XI.E4 METAL ENCLOSED BUS

Program Description

The purpose of this aging management program (AMP) is to provide an internal and external inspection of Metal Enclosed Buses (MEBs) to identify age-related degradation of insulating material (i.e., porcelain, xenoy, thermoplastic organic polymers), and metallic and elastomer components (e.g., gaskets, boots, and sealants).

MEBs are electrical buses 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 (non-segregated bus), or all phase conductors in a common metal enclosure, but separated by metal barriers between phases (segregated bus). The conductors are adequately separated and insulated from ground by insulating supports or bus insulation. The MEBs 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 failures of MEBs have been caused by cracked insulation and moisture, debris, or excessive dust buildup internal to the bus duct housing. Cracked insulation has resulted from high ambient temperature 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. 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.

MEBs 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, SAND 96-0344 identified instances of termination loosening at several plants due to thermal cycling and NRC IN 2000-14 identified torque relaxation of splice plate connecting bolts as one potential cause of a MEB fault.

This AMP includes the inspection of all bus ducts within the scope of license renewal and a sample of accessible MEB bolted connections for increased resistance of connection. The technical basis for the sample selections should be 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.

Evaluation and Technical Basis

1. ***Scope of Program:*** This AMP manages the age-related degradation effects for electrical bus bar bolted connections, bus bar insulation, bus bar insulating supports, bus enclosure assemblies (internal and external), and elastomers. This program does not manage the aging effects on external bus structural supports, which are managed under AMP XI.S6, “Structures Monitoring.” Alternatively, the aging effects on elastomers can be managed under AMP XI.M38, “Inspection of Internal Surfaces in Miscellaneous Piping and Ducting Components,” and the external surfaces of MEB enclosure assemblies can be managed under AMP XI.S6, “Structures Monitoring.”

2. ***Preventive Actions:*** This is a condition monitoring program and no actions are taken as part of this program to prevent or mitigate aging degradation.

3. ***Parameters Monitored/Inspected:*** This AMP provides for the inspection of the internal and external portions of the MEB. Internal portions (bus enclosure assemblies) of the MEB are inspected for cracks, corrosion, foreign debris, excessive dust buildup, and evidence of water intrusion. The bus insulation is inspected for signs of reduced insulation resistance due to thermal/thermoxidative degradation of organics/thermoplastics, radiation-induced oxidation, moisture/debris intrusion, or ohmic heating, as indicated by embrittlement, cracking, chipping, melting, discoloration, or swelling, which may indicate overheating or aging degradation. The internal bus insulating supports are inspected for structural integrity and signs of cracks. A sample of accessible bolted connections is inspected for increased resistance of connection. Alternatively, for accessible bolted connections covered with heat shrink tape, sleeving, insulating boots, etc., the sample may be visually inspected for insulation material surface anomalies. The external portions of the MEB, including accessible gaskets, boots, and sealants, are inspected for hardening and loss of strength due to elastomer degradation that could permit water or foreign debris to enter the bus. MEB external surfaces are inspected for loss of material due to general, pitting, and crevice corrosion.

4. ***Detection of Aging Effects:*** MEB internal surfaces are visually inspected for aging degradation including cracks, corrosion, foreign debris, excessive dust buildup, and evidence of moisture intrusion. MEB insulating material is visually inspected for signs of 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 and 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 should be 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.

   The first inspection using thermography or measuring connection resistance is completed prior to the period of extended operation and every 10 years thereafter provided visual inspection is not used to inspect bolted connections. This is an adequate period to preclude failures of the MEBs since experience has shown that MEB aging degradation is a slow process.

   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. When this alternative visual inspection is

used to check the bolted connection sample, the first inspection is completed prior to the period of extended operation and every 5 years thereafter.

5. ***Monitoring and Trending:*** 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.

6. ***Acceptance Criteria:*** MEB insulation materials are free from regional indications of surface anomalies such as embrittlement, cracking, chipping, melting, discoloration, and swelling, or surface contamination. MEB internal surfaces show no indications of corrosion, cracks, foreign debris, excessive dust buildup, or evidence of moisture intrusion. Accessible elastomers (e.g., gaskets, boots, and sealants) show no indications of surface cracking, crazing, scuffing, dimensional change (e.g. “ballooning” and “necking”), shrinkage, discoloration, hardening, and loss of strength. MEB external surfaces are free from loss of material due to general, pitting, and crevice corrosion.

   Bolted connections need to be below the maximum allowed temperature for the application when thermography is used or a low resistance value appropriate for the application when resistance measurement is used. 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.

7. ***Corrective Actions:*** Corrective actions are taken and an engineering evaluation is performed 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 MEBs. As discussed in the Appendix for GALL, the staff finds the requirements of 10 CFR Part 50, Appendix B, acceptable to address the corrective actions.

8. ***Confirmation Process:*** As discussed in the Appendix for GALL, the staff finds the requirements of 10 CFR Part 50, Appendix B, acceptable to address the confirmation process.

9. ***Administrative Controls:*** The administrative controls for this AMP provide for a formal review and approval process. As discussed in the Appendix for GALL, the staff finds the requirements of 10 CFR Part 50, Appendix B, acceptable to address the administrative controls.

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

    This AMP considers the technical information and guidance provided in SAND 96-0344, IEEE Std. 1205-2000, NRC IN 89-64, NRC IN 98-36, NRC IN 2000-14, and NRC IN 2007-01.

References

10 CFR Part 50, Appendix B, *Quality Assurance criteria for Nuclear Power Plants*, Office of the Federal Register, National Archives and Records Administration, 2009.

IEEE Std. 1205-2000, *IEEE Guide for Assessing, Monitoring and Mitigating Aging Effects on Class 1E Equipment Used in Nuclear Power Generating Stations*.

NRC Information Notice 89-64, *Electrical Bus Bar Failures*, September 7, 1989.

NRC Information Notice 98-36, *Inadequate or Poorly Controlled, Non-Safety-Related Maintenance Activities Unnecessary Challenged Safety Systems*, September 18, 1998.

NRC Information Notice 2000-14, *Non-Vital Bus Fault Leads to Fire and Loss of Offsite Power*, September 27, 2000.

NRC Information Notice 2007-01, *Recent Operating Experience Concerning Hydrostatic Barriers*, January 31, 2007.

SAND 96-0344, *Aging Management Guideline for Commercial Nuclear Power Plants – Electrical Cable and Terminations*, prepared by Sandia National Laboratories for the U.S. Department of Energy, September 1996.