UNITED STATES
NUCLEAR REGULATORY COMMISSION
OFFICE OF NUCLEAR REACTOR REGULATION
OFFICE OF NEW REACTORS
WASHINGTON, DC 20555-0001

September 26, 2017

NRC INFORMATION NOTICE 2017-06: BATTERY AND BATTERY CHARGER SHORT-CIRCUIT CURRENT CONTRIBUTIONS TO A FAULT ON THE DIRECT CURRENT DISTRIBUTION SYSTEM

ADDRESSEES

All holders of an operating license or construction permit for a nuclear power reactor under Title 10 of the *Code of Federal Regulations* (10 CFR) Part 50, "Domestic Licensing of Production and Utilization Facilities," except those who have permanently ceased operations and have certified that fuel has been permanently removed from the reactor vessel.

All holders of and applicants for a power reactor early site permit, combined license, standard design approval, or manufacturing license under 10 CFR Part 52, "Licenses, Certifications, and Approvals for Nuclear Power Plants." All applicants for a standard design certification, including such applicants after initial issuance of a design certification rule.

PURPOSE

The U.S. Nuclear Regulatory Commission (NRC) is issuing this information notice (IN) to inform addressees of the results of a recent NRC-led battery testing program. The testing program evaluated the magnitude of direct current (DC) fault current contributions from batteries and battery chargers to a downstream short-circuit fault on the DC distribution system. The detailed test results, conclusions, and recommendations are provided in NUREG/CR-7229, "Testing to Evaluate Battery and Battery Charger Short-Circuit Current Contributions to a Fault on the DC Distribution System" (Agencywide Documents Access and Management System (ADAMS) Accession No. ML17039A869). The NRC expects that recipients of this IN will review the information for applicability to their facilities and consider actions, as appropriate, for potential impacts on DC fault studies and other related calculations. The suggestions in this IN are not NRC requirements; therefore, the NRC requires no specific action or written response.

DESCRIPTION OF CIRCUMSTANCES

On September 6, 2013, the NRC issued IN 2013-17, "Significant Plant Transient Induced by Safety-Related Direct Current Bus Maintenance at Power" (ADAMS Accession Number ML13193A009). It informed addressees of an event involving the loss of one train of the DC distribution system in a nuclear power plant. Specifically, both the battery and the battery charger on one DC Class 1E power division tripped on overcurrent when a fault occurred in a downstream DC panel.

The event demonstrated that the fault impact on the DC distribution system at a nuclear power plant can have a significant impact, as described in IN 2013-17. While the cause of the battery

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trip was well understood by the NRC staff, the cause of the battery charger trip was not clear. The NRC staff assumed that the cause of the battery charger trip could have been because of the initial higher fault current contribution by the battery charger to the downstream fault, whether connected in parallel with the battery or not. However, this configuration was inconsistent with the language provided in the Institute of Electrical and Electronics Engineers' (IEEE) Standard (Std) 946-2004, "IEEE Recommended Practice for the Design of DC Auxiliary Power Systems for Generating Stations," Subclause 7.9.2, which states, "When the battery charger is connected in parallel with the battery, the battery capacitance will prevent the battery charger contribution from rising instantaneously. Therefore, the maximum current that a charger will deliver on short circuit will not typically exceed 150 [percent] of the charger full load ampere rating. Instantaneous battery charger current rise should only become a concern during periods when the battery is disconnected." Therefore, the Office of Nuclear Regulatory Research (RES) collaborated from 2014 through 2016 in a battery testing program with Brookhaven National Laboratory (BNL) to validate the assumptions. The purpose of the testing program was to determine if the battery and battery charger current contributions to the fault on the DC distribution circuit would be different when connected individually or when connected in parallel, which could impact the DC system device coordination.

In February 2017, the testing results were documented and published in NUREG/CR-7229. One of the methods potentially used at nuclear power plants to estimate the short-circuit current contributions is described in IEEE Std 946-2004. The use of this standard neglects the initial fault current contribution from the charger. The DC system overcurrent protective device sizing selection and/or coordination setting could result in a fault not being isolated as intended. This can lead to undesirable system responses to a fault on the DC distribution system.

BACKGROUND

The DC power system provides power for Class 1E equipment such as breaker control, plant instrumentation and control, monitoring, lighting (main control room and remote shutdown area), and other functions. The battery supplies the load without interruption should the battery charger or associated preferred alternating current source fail.

Criterion 21, "Protection System Reliability and Testability," of Appendix A, "General Design Criteria for Nuclear Power Plants," to 10 CFR 50, "Domestic Licensing of Production and Utilization Facilities," states, "The protection system shall be designed for high functional reliability and inservice testability commensurate with the safety functions to be performed." Proper fault current calculations and protective device setttings on the DC system are important so that a fault can be isolated as close to the location of the fault as possible, thereby minimizing the impact on plant operations and safety.

DISCUSSION

Reliability of the Class 1E DC power system is important in a nuclear power plant. The DC power system is designed so that no single failure of an electrical panel, battery, or battery charger will result in a condition that will prevent the safe shutdown of the plant.

During the battery testing program, BNL performed various short-circuit tests that simulated fault conditions on a DC distribution system typical within a nuclear power plant. More specifically, two types of battery chargers were considered, a silicon controlled rectifier (SCR)-type and a controlled ferroresonant (CF) transformer-type, connected individually and in parallel with three Class 1E vented lead-acid batteries from different vendors. The three nuclear-qualified

batteries from three different vendors are representative of battery models used in more than 75 percent of the nuclear power plants currently in the United States. The SCR and CF battery chargers represent about 90 percent of the battery charger designs used in nuclear power plants currently in the United States.

The testing validated that the initial fault current contribution to a downstream fault from a battery charger (specifically the SCR-type chargers vs. the CF-type) is much higher—in the range of 7 to 10 times the charger full load ampere rating—during the first 100 milliseconds than what is currently stated as 150 percent in IEEE Std 946-2004. The test results indicated that the initial short circuit contribution from the charger is not limited when connected in parallel with the battery. The SCR-type charger contributed more to the fault current due to the longer response time of its current limiting circuit than the CF-type. The initial higher short circuit current contribution from the battery charger could impact the coordination of protective device settings on the battery charger and downstream devices. If IEEE Std 946-2004 was utilized to estimate short circuit current contributions in DC distribution systems, licensees should consider performing a comprehensive review of the entire DC system protection coordination and assumptions of battery and charger short circuit currents that were used to select their protection fault interruption ratings and setpoints. Specifically, licensees are encouraged to review their fault current calculations, make any necessary revision to size, and coordinate the protective device settings based on the new information documented in NUREG/CR-7229. Additionally, there are efforts currently underway by the IEEE 946 Working Group to consider appropriate revisions to the standard. The NRC staff that are involved in IEEE Standard 946 have communicated to the working group the test results, conclusions, and recommendations provided in NUREG/CR 7229.

CONTACTS

Please direct any questions about this matter to the technical contact(s) listed below or the appropriate RES or Office of Nuclear Reactor Regulation (NRR) project manager.

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