Neutron shielding calculations and measurements for mcrotron based photoneutron source

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Introduction

Microtron based photoneutron source of strength (2×10^9n/sec)[1] had been installed at Microtron centre, Mangalore University. The photoneutron generator is fabricated using the Beryllium as photoneutron target (supplied by Beryllium Plant, BRIT, Unit of DAE, India) and High Density Polyethylene (HDPE) blocks, borated wood and borated rubber as shielding materials. Adequate leads blocks are also used to shield the gamma rays. The characteristic parameters of the neutron beam measured are as shown in table 1.

Table 1: Neutron beam parameters

Beam Parameter	Value
Thermal neutron flux At (collimator inlet)	6.82E+06 n/cm^{2}sec.
Thermal neutron flux (at collimator exit)	6.48E+04 n/cm^{2}sec 4.71E+03n/cm^{2}sec) (with Cd lining)
Neutron/gamma ratio	3.03E+02 n/cm^{2}sec mR.
Cadmium ratio	6
L/*D* ratio	18

The applications that can be carried out using this photoneutron are: elemental analysis, neutron cross section measurements, and also for neutron radiography studies. In order to perform these experiments one must have proper neutron and gamma shielding.

Shielding Calculations

We have employed MCNP [2] code for neutron transport calculations. The values of the characteristic parameters of the neutron beam are used as the source term for MCNP calculation. Surface tally F2 tally (unit 1/cm^2) is used which gives the number neutron crossing a surface of interest. Simulation is carried out for 1500000 histories so that relative error in calculations is kept below 5%. Calculations are made for different thickness of borated wood which contains 4% boron and borated rubber which contains 40% boron. Calculations showed that combination 5.08cm boronated (4% boron content) wood and 3.1 mm boronated (41% boron content) rubber is suffice to block completely the neutrons leaking out from the HDPE block. Therefore we have also estimated the neutron dose using MCNP at various locations of work place. It is found that neutron dose is almost zero.

Experimental details

The layout of microtron building housing neutron generator is shown fig 1. The neutron shielding materials boronated rubber (Boron Rubber (INDIA), Gujarat) and Borated wood (Western India Plywood Ltd. Connanore, Kerala, India) used for shielding assembly are shown in fig. 2 and fig. 3.

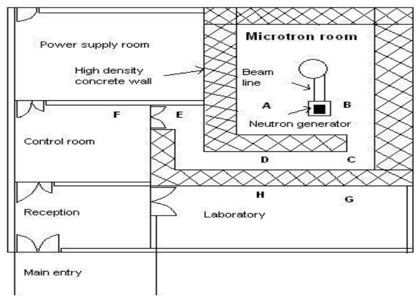

Fig. 1. The layout of microtron building housing neutron genetrator,

Fig. 2. A sheet of Boronated rubber for neutron shielding (41% boron content),

Fig. 3. A block of Boronated wood for neutron thermalizing and shielding (4% boron content),

Neutron dose measurement

It is expected that the presence of leakage neutrons due to streaming in shielding materials. In order to confirm the neutron dose level at the work place leakage neutron dose measurement is carried out using REM meter. The Eberline Neutron Rem Detector (Procured from Thermo Electron Corporation, USA) (NRD) sphere is a portable instrument for the detection and measurement of the dose equivalent rate from neutron radiation. Neutron rem detector is a nine-inch-diameter, cadmium loaded polyethylene sphere with a boron trifluoride (BF3) detector in the centre consists of a cylindrical aluminum proportional tube filled with a BF3 fill gas at a pressure of 0.5–1.0 atmospheres. The energy response of this detector for the neutrons of the energy range from 0.025 eV to about 10 MeV. The BF3 tube allows excellent gamma rejection. The detector is shown to be having gamma rejection up to 500 R/h (5 Sv/h).

Leakage neutron dose measurement is carried out was carried at various locations (shown in Fig. 1) of interest inside the accelerator room by covering neutron generator with these shielding materials and results are presented in the Table 2

Results and discussion

Shielding calculations using MCNP code show that combination 5.08cm boronated (4% boron content) wood and 3.1 mm boronated (41% boron content) rubber is suffice to block most of the neutrons leaking out from the HDPE block. Table 2 shows that experimentally measured leakage neutron dose is not zero at various locations of work place, though estimated the neutron dose using MCNP at various locations of work place is almost zero. This is due to the fact that the presence of streaming of neutrons in the shielding material layers. Experimental results shows that dose level at work places are well within the safety limit prescribed by the ICRP[3].

Table 2: Neutron dose level at locations inside the microtron building

Location	REM meter reading μR/h
A	66
B	68
C	65
D	25
E	0.078
F	0.002
G	0.006
H	0.006

Conclusions

Monte Calculations using MCNP shows that using the combination 5.08cm boronated (4% boron content) wood and 3.1 mm boronated (41% boron content) rubber is suffice to block most of the neutrons and estimated neutron dose at work place is zero. Because of the presence of the streaming neutrons, measured neutron dose is not zero at various work places. Experimental results shows that dose level at work places are well within the safety limit prescribed by the ICRP[3].

References

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