Regulatory Issue Resolution Protocol – NRC Team

Cable Performance Issues at Nuclear Power Plants

1. Identification Phase

Various inspection reports and LERs have identified cable performance issues. This issue is significant and applicable to multiple plants. This issue is recommended for further screening in accordance with RIRP.

2. Screening Phase

Screening Criteria	Weight	Range of Priority Values	Screening Values
Relative safety significance	3	2	6
Relative risk significance	2	2	4
Industry resource availability	1	1	1
NRC resource availability	1	-1	-1
Compliance issue?	3	1	3
Operability issue?	2	1	2
Shutdown issue?	3	0	0
Cost-Benefit	1	1	1
Degree of complexity	2	0	0
Degree of initial consensus	1	0	0
Scope of applicability	2		2
Subjective criteria?	N/A	N/A	
Total			18

Screening Value =18

Screening Acceptance Value (>12)

Accepted into RIRP

3. Evaluation Phase

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Problem Statement:

1. Cables within the scope of maintenance rule are subjected to environments they are not designed or qualified for.

2. Cables within the scope of maintenance rule are not being monitored by the licensees to demonstrate that the cables can perform their design functions when called upon.

Regulatory Basis**:**

NRC regulations require that cables be capable of performing their design function when subjected to anticipated environmental conditions, such as moisture, flooding, heat, and radiation. Further, the design should minimize the probability of power interruption when transferring power between sources. The cable failures that could disable safety-related or risk-significant equipment are expected to have monitoring programs to demonstrate that the cables can perform their design function when called upon. The applicable regulatory requirements include the following:

Regulatory Requirements:

NRC regulations in 10 CFR Part 50, Appendix A, General Design Criterion (GDC) 2, "Design bases for protection against natural phenomena," states that "structures, systems, and components important to safety shall be designed to withstand the effects of natural phenomena such as earthquakes, tornadoes, hurricanes, floods, tsunami, and seiches without loss of capability to perform their safety functions……"

NRC regulations in 10 CFR Part 50, Appendix A, General Design Criterion (GDC) 4, "Environmental and Dynamic Effects Design Bases," states that "structures, systems, and components important to safety shall be designed to accommodate the effects of and to be compatible with the environmental conditions associated with normal operation."

NRC regulations in 10 CFR Part 50, Appendix A, GDC 17, "Electric Power Systems," states that "provisions shall be included to minimize the probability of losing electric power from any of the remaining power supplies...a loss of power from the transmission network, or the loss of power from the onsite electric power supplies."

NRC regulations in 10 CFR Part 50, Appendix A, GDC 18, "Inspection and Testing of Electric Power Systems," states that "electric power systems important to safety shall be designed to permit appropriate periodic inspection and testing of important...features, such as wiring, insulation" and "to assess the continuity of the systems and the condition of their components,"

“the operability of the systems as a whole,” and “the transfer of power among the nuclear power unit, the offsite power system, and the onsite power system.”

NRC regulations in 10 CFR 50.65(a)(1), “Maintenance Rule,” states that “each holder of a license to operate a nuclear power plant...shall monitor the performance or condition of structures, systems, or components...in a manner sufficient to provide reasonable assurance that such structures, systems, and components...are capable of fulfilling their intended functions.”

NRC regulations in 10 CFR 50.49, “Environmental Qualification of Electric Equipment Important to Safety for Nuclear Power Plants," requires that three categories of electric equipment important to safety be qualified for their application and specified performance and provides requirements for establishing environmental qualification methods and qualification parameters.

NRC regulations in 10 CFR Part 50, Appendix B, Criterion III, “Design Control,” states that measures shall be established for the selection and review for suitability of application of materials, parts, equipment, and processes that are essential to the safety-related functions of structures, systems, and components.

NRC regulations in 10 CFR Part 50, Appendix B, Criterion V, “Instructions, Procedures, and Drawings,” states that activities affecting quality shall be prescribed by documented instructions, procedures, or drawings, of a type appropriate to the circumstances and shall be accomplished in accordance with these instructions, procedures, or drawings. Instructions, procedures, or drawings shall include appropriate quantitative or qualitative acceptance criteria for determining that important activities have been satisfactorily accomplished.

NRC regulations in 10 CFR Part 50, Appendix B, Criterion XI, “Test Control,” states that “a test program shall be established to assure that all testing required to demonstrate that...components will perform satisfactorily in service is identified and performed.”

NRC regulations in 10 CFR Part 50, Appendix B, Criterion XVI, “Corrective Actions,” states that measures shall be established to assure that conditions adverse to quality, such as failures, malfunctions, deficiencies, deviations, defective material and equipment and nonconformance are promptly identified and corrected.

Technical Basis**:**

Electric cables are one of the most important components in a nuclear plant to provide the various plant systems function to mitigate the effects of an accident and preserve the safety of the plant during normal, abnormal, and anticipated operational occurrences. If cable degradation from aging or other mechanisms remain undetected, it can lead to deterioration of cable performance or result in cable failure when it is relied on to mitigate design bases accidents and transients. Based on response to Generic Letter 2007-01, licensees provided data showing that the number of cable failures is increasing with plant age, and that cable failures are occurring within the plants’ 40-year licensing periods. These cable failures have resulted in plant transients and shutdowns, loss of safety redundancy, entry into limiting conditions for operation, and undue challenges to plant operators. The staff’s safety

determination during plant licensing was based on licensees meeting the regulatory requirements cited above to ensure that components such as cables will perform its design functions during the design bases events.

Staff Positions and Applicable Guidance Documents**:**

The staff position is that (1) cables within the scope of maintenance rule should be monitored by the licensees at an appropriate frequency to demonstrate that the cables can perform their design functions when called upon; and (2) cables must be designed to meet its intended design function for the environment that they are subjected to. If cables have been exposed to conditions for which they are not designed or qualified, the licensees must demonstrate, through adequate testing or condition monitoring, that the cables can perform their intended design function for the duration of the qualified period.

Guidance Documents

See Appendix A for list of guidance documents

Applicable Generic Communications and Inspection Findings **:**

The following NRC generic communications identify performance issues associated with cables:

Information Notice 1989-63: Possible Submergence of Electric Circuits Located Above the Flood Level Because of Water Intrusion and lack of Drainage

Information Notice 2002-12: Submerged Safety-Related Electrical Cables (ADAMS Accession No. ML020790238)

GL 2007-01: Inaccessible or Underground Power Cable Failures that Disable Accident Mitigation Systems or Cause Plant Transients (ADAMS Accession No.ML070360665).

SUMMARY REPORT: Generic Letter 2007-01, “Inaccessible or Underground Power Cable Failures That Disable Accident Mitigation Systems or Cause Plant Transients” (ADAMS Accession No.ML082760385)

Inspection Findings

The NRC inspection reports for the last 10 years identified cable performance issues at various facilities. It identified violations of NRC regulations 10 CFR 50, Appendix B, Criterion III, “Design Control,” Criterion V, “Instructions, Procedures, and Drawings,” Criterion, XI, “Test Control,” Criterion XVI, “Corrective Actions,” 10 CFR 50.65, “Requirements for Monitoring the Effectiveness of Maintenance at Nuclear Power Plants,” and other performance issues (Green/White findings).

See Appendix B for List of Inspection Reports.

4. Implementation Phase

Staff Recommendations

1. Licensees must be in full compliance with NRC regulatory requirements specified above for cable systems.

2. If cable systems (cables, splices, connections, trays, supports, enclosures, etc.) have been exposed to conditions for which they are not designed or qualified, the licensees must demonstrate its qualification for plant-specific application. Licensees then must demonstrate, through adequate testing or condition monitoring, that the cables can perform their intended design function for the duration of its expected service life.

3. Nuclear industry to develop and implement a cable monitoring program to comply with Commissions regulatory requirements.

4. NRC verifies licensees' implementation through routine Baseline inspections.

5. Issue a NUREG report that identifies the essential elements for a cable condition monitoring program.

6. Issue a Regulatory Guide that provides guidance for maintaining the cable qualification and verifying that the cables can perform their design functions when called upon.

Appendix A – List of Guidance Documents

NRC Guidance Documents

Standard Review Plan, Section 8.0

Regulatory Guide 1.32: Criteria for Power Systems for Nuclear Power Plants

Regulatory Guide 1.89: Environmental Qualification of Certain Electric Equipment Important to Safety for Nuclear Power Plants

Environmental Qualification of Certain Electric Equipment Important to Safety for Nuclear Power Plants

Regulatory Guide 1.93: Availability of Electric Power Sources

Regulatory Guide 1.156: Environmental Qualification of Connection Assemblies for Nuclear Power Plants

Regulatory Guide 1.118: Periodic Testing of Electric Power and Protection Systems

Regulatory Guide 1.160: Monitoring the Effectiveness of Maintenance at Nuclear Power Plants

Regulatory Guide 1.211: Qualification of Safety-Related Cables and Field Splices for Nuclear Power Plants

NUREG/CR-6794: Evaluation of Aging and Environmental Qualification Practices for Power Cables Used in Nuclear Power Plants.

NUREG/CR-6788: Evaluation of Aging and Qualification Practices for Cable Splices Used in Nuclear Power Plants

NUREG/CR-6704: Assessment of Environmental Qualification Practices and Condition Monitoring Techniques for Low-Voltage Electric Cables

NUREG/CP-0135: Workshop on Environmental Qualification of Electric Equipment

NUREG/CR-5772: Aging, Condition Monitoring, and Loss-of-Coolant Accident Tests of Class 1E Electrical Cables (3 Volumes)

Industry Standards

SAND96-0344: Aging Management Guideline for Commercial Nuclear Power Plants-Electrical Cable and Terminations.

IEEE Std 308, Criteria for Class 1E Power Systems for Nuclear Power Generating Stations

IEEE Std 323: IEEE standard for qualifying class 1E equipment for nuclear power generating

IEEE Std 1142: IEEE guide for the design, testing, and application of moisture-impervious, solid dielectric, 5-35 kV power cable using metal-plastic laminates

IEEE Std 383: IEEE standard for qualifying class 1E electric cables and field splices for nuclear power generating stations

IEEE Std. P1205-2000: IEEE Guide for Assessing, Monitoring, and Mitigating Aging Effects on Class 1E Equipment used in Nuclear Generating Stations

IEEE Std. 400-2001- IEEE Guide for Field Testing and Evaluation of the Insulation of Shielded Power Cable Systems

IEEE Std. 400.2-2004-IEEE Guide for Field Testing of Shielded Power Cable Systems Using Very Low Frequency

IEEE Std. 141-1993 (Red Book) – IEEE Recommended Practice for Electric Power Distribution for Industrial Plants, Chapter 12

IEEE Std. 400.1-2007 – IEEE Guide for Field Testing of Laminated Dielectric, Shielded Power Cable Systems Rated 5 kV and Above with High Direct Current Voltage

IEEE Std 400.3-2006 – IEEE Guide for Partial Discharge testing of Shielded Power Cable Systems in a Field Environment

ASTM Standard D150- Test Methods for AC Loss Characteristics and Permittivity (Dielectric Constant) of Solid Electrical Insulating Materials, ASTM International.

ASTM Standard D257: test Methods for DC Resistance or Conductance of Insulating Materials- ASTM International

ASTM Standard D470 – Standard Test Methods for Crosslinked Insulations and Jackets for Wire and Cable – ASTM International

ASTM D2633: Standard Test Methods for Thermoplastic Insulations and Jackets for Wire and Cable – ASTM International

Presentation to NRC: Wire System Aging Condition Monitoring and Fault Detection Using Line Resonance Analysis, April 5, 2005, Paolo F. Fantoni, OECD Halden Reactor project, Institutt for Energitenikk, Halden, Norway

EPRI TR-103834-P1-2: Effects of Moisture on the Life of Power Plant Cables

Appendix B- List of NRC Inspection Reports

1. Inspection Report No: 05000346/2004-017

2. Inspection Report Nos. 50-269/99-12, 50-270/99-12

3.Inspection Report No: 05000263/ 2008-009

4.Inspection Report No: 05000482/2008-003

5. Inspection Report No: 05000286/2003-002

6.Inspection Report Nos: 05000266/2002-013, 05000301/2002-013

7.Inspection Report No: 05000302/2002-003

8.Inspection Report Nos: 05000250/2000-006, 0500025/2000-006

9.Inspection Report Nos: 05000280/2000-007, 05000281/2000-007

10.Inspection Report No: 05000482/2006-010

11.Inspection Report No: 05000287/2004-011

12.Inspection Report No: 05000286/2001/009

13.Inspection Report No: 05000293/2001-005

14.Inspection Report No: 05000247/2000-008

15.nspection Report No: 05000266 /2008-007 (2 findings)

16.Inspection Report Nos: 05000313/2005-003, 05000368/2005-003

17.Inspection Report No: 05000416/2009-06

18.Inspection Report Nos: 05000335/2008-004, 05000389/2008-004

19.Inspection Report No: 05000482/2008-004

20.Inspection Report No: 05000247/2008-002

21.Inspection Report No: 05000461/2007-008

22.Inspection Report Nos: 05000259/2007-007, 05000260/2007-007, 05000296/2007-007

23.Inspection Report No: 05000331/2007-007

24. Inspection Report No: 05000341/2007-003

25. Inspection Report No: 05000346/2004-017

26. Inspection Report No: 05000220/2004-004

27. Inspection Report No: 05000331/2004-003

28. Inspection Report Nos: 05000325/2000-004, 05000324/2000-004

29. Inspection Report Nos: 05000219/2003-005 and 2004-007