

§7. Tritium Measurement in Components Activated by Neutron by an Imaging Plate

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Non-destructive and quantitative measurements of the amount of tritium retained on/in plasma-facing materials (PFMs) of magnetic fusion devices are of great importance to control of fuel particles and ensure safety for maintenance work in the fusion systems. We have been developing an approach to detect tritium using the bremsstrahlung induced by beta rays with an imaging plate (IP) in order to detect tritium in regions deeper than the escape depth of beta rays^{1,2)}. An IP, a photostimulated luminescence (PSL) material, is a two-dimensional radiation sensor. In the fuel-processing systems of D-T fusion facilities, gamma-ray radiation deriving from components activated by neutron would seriously affect tritium measurement. Separation measurement method of radiation dose from tritium and those from other nuclides is required. In the previous study²⁾, we determined that dominant gamma nuclides produced by neutron activation after operation in fusion reactors are ⁵⁵Fe, ⁶⁰Co, and ⁵⁴Mn, based on a preceding work³⁾. Then, we showed that the bremsstrahlung X-ray induced by tritium beta ray was easily separated from gamma ray emitted from ⁶⁰Co or ¹³⁷Cs in mixed radiation fields by utilizing the large difference in the PSL response to photon energy. We found that the effect of ⁶⁰Co irradiation to PSL value, obtained by irradiated with tritium of 12.5 MBq, was negligible by dose rate of 4.38 μ Gy/min and there was only 7.0% difference of PSL value, obtained by irradiated with tritium of 100 MBq, between dose rate of 0.0013 and 9.22 μ Gy/min. However, ⁶⁰Co emits beta particles with a maximum energy of 0.318MeV and it would affect tritium measurement using the bremsstrahlung X-rays from tritium as well. In this study, we examined the effect of beta ray emitted from a ⁶⁰Co source to PSL values, obtained by irradiated with tritium sources, varying the amount of tritium radioactivity.

A BAS-MS type-IP (Fujifilm Co., Ltd.) was used to detect bremsstrahlung X-rays from tritium. We used four small borosilicate glass tubes filled with pure tritium gas of 11.4, 22.8, 48.2, and 91.0 MBq, respectively as the tritium sources. A ⁶⁰Co disk shaped source having a thin, aluminum window (~ 5 mg/cm²) was used as a beta/gamma-ray source. The activity of the ⁶⁰Co source was determined as 113 Bq with HP-Ge Spectrometer measurement using gamma ray. The absorption curve in PSL values of the ⁶⁰Co beta rays by varying the thickness of aluminum foil was obtained. The IP was irradiated with the ⁶⁰Co beta rays and bremsstrahlung X-rays from tritium, respectively for 1 h. The image was read out with a model FLA-9000 IP reader (Fujifilm Co., Ltd.) and then the PSL values were compared.

In Fig.1, the PSL values obtained by tritium sources were compared with those by ⁶⁰Co. The absorption curve in PSL values of the ⁶⁰Co beta rays as a function of the thickness of aluminum foil was also shown in the figure. Estimated maximum range of beta ray from the absorption curve was consistent to that obtained from the maximum energy of ⁶⁰Co beta rays using empirical relationships between range and beta particle energy, though the ⁶⁰Co source emits both beta and gamma rays. The result in Fig.1 shows that the effect of ⁶⁰Co irradiation to PSL values, obtained by irradiated with tritium of 48.2 or 91.0 MBq, was negligible, however, the effect became larger as the amount of tritium activity decreased. H. Handa *et al.*³⁾ estimated the activation levels of a vacuum vessel (SS316) after some 100 shots per year for 6 years of operation using the THIDA-2 code system. Based on their results, the amount of ⁶⁰Co/Co was calculated as 15 kBq/g at most even just after shutdown. The amount of ⁶⁰Co/Co in the source used in this study was estimated as >1 GBq/g, resulting in 66,000 times higher activity than that in estimated results be Handa *et al.* From these observations, it was considered that the effect of beta particles emitted from ⁶⁰Co to tritium measurement using the bremsstrahlung X-rays from tritium with the IP was quite small in practice.

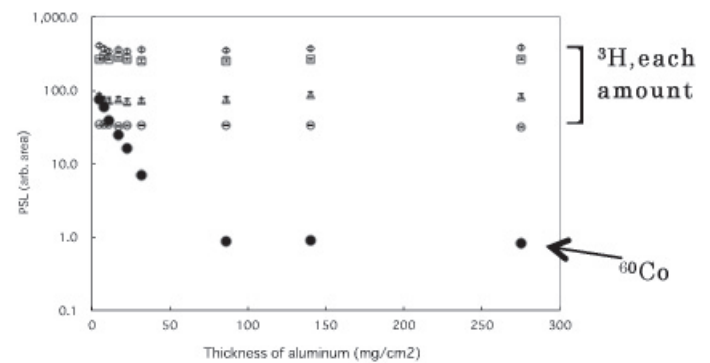


Fig. 1. PSL values obtained by tritium sources and the ⁶⁰Co source. The absorption curve in PSL values of the ⁶⁰Co beta rays as a function of the thickness of aluminum foil was also shown.

- 1) Ohuchi-Yoshida, H. *et al.*, Fus. Eng. Des. in press.
- 2) Ohuchi, H., *et al.*, Fus. Sci. Technol. **60** (2011) 944.
- 3) Handa, H. *et al.*: Fus. Eng. Des. **28** (1995) 515.