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 \( \rho_1 \) 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 \( t_2, \rho_2, E_2 \) 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\text{$_2$}.)
Don

-

Eczrth

<table>
<thead>
<tr>
<th>$E$</th>
<th>$\rho$</th>
<th>$\rho$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.00</td>
<td>1.8</td>
<td>7.8</td>
</tr>
</tbody>
</table>

$E = 1.00 \times 1.8 = 1.8$

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

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

$$A_2 = \frac{5 \times 19.3 \times 0.46}{11.7 \times 7.8 \times 0.69} = 10^{-5} \times 0.705$$

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

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 $SiO_2$?

<table>
<thead>
<tr>
<th>$Z$</th>
<th>$E$</th>
<th>relative abundance</th>
<th>$E \text{(abundance)}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>8</td>
<td>1.06</td>
<td>.67</td>
</tr>
<tr>
<td>Si</td>
<td>14</td>
<td>.88</td>
<td>.33</td>
</tr>
</tbody>
</table>

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

- 2 -
Shielding Efficiency vs Atomic Number

Reference material is SiO₂
Only applies to high energy particles
with strong nuclear interactions
(not electrons or x-rays)
Assumes that cross section per nucleus
is proportional to \( A^{2/3} \).