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Characterization and calibration of thermoluminescent dosimeters of LiF:Mg, Ti in the quantity $H_p(0.07)$

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ABSTRACT

The extremity dosimeters are devices used to quantifying the radiation dose that the occupationally exposed individual receives in specific regions of the body during the work time. Dosimeter calibration is essential so that the dosimeter response is equivalent to the received dose. Tests such as batch homogeneity and lower detection limit are part of the dosimeter calibration process. The rod phantom simulates the region of interest regarding the interaction with radiation and the scattered dose. The extremity dosimeters used were the LiF:Mg,Ti thermoluminescent dosimeters.

Keywords: **Calibration, Extremity dosimeter, Quantity $H_p(0.07)$.**

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1. INTRODUCTION

Extremity dosimeters are used by occupationally exposed individuals who inevitably receive radiation in specific regions of the body [1]. The development and implementation of an extremity dosimetry system for routine use involves characterization tests and calibration of the dosimeters to be used. These tests evaluate the quality of the results obtained in comparison with the adopted reference characteristics.

In Brazil, so far, there are no recommendations for extremity dosimetry [1]. However, in this work, the recommendations of the Testing and Calibration Services Evaluation Committee (CASEC) [2] were used, which establishes procedures for the performance of the dosimeter characterization tests, adapted for the extremity (ring) dosimeters.

In this work the following tests were performed batch response homogeneity and lower detection limit determination.

2. MATERIALS AND METHODS

The ring model dosimeter used contains a thermoluminescent detector of LiF:Mg, Ti, it is manufactured by the Harshaw/Bicron company, commercially known as TLD-100. The detector is fixed to a PTFE-Teflon® holder shown in Figure 1.

Figure 1: *PTFE-Teflon® holder and thermoluminescent detector of LiF:Mg, Ti.*
Source: Copyright image

The phantom rod type indicated in the recommendations of International Commission on Radiation Units and Measurements (ICRU) Report 47 [3] was used to calibration irradiations in $H_p(0.07)$. It is a water-filled hollow cylinder with PMMA walls, with outer diameter of 73 mm and length of 300 mm. The cylinder walls are 2.5 mm thick and the faces 10 mm thick [4], shown in Figure 2.

Figure 2: *Rod-type phantom used to irradiations in $H_p(0.07)$.*
Source: Copyright image

The TL readings were carried out using a thermoluminescent reader Harshaw 4500 [5], always 60 min after the irradiations. The reuse heat treatment of the LiF:Mg, Ti dosimeters was performed on the Harshaw 4500 reader, according to manufacturer instructions.

The irradiations were carried out using a Cesium-137 gamma source, with the rod-type simulator in a vertical position. Ten dosimeters were irradiated at source-dosimeter distance of 60 cm, centered on the long axis of the phantom.

The position and distance between the dosimeters were maintained in all irradiations.

2.1- Methods

1- **Batch homogeneity test**

A group of 23 TL dosimeters were irradiated with conventional true value of 2 mSv in the quantity Hp(0.07). The evaluated value A for each dosimeter was determined and the detectors that presented the highest and lowest values were identified to verify the system performance [2]. According to Equation 1.

$$\frac{A_{max}-A_{min}}{A_{min}} \leq 0.3 \quad (1)$$

Where:

A_{max} is the highest value of the assessed dose;

A_{min} is the lowest value of the assessed dose.

2- **Lower detection limit determination test**

This test was performed according to the document IRD-RT 002.01/95 [3]. A group of 20 monitors was irradiated with the conventional true value of 0.20 mSv in the quantity $H_p(0.07)$. The mean value of the readings and the standard deviation of the mean $s_{\bar{A}}$ were determined for all dosimeters. The purpose of the test is to ensure that the lower detection limit of the thermoluminescent is according to Equation 2.

$$t_n \cdot s_{\bar{A}} \leq 0.20 \text{ mSv} \quad (2)$$

Where:

0.20 mSv is the lower detection limit;

t_n is Student's *t* for n-1 degrees of freedom (n= number of dosimeters used in the test), which can be found in the document IRD-RT 002.01/95 [3];

$s_{\bar{A}}$ is the standard deviation of the mean.

3. RESULTS AND DISCUSSION

3.1- Batch homogeneity test

The result obtained was:

A_{max} = 2.105

A_{min} = 1.712

$$\frac{2.105-1.712}{1.712} = 0.2$$

The obtained result ensures a good level of homogeneity in the response of the extremity dosimetry system.

3.2- Lower detection limit determination test

The result obtained was as follows:

t_n = 2.09

$s_{\bar{A}}$ = 0.0132

$$2.09 \cdot 0.0132 \leq 0.028 \text{ mSv}$$

4. CONCLUSION

The obtained results indicate that the studied dosimetry system fulfills the requirements of calibration and characterization in the quantity Hp(0.07), using a rod phantom recommended by ICRU in Report 47 [3], in gamma radiation field (137Cs) and by CASEC.

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