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SHOREHAM NUCLEAR POWER STATION
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July 22, 1982 SNRC-719

Mr. Ronald C. Haynes
Office of Inspection and Enforcement,
Region I
U.S. Nuclear Regulatory Commission
631 Park Avenue
King of Prussia, PA 19406

NFP-25 Indented Control Cable
Shoreham Nuclear Power Station - Unit 1
Docket No. 50-322

Dear Mr. Haynes:

On May 14, 1981, in accordance with 10CFR50.55(e), we reported verbally to Region I a potential deficiency with 9/c, No. 14 AWG control cables manufactured by the Rockbestos Company. On November 16, 1981, we submitted a written report of this potential deficiency to your attention. This letter serves as our final report.

Description of Deficiency

Construction electricians, while performing terminations of field run cables, discovered several lengths of cables which exhibited unusual physical characteristics. These cables had indentations in their cross-linked polyethylene (XLPE) insulation which were caused by a binder thread which was spirally wrapped around the insulated conductors, under the cable jacketing. In some cases, this binder thread had indented the conductor insulation at the point of contact, reducing the insulation wall thickness below the minimum required by the purchase specification. This 9/c No. 14 control cable, manufactured by the Rockbestos Company, is identified for Shoreham use as type NFP-25.

Investigations into this problem determined that the installation of a binder thread on this type of cable was a mis-application by the manufacturer. A survey performed by Rockbestos indicated that, although 26 reels of NFP-25 cable supplied to Shoreham were constructed using a binder thread, only those cables jacketed during a particular two-week period, from December 29, 1974 through January 11, 1975, exhibited a significant degree of

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indentation. Factors associated with the fabrication process determined whether the binder thread indented the conductor insulation, and if so, how deeply. Documentation and testing indicates that the greater degree of insulation indentation may have been caused by inadvertently allowing the cables jacketed during this two-week period to remain in the curing ovens longer than the specified 24-hour curing cycle.

Extensive field measurements and statistical analysis of the insulation wall thickness for this cable have been performed to verify the results of the study performed by Rockbestos. These measurements indicate that only cables taken from 7 of the 26 reels experienced a significant degree of indentation. Correlation of the field measurements and the results of Rockbestos' study confirm that only cables from the 7 reels jacketed between December 29, 1974 and January 11, 1975 are subject to significant indentations. Accordingly, NFP-25 cables used in safety related services at Shoreham have been categorized into two lots: Lot #1, those which have minor indentations; and Lot #2, those which have a potentially significant degree of indentation.

A review of cable traceability records has shown that the 26 reels of indented NFP-25 cable have been installed in both safety and non-safety related applications at Shoreham; however, none of this cable has been used within the primary containment.

Although all initial tests performed on unaged samples of indented cables from Lot #2 indicated no significant reduction in electrical properties, it was decided that a series of qualification tests would be conducted on these cables to prove their suitability for use in Shoreham's secondary containment. Since the results of the qualification testing (including aging) would not be known for several months, the potentially significant impact on Shoreham construction and startup schedules associated with the possible late failure of the Lot #2 cables (significant indents) dictated that these cables be removed from Cat IE services. Therefore, only Lot #1 (minor indents) NFP-25 cables remain installed in Category 1E applications.

Analysis of Cable Insulation

NFP-25 cable has been purchased with insulation rated for 600V, although the highest circuit voltages for which this type of cable is utilized at Shoreham are 120 VAC and 125 VDC circuits. NFP-25 cable is control cable, and its conductor size is determined by voltage drop due to control circuit length, not by current capacity; therefore, the internal heat generated is

not the governing factor in selection of conductor size. Industry standards for 600 Volt cable require insulation thicknesses based on conductor size, i.e., average insulation thickness for #14 AWG is 30 mils insulation and for #16 AWG is 25 mils, with the minimum thickness at any given point not less than 90 percent. Therefore, the minimum thickness for #14 AWG is 27 mils and for #16 AWG is 22.5 mils.

The applications in which NFP-25 have been used would normally be serviced with 9/c, No. 16 AWG cable, but have been upgraded to 9/c, No. 14 AWG to improve voltage drops caused by long cable runs. The maximum electrical stress for conductors with the same insulation thickness decreases as the conductor size increases. Therefore, the maximum electrical stress on a No. 14 AWG conductor with 22.5 mils of insulation will be less than that for a No. 16 AWG conductor with the same 22.5 mils of insulation. The maximum electrical stresses, at 600 Volts, for 22.5 mils insulated Nos. 14 and 16 AWG conductors are 34.2 volts/mil and 36.6 volts/mil, respectively. Since this maximum electrical stress is less for the No. 14 AWG conductor, a minimum thickness of 22.5 mils of insulation is adequate for Shoreham's NFP-25 cable.

Cables from Lot #1 have been statistically analyzed and it has been determined that their insulation wall thicknesses are greater than 22.5 mils.

Preliminary Testing of NFP-25 Cables

As stated above, no indented NFP-25 cable has been used within the primary containment. Nevertheless, initial qualification testing was conservatively performed using primary containment accident (LOCA) conditions.

Initial primary containment testing on unaged and un-irradiated Lot #2 cable samples showed no significant differences between the performance of the indented cable and NFP-25 cables with no binder thread or indentations.

After successful completion of this initial testing, several cable samples were aged, irradiated and tested to primary containment conditions to determine how they would perform. Suitability of these aged and irradiated Lot #2 cables for primary containment usage could not, however, be successfully demonstrated.

The failure of these samples is believed to be due to the accelerated thermal aging technique which required artificially high (250°F) temperatures in order to age the cable in a reasonably short time.

Secondary Containment Testing

In order to demonstrate the ability of the Lot #1 cables to resist the effects of long-term aging and secondary containment pipe break environments, another series of qualification tests were performed. Although all Lot #2 NFP-25 cables had been removed from Cat IE applications, these tests were performed on Lot #2 samples which were more indented than any cables found in Lot #1. This was done in order to provide margin with respect to the degree of indentation of insulation.

The binder thread indentation of NFP-25 cable has been determined to be a heat-related phenomenon which takes place with the thermal expansion and slight softening of its cross-linked polyethylene insulation. This makes the accelerated thermal aging of this cable (at 250°F) far more severe an aging mechanism than the cable would experience by natural aging. The maximum temperature in the secondary containment under accident (PBOC) conditions is 218°F, and this temperature decays to less than 150°F in several hours. In order to artificially age NFP-25 cable for 40-year life at 70°C service, the cable must be maintained at 250°F for more than 1000 hours. For this reason, and since the tests were performed on Lot #2 cables, the results of this test program are clearly very conservative.

Secondary Containment Test Procedure

Cable samples were selected from Lot #2 cable removed from the plant and were tested in accordance with IEEE standard 383-1974. These cables were thermally aged at 250°F (121°C). The first sample was aged to simulate 5 years of life at 60°C service. The second sample was aged to simulate 40 years of life at 70°C service. These samples were then irradiated to a total cumulative dose of 2×10^8 rads.

The next stage of testing simulated exposure of the aged and irradiated samples to a PBOC environment while operating at rated current and voltage (600V). The samples were then maintained in a 100% humidity, high temperature environment to simulate 180 days of post-pipe break conditions. The cable samples were subsequently removed from their test reels, straightened, and recoiled on a metal cable reel 40 times the diameter of the cable samples.

Finally, the reels and cables were submerged in water and energized at 2400 volts for 5 minutes.

Both cable samples held the 2400 volts for the full five-minute test interval without any breakdowns.

Test Results and Conclusions

The results of this testing conservatively demonstrate that indented Lot #1 cables will be capable of operating during and after a PBOC any time up to 40 years of continuous service in the secondary containment.

With the successful conclusion of this testing and the removal of the Lot #2 cables from Cat IE applications, all actions necessary to resolve this deficiency have been completed.

Very truly yours,

G K Price for MHM

M. H. Milligan
Project Engineer
Shoreham Nuclear Power Station

TJS/law

cc: Mr. Victor Stello, Director
NRC Office Inspection & Enforcement
Division of Reactor Operations Inspection
Washington, D.C. 20555

Mr. J. Higgins, Site NRC

All Parties