SEPARATION OF SR/Y-90 AND TL-204 BETA PARTICLES WITH MODIFIED TELEDYNE P-300-AS BADGE TO MEET THE REVISED ANSI N13.11(1993) REQUIREMENTS

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ABSTRACT

This paper describes a method to separate Sr/Y-90 and Tl-204 beta particles by a simple modification of Teledyne P-300-AS TLD badge system, which is currently used in the Korea Atomic Energy Research Institute for personnel dosimetry, by attaching small ^{7}LiF disk to the back-up open window filter area(A5). This modified badge system can evaluate the delivered dose from both Sr/Y-90 and Tl-204 within ±5% error bound even in the randomly selected irradiation condition

INTRODUCTION

The response of many personnel thermoluminescence dosimeters is extremely energy dependent when they are used in beta particle fields of somewhat significant levels in many working places. This energy dependence is generally taken into account by considering the response of the TL dosimeters as a function of the beta energy, and for this reason, low energy Tl-204 beta source was newly added in personnel dosimeter performance test criteria in addition to high energy Sr/Y-90 beta source in the revised ANSI N13.11(1). Both sources are recommended for use as reference beta sources by ISO Standards 6980(2).

In most cases the dosimeters for measuring beta doses use only one filter area, generally called open-window area, and usually evaluate beta doses by gross amounts of energy response not by separating their energies. To separate beta particles by energies, it is possible to improve the badge design by adding one more supplementary dosimeter with different filter in the badge case.

The Teledyne P-300-AS TL dosimeter badge system, used in the KAERI for personnel dosimetry, could not separately evaluate the beta doses from Sr/Y-90 and Tl-204 beta particles because this badge had an originally thick beta shield area(A2) enough to stop all the weakly penetrating beta particles. If we evaluate the beta dose only using open window filter area(A1) for beta particle mixtures, it would result in underestimation for Tl-204 beta dose because of the shielding effect by 7 mg/cm^2 mylar on the open window filter area(A1).

So, the purpose of this paper is to describe a method to separate Sr/Y-90 and Tl-204 beta particles by attaching small ^{7}LiF disk to the back-up open window filter area(A5) of the original Teledyne P-300-AS badge system, and to verify the performance of this method.

EXPERIMENTAL DETAILS

Teledyne P-300-AS multi-element badge case and C-300-A beta/gamma TLD card are used to determine the response of the TLDs to the beta particles. This badge system consists of 4 main areas and 4 back-up areas. The open window filter area(A1) simulates body surface and consists of a 7 mg/cm^2 black polyethylene mylar on the open window of the badge case. The beta shield filter area(A2) attenuates most beta energies less than approximately 2.2 MeV. To separate the beta particles with energies, it was covered with small ^{7}LiF disk on the back-up open window filter area(A5) to attenuate most of the Tl-204 beta particles and to measure Sr/Y-90 beta only. The filter materials in badge case are given in Table 1.

Table 1. Filter Materials for Each Area of Modified P-300-AS Badge Case.

Area	Filter Materials and Thicknesses
A1	7 mg/cm^2 Black Polyethylene
A5	7 mg/cm^2 Black Polyethylene + 211 mg/cm^2 ^{7}LiF
A2 & A6	863 mg/cm^2 , Plastic
A3 & A7	866 mg/cm^2 , Al
A4 & A8	1,245 mg/cm^2 , Al + Cu + Sn/Pb

The dosimeters were placed on a 30 X 30 X 5 cm PMMA slab phantom and irradiated by the PTB certified Sr/Y-90(74 MBq) and Tl-204(18.5 MBq) source in the Beta Secondary Standard System(Buchler Co., Germany) at the Calibration Laboratory in KAERI. The absorbed dose rate was given by the PTB certificate of each source at specified distances.

RESULTS AND DISCUSSIONS

The TL response as a function of absorbed dose was measured for Sr/Y-90 and Tl-204 radiations between 1.5 mGy and 10 mGy according to the requirements of ANSI N13.11. The linearity of TL response in this range is shown in Fig. 1. The response for Sr/Y-90 betas is linear and the measured doses are quite the same as the delivered doses. But even though the response of the TL dosimeters to the Tl-204 is linear, the measured doses are about 20 % lower than the delivered. From this a beta correction factor(BCF) for Tl-204 was derived to be 1.25, and the measured TL response for Tl-204 was then corrected by this BCF. The corrected dose shows good agreement with the delivered as seen in the same figure.

If the types of beta particles are known, the beta doses can be easily evaluated by multiplying the BCF obtained above. But in the case of randomly choosing beta sources to irradiate each dosimeter as defined in ANSI N13.11, the delivered dose would be under-estimated by about 20 % for the Tl-204 beta if it is not separated into Sr/Y-90 and Tl-204 betas as shown in Fig.1. To separate two betas, the ratios of A1 to A5 for the case of covering and uncovering ^{7}LiF disk on A5 were obtained and the results are given in Table 2.

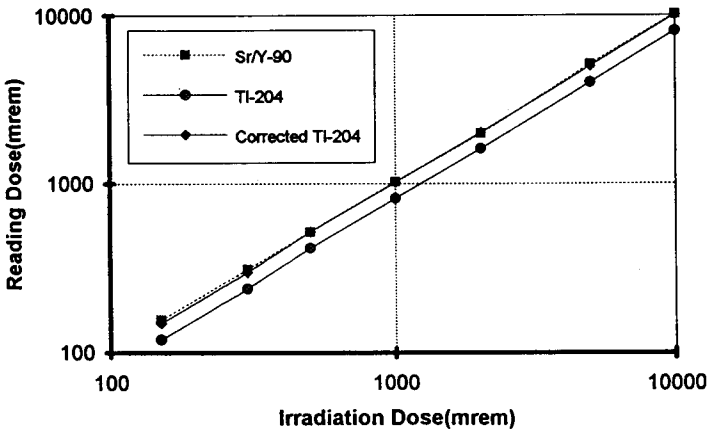

Figure 1. Linearity of Sr/Y-90 and Tl-204 Beta Particles.

Dose evaluation algorithm detects the beta or beta mixtures at first, separates the type of beta sources by A1/A5 ratio, and then evaluates beta dose by multiplying the relevant beta correction factor which is 1.0 for Sr/Y-90, 1.2 for Tl-204.

Table 2. Delivered to Evaluated Dose Ratios with and without Cover of ^{7}LiF Disk.

Sources	A1	A5 Without Cover	A5 With Cover	A1/A5(With Cover)
Sr/Y-90	1	1	0.9	1.1
Tl-204	0.8	0.8	0.05	16.0

To verify the performance of the modified badge system, a simple performance test was conducted and the results are given in Table 3. The test categories and delivered doses were selected from ANSI N13.11. It is shown that all results meet the performance test criteria even without any modification of original P-300-AS badge case, but the performance index (bias plus standard deviation) is much larger than that of modified P-300-AS badge case, by which the accuracy can be improved by more than 20 % compared with the original Teledyne design.

Table 3. Results of Performance Test for the Modified P-300-AS Badge Case.

ANSI N13.11 Test Categoriy	Delivered Dose(mSv)	Reported Dose(mSv)	Test Results | B | + S[(1)]	Tolerance Level
VA Sr/Y-90	10	9.8 (9.8)[(2)]	0.03 (0.04)	0.5
VB Tl-204	10	9.7 (7.8)	0.04 (0.25)	0.5
VC Sr/Y-90 + Tl-204	10	9.8 (8.7)	0.05 (0.16)	0.5

(1) B : Bias, S : Standard Deviation
(2) Values in parentheses are results from original P-300-AS Badge Case.

CONCLUSION

Teledyne P-300-AS badge case and dosimeters used for personnel monitoring of beta radiations suffer from an energy dependent problem because this does not provide the filters needed to evaluate different types of betas separately. To improve this, back-up filter area A5, having same filter material and thickness as open window filter area A1 for beta measurement, was covered with a small ^{7}LiF disk to provide multi-element filter areas for separating beta energies.

The TL response to beta radiation energy showed that the evaluation data for Tl-204 was about 80 % of the response obtained with Sr/Y-90 source. However, by separating Tl-204 and Sr/Y-90 beta sources with a modified badge system, the delivered dose can be evaluated within $\pm$5 % error bound even in the randomly selected irradiation condition.

REFERENCES

1. American National Standards Institute, *ANSI N13.11* (1993).
2. International Organization for Standardization, *ISO 6980* (1983).