§10. Design of an Integrating Type Neutron Dose Monitor

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It is required to use an appropriate neutron dose monitor which can measure neutron dose in accurate. An integrating type neutron dose monitor has been designed for dose monitoring in a workplace adjacent to the cellar in the LHD building. There has only narrow space around the outlet of the through-hole in the room, a compact monitor would be better. In the previous study, multilayer spherical neutron dose monitor was developed, which has better dose response up to 15 MeV than REM-counter. Based on this design, the design has been modified for easier fabrication. The number of TLD has been reduced to seven, and total shape has been changed to a hexagonal cylinder as shown in Fig. 1. Seven TLDs are set on the same horizontal plane. The monitor has a size of 25-cm diameter and 16-cm length. The top and bottom sides are set polyethylene slab of 35-mm in thickness. TLDs are set at three depths between the moderators. The outermost layer is composed of 10-mm thickness of a polyethylene (PE). The TLD-1 after the layer detects low energy of neutrons. A 15-mm-thick boron carbide (B_4C) and 10-mm-thick PE is used as the second layer. After absorption of low energy of neutrons by the second layer, the TLD-2 detects intermediate energy of neutrons. And the TLD-3 detects fast neutrons which are moderated with all moderators. One TLD set will consist of $^{6}Li_2{}^{10}B_4O_7(Cu)$ and $^{7}Li_2{}^{11}B_4O_7(Cu)$ which have different sensitivity to neutrons. Seven TLDs are arranged as the total. The reaction of TLD, ^{6}Li (n, α) T and ^{10}B (n, α) ^{7}Li, in the monitor was calculated using MCNP5. Since three depths of TLDs were used to get the different specific responses, therefore, the ambient dose equivalent can be described using the linear combination of Eq. (1).

$$D = \alpha_1 R_1 + \alpha_2 R_2 + \alpha_3 R_3 \qquad (1),$$

where, D is the calculated dose, α_i is the linear co-factors for i-th TLDs; R_i the response of the TLDs of i-th depth. The expected value of each TLD, R_i, corresponds to the product of the neutron fluence and the energy response. The set of the linear co-factors is derived in advance by a least square mean method comparing the dose from standard source of the D_2O moderated ^{252}Cf source in each energy bin between the expected dose and the evaluated dose. Fig. 2 shows the comparison of energy response, ratio of the evaluated dose to the expected dose, between a REM-counter and the present monitor. The present monitor has better energy response than a REM-counter which has a 13-cm-thick PE moderator in this calculation.
Fig. 3 shows the comparison of dose between the two monitors at the outlet of through-hole in the workplace. The doses for the one shot by REM counter and this developed monitor were calculated to 3.0×10^{-4} and 1.7×10^{-4} mSv, respectively. On the other hand, the expected dose is 1.8×10^{-4} mSv. The developed monitor shows a more accurate result of dose at this work place than that of a REM-counter.

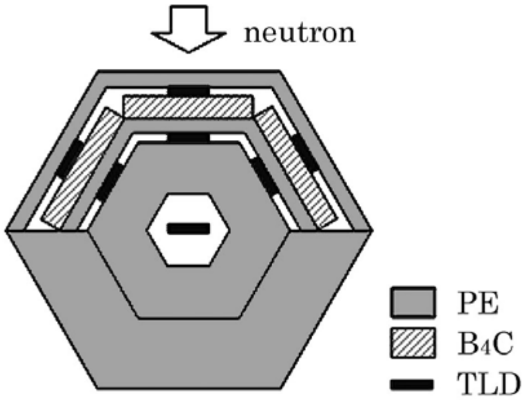

Fig. 1. Horizontal cross-sectional view of the designed monitor. The most outer three TLDs are named as TLD-1, and middle three TLDs are named TLD-2. TLD-3 is the center placed TLD.

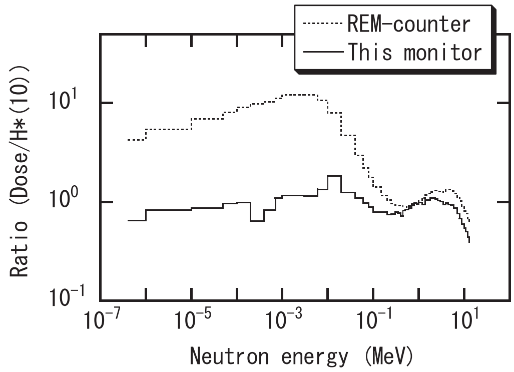

Fig. 2. Ratio of the evaluated dose to the expected dose on each energy bin.

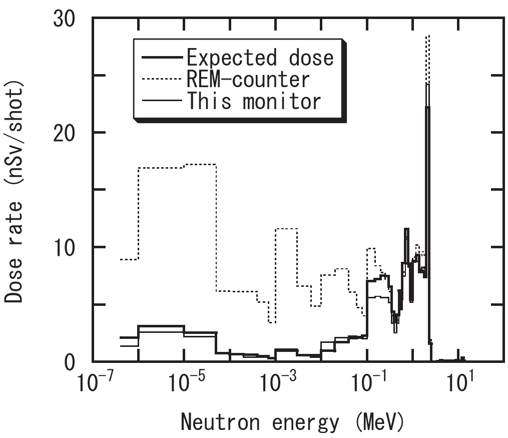

Fig. 3. Calculated dose rate at the outlet of the through-hole.