UNITED STATES
NUCLEAR REGULATORY COMMISSION
REGION II
101 MARIETTA STREET, N.W., SUITE 2900
ATLANTA, GEORGIA 30323

Report Nos.: 50-400/92-26

Licensee: Carolina Power and Light Company
P. O. Box 1551
Raleigh, NC 27602

Docket Nos.: 50-400 License Nos.: NPF-63

Facility Name: Harris 1

Inspection Conducted: October 19-23, 1992

Inspectors: Merle N. Miller 11/10/92
M. Miller Date Signed

MB Shymlock for 11-12-92
G. MacDonald Date Signed

Approved by: MB Shymlock 11-12-92
M. Shymlock, Chief Date Signed
Plant Systems Section
Engineering Branch
Division of Reactor Safety

SUMMARY

Scope:

This routine announced inspection was conducted to assess the adequacy of the licensee's plans for proposed long term corrective action for the 480 V metal clad LK-16 circuit breakers. In addition, the follow-up of a maintenance team inspection unresolved item was examined.

Results:

In the areas inspected, no violations or deviations were identified.

The licensee had completed a very thorough investigation of the LK-16 circuit breakers and determined long term corrective action was needed. The licensee stated their decision for long term corrective action would be determine by the end of 1992 and the first phase would be implemented during the next refueling outage. The Unresolved Item 89-16-01, "Testing Molded Case Circuit Breakers in the 125 VDC Power System" was satisfactorily closed.

Strengths:

The licensee's engineering staff and electrical maintenance department were very knowledgeable and acted in a professional manner. The investigation of the LK-16 circuit breakers problems was exceptionally thorough indicating the engineering staff was highly qualified to perform such a difficult task. The electrical maintenance department personnel had a complete understanding of the LK-16 breaker problems and performed the required preventive maintenance in an exceptional manner.

REPORT DETAILS

1. Persons Contacted

Licensee Employees

*M. Bodnar, Senior Specialist, Nuclear Engineering Department
A. Cockerill, Manager, Nuclear Engineering Department, Electrical
*J. Collins, Manager, Operations
*J. Cribb, Manager, Quality Control
W. DeLuck, Supervisor, Electrical Maintenance
*C. Gibson, Manager, Programs and Procedures
*C. Hinnant, General Manager, Harris Plant
*M. Hamby, Project Specialist Regulatory Compliance
*D. Knepper, Manager, Nuclear Engineering Department Site Unit
*W. Levis, Principal Engineer, Nuclear Plant Support
*J. McKay, Manager, Engineering/Technical Support Assess
J. Morris, Supervisor, Electrical Maintenance
*T. Morton, Manager, Maintenance
*J. Nevill, Manager, Technical Support
C. Olexik, Manager, Regulatory Compliance
*D. Rodden, Specialist, Technical Support
*W. Seyler, Manager, Outages and Modifications
*G. Vaughn, Vice President, Harris Nuclear Project
*M. Wallace, Senior Specialist, Regulatory Compliance
*L. Woods, Manager System Engineers
R. Zula, Supervisor, Technical Support Electrical and Instrumentation and Control

Other licensee employees contacted during this inspection included craftsmen, engineers,technicians, and administrative personnel.

Other NRC Employees:

*C. Julian, Chief, Engineering Branch, Region II
*J. Tedrow, Senior Resident Inspector
*M. Shannon, Resident Inspector

*Attended exit interview

2. Brown Boveri LK-16 Circuit Breaker Concerns

Harris has a total of 203 LK-16 circuit breakers installed in the 480 VAC power systems. Thirty are installed in the four safety buses (5 in 1A2, 10 in 1A3, 5 in 1B2, and 10 in 1B3). Of these 30, twelve are spares and only two are considered to be cycled or operated frequently. None of these safety related breakers have ever failed.

There are eight breakers in the non-safety related emergency buses 1A1 and 1B2. Four of these breakers are considered to be cycled frequently. The remaining 165 breakers are in the balance of plant (BOP) buses where 22 are considered to be frequently cycled. All of the breaker failures have been in the non-safety related power systems. However, there was a

concern by both the licensee and the NRC that the potential for failure of the 30 breakers in the safety related power system needed to be addressed.

Background (Information from licensee's documentation)

During Start Up Testing in January and February 1986, the first failure-to-open problems with the LK-16 breakers were identified by the licensee. Brown Boveri (BB) evaluated that the three breakers failed because of the accumulation (increasing) of friction in the various moving parts of the trip system. Brown Boveri recommended a modification of adding booster springs to the opening springs to overcome the frictional forces, contact cleaning, and relubrication. The licensee implemented the BB recommended modification for the breakers.

In August 1986, one of the modified LK-16 breaker failed to open. Brown Boveri determined that the problem was an isolated incident involving misalignment of the contact bridge blade. A one time alignment of all the breaker contacts was recommended and implemented by the licensee to correct this problem. However, the LK-16 breakers continued to fail. By September 1989, an additional nine failures had occurred. ASEA Brown Boveri (ABB) suggested that periodic realignment of the frequently cycled breakers may be necessary to correct the problem. The licensee's maintenance procedures were revised to check the alignment as suggested by ABB. Subsequent alignment checks by maintenance personnel did not identify any misalignment in any of the failed breakers.

An increase in the LK-16 failure rates prompted the On Site Nuclear Safety (ONS) group to initiate an investigation in August 1988. ONS recommended that the root cause of the LK-16 failures be determined. In March 1989, ABB proposed that a new root cause of the failure-to-open problem was that maintenance was using freon to clean the breakers. The freon was breaking down the lubricants causing the mechanisms to bind. Maintenance discontinued the use of freon. Starting in April 1989, seven more failures occurred in a period of approximately one month.

In May 1989, ABB proposed the installation of bridge blade torsion springs in the LK-16 breakers. ABB indicated that torsion springs should correct the "root cause" of the failure-to-open problem which ABB characterized as a fundamental design problem. ABB also identified the out-of-tolerance arcing contact compression springs as a contributor to the problem. This modification was contingent upon a modified breaker passing an ANSI close-and-latch test. In June 1989, ABB notified the licensee that the breaker failed the test. The torsion spring was redesigned by ABB and subsequents tests were successfully completed. In August 1989, installation of the torsion springs in non-safety related LK-16 breakers began. The breakers were being modified in the ABB plant in South Carolina. The first torsion spring modified breaker failed in service on April 27, 1990. The modifications at ABB's plant were suspended by the licensee, 49 LK-16 breakers had been modified.

Because of continuing failures and the lack of confidence in previous corrective actions recommended by Brown Boveri; in October 1989, the licensee commissioned a Task Force to investigate and determine the root cause of the LK-16 failure-to-open problem. In addition, the Task Force was to recommend corrective action to achieve long term reliability of the LK-16 breakers. The inspectors considered that this engineering investigation was very thorough and the licensee's staff did an exceptional job in completing it. It appeared that every possible reason for the failures was examined and tested to determine the real root cause.

The Task Force's efforts are briefly described as follows:

I. An analysis of the breaker mechanism was performed to determine the force required to open the breaker and the sensitivity of this force to lubrication.

II. A series of load tests were performed under simulated load conditions to identify and analyze the attributes why some breakers failed and others did not.

III. Tests were performed to isolate and measure the forces required to separate the contacts.

IV. Tests were performed to verify that the main opening and booster springs (forces) were within specifications.

V. Tests were performed to measure any difference in the arcing contact compression spring forces under various conditions.

VI. Measurements were taken of contact dimensions and contact alignment to determine if orientation and physical characteristics were contributors to the problem.

VII. Test were performed that involved a series of pulls to measure the frictional forces supplied by the pivot points on the jack shaft assembly.

VIII. A metallurgical analysis of the arcing contact material and the jack shaft bearing material was performed to determine its compatibility.

IX. Tests were performed on modified breakers to validate proposed corrective action. (The breakers were modified according to the findings of the Task Force).

The recommendations of the Task Force for modifications and service are briefly listed as follows:

1. Tear down, clean and relubricate each breaker with Anderol 757 in accordance with the manufacturer's recommendations.

2. Verify the opening springs (forces) are within specifications. Remove any booster and torsion springs.

3. Remove old arcing contact springs and washers and replace with new springs.

4. Use the ABB inspection tool to verify spacing between the blades and the moving contacts. If spacing was incorrect or there was evidence of galling, replace the components.

5. Perform arcing contact alignment on each blade.

6. Increase the preventive maintenance frequency to every 100 cycles of operation.

7. Complete a training course provided by ABB on LK-16 breaker maintenance and adjustment. This course will be for everyone working on the LK breakers.

The Task Force determined that the root cause of the failure-to-open problem was inadequate design margin in the available opening forces. Testing and analysis revealed that critical characteristics affecting the opening and restraining forces (friction) were not adequately controlled... The causal factors contributing to the inadequate design margin included:

* Defective stationary arcing contact compression springs.

* Inappropriate use of washers on the arcing contact springs.

* Ineffective booster spring application.

The Task Force Report stated that the recommended corrective actions would significantly improve the reliability of the LK-16 breakers. Further improvement in the reliability would require a fundamental redesign of the arcing contact assembly.

Inspection

The licensee implemented the Task Force's recommendations in plant modification PCR-3510. The licensee believed this corrective action would be adequate for the failure-to-open problem. However, six of these modified breakers had failed since September 1990. In addition, five other breakers had failed. Because of these additional problems the site management requested that the Electrical Section in the Nuclear Engineering Department (NED) initiate a project to provide a "long term solution" to correct this LK-16 breaker problem. The inspectors attended a meeting where NED discussed the scope and the various options for the "long term solution" to the site staff and management. NED intentions were to have their recommendations and completed scope input to management by December 15, 1992. The licensee stated that management

approval and implementation of the "long term solution" would be completed by the end of 1992. In addition, the first phase of the corrective action would be completed during the next refueling outage. This corrective action would be implemented for at least one of the two safety related trains. The other safety related train would be completed during the following refueling outage.

The inspectors reviewed NRC reports, LK-16 breaker work requests, LK-16 preventive maintenance procedures, the licensee's LK-16 Task Force Report dated September 1990, and the report of the 11 recent LK-16 failures. In addition, preventive maintenance on LK-16 breakers was observed in the licensee's electric shop. The inspectors determined that the licensee's engineering staff and the electrical maintenance group have done an exceptional job regarding the LK-16 breakers. However, the inspectors agreed with the licensee's Task Force that there was inadequate design margin and further improvement of the LK-16 breaker reliability would require a fundamental redesign. The inspectors concluded that the licensee needs to implement corrective action that will permanently fix the failure-to-open problem of the LK-16 breakers installed in the safety related power system.

3. Followup (92701)

(closed) Unresolved Item 50-400/89-16-01, Testing Molded Case Circuit Breakers In The Safety-Related 125 VDC Power System.

During the Maintenance Team Inspection the inspectors reviewed the original purchase order and technical specifications for the safety-related 125 VDC switchgear. These documents were reviewed to determine how the equipment was qualified and the maintenance requirements since Gould Inc. had sold their ITE Circuit Breaker Division to Siemens. The ITE Circuit Breaker Division was the original manufacturer of the breakers and switchgear installed in Harris. The Qualification And Test Summary Report (Qualification Report) for Class 1E Switchgear was prepared by another division of Gould Inc.(Telemechanique) to document the up-grading of commercial switchgear for Class 1E service. (Gould ITE did not make Class 1E equipment). Since Gould Inc. had sold their ITE Division to Siemens Inc. the inspectors were concerned about maintenance and replacement parts. The Qualification Report contained a Maintenance Section specifying that field testing of the molded case circuit breakers was aimed at assuring that the breakers were functionally operable. The licensee was to evaluate the maintenance requirements in the Qualification Report since these requirements were originally overlooked.

The inspectors reviewed the drawings for the 125 VDC power system to determine the number and the use of the molded case circuit breakers (MCCBs) installed in the two main safety related 125 VDC distribution buses Numbers DP-1A-SA and DP-1B-SB. The breakers can be used in both feeder circuits and branch circuits. A "branch" supplies only a single circuit (one function). A "feeder" supplies another distribution panel having several circuits. The MCCBs in the two safety related

distribution buses were used in branch circuits. All feeder circuits from these main buses used fuses (with disconnect switches) instead of using MCCBs. However, each bus was fed from two battery chargers each using a MCCB (two chargers per bus). The battery chargers were redundant and each one was capable of providing full load current to its bus. Safety Bus DP-1A-SA had a total of five MCCBs. Safety Bus DP-1B-SB had a total of six MCCBs. The inspectors considered that the safety function of the MCCBs to carry rated current was verified by other testing activities. For example, the MCCBs for the inverters and the battery chargers were verified operable during their full load tests. The other MCCBs were verified operable when their single load was operated. In addition, the breakers are periodically toggled on and off. This toggling verified the breakers would reset. Since the licensee indirectly verified the MCCBs operable, there was no safety concern. The inspectors determined that since none of the MCCBs are used as feeders (except from battery chargers) and all are verified operable, this item was closed. However, the NRC is reviewing the requirements for testing molded case circuit breakers as a generic issue.

This item was closed.

4. Exit Interview

The inspection scope and results were summarized on October 23, 1992, with those persons indicated in paragraph 1. The inspector described the areas inspected. Proprietary information is not contained in this report. Dissenting comments were not received from the licensee.

5. Acronyms and Initialisms

ABB	Asea Brown Boveri
ANSI	American National Standards Institute
BOP	Balance Of Plant
CP&L	Carolina Power and Light
HESS	Harris Engineering Support Section
I&C	Instrumentation and Control
MCCB	Molded Case Circuit Breakers
NED	Nuclear Engineering Department
NRC	Nuclear Regulatory Commission
ONS	Onsite Nuclear Safety (group)
PCR	Plant Change Request
QA	Quality Assurance
RFO	Refueling Outage
RI	Resident Inspector
SRI	Senior Resident Inspector
VAC	Volts Alternating Current
VDC	Volts Direct Current