FACTORS AFFECTING POLYAMIDE PROTOTYPES DESIGN OF ALBEDO DOSIMETERS

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ABSTRACT

This work studies the most important factors which affect the response of albedo neutron dosimeters containing LiF TLDs with the aim to improve their sensitivity. It includes tests of thickness and shape of the polyamide moderator body prototypes, albedo window diameter and TLD position inside the moderator. Analyzing the results, an albedo neutron dosimeter prototype, B_4C covered, was developed. The prototype has a response three times higher than the albedo dosimeter now in use in Brazil.

INTRODUCTION

Albedo dosimeters have been extensively used in neutron personnel monitoring with good results (1). Since 1983, Instituto de Radioproteção e Dosimetria (IRD) operates the only Neutron Personnel Monitoring Service in Brazil. This service monitors about two hundred workers in nuclear and non-nuclear facilities. An albedo dosimeter developed in 1975 is used (2). For ^{241}Am-Be sources, the IRD albedo neutron dosimeter is about 50 times less sensitive than for neutron fields around reactors (3).

The restrictions on individual dose limits recommended in ICRP60 (4), together with the lack of a neutron dosimeter with a low detection limit, mainly for fast neutron fields, have stimulated the research to obtain a more sensitive personal neutron dosimeter. Also, the IRD needs a cheaper and easier to manufacture neutron dosimeter than the actual. The objective of this work is to identify the most important factors which affect the response of albedo dosimeters containing TLDs and improve their sensitivity, taking into account cost-benefit considerations.

MATERIAL AND METHODS

All prototypes were made with a moderator body of polyamide. And, for the detection system ^{6}LiF and ^{7}LiF TLD chips (3.2x3.2x0.89 mm^3 TLD600 and TLD700 from Harshaw Chemical Company, respectively) were used. Three prototype sets with a cavity in the geometric axis for the TLD pairs were manufactured:

a) semispherical shape with same height (24.2 mm) and albedo window diameters from 32 to 52 mm;
b) cylindrical shape with same albedo window (32 mm) and heights from 18 to 36 mm;
c) cylindrical shape with same albedo window (50 mm) and heights from 5 to 20 mm.

To understand the influence of some geometrical factors in the albedo dosimeter response, some tests were carried out, changing the moderator body of the prototypes:

a) the influence of shape: cylindrical or semispherical;
b) the influence of the LiF TLD pair position;
c) the influence of the moderator dosimeter thickness, for a same shape;
d) the influence of albedo window diameter.

The assays took place in a low scattering room with the prototypes on a cubic water phantom of polymetylmethcrylate. In the experimental set-up, the total phantom area for irradiation of prototypes was 0.4x0.4 m^2. Irradiations were made with a ^{241}Am-Be bare source, at 1 m distance, with doses around 8 mSv. The response of TLD-600 and TLD-700 were evaluated in a Harshaw model 3500 TLD reader, using a nitrogen flow of 0.13 $m^3.h^{-1}$. Annealing procedures for TLD are those recommended by Harshaw: 1 h at 400°C plus 2 h at 100°C. After irradiation, the TLDs are heated during 15 minutes at 100°C before their evaluation. The reading cycle consists of no pre-heat and a linear heating of 10°C.s^{-1} from 70°C up to 350°C. The total heating time was 30 s. For neutron dose evaluations the difference between TLD600 and TLD700 integration value of peak 5 was used.

RESULTS

Concerning the results, it can be summarized that:

- The response increases in proportion with albedo window area, however it tends to saturate.
- Independently of the geometric shape, but for a same albedo window, the response has a linear decrease when the TLD position is changed from surface (phantom) to inside the moderator body. Figure 1 shows this effect for different shapes and thickness of the moderator. These results are in agreement with the ones obtained by Hankins (5) using polyethylene moderator and cadmium absorber.
- For a same geometric shape (cylinder), the response increases for higher height (however it tends to saturate), as it is shown in figure 2.
- The angular dependence difference is statistically non significant for semispherical or cylindrical shape.

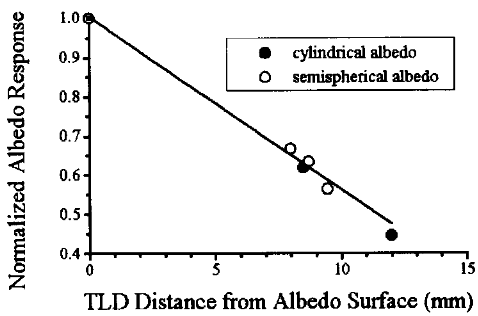

Figure 1. Variation of albedo response as a function of TLD distance from surface.

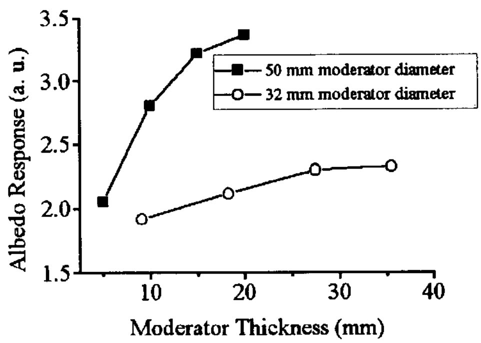

Figure 2. Albedo response as a function of polyamide moderator thickness.

CONCLUSION

Analyzing the results, a cylindrical albedo neutron prototype with a polyamide moderator body (46 mm diameter and 15 mm height), covered with 2 mm of boron-resin, was developed using two LiF TLD pairs: one for albedo and another for incident neutrons (figure 3). This prototype has a response about three times higher than the albedo dosimeter now in use in Brazil. For ^{241}Am-Be bare source, the new low detection limit is around 0.15 mSv, lower than the Register Level (0.2 mSv) adopted in Brazil. This prototype is now in test on other neutron fields.

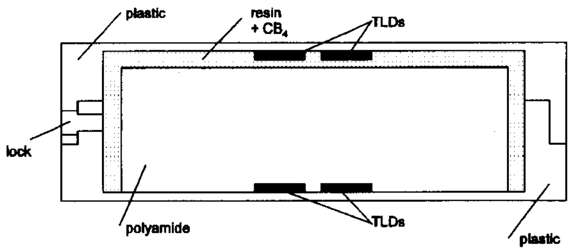

Figure 3. Albedo dosimeter prototype.

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