EQUATIONS USEFUL FOR RADIATION SAFETY

RADIOACTIVE DECAY EQUATION.

$$A = A_0 e^{-0.693t/hl}$$

This equation corrects the activity of a radioactive material for decay.

where, A = present activity, A_0 = reference activity, t = time elapsed since A_0 was assessed, hl = half-life of radionuclide. Note: t and hl must be in the same units.

Example: Calculate the activity remaining in a vial that originally contained 5 mCi of ^{32}P three weeks ago. None of the sample has been extracted. [Note: 3 weeks equals 7 days; hl for ^{32}P = 14.3 days.]

$A = (5 \text{ mCi}) e^{[-0.693 * 21 \text{ days} / 14.3 \text{ days}]} = (5 \text{ mCi}) e^{[-1.018]} = (5 \text{ mCi})(0.361) = 1.8 \text{ mCi}$

DISTANCE EQUATION.

This equation uses the *inverse square law* to calculate the change in dose rate when a person moves farther or closer to a point source of x or γ radiation.

$$D_1 = D_2 \frac{X_2^2}{X_1^2}$$

where, D_1 and D_2 = dose rate (or intensity) at positions 1 and 2, respectively; X_1 and X_2 = the distance from the source at positions 1 and 2, respectively.

Example: The dose rate is 10 mrem/hour at 2 feet from a ^{137}Cs source. What is the dose rate at 9 feet?

[D_2 = 10 mrem/hour; X_1 = 9 feet; X_2 = 2 feet]

$D_1 = (10 \text{ mrem/hour})(2 \text{ feet} / 9 \text{ feet})^2 = (10 \text{ mrem/hour})(0.049) = 0.5 \text{ mrem/hour}$

SHIELDING EQUATION.

This equation calculates the attenuation when a shield is placed between a detector and a point source of x or γ rays. The linear attenuation coefficient (μ) is strongly dependent on the shield composition and energy of the radiation. [Note: Beta particles are more strongly affected by shielding because they have charge and mass. The computation is much more complex for beta particles.]

$$D = D_0 e^{-\mu x}$$

where, D = dose rate (or intensity) with shielding, D_0 = dose rate (or intensity) without shielding, x = thickness of shielding, and μ = linear attenuation coefficient. Note: x and μ must use the same units.

Example: The dose rate at 2 feet from a ^{137}Cs source is 10 mrem/hour. What is the dose rate at this point if a 2 inch (5 cm) lead shield is erected between the source and detector?

[μ (for Pb, 662 keV gamma ray) = 1.23 cm^{-1}]

$D = (10 \text{ mrem/hour}) e^{[-1.23 * 5]} = (10 \text{ mrem/hour})(0.00213) = 0.02 \text{ mrem/hour}$