UNITED STATES
NUCLEAR REGULATORY COMMISSION
REGION II
101 MARIETTA ST., N.W.
ATLANTA, GEORGIA 30323

Report Nos.: 50-269/88-14, 50-270/88-14, and 50-287/88-14

Licensee: Duke Power Company
422 South Church Street
Charlotte, NC 28242

Docket Nos.: 50-269, 50-270, and 50-287

License Nos.: DPR-38, DPR-47, and DPR-55

Facility Name: Oconee 1, 2, and 3

Inspection Conducted: May 16-19, 1988

Inspector: Paul J. Fillion — June 14, 1988
P. Fillion — Date Signed

Approved by: T E Conlon — 6-14-88
T. Conlon, Section Chief — Date Signed
Plant Systems Section
Division of Reactor Safety

SUMMARY

Scope: This announced inspection was conducted at the corporate offices in the area of emergency power. Program areas covered in part were engineering, design changes, resolution of design problems, and surveillance testing.

Results: No violations or deviations were identified. The licensee's program for resolving design problems was shown to be effective.

REPORT DETAILS

1. Persons Contacted

Licensee Employees

*J. Tannery, Design Engineer, Electrical
*R. Dobson, Design Engineer, Electrical
*J. Stoner, Design Engineer, Electrical

*Attended exit interview

2. Event Report Followup (592700)

The requirements of 10 CFR 50, Appendix A, Criterion 17 are interpreted by the NRC to mean that offsite and onsite power sources considered together must meet the single failure criterion on a system basis without loss of capability to provide power for all safety functions. However, on April 26, 1988, the licensee reported to the NRC that a condition existed for 16 days whereby the onsite and offsite power supplies would not have been available within a few seconds following a loss-of-coolant accident assuming a single failure (e.g. misoperation of the transformer differential relay). During the Unit 2 refueling outage, which began in February 1988, the 230 KV circuit breakers that control the startup/standby transformer CT2 were replaced with higher rated breakers. The high-voltage windings of transformer CT2 are connected in a wye configuration with the neutral point solidly grounded. It must be recognized that, for each phase, the circuit breaker contact voltage gradient capacitors are in series with the transformer winding, which is essentially a saturable inductor. With the source bus energized and the source side and load side breakers both open a ferroresonant condition was set up in the capacitive/inductive series circuit. The ferroresonant condition could produce 4000 volts on the transformer secondary, and cause undervoltage relays to not operate when they would otherwise be expected to operate. Therefore, given the pre-existing potential for ferroresonance to occur, the safety-related systems would have been without any AC power for certain design basis events until operator actions could recover from the failure.

The inspection was conducted at the corporate offices in Charlotte, NC, and consisted of discussions with the cognizant design engineers as well as review of related documents. A chronology of events, starting with placement of the purchase order for the new circuit breakers, was established. The theory of ferroresonance and the circuit breaker ratings were reviewed. The listing of documents reviewed and reference documents given in Section 3 is indicative of the depth and scope of the inspection. Possible generic implications of this event were addressed. In order to evaluate the licensee's program in dealing with design engineering problems, the inspection focussed on two questions:

a. Was the engineering analysis at the design phase of the breaker upgrade project adequate?

b. Were the corrective actions taken, after the ferroresonance problem was first identified, adequate and timely?

In order to predict, in the design stages, the problem that occurred, the design engineer would have to have been familiar with this type of problem from previous experience. However, ferroresonance, as manifested in the Oconee event, occurs quite rarely. The manufacturer of the circuit breakers (Cogenel-Alsthom) although aware of the particular application did not mention the possibility of ferroresonance during five contract meetings. While it was possible to predict the problem in the design stages, the problem was sufficiently hidden that it would not be fair to conclude that the licensee's design analysis was inadequate.

On April 1, 1988, the licensee became aware that startup/standby transformer CT2 had been subjected to ferroresonance for several hours on the previous day. The ferroresonance condition was confirmed by making oscillograms of the current on the high-voltage side of the transformer. The recorded waveshape had periodic impulses separated by periods of essentially zero current. This is the characteristic waveshape of ferroresonance. According to Duke Power Co. general practice, whenever a transformer differential relay operates, the transformer is tested. An oil sample analysis, a power factor measurement (Doble test) and ratio test were conducted on April 1, to demonstrate the integrity of the transformer's insulation. The interval for preventive maintenance on the transformer will be reduced in the future.

On April 26, the licensee identified the scenario whereby ferroresonance could cause loss of all AC power for certain design basis events. A test demonstrated that ferroresonance could cause 4000 volts to appear on the transformer secondary. Since 4000 volts is above the undervoltage relay setpoint, the problem was confirmed to exist. Corrective action taken on April 26, was to re-align the distribution system to preclude ferroresonance from occurring while still maintaining the design basis. On May 1, the capacitors on the circuit breakers that control startup/standby transformer CT2 were replaced with capacitors that, when coupled with the inductance, would produce only about 400 volts on the 4160 volt winding. This was confirmed by test, and transformer CT2 was returned to service.

When one reviews the licensee's actions from April 1 to May 1, 1988 aimed at rectifying a self identified design problem, one may conclude that in the balance their program was effective in resolving the problem. Particularly noteworthy was the speed with which the oscillograms were made and interpreted. In hindsight, the problem scenario could have been identified sooner, but then the capacitors were replaced in a timely manner. All appropriate actions were taken.

In NRC Report 88-12, this matter was identified as Licensee Identified Violation 270/88-12-01, Potential Complete Loss of All AC Power Due to 230KV Switchguard Modifications. The conclusions of this inspection are in agreement with that finding.

3. Documents Reviewed and Reference Documents

Qualification Report for Cogenel - Alsthom FX-22 Breakers and IF-242 Current Transformers Rated 230 KV/ 67.5 KA /900KV BIL
Approved March 23, 1988.
Includes: Qualification statement, Purchase Specification, Seismic Analysis, Short-Circuit Test Data (prototype) and Alsthom QA Program.

Drawing, Oconee Nuclear Station Units 1, 2, and 3 One-Line Diagram 6900 V and 4160 V Station Auxiliary System, Dwg No. O-702-1, Rev.14

Procedure, EPSL E.S. Actuation Keowee Emergency Start Test, No. PT/2/A/0610/01J, performed on March 28 and 29, 1988 [Note: Ferroresonance problem affected the completion of this procedure]

Work Request No. 14280C, initiated and completed on March 29, 1988, to investigate transformer CT2 lockout which occurred during performance of test.

Copies of six oscillograms taken on April 1, 1988, at current transformer 50B/CT2.

Problem Investigation Report Serial No. 4-088-0096 initiated on April 8, 1988, to resolve the "Possibility of resonance build up on startup transformer .....".

Project Change Authorization No. 942 for Nuclear Station Modification (NSM) ON-22637, approved on April 4, 1988, to replace the existing capacitors provided with the new PCB's with ones having smaller capacitance rating.

Calculation No. OSC-3023, "Investigation of PCB/Startup Transformer Voltages Dependent Upon PCB Contact Capacitance," approved April 29, 1988.

Data Sheet, Voltage Verification Record, Recorded voltages at transformer secondary after capacitors were replaced, dated May 1, 1988.

Book, "Magnetic Saturation in Circuits at Rest" Chapter 48, Saturation of Iron in Oscillatory Circuits, Pages 642-656.

Paper, "Analyzing and Understanding Ferroresonance on Distribution Systems" from Transmission and Distribution Magazine, June 1968, by Kilgour, Harlow and Phadki.

IEEE Paper, "Transient Recovery Voltage and Arc Interruption" by R. G. Colclaser, Jr., part of IEEE Tutorial Course 75CH0975-3-PWR.

4. Licensee Action on Previous Enforcement Matters

This subject was not addressed in the inspection.

5. Unresolved Items

Unresolved Items were not identified during this inspection.

6. Exit Interview

The inspection scope and results were summarized on May 19, 1988, with those persons indicated in Paragraph 1. The inspector described the areas inspected and discussed in detail the inspection results listed below.

One violation was identified at the exit interview in the area of corrective action or, more specifically, the timeliness for the corrective actions taken. The licensee stated that the proposed violation was not valid. Subsequent to the inspection the matter received further NRC review at the Region II office. An NRC panel concluded that NRC requirements were not violated because the licensee's corrective actions for the matter and time period in question were prudent and reasonable. Therefore, there will not be a citation.

The licensee did not identify as proprietary any of the material provided to or reviewed by the inspector during this inspection.