UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

August 22, 2016

Vice President, Operations
Entergy Nuclear Operations, Inc.
Palisades Nuclear Plant
27780 Blue Star Memorial Highway
Covert, MI 49043-9530

SUBJECT: PALISADES NUCLEAR PLANT – SAFETY EVALUATION REGARDING IMPLEMENTATION OF MITIGATING STRATEGIES AND RELIABLE SPENT FUEL POOL INSTRUMENTATION RELATED TO ORDERS EA-12-049 AND EA-12-051 (CAC NOS. MF0768 AND MF0769)

Dear Sir or Madam:

On March 12, 2012, the U.S. Nuclear Regulatory Commission (NRC) issued Order EA-12-049, "Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond Design-Basis External Events" and Order EA-12-051, "Order to Modify Licenses With Regard To Reliable Spent Fuel Pool Instrumentation," (Agencywide Documents Access and Management System (ADAMS) Accession Nos. ML12054A736 and ML12054A679, respectively). The orders require holders of operating reactor licenses and construction permits issued under Title 10 of the *Code of Federal Regulations* Part 50 to modify the plants to provide additional capabilities and defense-in-depth for responding to beyond-design-basis external events, and to submit for review Overall Integrated Plans (OIPs) that describe how compliance with the requirements of Attachment 2 of each order will be achieved.

By letter dated February 28, 2013 (ADAMS Accession No. ML13246A399), Entergy Nuclear Operations, Inc. (Entergy, the licensee) submitted its OIP for Palisades Nuclear Plant (Palisades) in response to Order EA-12-049. At six month intervals following the submittal of the OIP, the licensee submitted reports on its progress in complying with Order EA-12-049. These reports were required by the order, and are listed in the attached safety evaluation. By letter dated August 28, 2013 (ADAMS Accession No. ML13234A503), the NRC notified all licensees and construction permit holders that the staff is conducting audits of their responses to Order EA- 12- 049 in accordance with NRC Office of Nuclear Reactor Regulation (NRR) Office Instruction LIC-111, "Regulatory Audits" (ADAMS Accession No. ML082900195). By letters dated February 10, 2014 (ADAMS Accession No. ML13365A264), and October 13, 2015 (ADAMS Accession No. ML15272A324), the NRC issued an Interim Staff Evaluation (ISE) and audit report, respectively, on the licensee's progress. By letter dated December 16, 2015 (ADAMS Accession No. ML15351A351), Entergy submitted a compliance letter and Final Integrated Plan (FIP) in response to Order EA-12-049. The compliance letter stated that the licensee had achieved full compliance with Order EA-12-049.

By letter dated February 28, 2013 (ADAMS Accession No. ML13060A360), Entergy submitted its OIP for Palisades in response to Order EA-12-051. At six month intervals following the submittal of the OIP, the licensee submitted reports on its progress in complying with Order EA- 12-051. These reports were required by the Order, and are listed in the attached safety

October 13, 2015 (ADAMS Accession No. ML15272A324), the NRC staff issued an ISE and audit report, respectively, on the licensee's progress. By letter dated March 26, 2014 (ADAMS Accession No. ML14083A620), the NRC notified all licensees and construction permit holders that the staff is conducting audits of their responses to Order EA-12-051 in accordance with NRC NRR Office Instruction LIC-111, similar to the process used for Order EA-12-049. By letter dated December 16, 2015 (ADAMS Accession No. ML15351A126), Entergy submitted a compliance letter in response to Order EA-12-051. The compliance letter stated that the licensee had achieved full compliance with Order EA-12-051.

The enclosed safety evaluation provides the results of the NRC staff's review of Entergy's strategies for Palisades. The intent of the safety evaluation is to inform Entergy on whether or not its integrated plans, if implemented as described, provide a reasonable path for compliance with Orders EA-12-049 and EA-12-051. The staff will evaluate implementation of the plans through inspection, using Temporary Instruction 191, "Implementation of Mitigation Strategies and Spent Fuel Pool Instrumentation Orders and Emergency Preparedness Communications/Staffing/ Multi-Unit Dose Assessment Plans" (ADAMS Accession No. ML15257A188). This inspection will be conducted in accordance with the NRC's inspection schedule for the plant.

If you have any questions, please contact John Hughey, Orders Management Branch, Palisades Project Manager, at 301-415-3204 or at John.Hughey@nrc.gov.

Sincerely,

Mandy K Halter

Mandy K. Halter, Acting Chief
Orders Management Branch
Japan Lessons-Learned Division
Office of Nuclear Reactor Regulation

Docket No.: 50-255

Enclosure:
Safety Evaluation

cc w/encl: Distribution via Listserv

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SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELATED TO ORDERS EA-12-049 AND EA-12-051

ENTERGY NUCLEAR OPERATIONS, INC.

PALISADES NUCLEAR PLANT

DOCKET NO. 50-255

1.0 INTRODUCTION

The earthquake and tsunami at the Fukushima Dai-ichi nuclear power plant in March 2011 highlighted the possibility that extreme natural phenomena could challenge the prevention, mitigation and emergency preparedness defense-in-depth layers already in place in nuclear power plants in the United States. At Fukushima, limitations in time and unpredictable conditions associated with the accident significantly challenged attempts by the responders to preclude core damage and containment failure. During the events in Fukushima, the challenges faced by the operators were beyond any faced previously at a commercial nuclear reactor and beyond the anticipated design-basis of the plants. The U.S. Nuclear Regulatory Commission (NRC) determined that additional requirements needed to be imposed at U.S. commercial power reactors to mitigate such beyond-design-basis external events (BDBEEs).

On March 12, 2012, the NRC issued Order EA-12-049, "Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events" [Reference 4]. This order directed licensees to develop, implement, and maintain guidance and strategies to maintain or restore core cooling, containment, and spent fuel pool (SFP) cooling capabilities in the event of a BDBEE. Order EA-12-049 applies to all power reactor licensees and all holders of construction permits for power reactors.

On March 12, 2012, the NRC also issued Order EA-12-051, "Order Modifying Licenses With Regard to Reliable Spent Fuel Pool Instrumentation" [Reference 5]. This order directed licensees to install reliable SFP level instrumentation with a primary channel and a backup channel, and with independent power supplies that are independent of the plant alternating current (ac) and direct current (dc) power distribution systems. Order EA-12-051 applies to all power reactor licensees and all holders of construction permits for power reactors.

2.0 REGULATORY EVALUATION

Following the events at the Fukushima Dai-ichi nuclear power plant on March 11, 2011, the NRC established a senior-level agency task force referred to as the Near-Term Task Force (NTTF). The NTTF was tasked with conducting a systematic and methodical review of the NRC regulations and processes and determining if the agency should make additional improvements to these programs in light of the events at Fukushima Dai-ichi. As a result of this review, the NTTF developed a comprehensive set of recommendations, documented in SECY-11-0093, "Near-Term Report and Recommendations for Agency Actions Following the Events in Japan," dated July 12, 2011 [Reference 1]. Following interactions with stakeholders, these recommendations were enhanced by the NRC staff and presented to the Commission.

On February 17, 2012, the NRC staff provided 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 2] to the Commission. This paper included a proposal to order licensees to implement enhanced BDBEE mitigation strategies. As directed by the Commission in staff requirements memorandum (SRM)-SECY-12-0025 [Reference 3], the NRC staff issued Orders EA-12-049 and EA-12-051.

2.1 Order EA-12-049

Order EA-12-049, Attachment 2, [Reference 4] requires that operating power reactor licensees and construction permit holders use a three-phase approach for mitigating BDBEEs. The initial phase requires the use of installed equipment and resources to maintain or restore core cooling, containment and SFP cooling capabilities. The transition phase requires providing sufficient, portable, onsite equipment and consumables to maintain or restore these functions until they can be accomplished with resources brought from off site. The final phase requires obtaining sufficient offsite resources to sustain those functions indefinitely. Specific requirements of the order are listed below:

1) Licensees or construction permit (CP) holders shall develop, implement, and maintain guidance and strategies to maintain or restore core cooling, containment, and SFP cooling capabilities following a beyond-design-basis external event.

2) These strategies must be capable of mitigating a simultaneous loss of all ac power and loss of normal access to the ultimate heat sink [UHS] and have adequate capacity to address challenges to core cooling, containment, and SFP cooling capabilities at all units on a site subject to this Order.

3) Licensees or CP holders must provide reasonable protection for the associated equipment from external events. Such protection must demonstrate that there is adequate capacity to address challenges to core cooling, containment, and SFP cooling capabilities at all units on a site subject to this Order.

4) Licensees or CP holders must be capable of implementing the strategies in all modes of operation.

5) Full compliance shall include procedures, guidance, training, and acquisition, staging, or installing of equipment needed for the strategies.

On August 21, 2012, following several submittals and discussions in public meetings with NRC staff, the Nuclear Energy Institute (NEI) submitted document NEI 12-06, "Diverse and Flexible Coping Strategies (FLEX) Implementation Guide," Rev. 0 [Reference 6] to the NRC to provide specifications for an industry-developed methodology for the development, implementation, and maintenance of guidance and strategies in response to the Mitigation Strategies order. The NRC staff reviewed NEI 12-06 and on August 29, 2012, issued its final version of Japan Lessons-Learned Directorate (JLD) 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 7], endorsing NEI 12-06, Rev. 0, with comments, as an acceptable means of meeting the requirements of Order EA-12-049, and published a notice of its availability in the *Federal Register* (77 FR 55230).

2.2 Order EA-12-051

Order EA-12-051, Attachment 2, [Reference 5] requires that operating power reactor licensees and construction permit holders install reliable SFP level instrumentation. Specific requirements of the order are listed below:

> All licensees identified in Attachment 1 to the order shall have a reliable indication of the water level in associated spent fuel storage pools capable of supporting identification of the following pool water level conditions by trained personnel: (1) level that is adequate to support operation of the normal fuel pool cooling system, (2) level that is adequate to provide substantial radiation shielding for a person standing on the spent fuel pool operating deck, and (3) level where fuel remains covered and actions to implement make-up water addition should no longer be deferred.
>
> 1. The spent fuel pool level instrumentation shall include the following design features:
>
> 1.1 Instruments: The instrumentation shall consist of a permanent, fixed primary instrument channel and a backup instrument channel. The backup instrument channel may be fixed or portable. Portable instruments shall have capabilities that enhance the ability of trained personnel to monitor spent fuel pool water level under conditions that restrict direct personnel access to the pool, such as partial structural damage, high radiation levels, or heat and humidity from a boiling pool.
>
> 1.2 Arrangement: The spent fuel pool level instrument channels shall be arranged in a manner that provides reasonable protection of the level indication function against missiles that may result from damage to the structure over the spent fuel pool. This protection may be provided by locating the primary instrument channel and fixed portions of the backup instrument channel, if applicable, to maintain instrument channel separation within the spent fuel pool area, and to utilize inherent shielding from missiles provided by existing recesses and corners in the spent fuel pool structure.
>
> 1.3 Mounting: Installed instrument channel equipment within the spent fuel pool shall be mounted to retain its design configuration during and following the maximum seismic ground motion considered in the design of the spent fuel pool structure.

1.4 Qualification: The primary and backup instrument channels shall be reliable at temperature, humidity, and radiation levels consistent with the spent fuel pool water at saturation conditions for an extended period. This reliability shall be established through use of an augmented quality assurance process (e.g., a process similar to that applied to the site fire protection program).

1.5 Independence: The primary instrument channel shall be independent of the backup instrument channel.

1.6 Power supplies: Permanently installed instrumentation channels shall each be powered by a separate power supply. Permanently installed and portable instrumentation channels shall provide for power connections from sources independent of the plant ac and dc power distribution systems, such as portable generators or replaceable batteries. Onsite generators used as an alternate power source and replaceable batteries used for instrument channel power shall have sufficient capacity to maintain the level indication function until offsite resource availability is reasonably assured.

1.7 Accuracy: The instrument channels shall maintain their designed accuracy following a power interruption or change in power source without recalibration.

1.8 Testing: The instrument channel design shall provide for routine testing and calibration.

1.9 Display: Trained personnel shall be able to monitor the spent fuel pool water level from the control room, alternate shutdown panel, or other appropriate and accessible location. The display shall provide on- demand or continuous indication of spent fuel pool water level.

2. The spent fuel pool instrumentation shall be maintained available and reliable through appropriate development and implementation of the following programs:

2.1 Training: Personnel shall be trained in the use and the provision of alternate power to the primary and backup instrument channels.

2.2 Procedures: Procedures shall be established and maintained for the testing, calibration, and use of the primary and backup spent fuel pool instrument channels.

2.3 Testing and Calibration: Processes shall be established and maintained for scheduling and implementing necessary testing and calibration of the primary and backup spent fuel pool level instrument channels to maintain the instrument channels at the design accuracy.

On August 24, 2012, following several NEI submittals and discussions in public meetings with NRC staff, the NEI submitted 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," Rev. 1 [Reference 8] to the NRC to provide specifications for an industry-developed methodology for compliance with Order EA-12-051. On August 29, 2012, the NRC staff issued its final version of Japan Lessons-Learned Directorate (JLD) Interim Staff Guidance (ISG) JLD-ISG-2012-03, "Compliance with Order EA-12-051, Reliable Spent Fuel Pool Instrumentation" [Reference 9], endorsing NEI 12-02, Rev. 1, as an acceptable means of meeting the requirements of Order EA-12-051 with certain clarifications and exceptions, and published a notice of its availability in the *Federal Register* (77 FR 55232).

3.0 TECHNICAL EVALUATION OF ORDER EA-12-049

By letter dated February 28, 2013 [Reference 10], Entergy Nuclear Operations, Inc. (Entergy, the licensee) submitted its Overall Integrated Plan (OIP) for Palisades Nuclear Plant (PNP, Palisades) in response to Order EA-12-049. By letters dated August 28, 2013 [Reference 11], February 28, 2014 [Reference 12], August 28, 2014 [Reference 13], February 27, 2015 [Reference 14] and August 28, 2015 [Reference 15] (Agencywide Documents Access and Management System ADAMS Accession Nos. ML13241A234, ML14059A078, ML14240A279, ML15062A011 and ML15240A074, respectively), the licensee submitted its first five six-month updates to the OIP. By letter dated August 28, 2013 [Reference 16], the NRC notified all licensees and construction permit holders that the staff is conducting audits of their responses to Order EA-12-049 in accordance with NRC Office of Nuclear Reactor Regulation (NRR) Office Instruction LIC-111, "Regulatory Audits" [Reference 23]. By letters dated February 10, 2014 [Reference 17] and October 13, 2015 [Reference 18], the NRC issued an Interim Staff Evaluation (ISE) and an audit report on the licensee's progress. By letter dated December 16, 2015 [Reference 19], the licensee reported that full compliance with the requirements of Order EA-12-049 was achieved, and submitted a Final Integrated Plan (FIP).

3.1 Overall Mitigation Strategy

Attachment 2 to Order EA-12-049 describes the three-phase approach required for mitigating BDBEEs in order to maintain or restore core cooling, containment and SFP cooling capabilities. The phases consist of an initial phase (Phase 1) using installed equipment and resources, followed by a transition phase (Phase 2) in which portable onsite equipment is placed in service, and a final phase (Phase 3) in which offsite resources may be placed in service. The timing of when to transition to the next phase is determined by plant-specific analyses.

While the initiating event is undefined, it is assumed to result in an extended loss of ac power (ELAP) with loss of normal access to the LUHS. Thus, the ELAP with the LUHS is used as a surrogate for a BDBEE. The initial conditions and assumptions for the analyses are stated in NEI 12-06, Section 3.2.1, and include the following:

1. The reactor is assumed to have safely shut down with all rods inserted (subcritical).
2. The dc power supplied by the plant batteries is initially available, as is the ac power from inverters supplied by those batteries; however, over time the batteries may be depleted.
3. There is no core damage initially.
4. There is no assumption of any concurrent event.

5. Because the loss of ac power presupposes random failures of safety-related equipment (emergency power sources), there is no requirement to consider further random failures.

Palisades is a Combustion Engineering (CE) pressurized-water reactor (PWR) with a dry ambient-pressure containment. The FIP describes the licensee's three-phase approach to mitigate a postulated ELAP event.

Phase 1

At the onset of an ELAP, the reactor is assumed to trip from full power. The primary coolant pumps coast down and flow in the primary coolant system (PCS) transitions to natural circulation. Operators will take prompt actions to minimize PCS inventory losses by isolating potential PCS letdown paths. Within 20 minutes of the initiation of the event, primary coolant pump (PCP) seal controlled bleedoff (CBO) is isolated to minimize seal leakage. Decay heat is removed by steaming from the steam generators (SGs) through the atmospheric dump valves (ADVs) or main steam safety valves, and makeup to the SGs is initially provided by the turbine-driven auxiliary feedwater (TDAFW) pump taking suction from the condensate storage tank (CST). The water supply for the TDAFW pump is initially from the CST; however with a PCS cooldown initiated at 2 hours into the event, this would only provide 4 hours of inventory. Therefore, at 1 hour, operators cross-connect the primary system makeup storage tank (T-81) with the CST. The tanks are cross-connected so that the T-81 tank inventory can be gravity drained into the CST prior to depleting the CST inventory. The combined inventory of the CST and T-81 tank will provide a minimum of 8 hours of inventory for makeup to the TDAFW pump for PCS decay heat removal, in addition to absorbing the latent heat necessary to support the planned PCS cooldown. At approximately 4 hours into the event, operators will begin deployment of the portable diesel-driven FLEX pump to the Lake Michigan access area, adjacent to the service water intake structure, in preparation for its use to provide SG makeup.

Once an ELAP has been declared at approximately 1 hour into the event, operators are directed to take steps to extend the life of the station batteries by shedding unnecessary loads. Completing load shedding by 2 hours conserves station battery life such that a minimum of 8 hours of functionality can be provided for the ELAP event prior to placing the battery chargers in service.

By 2 hours into the event, operators open the ADVs to commence a cooldown of the PCS. The PCS cooldown decreases the differential pressure across the PCP seals to reduce seal leakage and prolong seal life, allows for passive injection of borated water from the safety injection tanks (SITs), and places the PCS and secondary system in a low pressure state that would allow injection of water from low pressure sources available per the licensee's FLEX strategy. During the PCS cooldown, core cooling and heat removal will be achieved with the use of the TDAFW pump to provide makeup to the SGs for heat removal and ADVs for venting steam from the SGs. The plant will cool down at approximately 75 to 100 degrees Fahrenheit/hour (°F/hr) to a target temperature no less than 355°F (T_{cold}) in the PCS. Control of PCS temperature above this limit should be maintained by existing direction in Palisades' emergency procedures to terminate depressurization of the SGs at a target pressure of 148 pounds per square inch absolute (psia). Steam pressure to the TDAFW pump is controlled by throttling the steam supply valve, an air-operated valve (AOV) backed by a nitrogen supply station.

Control of PCS inventory during Phase 1 is maintained by commencing a plant cooldown, which allows passive injection of borated inventory from the nitrogen-pressurized SITs. This strategy will ensure that natural circulation is maintained during Phase 1 and therefore PCS makeup via FLEX equipment is not required at this stage of the event.

By 2 hours into the event, operators will begin deployment of the FLEX portable diesel generator to restore power to load control centers (LCCs) and other credited equipment. The actions for deployment, staging, and connection of the portable FLEX diesel generator will be completed by 8 hours into the event to prevent station battery depletion. This allows the station batteries to continuously supply power to critical instruments and controls throughout the ELAP event.

Phase 2

At approximately 4 hours into the event, operators will begin deploying the portable diesel-driven FLEX pump to the Lake Michigan access area (adjacent to the service water intake structure) in preparation for its use to provide SG makeup. Flexible hose will be dropped through removable grating (at locations currently utilized for the B.5.b pump suction) into the intake canal to provide access to the pump suction source, Lake Michigan. Once the pump is staged, hoses will be routed to diverse connections on the main feedwater (MFW) system piping or the auxiliary feedwater (AFW) system piping prior to using the entire inventory of the CST and T-81 tank.

The licensee stated that one portable diesel-driven FLEX pump can supply the water necessary for SG makeup, for spent fuel pool cooling, and for batching borated water in boric acid batching tank T-77 (tank T-77). There is ample hose available in either of the FLEX storage buildings to go around the turbine building to connect the FLEX pump and the AFW core cooling connection, and also to support the hose routings for all three SFP cooling strategies. The planned strategy remains to route the hoses through the turbine building, but there is sufficient hose to support the alternate routings, for defense-in-depth.

For PCS inventory control, the transition to the Phase 2 strategy is commenced at 8 hours into the event, at which time PNP will have a positive-displacement charging pump re-energized for PCS injection. The re-powered charging pump will initially draw borated water from the concentrated boric acid storage tanks (BASTs). Prior to depletion of the BASTs, boric acid batching operations will begin using boric acid batching tank T-77 (tank T-77). As noted above, a supply of water for mixing batches of borated coolant will be provided by the portable diesel-driven FLEX pump. Hose will be routed from the FLEX pump distribution manifold to tank T-77.

Phase 3

The operators will continue to implement the strategies from Phase 2, refilling the SGs with the portable diesel-driven FLEX pump through either the MFW (primary) or AFW (alternate) connections, and removing heat using the ADVs. At 24 hours after event occurrence, off-site equipment from the National Strategic Alliance of FLEX Emergency Response (SAFER) Response Center (NSRC) will be delivered to the site and is credited with being deployed and ready to support the Palisades strategy within 72 hours post-event. The NSRC will provide a complete set of FLEX replacement equipment for Palisades' onsite Phase 2 equipment, as well as additional equipment to process water, produce borated water, and assist in long-term plant recovery (e.g., service water pumps, large generators for energizing all Class 1 E equipment).

SFP Cooling

Under non-outage conditions, the licensee stated that the maximum SFP heat load is 4.47 megawatts thermal (MWt). The licensee calculated that a loss of SFP cooling with this heat load from an initial SFP temperature of 140°F results in a time to boil of 5.63 hours. Once boiling initiates, the SFP water level will decrease with time as liquid water is vaporized. Palisades will plan to provide SFP makeup at 18 hours into the event, prior to the water level reaching a height of 15 feet (ft.) above the top of the spent fuel. This is calculated to occur at 21.3 hours; therefore, completing the equipment line-up for initiating SFP make-up at 18 hours is conservative.

For outage conditions, the worst case SFP heat load is 9.02 MWt. Loss of SFP cooling with this heat load from an initial SFP temperature of 140°F results in a time to boil of 3.28 hours. With the entire core being located in the SFP, manpower resources otherwise allocated to core cooling in non-outage conditions can be allocated to aligning SFP make-up which ensures the system alignment can be established prior to the point at which SFP conditions become challenged. Assuming the worst case SFP heat load, the SFP water level will boil down to a height 15 ft. above the top of the spent fuel in just over 11 hours. The licensee plans to complete the equipment line-up necessary for initiating SFP make-up prior to this time.

The SFP is located in the unit's fuel handling building (FHB) where a vented pathway for steam and condensate to exit the FHB is met by opening the double leaf doors on the roof of the FHB. The double leaf doors will be opened prior to SFP boiling based on the heat load in the pool at the time of the event. The transition to Phase 2 strategies will be made as the inventory in the SFP slowly declines due to boiling. The SFP cooling through makeup and spray will be provided by using the portable diesel driven FLEX pump with water from Lake Michigan.

Containment Cooling

If containment cooling is lost for an extended period of time during an ELAP with the unit in Modes 1-4, and no cooling is provided to the containment building, temperature and pressure in containment will rise, but remain below design limits for at least 10 days. For Phases 1 and 2 the licensee's calculations demonstrate no actions are required to maintain containment pressure below design limits.

For Phase 3, the NSRC will supply a low pressure/high flow pump and two 4160 Volts (V)ac generators for long-term plant recovery. The low pressure/high flow pump allows for the restoration of service water flow to equipment such as the component cooling water (CCW) system and low pressure safety injection (LPSI) pump. The 4160 Vac generators allow for the restoration of one complete class 1-E distribution bus which provides power to a LPSI pump, a CCW pump, shutdown cooling (SDC) flow path valves and three containment air coolers (CACs).

Below are specific details on the licensee's strategies to restore or maintain core cooling, containment, and SFP cooling capabilities in the event of a BDBEE, and the results of the staff's review of these strategies. The NRC staff evaluated the licensee's strategies against the endorsed NEI 12-06, Rev. 0, guidance.

3.2 Reactor Core Cooling Strategies

In accordance with Order EA-12-049, licensees are required to maintain or restore cooling to the reactor core in the event of an ELAP concurrent with a LUHS. Although the ELAP results in an immediate trip of the reactor, sufficient core cooling must be provided to account for fission product decay and other sources of residual heat. Consistent with endorsed guidance from NEI 12-06, Phase 1 of the licensee's core cooling strategy credits installed equipment (other than that presumed lost to the ELAP/LUHS) that is robust in accordance with the guidance in NEI 12-06. In Phase 2, robust installed equipment is supplemented by onsite FLEX equipment, which is used to cool the core either directly (e.g., pumps and hoses) or indirectly (e.g., FLEX electrical generators and cables repowering robust installed equipment). The equipment available onsite for Phases 1 and 2 is further supplemented in Phase 3 by equipment transported from the NSRCs.

To adequately cool the reactor core under ELAP conditions, two fundamental physical requirements exist: (1) a heat sink is necessary to accept the heat transferred from the reactor core to coolant in the PCS and (2) sufficient PCS inventory is necessary to transport heat from the reactor core to the heat sink via natural circulation. Furthermore, inasmuch as heat removal requirements for the ELAP event consider only residual heat, the PCS inventory should be replenished with borated coolant in order to maintain the reactor in a subcritical condition as the PCS is cooled and depressurized.

As reviewed in this section, the licensee's core cooling analysis for the ELAP/LUHS event presumes that, per endorsed guidance from NEI 12-06, the reactor would have been operating at full power prior to the event. Therefore, the SGs may be credited as the heat sink for core cooling during the ELAP/LUHS event. Maintenance of sufficient PCS inventory, despite ongoing system leakage expected under ELAP conditions, is accomplished through a combination of installed systems and FLEX equipment. The specific means used by the licensee to accomplish adequate core cooling during the ELAP/LUHS event are discussed in further detail below. The licensee's strategy for ensuring compliance with Order EA-12-049 for conditions where the reactor is shut down or being refueled is reviewed separately in Section 3.11 of this evaluation.

3.2.1 Core Cooling Strategy and PCS Makeup

3.2.1.1 Core Cooling Strategy

3.2.1.1.1 Phase 1

Following the trips of the reactor and PCPs resulting from the initiating external event, PCS temperature and pressure will stabilize at no-load conditions. Core cooling would be accomplished by natural circulation flow in the PCS using the SGs as the heat sink. The SG inventory makeup would be promptly initiated using the TDAFW pump taking suction from the CST, with steam vented via the ADVs or main steam safety valves.

The fully protected CST will supply sufficient water to the TDAFW pump to cool the reactor core for 4 hours using the SGs. Prior to depletion of the CST, operators would align the T-81 tank to gravity drain into the CST; the combined water volume of the CST and T-81 tank represents a total of 8 hours' worth of inventory for core cooling in the ELAP event. The T-81 tank has been modified so as to be fully protected from all applicable external hazards, with the exception of large wind-borne missiles (e.g., an automobile). The licensee's FIP states that reasonable protection from wind-borne missiles is provided by surrounding structures, the low probability of tornadic activity at Palisades, and administrative controls. (The NRC staff's review of this topic is further discussed in Sections 3.10.1 and 3.14 of this evaluation.) If the T-81 tank were determined to be compromised during an actual event, FLEX Support Guidelines (FSGs) direct operators to align alternate suction inventory to the CST from one of several non-robust water sources before the CST volume is depleted.

Following event initiation, operators will verify feedwater flow is aligned to all SGs. Within 2 hours of event initiation, operators would further take control of the ADVs to commence a symmetric PCS cooldown at 75°F/hr within 2 hours of the initiation of the ELAP event. As noted in the licensee's FIP, the cooldown would proceed to a target PCS cold leg temperature of no less than 355°F. During the audit, the licensee stated that its emergency procedures direct that SG depressurization be halted at a pressure of 148 psia. According to the saturation relationship for water, this SG pressure should be appropriate to ensure a PCS cold leg temperature slightly above 355°F.

The ADVs at Palisades are air-operated valves. Under ELAP conditions, the supply of gas to the valves' pneumatic operators would be interrupted, as both the normal air system and backup bulk nitrogen system would be presumed to be unavailable. Therefore, a new backup nitrogen station (Nitrogen Station 9) has been installed to permit pneumatic operation of the ADVs during an ELAP event. The licensee's FIP states that the new nitrogen station is fully protected for all applicable external events. This station is in close proximity to the Main Control Room (MCR). Operators will open the ADVs and commence a cooldown of the PCS at 2 hours into the event; the nitrogen station has sufficient capacity for approximately 7.1 hours of operation after commencement of the cooldown, which covers the 8-hour duration of Phase 1.

3.2.1.1.2 Phase 2

The licensee's primary strategy in Phase 2 is to continue to cool the PCS by feeding the SGs and releasing steam through the ADVs at a controlled rate to maintain stable PCS conditions. Water injection to the SGs will be supplied by a portable, diesel-driven FLEX pump taking suction from Lake Michigan. Discharge hoses from the pump will be routed to a hose distribution manifold, and then to a primary SG makeup connection on the Main Feedwater (MFW) system or an alternate connection on the AFW system. Operators will begin deploying this FLEX pump at approximately 4 hours into the event and will have placed it into service by 8 hours into the event, before the combined inventory of the CST and T-81 tank has been depleted. The licensee's FIP states that the FLEX pump will provide a minimum SG makeup capacity of 136.5 gallons per minute (gpm) at a SG pressure of 200 psig. In addition to providing SG makeup, the pump is sized to support additional aspects of the FLEX strategy, including supplying SFP makeup and providing water for mixing borated coolant to inject into the PCS.

In Phase 2, a portable electric motor-driven air compressor is deployed from the FLEX storage facility and placed into service to maintain operability of the ADVs before the nitrogen station has been depleted. The compressor will be energized and aligned to the ADVs via a connection point on the supply piping from Nitrogen Station 9, no later than 8 hours into the event. The air compressor would be one of several loads powered by a 400 kilowatt (kW) FLEX portable diesel generator.

3.2.1.1.3 Phase 3

Although the initial delivery of NSRC equipment is scheduled to reach plant sites within 24 hours of being requested, the licensee's FIP does not formally credit the availability of NSRC equipment until 72 hours after the event begins. The NSRC will supply a large, low-pressure, high-flow pump in tandem with a booster pump, which together are capable of providing at least 5000 gpm from Lake Michigan to the Service Water System (SWS) via a hose connection header, effectively restoring access to the UHS. This restoration of SWS flow allows for the use of installed SDC heat exchangers for long-term core cooling and heat removal. In addition, two NSRC 4160 Vac generators with a combined capacity of 2 megawatts (MW) will repower one complete train of Class 1E equipment to bring the plant to cold shutdown, including a CCW pump and an SDC pump. However, as noted in the licensee's FIP, transitioning to SDC is considered a beneficial long-term recovery action, but was not explicitly analyzed as a required part of the licensee's strategy for indefinite coping to satisfy the order.

Additional equipment supplied by the NSRC to support core cooling includes a mobile water treatment unit to improve the quality of the water used for SG makeup, and a complete set of FLEX replacement equipment to provide backup for the Palisades Phase 2 equipment (e.g., a 500 gpm SG makeup pump).

3.2.1.2 PCS Makeup Strategy

3.2.1.2.1 Phase 1

Cooldown and depressurization of the PCS significantly extends the expected coping time under ELAP/LUHS conditions because it (1) reduces the potential for damage to PCP seals (as discussed in Section 3.2.3.3) and (2) allows coolant stored in the nitrogen-pressurized SITs to inject into the PCS to offset system leakage. In Phase 1, operators would depressurize and cool down the PCS to a cold leg temperature of 355°F, thereby accomplishing these objectives. The licensee's FIP further states that maintaining PCS conditions above this target value would prevent SIT nitrogen cover gas injection; therefore, isolation of the SITs is not necessary in Phase 1 to ensure that nitrogen intrusion to the PCS is prevented.

Upon diagnosis of a loss of all ac power, operators will transition to emergency operating procedure (EOP)-3.0, "Station Blackout Recovery." Operators will isolate PCS letdown and PCP seal CBO flow within 20 minutes of event initiation. These actions greatly reduce PCS inventory loss and delay or reduce the temperature rise at the PCP seals following the loss of seal cooling. With credit for passive injection of SIT inventory, the licensee's analyses demonstrate that natural circulation in the PCS will be maintained throughout Phase 1 without reliance upon FLEX PCS injection. Similarly, Palisades' ELAP analysis shows that the core will maintain sufficient Shutdown Margin during Phase 1 without additional boration of the PCS using FLEX equipment.

3.2.1.2.2 Phase 2

To provide PCS makeup in Phase 2, Palisades plans to use one of its two installed positive displacement charging pumps (P-55B or P-55C), each of which has a capacity of 40 gpm. The strategy of repowering installed equipment, as opposed to using a portable FLEX pump, is identified as an alternative to NEI 12-06 and discussed further in Section 3.14 of this evaluation. According to information provided by the licensee, the charging system can be aligned to provide diverse flowpaths to the reactor vessel from the discharge of either pump (i.e., the normal charging flowpath or the flowpath through high-pressure safety injection (HPSI) Train 2). In addition, diverse means of repowering the charging pumps exist: the two pumps are normally powered by different safety-related LCCs, LCC-11 and LCC-12; these can be cross-connected so that either pump can be powered by the other LCC as an alternate strategy. The LCC itself (LCC-11 or LCC-12) would be powered by either LCC-19 or LCC-20, which in turn would be connected to one of the two 400 kW portable FLEX diesel generators stored onsite.

Per the licensee's FIP, the charging pumps will take suction from the BASTs, with sufficient net positive suction head provided by gravity. Each BAST contains at least 4500 gallons of highly concentrated (greater than 10,000 parts per million (ppm)) boric acid solution. The licensee's ELAP analysis shows that with such a highly concentrated borated water source, approximately 1.2 hours of boration is sufficient to keep the core sub-critical indefinitely at the target PCS cold leg temperature of 355°F with no xenon-135 (which adds negative reactivity) present in the core. According to the sequence of events in the licensee's FIP, requisite supporting actions would be completed such that borated PCS injection can be commenced via the licensee's FLEX strategy no later than 8 hours into the ELAP event. As discussed further in subsequent detail, according to the licensee's calculations, initiating primary makeup by this time would maintain single-phase natural circulation in the PCS. The high boric acid concentration also means that the necessary boration represents a relatively small volume, approximately 2167 gallons, which minimizes the potential need for PCS letdown.

The licensee's FIP credits isolation of CBO flow, together with the PCS cooldown and depressurization, with minimizing PCS leakage. As noted above, the licensee's Phase 2 strategy for PCS makeup first draws upon the combined 9000 gallons of highly concentrated borated coolant in the BASTs. Once the BASTs are depleted, PCS makeup will be provided via boric acid batching using tank T-77, which drains into the BASTs by gravity. In Phase 2, untreated water for mixing batches of boric acid solution is supplied from Lake Michigan via the portable diesel-driven FLEX pump and hose distribution manifold. A target boron concentration of 1720 ppm will be used to ensure adequate boric acid dissolution, even at cold fluid temperatures.

3.2.1.2.3 Phase 3

The NSRC will provide both a mobile boration unit and a water purification unit, to ensure that long-term PCS makeup and boration is accomplished with purified water. The mobile boration unit can provide suction to either a Palisades FLEX pump or an NSRC pump to replenish tank (T-77) or directly inject to the PCS via connections in either the HPSI or LPSI systems.

As noted before, the licensee's FIP does not formally credit the use of NSRC-supplied equipment until 72 hours into the ELAP event. However, the initial delivery of NSRC equipment should arrive at the plant site within 24 hours of notification, with additional equipment deliveries following thereafter. As such, the capability to set up NSRC purification and boration equipment is expected to exist well before 72 hours into the event. During audit discussions, the licensee recognized the desirability of prioritizing the establishment of water purification equipment to limit potential impacts of using untreated water from Lake Michigan for PCS makeup. Therefore, the NRC staff expects the licensee to deploy the equipment necessary to provide purified water for PCS makeup as soon as permitted by available resources and the overall event response prioritization.

The Palisades FIP indicates that the NSRC will deliver a mobile boration unit to Palisades during Phase 3 of the ELAP event. The mobile boration unit can be used to provide PCS makeup using the onsite FLEX pumps or NSRC pumps; alternately, the mobile boration unit can be used to replenish tank T-77. The availability of the mobile boration unit in Phase 3 helps to ensure that sufficient borated makeup can be prepared to maintain PCS inventory.

In Phase 3, the UHS function of the SWS system would be restored by a high-capacity NSRC pump, as discussed in Section 3.2.1.1.3. Restoration of the UHS would allow the plant to transfer heat from the reactor core to the SDC heat exchangers in lieu of the SGs. Before the PCS can be cooled to SDC entry conditions, however, the SITs must be isolated to prevent injection of the nitrogen cover gas into the PCS. The motor control centers (MCCs) associated with the SIT isolation valves will be repowered by either the portable FLEX diesel generator or a generator supplied by the NSRC. For the purpose of the staff's review, actions associated with the transition to SDC are considered recovery actions that are not required to demonstrate indefinite coping in response to Order EA-12-049.

3.2.2 Variations to Core Cooling Strategy for Flooding Event

In its FIP, Section 2.6.2, the licensee states that Palisades is susceptible to flooding from seiche and precipitation hazards. Flooding due to intense precipitation is limited to 6 in. above grade, due to overland runoff to Lake Michigan. A seiche (i.e. a standing wave in a lake), would cause flooding that would reach a level no higher than 594.1 ft., per the Updated Final Safety Analysis Report (UFSAR), and would recede in 30 minutes. On-site FLEX equipment is protected against a flood to a level of 594.4, and would be accessed after the seiche has receded. Therefore, there are no variations to the core cooling strategy in the event of a flood. Refer to Section 3.5.2 of this safety evaluation (SE) for further discussion on flooding.

3.2.3 Staff Evaluations

2.3.1 Availability of Structures, Systems, and Components (SSCs)

Guidance document NEI 12-06 provides guidance that the baseline assumptions have been established on the presumption that other than the loss of the ac power sources and normal access to the UHS, installed equipment that is designed to be robust with respect to design-basis external events is assumed to be fully available. Installed equipment that is not robust is assumed to be unavailable. Below are the baseline assumptions for the availability of SSCs for core cooling during an ELAP caused by a BDBEE.

3.2.3.1.1 Plant SSCs

Core Cooling – Phase 1

The licensee's Phase 1 core cooling FLEX strategy relies on the TDAFW pump to remove heat from the PCS by providing cooling water flow to both SGs. The Palisades UFSAR Section 9.7.2.1, Rev. 27, states the TDAFW pump is located in a Design Class 1 portion of the Turbine Building. Furthermore, the licensee evaluated the TDAFW pump and support systems using PLP-RPT-13-00050, "Turbine Driven Auxiliary Feedwater (TDAFW) Upgrade and Evaluation for FLEX," Rev. 0. The report found the TDAFW system to be robust for all applicable seismic and tornado wind and missile hazards with the addition of tornado missile protection for the steam exhaust line, stiffening of support walls for Nitrogen Backup Station 2, and additional pipe supports in the TDAFW pump room and on the condensate makeup and return line. In addition, report PLP-RPT-13-00050, evaluates the flood protection of the TDAFW pump. The staff noted that the TDAFW pump room is located below the max expected flood height resulting from a seiche but is protected by a water tight door. Nitrogen Backup Stations 1 and 2 provide compressed nitrogen for operation of the feedwater control valve and steam inlet valve, which were evaluated in PLP-RPT-13-00050 to be robust. However, Palisades Nuclear Plant emergency operating procedure EOP Supplement 19, "Alternate Auxiliary Feedwater Methods," Rev. 11, directs operators to use local manual operation of the TDAFW pump if control power and air are not available. Based on the PNP UFSAR and PLP-RPT-13-00050, the staff finds the TDAFW and Nitrogen Backup Stations 1 and 2 are expected to be available at the start of an ELAP event consistent with NEI 12-06, Section 3.2.1.3. Further explanation and the NRC staff's evaluation of the robustness and availability of water sources for an ELAP event is discussed in Section 3.10 of this SE.

The licensee's Phase 1 core cooling FLEX strategy relies on the SG ADVs to vent steam from the SGs for a controlled cooldown. As described in the Palisades UFSAR, Rev. 29, Table 5.2-3, the ADVs are Seismic Category I. Palisades UFSAR, Rev. 26, Section 10.2.1.1, states the two atmospheric dump valves are located in each main steam header upstream of the main steam isolation valves (MSIVs). Furthermore, UFSAR, Rev. 19, Table 5.2-3 states that the main steam system up to and including the MSIVs is Seismic Category I. The FIP states that the ADVs are located in the Design Class 1 seismic Auxiliary Building and the staff noted that UFSAR, Rev. 29, Section 5.5.1.3.2 states the Auxiliary Building were designed to withstand the design-basis tornado missiles. In the Palisades UFSAR, Rev. 21, Section 5.4.1.2, states that Design Class 1 structures are flood-protected for the design-basis flood. During the audit process, the licensee stated the ADVs and the associated control circuit are powered from the Class 1E batteries, which will not be impacted by the extended load shed performed to extend battery capability for approximately 8 hours. The battery chargers will be restored approximately 8 hours after the event; therefore ADV controls will not be impacted.

Following an ELAP event, the pneumatic supply for the ADVs would be supplied from the newly installed Nitrogen Backup Station 9 located in the Auxiliary Building, which was determined to be seismically robust in EC-47346, "ADV Nitrogen Station," Rev. 0.

The licensee's Phase 1 core cooling FLEX strategy relies on its CST and tank T-81 as the water source for the TDAFW pump. The staff's evaluation of the robustness and availability of the CST and tank T-81 for an ELAP event is discussed in SE Section 3.10.1.

Core Cooling – Phase 2

The Palisades Phase 2 core cooling strategy continues to use the SGs as the heat sink. Palisades will transition to a diesel driven FLEX pump, with water supplied from the UHS, and does not rely on any installed plant SSCs other than installed systems with FLEX connection points and water sources discussed in SE Sections 3.7 and 3.10, respectively.

Core Cooling – Phase 3.

Palisades' Phase 3 core cooling strategy initially relies on Phase 2 strategies with the NSRC equipment providing backup equipment. Once NSRC equipment arrives on site, the licensee's Phase 3 core cooling strategy relies on the use of a CCW pump, SDC pump (also the LPSI pump) and flow to the SWS system on via a connection to the inlet flange of SWS pump strainer F-2C. Palisades UFSAR Table 5.2-3, Rev. 29, indicates that the CCW System, Essential Service Water System, and LPSI (SDC) pumps and systems are Design Class 1 components, and the FIP also states components in these systems are Design Class 1. The FIP states that the CCW and SDC (LPSI) systems are located in the Auxiliary Building and the connection to the SWS is located in the Intake Structure. The SWS FLEX connection is discussed in Section 3.7.

PCS Inventory Control – Phase 1

The licensee's Phase 1 RCS inventory control FLEX strategy relies on the PCS system integrity, including limited leakage through the PCP seals, and the licensee's analyses demonstrated that no FLEX RCS make up is needed prior to 8 hours.

PCS Inventory Control – Phase 2

The licensee's Phase 2 PCS inventory control FLEX strategy relies on one of two installed positive displacement charging pumps taking suction from the BASTs and discharging into the PCS injection or the HPSI lines. The staff considers the repowering of installed equipment for PCS inventory control an alternative to NEI 12-06. See Section 3.14 for further discussion of the acceptability of this alternative. In its FIP, the licensee states the two charging pumps are located in an Auxiliary Building which is robust for all applicable hazards. Furthermore, the licensee evaluated the charging pumps, power supplies, cabling and controls using PLP-RPT-13-00051, "Boric Acid Storage Tank (BAST) Suction Piping and Component Evaluation for FLEX," Rev. 0. The report determined the charging pumps, suction piping and controls to be robust for all applicable external hazards. As stated in Section 3.1.2.2. of EC-46465, "FLEX Basis," Rev. 0, the discharge piping of the charging pumps to the PCS loops and HPSI Train 2 are located in the Auxiliary Building. Based on the UFSAR, PLP-RPT-13-00050 and EC-46465, the staff finds the charging pumps are expected to be available during an ELAP event consistent with NEI 12-06, Section 3.2.1.3. The staff's evaluation of the robustness and availability of the BASTs for an ELAP event is discussed in SE Section 3.10.2.

PCS Inventory Control – Phase 3

The licensee's Phase 3 PCS inventory strategy does not rely on any additional installed plant SSCs other than those discussed in Phase 2.

3.2.3.1.2 Plant Instrumentation

Per the FIP, the following instrumentation credited for FLEX will be available following the stripping of non-essential loads:

- PCS Hot Leg Temperature
- PCS Cold Leg Temperature
- PCS Pressure (Wide Range)
- PCS Pressure (Narrow Range)
- Core Exit Thermocouples
- SIT Level (3 of 4 channels available after load shed)
- Pressurizer Level (Wide Range)
- Reactor Vessel Level
- Neutron Flux (Source Range and Wide Range)
- Auxiliary Feedwater Flow
- SG Pressure
- SG Water Level
- Containment Pressure
- Containment Temperature
- CST Level
- Battery Capacity/Voltage

The instrumentation available at Palisades to support the licensee's strategies for core cooling and PCS inventory during the ELAP event is consistent with and in some cases exceeds the recommendations specified in the endorsed guidance of NEI 12-06. Based upon the information provided by the licensee, the NRC staff understands that indication for the above instruments would be available and accessible continuously throughout the ELAP event. All of these instruments are located within Seismic Category 1 structures and are fully protected against all external events.

As recommended by Section 5.3.3 of NEI 12-06, FSG-7, "Loss of Vital Instrument or Control Power," provides instructions and information to obtain readings locally with the use of portable FLEX equipment. Furthermore, as described in its FIP, the portable FLEX equipment credited in the licensee's mitigating strategies is supplied with the instrumentation necessary to support local equipment operation.

3.2.3.2 Thermal-Hydraulic Analyses

In the analysis of the ELAP event performed by the Pressurized Water Reactor Owners Group (PWROG) in WCAP-17601-P, which the licensee in part relies upon, the Combustion Engineering Nuclear Transient (CENTS) code was chosen for the evaluation of CE-designed plants such as Palisades. The CENTS code was further used in additional plant-specific analysis that was cited in the licensee's FIP as its basis for the FLEX sequence of events timeline presented therein.

The CENTS code, as described in Westinghouse topical report WCAP-15996-A (ADAMS Accession No. ML053320174), is a general-purpose thermal-hydraulic computer code that the NRC staff has previously reviewed and approved for calculating the behavior of the primary and secondary systems of PWRs designed by CE and Westinghouse during non-loss-of-coolant accident (LOCA) (non-LOCA) transients. Although CENTS has been approved for performing certain design-basis non-LOCA transient analyses, the NRC staff had not previously examined its technical adequacy for performing best-estimate simulations of the ELAP event. Therefore, in support of mitigating strategy reviews to assess compliance with Order EA-12-049, the NRC staff evaluated licensees' thermal-hydraulic analyses, including a limited review of the significant assumptions and modeling capabilities of CENTS and other thermal-hydraulic codes used for these analyses.

Based upon this review, the NRC staff questioned whether CENTS and other codes used to analyze ELAP scenarios for PWRs would provide reliable coping time predictions in the reflux or boiler-condenser cooling phase of the event because of challenges associated with modeling complex phenomena that could occur in this phase, including boric acid dilution in the intermediate leg loop seals, two-phase leakage through PCP seals, and primary-to-secondary heat transfer with two-phase flow in the PCS. In particular, for PWRs with inverted U-tube SGs, the reflux cooling mode is said to exist when vapor boiled off from the reactor core flows out the saturated, stratified hot leg and condenses on SG tubes, with the majority of the condensate subsequently draining back into the reactor vessel in countercurrent fashion. A specific concern arose with the use of CENTS for ELAP analysis because the NRC staff's reviews for previous non-LOCA applications had imposed a condition limiting the code's heat transfer modeling in natural circulation to the single-phase liquid flow regime. This condition was imposed due to the lack of benchmarking for the two-phase flow models that would become active in LOCA scenarios. Although the PCS leakage rates in an analyzed ELAP event are significantly lower than what is typically evaluated for limiting small-break LOCA scenarios, nevertheless, over the extended duration of an ELAP event, two-phase natural circulation flow may eventually be reached in the PCS, dependent upon the timing of reestablishing PCS makeup.

In the PWROG's Core Cooling Position Paper, which was provided in a letter dated January 30, 2013, the PWROG recommended that the reflux or boiler-condenser cooling phase be avoided under ELAP conditions because of uncertainties in plant operators' ability to control natural circulation following reflux cooling and the impact of dilute pockets of water on criticality. Due to the challenge of resolving the above issues within the compliance schedule specified in Order EA-12-049, the NRC staff agreed that PWR licensees should provide makeup to the PCS prior to entering the reflux or boiler-condenser cooling phase of an ELAP, such that reliance on thermal-hydraulic code predictions during this phase of the event would not be necessary. However, the PWROG's Core Cooling Position Paper did not fully address the staff's issues with CENTS, and in particular, lacked a quantitative definition for the threshold of entry into reflux cooling.

To address the NRC staff's remaining concerns associated with the use of CENTS to simulate the two-phase natural circulation flow that may occur during an ELAP for CE-designed PWRs, the PWROG submitted a white paper entitled "Westinghouse Response to NRC Generic request for additional information (RAI) on CENTS Code in Support of the Pressurized Water Reactor Owners Group (PWROG) (PA-ASC-1187)" (ADAMS Accession No. ML14218A083). This white paper was originally submitted on September 24, 2013, and a revised version was resubmitted on November 20, 2013. The white paper focused on comparing several small-break LOCA simulations using the CENTS code to analogous calculations performed with the CEFLASH-4AS code, which was previously approved for analysis of design-basis small-break LOCAs for CE-designed reactors under the conservative Appendix K paradigm. The analyses in the CENTS white paper generally showed that CENTS' predictions were similar or conservative relative to CEFLASH-4AS for key figures of merit under conditions where natural circulation exists in the PCS, including predictions of PCS loop flow rates and the timing of the transition to reflux cooling. The NRC staff's review of the analyses in the white paper included performing confirmatory analyses with the TRACE code. In particular, the staff's TRACE simulations generally showed reasonable agreement with the predictions of CENTS regarding the fraction of the initial PCS mass remaining at the transition to reflux cooling. Therefore, as documented by letter dated October 7, 2013 (ADAMS Accession No. ML13276A555), the NRC staff endorsed the approach in the PWROG's white paper as an appropriate means for applying the CENTS code to beyond-design-basis ELAP analysis, with the limitation that reliance upon CENTS is limited to the phase of the event before reflux cooling begins.

Quantitatively, as proposed in the PWROG's white paper, the threshold for entry into reflux cooling is defined as the point at which the 1-hour centered time-average of the flow quality passing over the SG tubes' U-bend exceeds one-tenth (0.1) in any PCS loop. Considering this criterion relative to the PCS loop flow predictions of both the CENTS and TRACE codes, the NRC staff concurred with this definition as a practical expedient, which provides a reasonable criterion for determining the threshold of entering reflux cooling for the purpose of analyzing the beyond-design-basis ELAP event. Inasmuch as the transition of flow in the PCS loops from natural circulation to reflux cooling is a gradual process that typically occurs over multiple hours, a quantitatively defined threshold becomes necessary to assure consistent, objective treatment. As further discussed in Section 3.2.3.4, a second metric for ensuring adequate coping time is associated with maintaining sufficient natural circulation flow in the PCS to support adequate mixing of boric acid.

Applying the one-tenth flow quality criterion to the analyses completed in WCAP-17601-P, the November 20, 2013, revision of the PWROG's white paper on CENTS determined ELAP coping times prior to entering the reflux cooling mode for each CE reactor included in WCAP-17601-P. Unlike the generic calculations performed for reactors designed by other vendors, the analysis for CE plants in WCAP-17601-P was generally conducted at a plant-specific level. (One exception is that a single analysis was used to represent four plants of similar design, including Palisades.) With respect to Palisades, the CENTS white paper reported a coping time prior to entering reflux cooling of 24.7 hours, by which time PCS makeup should be provided. Additionally, the licensee performed further plant-specific analysis to support the sequence of events in its FIP. In specific, the licensee conservatively determined its time for establishing FLEX PCS makeup (i.e., 8 hours) on the basis of ensuring single-phase natural circulation flow in the PCS (i.e., prior to the initiation of vapor voids in the SG U-tube bend).

The licensee's criterion of ensuring single-phase natural circulation in the PCS is conservative because two-phase natural circulation flow would be expected to persist in the PCS for a significant additional period of time prior to the transition to reflux cooling, and the NRC staff's assessment of the CENTS code demonstrated adequate performance in this regime for analyzing the beyond-design-basis ELAP event. Finally, setting aside the arbitrary difference in applied acceptance criterion (reflux cooling versus single-phase natural circulation), the NRC staff's audit found good agreement between the calculated results for Palisades from WCAP-17601-P (as reported in the PWROG's CENTS white paper) and those in the licensee's plant-specific calculations.

The NRC staff further performed confirmatory simulations with the TRACE code for Palisades using an input deck generated from a mixture of plant-specific sources and generic information applicable to CE reactors. The results of the staff's calculations indicated that approximately 19 hours should be available prior to the plant entering the reflux cooling mode, thereby confirming the appropriateness of the licensee's mitigating strategy. It should further be understood that, similar to the simulations for Palisades in both WCAP-17601-P and the licensee's plant-specific analysis, the NRC staff's confirmatory calculations are expected to significantly underestimate the actual coping time available to Palisades because (1) these simulations assumed a PCP seal leakage rate significantly in excess of that subsequently endorsed by the NRC staff for the Flowserve N-9000 seals installed at Palisades and (2) no credit is taken for CBO isolation. As a result, the NRC staff considers the licensee's strategy for ensuring sufficient PCS makeup to avoid reflux cooling as having ample margin for mitigating the analyzed ELAP event.

Therefore, based on the evaluation above, the NRC staff concludes that the licensee's analytical approach should appropriately determine the sequence of events for reactor core cooling, including time-sensitive operator actions, and evaluate the required equipment to mitigate the analyzed ELAP event, including pump sizing and cooling water capacity.

3.2.3.3 Primary Coolant Pump (PCP) Seals

Leakage from PCP seals is among the most significant factors in determining the duration that a PWR can cope with an ELAP event prior to initiating PCS makeup. An ELAP event would interrupt cooling to the PCP seals, resulting in the potential for increased seal leakage and the failure of elastomeric o-rings and other components, which could further increase the leakage rate. As discussed above, as long as adequate inventory is maintained in the PCS, natural circulation can effectively transfer residual heat from the reactor core to the SGs and limit local imbalances in boric acid concentration. Along with cooldown-induced shrinkage of the PCS inventory, cumulative leakage from PCP seals governs the duration over which natural circulation can be maintained in the PCS. Furthermore, the seal leakage rate at the depressurized condition can be a controlling factor in determining the flow capacity requirement for FLEX pumps to offset ongoing PCS leakage and recover adequate system inventory.

Flowserve N-9000 4-stage seals are installed on the PCPs at Palisades. The N-9000 is a hydrodynamic seal that was developed by Flowserve in the 1980s. One of the design objectives for the N-9000 seal was to provide low-leakage performance under loss-of-seal-cooling conditions during events such as a station blackout. In support of its customers' efforts to address the ELAP event (which similarly involves a loss of seal cooling) in accordance with Order EA-12-049, on August 3, 2015, Flowserve submitted to the NRC staff its "White Paper on the Response of the N-Seal Reactor Coolant Pump (RCP) Seal Package to Extended Loss of All Power (ELAP)," (ADAMS Accession No. ML15222A366). The N-Seal white paper contains information regarding the expected leakage rates over the course of an ELAP event for each PWR at which Flowserve N-Seals are currently installed. By letter dated November 12, 2015 (ADAMS Accession No. ML15310A094), the staff endorsed the leakage rates described in the white paper for the beyond-design-basis ELAP event, subject to certain limitations and conditions.

During the audit, the NRC staff requested that the licensee address the status of its conformance with the Flowserve white paper and the limitations and conditions in the NRC staff's endorsement letter. The licensee responded that the plant design and planned mitigation strategy at Palisades are generally consistent with the information assumed in the calculation performed by Flowserve, which is summarized in Table 1 of the white paper. However, the licensee noted a discrepancy in that the actual cooldown rate during an ELAP event (75°F/hr) may be slightly lower than assumed in the white paper (90°F/hr). The NRC staff noted a further discrepancy in that the peak cold leg temperature prior to the PCS cooldown assumed in Flowserve's analysis (540°F) was slightly less than the saturation temperature corresponding to the lowest nominal setpoint for MSSV valve lift pressure (roughly 545°F). However, a confirmatory calculation performed by the NRC staff demonstrated that these slight discrepancies do not affect the conclusion that Palisades should have adequate seal performance with significant margin under ELAP conditions. Based upon its audit review, the NRC staff further considered the endorsement letter's condition on the density of the coolant leaking from the PCS to be addressed inasmuch as a conservative PCP seal leakage assumption was used for the determination of the time to enter reflux cooling.

According to measured data from Flowserve's 1988 N-Seal station blackout test, following CBO isolation at 0.5 hours, over the course of the succeeding period of 6 to 7 hours during which CBO isolation was maintained, the average seal leakage rate was slightly less than 0.05 gpm. The NRC staff noted that, similar to the test condition, Palisades's mitigating strategy for the ELAP event directs early isolation of all CBO flow (i.e., including the CBO relief isolation valve), within 20 minutes of event initiation. Although the NRC staff agreed that it is appropriate to allow credit for demonstrated performance, during its review of the Flowserve white paper, the staff questioned the extrapolation of evidence from a limited test period of 6 to 7 hours to the indefinite coping period associated with the ELAP event. Therefore, while the NRC staff ultimately agreed with the credit Flowserve's N-Seal white paper allowed for CBO isolation in determining the short-term thermal exposure profile of seal elastomers, the staff did not endorse direct application of the average leakage rate measured with the CBO isolated in the 1988 test for an indefinite period in the absence of demonstrated long-term seal performance.

Ultimately, the plant-specific calculations performed by Flowserve in its white paper determined that the Palisades FLEX scenario does not exceed the design margin demonstrated in the 1988 station blackout test, such that increased leakage during the ELAP event due to elastomer failure or other causes is not expected. Under this condition, according to the values listed in Table 3a of the Flowserve white paper, assuming a leakage rate of 1.5 gpm per PCP would be appropriate. Considering the plant has 4 PCPs and accounting for another 1 gpm of additional PCS leakage would result in a total PCS leakage of 7 gpm.

Comparing the assumed leakage rates in the licensee's analyses (i.e., including analysis from both WCAP-17601-P and its plant-specific calculation) to the endorsed values from the Flowserve white paper, the NRC staff observed that the licensee's analyses for determining the threshold for entry into reflux cooling did not credit the installation of the Flowserve N-Seals. Instead, the leakage rates were based on the assumption that PCP seal leakage would occur at an initial rate of 15 gpm (i.e., a rate just below that which would trigger closure of excess flow check valves in the CBO lines) at the PCS temperature and pressure conditions applicable when PCP inlet subcooling decreases below 50°F. Modeling PCP seal leakage in this manner was intended to envelop the potential for seal instability at low inlet subcooling conditions to result in "pop-open" seal failures. Thermal-hydraulic analysis indicates that the subcooling margin decreases below 50°F at approximately 3 hours into the event. At this juncture, the PCS cooldown is being conducted, which results in the PCS approaching saturation because the pressurizer heaters are presumed to lose power during the ELAP event. As the PCS cooldown and depressurization continue, the seal leakage rate is assumed to decrease in accordance with the choked flow correlation used in the licensee's CENTS analyses. Comparing the leakage rates from the licensee's CENTS analyses, as well as confirmatory analysis performed by the NRC staff with the TRACE code (see Section 3.2.3.2 above), the NRC staff concluded that the analytically assumed leakage rates are conservative relative to the expected leakage rate for Flowserve N-9000 seals during the analyzed ELAP event.

The NRC staff further reviewed the potential PCS leakage rate of 7 gpm relative to the makeup rate the licensee could supply using the T-77 batching tank. The licensee's FIP submittal asserts that batching a volume of 457 gallons every 90 minutes would be sufficient to account for PCS leakage. However, the NRC staff concluded that the rate of injection implied by the licensee's statement (i.e., approximately 5 gpm) may not be sufficient to match the long-term leakage rates endorsed in the Flowserve N-Seal white paper. As a result, the NRC staff requested during the audit that the licensee identify the actual amount of time required to complete one batch addition from the T-77 tank. In response, the licensee estimated that one batch addition of PCS makeup could be completed via this method in less than 30 minutes. This information provides confidence that the licensee should have adequate onsite FLEX PCS makeup capability to mitigate potential system leakage rates considered bounding in the Flowserve N-Seal white paper.

Based upon the discussion above, the NRC staff concludes that the PCP seal leakage rates assumed in the licensee's thermal-hydraulic analysis may be applied to the beyond-design-basis ELAP event for the site.

3.2.3.4 Shutdown Margin Analyses

In an analyzed ELAP event, the loss of electrical power to control rod drive mechanisms is assumed to result in an immediate reactor trip with the full insertion of all control rods into the core. The insertion of the control rods provides sufficient negative reactivity to achieve subcriticality at post-trip conditions. However, as the ELAP event progresses, the shutdown margin for PWRs is typically affected by several primary factors:

- the cooldown of the RCS and fuel rods adds positive reactivity

- the concentration of xenon-135, which (according to the core operating history assumed in NEI 12-06) would

    - initially increase above its equilibrium value following reactor trip, thereby adding negative reactivity
    - peak at roughly 12 hours post-trip and subsequently decay away gradually, thereby adding positive reactivity

- the passive injection of borated makeup from nitrogen-pressurized accumulators due to the depressurization of the RCS, which adds negative reactivity

At some point following the cooldown of the PCS, PWR licensees' mitigating strategies generally require active injection of borated coolant via FLEX equipment. In many cases, boration would become necessary to offset the gradual positive reactivity addition associated with the decay of xenon-135; but, in any event, borated makeup would eventually be required to offset ongoing PCS leakage. The necessary timing and volume of borated makeup depend on the particular magnitudes of the above factors for individual reactors.

In support of its review of the mitigating strategy for Palisades, the NRC staff audited the licensee's shutdown margin calculation. The licensee's calculation considered a case where borated coolant at a concentration of 1720 ppm boron is injected at flow rate of 30 gpm starting at 13 hours into the event. The licensee concluded that maintaining this PCS makeup flow for a duration of 7 hours will be sufficient to maintain adequate reactor shutdown margin indefinitely at the target PCS cold leg temperature of 355°F with no xenon remaining in the core. Based upon this calculation, Palisades will conservatively begin PCS boration at 8 hours into the event, and will initially draw suction from the BASTs, which contain coolant with a boron concentration of at least 10,000 ppm. As described in the sequence of events in the licensee's FIP, the licensee's FLEX strategy is capable of providing indefinite coping capability at the conditions above, without cooling the RCS to cold shutdown mode.

As described in its FIP, the licensee's shutdown margin calculation for Palisades assumed uniform mixing of boric acid. To support its plant-specific audit reviews, the NRC staff had requested that the industry provide additional information to justify that borated makeup would adequately mix with the PCS volume under natural circulation conditions potentially involving two-phase flow. In response, the PWROG submitted a position paper, dated August 15, 2013 (withheld from public disclosure due to proprietary content), which provided test data regarding boric acid mixing under single-phase natural circulation conditions and outlined applicability conditions intended to ensure that boric acid addition and mixing during an ELAP would occur under conditions similar to those for which boric acid mixing data is available. By letter dated January 8, 2014 (ADAMS Accession No. ML13276A183), the NRC staff endorsed the above position paper with three conditions:

- The required timing and quantity of borated makeup should consider conditions with no RCS leakage and with the highest applicable leakage rate.
- Adequate borated makeup should be provided either (1) prior to the RCS natural circulation flow decreasing below the flow rate corresponding to single-phase natural circulation, or (2) if provided later, then the negative reactivity from the injected boric acid should not be credited until one hour after the flow rate in the RCS has been restored and maintained above the flow rate corresponding to single-phase natural circulation.
- A delay period adequate to allow the injected boric acid solution to mix with the RCS inventory should be accounted for when determining the required timing for borated makeup. Provided that the flow in all loops is greater than or equal to the corresponding single-phase natural circulation flow rate, a mixing delay period of one hour is considered appropriate.

The NRC staff's audit review considered whether the licensee had followed recommendations from the PWROG's position paper and the associated conditions imposed in the NRC staff's endorsement letter. In particular, the NRC staff concluded that the licensee had considered a bounding range of PCS leakage rates, including a case with no PCS leakage. The NRC staff further concluded that initiating PCS makeup at a rate of 30 gpm by 8 hours into the event should ensure that adequate natural circulation flow exists in the PCS throughout the period that boric acid mixing would be credited. Finally, based on our audit review, the staff agreed that initiating boration at 8 hours would provide margin to the timeline defined in the licensee's shutdown margin calculation, even after accounting for a 1-hour delay period to ensure adequate mixing. Therefore, the NRC staff concluded that the licensee's boration strategy conforms to the PWROG position paper, including the additional conditions imposed in the NRC staff's endorsement letter.

The licensee's shutdown margin calculations also included analysis to determine minimum quantities of SIT injection in order to satisfy shutdown margin requirements, as well as maximum quantities of SIT injection for determining the PCS pressure necessary to prevent injection of the nitrogen cover gas into the PCS. In particular, the licensee's calculations determined that the SIT isolation valves should be closed prior to depressurizing the PCS pressure below approximately 144 psia in Phase 3, which is the approximate saturation pressure corresponding to the planned post-PCS-cooldown cold leg temperature of 355°F.

With regard to assessing the potential need for PCS venting to support injection of the volume of borated coolant necessary to ensure adequate shutdown margin, the licensee's FIP states that the 10,000 ppm boron concentration of the initial PCS injection source (i.e. the BASTs) results in only having to inject approximately 2167 gallons of coolant, which can be accommodated by the PCS without letdown, given the nominal pressurizer steam volume of 700 cubic ft. (over 5000 gallons). The NRC staff further observed that, inasmuch as the FLEX strategy directs that the PCS be cooled and depressurized prior to initiating PCS makeup, cooldown-induced contraction of the PCS inventory would create significant additional free volume beyond that existing during normal operation. Nevertheless, the NRC staff did not consider this justification adequate because the injection of coolant from the SITs could result in considerable refilling of the PCS in ELAP scenarios considering minimal PCS leakage. Thus, the potential for undesirable increases in PCS pressure at reduced PCS temperatures could not be ruled out in certain scenarios (e.g., a high-pressure charging pump refilling the PCS to a point approaching water-solid conditions) if PCS makeup were initiated without establishing a vent path.

However, the NRC staff observed that the licensee has the capability to vent the PCS if needed, via primary coolant gas vent system vent paths from both the reactor vessel upper head and pressurizer. These vent paths contain 7/32-in. orifices that limit the rate at which PCS coolant can be let down, and the valves in the flowpath are operated by dc power. Furthermore, as discussed during the audit, the licensee's FLEX procedures direct that a PCS vent path be opened when FLEX PCS makeup is being performed. According to procedure, the vent path would subsequently be isolated when FLEX PCS makeup is secured. Therefore, the NRC staff concluded that the licensee has an appropriate strategy for venting the PCS under ELAP conditions. Considering the limited volume of BAST injection required to ensure adequate shutdown margin and the size of the vent line orifice, in light of the results for the more limiting case documented in the licensee's shutdown margin calculation, the NRC staff's audit review concluded that the necessary actions could be completed within the required timeframe.

Guidance document NEI 12-06, Section 11.8.2, states that plant configuration control procedures will be modified to ensure that changes to the plant design will not adversely impact the approved FLEX strategies. Inasmuch as changes to the core design constitute changes to the plant design, the staff expects that any changes to the core design, such as those evaluated in a typical core reload analysis, will be evaluated to determine that they do not adversely impact the approved FLEX strategies, especially the analyses which demonstrate that no re-criticality will occur during a FLEX PCS cooldown.

Therefore, based on the evaluation above, the NRC staff concludes that the sequence of events in the proposed mitigating strategy should result in acceptable shutdown margin for the analyzed ELAP event.

3.2.3.5 FLEX Pumps and Water Supplies

The licensee's Phase 2 FLEX strategy relies on a centrifugal, trailer-mounted, portable diesel driven FLEX pump that can provide core cooling, SFP cooling and boric acid batching water supply. This FLEX pump takes suction from the UHS and discussion of its robustness is documented in SE Section 3.10. The licensee identified the performance criteria (e.g., flow rate, discharge pressure, total dynamic head) for its FLEX pump in FIP Section 3.2.10, which describes a FLEX pump supplied from a NSRC for Phase 3 would allow the NSRC pump to fulfill the mission of the onsite FLEX pump if the onsite FLEX pump were to fail.

The FLEX pump takes suction from the intake canal through removable grating and discharges to a portable FLEX manifold. From this manifold, hoses can be routed to the MFW system (primary connection) or the AFW system (alternate connection), the SFP and the boric acid tank. A single diesel driven FLEX pump provides full capability to perform all the FLEX functions with one portable pump stored in each of the two FLEX Storage Buildings; thus, the licensee satisfies the N+1 requirement outlined in NEI 12-06.

During the audit, the licensee provided Calculation EC-46465-06, "Hydraulic Analysis of FLEX Coping Strategies," Rev. 0, which determined the necessary pump performance criteria for the portable diesel driven FLEX pumps to support the licensee's core cooling, SFP cooling and boron batching strategies. The staff noted that this calculation assessed numerous possible lineups based on such variables as suction sources, connection points and hose paths to determine adequate performance criteria for the portable diesel driven FLEX pump while simultaneously injecting into the SGs, providing SFP makeup and providing water for boron batching. The calculation determined the total flow requirement was 410.5 gpm at 235 psi discharge pressure broken down to the following: 136.5 gpm into the SGs, 250 gpm of SFP overspray, 15 gpm for boron batching and 8.5 gpm margin. The FLEX pump can provide 410 gpm at 275 psi.

During the audit, the NRC staff performed a walkdown of the licensee's core cooling FLEX strategies and noted that the point of deployment for the portable FLEX pumps, hose routing and deployment connection points (primary and alternate) were consistent with the licensee's hydraulic analysis. The staff noted that the staging and operation of the portable diesel driven FLEX pump are directed in procedure, FIG-2, "FLEX Pump Stating and Operation," Rev. 0, and that procedure FIG-4, "Low Pressure Feedwater Alignment," Rev. 0, directs operators to feed the SGs using the portable diesel driven FLEX pump.

The licensee's Phase 2 RCS inventory control strategies rely on the use of one of two installed positive displacement charging Pumps taking suction from the BASTs to support injection into the RCS through the charging pumps discharge header. The licensee stated in its FIP that 32 gpm of RCS makeup is required and the each charging pump can provide 44 gpm. The licensee does plan to use a hose connected to the FLEX manifold to provide water from the portable diesel driven FLEX pump for boric acid mixing. The installed charging pumps were discussed further in Section 3.2.3.1.1. Repowering installed charging pumps to provide RCS makeup is considered an alternative to NEI 12-06 and acceptability of this alternative is documented in SE Section 3.14.1.

The FIP states they will continue with Phase 2 strategies during Phase 3 using the mobile boration and water purification units to purify and provide clean water from Lake Michigan. However, the licensee does intend on establishing SDC strategies that rely on the following pumps provided by the NSRC: a diesel-driven, low pressure, high flow, pump (5000 gpm and 150 psi) to provide flow to the SWS system, and a hydraulically driven, booster pump (26 ft. water lift and 5000 gpm) to provide flow to the high flow/low pressure pump. These pumps from the NSRC would be used in conjunction with the repowered CCW pump and SDC/LPSI pump to establish SDC. During the audit, the staff noted the licensee's procedure, FIG-11,"Service Water – NSRC (Phase 3)," provides guidance for deploying the NSRC pump, the booster pump, and the associated SWS strainer adapter, hoses, manifolds, and fittings.

Based on the staff's review of the FLEX pumping capabilities at PNP, as described in the above hydraulic analyses and the FIP, the NRC staff concludes that the portable FLEX pumps should perform as intended to support core cooling and RCS inventory control during an ELAP event, consistent with NEI 12-06, Section 11.2.

3.2.3.6 Electrical Analyses

The licensee's FIP defined strategies capable of mitigating a simultaneous loss of all ac power and loss of normal access to the ultimate heat sink (LUHS) resulting from a BDBEE by providing the capability to maintain or restore core cooling at Palisades. The Palisades electrical FLEX strategies are practically identical for maintaining or restoring core cooling, containment, and spent fuel pool cooling, except as noted in Sections 3.3.4.4 and 3.4.4.4 of this SE. Furthermore, the electrical coping strategies are the same for all modes of operation.

The NRC staff reviewed the licensee's FIP to determine whether the FLEX strategies, if implemented appropriately, should maintain or restore core cooling, containment, and spent fuel pool cooling following a BDBEE. As part of its review, the NRC staff reviewed conceptual electrical single-line diagrams, summaries of calculations for sizing the FLEX diesel and turbine generators and station batteries, and summaries of calculations that addressed the effects of temperature on the electrical equipment credited in the FIP as a result of losing heating, ventilation, and air conditioning (HVAC) during an ELAP as a result of a BDBEE.

According to the licensee's FIP, the Palisades Operators would declare an ELAP following a loss of offsite power, loss of all emergency diesel generators, and the loss of any alternate ac power with a simultaneous loss of normal access to the LUHS. In the FIP, the licensee assumes that this determination can be made less than1 hour after the onset of an ELAP/LUHS event.

During Phase 1, Palisades would rely on the station's safety-related batteries to provide support to instrumentation for monitoring parameters and support to controls for SSCs used to maintain the key safety functions (Reactor core cooling, PCS inventory control, and Containment integrity). The Palisades station batteries (ED-01 and ED-02) are safety-related Class 1E SSCs that are fully protected within the Auxiliary Building (Seismic Category 1 structure) and fully qualified for all applicable external events. The safety-related batteries were manufactured by C&D Technologies and are model LCR-25 that are rated 1770 ampere-hour at an 8-hour discharge rate to 1.78 volts per cell. Following the reactor transient as a result of losing offsite power and the unavailability of the emergency diesel generators, the licensee will initially shed loads from the battery utilizing the existing SBO procedure. Once an ELAP has been declared (approximately one hour after the event when it becomes evident that ac power will not be restored from onsite or off-site sources), the Palisades operators would initiate procedures to shed additional unnecessary loads on the station's safety-related batteries (FSG-4, "ELAP DC Load Shed and Management," Rev. 0). The licensee expects load shedding to be completed within 2 hours of event initiation. Based on its review of calculation EA-ELEC-LDTAB-021, "Station Batteries ED-01 & ED-02 FLEX Coping Capability," Rev. 0, the NRC staff confirmed that the Palisades station safety-related batteries will be available for a minimum of 8 hours during Phase 1 provided the load shedding is completed within 2 hours of event initiation. The calculated available battery capacity is sufficient since the licensee expects to have a FLEX 480 Vac Diesel Generator deployed, staged, and connected as part of its phase 2 transition to repower a station 480 Vac bus to power battery chargers within 8 hours of the onset of an ELAP/LUHS event.

Based on the evaluation above, the NRC staff concludes that the PNP load shed strategy should ensure that the batteries have sufficient capacity to supply power to required loads until the portable generators are deployed.

During Phase 2, the licensee will deploy one portable 480 Vac 463 kW FLEX diesel generator to restore power to the Class 1E Battery Charger, power up a Charging Pump, flow path motor-operator valves (MOVs), emergency lighting, the electric driven FLEX air compressor and the electric driven FLEX portable Battery Room ventilation. Two 480 Vac 463 kW FLEX diesel generators are available to satisfy N+1 requirement. The licensee expects that plant operators will begin deployment of a 463 kW 480 Vac FLEX portable diesel generator within 2 hours of event initiation to restore power to LCC-19 or LCC-20 and other strategy loads. The licensee plans to complete this action within 8 hours of event initiation to prevent station battery (ED-01 and ED-02) depletion. Once LCC-19 (primary connection point) or LCC-20 (alternate connection point) is being supplied power from the portable diesel driven 463 kW 480 Vac FLEX generator, MCC-1 or MCC-2 can be energized, which allows 2 of 4 Battery Chargers to be placed in service to recharge the station batteries using the normal Class 1E breakers.

The FLEX diesel generator will also provide power to the electric driven portable ventilation fan to remove hydrogen from the Battery Rooms, and provide the source of power to the portable electric driven air compressor which will supply air to the ADVs in support of SG pressure control and PCS temperature control. Once the Battery Chargers are placed in service, a portable electric driven FLEX ventilation fan will be placed in service for the associated Battery Room to maintain hydrogen below combustibility limits. To ensure hydrogen limits remain below combustibility limits, the portable electric driven FLEX ventilation/exhaust fan must be placed in service in the Battery Room by 1.5 hours after battery charging begins, or 9.5 hours after event initiation. The licensee will route a flexible duct from the Cable Spreading Room outside of the Turbine Building such that the hydrogen can be exhausted to the atmosphere, preventing hydrogen accumulation in other areas of the plant.

At the point when ELAP mitigation activities require connection of the FLEX diesel generators, in addition to existing electrical interlocks, the licensee will employ procedural controls, such as inhibiting EDG start circuits and breaker rack-outs (e.g., EDG breakers, offsite feeder breakers, etc.), to prevent simultaneous connection of both the FLEX diesel generators and Class 1E EDGs to the same ac distribution system or component. Additionally, repowering the Class 1E electrical buses from either FLEX diesel generators or subsequently the Class 1E EDGs (should they become available) will be accomplished manually and controlled by procedure; no automatic sequencing or automatic repowering of the buses will be utilized.

The NRC staff reviewed the licensee's Phase 2 and 3 FLEX generator calculations and procedures (EA-ELEC-LDTAB-022, "PLP FLEX Diesel Sizing Calculation," Rev. 0, Attachment 9.3.14 of Engineering Change 46465 (Phase 3 4160 Vac Turbine Generator sizing), FSG-5, "Initial Assessment and FLEX Equipment Staging," Rev. 0, FIG-1, "FLEX Generator Staging and Operation," Rev. 0, and FIG-12, "4160 Vac Generator – NSRC (Phase 3)," Rev. 2). Calculation EA-ELEC-LDTAB-022, "PLP FLEX Diesel Sizing Calculation," Rev. 0, showed that the required Phase 2 loads equal 325.11 kW. Therefore, one 463 kW FLEX Diesel Generator is adequate to support the electrical loads required for the licensee's Phase 2 strategies.

For Phase 3, the licensee will receive two 1-MW, 4160 Vac, 3-phase turbine generators (including a distribution panel, to connect them to a plant supplied FLEX 4160/2400 Vac transformer) and one 1-MW, 480 Vac, 3-phase turbine generator from an NSRC. These turbine generators could be used to supply power battery chargers, ventilation, MOVs, and other miscellaneous loads. The NRC staff reviewed calculations, conceptual single line electrical diagrams, the separation and isolation of the FLEX turbine generators from the Class 1E EDGs, and procedures that direct operators how to align, connect, and protect associated systems and components. Each turbine generator is capable of supplying approximately 1 MW, but two turbine generators will be operated in parallel to provide approximately 2 MW (2.5 MVA at .8 pf). Per calculation EA-ELEC-LDTAB-022, "PLP FLEX Diesel Sizing Calculation," Rev. 0, the total loads for Phase 3 equal 1646.24 kW.

The two 1-MW 4160 Vac turbine generators will provide the ability to supply power to one complete train of Class 1E equipment that can be used to bring the plant to cold shutdown and restore other auxiliaries such as CACs. One bus of Class 1E 2400 V switchgear will be energized with the NSRC turbine generator. Specifically, the 4160 Vac turbine generator will be used to supply (via a distribution panel and transformer) 2400 Vac power to Bus 1C or Bus 1D. The primary connection point is Bus 1D, due to its close proximity to where the NSRC turbine generator will be staged. Bus 1C is an alternate connection point for powering redundant loads in case power through Bus 1D fails or is unable to be used. Because the turbine generator will supply 4160 Vac power, a 4160/2400 V transformer is required to step down the voltage. The 4160/2400 V transformer will be connected to Bus 1C or 1D using temporary cables connected directly to the bus bars (all three phases) of an existing breaker 152-213 on Bus 1D (or 152-107 on Bus 1C). No breaker modifications are needed, but the connections will replace those from the onsite EDG for that bus. The transformer neutral will be grounded on the 4160 V side, and ungrounded on the 2400 V side, to match the system. The 4160 Vac NSRC supplied turbine generators have been sized to ensure the capability (as a minimum) to energize a CCW Pump, LPSI Pump, SDC flowpath MOVs, a SFP Pump, and 3 CACs. Additionally, the licensee has sized the plant supplied Phase 3 FLEX step down transformer to accommodate the capacity of 2 NSRC 1-MW turbine generators. Power cables will be supplied with the NSRC 4160 Vac turbine generators for connection to the Palisades Plant electrical buses.

The 480 Vac NSRC turbine generators come with the same style and size connectors as the on-site Phase 2 FLEX generators. Therefore, the licensee's Phase 3 strategy could utilize the Phase 2 electrical connections if needed. The capacity of the NSRC-supplied 480 Vac turbine generator is of greater capacity than the capacity of the licensee's Phase 2 FLEX Diesel Generators. Therefore, the NRC staff finds that the Phase 3 480 Vac turbine generators will provide adequate capacity to supply electrical loads (same as Phase 2) to maintain or restore core cooling, SFP cooling, and containment indefinitely following an ELAP.

Based on its review, the NRC staff finds that the plant batteries used in the strategy should have sufficient capacity to support the licensee's strategy, and that the FLEX DGs and turbine generators that the licensee plans to use should have sufficient capacity and capability to supply the necessary loads during an ELAP event.

3.2.4 Conclusions

Based on this evaluation, the NRC staff concludes that the licensee has developed guidance that should maintain or restore core cooling during an ELAP event consistent with NEI 12-06 guidance, as endorsed by JLD-ISG-2012-01, with the alternatives described in Section 3.14 of this SE, and adequately addresses the requirements of the order.

3.3 Spent Fuel Pool Cooling Strategies

In NEI 12-06, Table 3-2 and Appendix D, summarize an acceptable approach consisting of three separate capabilities for the SFP cooling strategies. This approach uses a portable injection source to provide the capability for 1) makeup via hoses on the refueling floor capable of exceeding the boil-off rate for the design-basis heat load; 2) makeup via connection to spent fuel pool cooling piping or other alternate location capable of exceeding the boil-off rate for the design basis heat load; and 3) spray via 2 portable monitor nozzles from the refueling floor using a portable pump capable of providing 125 gpm per nozzle or 250 gpm total. During the event, the licensee selects the method to use based on plant conditions. This approach also requires a strategy to mitigate the effects of steam from the SFP, such as venting.

As described in NEI 12-06, Section 3.2.1.7 and JLD-ISG-2012-01, Section 2.1, strategies that must be completed within a certain period of time should be identified and a basis that the time can be reasonably met should be provided. In NEI 12-06, Section 3 provides the performance attributes, general criteria, and baseline assumptions to be used in developing the technical basis for the time constraints. Since the event is beyond-design-basis, the analysis used to provide the technical basis for time constraints for the mitigation strategies may use nominal initial values (without uncertainties) for plant parameters, and best-estimate physics data. All equipment used for consequence mitigation may be assumed to operate at nominal setpoints and capacities. In NEI 12-06, Section 3.2.1.2 describes the initial plant conditions for the at-power mode of operation; Section 3.2.1.3 describes the initial conditions; and Section 3.2.1.6 describes SFP initial conditions.

In NEI 12-06, Section 3.2.1.1, provides the acceptance criterion for the analyses serving as the technical basis for establishing the time constraints for the baseline coping capabilities to maintain SFP cooling. This criterion is keeping the fuel in the SFP covered with water.

The ELAP causes a loss of cooling in the SFP. As a result, the pool water will heat up and eventually boil off. The licensee's response is to provide makeup water. The timing of operator actions and the required makeup rates depend on the decay heat level of the fuel assemblies in the SFP. The sections below address the response during operating, pre-fuel transfer or post-fuel transfer operations. The effects of an ELAP with full core offload to the SFP is addressed in Section 3.11.

3.3.1 Phase 1

The FIP states no action is required for Phase 1 makeup because the time to uncover the fuel is sufficient to deploy Phase 2 equipment. However, the FIP states that boiling may start as soon as 3.28 hours during an outage with the entire core located in the SFP after the ELAP (5.63 hours with a normal, non-outage SFP heatload), and may affect personnel habitability on the refueling floor. For this reason, the licensee's strategy is to complete the hose deployment and establish a vent path on the refueling floor prior to 3 hours after an ELAP declaration. The FIP also states that the time for boil-off to lower the water level to the top of the fuel racks is 11.07 hours after the loss of normal SFP cooling with the conservative assumption of a full-core offload scenario.

3.3.2 Phase 2

The licensee's Phase 2 SFP cooling strategy consists of deploying the portable diesel driven FLEX pump to provide makeup from Lake Michigan. As described in the FIP, hoses can be connected to the FLEX pump discharge manifold and routed to the refuel floor to provide direct makeup to the pool and spray flow. Additionally, a hose can be connected to the installed SFP cooling system, which does not require access to the refueling floor. As described in Section 3.2.3.5, the FLEX manifold is pressurized using the portable FLEX pump staged at the intake structure. The Diesel Driven FLEX Pump is capable of providing up to 250 gpm of spray flow.

3.3.3 Phase 3

The FIP states that the Phase 3 strategy can continue to utilize the Phase 2 strategies. However, the licensee will establish CCW and SWS, as described in SE Section 3.2.1.2.3. The licensee would then be able to restore SFP Cooling system operation.

3.3.4 Staff Evaluations

3.3.4.1 Availability of Structures, Systems, and Components

3.3.4.1.1 Plant SSCs

Condition 6 of NEI 12-06, Section 3.2.1.3, states that permanent plant equipment contained in structures with designs that are robust with respect to seismic events, floods, and high winds, and associated missiles, are available. In addition, Section 3.2.1.6 states that the initial SFP conditions are: 1) all boundaries of the SFP are intact, including the liner, gates, transfer canals, etc., 2) although sloshing may occur during a seismic event, the initial loss of SFP inventory does not preclude access to the refueling deck around the pool and 3) SFP cooling system is intact, including attached piping.

The FIP indicates that boiling begins at approximately 5.63 hours during a normal, non-outage situation. This analysis assumes a heat load of 4.47 million British Thermal Unit (Btu)/hr and a starting SFP temperature of 140°F. The staff noted that the licensee's sequence of events timeline in the FIP indicates that operators will deploy hoses and spray nozzles as a contingency for SFP makeup within 3 hours from event initiation. The staff noted that Procedure FIG-3, "Alternate SFP Makeup and Cooling," Rev. 0, contains a precaution that SFP hoses should be deployed prior to 3 hours to ensure the SFP area remains habitable for personnel entry.

As described in the FIP, the Phase 1 SFP cooling strategy does not require any prestaged equipment. However, the licensee does establish a ventilation path to cope with temperature, humidity and condensation from evaporation and/or boiling of the SFP. The staff noted that Procedure FIG-8, "Alternate Ventilation," Rev. 0, contains instructions for operators to establish a SFP vent path following the ELAP by opening the double leaf doors on the roof of the Fuel Building.

The licensee's Phase 2 and Phase 3 SFP cooling strategy involves use of the FLEX pump (or NSRC supplied pump for Phase 3), with suction from the UHS, to pressurize the portable FLEX manifold. The portable FLEX manifold can then be connected via hose to provide direct makeup and spray flow or can be connected to the installed SFP cooling system piping. The staff's evaluation of the robustness and availability of the UHS for an ELAP event is discussed in Section 3.10.3.

3.3.4.1.2 <u>Plant Instrumentation</u>

In its FIP, the licensee stated that the instrumentation for SFP level will meet the requirements of Order EA-12-051. Furthermore, the licensee stated that these instruments will have initial local battery power with the capability to be powered from the FLEX DGs. The NRC staff's review of the SFP level instrumentation, including the primary and back-up channels, the display to monitor the SFP water level and environmental qualifications to operate reliably for an extended period are discussed in Section 4 of this safety evaluation.

3.3.4.2 <u>Thermal-Hydraulic Analyses</u>

In its FIP, the licensee analyzed two different SFP cooling heat load cases when determining SFP makeup rate. These two cases are a maximum normal heat load during an outage following a normal batch discharge (Case 1), and a maximum abnormal heat load during an outage following a full core discharge (Case 2). The maximum heat load, boil-off time to top of the fuel and makeup rate can be found in the table below.

	Heat Load	Time to boil to 15 ft from top of fuel	Makeup rate
Case 1	4.47 million Btu/hr	21.3 hrs	33 gpm
Case 2	9.02 million Btu/hr	11.07 hrs	65 gpm

As stated in SE Section 3.2.3.5, the licensee's FLEX Pump is capable of supplying up to 250 gpm of SFP spray flow, which is more than either worst case SFP makeup requirements.

The staff noted that NEI 12-06, Section 3.2.1.6, states that one of the initial SFP conditions is that the SFP heat load assumes the maximum design-basis heat load for the site. Consistent with NEI 12-06, Section 3.2.1.6, the staff finds that the licensee has considered the maximum design-basis SFP heat load. Considering that the ELAP event is postulated to start from 100 percent power, it is not possible to have a full core offload in the SFP, and FIP states the required makeup rate would be 33 gpm. The licensee has the capability to provide this makeup rate.

3.3.4.3 FLEX Pumps and Water Supplies

As described in the FIP, the SFP cooling strategy relies on a FLEX pump to provide SFP makeup during Phase 2. In the FIP, Section 3.2.10 describes the hydraulic performance criteria (e.g., flow rate, discharge pressure) for the FLEX Pump. The staff noted that the performance criteria of a FLEX pump supplied from an NSRC for Phase 3 would allow the NSRC pump to fulfill the mission of the onsite FLEX pump if the onsite FLEX pump were to fail. As stated above, the SFP makeup rate of 33 gpm and SFP spray rate of 250 gpm both meet or exceed the maximum SFP makeup requirements as outlined in the previous section of this SE. Section 3.2.3.5 in the SE discusses the performance criteria (e.g., flow rate, discharge pressure, total dynamic head) of the portable diesel driven FLEX pump. Additionally during the onsite audit, the NRC staff performed a walkdown of the licensee's SFP cooling FLEX strategies and noted that the staging location for the portable FLEX pumps, hose routing and connection points were consistent with the licensee's hydraulic analysis. Further discussion regarding the robustness and availability of these connections and water sources are documented in SE Sections 3.7.3.1 and 3.10.3, respectively.

3.3.4.4 Electrical Analyses

The licensee's OIP and FIP define strategies capable of mitigating a simultaneous ELAP and loss of normal access to the ultimate heat sink resulting from a BDBEE by providing the capability to maintain or restore core cooling, containment, and SFP cooling at the PNP site. The electrical coping strategies are the same for all modes of operation.

The NRC staff performed a comprehensive analysis of the licensee's electrical strategies, which includes the SFP cooling strategy. The NRC staff's review is discussed in detail in Section 3.2.3.6.

3.3.5 Conclusions

Based on this evaluation, the NRC staff concludes that the licensee has developed guidance that, if implemented appropriately, should maintain or restore SFP cooling following an ELAP consistent with NEI 12-06 guidance, as endorsed by JLD-ISG-2012-01, and should adequately address the requirements of the order.

3.4 Containment Function Strategies

The industry guidance document, NEI 12-06, Table 3-2 provides some examples of acceptable approaches for demonstrating the baseline capability of the containment strategies to effectively maintain containment functions during all phases of an ELAP event. One such approach is for a licensee to perform an analysis demonstrating that containment pressure control is not challenged.

In accordance with NEI 12-06, Palisades performed a containment evaluation EA-EC46465-02, "MAAP Containment Analysis for BDBEE," Rev. 0, which was based on the boundary conditions described in Section 2 of NEI 12-06. The calculation concludes that the containment parameters of pressure and temperature remain well below the respective design limits of 55 psig and 283°F (UFSAR Section 5.8) for at least 10 days. In addition, key parameters instrumentation subject to the containment environment will remain available. From its review of the evaluation, the NRC staff noted that the required actions to maintain containment integrity and required instrumentation functions have been developed, and are summarized below.

The NRC staff reviewed calculation EA-EC46465-02, "MAAP Containment Analysis for BDBEE," Rev. 0. The calculation used the Modular Accident Analyses Program (MAAP) 4.0.6 computer code. The calculation forecasts the Containment pressure and temperature (pressures and temperatures are highest in the reactor cavity compartment) initially rise on loss of normal containment cooling to approximately 4.5 psig and 205°F, respectively. After the first 8 hours, the pressure and temperature gradually increases at a steady state. The maximum Containment pressure reached was calculated to be 8.6 psig (at 120 hours), remaining well below the design-basis limit of 55 psig. The calculation also indicates the maximum Containment temperature reached was 218.2°F (at 120 hours), which remains below the design limit of 283°F.

Eventual containment cooling and depressurization to normal values may utilize off-site equipment and resources during Phase 3. For the at-power scenario with SGs removing core heat, no specific coping strategy is required for maintaining containment integrity during Phase 1, 2 or 3. Results of the Mode 5 scenario at mid-loop inventory, with containment venting is discussed below in Section 3.11.

3.4.1 Phase 1

Containment pressure and temperature are expected to increase during an ELAP due to loss of Containment cooling and mass and energy transfer from the primary coolant system (PCS) to Containment. The Palisades Containment design pressure is 55 psig, and the design temperature is 283°F. The Containment Liner has been analyzed for temperatures up to 410°F for a design basis accident.

A Containment evaluation has been performed consistent with the boundary conditions described in Section 2 of NEI 12-06. Based on the performance of installed primary coolant pump (PCP) seals, the pressure and temperature of Containment are not expected to rise significantly. Calculation CN-SEE-II-13-5, "Palisades Reactor Coolant System (RCS) Inventory and Shutdown Margin Analysis to Support the Diverse and Flexible Coping Strategies (FLEX)," Rev. 1, demonstrated that as long as cooling water was restored to the SGs prior to fuel damage there would not be any structural concerns with Containment for this event.

The Phase 1 coping strategy for containment involves verifying containment isolation per procedure EOP-3.0, "Station Blackout Recovery," and monitoring containment temperature and pressure using installed instrumentation.

The results of the MAAP analysis confirm that the Containment function is not challenged early in the event for the at-power scenario. Therefore, no Phase 1 actions are required to maintain Containment integrity.

3.4.2 Phase 2

Consistent with WCAP-17601-P, "Reactor Coolant System Response to the Extended Loss of AC Power Event for Westinghouse, Combustion Engineering and Babcock and Wilcox NSSS Designs," Rev. 0, the Mode 1 analysis assumes an initial letdown rate of 75 gpm for the first ten minutes of the transient, and conservatively assumes an initial PCP seal leakage rate of 15 gpm per seal (PCP seal leakage decreases as the PCS is depressurized). The Containment analysis assumed a PCP seal leakage rate of 15 gpm because this maximizes the energy transfer into Containment and is therefore conservative. The analysis for Mode 1 follows the 75°F per hour cooldown case documented in the Westinghouse PCS analysis CN-SEE-II-13-5.

The Containment analysis, EA-EC46465-02, determines Containment temperature and pressure for the analysis duration of 120 hours. Results of this analysis show that Containment temperature and pressure remain below their respective design limits for the analysis duration of 120 hours. The rate of temperature and pressure increase in Containment at 120 hours is such that the design limits will not be challenged within the first 10 days after an event. Prior to 120 hours after the event, onsite and off-site equipment will be available to mitigate Containment conditions.

The Palisades containment analysis shows that there are no Phase 2 actions required. Containment pressure and temperature will continue to be monitored using installed instrumentation.

3.4.3 Phase 3

The containment analysis, EA-EC46465-02, showed that the CACs are not required before 120 hours for the at-power scenario. During the plant recovery phase (i.e. Phase 3) the CACs may be utilized, although they are not credited for the FLEX coping strategy.

The NSRC will supply a low pressure/high flow pump and two 4160 Vac generators for long-term plant recovery. The low pressure/high flow pump allows for the restoration of service water flow to equipment such as the CCW system and LPSI pump. The 4160 Vac generators allow for the restoration of one complete Class 1E distribution bus (1D or 1C) which provide power to a LPSI pump, a CCW pump, SDC flowpath valves and 3 CACs.

The licensee's analysis concluded that containment temperatures will remain below acceptable limits for critical instrumentation inside Containment for at least 6 days. The NSRC generator will be utilized to start and stop CACs as required to maintain temperatures within limits to preserve critical instrumentation. As required, the NSRC low pressure/high flow pump and

NSRC 4160 Vac turbine generators can be used to transition the plant to a long term recovery mode utilizing SDC, thereby maintaining Containment temperatures and pressures below design limits.

3.4.4 Staff Evaluations

3.4.4.1 Availability of Structures, Systems, and Components

The NEI 12-06 baseline assumptions have been established on the presumption that other than the loss of the ac power sources and normal access to the UHS, installed equipment that is designed to be robust with respect to design-basis external events is assumed to be fully available. Installed equipment that is not robust is assumed to be unavailable. Below are the baseline assumptions for the availability of SSCs for maintaining Containment functions during an ELAP.

3.4.4.1.1 Plant SSCs

Containment Building

The containment building is a post-tensioned concrete cylinder and dome connected to a conventionally reinforced slab foundation. Its entire inner surface is lined with a welded steel plate to ensure a high degree of leak tightness. The containment building completely encloses the reactor and the Primary Coolant System. The Containment Building is a Design Class 1, Seismic Category 1 structure that is qualified for all applicable external events.

Containment Air Coolers

The CACs, ducting and associated Service Water Valves are safety-related, Design Class 1, Seismic Category 1 structures. All equipment is located within the Design Class 1, Seismic Category 1 Containment Building. All equipment is fully protected and qualified for all applicable external events.

Service Water System

The SWS piping will provide the flowpath for cooling water from the NSRC supplied low pressure/high flow pump for cooling of various plant loads. Pressure boundary must be ensured to credit adequate flow. The service water connection piping is located within the Design Class 1 portion of the Intake Structure. The SWS piping segments utilized to support safety-related loads for plant recovery actions (CCW heat exchangers, CACs and LPSI pump via CCW) are supplied by the Design Class 1 SWS "A" or "B" critical headers. As such, these portions of the system are fully protected and qualified for all applicable external events.

CCW System

Portions of the CCW system utilized in the recovery phase of the Phase 3 FLEX strategy are located outside Containment within the Auxiliary Building. The Auxiliary Building is a Design Class 1 structure that fully protects the equipment from all applicable external hazards. The portions of the system piping outside Containment are safety-related, Seismic Category 1 structures. The CCW pumps are supplied power from Class 1E safety-related switchgear and associated cabling/controls. The CCW pumps themselves are seismically qualified, safety-related SSCs. Based on the above, all CCW SSCs required for the Phase 3 FLEX strategy are fully protected and qualified for all applicable external events.

LPSI System

The LPSI pump, associated piping and SDC heat exchanger provide the SDC function for the station. These components are used in the recovery phase of Phase 3. The associated piping segments and SDC heat exchanger of LPSI are Design Class 1 per the UFSAR Table 5.2-3 and located inside the Auxiliary Building such that the SSCs are protected from wind and flooding external events. Per UFSAR Table 5.2.3, interconnecting valves required to perform recirculation function (including HPSI and LPSI systems) are Class 1 safety-related. The MOVs are powered by Class 1E MCC-1 and, therefore, the MOV motors are completely qualified since they are bounded by the Class 1 SSCs they are connected to. Likewise, the LPSI pump (SDC pump) is Design Class 1 with Class 1E powered motor, located within Auxiliary Building and is fully qualified for all applicable external events. The subject SSCs supporting the FLEX strategy are fully protected and qualified for all applicable external events.

3.4.4.1.2 Plant Instrumentation

In NEI 12-06, Table 3-2, specifies that containment pressure is a key containment parameter which should be monitored by repowering the appropriate instruments. In the Palisades FIP, the licensee stated that the key parameters for the containment integrity function are containment pressure and containment temperature, which can be obtained from essential instrumentation (LPIR-0382/0383; and TI-1812, TI1813, TI1814, and TI1815, respectively).

The above instrumentation are seismically robust, fed by Class 1E power and are located within the Seismic Category 1 Auxiliary Building/Containment Building/MCR and as such, are qualified and protected for all applicable external events. The instruments indication are available (at least one channel depending on which train of load shed is performed) in the MCR for all three FLEX strategy phases (1, 2, and 3).

In the unlikely event that bus infrastructure is damaged, alternate FLEX strategy guidelines for obtaining the critical parameters locally is provided in FSG-7, "Loss of Vital Instrument or Control Power," in accordance with the guidelines of NEI 12-06 Section 5.3.3.

3.4.4.2 Thermal-Hydraulic Analyses

The NRC staff reviewed calculation EA-EC46465-02, "MAAP Containment Analysis for BDBEE," Rev. 0. This calculation used the MAAP computer code, Version 4.0.6. The analysis evaluates the containment response with the plant initially at full power in Mode 1 at the time of a BDBEE, and bounds plant configurations in Modes 1 through 4 with SGs available. The volume of water used to feed the SGs is approximately 576,000 gallons. The volume of borated water added to the primary system with a charging pump is approximately 43,600 gallons. An initial containment pressure was assumed to be 0 psig and an initial containment temperature was assumed to be 140°F. The calculation modeled the containment pressure and temperature over a 120-hour period during an extended loss of ac power event.

The TDAFW pump is used to feed the SGs with suction from the condensate storage tank for the first 24 hours. The steam extraction rate and injection flow rate is split evenly between both SGs. At 8 hours, SG injection is switched to the portable FLEX injection pumps. The portable FLEX pump will have a capacity of 230 gpm, and feed will be split evenly between the SGs. The assumed reactor coolant leakage is 15 gpm per RCP and 1gpm from unidentified sources for a total leakage of 61 gpm.

The maximum Containment pressure reached was calculated to be 8.6 psig (at 120 hours) and the maximum Containment temperature reached was 218.2°F (at 120 hours). The Containment building remains below the internal design limits of 55 psig and 283°F.

3.4.4.3 FLEX Pumps and Water Supplies

The NSRC is supplying a low pressure/high flow FLEX pump which will be connected to the SWS to support operation of SDC as described in Section 3.2.3.5 of this SE. Water supply will be provided by the Intake Canal/Lake Michigan.

3.4.4.4 Electrical Analyses

The licensee performed a containment evaluation analysis based on the boundary conditions described in Section 2 of NEI 12-06. Based on the results of this analysis, the licensee developed required actions to ensure maintenance of containment integrity and required instrumentation function. With an ELAP initiated, while Palisades is in Modes 1-4, containment cooling for that unit is also lost for an extended period of time. Therefore, containment temperature and pressure will slowly increase. The licensee's analysis concluded that containment temperature and pressure will remain below containment design limits and that essential instruments subject to the containment environment will remain functional for a minimum of 6 days. Therefore, actions to reduce containment temperature and pressure and to ensure continued functionality of the key parameters will not be required immediately. Eventual containment cooling and depressurization to normal values may utilize off-site equipment and resources during Phase 3.

The Phase 1 coping strategy for containment involves verifying containment isolation per 1(2)-EOP-3.0, "Station Blackout Recovery," and monitoring containment temperature and pressure using installed instrumentation. The Phase 2 coping strategy is to continue monitoring containment temperature and pressure using installed instrumentation. The Phase 3 coping strategy discussed in Section 3.2.3 of the FIP is to obtain additional electrical capability and redundancy for on-site equipment until such time that normal power to the site can be restored. This capability will be provided by 4160 Vac turbine generators provided from the NSRC. Two 4160 Vac turbine generators will be provided from an NSRC in order to supply power to a 2400 Vac bus through a plant supplied 4160/2400 V transformer. By restoring the Class 1E 2400 Vac bus, power can be restored to the CACs or SDC.

The NRC staff reviewed Attachment 9 of Engineering Change 46465 (Phase 3 4160 Vac Turbine Generator Sizing), conceptual single line electrical diagrams, the separation and isolation of the FLEX turbine generators from the Class 1E EDGs, and procedures that direct operators how to align, connect, and protect associated systems and components. Based on its review of the sizing calculation, the NRC staff confirmed that two 1-MW 4160 Vac turbine generators will provide sufficient capacity and capability to supply the necessary loads following an ELAP to maintain core cooling and containment. Refer to Section 3.2.3.6 above for additional analyses.

3.4.5 Conclusions

Based on this evaluation, the NRC staff concludes that the licensee has developed guidance that, if implemented appropriately, should maintain or restore containment functions following an ELAP event consistent with NEI 12-06 guidance, as endorsed by JLD-ISG-2012-01, and should adequately address the requirements of the order.

3.5 Characterization of External Hazards

Sections 4 through 9 of NEI 12-06, Rev. 0, provide the methodology to identify and characterize the applicable BDBEEs for each site. In addition, NEI 12-06 provides a process to identify potential complicating factors for the protection and deployment of equipment needed for mitigation of site-specific external hazards leading to an ELAP and LUHS.

Characterization of the applicable hazards for a specific site includes the identification of realistic timelines for the hazard, characterization of the functional threats due to the hazard, development of a strategy for responding to events with warning, and development of a strategy for responding to events without warning.

The licensee reviewed the plant site against NEI 12-06 and determined that FLEX equipment should be protected from the following hazards: seismic; external flooding; tornado high winds; snow, ice and extreme cold; and extreme high temperatures.

References to external hazards within the licensee's mitigating strategies and this SE are consistent with the guidance in NEI-12-06 and the related NRC endorsement of NEI 12-06 in JLD-ISG-2012-01. Guidance document NEI 12-06 directed licensees to proceed with evaluating external hazards based on currently available information. For most licensees, this meant that the OIP used the current design-basis information for hazard evaluation. Coincident with the issuance of Order EA-12-049, on March 12, 2012, the NRC staff issued a Request for Information pursuant to Title 10 of the *Code of Federal Regulations* Part 50, Section 50.54(f) [Reference 20] (hereafter referred to as the 50.54(f) letter), which requested that licensees reevaluate the seismic and flooding hazards at their sites using updated hazard information and current regulatory guidance and methodologies. Due to the time needed to reevaluate the hazards, and for the NRC to review and approve them, the reevaluated hazards were generally not available until after the mitigation strategies had been developed. The NRC staff has developed a proposed rule, titled "Mitigation of Beyond-Design-Basis Events [MBDBE]," hereafter called the MBDBE rule, which was published for comment in the *Federal Register* on November 13, 2015 [Reference 41]. The proposed MBDBE rule would make the intent of Orders EA-12-049 and EA-12-051 generically applicable to all present and future power reactor licensees, while also requiring that licensees consider the reevaluated hazard information developed in response to the 50.54(f) letter.

The NRC staff requested Commission guidance related to the relationship between the reevaluated flooding hazards provided in responses to the requested information and the requirements for Order EA-12-049 and related rulemaking to address beyond-design-basis external events (see COMSECY-14-0037), "Integration of Mitigating Strategies for Beyond-Design-Basis External Events and the Reevaluation of Flooding Hazards" [Reference 27]. The Commission provided guidance in a SRM to COMSECY-14-0037," dated March 30, 2105 [Reference 21]. The Commission approved the staff's recommendations that licensees need to address the reevaluated flooding hazards within their mitigating strategies for BDBEEs, and that licensees may need to address some specific flooding scenarios that could significantly impact the power plant site by developing scenario-specific mitigating strategies, possibly including unconventional measures, to prevent fuel damage in reactor cores or SFPs. The NRC staff did not request that the Commission consider making a requirement for mitigating strategies capable of addressing the reevaluated flooding hazards be immediately imposed, and the Commission did not require immediate imposition. In a letter to licensees dated September 1, 2015 [Reference 24], the NRC staff informed the licensees that the implementation of mitigation strategies should continue as described in licensee's OIPs, and that the related NRC SEs and inspections will rely on the guidance provided in JLD-ISG-2012-01, Rev. 0, and the related industry guidance in Rev. 0 to NEI 12-06. The hazard reevaluations may also identify issues to be entered into the licensee's corrective action program consistent with the OIPs submitted in accordance with Order EA-12-049.

As discussed above, licensees are reevaluating the site seismic and flood hazards as requested in the NRC's 50.54(f) letter. After the NRC staff approves the reevaluated hazards, licensees will use this information to perform flood and seismic mitigating strategies assessments (MSAs) per the guidance in NEI 12-06, Rev. 2, Appendices G and H [Reference 42]. The NRC staff endorsed Rev. 2 of NEI 12-06 in JLD-ISG-2012-01, Rev. 1 [Reference 43]. The licensee's MSAs will evaluate the mitigating strategies described in this SE using the revised seismic hazard information and, if necessary, make changes to the strategies or equipment. Licensees will submit the MSAs for NRC staff review.

The licensee developed its OIP for mitigation strategies by considering the guidance in NEI 12-06 and the site's design-basis hazards. Therefore, this SE makes a determination based on the licensee's OIP and FIP. The characterization of the applicable external hazards for the plant site is discussed below.

3.5.1 <u>Seismic</u>

In its FIP, the licensee stated that per the UFSAR, the seismic criteria for PNP includes two design-basis earthquake spectra: operating basis earthquake (OBE) and safe shutdown earthquake (SSE). A conservative SSE having peak horizontal ground acceleration (g) at the surface of 0.05 g is the recommended value in the UFSAR. However, to be conservative a hypothetical SSE of 0.2 g has been selected for designs and analyses, per UFSAR Section 2.4.4. It should be noted that the actual seismic hazard involves a spectral graph of the acceleration versus the frequency of the motion. Peak acceleration in a certain frequency range, such as the numbers above, is often used as a shortened way to describe the hazard.

As the licensee's seismic reevaluation activities are completed, the licensee is expected to assess the mitigation strategies to ensure they can be implemented under the reevaluated hazard conditions as will potentially be required by the proposed MBDBE rulemaking. The licensee has appropriately screened in this external hazard and identified the hazard levels to be evaluated.

3.5.2 Flooding

The licensee stated in its FIP, that the flood assessment for the PNP site provided in the PNP UFSAR considered flooding due to high levels in Lake Michigan, high rainfall, wind-generated waves concurrent with flooding, and seiches. High tides, hurricane surges, and tsunamis were determined to not affect the site due to the inland location. FLEX equipment is required to be accessible, deployable and functioning upon an external flood per NEI 12-06. PNP is susceptible to seiche and precipitation hazards. Palisades UFSAR Section 5.4.1.1 states that the current probable maximum flood (PMF) due to maximum expected precipitation is no higher than 6 inches (in.) above grade due to overland run-off to Lake Michigan. General plant grade elevation is 589 ft. -0 in. along Lake Michigan. Flooding due to precipitation is considered slow moving, with warning time of a few days and unknown duration.

The FIP also stated that the flood expected from a seiche would reach an elevation of 594.1 ft. per UFSAR Section 2.2.2.1. A seiche is defined as a standing wave in a partially enclosed body of water (i.e. a lake) and is characterized as an unpredictable event with no warning but is expected to recede in 30 minutes. FLEX Phase 2 portable equipment deployment will be initiated after the seiche has receded, and FLEX equipment is stored and will be staged above the PMF. All plant equipment that will be used for FLEX is protected against a flood to a level of 594.4 ft. per UFSAR Section 2.2.

As the licensee's flooding reevaluation activities are completed, the licensee is expected to assess the mitigation strategies to ensure they can be implemented under the reevaluated hazard conditions as will potentially be required by the proposed MBDBE rulemaking. The licensee has appropriately screened in this external hazard and identified the hazard levels to be evaluated.

3.5.3 High Winds

In NEI 12-06, Section 7, provides the NRC-endorsed screening process for evaluation of high wind hazards. This screening process considers the hazard due to hurricanes and tornadoes.

The screening for high wind hazards associated with hurricanes should be accomplished by comparing the site location to NEI 12-06, Figure 7-1 (Figure 3-1 of U.S. NRC, "Technical Basis for Regulatory Guidance on Design Basis Hurricane Wind Speeds for Nuclear Power Plants," NUREG/CR-7005, December, 2009), if the resulting frequency of recurrence of hurricanes with wind speeds in excess of 130 mph exceeds 1E-6 per year, the site should address hazards due to extreme high winds associated with hurricanes using the current licensing basis for hurricanes.

The screening for high wind hazard associated with tornadoes should be accomplished by comparing the site location to NEI 12-06, Figure 7-2, from U.S. NRC, "Tornado Climatology of the Contiguous United States," NUREG/CR-4461, Rev. 2, February 2007; if the recommended tornado design wind speed for a 1E-6/year probability exceeds 130 mph, the site should address hazards due to extreme high winds associated with tornadoes using the current licensing basis for tornados or Regulatory Guide 1.76, Rev. 1.

The licensee stated in its FIP, that SSCs credited for FLEX are evaluated for the design-basis tornado for PNP. The tornado design parameters are an extreme design event that bounds those parameters defined in the UFSAR for operating basis straight line wind speeds. PNP design-basis wind from tornado on existing class 1 SSCs results in an external pressure resulting from a tornado funnel having a tangential wind speed of 300 mph and a differential pressure of 3 psig. The tornado missile criterion varies for different class 1 SSCs within the plant. The NRC reviewed these missiles against NUREG-0800 (UFSAR, Section 5.5.1.3.2). The containment structure, auxiliary building, turbine building, intake structure, auxiliary building radwaste addition, auxiliary building addition, diesel fuel oil storage tank housing, and condensate storage tank tornado missile design parameters are defined in the UFSAR. All other SSCs for which there is no existing design-basis have been evaluated per NRC Regulatory Guide 1.76, Rev. 1, based on NUREG-0800, Chapter 3. Although the licensee did not address the impact of a hurricane in the integrated plan, the site is beyond the range of high winds from a hurricane per NEI 12-06 Figure 7-1.

Therefore, high-wind hazards are applicable to the plant site. The licensee has appropriately screened in the high wind hazard and characterized the hazard in terms of wind velocities and wind-borne missiles.

3.5.4 Snow, Ice, and Extreme Cold

As discussed in NEI 12-06, Section 8.2.1, all sites should consider the temperature ranges and weather conditions for their site in storing and deploying FLEX equipment consistent with normal design practices. All sites outside of Southern California, Arizona, the Gulf Coast and Florida are expected to address deployment for conditions of snow, ice, and extreme cold. All sites located north of the 35th Parallel should provide the capability to address extreme snowfall with snow removal equipment. Finally, all sites except for those within Level 1 and 2 of the maximum ice storm severity map contained in Figure 8-2 should address the impact of ice storms.

In its FIP, regarding the determination of applicable extreme external hazards, the licensee stated that the site is located at 42°18' N, - 86°18' W, and 42°20' N, - 86°19' W... In addition, the site is located within the region characterized by the Electric Power Research Institute (EPRI) as ice severity **level 5** (NEI 12-06, Figure 8-2, Maximum Ice Storm Severity Maps). Consequently, the site is subject to severe icing conditions that could cause severe damage to electrical transmission lines. The licensee concludes that the plant screens in for an assessment for snow, ice, and extreme cold hazard. In its FIP, the licensee stated that FLEX equipment is protected from severe temperatures.

In summary, based on the available local data and Figures 8-1 and 8-2 of NEI 12-06, the plant site does experience significant amounts of snow, ice, and extreme cold temperatures; therefore, the hazard is screened in. The licensee has appropriately screened in the hazard and characterized the hazard in terms of expected temperatures.

3.5.5 Extreme Heat

The licensee stated in its FIP, that due to PNPs' proximity to Lake Michigan, the site experiences cooler temperatures than most locations in their region, the 10-year maximum temperature is 95°F per UFSAR Section 2.5. However, the guidance in NEI 12-06 Section 9.2

states that all sites within the continental United States will address the high temperature scenarios. Thus, the PNP site screens in for the extreme heat hazard. The NEI 12-06 guidance requires consideration of extreme high temperatures up to 110-120°F. Per UFSAR Sections 2.5.1 and 5.9.1.4, because of the proximity of the cool lake, the extreme 10-year maximum temperature is 95°F. Deployable FLEX equipment is designed for high temperature operation and stored/maintained at a temperature that will ensure it will function when deployed.

In summary, based on the available local data and the guidance in Section 9 of NEI 12-06, the plant site does experience extreme high temperatures. The licensee has appropriately screened in the high temperature hazard and characterized the hazard in terms of expected temperatures.

3.5.6 Conclusions

Based on the evaluation above, the NRC staff concludes that the licensee has developed a characterization of external hazards that is consistent with NEI 12-06 guidance, as endorsed by JLD-ISG-2012-01 and should adequately address the requirements of the order in regard to the characterization of external hazards.

3.6 Planned Protection of FLEX Equipment

3.6.1 Protection from External Hazards

The Palisades FLEX storage configuration utilizes two storage locations; one located inside the protected area (PA) and one located outside the PA. FLEX storage building "A" is a pre-engineered metal building located inside the PA. FLEX storage building "A" protects the stored FLEX equipment from extreme temperatures, ice and heavy snow, PMF and seismic BDBEE. FLEX storage building "A" does not protect the stored FLEX equipment against a high wind BDBEE or tornado missiles.

FLEX storage building "B" is a hardened reinforced concrete building located outside the PA. FLEX storage building "B" protects the stored FLEX equipment from extreme temperatures, ice and heavy snow, probable maximum flooding and high wind BDBEE, including tornado missiles. FLEX building "B" itself protects against a seismic BDBEE. However, liquefaction concerns due to a seismic BDBEE were identified for the equipment haul path areas between FLEX building B and the PA. Therefore, FLEX equipment stored in FLEX building "B" cannot be credited for successful Phase 2 deployment into the PA staging areas in a seismic BDBEE. However, FLEX building "B" will also store selected Phase 3 FLEX equipment. The Phase 3 equipment stored in the FLEX storage building "B" is considered accessible in the case of a seismic event as it is not required until 72 hours (or later) following the BDBEE, which would allow adequate time to resolve accessibility issues due to a seismic BDBEE.

Guidance document NEI 12-06, Rev. 0, Section 10.1, stipulates that N+1 sets of FLEX equipment be protected from all applicable BDBEEs. While each FLEX storage building ("A" and "B") stores a complete set of FLEX equipment, including debris removal equipment, both storage locations are required to ensure that a single set (N) of FLEX equipment would be available for all applicable hazards. In its FIP, the licensee acknowledges that the Palisades FLEX storage configuration is an alternative to the guidance in NEI 12-06, Rev. 0. The FIP also describes, a reduced allowed out of service time for FLEX equipment maintenance to address the alternative configuration as discussed in Section 3.14.2 of this SE. Below are additional details on how FLEX equipment is protected from each of the external hazards.

3.6.1.1 Seismic

As discussed above, both storage buildings "A" and "B" have been shown to have sufficient margin to withstand SSE seismic loading. However, due to liquefaction concerns, deployment of the FLEX equipment in storage building "B," located outside the PA, may not be possible following a seismic event and, therefore, will not be credited for the seismic event. As noted in Section 3.14.2 below, the licensee has taken an alternate approach to the guidance of NEI 12-06, Rev. 0, for FLEX equipment storage regarding the seismic hazard utilizing a reduced outage time for FLEX equipment maintenance.

3.6.1.2 Flooding

As discussed above in Section 3.5.2 of this SE, both storage buildings "A" and "B" are designed to be protected against a flooding BDBEE.

3.6.1.3 High Winds

As discussed above, only storage building "B" is designed to be protected against high wind (tornado hazards). As noted above, the licensee had taken an alternate approach to the guidance of NEI 12-06, Rev. 0, for FLEX equipment storage regarding the high wind hazard.

3.6.1.4 Snow, Ice, Extreme Cold and Extreme Heat

As discussed above, both storage buildings "A" and "B" are designed to be protected against ice, snow, and extreme temperature conditions. The buildings will not be provided with heating or cooling capabilities, but other measures such as block heaters and natural ventilation will be used to maintain equipment ready for use in extreme temperature conditions.

3.6.2 Reliability of FLEX Equipment

Section 3.2.2 of NEI 12-06 states, in part, that in order to assure reliability and availability of the FLEX equipment, the site should have sufficient equipment to address all functions at all units on-site, plus one additional spare (i.e., an N+1 capability, where "N" is the number of units on site). It is also acceptable to have a single resource that is sized to support the required functions for multiple units at a site (e.g., a single pump capable of all water supply functions for a dual unit site). In this case, the N+1 could simply involve a second pump of equivalent capability. In addition, it is also acceptable to have multiple strategies to accomplish a function, in which case the equipment associated with each strategy does not require an additional spare. While each FLEX storage building ("A" and "B") stores a complete set of FLEX equipment, including debris removal equipment, both storage locations are required to ensure that a single set (N) of FLEX equipment would be available for all applicable hazards. In its FIP, the licensee acknowledges that the Palisdaes FLEX storage configuration is an alternative to the guidance in

NEI 12-06, Rev. 0. The FIP also describes a reduced allowed out of service time for FLEX equipment maintenance to compensate for the alternative FLEX storage configuration as discussed in Section 3.14.2 of this SE.

3.6.3 Conclusions

Based on this evaluation, the NRC staff concludes that the licensee has developed guidance that, if implemented appropriately, should protect the FLEX equipment during a BDBEE consistent with NEI 12-06 guidance, as endorsed by JLD-ISG-2012-01, using an alternate approach for storage and maintenance of FLEX equipment, and should adequately address the requirements of the order.

3.7 Planned Deployment of FLEX Equipment

In its FIP, the licensee described the PNP FLEX response strategies plan for deployment of pumps, DGs, and other equipment from the FLEX buildings to locations at the power block to support the various FLEX capabilities.

3.7.1 Means of Deployment

Areas adjacent to the equipment storage facilities and staging areas, as well as the deployment and routing paths, are kept normally accessible including removal of ice and heavy snow. FLEX building "A," located within the PA, stores a heavy duty pickup truck (with plow) that also supports towing of the FLEX equipment. The licensee's debris assessment concluded that the debris impact on the relatively short FLEX deployment path within the PA would be minimal for the external hazards addressed by FLEX building "A." Therefore, any debris would be expected to be removed using the heavy duty pickup truck.

FLEX building "B," located outside the PA, is credited for mitigation of a high wind event. The FLEX deployment path associated FLEX building "B" requires entrance into the PA through multiple security fences and barriers. A greater debris impact is expected on the FLEX deployment path associated with FLEX building "B" due to the longer deployment route and the propensity of the high wind event to generate debris. In addition to the heavy duty pickup truck, FLEX building "B" will also store a large Case 821F wheeled loader to remove any expected debris.

3.7.2 Deployment Strategies

As described in Section 3.6.1 above, liquefaction concerns due to a seismic BDBEE were identified for the equipment haul path areas between FLEX building B and the PA. Therefore, FLEX equipment stored in FLEX building "B" cannot be credited for successful Phase 2 deployment into the PA staging areas in a seismic BDBEE. This is compensated for by the alternate approach to maintenance times noted in Section 3.14.2 below. However, FLEX building "B" will also store selected Phase 3 FLEX equipment. The Phase 3 equipment stored in the FLEX storage building "B" is considered accessible in the case of a seismic event as it is not required until 72 hours (or later) following the BDBEE, which would allow adequate time to resolve accessibility issues due to a seismic BDBEE.

The licensee also performed an assessment (ADAMS Accession No. ML16174A171) regarding the potential for frazil ice development at the FLEX suction point of the UHS that determined that frazil ice would not impact the deployment/operation of FLEX equipment. This is due to the UHS intake structure configuration and the ability to recirculate warmer water from the FLEX pump back to the UHS intake inhibiting the formation of frazile ice.

3.7.3 Connection Points

3.7.3.1 Mechanical Connection Points

Core Cooling

The portable diesel driven FLEX pump will be staged west of the Intake Structure. A 6 in. suction hose and strainer will be lowered through a removed section of grating along the west wall of the intake structure and will be routed from the discharge of the FLEX pump to the hose distribution manifold located in the Turbine Building. The hose route paths pass through the turbine building to utilize the connection points in the MFW or AFW system where a new connection point is installed for this purpose. During the audit, the licensee stated that there is enough hose to route from the FLEX pump outside the Turbine Building, directly into the Auxiliary Building. The staff's evaluation of the robustness and availability of the UHS for an ELAP event is discussed in Section 3.10.3.

In the FIP, Section 2.3.4.16 states that the primary connection point is located in the MFW system between valves MV-FW907 and MV-FW909, on Feedwater Heater E-6B. The connection is a pipe tee on the existing MFW line that contains a hose connection and two new isolation valves that are normally closed. EC-46465, "FLEX Basis," Rev. 0, Section 3.1.2.2, evaluates the credited portion of the MFW system as robust for all applicable hazards.

Additionally, FIP Section 2.3.4.17 states that the alternate connection is located in the AFW system and is installed in the discharge piping of the motor-driven AFW pump P-8C. Specifically, a new pipe branch was added between valves CV-736A and CV-737A, and the pipe branch includes two, normally shut isolation valves. In the Palisades UFSAR, Table 5.2-3, indicates that the AFW piping is Design Class 1 with this connection point located in the West Safeguards Room of the Auxiliary Building; thus, this connection point is protected from all applicable external hazards. EC-46465, "FLEX Basis," the AFW connection is designed consistent with Design Class 1 standards as described in UFSAR, Rev. 29, Section 5.10.1.1.

Since the connections are in two diverse systems, the staff finds the licensee is consistent with NEI 12-06, Table D-1, and the licensee has the capability of SG make-up with a portable pump through primary and alternate injection points to inject through separate divisions/trains. The staff also noted that the primary and alternate FLEX pump discharge connection points and injection paths should be available during an ELAP event consistent with NEI 12-06, Section 3.2.2.

The portable electric driven FLEX air compressor that supports long-term ADV operation is powered by the portable diesel driven FLEX generator and staged within the Auxiliary Building. An extension cable will be run from either the primary or secondary generator staging location to the compressor staging location. As stated in Section 3.2.3.1.1, Nitrogen Backup Station 9 is located in the Auxiliary Building; thus, the air hose connection located on that station is protected from all applicable external hazards and should be available during an ELAP event consistent with NEI 12-06, Section 3.2.2.

The licensee's initial Phase 3 strategy relies on continuing Phase 2 strategies with additional NSRC equipment. However, the licensee will place the PCS on SDC. The SWS flow to cool the CCW heat exchangers is provided by removing the cover of the SWS pump strainer F-2C, and connecting a deployable hose connection header consisting of six 5 in. STORZ hose connections and a 16 in. flanged connection to allow for tie into the SWS piping. As stated in the FIP, the SWS connection piping is located within the Design Class 1 Intake Structure, and the SWS piping is Design Class 1; thus, the connection point is protected from all applicable external hazards and should be available during an ELAP event consistent with NEI 12-06, Section 3.2.2.

PCS Inventory Control

The Palisades FLEX strategy for Modes 1 through 4 does not require connections for portable FLEX equipment to the PCS, as the re-powered charging pumps are used to supply borated water from the BAST and the boric acid mixing tank T-77 to the PCS. However, connection points are required for the FLEX strategy for Modes 5 and 6. Newly installed connections are provided in the HPSI and LPSI systems to support direct injection to the PCS in Mode 5 or 6 or during Phase 3 as well.

SFP Cooling

There are no permanent system piping connections associated with the SFP makeup via hose directly to the pool or spray using portable monitor nozzles. All equipment is portable and does not require any physical connections to permanent plant equipment. For SFP makeup using installed SFP cooling piping, an existing hose connection and isolation valve located in the SFP heat exchanger room are used and do not require access to the SFP floor. As described in the FIP, the sections of the SFP cooling system relied on are designated Design Class 1 and are located in the Auxiliary Building, which is robust with respect to all applicable external hazards.

3.7.3.2 Electrical Connection Points

Electrical connection points are only applicable for Phases 2 and 3 of the licensee's mitigation strategies for a BDBEE. During Phase 2, the licensee has developed a primary and alternate strategy for supplying power to equipment required to maintain or restore core cooling, containment, and SFP cooling using a combination of permanently installed and portable components. There are two portable FLEX 480 Vac diesel generators provided for the strategy, one is stored in FLEX Building "A" and one in FLEX Building "B." The licensee will deploy a single 480 Vac 463 kW portable diesel generator during an ELAP event. The primary staging location for the FLEX diesel generator is northeast of the Containment Building. The licensee will route cables from the staging location to quick disconnect box EP-1901 in the North Penetration Area. The secondary staging location for the FLEX diesel generator is the courtyard north of the Turbine Building. The licensee will route cables from the staging location to the Electrical Equipment Room (EER) and over to quick disconnect box EP-2001.

Primary and alternate connections for the portable FLEX diesel generator are accomplished utilizing breakers installed in previously spare cubicles of 480 Vac LCCs 19 and 20. The primary connection is at LCC-19 and the alternate is LCC-20. The connection to LCC-19 will be via a new FLEX panel (EP-1901) installed in the North Penetration Area with one set of quick disconnect receptacles. Permanent cables complete the connection from EP-1901 to breaker 52-19FLEX in LCC-19. Energizing LCC-19 provides the means to power up MCCs 1, 21, and 23, and backfeed LCC-11. The LCC-11 can be cross-tied to LCC-12 through an existing permanently installed Class 1E breaker. The connection to LCC-20 will be via a new FLEX panel (EP-2001) installed in the EER with one set of quick disconnect receptacles. Permanent cables complete the connection from EP-2001 to breaker 52-20FLEX in LCC-20. Energizing LCC-20 provides the means to power up MCCs 2, 22 and 24, and backfeed LCC-12, which can be cross-tied to LCC-11 through an existing permanently installed Class 1E breaker.

Phase rotation for the 480 Vac diesel generators have been confirmed and will be controlled using color coded cables.

The MCCs provide power to various system MOVs required by the strategy, Class 1E Battery Chargers, emergency lighting panels, Charging Pumps and other components used in the Palisades FLEX strategy. The LCCs, MCCs and breakers are all safety-related, Class 1E components located within the Seismic Category 1 Auxiliary Building. As such, these SSCs are fully protected and qualified for all applicable external events. The downstream battery chargers and Class 1E loads are seismically robust, protected within the Auxiliary Building and are fully qualified for all applicable external events.

For Phase 3, the NSRC will supply two 4160 Vac, 1-MW combustion turbine generators to provide a combined capacity of 2 MW. The 4160 Vac NSRC turbine generators will be connected to one train of Class 1E 2400 Vac switchgear via the Step Down Transformer to either Bus 1C or Bus 1D. The transformer will step the voltage from the NSRC generator (4160 Vac) down to the Bus 1C (1D) voltage (2400 Vac). The 4160 Vac/2400 Vac Step Down Transformer will be connected to Bus 1D or 1C using temporary cables connected directly to an existing breaker 152-213 on Bus 1D (or 152-107 on Bus 1C) on the bus for all 3 phases. The switchgear is located within the Seismic Category 1 Auxiliary Building. All associated downstream switchgear providing power to loads used in the Phase 3 strategy are also safety-related, Class 1E SSCs and are also located within the Auxiliary Building. All electrical circuits are fully protected and qualified for all applicable external events. No modification or designed connection point is required for establishing the connection to the switchgear. The actions necessary to connect the cables are contained in FLEX procedures and plant staff is trained to perform the activity. Palisades stores the Phase 3, 4160Vac/2400Vac, Step Down Transformer in FLEX Building "B", which provides protection from all applicable external hazards.

Phase rotation for the 4160 Vac turbine generators will be confirmed and controlled using color coded cables and phase rotation meters in the transformer cabinet.

3.7.4 <u>Accessibility and Lighting</u>

In its FIP, the licensee stated that the MCR is served by emergency ac lighting, emergency dc lighting (powered by station batteries) and battery powered emergency lighting units (ELUs). During Phase 1 of a BDBEE, lighting in the MCR will be provided by the emergency dc lighting and ELUs. At 8 hours after the event (start of Phase 2) the portable diesel driven FLEX generator is connected to provide power to the battery chargers for the continued operation of emergency dc lighting. Operators will have portable LED flashlights and lanterns available as necessary to provide lighting for operator actions outside the MCR. Area lighting is required for outside deployment during the night and it is met by the lights on the truck used to haul the generator, as well as portable diesel driven FLEX light towers. Additional battery operated LED light towers are also stored in each FLEX storage building.

3.7.5 Access to Protected and Vital Areas

In its FIP, the licensee stated that the pathway from FLEX storage building "B" requires navigation through multiple security barriers and requires assistance from security personnel. The control of security gates after a FLEX event will be through the security program.

3.7.6 Fueling of FLEX Equipment

The FIP states that fueling of FLEX equipment is addressed in an evaluation that considered the amount of diesel fuel required to operate the portable diesel driven FLEX generator and one portable diesel driven FLEX pump from hours 8 to 72 (64 hours) following a BDBEE. Additionally, the evaluation identified an acceptable source of diesel fuel on site, the diesel fuel oil storage tank (DFOST) (T-10A), and determined the pumping requirements to ensure that this fuel is accessible during an ELAP. During the audit, the licensee stated the amount of diesel fuel consumed by the FLEX portable pump and the generator is approximately 3,300 gallons for a period of 64 hours. As stated in the FIP, the minimum required storage volume for tank T-10A is 30,554 gallons. In the UFSAR Table 3.2-1 indicates that the DFOST T-10A is a Design Class 1 component and protected from all applicable hazards. Therefore, the diesel fuel stored in tank T-10A is more than sufficient to provide the fuel oil required by the FLEX equipment to operate for approximately 24 days and provides sufficient time for the licensee to obtain additional fuel oil from off-site.

The strategy for refueling the portable diesel driven FLEX pump and portable diesel driven FLEX generator is to use a portable, dc powered fuel pump to transfer diesel fuel from tank T-10A into a 500 gallon tank mounted trailer. This dc fuel pump will be powered from the heavy duty FLEX truck wiring harness. The trailer towed by the heavy duty FLEX truck will be used to deliver fuel to the portable diesel driven FLEX pump and diesel generator, stopping by tank T-10A to refill the trailer as needed. A second dc powered fuel pump, powered from the FLEX truck, will be mounted on the trailer, and will be used to transfer fuel from the trailer to each piece of equipment. The evaluation estimates that the initial transfer of fuel from tank T-10A to each piece of FLEX equipment will require approximately 2 hours. Once the initial transfer of fuel from tank T-10A is complete, fuel can be re-delivered to either set of equipment in intervals of 90 minutes. The limiting FLEX equipment with regard to refuel frequency is the FLEX portable pump, which is conservatively estimated to require a refuel every 5 hours.

Two sets of FLEX refueling equipment (trailer mounted tank, pumps, etc.) are provided, with one set being stored in FLEX storage building "A" and the other in FLEX storage building "B". The fuel oil transfer tank is stored full of fuel (greater than 95 percent capacity). Each FLEX pump and generator is stored with fuel in their tanks. Fuel in each generator and pump is sampled and replaced on a preventive maintenance interval specified by Entergy fleet PM basis templates specific to the equipment. Diesel fuel in the tank T-10A is low sulfur (500 ppm sulfur) fuel oil or better, and is routinely sampled and tested commensurate with its use for the onsite

EDGs to assure fuel oil quality is maintained to American Society for Testing Material standards, which ensures this fuel oil is compatible with the Environmental Protection Agency tier 2 and tier 3 engines (which will run on low or ultra-low sulfur fuel) for the portable FLEX pumps and generators.

During the onsite audit, the licensee stated that the quality of fuel stored in the FLEX equipment will be confirmed through a periodic testing program. Additionally, the staff walked down the refueling strategy with licensee representatives. Palisades procedure FIG-10, "Fuel Oil Transfer," Rev. 0, contains refueling instructions for the FLEX equipment. This procedure also contains a table with fill times and consumption rates for the FLEX equipment. Based on the guidance provided in this procedure, the staff finds it is reasonable that diesel-powered FLEX equipment should be fueled and refueled to ensure uninterrupted operation to support the licensee's FLEX strategies.

3.7.7 Conclusions

The NRC staff concludes that the licensee has developed guidance that, if implemented appropriately, should allow deploying the FLEX equipment following a BDBEE consistent with NEI 12-06 guidance, as endorsed by JLD-ISG-2012-01, using an alternate approach for maintenance of FLEX equipment, and should adequately address the requirements of the order.

3.8 Considerations in Using Offsite Resources

3.8.1 PNP SAFER Plan

The licensee stated in its FIP, that the industry established two NSRCs that house backup equipment to be used by nuclear plant sites and additional equipment for long-term recovery in support of utilities during BDBEEs. One facility is located in Phoenix, Arizona and the other is in Memphis, Tennessee. Each NSRC holds five sets of equipment, four of which will be able to be fully deployed to the plant when requested. The fifth set allows removal of equipment from availability to conduct maintenance cycles. In addition, the plant's FLEX equipment hose and cable end fittings are standardized with the equipment supplied from the NSRC. Entergy has established contracts with the pooled equipment inventory company (PEICo) that operates these facilities and the NSRCs are obligated to provide one complete set of the sites Phase 2 equipment, as well as requested long-term recovery equipment unique to the sites strategy. The PNP on-site BDBEE equipment, hose and cable end fittings are standardized with the equipment supplied from the NSRC. In the event of a BDBEE and subsequent ELAP/LUHS condition, equipment will be moved from the NSRC to a local assembly area established by the SAFER team. The NSRC equipment will begin arriving at PNP designated site staging locations within the first 24 hours and all obligated equipment is received, staged and deployed no later than 72 hours after the event.

The equipment stored and maintained at the NSRC for transportation to the local assembly area to support the response to a BDBEE at PNP is listed in the FIP. Table 3 identifies the equipment that is specifically credited in the FLEX strategies for PNP.

By letter dated September 26, 2014 [Reference 22], the NRC staff issued its staff assessment of the NSRCs established in response to Order EA-12-049. In its assessment, the staff concluded that SAFER has procured equipment, implemented appropriate processes to maintain the equipment, and developed plans to deliver the equipment needed to support site responses to BDBEEs, consistent with NEI 12-06 guidance; therefore, the staff concluded in its assessment that licensees can reference the SAFER program and implement their SAFER Response Plans to meet the Phase 3 requirements of Order EA-12-049.

3.8.2 Staging Areas

In general, up to four staging areas for NSRC supplied Phase 3 equipment are identified in the SAFER Plans for each reactor site. These are a Primary (Area C) and an Alternate (Area D), if available, which are offsite areas (within about 25 miles of the plant) utilized for receipt of ground transported or airlifted equipment from the NSRCs. From Staging Areas C and/or D, the SAFER team will transport the Phase 3 equipment to the on-site Staging Area B for interim staging prior to it being transported to the final location in the plant (Staging Area A) for use in Phase 3. For PNP, the Alternate Staging Area D is Andrews University Airpark located in Berrien Springs, MI. Staging Area C is the West Michigan Regional Airport, located in Holland, MI. Staging Area B is PNP training building parking lot. Staging Area A is comprised of several primary and alternate locations around the plant where the FLEX equipment will be deployed.

Use of helicopters to transport equipment from Staging Area C to Staging Area B is recognized as a potential need within the PNP SAFER Plan and is provided for.

3.8.3 Conclusions

Based on this evaluation, the NRC staff concludes that the licensee has developed guidance that, if implemented appropriately, should allow utilization of offsite resources following a BDBEE consistent with NEI 12-06 guidance, as endorsed by JLD-ISG-2012-01 and adequately addresses the requirements of the order.

3.9 Habitability and Operations

3.9.1 Equipment Operating Conditions

3.9.1.1 Loss of Ventilation and Cooling

Following a BDBEE and subsequent ELAP event at Palisades, ventilation that provides cooling to occupied areas and areas containing required equipment will be lost. Per the guidance given in NEI 12-06, FLEX strategies must be capable of execution under the adverse conditions (unavailability of installed plant lighting, ventilation, etc.) expected following a BDBEE resulting in an ELAP/LUHS. The key areas identified for all phases of execution of the FLEX strategy activities are the MCR, TDAFW Pump Room, ADV Room, Charging Pump Rooms, Cable Spreading Room (CSR), and EER, Battery Rooms, Containment, and areas containing ADVs and ADV controls. The licensee has evaluated these areas to determine the temperature profiles following an ELAP/LUHS event.

The primary concern with regard to ventilation is the heat buildup which occurs with the loss of forced ventilation in areas that continue to have heat loads. The licensee performed several Loss of ventilation analyses to quantify the maximum steady state temperatures expected in specific areas related to FLEX implementation to ensure the environmental conditions remain acceptable for personnel habitability and within equipment qualification limits.

Main Control Room

During the audit process, the NRC staff reviewed calculation EA-EC-46465-03, "Control Room Heatup for Extended Loss of AC Power," Rev. 0, which modeled the MCR temperature transient when all MCR cooling is lost due to an ELAP event. The calculation uses the GOTHIC (Generation of Thermal-Hydraulic Information for Containments) Version 7.2b computer program. The calculation showed that opening doors and providing a 4000 cubic feet per minute (cfm) portable exhaust fan at or before 75 hours after the event initiation will maintain the MCR at a peak value of 104°F. Palisades procedure FIG-8, "Alternate Ventilation," Rev. 0, directs operators to deploy the temporary fan, which is powered from the portable FLEX generator. Based on MCR temperatures remaining below 120°F (the temperature limit, as identified in NUMARC-87-00, "Guidelines and Technical Bases for NUMARC Initiatives Addressing Station Blackout at Light Water Reactors," Rev. 1, for electronic equipment to be able to survive indefinitely), the NRC staff finds that the equipment in the MCR should not be adversely impacted by the loss of ventilation as a result of an ELAP event.

TDAFW Pump Room

The licensee's Phase 1 core cooling FLEX strategy relies on the TDAFW pump as the motive force for providing cooling water to the SGs. During the audit, the licensee provided the staff with EA-GOTHIC-AFW-01, "Auxiliary Feedwater Pump Room Heat Up Analysis," Rev. 0. This analysis accounted for the maximum design basis ambient conditions and assumed leakage from a steam trap in the room. The assumptions used in the analysis include: loss of offsite power, no active room ventilation, the turbine building temperature is 110°F, initial AFW room temperature is 104°F, and no credit for heat sinks from the insulated AFW piping in the room. The only credited cooling was via natural circulation through the ceiling vent pipe. The calculation showed the maximum temperature of the AFW room reached 159°F after 5 days with no ventilation required (i.e. open doors, portable fans). The licensee indicated that the TDAFW pump can withstand temperatures of up to 160°F without detrimental effects. Additionally, the licensee relies on the TDAFW pump for the first 8 hours after event and post 8 hours, the portable diesel driven FLEX pump will provide makeup water to the SGs using the UHS as a water source. Therefore, the staff finds it reasonable that the TDAFW pump should remain available during an ELAP event for the timeframe required by the licensee's strategy with loss of normal ventilation

Containment

With regard to containment instrumentation, the NRC staff reviewed calculation EA-EC46465-02, "PLP MAAP4 Containment Analysis for BDBEE," Rev. 0. This analysis identifies the temperature and pressure inside containment following a BDBEE. The licensee's analysis identified the reactor cavity as being the compartment in containment with the highest temperature. Based on the results of this analysis, the licensee evaluated the instrumentation relied upon during the FLEX strategy to ensure functionality of the equipment following an ELAP. The instrumentation evaluated included Steam Generator Pressure and Level, Pressurizer Pressure and Level, Hot Leg and Cold Leg Temperature, Nuclear Instrumentation, Reactor Vessel Level Instrumentation (RVLMS), Core Exit Thermocouples, Softline Cables inside Containment, and Containment Pressure.

According to the licensee's calculation, Containment temperatures will remain below acceptable limits (140°F) for critical instrumentation inside Containment for at least 6 days. Because of this, the licensee would rely on equipment received from an NSRC to reduce Containment temperature. The equipment from the NSRC that is necessary to support Containment cooling includes a low pressure/high flow pump and 4160 Vac turbine generators. The licensee plans to deploy this equipment within 72 hours after event initiation. The low pressure/high flow pump allows for the restoration of service water flow to equipment such as the CCW system and LPSI pump. The 4160 Vac turbine generators allow for the restoration of one complete Class 1E distribution bus (1D or 1C) which provide power to a LPSI pump, a CCW pump, SDC flowpath valves and 3 CACs. The licensee would use the 4160 Vac turbine generators to start and stop CACs as required to maintain temperatures within limits to preserve critical instrumentation. Additionally, since the 4160 Vac turbine generators can be used to power one complete Class 1E 2400 Vac train, SDC can be placed into service to further reduce primary coolant system temperature and pressure, minimizing released energy into the Containment due to leakage. Based on the NRC staff's review, instrumentation relied upon for the FLEX strategy should be available following an ELAP for continued plant coping.

ADV Room

The ADVs are located on the third floor of the CCW room, which is a large, open, multi-story room. Under extreme high temperatures, the licensee's procedures (FIG-8) direct operators to open one door on the lower level (590' elevation) and one large door on the upper level (625' elevation) to the atmosphere to provide chimney effect ventilation for this area. With this natural ventilation, temperatures in the area of the ADV would not adversely impact operation of the valves as a result of an ELAP event. The ADV local controls are located in the same room as the new Nitrogen Station 9, which provides backup nitrogen supply for ADV operation. Following depletion of Nitrogen Station 9 (approximately 9 hours into the event), the licensee will open the door to this room to route the air compressor hose into the connection location in this room. This door on the Auxiliary Building roof opens to atmosphere and provides a ventilation path for the room. With this ventilation path established, the staff noted that temperatures in the room are not expected to be significantly higher than the outside ambient temperature since there is no heat load in this room, and would therefore not adversely impact the ADV controls as a result of an ELAP event.

Charging Pump Rooms

During the onsite audit, the licensee provided engineering analysis EA-JEF-97-01, "Operation of Charging Pumps P-55B & C without CCW flow to the oil coolers," Rev. 0. This evaluation determined the equilibrium temperature for the charging pumps while cooling water was isolated for 72 hours. This analysis found that the charging pumps could reach a maximum temperature of 124.6°F in 72 hours, which is below the maximum temperature of the lube oil of 155°F. Additionally, as stated in UFSAR, Rev. 29, Section 9.8.5.2., item 3, the only heat input to the charging rooms would be the pumps. The UFSAR states that the room would reach 120°F approximately 83 hours after the event and the staff noted lube oil cooling could be established using NSRC equipment sometime after 72 hours. The staff finds it reasonable that the charging pumps should remain available during an ELAP event with loss of normal ventilation.

Electrical Equipment Room and Cable Spreading Room

The EER and CSR are the locations of the electrical connection boxes for the FLEX generator and contain the MCCs and LCCs to be repowered. During the onsite audit, the licensee provided Calculation EA-EC-46465-04, "BDBEE Temperature Calculation for CSR, EER, and Battery Rooms," Rev. 0. The focus of this calculation was to determine the expected temperature in the EERs, Battery Rooms, and Switchgear Rooms following an ELAP. This calculation did not take credit for any doors being opened, assumed a conservative heat load for each of these rooms, and assumed a constant outside temperature (i.e., no diurnal variation in temperature assumed). The calculation was revised (Rev. 1) to extend the analysis duration to 120 hours or greater, and to take credit for opening CSR and EER doors 24 hours into the event. The operator actions to open doors in the CSR and EER are contained in the licensee's FSGs. Palisades procedure FIG-8, "Alternate Ventilation," Rev. 0, contains steps to open both doors to the CSR and EER as part of providing ventilation for the Battery Rooms. The FIG contains a precaution to establish Battery Room ventilation within 9.5 hours of the event so that the doors will be open prior to 9.5 hours after the event.

Based temperatures remaining at or below 120°F (the temperature limit, as identified in NUMARC-87-00, "Guidelines and Technical Bases for NUMARC Initiatives Addressing Station Blackout at Light Water Reactors," Rev. 1, for electronic equipment to be able to survive indefinitely), the NRC staff finds that the equipment in the CSR and EER should not be adversely impacted by the loss of ventilation as a result of an ELAP event.

Battery Rooms

The NRC staff reviewed calculation EA-EC46465-04, "BDBEE Temperature Calculation for CSR, EER, and Battery Rooms," Rev. 1. The focus of this calculation was to determine the expected temperature in the EERs, Battery Rooms, and Switchgear Rooms following an ELAP. The calculation showed that with extreme high temperatures outside, operator actions to open doors may be required to maintain the temperature in these rooms less than 120°F and ensure long-term functionality of equipment in these rooms. The operator actions to open doors in the CSR and EERs are contained in the licensee's FSGs.

The Palisades safety-related batteries were manufactured by C&D Technologies. The qualification testing performed by C&D Technologies demonstrated the ability to perform under elevated operating temperature environments. The testing results indicate that the battery cells will perform as required in excess of 200 days under an estimated 122°F.

The elevated temperature also has an impact by increasing the charging current required to maintain the float charging voltage set by the charger. The elevated charging current will in turn increase cell water loss through an increase in gassing. Based on this, periodic water addition may be required or the float charging voltage reduced per the guidance contained in the C&D Technologies vendor manual. If battery cell plate uncovery were to occur, failure issues associated with plates being exposed would involve the potential development of sulfation and a subsequent reduction in capacity. If loss or failure of a battery string were to occur, the battery charger has the capability to carry the anticipated loads indefinitely provided that ac power remains available to power the charger.

Based on its review of the essential station equipment required to support the FLEX mitigation strategy, which are primarily located in the Containment, MCR, TDAFW Pump Room, Charging Pump Rooms, CSR, EER, Battery Rooms, and areas containing ADVs and ADV controls, the NRC staff finds that the equipment should perform their required functions at the expected temperatures as a result of loss of ventilation during an ELAP/LUHS event.

3.9.1.2 Loss of Heating

In NEI 12-06, Section 3.2.2, guideline (12) states that heat tracing is used at some plants to ensure cold weather conditions do not result in freezing important piping and instrumentation systems with small diameter piping. In the Palisades FIP, the licensee states that no outside staged equipment is credited for FLEX that would need heat tracing to prevent freezing.

Operation of the TDAFW pump involves steam flow through the turbine and associated piping. The TDAFW pump is located in a temperature-controlled area of the turbine building and is relied upon immediately at the start of an ELAP event and used for 8 hours until the CST and T-81 are exhausted. The staff finds it reasonable that low outside temperatures should not have an adverse effect on the TDAFW pump because of its location in an initially temperature-controlled area, steam flow through the components provides a heat load, and the components are in use early in the ELAP event.

During the audit, the licensee also stated that the FLEX equipment operated outdoors is designed to operate over the outdoor temperature range of -10°F to 95°F, which are the site temperature extremes per the Palisades UFSAR Section 9.8.2.1 and Table 9-13, Rev. 29. The licensee stated during the audit process that both the FLEX storage building inside the PA and the Flex storage Building outside the PA, are protected against extreme temperatures, but neither will have their own heating /cooling capabilities. The licensee will utilize block or jacket water heaters during cold conditions and open the storage building doors and ventilation louvers during hot weather conditions. Furthermore, FSG-5, "Initial Assessment and FLEX Equipment Staging," Rev. 0, has steps added to it to prevent freezing of the FLEX equipment such as intermittently establish flow, drain, etc. Also, FIG-2, "FLEX Pump Staging and Operation," Rev. 0, directs operators to establish a recirculation line to help prevent hoses from freezing.

The licensee analyzed electrolyte temperature for the batteries for an extreme low temperature event in Calculation EA-EC46465-04. The calculation showed that the electrolyte temperature for the batteries in both Battery Rooms will remain above 70°F (Technical Specification operability limit) for the duration that they are credited in the licensee's mitigating strategies (8 hours). After 8 hours, the FLEX diesel generator will be connected to the Battery Chargers. Therefore, the batteries will remain functional during the extreme low temperature event without any operator action to provide supplemental heat to the rooms.

Based on its review of the licensee's Battery Room assessment, the NRC staff finds that the Palisades safety-related batteries should perform their required functions at the expected temperatures as a result of loss of heating during an ELAP event.

3.9.1.3 Hydrogen Gas Control in Vital Battery Rooms

To mitigate hydrogen concentration in the Battery Rooms during battery charging, a portable ventilation fan is required. Calculation EA-DBD-1.07-001, "Battery Room Ventilation Requirements for Hydrogen Control," Rev. 1, provides the basis for Battery Room hydrogen control. The calculation states that when the batteries are being equalized (charged) and ventilation is lost, the time to reach two percent hydrogen in the rooms is 1.8 hours. Therefore, to prevent hydrogen accumulation above two percent, a portable ventilation/exhaust to the Battery Rooms will be deployed by 1.5 hours after battery charging begins, or 9.5 hours after initiation of the event. The installed Battery Room ventilation system is not credited because it is not seismically qualified and is not protected from wind-generated missiles. The portable ventilation fan, which is powered from a 120 volt ac receptacle on the FLEX diesel generator, is specified with a minimum exhaust flow of 1,000 cfm. This flow exceeds the minimum flow of 150 cubic ft. per hour calculated in EA-DBD-1.07-001. Calculation EA-DBD-1.07-001 identified the hydrogen concentration in the Battery Room as being 0.005 percent with an exhaust flow of 1,000 cfm, which is well below the explosive limit for hydrogen (4 percent). Flexible duct that connects to the portable fan will be routed from the cable spreading room outside of the turbine building such that the hydrogen can be exhausted to the atmosphere, preventing hydrogen accumulation in other areas of the plant.

Based on its review, the NRC staff concludes that hydrogen accumulation in the safety-related Battery Rooms should not reach the combustibility limit for hydrogen (4 percent) during an ELAP event.

3.9.2 Personnel Habitability

3.9.2.1 Main Control Room

During the audit, the licensee provided a copy of EA-EC-46465-03, “Control Room Heatup for Extended Loss of AC Power,” Rev. 0. This calculation concluded that, when the mitigating actions of opening specified doors in conjunction with starting an exhaust fan at 75 hours, the MCR temperature peaks at a temperature of 104°F. The licensee's procedure, FIG-8, “Alternate Ventilation,” Rev. 0, directs operators to take the appropriate actions corresponding with the analysis assumptions.

3.9.2.2 Spent Fuel Pool Area

See Section 3.3.4.1.1 above for the detailed discussion of ventilation and habitability considerations in the SFP Area. In general, the licensee plans to complete hose deployment and spray nozzle setup on the SFP refueling floor before conditions degrade to the point that boiling of the SFP affects habitability. The licensee also has the ability to add water to the SFP from the installed SFP cooling piping without accessing the refueling floor.

3.9.2.3 Other Plant Areas

The licensee's Phase1 core cooling FLEX strategies rely on the TDAFW pumps as the motive force for providing water to the SGs. The TDAFW pump trip and throttle valve, electronic governor, and all associated valves are powered by battery-backed Class 1E power and Nitrogen Backup Stations 1 and 2. However, in the unlikely event that that control power and air is lost, the steam supply valve, located in the turbine building above the TDAFW pump room, can be manually throttled. In its FIP, the licensee stated that access to the TDAFW pump room is not expected to be required, but the TDAFW pump is operated less than 8 hours after the event so access would be early in the event. The NRC staff noted that the TDAFW pump is located in a temperature-controlled area of the Turbine Building. The staff finds it reasonable that the TDAFW pump room will remain accessible in the event access is required.

In its FIP, the licensee stated the operator actions in the CSR and EER includes routing cables, positioning exhaust fans and opening doors, which occurs early in the event at a time when the temperature would not have increased significantly. Guideline FIG-1, "FLEX Generator Staging and Operation," Rev. 0, directs operators to deploy and connect the generator within 8 hours of the start of the event. Furthermore, FIG-8, "Alternate Ventilation," Rev. 0, directs operators to stage Battery Room ventilation and open the applicable doors within 9.5 hours of the event. Given the licensee's timeline and implementing procedures, the staff finds it reasonable that the CSR and EER rooms should remain accessible in the event access is required.

3.9.3 Conclusions

The NRC staff concludes that the licensee has developed guidance that, if implemented appropriately, should maintain or restore equipment and personnel habitability conditions following a BDBEE consistent with NEI 12-06 guidance, as endorsed by JLD-ISG-2012-01, and should adequately address the requirements of the order.

3.10 Water Sources

3.10.1 Steam Generator Make-Up

Phase 1

In the FIP, Section 2.3.1 states that the CST initially provides the main source of water for plant cool-down at the initial onset of the ELAP. Within 1 hour, operators will open two normally closed valves (CV-2008 and CV-2010) to cross-connect the CST and tank T-81 which will provide 8 hours of inventory.

Palisades UFSAR, Rev. 29, Table 5.2-3 states the CST is a Design Class 1 tank. Palisades UFSAR, Rev. 27, Section 9.7.4 states the minimum required level in the tank is 94,280 gallons. However, the CST was not fully missile protected; therefore, in EC-48187, "CST Analysis and Missile Barrier," the licensee designed and installed a CST missile barrier to fully protect the tank from all applicable tornado missile hazards. The licensee also evaluated the CST in PLP-RPT-13-00050, "Turbine Driven Auxiliary Feedwater (TDAFW) Upgrade and Evaluation for FLEX," Rev. 0, for all other applicable external hazards and determined it to be robust for all external hazards.

As stated in the FIP, tank T-81 was evaluated in PLP-RPT-13-00050, "Turbine Driven Auxiliary Feedwater (TDAFW) Upgrade and Evaluation for FLEX," Rev. 0, and determined the tank is robust for all applicable hazards, except for the large missile hazard (e.g., automobile), with the following modifications:

- Installing tornado missile protection of the cross-connect valves (CV-2008 and CV-2010).
- Adding of isolation valves on three sections of piping to maintain T-81 and suction piping robust.
- Tornado missile protecting the T-81 tank.

Calculation EC-48187, "CST Analysis and Missile Barrier," designed and installed the missile protection for the tank and the cross-connect valves; however, since tank T-81 tank is not robust with respect to all tornado missile hazards, the staff noted that the licensee's strategy of relying on T-81 as a water source is an alternative to NE 12-06. Specifically NEI 12-06, Section 3.2.1.3, states, in part, that water inventories contained in systems or structures with designs that are robust with respect to all applicable hazards are available. Although the licensee's strategy is an alternative to NEI 12-06, the staff finds it acceptable. See Section 3.14 for further discussion of the acceptability of this alternative.

During the onsite audit, the licensee provided a calculation in EC-46465-08, "Freezing of Coolant Sources for FLEX Event." Rev. 4, which determined the time to reach freezing temperatures for tanks and stagnant hoses exposed to cold air during a BDBEE. The calculation showed that the CST would not freeze during the first 8 hours of the event and the T-81 tanks will begin to freeze in 7.7 hours such that by the end of Phase 1 (8 hrs), the licensee showed that only 92 gal of the T-81 tank would be frozen. The FIP states that operators will begin staging the portable diesel driven FLEX pump 4 hours (2 hour duration) into the ELAP event. Given the conservative calculation assumptions the licensee made and the portable diesel driven FLEX pump will be staged before T-81 reaches a freezing temperature, the NRC staff finds it reasonable that both tanks should be available following an ELAP resulting from an extreme cold BDBEE.

If implemented appropriately and consistent with the FIP, the licensee should have a water source available during the Phase 1 core cooling strategies for SG inventory makeup. In addition, the licensee's strategy should provide sufficient time for operators to deploy and stage Phase 2 FLEX equipment. The licensee's sequence of events timeline, as documented in FIP Table 1, shows that the CST and T-81 have sufficient water inventory for approximately 8 hours into the ELAP event.

Phase 2

The licensee states in its FIP, that the Phase 2 FLEX strategy for reactor core cooling and heat removal uses water from Lake Michigan for feeding the SGs using a portable diesel driven FLEX pump. The licensee plans to drop a suction hose through one of two removable grates into the Intake Canal. The staff noted that the supply of water from Lake Michigan to the intake canal is robust and is protected from all applicable hazards and is available to support Phase 2 core cooling strategies. The licensee states in its FIP that in accordance with UFSAR Table 5.2.2 and Section 5.5.1.1.2, the Intake Structure is robust with respect to all applicable external events and expected to be available following a BDBEE.

Calculation EA-EC-46465-01, "Steam Generator Heat Transfer Capacity Using Lake Michigan," Rev. 0, determined the effects on the heat transfer capabilities of the SGs when using Lake Michigan as a long-term makeup source. This analysis assumed that demineralized water is available for SG injection for the first eight hours after the event and then SG makeup will transition to Lake Michigan water with the required AFW flow rates. The results of this calculation show a 4.4 percent loss of heat transfer capability in the SGs 120 hours after the event. The NRC staff noted this minor loss in heat transfer capability is acceptable for operation up to 120 hours after the event due to the decrease in decay heat in the reactor that is required to be removed by the SGs. Approximately 72 hours after the event, a mobile water purification unit from the NSRC will be available. The analysis duration of 120 hours was chosen to provide margin beyond the 72 hours for deployment and operation of the water purification unit. The mobile purification unit will provide demineralized water to the FLEX pump for injection to the SGs such that the only potential for SG fouling (i.e., loss of heat transfer capability) would occur during the period when lake water is injected directly into the SGs without treatment.

If implemented appropriately and consistent with the FIP, the licensee should have a water source available during the Phase 1 core cooling strategies for SG inventory makeup. In addition, the licensee's strategy should provide sufficient time for operators to deploy and stage Phase 2 FLEX equipment. The licensee's sequence of events timeline, as documented in FIP Table 1, shows that the CST and T-81 have sufficient water inventory for approximately 8 hours into the ELAP event.

Phase 3

The licensee's Phase 3 core cooling strategy does not rely on any additional water sources other than those discussed in Phase 2. However, the licensee does plan to use NSRC supplied portable water purifiers to provide cleaner water for SG makeup.

3.10.2 <u>Primary Coolant System Make-Up</u>

Phase 1

In the FIP, Section 2.3.1 states that the RCS reactivity and inventory control is achieved initially by injection from the SITs as a result of RCS depressurization. In the Palisades UFSAR, Rev. 29, Table 5.2-3 indicates that the SITs are Seismic Category I components. The FIP states that the SITs are located in the Reactor Building (Containment) which is described in UFSAR, Rev. 21, Table 5.2-2 as a Class 1 structure; thus, protected from all applicable hazards.

If implemented appropriately and consistent with the FIP, the licensee's approach should conserve RCS inventory to preclude the necessity for RCS system makeup during Phase 1. However, should makeup be necessary, the NRC staff finds that the SITs and associated piping and valves are robust and are expected to be available during ELAP event.

Phase 2 and 3

For PCS inventory control in Phase 2, PNP will utilize one of its two installed (FLEX portable diesel re-powered) positive displacement charging pumps, with borated water supplied from the BASTs. In its FIP, the licensee states the BASTs are estimated to provide PCS inventory control for greater than 24 hours after the event. Prior to depletion of the BASTs, boric acid batching operations will begin using the installed boric acid batching tank (T-77). Water for boric acid batching is supplied from the portable diesel driven FLEX pump. Hoses will be routed from the FLEX pump distribution manifold to tank T-77. During the audit process, the licensee provided report-RPT-13-00051, "Boric Acid Storage Tank (BAST) Suction Piping and

Component Evaluation for FLEX," Rev. 0. The report found the BASTs, T-77, and all related piping to be robust for all applicable external hazards. If implemented appropriately and consistent with its FIP, the licensee should have a sufficient source of water available during Phase 2 to maintain RCS inventory in order to maintain natural circulation cooling and control reactivity in the core.

3.10.3 Spent Fuel Pool Make-Up

The licensee stated in its FIP that SFP cooling through makeup and spray will be provided by using the portable diesel driven FLEX pump with water from Lake Michigan, as described in SE Section 3.10.1.

3.10.4 Containment Cooling

The licensee stated in its FIP that no containment cooling is required for 10 days into the event at which time equipment from the NSRC will be available.

As discussed in Section 3.4.3, the Containment analysis, EA-EC46465-02 showed that the CACs are not required for over 120 hours for the at-power scenario. During the plant recovery phase (i.e. Phase 3) the CACs may be utilized, although they are not credited for the FLEX coping strategy. During the recovery phase, the CACs may provide cooling water via the Phase 3 NSRC UHS pump and the SWS tie-in location to provide cooling water for necessary plant heat loads including containment heat removal.

3.10.5 Conclusions

Based on the evaluation above, the NRC staff concludes that the licensee has developed guidance that, if implemented appropriately, should maintain satisfactory water sources following a BDBEE consistent with NEI 12-06 guidance, as endorsed by JLD-ISG-2012-01, and should adequately address the requirements of the order.

3.11 Shutdown and Refueling Analyses

Order EA-12-049 requires that licensees must be capable of implementing the mitigation strategies in all modes. In general, the discussion above focuses on an ELAP occurring during power operations. This is appropriate, as plants typically operate at power for 90 percent or more of the year. When the ELAP occurs with the plant at power, the mitigation strategy initially focuses on the use of the steam-driven TDAFW pump to provide the water initially needed for decay heat removal. If the plant has been shut down and all or most of the fuel has been removed from the RPV and placed in the SFP, there may be a shorter timeline to implement the makeup of water to the SFP. However, this is balanced by the fact that if immediate cooling is not required for the fuel in the reactor vessel, the operators can concentrate on providing makeup to the SFP. The licensee's analysis shows that following a full core offload to the SFP, about 3.28 hours are available to implement makeup before boil-off results in the water level in the SFP dropping far enough to uncover fuel assemblies, and the licensee has stated that they have the ability to implement makeup to the SFP within that time.

When a plant is in a shutdown mode in which steam is not available to operate the steam-powered pump and allow operators to release steam from the SGs (which typically occurs when the PCS has been cooled below about 300°F), another strategy must be used for decay heat removal. On September 18, 2013, NEI submitted to the NRC a position paper entitled "Shutdown/Refueling Modes" [Reference 25], which described methods to ensure plant safety in those shutdown modes. By letter dated September 30, 2013 [Reference 26], the NRC staff endorsed this position paper as a means of meeting the requirements of the order.

The position paper provides guidance to licensees for reducing shutdown risk by incorporating FLEX equipment in the shutdown risk process and procedures. Considerations in the shutdown risk assessment process include maintaining necessary FLEX equipment readily available and potentially pre-deploying or pre-staging equipment to support maintaining or restoring key safety functions in the event of a loss of shutdown cooling. The NRC staff concludes that the position paper provides an acceptable approach for demonstrating that the licensees are capable of implementing mitigating strategies in shutdown and refueling modes of operation. In Section 2.16 of the FIP, the licensee described the procedural revisions that have been made to follow the guidance in the position paper.

Containment Analyses

Review of the scenario for Modes 5 and 6 indicates containment venting will be required to prevent exceeding containment design conditions.
The NRC staff reviewed calculation EA-EC46465-02, "MAAP Containment Analysis for BDBEE," Rev. 0. This calculation used the MAAP computer code, version 4.0.6. The Mode 5 and 6 analysis assumes that the plant has been shut down for 48 hours prior to the event, the PCS is at 200°F, 14.7 psia, and is at a reduced inventory (i.e., mid-loop). The PCS makeup is assumed available to prevent the core from being uncovered. As the PCS heats up and begins to boil, decay heat removal occurs by steam transfer into Containment. Without any mitigating actions in this scenario, Containment design limits of temperature and pressure were exceeded 14.6 hours after the event. The analysis also determined that by opening a 3.75-in. equivalent diameter penetration in Containment, the Containment temperature and pressure design limits are not exceeded for the analysis duration of 120 hours.

The analysis assumed that the action to open a Containment vent path would be taken after a 5 psig rise in Containment pressure following the event. Either one of two 8-in Containment purge headers (JBB-1-8 in and JBB-2-8 in) can be used to provide Containment venting. Two AOVs in either line (CV-1805 and CV-1806 on JBB-2-8 in; CV-1807 and CV-1808 on JBB-1-8 in) must be held open to permit flow. The air then discharges into a filter housing on the 607' elevation of the CCW Room. A door on the CCW filter will be opened to allow the Containment atmosphere to exhaust to the CCW Room. A double door on the 625-ft elevation of the CCW Room is also opened allowing the room to exhaust directly to the atmosphere completing the vent path. Nitrogen is supplied from Nitrogen Backup Station 9 on the 625-ft Auxiliary Bay Roof to the AOVs. In addition, the portable electric driven FLEX air compressor provides flexibility and can be used to supply the actuators of the valves if staged and available. The purge valves are initially opened with the nitrogen supply and then mechanically gagged in the open position to facilitate the venting of Containment.

Procedure ECN-56388 defines the containment vent path and guidance. Guideline FSG-15 (Station Blackout While Shutdown) provides actions necessary to ensure a controlled process is in place for containment venting.

The maximum Containment pressure reached was calculated to be 36.2 psig (at 58.98 hours) and the maximum Containment temperature reached was 281.4°F (at 58.98 hours). The Containment building remains below the internal design limits of 55 psig and 283°F.

Based on the licensee's incorporation of the use of FLEX equipment in the shutdown risk process and procedures, the NRC staff concludes that the licensee has developed guidance that if implemented appropriately should maintain or restore core cooling, SFP cooling, and containment following a BDBEE in shutdown and refueling modes consistent with NEI 12-06 guidance, as endorsed by JLD-ISG-2012-01, and should adequately address the requirements of the order.

3.12 Procedures and Training

The licensee stated in its FIP that the inability to predict actual plant conditions that require the use of FLEX equipment makes it impossible to provide specific procedural guidance. As such, the FSGs will provide guidance that can be employed for a variety of conditions. Clear criteria for entry into FSGs will ensure that FLEX strategies are used only as directed for BDBEE conditions, and are not used inappropriately in lieu of existing procedures. When FLEX equipment is needed to supplement EOP or abnormal operating procedure (AOP) strategies, the EOP or AOP, severe accident mitigation guidelines (SAMGs), or extreme damage mitigation guidelines (EDGMs) will direct the entry into and exit from the appropriate FSG procedure.

FLEX support guidelines will provide available, pre-planned FLEX strategies for accomplishing specific tasks in the EOPs or AOPs. The FSGs will be used to supplement (not replace) the existing procedure structure that establishes command and control for the event. Procedural Interfaces have been incorporated into Procedure EOP-3.0, “Station Blackout Recovery” to the extent necessary to include appropriate reference to FSGs and provide command and control for the ELAP. Additionally, procedural interfaces have been incorporated into AOP-38 “Acts of Nature” to include appropriate reference to FSGs:

The FSG maintenance will be performed by the site procedures group. In accordance with site administrative procedures, NEI 96-07, Rev. 1, “Guidelines for 10 CFR 50.59 Implementation,” and NEI 97-04, Rev. 1, “Design Bases Program Guidelines,” are to be used to evaluate changes to current procedures, including the FSGs, to determine the need for prior NRC approval. However, per the guidance and examples provided in NEI 96-07, Rev. 1, changes to procedures (EOPs, AOPs, EDMGs, SAMGs, or FSGs) that perform actions in response to events that exceed a site's design-basis should screen out. Therefore, procedure steps which recognize the ELAP/LUHS has occurred and which direct actions to ensure core cooling, SFP cooling, or Containment integrity should not require prior NRC approval. FSGs will be reviewed and validated by the involved groups to the extent necessary to ensure the strategy is feasible.

Regarding training, the licensee stated in its FIP, that Entergy's nuclear training program has been revised to ensure that personnel proficiency in the mitigation of BDBEEs is adequate and maintained. These programs and controls were developed and have been implemented in accordance with the systematic approach to training (SAT) process. Initial training has been provided and periodic training will be provided to site emergency response leaders on BDBEE emergency response strategies and implementing guidelines. Personnel assigned to direct the execution of mitigation strategies for BDBEEs have received the necessary training to ensure familiarity with the associated tasks, considering available job aids, instructions, and mitigating strategy time constraints. Care has been taken to not give undue weight (in comparison with other training requirements) for operator training for BDBEE accident mitigation. The testing/evaluation of operator knowledge and skills in this area has been similarly weighted. Per American National Standards Institute/American Nuclear Society 3.5, nuclear power plant simulators for use in operator training, certification of simulator fidelity is considered to be sufficient for the initial stages of the BDBEE scenario until the current capability of the simulator model is exceeded. Full scope simulator models will not be upgraded to accommodate FLEX training or drills.

The NRC staff finds that the licensee has adequately addressed the procedures and training associated with FLEX. The procedures have been issued and a training program has been established that will be maintained in accordance with NEI 12-06, Section 11.6.

3.13 Maintenance and Testing of FLEX Equipment

As a generic issue, NEI submitted a letter dated October 3, 2013, which included EPRI Technical Report 3002000623, "Nuclear Maintenance Applications Center: Preventive Maintenance Basis for FLEX Equipment." By letter dated October 7, 2013, the NRC endorsed the use of the EPRI report and the EPRI database as providing a useful input for licensees to use in developing their maintenance and testing programs. Preventative maintenance (PM) templates for the major FLEX equipment including the portable diesel pumps and generators have also been issued.

In its FIP, the licensee noted that maintenance and testing of FLEX equipment is governed by the Entergy PM Program as described in procedure EN-DC-324 and that the Entergy PM Program is consistent with Institute of Nuclear Power (INPO) INPO AP-913, "Equipment Reliability Process," and utilizes the EPRI PM Basis Database as an input in development of fleet specific Entergy PM Basis Templates. In those cases where EPRI templates were not available for the specific component types, the licensee developed PM actions based on manufacturer provided information/recommendations.
Due to Palisades's unique equipment storage plan, the portable FLEX equipment may be unavailable for 45 days provided that the site FLEX capability (N) is available. This is an alternate approach to the guidance of NEI 12-06. If portable equipment becomes unavailable such that the site FLEX capability (N) is not maintained, the licensee would initiate actions within 24 hours to restore the site FLEX capability (N) and implement compensatory measures (e.g., repair equipment, use of alternate suitable equipment or supplemental personnel) within 72 hours.

The NRC staff finds that the licensee has adequately addressed equipment maintenance and testing activities associated with FLEX equipment because a maintenance and testing program has been established in accordance with NEI 12-06, Section 11.5.

3.14 Alternatives to NEI 12-06, Revision 0

3.14.1 Use of Installed Charging Pumps

The licensee states in its FIP that the strategy of repowering installed equipment is allowed per Table D-1 of NEI 12-06. However, the licensee also recognizes that reliance on only installed equipment during Phase 2 for RPV/PCS/SG makeup conflicts with the guidance provided in NEI 12-06 Section 3.2.2(13). While the utilization of the installed charging pumps, with no portable equipment capability, does not meet the guidance of NEI 12-06, it is considered an alternate method to comply with the order. The NRC staff noted that the licensee's strategy involves:

- Two 100%-capacity, redundant pumps.
- One pump providing 44 gpm, which exceeds the flow requirement of 30 gpm from the licensee's calculations.
- Powering either pump from a separate LCC.
- Diverse injection paths from either charging pump discharge piping are provided through either PCS loop injection piping or through HPSI piping.
- A primary and alternate strategy for receiving power from the FLEX generator. The selected pump could be powered from the portable Phase 2 FLEX generator through either of two LCCs which can be cross-connected so that either charging pump can be powered by either connection point.

The NRC staff finds that the licensee has a strategy to provide PCS makeup that should prevent damage to the core following a BDBEE. Therefore, the NRC staff finds that the licensee's use of installed charging pumps is an acceptable alternative to NEI 12-06, and should meet the requirements of Order EA-12-049.

3.14.2 FLEX Equipment Outage Times

The Palisades FLEX storage configuration utilizes two storage locations; one located inside the PA and one located outside the PA. FLEX storage building "A" is a pre-engineered metal building located inside the PA. FLEX storage building "B" is a hardened reinforced concrete building located outside the PA. In NEI 12-06, Rev. 0, Section 10.1, stipulates that N+1 sets of FLEX equipment be protected from all applicable BDBEEs. While each FLEX storage building ("A" and "B") stores a complete set of FLEX equipment, including debris removal equipment, both storage locations are required to ensure that a single set (N) of FLEX equipment would be available for all applicable hazards. Therefore, the Palaisades FLEX storage configuration does not protect N+1 sets of FLEX equipment from all applicable BDBEEs as stipulated in NEI 12-06, Rev. 0, Section 10.1.

In its FIP, the licensee acknowledges that the Palisdaes FLEX storage configuration is an alternative to the guidance in NEI 12-06, Rev. 0. The FIP also describes a reduced allowed out of service time for FLEX equipment maintenance to address the alternative FLEX storage configuration. The NRC staff notes that by letter dated December 10, 2015, NEI submitted guidance document NEI 12-06, Rev. 2 [Reference 28] to the NRC for review. By letter dated January 22, 2016 [Reference 29], the NRC staff endorsed NEI 12-06, Rev. 2. Guidance document NEI 12-06, Rev. 2, contains modifications which resulted in NRC acceptance of the storage of backup (N+1) equipment such that it is not protected from the applicable BDBEE hazards. Section 11.5.4.b of NEI 12-06, Revision 2, contains the condition that if the site FLEX capability (N) is met, but not protected for all of the site's applicable hazards, then the allowed unavailability is reduced to 45 days (compared to the 90 day unavailability with any FLEX equipment unavailable, but with the FLEX capability (N) available and in a protected or diverse storage configuration). Although Palisades is evaluated to NEI 12-06, Rev. 0, in this SE, the licensee has committed to follow the 45 day unavailability limit stated in NEI 12-06, Rev. 2. Therefore, the NRC staff finds the Palisades storage configuration acceptable.

The NRC staff reviewed the licensee's proposal and finds that the methods used to ensure that the primary (N) set of equipment is available, with a reduction in allowed unavailability to 45 days if any N equipment is not protected for all of the site's applicable hazards, is an acceptable alternative to the NEI 12-06, and should meet the requirements of Order EA-12-049.

3.14.3 <u>Tank T-81 Tornado Missile Protection</u>

The licensee stated in its FIP that the method of protection for tornado generated missiles for tank T-81 is an alternate approach to the guidance of NEI 12-06. Specifically Section 2.1.1 of the FIP identifies that water inventories are available that are contained in systems or structures with designs that are robust with respect to all applicable hazards. Tank is fully protected from all design-basis missile hazards with the exception of the large missile hazard represented by an automobile. The licensee notes in Section 2.3.4.4 of its FIP that reasonable protection from the automobile missile hazard is provided by the following:

- Surrounding structures that intervene and provide protection from the design basis automobile-like missiles;
- Low likelihood of historic tornadic activity at the site/region;
- Administrative controls in AOP-38, "Acts Of Nature," Rev. 4, to remove any potential automobile-like missiles from the zone of influence given the onset of high winds;
- Implementation of modifications to restrain existing structures within the zone from becoming automobile like hazards; and
- Administrative controls in FSGs that take action to provide alternative suction inventory from one of several non-robust sources within 3.5 hours of the onset of an ELAP if T-81 is determined to be compromised.

During the audit, the licensee provided the evaluation, "Tornado Generated Missile Hazard Evaluation for the Primary System Makeup Storage Tank (T-81)," Rev. 2. This evaluation discussed in detail the above approach to providing automobile-like missile protection for T-81. While onsite, the NRC staff walked down the location of the T-81 tank and noted that the layout, intervening structures and potential automobile-like missiles were consistent with the licensee's evaluation. Given the procedural guidance the licensee has in place, the surrounding intervening structures and the additional protective measures, the NRC staff finds that the licensee's use of the above method to protect T-81 from an large, tornado-generated missile is an acceptable alternative to NEI 12-06, and that the licensee should meet the requirements of Order EA-12-049.

3.15 Conclusions for Order EA-12-049

Based on the evaluations above, the NRC staff concludes that the licensee has developed guidance to maintain or restore core cooling, SFP cooling, and containment following a BDBEE which, if implemented appropriately, should adequately address the requirements of Order EA-12-049.

4.0 TECHNICAL EVALUATION OF ORDER EA-12-051

By letter dated February 28, 2013 [Reference 30], the licensee submitted its OIP for PNP in response to Order EA-12-051. By letter dated July 18, 2013 [Reference 31] the NRC staff sent a RAI to the licensee. The licensee provided a response by letter dated August 19, 2013 [Reference 32]. By letter dated November 26, 2013 [Reference 33], the NRC staff issued an ISE and RAI to the licensee.

By letters dated August 28, 2013 [Reference 34], February 28, 2014 [Reference 35], August 28, 2014 [Reference 36], February 27, 2015 [Reference 37], and August 28, 2015 [Reference 38], the licensee submitted status reports for the Integrated Plan. The Integrated Plan describes the strategies and guidance to be implemented by the licensee for the installation of reliable SFP level instrumentation, which will function following a BDBEE, including modifications necessary to support this implementation, pursuant to Order EA-12-051. By letter dated December 16, 2015 [Reference 39], the licensee reported that full compliance with the requirements of Order EA-12-051 was achieved.

The licensee has installed a SFP level instrumentation system designed by Mohr Test and Measurement LLC. The NRC staff reviewed the vendor's SFP level instrumentation system design specifications, calculations and analyses, test plans, and test reports. The staff issued an audit report on August 27, 2014 [Reference 40].

The staff performed an onsite audit to review the implementation of SFP level instrumentation related to Order EA-12-051. The scope of the audit includes verification of (a) site's seismic and environmental conditions enveloped by the equipment qualifications, (b) equipment installation met the requirements and vendor's recommendations, and (c) program features met the requirements. By letter dated October 13, 2015 [Reference 18], the NRC issued an audit report on the licensee's progress. Refer to Section 2.2 above for the regulatory background for this section.

4.1 Levels of Required Monitoring

In its OIP, the licensee stated that Level 1 is elevation 645 ft. 7 in. Level 1 is the level adequate to support operation of the normal fuel pool cooling system. It is the higher of the level at which reliable suction loss occurs due to uncovering the coolant inlet pipe or any weirs or vacuum breakers associated with suction loss. Level 2 is elevation 634 ft. 5 in. (10 ft. above Level 3). Level 2 is the level adequate to provide substantial radiation shielding for a person standing on the spent fuel pool operating deck. Level 3 is elevation 624 ft. 5 in. Level 3 is the level where fuel remains covered. It is defined as the highest point of any fuel rack seated in the spent fuel pool (within ± 1 ft.).

In its letter dated August 19, 2013 [Reference 32], the licensee provided a sketch depicting that Level 1 is designated at 645 ft. - 7 in. Elevation, Level 2 is designated at 634 ft. – 5 in. Elevation, and Level 3 is designated at 625 ft. – 5 in. Elevation. The sketch also shows the measurement range for the spent fuel pool instrumentation (SFPI) is between 625 ft. – 2 in. and 647 ft. – 10 in. elevations.

The NRC staff noted that the designated Level 1 (elevation 645 ft. - 7 in.) is adequate for normal SFP cooling system operation and it is also adequate to ensure the required fuel pool cooling pump net positive suction head. This level also represents the higher of the two points described in NEI 12-02, Section 2.3.1 for Level 1. The designated Level 2 (elevation 634 ft. 5 in.) uses the first of the two options described in NEI 12-02 for Level 2, which is 10 ft. ± 1 ft. above the highest point of any fuel rack seated in the spent fuel pool. The designated Level 3 (elevation 625 ft. - 5 in.) is 1 ft. above the highest point of any spent fuel storage rack seated in the SFP.

The NRC staff finds that the licensee's proposed Levels 1, 2 and 3 are consistent with NEI 12-02 guidance, as endorsed by JLD-ISG-2012-03, and adequately addresses the requirements of the order.

4.2 Evaluation of Design Features

Order EA-12-051 required that the SFP level instrumentation shall include specific design features, including specifications on the instruments, arrangement, mounting, qualification, independence, power supplies, accuracy, testing, and display. Refer to Section 2.2 above for the requirements of the order in regards to the design features. Below is the NRC staff's assessment of the design features of the SFP level instrumentation.

4.2.1 Design Features: Instruments

In its OIP, the licensee stated that the primary instrument channel (Channel A) and backup instrument channel (Channel B) are permanent, fixed channels. The instrument channels will provide level indication through the use of Guided Wave Radar (GWR) technology through the principle of Time Domain Reflectometry (TDR). The instrument provides a single continuous span from above Level 1 to within 1 ft. of the top of the spent fuel racks.

In its OIP, the licensee also provided a sketch depicting the elevations identified as Levels 1, 2 and 3 and the SFP level instrumentation measurement range. The NRC staff noted that the measurement range goes from the 647 ft. – 10 in. to 625 ft. – 2 in. This measurement range will cover Levels 1, 2, and 3 as described in Section 4.1 above.
The NRC staff finds that the licensee's design, with respect to the number of channels and measurement range for its SFP, appears to be consistent with NEI 12-02 guidance, as endorsed by JLD-ISG-2012-03, and should adequately address the requirements of the order.

4.2.2 Design Features: Arrangement

In its OIP, the licensee stated that the location of the Channel A display/processor is in the MCR, and the location of the Channel B display/processor is in the Reactor Auxiliary Building. These locations are expected to be a mild environment after a BDBEE and can be easily accessed from the MCR; therefore, personnel can promptly obtain readings from the display. These areas provide adequate protection against the effects of temperature, flood, humidity, radiation, seismic events, and missile hazards.

In its OIP, the licensee also provided a sketch depicting the SFP instrument locations and conduit routings of both primary and back-up level instrument channels. The NRC staff noted that, and verified by walkdown during the onsite audit, that there is sufficient channel separation within the SFP area between the primary and back-up level instruments, sensor electronics, and routing cables to provide reasonable protection of the level indication function against missiles that may result from damage to the structure over the SFP.

The NRC staff finds that the licensee's arrangement for the SFP level instrumentation, if implemented appropriately, appears to be consistent with NEI 12-02 guidance, as endorsed by JLD-ISG-2012-03, and should adequately address the requirements of the order.

4.2.3 Design Features: Mounting

In its letter dated August 19, 2013 [Reference 32], the licensee stated that the loading on the probe mount and probe body includes both seismic and hydrodynamic loading using seismic response spectra that bound the PNP design basis maximum seismic loads applicable to the installation location(s). Seismic loading response of the probe and mount is separately modeled using finite element modeling software (GOTHIC). The GOTHIC-derived fluid motion profile in the pool at the installation site and resultant distributed hydrodynamic loading terms are added to the calculated seismic loading terms in the finite element model to provide a conservative estimate of the combined seismic and hydrodynamic loading terms for the probe and probe mount, specific to the chosen installation location for the probe. The proximal portion of the level probe is designed to be attached near its upper end to a Seismic Category I mounting bracket configured to suit the requirements of a particular SFP. The bracket may be bolted and/or welded to the SFP deck and/or SFP liner/wall according to the requirements of the particular installation per Seismic Category I requirements.

In its letter dated February 27, 2015 [Reference 37], the licensee further stated that the site specific seismic analysis bounds PNP's seismic criteria. The qualification report envelops all components of the new SFP level instrumentation required to be operational during a BDBEE and post-event. Calculations EA-EC46466-01 and EA-EC46466-02 determine that all components, supports, and anchorages required are structurally adequate and seismically qualified as all Interaction Ratios (IR) are less than one (1.0). The seismic qualification reports in combination with NAI-1725-003, NAI-1725-004, and PNP site specific Report NAI-1791-006 adequately bound the hydrodynamic loads associated with sloshing for PNP. Calculation EA-EC46466-01 also accounts for sloshing effects to the probe.

The NRC staff noted that the licensee adequately addressed the design criteria and methodology used to estimate and test the total loading on the mounting devices, including the design basis maximum seismic loads and the hydrodynamic loads that could result from pool sloshing. The site-specific seismic analyses demonstrated that the SFP level instrumentation's mounting design is satisfactory to allow the instrument to function per design following the maximum seismic ground motion. The NRC staff verified the instrument channel's mounting design by performing a walkdown and by reviewing the following:

- Calculation EA-EC46466-01, "Design of SFPI Probe Mounting Bracket," Rev. 0
- Calculation EA-EC46466-02, "Qualification of SFP Instrumentation Mounting Details," Rev. 0
- NAI-1791-006, "Seismic Induced Hydraulic Response in the Palisades Spent Fuel Pool," Rev. 0

Based on the discussion above, the NRC staff finds the licensee's proposed mounting design appears to be consistent with NEI 12-02 guidance, as endorsed by JLD-ISG-2012-03, and should adequately address the requirements of the order.

4.2.4 Design Features: Qualification

4.2.4.1 Augmented Quality Process

Appendix A-1 of the guidance in NEI 12-02 describes a quality assurance process for non-safety systems and equipment that is not already covered by existing quality assurance requirements. Per JLD-ISG-2012-03, the NRC staff found the use of this quality assurance process to be an acceptable means of meeting the augmented quality requirements of Order EA-12-051.

In its OIP, the licensee stated that augmented quality requirements will be applied to all components in the instrumentation channels for:

- design control
- procurement document control
- instructions, procedures, and drawings
- control of purchased material, equipment, and services
- inspection, testing, and test control
- inspections, test, and operating status
- nonconforming items
- corrective actions
- records
- audits

In its letter dated December 16, 2015 [Reference 39], the licensee further stated that the SFP instrumentation channels have been designated as augmented quality per Entergy processes covering procurement, design, and installation. Per Entergy procedures, augmented quality refers to SSCs that have been designated as requiring additional quality level oversight or requirements beyond what would be required for non-safety related SSCs. As such, the SFP instrument channels have demonstrated reliability through establishment of an augmented quality processes at applicable environmental extremes.

The NRC staff noted that the licensee's proposed augmented quality assurance process appears to be consistent with NEI 12-02, as endorsed by JLD-ISG-2012-03. If implemented appropriately, this approach appears to be consistent with NEI 12-02 guidance, and should adequately address the requirements of the order.

4.2.4.2 Equipment Reliability

The NRC staff reviewed the Mohr SFP level instrumentation's qualification and testing during the vendor audit for temperature, humidity, radiation, shock and vibration, and seismic [Reference 40]. The staff further reviewed the anticipated Palisades' environmental conditions during the on-site audit [Reference 18].

4.2.4.2.1 Temperature, humidity, and radiation

In its OIP, the licensee stated that components in the area of the SFP will be designed for the temperature, humidity, and radiation levels expected during normal, event, and post-event conditions for no fewer than seven days post-event or until off-site resources can be deployed by the mitigating strategies resulting from Order EA-12-049. Equipment located in the SFP will be qualified to withstand a total accumulated dose of expected lifetime at normal conditions plus accident dose received at post event conditions with SFP water level within 1 foot of the top of the fuel rack seated in the spent fuel pool. The probe and cable in the spent fuel pool area are robust components that are not adversely affected by expected radiation, temperature, or humidity. The areas selected for display/processor installation are considered mild environments.

In its letter dated August 19, 2013 [Reference 32], the licensee stated that the signal processor is designed for mild environment with radiation levels similar to background radiation. Physical testing in an environmental chamber to demonstrate normal operation at the operating temperatures and humidity specified for the instrument. The probe assembly is qualified by materials properties and use history of substantially similar probe designs in SG applications at significantly higher temperatures and pressures and saturated steam environments.

In its letter dated February 27, 2015 [Reference 37], the licensee further stated that the Palisades Control Room (Channel A display's location) and the C-40 Panel Room (Channel B display's location) are considered a mild environment. Radiation levels in the Control Room and C-40 Panel Room are not impacted by a reduction in SFP water level. Calculation EA-EC46465-03 determined that the maximum temperature in the control room will be 121°F. The operating temperature of the C-40 Panel Room is 50-110°F. Humidity in the Control Room and C-40 Panel Room are normally regulated by the HVAC system at 50 percent. The SFPI system electronics was tested to a nominal temperature range of 14°F to 131°F and a humidity range of 5 percent to 95 percent relative humidity (RH). During an extended loss of ac power, the HVAC system is no longer available. Assuming the Control Room and C-40 Panel Room remain isolated from outside air, the temperature is expected to increase and the humidity is expected to decrease because the heat loads are dominated by the sensible heat of electrical equipment. Therefore, the maximum temperatures of 121°F for the Control Room and 110°F for the C-40 Panel Room at a humidity below 50 percent is bounded by results from the test case of 55°C (131°F), which is the 50 percent RH.

The NRC staff found that the licensee adequately addressed the equipment reliability of SFP level instrumentation with respect to temperature, humidity and radiation. The equipment qualification envelops the expected Palisades' radiation, temperature, and humidity conditions during a BDBEE. The equipment environmental testing demonstrated that the SFP instrumentation should maintain its functionality during the expected BDBEE conditions.

4.2.4.2.2 Shock and Vibration

In its letter dated February 27, 2015 [Reference 37], the licensee stated that the probe and repairable head are considered inherently resistant to shock and vibration. They are evaluated to be adequately designed for resilience against shock and vibration. The probe mounting components and fasteners are designed as rigid components inherently resistant to vibration effects. The probes will be affixed to the bracket using a machine screw connection designed with proper thread engagement and lock washers. The indicator and battery enclosures will be mounted in the Control Room and C-40 Panel Room. The equipment is not affixed or adjacent to any rotating machinery that would cause vibration effects in the area of installation. The instrument mounting components and fasteners are designed as rigid components inherently resistant to vibration effects.

The NRC staff found that the licensee adequately addressed the equipment reliability of SFP level instrumentation with respect to shock and vibration qualifications. The staff also reviewed the shock and vibration test report during the vendor audit and found it acceptable.

4.2.4.2.3 Seismic

In its letter dated August 19, 2013 [Reference 32], the licensee stated that triaxle shake-table testing is planned to be performed for the signal processor to envelope Seismic Category I SSE conditions or Palisades design-basis maximum seismic loads using Institute of Electrical and Electronics Engineers (IEEE) 344-2004 methodology. A seismic and hydrodynamic finite element analysis is performed by the vendor using enveloping Seismic Category I SSE conditions or Palisades design-basis maximum seismic loads relative to the location where the equipment is mounted. Combined seismic and hydrodynamic analysis will be used to demonstrate that the probe waveguide's geometric dimensions do not change significantly as a result of the seismic conditions.

In its letter dated February 27, 2015 [Reference 37], the licensee further stated that the site specific seismic analysis bounds Palisades seismic criteria. The qualification report envelops all components of the new SFP level required to be operational during BDBEE post-event. Calculations EA-EC46466-01 and EA-EC46466-02 determine that all components, supports, and anchorages required are structurally adequate and seismically qualified as all IRs are less than one (1.0).

The NRC staff found that the licensee adequately addressed the equipment reliability of SFP level instrumentation with respect to seismic qualification. The equipment's seismic qualifications envelop the expected Palisades' seismic condition during a BDBEE. The site-specific seismic analyses demonstrated that the SFP level instrumentation's mounting design is satisfactory to allow the instrument to function per design following the maximum seismic ground motion. Further discussion of the instrument channel's mounting design is described in Subsection 4.2.3, "Design Features: Mounting". The NRC staff reviewed the vendor's factory acceptance test reports and found the Palisades SFPI design and qualification process acceptable. However, during the onsite audit, the NRC staff learned that there were incidents at other nuclear facilities, in which the Mohr's SFPI equipment experienced failures of the filter coil (or choke). The staff requested Palisades to address the impact of SFPI equipment failures on the Palisades' SFP level instrument.

In its letter dated August 28, 2015 [Reference 38], the licensee provided a response, in which it stated that the vendor determined that the source of the failures is a miniature surface mount common-mode choke component used on the Video and Digicomp printed circuit boards within the EFP-IL Signal Processor. Per the vendor's recommendation, the two boards have been replaced in both EFP-IL Signal Processors at Palisades. Corrective actions were performed under condition report CR-HQN-2015-0345 to replace each of the two circuit boards within the two EFP-IL Signal Processors at the site. The new boards have equivalent substitute components that are less susceptible to transient electrical events. The substitute components have equivalent size, mass, and solder attachment technique as the original component such that there is no impact to the system mechanical characteristics. The components demonstrate equivalent electrical performance such that electromagnetic compatibility (EMC) characteristics are not significantly changed.

During the onsite audit, the NRC staff reviewed Condition Report CR-HQN-2015-0345 and the Mohr Root Cause Analysis Report, Rev. 1 dated June 1, 2015. The NRC staff found Palisades' approach to address the equipment failure appropriate. However, the Mohr Root Cause Analysis Report did not adequately address the impact to order compliance. Section 6.2, "Impact to Regulatory Compliance," of the report stated, in part, that no impact to regulatory compliance was identified. On-going repairs are being carried out using more rugged but otherwise equivalent choke components with equivalent form, fit, and function using equivalent solder technique. Alteration of enclosure mass due to the repair is negligible (0.002 percent) and well within the expected variation of mass from enclosure to enclosure due to normal manufacturing variation of PCB assemblies, cables, and other components. Credit is therefore taken for previously documented regulatory qualification, including seismic qualification, per Order EA-120-051, NEI 12-02, Rev. 1 and JLD-ISG-2012-03. Repairs are being carried out in compliance with the quality requirements of NEI 12-02, Rev. 1, Appendix A-1, "Quality Assurance".

The NRC staff found that the justifications for the repaired equipment's qualification with respect to seismic and EMC in the Mohr Root Cause Analysis Report are not sufficient. The report also did not address the shock, vibration, and environmental qualifications (temperature and humidity) for the replaced components. During the onsite audit, Palisades coordinated a conference call with Mohr Test and Measurement LLC. During the call, the NRC staff requested that Mohr provide a detailed description of what changes Mohr made to the SFPI equipment that have been sent to the Mohr facility for repair. The NRC staff also requested that Mohr provide the following qualifications for each replaced component/part to meet the Order EA-12-051 requirements:

- Seismic
- Shock
- Vibration
- Temperature
- Humidity
- EMC

Mohr issued Qualification Report: EFP-IL MOD 1 Modification Package, Rev. 0, dated July 16, 2015, to document regulatory qualification of its SFPI equipment. In this report, Mohr provided evaluation of the following hardware modifications:

- In-place replacement of the miniature T1 surface mount choke on the 01-EFP-IL-50001 board with an equivalent component.

- In-place replacement of the miniature T1 surface mount choke on the 01-EFP-IL-50006 board with an equivalent component.

- Incorporation of a fusible link in the 01-EFP-IL-50204 cable assembly.

- Full electrical isolation added to the 01-EFP-IL-50007 (USB interface) board.

Below is the summary of the evaluation of the above modifications:

<u>T1 Choke Replacement Evaluation</u>

<u>Temperature and Humidity</u>
The replacement choke has an operating temperature range of -40 °C to +85 °C, exceeding the -10 °C to +55 °C requirement. Non-condensing humidity does not alter performance of this component.

<u>Electromagnetic Compatibility (EMC)</u>
There is no change to EMC qualification. The choke demonstrates equivalent or higher impedance to common mode noise.

<u>Shock and Vibration</u>
The mass differences are 0.002% and 0.47% for 01-EFP-IL-50001 enclosure mass and the board mass respectively and 0.0003% and 0.18% for 01-EFP-IL-50006 enclosure mass and the board mass respectively.

<u>Seismic</u>
Qualification by similarity to existing qualified equipment is permitted by IEEE Std. 344-2004. Replacement of T1 choke does not significantly alter equipment mass, mass distribution, or other mechanical characteristics.

<u>Fusible Link Evaluation:</u>

The 01-EFP-IL-50204 Fusible Link is added to the existing power board power cable. One Fusible Link is used per EFP-IL signal processor.

<u>Temperature and Humidity</u>
The Fusible Link's fuses are rated for -55 °C to +125 °C and 100% RH per MIL-STD-201 Method 106.

<u>Electromagnetic Compatibility (EMC)</u>
There is no change to EMC qualification. The Fusible Link uses insulated wiring and connectors identical in configuration to the remainder of the previously qualified cable assembly and expected emissions are unchanged.

Shock and Vibration
The Fusible Link uses insulated wiring and connectors identical in configuration to the remainder of the cable assembly and is secured using identical tie-down and strain-relief methods which have been previously qualified.

The Fusible Link contributes approximately 0.14% enclosure mass, well within the expected variation of the unmodified EFP-IL signal processor enclosure mass due to manufacturing tolerances of system components.

The connectors are qualified by the manufacturer for vibration conditions per EIA 364-28 and shock loading at 50g. The connector rated minimum pull force is 8.0 lbf per wire terminal, for a total rating of 80.0 lbf for the 10 wire connector, equivalent to 2086g loading assuming Fusible Link mass of 17.4 g.

The Littelfuse fuse lead axial pull force is rated at 7 lbs. per MIL-STD-202, which is equivalent to 182 g static loading per fuse (two fuses per cable), assuming cable mass of 17.4 g and conservatively neglecting stress shielding by cable wiring and insulation.

Seismic
The Fusible Link contributes approximately 0.14% enclosure mass, well within the expected variation of the unmodified EFP-IL signal processor enclosure mass due to manufacturing tolerances of system components.

Electrical Isolation Evaluation:
The front panel USB board 01-EFP-IL-50007 has been modified through addition of the component to provide galvanic USB isolation and enhance ESD protection (±15kV)

Temperature and Humidity
The additional component is rated for normal operation at -40 °C to +85 °C. The component is a hermetic plastic BGA package that is not susceptible to elevated humidity.

Electromagnetic Compatibility (EMC)
There is no change to EMC qualification. The isolation technology within the additional component is compliant with applicable standards including radiated emissions limit per IEC 61000/CISPR 22. The device reduces the equipment's already low radiated emissions when the USB device is in use because it isolates and prevents noise on internal data and power lines from propagating to external devices connected to the front-panel USP port. The device is not active when USB devices are not in use.

Shock and Vibration
There is insufficient mass difference to alter the equipment shock and vibration response characteristics. The additional component is a rugged, compact, encapsulated surface-mount BGA package enveloped in size and mass by other components in the system. Surface mount components as a class are not susceptible to required levels of shock and vibration when mounted within the EFP-IL equipment enclosures.

Seismic
The nominal difference in enclosure mass is trivial at 0.014, well within the expected variation of EFP-IL signal processor enclosure mass due to manufacturing tolerances of system components.

The NRC staff found that the vendor adequately addressed the staff concern with regard to the modified equipment qualifications. The temperature and humidity ratings of the replacement parts envelop the expected Control Room's and C-40 Panel Room's conditions during a BDBEE. There is no indication that new electromagnetic emissions will be introduced by the replacement parts. The mass differences are insufficient to alter the seismic, shock, and vibration response characteristics.

Based on the discussion above, the NRC staff finds that the licensee's proposed instrument qualification process appears to be consistent with NEI 12-02 guidance, as endorsed by JLD-ISG-2012-03, and should adequately address the requirements of the order.

4.2.5 Design Features: Independence

In its OIP, the licensee stated that the primary instrument channel will be independent of the backup instrument channel. Independence is obtained by physical separation of components between channels and the use of normal power supplied from separate 480V buses. Independence of power sources is described in Section 11. The 2 level instruments and any associated cabling (for each Unit SFP) will be physically separated and electrically independent of one another.

In its letter dated August 19, 2013 [Reference 32], the licensee further stated that power for each channel is provided from independent 120Vac, 60 Hertz (Hz) power sources. Backup power is provided by a battery capable of providing continuous display operation for at least 3 days. The battery will be provided with the display/processor. The design prevents failure of a single channel from causing the alternate channel to fail. Physical separation of the two channels will be accomplished by separately routing cable and conduit as much as practical.

In its letter dated August 28, 2014 [Reference 36], the licensee further stated that instrument Channel A is being powered from Lighting Panel (L-25B) through existing 20A breaker #5, which is supplied from MCC #1. Instrument Channel B is being powered from Lighting Panel (L-76) through existing 20A breaker #12, which is supplied from MCC #82. These two buses represent independent 480 V power sources.
The NRC staff noted that the licensee adequately addressed the instrument channel independence. The primary instrument channel is physically and electrically independent of the backup instrument channel. The instrument channels' physical separation is discussed in Subsection 4.2.2, "Design Features: Arrangement". With the licensee's proposed power arrangement, the electrical functional performance of each level measurement channel would be considered independent of the other channel, and the loss of one power supply would not affect the operation of other independent channel under BDBEE conditions.

Based on the discussion above, the NRC staff finds the licensee's proposed design, with respect to instrument channel independence, appears to be consistent with NEI 12-02 guidance, as endorsed by JLD-ISG-2012-03, and should adequately address the requirements of the order.

4.2.6 Design Features: Power Supplies

In its OIP, the licensee stated that each instrument channel is normally powered from 120Vac 60 Hz plant power to support continuous monitoring of SFP level. The primary channel receives power from a different 480V bus than the backup channel. Therefore, loss of any one 480V bus does not result in loss of normal 120 Vac power for both instrument channels. On loss of normal 120 Vac power, each channel's UPS automatically transfers to a dedicated backup battery. If normal power is restored, the channel will automatically transfers back to the normal ac power. The backup batteries are maintained in a charged state by commercial-grade uninterruptible power supplies. The batteries are sized to be capable of supporting intermittent monitoring for a minimum of 3 days of operation. This provides adequate time to allow the batteries to be replaced or until off-site resources can be deployed by the mitigating strategies resulting from Order EA-12-049. An external connection permits powering the system from any portable DC source.

In its letter dated August 19, 2013 [Reference 32], the licensee further stated that permanent installed battery capacity for 7 days continuous operation is planned consistent with NEI 12-02 duration without reliance on or crediting of potentially more rapid FLEX Program power restoration. Batteries are readily replaceable via spare stock without the need for recalibration to maintain accuracy of the instrument. These measures should ensure adequate power capacity and margin.

During the onsite audit, the NRC staff inquired about the power restoration strategy following an ELAP and prior to the back-up battery depletion. The licensee provided a response, in which it stated that ac power is not credited for restoring power to the instrumentation in the event of an ELAP. Instead, external batteries will be used to supply power through the external connection ports along the bottom of the Battery Enclosure. Battery cables are stored in the storage area of the Control Room. This is captured in FSG-11, "Alternate SFP Makeup and Cooling," Rev. B. At least one battery per channel will kept on site and additional batteries can be taken from cars as needed.

The NRC staff found the response acceptable. However, while verifying the response by reviewing FSG-11, the NRC staff noted that the battery's voltage was specified with different values (24 Vdc, 9-36 Vdc, and 12 Vdc). In response to the NRC staff's concern, the licensee issued Corrective Action CA-5 of CR-PLP-2015-02482 to clarify the verbiage within FSG-11 concerning the proper and appropriate voltage source to provide an external source of power to the SFPI when normal and back-up power may be unavailable.

Based on the discussion above, the NRC staff finds the licensee's proposed power supply design appears to be consistent with NEI 12-02 guidance, as endorsed by JLD-ISG-2012-03, and should adequately address the requirements of the order.

4.2.7 Design Features: Accuracy

In its OIP, the licensee stated that the absolute system accuracy is better than ± 3 in. This accuracy is applicable for normal conditions and the temperature, humidity, chemistry, and radiation levels expected for BDBEE conditions.

In its letter dated August 19, 2013 [Reference 32], the licensee further stated that in general, relative to normal operating conditions, any applicable calibration procedure tolerances (or acceptance criterion) are planned to be established based on the manufacturer's stated/recommended reference accuracy (or design accuracy). The methodology used is planned to be captured in plant procedures and/or programs.

The NRC staff found that instrument channel design accuracies and methodology sufficient for maintaining the instrument channels to within their designed accuracies before significant drift can occur. However, the NRC staff needed to verify that the channels will retain these accuracy performance values following a loss of power and subsequent restoration of power.

In its letter dated February 27, 2015 [Reference 37], the licensee further stated that Report 1-0410-10 concludes that the accuracy is not affected by an interruption in power. Report 1-0410-8 concludes that the presence of borated water and/or boric acid deposits will not significantly impair the ability of the Mohr EFP-IL SFPI system to accurately measure water level in the SFP environment. Visual inspection and/or wash down of the probe assembly could be initiated by accuracy requirements or routine inspection. The probe head assembly includes a connection mechanism for flushing water to remove boron build-up as may be necessary. Alternatively, the SFP water level can be raised until it covers and dissolves the boric acid deposit. Appendix A of Report 1-0410-12 states that the absolute accuracy is 76.2 mm or 3.0 in, not including boric acid deposition effects. This error complies with the limit of ±1 foot set by NEI 12-02. Additionally, the probe is designed to produce accurate level indication in boiling and frothing (multiphase) environments according to Report 1-0410-15.

The licensee has demonstrated that the instrument channels' accuracy is not significantly affected by BDBEE conditions. If implemented properly, the instrument channels should maintain the designed accuracy following a power source change or interruption without the need of recalibration. The NRC staff finds the licensee's proposed instrument accuracy appears to be consistent with NEI 12-02 guidance, as endorsed by JLD-ISG-2012-03, and should adequately address the requirements of the order.

4.2.8 Design Features: Testing

In its OIP, the licensee stated that the display/processor performs automatic in-situ calibration and automatically monitors for cable, connector, and probe faults using time domain reflectometry (TDR) technology. Channel degradation due to age or corrosion is not expected but can be identified by monitoring trends.

In its letter dated August 19, 2013 [Reference 32], the licensee further stated that the level instrument automatically monitors the integrity of its level measurement system using in-situ capability. Periodic calibration checks of the signal processor electronics to extrinsic National Institute of Standards and Technology (NIST)-traceable standards can be achieved through the use of standard measurement and test equipment. It is planned to be periodically inspected electromagnetically using TDR at the probe hardline cable connector to demonstrate that the probe assembly meets manufactured specification and visually to demonstrate that there has been no mechanical deformation or fouling.

Performance tests (functional checks) are automated and/or semi-automated (requiring limited operator interaction) and are performed through the instrument menu software and initiated by the operator. Other tests such as menu button tests, level alarm, and alarm relay tests are only initiated manually by the operator. Performance tests are planned to be performed periodically as recommended by the equipment vendor, for instance quarterly but no less often than the calibration interval of two years.

Channel functional tests per operations procedures with limits established in consideration of vendor equipment specifications are planned to be performed at appropriate frequencies established equivalent to or more frequently than existing spent fuel pool instrumentation.

Manual calibration and operator performance checks are planned to be performed in a periodic scheduled fashion with additional maintenance on an as-needed basis when flagged by the system's automated diagnostic testing features. Periodic (e.g., quarterly or monthly) review of the system level history and log files and routine attention to any warning message on the system display is recommended by the vendor. Formal calibration checks are recommended by the vendor on a 2-year interval to demonstrate calibration to external NIST-traceable standards. Formal calibration check surveillance interval and timing would be established consistent with applicable guidance (i.e., NEI 12-02, Section 4.3; on a refueling outage interval basis and within 60 days of a planned refueling outage). Items such as system batteries are planned to be assessed under the preventive maintenance (PM) program for establishment of replacement frequency. Surveillance/PM timing/performance are planned to be controlled via tasks in the PM program.

The NRC staff noted that the SFP level instrumentation is adequately designed to provide the capability for routine testing and calibration including in-situ testing/calibration. By comparing the levels in the instrument channels and the maximum level allowed deviation for the instrument channel design accuracy, the operators could determine if recalibration or troubleshooting is needed. The staff finds the licensee's proposed SFP instrumentation design allows for testing that appears to be consistent with NEI 12-02 guidance, as endorsed by JLD-ISG-2012-03, and should adequately address the requirements of the order.

4.2.9 Design Features: Display

In its OIP, the licensee stated that the primary and backup instrument displays will be located in the MCR and the Auxiliary Building. For both normal and expected BDBEE conditions, the displays are promptly accessible to plant staff and decision makers are properly trained in the use of the equipment. Station operators can obtain SFP level data trends and report those to decision makers within 30 minutes of request. The displays are inside a seismic structure that provides protection from adverse weather or flooding.

In its letter dated August 28, 2014 [Reference 36], the licensee further stated that the backup display will be mounted in the Radwaste Control Panel Room Cabinet C104 at the 590 ft. elevation of the Auxiliary Building. This cabinet is located in Room 121, and can be accessed via Stairwell No. 16 and Door 75, or via Corridor 106A through Door 190. Both Stairwell 16 and

Corridor 106A can be approached from the north, east, and west via Corridor 106. The back-up channel display can be considered promptly accessible, because it can be reached within the 30 minute deployment requirement that exists for portable instrumentation. The impact to habitability would be primarily from elevated temperatures, as the C-40 panel room is considered a mild radiation environment. Personnel will not be continuously stationed at the backup display, it will be monitored periodically. The site FLEX Support Guidelines will provide guidance for personnel to evaluate the room temperature and take actions as necessary.

The NRC staff noted that the licensee adequately addressed the display requirements. If implemented properly, the displays should provide continuous indication of SFP water level. The displays are located in seismically qualified buildings and the accessibility of the Radwaste Control Panel Room following an ELAP event is considered acceptable. The NRC staff finds that the licensee's proposed location and design of the SFP instrumentation displays appears to be consistent with NEI 12-02 guidance, as endorsed by JLD-ISG-2012-03, and should adequately address the requirements of the order.

4.3 Evaluation of Programmatic Controls

Order EA-12-051 specified that the spent fuel pool instrumentation shall be maintained available and reliable through appropriate development and implementation programmatic controls, including training, procedures, and testing and calibration. Below is the NRC staff's assessment of the programmatic controls for the spent fuel pool instrumentation.

4.3.1 Programmatic Controls: Training

In its OIP, the licensee stated that the Systematic Approach to Training (SAT) will be used to identify the population to be trained and to determine both the initial and continuing elements of the required training. Training will be completed prior to placing the instrumentation in service.

The NRC staff finds that the use of SAT to identify the training population and to determine both the elements of the required training is acceptable. The licensee's proposed plan to train personnel in the operation, maintenance, calibration, and surveillance of the SFPI and the provision of alternate power to the primary and backup instrument channels, including the approach to identify the population to be trained, appears to be consistent with NEI 12-02 guidance, as endorsed by JLD-ISG-2012-03, and should adequately address the requirements of the order.

4.3.2 Programmatic Controls: Procedures

In its OIP, the licensee stated that procedures for maintenance and testing will be developed using regulatory guidelines and vendor instructions. The BDBEE operation guidance will also address the following:

- A strategy to ensure SFP water addition is initiated at an appropriate time consistent with implementation of NEI 12-06, Rev. 1.
- Restoration of non-functioning SFP level channels after an event. Restoration timing will be consistent with the emergency condition. After an event, commercially available components that may not meet all qualifications may be used to replace components to restore functionality.

During the onsite audit, the licensee further stated that Palisades SFP instrument channels automatically monitor the integrity of the measurement system using in-situ capability or on-board diagnostics. Deviation of measured test parameters from manufactured or as-installed configuration beyond a configurable threshold prompts operator intervention. Channel design provides capability for calibration or validation against known/actual SFP level. The Palisades SFP instrument channels have a reasonably high certified design accuracy of equal to or better than +/- 3 in. (excluding boric acid deposition effects that cause a conservative decrease in indicated level). Corrective Action CA-10 has been initiated for condition report CR-PLP-2015-2482 to track completion of the generation of a calibration procedure for the SFPI.
Guideline FSG-11, "Alternate SFP Makeup and Cooling," provides actions to restore SFP level using an alternate makeup source for a BDBEE resulting in an ELAP. This procedure includes remote SFP level indicator display locations and a procedure for how and when to connect an external DC source to power the SFP level indicator.

The NRC staff noted that the licensee adequately addressed the procedure requirements to establish procedures for the testing, surveillance, calibration, and operation of the primary and backup SFP level instrument channels. The NRC staff finds that the licensee's proposed procedures appear to be consistent with NEI 12 02, as endorsed by JLD-ISG-2012-03, and should adequately address the requirements of the order.

4.3.3 Programmatic Controls: Testing and Calibration

In its OIP, the licensee stated that procedures and PM tasks will be developed to perform required surveillance testing, calibration, backup battery maintenance, functional checks, and visual inspections of the probes.

In its letter dated August 19, 2013 [Reference 32], the licensee further stated that the SFPI maintenance and testing program requirements ensure design and system readiness are planned to be established in accordance with Entergy's processes and procedures and in consideration of vendor recommendations to ensure that appropriate regular testing, channel checks, functional tests, periodic calibration, and maintenance is performed.

During the onsite audit, the NRC staff inquired about the specific compensatory actions for the for out-of-service SFPI channel(s). In response, licensee provided stated that control of compensatory actions for out of service SFPI channel(s) will be controlled by inclusion in the Plant's Operating Requirements Manual. Compensatory actions for extended out-of-service events are summarized as follows:

CONDITION	REQUIRED ACTION	COMPLETION TIME
1. The Primary OR Back-up Spent Fuel Pool level instrument does not meet the FUNCTIONAL requirements	1.a Restore spent fuel pool level instrument to FUNCTIONAL status	90 days
2. The Primary AND Back-up Spent Fuel Pool	2.a Initiate actions to restore one of the channels of	24 hours

level instruments do not meet FUNCTIONAL requirements.	instrumentation to FUNCTIONAL status. AND 2.b Implement compensatory measures such as use of alternate suitable equipment or supplemental personnel.	 72 hours
3. Required Action and associated Completion Time of Condition 1 not met.	3.a Implement compensatory measures such as use of alternate suitable equipment or supplemental personnel.	Immediately

During the onsite audit, the licensee also provided a list of PM tasks planned to be developed for the Entergy fleet is as follows:

Task Name	Objective	Frequency of Occurrence
Channel Calibration Check (Operator Rounds) eSOMS Tour	To validate that the Mohr instruments (both channels) are displaying the correct spent fuel pool level within the accuracy of the instruments and that the date stamp on the display is indicating correctly.	Seven Days
Channel Check/Panel Functional Check	To check each channel against each other for comparison and to perform functional assessments of each panel.	1 Year
Signal Processor Clock Battery Replacement	To prevent failure of the onboard clock battery and adverse impact to the signal processor operating system.	10 Year
Flush Probe Head Assembly	Based upon boron precipitation causing fouling of level detector probes.	As necessary via corrective action.

The NRC staff noted that the licensee adequately addressed necessary testing and calibration of the primary and backup SFP level instrument channels to maintain the instrument channels at the design accuracy. The testing and calibration are consistent with the vendor recommendations. Additionally, compensatory actions for instrument channel(s) out-of-service appear to be consistent with guidance in NEI 12-02.

The NRC staff finds that the licensee's proposed testing and calibration plan appears to be consistent with NEI 12 02, as endorsed by JLD-ISG-2012-03, and should adequately address the requirements of the order.

4.4 Conclusions for Order EA-12-051

In its letter dated December 16, 2015 [Reference 39], the licensee stated that they would meet the requirements of Order EA-12-051 by following the guidelines of NEI 12-02, as endorsed by JLD-ISG-2012-03. In the evaluation above, the NRC staff finds that, if implemented appropriately, the licensee has conformed to the guidance in NEI 12-02, as endorsed by JLD-ISG-2012-03. In addition, the NRC staff concludes that if the SFP level instrumentation is installed at Palisades Nuclear Station according to the licensee's proposed design, it should adequately address the requirements of Order EA-12-051.

5.0 CONCLUSION

In August 2013 the NRC staff started audits of the licensee's progress on Orders EA-12-049 and EA-12-051. The staff conducted an onsite audit in June, 2015 [Reference 18]. The licensee reached its final compliance date on October 19, 2015, and has declared that the reactor is in compliance with the orders. The purpose of this safety evaluation is to document the strategies and implementation features that the licensee has committed to. Based on the evaluations above, the NRC staff concludes that the licensee has developed guidance and proposed designs that if implemented appropriately should adequately address the requirements of Orders EA-12-049 and EA-12-051. The NRC staff will conduct an onsite inspection to verify that the licensee has implemented the strategies and equipment to demonstrate compliance with the orders.

6.0 REFERENCES

1. SECY-11-0093, "Recommendations for Enhancing Reactor Safety in the 21st Century, the Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident," July 12, 2011 (ADAMS Accession No. ML11186A950)

2. 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 (ADAMS Accession No. ML12039A103)

3. SRM-SECY-12-0025, "Staff Requirements – 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," March 9, 2012 (ADAMS Accession No. ML120690347)

4. Order EA-12-049, "Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events," March 12, 2012 (ADAMS Accession No. ML12054A736)

5. Order EA-12-051, "Order Modifying Licenses with Regard to Reliable Spent Fuel Pool Instrumentation," March 12, 2012 (ADAMS Accession No. ML12054A679)

6. Nuclear Energy Institute document NEI 12-06, "Diverse and Flexible Coping Strategies (FLEX) Implementation Guide," Rev. 0, August 21, 2012 (ADAMS Accession No. ML12242A378)

7. 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 (ADAMS Accession No. ML12229A174)

8. Nuclear Energy Institute 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," Rev. 1, dated August 24, 2012 (ADAMS Accession No. ML12240A307)

9. JLD-ISG-2012-03, "Compliance with Order EA-12-051, Order Modifying Licenses with Regard to Reliable Spent Fuel Pool Instrumentation," August 29, 2012 (ADAMS Accession No. ML12221A339)

10. Palisades Overall Integrated Plan in Response to March 12, 2012 Commission Order to Modify Licenses With Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events (Order Number EA-12-049) dated February 28, 2013 (ADAMS Accession No. ML13246A399)

11. Palisades Nuclear Plant First Six-Month Status Report in Response to March 12, 2012 Commission Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events (Order Number EA-12-049) dated August 28, 2013 (ADAMS Accession No. ML13241A234)

12. Palisades Nuclear Plant Second Six-Month Status Report in Response to March 12, 2012 Commission Order Modifying Licenses with Regard Requirements for Mitigation Strategies for Beyond-Design-Basis External Events (Order Number EA-12-049) dated February 28, 2014 (ADAMS Accession No. ML14059A078)

13. Palisades Nuclear Plant Third Six-Month Status Report in Response to March 12, 2012 Commission Order Modifying Licenses with Regard Requirements for Mitigation Strategies for Beyond-Design-Basis External Events (Order Number EA-12-049) dated August 28, 2014 (ADAMS Accession No. ML14240A279)

14. Palisades Nuclear Plant Fourth Six-Month Status Report in Response to March 12, 2012 Commission Order Modifying Licenses with Regard Requirements for Mitigation Strategies for Beyond-Design-Basis External Events (Order Number EA-12-049) dated February 27, 2015 (ADAMS Accession No. ML15062A011)

15. Palisades Nuclear Plant Fifth Six-Month Status Report in Response to March 12, 2012 Commission Order Modifying Licenses with Regard Requirements for Mitigation Strategies for Beyond-Design-Basis External Events (Order Number EA-12-049) dated August 28, 2015 (ADAMS Accession No. ML15240A074)

16. Letter from Jack R. Davis (NRC) to All Operating Reactor Licensees and Holders of Construction Permits, "Nuclear Regulatory Commission Audits of Licensee Responses to Mitigation Strategies Order EA-12-049," August 28, 2013 (ADAMS Accession No. ML13234A503)

17. Palisades Nuclear Plant - Interim Staff Evaluation Regarding Overall Integrated Plan in Response to Order EA-12-049 (Mitigation Strategies) (TAC NO. MF0768) dated February 10, 2014 (ADAMS Accession No. ML13365A264)

18. NRC Letter to Entergy, Palisades Nuclear Plant - Report for the Audit Regarding Implementation of Mitigating Strategies and Reliable Spent Fuel Pool Instrumentation Related of Orders EA-12-049 and EA-12-051 dated October 13, 2015 (ADAMS Accession No. ML15272A324)

19. Entergy Letter, Notification of Full Compliance with NRC Order EA-12-049, "Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events," dated December 16, 2015 (ADAMS Accession No. ML15351A369) and Final Integrated Plan, dated December 13, 2015 (ADAMS Accession No. ML15351A360)

20. U.S. Nuclear Regulatory Commission, "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 (ADAMS Accession No. ML12053A340)

21. SRM-COMSECY-14-0037, "Staff Requirements – COMSECY-14-0037 – Integration of Mitigating Strategies For Beyond-Design-Basis External Events and the Reevaluation of Flooding Hazards," March 30, 2015 (ADAMS Accession No. ML15089A236)

22. Letter from Jack R. Davis (NRC) to Joseph E. Pollock (NEI), "Staff Assessment of National SAFER Response Centers Established In Response to Order EA-12-049," September 26, 2014 (ADAMS Accession No. ML14265A107)

23. NRC Office of Nuclear Reactor Regulation Office Instruction LIC-111, Regulatory Audits, dated December 16, 2008 (ADAMS Accession No. ML082900195)

24. Letter from William Dean (NRC) to Power Reactor Licensees, “Coordination of Request for Flooding Hazard Reevaluations and Mitigating Strategies for Beyond-Design Bases External Events,” dated September 1, 2015 (ADAMS Accession No. ML15174A257)

25. NEI Position Paper: “Shutdown/Refueling Modes,” dated September 18, 2013 (ADAMS Accession No. ML13273A514)

26. Letter from Jack R. Davis (NRC) to Joseph E. Pollock (NEI), regarding NRC endorsement of NEI Position Paper: “Shutdown/Refueling Modes,” dated September 30, 2013 (ADAMS Accession No. ML13267A382)

27. COMSECY-14-0037, “Integration of Mitigating Strategies for Beyond-Design-Basis External Events and the Reevaluation of Flooding Hazards,” dated November 21, 2014 (ADAMS Accession No. ML14309A256)

28. Nuclear Energy Institute document NEI 12-06, “Diverse and Flexible Coping Strategies (FLEX) Implementation Guide,” Rev. 2, December 31, 2015 (ADAMS Accession No. ML16005A625)

29. 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,” Revision 1, January 22, 2012 (ADAMS Accession No. ML15357A163)

30. Palisades Overall Integrated Plan in Response to March 12, 2012 Commission Order Modifying License With Regard to Reliable Spent Fuel Pool Instrumentation (Order Number EA-12-051) dated February 28, 2013 (ADAMS Accession No. ML13060A360)

31. NRC Request For Additional Information Regarding Spent Fuel Pool Instrumentation (Order EA-12-051), July 18, 2013 (ADAMS Accession No. ML13200A328)

32. Palisades Nuclear Plant, Response to Request for Additional Information for the Overall Integrated Plan in Response to the Commission Modifying Licenses with Regard to Requirements for Reliable Spent Fuel Pool Instrumentation (Order EA-12-051), dated August 19, 2013 (ADAMS Accession No. ML13231A126)

33. NRC Issuance of Palisades Interim Staff Evaluation and Request For Additional Information Regarding The Overall Integrated Plan For Implementation Of Order EA-12-051, Reliable Spent Fuel Pool Instrumentation, dated November 26, 2013 (ADAMS Accession No. ML13312A423).

34. Palisades Nuclear Plant First Six-Month Status Report in Response to March 12, 2012 Commission Order Modifying Licenses with Regard to Reliable Spent Fuel Pool Instrumentation (Order Number EA-12-051), dated August 28, 2013 (ADAMS Accession No. ML13241A235).

35. Palisades Nuclear Plant-Second Six-Month Status Report in Response to March 12, 2012 Commission Order Modifying Licenses with Regard to Reliable Spent Fuel Pool Instrumentation (Order Number EA-12-051), dated February 28, 2014 (ADAMS Accession No. ML14059A077).

36. Palisades, Third Six-Month Status Report in Response to March 12, 2012 Commission Order Modifying Licenses with Regard to Reliable Spent Fuel Pool Instrumentation (Order Number EA-12-051), dated August 28, 2014 (ADAMS Accession No. ML14240A278).

37. Palisades Nuclear Plant, Fourth Six-Month Status Report in Response to March 12, 2012 Commission Order Modifying Licenses with Regard to Reliable Spent Fuel Pool Instrumentation (Order Number EA-12-051), dated February 27, 2015 (ADAMS Accession No. ML15062A056).

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39. Palisades - Notification of Full Compliance with NRC Order EA-12-051, "Order to Modify Licenses with Regard to Reliable Spent Fuel Pool Instrumentation", dated December 16, 2015 (ADAMS Accession No. ML15351A126).

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41. U.S. Nuclear Regulatory Commission, "Mitigation of Beyond-Design-Basis Events," *Federal Register*, Vol. 80, No. 219, November 13, 2015, pp. 70610-70647.

42. Nuclear Energy Institute document NEI 12-06, "Diverse and Flexible Coping Strategies (FLEX) Implementation Guide," Revision 2, dated December 31, 2015 (ADAMS Accession No. ML16005A625)

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Date: August 22, 2016

October 13, 2015 (ADAMS Accession No. ML15272A324), the NRC staff issued an ISE and audit report, respectively, on the licensee's progress. By letter dated March 26, 2014 (ADAMS Accession No. ML14083A620), the NRC notified all licensees and construction permit holders that the staff is conducting audits of their responses to Order EA-12-051 in accordance with NRC NRR Office Instruction LIC-111, similar to the process used for Order EA-12-049. By letter dated December 16, 2015 (ADAMS Accession No. ML15351A126), Entergy submitted a compliance letter in response to Order EA-12-051. The compliance letter stated that the licensee had achieved full compliance with Order EA-12-051.

The enclosed safety evaluation provides the results of the NRC staff's review of Entergy's strategies for Palisades. The intent of the safety evaluation is to inform Entergy on whether or not its integrated plans, if implemented as described, provide a reasonable path for compliance with Orders EA-12-049 and EA-12-051. The staff will evaluate implementation of the plans through inspection, using Temporary Instruction 191, "Implementation of Mitigation Strategies and Spent Fuel Pool Instrumentation Orders and Emergency Preparedness Communications/Staffing/ Multi-Unit Dose Assessment Plans" (ADAMS Accession No. ML15257A188). This inspection will be conducted in accordance with the NRC's inspection schedule for the plant.

If you have any questions, please contact John Hughey, Orders Management Branch, Palisades Project Manager, at 301-415-3204 or at John.Hughey@nrc.gov.

Sincerely,
/RA/
Mandy K. Halter, Acting Chief
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Office of Nuclear Reactor Regulation

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