(6.9) In a laboratory an irradiation area must be designed for γ-radiography using a 0.37 TBq ^{60}Co source. For this purpose a cubic building is erected with an interior side length of 2 m. The desired flux reduction is 10^6. How thick must the wall be and how much will the shielding material cost (i.e. not including labor costs) if it is made of (a) concrete? (b) lead ? Assume lead blocks cost $1.50 per kg and concrete $40 per m^3.

From Fig. 6.15 and E_γ 1.17 and 1.33; average 1.25 MeV, the thickness $d_{concrete}$ is obtained as:

$d_{concrete} := 133 \cdot 10^{-2} \cdot m$

The concrete volume is calculated as the difference in volume between a massive cube and a hollow cube having outer dimension = inner dimension + wall thickness.

$Volume := \left(2 \cdot m + 2 \cdot d_{concrete}\right)^3 - (2 \cdot m)^3$ $\qquad Volume = 93.195 \cdot m^3$

$Unitcost := 40 \cdot m^{-3}$ in \$/m^3

$Cost := Volume \cdot Unitcost$ $\qquad Cost = 3.728 \cdot 10^3$ $\qquad$ $ for concrete

From Fig. 6.17 we can read the total attenuation coefficient for lead as μ = 0.059 cm^2/g at 1.25 MeV:

$\rho_{Pb} := 11.3 \cdot \frac{gm}{cm^3}$ $\qquad \mu_o := 0.059 \cdot \frac{cm^2}{gm}$ $\qquad \mu := \mu_o \cdot \rho_{Pb}$

However, in this case we must also correct for scattered radiation by using the build-up factor, *B,* because the attenuation was measured on a collimated beam:

$\phi = \phi_o \cdot B \cdot e^{-\mu \cdot x}$ $\qquad$ which can be soved for μ*x $\qquad \mu \cdot x = ln\left(\frac{\phi_o}{\phi} \cdot B\right)$

$B := 1.0$ $\qquad$ a first guess: $\qquad x\mu := ln\left(10^6 \cdot B\right)$

$x\mu = 13.816$

$B := 5$ $\qquad$ From Fig. 6.20; second guess.

$x\mu := ln\left(10^6 \cdot B\right)$ $\qquad x\mu = 15.425$

$B := 5.5$ $\qquad$ From Fig. 6.20

$x\mu := ln\left(10^6 \cdot B\right)$ $\qquad x\mu = 15.52$ $\qquad$ Change in μx is small, so B=5.5 is OK

$x := \frac{x\mu}{\mu}$ $\qquad x = 0.233 \cdot m$

$Volume_{Pb} := (2 \cdot m + 2 \cdot x)^3 - (2 \cdot m)^3$ $\qquad Volume_{Pb} = 6.989 \cdot m^3$

$Unitcost := 1.50 \cdot kg^{-1}$ in \$/kg

$Cost_{Pb} := Volume_{Pb} \cdot Unitcost \cdot \rho_{Pb}$ $\qquad Cost_{Pb} = 1.185 \cdot 10^5$ $\qquad$ $ for Pb