FINAL AUDIT REPORT

DC POWER LOAD SHEDDING CALCULATIONS FOR DEMONSTRATING CAPABILTY OF THE SOUTH TEXAS PROJECT UNITS 3 AND 4 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 South Texas Project (STP), Units 3 and 4, combined license application 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," (ML12229A174) dated August 29, 2012 that endorses the Nuclear Energy Institute (NEI) 12-06, "Diverse and Flexible Coping Strategies (FLEX) Implementation Guide (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 (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.

Nuclear Innovation North America (NINA) has submitted the STP 3 & 4 Technical Report "STP 3 & 4 ABWR FLEX Integrated Plan," U7-C-NINA-NRC-130031, Revision 1 (ML14114A194), to address the actions taken to improve nuclear safety in response to the Fukushima Daiichi Nuclear Power Plant accident. For STP, the Beyond Design Basis External event evaluated is an extended Station Blackout (SBO) scenario, loss of AC power (ELAP) event, which assumes a simultaneous loss of all AC power plus loss of the ultimate heat sink. In the report, STP states that baseline coping capability is provided with installed equipment (Phase 1).

STP's mitigating strategy assumes that the only available power sources during the first phase are the station batteries. STP performed an analysis to determine how long the Class 1E battery capacity can be extended, and concluded that the battery discharge duration can be extended from 2 hours to eight hours and 30 minutes.

Since the station batteries were initially qualified for a two (2) hour duty cycle, the NRC Staff requested this audit to assess the methodology and calculations by which STP extended the discharge duration to thirty-six (36) hours (via load shedding).

III. OBJECTIVES

The objectives of the staff's audit were to:

- Confirm that the STP combined license application addresses the specific provisions related to baseline coping capability utilizing dc power in Interim Staff Guidance (ISG) JLD-ISG-2012-01.

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

- Verify STP's 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 thirty-six (36) hours.

IV. SCOPE OF AUDIT

The primary scope of this audit was the review of the methodology and calculations that demonstrate that STP combined license application addresses the provisions in JLD-ISG-2012-01 for Phase 1, as they pertain to DC power, and the batteries in the STP combined license application 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 STP DC power systems design includes four (4) independent Class 1E 125 VDC divisions, three (3) independent non-Class 1E 125 VDC load groups, and one (1) non-Class 1E 250 VDC computers and motor power supply. The 125 VDC Class 1E power is required for emergency lighting, diesel-generator field flashing, control and switching functions such as the control of medium voltage and 480V switchgear, control relays, meters and indicators, vital AC power supplies, as well as DC components used in the reactor core isolation cooling system. Each 125 VDC battery is provided with a charger, and a standby charger shared by two (2) divisions. A non-class 1E 125 VDC power supply is provided for non-Class 1E switchgear, valves, converters, transducers, controls and instrumentation. A non-Class 1E 250 VDC power supply is provided for the computers and the turbine turning gear motor. Single line diagrams depicting STP's divisions of DC system power distribution are incorporated by reference from the ABWR's Design Control Document, Revision 4, Figure 8.3-4.

During Phase 1, the batteries must support reactor core and SFP cooling as well as containment functions. STP's analyses/calculations provide an estimate of the duration that the Class 1E DC system can meet this requirement. The estimate provides the maximum time period in which the transition to portable onsite equipment (Phase 3) can be achieved.

VI. AUDIT ACTIVITIES AND SUMMARY OF FINDINGS

The audit was conducted by NRC staff, Tania Martinez Navedo and Sheila Ray, from the NRR, Division of Engineering. The audit was performed on June 2, 2014 at the Westinghouse Electric Company offices in Twinbrook, Rockville, Maryland. The following two files were provided for and became the focus of the staff audit:

1. Document 1: Load shedding the report titled, "Extended Station Blackout Scenario," dated August 9, 2012, by DP engineering;

2. Document 2: Calculation U7-DCE-E-CALC-DESN-6001, "STP Units 3 &4 Class 1E 125 VDC Battery Sizing Analysis, Voltage Drop, Short Circuit, and Charger Sizing Calculation," Revision A.

Document 1 contains the DC bus stripping calculation that contemplates an extended station blackout scenario. The staff audited the calculation and needed further clarification for the following items:

1. NINA stated that it followed the battery sizing methodology described in Appendix A of Institute of Electrical and Electronics Engineers (IEEE) Standard 485, "IEEE Recommended Practice for Sizing Lead-Acid Batteries for Stationary Applications," based on number of positive plates. However, the staff needed further clarification for the following items:

    a) The staff found that the values shown in the worksheets did not identify the parameters associated with battery sizing as specified in the examples in Annex A of IEEE Standard 485. A Request for Additional Information (RAI) was sent to the applicant requesting that it provide the necessary parameters in a revised worksheet for the "Extended Station Blackout Scenario," or use the format of the applicable example provided in Annex A of IEEE Standard 485. The applicant provided an example worksheet, outlining the parameters used in battery sizing, and in addition, provided a summary of the sizing methodology, which will be added in Section 1E.4, "DC Electrical Equipment Loading Considerations" in FSAR Appendix 1E. The NRC staff finds this acceptable, as the battery sizing is developed in accordance with IEEE 485 and is clearly shown in the worksheet. The battery sizing reflects the loads required for the extended station blackout scenario, and shows the battery is sized accordingly. The additional information was provided in the RAI response, dated June 5, 2014.

b) The staff needed clarification with respect to the loads included in the calculation's duty cycle. Therefore, the staff asked the applicant via an RAI to provide the battery duty cycle diagram that depicted the dc load profile and the battery division(s) providing power to the corresponding loads along the timeline for the mitigating strategies to maintain core cooling, containment, and spent fuel pool cooling during all modes of operation. The applicant provided a duty cycle diagram, depicting the dc load profile for each of the battery divisions and their corresponding loads, along the timeline for mitigating strategies in its RAI response dated June 4, 2014. The diagram provides information on the loads and respective timing, including the reactor core isolation cooling (RCIC) valve operation. Furthermore, the applicant provided the instrumentation and controls available at the remote shutdown panel for monitoring parameters listed in NEI 12-06 Section 3.2.1.10, "Instrumentation and Controls." The NRC staff finds this acceptable, as applicant has shown the battery divisions can provide power to the corresponding loads necessary to maintain core cooling, containment, and spent fuel pool cooling.

a) The staff needed clarification with respect to the basis for the assumed minimum battery voltage. Therefore, the staff asked the applicant via an RAI to provide the basis for the assumed minimum battery voltage that is required to ensure proper operation of all electrical equipment as included in the load profile. The applicant revised Document 2 to provide the maximum voltage drops to ensure the minimum battery voltage is met for the Division I and II batteries. The staff finds the basis for the assumed minimum battery voltage acceptable, as outlined in the calculation and provided in RAI response dated June 5, 2014. Furthermore, the NRC staff finds that the batteries can provide power to the equipment, as depicted in the load profile.

4. The staff needed clarification with respect to the tables showing the loads connected to each battery division since those tables did not provide sufficient information on the potential impact of the environmental condition on this required equipment. Therefore, the staff asked the applicant via an RAI to provide a discussion on the list of required equipment and its operability under the expected environmental conditions. Per, NEI 12-06 Section 3.2.1.12, Qualification of Installed Equipment, "Equipment relied upon to support FLEX implementation does not need to be qualified to all extreme environments that may be posed, but some basis should be provided for the capability of the equipment to continue to function." The applicant stated in its RAI response dated June 5, 2014, that safety related instrumentation inside the Reactor Building will be qualified for temperatures above the estimated temperatures for the Reactor Building spaces during the FLEX scenario. In addition, the applicant provided information regarding the solenoid valves, which will not experience radiation levels assumed in the loss of coolant accident. Furthermore, the

peak temperature inside containment does not exceed the drywell design temperature. As a result, the applicant has shown that the required equipment can operate under the expected environmental conditions, as stated in its June 5, 2014 RAI response.

5. The staff needed clarification regarding when the calculations were going to be finalized. The current version of the calculations was drafted based on available information. However, the level of detail provided in the calculations is constrained because detailed design for STP 3 & 4 is not yet finalized. Therefore, the staff asked the applicant via an RAI to provide a license condition that ensures that the final calculation for the Extended Blackout Scenario is finalized prior to fuel load. The applicant provided a license condition stating that, "The 'Extended Station Blackout Scenario' calculation will be updated to incorporate 'as-built' plant design information to verify that the Class 1E battery discharge duration is adequate to support Phase 1 of the mitigating strategies discussed in FSAR Appendix 1E," as documented in the RAI response dated June 5, 2014. This license condition will enable staff to verify the adequacy of the calculation and the supporting documentation including, but not limited to, vendor information to validate duty cycles greater than the maximum duty cycle length for which the battery is qualified .The staff finds this acceptable since the condition ensures the calculation will be finalized to ensure the Class 1E battery can support Phase 1 of the mitigating strategies.

6. The staff needed clarification in regards to the validity of the qualification of the batteries credited for the use during an ELAP. Current regulatory guidance on battery duty cycles for safety-related batteries limits qualification to eight (8) hours. IEEE Standard 535-1986, "IEEE Standard for Qualification of Class 1E Lead Storage Batteries for Nuclear Power Generating Stations," as endorsed by Regulatory Guide 1.158, "Qualification of Safety-Related Lead Storage Batteries for Nuclear Power Plants," provides guidance for qualifying nuclear-grade batteries and describes a method acceptable to the NRC staff for complying with Commission regulations with regard to qualification of safety-related lead storage batteries for nuclear power plants. Based on a previous concern with extended battery duty cycle durations, the NRC staff requested an official interpretation of IEEE Standard 535-1986. The NRC specifically requested the IEEE to identify the length of the duty cycle for which a vented lead-acid battery is qualified per IEEE Standard 535 and to identify any limitations on the length of the duty cycle for a vented lead-acid battery. In its response to the NRC's interpretation request (ML13094A397), the IEEE stated that in order to meet the requirements of IEEE Standard 535, applications with duty cycles over 8 hours will need to demonstrate that the battery cells fully comply with the qualification principles in clause 5 and meet the basis requirements in clause 8.2 of IEEE Standard 535. Based on the background considerations stated above and the fact that STP is proposing to credit the use of the Class 1E batteries for mitigation strategies, there is concern about the capability of STP 3 & 4's batteries to provide DC power for the durations specified in the STP 3 & 4 ABWR FLEX Integrated Plan, Revision 1 which did not include sufficient information to support a conclusion that batteries with duty cycles greater than 8 hours can meet the ELAP battery duty cycles as credited. Therefore, the staff asked NINA via an RAI to explain how STP 3 & 4 will validate battery duty cycles greater than 8 hours, and justify that the methodology used is consistent with applicable regulatory guidance regarding

determination of battery duty cycles. During the audit, the staff reviewed the discharge rates provided by the battery manufacturer, ensuring the batteries are able to support a duty cycle greater than 8 hours. The staff finds this acceptable. The extended discharge rates from the manufacturer are provided in RAI response dated June 5, 2014.

Document 2 provided supporting design information regarding the Class 1E batteries. These batteries are credited as the DC power source available during an ELAP event. No findings associated with this document were identified as they relate to the extended blackout scenario.

VII. CONCLUSION

In summary, the analysis provided in Document 1 and the calculation in Document 2 was audited by the NRC staff. Based on the review of the calculations and additional information provided by the applicant in response dated June 5, 2014, the NRC staff confirmed that the STP combined license application addresses the specific provisions related to baseline coping capability utilizing dc power in JLD-ISG-2012-01; confirmed that the battery sizing, qualification, capacity, and capability are still valid under the ELAP scheme; and verified 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 thirty-six (36) hours.

VIII. REFERENCES

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

2. Load shedding the report titled, “Extended Station Blackout Scenario,” dated August 9, 2012, by DP Engineering.

3. Calculation U7-DCE-E-CALC-DESN-6001, “STP Units 3 &4 Class 1E 125 VDC Battery Sizing Analysis, Voltage Drop, Short Circuit, and Charger Sizing Calculation,” Revision A.

4. 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.

5. 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.

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

7. 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.

8. 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.

9. Standard Review Plan Section 8.1, “Electric Power - Introduction””

10. Standard Review Plan Section 8.3.2, “DC Power Systems (Onsite)”

11. Standard Review Plan Section 8.4, “Station Blackout”