



Calculation of Correction Factors for Dosimeters Thermoluminescent of Lithium Fluoride (LiF-100) for Use in 6MV Photon Beams

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Abstract— Since the beginning of its use, radiation has already presented harm, justifying the necessity of controlled use. In order to monitor its effects and even avoid them, dosimetry has arisen. For the purpose of ensured all the necessary safety and monitor areas where there is radiation use, a lot of devices able to identify and quantify many types of radiation were developed. However, some these dosimeters are more widely used today like ionizing chamber, chemical dosimeters, photographic dosimeters and thermoluminescent dosimeters (TLD). When a group of TLD is obtained with a quantity n of dosimeters, there is a variation of answer of these dosimeters when they are subjected to the same irradiations conditions, from this comes the importance of individual calibration of these, to select the dosimeters with close answers, reducing the uncertainties of the measures. Therefore, this work presents the calculation of correction factors for the TLD of lithium fluoride (LiF-100) and shows how this factors can improve the TLD's readings.

Keywords— dosimetry, TLD, correction factor.

I. INTRODUCTION

Since the beginning of its use, radiation has already presented harm, justifying the necessity of controlled use. In order to monitor the effects and even avoid them, dosimetry has arisen, dealing with the measurement of absorbed dose, or dose rate, resulting from the interaction of ionizing radiation with matter. In a broader way, it refers to determining quantities that have some radiological relevance, like exposure, kerma, fluency, equivalent dose, deposited energy, and others, since by experimental measures than through calculation [1].

The use of radiation for therapeutic and radiology purposes must follow Radiological Protection's principles, those report that the practice must justified only when it provides more benefits than harm; it must be optimized, so that radiation dose used is as low as reasonable possible (ALARA) and limits of dose established, for exposed occupationally individuals (workers) and public individuals, must be respected, as limits taxes for even kind of organs and tissues of human body [1][2].

For the purpose of ensured all the necessary safety and monitor areas where there is radiation use, even as workers and public individuals, a lot of devices able to identify and quantify many types of radiation were

developed, each of them is better in determined situations and radiation kind. However, some these dosimeters are more widely used today, due many protocols of dosimetry that were created in order to standardize clinic dosimetry. The most used dosimeters, in medicine, are ionizing chamber, chemical dosimeters, photographic dosimeters and thermoluminescent dosimeters (TLD) [3].

TLD makes an important role in dosimetry, mainly in radiotherapy, due to facility of its manipulation and its use, since it has smaller dimensions, which is also a very important characteristic, facilitating its use in locals where others don't fit very well. Moreover, the fact that there are TLD of several formats and types of materials also make this dosimeter a strong ally in the evaluation of radiation beams of photons and electrons, as in the calibration of these [3][4].

Indeed, when a group of TLD is obtained with a quantity n of dosimeters, there is a variation of answer of these dosimeters when they are subjected to the same irradiations conditions, from this comes the importance of individual calibration of these, to select the dosimeters with close answers, reducing the uncertainties of the measures. Besides obtaining the dose-response curve for each TLD of the group, an option is to calculate an individual correction factor that makes the dosimeters toward a mean value of the group, reducing, also, the fluctuations in the measurements.

Therefore, this work aimed to calculate the individual correction factors for the 115 dosimeters thermoluminescents of lithium fluoride (LiF-100), which will be use, later, for evaluation of photons' beams of 6MV in dosimetry of clinical cases that use larges fields of irradiation.

II. METODOLOGIA

To calculate the correction factor is extremely important that all the procedures, since prepare of TLD until irradiation and reading these, be repeated exactly the same mode all the times which is realized. This importance occurs due to the fact of this correction takes place in reproducibility of the dosimeters, namely, checks how much each TLD is reproducible and the factor aims further improve this individual reproducibility, correcting the readings of all dosimeters for the closest possible of the mean reading of the group.



So, the proceedings described following were reproduced five times and the results obtained were utilized for the calculation of individuals correction factors.

A. TLD's preparation

Before of the irradiation, the TLDs need to pass through a thermal treatment, called pre-irradiation heat treatment that ensures that remains no noise related to previous irradiation.

For each kind of TLD there is a more appropriate heat treatment, so that for the group used, it has 115 TLDs, type LiF-100, the procedures adopted were the following:

- Heating for one hour at 400°C: it's performed to "clear" the dosimeters, that is, to reset the readings of these.
- Cooling: to remove from oven, the slab with the dosimeters are placed on other plaque of cold metal, which is in the fridge, to cool the dosimeters faster and to keep their properties;
- Heating for two hours at 100°C: it's performed to fix the impurities in the crystal's structure and make it more sensitive to the measures;
- Cooling: the same process have already described first is repeat.

The ovens used in this treatment are located in IPEN/MB-01's building reactor at Institute of Nuclear and Energy Research (IPEN/USP).

After the treatment is done, the dosimeters are removed of de slab used and stored every ten, in plastic pots with lids and, later, these pots are reserved in a single container, that is a plastic box, closed too, for ensure more safety in the dosimeters' transport.

B. TLD's irradiation

All TLDs are numbered for guarantee that the same would always take exactly the same position in the plaque used for their irradiation, as can be seen in the Fig. 1.

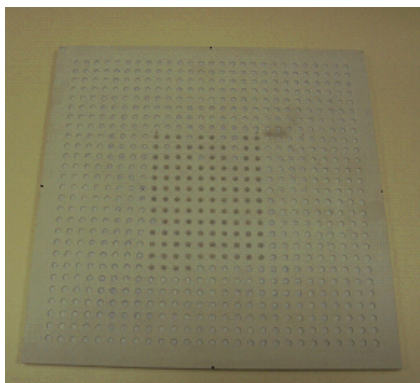


Fig. 1 Solid water plate used in irradiations procedures.

The irradiations are realized in the Hospital Israelita Albert Einstein (HIAE), in the Varian linear accelerator, model 6EX, with 6MV photon beam, using a 20cm x 20cm field, 100 monitor units (MU) and source-surface distance of the 100 cm.

TLDs were placed in the center of the solid water's plaque of the 30cmx30cmx1cm, with spacing of the 1 cm among them (Fig. 1) and, on this plaque, were put others solid water's plaques, making the TLD were irradiated to four inches deep.

C. TLD's reading

Always 24 hours after each irradiation, the dosimeters were read in a reader of HarshallQS, model 3500, localized ate HIAE (Fig. 2).

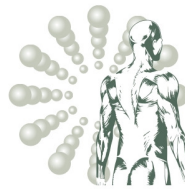


Fig. 2 TLD reader of HarshallQS, model 3500.

The procedure of reading starts performing three tests, to check the reader's constancy:

- Light Test: three readings are performed with open reader's drawer, without any TLD, and the mean of these readings is calculated;
- PTM Noise: it's the photomultiplier noise. Again, three readings are performed, but, this time, with semi-open reader's drawer, also without any TLD, and so the mean of these readings is calculated too;
- Background Noise: three readings are realized with closed drawer, without any TLD, and the mead of these is calculated and subtracted of the each TLD's reading.

After tests were done and reader's constancy was found, the reading of TLD can be initiated, so they are read individually as follows: each TLD is placed on a plaque in reader's drawer (Fig. 3), the drawer is closed and reading's button is pressed. From this, by passing electric current through the plate when TLD is positioned, there is heating of these since 50°C than, approximately, 296°C, occurring release of trapped electrons in the traps and, consequently, release of light photons, those are detected by a photomultiplier tube, and the software



presents a reading's window as shown in Fig. 4, reading were presented to the full peak given in Coulomb (C).



Fig. 3 Reader's drawer open.

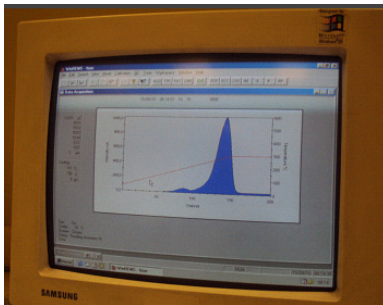


Fig. 4 Reading's window of reader's software.

After the readings, TLD were submitted to new heat treatment before they were irradiated again.

D. Calculation of correction factor

Calculation for achievement of individual correction factors follows the order to be described.

For each irradiation day, the average daily readings was obtained by equation 1, where M_j is the daily mean of j -th irradiation; L_i corresponds to reading of i -th TLD; N is total number of TLDs' group.

$$M_j = \frac{\sum_{i=1}^N L_i}{N} \quad (1)$$

Readings must, then, be divided for this average daily value, resulting in the daily standardized reading (L_{noj}). Made it for the five irradiations results obtained by five standardized readings values for each TLD. In sequence, should be obtained the mean of these five readings, according to equation 2, where M_i is the mean of normalized readings for each TLD; L_{noj} is normalized reading of the j -th irradiation; T is total number irradiations.

$$M_i = \frac{\sum_{j=1}^T L_{noj}}{T} \quad (2)$$

Thus, it has resulted in an average value for each TLD and the calibration factor is the inverse of this value (equation 3).

$$FC_i = \frac{1}{M_i} \quad (3)$$

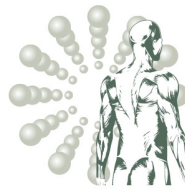
III. RESULTS AND DISCUSSION

From the readings obtained concerning the five irradiations taken, we calculated correction factors for each individual TLD, following the sequence presented in section II-D. The readings and the correction factors are presented in Table 1 for a few dosimeters because the great extent of the resulting data. The first column shows the number of TLDs, the second shows the average normalized readings, the third, the coefficient of variation (standard deviation / mean), and finally presents the calculated correction factors (CF).

Table 1 Presentation of values obtained from readings and calculation of correction factor

TLD	Mean (M_i)	Coefficient of Variation (%)	Correction Factor
1	1.155	1.943	0.866
2	1.086	2.091	0.921
3	1.292	1.515	0.774
5	1.027	1.802	0.973
6	1.157	2.260	0.864
9	1.145	1.467	0.874
10	0.850	0.901	1.177
.	.	.	.
.	.	.	.
.	.	.	.
120	1.152	1.881	0.868
121	0.942	1.210	1.061
122	1.056	1.887	0.947
123	1.091	1.710	0.916
124	1.101	1.662	0.908
Mean =	1.00	0.116	11.63

The TLDs were shown to be reproducible, since the coefficients of variation did not exceed 3%, the maximum value of 2.89% for TLD 108. However, the coefficient of variation of the batch had a high of 11.63%, so one should be alert when using these batch experimental



measurements, especially at the stage of exploring these, and even the interesting possibility of a selection of these TLDs and separate them into groups, whose responses to a given dose results in similar values.

The chart shown in Fig. 5 represents the values of the normalized readings for each TLD and Fig. 6 shows the behavior of these measures after corrected with the individual correction factor. It can be observed in Fig. 6 that all measures are within a range of only 5%, while previously, the variation of the batch was 11.67%, so these figures confirm the efficiency of correction factors calculated.

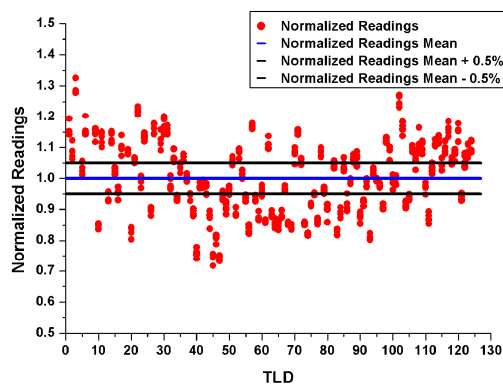


Fig. 5 Normalized readings for each TLD.

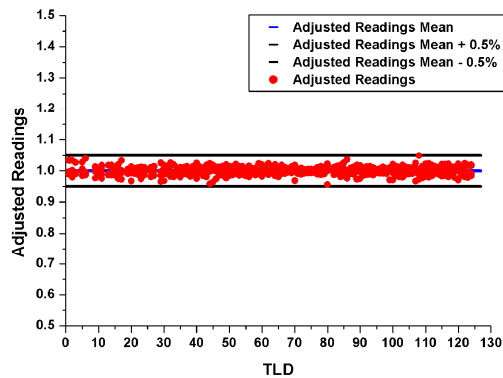


Fig. 6 Readings after correction with calculated factors.

IV. CONCLUSIONS

The radiation dosimetry is of paramount importance since the early days when they started to be used.

The thermoluminescent dosimeters are one of the main types of dosimeter used because of its ease of handling, possibility measures in places where others would not be possible, small dimensions and various types of material existents. However, lots of these dosimeters have high levels of fluctuations in their measurements, which is a

worrying factor, especially in medicine, so it is necessary to calculate correction factors for each individual dosimeter of the group and, how it can be observed in the present results, this calculation is valid and it really can be applied to reduce the variation of these measures, as happened with the group presented here, which had a reduction in variation of 11.67% to a value around 5 %, proving the efficiency factor calculated.

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