AMP 202 ELECTRICAL INSULATION FOR ELECTRICAL CABLES AND CONNECTIONS NOT SUBJECT TO ENVIRONMENTAL QUALIFICATION REQUIREMENTS USED IN INSTRUMENTATION CIRCUITS (VERSION 2020)

Programme Description

The purpose of this AMP is to provide reasonable assurance that the intended functions of electrical cables and connections (that are not subject to the environmental qualification requirements and are used in instrumentation circuits with sensitive, high‑voltage, low-level current signals exposed to adverse localized environments caused by temperature, radiation, moisture, wear, chemical or surface contamination) which are susceptible to age-related degradation are adequately age managed [1–9].

In most areas within a nuclear power plant, the actual operating environments (e.g. temperature, radiation, or moisture) are less severe than the plant design environment. However, in a limited number of localized areas, the actual environments may be more severe than the anticipated design environment. These localized areas are characterized as ‘adverse localized environments’ that represent a limited plant area where the operating environment is significantly more severe than the anticipated plant design environment for the cable or connection electrical insulation. A discussion of an adverse localized environment and methods for identification can be found in AMP 201.

Exposure of electrical cable and connection insulation material to stressors of adverse localized environments could lead to ageing degradation mechanisms such as thermal degradation of organic materials, radiation­‑induced oxidation, moisture intrusion, wear, chemical (e.g. such as leakage of solvents, hydraulic fluid and borates) or surface contamination, radiolysis and volatilization of plasticizers. These ageing related degradation mechanisms can result in ageing effects such as reduced insulation resistance (IR), shield degradation, or material hardening or loss of strength (e.g. dielectric or mechanical). Reduced IR causes an increase in leakage currents between conductors and from individual conductors to ground. A reduction in IR is a concern for all circuits, but especially those with sensitive, high­‑voltage, low­‑level current signals, such as radiation monitoring and nuclear instrumentation circuits because a reduced IR may contribute to signal inaccuracies [10].

In this AMP, in addition to the evaluation and identification of adverse localized environments, either of two methods can be used to identify the existence of ageing degradation. In the first method, calibration results or findings of surveillance testing programmes are evaluated to identify the existence of cable and connection electrical insulation ageing degradation. In the second method, direct testing of the cable system is performed. Visual inspection of cables and connections, and the identification of adverse localized environments, as applicable, provide additional means to detect cable and connection ageing effects due to temperature, radiation, moisture, wear, chemical or surface contamination (e.g. such as leakage of solvents, hydraulic fluid and borates) [11]. This AMP applies to high­‑range­‑radiation and neutron flux monitoring instrumentation cables in addition to other cables used in high­‑voltage, low­‑level current signal applications that are sensitive to reduction in IR. For these cables, AMP 201 does not apply.

Cables and 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 electrical insulation for electrical cables and connections will perform its intended function.

Evaluation and Technical Basis

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

This AMP applies to electrical cables and connections (cable system) used in circuits with sensitive, high-voltage, low­‑level current signals, such as radiation monitoring and nuclear instrumentation and subjected to adverse localized environments caused by temperature, radiation, moisture, wear, chemical (e.g. such as leakage of solvents, hydraulic fluid and borates) or surface contamination that are subject to ageing management review according to national regulatory requirements.

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

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

1. *Detection of ageing effects:*

Review of calibration results or findings of surveillance programmes can provide an indication of the existence of ageing effects based on acceptance criteria related to instrumentation circuit performance. By reviewing the results obtained during normal calibration or surveillance, an applicant may detect severe ageing degradation prior to the loss of the cable and connection intended function. All calibration or surveillance results that do not meet acceptance criteria are reviewed for ageing effects when the results are available.

Cable system testing is conducted when the calibration or surveillance programme does not include the cabling system in the testing circuit, or as an alternative to the review of calibration results described above. A proven cable system test such as insulation resistance tests, time domain reflectometry tests, or other testing proven to be effective in determining cable electrical insulation, physical, mechanical and chemical properties is performed. The test frequency of the cable system is determined based on engineering evaluation [12]. Visual inspection of cables and connections, and the identification of adverse localized environments, as applicable, provide an additional means to detect cable and connection ageing effects due to temperature, radiation, moisture, wear, chemical, or surface contamination. The visual inspection of cable jacket and connection insulation surfaces is used to infer the adequacy of the cable and connection insulation and is not a substitute for review of calibration results or cable system testing [13–15].

1. *Monitoring and trending of ageing effects:*

The parameters monitored are determined from the specific calibration, surveillances, or testing performed and are based on the specific instrumentation circuit under surveillance or being calibrated, as documented in plant procedures.

Trending actions are not part of this AMP because the ability to trend test results is dependent on the specific type of test chosen. However, test results that are trendable provide additional information on the rate of cable or connection degradation.

1. *Mitigating ageing effects:*

This programme is a condition monitoring programme. This programme has no specific operation, 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 [16]. 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.

1. *Corrective actions:*

Corrective actions, such as recalibration and circuit troubleshooting, are implemented when calibration, surveillance, cable system test results, or visual inspection do not meet the acceptance criteria. An engineering evaluation is performed when the acceptance criteria are not met in order to demonstrate that the electrical cable system will continue to perform its intended function. Such an evaluation is to consider the significance of the calibration, surveillance, cable system test results, or visual inspection. When an unacceptable condition or situation is identified, a determination is made as to whether the review of calibration results and cable system testing frequency needs to be increased.

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 demonstrate the continued effectiveness of ageing management.

Operating experience has identified cases where a change in temperature across a high range radiation monitor cable in containment resulted in a substantial change in the reading of the monitor. Plant trips due to electrical noise in nuclear instrumentation have also occurred. Changes in instrument calibration can be caused by degradation of the cable and are a possible indication of electrical cable ageing degradation.

Site specific and industry wide operating experience regarding neutron flux instrumentation circuits contains events related to cable/connector issues inside containment near the reactor vessel.

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. [17].

**References**

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16. UNITED STATES NUCLEAR REGULATORY COMMISSION, Condition Monitoring Techniques for Electric Cables Used in Nuclear Power Plants, USNRC Regulatory Guide 1.218, Washington, DC (2012).
17. UNITED STATES NUCLEAR REGULATORY COMMISSION, 10 CFR Part 50, Appendix B, Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants, US Govt Printing Office, Washington, DC (2015).
18. ELECTRIC POWER RESEARCH INSTITUTE, Low-Voltage and Instrumentation and Control Cable Aging Management Guide, Revision 1. EPRI, Palo Alto, CA: 2017. 3002010641.