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Determination of Uniformity Value Response and Calibration Factors TLD Chips Using GAMMA Sources

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ABSTRACT

The response of the Thermoluminescence Dosimeter (TLD) varies from one type of TLD to another depending on the material, thickness, holder, filter/absorber on each chip, type of radiation, energy and direction of radiation. This research was conducted to determine the uniformity value of the TLD chip response and to determine the calibration factor of the TLD chip using a gamma radiation source. The TLD response must be known so that the measurement results are accurate. TLD-100 irradiation in this study used a radiation source Cesium – 137. TLD used as many as 150 pieces with a large irradiation dose of 5 mSv. The irradiated TLD-100 response resulted in a standard deviation of 1% to 5% with each response corresponding to its standard deviation value. The results of the irradiation in this study the value of the calibration factor obtained for the standard deviation values of 1%, 2%, 3%, 4%, and 5% which ranged between 0,121 mSv/nC – 0,206 mSv/nC. With a large uniformity of variation in the range of 2,25% - 14%.

Keywords: TLD-100, calibration factor, standard deviation, TLD response, gamma rays.

I. INTRODUCTION

Gamma Ray research was discovered by Henri Becquerel and a married couple, namely Pierre Currie and Marie Currie, in the late 1890s. Gamma radiation is a form of ionizing radiation that has quite greater penetrating power than alpha or beta particles. Gamma rays form the electromagnetic spectrum with the highest energy. Gamma decay occurs in excited nuclei for light nuclei which have a magic number with scattered energy levels which will give the decay of one strong gamma photon, whereas in heavy nuclei with dense energy levels it will give gamma radiation in the form of a complex spectrum1. The use of ionizing radiation in the form of gamma rays apart from providing benefits to the medical world, also has the potential to have detrimental effects on workers, patients and society. One use of gamma rays in the medical field is for radiotherapy or radiation therapy for cancer treatment. However, it will be very risky for health and safety if the dose is not in accordance with the prescribed values. Measuring radiation exposure is one of the monitoring efforts to protect the general public from the detrimental impacts of using ionizing radiation2. Personal dosimeters commonly used by radiation workers is the Thermoluminescence Dosemeter (TLD).

TLD can be used for X-ray dose monitoring, neutron dose and gamma ray dose measurements, neutron fluence measurements, verification and improvement of neutron activation technology in nuclear fusion devices3. Before being used for radiation dose monitoring, the TLD response must be known. Various types of TLD have different responses depending on the material, thickness, holder, filter/absorber on each chip, type of radiation, energy, and direction of incoming radiation. Apart from that, different types of radiation will cause different characteristics because the interaction process of radiation with matter is different4.

Research conducted to find out whether the condition of the TLD still has a good response or has experienced a decline in function. Of course, the characteristics of equipment and materials can change as a function of time and frequency of use. Therefore, the response and sensitivity of the tool must be checked before use or after use for a period or several years. Likewise, continuous use of TLDs for the purposes of monitoring individual/radiation worker doses can reduce the performance of the TLD. To ensure that the TLD is in a suitable condition for use or within the permitted tolerance range, quality assurance or steps must be taken to guarantee the quality of the measurement results.

II. METHODS AND MATERIAL

In this research, TLD-100 responses will be sought using sources gamma radiation with a total of 150 TLD chips. Next this TLD will grouped and calibrated for use as radiation dose monitoring for workers.

a. Annealing TLD – 100

Annealing standards for LiF:Mg,Ti materials (TLD-100, TLD-600 and TLD-700) are two process temperatures. Implemented using two separate ovens, with each oven set, to one of two temperatures. First stage, Heating is carried out at a high temperature of 400°C for an hour and after cooling down, then the second heating is carried out at a lower temperature 200°C for two hours. This is done so that the remaining residue in the TLD can be disposed of properly.

b. Irradiation TLD – 100

TLD irradiation was carried out using a Cesium-137 source with an energy of 662 KeV. The TLD is attached to the center of the PMMA phantom has a standard phantom size of 30 x 30 x 15 cm3, with a distance between phantom with a source that is 200 cm away and a wide irradiation field 10 x 10 cm. Then determine the size of the dose to be given 5 mSv, determining the size of this dose is in accordance with the intended use TLD dosimeter for radiodiagnostic use, the dose used is close to the dose most often used in this procedure.

c. TLD Response Reading

After irradiation, all TLDs to be tested are left for 24 hours before reading, this aims to remove unstable energy peaks in traps crystal. This unstable energy peak will naturally is wasted because how many electrons are trapped at that energy level lower. Before TLDs Reader used for reading the first measured value background from five readings with a time of 30 seconds. After that measure the value lightsource from the five times reading with a time of 10 seconds followed by re-reading background tool after reading lightsource once in 30 seconds. TLD – 100 which has been irradiated is read with a TLD

Reader where the temperature range is between 50°C – 260°C.

d. Determination of TLD Response Uniformity Variation Values and Calibration Factors

For determine the uniformity variation value, SPC is used (Statistical Process Control). Then each TLD response is included in the control chart using the upper control limit and lower control limit equations as in the following equation:

$$UWL = \mu_r + k\sigma_r \quad (1)$$

$$LWL = \mu_r - k\sigma_r \quad (2)$$

$$\text{Uniformity Variation} = \frac{\sigma_r}{\mu_r} \times 100 \quad (3)$$

With μ_r is the average response of the TLD element, k is the control limit distance from the center with a value of 2 for LWL and UWL with a value of 3 for UAL and LAL. σ_r is the standard deviation of the TLD response.

After reading the TLD, you can then determine the TLD uniformity value and determine the calibration factor value of the TLD, with the calibration factor formula used:

$$FK = \frac{\text{Dmaks}}{\text{Reading value of TLD 100}} \quad (4)$$

where FK is the calibration factor (mSv/nC), Dmax is the radiation dose given during irradiation (mSv) and TLD Reading is the TLD net response value (Rnet) with units (nC).

III. RESULTS AND DISCUSSION

The results of the uniformity values for each response are plotted in the following graph:

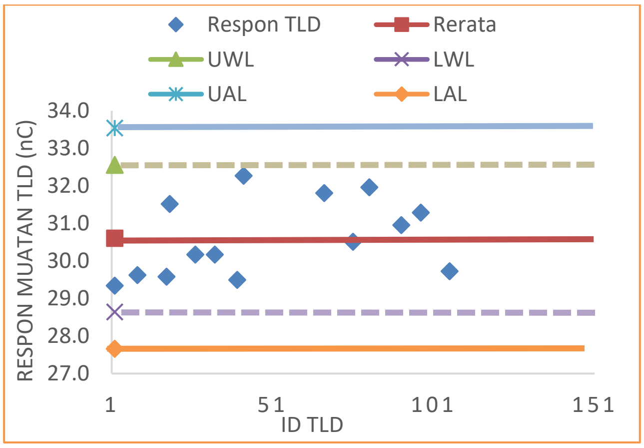

Figure 1. Uniformity of group responses standard deviation 1%.

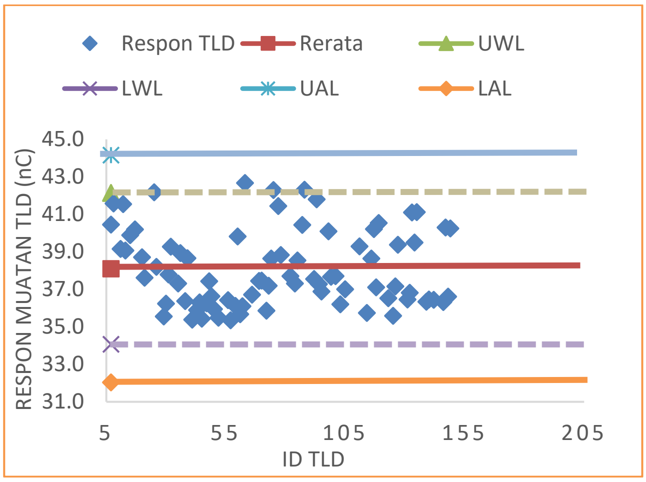

Figure 2. Uniformity of group responses standard deviation 2%.

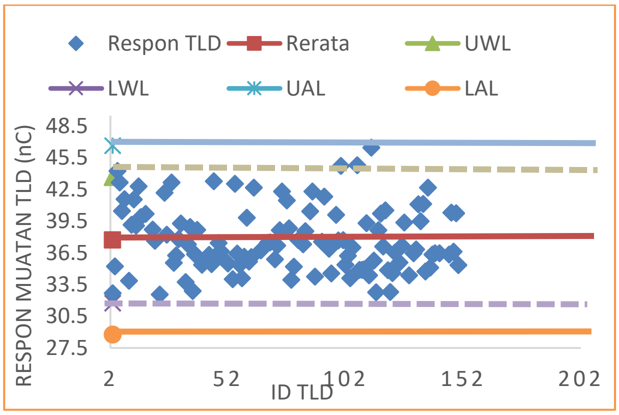

Figure 3. Uniformity of group responses standard deviation 3%.

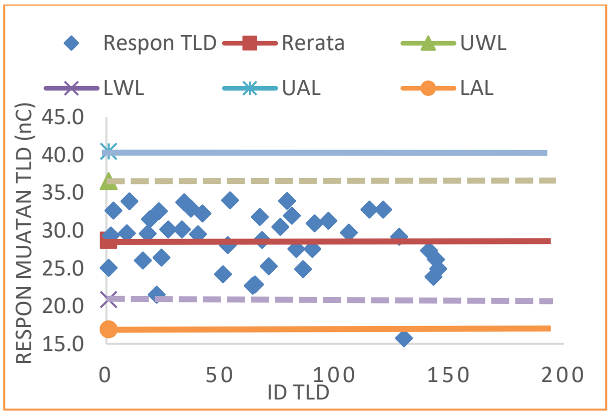

Figure 4. Uniformity of group responses standard deviation 4%.

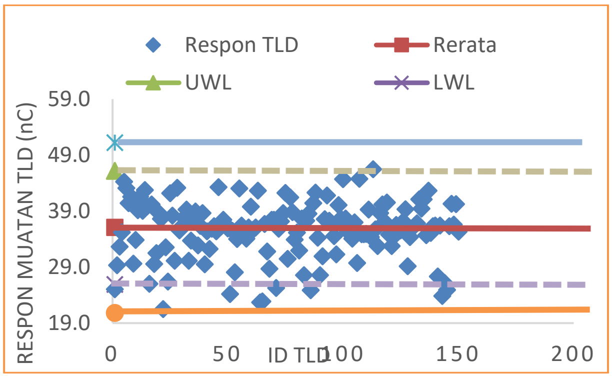

Figure 5. Uniformity of group responses standard deviation 5%.

The figure above is the result of grouping TLD reading responses based on their standard deviation values. From this research, deviation groups were obtained from 1% to 5%, with each deviation consisting of several groups, namely at 1% standard deviation there were 6 response groups, at 2% standard deviation there were 3 response groups, at 3% there were 2 response groups. and in the 4% and 5% groups there was only one response group. From grouping responses based on deviation values, it can be concluded that of the 150 TLD-100 pieces, there are 16 TLDs that need to be re-illuminated because they are outside the value range. Lower Warning Level And Upper Warning Level and there is a TLD that is no longer suitable for use or cannot be used again because it is out of value Lower Action Limit. The calibration factor values obtained in this study ranged from 0.121 mSv/nC – 0.206 mSv/nC.

IV. CONCLUSION

The results of this research showed that the TLD-100 response uniformity value was in a fairly uniform range. With a large uniformity of variation in the range of 2.25% - 14%.

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