Conf-770726--1

CURRENT SITUATION FOR EXOELECTRON DOSIMETERS OF BeO CERAMIC IN NEUTRON DOSIMETRY

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Much of the early enthusiasm for using exoelectron dosimeters (ceramic BeO Thermalox 995) in neutron dosimetry was predicated on the belief that the response to fast neutrons, relative to gamma rays, was 0.18 to 0.28 on a R_γ equiv/tissue rad n_f basis for neutron energies between 0.1 and 16 MeV.[1] Pairs of BeO disks had to be used, one covered with a polyethylene radiator for producing recoil protons, and the other covered with Teflon. More recent studies indicated a considerably lower ratio of 0.11 for Health Physics Reactor Research fission neutrons.[2] In the earlier work the BeO was coated with gold to enhance the surface conductivity during reading of the thermally stimulated exoelectron emission (TSEE). No metallic coating is now deemed to be necessary. Perhaps thermal neutron contamination of the fast neutron beams due to some thermalization within the hydrogenous radiator was sufficient to cause the high apparent fast neutron sensitivity via n,γ reactions. Whatever the cause, however, the lower value of 0.11 has caused a marked subsidence of enthusiasm in this technique of fast neutron monitoring.

The greatest drawback arises when attempting to measure neutron doses in mixed gamma, neutron fields in which the ratio of doses is biased in favor of the gamma component. A TSEE reading is accurate

*Research sponsored by the Energy Research and Development Administration under contract with Union Carbide Corporation.

to no better than 5%. Since the neutron dose is estimated from the differential of the readings of two exoelectron dosimeters, the relative error will be about 65%. Since in a 1:1 neutron to gamma field, the dosimeter with the proton radiator reads only 11% higher than the Teflon covered dosimeter, the difference of the TSEE readings is two-thirds as large as the desired fast neutron TSEE response. Such an undesirable situation is depicted in Fig. 1 with large error bars assigned to the fast neutron doses at positions under the boron paraffin shield. Inside the central cavity, where the neutron-to-gamma ratio of doses is 7:1, the relative error in measuring the neutron dose is lowered to 13%. In this experiment the fast-neutron dose was being profiled spatially. A TSEE reading takes only a few minutes so that the profiling operation was completed within 30 minutes.

The fast neutron response rapidly decreases to zero when the neutron beam becomes nearly parallel to the face of the BeO disk (recoil protons no longer enter the BeO). The directional response to fast neutrons and gamma radiation is shown in Fig. 2. A cube for holding BeO disks with polyethylene plugs (Fig. 3) that permits the incident direction of the neutrons to be rapidly ascertained[2] has been tested as a nuclear accident monitor.

It is worth mentioning that a dual TL-TSEE reading of a single polyethylene covered BeO disk now provides the same data as the previously used pair of BeO dosimeters.[3] The BeO as a TLD has only an extremely weak response to the recoil protons. The gamma dose can, therefore, easily be measured from the TL reading alone. This technique allows the number of BeO disks for mixed fast-neutron, gamma-radiation field measurements to be reduced by 50%.

Successful operation is, however, still dependent on the presence of a neutron rich field. This same requirement forces us to conclude that this dosimetry system is unsuitable for generalized fast neutron personnel monitoring.

REFERENCES

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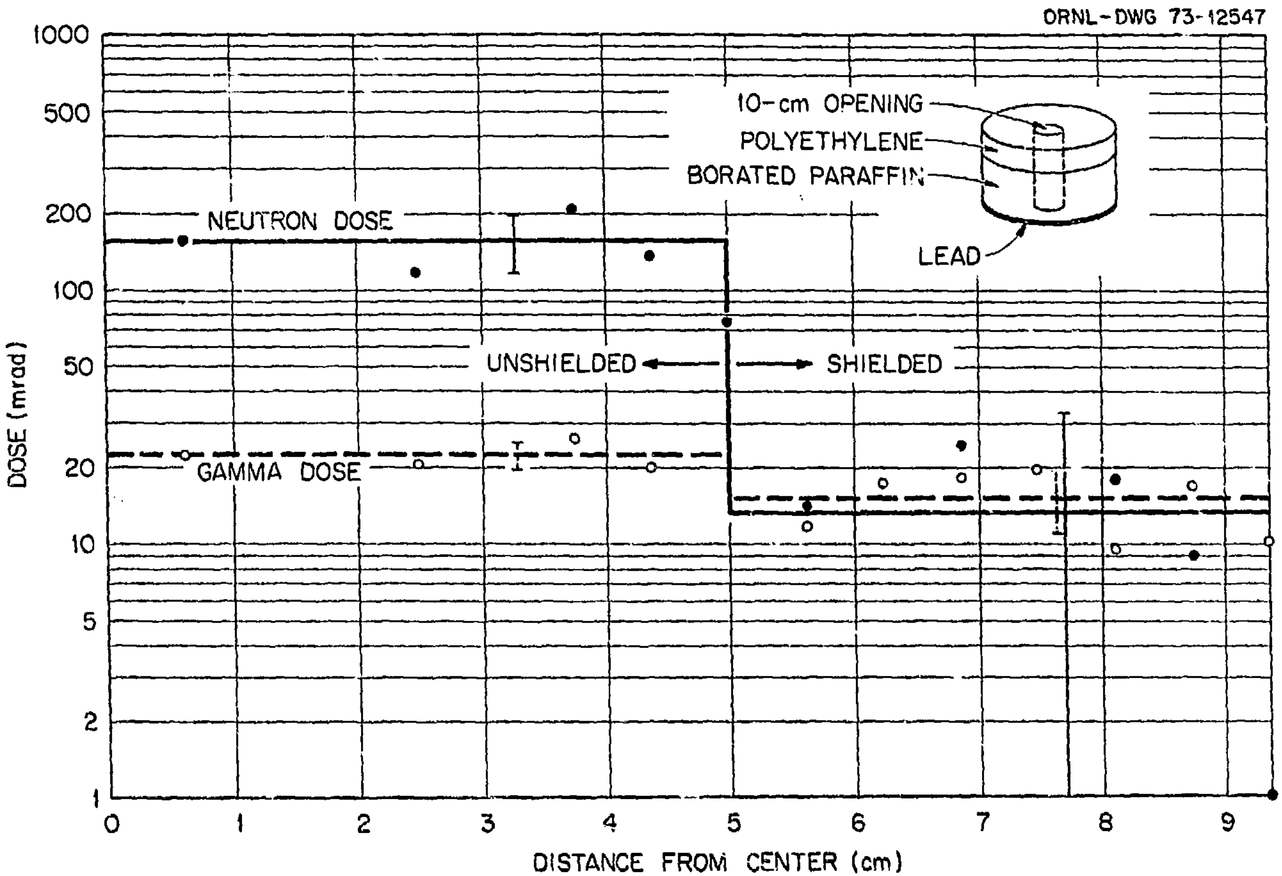
3. R. B. Gammage and A. K. Garrison, Proc. 4th Int. Symp. on Exoelectron Emission and Dosimetry, 1973, Ed. A. Bohun, Czech. Acad. of Sci. and A.E.C., 93 (1973).

FIGURE CAPTIONS

Fig. 1. Fast neutron (closed points) and gamma (open points) dose profile below a shield designed for the partial body irradiation of mice.

Fig. 2. Directional response of ceramic BeO disk TSEE dosimeters to 14 MeV neutrons and gamma radiation, using thick polyethylene and Teflon radiator covers.

Fig. 3. Teflon cube, 2.5 cm in diameter, with six recesses and plugs of polyethylene or Teflon to hold six BeO ceramic disks 1.25 cm in diameter. The device is used for locating the direction of a neutron beam as well as for measuring the fast neutron and gamma doses.



ORNL-DWG 73-12547
10-cm OPENING
POLYETHYLENE
BORATED PARAFFIN
LEAD
NEUTRON DOSE
UNSHIELDED
SHIELDED
GAMMA DOSE
DOSE (mrad)
1000
500
200
100
50
20
10
5
2
1
0
1
2
3
4
5
6
7
8
9
DISTANCE FROM CENTER (cm)

ORNL-DWG 74-1462