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A MCNP Model of Gloveboxes in a Plutonium Processing Facility

D. E. Dooley and D. E. Kornreich

Los Alamos National Laboratory

I. Background

Nuclear material processing usually occurs simultaneously in several gloveboxes whose primary purpose is to contain radioactive materials and prevent inhalation or ingestion of radioactive materials by workers. A secondary benefit of the gloveboxes is that they provide some radiation shielding. Lead and steel shield workers from low-energy photons and transparent hydrogenous shields can be placed around gloveboxes to moderate neutrons. If several operations occur simultaneously in the room, a worker on a given process receives a dose equivalent from the sources in his glovebox as well as a dose equivalent from sources in other gloveboxes throughout the room.

II. The Problem

A room in the Plutonium Facility at Los Alamos National Laboratory has been slated for installation of a glovebox for storing plutonium metal in various shapes during processing. This storage glovebox will be located in a room containing other gloveboxes used daily by workers processing plutonium parts. A MCNP[1] model of the room and gloveboxes has been constructed to estimate the neutron flux at various locations in the room for two different locations of the storage glovebox and to determine the effect of placing polyethylene shielding around the storage glovebox. A neutron dose survey of the room with sources dispersed as during normal

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production operations[2] was used as a benchmark to compare the neutron dose equivalent rates calculated by the MCNP model.

III. The MCNP Model

The MCNP model includes structures in the room such as walls, floor, ceiling, and containment structures, which are closely modeled from engineering drawings. Containment structures include gloveboxes, connecting trolley boxes (trunk lines), entry hoods, and drop boxes from an overhead trolley. The overhead trolley and containment support legs are not included in the model. The windows and the gloveports on the individual containment structures are modeled. The gloveboxes are modeled as steel (iron), glovebox windows are modeled as normal glass (SiO_2), and gloveports are modeled as a rubber (water), lead, rubber sandwich to simulate a leaded glove. The model of the room requires approximately 3000 cells.

Figure 1 displays an overhead view of the layout of gloveboxes with detector measurement locations shown for calculations and measurements. The two locations of the storage glovebox are also shown. The neutron dose equivalent was obtained from MCNP using point detectors as a neutron flux, and then converted to doses equivalent using ANSI fluence-to-dose factors.[3]

Figure 2 displays the results of the experimental and calculated neutron dose equivalents at various locations throughout the room. An additional curve that includes an estimated 1 mrem/hr background dose equivalent rate is provided as no background source is included in the MCNP model. Background radiation sources include natural radiation, sources in other rooms, and the storage vault in the basement. In general, good agreement between the experimental and

calculated neutron dose equivalent rates is obtained. A significant discrepancy occurs at locations 24 –27 where MCNP overestimates the dose equivalent rates. This may result from large pieces of equipment (power supplies, cabinets, etc.) that provide some shielding not being included in the model. Table 1 provides a comparison of neutron doses at various locations in the room with the storage glovebox in two alternative locations. Placing the storage glovebox closer to the center of the room (Location 1) results in larger dose equivalent rates throughout the room. The polyethylene shielding reduces the neutron dose by approximately a factor of 2.

References

1. "MCNP – A General Monte Carlo Code for Neutron and Photon Transport, Version 4B," LA-7396-M, Rev. 2, J. F. BRIESMEISTER, Ed., Los Alamos National Laboratory (1995).

2. HENCH, K. W., "Modeling Fabrication of Nuclear Components: an Integrative Approach," LA-UR-96-1270, Los Alamos National Laboratory (1996).

3. "American National Standard for Neutron and Gamma-Ray Fluence-to-Dose Factors," ANSI/ANS-6.1.1-1991, American Nuclear Society (1991).

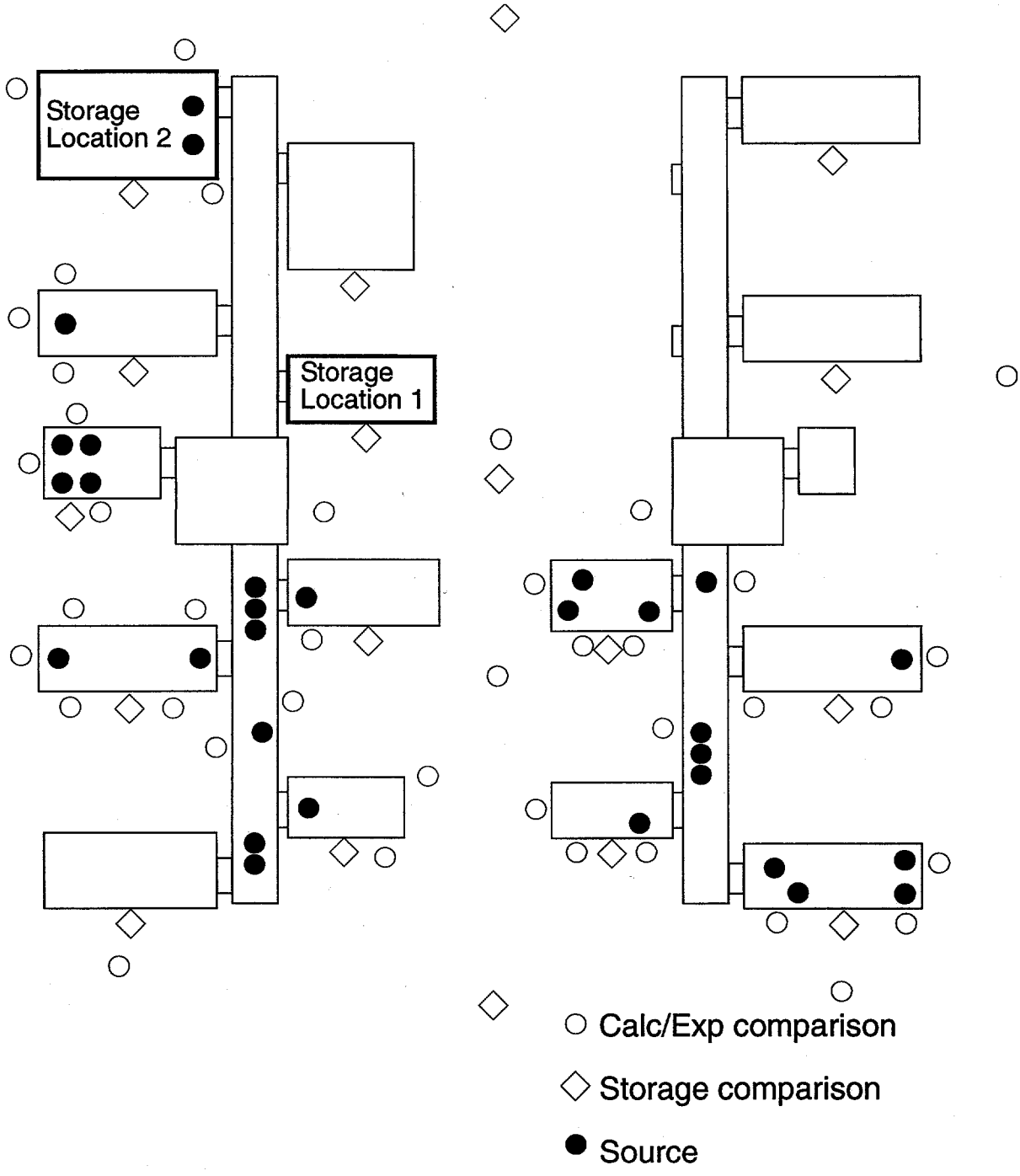

Figure 1. Overhead view of glovebox layout for the calculation/experimental comparison and for the storage comparison.

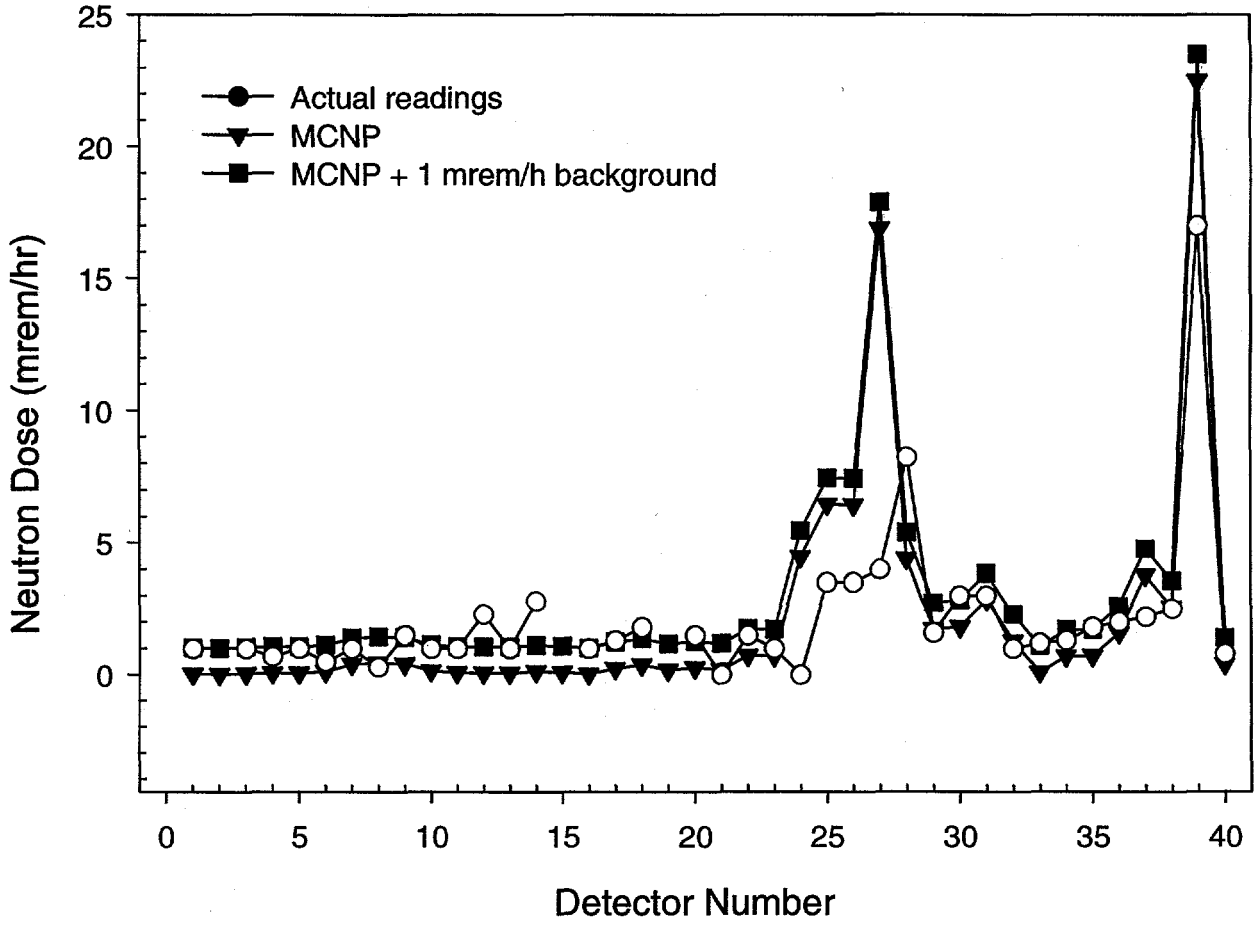

Figure 2. Comparison of measured and calculated neutron dose rates in a room.

Table 1. Neutron Dose (mrem/hr) at various detectors for two storage gloveboxes.

Detector	no polyethylene shielding		with polyethylene shielding	
	Location 1	Location 2	Location 1	Location 2
1	52.5	1.17	17.5	0.77
2	0.774	9.27	0.364	6.46
3	0.0385	0.362	0.0180	0.206
4	1.07	60.4	0.468	20.0
5	0.00477	0.0269	0.00251	0.0158
6	0.0540	0.909	0.0254	0.389
7	0.0434	0.591	0.0199	0.263
8	0.00607	0.0437	0.00371	0.0200
9	0.0617	0.413	0.0372	0.197
10	0.0340	0.0979	0.0193	0.0411
11	2.67	3.59	1.20	2.65
12	0.109	1.03	0.0571	0.665
13	0.0447	0.459	0.0200	0.299
14	0.211	3.60	0.106	2.36
15	5.20	5.18	2.84	2.51
16	0.0145	0.142	0.00734	0.0693
17	0.0115	0.0964	0.00743	0.0452
18	0.122	1.32	0.0702	0.526
19	0.208	1.20	0.124	0.230
20	1.28	0.969	0.818	0.477