Transactions of the Korean Nuclear Society Autumn Meeting
Gyeongju, Korea, November 2-3, 2006

ESR spectrum of cables in nuclear power plant

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1. Introduction

The need to ensure the performance of the individual functions of safety systems and equipment during normal operation as well as in the case of postulated accidents is fundamental for the safe operation of nuclear power plants(NPP) and for the protection of public health and safety through regulation.

Cable ageing under the nuclear power plant(NPP) conditions must be effectively managed to ensure that the required plant safety and reliability are maintained throughout the plant service life.

It is enforcing that the radiation level in cooperation with Wolsung Nuclear Power Plant and Yonggwang Nuclear Power Plant was evaluated by ESR dosimetry method with the alanine and lithium formate monohydrate sample already from Radiation Health Research Institute.

Actually, the condition of polymer-based cable material is researched with the elongation at break and the oxidation induction time(OIT). Also, ESR spectroscopy has been widely used in polymers degradation analysis. So, we scanned the cables in nuclear power plants(NPP) using the ESR spectrometer. The cable samples which is used here are provided from Korea Electric Power Research Institute.(KEPRI).

2. Methods and Results

ESR spectrometer was used to detect the electron spin resonance spectra of the cable samples. All the ESR-spectral properties of these samples are scanned at room temperature using cylindrical cavity along with 9GHz Microwave Bridge.

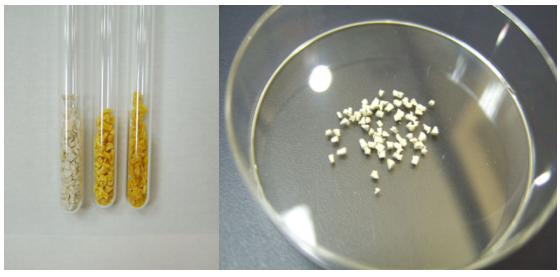

Fig.1 Crushed powder samples in a quartz tube.

The working parameters of the spectrometer are as follows: time constant = 5.12ms, modulated frequency = 100kHz, modulation amplifier = 2mT, microwave frequency = 9.73GHz, signal gain = 10^3, sweep time = 20.97s. ESR spectra were recorded on a Bruker EMX X-band spectrometer operating at 100kHz modulation.

The spectra were recorded by taking the powder samples in a quartz tube[Fig. 1]. Cable samples are the JR series and the RH series. All the temperature and humidity ,before and after irradiation, is constantly maintained as 22 c° & 20% by environment control system.

2.1 Identification of cable using the EPR spectrometer.

JR series cables are non-aged. And JR series insulation is EPR(Ethylene propylene rubbers)[Table 1.]. These results which are measured with FT-IR all are same. For most molecules, the FT-IR spectrum shows several absorption bands. In most cases these bands are caused by fundamental vibrations.

Table 1. Cable component materials.

Cable Serial No	**Insulation material (COLORANT)**	**Jacket material**
JR12	*EPR (White, Black)*	*CSP*
JR15	*EPR (White, Black, Red)*	*CSP*
JR25	*EPR (White, Black, Red)*	*CSP*

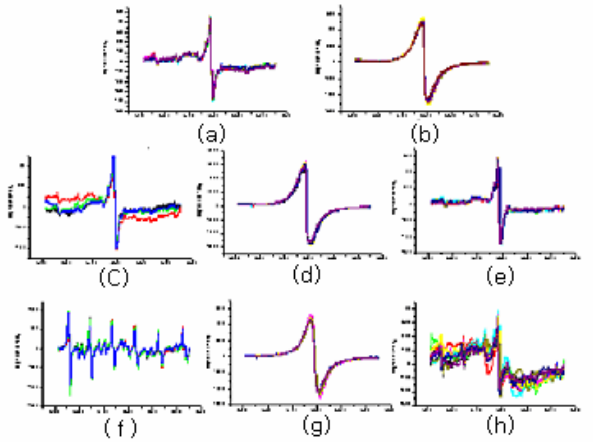

Fig. 2 ESR spectra of the JR series cable insulations (a)JR12-white (b)JR12-black (c)JR15-white (d)JR15-black (e)JR15-red (f)JR25-white (g)JR25-black (h)JR25-red.

But, ESR spectrum is observed a difference. This is Fig. 2. The JR series spectra have differences in type or color. It is well known that ESR spectroscopy is the only technique established to detect radicals. It has been

used to detect and characterize free radicals from different sources.

2.2 Radiation-induced ageing.

Nuclear radiation can interact strongly with dielectric materials to cause structural changes that alter their electrical properties through cross-linking, chain scission, gas evolution and radiation-induced oxidation.[5]. Ionizing radiation is one of the main stressors causing age-related degradation of polymer-based cable materials in air.

RH series are the cables that were located inside CV of NPP for twenty-seven years. But, These samples are no knowing about component materials.

First, this sample's original spectrum was measured at room temperature. And then, RH series cable samples were irradiated at room temperature using Cs-137 gamma ray source at average dose rates of 300 Gy/h with the doses up to 10 kGy. The IEEE 383 standard for type tests permits to irradiate the tested samples with the dose rates up to 10 kGy/h. Fig. 3. is the RH series ESR spectrum. The rectangular part in Fig 3 is changed and two peak lines are produced.

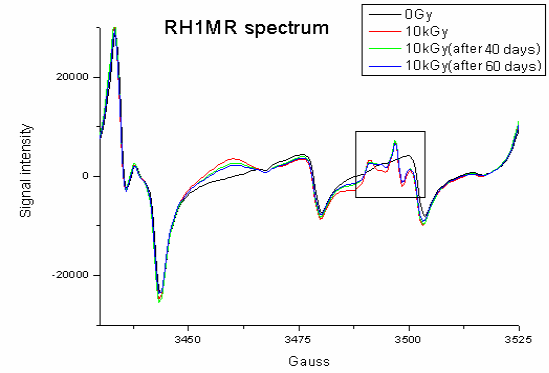

Fig3. Change of the RH1MR(Cables of unknown material gotten from Nuclear Power Plant) spectrum by irradiation..

3. Conclusion

Cable life prediction is necessary for nuclear power plant safety. So, the non-aged cables and the aged cables in nuclear power plant are measured using the ESR spectrometer. Cable sample's results are various.
For many polymers, oxidation is the dominant ageing mechanism. The results that are measured with the ESR spectrometer seem to be changed by oxidation.

Forward, JR series will be studied about radiation-induced ageing effects. And, RH series experiment will be developed. The induction period amounts to about 100-150 kGy for elongation at break and about 50 kGy for OIT.[3] So, RH series cable samples will be irradiated using Cs-137 gamma ray source with the doses up to 100 kGy.

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