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ENERGY AND ANGULAR RESPONSE OF A TLD-BASED PERSONAL DOSIMETRY BADGE: MONTE CARLO APPROACH

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Introduction: Thermoluminescent dosimeters (TLD) are often used in personal dosimetry. In assessing the operational quantity personal dose equivalent $H_p(10)$, appropriate for strongly penetrating radiation, the major contributors to uncertainties are the energy and angular dependence related to the TLDs and personal dosimeter's badge. To flatten the energy dependence of the dosimeter, usually a multi-detector system with different filtrations are employed. Monte Carlo simulation can be useful in determining the energy and angular dependence of a personal dosimeter. In this work, the energy and angular dependence of a personal dosimeter was assessed using Monte Carlo simulation with MCNPX code. The obtained energy and angular response factors can be used in the calculation algorithm for improved dose assessment.

Material and method: MCNPX code was used to simulate a personal dosimeter and radiation beams to study the energy and angular dependence of the dosimetric system. The simulated personal dosimeter consists of three TLD-900 pellets sandwiched in different filters (PMMA, copper and copper+lead) in a PMMA badge with 49.5 x 33 x 8.2 mm^3. The radiation beam of ^{137}Cs and X-rays of ISO qualities N30, N40, N60, N80, N100 and N120 were simulated. Combinations of the radiation qualities and the ^{137}Cs beams were also simulated to represent mixed (low and medium energy) beams. The energy response was evaluated as the ratio of the dosimeter's response for a given radiation quality to the response for ^{137}Cs. The angular dependence factors were calculated for angles of 45, 60, 90, -45, -60 and -90 degrees in respect to a perpendicular incidence (0 degree) of the beam on the dosimeter.

Results: There is a strong energy dependence for each individual set of TLD/filter in the badge, with maximum energy dependence factor being almost 30 for the TLD/PMMA set at the N30 radiation quality. The ratio between the doses in the TLD/Cu and TLD/Cu+Pb set largely flattens the energy response, as can be seen in Figure 1. A linear relation was found for the ratio of the TLD/PMMA set to the TLD/Cu+Pb set as a function of the ratio of the TLD/PMMA set to the TLD/Cu+Pb set for mixed radiation beams. Hence, the ratio between different sets in the badge can be used to discriminate the radiation quality in $H_p(10)$ assessments.

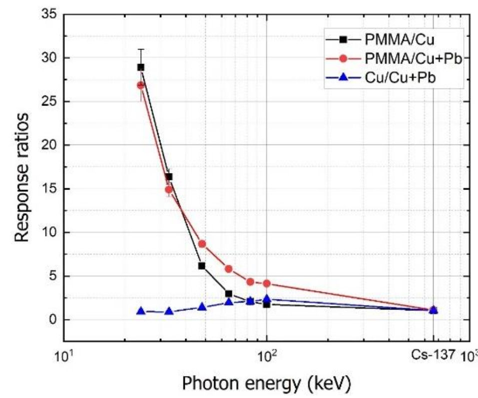

Figure 1: Response ratios of TLD/filter sets in the badge as a function of beam energy.

The badge also showed a strong angular dependence at large angles and lower radiation qualities. Given its non-symmetrical shape, the angular dependence factors were higher for the TLD/Cu and TLD/Cu+Pb sets. For the TLD/PMMA set, all values are in according to IEC 61526[1], that states the angular dependence factors should be within the limits of 0.71 and 1.67 for angles from 0° to 60°.

Conclusions: The energy and angular dependence for the multi-TLD/filter sets of a personal dosimeter badge was obtained using Monte Carlo simulation. The dependence factors can be used to improve accuracy in the assessment of the operational quantity personal dose equivalent.

References:

1. IEC 61526. Radiation protection instrumentation - Measurement of personal dose equivalents Hp(10) and Hp(0,07) for X, gamma, neutron and beta radiations – Direct reading personal dose equivalent meters and monitors (2004).