Characterization and Calibration of Glass Beads for Dosimetry in Gamma Range

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INTRODUCTION

Radiotherapy treatments require smallest detectors to determine the dose administered to patients at different intensities. Dose values are important for treatment to be effective according to well-defined protocols. Dose fractionation is often used, which doses below those defined as therapeutic may be ineffective, as well as higher doses may cause injury and burns for treatment. That process requires specific dosimeters for beam analysis with high spatial resolution and accuracy.

Figure 1: Sinergy Accelerator

MATERIALS

- Commercially evaluated glass thermoluminescent dosimeters (TL) exhibit properties that can be used in radiotherapy.

- They are small size, low cost, reuse, chemically inert, independent of the angular incidence of the beam and have high sensitivity to radiation with a large dose range (0.01 to 100 Gy).

- According to the TRS 457 (IAEA), radiotherapy determines the accuracy of 5% in absorbed dose delivery, considering a 95% confidence level estimated at a level of uncertainty, so that the calibration of dosimeters used in radiotherapy is accurate for irradiation to eradicate tumors and possible complications in healthy tissues.

Figure 2: Glass Beads

MATERIALS

The Irradiator OB85/1 is located in the Center for the Development of Nuclear Technology (CDTN), in the Calibration Laboratory of Dosimeters (LCD) and has three different sources, being Amerício-241, cesium-137 and cobalt-60. This output has a diameter of 8.6 cm and when collide, the output becomes 5.2 cm. The source of the cesium-137 has a activity of 740 Bq and dimension of 200 mm in diameter.

Figure 3 – The Irradiator OB85/1

MATERIALS

- For the selection of the TL glass dosimeters, irradiations, readings, and measurements were performed on the RISØ reader system, model TL / OSL-DA-20, RISØ (National Laboratory, Denmark).

- The RISØ consists of a light detection system (photomultiplier and filters), a beta radiator and a module with photomultiplier preamplifier, control and programming. The equipment has a carousel with a capacity of 48 TL dosimeters and a radioactive beta source of $^{90}Sr+^{90}Y$, with the activity of 1.48 GBq (on 23/05/2019) and half-life of 29.1 years.

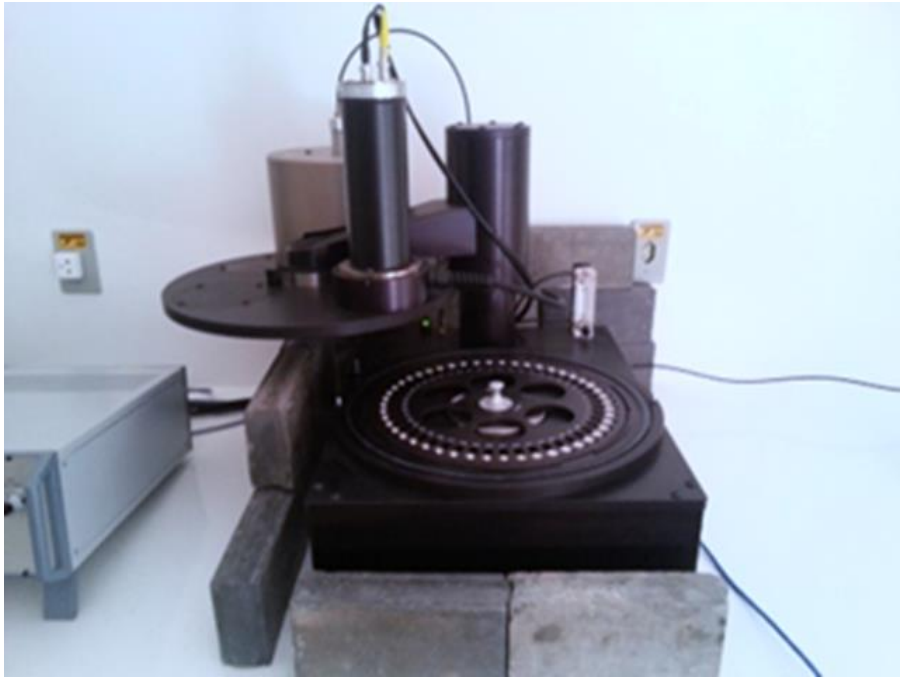

Figure 4: The RISØ TL/OSL

METHODOLOGY

- Previously irradiation, the preparation of TL dosimeters required annealing. Annealing eliminates precedent performed irradiation residues and records of natural radiation (background).

- The process was performed by a ramp method, heating the dosimeters to 400 ºC for one hour at a rate of 10 ºC.min^{-1}. Thereafter, the temperature was reduced to 100 °C and held for 2h followed by a temperature of 50 °C for 50 min at the same rate.

- The heat treatment was carried out in a Mufla industrial furnace of the Lavoisier manufacturer, model 402D, with the microprocessor digital electronic controller; model Eurotherm 2416, of the Coel manufacturer.

METHODOLOGY

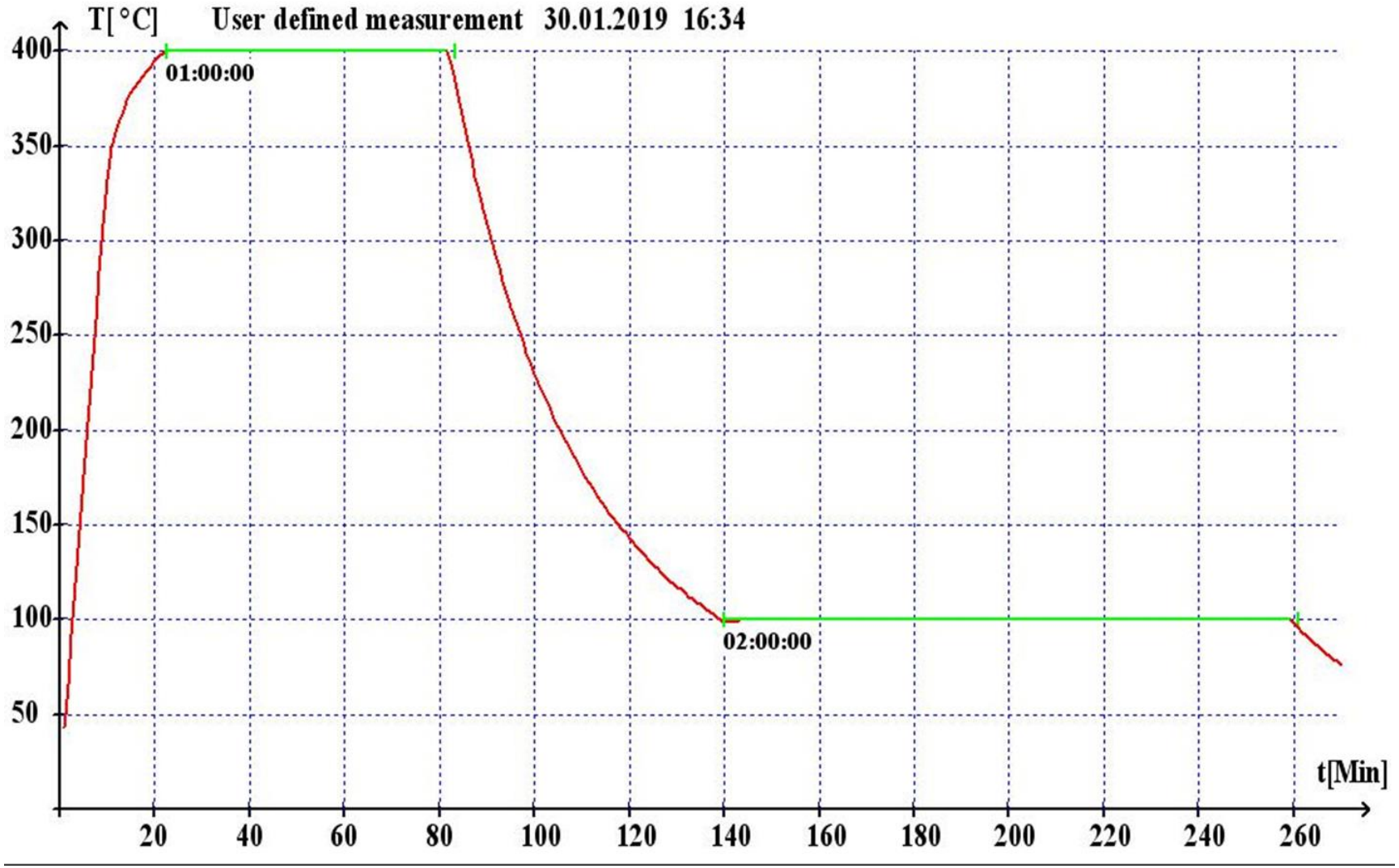

Figure 3: Annealing´s graph.

METHODOLOGY

- To demonstrate metrological reliability, five batches of TL dosimeters containing forty-eight on each carousel were selected, resulting in two hundred and forty TL dosimeters.

- The TL dosimeters were placed on the carousel, allowing positioning under the reader in a chamber below the photomultiplier where they were heated on a metal drawing board. This procedure was repeated ten times and the measurement results were recorded.

- Thermoluminescent emission peaks were analyzed and isolated to identify a higher dose peak in the temperature range of 200 to 250 ºC.

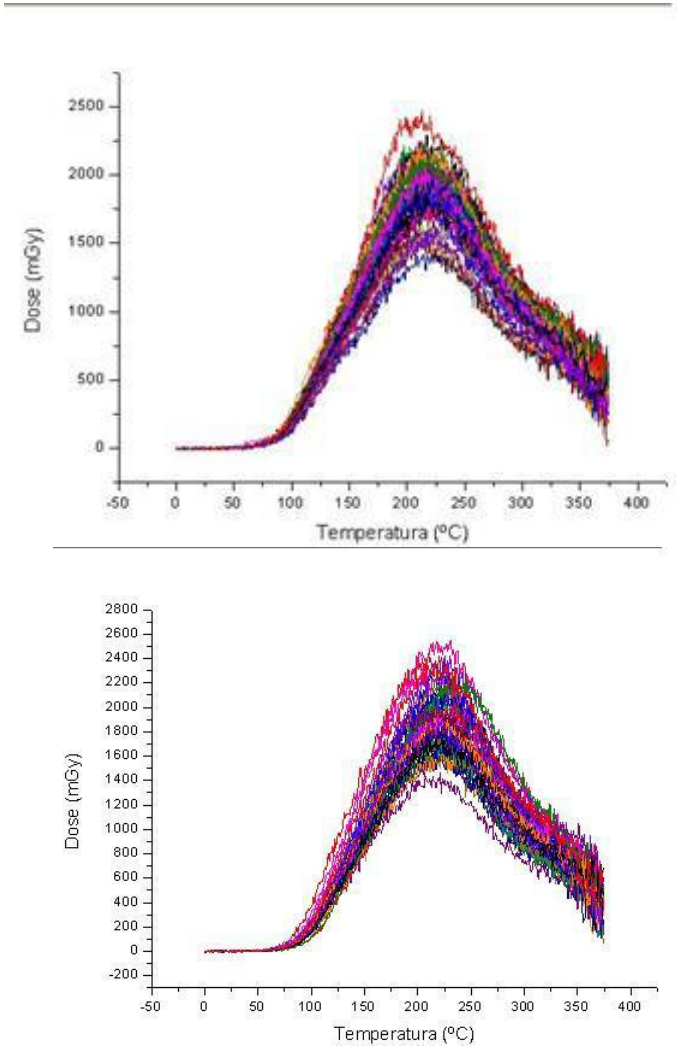

Figure 4 - Thermoluminescent response of glass beads

METHODOLOGY

- In the selection, a batch of 15 TL dosimeters were separated, being considered dosimeters suitable for measurements, irradiated in the energy of ^{137}Cs and read in the RISØ reader.

- The TL dosimeters were placed on the carousel, allowing positioning under the reader in a chamber below the photomultiplier where they were heated on a metal drawing board. This procedure was repeated ten times and the measurement results were recorded.

- For radiotherapy applications, it is desirable that a dosimetry system doesn´t take any practical change in energy response along the beams.

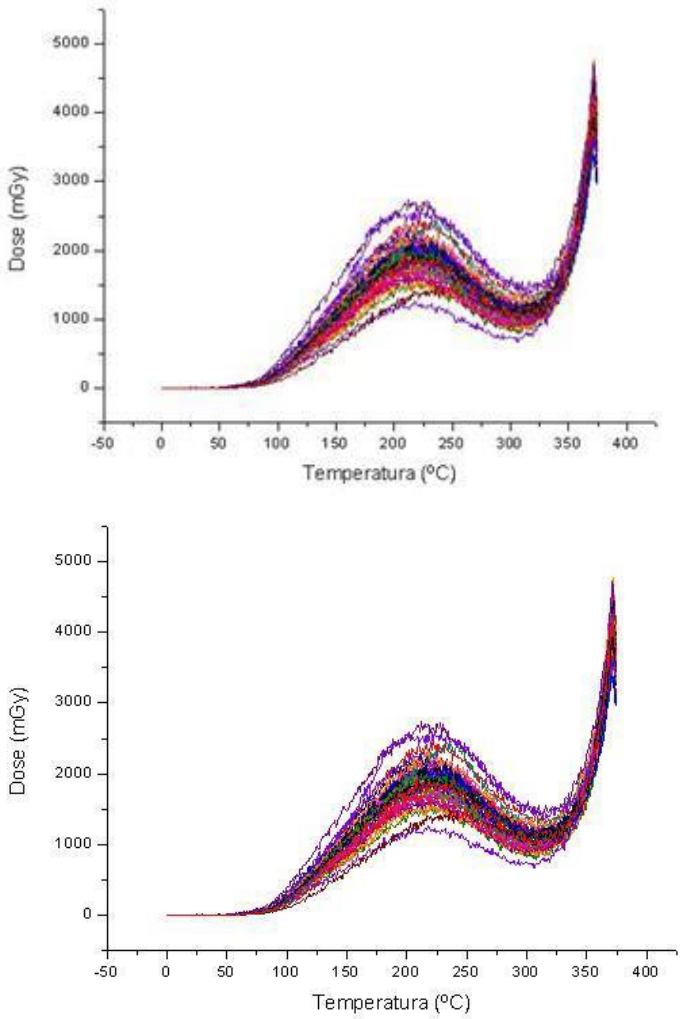

Figure 4 - Thermoluminescent response of glass beads

RESULTS AND DISCUSSION

- The results of the characterization of the batch of TL dosimeters, performed in the RISØ reader system, were based on the calculations to determine the individual sensitivity of the TL dosimeters, described be by equation:

$$v = \frac{S}{L} \times 100$$

- where S is the average of the readings in counts per second of the irradiations performed and L is the standard deviation is the average of the readings obtained in the batch.

- The results show the importance of dosimeter calibration to avoid dosimeter overestimation error.

RESULTS AND DISCUSSION

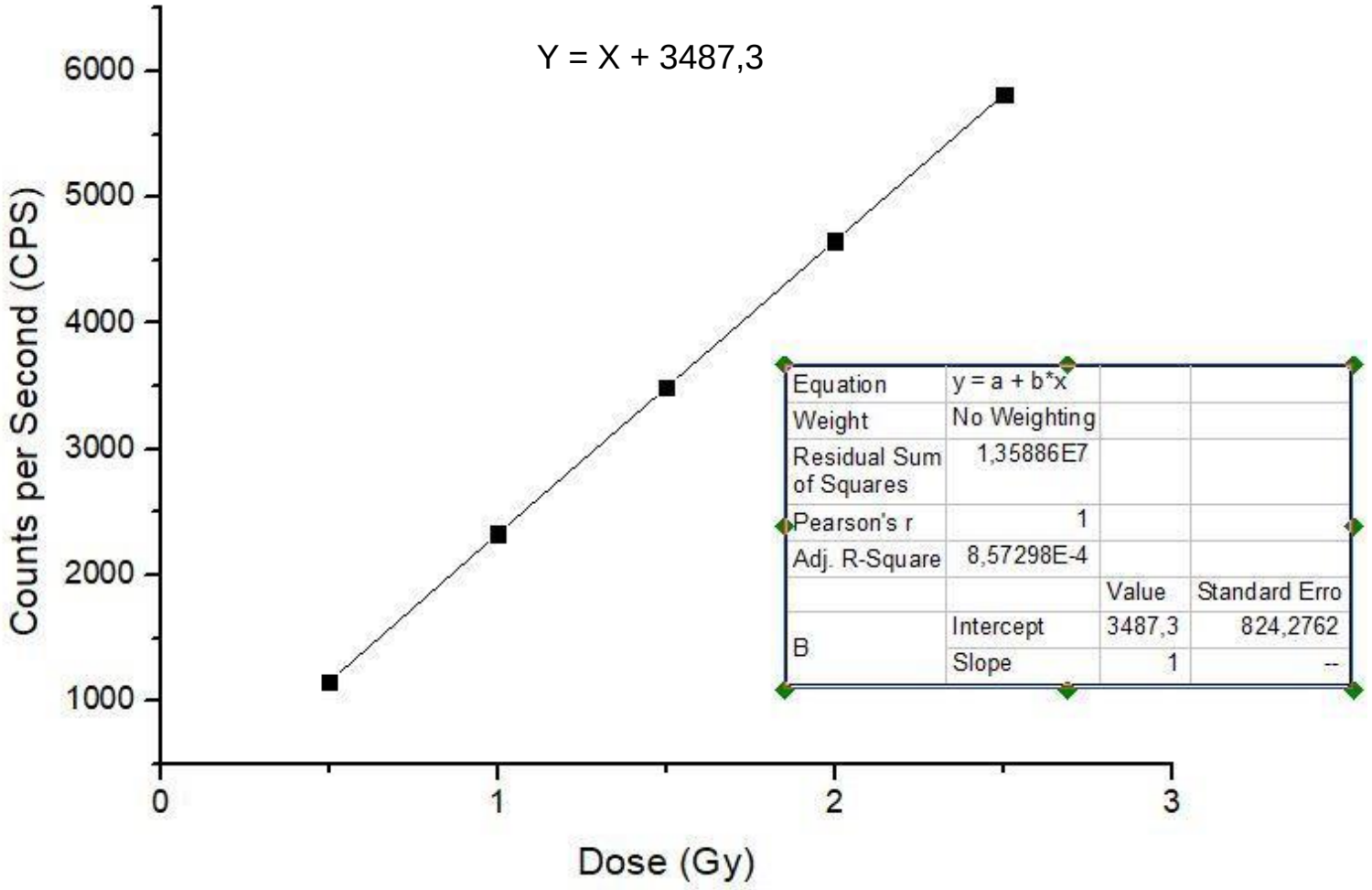

Figure 5: Calibration´s Graph.

CONCLUSIONS

The metrological reliability of the TL glass beads system was studied in the radiotherapy range with small variation of the gamma beam energy response (<5%). Regarding air kerma, the TL dosimeters showed a high linearity. The characteristics investigated show that there is a great potential in the use of glass beads as TL dosimeters for radiotherapy measurements, especially for the high dose sensitivity and their reuse and linear response.

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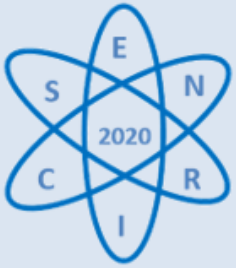

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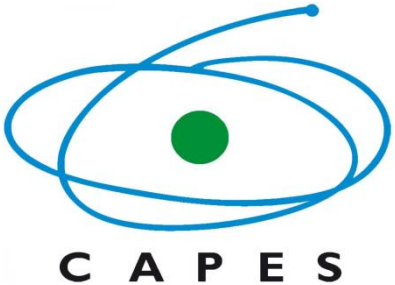

THANKS!