UNITED STATES
NUCLEAR REGULATORY COMMISSION
REGION II
101 MARIETTA ST., N.W., SUITE 3100
ATLANTA, GEORGIA 30303

Report Nos. 50-338/81-21 and 50-339/81-18

Licensee: Virginia Electric and Power Company
P. O. Box 26666
Richmond, VA 23261

Facility Name: North Anna Units 1 and 2

Docket Nos. 50-338 and 50-339

License Nos. NPF-4 and NPF-7

Inspection at North Anna site near Mineral, Virginia

Inspector: HC Dance /for 9/18/81
M. B. Shymlock, Resident Inspector — Date Signed

Accompanying Personnel: A. Ignatonis, Senior Resident Inspector, Turkey Point
W. Marsh, Resident Inspector, Turkey Point

Approved by: HC Dance 9/18/81
H. C. Dance, Section Chief, Division of Resident and Reactor Project Inspection — Date Signed

SUMMARY

Inspection on June 27 - July 31, 1981

Unit 1 Areas Inspected

This routine inspection by the resident inspectors involved 18 inspector hours on site in the areas of operational safety, maintenance, and surveillance.

Unit 1 Findings

Of the three areas inspected, no violations or deviations were identified.

Unit 2 Areas Inspected

This routine inspection by the resident inspector involved 69 inspector hours in the areas of operational safety, maintenance, surveillance and followup on Unit 2 transformer problems.

Unit 2 Findings

Of the four areas inspected, no violations or deviations were identified.

DETAILS

1. Persons Contacted

Licensee Employees

*W. R. Cartwright, Station Manager
*E. W. Harrell, Assistant Station Manager
*J. A. Hanson, Superintendent - Technical Services
*J. R. Harper, Superintendent - Maintenance
*S. L. Harvey, Superintendent - Operations
*F. Termenilla, Engineering Supervisor
*J. R. Stratton, Mechanical Maintenance Supervisor
*M. A. Harrison, Resident QC Engineer
*M. E. Fellows, Staff Assistant
*K. A. Huffman, Clerk

Other licensee employees included six technicians, four operators, mechanics, and several office personnel.

Other Organizations

A. Ignatonis, Senior Resident Inspector, Turkey Point
W. Marsh, Resident Inspector, Turkey Point

*Attended one or more exit interview

2. Exit Interview

The inspection scope and findings were summarized on July 17 and July 31, 1981 with those persons indicated in paragraph 1 above.

3. Licensee Action on Previous Inspection Findings

Not inspected.

4. Unresolved Items

Unresolved items were not identified during this inspection.

5. Unit 1

During this inspection period Unit 1 operated at or near 100% capacity. The unit experienced two trips, one due to a diaphragm failure in the turbine lube oil system and the other due to a bypass trip breaker failure during a performance test. There was also a power reduction due to a fire in Unit 2 B main transformer. In both cases safety systems functioned as designed.

6. Mechanical Maintenance, Equipment Calibration and Surveillance Test Observations

During this inspection period, portions of the following maintenance activities and surveillance testing were observed:

a. Shaft seal replacement on 1-CCW-P-1A pump and 2-QS-P-2A pump per general procedure MMP-C-GP-1. The observation of these activities verified that:

1) Current procedures were available and were in use.
2) Reviewed Work Request, Maintanance Reports, Radiation Work Procedures, Equipment Tagouts, and proper use of maintenance procedures.

b. Calibration of Unit 2 radiation monitor system (units 263 and 264) reactor containment and incore - instrumentation. The observations of these activities verified that:

1) Current procedures were available and were in use.
2) Reviewed Work Request, Maintenance Reports, Equipment Tagouts, and proper use of calibration procedures.

c. Surveillance test observations included witnessing the following:

1) 1-PT-30.1, NIS Channel Functional Test Prior to Startup
2) 1-PT-57.1B, ECCS Subsystem - Low Head SI Pump (1-SI-P-1B)
3) 2-PT-5. 1B, ECCS Subsystem - Low Head SI Pump (2-SI-P-1B)
4) 2-PT-82.1A, 2H Diesel Generator Test
5) 1-OP-6.3, Local Operation of 1H Emergency Diesel Generator
6) 1-OP-6.4, Local Operation of 1J Emergency Diesel Generator

All work observed appeared to be conducted correctly and the inspector had no further questions on these items.

7. Unit 2

During this inspection period Unit 2 was shutdown due to main transformer repairs. While attempting to return to service on July 3, the unit tripped after B main transformer failed resulting in a transformer oil fire. Details of this failure are provided in IE Inspection Report No. 50-338/81-19 and 50-339/81-16.

a. Failure of C Main Transformer

At 3:33 a.m. Saturday July 25, 1981 the C phase main transformer on Unit 2 experienced an apparent high-voltage winding to ground failure which tripped the switchyard 500 kV breaker thus isolating the damaged transformer from the balance of the station 500 kV distribution. The fault caused extensive damage to the transformer, rupturing the casing in several places and damaging the high voltage output bushing and adjacent lightning arrestor insulator. The oil contained in the transformer was spilled onto the gravel surrounding the transformer base. There was no fire during this event. The inspector viewed the damaged transformer. To determine the pre-operational servicing conducted on this transformer, station and system personnel were interviewed. This transformer was a replacement obtained from another utility, because a previously failed transformer had been returned to the vendor for repairs. The July 25 failure was the fourth such failure in a series which began in November 1980. All the failed transformers were in service on the Unit 2 main generator output distribution system at the time of their failure. The pre-operational service procedures performed on the failed C main transformer included the following:

1) The transformer had been maintained as an onsite spare at another utility. It had been maintained with an interior environment essentially identical to that maintained for such units in service i.e. filled with clean, dry insulating/cooling oil under a dry nitrogen blanket. Prior to shipment, the oil was drained, and the oil coolers removed. The coolers were removed by first closing two sets of isolation valves (one on the transformer tank and the other on the coolers) on both the oil supply and return sides. After removal, the mating flanges were blanked off. The tranformer windings were provided with additional temporary internal supports for the handling and shipping phase. The transformer case was filled and purged with dry air until the interior dew point was less than - 54°C. The transformer was instrumented with impact records and was continuously monitored by licensee personnel during the rail and truck shipment to the North Anna site.

2) After arrival onsite, the impact recorder was read and no shocks were indicated. A visual inspection of the transformer was made with negative results. The dry air pressure was determined to be 2-3 psig. The dew point was checked less than - 54°C.

3) The transformer was then errected at its final location and the dry air positive pressure and dew point were checked a final time. The temporary internal supports were removed; and the oil coolers, pumps, and fans were installed.

4). Normal licensee procedures call for vacuum drying by pulling a vacuum to less than 2 millimeters of mercury for 12 hours plus an additional hour for each 8 hours the transformer was open to ambient conditions. (Licensee procedures prohibit opening a 500 kV transformer to ambient conditions when the ambient relative humidity is greater than 65% however the utility owning the transformer requested a 24 hour vacuum drying period, even though VEPCO procedures called for about a 14 hour drying period. The 24 hour vacuum drying period was conducted by the licensee.

5) The transformer was then filled with hot (140°F to 160°F) clean, dry insulating/cooling transforme oil using a trailer mounted oil processing unit. A vacuum of less than 2 millime'ers of mercury was maintained during the filling process. When the transformer was full the vacuum was broken using dry nitrogen. Nitrogen continued to fill the transformer until 2 to 3 psig overpressure was obtained.

6) A Doble test was then performed. This test impresses a 10 kV voltage on the output windings and a measure of power factor is made. The test is designed to show impurities in the paper wrapped winding insulation and the insulating/cooling oil. A power factor of less than 0.5% is required for acceptability. The transformer passed this test.

7) The oil coolers were then unisolated and the oil pumps were energized to circulate the oil throughout the transformer. The pumps were then secured and the transformer was allowed to sit thus allowing any gas bubbles to rise to the surface of the oil. During this time the turn ratio was measured to verify that the high voltage tap settings were correct.

8). A sample of transformer oil was taken, and a satisfactory Doble test and GE dielectric test were performed. The dielectric test is normally not conducted by the licensee, however in this case oil from all three transformers were tested as further assurance that the oil exhibited satisfactory insulating properties. The dielectric test consists of placing two metal plates (one tenth of an inch apart) in the oil sample and impressing an increasing test voltage across the plates until the oil breaks down. Break down must not occur at less than 28 kV. In this case the breakdown voltage was greater than 28 kV.

b. <u>Transformer Failure Investigation</u>

A task force comprised of VEPCO and Westinghouse personnel was established to pursue the transformat failures. The task force used a failure tree analysis to outline the scope of the investigation and to direct supporting licensee and vendor personnel efforts in the disired areas. The four failures were characterized by two failure modes. Failures 1 and 4 were winding to ground faults. Failures 2 and 3 were high voltage bushing to ground failures. All of the failures apart from failure 2 had some high voltages to low voltage winding involvement.

The failed Unit 2 transformers shared a rather unique background with respect to the fact that they had all:

1) Been handled and shipped several times before being placed in service in Unit 2.

2) Had been in a bank of transformers which had experienced a failure of at least one bank transformer at least once prior to their owns failure

3) As a consequence of "a" above, the high voltage bushing for these transformers had also been handled more than usual and may have been stored improperly. Improper storage of the high voltage bushing coupled with an over-voltage condition could cause failure of the bushing as experienced in failures 2 and 3.

4) The transformers 1, 2, and 3 had been subjected to several documented over-voltage transients. Transformer 4 had been subjected to an over-voltage condition of unknown magnitude and short duration on the low voltage side during the failure of transformer 3.

It was concluded that failures 2 and 3 were a result of the high voltage bushing failing due to a combination of improper storage and over-voltage. Failure 1 resulted from a sudden drop in cooling oil temperature as a result of manual initiation of 150% additional cooling capacity when the oil temperature was already about 30 C° high. This sudden cooling caused a relatively rapid drop in oil level. The drop is oil coupled with isolation of the N2 gas blanket regulator preceded by the lifting of the mechanical relief resulted in a vacuum inside the transformer. The vacuum caused N2 gas dissolved in the oil to effervescence out reducing the dielectric strength of the insulating/cooling oil and allowing an arc to occur from the high voltage output lead to the low voltage winding. Both the effervescence phenomena and the oil breakdown at normal voltage were reproduced in the vondor's laboratory. The fourth failure actually began during the time the third failure occurred. The initiating fault did not lead to the failure of the fourth transformer simultaneously with the thrid because the protective relaying deenergized the transformer bank before the fourth transformer fault had grown sufficiently. When the fourth transformer was subsequently back fed, the previously initiated fault in the low voltage winding caused a catastrophic failure to occur after about two minutes.

c. Transformer Failure Investigation

The inspector observed selected activities associated with the removal of the fourth failed transformer and the handling, errection, and installation of its replacement on site 8/4 and 8/5/81. He closely observed the dissassembly and detailed inspection of the fourth failed transformer and its high voltage bushing on 8/8 and 8/9/81. He sat in on portions of the task force deliberations on 8/4, 8/5, 8/8, 8/9, and 8/10/81. He received briefings summarizing the deliberations and findings of the task force during meetings not attended. He also discussed the series of transformer failures with respect to failure modes, on-site preparation, servicing, and testing of all four failed transformers with site, corporate, and vendor personnel who were either members of the task force or otherwise involved with the operation, maintenance, servicing, testing, or installation of units. The inspector reviewed in detail the preliminary findings of the task force with respect to the areas of investigation, most probable failure modes, causes, and contributing factors for each of the four failures. He discussed these findings at length with the principle licensee and vendor task force members. The inspector determined that prior to energizing the Unit 2 main output transformer bank from the VEPCO grid:

1) The most probable cause of each failure had been determined through a careful review of operating logs and records, interviews with watchstanders, analysis of fault recorder data, detailed inspection of the failed components and supporting tests and experiments at the vendor factory, and

2) The existing transformer in the Unit 2 output bank, their high voltage bushings, insulating and cooling oil purity, associated on-site high and low voltage distribution components, protective relaying, alarms, and instrumentation were thoroughly tested and accepted for operation, and

3) Those site procedural and material matters which could have contributed to the failures had been corrected (e.g. automatic vice manual operation of the transformer oil coolers, winding temperature indication and transformer alarms operable).