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TITLE: MEASURED NEUTRON BEAM LINE SHIELDING EFFECTIVENESS OF SEVERAL IRON/POLYETHYLENE CONFIGURATIONS

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Measured neutron beam line shielding effectiveness of several iron/polyethylene configurations

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ABSTRACT: Neutron and gamma-ray leakage measurements were taken at various stages of shield construction for neutron flight path 5 (the Lash-up flight path) at LANSCE, to compare the relative effectiveness of several configurations. Dose equivalent rates were determined for three categories: "low-energy neutrons", below 20 MeV; "high-energy neutrons", above 20 MeV; and gamma rays, as measured by hand-held survey instruments. The low-energy neutrons were measured by activation of an indium foil in a paraffin-filled cadmium cannister, sized to be generally insensitive above 20 MeV. High-energy neutrons were measured by (n,2n) production of Carbon 11 in a plastic scintillator with a 20-MeV threshold. Thermal neutrons were not measured at the shield-leakage test points. Room-scattered neutrons were observed by Albatross IV detector readings, which were taken beside the shield as a measure of variation of room background as the shield configuration changed.

A sketch of the final shield cross section is shown in Figure 1. For these tests, the walls were completed as shown, and the top was added in stages. Measurements were taken directly above the beam pipe at two and four feet from the LANSCE bulk shield. The four-foot data is more representative of shielding a beam pipe with neutron collimators, as opposed to data taken nearer the inefficient interface between the flight path shield and the bulk shield. We think that a strong component of high-energy neutrons impinges on the beam path collimators and nearby shielding because of lack of adequate high-energy collimation within the bulk shield. Thus, the source is strengthened by spallation and evaporation spectra within the flight-path shield.

The data tabulated in Table 1 are generally self explanatory. "P" refers to commercial high-density polyethylene, typically of specific gravity 0.94. "BP" refers to five-wt.-percent borated polyethylene of generic commercial varieties. One important indication of these data is the utility of efficient lamination and relative thicknesses of shield materials.

Although the data represent a small and perhaps specialized sample, one interesting finding is that the "plain" polyethylene reduces the neutron and total doses (in spite of the 2.2 MeV gammas) more than the borated polyethylene. This effect is not unexpected for shields of this thickness, where a strong high-energy component occurs in the source; addition of the boron compounds displaces ~25% of the hydrogen in the polyethylene. The resulting effect is strongly source-dependent and may also be quite geometry-dependent, considering neutron buildup and reflection from opposite walls within the shielded cavity. Gary Russell has performed leakage calculations for a large number of shield configurations, reported elsewhere, which show the interplay of these effects.

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Table I

FLIGHT PATH FIVE SHIELD TEST RESULTS, OCTOBER 25-31, 1987

mrem/hr

SHIELD CONFIGURATION	2 FT				4 FT				SIDE
INCHES	LEN	HEN	G	TOTAL	LEN	HEN	G	TOTAL	LEN
6Fe	1540	32	160	1730	1000	36	104	1140	23
6Fe,4BP	355	36	40	425	116	27	14	157	6.1
12FE	1340	14	40	1400	787	10	25	822	20
12Fe,12BP	10	8	4	22	8	4	2	14	6.1
12Fe,2P,6Fe,4P	2.6	3.6	2.1	8.3	.9	1.2	1.1	3.2	0
12Fe,2P,6Fe	53	5.4	3.6	61	28	2	1.6	32	0.4
12Fe,2P,6Fe,4BP	4.7	3.4	1.6	9.7	3.2	1.8	0.6	5.6	1.4
Shutters Closed Background	0.6	6	0.4	7	0.6	6.4	0.4	7.4	3

HEN = High-energy neutrons, > 20 MeV, measured by carbon scintillator activation, using flux-to-dose rate conversion factor (5 n hr/mrem cm^2 s)

LEN = Low-energy neutrons, < 20 MeV, measured by moderated indium foil activation, using flux-to-dose rate conversion factor (7 n hr/mrem cm^2 s)

Thermal neutrons (< 3% of dose) not measured

Background (FP 4 and FP 5 shutters closed) subtracted from data

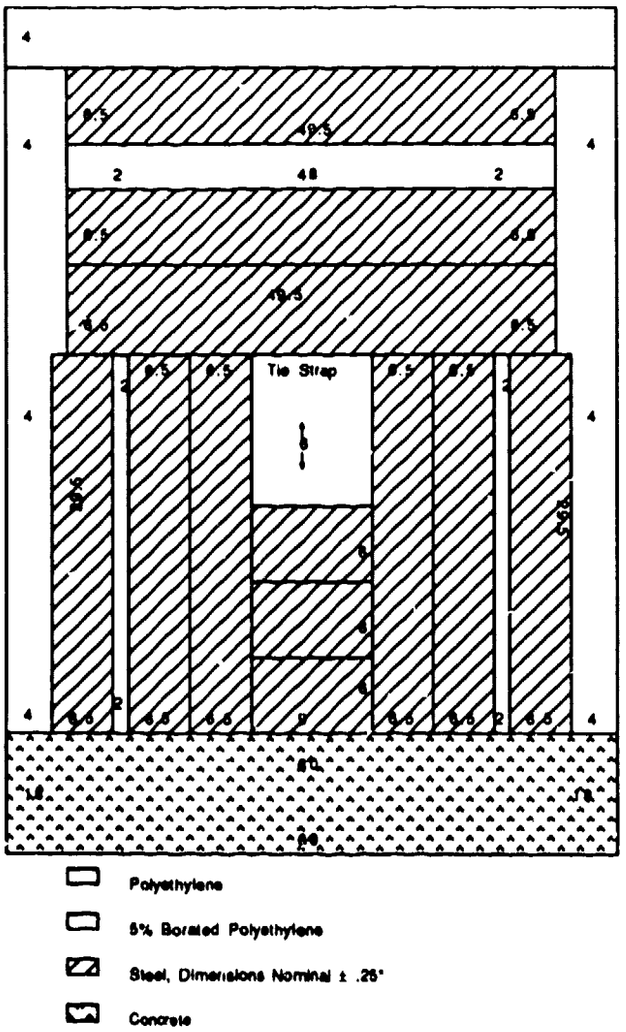

Fig. 1 Flight path 5 shielding cross section schematic diagram.