AMP208  HIGH-VOLTAGE INSULATORS AND CONNECTIONS, TRANSMISSION CONDUCTORS AND CONNECTIONS (VERSION 2020)

**Programme Description**

The purpose of this AMP is to provide reasonable assurance that the intended functions of high-voltage insulators and connections and transmission conductors and connections susceptible to ageing degradation due to localized environmental conditions are adequately managed [1–8].

The high‑voltage insulators portion of this programme includes visual inspections to identify age degradation of high‑voltage insulator sub-component parts, namely insulation and metallic elements. Visual inspection provides reasonable assurance that the applicable ageing effects are identified and high‑voltage insulator age degradation is adequately managed. The insulation and metallic elements of high‑voltage insulators are constructed of porcelain, cement, malleable iron, aluminium, and galvanized steel. These materials may degrade more rapidly than expected when installed in a localized environment conducive to component accelerated ageing. In such an environment, a significant loss of insulator metallic material can occur due to mechanical wear caused by oscillating movement or vibration induced by wind. Loss of material in metallic parts may also result from corrosion due to surface contamination or where galvanized or other protective coatings become degraded. Significant loss of insulator metallic material can result in the loss of function of the insulator to support the conductor. An environment that includes excessive airborne contaminants such as dust, salt, fog, cooling tower plume, or industrial effluent can contaminate the insulator surface leading to reduced insulation resistance. Excessive surface contamination can result in insulator flashover and failure.

Transmission conductors and connections within the scope of this programme are conductors and connections susceptible to ageing degradation due to localized environmental conditions [1–8].

The ageing effects managed for transmission conductors and connections are loss of material due to wind-induced oscillating movement or vibration, abrasion due to wind driven abrasive material, loss of conductor strength due to corrosion, and increased resistance of connection due to oxidation or loss of pre-load These ageing effects, if left unmanaged, may result in the loss of intended function the transmission conductor or connection.

The transmission conductors, high-voltage insulators, high-voltage insulator connections and transmission conductor connections within the scope of this programme are visually inspected at a frequency, determined, based on plant‑specific operating experience, including inspection results, and member state operating experience.

Ageing management of switchyard bus and connections may be included in this AMP as applicable.

Evaluation and Technical Basis

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

The scope of this AMP includes high-voltage insulators and connections and transmission conductors and connections.

This AMP manages the ageing degradation of high‑voltage insulators susceptible to airborne contaminants including dust, salt, fog, cooling tower plume, industrial effluent or loss of material. In addition, this AMP manages the ageing degradation of transmission conductors and connections susceptible to loss of material due to wind-induced oscillating movement or vibration, abrasion due to wind driven abrasive material loss of conductor strength due to corrosion and increased resistance of connections due to oxidations or loss of preload that are subject to ageing management according to member state regulatory requirements.

1. Preventive actions to minimize and control ageing degradation:

Although a condition monitoring programme the high-voltage insulator portion of this AMP relies on visual inspection, and as applicable, high-voltage insulator coating and cleaning to manage high-voltage insulator ageing effects. The high-voltage insulator visual inspection monitors the accumulation of insulator surface contamination.

1. Detection of ageing effects:

Periodic visual inspection is used to detect the following ageing effects: (1) loss of material and (2) change in insulation resistance.

Loss of material is due to corrosion caused by contaminants, mechanical wear due to wind induced oscillations or vibration, or due to wind driven abrasive material. Reduced insulation resistance can be caused by the presence of surface contamination. Increased resistance of connections results from oxidation or loss of preload.

Transmission conductors, transmission connections are inspected for hot spots, corrosion, loss of material caused due to wind-induced oscillating movement or vibration, abrasion, due to wind driven abrasive material, loss of conductor strength due to corrosion or fatigue, and increased resistance of connection due to oxidation or loss of preload. Insulator surfaces are visually inspected to detect signs of ageing degradation including cracks, foreign debris, excessive salt dust build-up or other contaminants leading to reduced insulation resistance. Metallic parts of the insulator are visually inspected to detect possible loss of material due to mechanical wear and/or corrosion that may result in the loss of function of the insulator to support the conductor.

Visual inspections may be supplemented with infrared thermography or other proven inspection means to detect high-voltage insulator reduced insulation resistance.

Transmission conductors and connections and high-voltage insulators and connections are visually inspected periodically. The inspection frequency is determined based on plant-specific operating experience, including inspection results, and member state operating experience.

High-voltage insulator and transmission conductors and connections can be monitored for the presence of corona using a corona camera or inspected by acoustic measurement to detect partial discharges or tracking using acoustic monitoring. Monitoring can be done in lieu of, or in combination with thermography and visual inspection to detect ageing degradation.

EPRI 1001997 [1] provides technical basis to define the inspection of high-voltage insulator and transmission conductors.

1. Monitoring and trending of ageing effects:

The parameters monitored are determined from the specific calibration, surveillances, or testing performed and is based on the specific surveillance 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, results that are trendable could provide additional information on the rate of degradation; for instance, if thermography is used for identifying hot-spots, thermography records are used to evaluate frequency of inspections on insulators and conductors.

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.

An unacceptable indication is a noted condition or situation that, if left unmanaged, could lead to a loss of the intended function.

Acceptance Criteria Visual Inspection: Surfaces are free of unacceptable contamination such as foreign material, excessive salt dust build-up or other contaminants that contribute to accelerated ageing. Metallic parts are free of unacceptable loss of materials due to pitting, crevice, and general corrosion.

A condition assessment is performed to assess conductor condition. The assessment depends on the type of inspection performed.

Acceptance Criteria - Thermography: Connections need to be below the maximum allowed temperature rise above reference for the application when thermography is used. For resistance measurement, a resistance value appropriate for the application is used.

Acceptance Criteria - Corona: Corona and indications of degradation due to partial discharge are not present.

Acceptance Criteria - Acoustic: Corona and partial discharge tracking and associated high frequency noise are not present.

1. Corrective actions:

An engineering evaluation is performed and corrective actions are taken when unacceptable conditions are found. The evaluation is to consider the age and operating environment of the component as well as the severity of the anomaly and whether such an anomaly has previously been correlated to high-voltage insulators or transmission conductors. Corrective actions may include, but are not limited to, cleaning, increase inspection frequency, replacement or repair of the affected components. If an unacceptable condition or situation is identified, a determination is made as to whether the same condition or situation is applicable to other high-voltage insulators or transmission conductors.

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 the ageing management.

Operating experience has identified where high-voltage insulators, transmission conductors, and connections ageing effects attributed to the installed environment (e.g., foreign material, excessive salt, dust build-up or cooling tower plume) have contributed to plant trips or transients.

EPRI 1000174 [2] includes a search of NRC generic communications, LERs and NRC NUREGs, where the following document was identified [3].

In Spain, the search of industry operating experience includes two events related to degraded insulators: The first event [4] was a ground fault event at a switchyard station (non-nuclear) close to the sea. The cause of the ground fault was attributed to corrosion of an insulator metallic part. The second event was arcing due to the loss of dielectric resistance of an insulator in the 400kV switchyard. The arcing was caused by excessive dust build-up on the insulators, due to road construction near the NPP site.

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., 10 CFR 50, Appendix B [5]).

References

1. ELECTRIC POWER RESEARCH INSTITUTE, Parameters that Influence the Aging and Degradation of Overhead Conductors, EPRI 1001997, EPRI, Palo Alto, CA, December 2003.
2. ELECTRIC POWER RESEARCH INSTITUTE, Oconee Electrical Component Integrated Plant Assessment and Time-limited Analysis for License Renewal, EPRI 1000174, Revision 1, EPRI, Palo Alto, CA, August 2000.
3. UNITED STATES NUCLEAR REGULATORY COMMISSION, Storm-related Loss of Offsite Power Events due to Salt Build-up on Switchyard Insulators, NRC Information Notice 93-95, USNRC, December 13, 1993.
4. NATIONAL ENERGY COMMISSION, Technical report on the events of the incident on July 23, 2007 at 10 hours 53 minutes that affected the power of Barcelona (approved by the Board of 4 October 2007), CNE, Madrid, Spain, 2007.
5. UNITED STATES NUCLEAR REGULATORY COMMISSION, 10 CFR Part 50, Appendix B, Quality Assurance Criteria for Nuclear Power Plants, Office of the Federal Register, National Archives and Records Administration, USNRC, 2019.
6. ELECTRIC POWER RESEARCH INSTITUTE, Long Term Operations: Subsequent License Renewal Electrical Handbook, , EPRI 3002010401, Palo Alto, , April 2018.
7. INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS, IEEE Standard 1205-2014, IEEE Guide for the Assessing, Monitoring, and Mitigating Aging Effects on Electrical Equipment Used in Nuclear Power Generating Stations and Other Nuclear Facilities. IEEE New York, New York, 2014.
8. UNITED STATES NUCLEAR REGULATORY COMMISSION, NUREG/CR-5643, Insights Gained from Aging Research, USNRC, March 13, 1992.