(C), times the energy of the source, (E)

If the name of the radioactive source is known and its quantity (or activity) in curies is known, as is usually the case, the value for its energy in mev can be obtained from handbooks Two words of warning (*a*) some radioactive materials, such as cobalt-60, emit more than one gamma, each with different energies The sum of the energy of the total emissions must be used This kind of information is given in handbooks (*b*) Terms must be consistent If the source activity is given in millicuries or microcuries it must be converted to curies

Example What radiation reading would be expected at a distance of 1 foot from an unshielded 100-millicurie cobalt-60 source?

Answer $C \cong 100$ millicuries = 0 1 curie, $E = 1\ 1$ mev + 1 3 mev, handbook values—Co-60 emits two gammas—one with an energy of approximately 1 1 mev, and the other with an energy of approximately 1 3 mev Hence, R/hr/1 ft = 6(0 1) (1 1 + 1 3) = 1 44 which is the same as 1,440 mR/hr

For a 10-millicurie cesium-137 source?

Answer R/hr/1 ft ≅ 6(0 01) (0 66) = 0 0396 which would be the same as 39 6 mR/hr at 1 ft

For a 500-microcurie iridium-192 source

Answer R/hr/1 ft ≅ 6(0 0005) (0 3 + 0 5) = 0 0024 which would be the same as 2 4 mR/hr at 1 ft

The two reasons for selecting the foregoing examples (*a*) to illustrate the use of the formula in calculating dose rates, (*b*) to show how the application of the formula can assist in the interpretation of fractional amounts of curies

The fact that a 500-microcurie source of iridium-192 is going to be used in his plant may not mean much to a safety engineer He is not sure just how much 500 microcuries is, or if it will be a big problem However, if the safety engineer can calculate the exposure rate of 2 4 mR/hr and then apply the distance rule of decreasing radiation (1 divided by distance squared) he becomes aware that 2 ft away from the source the radiation level would be 0 6 mR/hr, which is negligible

The following lists a number of gamma emitters and their radiation levels measured at various distances from a one curie source The numbers were obtained by using the previous formula and then applying the inverse square law for distances of other than one foot

Isotope	1 ft	2 ft	4 ft	8 ft	10 ft
Cobalt-60	14 5	3 6	0 9	0 23	0 145
Radium-226	9 0	2 3	0 6	0 14	0 09
Cesium-137	4 2	1 1	0 26	0 07	0 042
Iridium-192	5 9	1 5	0 4	0 09	0 059
Thulium-170	0 027	0 007	0 002	0 0004	0 00027

As an example of how to use the guides in interpreting problems, consider the following recommendations given in Table 44-D (page 1462) for the maximum dose of X radiation or gamma radiation permitted to the whole body, gonads, blood-forming organs, or lenses of the eye

Average weekly dose—0 1 R (100 milliroentgen)

13-week dose∼3 R (300mR)

Total accumulated dose in roentgen is equal to 5 times (age in years, minus 18)

Knowing the radiation levels that will exist at various distances from various radioactive sources, one can use control procedures to make sure that cumulative doses will not be in excess of the maximum permissible dose (M P D)

As a final example of how M P D figures can be used, assume that a 0 5 curie cobalt-60 source is involved in a fire The radiation meters have been damaged and there is reason to believe that the source container no longer is serving as an effective shield Until someone with a good meter can make a survey and determine how severe the problem is, at what distance should the area be fenced off?

1 Calculate *R*/hr/1 ft for a 0 5 curie cobalt-60 source [R/hr /1 ft ≅ (6) (0 5) (2 4) = 7 2 or 7200 mR/hr]

2 At a M P D of 100 mR per week, for a 40-hour week, the dose rate per hour should not exceed 100/40 or 2 5 mR/hr

3 Use the following mental tool

$$\text{Distance (ft)} = \sqrt{\frac{\text{mR/hr/1 ft}}{2\ 5\ \text{mr/hr}}}$$