A METHOD FOR THE EVALUATION OF THE “ZERO SIGNAL” FOR PERSONAL THERMOLUMINESCENT DOSEMETERS

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Introduction:

The personnel dosimetry service of the Greek Atomic Energy Commission (GAEC) assures the individual monitoring of almost 10,000 occupationally exposed workers all over the country. The monitoring system is based on thermoluminescent dosemeters (TLD). Three automatic TLD readers and one TLD irradiator, purchased from RADOS Co, are used for the needs of the individual monitoring service (IMS). The monitoring period is one month. Every month the IMS performs the measurement of nearly 10.000 dosemeters which means that there are almost 20,000 glow curves that have to be checked.

The usual shape of a glow curve of the LiF:Mg,Ti material in a constant temperature hot gas reader is distorted sometimes, giving an increase at the background signal at the last channels. In order to evaluate the doses properly, the glow curves have to be modified; The problem becomes worse when the pellet is not irradiated or irradiated to low dose (figures 1 and 2). Therefore, one of the most difficult problems in IMS is the calculation of the zero signal of dosemeters not irradiated and the subsequent separation of this signal from the Tl output that corresponds to the presence of a radiation field.

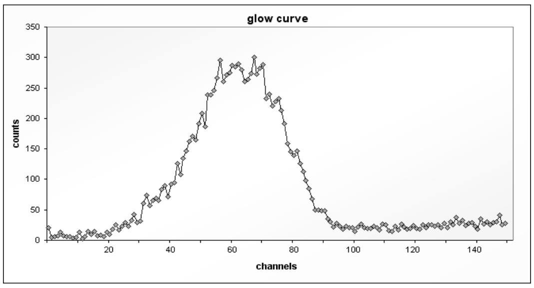

Figure 1: Glow curve of an irradiated (at about 0.1 mSv) LiF:Mg,Ti pellet

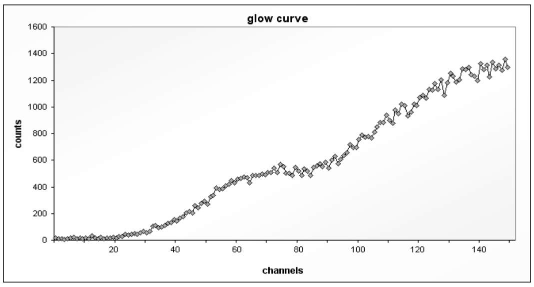

Figure 2: Glow curve of a an irradiated LiF:Mg,Ti (at about 0.1 mSv) pellet with a high background signal at the last channels

Methodology:

In this study a method for the proper calculation of the zero signal of the glow curve has been developed. The method is based on the heating profile of the TL pellet in a non linear heating system. According to the function of the automatic readers the pellet is inserted in the heating chamber and is exposed immediately to the hot nitrogen atmosphere. The system for the detection of the light emitted from the TLD pellet consists of a light guide and a photomultiplier tube (PMT). The mathematical function that describes the intensity of photons detected by the PMT of the reader can be expressed by a function of the absolute temperature of the pellet, T [1]. According to literature [2] the absolute temperature of the pellet is an exponential function of the time of the measurement, t, and therefore the number of detected photons by the PMT per second can be described by the formula: $I(t) = Io + a\,I(t)$.

In our case the following factors should be taken into account:

- The system counts the number of photons every 1/10 of the second (this is equal to one channel)
- The duration of the measurement is 15 s
- The calibration region (ROI) refers to the time interval between the 3rd and the 12th second of the measurement.

Therefore, the number of counts per channel can be given by the equation:

$$\Phi(t)=n+[\ (N-n)-(N-n)F(t)] \quad (1)$$

where:

n is the average counts of the first 10 channels of the measurements, N is the average counts of the last 30 channels of the measurements and F(t) is an exponential function $\exp(-\alpha t^x)$.

The parameters α and x have to be calculated. The parameter α is calculated using the non linear least square fit after the calculation of the parameter x. The exponential factor x is calculated experimentally. Values from 4 to 7 have been used and the results are shown in figure 3.

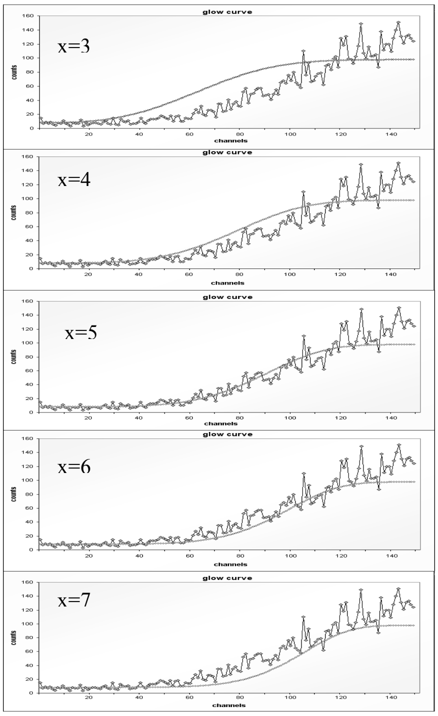

Figure 3: x-choice

As it seen from the figure the values 4 and 5 resulted in an overestimation of the zero signal, whereas the value of 7 underestimates the zero signal. The most proper choice for the parameter x can be the value of 6. Therefore, the formula (1) can be written: $\Phi(t)=n+[\ (N-n)-(N-n)\exp(-\alpha t^6)]$ (2)

Equation (2) is used for the calculation of the function that describes the zero signal. The integral of equation (2) is calculated for every pellet of every dosemeter and can be used as zero signal.

Results and Implementation:

The model has been implemented at the TL signal outputs of the occupational exposed workers monitored by the IMS for verification. The results showed an excellent agreement between the manual calculation of the zero signal and the one calculated by the above function.

In figure 4 it is shown the original glow curve, the integral of the zero signal and the resulted glow curve after the subtraction. The method is used in the every day measurements for all kind of dosemeters. The implementation of the method is done by a batch of macro commands built in the existing software used for the evaluation of the doses.

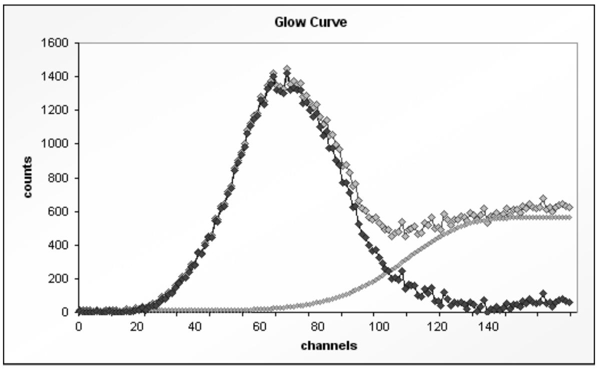

Figure 4: subtraction of the "zero" signal

Conclusions:

The methodology described can be used as a simple and automatic routine in the evaluation of the zero signal of the pellets measured in our system. The advantages of the calculation of the zero signal are the better evaluation of the zero or low doses without spending time and effort by the personnel responsible for the evaluation of the doses.

References:

[1] Van Dijk, J.W.E. and Busscher, F.A.I., 'The zero signal and glow curves of bare LiF:Mg,Ti detectors in a hot gas TLD system', *Radiation Protection Dosimetry*, Vol.101, 2002, pp. 59-64.

[2] Van Dijk, J.W.E and Julius H.W., 'Glow curve analysis for constant temperature hot gas TLD readers', *Radiation Protection Dosimetry* , Vol 47, 1993, pp 479-82.