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Title: ANGULAR DEPENDENCE OF A SIMPLE ACCIDENT DOSIMETER

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ANGULAR DEPENDENCE OF A SIMPLE ACCIDENT DOSIMETER

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Abstract

A simple dosimeter made of a sulfur tablet, bare and cadmium covered indium foils and a cadmium covered copper foil has been modeled using MCNP5. Studies of the model without phantom or other confounding factors have shown that the cross sections and fluence-to-dose factors generated by the Monte Carlo method agree with those generated by analytic expressions for the high energy component. The threshold cross sections for the detectors on a phantom were calculated. The resulting doses assigned agree well with exposures made to three critical assemblies. In this study the angular dependence on a phantom is studied and compared with measurements taken on the GODIVA reactor. The dosimeter positions on the phantom are facing the source, on the back and the side.

Introduction

In previous papers [1, 2] the modeling of a simple dosimeter made of a sulfur tablet, bare and cadmium covered indium foils and a cadmium covered copper foil has been modeled using MCNP5 [3]. The conclusion made was that most of the neutron dose from criticality assemblies results from the high energy neutron fluences determined by the sulfur and indium detectors. The results using doses measured from the GODIVA, SHEBA, and bare and lead shielded SILENE reactors confirmed this.

The angular dependence of an accident dosemeter is of interest in evaluating the exposure of personnel. To investigate this effect accident dosemeters were placed on a phantom and exposed to the GODIVA reactor at phantom orientations of 0°, 45°, 90°, 135°, and 180° to the assembly center line.

Materials and Methods

Critical Assembly

The GODIVA IV [4 5 6] assembly was used for the exposures. A simple description of the assembly and the calculated leakage spectrum are provided in reference 4. The leakage spectrum is not calculated below 10 keV. The assembly is housed in building with a considerable mass of peripheral equipment. Detailed modeling of the configuration is not feasible. The dosemeters on phantoms were exposed at three meters from the assembly to pulse of Δt of 71.1°C. The phantom orientations were 0°, 45°, 90°, 135°, and 180° to the assembly center line.

Dosemeter

The simple dosimeter[7] made of a sulfur tablet, bare and cadmium covered indium foils and a cadmium covered copper foil is shown in Figure 1. The holder is made of polymethyl methacrylate (LUCITE). The indium and copper foils are 0.0254 cm (1 mil) thick and the cadmium covers are 0.05 cm thick. The sulfur tablet is 1.27 cm in diameter. The dosimeter was place on a 40 cm x 40 cm by 15 cm thick LUCITE phantom.

Computation

MCNP5[8] was applied to this problem. This particular version of MCNP has the advantage of having a newer random number generator that combined with various variance reduction methods allows the modeling of the rather thin detectors on a large phantom. The thermal neutron scattering cross sections $S(\alpha,\beta)$ for polyethylene cross section was used since it models the H-C-H interaction in Lucite

The input leakage spectrum was modeled using a parallel and extended field that covered the phantom at all orientations.

The cross sections for computing the fluences were taken from Table G.2, Continuous-Energy and Discrete Neutron Data Libraries Maintained by X-5, Ref 8. The reaction cross sections are from Table G.6, Dosimetry Data Libraries for MCNP Tallies.

All tallies passed 10 statistical checks for the tally fluctuation chart bin result tests of MCNP5 and the net uncertainty was less than 5%.

Radioactivity Measurements

The sulfur pellets were measured after burning with a Berthold 770 gas proportional counter. The other foils were measured with a 92 percent relative efficiency high purity germanium detector in a tungsten-steel shield and analyzed by GammaVision software.

Doses from the sulfur pellet and high-energy indium foil counts were calculated using the cross sections and fluence-to-dose conversions based on 0° incidence determined with the

GODIVA spectrum. The thermal and intermediate dose was calculated using Dosimetry for Criticality Accidents, A Manual", IAEA Technical Report Series 211 (Vienna, 1962).

Results

The angular dependence of the response is shown in Figure 2. The uncertainties in the measured values come mainly from the determination of the activity of the high-energy indium foils. There is still considerable activity from the short half-life component excited by the thermal neutrons that must be decayed before the reading. The trend of the measured and calculated data is the same. The nominal dose at 0° for the reactor configuration is 0.42 Gy.

The calculated doses were plotted normalizing to the 0° result. The resultant number of interactions calculated was converted to activities using the half-lives. The calculated activities were entered into the same algorithm used for the measured activities to determine the dose.

The agreement for the cases when the dosimeter is exposed directly to the source, 0°, 45°, 90°, is good but there is a significant disparity for the angles where the phantom eclipses the source, 135° and 180°.

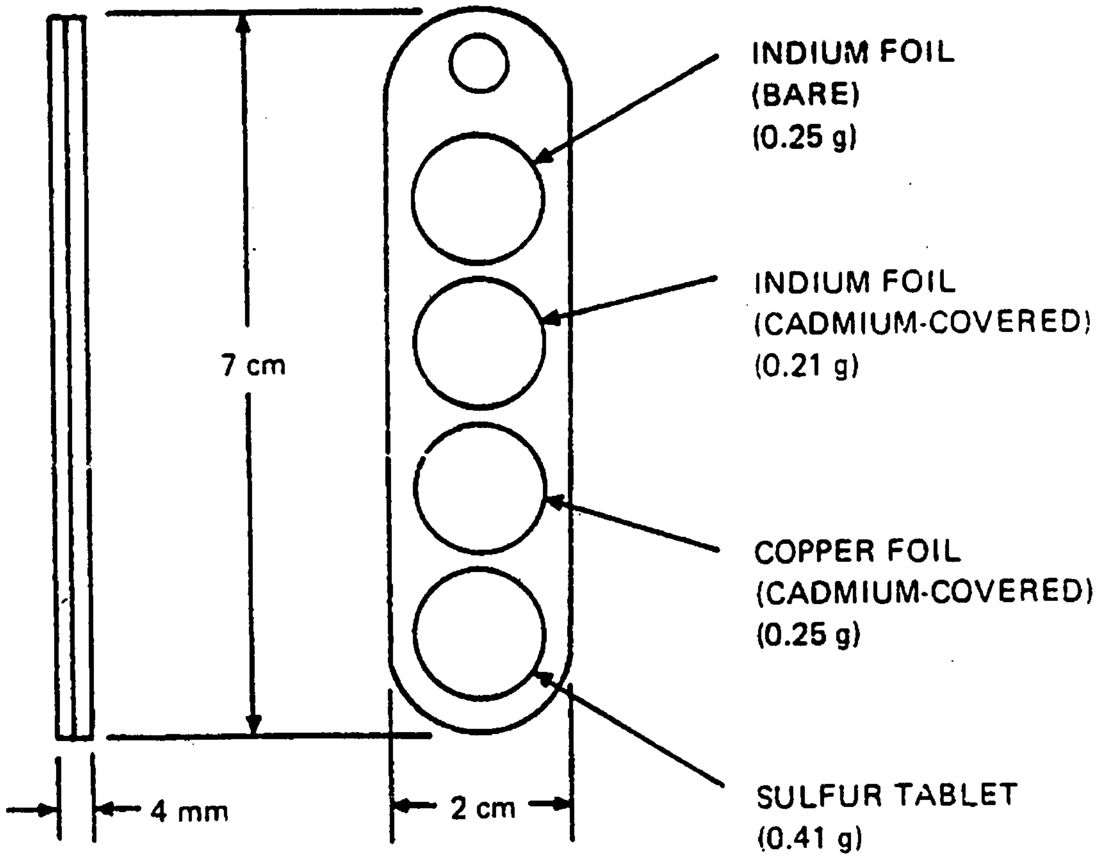

Figure 1, Los Alamos Personnel Criticality Dosimeter

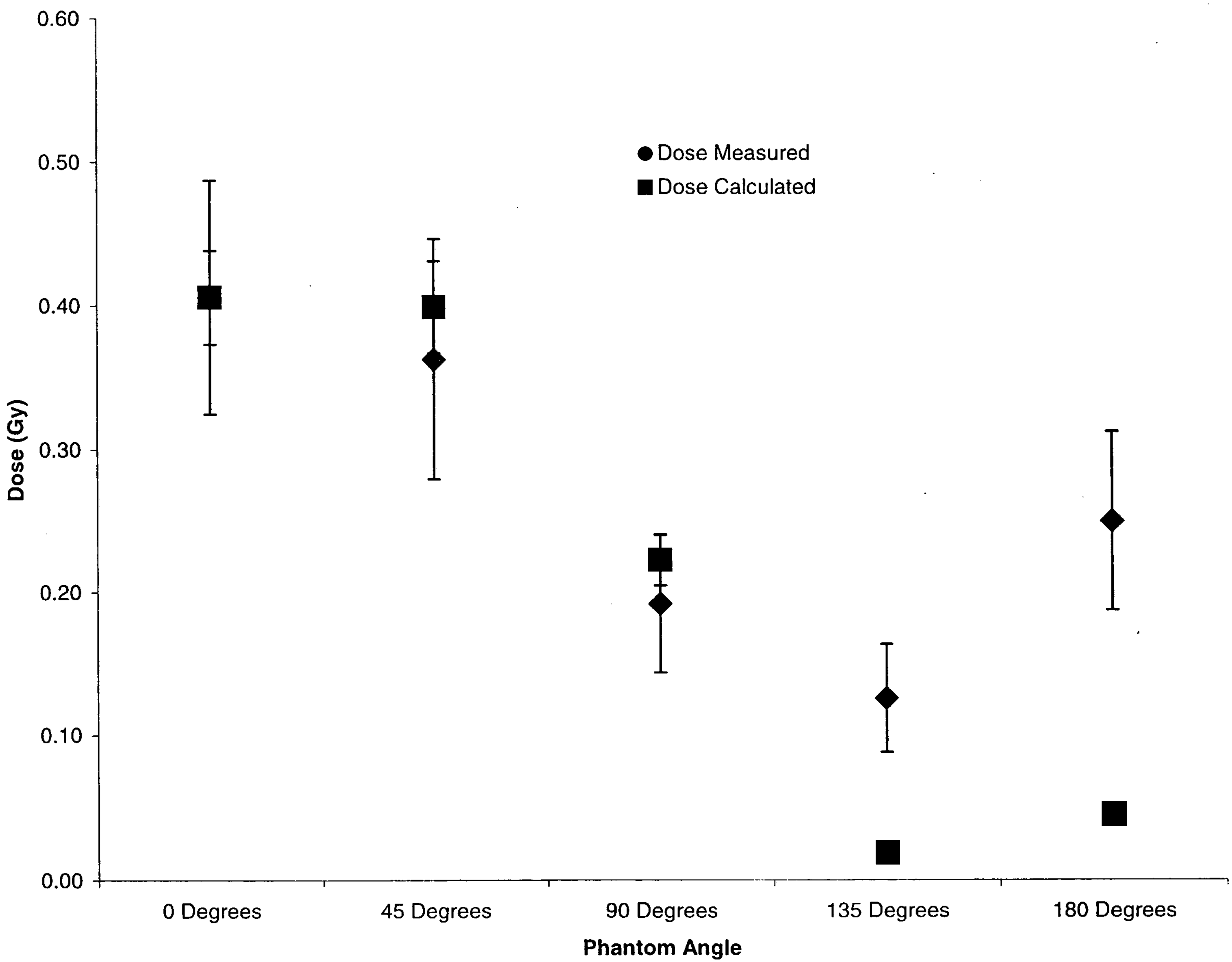

Figure 2, Angular Dependenece

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