AMP 215 SWITCHGEARS/ BREAKERS/ DISTRIBUTION PANELS/ CONTACTORS/ PROTECTION RELAYS/ RELAYS NOT SUBJECT TO ENVIRONMENTAL QUALIFICATION REQUIREMENTS (VERSION 2020)

Programme Description

The purpose of this AMP is to provide a programme for switchgears and active components normally included in switchgear cabinets, to identify age-related degradation.

Switchgear cabinets and buses are passive components with similar design as metal enclosed bus (MEB), and distribution cabinets, and as such covered by AMP 204 and AMP 212.  
Different types of fuse holders normally included in switchgear cabinets are also considered to be passive components and are covered by AMP 205.

Active components covered by this AMP are:

* Circuit breakers
* Contactors
* Relays
* Protection relays

Ageing factor/ageing mechanism/ageing effect are individually analysed and programmes are developed depending of the result from that analysis.

As an example, protection relays can be divided in four generations:

* Electromechanical relay
* Solid state relays
* Integrated relay
* Digital relays

Each generation has its own degradation mechanisms and different programmes are developed to cope with the different phenomena i.e. capacitor ageing, potentiometer ageing, whiskers, battery exchange etc. The document IAEA-TECDOC-1147 “Management of ageing of I&C equipment in nuclear power plants” [1] provides guidance how to manage ageing in I&C components and systems. Also, AMP 218 describes several methods that are used to ensure the maintainability of electronic equipment installed in I&C systems.

However, the list below will cover most ageing factors/ageing mechanisms/ageing effects related to active components normally included in switchgear cabinets.

|  |  |  |  |
| --- | --- | --- | --- |
| **Material** | **Ageing factor** | **Ageing mechanism** | **Ageing effect** |
| Metal | Humidity  Dust and dirt | Corrosion  Humidity build-up - corrosion | Increased contact resistance or disruption  Increased contact resistance causing overheating. |
| Oxygen | Oxidation | Changed material properties causing overheating |
| Vibration | Loss of material, fatigue, loosening of connection, changed contact pressure, dislocation | Increased contact resistance causing overheating. Contact failure |
| Physical impact | Wear, fatigue, cracking | Too much play, relaxation of springs Damaged manoeuvre mechanism  Damaged sliding surface in manoeuvre mechanism preventing on or off function  Loss of insulation resistance in manoeuvre coil. Cracks in moving parts. |
| Inductive load | Surge or voltage spike | Arcing causing material loss and/or contact sticking |
| Electrical current | Temperature rise | Inrush current to connected induction motors may be 6-8 time rated current, causing overheating and wear on contacts. |
|  | Organic lubricants | Soaking and corrosion | Increasing the mechanical friction on moving parts |
| Organic material | Temperature | Degradation | Reduced insulation resistance, loss of physical properties. |
|  | Oxidation | Degradation | Reduced insulation resistance, loss of physical properties. |

|  |  |  |  |
| --- | --- | --- | --- |
| **Material** | **Ageing factor** | **Ageing mechanism** | **Ageing effect** |
|  | Organic dissolvent | Soaking and degradation. | Softening or cracking lending to loss of physical or electrical properties. |
|  | Organic lubricants | Soaking and degradation. | Softening or cracking lending to loss of physical or electrical properties. |
|  | Physical impact | Wear | Loss of physical or electrical properties |
|  | Dust and dirt | Wear and dirt build-up | Loss of physical or electrical properties |
|  | Maintenance | Build-up of contaminated and/or aged lubricant | Loss of insulation resistance, changed dielectrical properties |
|  | Electrical current | Temperature rise | Loss of insulation resistance, or disruption |
| Non metallic material | Dust and dirt | Dirt build-up | Loss of insulation resistance, changed dielectrical properties |

Evaluation and Technical Basis

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

Indoor low and medium voltage switchgears and active components normally included in switchgear cabinets are covered by this AMP.

1. Preventive actions to minimize and control ageing degradation:

Some of the ageing effects are driven by high temperature while other effects are driven by low temperature. Thus, it is essential to secure that the switchgear ambient temperature is regulated.

1. Detection of ageing effects:

Visual inspection including cleaning is performed periodically. Anomalies in terms of discoloration, cracking, swelling or “hot” smell are observable indicators for ageing. Reference [2] provides guidance on visible indicators of ageing degradation.

Thermography is performed periodically. Scan all accessible components and connections for high resistance connections or abnormal heating pattern. In order to get useful results for the main circuits, connected objects are in operation.

Airborne acoustic testing may be used in medium voltage switchgear to detect discharges. Scan all components using an airborne ultrasonic detector to locate discharges. If any activity is detected, visually inspect and perform thermography scan of the area.

Preventive maintenance on breakers is performed periodically (e.g. every four years like required in [3]). Frequency and scope of activities is based on the manufactures recommendations.

Functional tests are performed periodically (and at least after each maintenance measure) on breakers and protection relays. Frequency and scope of tests are based on the manufactures recommendations. Time-response is normally one part of the functional tests for breakers, reduced manoeuvre voltage can in some applications give a early notice of degradation.

Surveillance testing is performed in such a way that safety functions of switchgear and components in the switchgears are included in the tests.

1. Monitoring and trending of ageing effects:

Trending actions are generally not included as 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 provide additional information on the rate of degradation. Especially results from breaker testing and protection relay testing are trended in order to identify degradation before functional failures.

1. Mitigating ageing effects:

This programme is a condition monitoring programme. This programme has no specific mitigation aspects.

1. Acceptance criteria:

The acceptance criteria for each test are defined by the specific type of test performed and the specific type of component tested.

1. Corrective actions:

An engineering evaluation is performed and corrective actions are taken when the test acceptance criteria are not met in order to ensure that the intended functions of the component can be maintained consistent with the current licensing basis. Such an evaluation is to consider the significance of the test results, the operability of the component, the reportability of the event, the extent of the concern, the potential root causes for not meeting the test acceptance criteria, the corrective action necessary, and the likelihood of recurrence.

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.

Industry experience for switchgears show a number of failures due to aged lubricants in manoeuvre coils or other moveable parts, fatigue of energy storage parts and temperature effects on polymers. Examples from German nuclear power plants are given below:

|  |  |
| --- | --- |
| Short description of the event | Reference |
| Ageing/Gumming of lubricant leads to sluggish-ness or failure to operate of circuit breakers and connectors due to inadvertent friction or interlocking of mechanical parts | GRS Information notice 2015/03 [4] |
| GRS Information notice 2004/02 [5] |
| GRS Information notice 1996/10 [6] |
| GRS Information notice 1987/02 [7] |
| Fatigue and deformation of the energy storage springs of EDG generator breakers | GRS Information notice 2011/03 [8] |
| GRS Information notice 1987/02 [7] |
| Temperature induced shrinking of contactor bobbins led to a sluggish/stuck armature | GRS Information notice 1988/01 [9] |
| GRS Information notice 1981/02 [10] |

This AMP considers technical information and guidance provided in EPRI 1013457 “Switchgear and Bus Maintenance Guide” [11].

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 [12]).

References

[1] INTERNATIONAL ATOMIC ENERGY AGENCY, IAEA-TECDOC-1147 Management of ageing of I&C equipment in nuclear power plants, IAEA, Vienna.

[2] ELECTRIC POWER RESEARCH INSTITUTE, Ageing Identification and Assessment Checklist - Electrical Components, EPRI 1011223, EPRI, Palo Alto, CA.

[3] KERNTECHNISCHER AUSSCHUSS, Switchgear, Transformers and Distribution Networks for the Electrical Power Supply of the Safety System in Nuclear Power Plants, KTA Standard 3705, KTA, Germany, 11/2006.

[4] GRS Weiterleitungsnachricht 2015/03: "Nichtschließen des Druckhalter-Abblaseabsperr-ventils" im Kernkraftwerk Brokdorf (KBR) am 07.10.2013, Gesellschaft für Anlagen- und Reaktorsicherheit (GRS), 2015.

[5] GRS Weiterleitungsnachricht 2004/02: "Aufgetretene Fehler bei Schaltvorgängen von Leistungsschaltern in Kernkraftwerken der Bundesrepublik Deutschland", Gesellschaft für Anlagen- und Reaktorsicherheit (GRS), 2004.

[6] GRS Weiterleitungsnachricht1996/10: „Verzögertes Ansprechen der Druckhalter-Abblasesteuerventile bei einer wiederkehrenden Prüfung“ im Kernkraftwerk Biblis A am 04.08.1996, Gesellschaft für Anlagen- und Reaktorsicherheit (GRS), 1996.

[7] GRS Weiterleitungsnachricht 1987/02: "Schäden an AEG-Leistungsschaltern vom Typ ME 630-2500 in Kernkraftwerken der Bundesrepublik Deutschland", Gesellschaft für Anlagen- und Reaktorsicherheit (GRS), 1987.

[8] GRS Weiterleitungsnachricht 2011/03: "Fehler am Generatorleistungsschalter des UNS-Notstromdiesels EY60" im Kernkraftwerk Brunsbüttel, Gesellschaft für Anlagen- und Reaktorsicherheit (GRS), 2011.

[9] GRS Weiterleitungsnachricht 1988/01: “Schrumpfen der Spulenkörper von in Ruhestrom betriebenen Schützen vom Typ AEG LS2G55 R”, Gesellschaft für Anlagen- und Reaktorsicherheit (GRS), 1988.

[10] GRS Weiterleitungsnachricht 1981/02: “Schrumpfen von Spulenkörpern an Gleichstrom-schützen”, Gesellschaft für Anlagen- und Reaktorsicherheit (GRS), 1981.

[11] ELECTRIC POWER RESEARCH INSTITUTE, Switchgear and Bus Maintenance Guide, EPRI 1013457, EPRI, Palo Alto, CA, 2006.

[12] 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, 2015.

[13] ELECTRIC POWER RESEARCH INSTITUTE, Aging Assessment Field Guide. EPRI, Palo Alto, CA: 2003. 1007933.