THE INFLUENCE OF THE ANNEALING PROCEDURE ON THE THERMOLUMINESCENCE READER CALIBRATION OF A PERSONAL DOSIMETRY SERVICE

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INTRODUCTION

Personal dosimetry services are required to distribute monthly a large quantity of dosemeters: their handling has thus to be easier and safer so that detectors could be read by an automatic reader. As a solution, badges have been devised containing more plastic encapsulated chips. Alternatively, individual detectors have been sealed into a plastic envelope with an appendix containing the identification bar code. A problem arises when these arrangements are applied to LiF:Mg,Ti (TLD-100) detectors: annealing is impossible because the procedure requires a 400°C heating step, that the plastic envelope cannot withstand.

The need to handle a large quantity of dosemeters has led to shorter set-up times. Thus, the annealing cycle for the unsealed chips has been modified from the "400°C, 1h and 80°C, 24 h" routine to the "400°C, 1h and 100°C, 2 h" one. The theory shows that the latter may worsen the reproducibility of repeated measurements and introduce sensitivity variations between chips of the same batch (1,2).

Objective of this paper is to compare the performances of three detector groups, two of them annealed by the two above-mentioned routines, while the third one is left without annealing.

METHODS

The batch of 90 individually coded TLD-100 chips has been divided in three 30 chip groups, A, B, C, each one further split to prepare a calibration set of six subgroups of five chips each. Five of these subgroups are irradiated with a Co-60 source in the range of kerma in air from 600 μGy to 10 mGy, under secondary particles equilibrium conditions. The sixth subgroup is read without irradiation, to evaluate the system background signal.

The reader is the manual Harshaw B+C type, always kept on. The applied HV to the PM tube is left unchanged. The operator acts carefully to obtain a good readouts reproducibility. The features of the reading cycle are:

- heating rate: 14°C s^{-1}
- initial temperature of the readings: 50°C
- integration interval: 120°C - 250°C
- at least five initialization cycles of heating and cooling with a dummy chip before reading the chips of the calibration sets.

The group A is annealed by the "400°C, 1h and 80°C, 24 h" routine and the group B by the "400°C, 1h and 100°C, 2 h" routine. The group C is not annealed, like the chips encapsulated in plastic.

The thermal features of the two ovens used for the annealing procedures have been investigated (3). They appear reproducibile. Within the heating volume, the temperature varies ±1°C in the 80°C or 100°C oven. It varies between a range of ±3°C for the 400°C oven. The value of the annealing temperature is read with a mini thermocouple fixed on the basis of the ceramic container of the chips.

Before the beginning of the test, the sensitivity S_i of each chip of each of the three groups is evaluated as the ratio of the mean readout of the chips of the group, exposed to the same value of irradiation, and the readout of the single chip.

The groups are then submitted to the same irradiation values and read through the same reading cycle, as already stated. The procedure is iterated 9 times. The sensitivity evaluation is then repeated as before the beginning of the test.

DATA PROCESSING AND RESULTS

Fig. 1 shows the S_i sensitivity values of every group as measured after the test as function of the values before the test for the same chip. The group B shows the minimum spread around the straight line with slope 1, while the unannealed group C shows the widest spread.

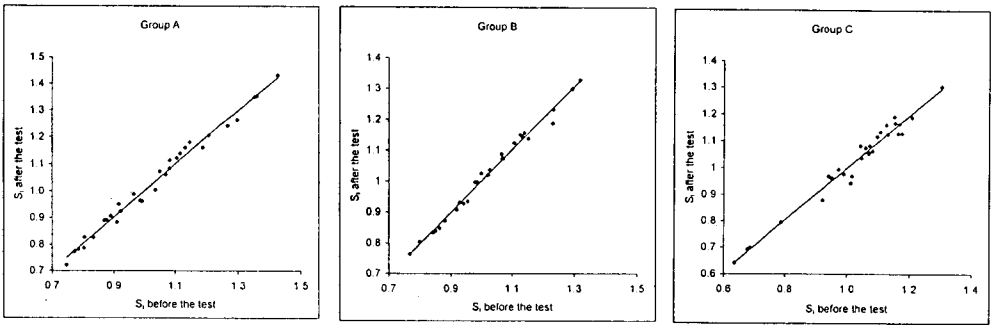

Fig. 1: S_i sensitivity values of the three groups

Fig. 2 shows the best fit obtained through a calibration set. Each dot is the average of subgroup's five detector readouts, sensitivity corrected, minus the average of sensitivity-corrected readouts of the unirradiated subgroup. The calibration factor is the reciprocal of the line' s slope. The calibration factors of the three groups are listed in Table 1 together with the related mean value and standard deviation. The mean value of the calibration factors of the group C unannealed chips is different from the mean values for the two other groups. The standard deviation shows the highest value.

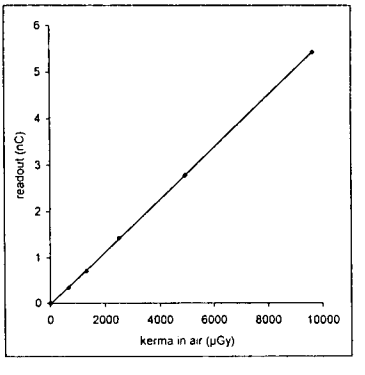

Fig. 2: Best fit of a calibration set

Table 1: Calibration factors (mGy/nC)

N. of test	Group A	Group B	Group C
1	1.80	1.74	1.18
2	1.85	1.88	1.38
3	1.87	1.90	1.39
4	1.91	1.89	1.28
5	1.89	1.90	1.31
6	1.86	1.81	1.31
7	1.91	1.92	1.28
8	1.89	1.89	1.33
9	1.96	1.95	1.52
mean	1.88	1.88	1.33
SD	0.045 (2.4%)	0.067 (3.6%)	0.094 (7.1%)

The mean values of the percent standard deviation (%SD) of each chip over 9 readouts for the same irradiation value are listed in Table 2. The Group B shows the lowest values with a low spread.

Table 2: Mean values of the %SD of each chip over 9 readouts for the same irradiation value

kerma in air (μGy)	Group A	Group B	Group C
9640	7.9	3.9	7.9
4940	3.5	2.6	5.3
2510	3.7	3.3	5.3
1300	3.1	3.3	11.3
690	5.4	3.8	7.3

CONCLUSIONS

The results show that a dosimetry service, adopting one of the two mentioned annealing routines will obtain better results than without anneling, if all other procedures are left unchanged.

Assuming the Table 2 results as an index of the variability of the reader and detector system, the group B evidences better results than group A.

Tests will continue to look for additional proof of such an evidence. Additional tests will also ascertain the reliability of the same detector, with or without annealing, until it lose its features.

ACKNOWLEDGEMENTS

Thanks to Mr. G. Minchillo for this assistance in the measurements.

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