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Aging Management for Non-EQ Electrical Cables and Connections

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1. Introduction

The aging management review is required for electrical cables and connections installed in power and I&C applications which are not subject to 10 CFR 50.49 EQ requirements prior to the continued operation of nuclear power plants. GALL report, NUREG-1801, rev. 1 defines three programs for aging management of electrical cables and non-metallic connections, electrical metallic cable connections, and electrical cables and connections used in instrumentation circuits. These programs require an inspection for the electrical equipments as a part of aging management for continued operation. Accordingly, no actions are taken to prevent or mitigate aging degradation as part of maintenance activities. This paper provides reasonable guidance and technical information for the inspection of electrical cables and connections that are not subject to the EQ requirements.

2. Selection of Inspection Scope

In selection of the electrical cables and connections to be examined, following electrical systems should be reviewed. Accessible electrical cables and connections are selected in the inspection scope.

- **Cables and non-metallic connections, and metallic cable connections** : 4.16kV power, 480AC power, 120V AC essential power, 125V DC power, other AC power and lighting system, offsite power, process control and protection, RPS, ESFAS, CRDM and NIS
- **Cables and connections used in instrumentation circuit** : NIS, RMS

Aging mechanisms of cables and connections are dependent on environments and insulation materials. Typical insulation materials are PVC or EPR for cables, and metal or non-metal for connections. Environments are defined as mild environment or adverse localized environment on the basis of following conditions.

- Temperature : 49°C (120°F) < adverse
- Pressure : 1.1kg/cm^2(15.7 psia) < adverse
- Chemical material jet : If yes, adverse
- Total radiation dose : 10^4 (Rad/hr) < adverse
- Internal flooding : If yes, adverse
- Relative humidity : mild > 80%

For metallic cable connections installed in mild and adverse environments are reviewed to select the inspection scope. However, among the cables and non-metallic connection, and cables and connections used in instrumentation circuits, only those installed in adverse localized environment are reviewed to select the inspection scope.

3. Inspection Considerations

Aging mechanisms of the electrical cables and connections are dependant on insulation materials and environments. General aging effects and its detection methods are described below.

Degradation of the integrity of Cables and non-metallic connections installed in inside or outside containment is caused by heat, radiation, and humidity. Aging effects of which in those adverse localized environments appear to be treeing, craze mark, discoloration, stickiness, bubbling and drooping that can be detected by visual examination. If unacceptable indications defined as below are detected, corrective action should be taken.

- Crack or discoloration on outer surface
- Outer surface contamination
- Bare conductor
- Deformation of insulated material
- Wet tray and cable
- A foreign substance in tray and cable
- Excessive bending and pulling
- Borated water invasion traces

Metallic connections lose its intended functions caused by resistant heat. Aging effects appear to be thermal cycling, ohmic heating, electrical transients, vibration, chemical contamination, corrosion, and oxidation that can not be detected by visual inspection. Thermography (refer fig. 1), contact resistance testing and other appropriate testing methods are recommended to detect aging degradations. Additional attentions listed below, should be paid for deciding the acceptance criteria.

- The acceptance criteria for each testing are defined by the specific type of testing performed and the specific type of cable connections tested.
- Testing methods should be demonstrated that it can detect loosening of bolted connections.

- Insulation resistance connected to each system should be less than 30 micro-ohms for station bus and switchyard system, 100 micro-ohms for exciter system, and 10 micro-ohms for generator excitation DC bus and generator exciter AC bus.

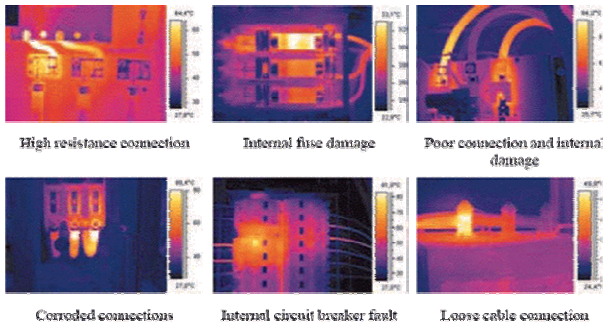

Figure 1. Thermography test method

Cables and connections installed in instrumentation circuits with sensitive, high voltage, low-level signals such as radiation monitoring systems and nuclear instrumentation system may lose intended function caused by heat, radiation or humidity. Degradation appears to be treeing, craze marks, discoloration, stickiness, bubbling, and drooping etc. Degradation detection parameters are determined from the specific calibration, surveillances or testing performed and are based on the specific instrumentation circuits under surveillance or being calibrated, as documented in plant procedures. In case that a calibration or surveillance program 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 for detecting deterioration of the insulation system such as insulation resistance tests, time domain reflectometry tests (refer fig. 2) may be performed.

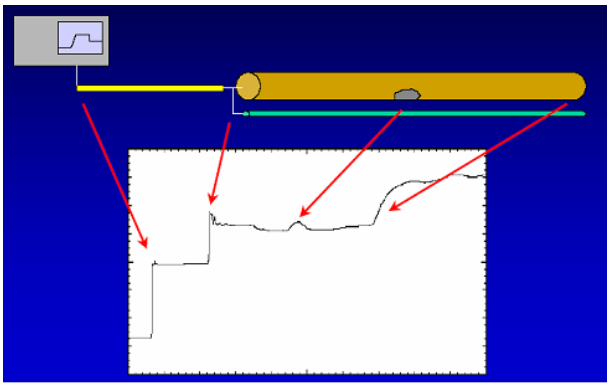

Figure 2. Time domain reflectometry tests

4. Inspection Intervals

Electrical cables and connections which are not subject to 10 CFR 50.49 EQ environment requirements are inspected at least once every ten years. This is an adequate period to preclude failure of the cables and connections since experience has shown that aging degradation is a slow process. The first inspection should be perfromed prior to continued operation.

5. Conclusion

Electrical cables and connections that are not subject to the environment qualification requirements and exposed to adverse localized environments caused by heat, radiation, or moisture should be maintained consistent with the current licensing basis through the period of continued operation. In this paper, technical information and guidance were discussed for selection of inspection scope, aging effects and detection methods, and acceptance criteria. Implementing the aging management program for cables and connections which are not subject to environment requirements of 10 CFR 50.49 will provide reasonable assurance that the intended function will be maintained for the period of continued operation.

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