U. S. NUCLEAR REGULATORY COMMISSION
REGION I

REPORT NOS.	50-277/92-23 50-278/92-23
DOCKET NOS.	50-277 50-278
LICENSE NOS.	DPR-44 DPR-56
LICENSEE:	Philadelphia Electric Company
FACILITY NAME:	Peach Bottom Atomic Power Station, Units 2 and 3
INSPECTION AT:	Chesterbrook Blvd, Wayne, Pennsylvania.
INSPECTION DATE:	August 19, 1992

INSPECTORS: C.H. Woodard for — 9/24/92
M. E. Lazarowitz, Reactor Engineer, Date
Electrical Section, EB, DRS

C. H. Woodard — 9/24/92
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APPROVED BY: Jacque M. Durr for — 9/25/92
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Results: The licensee determined that the electrical cable failures reported in LER 91-09 were due to a mechanism known as "treeing". Root causes of these failures were found to include light electrical load, the presence of moisture (water), high voltage, and the type of cable, cable wrap and cable insulation. Corrective actions taken included the replacement of affected cables. In addition, a long-term monitoring/predictive maintenance program was being established for the timely replacement of cables which are most susceptible to treeing.

1.0 FOLLOWUP OF PREVIOUSLY IDENTIFIED PROBLEM

The scope of this inspection was followup on an item identified in the NRC Inspection Report Nos. 50-277/91-16 and 50-278/91-16, dated June 19, 1991. This item involved the failure of a 5000 Vac (5 kV) electrical cable that connected the emergency auxiliary transformer OAX04 to the feeder breaker for the 4,160 Vac (4 kV) bus. The NRC was provided with samples of the failed cable for evaluation. The licensee also had samples of the failed cable evaluated.

The inspectors met with the licensee on August 19, 1992 to review the root cause analyses, corrective actions, and to determine if this issue warranted further NRC or licensee actions.

1.1 Peach Bottom Cable Failure Event

The Peach Bottom Atomic Power Station had several in-service failures of the 4kV and 13,800 Vac (13 kV) cables associated with the 2 emergency auxiliary transformer OAX04. Some of these failures were attributed to water treeing in the insulation. A cable tree is a form of physical cable insulation deterioration that usually propagates from an outer insulation flaw through its trunk and branches inward to the cable conductor. This physical deterioration can lead to cable failure. Cable trees occurring in the presence of water are called water trees. Those occurring in the absence of water are called electrical trees. Although some electrical treeing was observed, the causes of cable failure at Peach Bottom were attributed to water treeing. Water trees occur only in the presence of water and with a high voltage stress on the cables. The cables associated with the No. 2 emergency auxiliary transformer OAX04 were located in the underground duct banks and some were exposed to moisture in the conduits as well as the 4 kV stress.

Samples from various failed cables were provided by the NRC to Sandia National Laboratories (SNL) for evaluation. The testing at SNL consisted of elongation, tensile strength, density, hardness, dielectric withstand testing, and microscopic examination for the presence of trees. SNL concluded that the failures that occurred were the result of water treeing in the cable insulation. The mechanical properties of the cables were still very good and the failures would not be expected as a result of mechanical property degradation (at least for similar thermal aging conditions as occurred in the sections of cable that they tested).

The licensee had determined that treeing is related to the amount of time a cable is energized, the presence of moisture, the amount of ampere load placed on the cable, the configuration of the semiconducting wrapper around the insulation, and the initial manufactured quality of the cable. The cable installed at Peach Bottom utilized a wrapped type of semiconductor. Each wrap overlap creates a voltage stress riser. When the cable is bent around corners or otherwise handled in a normal way, the stress risers can allow a voltage or potential gradient to form which is greater than that in an un-handled cable. This gradient, which may be thousands of volts per millimeter contributes to the susceptibility for treeing. The licensee concluded that the main factors that determine if treeing will occur are the time the cable is

energized and the amount of ampere load on the cable. Testing showed that the length of time of high voltage application is directly related to the amount of damage done to the cable. Also, the higher the voltage, the more damage done. An inverse factor is the amount of electrical load on the cable. The heating caused by the electrical load reduces the growth of water treeing and seems to limit the growth of electrical treeing. The licensee reviewed the failed cable and found that although in this application it was continuously energized, it was usually very lightly loaded. Thus the potential for tree growth was enhanced.

In order to further assess this potential root cause, the licensee removed another cable from service and tested this cable for treeing. This cable was also exposed to moisture, was the same type of cable that failed in transformer service, but was not energized continuously, and when it was energized it was well loaded. The licensee found only two small trees in the several hundred samples of this cable examined.

The inspectors found good correlation between the SNL root cause analysis of the cable failures and those made by the licensee. (The licensee's evaluations were much more extensive.)

Based upon their root cause evaluations, the licensee made decisions to replace only those cables which were most susceptible to water treeing at this time. The emergency diesel generator system cables, high pressure service water system cables, and the residual heat removal system cables will not be replaced since the energization time for these cables is short and the cable is well loaded when it is energized.

The licensee reported that the cable treeing phenomenon is well known in the company's transmission and distribution areas, but is not as well known within the generating plant areas. As a consequence the licensee had taken steps to integrate this knowledge into the plant including a program for predictive maintenance (replacement) of water immersed cables.

2.0 Conclusions

The licensee's analysis of the Peach Bottom station cable failures properly identify the causes. Corrective actions taken to replace the affected cables was prompt. The continuing monitoring of cables for predictive maintenance (replacement) provides an assurance that cables which may be susceptible to "treeing" will be replaced in a timely manner if necessary.

3.0 MANAGEMENT MEETING

The inspectors met with those denoted in Attachment 1 on August 19, 1992, at the Chesterbrook offices to discuss the inspection findings detailed in this report. There are no outstanding or open items from this report.

ATTACHMENT I

Persons Contacted

Philadelphia Electric Company

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