W. W. Hansen Laboratories of Physics
Stanford University
Stanford, California

Report No. M-254
March 1961

SHIELDING EFFICIENCIES OF DIFFERENT MATERIALS

By
H. C. DeStaebler

A simple, approximate recipe will be given for scaling of shields made of different materials. This scaling rule is only appropriate for the attenuation of high-energy nuclear particles. It is not appropriate for the attenuation of electrons or x-rays.

Suppose we have a shield which is t_1 feet thick, which is made of a material with specific gravity ρ_1 and shielding efficiency E_1 (see graph) and which provides attenuation factor of A_1. Another shield made of a different material is characterized by t_2, ρ_2, E_2 and A_2.

a) What thickness of shield 2 gives the same attenuation as shield 1?

$$t_2 = t_1 \frac{\rho_1 E_1}{\rho_2 E_2}$$

b) What is the attenuation of shield 2 in terms of the attenuation A_1?

$$A_2 = (A_1)^{\frac{t_2 \rho_2 E_2}{t_1 \rho_1 E_1}}$$

Examples:

a) If 35 feet of earth gives an attenuation of 10^{-5}, how many feet of iron gives the same attenuation? (Assume that earth is all SiO_2.)

	Earth	Iron
ρ	1.8	7.8
E	1.00	0.69

$$t_2 = 35\ \frac{1.8 \times 1.0}{7.8 \times 0.69} = 11.7 \text{ feet}$$

b) If 11.7 feet of iron gives an attenuation of 10^{-5}, what is the attenuation of 5 feet of gold ($Z = 79$, $E = 0.46$, $\rho = 19.3$)?

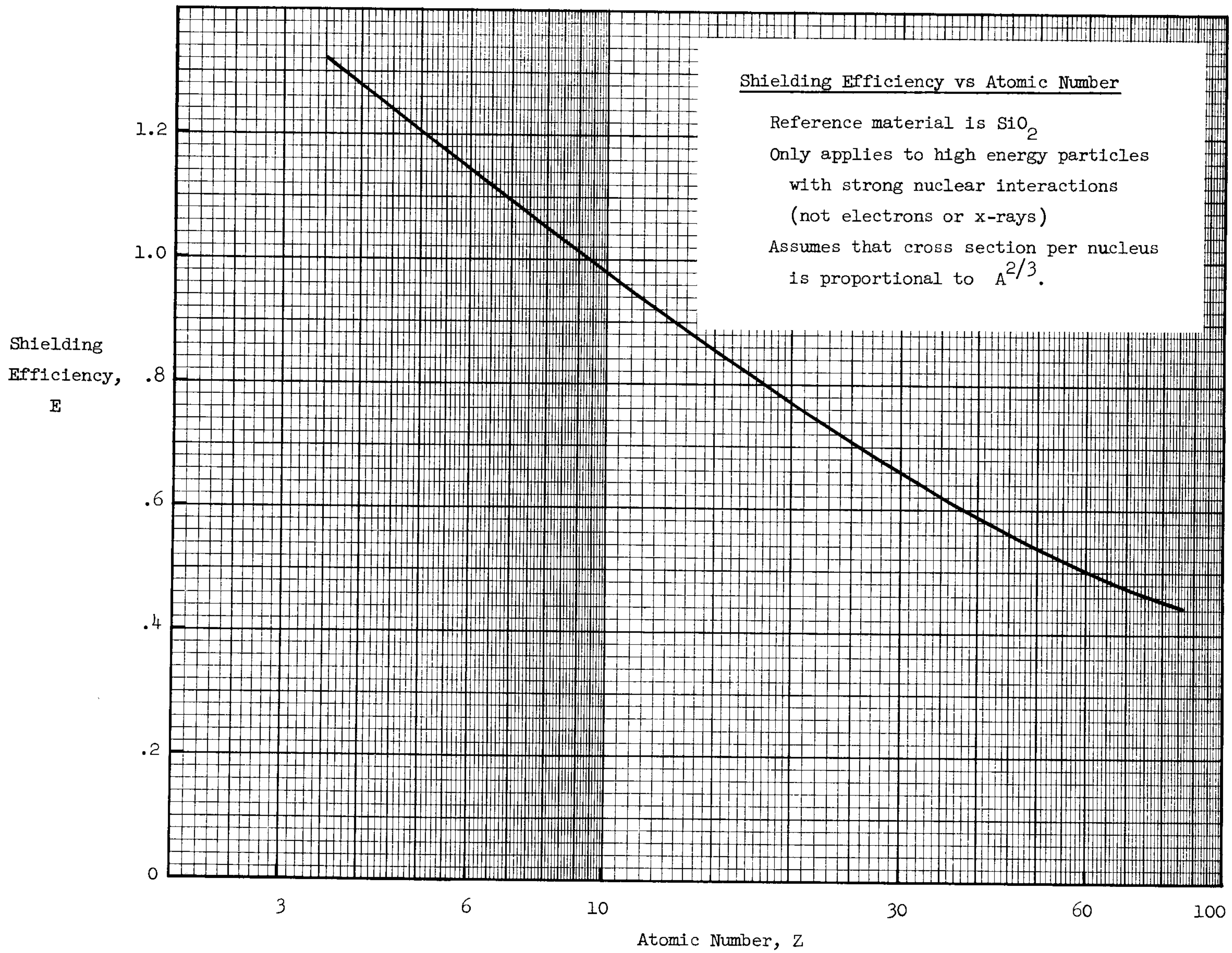
$$A_2 = (10^{-5})^{\frac{5 \times 19.3 \times 0.46}{11.7 \times 7.8 \times 0.69}} = 10^{-5 \times .705}$$

$$A_2 = 10^{-3.52} = 3.0\ 10^{-4}$$

The shielding efficiency of a compound is the sum of the efficiencies of the constituent atoms each multiplied by the fractional abundance of the atom in the compound. For example, what is E for SiO_2?

	Z	E	relative abundance	E (abundance)
O	8	1.06	.67	.71
Si	14	.88	.33	.29
				1.00

Thus $E(SiO_2)$ is 1.00. This was built into the graph because all of the efficiencies are given relative to SiO_2.


Shielding Efficiency vs Atomic Number
Reference material is SiO_2
Only applies to high energy particles with strong nuclear interactions (not electrons or x-rays)
Assumes that cross section per nucleus is proportional to $A^{2/3}$.
Shielding Efficiency, E
1.2
1.0
.8
.6
.4
.2
0
3
6
10
30
60
100
Atomic Number, Z