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The dosimetric characteristics of personal alarm dosimeter : Dependence of dose rate and photon energy

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1. Introduction

The applications of nuclear energy and radiation have been used throughout nuclear power plant, educational institutions, research institute, hospital and industry in general. And, workers under the radiation fields have continued to increase exposure to the radiation. There is a need to accurately measure the radiation dose.

The dosimeters such as TLD(main dosimeter) are cumulative personal dosimeter to be measured after the radiation exposure, not provide information in real-time personal dose.

Therefore, active dosimeter such as electronic personal dosimeters have used together as an alternative dosimeter to manage radiation dose of worker in the work place.

We have developed and produced electronic personal dosimeters using photo diode as a detector(Model name: CLOVER), have also programmed the dose calculating algorithms to fit this dosimeter.

2. Methods and Results

The requirements of dosimetric characteristic for electronic dosimeter present the standard of KS C IEC 61526: 2005(Radiation protection instrumentation – Measurement of personal dose equivalents Hp(10) and Hp(0.07) for X, gamma and beta radiations – Direct reading personal dose equivalent and/or dose equivalent rate dosemeters). This standard document provides the baseline or references such as relative intrinsic error, dose equivalent rate dependence, radiation direction dependency and radiation energy dependency etc.

This study will carry out relative intrinsic error, dose rate dependence and radiation energy dependence. The performance test have done in the reference radiation field at Korea Research Institute of Standards and Science(KRISS).

2.1. Relative intrinsic error

The relative intrinsic error of the dosimeter according to requirement of KS C IEC 61526:2005 must not exceed 20% within measurement range of radiation dose, the effective dose equivalent rate should not exceed 15%. Also it must not exceed 30% at the lowest dose rate measurement.

The result of performance of this dosimeter presents the table 1. The relative intrinsic error are 9.5% in 0.04 mSv, 7.4% in 0.40 mSv and 10.0% in 2.00 mSv.

Table 1. Relative intrinsic error

Reference dose	Response value	Relative intrinsic error(%)
40 μSv	(36.2 ± 0.98) μSv	9.5
400 μSv	(370.5 ± 2.08) μSv	7.4
2 mSv	(1.80 ± 0.00) mSv	10.0

2.2 Dose rate dependence

The relative intrinsic error of dose equivalent with respect to radiation response of electronic dosimeter is to be maintained within 20% for all dose equivalent rate within 1 Sv/h. Also it must not exceed 30% at the lowest dose rate measurement. The result of performance of this dosimeter presents the table 2. The relative intrinsic error in lowest dose rate(30 μSv/h) is not exceed 30%, and total average error of dose rate is – 9.0% , not exceed 20%.

Table 2. Dependence of dose rate

Reference dose rate	Response value	Relative intrinsic error(%)
30 μSv/h	(21.6 ± 1.14) μSv/h	-28.0
50 μSv/h	(43.2 ± 0.45) μSv/h	-13.6
70 μSv/h	(59.6 ± 0.55) μSv/h	-14.9
3 mSv/h	(2.92 ± 0.00) mSv/h	-2.7
5 mSv/h	(4.91 ± 0.00) mSv/h	-1.8
7 mSv/h	(6.89 ± 0.01) mSv/h	-1.6
100 mSv/h	(99.3 ± 0.03) mSv/h	-0.7
Total Average		-9.0

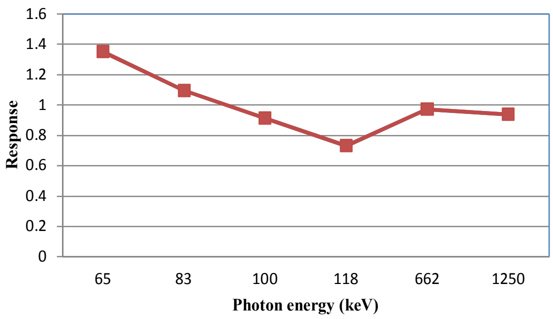
2.2. Radiation energy dependence

The response of dosimeter in the reference photon field is does not extend more than 30% for the incident photon radiation with energy from 20 keV to 1.5 MeV. For low energy photon, this study used narrow series of ISO X-ray beam and used isotopes of Cs-137 and Co-60 as gamma rays.
The result of performance of this dosimeter presents the table 3 and Figure 1. The response of radiation energy at 65 keV(NS 80 of X-ray) is exceed 30%, and the responses of rest of photon energy are 1.10 at 83 keV, 0.91 at 100 keV, 0.73 at 118 keV, of X-ray and 0.97 at 662 keV of Cs-137 and 0.94 at 1250 keV of Co-60.

Table 3. Dependence of radiation energy

Beam code (Energy)	Reference dose (mSv/h)	Response (mSv/h)	Ratio
NS 80 (65 keV)	2.589	3.500	1.35
NS 100 (83 keV)	1.166	1.278	1.10
NS 120 (100 keV)	1.128	1.030	0.91
NS 150 (118 keV)	9.082	6.650	0.73
137Cs (662 keV)	3	2.918	0.97
60Co (1250 keV)	1000	937.64	0.94

Figure 1. Dependence of radiation energy



3. Conclusions

We have developed and produced electronic personal dosimeters using photo diode as a detector, have also programmed the dose calculating algorithms to fit this dosimeter.
The result of tests to meet in KS C IEC 61526 requirements for this dosimeter could obtain the following conclusions.

3.1. The relative intrinsic error and the dependence of dose equivalent rate of this electronic dosimeter are not exceed 20%, and meet with requirements.

3.2. The dependence of energy in the low energy region is exceeded 30%. For this reason, it is necessary the additional study on the filtration of low energy photon.

4. References

[1] KS C IEC 61526 : 2005, Radiation protection instrumentation – Measurement of personal dose equivalents Hp(10) and Hp(0.07) for X, gamma and beta radiations – Direct reading personal dose equivalent and/or dose equivalent rate dosemeters
[2] ISO 4037-1 : 1996, X and gamma reference radiation for calibrating dosemeters and doserate meters and for determining their response as a function of photon energy – Radiation characteristics and and production methods
[3] ISO 4037-2 : 1996, X and gamma reference radiation for calibrating dosemeters and doserate meters and for determining their response as a function of photon energy – Dosimetry for radiation protection over the energy ranges 8 keV to 1.3 MeV and 4 MeV to 9 MeV
[4] ISO 4037-3 : 1996, X and gamma reference radiation for calibrating dosemeters and doserate meters and for determining their response as a function of photon energy – Calibration of area and personal dosemeters and the measurement of their response as a function of energy and angle of incidence