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Aging Evaluation for NPP Cable with XLPE Insulation by using Oxidation Induction Time Measurement Test

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1. Introduction

There are a lot of cables in the nuclear power plant. The cables, especially inside containment, are exposed in the harsh environment. Those cables may be aged more rapidly due to the high temperature and radiation, and the life time of them may be shorter. If the life time of the cables in the harsh environment is expired due to the rapid aging, those cables should be replaced immediately. For the replacement in the appropriate time before the end of life time, we should perform the frequent condition monitoring of the cable. Among the many method of condition monitoring, we used the oxidation induction time (OIT) measurement test method because the polymer aged by means of chemical reactions with oxygen [1]. Especially, in this paper, we analyze the OIT value affected by thermal and radiation aging.

2. Methods and Results

2.1 Sample Preparation

The material of the sample used in this paper is cross-linked polyethylene (XLPE) which is widely applied for insulation of the instrumentation and control cable installed in nuclear power plant. Especially, the insulation of DRPI cable installed in the containment of KORI Unit 3 is prepared. The sample cable is shown in figure 2.

Fig. 1. DRPI Cable sample

In order to OIT measurement test for condition monitoring, we should perform thermal and radiation aging. We prepared 11 pieces of samples that consisted of 1 unaged sample, 5 only thermal aged samples and 5 thermal and radiation aged samples. For accelerated thermal aging, we used Arrhenius methodology. The activation energy of the sample is 1.21 eV that calculated by TGA. Then, we prepared 20, 40, 60, 80 and 100 years only thermal aged samples, and 20, 40, 60, 80 and 100 years thermal and radiation aged samples. Accelerated thermal aging was performed in electrical oven and radiation aging was performed in KAERI.

2.2 OIT Measurement

OIT is a technique that can be used to evaluate aging of organic materials. OIT measurement test can be used as an evaluation of the cable life time technique for electric cable used in electric power plants, control, instrumentation, and power cables. Polymers age by means of chemical reactions with oxygen. Antioxidants are chemicals added to polymers in order to inhibit oxidative reactions. As long as antioxidants remain in an insulation polymer, the properties of the cable insulation do not degrade significantly. The OIT is related to the amount of antioxidant remaining in a polymer, and thus to the age, or remaining life, of the polymer.

For the OIT measurement test, we followed the recommendations provided by ASTM D3895 standard. The sample to be tested and the reference material are heated at a constant rate in a inert gaseous environment (nitrogen). When the specified temperature (typically between 180 ℃ to 220 ℃) has been reached, the atmosphere is changed to oxygen maintained at the same flow rate. The specimen is then held at constant

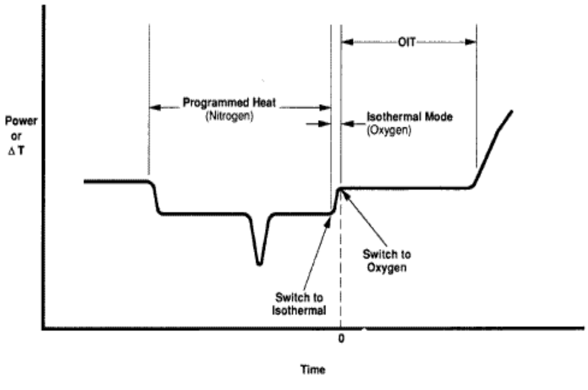

Fig. 2. Evaluation of OIT from recorded-time-base thermogram

temperature until the oxidative reaction is displayed on the thermal curve. The time interval from when the oxygen flow is first initiated to the oxidative reaction is referred to as the induction period. In Figure 1 shows how to evaluate OIT from recorded-time-base thermogram.

3. Experimental Results

OIT measurements were performed with Diamond Pyris DSC made in PerkinElmer. The OIT temperature of 220℃ was used for reduce the experiment time. And weight of 5mg recommended in ASTM D3895 was used. The OIT measurement test was performed twice in each sample for the accuracy. First, The OIT results of 5 only thermal aged samples are shown in figure 3.

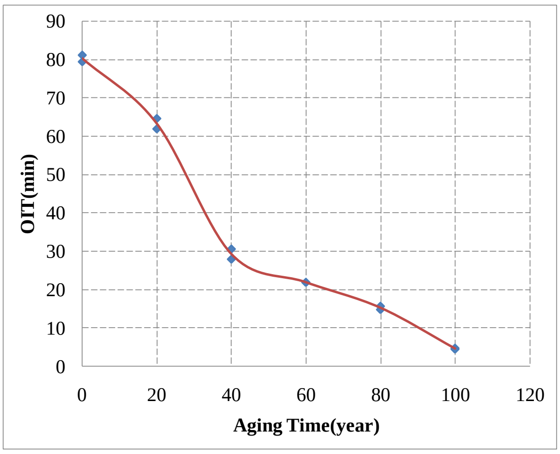

Fig. 3. The OIT measurement result of only thermal aged samples

In case of only thermal aged samples, OIT value decreases linearly according to thermal aging time. If the sample cable is installed in non-radiation region, the OIT value of that cable will decrease linearly according to the installed time like figure 1 graph.

The OIT results of 5 thermal and radiation aged samples are shown in figure 4.

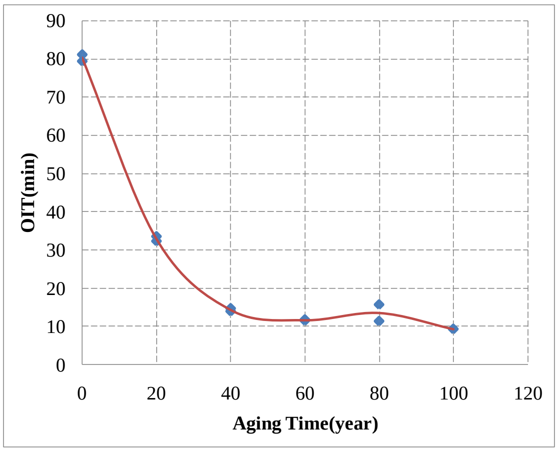

Fig. 4. The OIT measurement result of thermal and radiation aged samples

In case of thermal and radiation aged samples, OIT value decrease exponentially.

4. Conclusion

For the condition monitoring of cable, we used OIT measurement test method. We chose the material of XLPE as a test sample, and prepared two types of samples which are only thermal aged samples and thermal and radiation aged samples. Test results showed that the more aged, the less OIT value. In case of thermal and radiation aged samples, the speed which OIT value reduces is faster than the other case. That means that a cable in radiation region has less life time than a cable of non-radiation region at the same temperature. With this result, if we construct OIT value database according to the accelerated aging time, we can evaluate the aging state of the cable in the plant using simple OIT measurement test.

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REFERENCES

[1] L. R. Mason, Jr., A. B. Reynolds, “Reduction of Oxidation Induction Time Testing to Practice as a Life Assessment Technique for Cable Insulation”, EPRI-TR-106370-3427, EPRI, 1996.

[2] ASTM Standard D3895, “Standard Test Method for Oxidation-Induction Time of Polyolefin by Differential Scanning Calorimetry”, ASTM, 2004

[3] IAEA-TECDOC-1188, “Assessment and management of ageing of major nuclear power plant components important to safety: In-containment instrumentation and control cable”

[4] K. H. Park, “Calculation of Activation Energy by OIT Method for aging evaluation of NPP cable”, 2006 Spring Conference of Korea Nuclear Society, 2006