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A Study on Development of Aging Management Program for Cables and Connections

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1. Introduction

Cable integrity is vital to safe operation of nuclear power plant. It is especially important when plant enters into long-term operation. Cables and connections are considered passive, long-lived components that are very reliable. However, in a limited number of localized areas, the actual environments may be more severe than the design basis environment. The adverse localized equipment environment cause a faster than expected rate of aging of cables and connections.

Kori Nuclear Power Plant Unit 1, South Korea's first nuclear power reactor was permanently shut down in 2017. Currently six operating reactors are operated over 30 years and the number of long-term operated plants will increase as time goes by.

According to the increase of long-term operation nuclear power plants, development of effective Aging Management Program (AMP) of cables and connections is needed.

NUREG-1801[1] provides guideline for AMP to manage aging effects of systems, structures and components including cables and connections. However, detailed criteria for selection of cables and connections that are important to safety and reliability are not provided. Also detailed criteria to identify adverse localized equipment environments are not provided. This paper presents methods to select cables and connections and to identify adverse localized equipment environment. Detection method of aging effect of cables and connections according to cables and connections type are introduced.

2. Development of Cable and Connection AMP

2.1 Scoping of cables and Connections for AMP

With greater than 1,000 km of power, control, instrumentation, and other cables typically found in an NPP[2], testing or inspecting all the cables is ineffective.

Therefore, scoping process is very important. The list of cables and connections that have to be managed by AMP can be determined by following conditions;

- Safety- related Component
- Non Safety-related Affecting Safety Component
- Backfitting related component
  - Station Black Out (SBO)
  - Anticipated Transient Without Scram (ATWS)
  - Fire Protection(FP)
- Equipment Environment and Failure Mechanism
- Equipment Qualification(Mild Location)

Equipment Qualification Master List (EQML) can be used to classify safety-related and non-safety-related affecting safety related components with installed at mild location. Cable Management System (CMS) database and plant diagrams can be used to classify backfitting requirements related component because CMS includes information about cables and connected equipment.

It is important to identify adverse localized equipment environments that can accelerate the aging of cable and connection. The following factors are recognized adverse conditions of cables and connections [3].

- High-temperature and/or high radiation ambient
- High conductor temperature from ohmic heating
- High resistance connections at terminations or splices
- Long-term submergence(partial or full submergence)

Cables and connections can be classified according to the failure mechanism and detection method, as follows.

- Insulation Material for Electrical Cables and Connections
- Insulation Material for Electrical Cables and Connections used in instrumentation circuits
- Inaccessible Power Cables exposed to wetting or submergence
- Metallic parts of electric cable connections

Detailed criteria of adverse localized environments for insulation material for electric cables and connections are proposed as below.

- Ambient Temperature: > 40℃
  Cable thermal ratings are based on conductor temperature in a free air 40℃ environment, and long thermal life in a 40℃ environment would be expected.
- Radiation: > 0.2rd/hr
  $0.22\text{rd/hr} = 1\times10^5\text{rd}$ (boundary value of hash-mild) ÷ (50years × (365days/year) × 24housr/day)
- Vicinity of hot process lines or equipment
- Vibration, Moisture and Chemical spills

Detailed criteria of adverse localized environments for inaccessible power cables are below.

- Review design characteristic (drained automatically?)

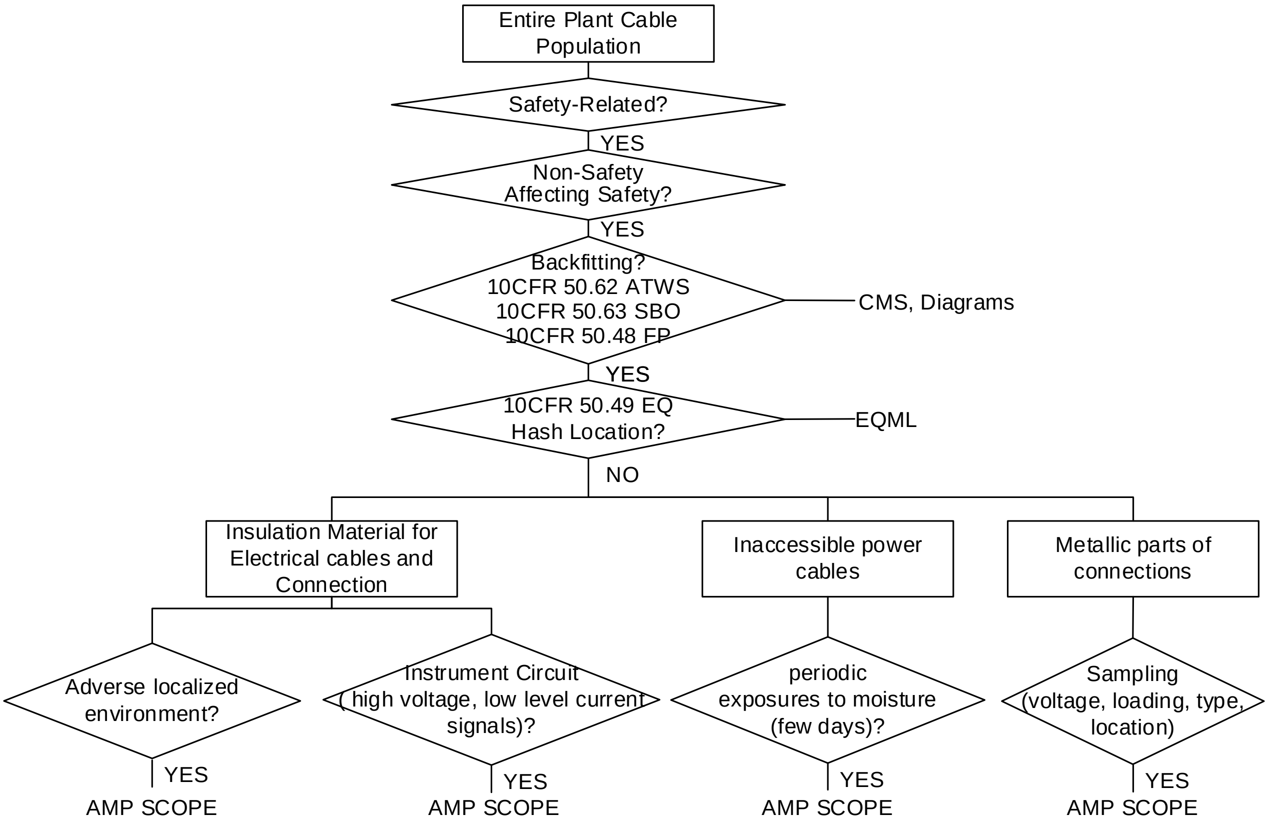

Fig. 1. Scoping process of cables and connections

2.2 Detection Method of Aging Effects

Detection method of aging effect of cables and connections can be different according to cables and connections types. The table below provides detection method of aging effect that generally applied in the nuclear industry through reviewing of report related cables and connections aging management [1][2][3][4].

Table 1: Detection Method of Aging Effect for Cables and Connections

Type	Detection Method
Insulation Materials	Visual inspection
Metallic parts of connections	Thermography -Temperature rise of contacts < 50℃ -Sampling(maximum 25 sample): considering voltage level, circuit loading, type and location
Insulation Materials in Instrument	Review of calibration results or findings of surveillance programs (for radiation monitoring, nuclear instrumentation)
Inaccessible power cables	Tan δ testing or VLF withstand testing

3. Conclusions

This paper has presented the methods and process for establishing effective AMP of cables and connections. This method is useful for making a cable and connection list to be managed by AMP and selecting detection method of aging effects.

Presented method and process can be directly applied to plant AMP procedures because it includes detail methods to select cables and connections and to identify adverse localized equipment environment.

REFERENCES

[1] Office of Nuclear Reactor Regulation, Generic Aging Lessons Learned (GALL) Report, U.S. NRC, NUREG-1801, Rev.2, 2010.

[2] SW Glass, LS Fifield, TS Hartman, Evaluation of Localized Cable Test Methods for Nuclear Power Plant Cable Aging Management Programs, PNNL-25432, U.S. Department of Energy Office of Nuclear Energy, 2016

[3] A. Mantey, G. Toman, Aging Management Program Guidance for Medium-Voltage Cable Systems for Nuclear Power Plants, Revision 1, TR-3002000557, Electric Power Research Institute, 2013.

[4] R. Roberts, Low-Voltage Cable Aging Management Guidance, TR-3002000924, Electric Power Research Institute, 2013.