

Preliminary Study on the Development of Extremity Dosimetry Program at Korean Nuclear Power Plants

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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.

From the mid 1990s, the standards to provide an estimate of whole body dose to radiation workers were established according to provisions of the atomic energy law and have been applied to Korean nuclear power plants (NPPs). However, there are no completed technical criteria to provide an estimate of extremity dose, so that the accuracy of dose assessment and the practical use of extremity dosimeter to Korean NPPs are relatively insufficient. Although several Korean NPPs are furnished with extremity dosimeters, they do not provide personnel extremity dosimetry service due to the insufficiency of standards for provision and dose calculation algorithm [2, 3].

In this study, to provide the technical background for the application of personnel extremity dosimetry service in Korean NPPs, the current status of technical standards and researches for extremity dosimetry was preliminarily investigated. In addition, this paper briefly described the extremity dose management at Korean NPPs.

2. Current Status of Technical Standards and Researches for Extremity Dosimetry

International Atomic Energy Agency (IAEA) requires that the special monitoring program for an individual should be conducted for works in a high radiation field. In particular, IAEA recommends that radiation workers wear extremity dosimeters including whole body dosimeters in an inhomogeneous radiation field [4, 5]. European Commission, also, demands that radiation workers use extremity dosimeters in case that extremity dose received by an individual exceeds the 30% of annual dose limit [4, 6]. In practice, to estimate the individual exposure dose, extremity dosimeters are worn by radiation workers even if the exposure dose would be less than 30% of annual dose limit. The absorbed dose

and dose equivalent calculations for the extremity dosimeters are based on the dose equivalents to soft tissue. The reference depth for the specification of dose equivalent to the extremities is 7 mg/cm², as recommended by both the International Commission on Radiological Protection (ICRP 1977) and the International Commission on Radiological Units and Measurements (ICRU 1985) [3].

In 1995, American National Standard Institute (ANSI) issued ANSI N13.32 to provide the criteria for acceptable performance and standardized testing conditions for personnel extremity dosimetry services [1]. The scope of performance criteria described in this standard is limited to extremity dosimeters. In particular, to determine dose equivalents to extremity, this standard presents the methodology including the dose calculation algorithm and the detailed conditions for performance test, such as test categories, irradiation ranges, and acceptable levels of performance. According to this standard, the test categories consist of 4 irradiation categories for photons and beta particles. Irradiation ranges are classified by both high-dose (absorbed dose in the range of 0.1 to 5 Gy) and low-dose dosimetry (dose equivalents in the range of 0.0025 to 0.1 Sv). To simulate the high-dose exposure resulting from an accident, Category I uses both 70 keV of M150 and 662 keV of ¹³⁷Cs as irradiation sources. In Category II, X-rays including M30, M60, M100, M150, and H150 using filter techniques developed by the National Institute of Standards and Technology (NIST) are used to simulate the low-energy photons. In Category III, both 662 keV of ¹³⁷Cs and 1.25 MeV of ⁶⁰Co are used to simulate the high-energy photons. Finally, the beta particles belong to Category IV. These beta particles are manufactured by a sealed ⁹⁰Sr/⁹⁰Y source with a 100 mg/cm² filtration to remove the ⁹⁰Sr component, a sealed ²⁰⁴Tl source with a 20 mg/cm² filtration, and a depleted uranium slab source. To meet acceptable performance levels, the values of the tolerance level should be 0.3 in the high-dose category (Category I) and 0.5 in the low-dose categories (Category II, III, and IV).

As the types of work environment in Korean nuclear industries are becoming diversified, Korea Institute of Nuclear Safety (KINS) conducted the research project preliminarily in 2003 to prepare safety regulations for personnel extremity dosimetry services [4]. In addition, to meet the increasing demands for extremity dosimetry at Korean NPPs, Korea Electric Power Research Institute (KEPRI) has started the research project since

2007 not only to provide the technical background but also to establish practical guides for personnel extremity dosimetry services at NPPs.

3. Extremity Dose Management at Korean NPPs

Korean NPPs currently use the two types of TLDs (Harshaw and Panasonic) to measure and to assess whole body dose of radiation workers. In particular, all Korean NPPs are approved to perform the reading TLDs by themselves. To meet the technical requirements for the operation of TLD reading system, all NPPs take the performance test regularly including quality assurance (QA) and quality control (QC), on the basis of the atomic energy law and the notification of Ministry of Science and Technology.

Contrary to whole body TLDs, there are no systemic standards and procedures for the use of extremity dosimeters at Korean NPPs. Although some NPPs tried to use extremity dosimeters, they did not accomplish the extremity dose management due to the lack of extremity dosimeter readout experiences and its program. Sometimes, a small quantity of extremity dosimeters are purchased by some NPPs when they buy a TLD reading system and a large quantity of whole body TLDs. However, most of extremity dosimeters are stored in a warehouse without use.

Half of NPPs are currently furnished with Panasonic TLD reading systems (UD-716) and each NPP retains approximately a few hundred of extremity dosimeters (UD-807AS). In case of Harshaw TLDs, NPPs are equipped with Harshaw 6600 as a TLD reading system and each NPP hold approximately a few hundred of extremity dosimeters (DXTRAD) [2]. The number of Harshaw extremity dosimeters retained by NPPs is relatively small compared with those of Panasonic. In addition, it is possible to perform the reading dosimeters without additional equipments for Panasonic extremity dosimeters, but it is necessary to equip additional gadgets inside TLD reading system for Harshaw extremity dosimeters.

4. Conclusion

This study provides the current status of technical standards and researches for personnel extremity dosimetry service including experiences at Korean NPPs. In relation to standard for extremity dose monitoring, both IAEA's position and European Commission's recommendation were introduced. The ANSI standard was also described to provide more detailed technical criteria for performance test. Especially, this standard presented test categories, irradiation ranges, and acceptable levels of performance. The previous research conducted by Korean regulatory body and ongoing research carried out by a research institute were, also, briefly introduced. Especially, since Korea Electric Power Research Institute (KEPRI) performs currently the research project of extremity

dosimetry program, it is expected that the technical guides and the methodology of dose calculation will be provided. Finally, some Korean NPPs are furnished with extremity dosimeters, but they do not provide personnel extremity dosimetry service due to the insufficiency of dose calculation algorithm and completed standards for provision.

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