§6. Personal Dosimetry Using Dose-meters in Neutron Fields with Wide Energy Range

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Personal dose-meters which measure photon and/or neutron are used in many radiation facilities. For example, in nuclear fusion facilities relating to deuterons, such as LHD, radiation workers might expose to neutrons with wide energy range. A passive neutron dose-meter consists usually a combination of PADC (Poly Allyl Diglycol Carbonate) and polyethylene sheet (PE1) with its thickness of one millimeter. However, it is hard to estimate neutron energy only using PADC with PE1. This type of dose-meter could not estimate personal dose equivalent *Hp*(10) effectively under some environmental conditions[1).]

We have been developing passive neutron dose-meters in recent years. We are focusing on responses of personal dose-meters, especially on energy response and angular responses, installed with worker's body. Results of dosimetry are sometimes affected by uncertainty on "situations" of target workers. Here we discuss uncertainty on external exposure dosimetry due to dose-meters' responses both to neutron energy and to incidence angular.

Figure 1 shows a schematic illustration which phantom is irradiated from various directions. *n* pieces personal dose-meters (1,2 ⋯n) are attached with an arbitrary edge of the human body model. Where g_1, g_2,, g_n shows radiation exposure from any directions and is used arbitrary units and fluence. $f_1, f_2, \cdots f_n$ (mSv) shows dose-meters readings value which each dose-meters shows. f_i was given by Eq.1; $a_{ji}g_j$ shows a contribution for dosimeter i by irradiated g_j from j^{th} direction. The coefficient a_{ji} is determined by experimental or calculation data of each energy and type of radiations.

$$f_i = \sum_{j=1}^{n} a_{ji} g_j \qquad (1)$$

On the other hand, Eq.2 shows whole body dose(WBD): D, $b_j g_j$ shows a contribution for D by irradiation g_i from j^{th} direction. The value of bj is effective dose coefficient of each energy and type of radiations given by ICRP.[1)]

$$D = \sum_{j=1}^{n} b_j g_j \qquad (2)$$

In the strictest sense, the goal of personal dose measurement is that we find D value using Eq.2 to determine g_i by measuring f_i.

After all we can get D from Eq.1 and Eq.2.

$$D=B\,(A^{-1}F) \qquad (3)$$

Eq.3 is the basic formula for estimating WBD by personal dose-meters.

Eq.3 will be

$$D = (b_1 \cdots b_n)\left[\begin{pmatrix} \alpha_{11} & \cdots & \alpha_{1n} \\ \vdots & \ddots & \vdots \\ \alpha_{n1} & \cdots & \alpha_{nn} \end{pmatrix}\begin{pmatrix} f_1 \\ \vdots \\ f_n \end{pmatrix}\right] \qquad (4)$$

In the current radiation control, the dose-meters is worn on one side of the body surface except in special cases. This fact shows that we are getting a single value of $f_1 \cdots f_n$ in Eq.4. In this case, we deal with the problem of quantitative assessment of uncertainty with the estimate of D value if we obtained f_1 of a single column vector of F as a measurement value.

We put $D \geqq d_0$ in Eq.3 to set the WBD:D greater than d_0.

$$D=B\,(A^{-1}F) \geqq d_0 \qquad (5)$$

We can calculate the cumulative distribution function (CDF) whether WBD exceed the dose limit or not by dose-meters measurements value.[2)]

Under this calculation condition, a worker was exposed to neutrons from four directions (n=4) with wide energy range, as shown in Fig.2. Here we suppose that the responses of our dose-meter are equal to those of PADC with PE1 which is installed around a water phantom (30*30*15 cm).

Figure.3 shows CDF of WBD when a dose-meters reading is 20 mSv. When we set the upper limit of the 95%confidential interval of CDF, we should set the limit of dose-meter value is 20 mSv in this neutron field to conform the dose limit: 50 mSv per year. If dosimeter reading exceeds this setting value, operators should re-evaluate to add radiation information and change the working plan.

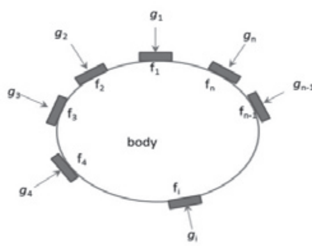

Fig.1. Exposure g_j, measured value f_i and body

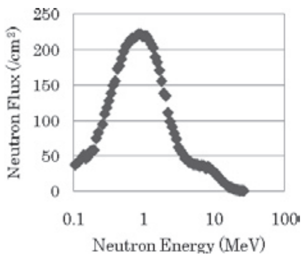

Fig.2. Neutron Energy Spectrum

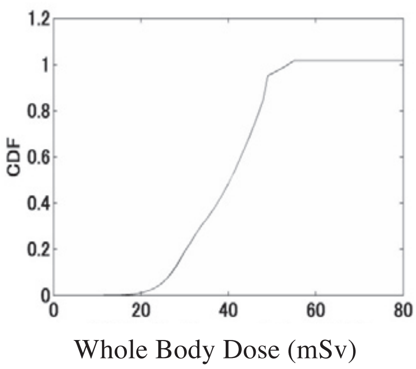

Fig.3. CDF of WBD (dosimeter reading: 20 mSv)

1) Ann. of the ICRP, 26, No.3/4
2) ANZAI,I et al., Japanese Journal of Health Physics (1968)