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

August 10, 2018

NRC INFORMATION NOTICE 2018-09: ELECTRICAL ARC FLASH CAUSED BY FOREIGN MATERIAL DAMAGES FIRE DOOR

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 combined license under 10 CFR Part 52, "Licenses, Certifications, and Approvals for Nuclear Power Plants."

PURPOSE

The U.S. Nuclear Regulatory Commission (NRC) is issuing this information notice (IN) to inform addressees of an event involving an electrical arc flash initiated by intrusion of foreign material into a switchgear cubicle. The arc flash resulted in a pressure wave that damaged a fire door serving as part of a 3-hour-rated fire barrier assembly. The NRC expects recipients to review the information for applicability to their facilities and consider actions, as appropriate, to avoid similar problems. However, suggestions contained in this IN are not NRC requirements; therefore, the NRC requires no specific action or written response.

DESCRIPTION OF CIRCUMSTANCES

Turkey Point Nuclear Generating, Unit 3

As part of the transition to the risk-informed fire protection standard outlined in National Fire Protection Association Standard 805, "Performance-Based Standard for Fire Protection for Light Water Reactor Electric Generating Plants," the licensee for Turkey Point committed to protecting power cables for Unit 3 equipment required for post-fire safe-shutdown. This involved installing Thermo-Lag 770-1 mats bound with high-temperature carbon fiber mesh (Thermo-Lag 75) and matting over Thermo-Lag 330-1 mats. This configuration yields a 3-hour fire rating, an improvement over the 1-hour rating provided by the Thermo-Lag 330-1 alone. The nuclear industry has used Thermo-Lag 770-1 since 1995.

Placement of the Thermo-Lag 770-1 requires that the mesh be cut to size to fit the application. This process creates carbon dust, carbon fibers, threads, and trimmings, which pose foreign material hazards as they become airborne.

On March 18, 2017, Turkey Point Units 3 and 4 were operating at 100-percent power. The 4A and 4B trains of high head safety injection (HHSI) were inoperable because of ongoing work to

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repair a leak on a common line off the minimum flow recirculation lines from the 4A and 4B HHSI pumps. The HHSI system at Turkey Point consists of four trains—3A, 3B, 4A, and 4B—any of which are available for injection to either unit. Despite the inoperability of the two trains, the licensee determined that sufficient measures were in place to allow them to proceed with installation of the Thermo-Lag 770-1 insulation material in the 3A switchgear room as part of a project to upgrade the fire protection barriers in the room. Although bulk cutting of the mats occurred outside the room, the metal and carbon fiber mesh were trimmed for final fit inside the 3A switchgear room where the installation was occurring.

At 11:07 Eastern Daylight Time, an internal fault on the 3A 4-kilovolt (kV) bus caused a high-energy arc flash and lockout of the bus. One of the workers involved in the Thermo-Lag installation was injured as a result of the blast, which also damaged parts of the bus and associated bus bars. Unit 3 tripped on the resulting undervoltage condition on a vital bus. The 3A reactor coolant pump, which is powered from the 3A bus, tripped when the bus was lost. The 3B and 3C reactor coolant pumps, powered from the 3B 4-kV bus, tripped on underfrequency. The force of the pressure wave blew open and destroyed the fire door between the 3A and 3B 4-kV switchgear rooms, resulting in smoke migration into the 3B switchgear room.

The licensee's evaluation found the most likely cause of the arc flash was conductive material that entered the reactor coil cabinet,[1] a cubicle in the switchgear between the "high side" of the switchgear, which provides power to the nonsafety-related reactor coolant pump and main feedwater pump, and the "low side," which provides power to safety-related loads including the 3A HHSI pump. Licensee testing after the event found that the Thermo-Lag 75 used in the installation of Thermo-Lag 770-1 is composed entirely of an electrically conductive carbon fiber. Some pieces and several fibers of the mesh material were found inside the reactor coil cabinet after the event. The foreign material entered either through the unscreened ventilation louvers or through gaps where the bus bars entered the cabinet and created an electrical bridge from the bus bars to the wall of the cubicle.

The root cause of the event was that the licensee's installation requirements for Thermo-Lag did not provide adequate guidance to address foreign material exclusion or specific precautions to control airborne debris during the Thermo-Lag installation process.

Prior to the March 18, 2017, event in the 3A switchgear room, Turkey Point experienced multiple potential precursor events which rendered the battery charger incapable of performing its design function. On February 2, 2017, the 3A2 battery charger input breaker and motor control center (MCC) supply breaker tripped, followed approximately 4 minutes later by a trip of the spare battery charger input breaker. On February 8, 2017, the 3B2 vital battery charger input breaker and MCC supply breaker unexpectedly tripped while in service. At the time of both trips, work related to Thermo-Lag 770-1 installation was in progress in the battery charger room in the vicinity of the affected chargers.

Subsequent investigation identified a notable level of dust in the battery charger room and also inside the charger cabinets, which the licensee determined was conductive. The battery chargers were cleaned and successfully returned to service without incident. The conductive

[1] The reactor coil, or current-limiting reactor, is an inductor-type protection device that serves to limit any fault current seen by the low side of the bus, which is constructed with smaller bus bars and breakers, to a value the low side is capable of withstanding.

properties of the Thermo-Lag 75 carbon fiber used in the Thermo-Lag 770-1 installation were not discovered until after the arc flash event of March 18, 2018.

Additional information appears in Turkey Point Licensee Event Report 05000250/2017-001-00, dated May 16, 2017 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML17136A372) and the following reports; NRC Reactive Inspection Report 05000250/2017008, 05000251/2017008, dated May 12, 2017 (ADAMS Accession No. ML17132A258), NRC Integrated Inspection Report 05000250/2017001, 05000251/2017001 dated May 11, 2017 (ADAMS Accession No. ML17131A318), NRC Integrated Inspection Report 05000250/2017002, 05000251/2017002 dated August 11, 2017 (ADAMS Accession No. ML17223A012), NRC Integrated Inspection Report 05000250/2017003, 05000251/2017003 dated November 9, 2017 (ADAMS Accession No. ML17313B131), and NRC Design Bases Assurance Inspection (Team) Report 05000250/2017007, 05000251/2017007 dated October 2, 2017 (ADAMS Accession No. ML17277A837).

DISCUSSION

The importance of foreign material exclusion controls has long been recognized, but such controls have traditionally focused on the vulnerability of open equipment, particularly during maintenance periods. This event shows that electrical equipment that is not designed to be airtight can be vulnerable to airborne dust and debris in its normal operating configuration. Best practices for avoiding this type of situation include the following:

- Work instructions for activities involving cutting or grinding specifically address potential foreign material hazards created by the work.

- The impact of ventilation systems and portable fans for habitability is carefully considered for work in the vicinity of energized electrical equipment, especially work that may generate electrically conductive dust or small pieces that may become airborne.

- Training and procedures cultivate a mindset that considers the potential for foreign material intrusion for all activities, not just during outages or when equipment enclosures are open.

- The corrective action program provides for thorough review, identification, and root cause analysis of potential precursor events related to maintenance activity failures.

The failure of the fire door was unexpected in this situation. NUREG/CR-6850, "EPRI/NRC-RES Fire PRA Methodology for Nuclear Power Facilities," Volume 2, "Detailed Methodology," issued September 2005, provides a method for determining the zone of influence from an arc flash event. This includes the assumption that components located within 0.91 meters (3 feet) horizontally of either the front or rear panels, at or below the top of the faulting cabinet section, will suffer physical damage and functional failure from an arc flash event. The distance from the reactor coil cabinet to the affected door is 4.42 meters (14.5 feet), well outside the high-energy arc flash impact assessment area. An NRC review confirmed that the 3-hour rated fire door met the licensing basis and design requirements, which do not require blast resistance for doors separating the two safety-related switchgear rooms. The NRC is engaged in testing to assess whether the method for estimating the zone of influence as discussed in NUREG/CR-6850 is appropriate for all configurations.

CONTACT

This IN requires no specific action or written response. Please direct any questions about this matter to the technical contacts listed below.

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Note: NRC generic communications may be found on the NRC public Web site, https://www.nrc.gov, under NRC Library.

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