AMP 206 ELECTRICAL CABLE CONNECTIONS NOT SUBJECT TO ENVIRONMENTAL QUALIFICATION REQUIREMENTS (VERSION 2020)

Programme Description

The purpose of the ageing management programme (AMP) described herein is to provide reasonable assurance that the intended functions of the metallic parts of electrical cable connections that are not subject to environmental qualification requirements and susceptible to age-related degradation are adequately age managed through the period of long term operation. Ageing degradation results in increased resistance of the connection. Stressors include thermal cycling, ohmic heating, electrical transients, wear (including vibration), surface or chemical contamination, corrosion or oxidation [1-3].

Cable connections are used to connect cable conductors to other cable conductors or electrical devices. Connections associated with cables within the scope according to national regulatory requirements are part of this AMP. The most common types of connections used in nuclear power plants are splices (butt or bolted), crimp-type ring lugs, compression/crimped connectors, terminal blocks, stress cones and coaxial/triaxial connections. Most connections involve insulating material and metallic parts. This AMP focuses on the metallic parts of the electrical cable connections. This AMP provides testing on a sampling basis, to ensure that either ageing of metallic cable connections is not occurring and/or that the existing preventive maintenance programme is effective such that a periodic inspection programme is not required.

AMP 201 manages the ageing of insulating material but not the metallic parts of the electrical connections [4].

Electrical cable connections exposed to appreciable ohmic or ambient heating during operation may experience increased resistance of connection caused by repeated cycling of connected loads or of the ambient temperature environment. Different materials used in various cable system components can produce situations where stresses between these components change with repeated thermal cycling. For example, under loaded conditions, ohmic heating may raise the temperature of a compression terminal and cable conductor well above the ambient temperature, thereby causing thermal expansion of both components. Thermal expansion coefficients of different materials may alter mechanical stresses between the components and may adversely impact the termination. When the current is reduced, the affected components cool and contract. Repeated cycling in this fashion can cause loosening of the termination and may lead to increased resistance of connection or eventual separation of compression-type terminations. Threaded connectors may loosen if subjected to significant thermally-induced stress and cycling [5].

A representative sample of cable connections within the scope according to national regulatory requirements are tested to provide an indication of the integrity of the cable connections. The specific type of test to be performed is a proven test for detecting increased resistance of connection, such as thermography, contact resistance testing, or another appropriate test. The tests need to be completed prior to the period of extended operation. Depending on the findings of the one-time test, subsequent testing may have to be performed.

As an alternative to thermography or resistance measurement of cable connections, for the accessible cable connections that are covered with insulation materials such as tape, the applicant may perform periodical visual inspections of the insulation material to detect ageing effects for covered cable connections. The basis for testing is to be documented.

This AMP, as described, is a sampling programme. The following factors are considered for sampling: voltage level (medium and low voltage), circuit loading (high loading), connection type and location (high temperature, moisture, wear, etc.). The technical bases for the sample selections are documented. If an unacceptable condition or situation is identified in the selected sample, a determination is made as to whether the same condition or situation is applicable to other connections not tested. The corrective action programme is used to evaluate the condition and determine appropriate corrective action.

Reference [6] indicated that loose terminations were identified by several plants. The major concern is failures of a deteriorated cable system (cables, connections including fuse holders, and penetrations) that could prevent it from performing its intended function. This AMP is not applicable to cable connections in adverse localized environments since they are addressed by environmental qualification in AMP 207 or AMP 209. Even though cable connections may not be exposed to adverse localized environments, increased resistance of connection is a concern due to the ageing mechanisms discussed above.

Since the cables and connections are not subject to environmental qualification requirements, an AMP is required to manage the ageing effects. This AMP provides reasonable assurance the metallic portion for cable connections will perform its intended function.

The metallic parts of electrical connections covered by this AMP are not subject to environmental qualification requirements, therefore this AMP is required to manage the ageing effects. This AMP provides reasonable assurance that the metallic portion of cables connections will perform its intended function.

Evaluation and Technical Basis

1. *Scope of the ageing management programme based on understanding ageing:*

Cable connections associated with cables within the scope according to national regulatory requirements that are external connections terminating at active or passive devices are in the scope of this AMP. Wiring connections internal to an active assembly are considered part of the active assembly and, therefore, are not within the scope of this AMP. This AMP does not include high-voltage (>35 kilovolts) switchyard connections. The cable connections covered under an environmental qualification programme are not included in the scope of this programme.

1. *Preventive actions to minimize and control ageing degradation:*

This is a condition monitoring programme, and no actions are taken as part of this programme to prevent or mitigate ageing degradation.

1. *Detection of ageing effects:*

This AMP focuses on the metallic parts of the connection. To verify that no ageing effects that require periodic testing occur, representative samples of electrical connections within the scope according to national regulatory requirements are tested. The following factors are considered for each sample: voltage level (medium and low voltage), circuit loading (high load), connection type, and location (high temperature, high humidity, vibration, etc.) A technical justification of the methodology and sample size used for selecting components for the testing is included as part of the AMP’s site documentation.

Testing may include thermography, contact resistance testing, or other proven test methods without removing the connection insulation, such as heat shrink tape, sleeving, insulating boots, etc. The testing provides additional confirmation to support industry operating experience that shows that electrical connections have not experienced a high degree of failures, and that existing installation and maintenance practices are effective. The tests need to be completed prior to the period of extended operation. The findings of the test are evaluated to determine whether periodic testing of the cable connections is necessary. The technical basis for a possible decision to omit periodic testing is to be documented (e.g., a discussion of identified degradations and whether they were ageing-related).

As an alternative to thermography or measuring connection resistance of the cable connection sample, for accessible cable connections that are covered with heat shrink tape, sleeves, insulating boots, etc., the applicant may use a periodic visual inspection of insulation materials to detect surface anomalies, such as embrittlement, cracking, chipping, melting, discoloration, swelling or surface contamination. The basis for performing only a periodic visual inspection to monitor age-related degradation of cable connections is documented.

1. *Monitoring and trending of ageing effects:*

Trending actions are not included as part of this AMP because it is a one-time test or, alternatively, a periodic visual inspection programme where the ability to trend inspection results is limited. However, results that are trendable provide additional information on the rate of degradation.

1. *Mitigating ageing effects:*

This programme is a condition monitoring programme. This programme has no specific operations, maintenance, repair or replacement mitigation aspects.

1. *Acceptance criteria:*

Any indication or relevant conditions of degradation may be evaluated for acceptance in accordance with the pertinent governing requirements or guidance documents. Examination results and flaws that exceed the acceptance criteria in the pertinent governing requirements or guidance documents may require repair or replacement activities, or further evaluation to demonstrate that the component will continue to perform its intended function.

Acceptance Criteria for Testing: Cable connections do not indicate abnormal temperature for the application, when thermography is used. A low resistance value appropriate for the application is determined when contact resistance measurements are used.

Acceptance Criteria for Visual Inspection: When the visual inspection alternative for covered cable connections is used, the absence of embrittlement, cracking, chipping, melting, discoloration, swelling or surface contamination indicates that the covered cable connection components are not loose.

1. *Corrective actions:*

An engineering evaluation is performed, and corrective action taken if acceptance criteria are not met. The member state quality assurance programme is used to perform an evaluation that considers the extent of the condition, the indications of ageing effect, and changes to the one-time testing programme or alternative inspection programme.

1. *Operating experience feedback and feedback of research and development results:*

This AMP addresses the industry-wide generic experience. Relevant plant-specific operating experience is considered in the development of the plant AMP to ensure the AMP is adequate for the plant. The plant implements a feedback process to periodically evaluate plant and industry-wide operating experience and research and development (R&D) results, and, as necessary, either modifies the plant AMP or takes additional actions (e.g. develop a new plant-specific AMP) to ensure the continued effectiveness of ageing management.

Electrical cable connections exposed to thermal cycling, ohmic heating, electrical transients, wear (including vibration), surface contamination, corrosion, during operation may experience increased resistance of connection. There have been limited numbers of age-related failures of electrical connections reported [7]. An applicant’s operating experience with connection reliability and ageing effects demonstrates the AMP effectiveness of including the programme’s capability to detect the presence or noting the absence of ageing effects for electrical connections.

At the time when this AMP was produced, no relevant R&D was identified.

1. *Quality management:*

Site quality assurance procedures, review and approval processes, and administrative controls are implemented in accordance with the different national regulatory requirements, e.g., [8].

References

1. UNITED STATES NUCLEAR REGULATORY COMMISSION, Electrical Cable Connections Not Subject To Environmental Qualification Requirements, NUREG 1801 Rev.2 Chapter XI.E6, USNRC, 2010.
2. INTERNATIONAL ATOMIC ENERGY AGENCY, Ageing Management and Development of a Programme for Long Term Operation of Nuclear Power Plants, IAEA Safety Standards Series No. SSG-48, IAEA, Vienna
3. KERNTECHNISCHER AUSSCHUSS, Ageing Management in Nuclear Power Plants, KTA Standard 1403, KTA, Germany, 2017.
4. ELECTRIC POWER RESEARCH INSTITUTE, Guideline for the Management of Adverse Localized Equipment Environments, EPRI TR-109619, EPRI, Palo Alto, CA, 1999.
5. ELECTRIC POWER RESEARCH INSTITUTE, Nuclear Maintenance Applications Center: Bolted Joint Fundamentals. EPRI 1015336, Palo Alto, CA: 2007.
6. SANDIA NATIONAL LABORATORIES, Ageing Management Guideline for Commercial Nuclear Power Plants – Electrical Cable and Terminations, SAND96-0344, prepared by Sandia National Laboratories for the U.S. Department of Energy, 1996.
7. UNITED STATES NUCLEAR REGULATORY COMMISSION, Inadequate Electrical Connections, NRC Information Notice 2010-25, USNRC, November 17, 2010.
8. UNITED STATES NUCLEAR REGULATORY COMMISSION, 10 CFR Part 50, Appendix B, Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants, Office of the Federal Register, National Archives and Records Administration, USNRC, 2019.
9. ELECTRIC POWER RESEARCH INSTITUTE, Nuclear Maintenance Applications Center: Switchgear and Bus Maintenance Guide. EPRI, Palo Alto, CA: 2006. 1013457.