

Preliminary Root Cause of Failure Analysis Emergency Diesel Generator 2A Failure to Carry Load

Event Date: June 14, 2004

Background

On June 14, 2004 in response to a Loss of Offsite Power event, Emergency Diesel Generator (EDG) 2A started, achieved rated speed and frequency, and began to accept loads. Upon auto closure of the EDG 4.16 kV output breaker, 480V load centers and motor control centers were energized, and 5 seconds later per the expected sequence for a Loss of Power event, battery chargers and other miscellaneous loads were energized. These loads were carried by the EDG until the 20-second sequence step when the first large motor for the essential cooling water pump 2MEWAP01 was loaded. At that point, the inrush current of the motor was present on the EDG output for approximately 1 second and then it abruptly dropped off. From that point forward there was no useful EDG output voltage even though the load sequencer continued to sequence loads. After approximately 15 minutes, Operations recognized that the EDG was not functional and shut it down.

Preliminary Evaluation

Extensive troubleshooting of the EDG excitation system was performed, including testing of the automatic voltage regulator (AVR), other associated voltage control equipment and the excitation power system components. Power diode CR3 in the excitation system bridge circuit was found to be shorted. This diode is one of six 275 ampere, 1000 PRV rated diodes that in conjunction with 3 SCRs, rectifies and controls the generator DC field current. The fact that this diode was shorted means that the output of two of the three phases in the excitation system were shorted, leaving only half-wave rectified voltage from B phase of the exciter. This lack of field current was the cause of the inability of the EDG to produce output voltage.

Each of the EDGs has two redundant excitation power bridges that each contain a complete set of diodes and SCRs. Until recently, PVNGS relied completely on only one of these bridges. In 2003, a decision was made to begin testing and using the other bridge so that it could be available in the event of a bridge failure. The 2A EDG was placed on this alternate bridge during its last refueling outage in the fall of 2003. This alternate bridge was fully tested during EDG post maintenance testing, Integrated Safeguards Testing (ISG) and Operability surveillance testing in this outage. On the basis of it meeting all acceptance criteria during all of the transient loading tests and 24 hour full load and 110% load tests, this bridge was declared fully capable of performing its safety related functions.

As a result of this recent switching to the alternate bridge, this bridge is estimated to have a lifetime total of approximately 65 hours of service.

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Root Cause

The failed diode has been sent to a Root Cause of Failure laboratory (HI-Rel Labs) for analysis and determination of the cause of failure. Results of this analysis are not expected until approximately August 1, 2004. Thus only an apparent cause can be stated at this time. Since diodes are highly reliable solid-state electronic components that have no significant age-related failure mechanisms and, since the diode has only seen 65 hours of service, the apparent cause of this failure appears to be infant mortality of the diode.

Corrective Actions

Definitive corrective actions are dependent on the determination of the root cause. The following are preliminary activities that are under consideration or in progress. These are subject to change as the investigation progresses.

There is limited industry experience with EDG diode failures. Our investigation has identified 5 instances, 3 of which happened at Grand Gulf nuclear station. We have obtained their periodic test program on their excitation bridge components and are evaluating it for application at PVNGS for both diodes and SCRs.

We will be contacting the manufacturer of the diode, International Rectifier, seeking their input on test techniques and test equipment that will provide the best diagnostic results.

We will develop and schedule periodic tests of all rectifier bridge circuits for the EDGs.