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Development of Effective Dose Measurement System (EDMS) to Measure Effective Dose on Real-time Basis

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1. Introduction

Effective dose is very important dose quantities in radiation protection[1]. It is determined as a weighted average of organ doses to 28 organs and tissues in a human body. Effective dose has been measured by some researchers by inserting hundreds of TLD chips into a RANDO phantom[2], which is however too complicated and time consuming to be used by a practicing health physicist in the fields. To this end, the present study developed a measurement system, called EDMS (Effective Dose Measurement System), which can quickly measure effective dose in the fields.

2. Methods

The EDMS is mainly made of a physical human phantom and many small MOSFET dosimeters. The physical phantom used in the EDMS is the ATOM adult male phantom (Model 701-C, CIRS, Virginia, U.S.A), which has a physique and skeleton of the reference man in ICRP-89[3]. The ATOM phantom has only four internal organs and, therefore, the other organs necessary to determine effective dose were defined by using the organ information in the MIRD5-type mathematical phantom. The ATOM phantom is made of tissue equivalent materials and the photon attenuation coefficients of these materials are very close to those of real tissues for a wide range of photon energies (0.03 - 20 MeV)[4].

The MOSFET dosimeters, which are very small and have immediate readout capability [5], were used in the EDMS to measure organ doses. The high-sensitivity MOSFET dosimeters (Model TN-1002RD, Thomson and Nielsen Electronics Ltd, Ottawa, Canada), which were used in the EDMS, are mainly made of silicon and, therefore, show some energy dependence for low energy photons[6]. That is, the MOSFET dosimeters tend to overestimate tissue dose for low-energy scattered photons in the phantom. The responses of the MOSFET dosimeters were, therefore, appropriately corrected for the energy dependence.

To determine effective dose, we need to know radiation dose to as many as 28 organs and tissues. The EDMS, however, does not measure all of these organs and tissues. Instead, the system measures only a total of 14 important organs with large tissue weighting factors. Effective dose is also determined from organ-averaged doses, i.e., equivalent doses (H_T). The EDMS, however, cannot measure the organ-averaged doses because it uses only a limited number of dosimeters. Note that the EDMS uses 1-6 MOSFET dosimeters to determine organ doses. The numbers and locations of the MOSFET dosimeters were selected very carefully after considering both the tissue weighting factors and the shapes and volumes of the organs under measurement.

3. Results

Fig. 1 shows the effective dose measurement system, EDMS, developed in the present study. The EDMS is constructed by inserting 38 high-sensitivity MOSFET dosimeters into the ATOM adult male phantom. The measure system also includes a user-interface software developed in the present study.

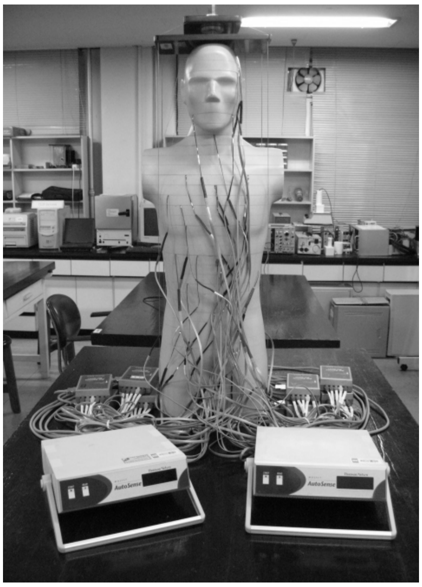

Fig. 1. Effective dose measurement system developed in the present study.

The EDMS was used to measure effective doses for ^{137}Cs and ^{60}Co radiation fields and then the measured values were compared with the values measured by the TL dosimeters for the same irradiation condition. Our results show that the measured organ doses agree, for the most cases, within 5% of difference, and that the measured effective doses agree within about 3-4% considering both ^{137}Cs and ^{60}Co radiation fields (Fig. 2). These results indicate that the EDMS measures effective dose very accurately.

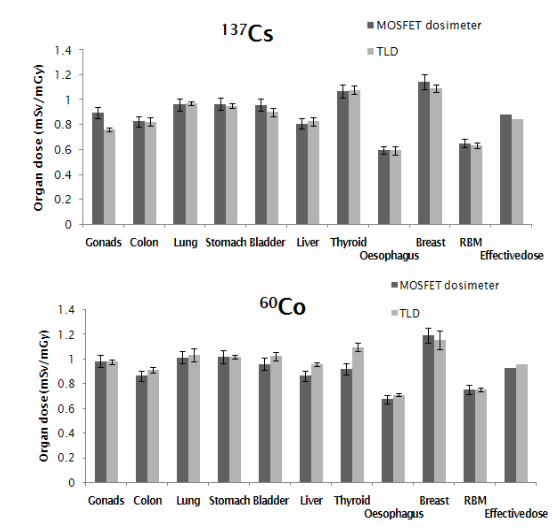

Fig. 2. Organ doses and effective dose measured by EDMS and TL dosimeters.

4. Conclusions

The present study developed a measurement system, called EDMS (Effective Dose Measurement System), using an ATOM adult male phantom and 38 high-sensitivity MOSFET dosimeters. Our measurement results indicate that the EDMS measures effective dose very accurately, e.g., less than a few percent of error.

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