Operational Experience of a Two-Dosimeter Algorithm for Better Estimation of Deep Dose at Korean Nuclear Power Plants

Hee Geun Kim [a*], Tae Young Kong [a]
[a]*Korea Electric Power Research Institute, 103-16 Munji-dong, Yuseong-gu, Daejeon, Korea*
[*]*Corresponding author: hkkim@kepri.re.kr*

1. Introduction

Radiation workers can be exposed to a high-level of radiation during the maintenance of reactor coolant pumps, pressurizers, and water chambers of steam generators for an overhaul of nuclear power plants (NPPs) in spite of the short working hours, as dose rate gradients are high in these areas. Generally, the radiation dose rate is high and the radiation field is inhomogeneous; hence, if radiation workers use only one thermoluminescent dosimeter (TLD) on their chest, the amount of exposure to radiation cannot be monitored precisely [1,2]. Therefore, additional dosimeters are provided to workers who work in an inhomogeneous radiation field in NPPs. Two dosimeters are typically provided; one on the chest and the other on the head [3-5]. In this way, the radiation dose to the entire body for radiation workers at NPPs is determined by the high deep dose between two radiation doses from these dosimeters. This represents a conservative method of evaluating the degree of exposure to radiation.

Unlike the past, two-dosimeters are practically provided to radiation workers at Korean NPPs applying the previous field test results, for a task that dose rate is more than 1 mSv/hr, difference of equivalent dose to specific parts of body is more than 30 % and an exposure of more than 2 mSv is expected in a single task. Furthermore, two-dosimeters are worn on the chest and back of radiation workers [6,7]. After a task, the deep dose of a radiation worker is estimated using a NCRP (55:50) algorithm for two-dosimeters [6-8].

In this paper, the operational experience of a two-dosimeter for a high radiation exposure task during maintenance periods at Korean NPPs were described. In particular, the previous application test results are briefly introduced and the results of deep dose estimation applying the improvement of use of two-dosimeters during 2 years were analyzed [9].

2. Methods and Results

2.1 Application Test on Two-dosimeter Algorithm

In previous study, the application of seven two-dosimeter algorithms developed by different nuclear regulatory agencies and facilities to Korean NPPs was investigated to analyze anticipated problems that may arise. Three additional dosimeters were provided to radiation workers who wore a TLD on the head, chest, and back simultaneously for high-radiation work in order to analyze the two-dosimeter application to Korean NPPs during a maintenance period at the Yonggwang NPP No. 2 and the Ulchin NPP No. 2. After the radiation work, the seven two-dosimeter algorithms were applied to two-dosimeter readouts and the deep doses were calculated. In the results, the calculated deep doses were very similar to one another, with the exception of Lakshmanan's algorithm. Thus, it was concluded that regardless of which algorithm is applied to Korean NPPs, the procedure used for estimating levels of exposure to radiation will be improved [6,7].

In particular, previous test showed that wearing two-dosimeters on the chest and back rather than on the chest and head reduces the potential for overestimations or underestimations of the deep dose [6,7,10]. In addition, as the NRC and NCRP recommends that a radiation worker wear two-dosimeters on the head and back, it is feasible for Korean NPPs to follow international standards and trends regarding the use of two-dosimeters. After interviews with the radiation workers, it was also found that they reacted positively to wearing two-dosimeters on the chest and back rather than on the chest and head. Thus, it was concluded that wearing two-dosimeters on the chest and back is suitable for a radiation worker. Finally, the NCRP (55:50) algorithm was regarded as the optimal two-dosimeter algorithm in an inhomogeneous radiation field as this involves no large degree of specificity and no large amount of variation depending on the location of the radiation source. Moreover, two dosimeters when worn on the chest and back reduce the risk of underestimating the deep dose [10,11].

2.2 Operational Experience of NCRP (55:50) Algorithm

The selected two-dosimeter algorithm in previous study, the NCRP (55:50) algorithm, was reflected in standard procedures of Korean NPPs at the end of 2005 [6]. As a result, this algorithm was applied extensively to all of Korean NPPs in 2006 and 2007.

In particular, the deep dose during the installation of a steam generator nozzle dam at Kori NPP No. 1 was analyzed. To compare the differences among the maximum, minimum, and calculated dose using the NCRP (55:50) algorithm, each result from these tests is displayed in Figs. 1 - 2. After an analysis of the data from all Korean NPPs, the results were found to be mostly similar to the earlier results of previous application test [6,7]. That is, the calculated deep dose equivalent was lower than the maximum dose equivalent on the chest or back by approximately 20 ~ 30 %.

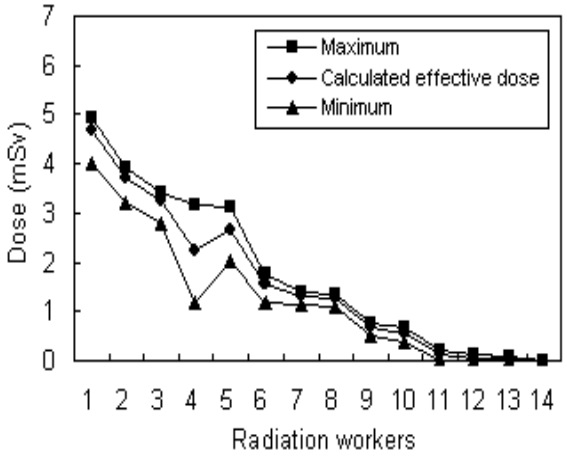

Fig. 1 Comparison of the Maximum, Minimum, and Calculated Deep Dose from TLD readouts for the installation of a steam generator nozzle dam at the Kori NPP No. 1

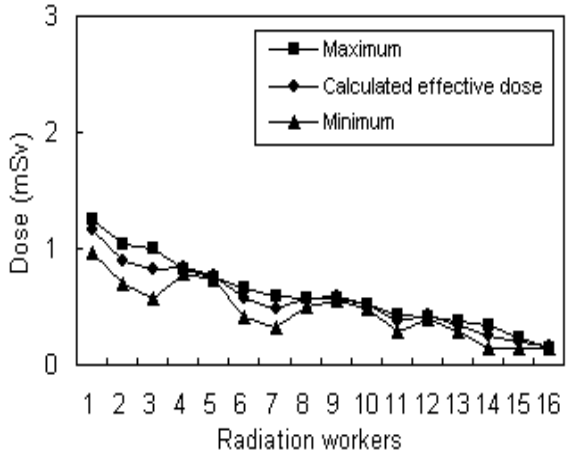

Fig. 2 Comparisons of the Maximum, Minimum, and Calculated Deep Dose from TLD readouts for a penetration test of a reactor head at the Kori NPP No.1

3. Conclusions

In a previous study, application test was conducted to increase the accuracy of deep dose calculation and convenience of radiation works at Korean NPPs. As a result, the NCRP (55:50) algorithm was selected for the optimal method of deep dose calculation and the position of two-dosimeter worn on the chest and back was recommended for convenience. In 2005, Korean NPPs provided new guidelines to calculate the deep dose and to wear a two-dosimeter applying previous results. This new guidelines have been applied to all of Korean NPPs since 2006.

In this study, the operational experience after application of previous test results to the practice at Korean NPPs was focused for analysis of deep dose and convenience between before and after application. As a result, it was found that this new guideline reduces the overestimation and prevents the underestimation of deep dose for radiation workers who participate in a task which is expected to produce a high radiation exposure. Moreover, after interviews with radiation workers, they presented that the convenience during radiation works has been much improved through the change of the position of two-dosimeter worn on from the head and chest to the chest and back.

ACKNOWLEDGEMENTS

This research was carried out with financial support from the Korea Hydro & Nuclear Power Corporation.

REFERENCES

[1] Institute of Nuclear Power Operation (INPO), Guidelines for Radiological Protection at Nuclear Power Stations, INPO 91-014 Revision 01, 1995.
[2] World Association of Nuclear Operations (WANO), Guidelines for Radiological Protection at Nuclear Power Plants, WANO GL 2004-01, 2004.
[3] American National Standards Institute (ANSI), An American National Standard Criteria for Performing Multiple Dosimetry, Report No. HPS N13.41, 1997.
[4] Personal Communication with Arif Khan and Dave Whillans of OPG, Summary of Changes to the Method of Assigning Dose from Multiple TLD Badges, 2002.
[5] International Commission on Radiation Units and Measurements (ICRU), Measurements of Dose Equivalents from External Photon and Electron Radiation, ICRU Report 51, 1992.
[6] Kim, H. G., and Kong, T. Y., A Study on the Application of Two-dosimeter Algorithm to Estimate the Effective Dose in an Inhomogeneous Radiation Field at Korean Nuclear Power Plants, Journal of Radiation Protection, 2008 December;33(4):151-160.
[7] Kim, H. G., and Kong, T. Y., Application of Estimating Effective Dose from External Radiation using Two Dosimeters during Maintenance Periods at KNPPS, Journal of Nuclear Science and Technology, 2008 June;(5):151-154.
[8] Korea Hydro and Nuclear Power Co. Ltd., Standard Procedure of Occupational Radiation Dose Assessment, 2006.
[9] Cha, S. C., Current Status of use of a Two-dosimeter, In: Proceedings of ALARA Symposium, 2008.
[10] Korea Electric Power Research Institute (KEPRI), Application of Two-dosimeter Algorithm for Better Estimation of Effective Dose Equivalent to Inhomogeneous Radiation Field at NPPs, TM.105NJ14.P2006.072, KEPRI, 2006.
[11] National Council on Radiation Protection and Measurements (NCRP). Use of Personal Monitors to Estimate Effective Dose Equivalent and Dose to Workers for External Exposure to Low-LET Radiation, NCRP Report No.122, Bethesda, 1995.