DOSE RESPONSE ON THE TESTING OF ^{137}CESIUM PANORAMIC IRRADIATION DEVICE PROTOTYPE FOR PERSONNEL DOSIMETER

Respon Dosis Pada Pengujian Prototipe Perangkat Penyinaran ^{137}Cesium Panoramik Untuk Dosimeter Personel

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Abstract

The dosimetry laboratory has to ensure that the implementation of quality assurance of testing meets clause 7.7 of the SNI ISO/ IEC17025: 2017. One of the activities to meet the quality assurance is to irradiate the personnel dosimeter at radiation facility that is traced to national or international standard. In this research it has been outlined the dose response of personnel on the prototype of the ^{137}Cs panoramic irradiation device and its dose rate distribution. It was prepared 40 dosimeters for each of OSLD and TLD-900 which were divided into 5 groups. Each group consists of 8 dosimeters with 6 dosimeters for irradiated and 2 dosimeters as control. The dosimeter were mounted on the holders of ^{137}Cs panoramic irradiation device prototype and exposed with irradiation time of 7.3 minutes, 54.5 minutes, 165 minutes, 330 minutes and 545.2 minutes respectively. Then they were evaluated using the OSLD microStar Reader or the TLD reader. Meanwhile, RaySafe Xi survey with its detector was prepared to measure dose rate in the holder 1 to 6 for 5 minutes. The study showed that the reading dose of TLD-900 were relatively higher than OSLD. The difference of TLD-900 reading dose to OSLD ranged from 0.10 – 1.44 mSv with a greater tendency for the higher dose. The linearity curve between reading dose to exposure time tends to be linear with a correlation factor (R^2) of 0.9999 for OSLD and 0.9988 for TLD-900. The linearity equation on OSLD is y = 0.0184x – 0.0326. While the linearity equation for TLD-900 is y = 0.0214x – 0.1201. The dose rate on the holder 1 to 6 has an average of 1.02 mSv/h with the standard deviation of 1.5%. The dose rate distribution at a distance of 29 cm from the source ranges from 1.01 - 1.04 mSv/jam.
***Keywords**: Dose, ^{137}Cs panoramic, personnel dosimeter*

Abstrak

Laboratorium dosimetri harus memastikan bahwa penerapan penjaminan mutu pengujian memenuhi klausul 7.7 dari SNI ISO/ IEC17025:2017. Salah satu kegiatan untuk memenuhi persyaran penjaminan mutu adalah dengan menyinari dosimeter personel di fasilitas radiasi yang tertelusur ke standar nasional atau internasional. Dalam penelitian ini diuraikan respon dosis personil pada penyinaran prototipe perangkat ^{137}Cs panoramik dan distribusi laju dosisnya. Disiapkan 40 dosimeter untuk OSLD dan TLD-900 yang terbagi menjadi 5 kelompok. Setiap kelompok terdiri atas 8 dosimeter dengan 6 dosimeter diiradiasi dan 2 dosimeter sebagai kontrol. Dosimeter dipasang pada holder prototipe perangkat penyinaran ^{132}Cs panoramik dan diiradiasi masing-masing pada 7,3 menit, 54,5 menit, 165 menit, 330 menit dan 545,2 menit. Kemudian dosimeter tersebut dievaluasi menggunakan OSLD microStar Reader atau TLD Reader . Alat ukur RaySafe Xi survei disiapkan untuk mengukur laju dosis pada holder 1 hingga 6 selama 5 menit. Hasil studi menunjukkan bahwa dosis bacaan TLD-900 relatif lebih tinggi dibandingkan OSLD. Perbedaan dosis bacaan pada TLD-900 terhadap OSLD berkisar 0.10 – 1.44 mSv dengan kecenderungan yang lebih besar pada dosis yang lebih tinggi. Kurva linearitas antara dosis bacaan terhadap waktu iradiasi cenderung linier dengan faktor korelasi (R^2) sebesar 0,9999 untuk OSLD dan 0,9988 untuk TLD-900. Persamaan linearitas pada OSLD adalah y = 0,0184x – 0,0326. Sedangkan persamaan linearitas untuk TLD-900 adalah y = 0,0214x – 0,1201. Laju dosis rata-rata pada holder 1 hingga 6 adalah 1,02 mSv/jam dan standar deviasi 1,5%. Distribusi laju dosis pada jarak 29 cm dari sumber berkisar antara 1,01 - 1,04 mSv/jam.
***Kata kunci**: Dosis, ^{137}Cs panoramik, dosimeter personel*

1. INTRODUCTION

Currently, in Indonesia, several dosimetry laboratories provide personnel dose testing services, for example, LTRSM NRIA (Laboratory for Technology of Radiation Safety and Metrology - National Research and Innovation Agency), HFSC (Health Facility and Security Center-Ministry of Health) Jakarta, and NuklindoLab. Indonesian National Standard (SNI) ISO/IEC17025:2017 state that the laboratory must perform comparative testing among similar laboratories to ensure that the quality of the personnel dosimeter testing result is guaranteed [1]. The dosimetry laboratory must ensure that the implementation of testing quality assurance meets clause 7.7 of the SNI ISO/ IEC17025: 2017. One of the activities to meet quality assurance is exposing the personnel dosimeter at radiation facilities traced to national or international standards. Currently, the personnel dose irradiation in the dosimetry laboratory is carried out in a collimated radiation of calibration facility. In LTRSM NRIA, irradiation is carried out at the Calibration Laboratory, Pasar Jumat, or the Secondary Standard Dosimetry Laboratory (SSDL), Mampang Prapatan. Both calibration facilities are equipped with a collimated radiation of calibration system. According to *Ismanto* [2], using a collimated irradiation system has limitations related to the number of dosimeters exposed in one irradiation. In addition, repeated irradiation will open up the possibility of errors that include inconsistency in the layout of the dosimeter, the speed of the shutter opened and closed, and the characteristic of radiation collimation.

Panoramic irradiation is done in air at areas potentially accessible to personnel. Panoramic irradiation has the advantages of shorter irradiation time, broader irradiation coverage, and relative simplicity. At the same time, its disadvantage is the increased radiation hazard because the area exposed to radiation is wider. *Ismanto* [2] stated that panoramic irradiation equipment consists of a radiation source, an emitter house with its source drive, a source drive control module, and an irradiation table. The source of radiation used is usually ^{137}Cs or ^{60}Co.

OB-85 collimated source is used by many secondary standard dosimetry laboratories worldwide [3,4]. Meanwhile, *Muhijrah et al.* [5] tried to analyze the output of ^{137}Cs panoramic dose in the calibration process of the pen dosimeter. Meanwhile, *Annkah et al.* [6] also had been measured dose response using TLD-100 on ^{137}Cs panoramic irradiation device.

The duration of the dose irradiation service at the Calibration Laboratory sometimes does not match the Dosimetry Laboratory's request because it also has to serve outside customers. So, to maintain the quality of the dose testing service and ensure that the implementation of quality assurance can be carried out under the provision, the Dosimetry Laboratory need personnel dose irradiation device that meet the requirements without interfering with the irradiation service process at the Calibration Laboratory. Therefore, the prototype of the 137Cs panoramic irradiation device has been tested to ensure that the device was worth utilizing to be used as an irradiation facility for personnel dosimeters. In this study, the dose-response of dosimeter personnel and the dose rate distribution of the 137Cs panoramic irradiation prototype were examined, as well as the linearity correlation between the reading dose and its time exposure so that the dose-response of dosimeter personnel and the dose rate distribution of the 137Cs panoramic irradiation prototype can be used to support Dosimetry Laboratory service.

2. .LITERATURE REVIEW

The prototype of the ^{137}Cs panoramic irradiation device for personnel dosimeter consists of a ^{137}Cs source, emitter house, drive control system module, and irradiation table. The dosimeter holder's height from the irradiation table's base is 21 cm, and the distance from the source to the dosimeter holder is 30 cm. The source of ^{137}Cs utilized had 50 mCi activity in June 2009.

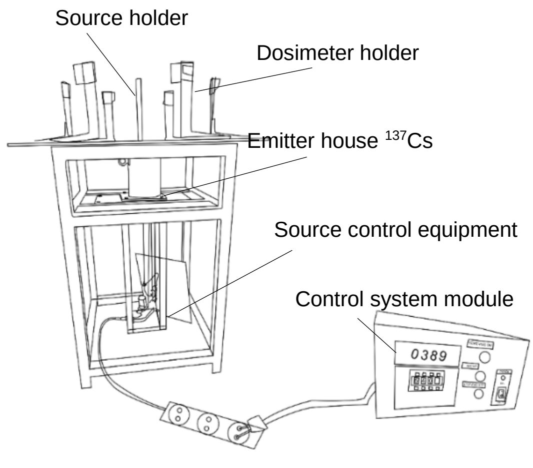

FIGURE 1 Prototype overview of ^{137}Cs panoramic irradiation device [2].

The drive control system module consists of a DC motor drive power circuit controlled by an industrial standard timer module and an interlock system. A prototype overview of the ^{137}Cs panoramic irradiation device is shown in **Figure 1**.

A personnel dosimeter is a measuring device used to measure individual radiation doses accumulatively. There are two types of personnel dosimeters: passive and active. Optically stimulated luminescence dosimeters (OSLD) and thermoluminescence dosimeters (TLD) are passive dosimeters, while pocket dosimeters are categorized as active dosimeters.

OSLD is made of Al_2O_3:C. The detector element is located between 2 layers of 0.3 mm polyester. The dosimeter element (casing) is inserted into the 6.3 cm x 3.8 cm x 0.9 cm badge. The casing is 5 cm x 2.4 cm x 0.6 cm. A commercial type of OSLD for personnel dose monitoring $H_p(10)$ coded XA or AA. **Figure 2** shows the OSLD casing and badge for personnel dose monitoring.

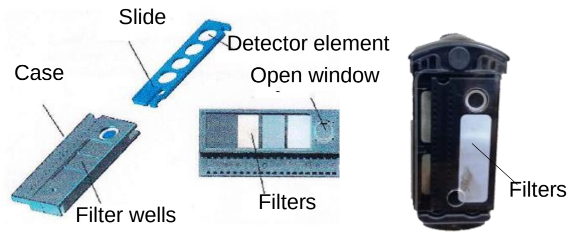

FIGURE 2 The OSLD Inlight XA and its casing (left) and the OSLD badge (right) [7].

TLD-900 is made of CaSO4: Dy Teflon. It can detect photons and beta in the linearity range of 0.1 mSv to 20 Sv with linearity ± 10%. TLD-900 has a central glow peak temperature of 230 ^oC. Within six months, 2-3% fading occurs [6]. **Figure 3** shows the TLD-900 card and TLD-900 badge.

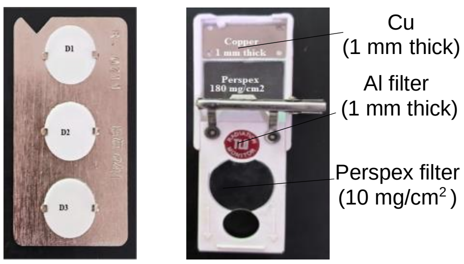

FIGURE 3 TLD-900 card (left) and TLD-900 badge (right) [7].

The radiation intensity is measured using a radiation-measuring device called a survey meter. The RaySafe Xi is intended for measuring in medical X-ray imaging applications. The survey detector is designed for measuring leakage or scattered radiation from X-ray tubes or examination rooms and leakage radiation from γ-emitting isotopes [8].

3. METHOD

This research prepared 40 dosimeters for each OSLD and TLD-900, divided into five groups. All dosimeters were annealed to release the remaining stored radiation dose using an annealer device. Each group consists of 8 dosimeters, with six dosimeters for irradiation and two dosimeters as control. Six dosimeters for each group were mounted on the panoramic irradiation prototype device holders. Group 1 to 5 were exposed with irradiation time of 7.3 minutes, 54.5 minutes, 165 minutes, 330 minutes and 545.2 minutes, respectively that it set on the device.

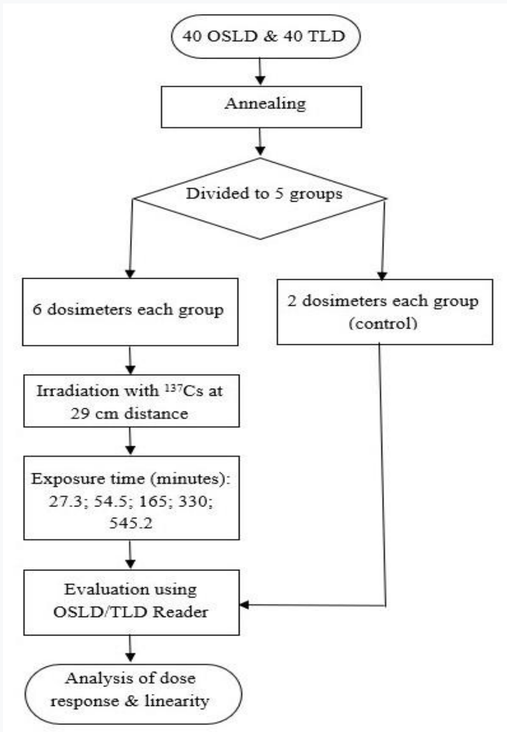

Figure 4 The stages of personnel dose exposure and its evaluation to OSLD and TLD.

After exposure, the dosimeters were sent to the Dosimetry Laboratory for evaluation using an OSLD MicroStar reader produced by Landauer or a TLD reader type 1010 S manufactured by Nucleonix. Then the Dosimetry Laboratory analyzed the result. The exposure and evaluation stages of the personnel dose to the OSLD and TLD are shown in **Figure 4.**

Meanwhile, this research prepared the RaySafe Xi survey with its detector to measure the dose rate in holders 1 to 6 of the ^{137}Cs panoramic irradiation prototype device. The distance of the source to the holder (SSD) is 29 cm. Each measurement of the dose rate was carried out for 5 minutes. **Figure 5** shows the steps for measuring the dose rate in the irradiation area of the ^{137}Cs panoramic irradiation device.

4. RESULT AND DISCUSSION

The average reading dose as a personnel dose of OSLD and TLD-900 at ^{137}Cs panoramic irradiation can be seen in **Table 1**. Meanwhile, the layout of the ^{132}Cs panoramic irradiation prototype device to OSLD or TLD is shown in **Figure 6**. There are 6 OSLD/TLD holders on the ^{132}Cs panoramic irradiation prototype device with a radius of 29 cm.

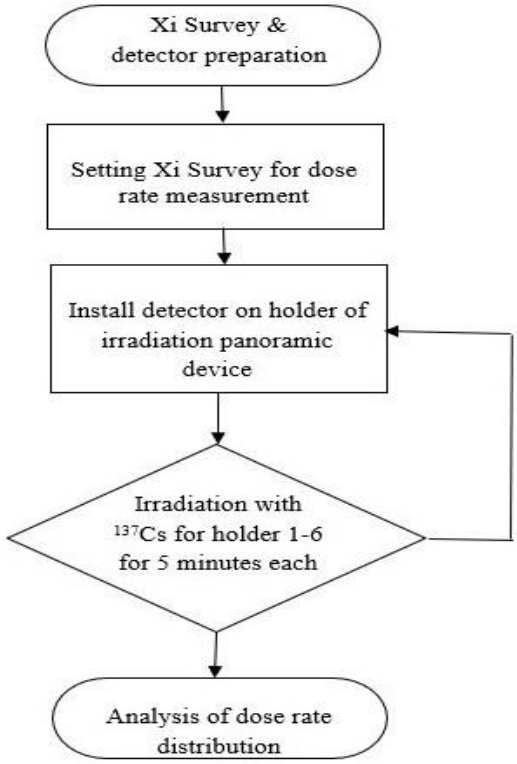

Figure 5 The steps for measuring the dose rate on the ^{137}Cs panoramic irradiation device.

TABLE 1 Reading dose of OSLD and TLD-900 on the 137Cs panoramic irradiation device prototype.

No.	Time of Exposure (Minute)	OSLD		TLD-900	
		Average of Reading Dose (mSv)	∆Reading Dose (%)	Average of Reading Dose (mSv)	∆Reading Dose (%)
1	27.3	0.43	10.3	0.54	7.3
2	54.5	0.97	16.5	1.07	10.0
3	165.0	3.03	3.9	3.17	6.2
4	330.0	6.08	4.6	7.12	3.4
5	545.2	9.96	26.2	11.50	7.3

Table 1 shows that the reading dose of TLD-900 was relatively higher than its response to OSLD. However, the standard deviation of measurements on the TLD-900 is somewhat lower. The difference between the TLD-900 reading dose to OSLD ranged from 0.10 – 1.44 mSv, with a greater tendency for the higher reading dose. *Annkah et al.* [6] stated that the relative response dose for TLD-100 ranged from 0.91 to 1.52 for the exposure dose of ^{137}Cs panoramic. Meanwhile, a study on $H_p(10)$ dose response by *Jumpeno et al.* [7] showed that the ratio of $H_p(10)_{Measurement}$ to $H_p(10)_{Exposure}$ for TLD-900 was relatively higher than OSLD.

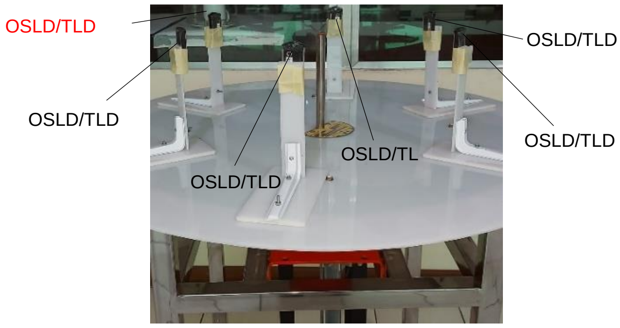

FIGURE 6 Layout of OSLD/TLD on the prototype of ^{137}Cs panoramic irradiation device.

The linearity curve between reading dose to exposure time on OSLD and TLD-900 is shown in **Figure 7**. The curve tends to be linear with a correlation factor (R^2) of 0.9999 for OSLD and 0.9988 for TLD-900.

This linearity curve is similar to the linearity curve between reading doses to exposure doses based on the result of research by *Jumpeno et al.* [9], *Pinto et al.* [10], and *Hashim et al.* [11] to OSLD. The relationship of OSLD is relatively linear compared to TLD-900. The linearity equation on OSLD is y = 0.0184x – 0.0326. In contrast, the linearity equation of reading dose to exposure time for TLD-900 is y = 0.0214x – 0.1201.

The result of the dose rate measurement using the RaySafe Xi Survey is shown in **Table 2**.

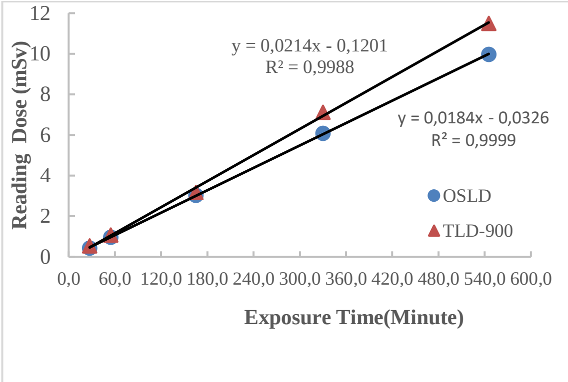

FIGURE 7 Linearity curve between reading dose to exposure time on ^{137}Cs panoramic irradiation.

TABLE 2 Dose rate measurement response on panoramic ^{137}Cs irradiation.

No.	Location of Measurement	Dose Rate (mSv/h)	Average of Dose Rate (mSv/h)	∆ Dose Rate (%)
1	Holder 1	1.01		
2	Holder 2	1.00		
3	Holder 3	1.02	1.02	1.5
4	Holder 4	1.04		
5	Holder 5	1.03		
6	Holder 6	1.03		

Table 2 illustrates that the measured dose rate on holders 1 to 6 has an average value of 1.02 mSv/h and a standard deviation of 1.5%. Dose rate distribution in the holder 1 to 6 ranged from 1.01-1,04 mSv/jam at a 29 cm distance. *Arwui et al.* [12] tried to utilize ^{137}Cs panoramic sources for TLD calibration. Meanwhile, *Purwajati et al.* [13] showed that the calibration factor of the panoramic ^{137}Cs source was not much different from the result of the calibration factor using the collimated ^{137}Cs source. However, dose irradiation using a panoramic system will take less time for the same number of dosimeters than irradiation using a collimated system.

5. CONCLUSION

The dose-response research on testing of ^{137}Cs panoramic irradiation prototype showed that the reading dose of TLD-900 was relatively higher than OSLD. The difference between the TLD-900 reading dose to OSLD ranged from 0.10 – 1.44 mSv, with a greater tendency for the higher dose. The linearity curve between reading dose to exposure time tends to be linear with a correlation factor (R^2) of 0.9999 for OSLD and 0.9988 for TLD-900.

The measured dose rate on holders 1 to 6 of the prototype has an average value of 1.02 mSv/h and a standard deviation of 1.5%. The dose rate distribution on the holder 1 to 6 ranged from 1.01-1,04 mSv/jam at a 29 cm distance.

The study on the personnel dose response of the ^{137}Cs panoramic irradiation device can be used as a reference for personnel dosimeter irradiation activities at the Dosimetry Laboratory of LTKMR NRIA. However, prior verification by the Calibration Laboratory is required regarding the method and result of the irradiation dose.

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