June 10, 2013

MEMORANDUM TO: John Segala, Chief
Licensing Branch 1
Division of New Reactor Licensing
Office of New Reactors

FROM: Michael Eudy, Project Manager ***/RA/***
Licensing Branch 1
Division of New Reactor Licensing
Office of New Reactors

SUBJECT: AUGUST 2013, AUDIT OF DIRECT CURRENT POWER LOAD SHEDDING CALCULATIONS FOR DEMONSTRATING CAPABILTY OF THE U.S. EPR DESIGN FOLLOWING A BEYOND DESIGN EXTERNAL EVENT IN ACCORDANCE WITH INTERIM STAFF GUIDANCE JLD-ISG 2012-01

By letter dated December 11, 2007, as supplemented by letters dated February 7, 2008, and February 20, 2008, AREVA Inc. (AREVA) submitted an application to the U.S. Nuclear Regulatory Commission (NRC) for a standard design certification (DC) of the U.S. EPR, pursuant to title 10 of the *Code of Federal Regulation* (10 CFR) Part 52, "Licenses, Certifications, and Approvals for Nuclear Power Plants."

The purpose of this audit was to verify that the U.S. EPR design acceptably addressed the specific provisions related to baseline coping capability utilizing direct current (DC) power in 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," (Agencywide Documents Access and Management System (ADAMS) Accession No. ML12229A174) dated August 29, 2012 that endorses the Nuclear Energy Institute (NEI) 12-06, "Diverse and Flexible Coping Strategies (FLEX) Implementation Guide (ADAMS Accession No. ML12242A378)." The staff assessed the methodology used to incorporate the mitigating strategies for an extended loss of alternate current (AC) power (ELAP) event, as referred to the use of DC power, following an ELAP.

The U.S. EPR has submitted AREVA Technical Report "U.S. EPR Mitigation Strategies for Extended Loss of AC Power Event," ANP-10329, Revision 0 (ADAMS Accession No. ML13126A328), to address the actions taken to improve nuclear safety in response to the

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Fukushima Daiichi Nuclear Power Plant accident. To assist in their review, the NRC staff reviewed documents provided by AREVA in a secure on-line electronic reading room at NRC Headquarters during the month of August 2013. Enclosed is a summary report of the audit along with the audit plan.

Docket No.: 52-020

Enclosure:
Audit Report

cc: See next page

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ADAMS Accession No.: ML14153A513 *via email NRO-002

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DATE	05/30/2014	05/29/2014	06/10/2014	06/10/2014

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FINAL AUDIT REPORT

DIRECT CURRENT POWER LOAD SHEDDING CALCULATIONS FOR DEMONSTRATING CAPABILTY OF THE U.S. EPR DESIGN FOLLOWING A BEYOND DESIGN EXTERNAL EVENT IN ACCORDANCE WITH JLD-ISG-2012-01

I. PURPOSE

The purpose of the audit was to verify that the U.S. EPR design acceptably addressed the specific provisions related to baseline coping capability utilizing direct current (DC) power in 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," (Agencywide Documents Access and Management Systems (ADAMS) Accession No. ML12229A174) dated August 29, 2012 that endorses the Nuclear Energy Institute (NEI) 12-06, "Diverse and Flexible Coping Strategies (FLEX) Implementation Guide (ADAMS Accession No. ML12242A378)." The staff assessed the methodology used to incorporate the mitigating strategies for an extended loss of alternate current (AC) power (ELAP) event, as referred to the use of DC power, following an ELAP.

This audit follows the guidelines in Office of New Reactors (NRO) Office Instruction NRO-REG-108 (Revision 0), "Regulatory Audits."

II. BACKGROUND AND AUDIT BASES

Following the March 2011 accident at the Fukushima Daiichi Nuclear Power Plant in Japan, the U.S. Nuclear Regulatory Commission (NRC) took specific regulatory actions in areas of nuclear power plant design and emergency planning to improve the availability and reliability of plant safety systems to mitigate a beyond design basis event from external hazards. Among the actions taken by the NRC, Order EA-12-049, "Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events (ADAMS Accession No. ML12054A736)," was issued and followed by JLD-ISG-2012-01, which endorses NEI 12-06, to assist nuclear power reactors applicants and licensees with the identification of measures needed to comply with requirements to mitigate challenges to key safety functions.

The Order requires a three-phase approach for mitigating beyond-design-basis external events. The initial phase requires the use of installed equipment and resources to maintain or restore core cooling, containment, and spent fuel pool (SFP) cooling. The initial response phase will be accomplished using installed equipment. Licensees should establish and maintain current estimates of their capabilities to maintain core and SFP cooling and containment functions assuming a loss of ac electric power to the essential and nonessential switchgear buses except for those fed by station batteries through inverters.

The U.S. EPR has submitted AREVA Technical Report "U.S. EPR Mitigation Strategies for Extended Loss of AC Power Event," ANP-10329, Revision 0 (ADAMS Accession No. ML13126A328), to address the actions taken to improve nuclear safety in response to the

Fukushima Daiichi Nuclear Power Plant accident. For the U.S. EPR, the Beyond Design Basis External event evaluated is an extended loss of AC power (ELAP) event, which assumes a simultaneous loss of all AC power (loss-of-offsite power, plus loss of emergency diesel generators, plus loss of alternate AC source) plus loss of normal access to the ultimate heat sink. In the report, there is a description of the way in which the U.S. EPR provides baseline coping capability with installed equipment (Phase 1).

The U.S. EPR mitigating strategy assumes that the only available power sources during the first phase are the station batteries. The U.S. EPR performed an analysis to determine how long the Class 1E uninterruptible power supply (EUPS) system battery capacity can be extended, and concluded that the EUPS battery discharge duration can be extended from two hours to eight hours and 30 minutes.

Since the station batteries were initially qualified for a two hour duty cycle, the NRC Staff requested this audit to assess the methodology and calculations by which the U.S. EPR extended the discharge duration to eight hours and 30 minutes (via load shedding).

III. OBJECTIVES

The objectives of the staff's audit were to:

- Confirm that the U.S. EPR design addresses the specific provisions related to baseline coping capability utilizing DC power in JLD-ISG-2012-01.

- Confirm that the battery sizing, qualification, capacity, and capability are still valid under the ELAP scheme.

- Verify the US EPR claim that the Class 1E batteries, when utilized per their proposed procedures for dealing with a Beyond-Design-Basis External Event that includes ELAP, could provide the necessary DC power to support the Phase 1 of such event, which is the first 8.5 hours.

IV. SCOPE OF AUDIT

The primary scope of this audit was the review of the methodology and calculations that demonstrate that the U.S. EPR design addresses the provisions in JLD-ISG-2012-01 for Phase 1, as they pertain to DC power, and the batteries in the U.S. EPR design are capable of undergoing an extended duty cycle by way of a load shedding scheme.

The audit focused on the areas below:

- DC load shedding analysis/analytical methods,

- DC load shedding profiles, and

- Results/conclusions that determined the battery discharge duration can be extended for Phase 1 while maintaining design capacity and capability.

V. DESCRIPTION OF THE DC POWER SYSTEM

The US EPR Design includes three battery systems: (1) the Emergency Uninterruptible Power Supply (EUPS), (2) the Non-Class 1E UPS (NUPS) system and (3) the 12-Hour UPS (12UPS) system. The EUPS is the protected safety-related battery system that produces and distributes stable AC and DC class 1E power to connected safety-related loads and to select non-safety related loads. In general, the EUPS system provides uninterruptible DC control power for safety-related switchgear and load centers, Instrumentation and Control (I&C) systems and uninterruptible AC power for safety-related valves. The NUPS and 12UPS are non-protected non-safety-related battery systems and per the guidance of NEI 12-06 are assumed unavailable for ELAP mitigation.

Four EUPS divisions exist in the US EPR design. Each EUPS division consists of one battery connected in parallel with one batter charger and one standby battery charger to a DC distribution bus. The EUPS battery supplies uninterruptible AC power to motor control center and panel-boards through an inverter via the DC distribution bus. Each EUPS division also includes dedicated load shedding buses to aid in shedding loads during ELAP. Simplified single line diagrams depicting the divisions of DC system power distribution are provided in AREVA Technical Report ANP-10329, Revision 0.

During Phase 1, the batteries must support reactor core and SFP cooling as well as containment functions. AREVA's analyses/calculations provide an estimate of the duration that the EUPS system can meet this requirement. The estimate provides the maximum time period in which the transition to portable onsite equipment (Phase 2) can be achieved.

VI. AUDIT ACTIVITIES AND SUMMARY OF FINDINGS

The audit was conducted by NRC staff, Mr. Robert Fitzpatrick, from the Office of Nuclear Reactor Regulation (NRR), Division of Engineering. The original plan was for the staff to travel to the applicant's facility and conduct a formal multi-day on-site regulatory audit. However, AREVA was able to provide the necessary documentation by providing the staff access via an on-line secure reading room. The audit was performed in August 2013, over a multiday period. The following two files were provided for and became the focus of the staff audit:

1. Document 1: A calculation: 32-7012304-000, "Class 1E Uninterruptible Power Supply (EUPS) Battery Load Shedding Calculation for Fukushima Near-Term Task Force (NTTF) Recommendation 4.2". The purpose of this calculation is to determine the U.S. EPR™ EUPS system battery capacity that can be achieved for an ELAP using load shedding and other battery cycle extension strategies.

2. Document 2: An analysis: 51-7012342-000, "Class 1E Uninterruptible Power Supply (EUPS) Battery Load Shedding Analysis for Fukushima Near-Term Task Force (NTTF)

Recommendation 4.2". This document provides a technical evaluation that determines the load shedding and battery cycle extension strategies to be used for the Class 1E EUPS system to extend the battery capacity for an ELAP. In addition, this document discusses the extended battery capacity that can be achieved for the EUPS batteries as found in Document 1.

The staff finds that Document 2 (above) provided the analysis of the actual needs (DC loads) of the EPR design given an ELAP event, established a timeline for the DC loads (on/off) based upon those needs and thereby provided the basic input required for the calculations addressed in Document 1.

The staff finds Document 1 (above) contained the time(s), duration(s) and energy consumption of all of the DC loads including each DC load identified as required to help cope with an ELAP event as well as those loads that can be shed from the outset as soon as the operators can determine that an ELAP has occurred, and other battery cycle extension strategies. The loads were tabulated and input into a spreadsheet in accordance with the guidelines of the Institute of Electrical and Electronics Engineers, Inc. (IEEE) Std. 485, "Recommended Practice for Sizing Large Lead Storage Batteries for Generating Stations and Substations." The spreadsheet was designed to perform the energy consumption calculations on the station battery and track terminal voltages, given the loading profile. Success of the calculation was demonstrated by the battery terminal voltage remaining above that needed to properly power the loads at the 8.5 hour mark, as depicted in the overall timeline for DC load shedding in Figure 4-13, ELAP Battery Discharge Duration, provided in the Areva Technical Report ANP-10329, Rev 0.

Staff notes that a generic concern evolved out of the review of the operating reactor fleet with respect to meeting the requirements of Order EA-12-049. The generic concern related to extended battery duty cycles and the capability of the existing vented lead-acid station batteries to perform their expected function for durations greater than 8 hours throughout their expected service life. NEI provided a position paper entitled "Battery Life Issue" (ADAMS Accession No. ML13241A186) was subsequently endorsed by NRC (ADAMS Accession No. ML13241A188). The NEI paper provided sufficient basis to resolve this concern by developing an acceptable method for demonstrating that batteries will perform as specified in a plant's Integrated Plan that satisfy NRC Order EA-12-049. The methodology relies on the licensee's battery sizing calculations developed in accordance with IEEE Standard 485, "Recommended Practice for Sizing Large Lead Storage Batteries for Generating Stations and Substations," load shedding schemes, and manufacturer data to demonstrate that the existing vented lead-acid station batteries can perform their intended function for extended duty cycles (i.e., beyond 8 hours). Since EPR has performed these battery calculations in accordance with IEEE Std. 485 and will procure the station batteries accordingly, this generic concern does not apply.

In addition to the methodology, the staff reviewed the details of the identified ELAP Phase 1 equipment, load types considered, type of loads to be shed from the EUPS battery, development of the ELAP Phase 1 Duty Cycle, and design inputs for battery types considered for the calculation, and found that the methodology follows the guidance provided in IEEE Standard 485. For the purposes of this audit, the staff concentrated on the methodology and not the details of load lists or the ELAP load screening tables as they were developed under a formal 10 CFR 50 Appendix B quality assurance program.

VII. CONCLUSION

In summary, the analyses provided in Document 2 were detailed and thorough and the ensuing calculations provided in Document 1 were straightforward and in accordance with IEEE Std. 485 methodology. Therefore, based upon this audit, the staff finds that the methodology used to perform this set of calculations is acceptable and the applicant's results are reasonable.

VIII. REFERENCES

1. NRO Office Instruction NRO-REG-108 (Revision 0), "Regulatory Audits."

2. AREVA Technical Report, "U.S. EPR Mitigation Strategies for Extended Loss of AC Power Event," ANP-10329, Revision 0

3. IEEE Standard 450-2002, "IEEE Recommended Practice for Maintenance, Testing and Replacement of Vented Lead-Acid Batteries for Stationary Applications," Institute of Electrical and Electronics Engineers, 2003.

4. IEEE Standard 484-2002, "IEEE Recommended Practice for Installation Design and Installation of Vented Lead-Acid Batteries for Stationary Applications," Institute of Electrical and Electronics Engineers, 2003.

5. IEEE Standard 485-1997, "IEEE Recommended Practice for Sizing Lead-Acid Batteries for Stationary Applications," Institute of Electrical and Electronics Engineers, 1997.

6. IEEE Standard 535-1986, "IEEE Standard for Qualification of Class 1E Lead Storage Batteries for Nuclear Power Generating Stations," Institute of Electrical and Electronics Engineers, 1986.

7. IEEE Standard 946-2004, "IEEE Recommended Practice for the design of DC Auxiliary Power Systems for Generating Stations," Institute of Electrical and Electronics Engineers, 2005.

8. Standard Review Plan Section 8.1, "Electric Power - Introduction""

9. Standard Review Plan Section 8.3.2, "DC Power Systems (Onsite)"

10. Standard Review Plan Section 8.4, "Station Blackout"

AUDIT PLAN: AUDIT PLAN OF THE DIRECT CURRENT POWER CALCULATIONS FOR DEMONSTRATING CAPABILTY FOLLOWING A BEYOND DESIGN EXTERNAL EVENT IN ACCORDANCE WITH JLD-ISG-2012-01 OF THE U.S. EPR DESIGN

IX. PURPOSE

The purpose of the audit is to verify that the U.S. EPR design addresses the specific provisions related to baseline coping capability utilizing dc power in 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," (Agencywide Documents Access and Management Systems (ADAMS) Accession No. ML12229A174) dated August 29, 2012 that endorses the Nuclear Energy Institute (NEI) 12-06, "Diverse and Flexible Coping Strategies (FLEX) Implementation Guide." Specifically, the staff will assess the method used to incorporate the FLEX strategies for an extended loss of alternate current (AC) power (ELAP) event, as referred to the use of direct current (DC) power, following deep load shedding.

This audit follows the guidelines in Office of New Reactors (NRO) Office Instruction NRO-REG-108 (Revision 0), "Regulatory Audits."

X. BACKGROUND AND AUDIT BASES

Following the March 2011 accident at the Fukushima Daiichi Nuclear Power Plant in Japan, the U.S. Nuclear Regulatory Commission (NRC) took specific regulatory actions in areas of nuclear power plant design and emergency planning to improve the availability and reliability of plant safety systems to mitigate a beyond design basis event from external hazards. Among the actions taken by the NRC, Order EA-12-049, "Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events," was issued and followed by JLD-ISG-2012-01, which endorses NEI 12-06, to assist nuclear power reactors applicants and licensees with the identification of measures needed to comply with requirements to mitigate challenges to key safety functions.

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The U.S. EPR has submitted the Technical Report "U.S. EPR Mitigation Strategies for Extended Loss of AC Power Event," ANP-10329, Revision 0, to address the actions taken to improve nuclear safety in response to the Fukushima Daiichi Nuclear Power Plant accident. For the U.S. EPR, the Beyond Design Basis External event evaluated is an ELAP event, which assumes a simultaneous loss of all AC power (loss-of-offsite power, plus loss of emergency diesel generators, plus loss of alternate AC source) plus loss of normal access to the ultimate heat sink. Among other things, It also demonstrates the way in which the U.S. EPR provides baseline coping capability with installed equipment.

The U.S. EPR assumes that the only available power sources during the first phase are the station batteries. The U.S. EPR performed an analysis to determine how long the Class 1E uninterruptible power supply (EUPS) system battery capacity can be extended, and concluded that the EUPS battery discharge duration can be extended from two hours to eight hours and 30 minutes.

Since the station batteries were initially qualified for a two hour duty cycle, the NRC Staff wants to assess the method and calculations by which the U.S. EPR extended the discharge duration.

XI. OBJECTIVES

The objectives of the staff's on-site audit are to:

- Confirm that the U.S. EPR design addresses the specific provisions related to baseline coping capability utilizing DC power in 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," (ADAMS Accession No. ML12229A174) dated August 29, 2012 that endorses the NEI 12-06, "Diverse and Flexible Coping Strategies (FLEX) Implementation Guide."

- Confirm that the battery sizing, qualification, capacity, and capability is still valid under the deep load shedding scheme.

XII. SCOPE

The primary scope of this audit is the review of the calculations that demonstrate that the U.S. EPR design addresses the provisions in JLD-ISG-2012-01 as they pertain to DC power, and the batteries in the U.S. EPR design are capable of undergoing an extended duty cycle by way of a load shedding scheme.

The reviewers will focus the audit on the areas shown in the list below:

1. Verify that the DC load shedding analysis including analytical methods, key assumptions, dc load shedding profiles, and results that determined the battery discharge duration can be extended for FLEX Phase 1 and 2 while maintaining design capacity and capability.

XIII. AUDIT ACTIVITIES

The audit will be conducted by NRC staff from the Office of Nuclear Reactor Regulation (NRR), Division of Engineering. Staff from the Electrical Engineering Branch (EEEB) knowledgeable of the U.S. EPR Final Safety Analysis Report (FSAR), Standard Review Plan, Sections 8.1, 8.3.2, and 8.4 will comprise the audit team.

The NRC team leads for this regulatory audit are Ms. Tania Martinez-Navedo, Electrical Engineer, and Mr. Sikhindra Mitra, Project Manager. The audit activities in July 2013 are

provided herein. Documents related to the DC load shedding analysis including analytical methods, key assumptions, DC load shedding profiles, and results that determined the battery discharge duration can be extended for FLEX Phase 1 and 2 will be assessed.

Audit findings will be discussed with AREVA at the audit exit and may result in additional questions to be asked after the audit.

XIV. SCHEDULE AND DELIVERABLES

The regulatory audit will be tentatively scheduled July 2013. The staff will have internal meetings from 3 – 3:30 p.m. and meetings with AREVA staff to provide the summary of preliminary findings from 3:30 – 4 p.m. at the end of that day's audit. The audit entrance meeting and exit meeting will be respectively scheduled at 1 p.m. on Monday and 10 a.m. on Friday. A written summary audit report will be completed within 45 days following completion of the audit.

XV. PROPOSED TEAM

The proposed audit team includes the following individuals:

- Mr. Sikhindra Mitra, Project Manager
- Ms. Tania Martinez-Navedo, Electrical Engineer

VIII. REQUESTED REFERENCE MATERIAL (FROM APPLICANT)

The audit will take place at AREVA office at Lynchburg, Virginia. In addition to personnel knowledgeable regarding the U.S. EPR FSAR and the following documentation should be available to the audit team:

- Documents related to the DC load shedding analysis including analytical methods, key assumptions, DC load shedding profiles, and results that determined the battery discharge duration can be extended for FLEX Phase 1 and 2.

- Other documents that the licensee deems as necessary to support the NRC staff's audit.

XVI. SPECIAL REQUESTS

The team requests the following to support the regulatory audit:

- Private conference room to support document review, and audit team meetings

- Internet and power outlet connections available for laptop computers

- Availability of subject matter experts knowledgeable in the NRC selected audit components.

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