TOWARDS AN AUTOMATED TLD SYSTEM THAT MEETS INTERNATIONAL REQUIREMENTS

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1. INTRODUCTION

The new recently introduced fully automated TLD system developed by Alnor OY on the basis of the Risø prototype (1), is intended to meet draft IEC/ISO proposals and ANSI requirements. Part of the system is a personal dosemeter badge and an environmental dosemeter package following ICRU recommendations.

The overall system consists of a software-controlled automated reader, a programable irradiator/calibrator, a computer, and dosemeters for environmental, whole body, extremity and clinical applications.

The personal TLD badge that contains four TLD pellets is designed to agree wigh ICRU $H_p(10)$ and $H_s(0.07)$ quantities for determining dose equivalent. The badge can accommodate a large variety of the most commonly used solid TL dosemeter products. A special effort was put into the evaluation of skin dose by considering the use of graphite-mixed hot-sintered LiF pellets (2).

The TLD system is described and results from a performance test that comprised measurements of photon energy response, angular dependence, and reproducibility are presented.

2. SYSTEM CONFIGURATION

2.1. The Alnor TLD reader and irradiator/calibrator

The automated Alnor TLD system consists of a software-controlled reader unit and a programable Sr/Y-90 irradiator/calibrator unit both of which can be loaded with identical cassettes containing dosemeter cards.

The read-out system is based on heating solid TL detectors with a hot nitrogen jet. The reader is equipped with a high-performance single photon counting system, and it measures and files raw glow-curve data by means of an on-board computer. Alternatively, data can be transferred to a host personal computer adapted to specific user requirements with software. The beta irradiator/calibrator unit can be programmed to give either equal doses for normalisation of individual TL detector sensitivities or stepwise increased individual doses to obtain response versus dose calibration curves.

2.2. The Alnor TL dosemeter card

The new Alnor TL dosemeter card consists of a two-part moulded plastic unit developed for automatic processing. The dosemeter slide contains four solid TL detectors kept in depressions and an identification number with corresponding hole code. The slide cover has four positions, three for interchangeable filters and a fourth as an open window position (3.5 mm diameter) with 45° shaped edges.

Fig. 1. The Alnor TLD personal badge, dosemeter card and finger dosemeter.

Any solid TL dosemeters with max. dimensions of 4.5 mm diameter x 0.9 mm can be used with the TL dosemeter card. Twenty dosemeter cards are contained in each cassette and ten cassettes may be loaded in an automatic cassette feeder system that is also provided.

The dosemeter card fits into the Alnor personal TLD badge made of plastic material (see Fig. 1).

For environmental monitoring purposes dosemeter cards containing four LiF dosemeters are kept in a welded plastic bag to withstand weather conditions. Each environmental dose is thus determined from the mean value of four individual dosemeter responses.

3. SYSTEM PERFORMANCE

A single photon counting technique in connection with the time-controlled multiscaling system of the Alnor reader produces glow curves as histograms over typically 120 counting channels. Channels at low- as well as high temperatures can easily be discriminated by the software resulting in a fraction of the glow curve being centred around the stable glow peak. A proper discrimination can thus exclude both unstable low-temperature peaks as well as thermal background signals at high temperatures.

Experience with repeated measurements has shown that as far as low dose measurements are concerned oven annealing of LiF materials can be replaced by annealing performed as a normal read-out in the reader when combined with a proper time discrimination of the TL glow curve, whereby even a higher reproducibility is obtained.

Reproducibility of the Alnor TL system including the Alnor beta doser was tested with repeated measurements of batches of different TL dosemeters exposed to a beta dose equal to 1 mSv Co-60 gamma irradiation. No annealing other than a normal read-out was applied. Low-temperature peaks and thermal background were removed by software time discrimination of the obtained glow curves.

Measurements were carried out each day over a 7-day period with LiF, TLD-700, hot-pressed round pellets, and $Li_2B_4O_7$:Mn, Alnor, hot-sintered round pellets. At the same time the reproducibility of the LED stability test facility of the Alnor reader was tested. The results are listed in Table 1. Figure 2 shows a typical glow curve of LiF, TLD-700 with the selected time discrimination indicated by the painted fraction.

Table 1. Reproducibility of the Alnor TLD system. Dose: Alnor beta doser (~1 mSv Co-60).

Day no.	$Li_2B_4O_7$:Mn (Alnor)	LiF-7 (Harshaw)	Light source (LED)
1	1.000	1.000	1.000
2	0.999	0.976	1.000
3	0.992	0.988	1.001
4	0.986	0.976	1.000
5	0.996	0.981	1.004
6	0.994	0.976	0.993
7	0.967	0.971	0.989
Mean	0.991	0.981	0.998
SD(%)	1.2	1.0	0.5

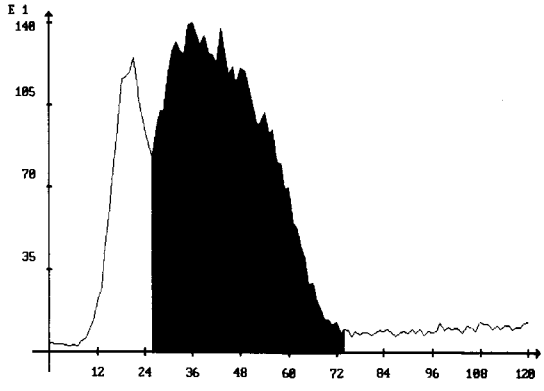

Fig. 2. Glow curve of LiF, TLD-700. The intregration area is indicated. (Dose ~ 1 mSv Co-60).

4. DOSIMETRIC PERFORMANCE OF THE ALNOR TLD BADGE

The dosimetric performance of the Alnor TLD badge was investigated for exposures to photon and beta radiations. For personal monitoring the ICRU quantities $H_p(10)$ and $H_s(0.07)$ are considered for photon radiations and $H_s(0.07)$ for beta radiations.

Photon energy response curves were obtained with different dosemeters contained in the new Alnor dosemeter card equipped with different filters (one window position) and attached to a cubic perspex phantom with dimensions 300 x 300 x 300 mm. Photons were ISO quality X-rays of 17 keV, 33 keV, 48 keV, 65 keV, 100 keV, 161 keV, and 248 keV in addition to gamma photons from Cs-137 and Co-60 sources. The measured values were converted from cubic to spherical shape by calculations following the procedure of Grosswendt et al. (3).

An example of the photon energy response of the depth dose and skin dose detectors of the Alnor TLD badge equipped with LiF, TLD-700 dosemeters, and 1 mm aluminium filters (one window position) compared with the energy dependence of the ICRU conversion coefficients that convert the dose in free air to $H_p(10)$ and $H_s(0.07)$ quantities is illustrated in Fig. 3.

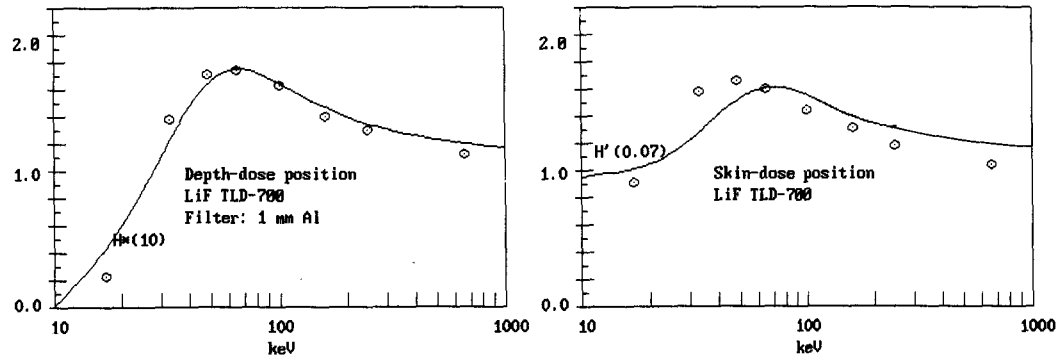

Fig. 3. The photon energy response of the Alnor TLD badge compared with the ICRU $H_p(10)$ and $H_s(0,07)$ quantities. (O = measured values.)

The angular dependence of the TLD badge was measured with LiF TLD-700 dosemeters. TLD badges were attached to a cubic perspex phantom that was turned in two planes and exposed to 65-keV X-rays. The results compared with conversion factor values given by Grosswendt et al. (3) are presented in Table 2.

Table 2. Angular dependence of the Alnor TLD badge (LiF, TLD-700). Irradiation: 65 keV X-rays.

	Horizontal plane				Vertical plane			
Angle(α)	0°	20°	40°	60°	0°	20°	40°	60°
Alnor (meas.)	1.00	0.98	0.93	0.85	1.00	0.98	0.97	0.87
PTB($H10,\alpha$)	1.00	0.99	0.94	0.83	1.00	0.99	0.94	0.83
Alnor/PTB	1.00	0.99	0.99	1.02	1.00	0.99	1.03	1.05

5. CONCLUSION

The new Alnor TL system has proved to have an excellent stability, and a high flexibility is achieved due to the ability of the dosemeter card to accommodate a large variety of different filters and TL dosemeter products. The measurement results demonstrate that the system satisfies international requirements well.

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