

## Development of Aging Management Program for Non-EQ Electrical Cables and Non-metallic Connections in Nuclear Power Plants

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### 1. Introduction

The objective of this program is to effectively manage the intended functions of electrical cables and non-metallic connections not subject to the environmental qualification (EQ) requirements and that are exposed to adverse localized environments (ALEs) caused by heat, radiation, or moisture. Considering the design/operational characteristics and operating experience of nuclear power plants (NPPs), the existence of related procedures and their effectiveness were examined. We examined whether the existing programs could remain valid during periods of continued operation.

### 2. EVALUATION AND TECHNICAL BASIS

The program for electrical cables and non-metallic connections not subject to the environmental qualification requirements includes the scope of application, parameters monitored/inspected, detection of aging effects, monitoring and trending, acceptance criteria, and corrective actions.

Major items checked for continued operation include the following : (a) the preparation of a list of accessible electrical cables and non-metallic connections installed in ALEs caused by heat or radiation in the presence of oxygen, (b) the selection of the representative samples of accessible electrical cables and non-metallic connections and the implementation of visual inspection for the surface of these electrical cables and connections.

#### 2.1 Scope of Aging Management Program (AMP)

The components within the scope of this AMP are divided into two categories: (a) components subject to backfitting rule among non-safety class cables, (b) components in mild environments among those subject to environmental qualification requirements. In most areas within a nuclear power plant, the actual ambient environments (eg. temperature, radiation, or moisture) are less severe than the plant design environment. However, in a limited number of localized areas, the actual environments may be more severe than the plant design environment. Conductor insulation materials used in cables and connections may degrade more rapidly than expected in these ALEs. ALEs are a condition in limited plant areas that is significantly more severe than the specified service environment for the cable, and the walkdown method is widely used to identify ALEs. The criteria to classify harsh and mild environments are described below based on the data

produced from the consulting service for the environmental qualification of an NPP.

- Temperature: 60°C
- Radiation: 5.0E + 04rad
- Moisture: 100%

#### 2.2 Parameters Monitored/Inspected

Representative samples taken from accessible electrical cables and non-metallic connections installed in ALEs are selected and visually inspected for the presence of anomalies such as embrittlement, discoloration, cracking, or surface contamination of the electrical cables and non-metallic connections.

#### 2.3 Detection of Aging Effects

Aging degradation of insulation by heat, radiation, or moisture in the presence of oxygen causes cable and non-metallic connection surface anomalies. To identify such symptoms, periodic visual inspections are performed for accessible electrical cables and non-metallic connections installed in ALEs. Based on the experience that aging degradation occurs at a slow rate, it is appropriate to perform visual inspection at least every 10 years to prevent insulation damages.

The main purpose of this program is to perform visual inspection on samples selected from the accessible cable and non-metallic connection areas. In the case of NPPs, cables and non-metallic connections subject to aging management were divided, according to the plant space approach, into those for buildings, floors and zones, and a list was prepared. Environmental analysis for each zone will be performed on plant specific environmental parameters such as temperature, radiation and moisture. By utilizing the analysis results, the zones, where the environment is harsh and the loss of materials may occur, will be identified and visual inspection will be performed on cables and non-metallic connections located in such areas prior to continued operation. For this purpose, the NPP specific procedure 'Aging Inspection Procedure for Non-EQ Electrical Cables and Non-metallic Connections' has been developed. The first visual inspection will be completed prior to continued operation and will be repeated at least every 10 years afterwards.

#### 2.4 Monitoring and Trending

Trending actions are not included in this program because the ability to trend inspection results is limited.

As part of the effort to manage and maintain environmental qualification program for NPP, the areas subject to environmental monitoring as well as the

components will be selected, and the data of temperature and radiation will be collected, documented and maintained throughout the period of continued operation. Related procedures will also be established and utilized in the future for evaluation and maintenance purposes.

#### 2.5 Acceptance Criteria

Accessible cables and non-metallic connections should not show unacceptable surface anomalies when the symptoms of aging degradation of conductor insulation and non-metallic connections are found during visual inspection. Unacceptable symptoms will lead to the loss of intended functions, if left unmanaged.

#### 2.6 Corrective Actions

All unacceptable visual indications of cable and connection jacket surface anomalies are subject to an engineering evaluation. Such an evaluation is to consider the age and operating environment of the component, as well as the severity of the anomaly and whether such an anomaly has previously been correlated to the degradation of conductor insulation or connections. Corrective actions may include, but are not limited to, testing, shielding or otherwise changing the environment, or relocation or replacement of the affected cable or connection. When 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 cables or connections.

In the case of NPPs, when the results of the visual inspection of cable and connection surface anomalies fail to satisfy acceptance criteria, further inspection is performed using auxiliary tools including magnifying glasses, flashlight, etc. If it is found from the detailed inspection prior to continued operation that the aging has progressed to an unacceptable point, cables or connections will be repositioned or replaced.

### 3. CONCLUSIONS

This program has verified the suitability of the management plan for electrical cables and non-metallic connections not subject to environmental qualification requirements based on attributes from the scope of application required by law to operating experience taking into consideration the design, operational characteristics and operating experience of NPPs. The results of the evaluation are as follows:

○ This program includes accessible electrical cables and non-metallic connections and installed in ALEs caused by heat, radiation, or moisture. The components subject to this program are divided into two categories: (a) components subject to the backfitting rule, and (b) components in mild environments among those subject to environmental qualification.

○ For NPPs, a new procedure 'Aging Inspection Procedure for Non-EQ Electrical Cables and Non-metallic Connections' has been developed and will be applied prior to continued operation. In addition, to identify the environmental conditions of each area, temperature and radiation data will be collected, documented and kept during continued operation.

○ The objective of this program is to select representative samples of electrical cables and non-metallic connections and detect surface anomalies. The first inspection will be performed prior to continued operation, and visual inspection will be implemented at least every 10 years afterwards.

○ If visual inspection on cable and connection surface anomalies fails to satisfy the acceptance criteria, further inspection will be performed using auxiliary tools such as magnifying glasses and flashlight. If it is found from the detailed inspection prior to continued operation that signs of aging progressed to a point not acceptable, cable or connections will be repositioned or replaced.

The aging management program of electrical cables and non-metallic connections has been reviewed. And for the evaluation items of this program, inspection will be completed prior to continued operation. Through the program, the effects of the aging degradation of electrical cables and non-metallic connections not subject to environmental qualification requirements can be properly managed.

### REFERENCES

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