

Shielding Measurements for a Proton Therapy Facility

We evaluated the precision of the analytical calculations for the Roberts Proton Therapy Center (1) against dosimeter readings in the facility.

To evaluate the precision of the calculations they had to be compared to dosimeter readings at the same locations. Neutrak dosimeters were used in two batches. The first batch was placed for one month and was sensitive to photons with a minimum dose needed of 1 mrem. The second batch was dosimeters sensitive to photons and neutrons with a minimum dose needed of 1 mrem and was placed for two. The dosimeters used for evaluation were chosen based on two criteria: they registered above the minimum dose needed for the dosimeters to register a dose and the thickness of shielding between them and neutron sources were easy to calculate. Only points A(1), F(5), G(5,R), and H(5) fit the criteria required for evaluation. All four points were from dosimeters in the second batch.

The distances to these points from the nearest neutron sources and the amount of wall shielding between them were measured. These numbers in addition to other shielding factors of these points were plugged into Equation 1 to yield the expected dose reading at that point over a 2 month period and compared to the actual readings (Figure 1).

Points F(5) and G(5,R) were shielding from the primary sources of neutron spectra by concrete only. Point H(5) was shielded by both concrete from the maze wall in GR4 and pre-cast block in the wall directly West of it. Point F(5) was shielded by concrete from the walls West of it and the cyclotron. Shielding materials other than concrete were not calculated in Avery, et al. and are the likely cause of the less than precise calculations seen for points F(5) and H(5). Thus the analytical calculations of Avery, et al. are precise for points in a facility shielded only by concrete but may require additional computations for points shielded by other materials.

$$H_{2month} = \frac{52 \cdot 1000}{6} \cdot \sum U \cdot T \cdot W \cdot \frac{C \cdot N_p \cdot A \cdot F \cdot t_{wall} \cdot 235 \cdot e^{b \cdot c}}{d^2}$$

Equation 1: Calculation of 2 month total dose equivalent. d is the distance from a particular neutron source to the dosimeter point with t_{wall} the thickness of wall shielding between those two points. U is use factor, T is occupancy factor, W is the workload, C is a unit conversion factor, N_p is number of proton per minute, A is attenuation of nearby material, F is the beam loss factor, and b and c are from fits of the neutron spectra of the neutron source.

Dosimeter	Analytical TDE (μ Sv)	Observed Dose (μ Sv)	% Difference
A(1)	37.50174019	10	-73.33%
F(5)	52.82528655	50	-5.35%
G(5,R)	54.54721287	50	-8.34%
H(5)	1.37988956	15	987.04%

Figure 1: Comparison of analytically calculated total dose equivalent over 2 months at the dosimeter points versus the dosimeter readings.

References:

¹Avery, S., Ainsley, C., Maughan, R., and McDonough, J. *Analytical Shielding Calculations for a Proton Therapy Facility.* Radiat. Protect. Dosim. 131, 167-179 (2008).