A MODERN AUTOMATIC READ-OUT SYSTEM FOR PHOSPHATE GLASS DOSEMETERS

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1. INTRODUCTION

After the high efforts in developing automatic TLD systems, the producers of RPL systems lost their interest in this field if not stopped their activities in producing readers and glass dosemeters. Germany seems to be the only country where RPL dosemeters are still used in an old fashioned design of 1964 as a replace or support of film dosemeters in routine personnel monitoring [1-3]. RPL systems,not comparable with TLD systems mainly in the lower detection limit are still superior to TLD systems with respect to the simplicity of the read-out procedure, the excellent batch uniformity, the long-term stability and permanent availability of dose information.

The actual interest in RPL dosimetry today is partly based on some how disappointing experiences with commercially available automatic TLD systems [4], but mainly on the advantages of glass dosemeters with respect to an automatic read-out and the opportunity to optimize energy compensation filters in order to separate dose fractions of different energy ranges or to indicate different kind of operational dose quantities of interest practically independent of photon energy above 15 keV.

In the last years the activities of our laboratory have been again focused to the construction of a commercial prototype reader for a fully automatic RPL system. With respect to the RPL system the following objectives have been considered:

- the dosemeter encapsulation, dust-tight and locked by a magnetic latch will be automatically opened within the reader,

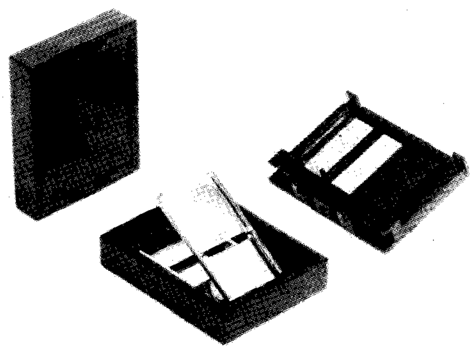

Fig. 1: KfK phosphate glass dosemeter for automatic opening

- two types of magazins are used, one for dosemeters, another one for dosemeter cards, which allows an exchange between used and annealed dosemeter cards,
- with respect to UV excitation the read-out system is applicable for conventional mercury lamp as well as N_2 gas laser,
- two different code systems identify the number of card and capsule,
- the microprocessor controlled evaluation technique allows a flexible change of the read-out procedure,
- the system has been optimized with respect to the dosimetric properties, i.e. reduction of pre-dose, standard deviation, energy and directional dependence.

2. DESCRIPTION OF THE RPL SYSTEM

2.1 Dosemeter

The dosemeter design presented in Fig. 1 makes use of a Toshiba glass D-7 or Schott glass DOS-8 of the size 16 x 16 x 1.5 mm^3 fixed in a stainless steel holder (dosemeter card) bearing the dosemeter number (hole code). In a plastic encapsulation the dosemeter card is shielded from both sides by a flat energy compensation filter consisting of a two-part tin filter of 1 mm in thickness with a plastic part of 3.3 mm width. A magnetic latch avoids an unauthorized opening and a rubber closes the dosemeter dust-tight. The encapsulation is marked with a number and the name of the user.

2.2 Read-out system

The read-out system makes use of a mercury lamp for UV-light excitation all over the glass volume and, on the other hand, only in the center of the glass area 1 x 1.5 mm^2 with an UV-light beam of 1.5 mm Ø. The photomultiplier in front of the glass area 16 x 16 mm^2 registers the RPL light from the glass. The read-out system is thus applicable for common as well as UV-laser beam excitation.

The commercial prototype of a fully automatic RPL system now under construction makes use of a moving grap in the center of the reader which allows the transportation of the dosemeter to all stations at the peripherie. The reader contains a dosemeter magazin for a large scale evaluation as well as a slot for the input of single dosemeters. The stations for the read-out cycle are the following: registration of the dosemeter number on the capsule, automatic opening of the dosemeter, registration of the number of the dosemeter card, UV-excitation and read-out of the dosemeter card in the optical chamber.

In routine operation, the dosemeter card can be stored in the card magazin if a washing step is needed before read-out or if a high reading requires an annealing step before reuse. In the latter case the glass is exchanged by a new annealed one from the card magazin which after pre-dose read-out will be closed in the dosemeter capsule and transported to the dosemeter magazin for reuse. About 300 dosemeters can be measured simultaneously without re-loading the reader.

The complete read-out system is microprocessor controlled. This easily allows changes in the read-out procedure and a comfortable self-check system for reliable read-out of many dosemeters with a high reading rate. An on-line desk computer is used for the identification of the actual dosemeter capsule and card numbers as well as for the data processing of the pre-dose reading before the monitoring period, the random error of measurement, the dose accumulated in the past monitoring period, the total accumulated dose of a person, as well as dose accumulations required by regulations. Personal data can be stored in a data-file for a group of 10.000 persons.

The modified automatic evaluation allows daily entrance and exit controls by the user himself.

3. DOSIMETRIC PROPERTIES

Using a cylindrical polyethylene phantom of 30 cm diam. the energy dependence of the glass dosemeter (Fig. 2) has been found to be within ± 15 % for photon energies above 15 keV for the measurement of the dose equivalent H_{10} in a tissue depth of 1 cm as well as within ± 15 % above 20 keV for the measurement of the dose equivalent $H_{0.07}$ and H_3 in a tissue depth of 0.07 for the unprotected skin and of 3 mm for the lens of the eye. Free in air, the dosemeter indicates the exposure within ± 20 % above 23 keV. The mean energy and angular response ranging for 0° to 60° (Fig. 3) has been found to be about ± 30 % above 25 keV and thus comparable to TLD dosemeters. The RPL dosemeter system generally allows to apply different calibration factors or other energy compensation filters or other read-out techniques to measure the dose equivalent in different specific depths of tissue or to analyse the radiation field [5,6].

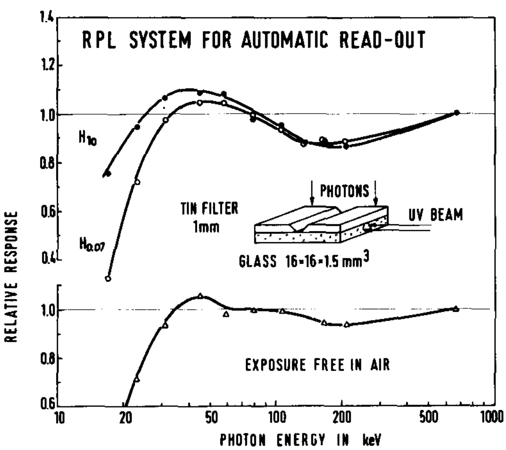

Fig. 2: Energy response of the flat glass dosemeter

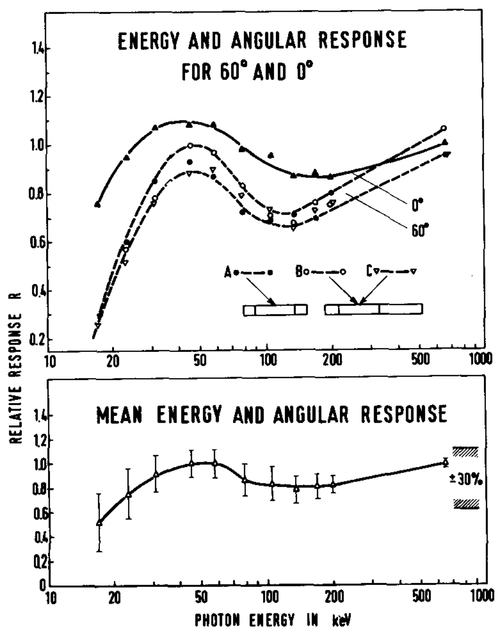

Fig. 3: Energy response for H_{10} and angles of 60° and 0°

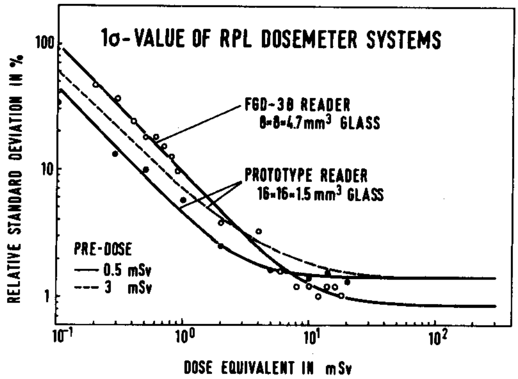

Fig. 4: Relative standard deviation vs. dose

Taking into account the subtraction of the pre-dose namely 0.5 mSv after annealing and 3 mSv after pre-exposure, the random statistic uncertainty of dose measurement is presented in Fig. 4 as a function of dose. The empirical standard deviation calculated from the readings of 10 dosemeters indicates the short-term reproducibility of the read-out system as well as influences of the washing procedure. Thus, a dose of 0.2 mSv can be measured with a standard deviation within ± 20 % for the new RPL system and ± 50 % for the old Toshiba FD-3B reader and the glass size 8 x 8 x 4.7 mm^3.

Further characteristics of RPL systems are the capability for repeated measurements, the linearity of the dose range from 0.1 mSv up to 30 Sv and the long-term stability of information (for FD-1 glasses only 10 % fading have been found after 10 years storage at room temperature).

The automatic read-out procedure of a one-element dosemeter offers new aspects in personnel monitoring so far not offered by TLD systems. These are the permanent availability of dose information during excit controlls, i.e. repeated daily read-outs and at the end of the monitoring period subsequent control readings at an independent central laboratory. A pilot test of such a one-element dosemeter with repeated read-outs at the facility and a control read-out at the central laboratory at the end of the monitoring period has been recently performed resulting in an agreement within ± 3 % for the total accumulated dose

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