the fire water storage tanks.

4.1.5.2.2.2 SG Steaming Paths

The SG steaming paths are provided by the main steam relief trains (MSRT). Each SG is provided with an MSRT that consists of a main steam relief isolation valve (MSRIV) and a main steam relief control valve (MSRCV). Steaming one of the SGs requires opening the MSRIV and throttling the MSRCV to achieve the desired steam flow.

The MSRIVs (30LBA13/23/33/43AA001) are pilot-operated valves and are opened by venting pressure from the area above the main operating piston. Each MSRIV has four solenoid-operated pilot valves arranged as two pilot valves in series on each of the two redundant control lines. Two pilot valves in series must be energized to vent the steam pressure and maintain the MSRIV open. If the pilot valves are de-energized they close, and if at least one pilot valve in each control line is closed, the MSRIV closes. Each of the four solenoid-operated pilot valves are powered from a different EUPS division. The solenoid power supplies are assigned in such a way that Divisions 1 and 2 powered solenoids are in series on one control line, and Divisions 3 and 4 powered solenoids are in series on the other control line.

Additional defense-in-depth is provided by a third control line in parallel with the other two control lines. The third control line has two manual valves in series to provide a power independent means to open the MSRIV locally. The MSRIV opens when both of the manual valves in the third control line are opened.

For ELAP events initiated in Modes 1 through 4, the Division 1 and Division 2 MSRCVs (30LBA13/23 AA101) are throttled to cool and depressurize the RCS and to reduce SG pressure below the discharge head of the diesel-driven fire pumps. For ELAP events initiated in Mode 5, the Division 1 and Division 2 MSRCVs (30LBA13/23 AA101) are fully opened and left open.

The MSRCVs are powered from their respective divisional EUPS busses. Power from Division 1 and Division 2 EUPS busses is available during the period of SG depressurization. The valves fail as-is when power is lost, and are provided with the capability for local manual control.

4.1.5.2.2.3 Initiation of Controlled Cooldown and Depressurization

An ELAP event is diagnosed within 10 minutes after event initiation when the SBO diesel generators fail to start or load. To mitigate ELAP events initiated in Modes 1 through 4, the results of Case 4 in Section 4.1.3.1 demonstrate that the core can be adequately cooled if only two SGs and two MSRTs are used for controlled depressurization. Accordingly, a controlled depressurization of SG1 and SG2 is initiated at 30 minutes by opening SG1 and SG2 MSRIVs (30LBA13AA001 and 30LBA23AA001) and manually controlling SG 1 and SG2 MSRCVs (30LBA13AA101 and 30LBA23AA101) from the MCR for an RCS cooldown rate of 90 °F/hr. For ELAP events initiated in Mode 5, the RCS will be allowed to heat up into Mode 4 and the MSRCVs will be left fully open.

Manual isolation valve (30SGA01AA091) inside the Fire Protection Building is normally maintained open. Motor-operated valves (30LAR55AA005 and 30LAR55AA002) are opened from the MCR to align the diesel-driven fire pump discharge to the EFW discharge cross-connect header. The EFW Train 1 and Train 2 discharge cross-connect valves (30LAR14AA001 and 30LAR24AA001) are opened to align the feed supply to SG1 and SG2. One diesel-driven fire pump is started prior to SG1 and SG2 dryout.

The analysis of an ELAP event initiated in Mode 1 indicated that dryout for SG1 and SG 2 occurred approximately 37 minutes after the start of depressurization, and would be detected by an increasing trend in RCS temperatures. When dryout is detected, the SG1 and SG2 MSRCVs (30LBA13AA101 and 30LBA23AA101) are set to control SG pressures at 100 psia. As SG1 and SG2 pressure drops below the shutoff head of the diesel-driven fire pumps, flow begins to the SGs. The diesel-driven fire pumps were conservatively assumed to have a capacity of greater than 2500 gpm at 185 psi (capacity of the pumps is 2500 gpm at 213 psi). A minimum of 660 gpm (330 gpm to each of two SGs) is delivered to the SGs when SG pressures are 100 psia.

Feed flow to the SGs re-establishes primary to secondary heat transfer and the RCS starts cooling again.

SG1 and SG2 levels begin to recover about three hours after initiation of the event. When SG levels have reached normal level (48% narrow range), the Train 1 and Train 2 EFW discharge cross-connect valves (30LAR14AA001 and 30LAR24AA001) are throttled from the MCR to control level. This action conserves fire water storage tank inventory and prevents SG overfill.

Depletion of fire water storage tank 1 is calculated to occur at approximately 18 hours after the start of the event. Fire water storage tank 1 must be replenished from other sources using the fill connections provided, or a portable pump and water supply must be placed in service prior to tank depletion, which is prior to 17 hours after event initiation. Requiring replenishment or alternate feed source at 17 hours provides margin to loss of pump suction.

The diesel-driven fire pump fuel oil storage tanks require replenishment prior to depletion utilizing the provided external fill connections. The fuel oil storage tank sizing and diesel fuel usage at the required fire water flow rates provide reasonable assurance that replenishment is not required until three and a half days after the event.

4.1.5.2.3 Reactivity Control

Reactivity control is required to provide reasonable assurance that criticality does not occur due to the positive reactivity addition caused by RCS cooling. The reduction in RCS pressure resulting from primary to secondary heat transfer during SG depressurization enables the accumulators to inject borated water for RCS inventory makeup and reactivity control. Approximately 37,000 gallons of accumulator inventory is available to maintain the flow required to make up for RCS leakage and contraction until pumped injection can be placed into service.

In Section 4.1.3.1, analyses were performed to characterize the RCS response to an ELAP event initiated in Mode 1. These results indicated that accumulator injection began at approximately two and a half hours into the event and continued until approximately 24 hours without exhausting the accumulator inventory. These results indicated that the reactor is maintained subcritical throughout the period of accumulator injection.

Reactivity control in Phase 2 of event mitigation is accomplished by providing a borated suction source for a portable self-powered RCS makeup pump as discussed in Section 4.1.5.2.1).

4.1.5.3 Core Cooling in Mode 6 with the Reactor Vessel Head Removed (Primary Side Feed and Bleed)

Four main functional objectives must be satisfied to provide core cooling in Mode 6 with the reactor vessel head removed using primary side feed and bleed:

- RCS inventory control.
- Primary heat removal.
- Reactivity control.
- Prevention of boron precipitation.

An overview of the mitigation strategies for these functional objectives is provided in Table 4-4. Details of the mitigation strategies for each of these functional objectives are provided in the following subsections.

Table 4-4—FLEX Capability – Core Cooling Summary – Mode 6

Safety Function		Method	Phase 1	Phase 2 and 3
Core Cooling	Core Cooling and Heat Removal (Mode 6 reactor vessel head removed)	• Borated water injected. • Primary side feed and bleed with RCS vented to containment.	• Accumulator volume (~37,000 gallons total) initially to maintain RCS inventory and borate RCS. • Accumulator addition rate is controlled by adjusting accumulator pressure prior to Mode 5 entry and by opening accumulator isolation valves to pre-determined positions after event initiation. The required accumulator pressure and discharge valve positions are determined as a part of the Initial Test Program. This provides at least two hours to transition to Phase 2.	• Prestaged, primary coolant injection pump installed in parallel with MHSI pump with suction from the IRWST and discharge through an MHSI discharge line. • Primary coolant injection pump is powered from either the ELAP diesel generator in the Fire Protection Building or by portable generators. • A permanent connection for a portable, self-powered, low pressure RCS makeup pump.
	Key Reactor Parameters	• RCS pressure • RCS temperature	• Instruments powered by Class 1E DC bus. • DC load shedding used to extend baseline coping.	• Power Divisions 1 and 2 Class 1E batteries using either the ELAP diesel generator in the Fire Protection Building or by portable generators.

4.1.5.3.1 RCS Inventory Control

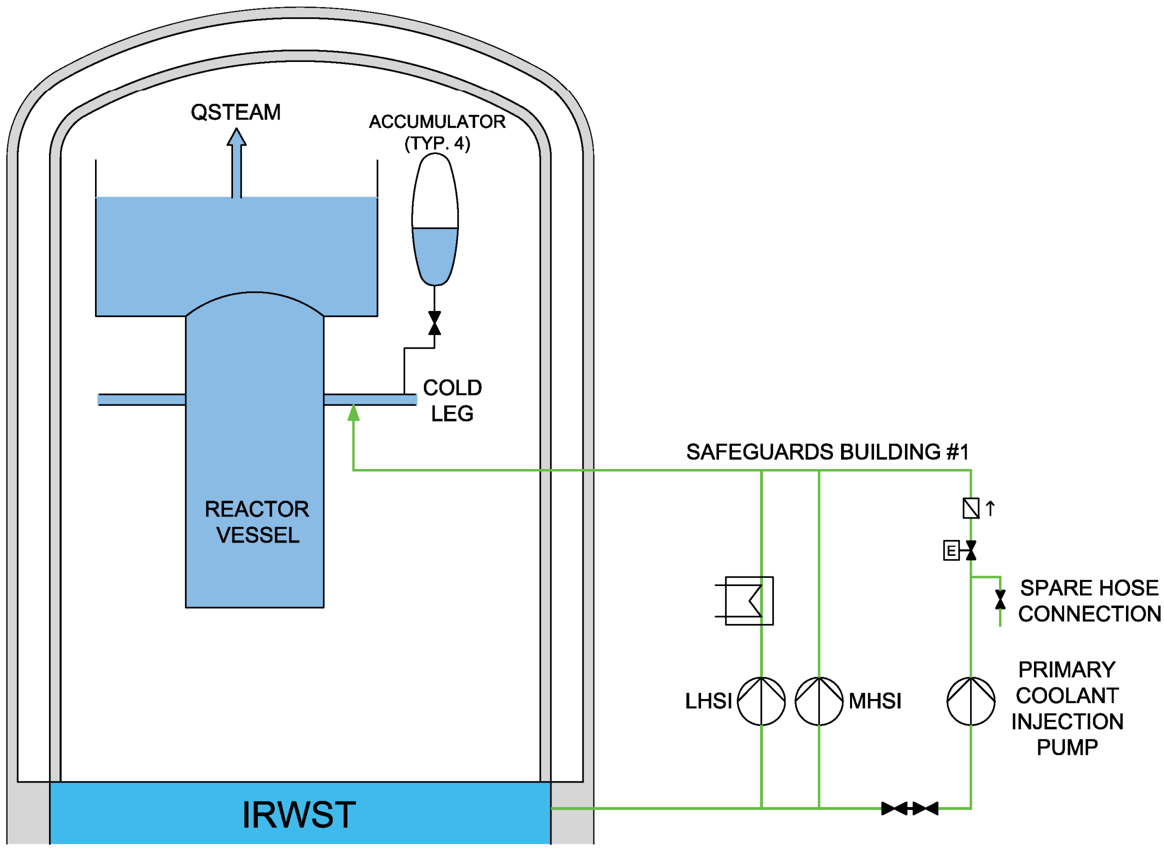
Adequate core cooling is provided by maintaining the liquid level in the reactor vessel above the top of the fuel in the core (refer to Section 4.1.2). Core cooling is challenged during an ELAP event in Mode 6 with the reactor vessel head removed by the loss of all AC powered RCS injection sources and by the loss of normal access to the UHS. Mitigation of the challenge to core cooling requires a source of makeup to the RCS. With the head removed, no additional RCS vent path is required.

When an ELAP event occurs in Mode 6 with the reactor vessel head removed, normal RCS heat removal using the residual heat removal system stops because of a loss of power to the pumps and loss of normal access to the UHS. The RCS heats up until it reaches saturation, and then begins to boil. The inventory in the RCS is converted to steam as boiling continues and the RCS water level decreases. Additional inventory must be added to the RCS at a rate greater than or equal to the rate of boil off to prevent core uncovery. A calculation was performed to determine makeup flow requirements to maintain core cooling in Mode 6. As discussed in Section 4.1.3.2, this calculation determined that a minimum makeup flow rate of 230 gpm is required for core cooling.

For Phase 1 event mitigation in Mode 6, the accumulators are used as the source of RCS injection. Accumulator pressure is adjusted to a pre-determined value and the accumulator isolation valve breakers on 31/32/33/34BRA are closed prior to entry into Mode 5. The accumulator isolation valves (30JNG13/23/33/43 AA008) are opened to pre-determined positions after event initiation. Accumulator injection flow rate is controlled by accumulator pressure and discharge isolation valve positions to support adequate borated water injection for core cooling and reactivity control. The required accumulator pressure and valve positions required to deliver a minimum of 230 gpm to the RCS are determined during Initial Plant Testing. Refer to U.S. EPR FSAR Section 14.2 Test # 058. The accumulators have a combined inventory of approximately 37,000 gallons, and will provide flow for approximately 2.7 hours at a flow rate of 230 gpm. The primary coolant injection pump is required to be placed in service within two hours after the start of the event to provide margin to accumulator depletion.

For Phase 2 event mitigation in Mode 6 with the reactor vessel head removed, actions to place a source of pumped injection into service are required prior to exhaustion of the accumulator inventory (refer to simplified Figure 4-18). A prestaged primary coolant injection pump (30JND11AP002) is installed in parallel with the Train 1 MHSI pump. The primary coolant injection pump is located in the reasonably protected SB 1. The pump is sized to provide at least 330 gpm flow to the RCS. As described in Section 4.1.3.2, an injection flow of 330 gpm provides margin to the minimum flow required for core cooling (230 gpm) and the minimum flow required to prevent boron precipitation (300 gpm). The required pump head rise is 150 ft at 330 gpm. The required NPSH of the pump at this flow rate of 330 gpm needs to be less than the calculated available at 330 gpm of 14 ft. Mitigation of boron precipitation is discussed in Section 4.1.5.3.4.

Figure 4-18—Core Cooling in Mode 6 (Head Off) Simplified Diagram



The primary coolant injection pump is powered from EPSS 480V MCC 31BNB01, which is powered from EPSS 480V load center 31BMB. Refer to Figure 4-14 and U.S. EPR FSAR Tier 2, Figure 8.3-2. The pump discharge valve is powered from Division 1 EUPS bus 31BRA. The pump suction line connects to the MHSI pump suction line and is provided with two manual isolation valves (30JND11AA008 and 30JND11AA008). The pump discharge line connects to the MHSI pump discharge line downstream of MHSI outside containment isolation valve (30JND10AA002). The pump discharge line is provided with a thermal relief valve (30JND11BR192), a check valve (30JND11AA011), and a motor-operated discharge throttle valve (30JND11AA012). The pump discharge line is also provided with a hose connection and manual isolation valve (30JND11AA013) to allow connection of a portable self-powered pump. Only one pump is necessary to meet the FLEX N +1 requirement, because the installed pump is reasonably protected in SB 1, and it has two independent power sources.

4.1.5.3.2 Primary Heat Removal

Primary heat removal is required to remove the decay heat transferred from the core to the RCS. The primary feed and bleed process used to provide core cooling by maintaining RCS liquid level above the top of the core also provides primary heat removal. Primary heat removal is accomplished by releasing high enthalpy steam from the open reactor vessel to containment, and by replacing the released inventory with low enthalpy RCS makeup from the accumulators, the IRWST using the primary coolant injection pump,

4.1.5.3.3 Reactivity Control

Reactivity control is required to provide reasonable assurance that criticality does not occur. The primary feed and bleed process used to provide core cooling by maintaining RCS liquid level above the top of the core also provides reactivity control.

During Phase 1 of event mitigation, reactivity control is accomplished by injection of borated water from the accumulators. Approximately 37,000 gallons of borated water are available in the accumulators for injection into the RCS.

During Phases 2 and 3 of event mitigation, reactivity control is accomplished by injection of borated water from the IRWST using the primary coolant injection pump. The equivalent boron concentration of the portable borated water supply is in the range of 1700 ppm enriched boron to 1900 ppm enriched boron. These values correspond to the minimum and maximum Technical Specification limits for the IRWST and accumulators.

4.1.5.3.4 Prevention of Boron Precipitation

Saturated primary feed and bleed cooling can lead to significant boron concentration increases in the reactor vessel. These increases can be large enough to cause the boron to precipitate out on the fuel and possibly cause blockage of flow channels. The boron begins to precipitate out of the RCS when the boron concentration reaches the solubility limit for prevailing RCS temperature conditions.

The mechanism that causes the boron concentration to increase is evaporation of reactor coolant. When the RCS is saturated, steam forms in the core. As the reactor coolant vaporizes into steam, nearly all of the boron remains behind. As the steam exits the RCS and borated water is supplied to the RCS, a feed and bleed mode is established. The feed stream is the borated RCS makeup water, and the bleed stream is the flow of steam, which is essentially unborated water, out of the RCS. In this mode, the RCS is operating as a distiller, or evaporator, where the concentration product is boron in the core region. Excess liquid flow through the core, above that required to remove core decay heat, is required to prevent the boron concentration of the liquid in the reactor vessel from reaching solubility limits.

In Section 4.1.3.2, analyses are described that determined the minimum required RCS injection rate that provides enough flow through the core to prevent boron precipitation. The analysis utilized ANS 1973 decay heat and conservatively utilized 38,500 ppm, the solubility limit at 212 °F, as the concentration limit. The results of the analysis indicated that a minimum RCS injection flow of 300 gpm was required to avoid exceeding the solubility limit. A 10% margin was added to this value, resulting in a minimum required injection flow of 330 gpm. This value was used to establish the minimum injection capability of the primary coolant injection pump. The analysis results indicated that with an RCS injection flow of 330 gpm, the concentration of the fluid in the reactor vessel would not exceed 25,000 ppm and boron precipitation would not occur.

4.1.5.3.5 Implementation of Primary Feed and Bleed Cooling

To implement primary feed and bleed cooling in Mode 6 with the reactor vessel head removed, two types of actions are taken:

1. Actions to prestage and/or pre-position equipment upon entry into Mode 5.

2. Actions to implement primary feed and bleed cooling following an ELAP event in Mode 6 with the reactor vessel head removed.

During cooldown in preparation for entry into Mode 6, the following actions are taken to prestage and/or pre-position equipment upon entry into Mode 5:

- The required accumulator pressure is set to deliver a minimum of 230 gpm to the RCS based on Initial Plant Testing (refer to U.S. EPR FSAR Section 14.2 Test # 058. In addition, the accumulator isolation valve breakers on 31/32/33/34BRA are closed.
- The IRWST three-way isolation valve (30JNK10AA001) is aligned to provide suction from the IRWST to both the MHSI Train 1 pump and the primary coolant injection pump.
- Manual suction isolation valves (30JND11AA008 and 30JND11AA008) are opened.
- The Train 1 MHSI outside containment isolation valve (30JND10AA002) is closed to prevent recirculation from the primary coolant injection pump discharge to its suction.
- The Train 1 MHSI small minimum flow isolation valve (30JND10AA004) is closed to prevent diversion of flow to the IRWST.
- The Train 1 MHSI large minimum flow isolation valve (30JND10AA005) (normally closed) is verified closed to prevent diversion of flow to the IRWST.

When an ELAP event is identified in Mode 6 with the reactor vessel head removed, the accumulator isolation valves (30JNG13/23/33/43 AA008) are opened to predetermined positions to deliver borated RCS makeup flow to the core. The four accumulator isolation valves can be opened for the first eight hours and 30 minutes after event initiation because the four EUPS divisions are energized. The accumulator isolation valve positions required to deliver a minimum of 230 gpm to the RCS will be determined during Initial Plant Testing (refer to U.S. EPR FSAR Section 14.2 Test # 058.

During Phase 2, the primary coolant injection pumpis placed into service prior to exhaustion of the accumulator inventory. The EPSS 480V MCC 31BNB01 is energized as described in Section 4.1.5.1 within two hours of event initiation. This provides power to the primary coolant injection pump. The motor-operated discharge throttle valve (30JND11AA012) is powered from EUPS bus 31 BRA. The primary coolant injection pump discharge valve is opened and the pump is started to provide injection flow to the RCS.

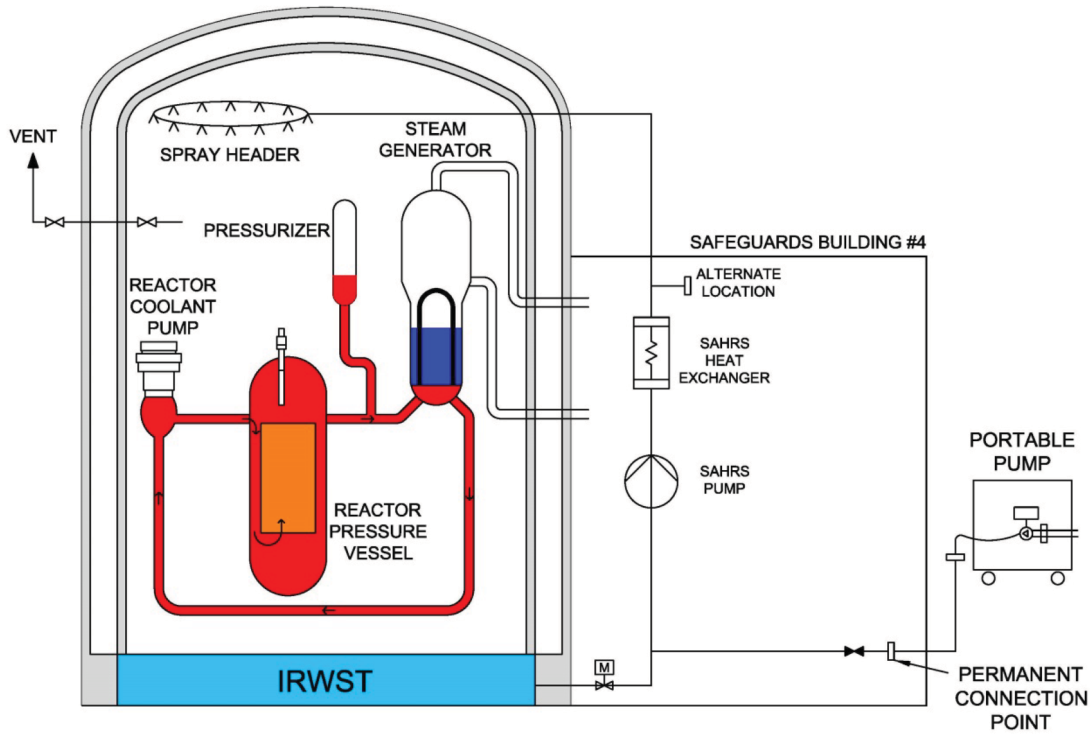
Action is required to power the Division 1 and Division 2 250 VDC switchboards and EUPS busses from the ELAP diesel generator prior to depletion of the Division 1 and Division 2 batteries at eight hours and 30 minutes after event initiation as described in Section 4.1.5.1.

4.1.5.4 Containment Pressure Control (Integrity)

Following an ELAP event, normal methods of active containment heat removal and pressure control are lost when AC power sources are lost. It is for this reason that analyses were performed in Section 4.1.3.4 to evaluate the rate of containment pressurization and compensatory actions. For events initiated in Modes 1 through 5, the containment pressurizes very slowly due to ambient heat losses and RCS leakage. For events initiated in Mode 6 with the reactor vessel head removed, the containment pressurizes more rapidly due to ambient heat losses and primary feed and bleed cooling, which transports all of the core decay heat to the containment. As a result, containment pressure must be controlled to preserve containment integrity.

The analyses described in Section 4.1.3.4 demonstrated the feasibility of two methods to control containment pressure following an ELAP event. Both methods demonstrated that the containment pressure can be maintained below the containment integrity acceptance criteria, which is to maintain containment pressure less than the ultimate design pressure of 118.5 psig (133.2 psia) provided in Section 4.1.2. The two methods of containment pressure control, containment venting and containment spray, are illustrated in the simplified Figure 4-19.

Figure 4-19— Containment Cooling and Venting Simplified Diagram



An overview of the containment mitigation strategies is provided in Table 4-5. Details of the mitigation strategies are provided in the following sections.

Table 4-5—FLEX Capability – Containment Summary

Safety Function		Method	Phase 1	Phase 2 and 3
Containment	Containment Function, Containment Pressure Control/Heat Removal	• Containment spray, or alternate capability, or analysis	• Analysis demonstrates that containment pressurizes at slow rate.	• Primary method is to vent containment through low flow purge. • Alternate method is to supply SAHRS spray header using a portable, self-powered pump through a permanent connection.
	Key Containment Parameters	• Containment pressure	• Instruments powered by Class 1E DC bus. • DC load shedding used to extend baseline coping.	• Power Divisions 1 and 2 Class 1E batteries using either the ELAP diesel generator in the Fire Protection Building or by portable generators.

4.1.5.4.1 Containment Venting

The containment low flow purge must be placed in service prior to 30 psig containment pressure to avoid exceeding the 35 psig design pressure of the low flow purge ductwork. Based on the analyses in Section 4.1.3.4, containment pressure will remain less than 30 psig at five hours after ELAP events initiated in Mode 6 with the reactor vessel head removed. Considerably more time is available to initiate containment venting for events initiated in Modes 1 through 5. Analysis results indicate that containment pressure does not exceed 30 psig for approximately five and a half days for events initiated in Modes 1 through 5. In either case, ample time is available to initiate containment venting prior to exceeding the 35 psig design pressure of the low flow purge ductwork.

The low flow purge exhaust system is used to vent containment. The low flow purge system is periodically used to clean the containment atmosphere during normal plant operation for access to containment and also during refueling. The exhaust system consists of duct inside containment, inside and outside containment isolation valves, and two redundant engineered safety feature (ESF) filter trains. The filtered exhaust is discharged to the vent stack.

The low flow purge exhaust fans are not available during an ELAP event. As a result, containment pressure is the only driving force for containment purge flow. Using containment pressure as only the driving force, the Section 4.1.3.4 analysis determined that the pressure drop across the ESF filter bank was too high to allow sufficient purge flow. A Seismic Category I 15-by-15 inch duct is provided that bypasses the ESF filter bank and fans to provide a low resistance vent path during an ELAP event. The bypass duct connects to duct 30KLA20BR010 upstream of the filters prior to entry into room 30UFA24081. The bypass duct connects in downstream of the ESF filter banks into branch 30KLA20BR018 in room 30UFA24095. Refer to U.S. EPR FSAR Tier 2, Figure 9.4.7-2. The vented containment air then flows through the low flow purge exhaust duct to the vent stack.

The bypass duct is normally isolated by manual air tight dampers (30KLA24AA001 and 30KLA24AA003). A fire damper is provided where the bypass duct passes through the three-hour fire barrier wall between rooms 30UFA24045 and 30UFA24095. The fire damper is a combination fire and smoke damper paired with a temperature override option. The design allows normal closure of the damper assembly at 165°F degrees during normal operation and the ability to override the 165 °F closure command and remain open during an ELAP event provided the temperature does not exceed 350°F. Fire damper (30KLA20AA014), at the vent stack downstream of the bypass duct, has the same specification. Analysis results in Section 4.1.3.4 indicate that containment temperature does not exceed 350 °F before opening the low flow purge valves for ELAP events initiated in any mode.

The low flow purge inside containment isolation valve (30KLA20AA001) is an air operated valve. It is normally closed, but if open, fails closed on loss of power or loss of air. The valve closes on a containment isolation signal or remote command, which causes a solenoid valve (30KLA20AA001A) in the air supply path to fail closed. The solenoid valve also vents the air from the valve operator, and the containment isolation valve closes under its own weight. The power source to the solenoid valve is the Division 1 EUPS bus (31BRA). This bus remains energized throughout the event. The inside containment isolation valve can be remotely opened if a source of air can be provided inside containment.

The low flow purge outside containment isolation valve (30KLA20AA003) is an air-operated valve. It is normally closed, but if open, fails closed on loss of signal or loss of air. The valve closes on a containment isolation signal or remote command, which causes either of two solenoid valves (30KLA20AA003A or 30KLA20AA003B) in the air supply path to fail closed. The solenoid valves also vent the air from the valve operator, and the valve closes due to spring pressure. The solenoid valves are powered from Division 1, 31BNB03, and Division 4, 34BNB03. Although 31BNB03 can be re-energized, power to 34BNB03 may be not available since Division 4 is not powered from the ELAP diesel generator. Both solenoids are required to be open to open the outside low flow purge containment isolation valve. The solenoid valves must be bypassed to open the valve when power to the solenoids is not available. Manual isolation valve (30SCB50AA004) is provided to isolate the vent path from the valve operator through the solenoid valves. A line (30SCB50BR001/002) that tees between the valve operator and manual valve (30SCB50AA004) is provided to connect the operator air supply to the piping upstream of the compressed air outside containment isolation valve. This line is provided with three manual isolation valves (30SCB50AA001/002/003).

The compressed air system (CAS) is normally used to open the low flow purge containment isolation valves and maintain them open. The air compressors that normally pressurize the compressed air system are not available following an ELAP event. A portable air supply is used to pressurize the control air system for the low flow purge valves. The compressed air supply to the inside low flow purge valve also has containment isolation valves. The outside (30SCB01AA001) and inside (30SCB01AA002) compressed air containment isolation valves are motor-operated valves. The power source for inside containment isolation valve (30SCB01AA002) is the Division 1 EUPS bus 31BRA. This bus remains energized throughout the event. The outside containment isolation valve (30SCB01AA001) is powered from 34BNB03, which may not be available during the period of time that the low flow purge is in service. However, the containment isolation valve (30SCB01AA001) can be manually repositioned. A test connection (30SCB01BR251) with a manual isolation valve (30SCB01AA251) is provided between outside containment isolation valve (30SCB01AA001) and upstream manual isolation valve (30SCB01AA005) to allow connection of a portable compressed air supply. Refer to U.S. EPR FSAR Tier 2, Figure 9.3.1-2. This connection point allows the portable air supply to provide air to both low flow purge containment isolation valves. A portable air compressor or pressurized gas bottles can be used to supply air to both low flow purge containment isolation valves. The portable air supply is capable of supplying air at a pressure between 58.8 psig and 147 psig. A volume of 1.24 ft^3 is required to open both of the low flow purge containment isolation valves.

The containment low flow purge system is placed in service to vent the containment prior to containment pressure exceeding 30 psig. The portable air supply is attached to the test connection at valve (30SCB01AA251). Manual isolation valve (30SCB01AA005) is closed to isolate the upstream portion of the compressed air system. Manual isolation valves (30SCB50AA001, 30SCB50AA002, and 30SCB50AA003) are opened to align compressed air to the low flow purge outside containment isolation valve, and manual valve (30SCB50AA004) is closed to isolate the vent path through the solenoid valves. The compressed air outside containment isolation valve (30SCB01AA001) is manually opened and the compressed air inside containment isolation valve is remotely opened from the MCR.

The low flow purge flow path to the stack is aligned by opening the bypass duct manual air tight isolation dampers (30KLA24AA001 and 30KLA24AA003). Isolation dampers (30KLA21AA004 and 30KLA22AA004) upstream of the ESF filters are verified closed.

The portable air compressor, or gas bottle, is started (opened) and the test connection isolation valve (30SCB01AA251) is opened to pressurize the system. Outside containment isolation valve (30KLA20AA003) opens when the system is pressurized because the compressed air is aligned directly to the valve operator, bypassing the control solenoid valves. The low flow purge inside containment isolation valve, (30KLA20AA001), is then opened from the MCR to initiate containment venting.

4.1.5.4.2 Containment Spray

The containment spray must be placed in service prior to 14.76 days after initiation of the event in Modes 1 through 5, or prior to 24 hours after the initiation of the event in Mode 6 with the reactor vessel head removed. To avoid exceeding the 118.5 psig (133.2 psia) ultimate pressure of the containment, the analyses in Section 4.1.3.4 show that, in either case, ample time is available to initiate containment spray prior to exceeding ultimate pressure of the containment.

A portable, self-powered pump and borated water supply is used for containment spray. A calculation was performed to determine the performance requirements of the portable spray pump. The containment pressure analysis required a pump capable of providing 700 gpm against a containment pressure of 105 psia. These values include margin to the analytical values. The calculation of pump performance requirements determined that the pump must be sized to provide 700 gpm with a head rise across the pump of 447.4 ft. The pump discharge pressure expected under these conditions would be in the range of 204 to 209 psia, depending on the elevation of the pump above ground level.

The preferred connection point for the portable containment spray pump is at the blind flange on six-inch line (30JMQ45BR001) upstream of manual valve (30JMQ45AA001), located in the SB at grade level. Three additional blind-flanged connection points are provided to meet the FLEX N+1 criterion. Two of these are blind flanged connections on the two, four-inch lines (30JMQ40BR450 and 30JMQ40BR420) provided for installation of a mobile decontamination loop. The third connection point is at the blind flange on the four-inch line (30JMQ40BR430) that ties in to the SAHRS pump discharge line. Refer to U.S. EPR FSAR Tier 2, Figure 19.2-22.

The portable containment spray pump and water supply are set up outside the Access Building. A six-inch hose is connected between the water supply and the portable pump suction. A six-inch hose is connected to the pump discharge and routed through the Access Building to the connection point in the SB.

The flange is removed from the selected connection point and the six-inch pump discharge hose is attached to the connection point. If the preferred connection point is used, manual valve (30JMQ45AA001) is opened to align the connection to the SAHRS pump suction header. Manual valves (30JMQ40AA001, 30JMQ42AA001, and 30JMQ43AA001) are closed to ensure flow is only provided to the spray header. The SAHRS motor-operated containment isolation valve for the spray line (30JMQ41AA001) is manually opened to align the spray header flow path. The portable pump is then started to initiate containment spray. Containment spray does not have to run continuously, but can be operated intermittently, as required to maintain containment pressure within limits.

4.1.5.5 Spent Fuel Cooling

In Section 4.1.3.8, analyses were described to determine the bulk SFP heatup time and boil-off rate. For a worst-case full core off-load, these analyses concluded the following:

- The operators have approximately 35 hours to restore cooling and/or makeup to the SFP in order to keep the spent fuel covered (refer to Section 4.1.2). Therefore, boiling of the SFP can be credited as the Phase 1 event mitigation method.

- To maintain at least 10 ft of water inventory over the fuel assemblies, makeup to the SFP is provided within 22 hours.

- For Phase 2 and 3 event mitigation, a SFP makeup rate of 140 gpm is needed to match the initial boil-off rate. The boil-off rate decreases over time as the spent fuel decay heat decreases.

Based on this information, an overview of the spent fuel cooling mitigation strategies is provided in Table 4-6. Details of the spent fuel cooling mitigation strategies are provided in the following sections.

Table 4-6—FLEX Capability – Spent Fuel Cooling Summary

Safety Function		Method	Phase 1	Phase 2 and 3
Spent Fuel Cooling	Spent Fuel Cooling	• Makeup through connection to SFP makeup piping or other suitable means (e.g., sprays). • Makeup with portable injection source. • Vent pathway for steam.	• Analysis demonstrates that spent fuel heats up slowly and remains cooled by water inventory above the top of the spent fuel. • Vent path from SFP area to environment established for removal of steam.	• Permanent connections (primary and alternate) for portable, self-powered, SFP makeup pump. • Two permanent connections for make from fire protection system • Vent path established in Phase 1 is maintained open to provide a vent path for steam.
	SFP Parameters	• SFP Level	• Instruments powered by Class 1E DC bus • EPR design includes redundant, safety-related wide range level sensors in SFP that fulfill EA 12-051 order.	• Power Divisions 1 and 2 Class 1E batteries using either a prestaged ELAP diesel generator in the Fire Protection Building or by portable generators. • Power SFP level instruments using portable battery powered indication device in accordance with EA 12-051 Order.

For Phase 1 event mitigation, a vent path from the SFP area must be established prior to onset of SFP boiling to allow release of steam from this area. Based on the analyses in Section 4.1.3.8, SFP boiling is calculated to occur no sooner than 4.3 hours after the ELAP event occurs. The vent path is provided by opening selected doors from the SFP area to the material lock area (refer to U.S. EPR FSAR Tier 2, Figures 3.8-41 and 3.8-46). The following actions are performed to provide the required vent path:

- On the +64 elevation, open the double doors and the single door between the fuel pool operating floor and the laydown area.
- On the +64 elevation, open the rollup door between the laydown area and the material lock area.
- On the +64 elevation, unlatch the material lock (labeled “Removable Floor” on Figures 3.8-41) and the lock doors will fall open.
- On the 0 elevation, open the rollup door at grade level in the material lock room to provide a vent path to the environment.

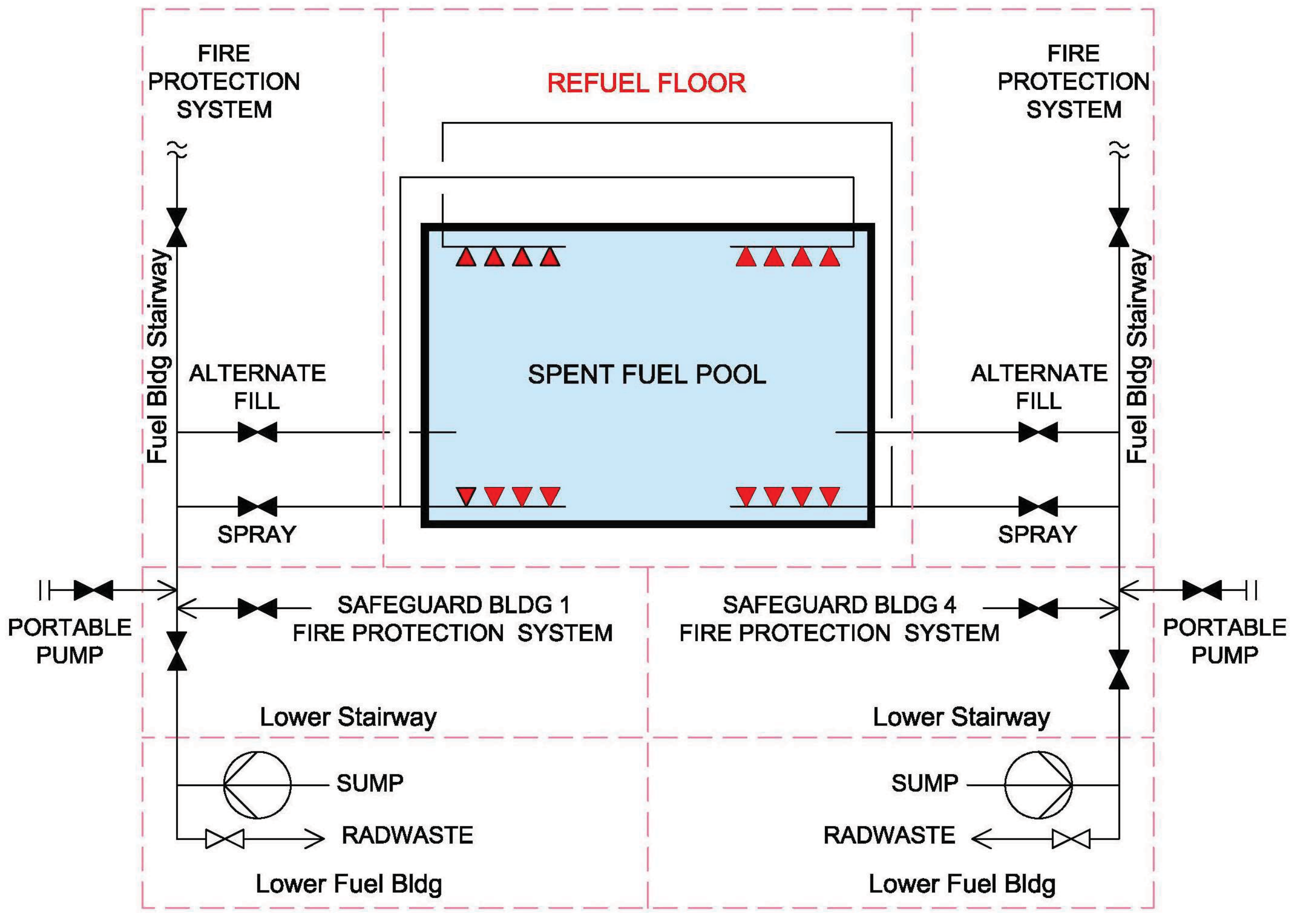
The vent path for the spent fuel area that is established in Phase 1 is maintained open in Phases 2 and 3.

For Phase 2 and 3 event mitigation, makeup is required to the SFP. Based on the Section 4.1.3.8 analyses, a minimum flow rate of 140 gpm is required to match the SFP boil-off rate. This SFP makeup flow requirement is bounded; however, by the SFP makeup flow requirement (i.e., 500 gpm) needed to mitigate a beyond design basis loss of large area fire (10 CFR 50.54 (hh)(2)). The self-powered, portable SFP makeup pump relied on to mitigate a beyond design basis loss of large area fire is therefore credited to mitigate an ELAP event.

Flow from the self-powered, portable SFP makeup pump is provided to the SFP as shown in simplified Figure 4-20.Figure 4-20—Spent Fuel Spray System Simplified Diagram and U.S. EPR FSAR Tier 2, Section 9.3.3.2.1 and Figure 9.3.3-1. The spent fuel pool spray system (SFPS) system provides both a spray cooling function and an alternate fill pipe for makeup to the SFP. Flow paths in the SFPS system are aligned using manual valves. The SFPS system is a dry system consisting of two separate, but redundant trains that are physically located on opposite sides of the SFP. Two separate and independent hose connections, located at grade elevation level on the exterior of the FB are provided, on opposite sides of the building, to attach a pumper truck or portable pump. The two external connections satisfy the FLEX N+1 criterion because the FB is adequately protected and the two connections are located on opposite sides of the FB.

Alternatively, flow to the SFP can be provided by the fire protection system, as shown in simplified Figure 4-20 and U.S. EPR FSAR Tier 2, Figure 9.5.1-1. This portion of the fire protection system consists of two separate, but redundant trains that are physically located on opposite sides of the SFP. Each of these redundant trains contains connections from the fire protection system within the FB and the SBs 1 and 4. Flow paths to the SFP for this portion of the fire protection system are aligned using manual valves.

Figure 4-20—Spent Fuel Spray System Simplified Diagram



When an ELAP event is identified, the following actions are taken to ensure spent fuel cooling:

- During Phase 1 event mitigation, align the vent path from the SFP area to the material lock area.
- During Phase 2 and 3 event mitigation, align manual valves (as appropriate) to provide flow from either a portable pump or the fire protection system to the SFP.
- Monitor level in the SFP using the SFP level instrumentation described in Section 4.2.1.

4.1.5.6 Instrumentation and Controls

Mitigation of the ELAP event is accomplished using the SICS. The SICS is a safety related I&C system. It provides the human-system interface (HSI) to perform control and indication functions needed to monitor the safety status of the plant, and bring the unit to and maintain it in a safe shutdown state.

The SICS provides conventional I&C controls and indications needed to mitigate the consequences of accidents. The SICS is located in the MCR.

Instrumentation

The following minimum set of instruments required to support ELAP event mitigation are provided on SICS:

- Fire water storage tank levels.
- SG pressures.
- SG wide range levels.
- RCS hot leg pressure.
- RCS hot leg temperature.
- Pressurizer level
- Core exit thermocouple temperatures.
- Source range neutron flux.
- Containment pressure.
- Containment high range radiation.
- SFP level.

Controls

The following components are provided with controls and status indication on SICS:

- RCP SSSS Nitrogen Vent Isolation Valves (30JEB10/20/30/40 AA020) – Open / Close.
- RCP SSSS Nitrogen Injection Isolation Valves (30JEB10/20/30/40 AA018) – Open / Close.
- RCP No. 3 Seal Leak Off Isolation Valves (30JEB10/20/30/40 AA017) – Open / Close.
- RCP No. 2 Seal Leak Off Isolation Valves (30JEB10/20/30/40 AA010) – Open / Close.
- RCP No. 1 Seal Leak Off Isolation Valves (30JEB10/20/30/40 AA009) – Open / Close.
- EUPS Bus Load Shed Breakers (Divisions 1, 2, 3, 4) – Open / Close.
- 250 VDC Switchboard Load Shed Breakers (Divisions 1, 2, 3, 4) – Open / Close.
- Diesel-driven Fire Water Pumps – Start / Stop.
- Fire Protection System to EFW Isolation Valves (30LAR55 AA002/005) – Open / Close.
- EFW Discharge Cross-Connect Valves (30LAR14/24/34/44 AA001) – Open / Close / Throttle.
- Primary Coolant Injection Pump (30JND11AP002) - Start / Stop.
- Primary Coolant Injection Pump Discharge Throttle Valve (30JND11AA012) – Open / Close / Throttle.
- ELAP Diesel Generator – Start / Stop.
- EBS Containment Isolation Valves (30JDH10/40 AA006) – Open / Close.
- EBS RCS Isolation Valves (30JDH10/20/30/40 AA015) – Open / Close.

- Pressurizer Continuous Degas Isolation Valves (30JEF10AA 503/504) – Open / Close.
- CVCS Letdown Isolation Valve (30KBA10AA001) – Open / Close.
- Main Steam Relief Isolation Valves (30LBA13/23/33/43 AA001) – Open / Close.
- Main Steam Relief Control Valves (30LBA13/23/33/43 AA101) – Open / Close / Throttle.
- Accumulator Isolation Valves (30JNG13/23/33/43 AA008) – Open / Close / Throttle.
- Compressed Air Inside Containment Isolation Valve (30SCB01AA002) – Open / Close.
- Containment Low Flow Purge Inside Containment Isolation Valve (30KLA20AA001) – Open / Close.
- SBVSE Supply Fans (Divisions 1 & 2) (30SAC01/02 AN001) – Start / Stop.
- SBVSE Exhaust Fans (Divisions 1 & 2) (30SAC31/32 AN001) – Start / Stop.
- SBVSE Battery Room Exhaust Fans (Divisions 1 & 2) (30SAC51/52 AN001) – Start / Stop.

4.1.5.7 Support Functions

To support the overall functional requirements of Order EA-12-49 (Reference 1) (i.e., core cooling, containment and spent fuel cooling), five main support functions must be provided:

- AC Power –refer to Section 4.1.5.1.
- DC Power –refer to Section 4.1.5.1.
- Lighting.
- Communications.

- Heating, Ventilation, Air Conditioning.(HVAC).

An overview of the mitigation strategies for each of these support functions is provided in Table 4-7. Details of the mitigation strategies for each of these support functions are provided in the following subsections.

Table 4-7—FLEX Capability – Support Functions Summary

Safety Function		Method	Phase 1	Phase 2 and 3
Support Functions	AC power	• AC distribution system	• AC distribution system housed in reasonably protected structures.	• Power Divisions 1 and 2 Class 1E batteries using either a prestaged ELAP diesel generator in the Fire Protection Building or by portable generators.
Support Functions	DC power	• Batteries • DC distribution system	• Batteries and DC distribution system housed in reasonably protected structures.	• Power Divisions 1 and 2 Class 1E batteries using either a prestaged ELAP diesel generator in the Fire Protection Building or by portable generators.
Support Functions	Lighting	• Emergency lighting	• Applicable emergency lighting powered by DC power system. • Applicable emergency lighting systems housed in reasonably protected structures.	• Power Divisions 1 and 2 Class 1E batteries using either a prestaged ELAP diesel generator in the Fire Protection Building or by portable generators. • Utilize portable lighting equipment.
Support Functions	Communications	• Plant COMS	• Applicable communication systems powered by DC power system. • Applicable plant communication systems housed in reasonably protected structures.	• Power Divisions 1 and 2 Class 1E batteries using either a prestaged ELAP diesel generator in the Fire Protection Building or by portable generators. • Utilize portable communication equipment.

Safety Function		Method	Phase 1	Phase 2 and 3
	HVAC	• Re-power SBVSE fans • Portable Cooler in MCR	• Analysis demonstrates that areas housing ELAP event mitigation equipment heats up slowly without active ventilation (e.g., open doors in Electrical Division Rooms in SB 1 and 2).	• Power Divisions 1 and 2 Class 1E batteries and EPSS 480V MCC 31/32BNB01 using either a prestaged ELAP diesel generator in the Fire Protection Building or by portable generators. • Start SBVSE Trains 1 and 2 supply, exhaust, and battery room fans. • Provide portable cooler in MCR with heat exhaust to SB 3.

4.1.5.7.1 Lighting

The plant lighting systems are divided into two main categories:

- Lighting for the MCR and RSS.
- Lighting outside of the MCR and RSS.

The impact on lighting in each of these areas following an ELAP event is as follows:

- The special emergency lighting (SE-LGT) provides approximately 33% of the MCR and RSS lighting. SE-LGT loads (32UJK22GP401 and 33UJK22GP402) are located on Divisions 2 and 3 of the EUPS. As discussed in Section 4.1.5.1, Division 2 of the EUPS will remain energized throughout the duration of an ELAP event. The other 67 percent of the MCR and RSS lighting is provided by the emergency lighting (E- LGT) system and is powered from the emergency power supply system (EPSS). The E-LGT would be lost following an ELAP event.
- Escape route egress battery pack lighting (ESR-LGT) will provide a minimum of 90 minutes of illumination in areas such as stairwells, corridors, rooms, building exit ways, and/or doors. Battery pack emergency lighting (BPE-LGT) will provide a minimum of eight hours of illumination and the battery pack units are located in the access route from the MCR to the RSS.
- Portable lighting is provided to support implementation of mitigation strategies.

4.1.5.7.2 Communications

The plant COMS consists of the following subsystems:

- Portable wireless communication system.
- Digital telephone system.
- Public address (PA) and alarm system.
- Sound-powered system.

- Emergency offsite communication system.
- Security communication system.

Each communication subsystem provides an independent mode of communications. A failure of one subsystem does not affect the capability to communicate using the other subsystem. These diverse COMS are independent of each other to provide effective communications, including usage in areas exposed to high ambient noise in the plant.

Electrical power from a Class 1E standby power source is provided for the portable wireless COMS base station, emergency offsite communication capability, and plant security communications. Portable wireless communication subsystem base stations (30CYV10GW001 and 30CYV10GW002) are powered from Divisions 2 of the EUPS. Portable wireless communication subsystem base stations (30CYV10GW003 and 30CYV10GW004) are powered from Divisions 3 of the EUPS. As a result of this divisional arrangement of power supplies, at least two of the portable wireless communication subsystem base stations have power available throughout the ELAP event. The portable wireless communication subsystem base stations are located in Seismic Category I structures in separate rooms. The location of the base station equipment cabinets are physically separated from the other subsystem equipment (i.e., PABX/VoIP, PA and Alarm System) to provide for added protection against a single accident or fire disabling multiple modes of communication throughout the plant.

4.1.5.7.3 HVAC

Following an ELAP event, all plant AC-powered forced ventilation is lost. The loss of ventilation affects mitigation of an ELAP event in three areas:

- SBs electrical areas.
- MCR.
- Fire Protection Building.

Safeguard Buildings

Action is required to open five Safeguard Building 2 doors within 30 minutes and to restore forced ventilation flow to the Division 1 and Division 2 Safeguard Buildings within seven hours after initiation of the event to maintain SBs 1 and 2 temperatures within equipment operability limits.

The following doors are opened within 30 minutes of event initiation (Refer to U.S. EPR FSAR Tier 2, Figure 3.8-68):

- Switchgear room 2UJK18029 door to switchgear room 2UJK18002.
- Switchgear room 2UJK18029 door to staircase and elevator access area 2UJK18040.
- Switchgear room 2UJK18002 door to staircase and elevator access area 2UJK18040.
- Switchgear room 2UJK18002 door to escape staircase 2UJK18004.
- Staircase and elevator access area 2UJK18040 door to staircase 2UJK18023.

EPSS 480V MCC 31BNB01 and 480V MCC 32BNB01 are energized from the ELAP diesel generator as described in Section 4.1.5.1. Recirculation dampers (30SAC01AA004 and 30SAC02AA004) are manually positioned full closed, and exhaust dampers (30SAC31AA002 and 30SAC32AA002) are manually positioned full open. Supply fans (30SAC01AN001 and 30SAC02AN001), exhaust fans (30SAC31AN001 and 30SAC32AN001), and battery room fans (30SAC51AN001 and 30SAC52AN001) are then started to initiate ventilation flow.

Main Control Room

For the MCR action is required to place a portable cooler in service in the MCR within seven hours to maintain MCR habitability. Refer to U.S. EPR Tier 2, Figure 3.9-70. Exhaust air from the portable cooler condenser is conveyed by portable ductwork to SB 3. The exhaust ductwork is routed through the doors between the MCR (2UJK26030) and the interconnecting passageway (3UJK26020), east through the interconnecting passageway to the MCR entrance HVAC control airlock (3UJK26001), and through both doors of the MCR entrance HVAC control airlock to the escape staircase (3UJH01004).

Fire Protection Building

The Fire Protection Building is equipped with an HVAC system to ventilate the Fire Protection Building during Phase 1, 2, and 3 event mitigation.

4.1.6 Sequence of Events /Critical Operator Actions

The overall sequence of events and critical operator actions to mitigate postulated ELAP events are provided in Table 4-8 for events initiated in Modes 1 through 4, and in Table 4-9 for events initiated in Mode 6.

The actions described in the Modes 1 through 5 sequence of events are based on actions required for events initiated from Modes 1 through 4, and some of these actions are not applicable to ELAP events initiated in Mode 5. The primary difference is that the SG depressurization to enable accumulator injection and SG feed flow is not required in Mode 5. The timing for the required actions may differ in Mode 5, but the required action times in Modes 1 through 4 are considered to be more limiting values because the low RCS and SG pressures in Mode 5 result in immediate accumulator and SG feedwater flow once aligned. Mode-specific actions are provided where the required actions for events initiated in Mode 5 differ from those required for events initiated in Modes 1 through 4.

Table 4-8—Sequence of Events – ELAP Initiated in Modes 1 through 5

Event	Time Limit	Time Constraint? (Y/N)	Technical Basis for Time Requirement	How Time is Reasonably Achievable
LOOP with loss of all AC power except from battery backed inverters.	0	N	N/A	RCPs trip due to LOOP, followed by reactor trip on low RCP speed. Because there is no offsite or onsite generated AC power available, no feedwater is being delivered to any SG.
Reactor trip procedure entered.	1 min	N	N/A	Operators perform immediate actions for reactor trip before mitigating loss of power.
RCP seal leakage is assumed to increase to 25 gpm per RCP.	2 min	N	N/A	25 gpm per RCP leakage plus 11 gpm identified and unidentified RCS leakage for a total of 111 gpm leakage during this phase.
Operators attempt to start EDGs.	2 min	N	N/A	N/A
Four additional EDG start attempts fail.	9 min 20 sec	N	N/A	(125 seconds between each start attempt, 15 seconds crank time)
SBO diagnosed – operators enter SBO procedure.	9 min 20 sec	N	N/A	N/A

Event	Time Limit	Time Constraint? (Y/N)	Technical Basis for Time Requirement	How Time is Reasonably Achievable
Operators attempt to start SBO diesel generators.	9 min 30 sec	N	N/A	N/A
SBO diesel generators fail to start or connect to EPSS busses.	10 min	N	N/A	N/A
ELAP event is diagnosed.	10 min	Y	The SBO diesel generator is required to be capable of powering loads within 10 minutes of loss of all AC power. The ELAP event is diagnosed upon failure of the SBO diesel generator to start or load.	Operators are trained to place the SBO diesel generator in service within 10 minutes. Procedural guidance will direct initiation of ELAP mitigation upon failure of the SBO diesel generator to start or load.
Operators close RCP SSSS and close all seal return valves from MCR.	15 min	Y	Analysis assumed reduction of leakage to 13 gpm at 15 minutes as a result of this action.	Action only requires operation of five valves from the MCR per RCP. Operators are trained to perform this sequence of actions. (RCS leakage is reduced to 13 gpm (11 gpm RCS leakage plus 2 gpm total SSSS leakage)).

Event	Time Limit	Time Constraint? (Y/N)	Technical Basis for Time Requirement	How Time is Reasonably Achievable
Operators open five doors in SB 2 to limit temperature rise in switchgear room.	30 min	Y	Analysis indicated that SB temperatures would remain below equipment operability limits if specified doors were opened 30 minutes after event initiation, and forced ventilation was initiated by seven hours after event initiation.	Action requires opening five doors in the same area of the building. Operators are trained to open these doors within the required time.
Operators perform SBO containment isolation actions.	30 min	N	N/A	N/A
Modes 1 through 4 - Operators set SG-1 and SG-2 MSRTs to control cooldown at 90 °F/hr, and initiate controlled depressurization of SG-1 and SG-2. Mode 5 - Operators open MSRTs and leave them open.	30 min	Y	Analysis assumed initiation of 90 °F/hr cooldown at 30 minutes. Delay in initiating cooldown results in less inventory in the SGs at start of cooldown.	MSRTs are powered from EUPS busses, and can be operated from the MCR.

Event	Time Limit	Time Constraint? (Y/N)	Technical Basis for Time Requirement	How Time is Reasonably Achievable
Operators open 30LAR55AA005, 30LAR55AA002, 30LAR14AA001, and 30LAR24AA001 from the MCR to align the diesel-driven fire pump discharge to SG-1 and SG-2. Operators start diesel-driven fire pump.	1 hr	Y	Analysis assumes feed supply is available when SGs dry out at approximately 4000 sec Feed supply to SGs required for primary to secondary heat transfer.	All valves required to align the flow path are motor operated from the MCR. The diesel-driven fire pump is started from the MCR.
Operators detect SG dryout by observing increasing trend in RCS temperatures and reset SG-1 and SG-2 MSRCVs to control pressure at 100 psia.	1 hr 6 min	Y	SG-1 and SG-2 pressures must be reduced below diesel-driven fire pump discharge pressure before feed flow begins. Analysis assumed depressurization to 100 psia to ensure at least 300 gpm per SG.	MCR operators monitor progression of cooldown and are trained to detect SG dryout. SG levels decreasing to zero provide an indicator of impending dryout.
SG-1 and SG-2 pressure ≤100 psia.	1 hr 8 min	N	N/A	N/A
Fire water feed to SGs at 300 gpm/SG.	1 hr 9 min	N	N/A	N/A
Primary to secondary heat transfer is restored as indicated by lowering RCS temperature trend.	1 hr 10 min	N	N/A	N/A

Event	Time Limit	Time Constraint? (Y/N)	Technical Basis for Time Requirement	How Time is Reasonably Achievable
Action completed to shed non-essential loads from all 250 VDC switchboards and EUPS busses.	1 hr 10 min	Y	Analysis of battery coping time assumed all non-essential loads were disconnected by 70 minutes after initiation of the event.	All non-essential loads with the exception of the I&C cabinets are segregated from essential loads on a separate load shed bus. Non-essential loads are shed by opening four breakers from the MCR. It is reasonable to assume that four breakers can be operated from the MCR within 60 minutes of recognition that an ELAP event has occurred. The I&C cabinets in each division are located in the same room. It is reasonable to assume that an operator can reach each room and de-energize the cabinets within 60 minutes of recognition that an ELAP event has occurred.
Accumulators begin to inject into the RCS.	2 hr 30 min	N	N/A	N/A
SG levels begin to recover.	2 hr 57 min	N	N/A	N/A

Event	Time Limit	Time Constraint? (Y/N)	Technical Basis for Time Requirement	How Time is Reasonably Achievable
Fire water flow throttled to control SG level.	4 hr	N	N/A	N/A
Doors are opened to provide vent path from SFP area to exterior.	4 hr	Y	Vent path is required to prevent pressurization of FB.	Aligning vent path requires opening four doors, three of which are on the same elevation. Four hours is adequate time to accomplish this task.
SFP boiling begins.	4 hr 17 min	N	N/A	Limiting time for heatup of SFP.
Electrical power is aligned from the ELAP diesel generator to the SBVSE Divisions 1 and 2 supply, exhaust, and battery room fans, the ELAP diesel generator is started, Division 1 and 2 SBVSE recirculation damper is manually closed, the exhaust damper is manually opened, and the supply, exhaust, and battery room fans are placed in service.	7 hr	Y	Analysis indicated that SB temperatures would remain below equipment operability limits if specified doors were opened 30 minutes after event initiation, and forced ventilation was initiated by seven hours after event initiation.	Action requires operators to access and position two dampers in the field. Since the installed fans are being repowered, only electrical alignment is required to place the fans in service once the dampers have been positioned. Seven hours is adequate time to start the ELAP diesel generator, position two dampers, and perform the required electrical alignment.

Event	Time Limit	Time Constraint? (Y/N)	Technical Basis for Time Requirement	How Time is Reasonably Achievable
Operators route MCR portable cooler exhaust ductwork to SB 3 and place MCR portable cooler in service.	7 hr	Y	Analysis assumed cooler placed in service to limit MCR temperature.	Doors are located in the vicinity of the MCR.
Operators open EBS Division 4 containment isolation valve (30JDH40AA006) either EBS Division 3 RCS isolation valve (30JDH30AA015) or EBS Division 4 RCS isolation valve (30JDH40AA015) from the MCR.	8 hr 30 min	Y	Division 3 and Division 4 EBS RCS isolation valves are located inside the containment and must be opened prior to depletion of the Division 3 and 4 batteries to create a viable RCS makeup path from EBS Division 4 to maintain N+1 capability.	Valves are operated from the MCR.
Operators energize Division 1 and 2 250 VDC switchboards and EUPS busses from ELAP diesel generator.	8 hr 30 min	Y	Mitigation strategy assumes availability of Divisions 1 and 2 powered equipment. Divisions 1 and 2 must be powered from the ELAP diesel generator or portable generators prior to battery depletion.	Action requires placing two battery chargers in service. Eight hours and 30 minutes is sufficient time to allow performance of these actions.

Event	Time Limit	Time Constraint? (Y/N)	Technical Basis for Time Requirement	How Time is Reasonably Achievable
Operators de-energize Division 3 and 4 250 VDC switchboards and EUPS busses.	8 hr 30 min	N	N/A	Action is performed for equipment protection and is not required for event mitigation. Action can be delayed if required to allow performance of actions that are required for event mitigation.
Replenish ELAP diesel generator fuel oil storage tank.	15 hr	Y	ELAP diesel generator is required to power essential mitigation equipment. The ELAP diesel generator is provided with a minimum eight-hour fuel oil supply. The ELAP diesel generator is placed in service by seven hours. Requiring replenishment at 15 hours is conservative since the ELAP diesel generator will not be at full load until Divisions 1 and 2 250 VDC switchboards and EUPS busses are connected.	A means of tank replenishment exists that is capable of filling the fuel oil storage tank within 15 hours. Note: If the ELAP diesel generator is started earlier than seven hours, the required time of fuel replenishment is earlier by an equal amount.

Event	Time Limit	Time Constraint? (Y/N)	Technical Basis for Time Requirement	How Time is Reasonably Achievable
Fire water storage tank is replenished from other sources using the provided fill connections, or a portable pump and water supply is placed in service.	17 hr		Analysis indicated that fire water storage tank would empty in 18 hours 20 minutes. Requiring replenishment or alternate source of feed at 17 hours provides margin to loss of suction.	A means of tank replenishment or alternate feed supply exists that is capable of being placed in service within 17 hours.
Makeup to the SFP is provided to maintain at least ten ft of water inventory over the fuel assemblies.	22 hr	Y	Maintain adequate radiological shielding for access.	Pre-installed engineered features are provided to facilitate pool replenishment.
A portable self-powered RCS makeup pump is placed in service.	24 hr	Y	Analysis verified that accumulators will provide required RCS makeup for 24 hours. A source of RCS makeup is required after 24 hours.	A portable pump and borated water supply exist that are capable of being placed in service within 24 hours.

Event	Time Limit	Time Constraint? (Y/N)	Technical Basis for Time Requirement	How Time is Reasonably Achievable
If diesel-driven fire pump is still being used as feed source, replenish fuel oil storage tank.	3.5 days	Y	Fuel oil storage tank has a minimum capacity sufficient to fuel the pump for 84.4 hours at a pump flow of 660 gpm. Diesel-driven fire pump is placed in service by one hour after event initiation.	A means of tank replenishment exists that is capable of filling the fuel oil storage tank within 3.5 days. Note: If the diesel-driven fire pump is started earlier than 1 hour, the required time of fuel replenishment is earlier by an equal amount.
If containment venting is the selected method of containment pressure control, the low flow purge flow path is opened to control containment pressure.	5.5 days	Y	The low flow purge vent path must be placed in service prior to containment pressure exceeding 30 psig to avoid exceeding the design pressure of the low flow purge ductwork. Analysis indicates that containment pressure reaches 30 psig at approximately 5.5 days.	5.5 days provides sufficient time to place the low flow purge vent flow path in service. (This action is only critical when the low flow purge vent path is selected for containment pressure control.)

Event	Time Limit	Time Constraint? (Y/N)	Technical Basis for Time Requirement	How Time is Reasonably Achievable
If containment spray is the selected method of containment pressure control, a containment spray flow of at least 88.2 lbm/sec is initiated to lower containment pressure.	14.76 days	Y	Analysis indicated that the containment ultimate design pressure shall not be exceeded for 14.76 days. Initiating a containment spray flow of at least 88.2 lbm/sec prior to that time prevents exceeding the pressure limit.	A portable pump and borated water supply exist that are capable of being placed in service within 24 hours to support Mode 6 operation. It is reasonable to assume that this pump can be placed in service within approximately two weeks.

Table 4-9—Sequence of Events – ELAP Initiated in Mode 6

Event	Time Limit	Time Constraint? (Y/N)	Technical Basis for Time Requirement	Description of Why Time is Reasonably Achievable (comments)
LOOP with loss of all AC power except from battery backed inverters.	0	N	N/A	N/A
Operators attempt to start EDGs.	2 min	N	N/A	N/A
Core boiling begins.	3 min 24 sec	N	N/A	N/A
Four additional EDG start attempts fail.	9 min 20 sec	N	N/A	(125 seconds between each start attempt, 15 seconds crank time)
SBO diagnosed – operators enter SBO procedure.	9 min 20 sec	N	N/A	N/A
Operators attempt to start SBO diesel generators.	9 min 30 sec	N	N/A	N/A
SBO diesel generators fail to start or connect to EPSS busses.	10 min	N	N/A	N/A

Event	Time Limit	Time Constraint? (Y/N)	Technical Basis for Time Requirement	Description of Why Time is Reasonably Achievable (comments)
ELAP event is diagnosed.	10 min	Y	The SBO diesel generator is required to be capable of powering loads within 10 minutes of loss of all AC power. The ELAP event is diagnosed upon failure of the SBO diesel generator to start or load.	Operators are trained to place the SBO diesel generator in service within 10 minutes. Procedural guidance directs initiation of ELAP mitigation upon failure of the SBO diesel generator to start or load.
Operators throttle open all four accumulator isolation valves to positions that have been pre-determined to provide sufficient flow to make up for core boil off.	12 min	Y	Replenishment of RCS inventory to makeup for boil off is required as soon as practical. Since the ELAP event is diagnosed at 10 minutes, 12 minutes is the earliest injection could be realistically achieved.	Accumulator isolation valve breakers are closed upon entry into Mode 5 from Mode 4. Valves are powered from the EUPS busses and are operated from the MCR.
Operators open 5 doors in SB 2 to limit temperature rise in switchgear room.	30 min	Y	Analysis indicated that SB temperatures would remain below equipment operability limits if specified doors were opened 30 minutes after event initiation, and forced ventilation was initiated by seven hours after event initiation.	Action requires opening five doors in the same area of the building. Operators are trained to open these doors within the required time.

Event	Time Limit	Time Constraint? (Y/N)	Technical Basis for Time Requirement	Description of Why Time is Reasonably Achievable (comments)
Action completed to shed non-essential loads from all 250 VDC switchboards and EUPS busses.	1 hr 10 min	Y	Analysis of battery coping time assumed all non-essential loads were disconnected by 70 minutes after initiation of the event.	All non-essential loads with the exception of the I&C cabinets are segregated from essential loads on a separate load shed bus. Non-essential loads are shed by opening four breakers from the MCR. It is reasonable to assume that four breakers can be operated from the MCR within 60 minutes of recognition that an ELAP event has occurred. The I&C cabinets in each division are located in the same room. It is reasonable to assume that an operator can reach each room and de-energize the cabinets within 60 minutes of recognition that an ELAP event has occurred.

Event	Time Limit	Time Constraint? (Y/N)	Technical Basis for Time Requirement	Description of Why Time is Reasonably Achievable (comments)
ELAP diesel generator started, power is aligned to the primary coolant injection pump, primary coolant injection pump flow path is aligned, and the primary coolant injection pump.	2 hr	Y	Accumulator discharge valve positions and pressures are set to provide at least 230 gpm to make up for core boil off. Accumulator inventory is approximately 37,000 gpm, which will provide 2 to 2.5 hours of RCS injection before the accumulators empty (neglecting RCS inventory). A source of pumped RCS injection must be provided by that time.	The ELAP diesel generator and the primary coolant injection pump are started from the MCR. All manual valves in the primary coolant injection pump flow path are aligned upon entry into Mode 5. Motor operated valves required to align the flowpath are operated from the MCR. The only local actions required to place the primary coolant injection pump are to align two transfer switches, strip all loads from EPSS 480V load center 31BMB and 480V MCC 31BNB01, and to close the feeder breaker to 31BNB01. These actions can be completed within two hours of event initiation.

Event	Time Limit	Time Constraint? (Y/N)	Technical Basis for Time Requirement	Description of Why Time is Reasonably Achievable (comments)
Doors are opened to provide vent path from SFP area to exterior.	4 hr	Y	Vent path is required to ensure that pressurization of FB does not occur.	Aligning vent path requires propping four doors open, three of which are on the same elevation. Four hours is adequate time to accomplish this task.
SFP boiling begins.	4 hr 17 min	N	N/A	Limiting time for heatup of SFP.
If containment venting is the selected method of containment pressure control, the low flow purge flow path is opened to control containment pressure.	5 hr	Y	The low flow purge vent path must be placed in service prior to containment pressure exceeding 30 psig to avoid exceeding the design pressure of the low flow purge ductwork. Design pressure of the ductwork is 35 psig; an upper limit of 30 psig for initiation of purge provides margin to the design pressure. Analysis indicates that containment pressure reaches 30 psig at approximately 5 hours.	5 hours provides sufficient time to place the low flow purge vent flow path in service.

Event	Time Limit	Time Constraint? (Y/N)	Technical Basis for Time Requirement	Description of Why Time is Reasonably Achievable (comments)
Electrical power is aligned from the ELAP diesel generator to the SBVSE Divisions 1 and 2 supply, exhaust, and battery room fans, the SBVSE Division 1 and 2 recirculation damper is manually closed, exhaust damper is manually opened, and the supply, exhaust, and battery room fans are placed in service.	7 hr	Y	Analysis indicated that SB temperatures would remain below equipment operability limits if specified doors were opened 30 minutes after event initiation, and forced ventilation was initiated by seven hours after event initiation.	Action requires operators to access and position two dampers in the field. Since the installed fans are being repowered, only electrical alignment is required to place the fans in service once the dampers have been positioned. Seven hours is adequate time to position two dampers, and perform the required electrical alignment.
Operators route MCR portable cooler exhaust ductwork to SB 3 and place MCR portable cooler in service.	7 hr	Y	Analysis assumed cooler placed in service to limit MCR temperature.	Doors are located in the vicinity of the MCR.
Operators energize Division 1 and 2 250 VDC switchboards and EUPS busses from ELAP diesel generator.	8 hr 30 min	Y	Mitigation strategy assumes availability of Divisions 1 and 2 powered equipment. Divisions 1 and 2 must be powered from the ELAP diesel generator or portable generators prior to battery depletion.	Action requires placing two battery chargers in service. Eight hours and 30 minutes is sufficient time to allow performance of these actions.

Event	Time Limit	Time Constraint? (Y/N)	Technical Basis for Time Requirement	Description of Why Time is Reasonably Achievable (comments)
Operators de-energize Division 3 and 4 250 VDC switchboards and EUPS busses.	8 hr 30 min	N	N/A	Action is performed for equipment protection and is not required for event mitigation. Action can be delayed if required to allow performance of actions that are required for event mitigation.
Replenish ELAP diesel generator fuel oil storage tank.	10 hr	Y	ELAP diesel generator is required to power essential mitigation equipment. The ELAP diesel generator is provided with a minimum 8 hour fuel oil supply. The ELAP diesel generator is placed in service by two hours to power the primary coolant injection pump. Requiring replenishment at 10 hours is conservative since the ELAP diesel generator will not be at full load until Divisions 1 and 2 250 VDC switchboards and EUPS busses are connected.	A means of tank replenishment exists that is capable of filling the fuel oil storage tank within 10 hours. Note: If the ELAP diesel generator is started earlier than 2 hours, the required time of fuel replenishment is earlier by an equal amount.

Event	Time Limit	Time Constraint? (Y/N)	Technical Basis for Time Requirement	Description of Why Time is Reasonably Achievable (comments)
Makeup to the SFP is provided to maintain at least ten ft of water inventory over the fuel assemblies.	22 hr	Y	Maintain adequate radiological shielding for access.	Pre-installed engineered features are provided to facilitate pool replenishment.
If containment spray is the selected method of containment pressure control, a containment spray flow of at least 88.2 lbm/sec is initiated to lower containment pressure.	24 hr	Y	Analysis verified that initiating 88.2 lbm/sec spray flow at 24 hours prevented exceeding the containment ultimate pressure limit of 133.2 psia.	A portable pump and borated water supply exist that are capable of being placed in service within 24 hours.

4.1.7 Performance Requirements Equipment

Performance requirements for portable equipment required for long-term event mitigation (i.e., Phase 2 and 3) are summarized in Table 4-10.

Table 4-10—Performance Requirements for Portable Equipment

Equipment	Performance Requirements	Interface Requirements
Core Cooling		
Portable SG Feed Pump	• Pump shall be sized for a flow rate of 660 gpm (330 gpm to each of two SGs). • Required head increase across the pump shall be 483 ft at 660 gpm.	• Connections are sized for a flow rate of 660 gpm (330 gpm to each of two SGs). • Connections points are outside the Fire Protection Building (30SGA01AA092), outside SB 1 (30LAR55AA004), inside SB 1 (3030LAR55AA003), or inside SB 4 (30LAR54AA501).
Portable RCS Makeup Pump and Tank (Modes 1 through 5)	• The pump shall be sized for a flow rate of 50 gpm with a head increase across the pump of 1242 ft. • The pump discharge pressure under these conditions shall be greater than 548.4 psia.	• Connections points are EBS vent line in FB (30JDH10AA506 or 30JDH40AA506).
Containment Integrity		
Portable Air Compressor or Pressurized Gas Bottle	• The portable air compressor or gas bottle shall be capable of supplying air at a pressure between 58.8 psig and 147 psig with a volume of 1.24 ft3 (35 liters).	• Connections point is CAS vent line in FB (30SCB01AA251).
Portable Spray Pump	• The pump shall be sized for a flow rate of 700 gpm with a head increase across the pump of 447.4 ft. • The pump discharge pressure under these conditions shall be greater than 209 psia.	• Connections points are inside SB 4 (30JMQ45AA001) or at flanged connections (30JMQ40BR430, 30JMQ40BR420, 30JMQ40BR450).

Equipment	Performance Requirements	Interface Requirements
Spent Fuel Pool Cooling		
Portable Spent Fuel Pool Makeup Pump and Water Source	• The pump shall be sized for a flow rate of 500 gpm with a discharge head of 130 ft.	• Actual SFP makeup requirement for ELAP event is 140 gpm. This flow rate is enveloped 10 CFR 50.54 (hh)(2) requirement of 500 gpm. • Connections points are outside FB (30KTC30AA074 or 30KTC30AA084).
Electrical and DC Load Shedding		
Portable ELAP Diesel Generators	• If one portable ELAP diesel generator is used to repower Divisions 1 and 2, the required output shall be at least 650 kW. • If Divisions 1 and 2 are powered by separate portable generators, the required output for each shall be at least 350 kW. • Output voltage shall be 480 VAC.	• Connections points are in SB (31BMB and 32BMB buses).
HVAC		
Portable Cooler	• The cooler (air conditioner) shall be sized to provide a minimum of 32,000 BTUs/hr of cooling to MCR.	• Hot exhaust from cooler condensing unit is directed to SB 3.

4.2 *NTTF 7, Enhancing Spent Fuel Pool Makeup & Instrumentation*

4.2.1 NTTF 7.1, Safety-Related Spent Fuel Pool Level Instrumentation

4.2.1.1 Overview

Recommendation 7.1 is a Tier 1 recommendation that resulted in the issuance of NRC Order EA-12-051 (Reference 2). This order stated that Licensees must provide sufficiently reliable instrumentation to monitor SFP water level and be capable of withstanding design basis natural phenomena.

4.2.1.2 Conformance

Consistent with the information in Attachment 3 to Order EA-12-051 (Reference 2), the U.S. EPR addresses the requirements in Attachment 2 to Order EA-12-051 by providing two physically separate and independent divisions of safety-related SFP level sensing with two redundant wide range level sensor channels in each division. The instruments measure the level from the top of the SFP normal operating range to below the top of the fuel racks. This span provides indication of:

- A level that is adequate to support operation of the normal SFP cooling system.
- A level that is adequate to provide substantial radiation shielding for a person standing on the SFP operating deck.
- A level where fuel remains covered and actions to implement makeup water addition should no longer be deferred.

The SFP level instrumentation is safety-related and has the following design features:

- Seismic and environmental qualification of the instruments.
- Independent power supplies.
- Electrical isolation and physical separation between instrument divisions.
- Continuous display in the MCR.
- Routine calibration and testing.

In addition, the following requirements that are specified in Attachment 3 to Order EA-12-051 are addressed in a manner consistent with JLD-ISG-2012-03 (Reference 12), Order EA-12-051 (Reference 2), and NEI 12-02, Revision 1 (Reference 16), as endorsed by JLD-ISG-2012-03.

Arrangement

The SFP includes four SFP wide range level sensors. The safety-related wide range level sensors are Seismic Category I components. The sensors are located in separate corners, or recesses, of the SFP to provide reasonable protection against missiles and debris.

Refer to U.S. EPR FSAR Tier 2, Table 3.2.2-1 and Section 9.1.3.6.

Qualification

The wide range level sensors and cabling for the wide range level instrument channels are qualified to operate for a minimum period of seven days under the following conditions:

- Radiological conditions for a normal refueling quantity of freshly discharged (100 hours) fuel with the SFP water level where fuel remains covered.
- Temperature of 212 °F and 100% relative humidity.
- Boiling water and/or steam environment.
- Concentrated borated water environment.

Refer to U.S. EPR FSAR Tier 2, Table 3.11-1.

Power Supplies

The primary instrument channels normally receive power from plant vital AC power. Each of the two divisions of wide range level sensors includes the capability to connect a sensor directly to a battery-operated portable indication device. The two portable indication devices provide on demand push-button-activated indication of SFP level with no dependence on other station power sources. Each portable indication device is located in the associated division instrumentation and controls (I&C) room, which is protected and accessible during normal operation, event, and post-event conditions. The portable indication device batteries are maintained in a charged state during normal operation with a minimum battery capacity of seven days of on-demand operation.

Refer to U.S. EPR FSAR Tier 2, Sections 9.1.3.1 and 9.1.3.3.2.

Accuracy

The accuracy of the wide range level instrument channels is less than ±1 ft over their total instrument range of 33 ft (from elevation +30’ 0” to +63’ 0”). This configuration provides reasonable assurance that the instrument channel indication demonstrates that the stored fuel is covered with water. Accuracy is maintained without recalibration following a power interruption, change in power source, or connection of a battery-powered indication device.

Refer to U.S. EPR FSAR Tier 2, Section 9.1.3.6.

Display

Continuous display of the SFP level is available in the MCR.

On-demand indication of the SFP level is available in the I&C rooms in Divisions 1 and 4. On-demand display is provided by portable battery-powered indication devices that can be operated independently of normal and emergency station power sources.

Training

U.S. EPR U.S. EPR FSAR Tier 2, Section 13.2 discusses the U.S. EPR requirements for development of a training programs for plant personnel. The training program will demonstrate that the SFP instrumentation is maintained available and reliable in an ELAP event. Personnel will be trained in the use and the provision of alternate power to the safety-related level instrument channels.

4.2.2 NTTF 7.3, Plant Technical Specification

4.2.2.1 Overview

Recommendation 7.3 is a Tier 2 recommendation that requests that Plant Technical Specifications require one train of emergency onsite electrical power to be operable for SFP makeup/instrumentation when there is irradiated fuel in the SFP, regardless of plant operating mode.

4.2.2.2 Conformance

The EPR Plant Technical Specifications require one train of emergency onsite power to be available to operate SFP makeup and instrumentation when there is irradiated fuel in the SFP regardless of the plant operating mode.

Refer to U.S. EPR FSAR Tier 2, Chapter 16, Technical Specification 3.8.11.

4.2.3 NTTF 7.4, Seismically Qualified Spent Fuel Pool Spray System

4.2.3.1 Overview

Recommendation 7.4 is a Tier 2 recommendation that requests that a seismically qualified means to spray water into SFPs be provided, including an easily accessible connection to supply water, such as using a portable pump or pumper truck, at grade level outside of the building.

4.2.3.2 Conformance

Spent Fuel Pool Spray (SFPS) System

The SFPS system is a subsystem of the Nuclear Island Drain and Vent System. The SFPS system provides a spray cooling function and an alternate fill pipe for makeup to the SFP. Refer to simplified Figure 4-20.

The SFPS system is a dry system consisting of two separate, redundant trains that are physically located on opposite sides of the SFP. Piping is routed from ground elevation to the SFP elevation through stairwells.

Each SFPS train is capable of being supplied water from four sources:

- Fire water distribution system connection within the FB.
- Fire water distribution system connection within either SB 1 (Train 1) or SB 4 (Train 2).
- A separate and independent hose connection, located on the exterior of the FB at grade elevation, can be used to attach a pumper truck or portable pump.

The SFPS system is classified as Supplemented Grade (NS-AQ) and Seismic Category II. To ensure adequate functionality following a safe shutdown earthquake (SSE), the following supplemental seismic requirements are imposed:

- For valves and piping - ANSI/ASME B31.1 (Reference 24).
- For other SSC – ASCE 43-05, “Seismic Design Criteria for Structures, Systems, and Components in Nuclear Facilities” (Reference 23).

This seismic qualification strategy is consistent with the seismic qualification strategy used for the non-safety-related fire protection system, as described in U.S. EPR FSAR Tier 2, Section 9.5.1.

Also refer to U.S. EPR FSAR Tier 2, Section 9.3.3.2.1 and Figure 9.3.3-1.

4.3 *NTTF 9.3, Enhanced Emergency Preparedness*

A portion of Recommendation 9.3 is Tier 1, and requires that enhanced emergency preparedness staffing and communications be addressed.

4.3.1 Overview

This section describes provisions for enhancing emergency preparedness as it relates to staffing and communications associated with Recommendation 9.3, outlined in Enclosure 5 of the March 12, 2012 letter "Request for information pursuant to Title 10 of the Code of Federal Regulations 50.54(f) regarding Recommendations 2.1, 2.3, and 9.3, of the near-term task force review of insights from the Fukushima Daiichi accident," (Reference 9). The letter requested that an assessment of the COMS and equipment used during an emergency event be provided to identify any enhancements that may be needed to ensure communications are maintained during a large scale natural event.

4.3.2 Conformance

4.3.2.1 Enhanced Emergency Plan Staffing and Communications

4.3.2.1.1 Communications

The U.S. EPR includes onsite COMS that are independent and diverse. The COMS for the U.S. EPR FSAR is described in U.S. EPR FSAR Tier 2, Section 9.5.2.

As noted in U.S. EPR FSAR Tier 2, Section 9.5.2, the COMS consists of the following subsystems:

- Portable wireless COMS.
- Digital telephone system.
- PA and alarm system.
- Sound-powered system.
- Emergency offsite communication.
- Security communication.

Each communication subsystem provides an independent mode of communications. A failure of one subsystem does not affect the capability to communicate using the other subsystem. These diverse COMS are independent of each other to provide effective communications, including usage in areas exposed to high ambient noise in the plant.

As noted in U.S. EPR FSAR Tier 2, Section 9.5.2, electrical power from a Class 1E standby power source is provided for the portable wireless COMS base station, emergency offsite communication capability, and plant security communications. An isolation device is placed between non-Class 1E COMS components and the Class 1E power supply to provide the required independence per IEEE Std 384-1992. The backup power supplies for other communication subsystems (with the exception of the sound powered phone system) and components are either from integral DC power units or other plant backup power supplies based on their operational significance and location. Isolation of the non-safety-related AC sources to the Class 1E uninterruptible power supply is also provided as described in U.S. EPR FSAR Tier 2, Section 8.3.1.1.9.

U.S. EPR FSAR Tier 2, Section 9.5.2.1.3 discusses the requirements for emergency response facilities and associated communication capabilities.

U.S. EPR FSAR Tier 2, Section 9.5.2.1.3 describes the offsite COMS that interfaces with the onsite communication system, including type of connectivity, radio frequency, normal and backup power supplies, and plant security system interface.

U.S. EPR FSAR Tier 2, Section 9.5.2.1.3 discusses the requirements for emergency response facilities and associated communication capabilities.

4.3.2.1.2 Staffing

U.S. EPR FSAR Tier 2, Section 13.0 discusses requirements for adequate plant staff size and technical competence.

5.0 REFERENCES

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2. NRC Order EA-12-051, “Order Modifying Licenses with Regard to Reliable Spent Fuel Pool Instrumentation,” March 12, 2012.
3. NEI 12-06, Revision 0, “Diverse and Flexible Coping Strategies (FLEX) Implementation Guide,” Nuclear Energy Institute, August 2012.
4. SECY-11-0093, “Recommendations for Enhancing Reactor Safety in the 21st Century, the Near-Term Task Force Review of Insights from the Fukushima Daiichi Accident,” July 12, 2011.
5. SECY-11-0124, “Recommended Actions to be Taken without Delay from the Near-Term Task Force Report,” September 9, 2011.
6. SECY-11-0137, “Prioritization of Recommended Actions to be Taken in Response to Fukushima Lessons Learned,” October 3, 2011.
7. SECY-12-0025, “Proposed Orders and Requests for Information in Response to Lessons Learned from Japan’s March 11, 2011, Great Tohoku Earthquake and Tsunami,” February 17, 2012.
8. SECY-12-0095, “Tier 3 Program Plans and 6-Month Status Update in Response to Lessons Learned from Japan’s March 11, 2011, Great Tohoku Earthquake and Subsequent Tsunami,” July 13, 2012.
9. NRC Letter, “Request for Information Pursuant to Title 10 of the Code of Federal Regulations 50.54(f) Regarding Recommendations 2.1, 2.3, and 9.3, of the Near-Term Task Force Review of Insights from the Fukushima Dai-Ichi Accident,” March 12 2012.
10. SECY-13-0020, “Third 6-Month Status Update on Response to Lessons Learned from Japan’s March 11, 2011, Great Tohoku Earthquake and Subsequent Tsunami,” February 14, 2013.
11. JLD-ISG-2012-01, “Compliance with Order EA-12-049, Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events,” August 29, 2012.
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13. NEI 12-02, Revision 1, “Industry Guidance for Compliance with NRC Order EA-12-051, To Modify Licenses with Regard to Reliable Spent Fuel Pool Instrumentation,” Nuclear Energy Institute, August 2012.

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15. SRM-12-0025, “Proposed Orders and Requests for Information in Response to Lessons Learned from Japan’s March 11, 2011, Great Tohoku Earthquake and Tsunami,” February 17, 2012.
16. ANP-10263(P)(A), “Codes and Methods Applicability Report for the U.S. EPR,” AREVA NP Inc., November 2007.
17. EMF-2328(P)(A), “PWR Small Break LOCA Evaluation Model, S-RELAP5 Based.”
18. BAW-10240(P) (A), “Incorporation of M5™ Properties in Framatome ANP Approved Methods,” Framatome ANP, Inc., August 2004.
19. BAW-10252PA-00, “Analysis of Containment Response to Pipe Ruptures using GOTHIC,” Framatome ANP, Inc., December 2005.
20. ANP-10299P, Revision 2, “Applicability of AREVA NP Containment Response Evaluation Methodology to the U.S. EPR™ for Large Break LOCA Analysis Technical Report,” AREVA NP Inc., December 2009.
21. Regulatory Guide 1.221, Revision 0, “Design-Basis Hurricane and Hurricane Missiles for Nuclear Power Plants,” October 2011.
22. ASCE 7-10, “Minimum Design Loads for Buildings and Other Structures,” American Society of Civil Engineers, 2010.
23. ASCE 43-05, “Seismic Design Criteria for Structures, Systems and Components in Nuclear Facilities,” American Society of Civil Engineers, 2005.
24. ANSI/ASME B31.1-2004, “Power Piping,” American National Standards Institute/The American Society of Mechanical Engineers, 2004.
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