May 2, 2000

MEMORANDUM TO: Samuel J. Collins, Director
Office of Nuclear Reactor Regulation

FROM: Ashok C. Thadani, Director **/RA/**
Office of Nuclear Regulatory Research

SUBJECT: RECENT REPORTED FAILURE OF LOW-VOLTAGE I&C CABLES WITH BONDED JACKET DURING LOSS-OF-COOLANT ACCIDENT (LOCA) TESTS

The purpose of this memorandum is to inform you of the results of recent tests performed as part of the research program to resolve Generic Safety Issue # 168, "Environmental Qualification of Electric Equipment." The objectives of this research program resulting from NRR's EQ Task Action Plan are listed below:

- To determine whether the qualification methods currently used by nuclear power plants provide reasonable assurance that low-voltage electric cables within the scope of 10 CFR 50.49 can maintain their safety function during a LOCA;

- To study the performance of selected cable samples in extended nuclear service (60 years) for license renewal; and

- To provide LOCA survivability data in support of the cable condition monitoring program.

As part of this research, six LOCA tests are planned on different types of I&C cables. Five LOCA tests have been completed.

In LOCA test # 5, ethylene propylene rubber (EPR) insulated I&C cables with bonded jackets were tested. The specific purpose of this test was to determine if cables with bonded jackets have a unique failure mechanism that is not present in unbonded jacket cables under postulated LOCA conditions. The testing was performed at the Wyle Laboratories, Huntsville, Alabama, in accordance with IEEE Std. 323-1974, "Standard for Qualifying Class 1E Equipment for Nuclear Power Generating Stations," and IEEE Std. 383-1974, "Standard for Type Test of Class 1E Electric Cables, Field Splices, and Connections." The pre-aging and LOCA test conditions were the same as those used in the original manufacturer's qualifications.

In this test, the following cables received accelerated thermal and radiation aging, and were then exposed to LOCA conditions:

Okonite: EPR Insulation with bonded chlorosulfonated polyethylene (CSPE) jacket, 1/C; 12 AWG

CONTACT: Satish Aggarwal (415-6005)

Samuel Moore: Ethylene propylene diene monomer (EPDM) insulation with bonded CSPE jacket, 2/C with shield & ground; 16 AWG

Anaconda: EPR Insulation with unbonded CSPE jacket, 3/C; 12 AWG

Subsequent to accelerated aging, the Okonite specimens aged to 40 years were observed to be relatively stiffer compared to the unaged cable. Several circumferential cracks in the jacket were observed in Okonite specimens.

During the LOCA test, leakage currents were observed for three Okonite specimens aged to 40 years of qualified life.

Subsequent to the LOCA test, it was observed that the LOCA environment caused the jacket on all five of the aged Okonite specimens to split longitudinally. On one of the Okonite specimens aged to 20 years, a section of jacket opened exposing the bare conductor underneath. On all three of the Okonite specimens aged to 40 years, the jacket opened along the length of the cable exposing the bare copper conductor.

All three of the Okonite test specimens aged to 40 years, and 1 of the 2 Okonite specimens aged to 20 years failed instantaneously when the submerged voltage withstand tests were performed, in accordance with IEEE Std. 383-1974. All of the other specimens, Samuel Moore and Anaconda successfully passed the voltage withstand tests. Results of LOCA test #5 on Bonded Jacket Electric Cables are documented in Attachment 1.

We have considered approaches that might be used in addressing these results. Obviously, a traditional regulatory approach involving requirements for licensees to address this issue as a potential non-compliance with the original qualification is one approach, although we believe this could impose unnecessary burdens. An alternative approach is to address typical applications of this cable and then to assess the significance of these applications, preferably in a risk-informed context. In order to reasonably assess the risk significance of these test results, we would need to have an understanding of the locations, realistic environmental conditions, and the functions affected.

We had made initial contacts with the industry to pursue the alternative approach. The staff met with representatives of the Okonite Company and the nuclear industry to discuss these research results. The minutes of the meetings are documented in Attachments 2 and 3. In general, the Okonite representatives have stated that the pre-aging conditions were too severe for the cable even though they were the same as those used in the original qualification tests of the cable. In addition, presentations from other industry representatives have suggested that the pre-aging qualification parameters are not representative of actual plant operating conditions. The industry representatives also stated that there is no immediate safety concern related to bonded jacket cables because installed cables have not experienced sufficient thermal aging to render them susceptible to LOCA failures.

The staff does not currently know how many plants use cables such as those tested in safety-related applications in containment.[1] Therefore, to assess the significance of the failures of the bonded Okonite cables requires knowledge of the specific applications in which these cables are used, which is a plant-specific issue and not amenable to generic assessments. We verbally contacted representatives from NEI and Nuclear Utility Group on Equipment Qualification seeking their assistance in getting such plant specific information. During the subsequent discussions, these industry representatives stated that providing this information would be costly and proposed that the staff proceed with issuing an Information Notice.

Although, Okonite has made statements regarding the overly severe pre-aging of the cables, the original qualification would permit use of the cable in very aggressive environments. Absent plant-specific information, its use in such environments in specific applications cannot be precluded. Further, we have not found information that the test conditions did not reflect those specified in the original qualification report, or that the tests were performed incorrectly. Therefore, it should be concluded that these cables will not survive the original qualification criteria.

It is my understanding that you anticipate issuing an Information Notice on these results and have sought industry input on typical applications of this cable.

Dissemination of research results described in this memorandum has been coordinated with NRR/DE staff.

Attachments: As stated

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[1] In 1992, data supplied by Okonite indicated that single conductor bonded cables are used in approximately 62 plants. Based on data collected by EPRI in 1992, Okonite single conductor bonded cables are used in the reactor containments of about 25 nuclear power plants. The data does not specify whether these cables are all safety-related applications. In the recent meetings the industry representatives stated that use of these cables in containments is limited.