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

February 16, 2017

Mr. Bryan Hanson
Senior Vice President
Exelon Generation Company, LLC
President and Chief Nuclear Officer
Exelon Nuclear
4300 Winfield Road
Warrenville, IL 60555

SUBJECT: DRESDEN NUCLEAR POWER STATION, UNITS 2 AND 3 – 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. MF1046, MF1047, MF1050, AND MF1051)

Dear Mr. Hanson:

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. ML13063A320), Exelon Generation Company, LLC (Exelon, the licensee) submitted its OIP for Dresden Nuclear Power Station, Units 2 and 3 (Dresden) 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 November 22, 2013 (ADAMS Accession No. ML13220A238), and October 9, 2015 (ADAMS Accession No. ML15261A550), the NRC issued an Interim Staff Evaluation (ISE) and audit report, respectively, on the licensee's progress. By letter dated August 16, 2016 (ADAMS Accession No. ML16230A487), Exelon 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. ML13060A125), the licensee submitted its OIP for Dresden 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 evaluation. By letters dated October 29, 2013 (ADAMS Accession No. ML13275A111), and October 9, 2015 (ADAMS Accession No. ML15261A550), 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 January 12, 2016 (ADAMS Accession No. ML16012A219), Exelon 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 Exelon's strategies for Dresden. The intent of the safety evaluation is to inform Exelon on whether or not its integrated plans, if implemented as described, appear to adequately address the requirements of 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 Boska, Orders Management Branch, Dresden Project Manager, at 301-415-2901 or at John.Boska@nrc.gov.

Sincerely,

Mandy K Halter

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

Docket Nos.: 50-237 and 50-249

Enclosure:
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SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

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

EXELON GENERATION COMPANY, LLC

DRESDEN NUCLEAR POWER STATION, UNITS 2 AND 3

DOCKET NOS. 50-237 AND 50-249

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

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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 alternating current (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," Revision 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, Revision 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," Revision 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 JLD-ISG-2012-03, "Compliance with Order EA-12-051, Reliable Spent Fuel Pool Instrumentation" [Reference 9], endorsing NEI 12-02, Revision 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], Exelon Generation Company, LLC (Exelon, the licensee) submitted an Overall Integrated Plan (OIP) for Dresden Nuclear Power Station, Units 2 and 3 (Dresden) in response to Order EA-12-049. By letter dated August 28, 2013, Exelon submitted a revised OIP [Reference 11]. By letters dated February 28, 2014 [Reference 12], August 28, 2014 [Reference 13], February 27, 2015 [Reference 14], August 28, 2015 [Reference 50], and February 26, 2016 [Reference 51], the licensee submitted six-month updates to the OIP. By letter dated August 28, 2013 [Reference 15], 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 36]. By letters dated November 22, 2013 [Reference 16], and October 9, 2015 [Reference 17], the NRC issued an ISE and an audit report on the licensee's progress. By letter dated August 16, 2016 [Reference 18], 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 alternating current (ac) power (ELAP) with a loss of normal access to the UHS. Thus, the ELAP with loss of normal access to the UHS 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.

Dresden, Units 2 and 3 are General Electric (GE) boiling-water reactors (BWRs) Model 3 with Mark I containments and isolation condensers (ICs). There is no reactor core isolation cooling (RCIC) system, but there is a high-pressure coolant injection (HPCI) system. The licensee's three-phase approach to mitigate a postulated ELAP event, as described in the FIP, is summarized below. The approach is somewhat different if the plant receives warning of a pending flood, but the initial actions are similar.

At the onset of an ELAP both reactors are assumed to trip from full power. The main condenser becomes unavailable due to the loss of circulating water. Decay heat is initially removed when valves from the reactor pressure vessel (RPV) outlet piping to the IC open automatically and steam from the RPV is cooled in the IC. The steam condenses in the tube side of the IC and flows back to the RPV via natural circulation. The shell side of the IC contains water that boils to the atmosphere to remove heat. Within about 20 minutes, cooling from the IC is lost due to the inability to refill the shell side of the IC. Once the IC is lost, HPCI would be used to control RPV water level. If the steam flow to HPCI is not enough to remove all the core decay heat, the safety-relief valves (SRVs) will open on high RPV pressure and discharge steam to the torus, which removes decay heat. The torus contains a large quantity of water called the suppression pool. The HPCI suction is normally aligned to the condensate storage tank (CST), but because the CST is not protected from all external hazards, the licensee's mitigating strategy assumes that the HPCI pump suction realigns to the suppression pool water in the torus. As pressure in the RPV increases, HPCI will also be used to control RPV pressure. At about 2.5 hours from the start of the event, the licensee expects to restore flow to the shell side of both unit's ICs using one of four pre-staged electric FLEX pumps located in the reactor building basements near the torus and powered from a FLEX generator, with makeup water taken from the suppression pool. This will allow the licensee to resume decay heat removal using the IC, and shut down HPCI to avoid heating of the containment. The running electric FLEX pump will also supply the FLEX valve manifold, which has eight hose connections to supply water to both units as needed. The suppression pools are the suction source for the electric FLEX pumps, which will supply the makeup water for the FLEX safety functions. The one running electric FLEX pump will supply the shell side of the ICs for decay heat removal, will fill the tanks for the standby liquid control (SBLC) system for both units as needed to provide makeup water to the RPV using the SBLC pumps, and will provide water to fill or spray the SFPs when needed.

The licensee will deploy a diesel-powered FLEX pump to pump water from the intake canal, which is the UHS for the plant, and is supplied from the Kankakee River. The intake canal is large enough to hold a substantial supply of water if flow from the river is not available, possibly due to failure of a downstream dam. The water from the UHS will be used to fill the suppression pools.

Both reactors have Mark I containments, which are inerted with nitrogen at power. The licensee performed a containment evaluation and determined that with no venting or active cooling of the containment, the containment pressure and temperature will not exceed design limits.

Each reactor has an SFP in its reactor building. To maintain SFP cooling capabilities, the licensee stated that the required action is to establish the water injection lineup before the environment on the refueling floor degrades due to boiling in the SFP, so that personnel can access the refueling floor to accomplish the coping strategies. The SFP will initially heat up due to the unavailability of the normal cooling system. The licensee has calculated that, depending on the spent fuel loading in the SFP, boiling could start as soon as about 9.5 hours after the start of the ELAP. The SFP water level would drop to the top of the fuel racks in approximately 110 hours. The licensee determined that habitability of the refueling floor could become compromised as early as 12 hours after the ELAP, so valve lineups and hose deployments are planned prior to that time. Piping and hoses will bring water from the FLEX valve manifold to the SFPs.

The operators will perform dc bus load stripping within the initial 30 minutes following event initiation to ensure safety-related battery life is extended up to 6 hours. Following dc load stripping and prior to battery depletion, one 800 kilowatt (kW), 480 volt alternating current (Vac) generator will be started inside the nearby FLEX storage building A (FSB-A) and cables connected to each unit. This generator will be used to repower essential battery chargers within 6 hours of ELAP initiation, as well as powering the electric FLEX pumps in the reactor building basements, and the SBLC pumps for RPV injection.

In addition, a National Strategic Alliance of FLEX Emergency Response (SAFER) Response Center (NSRC) will provide high capacity pumps and large combustion-turbine-driven generators (CTGs), which the licensee stated would be used as spares to supplement the onsite equipment. There are two NSRCs in the United States.

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, Revision 0, guidance.

3.2 Reactor Core Cooling Strategies

Order EA-12-049 requires licensees to maintain or restore cooling to the reactor core in the event of an ELAP concurrent with a loss of normal access to the UHS. 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 with loss of normal access to the UHS) 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.

As reviewed in this section, the licensee's core cooling analysis for the ELAP with loss of normal access to the UHS event presumes that, per endorsed guidance from NEI 12-06, both units would have been operating at full power prior to the event. Therefore, the suppression pool may be credited as the heat sink for core cooling during the ELAP with loss of normal access to the UHS event. Maintenance of sufficient RPV inventory, despite steam release from the SRVs and 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 with loss of normal access to the UHS event are discussed in further detail below. The licensee's strategy for ensuring compliance with Order EA-12-049 for conditions where one or more units are shut down or being refueled is reviewed separately in Section 3.11 of this evaluation.

3.2.1 Core Cooling Strategy and RPV Makeup

3.2.1.1 Phase 1

Per the Dresden FIP, maintaining reactor core cooling and controlling RPV pressure will initially be accomplished through the use of the IC and the HPCI system. The IC will automatically commence operation upon the initiation of the ELAP event and provide decay heat removal for the RPV. The injection of makeup water into the RPV will be initially accomplished through the HPCI system. The HPCI system is aligned to initially take suction from the CST, which is assumed to be lost at the initiation of the ELAP event. The HPCI system suction will automatically swap to the suppression pool on the loss of the CST and will pump water into the RPV maintaining adequate inventory and pressure control.

With the reactor at power, the IC is maintained with normal water level in the shell side. Following the initiation of the ELAP event, steam from the RPV will automatically be admitted to the IC tube side. Steam condensed in the IC will be returned to the RPV through natural circulation. Due to the ELAP event the licensee does not have a means to supply water to the shell side of the IC with installed plant equipment. The licensee has calculated that the existing water in the shell side of the IC will provide for 20 minutes of decay heat removal and pressure control.

Following the initiation of the ELAP event the HPCI system will automatically start and supply water from the suppression pool to the RPV. In the event of a failure of the HPCI system to automatically start, procedural guidance directs the operators to manually start the pump. Steam from the RPV will power the HPCI turbine and the exhaust steam will be directed to the suppression pool. The licensee assumes that the HPCI system will remain operable at least until the suppression pool temperature rises to 140 °F. Per the licensee's calculations this temperature will be reached approximately 2.5 hours after the initiation of the ELAP event. Per the FIP, the operation of the HPCI system is independent of ac power.

Station batteries and Class 1E 125 volt direct current (Vdc) and 250 Vdc distribution systems provide power to the HPCI system and instrumentation. The dc load shedding is accomplished within 30 minutes to extend the battery capacity to power the Phase I systems and instrumentation. Installed batteries can maintain necessary voltage for a minimum of 6 hours. Prior to battery depletion, FLEX diesel generators (DGs) are deployed and used to recharge the Division I and Division II batteries.

3.2.1.2 Phase 2

For Phase 2 core cooling strategy, the licensee relies on FLEX components that consist of two pre-staged 480 Vac pumps (per unit) powered by an 800 kW, 480 Vac DG. The pre-staged FLEX pumps are mounted in the reactor building basement to reduce the time required to line up flow to the IC. The FLEX DG is staged inside a FLEX storage building (FSB-A) near the Unit 3 reactor building. The building is robust to all applicable hazards. An N+1 spare generator is staged on site in a non-robust FLEX storage building (FSB-C).

The licensee states that IC shell side makeup will be restored within 2.5 hours of the initiation of the ELAP event. Completion of this will require the licensee to route temporary electrical supply cables from the FLEX DG, through penetrations in the reactor building wall, to the associated FLEX pump. Only one of the four FLEX pumps is run at a time. The FLEX pumps in Unit 2 are labeled 2A and 2B, the ones in Unit 3 are labeled 3A and 3B. The FIP states that the preferred pump to run first is the 3A pump, as it requires pulling less electrical supply cable compared to the other pumps. FLEX pump suction will be provided from a hose connection on the low pressure coolant injection (LPCI) system which enables water from the suppression pool to be drawn into the FLEX pump. The FLEX pump discharge is routed through a combination of hoses and LPCI system discharge piping to a demineralized water header and the FLEX valve manifold connected to it. From this header water can be routed into the shell side of the IC to restore its ability to cool the RPV. Hoses will be connected to the FLEX valve manifold for other FLEX makeup functions.

The restoration of the IC will provide the licensee with the ability to remove decay heat and cool the reactor to about 212 degrees Fahrenheit (°F). Per the licensee's calculations, the IC will provide the ability to complete this cooldown in approximately 22.3 hours. Use of the IC will not result in any further suppression pool heat input.

Per the FIP, RPV inventory will be reduced by RPV leakage including recirculation pump seal leakage. RPV inventory will be maintained by supplying the SBLC tanks with water from the FLEX valve manifold, which will be pressurized by the FLEX pump. The FLEX DG will power SBLC pumps to provide high-pressure makeup to the RPV.

In addition to supplying the IC and RPV inventory, the suppression pool water also is used to provide SFP makeup. Based on the licensee's calculations, there is adequate water available in the suppression pools to provide for 18 hours of usage. When one suppression pool reaches a low level, the running FLEX pump is swapped to a pump connected to the other unit's suppression pool. As there is no loss of water from the suppression pools for the first 2.5 hours of the event, the total water in the two suppression pools will provide inventory until 20.5 hours after the initiation of the ELAP event. The licensee plans to replenish the suppression pool inventory by utilizing a FLEX submersible diesel-driven hydraulic pump that will transfer water from the UHS (the intake canal) to the suppression pool via hoses and LPCI pump discharge piping. The licensee estimates that the intake canal contains approximately 2.144 million gallons of water. Per the FIP, this will provide full flow for the FLEX pumps for an additional 40 hours. Additionally, water is available in the cooling lake that contains an essentially inexhaustible supply, although the cooling lake is not seismically qualified.

The licensee states in the FIP that the flowpath of water drawn from the suppression pool will be flow through the emergency core cooling system (ECCS) suction strainers in the suppression pool. This will filter the water and prevent the injection of solids greater than 1/8 inch diameter into the RPV.

3.2.1.3 Phase 3

The Phase 3 strategy includes the use of equipment from the NSRC. Per the FIP, Dresden continues the use of Phase 2 equipment, or replacements from NSRC equipment as necessary. Water from the UHS will continue to be supplied to the suppression pool during Phase 3.

Per the list of NSRC equipment delivered to Dresden, there is no discussion of a means of water purification being provided to the site. The NRC staff recognizes that the licensee's plan to provide filtration by drawing water used for evaporative cooling in the IC condenser and injection into the RPV through the ECCS strainers provides some filtration of solids. The river water in the UHS has low salt content, but some scenarios, such as a failure of a non-seismic downstream dam, may mean that there is no makeup to the UHS from the river. At about 60 hours after the ELAP event, there may be a need for additional water supplies.

3.2.2 Variations to Core Cooling Strategy for Flooding Event

Elevations given in this safety evaluation (SE) are elevation above mean sea level (MSL). The Dresden site is located on the south bank of the confluence of the Des Plaines and Kankakee Rivers that forms the Illinois River. The site is just upstream of the United States Army Corps of Engineers (USACE) Dresden Island Lock and Dam. The normal river level is about elevation 505 feet. The site grade at the power block is about 517 feet. The current design basis probable maximum flood (PMF) is due to river flooding with a postulated water level on the site of 528 feet, including wave runup [Reference 21]. The site receives advance warning of river flooding, as it results from heavy precipitation upstream with some partial dam failures.

The licensee stated in its FIP that with the advance warning of severe flooding, the reactors will be shut down and cooled down per existing procedures. If the river level reaches 513 feet, the reactor cooling will be switched to the ICs. Vent line extension pipes will be installed on the underground Unit 2/3 emergency diesel generator (EDG) fuel oil tank to permit pumping diesel fuel oil from that tank during the flood. Two barge-mounted diesel-powered FLEX flood pumps will be placed in the Unit 3 turbine building trackway, where they will float with the rising water and can be used to supply the shell side of the ICs by pumping water through the fire header, which has a connection to the shell side of the ICs. The licensee stated in the FIP that one flood pump can supply sufficient water to keep the shell side of the ICs supplied and maintain water level in both RPVs and both SFPs, and that the second pump provides redundancy. As noted in guideline FSG-62, "FLEX Generator Deployment During a Flood," Revision 1, two FLEX DGs and their associated power distribution units will be placed in the turbine building at a level above the highest postulated flood level, with exhaust ducted outside of the building, and cables run to power vital plant equipment if other power sources are lost. One DG is capable of supplying all necessary electrical loads for both reactors, the second DG is a backup.

3.2.3 Staff Evaluations

3.2.3.1 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

The licensee described in its FIP, that the IC is used to provide reactor core cooling in the event that the reactor becomes isolated from the turbine and the main condenser by closure of the main steam isolation valves. An IC is located in each of the reactor buildings and is capable of operation without ac electrical power. Each IC consists of two tube bundles immersed in a large water storage tank. During IC system operation, steam flows from the RPV to the IC, condenses in the tubes of the heat exchanger, and returns by gravity to the RPV via the A recirculation loop. Once a FLEX pump in the reactor building basement is powered by a FLEX DG, it is used to supply makeup water from the suppression pools to the IC shell side (described below in SE Section 3.7.3.1). This occurs about 2.5 hours after ELAP is declared and allows the IC to again remove core decay heat, with no loss of RPV inventory and no additional heat added to containment via the suppression pools, with the exception of recirculation pump seal leakage. The licensee also stated that the HPCI system will be utilized to support core decay heat removal when the IC is unavailable. The licensee stated that additional measures to provide ventilation for the HPCI pump room would need to be taken to allow up to 6 hours operation. However, the FLEX strategy will rely upon using electric FLEX pumps taking suction from the suppression pools and providing makeup water to the IC shell side once the FLEX pumps receive electrical power.

The SBLC system will also be used for providing RPV makeup once the FLEX DGs repower the 480 Vac safety busses around the 6 hour mark after ELAP is declared. An SBLC system and associated equipment is located in each of the reactor buildings. An SBLC system consists of an unpressurized tank for low-temperature sodium pentaborate solution storage, two positive displacement pumps, and the piping. The sodium pentaborate solution is delivered to the RPV by either one or both of two SBLC pumps, each capable of pumping about 45 gallons per minute (gpm), that draw from the SBLC tank which has a capacity of 5250 gallons available for use until makeup to the tank is provided by FLEX pumps.

The licensee described the suppression pools, located in both units' reactor buildings, as being the suction source for IC shell side, RPV, SFP, and containment cooling makeup. The licensee stated that 794,058 gallons of water is available and is expected to last about 18 hours for FLEX makeup strategies. Makeup to the suppression pools will be provided from the UHS through the LPCI riser connections. FLEX Support Guideline (FSG)-09, "FLEX Torus Makeup," directs operators to use FLEX hydraulic submersible pumps to be lowered in the intake bay to access about 40 hours' worth of makeup water. After that, suction can be taken from the cooling lake for long-term makeup to the suppression pools. The submersible pump is fitted with a suction strainer to prevent large debris from entering the pump. The reactor buildings are both protected from all applicable external hazards, with the exception of flooding. The FLEX flooding strategy, involving FLEX pumps and associated equipment to be deployed on barges, is briefly described in SE Section 3.2.2.

The NRC staff reviewed the FSGs related to the utilization of the installed Dresden SSCs used for FLEX makeup strategies and found that the accessibility of the proposed connection points will allow adequate access based upon the protection of the connection points within the respective reactor buildings. The NRC staff also confirmed during the audit process that the proposed locations for the FLEX pumps and equipment for a flood scenario would be protected from the site engulfing design basis flood. Based on the location and design of the credited plant SSCs, as described in licensee's updated final safety analysis report (UFSAR), and if implemented according to the overall FLEX strategy as described in the FIP, the credited plant SSCs should be available to support core cooling during an ELAP, consistent with NEI 12-06, Section 3.2.1.3, Condition 6.

3.2.3.1.2 Plant Instrumentation

According to the FIP, the following instrumentation would be relied upon to support the licensee's core cooling and RPV makeup strategy for all phases:

- RPV level (narrow and medium range)
- RPV pressure (wide range)
- Suppression pool water level (narrow range)
- Suppression pool temperature
- IC shell side level
- Drywell pressure

The instrumentation identified by the licensee to support its core cooling strategy is consistent with the recommendations specified in the endorsed guidance of NEI 12-06.

All of these instruments are powered by installed safety-related station batteries. To prevent a loss of vital instrumentation, operators will extend battery coping time to a minimum of 6 hours by shedding unnecessary loads. The load shedding will be completed within 30 minutes from the initiation of the ELAP event. A FLEX DG (480 Vac) will repower the battery chargers within 6 hours of the ELAP event initiation. The safety-related battery chargers will be energized before the battery's coping time is exceeded.

In accordance with NEI 12-06 Section 5.3.3.1, guidelines for obtaining critical parameters locally are provided in an FSG. Should it be required, the licensee will use guidance that provides a list of key parameters, locations, and equipment needed to obtain local readings of key parameters. Guideline FSG-30, "FLEX Strategy for Obtaining Alternate Readings," provides the guidance for obtaining alternate readings for the following parameters:

- IC shell side level
- Torus level
- Torus temperature
- Drywell pressure
- Reactor pressure

- Reactor level

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.

The instrumentation available to support the licensee's strategies for core cooling and RCS inventory during the ELAP event is consistent with the recommendations specified in the endorsed guidance of NEI 12-06. Based on 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.

3.2.3.2 Thermal-Hydraulic Analyses

The licensee based its mitigating strategy for reactor core cooling in part on thermal-hydraulic analysis performed using Version 4 of the Modular Accident Analysis Program (MAAP). Because the thermal-hydraulic analysis for the reactor core and containment during an ELAP event are closely intertwined, as is typical of BWRs, the licensee has addressed both in a single, coupled calculation. This dependency notwithstanding, the NRC staff's discussion in this section of the SE solely focuses on the licensee's analysis of reactor core cooling. The review of the licensee's analysis of containment thermal-hydraulic behavior is provided in Section 3.4.4.2 of this evaluation.

MAAP is an industry-developed, general-purpose thermal-hydraulic computer code that has been used to simulate the progression of a variety of light-water reactor accident sequences, including severe accidents such as the Fukushima Dai-ichi event. Initial code development began in the early 1980s, with the objective of supporting an improved understanding of and predictive capability for severe accidents involving core overheating and degradation in the wake of the accident at Three Mile Island Nuclear Station, Unit 2. Currently, maintenance and development of the code is carried out under the direction of the Electric Power Research Institute (EPRI).

To provide analytical justification for their mitigating strategies in response to Order EA-12-049, a number of licensees for BWRs and pressurized-water reactors (PWRs) completed analysis of the ELAP event using Version 4 of the MAAP code (MAAP4). Although MAAP4 and predecessor code versions have been used by industry for a range of applications, such as the analysis of severe accident scenarios and probabilistic risk analysis (PRA) evaluations, the NRC staff had not previously examined the code's technical adequacy for performing best-estimate simulations of the ELAP event. In particular, due to the breadth and complexity of the physical phenomena within the code's calculation domain, as well as its intended capability for rapidly simulating a variety of accident scenarios to support PRA evaluations, the NRC staff observed that the MAAP code makes use of a number of simplified correlations and approximations that should be evaluated for their applicability to the ELAP event. Therefore, in support of the reviews of licensees' strategies for ELAP mitigation, the NRC staff audited the capability of the MAAP4 code for performing thermal-hydraulic analysis of the ELAP event for both BWRs and PWRs. The NRC staff's audit review involved a limited review of key code models, as well as confirmatory analysis with the TRACE code to obtain an independent assessment of the predictions of the MAAP4 code.

To support the NRC staff's review of the use of MAAP4 for ELAP analyses, in June 2013 EPRI issued a technical report entitled "Use of Modular Accident Analysis Program (MAAP) in Support of Post-Fukushima Applications." The document provided general information concerning the code and its development, as well as an overview of its physical models, modeling guidelines, validation, and quality assurance procedures.

Based on the NRC staff's review of EPRI's June 2013 technical report, as supplemented by further discussion with the code vendor, audit review of key sections of the MAAP code documentation, and confirmation of acceptable agreement with NRC staff simulations using the TRACE code, the NRC staff concluded that, under certain conditions, the MAAP4 code may be used for best-estimate prediction of the ELAP event sequence for BWRs.

The NRC staff issued an endorsement letter dated October 3, 2013 [Reference 45], which documented these conclusions and identified specific limitations that BWR licensees should address to justify the applicability of simulations using the MAAP4 code for demonstrating that the requirements of Order EA-12-049 have been satisfied.

During the audit process, the NRC staff verified that the licensee's MAAP calculation, along with an associated addendum, addressed the limitations from the NRC staff's endorsement letter. The licensee utilized the generic roadmap and response template that had been developed by EPRI to support consistency in individual licensee's responses to the limitations from the endorsement letter. In particular, based upon review of the MAAP calculation documentation, the staff concluded that appropriate inputs and modeling options had been selected for the code parameters expected to have dominant influence for the ELAP event. The NRC staff further observed that the limitations imposed in the endorsement letter, particularly those concerning the RPV collapsed liquid level being maintained above the reactor core and the primary system cooldown rate being maintained within Technical Specification limits, were satisfied. Specifically, the licensee's analysis calculated that Dresden would maintain the collapsed liquid level in the reactor vessel above the top of the active fuel region throughout the analyzed ELAP event. The licensee calculated the minimum RPV water level above the top of active fuel is 9 feet. By maintaining the reactor core fully covered with water, adequate core cooling is assured for this event. Additionally, as Dresden's primary system cooldown rate will be limited to approximately 15 °F per hour, thermally induced volumetric contraction and other changes in primary system thermal-hydraulic conditions should proceed relatively slowly with time, which supports the NRC staff's confidence in the predictions of the MAAP code.

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 Recirculation Pump Seals

An ELAP event would result in the interruption of cooling to the recirculation pump seals, potentially resulting in increased leakage due to the distortion or failure of the seals, elastomeric O-rings, or other components. Sufficient primary make-up must be provided to offset recirculation pump seal leakage and other expected sources of primary leakage, in addition to removing decay heat from the reactor core.

Dresden's recirculation pumps have Flowserve N-7500 seals. The licensee's calculations assume an initial seal leakage rate at full system pressure and temperature of 18 gpm per recirculation pump. This assumption was based on the leakage rate used in the existing station blackout analysis, which originally derives from industry document NUMARC 87-00. In addition, the licensee's calculation assumed additional primary system leakage at a rate of 25 gpm per maximum allowed technical specification leakage at full system pressure. Thus, between the two recirculation pumps and the additional primary system leakage, the total primary leakage rate assumed for Dresden at full system pressure and temperature during the initial phase of the ELAP event was 61 gpm. The leakage is expected to lower as the reactor is cooled and depressurized.

The Flowserve N-7500 seals installed on the Dresden recirculation pumps are similar in design to the N-Seals for which the NRC staff has reviewed and endorsed leakage rates for application to the ELAP event for specific pressurized-water reactors (PWRs). As noted in the NRC staff's endorsement letter on this topic, dated November 12, 2015 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML15310A094), the upper bound leakage rates under ELAP conditions that have been estimated for Flowserve N-Seals installed at PWRs vary based on plant-specific conditions, but are in all cases less than 5 gpm. Among the noteworthy differences between the N-Seals installed at BWRs and PWRs are that current BWR installations (1) rely on a reduced number of stages due to the lower BWR operating pressure, (2) are scaled-down geometrically compared to most PWRs, according to differences in pump shaft size, and (3) do not provide for the possibility of isolating the controlled leakoff flow from the seal, as is possible for some PWRs. However, the NRC staff does not expect these differences to have a significant impact on the expected seal leakage rate for BWR applications because (1) the design of each seal stage is intended to be capable of sealing against full system pressure, and, furthermore, the vendor's method for determining the leakage rate for PWRs was not dependent upon the number of stages in the seal design, (2) the staff's review of Flowserve's determination of the expected N-Seal leakage for PWRs explicitly considered pump shaft sizes for which the N-7500 model would be applicable, and (3) isolation of the controlled seal leakoff flow was not explicitly credited in determining the leakage rates determined in Flowserve's white paper, with the exception of determining the short-term thermal exposure profile for seal elastomers. These differences notwithstanding, according to the basic design of the hydrodynamic seals and pressure breakdown devices and their materials of construction, the NRC staff would expect a roughly similar level of performance for equivalent inlet conditions.

The NRC staff considered the expected leakage rate for the N-7500 seals installed at Dresden in light of experience obtained reviewing the application of N-Seals to PWRs. In particular, the NRC staff noted during its audit of the Dresden thermal-hydraulic analysis that the expected primary temperature and pressure conditions during an ELAP event generally compare favorably to those of the PWRs considered in the staff's endorsement letter. Furthermore, as is typical of the majority of U.S. BWRs, Dresden has an installed steam-driven pump (i.e., HPCI) that is capable of injecting to the primary system under ELAP conditions. Dresden's HPCI system flow rate exceeds the makeup flow requirement due to the expected system leakage. As Dresden is equipped with an IC, there are no evaporative losses. The SBLC system will be able to provide 45 gpm (90 gpm if both pumps are available) after the HPCI pump is assumed to be lost (due to suppression pool temperatures exceeding the HPCI design temperature limit of 140 °F). As such, the NRC staff concludes that the makeup flow is sufficient to accommodate the expected primary system leakage, with margin if the leakage rates are greater than expected.

In its FIP, the licensee discussed system response to the variation of seal leakage rate as a function of RPV pressure in the thermal hydraulic simulation. The initial primary leakage rate was assumed to be 61 gpm. As the RPV is depressurized and the seals are isolated following the restoration of power from the FLEX DG the seal leakage rate will be reduced. The leakage rate was assumed to be 25 gpm at a time 7 hours after the initiation of the ELAP event when SBLC is available for injection. The SBLC system is capable of providing makeup flow at a maximum rate of approximately 45 gpm (90 gpm if both pumps are available). The licensee concluded that the RPV water level would remain above the top of the active fuel throughout the simulation period with makeup provided from the SBLC system.

Based upon the discussion above, the NRC staff concludes that the recirculation pump 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

As described in its UFSAR, the licensee's design is such that the control rods provide adequate shutdown margin under all anticipated plant conditions, with the conservative assumption that the highest-worth control rod remains fully withdrawn. Dresden Technical Specification Section 1.1 further clarifies that shutdown margin is to be calculated for a cold, xenon-free condition to ensure that the most reactive core conditions are bounded.

Based on the NRC staff's audit review, the licensee's ELAP mitigating strategy maintains the reactor within the envelope of conditions analyzed by the licensee's existing shutdown margin calculation. Furthermore, the existing calculation retains conservatism because the guidance in NEI 12-06 permits analyses of the beyond-design-basis ELAP event to assume that all control rods fully insert into the reactor core.

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 indicated in its FIP, that each unit will have two motor-driven FLEX Pumps ("N" and "N+1") on the 476 foot elevation of each reactor building. The FLEX pumps are pre-installed and seismically qualified to support makeup from the suppression pools to the IC shell side (for core cooling) and SBLC tanks (for RPV makeup) for non-flooding ELAP events. All FLEX pumps installed on the 476 foot elevation are electric motor driven (150 horsepower, 460 Vac) powered by FLEX DGs, and each pump is capable of approximately 1,000 gpm flow. The second FLEX pump in each reactor building is a spare pump provided to meet the "N+1" criteria in NEI 12-06, however the FLEX pumps are pre-installed in the locations instead of being deployed from the FLEX storage buildings on site. This is an alternative to the guidance in NEI 12-06, Rev. 0, and is further discussed below in SE Section 3.14.3. The associated hoses for the FLEX pumps are also located within the reactor buildings, which are protected from all applicable external hazards except for the flooding event. FLEX pumps also provide makeup to the suppression pools using the FLEX diesel-driven submersible pumps which will be positioned in the UHS. Operators are directed by guideline FSG-09, "FLEX Torus Makeup," to deploy one of the submersible pumps from the "B" FLEX storage building and use a mobile crane to lower the pump directly into the intake canal near the Unit 2 and 3 intake structure (also known as the crib house). For the ELAP flooding event, the licensee described that two diesel-driven pumps (FLEX diesel flood pumps) will be pre-staged on top of a floating barge. The pumps will be stored in the "C" FLEX storage building, but both pumps will be pre-staged prior to the flooding event on a floatable barge placed in the Unit 3 turbine building trackway in accordance with the existing site flooding procedure. One pump is sized to provide flow to meet the cooling needs of the RPV, containment, and SFP for both units during a flooding event, while the second pump is a spare (N+1).

Section 11.2 of NEI 12-06 states that design requirements and supporting analysis should be developed for portable equipment that directly performs a FLEX mitigation strategy for core cooling, SFP, and RPV makeup that provides the inputs, assumptions, and documented analysis that the mitigation strategy and support equipment will perform as intended. During the audit review, the licensee provided calculation DRE14-0008, "IC Shell, Spent Fuel Pool and RPV Makeup Requirements under FLEX Scenarios," which evaluated the use of a FLEX pump pumping water from the UHS (the intake canal) to supply makeup water to the suppression pools, and the electric FLEX pumps supplying water from the suppression pool to the IC shell, and to the FLEX valve manifold for the respective makeup to the RPV and SFP. The calculation also describes how the FLEX diesel-powered flood pumps will take suction from the bottom of the turbine building to provide makeup water for RPV and IC shell. Also, as described in SE Section 3.3.4.2, the FLEX valve manifold supplies makeup water to the SFP. The licensee provided calculation DRE14-0006, "FLEX Hydraulic Analysis," which provided the flow rates for the FLEX pumps and FLEX diesel-powered flood pumps for the designated hose runs throughout Unit 2 and Unit 3 for makeup for both the non-flooding and flooding ELAP events.

The NRC staff reviewed the hydraulic analyses and makeup requirements in the above calculations and also conducted a walkdown of the hose deployment routes and electric FLEX pumps and FLEX diesel-powered flood pumps staging areas during the audit to confirm the evaluations of the length of hose runs in the hydraulic analyses. Based on the NRC staff's review of the FLEX pumping capabilities at Dresden, 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 electrical strategies provide power to the equipment and instrumentation used to mitigate the ELAP and LUHS. The electrical strategies described in the FIP are practically identical for maintaining or restoring core cooling, containment, and SFP cooling, except as noted in Sections 3.3.4.4 and 3.4.4.4 of this SE.

The NRC staff reviewed the licensee's FIP, conceptual electrical single-line diagrams, and the summary of calculations for sizing the FLEX generators and station batteries. The staff also reviewed the licensee's evaluations that addressed the effects of temperature on the electrical equipment credited in the FIP as a result of the loss of heating, ventilation, and air conditioning (HVAC) caused by the event.

According to the licensee's FIP, operators would declare an ELAP following a loss of offsite power, emergency diesel generators (EDGs), and station blackout (SBO) diesel generators, with a simultaneous loss of access to the UHS. The plant's indefinite coping capability is attained through the implementation of pre-determined FLEX strategies that are focused on maintaining or restoring key plant safety functions. A safety-function-based approach provides consistency with, and allows coordination with, existing plant emergency operating procedures (EOPs). The FLEX strategies are implemented in support of EOPs using FSGs.

During the first phase of the ELAP event, Dresden relies on the Class 1E (safety-related) station batteries to provide power to key instrumentation for monitoring parameters and power to controls for SSCs used to maintain the key safety functions (reactor core cooling, RCS inventory control, and containment integrity). The Dresden Class 1E station batteries and associated dc distribution systems are located within a safety-related structure designed to meet all applicable design basis external hazards. Guideline FSG-01, "Extended Loss Of AC Power-Loss Of Ultimate Heat Sink Flowchart," DGA-13, "Loss of 125 VDC Battery Chargers with Simultaneous Loss of Auxiliary Power," and DGA-03, "Loss of 250 VDC Battery Chargers with Simultaneous Loss of Auxiliary Power," direct operators to conserve dc power during the event by stripping non-essential loads. Operators will strip or shed unnecessary loads to extend battery life until backup power is available. The plant operators would commence load shedding within 15 minutes and complete load shedding within 30 minutes from the onset of an ELAP event.

Each unit at Dresden has one 125 Vdc safety-related main station battery and one 250 Vdc safety-related station battery. The 125 Vdc and 250 Vdc safety-related station batteries were manufactured by Exide Technologies and are model NCN-21. The capacity of the NCN-21 battery is 1496 ampere-hours at an 8-hour discharge rate to 1.75 V per cell.

The NRC staff reviewed the licensee's engineering change EC 391973, "Extend 125VDC and 250VDC Battery Coping Time with Load Shedding," Revision 0, which verified the capability of the dc system to supply power to the required loads during the first phase of the FLEX mitigation strategy plan for an ELAP as a result of a BDBEE. The licensee's evaluation identified the required loads and their associated ratings (ampere (A) and minimum required voltage) and the non-essential loads that would be shed within 30 minutes to ensure battery operation for at least 6 hours.

Based on the NRC staff's review of the licensee's analysis and procedures, and the battery vendor's capacity and discharge rates for the Class 1E station batteries, the NRC staff finds that the Dresden dc systems have adequate capacity and capability to power the loads required to mitigate the consequences during Phase 1 of an ELAP as a result of a BDBEE provided that necessary load shedding is completed within the times assumed in the licensee's analysis.

The licensee's Phase 2 strategy includes repowering 480 Vac buses within 6 hours after initiation of an ELAP. The strategy will use a pre-staged and portable 800 kW 480 Vac FLEX DG located inside a robust structure (FLEX Building "A") with respect to seismic events, high winds and associated missiles near the Unit 3 Reactor Building. The spare FLEX DG (N+1) is located in FLEX Building "C" outside the protected area at the south end of the contractor parking lot. The FLEX DG would supply power to one FLEX pump, Dresden's vital 480 Vac vital buses (28, 29, 38, 39), and other required loads.

The NRC staff reviewed the licensee calculation DRE14-0037, "Unit 2(3) 480 Vac FLEX Diesel Generator and Cable Sizing for Beyond Design Basis FLEX Event," Revision 0, conceptual single line diagrams, and the separation and isolation of the FLEX DGs from the EDGs. Based on the NRC staff's review, Dresden's minimum required loads (both units combined) for the Phase 2 800 kW FLEX DGs is 668 kW. Therefore, one 800 kW FLEX DG is adequate to support the electrical loads required for both units for the licensee's Phase 2 strategy.

The "N+1" FLEX DG is identical to the "N" FLEX DG, thus ensuring electrical compatibility and sufficient electrical capacity in an instance where substitution is required. Since the "N+1" FLEX DG is identical and interchangeable with the "N" FLEX DG, the NRC staff finds that the licensee has met the provisions of NEI 12-06, Revision 0, for spare equipment capability regarding the Phase 2 FLEX DGs.

For Phase 3, the licensee plans to continue the Phase 2 coping strategy with additional assistance provided from offsite equipment/resources. The offsite resources that will be provided by an NSRC includes four (two per unit) 1-megawatt (MW) 4160 Vac combustion turbine generators (CTGs), two (one per unit) 1 MW 480 Vac CTGs, and distribution panels (including cables and connectors). If circumstances permit, the licensee plans to only connect the 480 Vac CTGs and not the 4160 Vac CTGs. Based on the additional margin available due to the higher capacity (1 MW) of the 480 Vac CTGs as compared to the Phase 2 FLEX DGs (800 kW), the NRC staff finds that each of the two 480 Vac CTGs being supplied from an NSRC have sufficient capacity and capability to supply the required loads.

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 CTGs 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 and RCS inventory during 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.

3.3 Spent Fuel Pool Cooling Strategies

In NEI 12-06, Table 3-1 and Appendix C 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 portable monitor nozzles from the refueling floor using a portable pump capable of providing a minimum of 200 gallons per minute (gpm) per unit (250 gpm if overspray occurs). During the event, the licensee selects the SFP makeup 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 are addressed in Section 3.11.

3.3.1 Phase 1

The licensee indicated in its FIP, that for Phase 1, operators will mainly monitor SFP level using the SFP instrumentation installed per Order EA-12-051, and that the time to boil is sufficient to enable deployment of Phase 2 equipment. Adequate SFP water level will exist to provide radiation shielding for personnel well beyond the time of boiling. The operators are directed by FSG-12, "FLEX Spent Fuel Pool Spray Strategy," to establish the FLEX equipment lineup for SFP makeup prior to the 12 hour mark of the ELAP for events starting from normal operating conditions (not involving floods). The operators are also directed by FSG-12 to set up FLEX equipment for SFP makeup within 6 hours after ELAP is declared for events starting during outage conditions. For normal conditions, the SFP makeup would be started at about 12 hours, whereas for outage conditions SFP makeup would be started at about 8 hours after ELAP is declared. For the flooding scenario, the licensee described that no equipment deployment would be required when an ELAP is declared since the FLEX diesel-powered flood pumps and FLEX DGs will be pre-staged for SFP makeup prior to the flood waters arriving at the site.

3.3.2 Phase 2

The licensee described the SFP Phase 2 strategy in its FIP as connecting the flexible hoses to the new FLEX valve manifold. The FLEX valve manifold is located on the Unit 2 reactor building 545 foot elevation and is supplied with makeup water from the pre-staged FLEX pump. Guideline FSG-10, "FLEX Spent Fuel Pool Makeup," directs operators to make hose connections from the FLEX valve manifold to the SFP cooling piping through the installed shutdown cooling (SDC) system (on the same floor) which feeds directly to the fuel pool cooling system piping. Guideline FSG-12 also specifies the FLEX equipment to be set up prior to higher temperatures and high dose rates on the refuel floor, including spray monitor nozzles, for

ELAP events that do not include flooding. For flooding events, the barge-mounted FLEX diesel-powered flood pump is aligned to take suction from a pit in the turbine building and delivers the flood water to the fire header connection above the Unit 3 turbine building trackway. This fire header will be connected to fire headers in the Unit 2 and 3 reactor buildings which will be used to supply makeup water to the SFPs.

3.3.3 Phase 3

The licensee indicated in its FIP, that the SFP makeup strategy for Phase 3 will utilize Phase 2 connections and NSRC-supplied equipment as backup. Operators are provided direction for using NSRC equipment for indefinite SFP makeup through the procedure CC-DR-118-1001, "SAFER Response Plan For Dresden Nuclear Power Station," and FSG-14, "Transition From Phase 2 to Phase 3 Equipment."

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 NRC staff reviewed the licensee's calculation EC 371913, Rev. 2, "Time To Boil Curves - OP-DR-104-1001," to understand limits on habitability on the SFP refuel floor. This calculation and the FIP indicated that boiling begins at approximately 9.54 hours during a normal, non-outage situation, or 3.58 hours for the worst case outage scenario with a full core offload. The NRC 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 prior to 12 hours from event initiation from normal conditions (and prior to 6 hours from event initiation from outage conditions) to ensure the SFP area remains habitable for personnel entry.

As described in the licensee's FIP, the licensee's Phase 1 SFP cooling strategy does not require any operator actions besides pre-staging FLEX equipment that will be used for SFP makeup on the refuel floor. However, the licensee does establish a ventilation path to cope with temperature, humidity and condensation from evaporation and/or boiling of the SFP. The operators are directed to open doors to allow air to flow into the reactor building and out through the refuel floor doorway to the turbine building roof utilizing natural circulation.

The licensee's Phase 2 and Phase 3 SFP cooling strategy involves the use of one electric FLEX pump (or NSRC-supplied pumps with suction from the UHS for Phase 3), with suction from the suppression pool, to supply water to the FLEX valve manifold to supply the SFPs for each unit. For flooding events, the FLEX diesel-powered flood pumps are pre-staged on a floating barge to supply flood water from a pit in the Unit 3 turbine building to the fire header connection located above the Unit 3 turbine building trackway. The staff's evaluation of the robustness and availability of FLEX connections points for the FLEX pumps is discussed in Section 3.7.3.1 below. Furthermore, the staff's evaluation of the robustness and availability of the UHS for an ELAP event is discussed in Section 3.10.4.

3.3.4.1.2 Plant Instrumentation

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 SE.

3.3.4.2 Thermal-Hydraulic Analyses

Section 11.2 of NEI 12-06 states, in part, that design requirements and supporting analysis should be developed for portable equipment that directly performs a FLEX mitigation strategy for core, containment, and SFP that provides the inputs, assumptions, and documented analysis that the mitigation strategy and support equipment will perform as intended. In addition, NEI 12-06, Section 3.2.1.6, Condition 4, states that SFP heat load assumes the maximum design-basis heat load for the site.

In accordance with NEI 12-06, the licensee performed a thermal-hydraulic analysis of the SFP as a basis for the inputs and assumption used in its FLEX equipment design requirements analysis. During the audit, the licensee referenced calculation EC 371913, Rev. 2, "Time To Boil Curves - OP-DR-104-1001," to describe the normal and worst case outage conditions for the SFP. The licensee evaluated the SFP with the maximum design-basis heat loads for an operating plant to conclude that the minimum time to boil is 9.54 hours with loss of normal SFP cooling with 110.07 hours of SFP inventory available to boil until the water level drops to the top of the active fuel for each SFP. During the audit, the licensee also provided calculation DRE14-0006, "FLEX Hydraulic Analysis," which concluded that a flow rate of 1,000 gpm for each unit's SFP can be provided as makeup using the FLEX pumps. The SFP spray rate will be provided at 250 gpm for the SFP spray makeup requirements. The licensee also concluded that the required SFP makeup is available within 8 hours of declaration of ELAP.

The NRC staff evaluated the calculation during the audit to verify that the licensee's analysis demonstrated that the FLEX pumps were capable of providing the necessary flow for SFP makeup and maintaining the volume of the SFP for shielding purposes. Based on the information contained in the FIP and the above hydraulic analysis, the NRC staff finds that the licensee has provided an analysis that considered maximum design-basis SFP heat load during operating, pre-fuel transfer or post-fuel transfer operations, and the basis for assumptions and inputs used in determining the design requirements for FLEX equipment used in SFP cooling consistent with NEI 12-06 Section 3.2.1.6, Condition 4 and Section 11.2.

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 2.3.9 describes the hydraulic performance criteria (e.g., flow rate, discharge pressure) for the FLEX pumps and FLEX diesel-powered flood pumps. The NRC 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 licensee indicated that the SFP makeup flow rate of 1000 gpm and the SFP spray rate of 250 gpm both meet or exceed the maximum SFP makeup requirements as described in calculation DRE14-0006.

3.3.4.4 Electrical Analyses

The licensee's FIP defines strategies capable of mitigating a simultaneous loss of all ac power and loss of normal access to the UHS resulting from a BDBEE, by providing the capability to maintain or restore core cooling, containment, and SFP cooling at all units on the Dresden site. The staff performed a comprehensive analysis of the licensee's electrical strategies, which includes the SFP cooling strategy.

The licensee's Phase 1 strategy is to monitor SFP level using installed instrumentation (the capability of this instrumentation is described in Section 4 of this SE). In its FIP, the licensee stated that the SFP level instrumentation has a battery backup that will provide power to the instrumentation for 72 hours.

The licensee's Phase 2 strategy is to continue monitoring SFP level and repower the SFP level instrumentation using the 480 Vac FLEX DG. Guideline FSG-06, "FLEX Strategy for Aligning Power To U2(3) 480 Volt Safety Related Busses 28(38) and 29(39)," provides guidance to repower the SFP level instrumentation from the FLEX DG. The NRC staff reviewed licensee calculation DRE14-0037 and determined that the 480 Vac FLEX DG has sufficient capacity and capability to supply SFP level instrumentation.

The licensee's Phase 3 strategy is to continue with the Phase 2 strategy, and if necessary, provide alternative power within 72 hours to the SFP level instrumentation using onsite portable generators to provide power to the instrumentation and display panels, and to recharge the backup battery. Based on the additional margin available due to the higher capacity (1 MW) of the 480 Vac CTGs as compared to the Phase 2 FLEX DGs (800 kW), the NRC staff finds that the 480 Vac CTGs being supplied from an NSRC have sufficient capacity and capability to supply the SFP level instrumentation.

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 3-1, 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. Dresden has two GE BWRs with Mark I containments.

The licensee performed a containment evaluation, DR-MISC-043, "MAAP Analysis to Support FLEX Initial Strategy," Revision 2, which was based on the boundary conditions described in Section 2 of NEI 12-06. The calculation analyzed the strategy of removal of decay heat from the RPV utilizing the IC, as well as isolating containment and monitoring containment pressure and temperature, and concluded that the containment parameters of pressure and temperature remain well below the respective UFSAR Section 6.2.1.1 design limits of 62 pounds per square inch gage (psig) and 281 °F for the drywell and 62 psig for the suppression pool (torus) for more than 72 hours. 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.

3.4.1 Phase 1

The FIP states that during Phase 1 RPV pressure control is initially controlled with the IC for the first 20 minutes. The RPV water level and pressure control is then supplemented using the HPCI system which is independent of all ac power. Operation of the HPCI turbine will result in a heat input to the suppression pool. Once shell side make-up for the IC is established (2.5 hrs), the operation of the IC results in reactor decay heat being removed with minimal heat input into the primary containment. As a result, containment parameters are not challenged and venting is not anticipated.

For a beyond-design-basis (BDB) flooding event, the series of FLEX flooding actions described in Section 3.2.2.1 also support containment integrity with no additional actions involved.

3.4.2 Phase 2

In Phase 2, the operators continue to remove decay heat from the RPV using the ICs. Isolation condenser make-up will be provided by the FLEX valve manifold aligned to the IC clean demineralizer make-up header. Containment temperature and pressure will continue to be monitored. Based on evaluation DR-MISC-043, the licensee has demonstrated that the containment temperature and pressure will remain below limits.

Suppression pool volume contains an adequate supply to provide the water needed for all FLEX strategies for the first 14.5 hours while maintaining the downcomers submerged. Guideline FSG-9, "FLEX Suppression Pool Make-up" directs personnel to use a submersible pump positioned in the UHS to provide make-up water to the suppression pool. This line-up is accomplished at 14 hours. Margin is built into the strategy in that suppression pool inventory may be reduced below the downcomers to one foot above the ECCS strainers providing an additional 6 hours of inventory.

For a BDB flooding event, when the crib house water level exceeds elevation 518 feet, the barge-mounted FLEX flood pump is aligned and started. The pump takes flood water suction from the test boiler pit and delivers to the fire header at elevation 538 feet. The flood pump provides make-up water to the IC until flood waters recede and recovery and cleanup activities start.

3.4.3 Phase 3

The FIP states that the Phase 3 strategy will utilize Phase 2 connections and NSRC equipment as spares. Dresden relies on equipment stored off-site for Phase 3 of the FLEX mitigation strategy. Equipment may be provided from the NSRCs or another nuclear plant may also provide Phase 3 equipment, if response would be faster than from the NSRCs. Temporary staging areas have been identified and details for their use in supporting Phase 3 equipment receipt, inspection and deployment to operating areas are provided in CC-DR-118-1001, "SAFER Response Plan For Dresden Nuclear Power Station," and FSG-14, "Transition From Phase 2 to Phase 3 Equipment."

3.4.4 Staff Evaluations

3.4.4.1 Availability of Structures, Systems, and Components

Guidance document 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

Section 3.8.2.1 of the Dresden UFSAR, Revision 9, describes a GE Mark 1 pressure suppression containment consisting of three interconnected steel structures: the drywell, the vent system, and the pressure suppression chamber (torus or wetwell). Each Mark I primary containment consists of a drywell, which encloses the reactor vessel, reactor coolant recirculation system, and branch lines of the reactor coolant system; a toroidal-shaped pressure suppression chamber containing a large volume of water; and a vent system connecting the drywell to the water space of the suppression chamber.

The drywell is a steel pressure vessel with a spherical lower section and a cylindrical upper section. A portion of the lower spherical drywell section is embedded in concrete. This embedment, in combination with lateral restraints which are attached to the cylindrical section, forms the drywell support system. Approximate free volume of the drywell is 160,000 cubic feet. The drywell spherical section is 66 feet in diameter and varies in thickness from 13/16 inches to 1-1/16 inches. The cylindrical neck section is 37 feet in diameter and varies in thickness from 3/4 inches to 1-1/2 inches. The spherical to cylindrical transition is 2-3/4 inches thick. The removable top head ranges from 1-1/4 inches to 1-7/16 inches in thickness. The drywell stands 111 feet, 11 inches tall. In the UFSAR, Section 6.2.1.1 gives the internal design pressure as 62 psig with an internal maximum design temperature of 281 °F.

The suppression chamber (also called the torus) is a steel pressure vessel, shaped like a torus, encircling and located below the drywell. The suppression chamber is mounted on support structures which transmit loads to the concrete foundation of the reactor building. The torus approximate free volume is approximately 120,000 cubic feet. In the UFSAR, Section 6.2.1.1, gives the internal design pressure as 62 psig with an internal maximum airspace design temperature of 281 °F.

The drywell and suppression chamber are interconnected by a vent system. Eight main vents connect the drywell to a vent ring header, which is located within the suppression chamber airspace. A bellows assembly is located at the junction where each main vent penetrates the suppression chamber shell to permit differential movement of the suppression chamber and drywell/vent system. Projecting downward from the vent ring header are downcomer pipes, arranged in 48 pairs around the vent header circumference, terminating below the surface of the suppression chamber water volume.

The containment is designed as a Seismic Class I structure. The staff noted that being a Seismic Category I structure, the containment has been designed to maintain its function during all design basis external hazards, and therefore, following the guidance of NEI 12-06, it can be credited for use in the mitigation strategies.

Isolation Condenser (IC)

The performance objective of the IC is to provide reactor core cooling in the event that the reactor becomes isolated from the turbine and the main condenser by closure of the main steam isolation valves. To achieve this objective, the IC was designed for a cooling rate of 252.5 x 10^6 British Thermal Units per hour. The IC system is capable of operation without ac electrical power. The IC consists of two tube bundles immersed in a large water storage tank. The tubes are Type 304 stainless steel U-tubes. The shell is carbon steel. The IC system operates by natural circulation. During IC system operation, steam flows from the reactor, condenses in the tubes of the heat exchanger, and returns by gravity to the reactor via the "A" recirculation loop. The differential water head, created when the steam is condensed, serves as the driving force. The capacity of this system is equivalent to the decay heat rate about 530 seconds (8.83 minutes) after a scram. With no make-up water, the water level in the IC shell approaches the bottom of the tube bundles in 20 minutes. The decay heat evaluation was based on the decay heat calculation method of ANSI/ANS-5.1-1979. In Phase 1 there are no shell side make-up sources that meet requirements for FLEX qualification. Therefore, the IC will lose efficiency from operation with inadequate shell-side level and will not be able to remove enough decay heat for RPV heat removal. The decay heat will then be removed by steam flow to HPCI or to the RPV safety valves.

Once the IC shell side receives make-up water flow from FLEX equipment, the IC will remove decay heat with no loss of inventory from the reactor coolant system (although there still may be some leakage from the assumed RPV leakage into the drywell), and with no addition of heat to the suppression pool. As long as the shell side of the IC is replenished (during phase 2) with sufficient water, the IC will remove adequate decay heat to maintain core cooling.

FLEX scenario design analysis calculation DRE14-0008 credits the IC to achieve hot shutdown and assumes a reactor vessel cooldown rate of 15 °F per hour. Assuming reactor vessel water temperature starts at 546 °F, it would take approximately 22.3 hours to reach an RPV temperature of 212 °F utilizing a 15 °F per hour cool down rate.

High Pressure Coolant Injection (HPCI)

The IC is backed up by the HPCI system. The HPCI subsystem is designed to use steam from the RPV to pump water into the RPV under loss-of-coolant-accident conditions which do not result in rapid depressurization of the RPV. The loss of coolant might be due to a loss of reactor feedwater which does not cause immediate depressurization of the reactor vessel. The HPCI subsystem includes a steam turbine driving a two-stage high pressure pump and a gear driven, single-stage booster pump, valves, high pressure piping, water sources, and instrumentation.

Operation of the HPCI system in the emergency mode is completely independent of ac power with the exception of the HPCI room cooler fans, and requires only dc power from the station battery to operate the controls. Operation of the HPCI system removes heat from the RPV. This heat removal will be used to control RPV pressure after the IC becomes ineffective. Additionally, HPCI will provide make-up to the RPV to maintain water level during operation. Operation of the HPCI turbine will result in a heat input to the suppression pool. There is no current method to remove heat from the suppression pool without ac power. Once the IC shell side make-up has been initiated from FLEX equipment, the HPCI system will be secured in order to avoid heating and pressurizing the containment.

3.4.4.1.2 Plant Instrumentation

In NEI 12-06, Table 3-1, specifies that containment pressure, suppression pool level, and suppression pool temperature are key containment parameters which should be monitored by repowering the appropriate instruments.

The FIP identifies the following as key parameters credited for all phases of the strategy for maintaining the containment integrity:

Drywell Pressure - FSG-30, “FLEX Strategy For Obtaining Alternate Readings" provides guidance to obtain drywell pressure using a handheld electronic meter from the control room or from instrumentation panels in the plant.

Suppression Pool Level - Control room indication of narrow range suppression pool level (-20 inches to +20 inches) remains available due to the FLEX load shedding procedural guidance and restoration of battery chargers. When suppression pool level is outside this band, FSG-60 provides guidance on obtaining a reading from the wide range level indication (0 feet to 30 feet).

Suppression Pool Temperature - Upon a FLEX event, suppression pool temperature monitoring in the control room is lost. Guideline FSG-30 provides guidance to obtain suppression pool temperature using a handheld electronic meter from the control room or from instrumentation panels in the plant.

In the unlikely event that 125 Vdc and/or vital electrical bus infrastructure is damaged, FLEX strategy guidelines for alternately obtaining the critical parameters is provided in FSG-30, "FLEX Strategy For Obtaining Alternate Readings."

Based on this information, the licensee should have the ability to appropriately monitor the key containment parameters as delineated in NEI 12-06, Table 3-1.

3.4.4.2 Thermal-Hydraulic Analyses

The licensee performed a containment evaluation, DR-MISC-043, "MAAP Analysis to Support FLEX Initial Strategy," Revision 2, which was based on the boundary conditions described in Section 2 of NEI 12-06. This calculation utilized the Modular Accident Analysis Program (MAAP) computer code, version 4.0.5, to perform numeric computations of the fundamental thermodynamic equations which predict the heat-up and pressurization of the containment atmosphere under ELAP conditions.

As discussed in Section 3.4.1 above, the licensee's calculation indicates HPCI will be running for approximately 2.5 hours, which causes an increase in the suppression pool temperature to 140 °F (the maximum temperature reached in the suppression pool). At this time, the IC shell side make-up is established and HPCI is secured, stopping the heat input to the suppression pool. With the IC shell side make-up established, a controlled cooldown of the RPV is commenced. RCS leakage is assumed to be 61 gallons per minute at normal operating conditions. These actions provide margin to the primary containment design pressure limit.

The calculation shows the drywell temperature reaches 279 °F at 72 hours. The drywell pressure reaches a maximum of 20 psig and the suppression pool pressure reaches a maximum of 19.3 psig during the 72-hour period. The maximum values calculated are below the UFSAR design parameters stated above in Section 3.4, so the licensee has adequately demonstrated that there is significant margin before a limit would be reached.

3.4.4.3 FLEX Pumps and Water Supplies

There are no FLEX pumps or water supplies specifically used to maintain containment pressure and temperature below limits. The FLEX equipment and water supplies for containment integrity uses the same flow path described in Section 2.3.5 up to the IC make-up header connection. Once that connection is made, there is a direct path to each unit's IC shell side.

3.4.4.4 Electrical Analyses

The licensee performed a containment evaluation based on the boundary conditions described in Section 2 of NEI 12-06. Based on the results of its evaluation, the licensee developed required actions to ensure maintenance of containment integrity and required instrumentation continues to function. With an ELAP initiated, while either unit is in Modes 1-4, containment cooling is lost for an extended period of time. Therefore, containment temperature and pressure will slowly increase. As long as the isolation condenser functions to remove the core decay heat from the primary containment, structural integrity of the primary containment due to increasing containment pressure will not be challenged for a significant period of time. However, with no cooling in the containment, temperatures in the containment are expected to rise and could reach a point where continued reliable operation of key instrumentation and components might be challenged if left unmitigated. The expected rate of containment temperature rise is low such that no immediate actions are required.

The licensee's Phase 1 coping strategy for containment involves initiating and verifying containment isolation, and monitoring containment pressure and temperature using installed instrumentation. The licensee's strategy to repower instrumentation using the Class 1E station batteries is identical to what was described in Section 3.2.3.6 of this SE and is adequate to ensure continued containment monitoring.

The licensee's Phase 2 coping strategy is to continue monitoring containment pressure and temperature using installed instrumentation. The licensee's strategy to repower instrumentation using the 480 Vac, 800 kW FLEX DGs is identical to what was described in Section 3.2.3.6 of this safety evaluation and is adequately sized to ensure continued containment monitoring.

The licensee's Phase 3 coping strategy is to continue monitoring containment pressure and temperature, and use NSRC-supplied equipment as necessary. If necessary, an NSRC supplied 480 Vac CTG could replace the Phase 2 480 Vac FLEX DG.

Based on its review of licensee calculation DRE14-0037, the NRC staff determined that the electrical equipment available onsite (e.g., 480 Vac FLEX DGs) supplemented with the equipment that will be supplied from an NSRC (e.g., 480 Vac CTGs), has sufficient capacity and capability to supply the required loads to reduce containment temperature and pressure, if necessary, to ensure that the key components including required instruments remain functional.

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-2012-0, and should adequately address the requirements of the order.

3.5 Characterization of External Hazards

Sections 4 through 9 of NEI 12-06 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 applicable site-specific external hazards leading to an ELAP and loss of normal access to the UHS.

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; severe storms with high winds; snow, ice and extreme cold; and extreme high temperatures.

References to external hazards within the licensee's mitigating strategies and this safety evaluation 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 19] (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," hereafter called the MBDBE rule, which was published for comment in the Federal Register on November 13, 2015 [Reference 52]. 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 response to the 50.54(f) letter and the requirements for Order EA-12-049 and the MBDBE rulemaking (see COMSECY-14-0037, Integration of Mitigating Strategies for Beyond-Design-Basis External Events and the Reevaluation of Flooding Hazards" [Reference 47]. The Commission provided guidance in an SRM to COMSECY-14-0037 [Reference 20]. The Commission approved the staff's recommendations that licensees would 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 37], the NRC staff informed the licensees that the implementation of mitigation strategies should continue as described in licensee's OIPs, and that the NRC safety evaluations and inspections related to Order EA-12-049 will rely on the guidance provided in JLD-ISG-2012-01, Revision 0, and the related industry guidance in NEI 12-06, Revision 0. 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, Revision 2, Appendices G and H [Reference 53]. The NRC staff endorsed Revision 2 of NEI 12-06 in JLD-ISG-2012-01, Revision 1 [Reference 54]. The licensee's MSAs will evaluate the mitigating strategies described in this safety evaluation 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 Seismic

In its FIP, the licensee described the current design-basis seismic hazard, the design-basis earthquake (DBE). Current NRC terminology for the DBE is the safe shutdown earthquake (SSE). As described in UFSAR Sections 2.5.1.2, Seismology, and 3.7.1, Seismic Input, the SSE seismic criteria for the site is two-tenths of the acceleration due to gravity (0.20g) peak horizontal ground acceleration and 0.133g peak ground acceleration acting vertically. 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 Dresden site is located on the south bank of the confluence of the Des Plaines and Kankakee Rivers that forms the Illinois River. The site is just upstream of the United States Army Corps of Engineers Dresden Island Lock and Dam. In its FIP, the licensee described that the nominal ground elevation of the Dresden site is about elevation 516 feet above MSL at the location of the principal structures of Units 2 and 3, and the design plant grade is elevation 517 feet MSL. The finished floor elevation of the plant structure is 517.5 feet MSL.

In its FIP, the licensee described that the Dresden station has two flood scenarios that must be considered for the FLEX Strategies: river flooding and local intense precipitation (LIP). As described in the FIP, river flooding is the worst case BDBEE flooding event for Dresden and is the result of precipitation occurring over an extended period of time. In the UFSAR, Section 2.4.3, Probable Maximum Flood on Streams and Rivers, describes the current design basis flood as 528 feet MSL. The FIP describes newer flood analyses that concluded that the maximum credible flood level with wave run-up for Dresden is about 529 feet MSL, approximately 12 feet above grade level.

In its FIP, the licensee described that the LIP event for Dresden is characterized by a one-hour, one square mile probable maximum precipitation (PMP) event. Using this, the licensee computed a cumulative depth of the one-hour, one-square mile PMP of 17.97 inches. Based on this rainfall model, flooding depths were computed for several openings around the reactor and turbine building. The maximum flood elevation of 518.1 feet MSL occurs at several Category 1 structures. The flooding depths range between 0.1 feet (reactor building, Unit 3) to 1.7 feet (turbine building, Unit 2). The maximum flood inundation time above elevation 517.5 feet MSL is 1.75 hours. The licensee stated that the largest leak path for water ingress to the reactor building is due to the Unit 2 trackway interlock door where the maximum flood height is 0.54 feet for 1.35 hours. The licensee stated in the FIP that an evaluation of the impact of the LIP event determined that no safety related equipment or FLEX equipment was adversely impacted by the water ingress.

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. 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. The NRC staff concludes that a hurricane hazard is not applicable and need not be addressed.

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.

In its revised OIP [Reference 11], the licensee explained that the Dresden site is located at 41°23'23" north latitude and 88°16'09" west longitude. Furthermore, they referenced NEI 12-06 for guidance related to tornado hazards and concluded that tornado hazards are applicable to Dresden and that Dresden screens in for an assessment for High Wind Hazard. In addition, the licensee described in its FIP and UFSAR Section 3.3.2.1, Applicable Design Parameters, that the tornado parameters used in the design of structures at the Dresden Station have a maximum tangential velocity of 300 miles per hour (mph) and a pressure drop of 6.3 pounds per square inch (psi). In the UFSAR, Section 3.5.4 describes the design basis tornado missiles for the site. Although the licensee did not address the impact of a hurricane in the integrated plan, Dresden is located beyond the range of high winds from a hurricane per NEI 12-06 Figure 7-1. The NRC staff concludes that a hurricane hazard is not applicable and need not be addressed.

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 revised OIP [Reference 11], regarding the determination of applicable extreme external hazards, the licensee stated that the site is located at 41°23'23" north latitude and 88°16'09" west longitude. In addition, the site is located within the region characterized by 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.

In its FIP, the licensee described that an extreme cold BDBEE for Dresden is defined as an event where a regional weather pattern characterized by low external temperatures reaching a minimum of -6 °F daily over a prolonged period of time or heavy snowfall/ice challenges off-site power and on-site power capabilities by stressing the grid resulting in an extended loss of ac power. The licensee concluded 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 <u>Extreme Heat</u>

In the section of its FIP regarding the determination of applicable extreme external hazards, the licensee described that, as per NEI 12-06 Section 9.2, all sites are required to consider the impact of extreme high temperatures. Summers at the site may bring periods of extremely hot weather characterized by high external temperatures reaching a maximum of 94 °F daily over a prolonged period of time. Therefore, the plant site screens in for an assessment for extreme high temperature hazard.

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 <u>Conclusions</u>

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

In its FIP, the licensee described the onsite FLEX storage areas consisting of two buildings protected from BDBEEs (FSB-A and FSB-B), one commercial building (FSB-C) and various smaller storage areas throughout protected areas in the existing plant structure (reactor building, main control room, etc.). Figure 23 of the FIP has an overhead view indicating the location of the FLEX storage buildings.

In its FIP, the licensee described that FSB-A is a 31 foot by 40 foot protected structure located inside the protected area at the southwest corner of the reactor building and west of the Unit 3 HRSS building. FSB-A houses an 800 kW, 480 Vac FLEX diesel generator (DG). Equipment to support or connect the DG to support FLEX needs will also be stored in this building. These include the temporary power distribution unit (TPDU), submersible fuel oil pumps and temporary electrical cables.

In its FIP, the licensee described that FSB-B is a 50 foot by 75 foot protected structure located inside the protected area east of the chemical cleaning building. This building houses FLEX equipment such as at least one of the CCSW emergency pumps (FLEX submersible pumps), Ford F-750 truck, carry deck crane, hose trailer(s), and miscellaneous smaller FLEX equipment.

In its FIP, the licensee described that FSB-C is a 50 foot by 125 foot commercial building located outside the protected area at the south end of the contractor parking lot. The building houses the "N+1" 800 kW, 480 Vac FLEX DG, "N+1" TPDU, FLEX flood pumps, FLEX flood barge, hoses to support the FLEX flood pumps, boats and various smaller pieces of equipment. The use of a commercial building for the storage of FLEX equipment is an alternative to the guidance in NEI 12-06 and is further evaluated in Section 3.14 below.

Below are additional details on how FLEX equipment is protected from each of the applicable external hazards.

3.6.1.1 Seismic

The reactor building and control building are designed to the plant's seismic licensing basis.

As described in specification number 151871-DC-C-00001-0, "Civil/Structural Design Criteria for Exelon FLEX Storage and Commercial Buildings," revision 0, FSB-A and FSB-B are designed for the most limiting of the seismic intensity required by the ASCE 7-10, Minimum Design Loads for Buildings and Other Structures, response spectrum and that required by the plant's design spectra. In addition, Exelon requires that the earthquake used in the ASCE 7-10 design be at least equal to the site SSE ground response spectra (GRS). The design for FSB-A and FSB-B are performed in accordance with ASCE 7-10.

As described in the FIP, FSB-A and FSB-B are constructed of reinforced concrete with a tornado missile barrier in front of the overhead door. Access to FSB-A and FSB-B does not require ac power and all of the doors are manually operated.

In its FIP, the licensee describes that equipment spacing is credited during a seismic event to preclude seismic interaction that could cause damage to the equipment. Where a specific piece of equipment could not be credited based on spacing, tie-downs are used. Tie-downs are used on all applicable equipment in the building as an additional barrier to seismic interaction. Miscellaneous items are stored on shelves attached to the FLEX building walls. Equipment is located a sufficient distance away from shelves to ensure items stored on shelves will not contact equipment if they fall from the shelves during a seismic event.

As described in Engineering Change 0000398866, "Design of New Non-Robust 50' x 125' FLEX Storage Bldg Outside of Protected Area," FSB-C is a non-seismic building. In addition, as discussed in specification 151871-S-C-00008-1, "Pre-Engineered Buildings Design/Build," the building is designed for the loads required by the applicable state/local building code.

3.6.1.2 Flooding

FLEX storage buildings A, B and C are not protected against river flooding. For the river-flooding event, there is time available to pre-stage or relocate the applicable equipment necessary to support the mitigating strategies.

In its FIP, the licensee described that FSB-A is not flooded by the LIP event since its floor level is at elevation 518.5 feet MSL, which is above the expected water level at the FSB-A location during a LIP event.

In its FIP, the licensee described that FSB-B has a finished floor level at elevation 517.5 feet MSL. All equipment in this building is either trailer mounted or elevated so that it is not impacted by a LIP flood, which might reach 518.8 feet at this building's location.

In its FIP, the licensee described that the FLEX Building C has a floor level at elevation 517.83 feet MSL and there is the potential for a LIP flood to go higher than that. None of the equipment is needed during a LIP flooding event.

3.6.1.3 High Winds

As described in specification number 151871-DC-C-00001-0, FSB-A and FSB-B are designed for a tornado that has a total maximum basic wind speed of 360 mph; this envelopes the design bases at all nine Exelon sites. In addition, all tornado barriers are required to be passive. Due to the lack of available space, openings at equipment access doors shall have tornado missile barrier protection provided by either the door or an additional barrier. The door, or door and barrier, are to be temporary, removable using manual methods without the assistance of powered devises; e.g., no electricity, forklifts, etc. As described in the FIP, both FSB-A and FSB-B are constructed of reinforced concrete with a tornado missile barrier in front of the overhead door. The FSB-C is a commercial building designed to meet the applicable state/local building code.

3.6.1.4 Snow, Ice, Extreme Cold and Extreme Heat

As described in specification number 151871-DC-C-00001-0, FSB-A and FSB-B are designed for snow load in accordance with ASCE 7-10. The minimum applied snow load to be considered shall be 105 pounds per square foot (psf), which envelops all nine Exelon sites. In addition, snowdrift loading is addressed in accordance with ASCE 7-10 Section 7.7.

For snow loading, FSB-C is a commercial building designed to meet the applicable state/local building code.

As described in the FIP, FLEX buildings A, B and C are heated. In addition, the DG enclosure (FLEX buildings A and C) and the large diesel driven equipment (FLEX building B) are maintained warm in winter months by maintaining a keep-warm system in operation. Operator rounds verify the keep-warm systems are functional in both buildings.

The licensee stated that the large diesel-driven equipment that can be susceptible to extreme cold weather are outfitted with battery chargers/tenders and onboard heating equipment, as necessary, to ensure their starting capability even if the building heating system is inoperable for some period of time. Otherwise, the installed building heating and ventilation systems are capable of maintaining acceptable temperature conditions in both the winter and summer.

3.6.1.5 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, with certain approved alternatives to NEI 12-06 as discussed in Section 3.14, and should adequately address the requirements of the order.

3.6.2 Availability 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.

In its FIP, the licensee described that each unit has two motor-driven FLEX pumps (N and N+1) on elevation 476 feet in the reactor building to support all BDBEE except for flooding. Each of the four FLEX pumps is individually capable of supplying the required flow to serve all required plant cooling loads during the transition phase. In addition, during a postulated flooding BDBEE, two diesel-driven pumps pre-staged on top of a floating platform will be placed in the Unit 3 turbine building. One pump is sized to provide adequate flow to meet the cooling needs of the RPV, Containment, and SFP for both units during a flooding event.

As described in the FIP, one 800 kW FLEX DG is located in FSB-A and is protected for all BDBEE except river flooding. The N+1 800 kW FLEX DG is located in FSB-C. Both of the 800 kW FLEX DGs are trailer-mounted units and each is capable of supplying power to all anticipated loads for both units at Dresden after the BDBEE.

In its FIP, the licensee described that sufficient equipment has been purchased 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 equipment required by FLEX strategies for all units on-site. In addition, where a single resource is sized to support the required function of both units, a second resource has been purchased to meet the N+1 capability. Where multiple strategies to accomplish a function have been developed, (e.g., two separate means to repower instrumentation) the equipment associated with each strategy does not require N+1 capability.

As described by the licensee in its FIP, in the case of hoses and cables associated with FLEX equipment required for FLEX strategies, an alternative approach to the guidance in NEI 12-06 to meet the N+1 capability has been selected. These hoses and cables are passive components being stored in a protected facility. The most probable cause for degradation/damage of these components would occur during deployment of the equipment. Therefore the N+1 capability is accomplished by having sufficient hoses and cables to satisfy the N capability plus 10 percent spares or at least 1 length of hose and cable. This 10 percent margin capability ensures that failure of any one of these passive components would not prevent the successful deployment of a FLEX strategy. See Section 3.14 below for further information.

Based on the number of portable FLEX pumps, FLEX DGs, and support equipment identified in the FIP and during the audit review, the NRC staff finds that, if implemented appropriately, the licensee's FLEX strategies include a sufficient number of portable FLEX pumps, FLEX DGs, and equipment for RPV makeup and core cooling, SFP makeup, and maintaining containment consistent with the N+1 recommendation in Section 3.2.2 of NEI 12-06, with certain approved alternatives to NEI 12-06 as discussed in Section 3.14.

3.7 Planned Deployment of FLEX Equipment

In its FIP, the licensee describes that primary and alternate deployment routes for portable FLEX equipment are identified in the FLEX Support Guidelines (FSGs). If a path is found blocked, the Shift Manager is notified to evaluate the obstruction and establish alternate pathways as needed. In addition, the primary haul paths minimize travel through areas with power lines, narrow passages, etc. to the extent practical. However, high winds can cause debris from distant sources to interfere with planned haul paths. Debris removal equipment is stored inside FSB-B and is protected from the severe storm and high wind hazards such that the equipment remains functional and deployable to clear obstructions from the pathway between the storage building and its deployment locations.

As described in the FIP, equipment has been pre-staged to allow for quicker availability of FLEX pumps to meet the 2.5-hour time critical action. Flexible cables are stored on cable reel enclosures in FSB-A as well as inside the reactor building. These will be deployed from there, through penetrations into the Unit 3 reactor building. Since debris may block access from FSB-A penetrations to the preferred reactor building access penetration, multiple penetrations have been provided.

3.7.1 Means of Deployment

In its FIP, the licensee described that deployment paths shall be reviewed on a monthly basis to ensure they are maintained available, are in a condition to allow transport of FLEX equipment, and are not blocked.

In addition, as described in the FIP, the FLEX deployment area, near the Unit 2/3 intake structure (also referred to as the cribhouse or the intake screen and pump house), provides two access routes and pump staging areas. Either of the travel paths could require some minor debris removal to allow a FLEX pump to be placed in close proximity to the cribhouse in order to access water from the UHS at the intake. FLEX strategies include reasonable time to remove enough debris to clear a usable travel path using the Ford F-750 with the snow plow and additional debris removal equipment stored in FSB-B.

In its FIP, the licensee describes that the site has two barges, two Ford F-750 stake bed trucks with plows (located in FSB-B), and two mobile cranes, jon boats and inflatable rafts available to support the FSGs.

3.7.2 Deployment Strategies

In its FIP, the licensee described that deployment routes have been reviewed for potential soil liquefaction and have been determined to be stable following a seismic event. In addition, deployment paths and staging areas are contained in the snow removal plan. These areas are maintained as a priority after site safety concerns are addressed.

In the FIP, the licensee described that for river flooding, the maximum credible flood level with wave run-up for Dresden is approximately 12 feet above grade level. None of the structures on site are protected from external flooding. Applicable FLEX equipment will be moved from storage to locations that are above the flood levels. As an example, the FLEX diesel-driven flood pumps will be placed on a barge. The barge will be moved into a location that allows connection to plant piping. The barge will float keeping the pumps above the floodwaters. In addition, both FLEX DGs, one DG from FSB-A and one DG from FSB-C, will be placed at a location above the highest flood level, during site flooding preparation actions.

3.7.3 Connection Points

3.7.3.1 Mechanical Connection Points

Suppression Pool Supply and Makeup Through the LPCI System

The licensee indicated in the FIP that the two suppression pools would be replenished with the use of FLEX pumps pre-staged in each reactor building with a 6 inch Storz fitting on the suction side and a 5 inch Storz fitting on the discharge side to allow hoses to be connected quickly. The use of pre-staged pumps is an alternative to NEI 12-06 and is evaluated in Section 3.14.3 below. The licensee stated that at around the 2.5 hour mark after ELAP is declared for non-flooding conditions the operators are directed by guideline FSG-04, "Aligning FLEX Pumps for Operation," to attach flexible hoses from the suction and discharge portions of the FLEX pumps to one division of the LPCI system in the reactor building. One portion of the LPCI system connection will allow for suction from the suppression pool, and discharge to the LPCI discharge risers to send water to the IC makeup header to fill the IC shell side for reactor core cooling. This IC makeup header also includes a branch line to connect to the new FLEX valve manifold, which will supply RPV makeup using the SBLC system, and also supply SFP makeup. When the suppression pool level is reduced to about 11 feet, the FLEX submersible pump outdoors at the UHS is aligned to take a suction on the UHS and pump to a suppression pool. The submersible pump discharge is connected by hoses to the LPCI discharge riser. The LPCI riser has a hard-piped connection to the suppression pool. The licensee stated that around the 6 hour mark after ELAP is declared, both suppression pools would be aligned to receive makeup from the UHS through the LPCI riser connections in both reactor buildings. The LPCI riser connections are all located within the reactor buildings, which are protected from all applicable external hazards except floods.

RPV and SFP Makeup Using the FLEX Valve Manifold

The licensee described the FLEX valve manifold, which is connected to an 8 inch branch line from the IC makeup header on the 545 foot elevation near the south wall of the Unit 2 reactor building. The licensee stated that eight Storz fitting connections and isolation valves, varying in size from 2 inch to 6 inch are installed on the manifold. The licensee designed this new FLEX valve manifold to be connected with flexible hoses to makeup connections to supply the RPVs and the SFPs. The FLEX valve manifold is designed to provide makeup for both units, with flexible hoses being routed through the respective reactor buildings to the LPCI system to access the suppression pools for continuous makeup. The licensee stated that the operators are directed by SFG-08, "FLEX High Pressure And Low Pressure Level Control Using SBLC," to route 2 inch flexible hoses from the FLEX valve manifold, which is on elevation 545 feet, up to elevation 589 feet on both units to makeup to the SBLC tanks. The SBLC pumps take suction from this tank and inject into the RPV once they have been repowered by the FLEX generator by energizing the necessary busses, as directed by guideline FSG-06, "FLEX Strategy for Aligning Power to U2(3) 480 Volt Safety Related Busses 28(38) and 29(39)." The licensee also indicated that the RPV can receive makeup through the SBLC system by using a flexible hose from the FLEX valve manifold and being connected to the SBLC test connection line, which can directly inject makeup water into the RPV using the FLEX pumps in place of the SBLC pumps as an alternate method.

For SFP makeup, the licensee described the primary connection from the FLEX valve manifold being connected with 2 inch hose to the shutdown cooling (SDC) system, which is directly connected to the SFP cooling system piping. The FLEX valve manifold has two connections (one for each unit) to supply makeup water from the LPCI riser connections and distribute to the SFPs through the SDC system. The alternate SFP makeup strategy is described in the FIP as running the same hoses from the FLEX valve manifold to installed SFP hydrolazing taps with isolation valves. The licensee indicated that this will call for longer hose runs for both units. The licensee also stated that pipe caps on the hydrolazing taps would need to be removed and replaced with Storz fittings in order to attach the hoses. An additional SFP makeup strategy is to utilize portable spray monitor nozzles that will be set up on the refuel floor (the 613 foot elevation) next to the SFPs. For each unit, a 6 inch hose will be run from the FLEX valve manifold to the Unit 2 equipment hatch. A pair of 3 inch hoses will then be lowered from the refuel floor and attached to the 6 inch hose with a gated wye. The 3 inch hoses are connected to two spray monitor nozzles (one oscillating and one fixed directional) and pre-staged prior to the refuel floor environment reaching dangerous levels from temperature or dose. Once the spray system is set up, makeup flow can be controlled through the gated wyes on the 545 foot elevation. The oscillating spray monitor nozzles will be set up at opposite ends of the refuel floor to spray its respective SFP. At the level of the refuel floor, the two reactor buildings are connected with no dividing wall. The fixed directional monitor nozzles are set up at opposing ends of each SFP and spray towards its respective SFP. These spray nozzles will spray water into the SFP to maintain water level.

The NRC staff notes that the use of a single FLEX valve manifold is an alternative to the guidance in NEI 12-06, Revision 0, Section 3.2.2, to have primary and alternate connections for the FLEX strategies. This alternative is further discussed in Section 3.14.4.

BDB Flooding Strategies for IC, RPV, and SFP Makeup

For flooding events at Dresden, the licensee described that guideline FSG-60, "FLEX Flood Pump Deployment/Operation," would be used to have operators stage a FLEX diesel flood pump on a floating barge, which will occur prior to the flooding event. The FLEX diesel flood pump will take suction from flood waters in the turbine building and connect to the fire header at elevation 538 foot of the Unit 3 turbine building trackway. The licensee described the fire header connection in the Unit 3 turbine building as having a 6 inch Storz fitting and will have a connection to each of the fire protection headers associated with the two reactor buildings. The FLEX diesel flood pump provides flow to the fire header through these connections, which provides makeup water to the IC shell side, SBLCs, and the SFPs for both units. The SBLC tanks can be used to inject into the RPV by using the local hose reel in each of the respective reactor buildings. The SFP can also be supplied with makeup water using a local fire hose reel from the fire protection header in each unit's reactor building to the SFPs on the 613 foot elevation.

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's strategy is to supply power to equipment required to maintain or restore core cooling, containment, and SFP cooling using a combination of permanently installed and portable components. The licensee's primary strategy is to use the pre-staged and portable "N" 480 Vac FLEX DG located inside FLEX Building "A". The licensee strategy involves operating the FLEX DG inside FLEX Building "A", but the licensee has the capability to move and operate the FLEX DG outside the building, if necessary. The "N+1" FLEX DG, if required, is stored in FLEX Building "C" and would be towed to the vicinity of FLEX Building "A" where the electrical cable connections are located. The licensee has preferred and alternate cable routing penetrations to connect the 480 Vac FLEX DG. The preferred penetration is located on the Unit 3 reactor building west wall. The alternate penetrations are located on the wall in the Unit 3 west corner room and on the south side of the Unit 3 reactor building near the RPR interlock. Guideline FSG-06 provides instructions for connecting the 480 Vac FLEX DG to electrical buses 28(29) and 38(39) during a non-flood and flood event. During the audit, the licensee stated that they would perform phase rotation checks on the FLEX DGs before placing them in service.

Non-flood FLEX DG Connection Strategy

Temporary cables would be routed from the 480 Vac FLEX DG to a temporary power distribution unit (TPDU). Temporary cables would also be routed from the TPDU through penetrations in the reactor building wall to the desired FLEX pump and also to bus connection devices (BCDs) which will power the 480 Vac electrical buses. Guideline FSG-03, "FLEX Strategy for Supplying Power to FLEX Pumps," provides guidance to power the FLEX pumps.

FLEX DG Connection Strategy for a Flood

There is advance warning of floodwaters coming downstream in the adjacent rivers. As noted in guideline FSG-62, "FLEX Generator Deployment During a Flood," Revision 1, two FLEX DGs and their associated TPDUs will be placed in the turbine building at a level above the highest postulated flood level, with exhaust ducted outside of the building, and cables run to power vital plant equipment if other power sources are lost. Temporary cables would be routed from the TPDU through the turbine building/reactor building interlock where they are connected to BCDs which will power the 480 Vac electrical buses.

For Phase 3, the licensee will receive four (two per unit) 1 MW 4160 Vac and two (one per unit) 1 MW 480 Vac CTGs from an NSRC. The licensee plans to only connect the 480 Vac CTGs and not the 4160 Vac CTGs. The NSRC supplied 480 Vac CTGs will be staged in the vicinity of the portable 480 Vac FLEX DGs and provide backup power, if necessary. Guideline FSG-14, "Transition From Phase 2 to Phase 3 Equipment," provides guidance for removing the Phase 2 480 Vac FLEX DGs and placing in service the 480 Vac CTGs.

3.7.4 Accessibility and Lighting

In its FIP, the licensee described that deployment paths shall be reviewed on a monthly basis to ensure they are maintained available, are in a condition to allow transport of FLEX equipment, and are not blocked. The potential impairments to required access are: 1) doors and gates, and 2) site debris blocking personnel or equipment access. The coping strategy to maintain site accessibility through doors and gates is applicable to all phases of the FLEX coping strategies.

In addition, the FIP described that equipment deployment from FSB-A or FSB-B may require minimal debris removal at the buildings. The FLEX storage building incorporates multiple access doors for equipment deployment.

The FIP described that at Dresden, doors and gates serve a variety of barrier functions on the site. One primary function, security, is discussed below. However, other barrier functions include fire, flood, radiation, ventilation, tornado, and high energy line break (HELB). These doors and gates are typically administratively controlled to maintain their function as barriers during normal operations. Following a BDBEE and subsequent ELAP event, FLEX coping strategies require the routing of hoses and cables through various barriers in order to connect portable BDB equipment to station fluid and electric systems. For this reason, certain barriers (gates and doors) will be opened and remain open. This departure from normal administrative controls is acknowledged and is acceptable during the implementation of FLEX coping strategies.
In its FIP, the licensee described that battery powered emergency lighting is available at critical plant locations to support in-field activities. Operators are provided with hard hat mounted LED lights and/or flashlights that provide illumination for task completion. Portable light stands have been purchased to support lighting in deployment locations as desired when power is available. Additionally, small diesel generators have been purchased and are used to power electrical devices including lighting in remote locations including light stands and light stringers.

The licensee further described that FSB-A contains three installed battery pack emergency lights with 8-hour batteries, which provide immediate lighting on a loss of building power. In addition, one light stand is pre-staged in FSB-A. Other light stands are stored in FSB-B and staged as follows: two light stands for Unit 2 trackway area, two light stands for Unit 3 trackway area, four light stands for 2/3 emergency diesel generator (EDG) interlock area and ingress to the reactor building, and two light stands for the auxiliary electrical equipment room area. All light stands are powered by portable DGs. All auxiliary equipment is deployed per FSG-38, "FLEX Auxiliary Equipment Deployment."

3.7.5 Access to Protected and Vital Areas

During the audit process, the licensee provided information describing that access to protected areas will not be hindered. The licensee has contingencies in place to provide access to areas required for the ELAP response if the normal access control systems are without power.

3.7.6 Fueling of FLEX Equipment

In its FIP, the licensee described that there are three EDG main fuel oil storage tanks. Each has a technical specification minimum volume of 10,000 gallons. The fuel quality of the EDG main fuel oil storage tanks is maintained through existing station processes. A submersible pump capable of being lowered directly into a EDG main fuel oil storage tank was identified. Guideline FSG-32, "Fueling Flex Portable Equipment," has been developed to provide direction for use of the pump and methods to refuel FLEX equipment. Use of the submersible pump allows greater flexibility in that fuel oil can be obtained from any EDG main fuel oil storage tank. Off-site testing of the submersible pump confirms a minimum pumping capacity of 1.3 gallons per minute (gpm) or 78 gallons per hour (gph) for each submersible pump. During the audit, the licensee noted that only the two FLEX DGs would be stored with diesel fuel already in their fuel tanks, as there will be sufficient time to fuel the remaining FLEX equipment prior to use.

As described in the FIP, a fuel oil use evaluation was performed for equipment requiring refueling during a BDBEE and identified that fuel usage is approximately 68 gph. During a maximum probable flooding event, the fueling requirement of the pump moved next to the UHS is eliminated and is replaced with the diesel-driven barge-mounted flood pump. The barge-mounted flood pump maximum fuel oil consumption at full load is 12.2 gph, resulting in a total fuel usage of approximately 73 gph for a flooding event. These calculated fueling requirements are within the capacity of 1 submersible fuel oil pump with margin. With an overall fuel consumption rate of approximately 68 gph, each storage tank would provide a minimum of six days fuel requirements. Within this time off-site support would be available to obtain additional fuel.

In the FIP, the licensee described that the same basic strategy is employed during flood events with some differences. The Dresden flood event is precipitation based and therefore, time is available to prepare for the flood. During those preparations, station personnel will install a standpipe on the 2/3 EDG Main Fuel Oil Tank vent line. The standpipe is designed such that additional sections can be added/removed as the flood waters rise and recede. The submersible fuel oil pump described above will be lowered into the standpipe. A floating platform will provide a working location for personnel and equipment to support pumping fuel oil out of the 2/3 EDG fuel oil tank.

3.7.7 Conclusions

Based on this evaluation, 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, and should adequately address the requirements of the order.

3.8 Considerations in Using Offsite Resources

3.8.1 Dresden Nuclear Power Station SAFER Plan

The industry has collectively established the needed off-site capabilities to support FLEX Phase 3 equipment needs via the SAFER Team. The SAFER team consists of the Pooled Equipment Inventory Company (PEICo) and AREVA Inc. and provides FLEX Phase 3 management and deployment plans through contractual agreements with every commercial nuclear operating company in the United States.

There are two NSRCs, located near Memphis, Tennessee and Phoenix, Arizona, established to support nuclear power plants in the event of a BDBEE. 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.

By letter dated September 26, 2014 [Reference 23], the NRC staff issued its 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.

The NRC staff noted that the licensee's SAFER Response Plan contains (1) SAFER control center procedures, (2) NSRC procedures, (3) logistics and transportation procedures, (4) staging area procedures, which include travel routes between staging areas to the site, (5) guidance for site interface procedure development, and (6) a listing of site-specific equipment (generic and non-generic) to be deployed for FLEX Phase 3.

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 Dresden, the Alternate Staging Area D is LaSalle County Generating Station. Staging Area C is the Pontiac Municipal Airport. Staging Area B is located just to the east of FSB-C and Staging Area A is the point-of-use for the FLEX response equipment.

Use of helicopters to transport equipment from Staging Area C to Staging Area B is recognized as a potential need within the Dresden Nuclear Power Station 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 should adequately address 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 BDB external event and subsequent ELAP event at Dresden, 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 BDB external event resulting in an ELAP.

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 a loss of ventilation analyses to quantify the maximum steady state temperatures expected in specific areas of the plant related to FLEX implementation to ensure the environmental conditions remain acceptable for personnel habitability and within equipment qualification limits.

The key areas identified for all phases of execution of the FLEX strategy activities are the main control room (MCR), HPCI room, auxiliary electrical equipment room (AEER), refuel floor, battery rooms, primary containment, and reactor building basement rooms with FLEX pumps. The licensee evaluated these areas to determine the temperature profiles following an ELAP/LUHS event. The results of the licensee's room heat-up evaluations have concluded that temperatures remain within acceptable limits based on conservative input heat load assumptions for all rooms/areas using passive and active means of portable ventilation.

Main Control Room (MCR)

The NRC staff reviewed SBO calculation 3C2/3-0389-001, "Loss of Ventilation During a Station Blackout (SBO)," Revision 4, which the licensee performed to determine what actions need to be taken for the loss of AEER and MCR ventilation based on the temperature response following a SBO event. Procedure DOA 5750-01 directs operators to block open MCR doors to establish natural air flow. Based on this calculation, the licensee's strategy is to direct operators to open several doors, open all the panel doors, and position portable fans to supply air into the control room within 15 minutes after the temperature in the control room exceeds 95 °F. The licensee determined that that with two 13,000 cubic feet per minute (cfm) fans providing supply and exhaust flow, the steady state temperature of the MCR would be approximately 11 °F higher than the ambient air temperature. For this task, the licensee has two 42 inch fans which are rated for 13,300 cfm. For all postulated extreme heat events, this configuration should be sufficient to keep the MCR below 120 °F. Operators will utilize guideline FSG-31, “FLEX Ventilation Strategies,” to perform these necessary actions. Actions may not be required based on temperatures in the MCR.

The licensee included actions in their FLEX sequence of events timeline at 30 minutes to address MCR ventilation. Additionally, when power is restored to the 480 Vac bus (planned at 6 hours following an ELAP-initiating event), the licensee stated that a MCR ventilation fan will also be available. The licensee also stated that MCR conditions will be monitored, heat stress countermeasures will be administered, and that the rotation of personnel will be employed to the extent feasible.

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,” Revision 1, for electronic equipment to be able to survive indefinitely), the NRC staff expects that the equipment in the MCR should not be adversely impacted by the loss of ventilation as a result of an ELAP event.

HPCI Room

The NRC staff reviewed calculation 2013-01671, “Transient Analysis of HPCI Pump Room for Extended Loss of AC Power,” Revision 0, which the licensee performed to model the HPCI room transient temperature response for 72 hours following an ELAP. The calculation uses the GOTHIC version 8.0 computer program. The licensee’s acceptance criterion for maximum HPCI room temperature is 189 °F, based on the capability of the equipment and the high temperature isolation signal.

The calculation concluded that, when doors are opened 2 hours after the event, the HPCI room reaches a maximum temperature of approximately 160 °F at the end of the 72-hour period of analysis. This evaluation considers that gland seal leakage continues to flow into the room for the duration of the analysis. A sensitivity case was also performed which modeled the gland seal leakage as being isolated 6 hours into the event. Under these conditions, the maximum room temperature at the end of the 72-hour analyzed period was approximately 150 °F. The licensee stated that the HPCI system isolates at a room temperature of 189 °F. In the current mitigation strategy, the HPCI system is only credited to operate for the first 2.5 hours following an ELAP-initiating event due to the temperature rise in the suppression pool. The temperature of the room at this time is calculated to be approximately 135 °F. Also, there are no manual actions needed in the HPCI room to employ the FLEX strategy given the boundary conditions of the order. Guideline FSG-31, “FLEX Ventilation Strategies”, directs operators to open the HPCI room doors as assumed in the GOTHIC evaluation. In addition, per guideline FSG-02, "FLEX Strategy HPCI Operation During An ELAP Event," HPCI room high temperature isolation is bypassed.

Based on the licensee taking actions to open doors and HPCI temperature remaining less than HPCI room limits for the duration that the HPCI system is required, the NRC staff expects that the equipment in the HPCI room should not be adversely impacted by the loss of ventilation as a result of an ELAP event.

Auxiliary Electrical Equipment Room (AEER)

The NRC staff reviewed SBO calculation 3C2/3-0389-001, which the licensee performed to determine what actions need to be taken for the loss of AEER and MCR ventilation based on the temperature response following a SBO event. The AEER temperature will rise if no ventilation is available. The licensee determined that two fans will limit the room temperature to approximately 12 °F above the incoming air supply. Thus, if the outside air is 95 °F, long-term steady state temperature of the room will be about 107 °F. Based on the vendor manual, the emergency safety system (ESS) uninterruptible power supply (UPS) unit may be operated at reduced loads at temperatures of 122 °F. The licensee developed the actions of DOA 5750-01, "Ventilation System Failure," and similar actions in FSG-31, to keep AEER temperatures below 120 °F. These actions include opening doors and utilizing portable fans when possible. FLEX related revisions to procedure DGA-03, provide direction to open selected breakers on the ESS Bus to reduce loading.

Based on 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," Revision 1, for indefinite equipment operation), the NRC staff finds that the electrical equipment in the AEER will not be adversely impacted by the loss of ventilation as a result of an ELAP event.

Refuel Floor

In its FIP, the licensee stated that the SFP area is ventilated by opening doors to allow air to flow into the reactor building and out through the refuel floor doorway to the turbine building roof utilizing natural circulation. Further discussions of ventilation and habitability considerations in the SFP area are discussed in Section 3.9.2.2.

Battery Rooms

In the Unit 2 compliance letter dated January 12, 2016 [Reference 22], the licensee stated that under SBO conditions, the heat load in the battery rooms is negligible as compared to the MCR and AEER. Thus, similar ventilation strategies identified in FSG-31 will ensure that the temperature rise in the battery rooms is less than 10 °F. Guideline FSG-31 provides guidance for opening doors and setting up portable ventilation in the battery rooms. While the battery vendor's analysis shows that the batteries are capable of performing their function up to 120 °F, periodic monitoring of electrolyte level may be necessary to protect the battery since the battery may gas more at higher temperatures.

Based on the above, the NRC staff finds that the licensee's ventilation strategy will maintain the battery room temperatures below the maximum temperature limit (120 °F) of the batteries, as specified by the battery manufacturer (Exide Technologies). Therefore, the batteries will not be adversely impacted by the loss of ventilation as a result of an ELAP event.

Primary Containment

The NRC staff reviewed calculation DR-MISC-043, "MAAP Analysis to Support FLEX Initial Strategy," Revision 2, which the licensee performed to model the transient temperature response in the RPV and containment following an ELAP event. The calculation analyzed the containment pressure and temperature response for 72 hours following an ELAP. The results of this analysis determined that due to the isolation condenser removing the core decay heat from the containment, the containment design limits for pressure (62 psig) and temperature (281 °F) are not challenged during this period. Based on the licensee's evaluation, both pressure and temperature will remain below the limits for electrical components being credited as part of the licensee's mitigating strategies during an ELAP. The licensee also has the capability to replace the Phase 2 480 Vac FLEX DG with the NSRC-supplied 480 Vac CTG to supply the required loads to reduce containment temperature and pressure, if necessary. Based on containment temperature and pressure remaining below their respective design limit, the NRC staff expects that the necessary equipment, including credited instruments, located inside containment should remain functional throughout an ELAP event.

Reactor Building Basement Rooms

The four electric FLEX pumps are permanently located in the reactor building basement rooms. Guideline FSG-31, "FLEX Ventilation Strategies," provides instructions for starting the standby gas treatment system, with power from the FLEX generator, which will assist in mitigating high temperatures in these rooms. Engineering change EC 394205, "Fukushima NRC Order EA-12-049, U2 FLEX Modifications," Section 4.1.14, states that the rooms where the FLEX pumps are located were evaluated for high temperature during a BDBEE. The evaluation showed that one of the rooms could reach 139 °F, and the other could reach 153 °F. It also stated that the FLEX pumps and their motors are designed for an ambient temperature of 160 °F.

Conclusion

Based on its review of the essential station equipment required to support the FLEX mitigation strategy, which are primarily located in the MCR, HPCI Room, AEER, Refuel Floor, Battery Rooms, Primary Containment, and Reactor Building Basement Rooms, 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

The licensee indicated during the audit process that the pre-staged FLEX pumps inside the reactor building will not be subjected to any extreme cold temperatures. No heat tracing equipment will be required to allow these FLEX pumps to perform their intended functions in drawing suction from the suppression pool. The licensee also indicated that the suppression pool makeup is supplied from the UHS (the plant intake canal) utilizing diesel-powered, hydraulically-driven submersible pumps. Dresden operates in a closed cycle mode during winter months. The hot water from the plant discharge is routed through a cooling lake and back to the plant intake. Furthermore, Dresden has the ability to utilize a de-icing pipe line that cross-connects the hot water from the plant discharge to the plant intake, in order to prevent the water in the intake from freezing. The initial conditions of NEI 12-06 identify that the plant has been operating at 100 percent power for the last 100 days. In this condition, the UHS will be above freezing. The submersible pump is deployed within 14 hours of ELAP event initiation. The licensee also referenced guideline FSG-09, "Torus Makeup," which contains direction for operators to disconnect and drain hoses if flow is stopped during conditions with outside temperatures below freezing. The licensee also stated that no other external tanks or piping would be involved for FLEX strategies.

The Dresden Class 1E station battery rooms are located inside the turbine building and not exposed to exterior walls, and therefore, would not be exposed to extreme low temperatures. At the onset of the event, the battery rooms would be at their normal operating temperature and the temperature of the electrolyte in the cells would build up due to the heat generated by the batteries discharging and during re-charging. In the Unit 2 compliance letter dated January 12, 2016 [Reference 22], the licensee stated that the overall temperature drop in the battery area will be less than 1 °F per hour under extremely cold conditions. The licensee also stated that given the relatively slow temperature drop following the loss of ventilation, the heat-up of the electrolyte as the batteries discharge, and the heating effect of the thermal resistance of the batteries it is reasonable to assume the battery capabilities are adequate to support FLEX actions until battery chargers are restored. Therefore, the NRC staff finds that Dresden station batteries should perform their required functions as a result of loss of normal heating during an ELAP event.

3.9.1.3 Hydrogen Gas Control in Vital Battery Rooms

An additional ventilation concern that is applicable to Phases 2 and 3, is the potential buildup of hydrogen in the battery rooms as a result of loss of ventilation during an ELAP event. Off-gassing of hydrogen from batteries is only a concern when the batteries are charging. In the FIP, the licensee stated that the amount of hydrogen calculated to reach 1 percent concentration in the battery room is reached at approximately eight hours after event initiation, and opening the doors early and subsequent placement of fans in the battery rooms prevents the hydrogen build-up from reaching explosive concentrations. Guideline FSG-31 provides guidance for opening doors and setting up portable ventilation in the battery rooms.

Based on its review of the licensee's battery room ventilation strategy, the NRC staff finds that hydrogen accumulation in the Dresden vital battery rooms should not reach the combustibility limit for hydrogen (4 percent) during an ELAP as a result of a BDBEE.

3.9.2 Personnel Habitability

3.9.2.1 Main Control Room (MCR)

As described above in Section 3.9.1.1, actions for loss of MCR ventilation are taken as required based on temperatures following an ELAP. SBO Calculation 3C2/3-0389-001 identified requirements for AEER and MCR temperatures. Performance of DOA 5750-01 actions results in MCR doors blocked open to establish natural air flow. Further actions are taken to provide forced circulation using portable fans to force air flow via FSG-31, "FLEX Ventilation Strategies." These fans can be powered from a FLEX DG or smaller portable DG. Actions may not be required based on temperatures in the MCR. The licensee also stated that MCR conditions will be monitored, heat stress countermeasures will be administered, and the rotation of personnel will be employed to the extent feasible. Bottled water is stored onsite, and cooling garments will be stored in freezers which are capable of being powered by a FLEX DG or smaller portable DG. The combination of all of these measures provides sufficient assurance that the MCR environmental conditions will not be so adverse as to preclude execution of the FLEX strategies.

3.9.2.2 Spent Fuel Pool Area

The licensee's strategy is to establish ventilation to the reactor building and deploy hoses before the SFP boiling affects habitability. Guideline FSG-31, "FLEX Ventilation Strategies," provides direction on opening as many reactor building doors as possible including the personnel door from the refuel floor to the turbine building roof. This will create natural air circulation in the reactor building. The licensee also indicated that additional actions to start the standby gas treatment system should provide additional ventilation flow after the 480 Vac power is available to ventilate areas after an ELAP event. Additionally, FSG-12, "Flex Spent Fuel Pool Spray Strategy," sets up equipment in advance of high dose rates or temperatures on the refuel floor precluding access to the refuel floor.

3.9.2.3 Other Plant Areas

In its FIP, the licensee stated that certain areas of the plant critical for the success of the FLEX shutdown mitigation strategy will exceed 120 °F, however operating personnel working in these areas will be protected through the application of heat stress control measures such as the use of cooling garments and personnel rotation. Exelon procedure SA-AA-111, "Heat Stress Control," defines a very high temperature area as one in which the dry bulb temperature is between 145 °F and 160 °F. Procedure SA-AA-111 also provides direction for the use of cooling garments to extend stay times in areas with elevated temperatures and allows for personnel working in cooling garments to work for 60 minutes in areas with elevated temperatures. The FLEX shutdown mitigation strategy will employ use of cooling garments. Freezers capable of being supplied by sources powered from the pre-staged 800 kW FLEX DG or a smaller portable DG will be used to maintain a sufficient supply of these cooling garments throughout the shutdown timeline. Based on the use of cooling garments and other heat stress controls such as working in pairs and rotating personnel it is reasonable to assume the operator actions required to implement the FLEX strategies can be accomplished.

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

Condition 3 of NEI 12-06, Section 3.2.1.3, states that cooling and makeup water inventories contained in systems or structures with designs that are robust with respect to seismic events, floods, and high winds, and associated missiles are available. As described in Dresden's FIP, Dresden uses the suppression pool as the primary water source and the UHS as its makeup for RPV level, containment cooling and SFP makeup throughout the ELAP/LUHS non-flood event. For river flooding events, barge-mounted flood pumps will be used to pump floodwaters to support RPV level, containment cooling and SFP make-up. One flood pump is sized to meet all make-up requirements for both units. A second flood pump on the barge serves as a backup pump.

In its FIP, the licensee described that when the water available in both suppression pools has been exhausted, the BDBEE shutdown mitigation strategy relies on pumping water from the UHS to the suppression pool in support of RPV core cooling, containment cooling and spent fuel pool cooling. Plant personnel will stage a diesel-driven submersible pump into the UHS and route hoses from the UHS to the low pressure coolant injection (LPCI) system where the UHS water will be routed to one of the suppression pools through existing LPCI system piping.

3.10.1 Reactor Pressure Vessel Makeup

At the onset of the event, RPV makeup is by use of HPCI. The CST will be used to supply HPCI if it is available but it is not a robust tank. If the CST is not available, HPCI will be realigned to take suction from the suppression pool (located in the torus), which is in the basement of the reactor building and protected against all hazards. In its FIP, the licensee described that at the middle of the technical specification allowed suppression pool water level band, the total volume of water contained is 882,181 gallons (adding up both pools). However, for FLEX strategies, only 794,058 gallons is expected to be available for makeup before makeup water from the UHS will be required. The licensee's calculations indicate that the suppression pools can provide all makeup water for about 18 hours.

In its FIP, the licensee described that the UHS is the water contained in the intake canal between elevation 494.2 feet and 487.67 feet. This volume of water is estimated to be approximately 2.144 million gallons. Assuming that 900 gpm of cooling water is required during the initial phase of a BDBEE, the 2.144 million gallons of water available in the intake canal would be exhausted in about 40 hours.

In its FIP, the licensee described that the Dresden cooling lake was formed by constructing an impervious earth-fill dike. The purpose of the cooling lake is to provide adequate cooling of the circulating and service water before discharge to the Illinois River. The lake is connected to the intake and discharge flumes of Units 2 and 3 by two canals (one intake and one discharge); each canal is about 11,000 feet long. Due to the topography of the circulating water canals and piping, approximately 9 million gallons of river water are trapped within the canals, not including water in the cooling lake. The cooling lake encompasses a storage area of 1,284 acres with an average depth of 8 feet; thus, the lake contains a maximum volume of 14,590 acre-feet. At 325,853 gallons per acre-foot, this equates to 4.75E+9 gallons. Lake water or the river water in the canals would be used as a heat sink for the long-term removal of decay heat from the reactors. The flow control station and cooling lake spillway gates, etc. would be adjusted to prevent loss of lake water to the river. However, the NRC staff notes that the cooling lake was not seismically constructed and may not be available for all events. The licensee also has a procedure (DOA 0010-01, "Dresden Lock and Dam Failure") which contains instructions for pumping river water into the intake canal (the UHS) using portable pumps.

In winter, Dresden operates in a closed cycle mode of operation to prevent ice buildup in the intake canal. Warm water from the outlet of the main condensers is circulated to the Dresden cooling lake and back to the intake canal. The licensee reports that with either unit operating at power, the water returning to the intake canal is above freezing. Following reactor shutdown, and considering the amount of water in the intake canal, it is reasonable to assume the water will not freeze in less than 72 hours. When the licensee deploys a hydraulic submersible FLEX pump in the intake canal for long-term makeup, the discharge hose configuration has a minimum flow line which directs some of the water back into the intake canal. This flow will aid in preventing freezing near the suction of the pump. The licensee plans to have the FLEX pump in the intake canal working within 14 hours after the event initiation.

For river flooding events, barge-mounted flood pumps will be used to pump floodwaters to support RPV level, IC make-up, containment cooling, and SFP make-up. One flood pump is sized to meet all make-up requirements for both units. A second flood pump on the barge serves as a backup pump.

3.10.2 Isolation Condenser Shell Side Makeup

The sources of water are the suppression pool and the UHS.

3.10.3 Suppression Pool Makeup

The sources of water are the UHS and the Dresden cooling lake and canals for non-flood events and barge-mounted flood pumps for flood events. These water sources were described in Section 3.10.1. Guideline FSG-9, "FLEX Suppression Pool Make-up," directs personnel to use a submersible pump positioned in the UHS to provide makeup water to the suppression pool.

3.10.4 Spent Fuel Pool Makeup

The sources of water are the suppression pool, the UHS, and the Dresden cooling lake for non-flood events and barge mounted flood pumps for flood events. These water sources were described in Section 3.10.1.

3.10.5 Containment Cooling

Using the ICs to remove core decay heat means that the heat input into containment is greatly reduced. The licensee's calculations show that with no venting or active cooling of the containment, the containment pressure and temperature will not exceed design limits. If needed, the sources of water are the UHS and the Dresden cooling lake for non-flood events and barge mounted flood pumps for flood events. These water sources were described in Section 3.10.1.

3.10.6 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 at Dresden for core decay heat removal initially focuses on the use of the ICs for the first 20 minutes, then the steam-driven HPCI pump until the IC shell sides can be refilled with water. 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 41 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 a steam-powered pump such as HPCI (which typically occurs when the RPV 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 38], which described methods to ensure plant safety in those shutdown modes. By letter dated September 30, 2013 [Reference 39], 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 its FIP, the licensee informed the NRC staff of its plans to follow the guidance in this position paper.

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

3.12.1 Procedures

In its FIP, the licensee described that the inability to predict actual plant conditions that require the use of BDB 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 accomplish FLEX strategies or supplement EOPs, the ELAP flowchart, Severe Accident Mitigation Guidelines (SAMGs), or Extreme Damage Mitigation Guidelines (EDMGs) will direct the entry into and exit from the appropriate FSG procedure.

The FIP also described that FSGs have been developed in accordance with BWR Owners Group (BWROG) guidelines. The FSGs will provide available, pre-planned FLEX strategies for accomplishing specific tasks. The FSGs will be used to supplement (not replace) the existing procedure structure that establishes command and control for the event. Figure 45 of the FIP contains a listing of Dresden FSGs.

In its FIP, the licensee described procedural interfaces have been incorporated into guideline FSG-01, "Extended Loss of AC Power/Loss of Ultimate Heat Sink Flowchart," to the extent necessary to include appropriate reference to FSGs and provide command and control for the ELAP.

The FIP described that changes to FSGs are controlled by Exelon fleet procedure AD-AA-101, "Processing of Procedures and T&RMs." FSG changes will be reviewed and validated by the involved groups to the extent necessary to ensure the strategy remains feasible. Validation for existing FSGs has been accomplished in accordance with the guidelines provided in NEI APC 14-17, "FLEX Validation Process," issued July 18, 2014.

3.12.2 Training

In its FIP, the licensee described that Dresden's Nuclear Training Program has been revised to assure 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.

In addition, the FIP described that using the SAT process, job and task analyses were completed for the new tasks identified applicable to the FLEX mitigation strategies. Based on the analysis, training for Operations was designed, developed and implemented for Operations continuing training. Certification of simulator fidelity per ANSI/ANS [American National Standards Institute/American Nuclear Society] 3.5, "Nuclear Power Plant Simulators for use in Operator Training," is considered to be sufficient for the initial stages of the BDBEE scenario training. Full scope simulator models have not been explicitly upgraded to accommodate FLEX training or drills. Overview training on FLEX Phase 3 and associated equipment from the SAFER NSRCs was also provided to Dresden operators. Upon SAFER equipment deployment and connection in an event, turnover and familiarization training on each piece of SAFER equipment will be provided to station operators by the SAFER deployment and operating staff. The FIP further described that initial training has been provided and periodic training will be provided to site emergency response leaders on BDB emergency response strategies and implementing guidelines. Continuing training including FLEX drills has been incorporated into EP-AA-122, "Drills and Exercise Program." 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.

In its FIP, the licensee described that where appropriate, integrated FLEX drills will be conducted periodically; with all time-sensitive actions evaluated over a period of not more than eight years. It is not required to connect/operate temporary/permanently installed equipment during these drills. Dresden has incorporated FLEX drills into the Drill and Exercise program per EP-AA-122.

3.12.3 Conclusions

Based on the description above, the NRC staff finds that the licensee has adequately addressed the procedures and training associated with FLEX. The procedures have been issued in accordance with NEI 12-06, Section 11.4, and a training program has been established 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 to the NRC dated October 3, 2013 [Reference 40], which included EPRI Technical Report 3002000623, "Nuclear Maintenance Applications Center: Preventive Maintenance Basis for FLEX Equipment." By letter dated October 7, 2013 [Reference 41], 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. In its FIP, the licensee stated that they would conduct maintenance and testing of the FLEX equipment in accordance with the industry letter.

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 Reduced Set of Hoses and Cables As Backup Equipment

In a letter dated February 26, 2016 [Reference 51], the licensee took an alternative approach to the NEI 12-06 guidance for hoses and cables. In NEI 12-06, Section 3.2.2 states that in order to assure reliability and availability of the FLEX equipment required to meet these capabilities, 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. Thus, a single-unit site would nominally have at least two portable pumps, two sets of portable ac/dc power supplies, two sets of hoses & cables, etc. The NEI, on behalf of the industry, submitted a letter to the NRC [Reference 48] proposing an alternative regarding the quantity of spare hoses and cables to be stored on site. The alternative proposed was that that either a) 10 percent additional lengths of each type and size of hoses and cabling necessary for the N capability plus at least one spare of the longest single section/length of hose and cable be provided or b) that spare cabling and hose of sufficient length and sizing to replace the single longest run needed to support any FLEX strategy. The licensee has committed to following the NEI proposal. By letter dated May 18, 2015 [Reference 49], the NRC agreed that the alternative approach is reasonable, but that the licensees may need to provide additional justification regarding the acceptability of various cable and hose lengths with respect to voltage drops, and fluid flow resistance. The NRC staff approves this alternative as being an acceptable method of compliance with the order.

3.14.2 Storage of Backup (N+1) Equipment in a Non-Robust Building

In a letter dated February 26, 2016 [Reference 51], the licensee proposed an alternative approach to NEI 12-06 for protection of FLEX equipment as stated in Section 5.3.1 (seismic), Section 7.3.1 (severe storms with high winds), and Section 8.3.1 (impact of snow, ice and extreme cold). In general, the guidance in NEI 12-06 is to store the backup (N+1) equipment in a robust storage location, such that it would be available following a BDBEE. The licensee has stored the N+1 equipment in a non-robust (commercial) building, FSB C. The licensee addressed this in its letter as follows:

> Proposed Alternative:
> This alternate approach will be to store "N" sets of equipment in a fully robust building and the +1 set of equipment in a commercial building. For all hazards scoped in for the site, the FLEX equipment will be stored in a configuration such that no one external event can reasonably fail the site FLEX capability (N).
>
> Basis for the alternative approach:
> To ensure that no one external event will reasonably fail the site FLEX capability (N), Exelon will ensure that N equipment is protected in the robust building. To accomplish this, Exelon has developed procedures to address the unavailability allowance as stated in NEI 12-06, Revision 0, Section 11.5.3., (see Maintenance and Testing section below for further details). This section allows for a 90-day period of unavailability. If a piece of FLEX equipment stored in the robust building were to become or found to be unavailable, Exelon will impose a shorter allowed outage time of 45 days. For portable equipment that is expected to be unavailable for more than 45 days or expected to be unavailable during forecast site specific external events, actions will be initiated within 24 hours of this determination to restore the site FLEX capability (N) in the robust storage location and implement compensatory measures (e.g., move the +1 piece of equipment into the robust building) within 72 hours where the total unavailability time is not to exceed 45 days. Once the site FLEX capability (N) is restored in the robust storage location, Exelon will enter the 90-day allowed out of service time for the unavailable piece of equipment with an entry date and time from the discovery date and time.

The NRC staff notes that by letter dated December 10, 2015 [Reference 53], NEI submitted guidance document NEI 12-06, Revision 2, to the NRC for review. By letter dated January 22, 2016 [Reference 54], the NRC staff endorsed NEI 12-06, Revision 2. NEI 12-06, Revision 2, contains modifications which resulted in NRC acceptance of the storage of backup (N+1) equipment in a non-robust storage building. 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 Dresden is evaluated to NEI 12-06, Revision 0, in this safety evaluation, the licensee has committed to follow the 45 day unavailability limit accepted by the NRC in NEI 12-06, Revision 2. Therefore, the NRC staff finds the Dresden 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, Revision 0, guidance, and meets the requirements of the order.

3.14.3 Use of Pre-Staged FLEX Equipment

As described in Section 2.3.2 of the FIP, Dresden is using four permanently pre-staged FLEX pumps (two in each reactor building, one of which is a backup pump), which are located in the reactor building basement rooms at the 476 foot elevation. This is an alternative from the guidance in NEI 12-06, Rev. 0, Section 3.2.2, paragraph 13, which specifies that "...all plants will include the ability to use portable pumps to provide RPV/RCS/SG makeup as a means to provide a diverse capability beyond installed equipment." The licensee does not have a strategy to provide makeup to prevent core damage using portable pumps, but instead relies on the permanently pre-staged FLEX pumps. However, those pumps are installed in the reactor buildings which are Seismic Category I structures. In addition to the seismic hazard, the reactor buildings provide protection from external ice, high wind and extreme high temperature hazards. The NRC staff performed walkdowns of the licensee's proposed locations for the FLEX pumps during the onsite audit to confirm that the FLEX pumps would be protected from all applicable external hazards. The NRC staff also verified that each primary FLEX pump would be accompanied by a backup (N+1) pump, which will reduce any deployment time needed to hook up the backup pump if the primary pump is unavailable. Given that the installed equipment is located in a structure that is robust to the hazards considered within the scope of Order EA-12-049, and a backup pump is readily available, the NRC staff found the alternative to be acceptable. The NRC staff expects that although the guidance of NEI 12-06 has not been met, if the alternative is implemented as described by the licensee, the requirements of the order should be met.

3.14.4 FLEX Water Distribution

In its FIP, the licensee identified the use of a single FLEX valve manifold in the Unit 2 reactor building on the 545 foot elevation. The FLEX valve manifold has hose connections to route the water from the electric FLEX pump in the reactor building basement to those components for both reactors that need water, such as RPV makeup and SFP makeup, and as an alternate flowpath to IC shell side makeup. There are multiple ways to hook up to the components being supplied by the FLEX valve manifold, but in the current strategies the water must pass through the FLEX valve manifold. This is an alternative from the guidance in NEI 12-06, Revision 0, Section 3.2.2, to have primary and alternate connections for the FLEX strategies. The licensee stated that the FLEX valve manifold is protected from all applicable external hazards and is seismically robust. The NRC staff concluded that the FLEX valve manifold will be available to support the FLEX mitigation strategies for the BDBEE. Due to the robust installation of the FLEX valve manifold with protection from all applicable hazards, the NRC staff approves this alternative as being an acceptable method of compliance with the order.

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 24], the licensee submitted its OIP for Dresden in response to Order EA-12-051. By letter dated June 26, 2013 [Reference 25], the NRC staff sent a request for additional information (RAI) to the licensee. The licensee provided a response by letter dated July 18, 2013 [Reference 26]. By letter dated October 29, 2013 [Reference 28], the NRC staff issued an ISE and RAI to the licensee.

By letters dated August 28, 2013 [Reference 27], February 28, 2014 [Reference 29], August 28, 2014 [Reference 30], February 27, 2015 [Reference 31], and August 28, 2015 [Reference 32], the licensee submitted status reports for the Integrated Plan and the RAI in the ISE. 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 January 12, 2016 [Reference 33], the licensee reported that full compliance with the requirements of Order EA-12-051 was achieved. By email dated February 2, 2017 [Reference 35], the licensee responded to further NRC questions.
The licensee has installed a SFP level instrumentation system designed by Westinghouse, 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 18, 2014 [Reference 34].

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 included 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 9, 2015 [Reference 17], 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

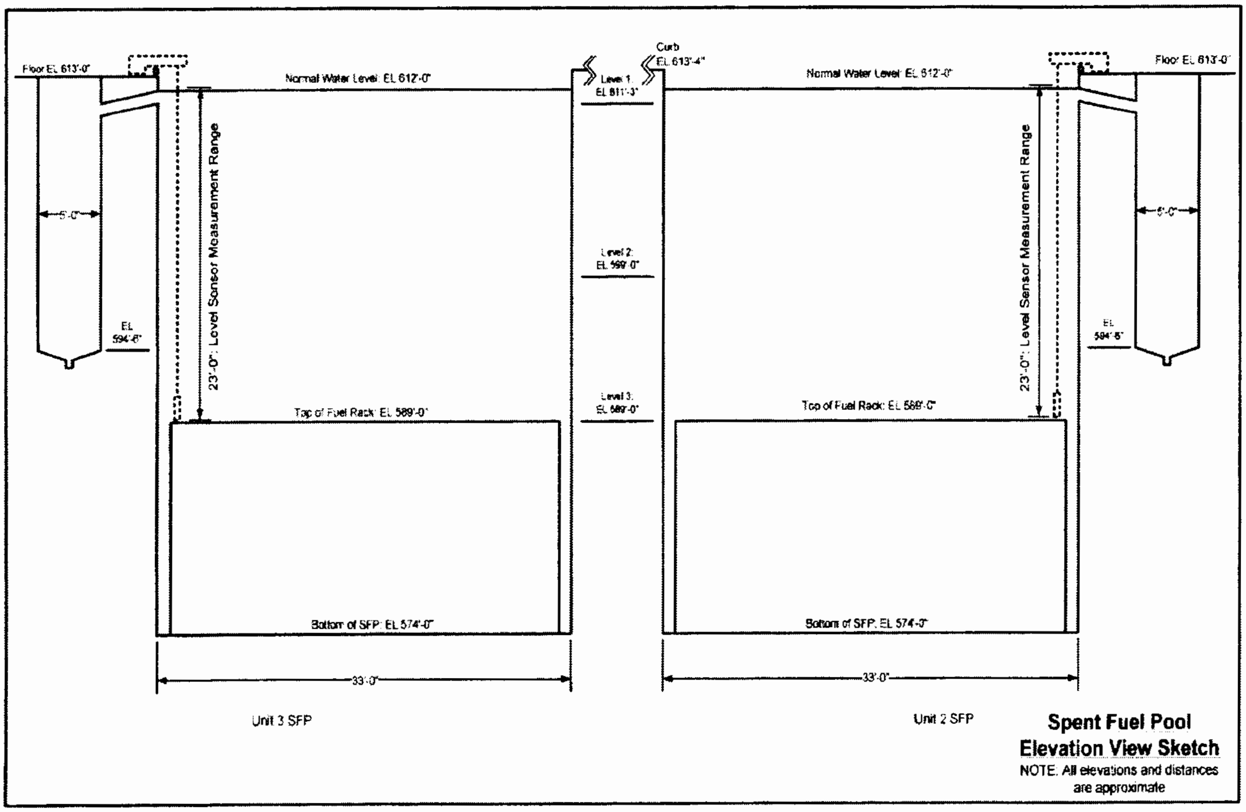

Figure 1 - "Dresden SFP Levels of Monitoring"

Dresden Nuclear Power Station, Units 2 and 3, has two independent SFPs located in the Reactor Building. The pools are identical and are not interconnected. In its OIP, the licensee identified the SFP levels of monitoring as follows:

- Level 1 corresponds to the 612 foot 0 inch (612' 0") plant elevation
- Level 2 corresponds to the 599' 0" plant elevation
- Level 3 corresponds to the 589' 0" plant elevation

In its letter dated July 18, 2013 [Reference 26], the licensee revised the Level 1 from 612' to 611' 3" plant elevation. In this letter, for the modified Level 1, the licensee stated that the SFP at Dresden Station has skimmers and scuppers located at an approximate 611'-3" elevation that water must flow into. From there the water is routed to the surge tanks from which the SFP cooling pumps draw suction. The suction trip is at an approximate 595'-0" elevation. The licensee also provided a sketch depicting the final SFP levels of monitoring and the measurement ranges for the instrument channels as shown above in Figure 1, "Dresden SFP Levels of Monitoring." The NRC staff's assessment of the licensee selection of the SFP levels of monitoring is as follows.

Per NEI 12-02, Section 2.3.1, Level 1 will be the HIGHER of two points. The first point is the water level at which suction loss occurs due to uncovering of the spent fuel cooling inlet pipe. This was identified by Dresden as elevation 611' 3". The second point is the water level at which loss of spent fuel cooling pump net positive suction head occurs under saturated conditions. This was identified by Dresden as elevation 595' 0". Dresden designated Level 1 (611' 3") as the HIGHER of the above two points and therefore consistent with NEI 12-02. Level 2 was identified as elevation 599' 0". This level is consistent with the first of the two options in NEI 12-02 for Level 2, which is 10 feet (+/- 1 foot) above the highest point of any fuel rack seated in the SFP. Level 3 is consistent with the NEI 12-02 parameter for Level 3, which is the highest point of any fuel rack seated in the SFP.

Based on the evaluation above, the NRC staff finds that the licensee's selection of Levels 1, 2 and 3 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 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 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 for both units, the primary and backup instrument channels level sensing components will be located and permanently mounted in the unit's dedicated SFP. The level indication will be provided by a guided wave radar system, with a submersible pressure transducer.

In its letter dated July 18, 2013 [Reference 26], the licensee provided a sketch depicting the final SFP levels of monitoring and the instrument's measurement range (Figure 1 of this evaluation). In this figure, the measurement range is from 612' 0" to 589' 0" plant elevation. The NRC staff noted that the 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 SFP instrument channels and measurement range, 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

Regarding the SFP level instrument arrangement, in its letter dated August 28, 2015 [Reference 32], the licensee provided a sketch depicting the SFP level instrument probe locations for both units. The Unit 2 level probes are located at the west wall and northeast corner of the pool. The Unit 3 level probes are located at the east wall and northwest corner of the pool. Based on this sketch, the probes are separated by a distance greater than the span of the shortest side of the pool.

The NRC staff noted, with verification by walkdown during the onsite audit, that there is sufficient channel separation within the SFP area between the primary and backup level instrument channels, sensor electronics, and routing cables to provide reasonable protection against loss of SFP level indication due to missiles that may result from damage to the structure over the SFP.

Based on the evaluation above, 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

With regard to the mounting design of the SFP level probe, in its letter dated August 28, 2015 [Reference 32], the licensee stated that all SFP instrumentation system equipment is designed in accordance with the Dresden safe shutdown earthquake (SSE) design requirements. Westinghouse evaluated the structural integrity of the mounting brackets in calculations CN-PEUS-14-20, "Pool-side Bracket Seismic Analysis." The GTSTRUDL model was used to calculate the stresses in the bracket assembly, and considered load combinations for the dead load, live load, and seismic load on the bracket. The reactionary forces calculated from these loads become the design inputs to design the mounting bracket anchorage to the refuel floor to withstand an SSE. The seismic loads are obtained from Dresden's response spectra curves.

For the hydrodynamic effects on the SFP level probes, in the same letter above the licensee stated that sloshing forces were obtained by analysis. Horizontal and vertical impact force on the bracket components was calculated using the wave height and natural frequency obtained using document TID-7024, "Nuclear Reactors and Earthquakes," 1963, by the U.S. Atomic Energy Commission. Using this methodology, sloshing forces have been calculated and added to the total reactionary forces that would be applicable for bracket anchorage design. The analysis also confirms that the level probe can withstand a design-basis seismic event.

As for the mounting design of the SFP level instrument electronics, in its letter dated August 28, 2015 [Reference 32], the licensee stated that the Dresden-specific calculation DRE14-0048, "Seismic Qualification of the Spent Fuel Pool Level Instrumentation System Components," has been developed to address the seismic qualification of the readout display in the turbine building. The design criteria in this calculation will meet the requirements to withstand an SSE. The methods used in the calculation follow Institute of Electrical and Electronics Engineers (IEEE) Standard 344-2004 and IEEE Standard 323-2003 for seismic qualification of the instrument.

During the onsite audit, the NRC staff reviewed calculation DRE14-0048, "Seismic Qualification of the Spent Fuel Pool Level Instrumentation System Components," Rev. 0, which qualified the mounting for the electronics enclosures, transmitters, and pull boxes. The staff noted that this calculation does not address the design and mounting of the SFP level instrument conduit supports. The licensee provided a response in an email dated February 2, 2017 [Reference 35], in which it stated that standard Seismic Category 1 conduit supports for the SFP level instrumentation (SFPLI) are installed per Dresden Standard Electrical Conduit Supports Specification K-4081, which are depicted on drawings B-1958, B-1959, and B-1960. Where engineered (non-standard) conduit supports were required, Calculation DRE14-0047, "SFPLI

Special Conduit Supports and Core Holes," qualified those supports. Calculation DRE14-0047 qualifies these non-standard conduit supports for normal loads and design-basis seismic loads.

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 assumptions, analysis, and modeling used in the sloshing analysis for the sensor mounting bracket are adequate.

Based on the evaluation 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 are not already covered by existing quality assurance requirements. In 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 reliability will be established through the use of an augmented quality assurance process (e.g., a process similar to that applied to the site fire protection program).

The NRC staff finds that, if implemented appropriately, this approach 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.

4.2.4.2 Equipment Reliability

Section 3.4 of NEI 12-02 states, in part:

> The instrument channel reliability shall be demonstrated via an appropriate combination of design, analyses, operating experience, and/or testing of channel components for the following sets of parameters, as described in the paragraphs below:
>
> - conditions in the area of instrument channel component use for all instrument components,
> - effects of shock and vibration on instrument channel components used during any applicable event for only installed components, and
> - seismic effects on instrument channel components used during and following a potential seismic event for only installed components.

Equipment reliability performance testing was performed by the vendor to (1) demonstrate that the SFP instrumentation will not experience failures during BDB conditions of temperature, humidity, emissions, surge, and radiation, and (2) to verify those tests envelope the plant-specific requirements.

During the vendor audit [Reference 34], the NRC staff reviewed the Westinghouse SFP level instrumentation's qualifications and testing for temperature, humidity, radiation, shock and vibration, and seismic. The staff further reviewed Dresden's seismic, radiation, and environmental anticipated conditions during the on-site audit [Reference 17]. Below is the staff's assessment of the equipment reliability of Dresden SFP level instrumentation.

4.2.4.2.1 Temperature, Humidity, and Radiation

For the BDB environmental and radiological conditions in Dresden's SFP area with regard to the SFP level instrument qualifications, in its letter dated August 28, 2015 [Reference 32], the licensee stated that Westinghouse qualified the components (probe, connector, and cable) of the SFP instrument system located in the SFP area to the BDB environment. Components of the system were subjected to beyond-design-basis conditions of heat and humidity, thermal and radiation aging mechanisms. This testing confirmed functionality of these system components under beyond-design-basis environmental conditions. The licensee further stated that the level sensor probe, coax coupler and connector assembly, launch plate and pool side bracket assembly, and coax cable are designed and qualified to operate reliably in the below specified environmental conditions (Table 1 –Environmental and Radiological Limits for Equipment in SFP Area).

Table 1 –Environmental and Radiological Limits for Equipment in SFP Area

Parameter	Normal	BDB
Temperature	50-140 °F	212 °F
Humidity	0-95% Relative Humidity (RH)	100% RH (saturated steam)
Radiation Total Integrated Dose (TID) γ (above pool)	1E03 Rad	1E07 Rad
Radiation TID γ (12" above top of fuel rack)	1E09 Rad (TID Max Life Dose) (probe and weight only)	1E07 Rad (7-Day Dose)

Based on the information in this letter, in the Westinghouse document, and the NEI 12-02 guidance regarding expected environmental and radiological conditions in the SFP area during a BDB event, the NRC staff finds that the equipment qualifications envelop the expected environmental and radiological conditions in Dresden's SFP area.

As for the environmental and radiological conditions outside of the SFP area, in its letter dated August 28, 2015 [Reference 32], the licensee stated that the level sensor transmitter and bracket and the electronics display enclosure and bracket are designed and qualified to operate reliably in the below specified environmental conditions (Table 2 –Environmental and Radiological Limits for Equipment Outside of SFP Area).

Table 2 –Environmental and Radiological Limits for Equipment Outside of SFP Area

Parameter	Normal	BDB	BDB (Level Sensor Electronics Only)
Temperature	50-120 °F	140 °F	140 °F
Humidity	0-95% RH	0-95% RH (non-condensing)	0-95% RH (non-condensing)
Radiation TID γ	≤ 1E03 R γ	≤ 1E03 R	≤ 1E03 R

The NRC staff noted that the licensee did not provide the expected environmental and radiological conditions of the turbine building during a BDB event; and therefore, the staff was unable to verify that the SFP level instrument is able to maintain its designed functionality during a BDB event. In response to the staff's concern, in its email dated February 2, 2017 [Reference 35], the licensee stated that the normal and abnormal design temperature conditions for the Turbine Building, which contains the transmitters and electronics enclosures, is 120 °F for both conditions (Environmental Zone 39, Ref. DRE01-0041). These components are required to operate reliably per the service environmental conditions specified above. These environment conditions occur during normal plant operation, including any abnormal operating occurrence. An abnormal operating occurrence would be a loss of HVAC in the installed equipment location. The testing was conducted in accordance with EQ-TP-328. The results of the testing are summarized in Westinghouse document EQ-QR-269. EQ-QR-269 shows that the electronics enclosure and level transmitter enclosure are environmentally tested up to 140 ºF while maintaining the accuracy requirement of ±3 inches. This shows that the equipment operates per its requirements in the normal and abnormal conditions.

The licensee further stated that for the Unit 2 backup electronics enclosure and transmitter on the Unit 2 side of the plant, the straight line distance from the pool to the electronics enclosure mounted in the Turbine Building at EL. 561'-6" is about 56'. For conservatism, using a distance of 50', and treating all walls and floors as a combined 3' in straight thickness, an overall dose rate for the area can be obtained. Based on Design Analysis BYR13-187 Table 7.4-1 (which lists calculated dose rates as a function of distance) and Table 7.3-4 (which lists wall thickness scaling factors), the dose rate is 1.21E+02 roentgen equivalent man (rem)/hr (function of distance from spent multiplier) x 2.151E-10 (wall thickness scaling multiplier) = 2.6E-08 rem/hr at the backup channel electronics enclosure and transmitter during a BDBEE when the water in the SFP is the top of the fuel assemblies as a result of spent fuel pool drain down. As the Unit 2 primary electronics enclosure and transmitter are farther away from the pool and separated by the same amount of walls as the backup electronics enclosure and transmitter, the dose rate of 2.6E-08 rem/hr is applied to both channels for conservatism.

For the Unit 3 primary and backup electronics enclosure and transmitter on the Unit 2 side of the plant, the straight line distance from the pool to the electronics enclosure mounted in the Turbine Building at EL. 561'-6" is 57'. For conservatism, using a distance of 50', and treating all walls and floors as a combined 3' in straight thickness, an overall dose rate for the area can be obtained. Based on Design Analysis BYR13-187 Table 7.4-1 (which lists calculated dose rates as a function of distance) and Table 7.3-4 (which lists wall thickness scaling factors), the dose rate is 1.21E+02 rem/hr (function of distance from spent multiplier) x 2.151E-10 (wall thickness scaling multiplier) = 2.6E-08 rem/hr at both channels electronics enclosure and transmitter during a BDBEE when the water in the SFP is the top of the fuel assemblies as a result of spent fuel pool drain down.

The NRC staff noted that the licensee used Byron Design Analysis BYR13-187, "Radiation Doses in the Vicinity of the Spent Fuel Pool at Reduced Water Level" to analyzed the expected radiological condition for the Dresden Turbine Building. However, as stated in BYR13-187, Rev.9, dated March 19, 2014, the configuration of the SFP and Fuel Handling Building for each Exelon-operated nuclear fleet's station [as of the time the analysis was issued] is evaluated in order to extend the applicability of the analysis to each Exelon-operated station including Dresden Generating Station, BYR13-187 therefore is applicable to Dresden.

In addition, in its email dated February 2, 2017 [Reference 35], the licensee stated that NRC Order EA-12-051 requires that 7 days (168 hours) with the water level at the top of the fuel rack in the SFP be considered to establish TID. Using the dose rate of any of the Unit 2 or 3 channels of 2.6E-08 rem/hr, and a duration of 168 hours, the 7 day TID can be calculated as 4.4E-06 rem. This dose is considered negligible and will not impact the operation of the SFP equipment, located outside the SFP area which is qualified to withstand a TID up to 1E03 R.

Based on this response, the NRC staff found that the environmental and radiological conditions at the turbine building locations, where the SFP level instrument electronics are located, are bounded by the equipment qualifications; and therefore, if installed and maintained properly, the equipment should provide its designed functions during a postulated BDBEE.

Based on the evaluations above, the NRC staff finds that the licensee adequately addressed the equipment reliability of SFP level instrumentation with respect to temperature, humidity and radiation. The equipment qualifications envelop Dresden's anticipated conditions of radiation, temperature, and humidity during a postulated BDBEE and post event. The equipment environmental testing demonstrated that the SFP instrumentation should maintain its functionality under expected BDB conditions.

4.2.4.2.2 Shock and Vibration

In its letter dated August 28, 2015 [Reference 32], the licensee stated that the SFPLI pool side brackets for both the primary and backup SFP measurement channels will be permanently installed and fixed to rigid refuel floors or walls, which are Seismic Category 1 structures. The SFPLI components, such as the level sensor and its bracket and the display enclosure and its bracket, were subjected to seismic testing, including shock and vibration test requirements. The level sensor electronics are enclosed in a NEMA-4X housing. The display electronics panel utilizes a NEMA-4X rated stainless steel housing as well. These housings will be mounted to a seismically qualified wall and will contain the active electronics, and aid in protecting the internal components from vibration-induced damage.

The NRC staff noted that the licensee adequately addressed the equipment reliability of SFP level instrumentation with respect to shock and vibration. The test parameters envelop Dresden's potential shock and vibration conditions during a postulated BDBEE.

4.2.4.2.3 Seismic

For the SFP level instrument design with respect to seismic events, in its letter dated August 28, 2015 [Reference 32], the licensee stated that the seismic loads were obtained from Dresden's response spectra curves (Reference TDBD-DQ-1 for Dresden Nuclear Generating Station). The following methodology was used in determining the stresses on the bracket assembly:

- Frequency analysis, taking into account the dead weight and the hydrodynamic mass of the structure, is performed to obtain the natural frequencies of the structure in all three directions.
- SSE response spectra analysis is performed to obtain member stresses and support reactions.
- Modal responses are combined using the Ten Percent Method per NRC Regulatory Guide 1.92, Revision 1, "Combining Modal Responses and Spatial Components in Seismic Response Analysis."
- The seismic loads for each of the three directions are combined by the Square Root of the Sum of Squares Method.
- Sloshing analysis is performed to obtain liquid pressure and its impact on bracket design.
- The seismic results are combined with the dead load results and the hydrodynamic pressure results in absolute sum. These combined results are compared with the allowable stress values.

The NRC staff noted that the licensee adequately addressed the equipment reliability of SFP level instrumentation with respect to seismic events. The SFP level instrument was tested to the seismic conditions that envelop Dresden's SSE. The NRC staff also noted that the assumptions, analytical, and conclusion model used in the sloshing analysis for the sensor mounting bracket are adequate. Further seismic qualifications of the SFP level instrumentation mounting is addressed in Subsection 4.2.3, "Design Features: Mounting," of this evaluation.

4.2.4.2.4 Aging

Depending on the installation configurations, Westinghouse provided two types of SFP cable connectors, a straight connector or a 90-degree connector. Both of them originally were qualified for a 15-month life. Westinghouse performed the life-upgrade tests for both straight and 90-degree cable connectors. The tests include radiation aging, thermal aging, and steam tests. While the 90-degree connector passed the initial tests, the straight connector failed the steam test due to leakage caused by the sealant around the connector. Westinghouse's solution was to encapsulate the exposed epoxy of the connector with Raychem boots. The straight connector modification eventually passed the aging tests.

In its email dated February 2, 2017 [Reference 35], the licensee stated that Dresden utilizes the 90-degree connectors at the SFP level probes (pool side). Since modification is required only for the straight connector if it is installed at the pool side, which is not applicable to Dresden, the NRC staff found that the design of the cable connector at Dresden is adequate.

4.2.4.2.5 Electromagnetic Compatibility

As a result of the NRC staff's evaluation of the Electromagnetic Compatibility (EMC) testing results during the vendor audit, the staff identified a generic open item, applicable to all licensees using Westinghouse SFP level instruments, to identify any additional measures, site-specific installation instructions or positions taken to address the potential effect of an EMC event on the SFPLI equipment. During the onsite audit, the NRC staff enquired as to an assessment of potential susceptibilities of Electromagnetic Interference/Radio Frequency Interference (EMI/RFI) in the areas where the SFP instrument located and how to mitigate those susceptibilities.

In its email dated February 2, 2017 [Reference 35], the licensee provided an assessment of potential susceptibilities of Electromagnetic Interference/Radio Frequency Interference (EMI/RFI) in the areas where the SFP level instrument is located and how to mitigate those susceptibilities. In this email, the licensee stated that the SFPLI system has been designed to meet the necessary EMC requirements. The EMC-compliant design utilizes an insulated tracer wire for electromagnetic shielding that is routed along with the coaxial cable and grounded to both the probe launch plate and the transmitter housing mounting bracket. Additionally, a 470 picofarad capacitor is installed in the level transmitter between the level transmitter ground terminal and shield of the 4-20 milliamp cable, and 360° bonding is applied to the 4-20 milliamp cable at the electronics enclosure.

Three different test configurations for the new equipment (receiver configuration, transmitter configuration, and wired configuration) have been subjected to EMC emissions and susceptibility type testing to satisfy the necessary requirements outlined in Westinghouse document EQ-PP-8, "Seismic, Environmental, and Electromagnetic Compatibility Test Plan for the Spent Fuel Pool Instrumentation System." This document provides acceptable EMC evaluation. As documented in Westinghouse document EQ-QR-269, "Design Verification Testing Summary Report for the Spent Fuel Pool Instrumentation System," the necessary EMC tests must be performed on the equipment. Per EQ-QR-269, the equipment is required to meet the criteria defined in Performance Criterion B, which states, "the apparatus (equipment) shall continue to operate after the test. No degradation or loss of function is allowed below a performance level specified by the manufacturer when the apparatus (equipment) is used as intended." The equipment was found to be compliant when subjected to the following emissions tests:

MIL-STD-461E, CE101
MIL-STD-461E, CE102
MIL-STD-461E, RE101
MIL-STD-461E, RE102

Additionally, the equipment was found to be compliant when subjected to the following International Electrotechnical Commission (IEC) susceptibility tests:

IEC 61000-4-16 (Not included in CC-AA-103-1005)
IEC 61000-4-6
IEC 61000-4-4
IEC 61000-4-5
IEC 61000-4-12 (Not included in CC-AA-103-1005)

These testing standards for emission and susceptibility, unless otherwise noted, are specifically the standards set forth in Exelon procedure CC-AA-103-1005, "Evaluating and Mitigating Electrically Induced Noise in Instrumentation and Control Circuits."

Also, to alleviate further concerns related to EMI/RFI, a two foot minimum exclusion zone has been implemented around the electronics enclosures and transmitters at Dresden. The modification test operated a radio outside of the two foot perimeter radio exclusion zone for the electronics enclosures and transmitters and verified that no noticeable interference is introduced.

The NRC staff finds that the licensee adequately addressed the electromagnetic compatibility of the SFP level instrumentation. In addition, the radio exclusion zone will provide preventive measures for EMI/RFI susceptibilities.

In conclusion of the staff's assessment of the equipment reliability, the NRC staff finds 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

For the SFP level instrument channel's physical independence, in its letter dated August 28, 2015 [Reference 32], the licensee stated that the level probes will be mounted on the east and west side of each SFP and will be separated by a distance greater than the span of the shortest side of the pool. Three of the primary and backup instrument channel displays will be located on the main floor of the turbine building mounted on a wall shared with the reactor building. The fourth channel is in the immediate vicinity on an extension wall. There will be physical and spatial separation between the displays. Each system's cables will be spatially separated using Dresden's divisional spatial separation criteria.

For the SFP level instrument channel's electrical independence, in its letter dated August 28, 2015 [Reference 32], the licensee stated that the independent power sources will consist of powering each train from a separate power supply.

The NRC staff verified during the onsite walkdown that the licensee adequately addressed the SFP level instrument channel independence. The instrument channels' physical separation is further discussed in Subsection 4.2.2, "Design Features: Arrangement." With the licensee's proposed design, the loss of one level instrument channel would not affect the operation of the other channel under BDBEE conditions. The 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 letter dated August 28, 2015 [Reference 32], the licensee stated that the primary and backup SFPLI instrument channels will be normally powered from 120 Vac. Upon loss of normal ac power, individual batteries installed in each channel's electronics/UPS enclosure will automatically maintain continuous channel operation for at least three days. Additionally, a receptacle and a selector switch are installed in each channel electronics/UPS enclosure to allow direct connection of emergency power to the SFPLI.

The Westinghouse report, WNA-CN-00300-GEN, provides the results of the calculation depicting the battery backup duty cycle. This calculation demonstrates that battery capacity is 4.22 days to maintain the level indicating function to the display location, which is located in the turbine building. The calculation also determines that the battery will last for 72 hours. The Dresden readout display of level indication in the turbine building will be available for at least 72 hours of operation.

During the onsite audit, the NRC staff inquired as to how the SFP instrument channels are powered during an ELAP event, prior to the depletion of the back-up batteries. In response, the licensee stated that the 120 Vac power for the primary and backup level indicating displays will be provided from Unit 2 Essential Service Bus (Unit 2 primary and Unit 3 primary) and Unit 3 Essential Service Bus (Unit 3 backup and Unit 2 backup). The ESS busses are initially powered from the safety-related 250 Vdc batteries during an ELAP. Procedure FSG-6 restores power to the 480 Vac buses 28/29/38/39 with the use of the FLEX DG, and procedure DGA-3 restores power to the battery system prior to the depletion of the batteries. Therefore, the SFPLI systems will not lose power during an ELAP.

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 letter dated August 28, 2015 [Reference 32], the licensee stated that Westinghouse documents WNA-CN-00301-GEN and WNA-DS-02957-GEN describe the channel accuracy under both normal SFP level conditions and at the BDB conditions that would be present if SFP level were at Level 2 and Level 3 datum points. Each instrument channel will be accurate to within ±3" during normal SFP level conditions. The instrument channels will retain this accuracy after BDB conditions.

The NRC staff noted that the licensee adequately addressed the SFP level instrumentation accuracy requirements including the expected instrument channel accuracy performance under both normal and BDB 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

For the SFP level instrument's periodic testing and calibration, in its letter dated August 28, 2015 [Reference 32], the licensee stated that Westinghouse calibration procedure WNA-TP-04709-GEN and functional test procedure WNA-TP-04613-GEN describe the capabilities and provisions of SFPLI periodic testing and calibration, including in-situ testing. Westinghouse calibration and functional test procedures are acceptable for Dresden. The licensee has reviewed the procedures to ensure the instruments can be calibrated, functionally tested, and in-situ tested per the Order requirements.

The level displayed by the channels has been verified per the Dresden administrative and operating procedures, as recommended by Westinghouse vendor technical manual WNA-GO-00127-GEN. If the level is not within the required accuracy per Westinghouse-recommended tolerances in WNA-TP-04709-GEN, channel calibration will be performed.

Functional checks will be performed per Westinghouse functionality test procedure WNA-TP-04613-GEN at the frequency determined by Dresden maintenance and operating programs based on the Westinghouse recommended frequency. Calibration tests will be performed per Westinghouse calibration procedure WNA-TP-04709-GEN at the frequency determined by Dresden maintenance and operating programs based on the Westinghouse recommended frequency. In accordance with Dresden maintenance and operating programs, the licensee has developed calibration, functional test, and channel verification procedures per Westinghouse recommendations to ensure reliable, accurate and continuous SFPLI functionality.

Dresden has developed preventive maintenance tasks for the SFPLI per Westinghouse recommendation identified in the technical manual WNA-GO-00127-GEN to assure that the channels are fully conditioned to accurately and reliably perform their functions when needed.

The NRC staff finds that the licensee's proposed SFP instrumentation design allows for testing, including functional test and channel check, and 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 letter dated August 28, 2015 [Reference 32], the licensee stated that the primary and backup instrument channel displays are located in the turbine building, along the reactor building wall. This location was selected due to the display location proximity to the main control room. Dresden UFSAR Section 3.8.4 states that the turbine building portion of the structural complex is a Class II structure as explained in Section 3.8.5. In the UFSAR, Section 3.8.5 states that Class II structures supporting Class I structures, systems and components were designed to Class II requirements and have been investigated to assure that the integrity of the Class I items is not compromised. The instrument channel display location has been investigated to assure that the integrity of the display items is not compromised. Both primary and backup instrument channel display locations are selected to reduce the likelihood of missile damage to the displays.

For the radiological and environmental habitability of the SFP level instrument display location, in its letter dated August 28, 2015 [Reference 32], the licensee stated that UFSAR Table 3.11-2 shows zone 38 with a normal maximum temperature of 120 °F, which would allow emergency responders to perform level display monitoring. Radiological habitability at the display location and the path to the display location was evaluated against estimated dose rates from SFP draindown conditions to Level 3, and exposure to personnel monitoring SFP levels are expected to remain less than emergency exposure limits allowable for emergency responders to perform this action. Also, for severe accident scenarios involving core damage and increased radiological exposure levels, short-term access to these SFP level displays can be achieved (see UFSAR Appendix 12A). Exposure duration to personnel monitoring SFP levels would be limited to remain less than emergency exposure limits allowable for emergency responders to perform this action. The SFP electronics and displays are not expected to accumulate radiation dose higher than the qualified TID of 1.0E03 rad. This is because the location is outside secondary containment and not near any piping systems that could contain fission products (see UFSAR Appendix 12A). Heat and humidity from SFP boildown conditions was evaluated for this location. The location is at an elevation below the SFP operating floor and physically separated by secondary containment such that heat and humidity from a boiling SFP is not expected to compromise habitability at this location or along the path to the display location.

As for the accessibility of the SFP level instrument display location, in its letter dated August 28, 2015 [Reference 32], the licensee stated that travel time from the control room to the primary and secondary display is approximately 5 minutes based on walkdowns. There are alternate paths if the primary path is blocked or is not habitable. The maximum time to reach the display locations via the alternate paths is 8 minutes.

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

4.3.1 Programmatic Controls: Training

In its OIP, the licensee stated that personnel performing functions associated with these SFP level instrumentation channels will be trained to perform the job specific functions necessary for their assigned tasks (maintenance, calibration, surveillance, etc.). This training will be consistent with equipment vendor guidelines, instructions and recommendations. The Systematic Approach to Training will be used to identify the population to be trained and to determine the initial and continuing elements of the required training. Training will be completed prior to placing the instrumentation in service.

Guidance document NEI 12-02 specifies that the Systematic Approach to Training process can be used to identify the population to be trained, and also to determine both the initial and continuing elements of the required training. The NRC staff finds that the licensee's proposed plan to train personnel in the operation, maintenance, calibration, and surveillance of the SFPLI and in 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

For Dresden procedures related to the SFPLI, in its letter dated August 28, 2015 [Reference 32], the licensee stated that site procedures will be developed for system inspection, calibration and test, maintenance, repair, operation and normal and abnormal responses, in accordance with Exelon's procedure control process. Technical objectives to be achieved in each of the respective procedures are described below:

- System Inspection: To verify that system components are in place, complete, and in the correct configuration, and that the sensor probe is free of significant deposits.

- Calibration and Test: To verify that the system is within the specified accuracy, is functioning as designed, and is appropriately indicating SFP water level.

- Maintenance: To establish and define scheduled and preventive maintenance requirements and activities necessary to minimize the possibility of system interruption.

- Repair: To specify troubleshooting steps and component repair and replacement activities in the event of system malfunction.

- Operation: To provide sufficient instructions for operation and use of the system by plant operation staff.

In its email dated February 2, 2017 [Reference 35], the licensee noted that the following procedures, have been developed for the SFP level instrumentation system:

- Calibration procedure DIS 1900-01, "Spent Fuel Pool Level Primary Indication Calibration" and DIS 1900-02, "Spent Fuel Pool Level Backup Indication Calibration" provide guidance for calibration check using the two-point verification/ calibration check. These procedures also include acceptance criteria for the equipment accuracy and tolerance, functional testing, channel check (cross-channel comparison) and in-situ testing. The procedures provide guidance when a repair is required.

- Operator Rounds Program (OP-AA-102-102): SFPLI Channel Checks to verify both channels indicate approximately the same level to insure the instruments are meeting their accuracy requirements.

- Procedure CC-DR-118, "Site Implementation of Diverse and Flexible Coping Strategies (FLEX) and Spent Fuel Pool Instrumentation Program," with instructions to take compensatory actions when either one or both channels are out of service.

- FLEX Support Guideline FSG-10, "FLEX Spent Fuel Pool Make-Up," provides guidance for using the SFPLI to monitor the SFP level in a FLEX event.

- Procedure DOA 1900-01, "Loss of Fuel Pool Cooling," provides direction for operations to monitor the SFP level with the SFPLI.

The NRC staff noted that the licensee adequately addressed the SFP level instrument procedure requirements. The procedures have been established for the testing, surveillance, calibration, operation, and abnormal responses for the primary and backup SFP level instrument channels. The staff finds that the scope of the licensee's 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

For the SFP level instrument testing and calibration programs, in its letter dated August 28, 2015 [Reference 32], the licensee stated that performance tests (functional checks) are described in the vendor operator's manual and plant operating procedures. Performance tests are planned to be performed periodically as recommended by the vendor. Channel functional tests per operations procedures with limits established in consideration of vendor equipment specifications will be performed at appropriate frequencies established equivalent to or more frequently than existing SFPLI. Manual calibration is planned to be performed periodically with additional maintenance on an as-needed basis when flagged by the system's automated diagnostic testing features. Channel calibration tests are planned to be performed at frequencies established in consideration of vendor recommendations. SFPLI channel/equipment maintenance/preventative maintenance and testing program requirements to ensure design and system readiness are planned to be established in accordance with Exelon'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 (and available for inspection and audit).

During the onsite audit, the NRC staff inquired about the scope of the Dresden preventive maintenance program to maintain the equipment reliability. In response, the licensee stated that the following preventive maintenances (PMs) will be developed:

- SFPLI Battery Replacement: 2 Years
- Channel Check- SFP Level Indication: 7 Days
- Electronic Component replacement SFP Level Indication Component: 88.7 Years
- Spent Fuel Pool Instrument Calibration: 12 Months
- Probe Replacement PM: 40 Years
- Transmitter Replacement PM: 7 Years
- Verify Power Source Walkdown: 4 Days
- Perform camera inspection of the sensor probe (full range) to ensure there is no damage or corrosion. Inspection is to be performed once a year: 1 Year

In its email dated February 2, 2017 [Reference 35], the licensee further stated that an annual SFPLI inspection and calibration check will be performed. The inspection includes a camera inspection of the sensor probe (full range) to ensure there is no damage or corrosion. The calibration check uses the two-point verification/ calibration check from procedures DIS 1900-01 and DIS 1900-02.

As for the compensatory measures for the SFP level instrument channel(s) out-of-service, in its letter dated August 28, 2015 [Reference 32], the licensee stated that both primary and backup SFPLI channels will incorporate permanent installation (with no reliance on portable, post-event installation) of relatively simple and robust augmented quality equipment. Permanent installation coupled with stocking of adequate spare parts reasonably diminishes the likelihood that a single channel is out-of-service for an extended period of time, and greatly diminishes the likelihood that both channels are out-of-service for an extended period of time. Planned compensatory actions for unlikely extended out-of-service (OOS) events are summarized as follows in Table 3.

Table 3 – Compensatory Measures for SFP Level Instrument Channel(s) Out-of-Service

# Channel(s) OOS	Required Restoration Action	Compensatory Action if Required Restoration Action not Completed within Specified Time
1	Restore channel to functional status within 90 days (or if channel restoration not expected within 90 days, then proceed to Compensatory Action)	Immediately initiate action in accordance with Note below
2	Initiate action within 24 hours to restore one channel to functional status and restore one channel to functional status within 72 hours	Immediately initiate action in accordance with Note below

Note: Initiate an Issue Report to enter the condition into the Corrective Action Program. Identify the equipment out of service time is greater than the specified allowed out of service time, develop and implement an alternate method of monitoring, determine the cause of the non-functionality, and the plans and schedule for restoring the instrumentation channel(s) to functional status.

The NRC staff noted that the licensee adequately addressed testing and calibration programs to maintain the SFP instrument channels at the design accuracy. The licensee testing and calibration plan appears to be 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 staff finds that the licensee's proposed testing and calibration program 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 January 12, 2016 [Reference 33], 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 Dresden 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 August 2015 [Reference 17]. The licensee reached its final compliance date on June 17, 2016, and has declared that both of the reactors are 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 and which the NRC staff has evaluated to be satisfactory for compliance with these orders. Based on the evaluations above, the NRC staff concludes that the licensee has developed guidance and proposed designs which 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

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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," Revision 0, August 21, 2012 (ADAMS Accession No. ML12242A378)

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11. Exelon letter to NRC, "Dresden Nuclear Power Station, Units 2 and 3, First Six-Month Status Report [With Revised OIP] 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)," August 28, 2013 (ADAMS Accession No. ML13241A282)

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Date: February 16, 2017

DRESDEN NUCLEAR POWER STATION, UNITS 2 AND 3 - SAFETY EVALUATION REGARDING IMPLEMENTATION OF MITIGATING STRATEGIES AND RELIABLE SPENT FUEL POOL INSTRUMENTATION RELATED TO ORDERS EA-12-049 AND EA-12-051 DATED February 16, 2017

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