Design Characteristics and Operational Experiences of Extremity Dosimeters

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1. Introduction

The extremities are defined as the portions of the whole body from the upper elbow to the fingers and the knees to the toes including the knee. The extremity dosimetry system is the thermoluminescent dosimeter (TLD) used to assess dose equivalent resulting from external radiation to the extremities [1]. In particular, these dosimeters were used in possible cases of high radiation exposure to extremities during radiation works to provide an estimate of shallow absorbed dose received when worn by an individual. Korean nuclear power plants (NPPs) currently hold two types of extremity dosimeters (Harshaw and Panasonic) to prepare for high radiation exposure to worker's extremities, especially in an inhomogeneous radiation field. In fact, Korean NPPs do not use personnel extremity dosimeters due to the lack of necessity of extremity dosimeters. The whole body TLDs cover and assure the effective dose of workers under normal working circumstances. However, the extremity may occasionally receive the unexpected high dose radiation during maintenance periods so that it has been demanded to prepare for the extremity monitoring. The purpose of this paper is not only to describe the design characteristics of extremity dosimeters retained by Korean NPPs but also to provide the technical background prior to the establishment of guides for personnel extremity dosimetry services at NPPs.

2. Design Characteristics and Operational Experiences of Extremity Dosimeters

Half of Korean NPPs are currently furnished with Harshaw TLD reading system (Harshaw 6600) and each NPP holds approximately a few hundred of extremity dosimeters. In case of Panasonic TLDs, NPPs are equipped with Panasonic UD-716 as a TLD reading system and each NPP retains several hundreds of extremity dosimeters. First, arshaw extremity dosimeters consist of two types of dosimeters, DXTRAD (ring type) and EXTRAD (strap type) according to the appearance and the manufacturer recommends to select the one of them by user's convenience. Harshaw DXTRAD is a ring type of small dosimeter which features individual numbers with barcode that makes human and system possible to read and identify each dosimeter [2]. The DXTRAD is composed of three parts: ringlet, ring cap, and finger ring container (Fig. 1). The main materials of ringlet are either LiF:Mg,Ti or LiF:Mg,Cu,P and they are available in the form of pellet or powder. The ring cap locates on the top of the ringlet and provides the necessary filtration to the thermoluminescent (TL) element. For easier grouping by a task, the manufacturer provides different colors of finger ring container. The ring cap and finger ring container are disposable after one use, but the ringlet is readable approximately 500 times. Harshaw EXTRAD is a strap type of extremity dosimeter easy to wear on fingers and wrists (Fig. 2). The EXTRAD uses a chipstrate, consisted of Polyamide strip which includes a TL chip and a 5-digit barcode ID, instead of a ringlet of the DXTRAD [3]. This TL chip enables to measure a photon, beta or neutron. The materials of TL chips are either LiF:Mg,Ti or CaF_2:Mn which has 3 mm^2 in area and is fixed on an inert substrate. Two types of dosimeters are available: one-chipstrate and two-chipstrate dosimeter. A one-chipstrate dosimeter has a single chipstrate sealed in a disposable pouch and then attached to straps. For read-out of dosimeter, the TL chip should be located at position *II* or *III* in a carrier card which is inserted into a Harshaw TLD reader for reading. A two-chipstrate dosimeter has two different chipstrates and these are also sealed in each disposable pouch and then attached to straps. In particular, the two-chipstrate dosimeter has the capability to discriminate the radiation sources. In case of two-chipstrate dosimeter, each TL chip can be loaded in position II and III in a carrier card for the top chipstrate and the bottom chipstrate, respectively. Positions I and IV in a carrier card are

not used. The total thickness of the filter incorporated in the plastic pouch for one and two chipstrate dosimters is 6.6 mg/cm^2 which enables the estimation of the shallow dose. In addition, it is necessary to equip additional gadgets inside TLD reading system for read-outs of Harshaw extremity dosimters.

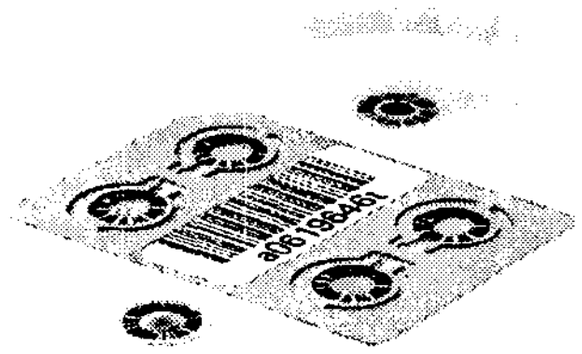

Fig. 1 Harshaw DXTRAD Dosimeter

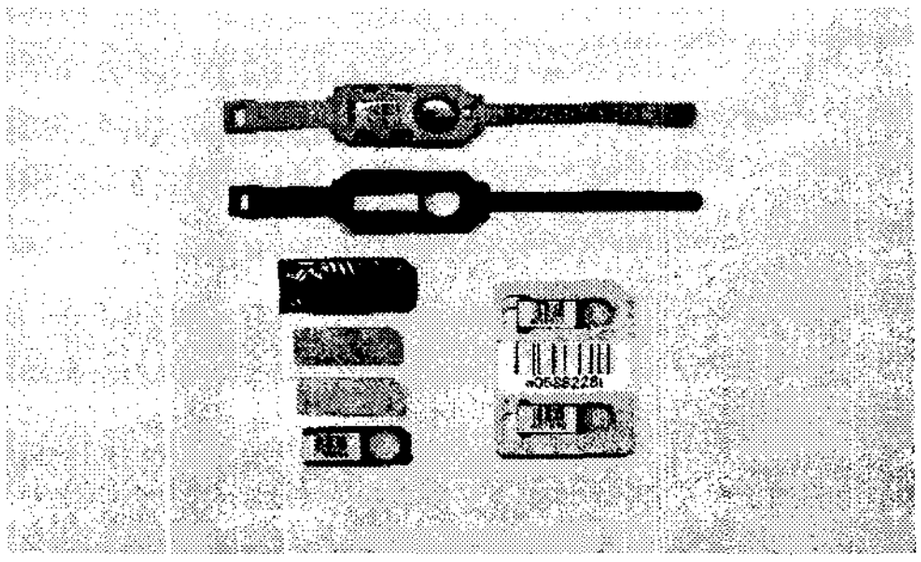

Fig. 2 Harshaw EXTRAD Dosimeter

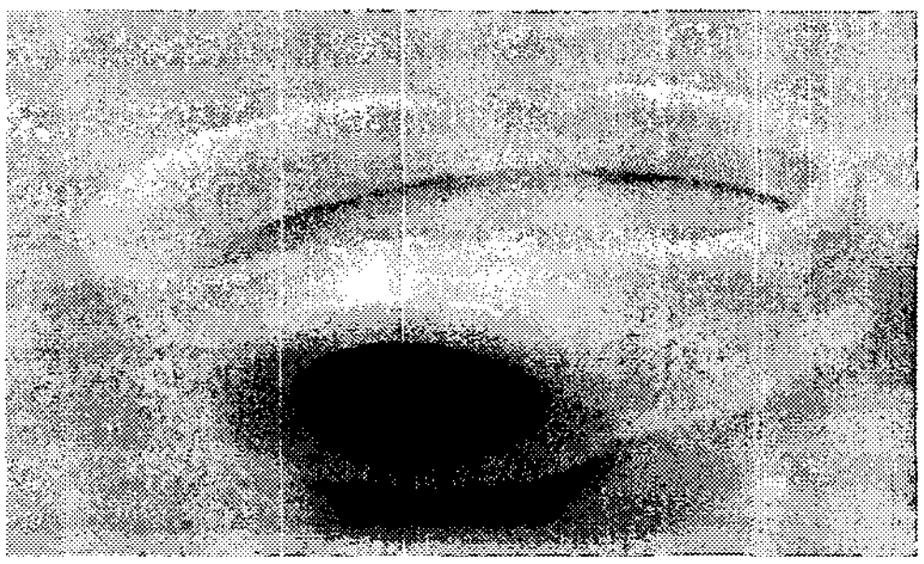

Fig. 3 Panasonic Extremity Dosimeter

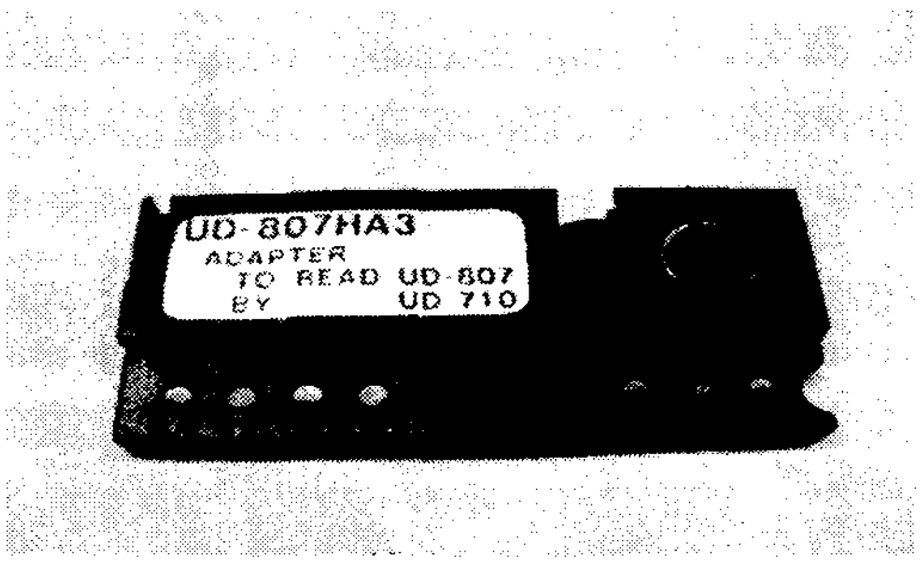

Fig. 4 Panasonic Extremity Card Holder

Panasonic adopts the ring type of extremity dosimeter and $^{n}Li_2{}^{n}B_4O_7(Cu)$ is used the material of TL chips inserted into a ring (Fig. 3). This dosimeter can measure the skin dose in range of 0.1 mSv ~ 10 Sv. The weight of TL chip is less than 1 g and it is classified as UD-807AS (without numbers) or UD-807ASN (with visible numbers) whether specified numbers are given or not. After performance of tasks, the TL chip should be removed from a ring and be inserted into a card holder for read-out of extremity dosimeters. Panasonic TLD reading system (UD-710A and UD-716A) can read these dosimeters using a card holder (UD-807HA3). In particular, UD-716A is the model currently used at Korean NPPs and it is possible to perform the read-out of extremity dosimeters without the installation of additional devices.

3. Conclusion

This study describes the design characteristics of extremity dosimeters to provide the technical background of extremity monitoring at NPPs. In particular, Harshaw and Panasonic extremity dosimeters, which are currently used at Korean NPPs were investigated and it is expected this result helps to prepare the personnel extremity dosimetry services at NPPs.

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