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TITLE A COMPARISON OF ANALYTIC MODELS FOR ESTIMATING DOSE EQUIVALENT RATES IN SHIELDING WITH BEAM SPILL MEASUREMENTS

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MASTER

A COMPARISON OF ANALYTIC MODELS FOR ESTIMATING DOSE EQUIVALENT RATES IN SHIELDING WITH BEAM SPILL MEASUREMENTS

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ABSTRACT

A comparison of 800-MeV proton beam spill measurements at the Los Alamos Meson Physics Facility (LAMPF) with analytical model calculations of neutron dose equivalent rates (DER) show agreement within factors of 2-3 for simple shielding geometries. The DER estimates were based on a modified Moyer model for transverse angles and a Monte Carlo based forward angle model described in the proceeding paper.[1]

1. Beam Spill Measurements in the LAMPF Switchyard Area

Two measurements were made in the LAMPF switchyard area, where the Los Alamos Neutron Scattering Center (LANSCE) beam line makes a 89° bend with respect to the linac. Bending magnet failures can allow the beam to exit the beam line toward a vehicle access filled with concrete blocks. A tungsten block was inserted between two bending magnets and the first magnet was turned off, simulating a beam spill within a bending magnet. Two neutron radiation detectors, Albatrosses, were located on top of the truck access shielding. The overall path length from spill to observation point was approximately 12m comprised of 0.3m of steel, 5.7m of air, and 6m of concrete shielding. The measured(calculated) neutron DER for the two Albatrosses were 80.6(40.6) and 35.6(16.2) mrem/hr/μA. These calculations meet our requirements for the analytical model.

2. Beam Spill Measurements at LANSCE

The LANSCE proton beam line enters the upper floor of the Target 1 area and makes a 90° bend downwards into the neutron spallation production target. If any of three bending magnets fails, the proton beam can exit the beam line and continue toward Experimental Room 1 and 2 (ER1 and ER2). ER1 is located on the lower level of the Target 1 area and ER2 is an adjacent building. The shielding and room geometry is very complicated for both ER1 and ER2. Four beam spill locations and a variety of Albatross layouts were used in these measurements. Three Albatrosses were located in ER2 along the beam line direction for these spill tests. One of these, A, was located at approximately beam line height (upper level) of ER2 while the other two, B and C, were located at the lower level of ER2. Albatrosses B and C are shielded by many meters of tuff in addition to the steel, concrete, magnetite concrete, and air that shield all three. Table 1 details the measurements and calculations for these Albatrosses for the four spill tests.

Table 1: A Comparison of DER Measurements (in mrem/hr/μA) with Calculations for ER2

Spill Point	*Albatross A* *Meas.(Calc.)*	*Albatross B* *Meas.(Calc.)*	*Albatross C* *Meas.(Calc.)*
1	251 -- 495 (434)	43 (0.0)	79 (6.8)
2	303 – 597 (752)	52 (0.01)	91 (10.6)
3	9.1 – 18 (–)	1.5 (0.0)	4.2 (5.6)
4	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)

The model estimates worked well for a number of spill and Albatross locations, but failed for spills 1-3 for Albatross B and spills 1-2 for Albatross C. The model underestimates the DER by not including indirect contributions. The ratios for Albatross B to A are 0.087, 0.087, and 0.083, and the ratios for Albatross C to A are 0.146 and 0.135. The ratios are constant and independent of spill location indicating that the DER is primarily due to indirect sources. Since ER2 is an enclosed area, the indirect contributions are primarily due to backscattered neutrons. The measured DER can be dominated by contributions from indirect sources and will depend upon geometry and detector location. This effect was most dramatic in ER1 because it is surrounded on three sides by tuff and is much closer to the complicated shielding geometry of the target cell area.

3. Conclusion

The analytical model was successful in estimating the neutron DER for spill/observation point combinations where the geometry was uncomplicated, but failed to accurately estimate the neutron DER for complicated geometries. This type of model must be used with a great deal of caution; the shielding geometry must be well understood so that significant indirect contributions to the DER can be included.

1. Wilkinson et al., *DPF Conference Proceedings* (1992).