STANDARDIZATION OF AN IRRADIATION FIELD USING ^{60}Co AND ^{137}Cs SOURCES (AT RADIOISOTOPE RESERCH CENTER OF OSAKA UNIVERSITY)

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INTRODUCTION

On the occasion of installing the γ-ray irradiation system for animal experiments at the Radioisotope Research Center of Osaka University both lead collimators and shield screen have been supplemented to the system in order to satisfy the Japanese legal regulation that the dose equivalent rate outside the controlled area should be less than 300 μSv/w because the experimental room has not been so designed as to install such an apparatus.

The original use of the system is to study the internal β-ray exposure of a small animal on a dosage of tritium water, which will be eliminated from a body with a biological half-life. Accordingly, the dose rate of internal exposure due to β-rays will change with time, and hence such a situation could be simulated with an external exposure due to γ-rays by changing the dose rate spatially, that is, the distance between the γ-ray source and a sample.

It is, however, anticipated that improvement of the system would bring increase in the scattered γ-rays at an irradiation point and hence it becomes the purpose of the present paper to obtain precise exposures including scattered γ-rays at each irradiation point for animal experiments and also to find an optimum point for standard calibration where no scattered γ-rays are observed. For that purpose the effect of them will be evaluated with both calculations due to the Monte Carlo code for neutron photon transport (MCNP) and experiments due to the ionization chamber calibrated at the National Bureau of Standard in Japan.

EXPERIMENTAL APPARATUS

The γ-ray irradiation system is composed of fixed γ-ray source part and an exposure deck movable along the rail. The latter is so controllable remotely with a computer that the dose rate could continuously be changed from 0.0668 mSv/h to 10.7 mSv/h by adjusting the distance between the source and the measuring point. In the source part are contained three kinds of radioisotopes, ^{137}Cs's of 111GBq and 11.1GBq, and ^{60}Co of 3.7GBq (nominal activity).

The irradiation system has been improved to clear the legal regulation for the radiation safety in the following two items. One is that the exposure deck has been mounted with a lead shield screen (1200w × 1200h × 30t) covered with iron plates (20t) at the back edge side as shown in Fig. 1. The other is that a lead ring collimator system has been supplemented to the source part. It is composed of three kinds of square collimators whose angular apertures are 6.03°, 9.27° and 20.02°, respectively. They can selected automatically by rotating the ring collimator system as shown in Fig. 2 in response to the distance between the source and the deck, which enables the irradiation field to be confined within the added screen.

The collimator system can smoothly rotate round the RI sources owing to the compact structure though it weighs to be about 280 kg, which assures high stability and reliability in operation.

CALCULATED AND EXPERIMENTAL RESULTS AND DISCUSSIONS

The Monte Carlo code for neutron and photon transport (MCNP) has been used to evaluate the effect of the scattered γ-rays on the energy spectrum of the irradiation field. In Fig. 3 are shown the calculated results of normalized energy spectra including the scattered γ-rays for three different aperture sizes of the collimators. In the calculation a point source of ^{137}Cs has been set on the axis of the cylindrical irradiation part at a height of 1.2 m from the floor, and three right pyramid holes have been excavated through the lead cylinder perpendicularly to the axis as collimators, whose outlet areas are $3\times5cm^2$, $6\times8cm^2$ and $9\times11cm^2$, respectively.

The calculation has been carried out assuming that a detector with a known energy resolution is set at a point of 1m from the source. It is obvious from the figure that adopting a collimator of the smaller aperture would cause decrease in the effect of scattered γ-rays, that is, the total energy peak becomes more remarkable.

In Fig. 4 are shown the calculated results of dependence of the absorbed dose rate on the distance from the source in order to clarify the effect of the added shield screen on the spectra which would be a little modified by scattered γ-rays. In the calculation the absorbed dose rates of 10 different points located between two reference points, distances of 0.5mand 2.2m from the source point, have been obtained with a collimator of $9\times11cm^2$ and with the shield screen at 2.2m from the source.

In the same figure the absorbed doses measured with an ionization chamber are also shown together with the $1/r^2$-dependence curve. The chamber has been calibrated at the Electrotechnical Laboratory(National Bureau of Standard in Japan). It can be seen from the figure that the effect of scattered γ-rays on the absorbed dose is remarkable in the neighborhood of both collimator and screen. The difference between calculated and measured results is mainly attributed to the fact that the collimator size adopted in the calculation was different from the real collimator one. It is, however, found that there exist several points near the middle region where both numerical and experimental results obey the inverse square law. In other words the absorbed dose rates observed there include no scattered component of the irradiated γ-rays.

CONCLUSION

A well-controlled γ-ray field has been established with the improved commercial γ-ray irradiator system. It is ascertained that in some limited region the observed dose rate coincides with the calculated results and also satisfies the inverse square law, which means that the γ-ray field could be a standard one for calibration of both survey meters and all kinds of dosimeters prevailing in Osaka University.

REFFRENCES

Yoshiaki Yamaguchi, Junji Yamamoto, Taisei Nomura and Jinpei Yamashita, Radioisotopes, Vol. 43, 341-345(1994), in Japanese.

Yoshiaki Yamaguchi, Junji Yamamoto, Taisei Nomura, Jinpei Yamashita and Takayoshi Yamamoto, J. Health Physics, in Japanese, in press.

Los Alamos Radiation Transport Groupe, MCNP -A general Monte Carlo code for neutron and photon transport, LA-7396-M(1981).

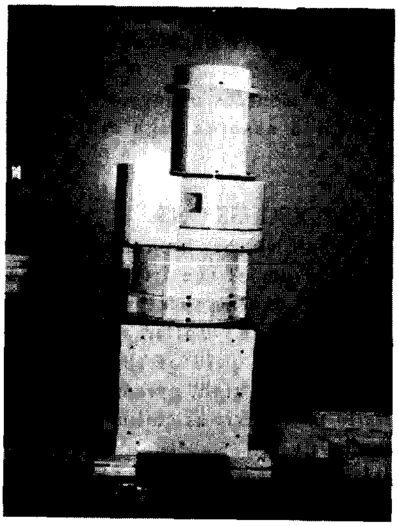

Fig. 1 An irradiator of an irradiation system

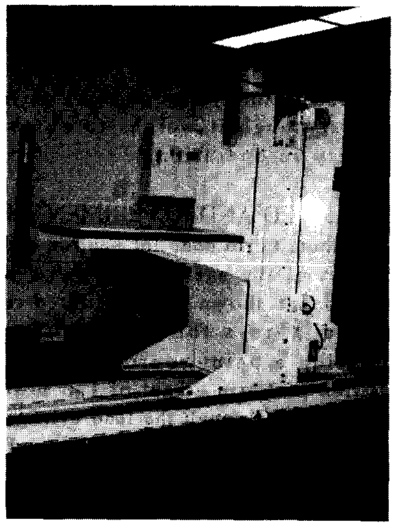

Fig. 2 A mobile exposure deck of an irradiation system

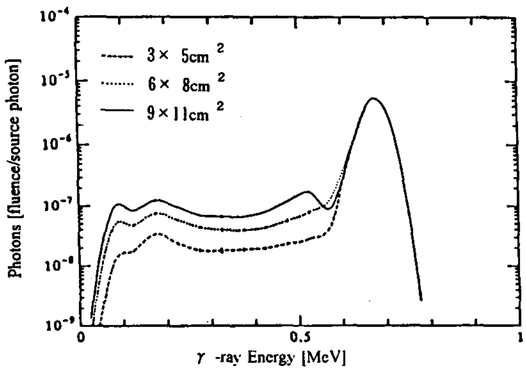

Fig. 3 Caluculated energy spectra from ^{137}Cs source passing through the collimator with exit dimensions of 3×5, 6×8 and 9×11cm [2]

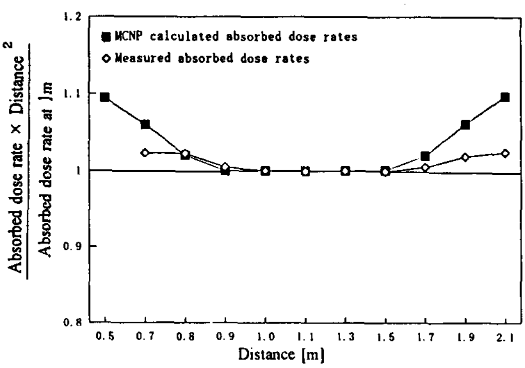

Fig. 4 Dependence of normalized absorbed dose rates on distance