

Derivation of the Particulate Emission Factor

$$PEF = Q/C * \frac{3,600}{0.036 * (1-V) * (U_m/U_t)^3 * F(x)} \quad (4)$$

Parameter/Definition (units)	Default	Source
PEF/particulate emission factor (m ³ /kg)	1.32 x 10 ⁹	--
Q/C/inverse of mean conc. at center of square source (g/m ² -s per kg/m ³)	90.80	Table 3 (for 0.5-acre source in Minneapolis, MN)
V/fraction of vegetative cover (unitless)	0.5 (50%)	U.S. EPA, 1991b
U _m /mean annual windspeed (m/s)	4.69	EQ, 1994
U _t /equivalent threshold value of windspeed at 7 m (m/s)	11.32	U.S. EPA, 1991b
F(x)/function dependent on U _m /U _t derived using Cowherd et al. (1985) (unitless)	0.194	U.S. EPA, 1991b

2.4 External Exposure from Radionuclides in Soil

Individuals residing on a contaminated site will be exposed to photons emitted by those radionuclides present in the soil. In modeling external exposure to contaminated soil, the RAGS/HHEM Part B model (EPA91a) does not account for the following processes:

- radioactive decay and progeny ingrowth (i.e., radioactive daughters);
- correction factors for the geometry of the contaminated soil;
- depletion of the contaminated soil horizon by environmental processes, such as leaching, erosion, or plant uptake; and
- corrections for shielding by clean cover material.

The RAGS/HHEM Part B model effectively assumes that an individual is continually exposed to a non-depleting source term with a geometry that is effectively an infinite slab. The concept of an "infinite slab" means that the thickness of the contaminated zone and its aerial extent are so large that it behaves as if it were infinite in its physical dimensions. In practice, soil contaminated to a depth greater than about 15 cm and with an aerial extent greater than about 1,000 m² will create a radiation field comparable to that of an infinite slab. For calculation of SSLs for a residential setting, an adjustment for small areas is considered to be an important modification to the RAGS/HHEM Part B model, since in most residential settings the assumption of an infinite slab source will result in overly conservative SSLs. Thus, an area correction factor, ACF, has been added to the model for the calculation of SSLs. For the purposes of this report, adjustments for clean cover are not needed since, in all cases, it is assumed that the contaminated soil extends to the surface. The model provides adjustments for indoor occupancy and associated shielding effects by the simple application of a shielding factor and indoor occupancy time adjustment.

Screening Level Equation for External Exposure to Radionuclides in Soil

$$SSL = \frac{TR}{SF_e * \frac{EF}{365} * ED * ACF * [ET_o * (ET_i * GSF)]} \quad (5)$$

Parameter/Definition (units)	Default	Source
TR/target cancer risk (unitless)	10 ⁻⁶	U.S. EPA, 1991b
SF _e /external exposure slope factor (g/pCi/yr)	See Table 2.2	See Part 2.1
EF/exposure frequency (d/yr)	350	U.S. EPA, 1991b
ED/exposure duration (yr)	30	U.S. EPA, 1991b
ACF/area correction factor	0.9	ANL, 1993b
ET _o /exposure time fraction, outdoor (unitless)	0.073	U.S. EPA, 1997b
ET _i /exposure time fraction, indoor (unitless)	0.683	U.S. EPA, 1997b
GSF/gamma shielding factor	0.4	U.S. EPA, 1996d

With the exception of the area correction factor, default values are used for all input parameters in Equation 5 to calculate generic external exposure SSLs. The amount of data required to derive site-specific values for these parameters makes their collection and use impracticable for calculation of simple site-specific SSLs. Therefore, site-specific data are generally not available for this exposure pathway. An area correction factor less than 0.9 will only apply to very small sites (i.e., those with an area less than 1,000 m²). Alternative area correction factors are discussed in Section 5.1.

2.4.1. Gamma Shielding Factor - GSF (unitless)

The gamma shielding factor is the ratio of the external gamma radiation level indoors on site to the radiation level outdoors on-site. It is based on the fact that a building provides shielding against penetration of gamma radiation. Therefore, the calculation of the risk posed by gamma radiation from radionuclides in the soil should take into account this shielding effect.

EPA's previous gamma shielding factor default value, taken from RAGS/HHEM Part B (U.S. EPA, 1991b), is 0.8, which assumes that the external gamma radiation level indoors is 20% lower than the outdoor gamma radiation level. This value is based on information presented in two EPA reports, *Natural Radiation in the United States* (U.S. EPA, 1972) and *Population Exposure to External Natural Radiation Background in the United States* (U.S. EPA, 1981). Based on a review of the literature provided in these reports, EPA concluded that external background exposures in frame dwellings are 70 to 80% of outdoor values. This conclusion is based on empirical data for natural background radiation. As such, it includes the contribution from both terrestrial and cosmic radiation and from the radionuclides present in structure material.

A further review of the literature performed in the EPA report, *Reassessment of Radium and Thorium Soil Concentrations and Annual Dose Rates* (U.S. EPA, 1996d) reveals numerous publications that address indoor/outdoor gamma ray shielding factors as applied to radioactive fallout from nuclear weapons and reactor accidents. In U.S. EPA, 1981, the authors performed a review of experimentally measured reduction factors from fallout. The authors concluded that "reduction factors of 0.4 to 0.2 are recommended as representative values for above-ground lightly constructed (wood frame) and heavily constructed (block and brick) homes, respectively." On the basis of this review, U.S. EPA 1996d, suggests that a default gamma shielding factor of 0.4 based solely on the contribution of terrestrial radiation might be a more appropriate value to use at sites with soil contaminated with radionuclides than the previous EPA default of 0.8 which also included the effects of cosmic radiation and the inherent radioactivity in structure materials. Based on this rationale, the value of 0.4 is adopted in this guidance as EPA's new default gamma shielding factor.