A Survey of Cable Ageing Management and Condition Monitoring in Nuclear Power Plants

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1. Introduction

Cable is one of the major nuclear power plant components that are directly related to safety, so that life assessment of the cable system is an important issue as one of international nuclear safety concerns.

In general, cables installed in nuclear power plants have been regarded as maintenance-free component. However, for the long term operation, maintenance activities for cables important to safety should be done appropriately to ensure their capability for the required function

This paper is summarized the findings from a review of published documents dealing with research on ageing management of safety-related electric cables used in nuclear power plants. Significant research in this area has been performed in several countries and international research projects.

2. Ageing Management and Condition Monitoring

The ageing degradation of cable is related to cable insulating and cable sheathing materials which are polymers. The degradation of cable is more complicated because of the diversity of conditions, phenomena of the performance of cable systems, the wide range of polymeric materials, and types of cable products and the presence of such additives as antioxidant, fire retardant, pigments, plasticizers, and filler which can enter into the degradation pathways that have not been extensively studied.[1]

Throughout the plant operating period, it is important to implement a comprehensive aging management program starting early in the plant life to ensure safe long term operation. The results of the survey are summarized the reports of international organization and countries that have been studied for a long time.

All condition monitoring techniques are aimed at ensuring the operability of cables. The operability is mainly guaranteed by maintaining the most important electrical parameters (such as insulation resistance, leakage current, breakdown voltage, etc.)

Effective monitoring of ageing degradation requires knowledge of one or more condition indicators which indicate the physical state of the cable at the time of observation.[1, 2]

2.1 IAEA

IAEA published the report entitled Assessment and management of ageing of major nuclear power plant (NPP) components important to safety in 2000 that is one in a series of guidance reports on the assessment and management of ageing of the major NPP components important to safety. [1, 2]

The reports are based on experience and practices of NPP operators, regulators, designers, manufacturers, and technical and presents, in two volumes, results of a Coordinated Research Project on the management of ageing of in-containment I&C Cables.

Most of the currently available condition monitoring methods give information on the state of degradation of the cable material only at the position measured, and do not give direct data on adjacent areas. Measurements at intervals along a cable will give some information on general trends but will not identify a highly localized area of degradation. Most methods are also limited to the accessible parts of the cable.[1]

The report describes condition monitoring methods such as visual/tactile inspection, indenter measurements, oxidation induction time/oxidation induction temperature measurements, thermo-gravimetric analysis, Density measurements, and elongation measurements.

Suggestion on the report is a systematic ageing management process which is an adaptation of Deming's Plan-Do-Check-Act cycle to ageing management. The ageing management program should be developed and implemented in accordance with guidance prepared by an interdisciplinary cable ageing management team organized at a corporate or owner's group level.

2.2 OECD NEA

14 OECD NEA member countries joined the project in 2006 to share knowledge and finally, 17 countries have joined the project. The final report was opened after the international symposium in Tokyo, Japan in 2010. The scope of this project involves the development of a knowledge base and commendable practices that address common elements in the management of ageing and mitigation of failures for components and cables.

To maintain degradation to an acceptable level, it is necessary to understand possible degradation mechanisms; suitable operational conditions that are designed to minimize degradation; control, inspection and monitoring techniques that need to be used to detect degradation in time; evaluation criteria to determine if sufficient safety margins remain if degradation is detected, and methods to manage, repair or replace components. [2]

Ukraine only provided the information that the program of nuclear power plant cable ageing management specifies the requirements to the development, implementation and context of methodical, organizational and technical activity related to the plant cable ageing management.

The purpose of the ageing management is to assure cable operational safety, reliability, cost-effectiveness for the normal operating conditions over the specified cable lifetime and in the design accident conditions. [2]

There are 18 cable condition monitoring techniques recorded in the database and their classifications of application. It has varying levels of capabilities and weaknesses. Each technique has its own specialties that are better suited for certain kinds of cables.

2.3 USA

In January 2010 USNRC published NUREG/CR-7000 "Essential Elements of an Electric Cable Condition Monitoring Program." This publication is based upon the results of the NRC's electric cable and equipment research programs, industry guidance and standards, and the experience and observations of others electric cable condition monitoring and qualification testing.

The program methodology presented in this report provides guidance on the selection of cables to be included in the program, characterization and monitoring of cable operating environments and stressors, selection of the most effective and practical condition monitoring techniques, documentation and review of cable condition monitoring testing and inspection results, and the periodic review and assessment of cable condition and operating environments. [2]

US NRC also published a draft regulatory guide DG-1240 in June 2010. The guide is intended to provide a compilation of techniques available for monitoring cable performance and describes some of the typical condition monitoring techniques and inspection methods that have been or are being used for cable condition monitoring.

Special consideration on this guide is to the problem of monitoring the operating environment for cable circuits routed through inaccessible underground cable ducts and conduits, covered cable distribution trenches, bunkers, and manhole vaults. Since most of these underground distribution systems are largely inaccessible, wetted and flooding conditions remain undetected for extended periods of time.[3]

2.4 JAPAN

In Japan, all cables installed in nuclear power plants are inspected periodically in compliance with the acceptance criteria. These acceptance criteria cannot be used for the evaluation of integrity in the DBE environment.

The project, assessment of cable aging for nuclear power plant (ACA), was carried out FY2002 to FY2008. This project obtains thermal aging data, as well as simultaneous aging data of various cable insulators.

These data are the basis of the aging assessment of the cables, and establishes an aging assessment method that will also form indicators for the cable aging management. The essential part of the ACA project is the cable aging evaluation test to obtain thermal and simultaneous aging data for the cables.[4]

3. Conclusions

Efforts laid a systematic framework for cable ageing condition monitoring and ageing management program for nuclear power plant have been conducted through-out international collaborate researches and country itself studies. Electrical cables like passive and long lived component in nuclear power plant have to be managed for the life time, current status and ageing trend on their place, appropriate monitoring techniques, failure history, hot spots and related material with environmental qualification document during plant life time.

REFERENCES

[1] IAEA, "Assessment and Management of Ageing of Major NPP Components Important to Safety," IAEA-TECDOC-1188, Vol. I, II, December 2000

[2] OECD NEA, SCC and Cable Ageing Project (SCAP), Final report, 02 June 2010.

[3] NUREG/CR-7000, "Essential Elements of an Electric Cable Condition Monitoring Program," Brookhaven National Laboratory, Upton, NY, January 2010.5

[4] Toshio Yamamoto, Takefumi Minakawa, Japan Nuclear Energy Safety Organization (JNES), JNES-SS-0903, The Final Report of the project of "Assessment of Cable Aging for Nuclear Power Plants". July 2009.

[5] US NRC, Draft Regulatory Guide DG-1240 "Condition Monitoring Program for Electric Cables Used in Nuvlear Power Plants, June 2010.