A SIMPLE CALIBRATION METHOD FOR THERMOLUMINESCENCE DETECTORS USED IN ENVIRONMENTAL MEASUREMENTS

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INTRODUCTION

Recently, it has been proposed a calibration method for potassium halide thermoluminescence (TL) detectors (1). The procedure is based on the irradiation of potassium halide TL detector due to β particles, emitted by natural radioactive nuclide ^{40}K contained in the crystal itself as well as in a coat made of crystalline KCl salt surrounding the detector during a period of the calibration exposure time. The aim of this paper is to extend the proposed method to TL detectors manufactured from other materials. This is especially important for high sensitivity TL detectors used in environmental investigation, since the doses involved in the proposed method are comparable to the doses usually measured in environment.

GENERAL CONSIDERATION

To illustrate the method let us at first consider TL detector manufactured from KCl (for example, KCl:Eu) embedded into a coat of KCl crystalline salt as depicted in Fig. 1.

KCl SALT   AIR-FILLED GAPS

TL DETECTOR
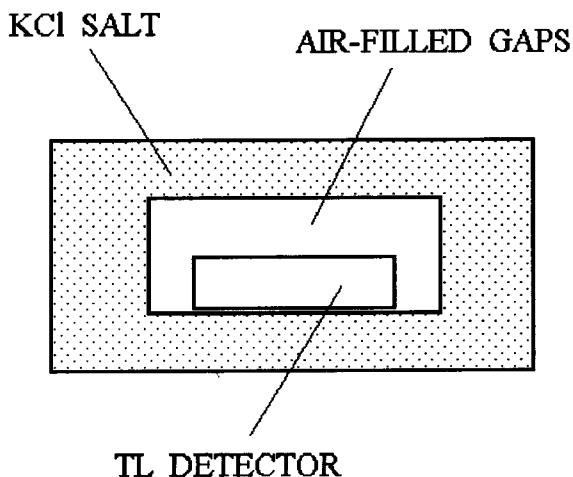
Figure 1. Schematic diagram for detector calibration exposure

If the thickness of the KCl coat is much larger than the range of the most energetic β particles, emitted by ^{40}K, and if the air filled gaps between detector and the inner surface of KCl coat are small enough, according to the cavity theory (2) the absorbed energy in the detector is equal to the energy produced per unit mass of KCl. Thus, the absorbed in the detector dose D is given by

$$D = C \, E \, t$$

where C is the activity of ^{40}K per unit mass of KCl, E is the average β ray energy per disintegration, and t is the time of exposure. Substitution of the values of C and E (3) in this expression gives the absorbed dose in the detector

$$D = 4.9 \, t, \ \mu Gy,$$

where t must be expressed in hours. Therefore the exposure rate in potassium halide thermoluminescence detector embedded into a crystalline coat is 4.9 μGy/h and if the exposure time is equal 1 - 2 days, the absorbed dose must be equal to 100 - 200 μGy (10 - 20 mrad), i.e. the value, comparable to quarter dose usually measured in environment. Thus the calibration method is useful for detectors applied in environmental investigations. Unfortunately the fading of the KCl:Eu detectors according to recent investigation (4) is large, and because of that these detectors are not promising in environmental measurements. More perspective are LiF or Al_2O_3 detectors which show high sensitivity and low fading, adequate for environmental dosimetry.

RESULTS OF MEASUREMENTS AND ACCURACY OF THE METHOD

It is clear, that for LiF or Al_2O_3 detectors embedded into a KCl coat the exposure rate must be less (compared to potassium halide detectors) for lack of the self-irradiation effect. In order to determine the exposure rate for LiF and Al_2O_3 detectors we have made a comparison of TL signals, obtained from these detectors after theirs exposure in KCl coat, and TL signals, obtained after the detectors irradiation by using ^{137}Cs γ-ray source of well-known activity. The irradiation was made in condition of the existing of the electron equilibrium. In experiments were used detectors LiF:(Ti, Mg) and anion-defective α-Al_2O_3 :C single crystals, commercially grown in Russia as DTG-4 and TLD-500K, respectively. The size of the crystals were 5 mm diameter and 1 mm thickness. The crystalline KCl coat salt used for irradiation was with wall thickness around 1 g cm^{-2}. From the results of the comparison it was found that exposure rate in TL detectors LiF and Al_2O_3 embedded into a cavity in KCl crystalline block is 2.09 μGy/h and 1.73 μGy/h, respectively. These values of the exposure rates may be used for detectors calibration.

As was shown in (1), the main sources of errors in the proposed calibration method are: the impurities of the KCl salt which may change the content of ^{40}K per unit mass of salt as compared to that of pure KCl salt, the energy lost by the β particles because of the existing air-filled clearances between the surface of the detector and that of the cavity in the KCl salt, the ^{40}K γ radiation which may give a small contribution to the absorbed detector dose, variations of the natural radiation background during the exposure time, the statistical variation of the number of β particles which were absorbed by the detector during the

exposure time. In (1) was also shown that the total uncertainty of the absorbed detector dose due to all these sources of errors under certain conditions does not extend the common error of 1.5% - 2.0% of traditional calibration methods practiced in specially equipped metrological laboratories (5).

CONCLUSION

In conclusion, we have developed a very simple and highly accurate calibration procedure for LiF and Al_2O_3 detectors based on application crystalline KCl salt block as a source of β radiation due to the natural content of the radionuclide ^{40}K. The method does not require artificial radiation sources or precision equipment and may be carried out in any laboratory. The proposed procedure may be used in environmental investigation, since the doses involved in the method are comparable to the doses usually measured in environmental dosimetry.

REFERENCES

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