INDIVIDUAL MONITORING AND TL DOSIMETRY IN HUNGARY

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FILM DOSIMETRY

The widespread development and application of X-ray and nuclear energy resulted in the problem of ionizing radiation dosimetry also in Hungary. The individual monitoring started in 1955 using film badge and various "pen type" ionization chambers with different measuring ranges to determine the external photon radiation doses.

Since 1966 the film badge has been accepted as the official personal dosimeter system in Hungary. The film monitors are presently processed bimonthly. The value of customers of whole body dosimeters are given in Table 1.

Table 1. Distribution of dosimeters (97 000/year)

Medicine	54%
Dentist	1%
Industry	9%
Nuclear Industry	31%
Research	2%
Army	2%
Veterinary	0.1%
Other	0.9%

The personal monitoring for about 16 000 occupationally exposed "A category" workers is conducted by the National Research Institute of Radiobiology and Radiohygiene, with Kodak film badge. The calibration of dosimeters is performed in the primary standard laboratory of the National Standardization Laboratory (OMH) according to ISO17025 standard.

The plastic film badge used is provided with metal filters for photon radiation detection and with high and low energy discrimination. The plastic and open windows in its front side are provided for beta radiation detection. The registration level of the film dose is 0.2 mSv.

The annual doses received by workers in the past 3 years (2007 – 2009) were distributed in the following way:

- 98 % less than 10 mSv / year
- 2 % less than 20 mSv / year.

The external exposures were low, indicating high standards of safety.

THERMOLUMINESCENT DOSIMETRY

The thermoluminescent (TL) method for personal dosimetry purposes was introduced in Hungary in the early 1970's. Central Research Insitute of Physics and Insitute of Isotopes developed together a solid state dosimetry system using first 2 pieces of LiF (TLD-100) TL dosimeters in the same badge together with the film. Later, the Harshaw LiF dosimeters were changed to the Polish LiF (MTS-N) ones, having higher sensitivity to gamma and to mixed neutron-gamma field dosimetry purposes.

At present, besides the national film dosimetry service, there are three TL dosimetry services as well (Atomic Energy Research Institute, Institute of Isotopes, Nuclear Power Plant).

The thermoluminescent (TL) whole body dosimeters are used for individual monitoring parallel with the film and the evaluation of the various types of LiF (TLD-100, Polish MTS-N etc.) is performed at "home" dosimetry services using different manual and automatic TL readers (Harshaw 4000, Harshaw 3500, Alnor TLD reader).

Personal dosimety data measured by film and TL method are regularly compared.

The personal dosimetry of neutron radiation is restricted to Nuclear Power Plant (Paks), Research Reactor of the Atomic Energy Research Institute, Training Reactor of the Technical University and to the 3 small companies. About 300 workers are controlled by solid state track detectors and TL dosimeters. The measurements of $H_p(10)$ are based on TL technique. The TL badge consists of 2 pieces TLD: TLD-100 and TLD-700.

THERMOLUMINESCENT RESEARCH

In addition to the successful applications of various TL dosimeters for work place monitoiring, much effort was devoted to TL research. The selection from our results presented in this report, focuses on the main developments:

1. Al_2O_3:Mg,Y ceramic TL dosimeters for mGy – kGy gamma dosimetry

Al_2O_3:Mg,Y ceramic TL dosimeters were developed at the Institute of Isotopes for accidental and high dose dosimetry purposes (Hungarian Patent) [1]. The thermoluminescent glow curves of LiF(P), TLD-100 and Al_2O_3:Mg,Y dosimeters irradiated with gamma dose of 10 mGy are shown in Figure 1.

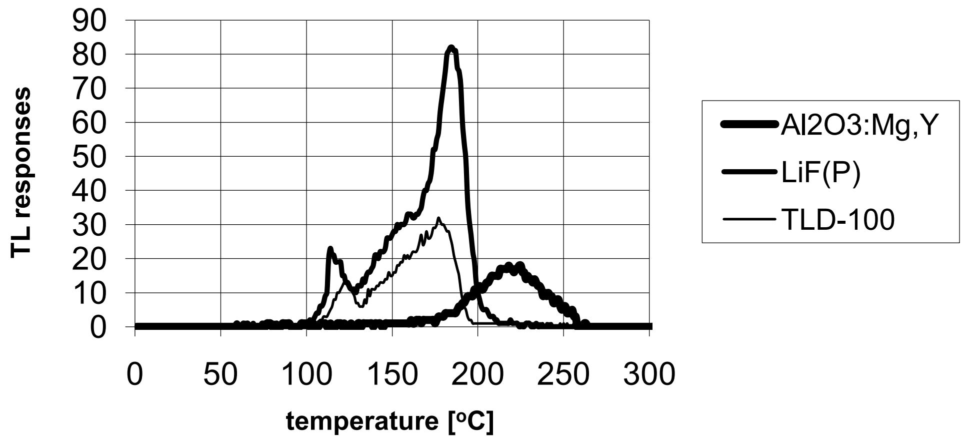

Figure 1. Glow curves of TLD-100, LiF(P) and Al_2O_3:Mg,Y ceramic TLDs irradiated with gamma dose of 10 mGy

The application of Al_2O_3:Mg,Y dosimeters was extended to high temperatures too, in order to measure the dose distributions within the hermetic zone of a power reactor, where the gamma doses are in the range of 0.1 Gy to 10 kGy and the temperatures are in the range of 50 – 100 °C.

Most thermoluminescent (TL) dosimeters are not suitable for use in such hostile environments since their signal saturates at high dose; they do not have proper high temperature TL peaks for use at high temperatures.

The new calibration and measuring method has been successfully applied for dose mapping within the hermetic zone of the Paks Nuclear Power Plant even at high temperature parts of the blocks [2].

2. Portable TL reader (PILLE) with bulb dosimeters for space dosimetry

The Atomic Energy Research Institute has developed and manufactured a series of TLD systems for spacecraft, consisting of a set of bulb dosimeters and a small compact TLD reader suitable for an on-board evaluation.

Highly accurate measurements were carried out on the board of the Salyut-6, -7 and Mir Space Station as well as in the Space Shuttle. The Pille reader was used with success for on-board evaluations by the First Hungarian Cosmonaut as well [3-4].

3. Environmental dosimetry using high sensitvity TLDs

A ballon experiment was made at about 38 km height in the stratosphere using our TL dosimeter system (Al_2O_3:C and $CaSO_4$:Tm) with various LET sensitivities [5] (Table 2).

Table 2. Main glow peak temperatures and TL sensitivities to γ and α exposures (normalized to TLD-100)

Dosimeter	LiF (TLD-100)	Al_2O_3:C	$CaSO_4$:Tm
Origin	Harshaw	Russia	Serbia
Peak (^{o}C)	200	190	240
γ sensitivity	1	120	40
α sensitivity	1	1	10

The large difference of sensitivities of TLD-s to high LET radiation was used to estimate the ratio of low to high LET radiation of stratospheric area.

The cosmic component of environmental radiation close to the sea level is about 30 nGy/h. Our result indicates that the cosmic radiation at 38 km altitude in the stratospheric area is about 100 times higher [6].

4. New TL system and its application for mixed neutron-gamma field dosimetry ($Li_2B_4O_7$ – $Li_2B_4O_7$:Cu)

The thermal neutron sensitivity of the newly developed lithium tetraborate ($Li_2B_4O_7$) single crystal is about 5 times lower, than of TLD-100 one. The scaling of relative thermal neutron sensitivities for the investigated TLDs is summarised in Figure 2.

The great difference of relative neutron sensitivities between the undoped ($Li_2B_4O_7$) and doped lithiumtetraborate ($Li_2B_4O_7$:Cu) single crystal dosimeters suggests the application of paired LTB ($Li_2B_4O_7$) and LTB:Cu ($Li_2B_4O_7$:Cu) for obtaining information about the neutron dose in a mixed-field [7].

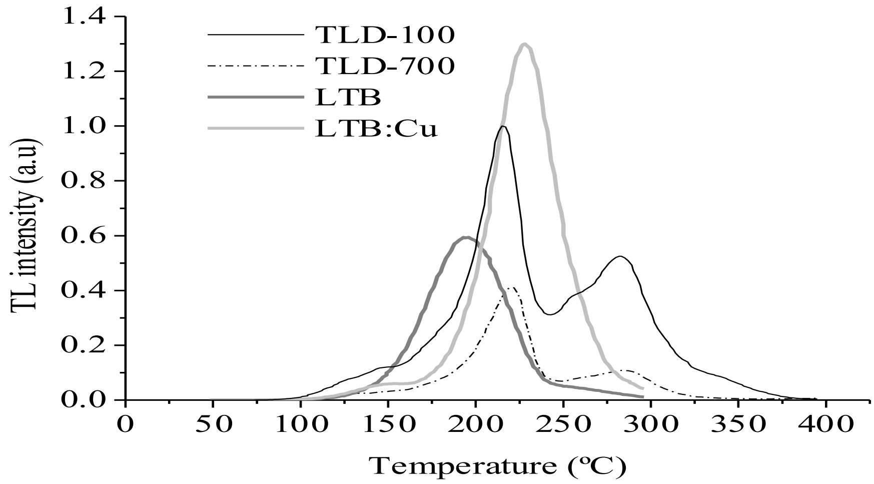

Figure 2. Thermoluminescence glow curves of dosimeters irradiated with mixed field (thermal neutron fluence: 10^{11} n_{th} cm^{-2}; gamma dose: 62 mGy)

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