Development of an Operational Multicomponent Personnel Neutron Dosimeter/Spectrometer DOSPEC*

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Introduction

The disadvantages of single component dosimeters such as albedos, NTA film, fission track and recoil track detectors have been discussed for many years.[1-2] Poor energy response, lack of sensitivity, high cost, use of fissionable radiators, fading and other problems can be attributed to one or more of the detectors currently used for operational dosimetry. A number of workers[3-5] have suggested using multiple detectors in personnel dosimeters. In this way, the advantages of each detector element would, to some degree, offset the disadvantages of the others.

The composite dosimeter concept has not received wide acceptance, in part because the use of additional detectors implies increased sample processing and cost. However, the albedo detector is one element commonly proposed for most multicomponent dosimeters. Noting that the TLD albedo is very sensitive and readily automated, we have developed a multicomponent dosimeter that uses the albedo detector both to provide the measurement of low energy neutrons and as a screening element. The track detector components -- CR-39 and polycarbonate -- need only be processed if the TLD indicates that there has been an exposure to neutrons. Since the three components each have significantly different energy responses,[4] the DOSimeter can act as a crude SPECtrometer, thus the name DOSPEC.

DOSPEC Description

The DOSPEC components are contained in a cadmium box originally used for the Hankins albedo dosimeter (Fig. 1). In addition to the TLD, we use three pieces of CR-39 and three of polycarbonate. Originally, the commercial cellulose nitrate--LR115--was included as a fourth component. However, we found that it has marginal sensitivity for neutrons of interest to us (less than 10 MeV) and the results had unacceptably high uncertainties.

The albedo component (TLD 600 and 700 chips) is processed using hot gas readout techniques. If the results indicate a neutron exposure, we etch the CR-39 and polycarbonate. The CR-39 is chemically pre-etched for five hours, then electrochemically etched on one side for five hours. We etch the polycarbonate electrochemically on both sides for five hours following a one-hour exposure ultraviolet light to enhance the normal photo-oxidation process. Processing details are provided elsewhere.[6]

Optical track counting, even when the tracks are enlarged by electrochemical etching, is a tedious and subjective process. We have adopted the use of bacterial colony counter[8] with a microscope and external TV camera to reduce counting time. The counter is now being interfaced to a desk top computer (Fig. 2) as a step toward eventual system automation. The responses from three components, plus those from control dosimeters exposed to either ^{252}Cf or PuBe sources, are used as input for an 800 step programmable pocket calculator code. The code calculates fluence values (spectrum) in energy bands thermal to 0.1 MeV, 0.1 to 1.5 MeV and above 1.5 MeV, as well as dose equivalent values in the same energy bands. A crude printer plot is also available on request.

*This work was performed under the auspices of the U. S. Department of Energy by Lawrence Livermore National Laboratory under contract No. W-7405-ENG-48.

DOSPEC Experience

As a result of a low incidence of neutron exposures at our laboratory, we have had little opportunity to evaluate DOSPEC operationally. However, we have participated in the 1982 CEC/ORNL Personnel Neutron Dosimetry Intercomparison. The dose equivalent results are presented in Table 1. It is important to note that the dose equivalent values were determined without making any corrections that require prior knowledge of the spectra. The largest error for administered dose equivalent values over 1.20 mSv (120 mrem) was 45%. This is in marked contrast to the experience of intercomparison participants using single component dosimeters.[10] This experience is, however, more consistent with others who have used the combination detector approach.[10] A summary of the spectral distributions determined by DOSPEC compared with reference values is presented in Table 2.

Summary

DOSPEC has been in operational use for over two years, but a low worker exposure history has limited the experience with system performance. However, participation in the CEC/ORNL intercomparison provided results that support the multiple detector concept and validate its ability to estimate the spectrum.

Table 1. DOSPEC Results Reported for the 1982 CEC-ORNL Personnel Neutron Dosimetry Comparison

Neutron Field Description	Reference Value - (mSv)	DOSPEC Value - (mSv)
HPRR-no shield	0.62	0.67
	11.1	9.3
HPRR-13 cm steel	0.64	0.51
	11.0	8.01
HPRR-20 cm concrete	0.48	0.43
	9.43	7.38
HPRR-12 cm Lucite	0.59	1.32
	11.0	11.8
0.57 MeV	0.70	0.98
	8.37	6.68
1.2 MeV	6.00	6.56
	1.50	2.17
5.3 MeV	6.50	7.33
	3.99	5.10
15.0 MeV	13.1	18.2
	1.05	1.31
^{252}Cf-15 cm D_2O	10.9	11.6
	1.20	1.91

Table 2. DOSPEC Spectral Distribution Comparison for 1982 CEC-ORNL Personnel Neutron Dosimetry Intercomparison Fields.

Neutron Field Description	Fluence per Energy Band, Normalized to Unity		
	Thermal - 0.1 MeV	0.1 - 1.5 MeV	>1.5 MeV
HPRR-no shield	0.295	0.459	0.246 D
	0.143	0.568	0.288 R(a)
HPRR-13 cm steel	0.478	0.388	0.134 D
	0.119	0.798	0.0833 R(a)
HPRR-20 cm concrete	0.718	0.181	0.101 D
	0.646	0.226	0.128 R(a)
HPRR-12 cm Lucite	0.681	0.193	0.126 D
	0.734	0.141	0.125 R(a)
0.57 MeV	0.000	1.000	0.000 D
	0.000	1.000	0.000 R
1.2 MeV	0.000	0.956	0.044 D
	0.000	1.000	0.000 R
5.3 MeV	0.000	0.318	0.682 D
	0.000	0.000	1.000 R
15.0 MeV	0.101	0.000	0.899 D
	0.000	0.000	1.000 R
^{252}Cf-15 cm D_2O	0.807	0.116	0.077 D
	0.721	0.149	0.130 R(b)

D-DOSPEC R-Reference Values: (a) - Calculated from data in [8]
(b) - Calculated from data in [9]

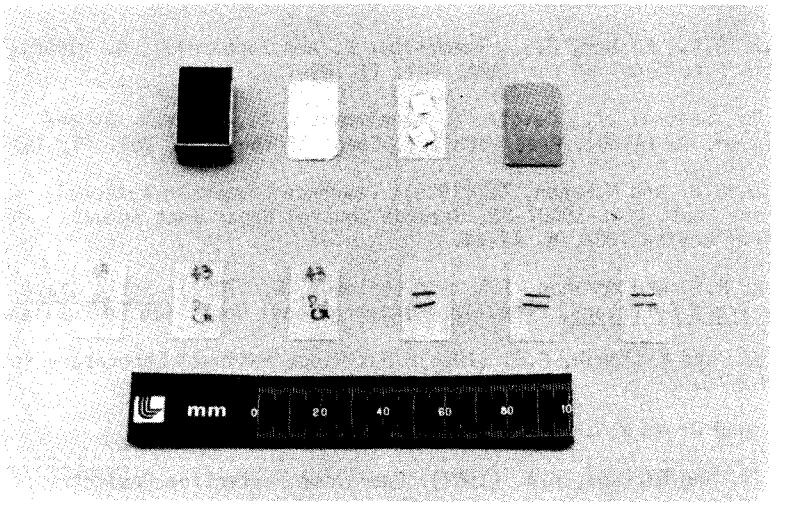

Figure 1. DOSPEC components with cadmium container.

Figure 2. Bacterial colony counter for measurement of track density on CR-39 and polycarbonate, together with desk top computer.

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