2021 International Nuclear Atlantic Conference – INAC 2021
Virtual meeting, Brazil, November 29 – December 2, 2021

ISBN: 978-65-594-1256-3

Characterization and calibration of thermoluminescent dosimeters of LiF:Mg, Ti in the 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. The tests consist of batch response homogeneity and lower detection limit determination.

2. Methodology

The ring model dosimeters that were 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 Fig 1.

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

The phantom used was of the rod type, indicated in the recommendations of International Commission on Radiation Units and Measurements (ICRU) Report 47 [3], 300 mm long and 19 mm in diameter. 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 and the faces 10 mm thick [4], shown in Fig 2.

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

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.

3. Results and Discussion

Batch homogeneity test: a group of 23 TL dosimeters were irradiated with conventional true value of 2 mSv in the quantity $H_p(0.07)$. 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.

$$\frac{A_{max}-A_{min}}{A_{min}} \leq 0.3 \tag{1}$$

Where:

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

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

The result obtained was:

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

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

Lower detection limit determination test: This test was performed according to the document 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.

$$t_n \cdot s_{\bar{A}} \leq 0.20 \text{ mSv} \tag{2}$$

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 RT 002.01/95 [3];
$s_{\bar{A}}$ is the standard deviation of the mean.
The result obtained was as follows:

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

The lower detection limit obtained is better than the maximum allowed limit.

4. Conclusions

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

Acknowledgements

The authors are grateful to the financial support given to this research to: FAPESP – Proc. No. 2018/05982-0 and CNPq - Proc. No. 426513/2018-5.

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