Alanine/ESR spectrum change in NPP

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1. Introduction

Two major environmental effects to the degradation of cables in nuclear power plant are known as temperature and radiation[1][2]. The effect of radiation to the cable material is known to be dependent on the total absorbed dose quantity[2]. In general, for estimation of the absorbed dose, alanine/ESR dosimeters were installed in-containment building of nuclear power plants for one or two operating cycles. L-α-alanine has been formally accepted as a secondary standard for high-dose and transfer dosimetry. Absorbed dose is estimated by comparing signal of installed dosimeters with that of standard dosimeters which were already irradiated to the gamma radiation source. Because effect of neutron dose to cable in normal plant operation can be neglected and installed position in containment vessel is not generally exposed to neutron ray, all of the dosimeter were supposed to be exposed to only gamma rays. But the spectrum shape of returned dosimeters from Containment Vessel of NPP showed different spectrum shapes with that of standard gamma exposed dosimeters ; the ratio of satellite and main peak of some dosimeters. From the other papers, it means alanine dosimeters were exposed to different quality of radiation : neutron rays. Peak ratio of alanine pallet returned from NPP is measured and compared to that of the only gamma exposed standard alanine pallets.

2. Methods and Results

1. Alanine dosimeters and standard pallet

In this experiment, BioMax alanine dosimeter is used which contain α-amino acid alanine, CH_3-$CH(NH_2)$-COOH and Teflon as binder material to form dosimeter as pallet. The alanine dosimeter pellets was 5mm in diameter and 3mm in height and weighed 64.5±0.5mg.

2. ESR systems

All the dose value of dosimeter is determined by e-scan which was corrected by weight of pallet and temperature. Determination of absorbed dose value of each pallet was done by e-scan which was calibrated by use of standard pallet, already exposed to Co-60 gamma radiation source in NPL. To measure peak ratio(No 7 over No 8 peak in Fig 1), measurements were performed at normal atmospheric conditions(RT, RH:25%) using Bruker EMX spectrometer equipped with X-band bridge and dual cavity. The dual cavity was installed in the case of using standard marker for compensating Q factor change during scanning time. Signal intensity could be corrected by putting the reference sample at the rear cavity and alanine sample at front cavity.

3.Spectrum comparison of dosimeters

As in Figure 1, we can see the spectrum of alanine samples irradiated with only gamma ray and both gamma and neutron rays scanned by EMX system. The ratio of signal peaks can be regarded as indicator of exposure to the neutron rays[3][4]. The shape changing after exposure to the mixed radiation field is acquired by choosing proper measuring factor.

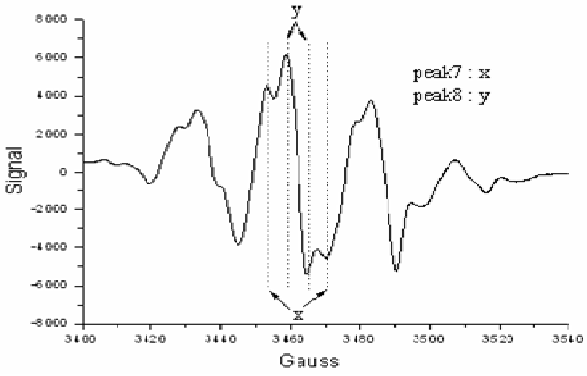

Figure 1. Signal ratio of alanine pallet γ-ray irradiated (NPL, exposed to gamma radiation)

The peak ratio of all the alanine pallet is sensitive to the change of temperature inside cavity[5]. Most of the ratio change was caused by no 7 peak's relatively high movement compared to that of no 8 peak. This movement affect ratio rate, so all of the data should be corrected by temperature correction factor as figure 2 plots

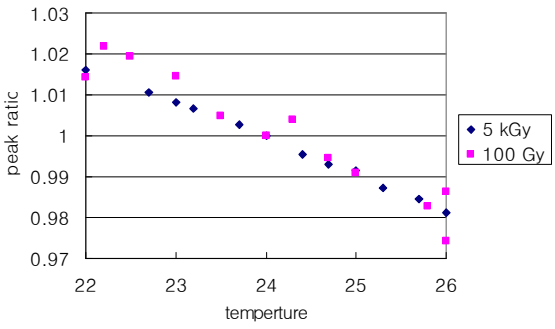

Figure 2. Peak ratio change on temperature change in cavity of EMX(peak ratio normalized to 24℃)

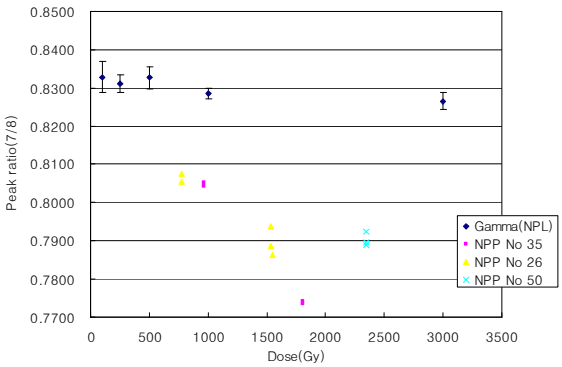

Figure 3. peak ratio of alanine pallet which is γ-ray irradiated from NPL and returned from NPP after 1 and 2 fuel cycle.

3. Conclusion

In nuclear power plant, the free radicals in alalnine pallet would be produced by ionization radiation like gamma rays and neutron rays which emitted from near equipments and main mixed radiation source, reactor. Among all of these radicals, discrimination of radicals from only gamma rays seems to be difficult. But, peak value change by exposure to the different radiation with different radiation quality might be the possible method to estimate approximate radical ratio produced by each different radiation. If we consider number of radicals in alanine pallet,

1) $N_t = N_r + N_n \qquad D_t = C_1 N_t$

Where N_t is the total number of free radical in alanine pallet and N_r, N_n radicals by gamma and neutron rays. In general, quantity of free radical is determined by G value and energy transferred to dosimeter by each radiation in mixed field, even though there is exceptional case. D_t means gamma equivalent absorbed dose which is indicated by e-scan signal peak amplitude.

Then, the peak ratio change by each radiation dose from neutron and photon is as follows.

2) $R_m D_t = R_r D_r + R_n D_n \qquad R_m, R_t, R_r = C_2$

R_m, R_r and R_n is peak ratio change over neutron and gamma dose quantity. The decreasing tendency of peak ratio by neutron radiation is already published by papers[3][4]. Normally, R_r value can be measured through additional gamma ray irradiation experiment, but R_n value could be only estimated from R_m and R_r value on the assumption that all the value is constant at interested dose range and, as above equation, the effect by radical in different condition affect just linearly without any extra terms. From fig. 5 plot, we can see that each absolute quantity of absorbed dose affects peak ratio value and ratio has no relation with the ratio of number of radicals produced by different radiation and above effect is constant at for the dose range.

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