XI.E1

Non-EQ Electrical Cables and Connections

INTRODUCTION

In most areas within a nuclear power plant, the actual ambient environments are less severe than the nominal plant environment. However, in a limited number of localized areas, the actual environments may be more severe than the nominal plant environment. Conductor insulation materials used in cables and connections may degrade more rapidly than expected in these adverse localized environments. The purpose of the aging management program described herein is to provide reasonable assurance that the intended functions of electrical cables and connections exposed to adverse localized environments caused by heat or radiation will be maintained consistent with the current licensing basis through the period of extended operation. This program meets NUREG/CR-5643, IEEE Std. P1205, SAND96-0344, and EPRI TR-109619.

The program described herein is written specifically to address cables and connections at plants whose configuration is such that most (if not all) cables and connections installed in adverse localized environments are accessible. The program, as described, can be thought of as a sampling program, i.e., selected cables and connections from accessible areas (the inspection sample) would represent, with reasonable assurance, all cables and connections in the adverse localized environments. When an unacceptable condition or situation is identified for a cable or connection in the inspection sample, a determination is made as to whether the same condition or situation is applicable to other accessible or inaccessible cables or connections. As such, this program focus may not be appropriate for plants with a significantly different configuration.

As stated in NUREG/CR-5643, *"The major concern with cables is the performance of aged cable when it is exposed to accident conditions."* The statement of considerations for the final license renewal rule (60FR22477) states, *"The major concern is that failures of deteriorated cable systems (cables, connections, and penetrations) might be induced during accident conditions."* The electrical cables and connections covered by this aging management program, being non-EQ, are either not exposed to harsh accident conditions or are not required to remain functional during or following an accident to which they are exposed

EVALUATION AND TECHNICAL BASIS

(1) ***Scope of Program:*** The inspection program includes accessible electrical cables and connections within the scope of license renewal that are installed in adverse localized environments caused by heat or radiation in the presence of oxygen. An adverse localized environment is a condition in a limited plant area that is significantly more severe than the specified service condition for the electrical cable or connection.

(2) ***Preventive Actions:*** No actions are taken as part of this program to prevent or mitigate aging degradation.

(3) ***Parameters Monitored/Inspected:*** Accessible electrical cables and connections installed in adverse localized environments are visually inspected for cable and connection jacket surface anomalies such as embrittlement, discoloration, cracking or surface contamination.

(4) ***Detection of Aging Effects:*** Cable and connection jacket surface anomalies are precursor indications of conductor insulation aging degradation from heat or radiation in the presence of oxygen. Accessible electrical cables and connections installed in adverse

localized environments are visually inspected at least once every 10 years, which is an adequate period to preclude failures of the conductor insulation.

(5) ***Monitoring and Trending:*** Trending actions are not included as part of this program because the ability to trend inspection results is limited. Although not a requirement, trending would provide additional information on the rate of degradation. The choice of a specific inspection method should take this into consideration.

(6) ***Acceptance Criteria:*** No unacceptable, visual indications of cable and connection jacket surface anomalies, which suggest that conductor insulation degradation exists, as determined by engineering evaluation. An unacceptable indication is defined as a noted condition or situation that, if left unmanaged, could lead to a loss of the intended function.

(7) ***Corrective Actions:*** Further investigation is performed on electrical cables and connections when the acceptance criteria are not met in order to ensure that the intended functions will be maintained consistent with the current licensing basis. Corrective actions may include, but are not limited to, testing, shielding or otherwise changing the environment, relocation or replacement of the affected cable or connection. When an unacceptable condition or situation is identified, a determination is made as to whether the same condition or situation is applicable to other accessible or inaccessible cables or connections. As discussed in the appendix to this report, the staff finds 10 CFR Part 50, Appendix B, acceptable in addressing corrective actions.

(8) ***Confirmation Process:*** As discussed in the appendix to this report, the staff finds 10 CFR Part 50, Appendix B, acceptable in addressing confirmation process.

(9) ***Administrative Controls:*** As discussed in the appendix to this report, the staff finds 10 CFR Part 50, Appendix B, acceptable in addressing administrative controls.

(10) ***Operating Experience:*** Operating experience has shown that adverse localized environments caused by heat or radiation for electrical cables and connections may exist next to or above (within three feet of) steam generators, pressurizers or hot process pipes such as feedwater lines.

REFERENCES

NUREG/CR-5643, *Insights Gained From Aging Research*, March 1992

IEEE Std. P1205, *IEEE Guide for Assessing, Monitoring and Mitigating Aging Effects on Class 1E Equipment Used in Nuclear Power Generating Stations*.

SAND96-0344, *Aging Management Guideline for Commercial Nuclear Power Plants - Electrical Cable and Terminations*, prepared by Sandia National Laboratories for the U.S. Department of Energy, September 1996.

EPRI TR-109619, *Guideline for the Management of Adverse Localized Equipment Environments*, June 1999.

XI.E2

Non-EQ Electrical Cables Used in Instrumentation Circuits

INTRODUCTION

In most areas within a nuclear power plant, the actual ambient environments are less severe than the nominal plant environment. However, in a limited number of localized areas, the actual environments may be more severe than the nominal plant environment. Conductor insulation materials used in electrical cables may degrade more rapidly than expected in these adverse localized environments. Exposure of electrical cables to adverse localized environments caused by heat or radiation can result in reduced insulation resistance (IR). Reduced IR causes an increase in leakage currents between conductors and from individual conductors to ground. A reduction in IR is a concern for circuits with sensitive, low-level signals such as radiation monitoring and nuclear instrumentation since it may contribute to inaccuracies in the instrument loop. When an instrumentation loop is found to be out of calibration during routine surveillance testing, trouble shooting is performed on the loop, including the instrumentation cable. The purpose of the aging management program described herein is to provide reasonable assurance that the intended functions of electrical cables used in circuits with sensitive, low-level signals exposed to adverse localized environments caused by heat or radiation will be maintained consistent with the current licensing basis through the period of extended operation. This program meets NUREG/CR-5643, IEEE Std. P1205, and SAND96-0344.

As stated in NUREG/CR-5643, *"The major concern with cables is the performance of aged cable when it is exposed to accident conditions."* The statement of considerations for the final license renewal rule (60FR22477) states, *"The major concern is that failures of deteriorated cable systems (cables, connections, and penetrations) might be induced during accident conditions."* The electrical cables covered by this aging management program, being non-EQ, are either not exposed to harsh accident conditions or are not required to remain functional during or following an accident to which they are exposed

EVALUATION AND TECHNICAL BASIS

(1) ***Scope of Program:*** This program includes electrical cables used in circuits with sensitive, low-level signals such as radiation monitoring and nuclear instrumentation that are within the scope of license renewal.

(2) ***Preventive Actions:*** No actions are taken as part of this program to prevent or mitigate aging degradation.

(3) ***Parameters Monitored/Inspected:*** The parameters monitored are specific to the instrumentation loop being calibrated as documented in the surveillance test procedure.

(4) ***Detection of Aging Effects:*** Calibration provides sufficient indication of the need for corrective actions by monitoring key parameters and providing trending data based on acceptance criteria related to instrumentation loop performance. The normal calibration frequency provides reasonable assurance that severe aging degradation will be detected prior to loss of the cable intended function.

(5) ***Monitoring and Trending:*** Trending actions are not included as part of this program because the ability to trend test results is dependent on the specific type of test chosen. Although not a requirement, test results that are trendable provide additional information on the rate of degradation. The choice of a specific test should take this into consideration.

(6) ***Acceptance Criteria:*** Calibration readings must be within the loop-specific acceptance criteria, as set out in the surveillance test procedure.

(7) ***Corrective Actions:*** Corrective actions such as recalibration and circuit trouble-shooting are implemented when an instrument loop is found to be out of calibration. As discussed in the appendix to this report, the staff finds 10 CFR Part 50, Appendix B, acceptable in addressing corrective actions.

(8) ***Confirmation Process:*** As discussed in the appendix to this report, the staff finds 10 CFR Part 50, Appendix B, acceptable in addressing confirmation process.

(9) ***Administrative Controls:*** As discussed in the appendix to this report, the staff finds 10 CFR Part 50, Appendix B, acceptable in addressing administrative controls.

(10) ***Operating Experience:*** Operating experience has shown that a significant number of cable failures are identified through routine calibration testing.

REFERENCES

NUREG/CR-5643, *Insights Gained From Aging Research*, March 1992

IEEE Std. P1205, *IEEE Guide for Assessing, Monitoring and Mitigating Aging Effects on Class 1E Equipment Used in Nuclear Power Generating Stations*.

SAND96-0344, *Aging Management Guideline for Commercial Nuclear Power Plants - Electrical Cable and Terminations*, prepared by Sandia National Laboratories for the U.S. Department of Energy, September 1996.

XI.E3

Non-EQ Inaccessible Medium-Voltage Cables

INTRODUCTION

Most electrical cables in nuclear power plants are located in dry environments. However, some cables may be exposed to condensation and wetting in inaccessible locations, such as conduits, cable trenches, cable troughs, duct banks, underground vaults or direct buried installations. When an energized cable not specifically designed for submergence is exposed to these conditions, water treeing or a decrease in the dielectric strength of the conductor insulation can occur. This can potentially lead to electrical failure. The purpose of the aging management program described herein is to provide reasonable assurance that the intended functions of inaccessible medium-voltage cables exposed to adverse localized environments caused by moisture while energized will be maintained consistent with the current licensing basis through the period of extended operation. This program meets NUREG/CR-5643, IEEE Std. P1205, SAND96-0344, and EPRI TR-109619.

As stated in NUREG/CR-5643, *"The major concern with cables is the performance of aged cable when it is exposed to accident conditions."* The statement of considerations for the final license renewal rule (60FR22477) states, *"The major concern is that failures of deteriorated cable systems (cables, connections, and penetrations) might be induced during accident conditions."* The electrical cables covered by this aging management program, being non-EQ, are either not exposed to harsh accident conditions or are not required to remain functional during or following an accident to which they are exposed

EVALUATION AND TECHNICAL BASIS

(1) ***Scope of Program:*** The program includes inaccessible (e.g., in conduit or direct buried) medium-voltage cables within the scope of license renewal that are exposed to significant moisture simultaneously with significant voltage. Significant moisture is defined as periodic exposures to moisture that last more than a few days (e.g., cable in standing water). Periodic exposures to moisture that last less than a few days (i.e., normal rain and drain) are not significant. Significant voltage exposure is defined as being subjected to system voltage for more than twenty-five percent of the time. The moisture and voltage exposures described as significant in these definitions are not significant for medium-voltage cables that are designed for these conditions (e.g., continuous wetting and continuous energization is not significant for submarine cables).

(2) ***Preventive Actions:*** Periodic actions are taken to prevent cables from being exposed to significant moisture such as inspecting for water collection in cable manholes & conduit and draining water as needed. Medium-voltage cables for which such actions are taken are not required to be tested.

(3) ***Parameters Monitored/Inspected:*** In-scope, medium-voltage cables exposed to significant moisture and significant voltage are tested to provide an indication of the condition of the conductor insulation. The specific type of test performed will be determined prior to each test.

(4) ***Detection of Aging Effects:*** In-scope, medium-voltage cables exposed to significant moisture and significant voltage are tested at least once every 10 years, which is an adequate period to preclude failures of the conductor insulation.

(5) ***Monitoring and Trending:*** Trending actions are not included as part of this program because the ability to trend test results is dependent on the specific type of test chosen. Although not a requirement, test results that are trendable provide additional information

on the rate of degradation. The choice of a specific test should take this into consideration.

(6) ***Acceptance Criteria:*** The acceptance criteria for each test is defined by the specific type of test performed and the specific cable tested.

(7) ***Corrective Actions:*** Further investigation is performed when the test acceptance criteria are not met in order to ensure that the intended functions of the electrical cables will be maintained consistent with the current licensing basis. When an unacceptable condition or situation is identified, a determination is made as to whether the same condition or situation is applicable to other inaccessible, in-scope, medium-voltage cables. As discussed in the appendix to this report, the staff finds 10 CFR Part 50, Appendix B, acceptable in addressing corrective actions.

(8) ***Confirmation Process:*** As discussed in the appendix to this report, the staff finds 10 CFR Part 50, Appendix B, acceptable in addressing confirmation process.

(9) ***Administrative Controls:*** As discussed in the appendix to this report, the staff finds 10 CFR Part 50, Appendix B, acceptable in addressing administrative controls.

(10) ***Operating Experience:*** Operating experience has shown that XLPE or high molecular weight polyethylene (HMWPE) insulation materials are most susceptible to water tree formation. The formation and growth of water trees varies directly with operating voltage. Treeing is much less prevalent in 4kV cables than those operated at 13 or 33kV.

REFERENCES

NUREG/CR-5643, *Insights Gained From Aging Research*, March 1992

IEEE Std. P1205, *IEEE Guide for Assessing, Monitoring and Mitigating Aging Effects on Class 1E Equipment Used in Nuclear Power Generating Stations*.

SAND96-0344, *Aging Management Guideline for Commercial Nuclear Power Plants - Electrical Cable and Terminations*, prepared by Sandia National Laboratories for the U.S. Department of Energy, September 1996.

EPRI TR-109619, *Guideline for the Management of Adverse Localized Equipment Environments*, June 1999.

XI.E4

Borated Water Leakage Surveillance for Non-EQ Electrical Connectors

INTRODUCTION

Ingress of borated water into electrical connectors, if not found and corrected, can lead to corrosion and connector failure. NRC Generic Letter (GL) 88-05 "*Boric Acid Corrosion of Carbon Steel Reactor Pressure Boundary Components in PWR Plants*," March 17, 1988 mandates that PWR licensees monitor the condition of the reactor coolant pressure boundary for occurrences of borated water leakage. The program described herein is an augmentation of the *Boric Acid Corrosion Program* (see XI.M5) and has the purpose of mitigating aging effects related to corrosion of electrical connector contact surfaces caused by intrusion of borated water. This program meets NRC Generic Letter 88-05 and NUREG/CR-5643.

As stated in NUREG/CR-5643, "*The major concern with cables is the performance of aged cable when it is exposed to accident conditions*." The statement of considerations for the final license renewal rule (60FR22477) states, "*The major concern is that failures of deteriorated cable systems (cables, connections, and penetrations) might be induced during accident conditions*." The electrical connectors covered by this aging management program, being non-EQ, are either not exposed to harsh accident conditions or are not required to remain functional during or following an accident to which they are exposed.

EVALUATION AND TECHNICAL BASIS

(1) ***Scope of Program:*** This program includes electrical connectors located in proximity to borated water systems; inside or outside a PWR containment.

(2) ***Preventive Actions:*** Visual inspections are performed of electrical connector and enclosure external surfaces for evidence of borated water leakage, such as discoloration or accumulated boric acid residue. Boric acid residue is removed and a determination is made as to the possible intrusion of borated water into the electrical connector or enclosure.

(3) ***Parameters Monitored/Inspected:*** Once any boric acid residue is removed from the external surfaces, the external areas where connector parts have mating surfaces or are sealed are inspected for evidence of borated water intrusion.

(4) ***Detection of Aging Effects:*** Inspections are performed each refueling outage. Operating experience supports this frequency as adequate for preventing loss of component intended function.

(5) ***Monitoring and Trending:*** No actions are taken as part of this program to trend the inspection results.

(6) ***Acceptance Criteria:*** No corrective action is necessary if borated water from leaks is determined not to have intruded into electrical connectors and enclosures.

(7) ***Corrective Actions:*** Corrective actions are implemented upon a determination of the possible intrusion of borated water into an electrical connector or enclosure. Corrective actions may include, but are not limited to, removing contaminants or corrosion from electrical connector contact surfaces, testing and sealing the electrical connector or enclosure to prevent future water intrusion. As discussed in the appendix to this report, the staff finds 10 CFR Part 50, Appendix B, acceptable in addressing corrective actions.

(8) ***Confirmation Process:*** As discussed in the appendix to this report, the staff finds 10 CFR Part 50, Appendix B, acceptable in addressing confirmation process.

(9) ***Administrative Controls:*** As discussed in the appendix to this report, the staff finds 10 CFR Part 50, Appendix B, acceptable in addressing administrative controls.

(10) Operating Experience: Based on industry-wide and plant-specific operating experience, augmentation of the Boric Acid Corrosion program (XI.M5), as described herein for electrical connectors, is adequate to mitigate aging effects caused by borated water leakage before there is a loss of component intended function.

REFERENCES

NRC Generic Letter 88-05, *Boric Acid Corrosion of Carbon Steel Reactor Pressure Boundary Components in PWR Plants*, March 17, 1988.

NUREG/CR-5643, *Insights Gained From Aging Research*, March 1992.