

REPRODUCIBILITY STUDY OF TLD-100 DOSIMETERS FOR ^{125}I SEEDS USED IN BRACHYTHERAPY

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ABSTRACT

In order to provide the dosimetry for ^{125}I seed production in Brazil, Harshaw thermoluminescent dosimeters (TLD-100) will be used. Even if measurements with TLD-100 of the same batch of fabrication are performed, the precision of the response will not be the same. As a consequence, they must be measured one by one. This paper presents the calculation methodology for selection procedure to TLD-100 dosimeter used, embracing 143 TLD-100 dosimeters prepared by Harshaw Company on December 19th, 2005. These dosimeters are LiF type with a micro-cube (1mm x 1mm x 1mm) shape. The annealing procedure used for these dosimeters consists of annealing the TLD dosimeters at 400°C for 65 minutes using a PC controlled annealing oven. This procedure is followed by an oven-typical cooling down profile to about 100°C for 127 minutes. The pre-readout thermal stabilization was used and it consists of an annealing at 100°C for 15 minutes. Irradiations were performed using 36 ^{125}I seeds with activity of 0,623 mCi (23,05 MBq) on October 20th, 2006 for approximately 150 minutes, to guarantee a minimum of 5 Gy absorbed dose in each dosimeter. Different evanescence times have been used. These complete procedures were carried out four times in order to compare the data and minimize the systematic error.

Key Words: Brachytherapy, Iodine 125, Quality Control.

I. Introduction

In the world, the number of new cases diagnosed was 15,3% of all types of cancer in development countries and only 4,3% in sub-developed countries. The main reason can be the previous diagnosis that has been done in the richest countries. However Brazil is not a developed country, the National Institute of Cancer (INCA) has reached a good index to the richest states (in South Region, the tax is 6,8% and in Southeast region is 6,3%), but worse index in the poorest regions, such North region with 2,2% and Northeast region with 3,4%. In Brazil the index was 4,74%. The diagnosis rate increases in regions that the Prostate Specific Antigen test was conducted. The mortality caused by prostate cancer has low rate explained mainly by previous diagnosis. The prostate cancer was considered a third age illness, because 75% of cases occur in 65 years old men [1].

One of the treatments used was interstitial brachytherapy with ^{125}I seed, because the procedure has low impact, allowing most patients to return to their normal activities between one or three days after the intervention, with a small or no pain. The other important benefits for the patients are the low impotence rates and few incidents of urinary incontinence.

In 1998, the IPEN / CNEN – SP (Nuclear Energetic Research Institute from the National Nuclear Energy Commission), the biggest institute in Brazil, start a project to develop and produce Iodine-125 seeds. The project must be finished in the end of the next year [2].

One part of this project is the dose evaluation of the seeds and the AAPM (American Association of Physicists in Medicine) recommends that all new products must have the dosimetric characteristics be evaluated at least once. The institute decides to carry on experimental study of the dose distribution using an appropriate phantom of which includes absolute dose-rate measurements [3].

In order to provide the dosimetry for ^{125}I seed production in Brazil, Harshaw thermoluminescent dosimeters (TLD-100) will be used. Even if measurements with TLD-100 of the same batch of fabrication are performed, the precision of the response will not be the same. As a consequence, they must be measured one by one. This paper presents the calculation methodology for an individual correction factor to each dosimeter used, embracing 143 TLD-100 dosimeters prepared by Harshaw Company on December 19th, 2005.

II. Materials and Methods

A. ^{125}I Source

The ^{125}I seeds used to irradiate TLDs were manufactured by Amershan - GE Healthcare Ltd, model 6711. The batch contains 36 seeds and the activity of batch was 829,836 MBq (22,428 mCi) in the reference date March 30, 2007, or individual activity of 23,051 MBq (0,623 mCi).

The Amershan – GE Healthcare Ltd design the model 6711 with a physical length of 4,5 mm and outer diameter of 0,8 mm. The ^{125}I was adsorbed on the surface of a 3 mm long and 0,5 mm diameter silver rod, which was encapsulated in a 0,05 mm thick titanium capsule. The silver rod serves as a x-ray marker.

B. Dosimeters

Dose distribution around the source was measured using a 143 LiF thermoluminescent dosimeters (TLD-100, Harshaw / Bicon). The TLD-100 chips dimensions used were 1,0 mm x 1,0 mm x 1,0 mm. The irradiated TLDs were read using a Harshaw Model QS 5500 with automatic positioning disc system.

The annealing procedure used for TL dosimeters consists of annealing the TLD dosimeters at 400°C for 65 minutes using a PC controlled annealing oven [4]. This procedure was followed by an oven-typical cooling down profile to about 100°C for 127 minutes. The oven is a PTW-TLDO, manufactured by Physikalisch-Technische Werkstätten (PTW), Freiburg, Germany.

The pre-readout thermal stabilization was used and it consists of an annealing at 100°C for 15 minutes. This treatment was also carried out in the PTW-TLDO oven.

For the irradiation of the TLDs for the experiment, one slab of polystyrene material was machined to accommodate the source and the LiF chips to guarantee the positioning of them in each batch experiment.

III. Experimental procedure

A. Irradiation and Measure

Four batches of measure were carried out in last November with 143 TLDs. The time of irradiation used was 2 hours and 20 minutes for each irradiation. As there are 143 dosimeters and 36 ^{125}I sources, all batches were done by the same sequence, described above.

- 1) All TLDs were put in a magazine with numbered cells and the position in the polystyrene slab was numbered also. Then, each TLD received a number that will guarantee that all measures are done in the same position.
- 2) The TLDs were placed in the polystyrene slab.
- 3) After the position of TLDs, the seeds used to irradiate the crystals were placed one by one. The irradiation time was 2 hours and 20 minutes, or approximately 5 Gy of absorbed dose.
- 4) After the time of irradiation finished, the seeds were left in the same sequence that they were placed. It is important to notice that the time between the first seed was placed and the first seed got out must be the same time that the last seed was placed and got out
- 5) The magazine with the TLDs irradiated was closed in a box to guarantee the absence of the light.

- 6) After passing the evanescence time that must be a minimum of 8 hours, in a low light room, the TLDs were placed in the automatic positioning disc maintaining the same number sequence that it was used.
- 7) After the reading of each dosimeter, it was placed again in the same position in the magazine. This sequence was repeated four times for each batch.

B. Procedures errors

In this work, we analyzed 143 TLD-100 crystals with different times of evanescence after the irradiation: 8 hours, 12 hours, 15 hours and 18,5 hours.

Each TLD-100 was measured in Harshaw model QS 5500. This equipment was used, because it has a system that guarantee the positioning of the crystal in the reading chamber. This positioning system reduces the geometrical system error [5].

Another error source that it needs to be discussed, it was about the irradiation time, because in each run, the time of irradiation was the same for all crystals, but in different batches this time may be almost the same, but it can not be guaranteed.

C. Data

The system used to calculate the measures was to divide each measure for the sum of all measures in the batch, to guarantee that each individual TLD-100 measure has the same irradiation time proportionally of each batch.

$$Q_i = \frac{M_i}{\sum M} \quad (1)$$

where M_i was the value of each individual dosimeter in each run.

For these measures we did two considerations:

- 1) Analyze the standard deviation for the four batches values ;
- 2) Analyze the mean for the values.

IV. Discussions

The standard deviation (SD) is directly related to the total reproducibility of the experiment. Then, the minimum SD is desired.

The mean of the four values presents the measurement procedure stability. Then, for the mean value is desired to be closed to one.

In the dosimeter selection procedure, it was used a limit of 15% SD maximum. Using this criterion, it was excluded 71 dosimeters.

Like it was done four batches of measurement for each dosimeter, we analyzed the mean of the runs.

It was used a limit of mean plus or minus 10%. Using this criterion, it was excluded 51 dosimeters.

The criterion SD used correlates the criterion mean value, because both are dependent of the average measures used in the experimental technique, by this way, the criteria are not totally independent but not also totally dependent, as it can be seen in equation (1), the mean values obtained depended on the sum value of the run. Then, to guarantee that each criteria was accepted, the dosimeter to be considered "usable" has to be accept in both criteria separately.

After the running of the batches we have only 45 dosimeters that passed in the criteria and 98 dosimeters were excluded.

V. Conclusion

The selection procedure used in this work presents a good accordance with the experimental apparatus and technical conditions available. This method of selection is simple and easy to use.

The values of the SD and the limit of mean used in this work was not so low, but like in the dosimeter measurement we will use an individual factor for each dosimeter, then the values used will be accepted for the brachytherapy dosimeter procedure.

Like you can see in the previous experimental measures showed in this work, the values of each dosimeter are not so closely, then, it is very important to a dosimetric measure that you use an individual factor for the calibration in each dosimeter. The individual measure will minimize the systematic error of the whole methodology, but this will be discussed in a future works.

VI. References

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