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DONALD F. SCHNELL
VICE PRESIDENT

March 15, 1984

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Mr. James G. Keppler
Regional Administrator
U. S. Nuclear Regulatory Commission
Region III
799 Roosevelt Road
Glen Ellyn, Illinois 60137

ULNRC-766

Dear Mr. Keppler:

FINAL 10 CFR 50.55(e)/21 REPORT U-62
EMERGENCY DIESEL GENERATOR WINDING FAILURE
CALLAWAY PLANT

On August 12, 1983 Union Electric informed the NRC Region III office of a potential 10 CFR 50.55(e) regarding failure of the stator winding on NE02B Emergency Diesel Generator at Callaway Plant. On February 7, 1984, Union Electric confirmed to Region III that this item was reportable under the criteria of 10CFR50.55(e)/21. A verbal extension was obtained from Mr. J. E. Konklin, Region III, on March 8, 1984, extending the due date for this response until March 15, 1984. The generator failed at Callaway during initial testing while carrying 3.95 MW. Differential and undervoltage relays operated to trip the generator's main breaker.

The emergency diesel generator is rated 8526 KVA, at 514 RPM, 3 phase, 60 hertz, 4160 volts, 0.8 PF. The diesel generator was supplied by Colt Industries, but the generator was manufactured by Beloit Power Systems. There are two identical units at Callaway Plant.

Following the failure, the generator was inspected at the site and a 1/2" x 13 UNC nut was found on the bottom plate under the stator core. No missing nuts were found on the machine; however the collector rings use the same size nut. Burned coils and iron necessitated returning the unit to the supplier.

Factory inspection and test results were as follows:

1. All three phases were grounded.

2. Coil distortion had occurred between phase group and coils showed evidence of failure.





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3. The major iron burning occurred at the diesel end in and around stator slot 165. The coil in slot 188 was burned and torn apart where the coil comes out of the slot and there was some iron damage at slot 188 and at other locations.

4. The nut found in the machine showed signs of electrical burning but no mechanical damage. There were small copper deposits on the nut.

5. A number of coils had small burn spots on the slot portion of the coil insulation.

6. After removal of the coils, a stator loop test was run which introduced magnetic flux into the stator iron. Shorted laminations, if present, would increase iron losses and raise the stator core temperature. These tests, even after repair of the iron, showed 27 C to 32 C temperature rise in areas that were not involved in the failure, thus indicating iron damage which was unrelated to the jobsite failure.

7. The rotor meggered satisfactorily and passed a 2000 volt high potential test. Mechanical damage to the rotor was superficial.

8. Portions of the removed stator coils were hi-pot tested and withstood the 18 kV design value except in areas damaged by their removal from the stator or by the original failure. Hi-pot tests made of the coil insulation with small burned spots, were all acceptable. The spots did not penetrate the outer winding layer.

The cause of the failure has been analyzed by both Bechtel and Beloit Power Systems. Two possible failure modes have emerged. Bechtel and Union Electric believe the failure was caused by an excessive volts-per-hertz ratio condition during shop testing; Beloit believes the failure resulted from foreign material in the generator. Regardless of which failure mode is correct, Union Electric believes that this was an isolated incident and not generic to the SNUPPS units.

The Beloit analysis concluded the failure occurred in slot 188 and was caused by the steel nut found during the site inspection. Beloit believes the nut mechanically damaged the insulation in this slot and the resulting short circuit caused the winding in this area to tear apart. Debris from this initial failure area was carried in the direction of rotation and resulted in subsequent damage to other areas. The source of the nut was not identified in the Beloit report.

The Bechtel analysis attributed the failure to damage caused by an exciter failure during a Colt shop test. During the acceptance testing at the Colt factory, the exciter voltage control set was in automatic at 4160 volts rather than in manual during reduced speed tests. The exciter attempted to maintain the voltage at 4160 volts at reduced speed and thus increased the volts-per-hertz ratio from the generator to the exciter. The exciter potential transformer (PT) failed with a phase to ground fault and consequently a generator main lead blew off the PT and went to ground. Considerable damage was done to the exciter and cable by this failure. The volts-per-hertz ratio increased to 1.47 per unit at the time of the failure (350 RPM).

Bechtel's analysis concluded that core iron damage resulted from the high volts-per-hertz ratio and that coil movement was experienced due to the short circuit forces caused by the factory test exciter failure. These events degraded the generator and subsequently caused its failure during startup testing. Mechanical damage observed in the machine was caused by rotor-carried debris resulting from the failure.

The human error which left the exciter voltage control in automatic during reduced speed factory tests was an isolated incident. The fact that it happened indicates a potential problem exists in the Colt test procedure. Colt has indicated that they do not believe that the procedure can be written with sufficient detail to specifically tell the tester exactly when to change the mode of operation of the excitation system under all test conditions. They have issued a warning to the test group to be cognizant of and limit the volts-per-hertz ratio by proper operation of the excitation equipment at all times.

Although Colt's response does not assure that other generators were not damaged by excess flux, we do not consider our generator failure to be a generic problem for the following reasons:

1. If the testing error had been repeated on other generators, we believe that the potential transformer, which is more susceptible to damage from a high volts-per-hertz ratio than the more massive generator, would have failed. The test reports do not indicate such a problem during the Colt test of the other SNUPPS generators.

2. The unfailed Callaway generator was given a Hi-pot test after installation at Callaway to insure the integrity of the insulation. It successfully withstood the Hi-pot and has been loaded without problem.

The NE02B emergency generator stator was replaced utilizing only the frame from the failed generator. The generator rotor was refurbished by Beloit. The emergency generator has been installed at the site and load tested. All preoperational testing will be repeated on the emergency generator at Callaway.

This is Union Electric's final report on this subject.

Very truly yours,

Donald F. Schnell

Donald F. Schnell

RWK/RWF/sla

cc: J. E. Konklin, NRC Region III
Richard DeYoung, Director I&E
NRC Resident Inspectors, Callaway Plant (2)
Missouri Public Service Commission