AMP 204 METAL ENCLOSED BUS NOT SUBJECT TO ENVIRONMENTAL QUALIFICATION REQUIREMENTS (VERSION 2020)

Programme Description

The purpose of this ageing management programme (AMP) is to provide an internal and external inspection of Metal Enclosed Buses (MEB) to identify and adequately manage age-related degradation of inspection windows, insulating material (e.g., porcelain, xenoy, thermoplastic organic polymers) or component metallic and elastomer seals (e.g. infra-red thermography windows, inspection port, manholes, gaskets, boots, and sealants) [1-4].

MEB are electrical bus installed on electrically insulated supports that are constructed with each phase conductor enclosed in a separate metal enclosure (isolated phase bus), all conductors enclosed in a common metal enclosure without barriers between the phases (non-segregated bus), or all phase conductors in a common metal enclosure, but separated by metal barriers between phases (segregated bus) [5]. The conductors are adequately separated and insulated from ground by insulating supports or bus insulation. The MEB are used in power systems to connect various elements in electric power circuits, such as switchgear, transformers, main generators, and diesel generators.

Industry operating experience indicates that primary failure modes of MEB have been caused by cracked insulation and moisture, debris, loose connections or excessive dust buildup internal to the bus duct housing. Cracked insulation has resulted from high ambient temperature, vibration and contamination from bus bar joint compounds. Cracked insulation in the presence of moisture or debris has provided phase-to-phase or phase-to-ground electrical tracking paths, which has resulted in catastrophic failure of the buses. Significant ohmic heating of the bus may result in loosening of bolted connections associated with repeated cycling of connected loads. Bus failure has led to loss of power to electrical loads connected to the buses, causing subsequent reactor trips and initiating unnecessary challenges to plant systems and operators [6-7].

MEB may experience increased resistance of connection due to loosening of bolted bus duct connections caused by repeated thermal cycling of connected loads. This phenomenon can occur in heavily loaded circuits (i.e., those exposed to appreciable ohmic heating). For example, NRC IN 2000-14 identified torque relaxation of splice plate connecting bolts as one potential cause of a MEB fault, and NRC IN 2010-25 identified instances of termination loosening at several plants due to thermal cycling [8-9]. In addition, it has been identified that a surface contamination reduces insulation resistance of the MEB’s insulation materials.

This AMP includes the inspection of accessible MEB and a sample of MEB bolted connections for increased resistance of connection.

MEB 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 Metal Enclosed Buses (MEB) will perform its intended function.

Evaluation and Technical Basis

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

This AMP manages the age-related degradation effects for MEB bolted connections, bus bar insulation, bus bar insulating supports, bus enclosure assemblies (internal and external), and elastomers. This programme does not manage the ageing effects on external bus structural supports, which are managed under AMP 212.

MEB are generally accessible structures and as such are inspected and tested in their entirety. However, depending on particular plant configurations, some segments of the MEB may be considered inaccessible due to close proximity to other permanent structures (e.g., nearby walls, ducts, cable trays, equipment or other structural elements). For inaccessible MEB internal or external segments, a plant demonstrates (e.g., through alternative analysis, inspection, test or plant operating experience) that the inaccessible MEB segments evaluation, together with the accessible MEB inspection and test program, will continue to adequately manage MEB age-related degradation through the period of long term operation.

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. However, avoidance of MEB moisture accumulation, debris or dust buildup can be considered a preventive action.

1. *Detection of ageing effects:*

MEB internal components are visually inspected for ageing degradation including cracks, corrosion, foreign debris, excessive dust buildup, and evidence of moisture intrusion. MEB insulating material is visually inspected for signs of reduced insulation resistance due to thermal degradation of organics, radiation-induced oxidation, moisture intrusion, or ohmic heating, as indicated by embrittlement, cracking, chipping, melting, discoloration, swelling, or surface contamination. Internal bus insulating supports are visually inspected for structural integrity and signs of cracks. MEB external surfaces are visually inspected for loss of material due to general, pitting, and crevice corrosion. Accessible elastomers (e.g., gaskets, boots, and sealants) are inspected for degradation including surface cracking, crazing, scuffing, dimensional change (e.g. “ballooning” and “necking”), shrinkage, discoloration, hardening or loss of strength.

A sample of accessible bolted connections is inspected for increased resistance of connection by using thermography or by measuring connection resistance using a micro-ohmmeter. Twenty percent of the population with a maximum sample of 25 constitutes a representative sample size. Otherwise, a technical justification of the methodology and sample size used for selecting components are included as part of the AMP’s site documentation. 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.

When thermography is employed by the applicant, the applicant demonstrates with a documented evaluation that thermography is effective in identifying MEB increased resistance of connection (e.g., infrared viewing windows installed, or demonstrated test equipment capability). In addition to thermography or resistance measurement, bolted connections not covered with heat shrink tape or boots are visually inspected for increased resistance of connection (e.g., loose or corroded bolted connections and hardware including cracked or split washers).

As an alternative to thermography or measuring connection resistance of bolted connections, for accessible bolted connections that are covered with heat shrink tape, sleeving, insulating boots, etc., the applicant may use visual inspection of insulation material to detect surface anomalies, such as embrittlement, cracking, chipping, melting, discoloration, swelling, or surface contamination.

1. *Monitoring and trending of ageing effects:*

Trending actions are not included as part of this AMP because 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 Visual Inspection**:** MEB insulation materials are free from unacceptable regional indications of surface anomalies such as embrittlement, cracking, chipping, melting, discoloration, and swelling, or surface contamination. MEB internal surfaces show no indications of unacceptable corrosion, cracks, foreign debris, excessive dust buildup, or evidence of moisture intrusion. Accessible elastomers (e.g., gaskets, boots, and sealants) show no indications of unacceptable surface cracking, crazing, scuffing, dimensional change (e.g. “ballooning” and “necking”), shrinkage, discoloration, hardening, or loss of strength. MEB external surfaces are free from unacceptable loss of material due to general, pitting, and crevice corrosion.

When the visual inspection alternative for bolted connections is used, the absence of embrittlement, cracking, chipping, melting, discoloration, swelling, or surface contamination of the insulation material provides positive indication that the bolted connections are not loose. Visual inspection of bolted connections not covered with heat shrink tape, sleeving, insulating boots, etc. are free from corrosion, loose connections and hardware sleeving, insulating boots, etc. are free from corrosion, loose connections and hardware including cracked or split washers.

Acceptance Criteria for Thermography and Resistance Measurement: Bolted connections need to be below the maximum allowed temperature (e.g., comparison of compartment temperatures, trending of temperature over time, or comparison to a baseline thermography signature) for the application when thermography is used or a low resistance value appropriate for the application when resistance measurement is used.

1. *Corrective actions:*

An engineering evaluation is performed, and corrective action are taken when the acceptance criteria are not met. Corrective actions may include, but are not limited, to cleaning, drying, increased inspection frequency, replacement, or repair of the affected MEB 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 accessible or inaccessible MEB.

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.

Industry experience has shown that failures have occurred on MEB caused by cracked insulation and moisture or debris buildup internal to the MEB [10]. Experience also has shown that bus connections in the MEB exposed to appreciable ohmic heating during operation may experience loosening due to repeated cycling of connected loads.

At the time when this AMP was produced/reviewed, no new relevant operating experience or 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].

References

1. UNITED STATES NUCLEAR REGULATORY COMMISSION, Metal Enclosed Bus, NUREG 1801 Rev.2 Chapter XI.E4, USNRC, 2010.
2. INTERNATIONAL ATOMIC ENERGY AGENCY, Ageing Management for Nuclear Power Plants, Safety Guide No. NS-G-2.12, IAEA, Vienna, 2009.
3. KERNTECHNISCHER AUSSCHUSS, Ageing Management in Nuclear Power Plants, KTA Standard 1403, KTA, Germany, 2010.
4. WORLD ASSOCIATION OF NUCLEAR OPERATORS, WER 2015-0284, Rev. 0, Plant Trip on Generator Trip, 2015.
5. INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS, IEEE Std. C37.23-2003, Metal Enclosed Bus, 2003.
6. UNITED STATES NUCLEAR REGULATORY COMMISSION, Electrical Bus Bar Failures, NRC Information Notice 89-64, USNRC, 1989.
7. UNITED STATES NUCLEAR REGULATORY COMMISSION, Inadequate or Poorly Controlled, Non-Safety-Related Maintenance Activities Unnecessarily Challenged Safety Systems, NRC Information Notice 98-36, USNRC, 1998.
8. UNITED STATES NUCLEAR REGULATORY COMMISSION Non-Vital Bus Fault Leads to Fire and Loss of Offsite Power, NRC Information Notice 2000-14, USNRC, 2000.
9. UNITED STATES NUCLEAR REGULATORY COMMISSION, Inadequate Electrical Connections, NRC Information Notice 2010-25, USNRC, 2010.
10. 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.
11. ELECTRIC POWER RESEARCH INSTITUTE, Nuclear Maintenance Applications Center: Switchgear and Bus Maintenance Guide. EPRI, Palo Alto, CA: 2006. 1013457.