

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

June 3, 2019

NRC INFORMATION NOTICE 2019-02: EMERGENCY DIESEL GENERATOR EXCITATION
SYSTEM DIODE FAILURES

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 that 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 operating experience with regard to emergency diesel generator (EDG) excitation system diode failures. The failure of EDG excitation system diodes may cause affected EDGs not to be able to operate for their full mission times following a loss of offsite power event. The NRC expects that recipients will review the information for applicability to their facilities and consider actions, as appropriate, to avoid similar problems. INs may not impose new requirements, and nothing in this IN should be interpreted to require specific action.

DESCRIPTION OF CIRCUMSTANCES

Catawba Nuclear Station, Unit 2

On April 11, 2017, during monthly surveillance testing of the 2A EDG, at Catawba Nuclear Station (Catawba), Unit 2, the EDG output breaker unexpectedly tripped open on an overcurrent relay actuation. The breaker opened approximately three minutes after reaching full load (5750 kW). The EDG was subsequently secured and declared inoperable. During troubleshooting, the licensee discovered that diode CR4 in the EDG excitation circuit shorted, causing the EDG output breaker to trip open on overcurrent. The 2A EDG was returned to service on April 14, 2017.

The Catawba EDG excitation system, consisting of a Portec voltage regulator design, is an overcompensated design type. This system supplies more power than required for the generator field. The voltage regulator uses shunt silicon control rectifiers (SCR) to bypass the excess excitation current away from the generator field to control generator output voltage. These SCRs direct the excess current through diodes CR2, CR4 and CR6. Diodes CR2, CR4 and CR6 also carry the generator field current. As such, these diodes are in a conducting state for longer intervals than other diodes in the bridge and, based on industry operating experience, internal temperatures can be approximately 60 degrees Fahrenheit greater than diodes CR1, CR3

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and CR5. During a review, the NRC inspectors found additional failures of these diodes. In 2005, a similar failure occurred at Catawba with the CR4 diode on the 1A EDG. The licensee attributed the 2005 failure to operation of the diode at higher than optimum operating temperatures.

The licensee's corrective actions included: 1) modifying the EDG voltage regulator to address design weaknesses for all four EDGs based on detailed simulation of the voltage regulator to prevent diode damage, 2) implementing a diode and SCR replacement preventive maintenance (PM) activity at a frequency of no greater than 18 months, and 3) issuing a revision to the Operating Experience Program that addressed previously completed actions for operating experience insight, future engineering changes, and reviewing historical performance trends to ensure PM strategy changes are identified.

On August 22, 2017, the NRC issued a preliminary White finding (Agencywide Documents Access and Management System (ADAMS) [Accession No. ML17234A678](#)) and an associated apparent violation related to this event. The NRC issued the final white finding to Catawba on October 16, 2017 ([ADAMS Accession No. ML17289A300](#)). Additional details of this operating event are provided in an NRC inspection report dated May 23, 2018 ([ADAMS Accession No. ML18143B537](#)).

Wolf Creek Generating Station, Unit 1

On October 6, 2014, during a scheduled 24-hour surveillance testing, Wolf Creek Generating Station's "B" EDG tripped, and a fire was observed in an associated excitation control cabinet. The fire was quickly suppressed, and, following post-maintenance surveillance, the EDG was restored to operable status on October 9, 2014. The failure of a diode in the power rectifier of the EDG excitation system caused the failure of the power potential transformer (PPT). During a post-maintenance surveillance on June 11, 2014, the licensee noted a vapor coming from the cabinet housing the PPT. The PPT exhibited the same symptoms during subsequent surveillances. The PPT was scheduled for replacement by the licensee in August 2014 during the next system outage. During the work management planning process, the PPT replacement was rescheduled for February 2015. The PPT failed on October 6, 2014.

The Wolf Creek Generating Station excitation system consists of a Westinghouse WNR voltage regulator design. In the root cause analysis, the licensee identified the most probable direct cause as thermal degradation of the Power Rectifier diodes. Due to the reduced contribution of field current and voltage from the PPT circuitry from a single diode failure, the voltage regulator would task the PPT to supply the remainder of the required current to the field. This increased current would increase the internal temperatures of the PPT, leading to degraded windings within the PPT. This condition resulted in the emission of vapor from the PPT, which was noticed by the licensee prior to the event. The second diode eventually shorted, causing a short in the generator field. This short caused a loss of excitation to the generator field and tripped the EDG. The root cause analysis also stated that the station did not recognize the significance of aging or life cycle factors associated with the EDG excitation system, resulting in an inadequate PM strategy of the excitation system. There were limited PM activities, limited knowledge of the exciter, and the design of the system lacked overcurrent protection/detection of the PPT.

The licensee's corrective actions included replacing the PPT and selecting the alternate rectifier bank to restore the availability of the B EDG. In addition to immediate actions taken, the licensee replaced all power diodes within all four rectifier bridges (two rectifier bridges for each EDG). On October 27, 2015, the licensee implemented a corrective action to generate new preventive

maintenance activities to periodically replace the diodes within the power rectifier and other excitation system components as recommended by the operating experience.

Additional details of this operating event are provided in the NRC inspection report dated August 19, 2016 ([ADAMS Accession No. ML16235A132](#)).

Grand Gulf Nuclear Station, Unit 1

On May 21, 2013, during the Division 2 standby diesel generator monthly surveillance test, the underfrequency alarm sounded, concurrent with a drop in indicated voltage from approximately 4220 Volts to 2100 Volts.

The Grand Gulf EDG excitation system consists of a Portec voltage regulator design. The licensee performed a failure modes analysis evaluation to determine the possible cause for the observed conditions. During troubleshooting efforts, the licensee addressed the potential transformer (PT1), the potential transformer's fuses, inline fuses, and the voltage regulator circuit bridge diodes. The failure modes analysis evaluation showed that all the listed components were in satisfactory condition, with the exception that one of the six diodes used in the voltage regulator circuit diode bridge (diode CR6) had shorted.

The licensee replaced the shorted diode and returned the diesel generator to operational status on May 24, 2013. Based on past similar issues with degraded diodes on the voltage regulator circuit, the licensee developed a preventive maintenance strategy to begin testing the diodes on all three divisions of diesel generators and to replace any suspect components before they caused a loss of excitation event.

Additional details of this operating event are provided in the NRC inspection report dated August 14, 2014 ([ADAMS Accession No. ML14226A998](#)).

DISCUSSION

The failure of EDG excitation system diodes can adversely impact the ability of EDGs to perform their safety functions. A review of operating experience indicates that events involving the failure of EDG excitation system diodes continue to occur. Such failures may cause affected EDGs not to be able to operate for their full mission times following a loss of offsite power event.

Underlying causes have been attributed to marginal design, postulated age-related failure, manufacturing defects coupled with voltage overstress, operation at elevated temperatures, and inadequate preventive maintenance. Because these diodes appear to have a limited life, licensees should consider establishing an appropriate replacement schedule as part of effective preventative maintenance in accordance with the Maintenance Rule.

Related NRC Generic Communications

[Information Notice 2010-04](#), "Diesel Generator Voltage Regulation System Component Due to Latent Manufacturing Defect," dated February 26, 2010, describes the failure of a linear power reactor in an EDG voltage regulation system at a plant where the licensee's preventive maintenance program did not address the EDG excitation system magnetic components that can be subject to deterioration with age or time in service. IN 2010-04 describes the corrective actions

implemented by the licensee in response to the event, which included adding a preventive maintenance task for thermography of EDG excitation system silicon controlled bridge rectifiers, power diode bridge rectifiers, current transformers, power transformers, and linear reactors.

[Information Notice 2007-36](#), "Emergency Diesel Generator Voltage Regulator Problems," dated November 15, 2007, describes several events involving EDG voltage regulator problems, including an event that involved anomalies with the gate firing circuit output pulses to the silicon controlled rectifiers on the rectifier assembly. The licensee's root cause evaluation for this event discussed that the EDG had a history of intermittent overvoltage problems because of a higher than expected impedance in the flyback diode portion of the rectifier chassis circuitry. IN 2007-36 discusses various types of problems that are not limited to a single component or model of voltage regulator, and states that, "In general, the performance of a voltage regulator is very sensitive to any minor defects in any component of the voltage regulation system."

CONTACT

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

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Note: NRC generic communications may be found on the NRC public Web site, <http://www.nrc.gov>, under "NRC Library," "Document Collections."

NRC INFORMATION NOTICE 2018-06, "EMERGENCY DIESEL GENERATOR EXCITATION SYSTEM DIODE FAILURES" DATE JUNE 3, 2019

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*concurrent via email

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