TN-61-27
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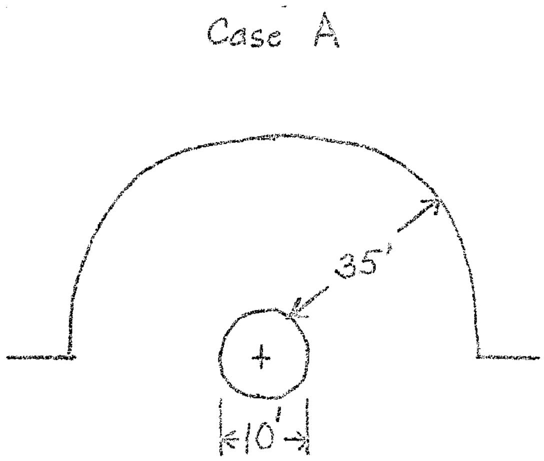
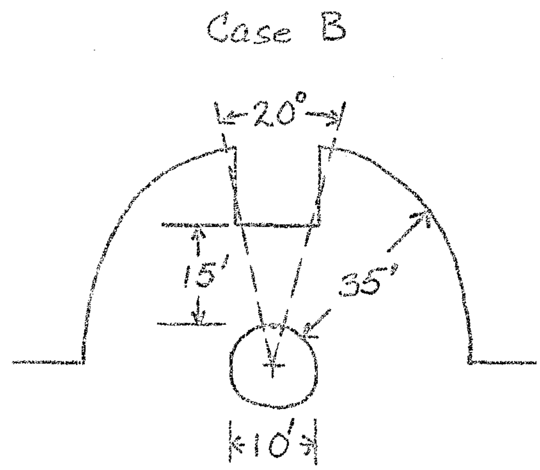
Radiation Levels if the Klystrons Are in a Trough

This note is a sequel to TN-61-11, 11A and 11B. Here we consider the radiation levels for two different tunnel cross-sections which are indicated schematically below. Case A is the classical solution. Case B is an approximation to the solutions which have been suggested recently in which the klystron area is cut into the shielding. We consider the levels for radiation workers in Section 1 and for the general population in Section 2. The actual details of a Case B solution only affect the general population level and some of the possible consequences are discussed in Section 2. We assume that only dirt is used as shielding. We estimate that the radiation levels we give are uncertain by about one order of magnitude.





1. Radiation Workers.

Beam Loss ($60\ \mu a \times 45$ Bev = 2.7 Mw)	Radiation Level Relative to Tolerance (tolerance = 0.75 mr/hr) Case A	Case B
Uniform Line Source ($.03 \times 2.7$ Mw/10^4 ft)	2×10^{-4}	0.3
Point Source (2.7 Mw)	2	5×10^3

Case A is calculated from Report M-262 with one change: for 300 Mev neutrons we use 2.0×10^{-7} rem/n cm^{-2} instead of 7.4×10^{-7} rem/n cm^{-2}.

Case B is scaled from Case A:

$$\text{Level} \propto \frac{e^{-t/\lambda}}{r} \quad , \text{ for line source}$$

$$\text{Level} \propto \frac{e^{-t/\lambda}}{r^2} \quad , \text{ for point source}$$

where $\lambda = 3.14$ ft for dirt

$$e^{t/\lambda} = 580 \text{ for } t = 20 \text{ ft}$$

2. General Population

Beam Loss	Radiation Level Relative to Tolerance (tolerance = .012 mr/hr ; distance from machine = 500 ft) Case A	Case B
Uniform Line Source ($.03 \times 2.7$ Mw/ 10^4 ft)	2×10^{-2}	1
Point Source (2.7 Mw)	4	200

Case A is calculated from Report M-262. We restate the essentials: Take an isotropic neutron source whose strength is 10 times the calculated yield from the shield of 300 Mev neutrons. Let these neutrons diffuse according to Lindenbaum's calculation and suppose that they have the biological effect of 1-5 Mev neutrons. Multiply by 2 for the effect of high energy skyshine.

Case B is scaled from Case A:

$$\text{Case B} = \text{Case A} \times \frac{20^\circ}{180^\circ} \; e^{20/3.14} = 65 \times \text{Case A}.$$

In Case B we assume that the radiation yield from the trough is much greater than the yield from the thick part of the shield.

Qualitatively the skyshine consists of two parts. The contribution from neutrons which have low energy and an isotropic distribution when they leave the shield, and a contribution from high energy neutrons which are more or less still directed outward from the machine. In Report M-262 we estimated that these two contributions are roughly of the same importance.

Here are some considerations which we have neglected which might apply to Case B.

a) An appreciable part of the low energy skyshine might be absorbed by the walls of the trough. From the solid angle alone about 5/6 of this radiation hits the sides of the trough.

b) The high energy skyshine maintains its initial direction for some distance into the air. The total cross-section is about 300 mb (≈ geometric) which gives a mean free path of 40 gcm^{-2} or 1000 ft in air. The energy is high enough so that elastic scattering is predominantly forward in the lab. The interaction mean free path is 4 or 5 times longer.

c) If the trough is above the accelerator, the secondaries from the high energy primaries have a long way to diffuse before becoming a radiation problem.

d) If the trough is on the side, these high energy interactions occur closer to the ground; however, the cuts provide some shielding. But where the machine is on fill, these direct high energy particles might go through buildings and be a problem.

Schematically we have