NUCLEAR ENERGY INSTITUTE

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Mr. Richard H. Wessman
Deputy Director
Division of Engineering
U. S. Nuclear Regulatory Commission
Washington, DC 20555

Dear Mr. Wessman:

Enclosed for your information is a report detailing the results of the NEI survey on industry's use of Okonite Okolon single conductor bonded jacket cables.

We conducted this survey in response to Mr. Sam Collins' May 18, 2000 letter to Mr. Ralph Beedle. That letter summarized the results of NRC research to support the resolution of Generic Safety Issue 168, "Environmental Qualification of Electrical Equipment." NRC's concern specifically focused on Test # 5 which was initiated to determine if cables with bonded jackets have a unique failure mechanism that is not present in unbonded jacketed cables. The letter states that "...the test results call into question the qualification of record for Okonite single conductor cable with EPR insulation and bonded CSPE jacketing as required by 10 CFR 50.49," and that "...information on the exact applications of the subject cabling is not readily available to the NRC."

We met with the NRC staff June 22, 2000 to discuss the Test # 5 results and agreed to conduct an industry survey with the following objectives:

- Determine the current significance of the issue, and
- Based on the significance, determine what actions, if any, are necessary.

We do not find the results of Test # 5 to be a significant industry issue with respect to current plant applications. Ninety nine of the 103 operating nuclear units either do not have single conductor bonded jacket Okonite Okolon cables installed in their facilities or if they do have them, the cables are not installed in an environment that is likely to affect the cable's performance. Four units have the cable installed in an environment that may affect the cable's service life. Of that number, one intends to replace the cable next year; another one will inspect the cable and determine whether or not replacement is warranted. The third unit has a thicker

jacket than the tested cable, and the fourth unit is waiting for issuance of the Regulatory Issue Summary (RIS) before determining a course of action.

We should note that the results in the enclosed report are slightly different than the preliminary results presented at the October 12, 2000 meeting with the NRC staff. Questions raised in that meeting prompted us to follow-up with the licensees that reported having the cables. In two instances, a two unit site reported having the cable in both units but only in one unit of the two did the average service environment exceed the survey's 60° C threshold. We reported six units as having the cables in an average service environment of greater than 60° C when in fact it is only four.

The NRC staff suggested during the October meeting that the NEI preliminary results were inconsistent with prior information provided to the NRC on the number of plants using Okonite Okolon single conductor bonded jacket cables for I&C applications. We reviewed this and our assessment is provided in Enclosure 2.

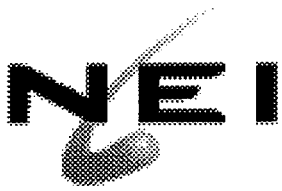
We trust that the enclosed report will be helpful to the NRC staff in resolving the Okonite Okolon single conductor bonded jacket issue. Also, we understand that the NRC will issue a regulatory issue summary on this topic. We would recommend its issuance as soon as practical.

Please contact Doug Walters at 202-739-8093, djw@nei.org or me at 202-739-8080, am@nei.org if you have any questions regarding the survey or the results.

Sincerely,

Alex Marion

cc: Joe Birmingham
Dr. Brian Sheron



NUCLEAR ENERGY INSTITUTE

NEI Survey Results on Okonite Okolon Single Conductor Cables

Prepared by the Nuclear Energy Institute
November 1, 2000

NEI Survey Results on
Okonite Okolon Single Conductor Cables

INTRODUCTION

The NRC Task Action Plan for resolution of Generic Safety Issue 168, "Environmental Qualification of Electrical Equipment," included six LOCA tests on different types of instrumentation and control cables. The six LOCA tests are completed.

In late 1999, the NRC initiated LOCA Test #5. The test included ethylene propylene rubber (EPR) insulated instrumentation and control cables with bonded jackets. The purpose of the test was to determine if the bonded jacket cables have a unique failure mechanism that is not present in unbonded jacket cables.

Cables from three manufacturers—Okonite, Samuel Moore, and Anaconda—were tested. The Okonite and Samuel Moore cables were considered bonded Hypalon jacket cables. The cables were pre-aged and then tested under LOCA conditions. One of the two single conductor Okonite Okolon cables pre-aged to simulate 20 years of qualified life, and three out of three single conductor Okonite Okolon cables pre-aged to simulate 40 years of qualified life, failed their tests. The cable aging was consistent with the vendor's qualification report. The aging parameters used by Okonite were based on qualifying the Okonite Okolon cable for 40 years at a service temperature of 90°C.

In a letter to NEI dated May 18, 2000, the NRC requested NEI's assistance in providing information on the application of single conductor bonded jacket Okonite cables. NEI distributed a survey on July 7, 2000 to the industry to collect this information.

PURPOSE OF AND BASIS FOR THE SURVEY

The survey had two objectives: 1) to determine the significance of the issue, and 2) based on the significance, determine what actions, if any, are necessary.

This survey was not intended to draw conclusions regarding licensee's compliance with 10CFR50.49. The survey questions were focused on whether or not licensees have any single conductor bonded jacket Okonite Okolon cables in a service environment greater than 60° C.

The 60°C threshold was selected rather than 90 °C (which was the basis for LOCA Test #5 aging) based on other qualification and research test data. Much of the data is documented in NUREG/CRs or qualification testing laboratory reports.

Table 1 (Attachment 1) summarizes the information; including results for an Okonite Okoprene cable style that is not part of this survey. Note in the table that one of the reports is NUREG/CR-3538. This test report represents the most severe thermal aging with all Okonite Okolon tests specimens successfully performing during the LOCA simulation.

Figure 1 (Attachment 2) represents calculated life values using the Arrhenius method and the accelerated thermal aging data from the various qualification/research tests cited in Table 1, at an activation energy of 1.15 eV. In this figure the curve symbols represent computed life values with intermediate points represented by simple straight-line approximations. The calculated life curve based on the accelerated thermal aging in NUREG/CR-3538 has been highlighted since it represents the most severe test conditions where all Okonite Okolon bonded jacket single conductor cables successfully performed without splitting. The tests with more severe aging are up and to the right of this curve. Those with less severe aging are down and to the left. The figure demonstrates that the NUREG/CR-3538 testing supports performance after thermal aging equivalent to 60°C for 40 years. For cables installed for shorter periods, higher operating temperatures can be tolerated.

Determining an appropriate material activation energy is important to estimating life values at operating temperature. Activation energy values ranging from 1.04 eV to 1.28 eV have been cited for several Hypalon formulations. The data support the use of 1.15 eV as a representative value when extrapolating qualification/research test data to plant operating conditions. Using 1.15 eV and available test data, operation of single conductor Okonite Okolon bonded jacket cables at temperatures equivalent to 60°C for 40 years should not produce the type failures observed in the BNL testing. Further confidence in this conservative screening value has been obtained using Sandia Hypalon thermal aging research data and detailed evaluations of Hypalon jacket conditions after the aging simulation portion of relevant qualification/research tests. This information indicates that Hypalon jackets must experience *significant* age-induced embrittlement in order for the LOCA-induced splitting to occur. Extrapolation of Sandia thermal-only aging data (see Gillen in NUREG/CP-0149 Vol. 3) to 60°C indicates that the *onset* of Hypalon embrittlement can be estimated to occur at approximately 70 years.

THE SURVEY

1. Do you use any Okonite Okolon single conductor cables in 10 CFR 50.49 applications (principally I&C applications) that are conductor sizes 8 AWG and smaller?

The first question was aimed at determining whether the licensee has Okonite Okolon bonded jacket single conductor cable in 10CFR50.49 applications in their plant. This question was limited to 8 AWG and smaller size conductors since Okonite literature indicates that these sizes utilize the 15 mil thick bonded jacket. Larger conductor sizes use a 30 mil or thicker jacket. Okonite has successfully tested the larger cables and therefore they are not of concern for purposes of the survey.

2. Are any of these cables exposed to an average service condition more severe than 60°C ?

If the licensee indicated such cables are located in their plant, Question 2 asks whether the cables are in an average service environment of greater than 60°C. The word "average" was intended to recognize that operating temperature variations occur at a particular location in the plant. It was not intended to represent a computed average temperature based on variations along the length of a cable. We assume licensees properly interpreted the intended meaning. The guidance we provided stated that the service environment may be based on actual operating experience, the design environment, the required service condition stipulated in the EQ files, or similarly defendable data. If the cables are in an average service environment greater than 60°C, then the licensee responded to third question.

3. For each cable, please identify the following: (tabulate on a separate sheet if necessary)

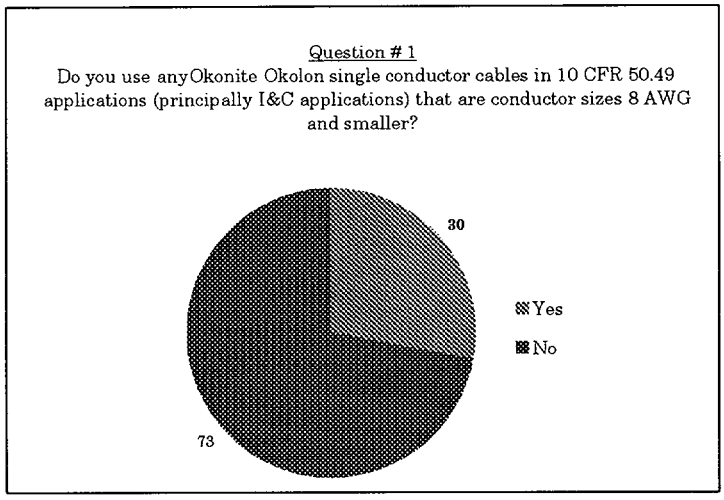
- **Average service environment (°C)**
- **Service Duration**
- **Safety function supported by the cable**
- **Is the cable inside primary containment: (Yes)____ (No)____**

The third question seeks specific information about the service condition and the length of time the cables have been exposed to the service environment. Also, we asked the licensee to identify the safety function (e.g. containment isolation) these cables perform and whether the cables are inside or outside containment.

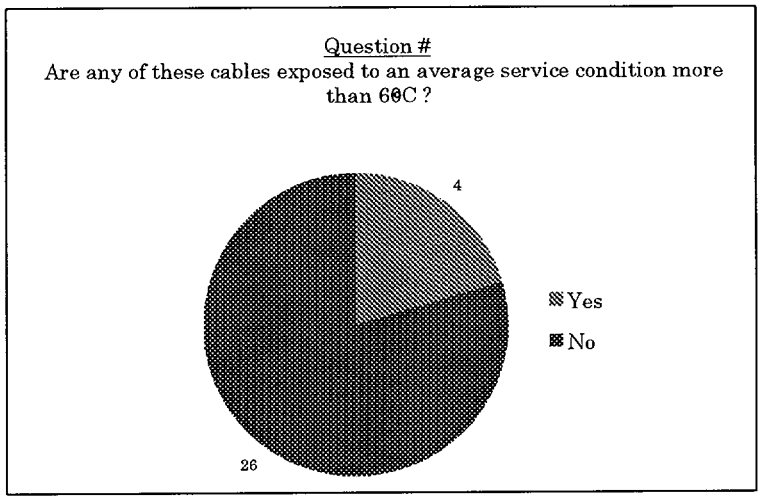
Regarding the safety function, licensees were requested to provide any relevant information related to the function such as the required operating times during accidents with "harsh for steam" conditions at the cable.

THE RESULTS

In response to the first question, 73 of the 103 units (68%) reported that they do not have any Okonite Okolon single conductor bonded jacket cables in 10 CFR 50.49 applications that are conductor sizes 8 AWG and smaller. It should be noted that there are some licensees that have multiconductor cables that, when the overall jacket is stripped back, expose an insulated conductor. We did not pursue these applications because they are outside the scope of NRC's request.



The 30 units that reported having Okonite Okolon single conductor bonded jacket cables responded to the second question in the survey. Twenty-six of the units (86%) did not have the cables in applications where the average service environment exceeds 60° C.



The remaining four units provided responses to the third question in the survey as noted below.

Unit A

This unit reported having one single conductor Okonite Okolon bonded jacket cable. The cable is located in the MOV control circuit for the 6" Reactor Water Cleanup System Suction Inboard Isolation Valve and has been installed for 28 years. This line takes suction from the recirculation system. If the cable were to short to ground, the fuse for the control circuit would blow causing loss of power to the circuit. This would result in the valve being unable to close. The outboard isolation valve would be unaffected. The length of the cable is approximately 50 feet.

The temperature at the location of the cable run is in the range of 140°F (60°C) to 150°F (65.5°C). A qualitative assessment was performed to determine qualified life based on the new test data and an estimate of qualified life to year 2003 was obtained. The licensee is replacing the cable in the next refueling outage, expected to begin in April 2001. The cable remains within its qualified life.

Unit B

This unit reported having four Okonite Okolon bonded jacket single conductor cables. All the cables are located outside containment and are used in valves in the Post Accident Sampling System. The service environment is the normal operating temperature, which is 71.1°C. The cables are not installed in cable in trays with power cables so they are at ambient temperature.

The cables have a 30-mil jacket. For purposes of the survey, these cables were excluded because they are not within the scope of the NRC's LOCA Test #5 and the thicker jackets are not of concern because of successful testing by Okonite.

Unit C

This unit reported having a single Okonite Okolon single conductor bonded jacket cable. The cable is used as jumper wire between the limit and torque switches in a motorized operator for one pneumatic supply isolation valve located in the drywell.

The average service environment, based on actual temperature monitoring data since 1985 when the cable was installed, is 61.7°C. The licensee is planning to inspect the cable in a refueling outage next year and replace it if necessary.

Unit D

This Unit reported having two cables located in the pressurizer cavity area inside containment. These cables have been installed for 19 years where the average service environment is 77° C. These cables provide 600V power to the pressurizer power relief isolation valves. Presently, the licensee is awaiting the issuance of the Regulatory Issue Summary before determining an appropriate course of action.

SUMMARY AND FOLLOW ON ACTIVITIES

Based on the NEI survey, 99 of the 103 operating units either do not use Okonite Okolon single conductor cables in 10 CFR 50.49 applications or if they do, they are installed in a service environment that is 60°C or less. Therefore, we do not consider the results of LOCA Test # 5 significant with respect to current plant applications.

Four units do have the cables installed in an environment that may affect the service life of the cables. However, one unit has a 30 mil jacket on the cable which is not of concern because the thicker jacketed cables have been successfully tested. One unit will replace the cable and another is likely to replace it following an inspection next year. The fourth unit is awaiting issuance of the regulatory issue summary before determining a course of action.

Table 1 -- Summary Information Okonite Okolon Test Programs

Report	Okonite Okolon Styles	Aging	Accident	Results
NUREG/CR-6095 (Sandia)	(10) 1/c #12awg 30/15 mil	130 Mrds then 336 hrs @ 158°C (circumferential cracks on 9 Sandia-damaged wires)	340°F/10 days	all fail/split starting at 14 to 182 hours
BNL/Wyle Test #5 (unaged)	(1) 1/c #12awg 30/15 mil	unaged	150 Mrd then 346°F/10 days	pass
BNL/Wyle Test #5 (20 year simulation)	(2) 1/c #12awg 30/15 mil	252 hrs @ 150°C and 25 Mrd (stiff but no cracks)	150 Mrd then 346°F/10 days	1 fail/split (visual at end of test)
BNL/Wyle Test #5 (40 year simulation)	(3) 1/c #12awg 30/15 mil	504 hrs @ 150°C and 50 Mrd (circumferential cracks)	150 Mrd then 346°F/10 days	all fail/split (visual at end of test)
NUREG/CR-5772/2 (Sandia) (unaged)	(1) 1/c #12awg 30/15 mil	unaged	~138 Mrd then 340°C/12+ days	all pass
" (20 year simulation)	(3) 1/c #12awg 30/15 mil	(S) 3 months @ 98°C + 17 Mrd	~110 Mrd then 340°F/10 days	all pass
" (40 year simulation)	(3) 1/c #12awg 30/15 mil	(S) 6 months @ 98°C + 29 Mrd	~110 Mrd then 340°F/10 days	all pass
" (60 year simulation)	(4) 1/c #12awg 30/15 mil	(S) 9 months @ 98°C + 56 Mrd	~110 Mrd then 340°F/10 days	1 fail/split beginning at 133 hr.
NUREG/CR-3538 (Sandia)	(2) 1/c #12awg 30/15 mil	(S) 169 hrs @ 139°C + 43 Mrd	(S) ~106 Mrd + 340°F/21 days	all pass
Wyle 17859-02B (ComEd)	(4) splices L5, L6, L7, L8 with 1/c #14awg (also others to less aging)	16 Mrds then 298 hrs @ 130°C	~184 Mrd then 340°F/10 days	no split Okonite wires
F-C3694** (Okonite)	(1) 7/c #12awg 47/15 mil w 60 mil jkt (1) 1/c #12awg 45 mil * (1) 7/c #12awg 30/15(n) mil w 60 mil jkt**	336 hrs @ 121°C then (S) 168 hrs @ 115.5°C + 50 Mrd	(S) ~150 Mrd + 340°F/31 days then 212°F/100 days	all pass 31 day exposure
Report 141 (Okonite)	(1) 4/c #12awg 47/15 mil w 45 mil jkt. (1) 1/c #14awg 30/15(n) mil (1) 1/c #4/0 55/45(n) mil (1) 4/c #14awg 30/15(n) mil w 45 mil jkt(n) (1) 7/c #14awg 30/15(n) mil w 45 mil jkt(n)	168 hrs @ 121°C	200 Mrd then 252F°C/7.5 days then 345F°C/100+ days	all pass

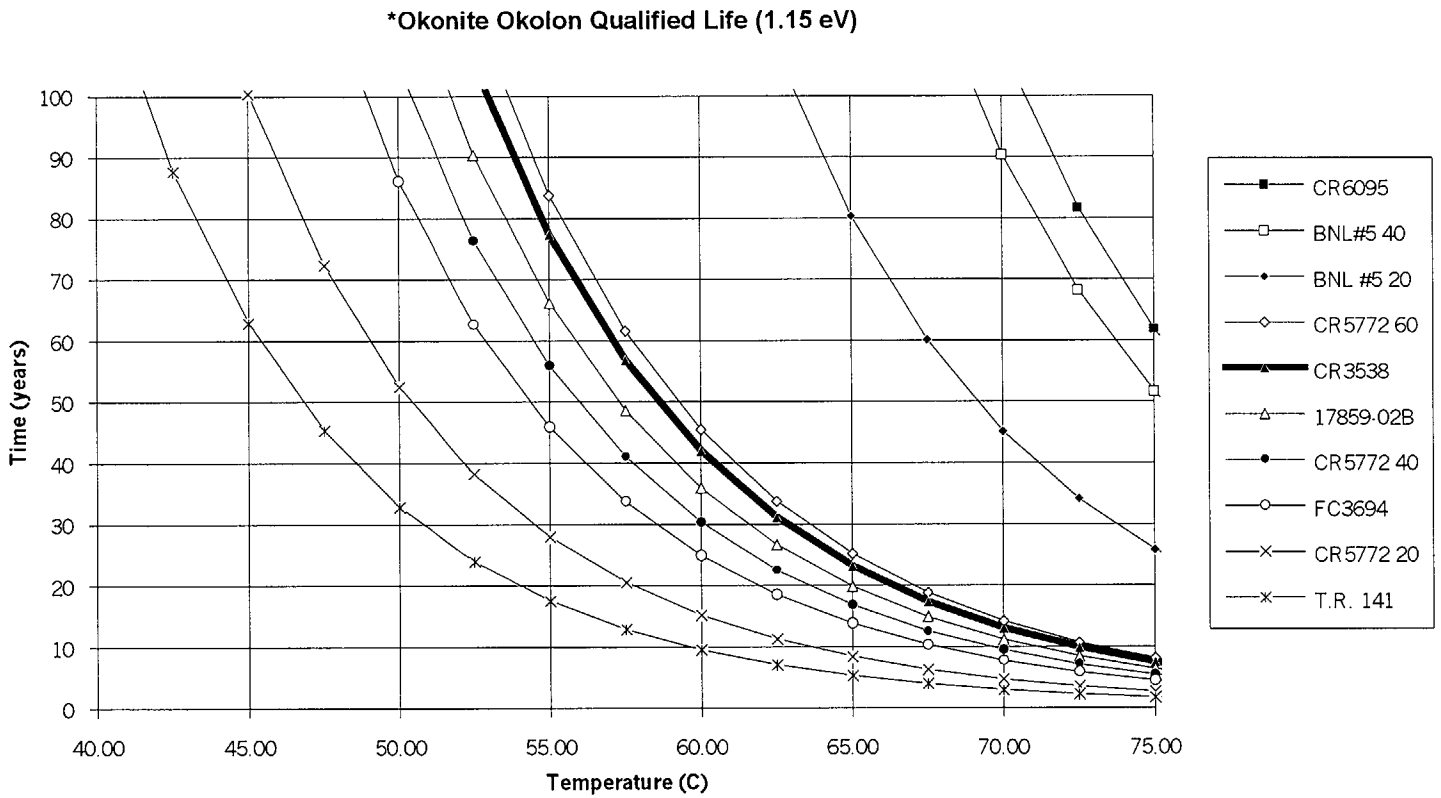
(n) neoprene jacket (i.e., Okonite Okoprene)

(S) Simultaneous aging (thermal and radiation) or simultaneous accident (high temperature steam and radiation)

* EPRI insulation only - no jacket layer

** neoprene jacket on singles; experimental thermoset overall jacket

Figure 1 - Calculated Life Values Based on Test Report Aging



RESPONSE TO NRC STATEMENT ABOUT CONFLICTING INFORMATION REGARDING THE NUMBER OF PLANTS USING OKONITE CABLES

NEI met with the NRC staff October 12 to discuss the preliminary results of the NEI survey on Okonite cables. During the meeting, the NRC Staff suggested that the survey results were inconsistent with prior information provided to the NRC on the number of plants using Okonite Okolon single conductor bonded jacket cables for I&C applications. The NRC staff did not provide specifics on who provided the information and when; however, we believe a December 10, 1992 memorandum to the Commission, *FAILURE OF OKONITE ELECTRICAL CABLES WITH BONDED JACKETS DURING TESTS PERFORMED BY SANDIA NATIONAL LABORATORIES*, may be helpful in clarifying these previous surveys.

The memorandum refers to two data sources, Okonite Company and EPRI. According to the memorandum the Okonite Company reported that 62 plants use the "Okonite product". This Okonite Company data was provided during a November 23, 1992 meeting with the NRC. The meeting summary, dated November 25, 1992, states that approximately 55 plants use the "Okonite product". This is apparently based on Enclosure 3 to the summary that is an Okonite provided list of power plants using Okonite Company power, instrument, and control cable products. Our review of the list indicates that approximately 60 domestic nuclear power plants had purchased Okonite instrument or control cables. These cables could be single or multiconductor cables with a variety of insulation and jacket materials. It is impossible to determine from this information the subset of plants that purchased single conductor Okonite Okolon I&C bonded jacket cables that are the subject of the NEI survey.

The EPRI data indicate that 25 plants used Okonite cable inside containment. A specific reference for the EPRI data is not cited; however, we believe the data source was the *Low Voltage-Environmentally Qualified Cable License Renewal Industry Report* (Cable IR). The report was issued to the NRC staff in 1990 and includes Appendix A, *In-Containment Cable Data Base*. The appendix characterizes in-containment cable types based on manufacturer, application (power, instrument, or control), and cable designation (e.g., trade name or material type). No database information differentiates between single and multiconductor cables. Our screening of the Okonite database entries indicates that approximately 25 plants used Okonite cables with designations containing EPR, CSPE, or Okolon. This appears to confirm the number quoted in the December 10 memorandum. However, it is impossible to determine from this information the number of plants with Okonite Okolon single conductor bonded jacket cables in I&C applications that are the subject of the NEI survey.

In summary, a review of this December 1992 memorandum reveals that while the information is relevant to the application of Okonite cable in nuclear power plants, it is not focused on Okonite Okolon single conductor bonded jacket cables for I&C applications. Therefore, it is inappropriate to compare it to the current, focused NEI survey.