PNL-SA-8753

MASTER

EXPERIMENTAL CONSIDERATIONS FOR THE CALIBRATION OF PERSONNEL DOSIMETERS WITH PHOTONS

C. D. Hooker
R. C. Yoder
J. W. Courtney

INTRODUCTION

Photon beams can be quite accurately calibrated to establish exposure rates under free in air conditions. This can be accomplished by centering a NBS certified ionization chamber at the point of interest in the beam and measuring the chamber's response. When the conditions of this calibration are changed, however, a larger degree of uncertainty is introduced, which requires the need for further examination.

The criteria for irradiating radiation dosimeters for test purposes are defined quite clearly in Draft ANSI Standard N13.11. In this Draft the use of phantoms, constructed of a near tissue equivalent material, is prescribed for backing the dosimeters while being irradiated, thus simulating a dosimeter being irradiated while attached to a person.

When the phantom is placed in the photon beam it becomes a major source of scattered radiation. The scatter component into the dosimeter is a function of the energy of the photon beam and must be defined for each effective energy used. In addition, it is usually cost effective to irradiate more than one dosimeter at the same time, which may result in mutual interference from the dosimeters themselves.

At Pacific Northwest Laboratory we have studied the effects of these parameters upon a centrally positioned dosimeter in the presence of a phantom.

METHOD

Because dosimeters are not of a standard size, shape, or material; two dosimeters of very different design were tested to see whether or not multiple dosimeter irradiations could be made without sacrificing quality or accuracy.

Prepared for the U.S. Department of Energy under Contract DE-AC06-76RLO-1830

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DISCLAIMER

The larger dosimeter measured about 1-3/4" x 3" and was constructed mainly of a plastic material, except for the metal fastener. It contained four cavities capable of accepting two TLD chips each. These cavities were coded A, B, C, and D and each had a different filtration package. The "A" cavity had minimal filtration, therefore it was expected to yield higher responses and for these tests was the point of main interest (Diagram I*).

The smaller dosimeter measured about 1/2" x 1-1/4" and was constructed of a phenolic material with a nearly all metal back including the fastener. It contained only one cavity for accepting the TLD chips (Diagram II*).

TLD chips were lithium fluoride 700s which were screened to within ±5% when exposed to 1 R of ^{137}Cs. A test dosimeter was centered in the photon beam and immediately in front of the phantom. Additional dosimeters were positioned around it in six different arrays to measure the effect of these upon the test dosimeter. The configurations are shown in Diagram III*.

Photon beams with effective energies of 32, 167 and 660 keV, respectively, were utilized for the exposures with equal amounts of radiation delivered to each array.

RESULTS

		High Response Positions		
		32 keV	167 keV	660 keV
Large Dosimeter	Cavity 'A'	#6 Array	#6 Array	#5 Array
	Cavity 'B'	#6 Array	#4 Array	#4 Array
Small Dosimeter	One Chip	#3 Array	#6 Array	---

*Slides of data will be shown.

Variation of the responses at the same position for all arrays were:

		High Response Positions 32 keV	167 keV	660 keV
Large Dosimeter	Cavity 'A'	5.1%	5.5%	5.9%
	Cavity 'B'	5.3%	3.7%	3.3%
Small Dosimeter	One Chip	8.4%	4.7%	---

CONCLUSION

This data shows that although the #6 array resulted in higher responses in four out of eight points, the percent of variation was not significantly outside of the ±5% uncertainty range of the TLD chips, with the exception of the 32 keV point with the small dosimeter.

The experiment was extended in an attempt to verify or deny the validity of this point, by replacing the test dosimeter with a small volume ionization. Here again similar arrays were used still surrounding the chamber with dosimeters. Only the 32 and 167 keV beams were used with the results showing a maximum variation of 1.5% at 32 keV and 2.1% at 167 keV.

There is no conclusive evidence that any of the arrays cause a significant amount of mutual interference to a centrally placed detector and multiple irradiations can be made with a large degree of confidence.

An interesting bit of side information arose from the study. The response of the large dosimeter's 'A' cavity chips averaged 20% higher than the average of the chips from the small dosimeter at 32 keV. A check was then made at 167 keV and still the larger dosimeter 'A' chips responded about 7.8% higher than the small dosimeter average.

Our theory was that the metal back plate on the small dosimeter did not allow the backscatter component to be accurately measured. Based on this theory, we added a plate of 1/16" steel to the phantom's face and positioned the ion chamber immediately in front of it toward the beam. Again at 32 keV the response of the ion chamber indicated a 20% reduction and at 167 keV a 7.8% reduction when compared to the responses with only the phantom present.

This would indicate that significant importance may be attached not only to the materials used in dosimeter construction but also in the manner and placement of the dosimeter when monitoring personnel exposure.

ACKNOWLEDGEMENTS

This work was conducted for the U. S. Department of Energy under Contract #DE-AC06-76RLO (1830).