§5. Dose Measurements Using CR-39 in Neutron Fields with Wide Energy Range

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Deuterium plasma experiments in the LHD could generate neutrons. Radiation workers exposing to neutrons should be controlled by the radiation safety regulation. Personal dose of radiation workers should be monitored and adequately estimated. When energy of neutron distributes over ten-digit range, in addition when incident angle to workers is not stable, then existing personal dosimeters could not succeed in realistic dosimetry. This study aims to discuss a new radiation control method using a CR-39 personal dosimeter in neutron fields with wide energy range.

Basic experiments on a neutron personal passive dosimeter using CR-39 combined with polyethylene had been finished by the end of 2010 BY. In addition, PHITS, a Monte Carlo simulation code, estimated the detection efficiency of the dosimeter and the result fit the experimental results.

In 2011 BY, the above experiments and fruits have been applied and developed more. Multiple radiators structure has been designed in order to elevate its detection sensitivity to neutrons with wide energy range. Detection efficiency of CR-39 to neutrons depending on incidence angles has been simulated and the calculated results fit our experiment data.

Dosimetric method has been developed for unidentified situations on incident angle of neutron to personal detectors. Our developing method on this point consists of following items.

1) A simultaneous inequality is introduced under the restricted condition as “radiation dose value is not negative”. The simultaneous inequality limits range of area of calculated answers.
2) Probabilistic distribution of whole body dose is calculated using obtained value of personal dosimeter.
3) A new estimation program is developed to convert mono-energy spectrum of neutron into continuous-energy spectrum.

Combination of these items succeeds in calculation of probabilistic density distribution of whole body dose for each energy range of neutron. The result is multiplied by real energy spectrum under an exposure situation. This leads to probabilistic distribution of whole body dose in each neutron work place.

Figure 1 indicates a probabilistic density distribution of whole body dose of each energy range of neutron when indication dose value of a personal dosimeter is 30 mSv, for example. According to the figure 1, personal dosimeter indicates a dose much lower than the real dose value when the energy of incident neutrons is exceeding some or several MeV.

Probabilistic distribution of whole body dose in a target radiation field can be calculated after multiplying the probabilistic density distribution with real neutron spectrum information. Figure 2 indicates an accumulated distribution function of whole body dose for neutrons generated by DD nuclear fusion, for example. This figure shows that the probability of a real effective dose being less than 50 mSv is about 30 % when a personal dosimeter indicates 30 mSv.

We conclude that dose limit of radiation workers can be fully kept when the alarm level or reporting level of the personal dosimeter is set as the value of 30 to 50 % of effective dose limit value determined by the radiation safety regulation. This certainty probability is estimated as about 90 to 95 %. The method we have developed realizes and ensure more adequate personal dose control of radiation workers using neutrons.

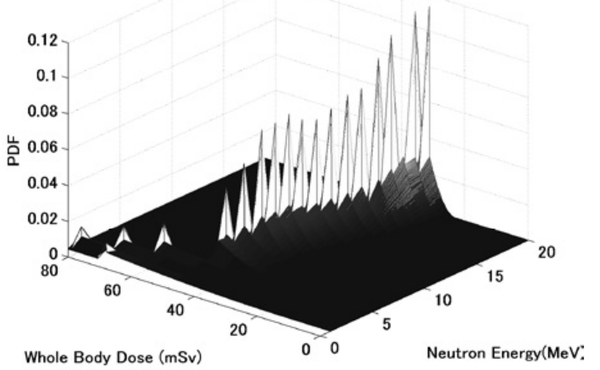

Figure 1 A probabilistic density distribution of whole body dose of each energy range of neutron when indication dose value of a personal dosimeter is 30 mSv.

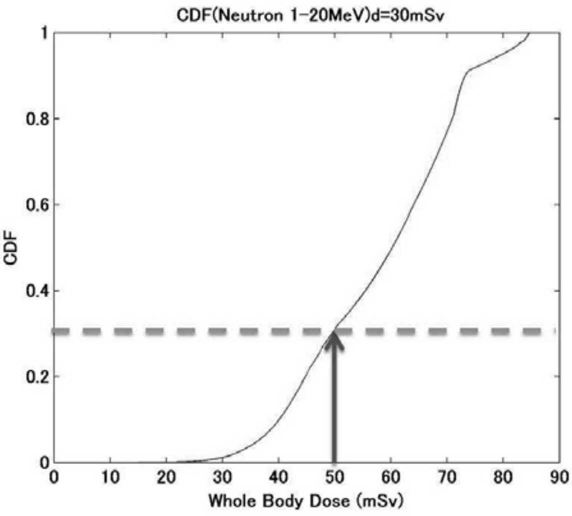

Figure 2 An accumulated distribution function of whole body dose for neutrons generated by DD nuclear fusion.