5 Shielding against ionizing radiation

In the shielding calculation for the radiation facility, simple dose estimation methods by using the shielding calculation constants are effective and widely used. These shielding calculation constants depend on the dose quantity to be estimated. Chapter 5 presents simple calculation methods and related constants for charged particles, photons and neutrons.

5.1 Introduction

Shielding is an essential element of practical radiation protection. The necessary precautions depend especially on the kind of radiation. Charged particles as electrons and alpha particles can be absorbed in matter totally, as they have a maximum penetration depth, depending on their charge, mass, energy and on the properties of the absorbing media. A shielding slab will attenuate photons and neutrons just to a fraction of their primary intensity on the other hand, without enabling total absorption.

Thus shielding calculations for charged particles mainly concern the evaluation of maximum penetration depths. As to photons an analytical calculation method has proved successful for simple geometries. It is based on the exponential law of attenuation of the unscattered photon component and a build-up portion for the scattered radiation component. The treatment of neutrons is more complicated than photon calculations. Simple methods to estimate dose rates can only be described for typical neutron sources and shielding materials, using results of more powerful shielding codes.

5.2 Stopping power and range

To calculate the penetration of charged particles in matter, it is necessary to have information on the basic interactions that govern the passage through the shield. The predominant effects of protons and alpha particles are the elastic and inelastic collisions with electrons. While elastic collisions are resulting in a change of direction for the incident particle, inelastic collisions lead to energy loss and production of secondary radiation. Electrons traversing some distance in matter lose energy in numerous inelastic collisions with bound atomic electrons along their track. Furthermore Bremsstrahlung production becomes important in electron transport especially for high-Z media and high energies.

The basic quantity for shielding purposes of charged particles is the stopping power, which is defined as the average energy loss per unit path length. It can be separated into the components collision stopping power S_{col} due to Coulomb collisions and radiative stopping power S_{rad} due to Bremsstrahlung production. The range of charged particles is usually estimated on the basis of the *continuous–slowing–down–approximation* (csda). In this approximation particles are assumed to loose their energy continuously in the course of slowing down, with a fixed energy loss per path length given by the stopping power. That means energy-loss fluctuations are neglected. Integrating the reciprocal of the total stopping power with respect to kinetic energy E gives the csda-range r_0, which is a rather good approximation of the *mean path length* by a particle on its course to rest. Generally the csda-range of a particle of initial energy E_0 slowing down in matter to the rest energy E_r is evaluated from the expression

$$r_0 = \int_{E_r}^{E_0} [S(E)_{col} + S(E)_{rad}]^{-1} dE \tag{5.2.1}$$

Because of the numerous scattering processes with angular deflections the csda-range is in most cases much larger than its projection on the initial direction of the particle track or the *penetration depth*. Tables of stopping powers and csda-ranges for protons and alpha particles are given in ICRU Report 49 [93ICR]. Corresponding values for electrons are presented in ICRU Report 35 [84ICR1], ICRU Report 37 [84ICR2], and ICRU Report 56 [97ICR]. An early review is given by Knop and Paul [64Kno].

5.3 Penetration depths of charged particles

5.3.1 Heavy charged particles

Protons and alpha particles keep their initial direction rather far on their way, except near the end of the track. Because of this deviation from linear tracks, caused by multiple scattering, the *average penetration depth R* is a more useful quantity than the csda-range. It gives the expectation value of the distance in the initial direction of motion to that point, where the particle has slowed down to rest. The deviation from linearity of the particle track is described by the *detour factor*. It is practically equivalent to R/r_0. The detour factor increases with increasing energy and decreasing atomic number. For this reason detour factors become important for low energies. The values are about 0.8 and 0.65 for protons and alpha particles of 1 MeV in lead, respectively. Fig. 5.3.1 gives average penetration depths R for common used materials of density ρ, estimated on the basis of the csda-range and detour factor tables of ICRU Report 49 [93ICR]. Table A5.3.1 gives the corresponding numerical values for some further materials as well (see Appendix).

As collision stopping powers at a given particle velocity are the same for all particles with the same charge number, proton ranges can be used as well for the estimation of the ranges of deuterons and positively charged pions and muons. At a given velocity the kinetic energy E of a particle with mass m is related to the kinetic energy E_p of a particle with mass m_p by

$$E = \frac{m}{m_p} E_p \tag{5.3.1}$$

The relation between the range $R(E)$ of particles with charge number z and the proton-range $R_p(E_p)$ is given by

$$R(E) = R_p(m_p / m \cdot E) \frac{m}{m_p} \frac{1}{z^2} F_{corr} \tag{5.3.2}$$

The correction factor F_{corr} can be assumed to be unity for deuterons and positively charged pions and muons. It takes into account above all uncertainties of the particle charge. It is near unity for light ions at high particle energies. As slow ions can capture and lose electrons the effective charge may become much smaller than the nominal charge, resulting in a reduced stopping power. For alpha particles F_{corr} approaches unity above 1 MeV and may increase to about 2 at lower energies. Fig. 5.3.2 gives further average penetration depths for protons and alpha particles in air on the basis of the csda-approximation. The average penetration depths for deuterons in air are calculated by Eq. (5.3.2). Table A5.3.2 gives the corresponding numerical values (see Appendix).

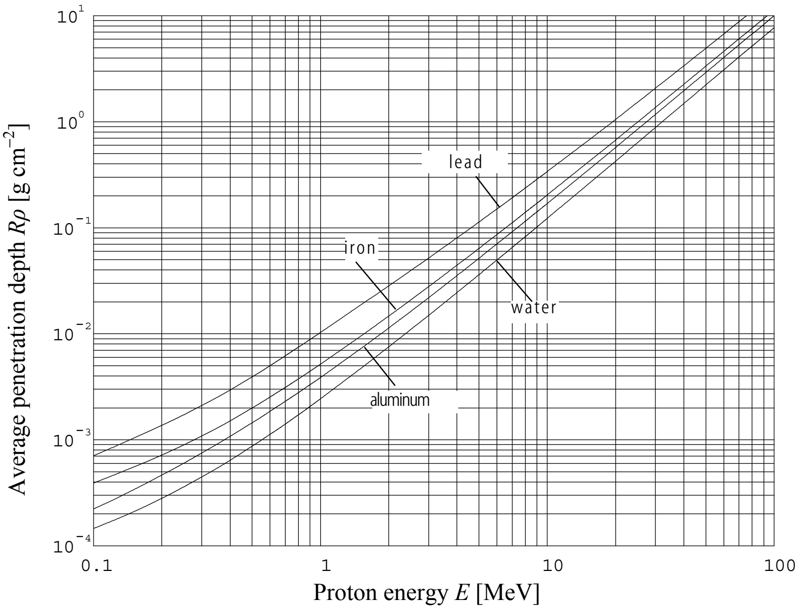

Fig. 5.3.1. Average penetration depth $R\rho$ of protons in water, aluminium, iron and lead.

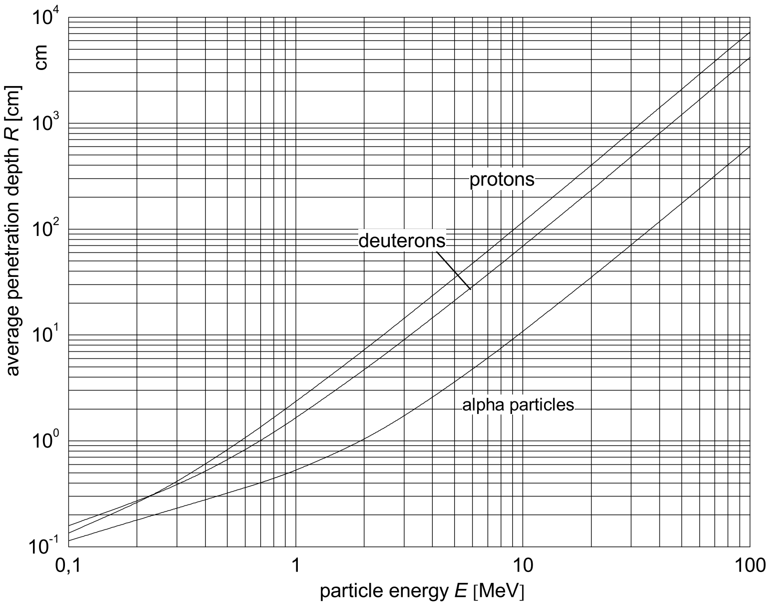

Fig. 5.3.2. Average penetration depth R of protons, deuterons and alpha particles in air. ($\rho = 1.205\times10^{-3}$ g/cm^3).

Sample problem

Average penetration depth of 3 MeV tritons in air.

From Eq. (5.3.2) and Fig. 5.3.2 results:
R(3 MeV) = R_p(1/3 · 3 MeV) 3/1 · 1/1^2 = 3 R_p(1 MeV) = 3 · 2.35 cm = 7.05 cm

5.3.2 Electrons and positrons

The range of electrons depends on the total (collision plus the radiative) stopping power. Monoenergetic electrons and beta rays suffer similar energy and angle straggling as heavy charged particles while slowing down. The deflections are however comparatively large because of their small mass. Thus the range resulting from the continuous-slowing-down-approximation (csda) is always larger than the projection of the particle track on the initial direction. The detour factor is near unit for low-Z media but reaches values up to 4 for lead.

Different range definitions are used for practical purposes. In shielding calculations the *maximum range* R_{max} is the most adequate quantity. It is defined as the depth at which the extrapolation of the tail of the transmission curve (versus electron beam axis depth) meets the Bremsstrahlung background. A frequently used numerical expression for the maximum range R_{max} of beta rays of maximum beta energy E_{max} in matter of density ρ is given by

$$R_{max}\rho = -0.11 + \sqrt{0.0121 + (E_{max}/1.92)^2} \qquad (5.3.3)$$

where E_{max} is in MeV and $R_{max}\,\rho$ in g cm^{-2} [97ICR]. The relation is useful in the energy range between 0.05 MeV and 5 MeV, for monoenergetic electrons as well. Fig. 5.3.3 gives maximum ranges for six common used materials, calculated by Eq. (5.3.3). Table A5.3.3 gives the corresponding numerical values (see Appendix).

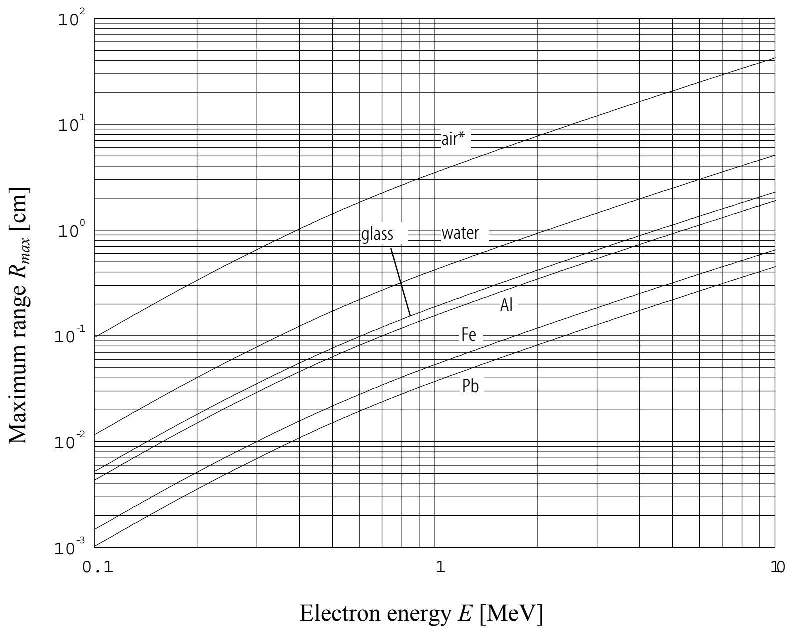

Fig. 5.3.3. Electron ranges R_{max} in air (1.205×10^{-3}), water (1.0), glass (2.23), Al (2.7), Fe (7.87) and Pb (11.35). Values in parentheses: densities in g/cm^3. *Maximum range R_{max} in m.

A rather simple empirical expression for the maximum range of electrons of energy E in matter of density ρ is given by

$$R_{max}\rho = E/2 \qquad (5.3.4)$$

where E is in MeV and $R_{max}\,\rho$ in g cm^{-2}. Maximum ranges evaluated from Eq. (5.3.3) and (5.3.4) are shown in Fig. 5.3.4 together with csda-ranges for water and lead [84ICR2]. Eq. (5.3.4) turns out to be a cautious overall approximation of the maximum range overestimating for energies below 0.3 MeV and above 20 MeV. Eq. (5.3.3) provides considerable overestimation only in the energy range above 20 MeV. Table A5.3.4 gives the numerical values of the csda-ranges of air, water, Be, Al, Fe, Pb (see Appendix).

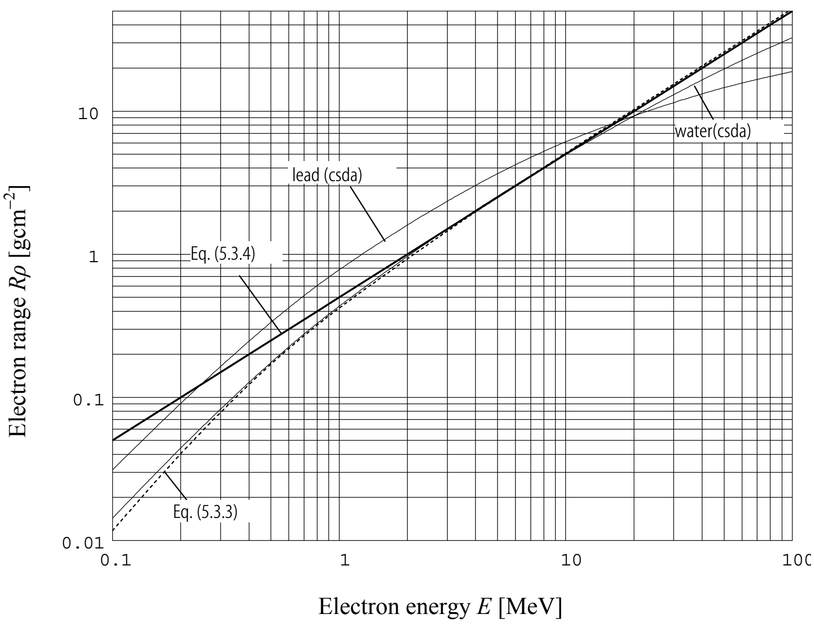

Fig. 5.3.4. Electron ranges $R\rho$ evaluated from Eq. (5.3.3), Eq. (5.3.4) and by csda-approximation for water and lead.

Positrons undergo the same interactions in matter as electrons. Because of differences in collision and radiative stopping powers the positron csda-range varies between shortening at low energies and prolongation at high energies. The shortening of the positron csda-range (with respect to the corresponding electron csda-range) will amount up to 7 % at 0.1 MeV. At energies near 100 MeV the prolongation will be up to 11 % in lead and up to 2 % in water. On the assumption of positrons being annihilated before being slowed down to rest a further shortening of the positron range of up to 4 % in lead has to be considered [84ICR2].

In shielding of beta sources the range curves will yield a sufficient estimate of the necessary slab thickness. With high source activities Bremsstrahlung resulting from the deceleration of the beta particles in the material may need to be shielded as well.

5.4 Photons

5.4.1 Basic shielding concept

For most gamma shielding studies photon energies of 10 keV to 10 MeV are important. In this energy range, the photoelectric effect, pair production and Compton scattering mechanisms of interaction predominate over all others. Of these three interactions, the photoelectric effect predominates at the lower photon energies; pair production is important only for higher-energy photons, while Compton scattering predominates at intermediate energies. In a few cases the shielding analyst may need to account also for coherent (Rayleigh) scattering, annihilation and fluorescence radiation. Most shielding analysis involves a study of the fluence field at pertinent locations with respect to the outside or inside shield. The purpose of such analysis is to predict the corresponding responses of some type of detector, and therefore the field information must be converted into the detector responses. These relate to the fluence by a multiplier called the detector response function. The fluence Φ of photons is the quotient of ΔN by Δa, where ΔN is the number of photons, which enter a sphere of cross-sectional area Δa. Detector responses for photons of interest are exposure, air kerma, absorbed dose and ambient dose equivalent.

In this chapter the ambient dose equivalent is used in accordance with ICRP Report 74 [96ICR]. The ambient dose equivalent rates are obtained by a shielding code that satisfies the Boltzmann transport equation. Using these calculated results, a simple method to estimate the ambient dose equivalent rate for typical radioactive sources and typical shielding media is introduced.

5.4.2 Attenuation data of radioactive sources in shielding materials

The radionuclides dealt with in this chapter are shown in Table 5.4.1. The value of the ambient dose equivalent rate depends on the photon energy, the geometric configuration of the source, the nature and the thickness of the shielding material. The photon fluences emitted from a radioactive source with ordinary concrete (ρ = 2.10 g/cm^3), iron, lead and water as shielding materials are calculated using the BERMUDA code [92Suz, 93Suz]. Densities and elemental weight fractions of ordinary concrete (ρ = 2.10 g/cm^3 and 2.35 g/cm^3) are shown in Table A5.4.1 (see Appendix). The mass attenuation coefficients used were taken from the photon library PHOTX [88DLC], which are shown in Table A5.4.2 (see Appendix).

In this text the ambient dose equivalent rate $\dot{H}^*(10)$ is represented as $\dot{H}^*_{10}(t)$, where t is the thickness of the shield layer. The purpose of shielding analysis is to predict the corresponding responses of certain types of detectors as defined by the symbol R, and to relate R to the fluence $\Phi(E, t)$ or to the flux density $\phi(E, t)$ of photons of energy E by a multiplier to be called the conversion coefficient; where the flux density $\phi(E,t)$ is defined as quotient of the incremental fluence $\Delta\Phi$ that occurs at a specified position and the time interval Δt'. The conversion coefficients of the exposure dose rate $(\dot{X}/\phi)_E$, of the air kerma rate $(\dot{K}_a/\phi)_E$ and of the ambient dose equivalent rate $(\dot{H}^*_{10}/\phi)_E$ for the flux density [cm^{-2} s^{-1}] are given in Table A5.4.3 (see Appendix). While the conversion coefficients of exposure rate $(\dot{X}/\phi)_E$ [µR h^{-1} cm^2 s] are taken from the third column of Table A.1 in ICRU Report 47 [92ICR], the ones of the air kerma rate $(\dot{K}_a/\phi)_E$ [nGy h^{-1} cm^2 s] and the ambient dose equivalent rate $(\dot{H}^*_{10}/\phi)_E$ [nSv h^{-1} cm^2 s] are taken from the fourth and fifth column of Table A.21 in ICRP Report 74 [96ICR]. Here, the three conversion coefficients are given in special units for convenience' sake of calculation.

Consider a point source of activity A [Bq] and a point detector P located at a distance $r + t$ [m] from the source, as illustrated in Fig. 5.4.1, where a shield layer of thickness t [m] is placed between the source and the detector. The energy spectrum of the photon flux density at point P is represented by $\phi(E,t)$. Then the air kerma rate and ambient dose equivalent rate at point P are represented by the following formulas.

$$\dot{K}_a(t) = \int \left(\dot{K}_a/\phi\right)_E \cdot \phi(E,t)\,\mathrm{d}E \tag{5.4.1}$$

$$\dot{H}^*_{10}(t) = \int \left(\dot{H}^*_{10}/\phi\right)_E \cdot \phi(E,t)\,\mathrm{d}E \tag{5.4.2}$$

By introducing the new constant Γ^*_{10}, the ambient dose equivalent transmission factor $T(t)$, and effective conversion coefficient $\bar{f}^*_{10}(E_0,t)$, the ambient dose equivalent rate $\dot{H}^*_{10}(t)$ is simply obtained.

5.4.2.1 Simple method of calculating the ambient dose equivalent rate $\dot{H}^*_{10}(t)$ for radionuclides listed in Table 5.4.1

The flux density ϕ_i of photon energy group 'i' emitted from a radioactive point source of activity A [Bq] is represented by the following formula, where the detector P is located at distance r [m] from the source.

$$\phi_i = \frac{A}{4\pi r^2} I_i \tag{5.4.3}$$

I_i represents the transition yield (number of gamma rays per decay). Then, the ambient dose equivalent rate is obtained by the following summation.

$$\dot{H}^*_{10} = \sum_i (\dot{H}^*_{10} / \phi)_i \cdot \phi_i \tag{5.4.4}$$

Constant: Γ^*_{10}

With regard to Eq. (5.4.3) and Eq. (5.4.4), the constant Γ^*_{10} [µSv m^2 MBq^{-1} h^{-1}] is defined as the sum of components $\Gamma^*_{10,i}$ for specified photon energy groups '*i*' of a gamma-emitting nuclide, as given in Eq. (5.4.5).

$$\Gamma^*_{10} = \sum_i \Gamma^*_{10,i} = \sum_i \frac{1}{4\pi} I_i \cdot (\dot{H}^*_{10} / \phi)_i \cdot 0.1 \tag{5.4.5}$$

That means, the value of Γ^*_{10} represents the ambient dose equivalent rate $\dot{H}^*_{10}$ [µSv h^{-1}] for A = 1 MBq and r = 1 m of a gamma-emitting nuclide. The values of Γ^*_{10} for 33 radionuclides are given in Table 5.4.1 [01JRIA]. With the constant Γ^*_{10} the ambient dose equivalent rate of a point source of a gamma-emitting radionuclide of activity A at distance r becomes

$$\dot{H}^*_{10} = \frac{A}{r^2} \Gamma^*_{10} \tag{5.4.6}$$

Ambient dose equivalent transmission factor: $T(t)$

The ambient dose equivalent transmission factor $T(t)$ is the quotient of the ambient dose equivalent rate $\dot{H}^*_{10}(t)$ by the ambient dose equivalent rate in the absence of shielding material $\dot{H}^*_{10}(0)$.

$$T(t) = \dot{H}^*_{10}(t) / \dot{H}^*_{10}(0) \tag{5.4.7}$$

The values of the ambient dose equivalent transmission factor $T(t)$ for 33 radionuclides are given in Table A5.4.4 through A5.4.36 (see Appendix) for four shielding materials, namely iron, lead, concrete (ρ = 2.10 g/cm^3) and water [01Sak]. Furthermore, the transmission factors $T(t)$ are presented in Fig. 5.4.2 through 5.38, as a function of the thickness t of shield layers [01Sak].

Using the constant Γ^*_{10} and the ambient dose equivalent transmission factor $T(t)$, the ambient dose equivalent rate $\dot{H}^*_{10}(t)$ at a point detector P located a distance $r + t$ [m] from the source, as illustrated in Fig.5.5, is obtained by Eq.(5.4.8).

$$\dot{H}^*_{10}(t) = \frac{A}{(r+t)^2} \cdot \Gamma^*_{10} \cdot T(t) \tag{5.4.8}$$

5.4.2.2 Simple calculation of ambient dose equivalent rate $\dot{H}^*_{10}(t)$ for radionuclides unlisted in Table 5.4.1

Effective (averaged) conversion coefficient: $\bar{f}^*_{10}(E_0,t)$

When $f^*_{10}(E)$ defines the quotient of conversion coefficient $(\dot{H}^*_{10}/\phi)_E$ by $(\dot{K}_a/\phi)_E$ for a specified energy E, the ambient dose equivalent rate in Eq. (5.4.2) is given by the following formula:

$$\dot{H}^*_{10}(t) = \int f^*_{10}(E)\cdot\left(\dot{K}_a/\phi\right)_E\cdot\phi(E,t)\,\mathrm{d}E \tag{5.4.9}$$

Equation (5.4.9) averaged by air absorbed dose rate spectrum at the point P in Fig. 5.4.1 gives Eq. (5.4.10). This formula was introduced as the effective conversion coefficient $\bar{f}^*_{10} = \bar{f}^*_{10}(E_0,t)$ for photons of primary energy E_0 and for shield layer thickness t is represented by Tanaka and Suzuki [91Tan]:

$$\bar{f}^*_{10} = \frac{\int f^*_{10}(E)\cdot\left(\dot{K}_a/\phi\right)_E\cdot\phi(E,t)\,\mathrm{d}E}{\int\left(\dot{K}_a/\phi\right)_E\cdot\phi(E,t)\,\mathrm{d}E} \tag{5.4.10}$$

Then, the relationship between the ambient dose equivalent rate and the air kerma rate becomes

$$\dot{H}^*_{10}(t) = \bar{f}^*_{10}\cdot\dot{K}_a(t) \tag{5.4.11}$$

Effective conversion coefficients $\bar{f}^*_{10} = \bar{f}^*_{10}(E_0,t)$ for iron, lead, concrete and water are given in Table A5.4.37 through A5.4.40 for photon energies from 15 keV to 10 MeV and shield layers up to 40 mfp (see Appendix) [01Sak].

5.4.2.3 Calculation method of ambient dose equivalent rate $\dot{H}^*_{10}(t)$ using exposure dose rate and effective conversion coefficient

Step 1: The flux density of uncollided photons of energy E_0 for source intensity $S = A\cdot I$ at distance $r+t$ behind a shield layer of thickness t is

$$\phi_0(E_0) = \frac{S}{4\pi(r+t)^2}\exp(-\mu t) \tag{5.4.12}$$

The mass attenuation coefficients μ are listed in Table A5.4.2 (see Appendix).

Step 2: The exposure dose rate for uncollided photons is

$$\dot{X}_0(E_0) = \phi_0(E_0)\cdot\left(\dot{X}/\phi\right)_{E_0} \tag{5.4.13}$$

The conversion coefficients $(\dot{X}/\phi)_E$ are listed in Table A5.4.3 (see Appendix).

Step 3: The total exposure dose rate including collided photons is

$$\dot{X} = B\cdot\dot{X}_0 \tag{5.4.14}$$

Exposure buildup factors $B = B(E_0, t)$ for a point isotropic source in iron, lead, concrete (ρ = 2.35 g/cm^3) and water are given in Table A5.4.41 through A5.4.44 for photon energies from 15 keV to 10 MeV and shield layers up to 40 mfp (see Appendix), which are taken from ANSI/ANS6-4-3 [91ANS].

Step 4: The air kerma rate obtained from the total exposure dose rate is

$$\dot{K}_a = 8.764 \cdot 10^{-3} \cdot \dot{X} \tag{5.4.15}$$

where $8.764 \cdot 10^{-3}$ is the value of a typical conversion coefficient from exposure to air kerma, $\dot{X}$ is in R h^{-1} and in Gy h^{-1}.

Step 5: Using the effective conversion coefficient $\bar{f}^*_{10}$ the ambient dose equivalent rate follows from Eq. (5.4.11).

Values for not tabulated energies are obtained by interpolation.

5.4.3 An example of the calculation of an ambient dose equivalent rate

Sample problem: ^{60}Co source of $A = 3.7 \cdot 10^{13}$ Bq (1,000 Ci) is treated in a room enclosed by concrete wall of 100 cm thickness. Calculate the ambient dose equivalent rate at a point P on the outside wall. The calculation model is illustrated in Fig. 5.4.1, where the distance *r* between the source and the front of the concrete wall is 500 cm.

5.4.3.1 The method using the constant Γ^*_{10} and ambient dose equivalent transmission factor *T*(*t*)

Using the value Γ^*_{10} of ^{60}Co in Table 5.4.1 and the one of $T(t)$ at concrete 100 cm in Table A5.4.11 (see Appendix), the ambient dose equivalent rate in Eq.(5.4.8) is obtained, as follows.

Eq. (5.4.8): $\dot{H}^*_{10}(t) = \dfrac{3.7 \cdot 10^7\, \Gamma^*_{10} T(t)}{(5+1)^2}$ = 1.028 · 0.354 · 1.55·10^{-4} Sv h^{-1} = 56.4 μSv h^{-1}

Values for not tabulated thicknesses of the shield layer are obtained by linear interpolation of log $T(t) - t$ [cm].

5.4.3.2 The method using the effective conversion coefficient $\bar{f}^*_{10}$ and the exposure dose rate conversion coefficient ($\dot{X} / \phi$)

Simplifying assumption: ^{60}Co emits two gamma rays of E_0 = 1.25 MeV per disintegration.

Step 1: The photon flux density for the uncollided photons is:

Eq. (5.4.12): $$\phi_0(E_0) = \frac{3.7 \cdot 10^{13} \cdot 2 \cdot \exp(-12.02)}{4 \cdot 3.14 \cdot 600^2}\ \text{cm}^{-2}\ \text{s}^{-1} = 98.56\ \text{cm}^{-2}\ \text{s}^{-1}$$

The linear attenuation coefficient of concrete (ρ = 2.10 g/cm^3) for 1.25 MeV photons is μ = 0.1202 cm^{-1}, which is obtained by the linear interpolation of log μ – log E, using the concrete mass attenuation coefficients of E_0 = 1 MeV and 1.5 MeV given in Table A5.4.2 (see Appendix). With t = 100 cm results μt = 12.02.

Step 2: Calculation of the exposure dose rate of the uncollided photons:

Eq. (5.4.13): $$\dot{X}_0(E_0) = \phi_0(E_0)\cdot\left(\dot{X}/\phi\right)_{E_0} = 98.56\cdot 2.182\cdot 10^{-6}\ \text{R h}^{-1} = 2.151\cdot 10^{-4}\ \text{R h}^{-1}$$

The conversion factor $(\dot{X}/\phi)_E$ for 1.25 MeV is obtained by linear interpolation of $\log(\dot{X}/\phi)_E$ – log E, using $(\dot{X}/\phi)_E$ for 1 MeV and 1.5 MeV given in Table A5.4.3 (see Appendix).

Step 3: Calculation of total exposure dose rate including collided photons:

Eq. (5.4.14): $$\dot{X} = B\cdot\dot{X}_0 = 21.84\cdot 2.151\cdot 10^{-4}\ \text{R h}^{-1}\ 4.698\cdot 10^{-3}\ \text{R h}^{-1}$$

The exposure buildup factor for E_0 = 1.25 MeV in infinite concrete material is obtained by the following procedure. At first, concrete buildup factors B = 27.01 and 18.36 are obtained for E_0 = 1 MeV and 1.5 MeV for μt = 12.02 mfp. They result from the linear interpolation of log $B(E)$ – μt [mfp], using buildup factors for μt = 10 and 15 mfp from Table A5.4.43 (see Appendix). Next, buildup factor B = 21.84 is obtained for E_0 = 1.25 MeV by the linear interpolation of log $B(E)$ – log E, using buildup factors of E_0 = 1 and 1.5 MeV at μt = 12.02.

Step 4: Conversion from exposure dose rate $\dot{X}$ to air kerma rate $\dot{K}_a$:

Eq. (5.4.15): $$\dot{K}_a = 8.764\cdot 10^{-3}\cdot 4.698\cdot 10^{-3}\ \text{Gy h}^{-1} = 4.117\cdot 10^{-5}\ \text{Gy h}^{-1}$$

Step 5: Conversion from air kerma rate $\dot{K}_a$ to ambient dose equivalent $\dot{H}^*_{10}(t)$:

The effective conversion coefficient $\bar{f}^*_{10}$ in Eq. (5.4.11) is obtained by the following procedure. At first, the effective conversion coefficients of concrete $\bar{f}^*_{10}$ = 1.308 and 1.256 are obtained for E_0 = 1 MeV and 1.5 MeV and for μt = 12.02. They result from the linear interpolation of log $\bar{f}^*_{10}$ – μt [mfp], using $\bar{f}^*_{10}$ for μt = 10 and 15 mfp from Table A5.4.39 (see Appendix). Next, $\bar{f}^*_{10}$ = 1.279 is obtained for E_0 = 1.25 MeV by the linear interpolation of log $\bar{f}^*_{10}$ – log E, using effective conversion coefficients of E_0 = 1 and 1.5 MeV at μt = 12.02.

Eq. (5.4.11): $$\dot{H}^*_{10}(t) = \bar{f}^*_{10}\cdot\dot{K}_a = 1.279\cdot 4.117\cdot 10^{-5}\ \text{Sv h}^{-1} = 52.7\ \mu\text{Sv h}^{-1}$$

The values of $\dot{H}^*_{10}(t)$ obtained by the methods in 5.4.3.1 and 5.4.3.2 agree within 7 %.

Table 5.4.1 Constant Γ^*_{10} [μSv m^2 MBq^{-1} h^{-1}]

Radionuclide	Γ^*_{10}	Radionuclide	Γ^*_{10}	Radionuclide	Γ^*_{10}	Radionuclide	Γ^*_{10}
^{18}F	0.166	^{65}Zn	0.0847	^{103}Pd*	0.0254	^{192}Ir	0.139
^{24}Na	0.492	^{67}Ga	0.0268	^{110m}Ag	0.416	^{198}Au	0.0685
^{51}Cr	0.00547	^{68}Ge*	0.158	^{111}In	0.0663	^{197}Hg	0.0193
^{54}Mn	0.130	^{75}Se	0.0660	^{124}Sb	0.266	^{201}Tl	0.0175
^{59}Fe	0.171	^{81}Rb*	0.104	^{123}I	0.0288	^{226}Ra*	0.251
^{56}Co	0.492	^{85}Kr	0.00037	^{125}I	0.0357	^{241}Am	0.00529
^{57}Co	0.0206	^{85}Sr	0.0826	^{131}I	0.0650		
^{60}Co	0.354	^{99}Mo*	0.0444	^{133}Xe	0.0170		
^{64}Cu	0.0307	^{99m}Tc	0.0214	^{137}Cs*	0.0927		

1) Radionuclides attached the mark * includes the effects of daughter's radiation equilibrium. As the daughter of ^{226}Ra, ^{222}Rn is only considered.

2) Γ^*_{10} does not include effects by photon energy of below 30 keV and emission ratio within 0.1 %. However ^{125}I and ^{103}Pd include the effect by photon energy of above 10 keV.

In Figs. 5.4.2 to 5.4.34 following symbols are used
T: Transmission factor
t_1: layer thickness of water and concrete
t_2: layer thickness of iron and lead

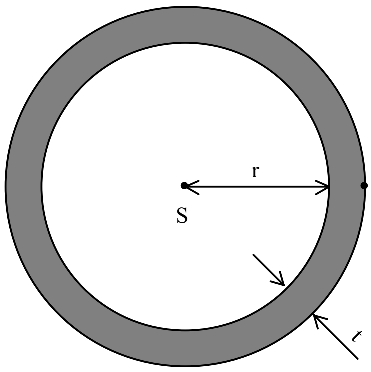

Fig. 5.4.1. A point isotropic source enclosed by concrete wall.

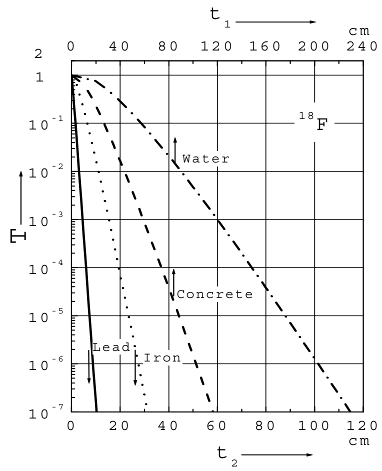

Fig. 5.4.2. Ambient dose equivalent transmission factor of 4 shields for ^{18}F source.

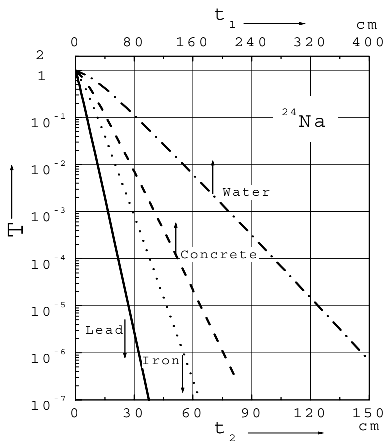

Fig. 5.4.3. Ambient dose equivalent transmission factor of 4 shields for ^{24}Na source.

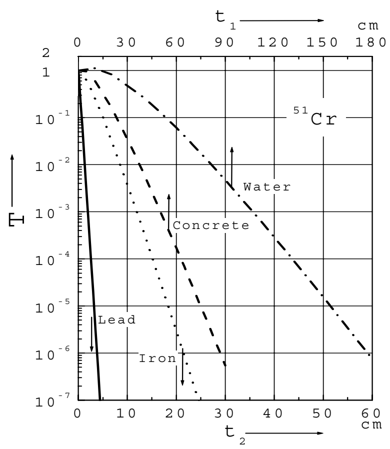

Fig. 5.4.4. Ambient dose equivalent transmission factor of 4 shields for ^{51}Cr source.

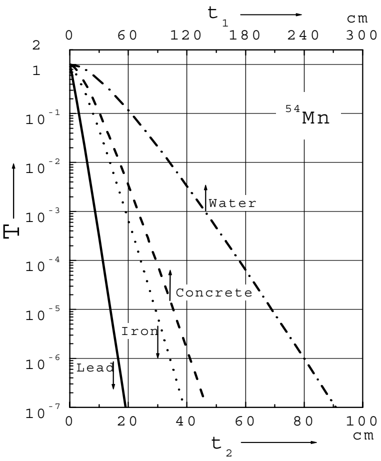

Fig. 5.4.5. Ambient dose equivalent transmission factor of 4 shields for ^{54}Mn source

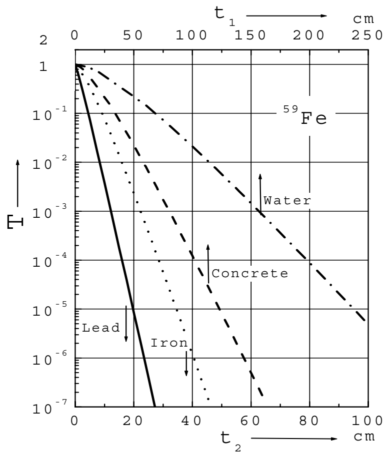

Fig. 5.4.6. Ambient dose equivalent transmission factor of 4 shields for ^{59}Fe source

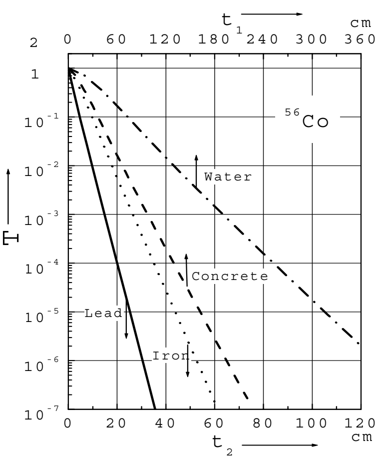

Fig. 5.4.7. Ambient dose equivalent transmission factor of 4 shields for ^{56}Co source.

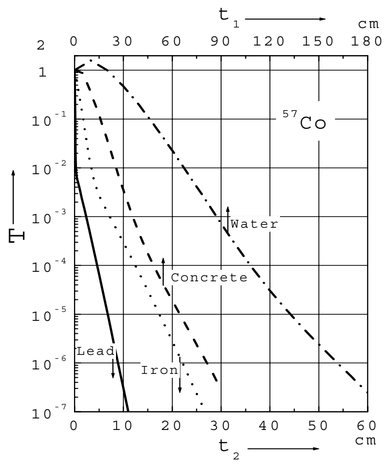

Fig. 5.4.8. Ambient dose equivalent transmission factor of 4 shields for ^{57}Co source.

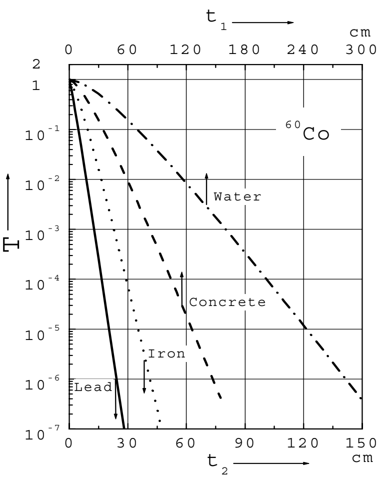

Fig. 5.4.9. Ambient dose equivalent transmission factor of 4 shields for ^{60}Co source

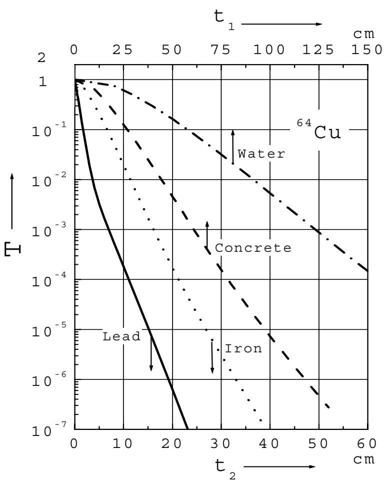

Fig. 5.4.10. Ambient dose equivalent transmission factor of 4 shields for ^{64}Cu source.

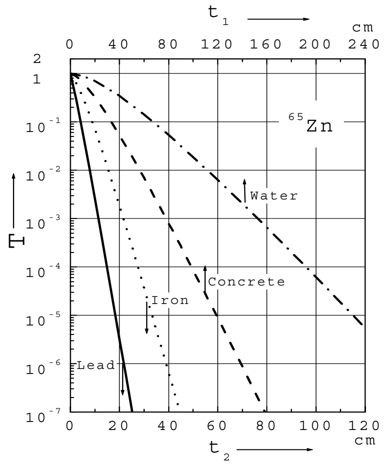

Fig. 5.4.11. Ambient dose equivalent transmission factor of 4 shields for ^{65}Zn source

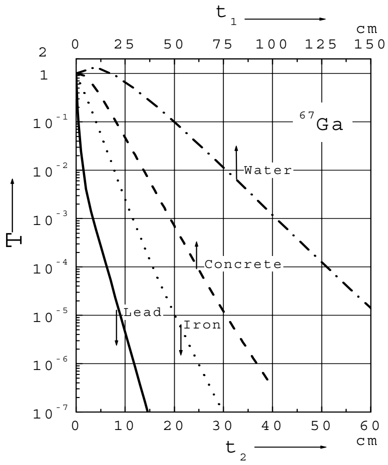

Fig. 5.4.12. Ambient dose equivalent transmission factor of 4 shields for ^{67}Ga source

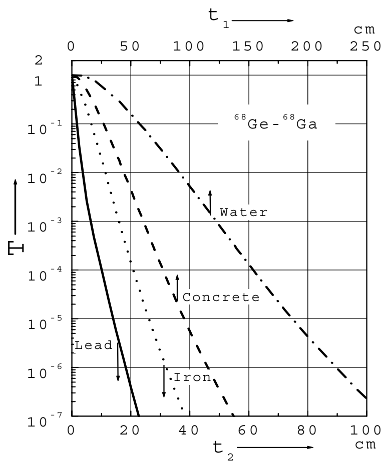

Fig. 5.4.13. Ambient dose equivalent transmission factor of 4 shields for ^{68}Ge-^{68}Ga source

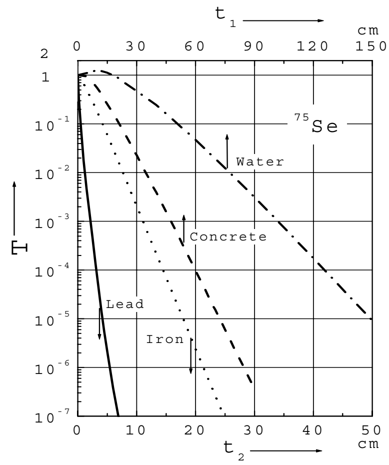

Fig. 5.4.14. Ambient dose equivalent transmission factor of 4 shields for ^{75}Se source

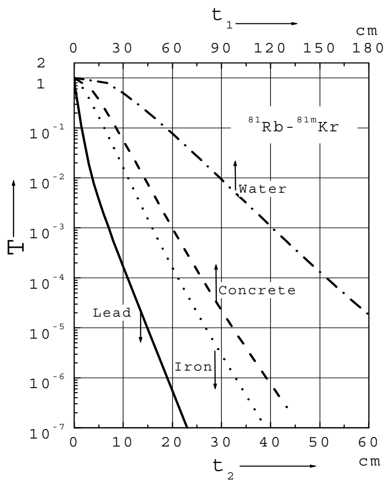

Fig. 5.4.15. Ambient dose equivalent transmission factor of 4 shields for ^{81}Rb-^{81m}Kr source

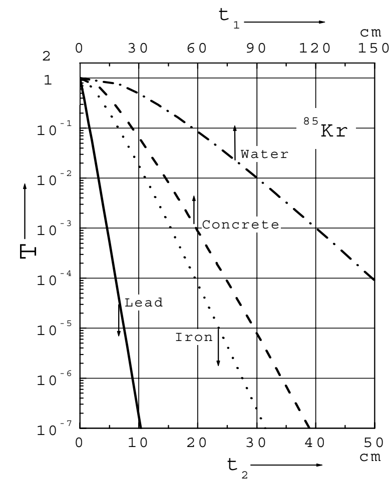

Fig. 5.4.16. Ambient dose equivalent transmission factor of 4 shields for ^{85}Kr source

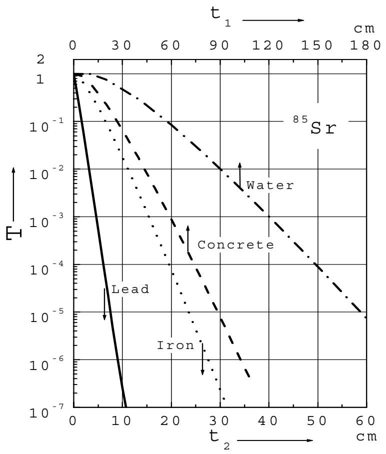

Fig. 5.4.17. Ambient dose equivalent transmission factor of 4 shields for ^{85}Sr source

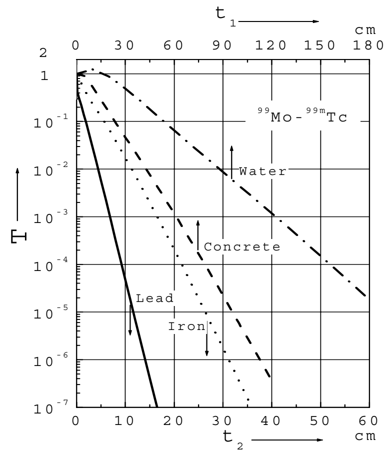

Fig. 5.4.18. Ambient dose equivalent transmission factor of 4 shields for ^{99}Mo-^{99m}Tc source

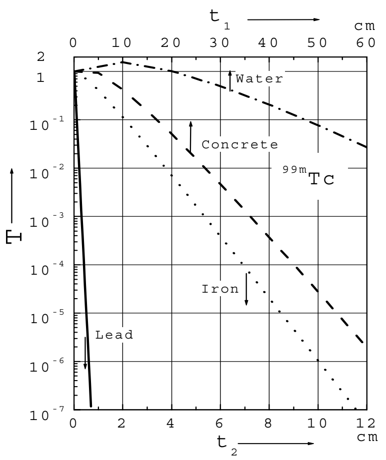

Fig. 5.4.19. Ambient dose equivalent transmission factor of 4 shields for ^{99m}Tc source

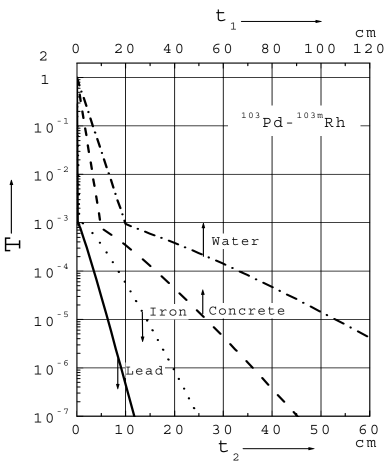

Fig. 5.4.20. Ambient dose equivalent transmission factor of 4 shields for ^{103}Pd- ^{103}Rh source

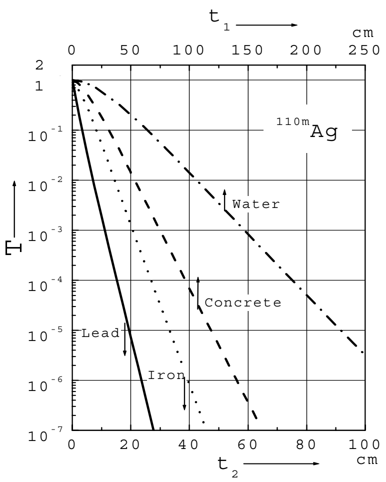

Fig. 5.4.21. Ambient dose equivalent transmission factor of 4 shields for ^{110m}Ag source

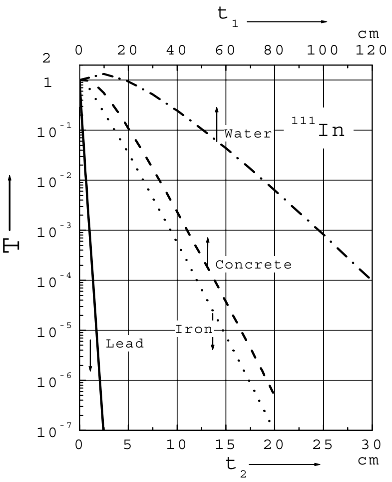

Fig. 5.4.22. Ambient dose equivalent transmission factor of 4 shields for ^{111}In source

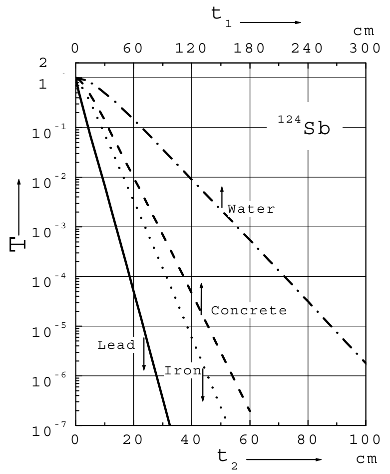

Fig. 5.4.23. Ambient dose equivalent transmission factor of 4 shields for ^{124}Sb source

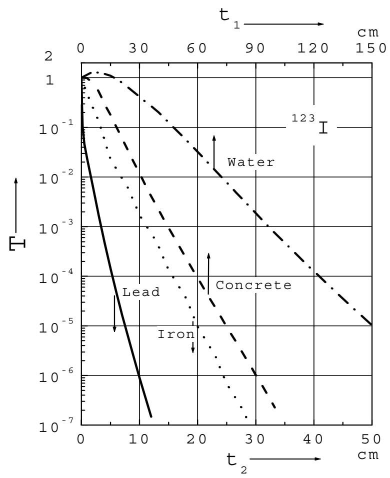

Fig. 5.4.24. Ambient dose equivalent transmission factor of 4 shields for ^{123}I source

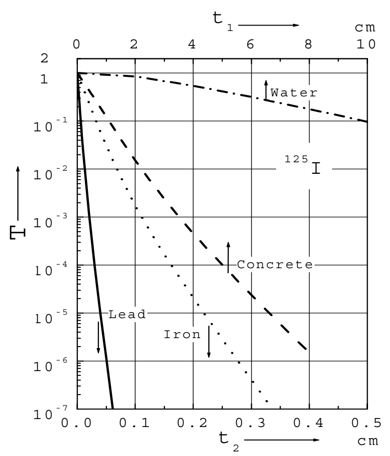

Fig. 5.4.25. Ambient dose equivalent transmission factor of 4 shields for ^{125}I source

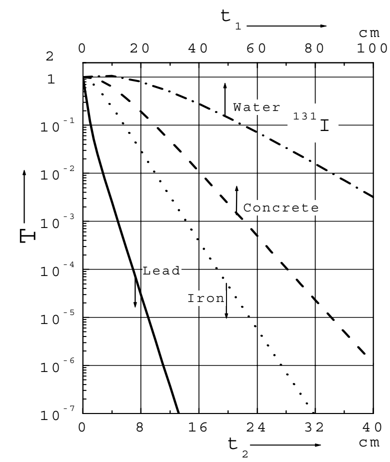

Fig. 5.4.26. Ambient dose equivalent transmission factor of 4 shields for ^{131}I source

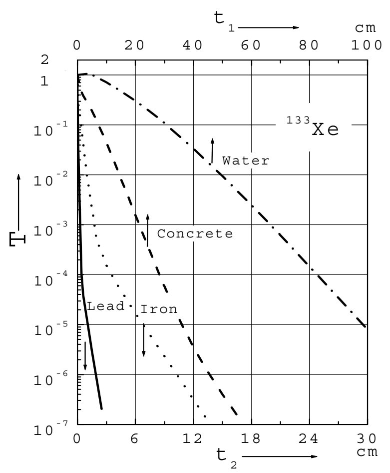

Fig. 5.4.27. Ambient dose equivalent transmission factor of 4 shields for ^{133}Xe source

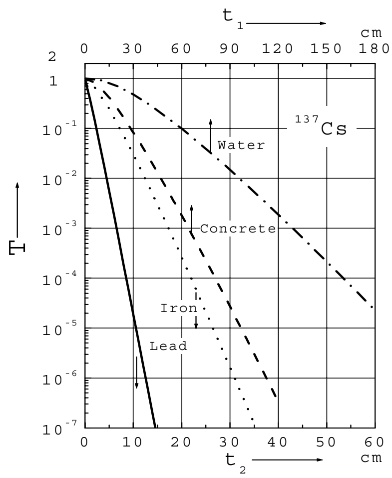

Fig. 5.4.28. Ambient dose equivalent transmission factor of 4 shields for ^{137}Cs source

5.5 Neutrons

5.5.1 Basic shielding concepts

In passing through shielding material, neutrons attenuate by elastic scattering, inelastic scattering and absorption. For high-energy neutrons over 10 MeV, inelastic scattering reaction is effective to decrease energy. Therefore iron is a suitable material because of its relatively big inelastic cross section. For neutrons with energy lower than 10 MeV, materials that contain hydrogen are used to utilize its elastic scattering reaction and absorption process.

Dose calculations of neutrons are more complicated than photons because secondary gamma-ray dose by neutron capture and inelastic scattering should be taken into account. Moreover, reaction type and cross section depends strongly on the neutron energy and the shielding material.

Therefore, dose evaluation is generally done by using a shielding code that solves the Boltzmann transport equation. In the present chapter a simple method to estimate dose rates from typical neutron sources and shielding materials is described using results of the shielding code ANISN [73Eng].

5.5.2 Attenuation data of various neutron sources in shield material

Fig. 5.5.1 shows the geometry of the transmission calculations by ANISN. A neutron point isotropic source with source intensity $S = 1\ s^{-1}$ is surrounded by a thick spherical shield.

The JENDL3.2 [90Shi] cross-section library is used in this calculation. The elemental composition and the density of each shield material are shown in Table 5.5.1. Dose rates were estimated using the calculated neutron and secondary gamma-ray flux and the flux-to-dose conversion factor of ambient dose equivalent $H^*(10)$ in ICRP Report 74 [96ICR].

Table 5.5.3 - 5.5.6 give the calculated neutron and secondary gamma-ray *ambient dose rates* for ^{252}Cf, Am-Be, D-D and D-T sources [01Sak]. The first column shows the distance r [cm] from the centre, the second column shows the equivalent dose rate at distance r when no shield material is present: $\dot{H}_0$ [μSv h^{-1}], the third to fifth columns show the neutron, secondary gamma-ray and total equivalent dose rates in water at distance r: $\dot{H}_n$ [μSv h^{-1}], $\dot{H}_g$ [μSv h^{-1}] and $\dot{H}_t$ [μSv h^{-1}], and the sixth to eighth columns show the neutron, secondary gamma-ray, and total transmission factors: $F_n\ (= \dot{H}_n / \dot{H}_0)$, $F_g\ (= \dot{H}_g / \dot{H}_0)$ and F_t $(= \dot{H}_t / \dot{H}_0)$ for water. F_n, F_g, F_t values for polyethylene, ordinary concrete and heavy concrete are also described. As for the simple shielding estimation, the constant Γ for various sources is shown in Table 5.5.2, representing the bare ambient dose equivalent rate at 1 m for unit source intensity.

Similar tables for the *effective dose rates* for AP (anterior - posterior) exposure geometry are shown in Table A5.5.1 - A5.5.4 [01Sak] (see Appendix).

Neutron and secondary gamma-ray ambient dose equivalent rates and effective dose rates are calculated by the following equation.

$$\dot{H} = \Gamma \cdot F(t)\,\frac{S}{d^2} \qquad (5.5.1)$$

Γ constant [μSv h^{-1} m^2 s] (Table 5.5.2 and A5.5.5 (see Appendix))
(bare ambient dose equivalent rate or effective dose rate at 1m for unit source intensity)
$F(t)$ transmission factor (F_n, F_g, F_t) for layer thickness t (Table 5.5.3 - 5.5.6 and A5.5.1 - A5.5.4, Fig. 5.5.2 - 5.5.17 and 5.5.20 - 5.5.35 (appendix))
S neutron source intensity [s^{-1}]
d distance from source to detector [m]
$\dot{H}$ Here $\dot{H}$ means ambient dose equivalent rate for table 5.5.3 - 5.5.6, and effective dose rate for table A5.5.1-A5.5.4

Fig. 5.5.2 - 5.5.5 show the neutron and secondary gamma-ray dose transmission curves for a ^{252}Cf source in water, polyethylene, ordinary concrete, and heavy concrete. As shown in these figures, secondary gamma-rays play dominant role from about 50 cm in water and polyethylene, and about 150 cm in ordinary concrete. The total transmission factor for heavy concrete is lower than that for the other materials, because it suppresses secondary gamma-rays efficiently.

Fig. 5.5.6 - 5.5.9 show the transmission curves for Am-Be source in each shield material. The neutron source spectrum from (α, n)-sources depends on the grain radius and mixing ratio. This transmission factor was calculated using the source spectrum measured by Greiss [68Gre]. Transmission factors for Am-Be are similar to these for ^{252}Cf source.

Fig. 5.5.10 - 5.5.13 show the transmission curves for D-D source in each shield material. The transmission factor is low because of the low source neutron energy (2.45 MeV). D(d, p)T and D(d, n)^{3}He reactions occur with almost the same probabilities. Therefore the ordinary D-D source produces a small amount of D-T neutrons by accumulated tritium. The D-T neutrons must be considered simultaneously.

Fig. 5.5.14 - 5.5.17 show the transmission curves for D-T source in each shield material. The transmission factor is very high for D-T neutrons because of the neutron energy being high (14.1MeV).

Similar figures for the *effective dose rate* for AP (anterior - posterior) exposure geometry are shown in Fig. 5.5.20 - 5.5.35 (see Appendix).

These attenuation calculations were done in sufficiently thick material, called infinite geometry. This means, calculated dose rates at every point contain the backscattered components. This causes unrealistic results, so that dose attenuation factor exceeds one. Backscattered dose contributions depend on the shield material and thickness. Attention has to be paid as well to a more realistic geometry, which usually shows a certain distance between the source and the shield wall. This effect increases the transmission factor to a certain extent.

Considering these effects, overestimation results at 0.5 m to about 1.4 for water and to about 1.2 for ordinary concrete. Although the attenuation factor is conservative, it is sufficient for easy evaluation.

Table 5.5.1 Elemental composition and densities of shield material. *) Type 02-a concrete from ANL-5800, p.660 (1963); **) From JAERI-M 6928, p.36 (1977).

Material	Water	Polyethylene	Ordinary concrete*	Heavy concrete**
Density [g cm^{-3}]	1.0	0.93	2.1	3.715
Element	Atomic densities [10^{24} cm^{-3}]			
H	$6.6738 \cdot 10^{-2}$	$7.9793 \cdot 10^{-2}$	$1.2985 \cdot 10^{-2}$	$9.9885 \cdot 10^{-3}$
C		$3.9930 \cdot 10^{-2}$	$1.0821 \cdot 10^{-4}$	
O	$3.3370 \cdot 10^{-2}$		$4.3051 \cdot 10^{-2}$	$4.3899 \cdot 10^{-2}$
Mg			$1.1614 \cdot 10^{-4}$	$4.3265 \cdot 10^{-5}$
Al			$1.6321 \cdot 10^{-3}$	$1.6502 \cdot 10^{-4}$
Si			$1.5582 \cdot 10^{-2}$	$3.7264 \cdot 10^{-3}$
Ca			$1.4086 \cdot 10^{-3}$	$2.2782 \cdot 10^{-3}$
Fe			$3.2353 \cdot 10^{-4}$	$2.3602 \cdot 10^{-2}$

Table 5.5.2 Constant Γ (ambient dose equivalent) for various neutron sources

Source	Γ[μSv h^{-1} m^2 s]
^{252}Cf	$1.11 \cdot 10^{-5}$
Am-Be	$1.13 \cdot 10^{-5}$
D-D	$1.19 \cdot 10^{-5}$
D-T	$1.49 \cdot 10^{-5}$

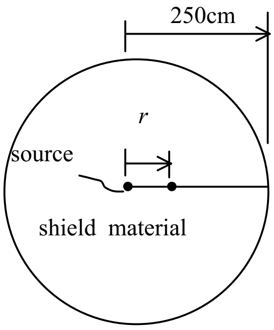

Fig. 5.5.1. Geometry for transmission calculation

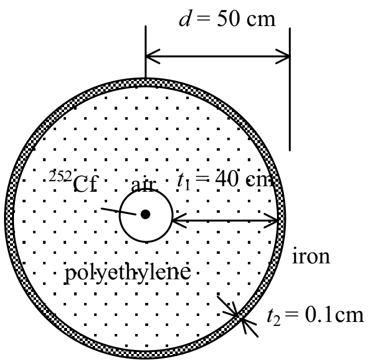

Fig. 5.5.18. ^{252}Cf storage container

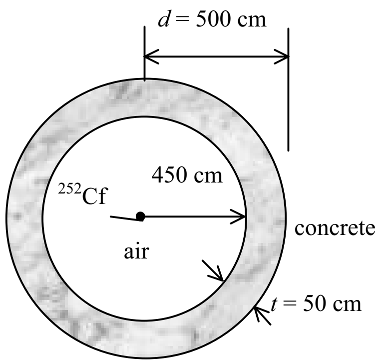

Fig. 5.5.19. ^{252}Cf exposure room

5.5.3 Sample shield calculation

Sample problem: ^{252}Cf neutron source of 37 MBq (1.88 μg: $S = 4.32 \cdot 10^6$ s^{-1}) is stored in a storage container that can be modelled as Fig. 5.5.18. The same bare source is used in a room that can be modelled as Fig. 5.5.19. Calculate ambient dose equivalent rates at the container surface and outside the room wall.

(1) Dose calculation at the surface of storage container

Neutron dose rate

The shielding effect by the 0.1 cm thick iron layer is small, therefore the iron is neglected, and polyethylene is the only shielding material to be considered. With Γ from Table 5.5.2 and the neutron transmission factor $F_n(40)$ for polyethylene from Table 5.5.3 ($t \rightarrow r$ = 40 cm) the neutron ambient dose equivalent rate is

$$\text{Eq. (5.5.1):}\quad \dot{H}_n = 1.11{\cdot}10^{-5} \cdot 5.74{\cdot}10^{-3} \cdot \frac{4.32 \cdot 10^6}{0.5^2}\ \mu\text{Sv h}^{-1} = 1.10\ \mu\text{Sv h}^{-1}$$

Secondary gamma-ray dose rate

The shielding effect by the 0.1 cm thick iron layer is small, therefore the iron is neglected, and polyethylene is the only shielding material to be considered. With Γ from Table 5.5.2 and the secondary gamma-ray transmission factor $F_g(40)$ for polyethylene from Table 5.5.3 ($t \rightarrow r$ = 40 cm) the secondary gamma ambient dose equivalent rate is

$$\text{Eq. (5.5.1):}\quad \dot{H}_g = 1.11{\cdot}10^{-5} \cdot 1.26{\cdot}10^{-2} \cdot \frac{4.32 \cdot 10^6}{0.5^2}\ \mu\text{Sv h}^{-1} = 2.42\ \mu\text{Sv h}^{-1}$$

Also, the primary gamma-rays of ^{252}Cf source should be considered.

(2) Dose calculation outside the exposure room

Neutron dose rate

With Γ from Table 5.5.2 and the neutron transmission factor $F_n(50)$ for ordinary concrete from Table 5.5.3 ($t \rightarrow r$ = 50 cm) the neutron ambient dose equivalent rate is

$$\text{Eq. (5.5.1):}\quad \dot{H}_n = 1.11{\cdot}10^{-5} \cdot 1.56{\cdot}10^{-1} \cdot \frac{4.32 \cdot 10^6}{5.0^2}\ \mu\text{Sv h}^{-1} = 0.299\ \mu\text{Sv h}^{-1}$$

Secondary gamma-ray dose rate

With Γ from Table 5.5.2 and the secondary gamma-ray transmission factor $F_g(50)$ for ordinary concrete from Table 5.5.3 ($t \rightarrow r$ = 50 cm) the secondary gamma-ray ambient dose equivalent rate is

$$\text{Eq. (5.5.1):}\quad \dot{H}_g = 1.11{\cdot}10^{-5} \cdot 1.63{\cdot}10^{-2} \cdot \frac{4.32 \cdot 10^6}{5.0^2}\ \mu\text{Sv h}^{-1} = 0.0313\ \mu\text{Sv h}^{-1}$$

5.5.4 Induced activity

Structure materials, air, coolant waters etc. are activated in neutron fields. The induced activity has to be considered in radiation protection design of nuclear reactors, fusion experimental reactors and high energy accelerators. Examples of well-known activation reactions, half-lives, and gamma-ray energies of produced nuclides – typical for nuclear reactors – are listed in Table 5.5.7.

These reaction cross sections strongly depend on neutron energy. The induced activity and gamma-ray dose rate can be estimated by the following three steps:

1) Estimation of the neutron energy spectrum with a computer code such as ANISN [73Eng].
2) Estimation of the induced activity and gamma-ray source strength for a given irradiation and decay time with a computer code such as ORIGEN [73Bel], using the neutron energy spectrum data
3) Estimation of the gamma-ray dose at a given point with a computer code such as ANISN.

Table 5.5.3 Neutron and secondary gamma-ray ambient dose equivalent rates for ^{252}Cf

	r [cm]	H_0	Water						Polyethylene			Ordinary Concrete			Heavy Concrete		
			H_n	H_g	H_t	F_n	F_g	F_t	F_n	F_g	F_t	F_n	F_g	F_t	F_n	F_g	F_t
1	5.00E+00	4.45E-03	4.15E-03	3.54E-05	4.18E-03	9.31E-01	7.95E-03	9.39E-01	8.73E-01	9.40E-03	8.82E-01	1.56E+00	4.82E-03	1.56E+00	1.72E+00	8.93E-03	1.73E+00
2	1.00E+01	1.11E-03	6.31E-04	2.02E-05	6.52E-04	5.67E-01	1.81E-02	5.85E-01	4.62E-01	2.01E-02	4.82E-01	1.47E+00	1.07E-02	1.48E+00	1.61E+00	1.82E-02	1.63E+00
3	1.50E+01	4.95E-04	1.62E-04	1.12E-05	1.73E-04	3.28E-01	2.26E-02	3.50E-01	2.26E-01	2.30E-02	2.49E-01	1.24E+00	1.66E-02	1.26E+00	1.28E+00	2.49E-02	1.31E+00
4	2.00E+01	2.78E-04	5.09E-05	6.30E-06	5.72E-05	1.83E-01	2.26E-02	2.06E-01	1.07E-01	2.18E-02	1.29E-01	9.82E-01	2.13E-02	1.00E+00	9.25E-01	2.70E-02	9.52E-01
5	2.50E+01	1.78E-04	1.79E-05	3.67E-06	2.16E-05	1.00E-01	2.06E-02	1.21E-01	5.05E-02	1.94E-02	6.99E-02	7.50E-01	2.40E-02	7.74E-01	6.29E-01	2.49E-02	6.54E-01
6	3.00E+01	1.24E-04	6.78E-06	2.22E-06	9.01E-06	5.48E-02	1.80E-02	7.28E-02	2.40E-02	1.69E-02	4.09E-02	5.61E-01	2.47E-02	5.85E-01	4.11E-01	2.07E-02	4.31E-01
7	3.50E+01	9.09E-05	2.72E-06	1.40E-06	4.12E-06	3.00E-02	1.54E-02	4.53E-02	1.16E-02	1.46E-02	2.62E-02	4.13E-01	2.38E-02	4.37E-01	2.61E-01	1.59E-02	2.77E-01
8	4.00E+01	6.96E-05	1.15E-06	9.05E-07	2.05E-06	1.65E-02	1.30E-02	2.95E-02	5.74E-03	1.26E-02	1.84E-02	3.01E-01	2.18E-02	3.22E-01	1.63E-01	1.15E-02	1.74E-01
9	4.50E+01	5.50E-05	5.05E-07	6.02E-07	1.11E-06	9.19E-03	1.09E-02	2.01E-02	2.91E-03	1.09E-02	1.38E-02	2.17E-01	1.91E-02	2.36E-01	1.00E-01	8.06E-03	1.08E-01
10	5.00E+01	4.45E-05	2.30E-07	4.09E-07	6.39E-07	5.17E-03	9.18E-03	1.44E-02	1.51E-03	9.37E-03	1.09E-02	1.56E-01	1.63E-02	1.72E-01	6.09E-02	5.47E-03	6.64E-02
11	5.50E+01	3.68E-05	1.09E-07	2.82E-07	3.91E-07	2.95E-03	7.67E-03	1.06E-02	8.02E-04	8.04E-03	8.84E-03	1.11E-01	1.36E-02	1.24E-01	3.68E-02	3.63E-03	4.04E-02
12	6.00E+01	3.09E-05	5.27E-08	1.98E-07	2.51E-07	1.70E-03	6.41E-03	8.11E-03	4.33E-04	6.86E-03	7.29E-03	7.87E-02	1.11E-02	8.97E-02	2.21E-02	2.38E-03	2.45E-02
13	6.50E+01	2.64E-05	2.62E-08	1.41E-07	1.67E-07	9.93E-04	5.34E-03	6.33E-03	2.37E-04	5.84E-03	6.08E-03	5.55E-02	8.87E-03	6.44E-02	1.32E-02	1.53E-03	1.47E-02
14	7.00E+01	2.27E-05	1.33E-08	1.01E-07	1.14E-07	5.85E-04	4.44E-03	5.02E-03	1.31E-04	4.95E-03	5.08E-03	3.90E-02	7.03E-03	4.61E-02	7.86E-03	9.82E-04	8.84E-03
15	7.50E+01	1.98E-05	6.87E-09	7.30E-08	7.98E-08	3.47E-04	3.69E-03	4.03E-03	7.37E-05	4.19E-03	4.26E-03	2.74E-02	5.51E-03	3.29E-02	4.67E-03	6.23E-04	5.29E-03
16	8.00E+01	1.74E-05	3.61E-09	5.31E-08	5.67E-08	2.07E-04	3.05E-03	3.26E-03	4.17E-05	3.53E-03	3.57E-03	1.91E-02	4.28E-03	2.34E-02	2.76E-03	3.94E-04	3.16E-03
17	8.50E+01	1.54E-05	1.92E-09	3.89E-08	4.09E-08	1.25E-04	2.53E-03	2.65E-03	2.38E-05	2.97E-03	3.00E-03	1.33E-02	3.30E-03	1.66E-02	1.63E-03	2.47E-04	1.88E-03
18	9.00E+01	1.37E-05	1.04E-09	2.87E-08	2.97E-08	7.53E-05	2.09E-03	2.16E-03	1.36E-05	2.49E-03	2.51E-03	9.26E-03	2.53E-03	1.18E-02	9.64E-04	1.55E-04	1.12E-03
19	9.50E+01	1.23E-05	5.64E-10	2.12E-08	2.18E-08	4.57E-05	1.72E-03	1.77E-03	7.88E-06	2.09E-03	2.10E-03	6.42E-03	1.93E-03	8.35E-03	5.68E-04	9.66E-05	6.65E-04
20	1.00E+02	1.11E-05	3.10E-10	1.58E-08	1.61E-08	2.78E-05	1.42E-03	1.45E-03	4.57E-06	1.75E-03	1.75E-03	4.45E-03	1.46E-03	5.91E-03	3.34E-04	6.01E-05	3.94E-04
21	1.05E+02	1.01E-05	1.72E-10	1.18E-08	1.20E-08	1.70E-05	1.17E-03	1.18E-03	2.67E-06	1.46E-03	1.46E-03	3.07E-03	1.11E-03	4.18E-03	1.97E-04	3.73E-05	2.34E-04
22	1.10E+02	9.20E-06	9.58E-11	8.83E-09	8.93E-09	1.04E-05	9.60E-04	9.70E-04	1.57E-06	1.22E-03	1.22E-03	2.12E-03	8.35E-04	2.96E-03	1.15E-04	2.31E-05	1.39E-04
23	1.15E+02	8.42E-06	5.39E-11	6.63E-09	6.69E-09	6.40E-06	7.88E-04	7.94E-04	9.22E-07	1.01E-03	1.01E-03	1.46E-03	6.28E-04	2.09E-03	6.78E-05	1.43E-05	8.21E-05
24	1.20E+02	7.73E-06	3.04E-11	5.00E-09	5.03E-09	3.94E-06	6.46E-04	6.50E-04	5.45E-07	8.41E-04	8.41E-04	1.01E-03	4.72E-04	1.48E-03	3.97E-05	8.82E-06	4.86E-05
25	1.25E+02	7.13E-06	1.73E-11	3.77E-09	3.79E-09	2.43E-06	5.30E-04	5.32E-04	3.24E-07	6.98E-04	6.98E-04	6.92E-04	3.54E-04	1.05E-03	2.33E-05	5.44E-06	2.87E-05
26	1.30E+02	6.59E-06	9.89E-12	2.86E-09	2.87E-09	1.50E-06	4.34E-04	4.35E-04	1.93E-07	5.79E-04	5.79E-04	4.75E-04	2.65E-04	7.40E-04	1.37E-05	3.35E-06	1.70E-05
27	1.35E+02	6.11E-06	5.68E-12	2.17E-09	2.17E-09	9.29E-07	3.55E-04	3.56E-04	1.15E-07	4.79E-04	4.79E-04	3.26E-04	1.99E-04	5.25E-04	7.99E-06	2.06E-06	1.01E-05
28	1.40E+02	5.68E-06	3.28E-12	1.65E-09	1.65E-09	5.76E-07	2.90E-04	2.91E-04	6.90E-08	3.97E-04	3.97E-04	2.23E-04	1.49E-04	3.72E-04	4.68E-06	1.27E-06	5.95E-06
29	1.45E+02	5.30E-06	1.90E-12	1.26E-09	1.26E-09	3.58E-07	2.37E-04	2.37E-04	4.14E-08	3.28E-04	3.28E-04	1.53E-04	1.11E-04	2.64E-04	2.74E-06	7.77E-07	3.52E-06
30	1.50E+02	4.95E-06	1.10E-12	9.57E-10	9.59E-10	2.23E-07	1.93E-04	1.94E-04	2.50E-08	2.71E-04	2.71E-04	1.05E-04	8.34E-05	1.88E-04	1.60E-06	4.77E-07	2.08E-06
31	1.55E+02	4.63E-06	6.44E-13	7.32E-10	7.32E-10	1.39E-07	1.58E-04	1.58E-04	1.51E-08	2.24E-04	2.24E-04	7.15E-05	6.25E-05	1.34E-04	9.36E-07	2.92E-07	1.23E-06
32	1.60E+02	4.35E-06	3.77E-13	5.60E-10	5.60E-10	8.67E-08	1.29E-04	1.29E-04	9.12E-09	1.85E-04	1.85E-04	4.89E-05	4.68E-05	9.57E-05	5.47E-07	1.79E-07	7.26E-07
33	1.65E+02	4.09E-06	2.22E-13	4.29E-10	4.30E-10	5.42E-08	1.05E-04	1.05E-04	5.53E-09	1.52E-04	1.52E-04	3.34E-05	3.51E-05	6.85E-05	3.20E-07	1.10E-07	4.29E-07
34	1.70E+02	3.85E-06	1.31E-13	3.30E-10	3.30E-10	3.39E-08	8.55E-05	8.56E-05	3.36E-09	1.26E-04	1.26E-04	2.28E-05	2.63E-05	4.91E-05	1.87E-07	6.70E-08	2.54E-07
35	1.75E+02	3.64E-06	7.74E-14	2.53E-10	2.54E-10	2.13E-08	6.97E-05	6.97E-05	2.04E-09	1.04E-04	1.04E-04	1.55E-05	1.98E-05	3.53E-05	1.09E-07	4.10E-08	1.50E-07
36	1.80E+02	3.44E-06	4.59E-14	1.95E-10	1.95E-10	1.34E-08	5.68E-05	5.68E-05	1.25E-09	8.54E-05	8.54E-05	1.06E-05	1.49E-05	2.54E-05	6.37E-08	2.50E-08	8.87E-08
37	1.85E+02	3.25E-06	2.73E-14	1.50E-10	1.50E-10	8.40E-09	4.62E-05	4.63E-05	7.61E-10	7.03E-05	7.03E-05	7.21E-06	1.12E-05	1.84E-05	3.72E-08	1.53E-08	5.25E-08
38	1.90E+02	3.08E-06	1.63E-14	1.16E-10	1.16E-10	5.29E-09	3.77E-05	3.77E-05	4.65E-10	5.79E-05	5.79E-05	4.91E-06	8.42E-06	1.33E-05	2.17E-08	9.34E-09	3.10E-08
39	1.95E+02	2.93E-06	9.76E-15	8.98E-11	8.98E-11	3.33E-09	3.07E-05	3.07E-05	2.85E-10	4.77E-05	4.77E-05	3.35E-06	6.34E-06	9.69E-06	1.27E-08	5.70E-09	1.84E-08
40	2.00E+02	2.78E-06	5.86E-15	6.96E-11	6.96E-11	2.10E-09	2.50E-05	2.50E-05	1.75E-10	3.93E-05	3.93E-05	2.28E-06	4.79E-06	7.06E-06	7.38E-09	3.47E-09	1.09E-08
41	2.05E+02	2.65E-06	3.52E-15	5.39E-11	5.39E-11	1.33E-09	2.04E-05	2.04E-05	1.07E-10	3.23E-05	3.23E-05	1.55E-06	3.62E-06	5.16E-06	4.30E-09	2.12E-09	6.42E-09
42	2.10E+02	2.53E-06	2.12E-15	4.19E-11	4.19E-11	8.41E-10	1.66E-05	1.66E-05	6.58E-11	2.66E-05	2.66E-05	1.05E-06	2.73E-06	3.79E-06	2.51E-09	1.29E-09	3.80E-09
43	2.15E+02	2.41E-06	1.28E-15	3.26E-11	3.26E-11	5.33E-10	1.35E-05	1.35E-05	4.05E-11	2.19E-05	2.19E-05	7.15E-07	2.07E-06	2.78E-06	1.46E-09	7.86E-10	2.25E-09
44	2.20E+02	2.30E-06	7.77E-16	2.54E-11	2.54E-11	3.38E-10	1.10E-05	1.10E-05	2.49E-11	1.80E-05	1.80E-05	4.85E-07	1.57E-06	2.05E-06	8.52E-10	4.78E-10	1.33E-09

[Ref. p. 5-32

Table 5.5.4 Neutron and secondary gamma-ray ambient dose equivalent rates for Am-Be

r [cm]		H_0	Water						Polyethylene			Ordinary Concrete			Heavy Concrete		
			H_n	H_g	H_t	F_n	F_g	F_t	F_n	F_g	F_t	F_n	F_g	F_t	F_n	F_g	F_t
1	5.00E+00	4.53E-03	4.88E-03	2.72E-05	4.91E-03	1.08E+00	6.01E-03	1.08E+00	1.05E+00	8.02E-03	1.06E+00	1.52E+00	5.48E-03	1.52E+00	1.68E+00	1.25E-02	1.70E+00
2	1.00E+01	1.13E-03	8.99E-04	1.64E-05	9.15E-04	7.94E-01	1.45E-02	8.09E-01	6.90E-01	1.79E-02	7.08E-01	1.56E+00	1.09E-02	1.57E+00	1.71E+00	2.07E-02	1.73E+00
3	1.50E+01	5.03E-04	2.73E-04	9.79E-06	2.83E-04	5.42E-01	1.95E-02	5.62E-01	4.11E-01	2.21E-02	4.33E-01	1.44E+00	1.59E-02	1.46E+00	1.47E+00	2.57E-02	1.50E+00
4	2.00E+01	2.83E-04	9.91E-05	5.85E-06	1.05E-04	3.50E-01	2.07E-02	3.71E-01	2.31E-01	2.21E-02	2.53E-01	1.24E+00	1.99E-02	1.26E+00	1.15E+00	2.70E-02	1.18E+00
5	2.50E+01	1.81E-04	3.98E-05	3.57E-06	4.33E-05	2.20E-01	1.97E-02	2.39E-01	1.27E-01	2.03E-02	1.47E-01	1.02E+00	2.23E-02	1.05E+00	8.44E-01	2.51E-02	8.69E-01
6	3.00E+01	1.26E-04	1.70E-05	2.24E-06	1.92E-05	1.35E-01	1.78E-02	1.53E-01	6.88E-02	1.80E-02	8.68E-02	8.17E-01	2.32E-02	8.41E-01	5.91E-01	2.14E-02	6.13E-01
7	3.50E+01	9.24E-05	7.61E-06	1.44E-06	9.05E-06	8.24E-02	1.55E-02	9.79E-02	3.73E-02	1.57E-02	5.29E-02	6.37E-01	2.27E-02	6.59E-01	4.01E-01	1.70E-02	4.18E-01
8	4.00E+01	7.07E-05	3.53E-06	9.44E-07	4.48E-06	5.00E-02	1.34E-02	6.33E-02	2.02E-02	1.36E-02	3.38E-02	4.87E-01	2.12E-02	5.08E-01	2.66E-01	1.29E-02	2.79E-01
9	4.50E+01	5.59E-05	1.69E-06	6.35E-07	2.33E-06	3.02E-02	1.14E-02	4.16E-02	1.10E-02	1.17E-02	2.27E-02	3.67E-01	1.90E-02	3.87E-01	1.73E-01	9.38E-03	1.82E-01
10	5.00E+01	4.53E-05	8.28E-07	4.35E-07	1.26E-06	1.83E-02	9.60E-03	2.79E-02	6.01E-03	1.00E-02	1.61E-02	2.74E-01	1.66E-02	2.91E-01	1.11E-01	6.64E-03	1.18E-01
11	5.50E+01	3.74E-05	4.14E-07	3.03E-07	7.17E-07	1.11E-02	8.08E-03	1.92E-02	3.30E-03	8.60E-03	1.19E-02	2.02E-01	1.42E-02	2.17E-01	7.03E-02	4.59E-03	7.49E-02
12	6.00E+01	3.14E-05	2.11E-07	2.13E-07	4.24E-07	6.70E-03	6.79E-03	1.35E-02	1.82E-03	7.34E-03	9.16E-03	1.48E-01	1.18E-02	1.60E-01	4.41E-02	3.12E-03	4.72E-02
13	6.50E+01	2.68E-05	1.09E-07	1.52E-07	2.61E-07	4.06E-03	5.68E-03	9.75E-03	1.00E-03	6.25E-03	7.26E-03	1.08E-01	9.72E-03	1.18E-01	2.75E-02	2.09E-03	2.96E-02
14	7.00E+01	2.31E-05	5.70E-08	1.10E-07	1.67E-07	2.47E-03	4.75E-03	7.21E-03	5.57E-04	5.31E-03	5.87E-03	7.82E-02	7.87E-03	8.61E-02	1.70E-02	1.38E-03	1.84E-02
15	7.50E+01	2.01E-05	3.01E-08	7.97E-08	1.10E-07	1.50E-03	3.96E-03	5.46E-03	3.09E-04	4.50E-03	4.81E-03	5.63E-02	6.30E-03	6.26E-02	1.05E-02	9.04E-04	1.14E-02
16	8.00E+01	1.77E-05	1.61E-08	5.84E-08	7.45E-08	9.10E-04	3.30E-03	4.21E-03	1.72E-04	3.80E-03	3.97E-03	4.04E-02	4.99E-03	4.54E-02	6.42E-03	5.87E-04	7.01E-03
17	8.50E+01	1.57E-05	8.66E-09	4.30E-08	5.17E-08	5.53E-04	2.75E-03	3.30E-03	9.62E-05	3.20E-03	3.30E-03	2.88E-02	3.92E-03	3.28E-02	3.92E-03	3.78E-04	4.30E-03
18	9.00E+01	1.40E-05	4.70E-09	3.19E-08	3.66E-08	3.36E-04	2.28E-03	2.62E-03	5.38E-05	2.70E-03	2.75E-03	2.05E-02	3.06E-03	2.36E-02	2.39E-03	2.42E-04	2.63E-03
19	9.50E+01	1.25E-05	2.57E-09	2.38E-08	2.63E-08	2.05E-04	1.89E-03	2.10E-03	3.01E-05	2.27E-03	2.30E-03	1.46E-02	2.37E-03	1.69E-02	1.45E-03	1.54E-04	1.60E-03
20	1.00E+02	1.13E-05	1.41E-09	1.78E-08	1.92E-08	1.24E-04	1.57E-03	1.69E-03	1.69E-05	1.90E-03	1.92E-03	1.03E-02	1.83E-03	1.21E-02	8.75E-04	9.80E-05	9.73E-04
21	1.05E+02	1.03E-05	7.78E-10	1.34E-08	1.41E-08	7.57E-05	1.30E-03	1.38E-03	9.49E-06	1.59E-03	1.60E-03	7.28E-03	1.40E-03	8.68E-03	5.28E-04	6.19E-05	5.90E-04
22	1.10E+02	9.35E-06	4.31E-10	1.01E-08	1.05E-08	4.61E-05	1.08E-03	1.12E-03	5.34E-06	1.33E-03	1.34E-03	5.13E-03	1.07E-03	6.20E-03	3.18E-04	3.90E-05	3.57E-04
23	1.15E+02	8.56E-06	2.40E-10	7.63E-09	7.87E-09	2.81E-05	8.91E-04	9.19E-04	3.00E-06	1.11E-03	1.12E-03	3.61E-03	8.13E-04	4.42E-03	1.91E-04	2.45E-05	2.16E-04
24	1.20E+02	7.86E-06	1.34E-10	5.79E-09	5.92E-09	1.71E-05	7.37E-04	7.54E-04	1.69E-06	9.30E-04	9.32E-04	2.53E-03	6.17E-04	3.15E-03	1.15E-04	1.53E-05	1.30E-04
25	1.25E+02	7.24E-06	7.53E-11	4.41E-09	4.49E-09	1.04E-05	6.09E-04	6.19E-04	9.55E-07	7.76E-04	7.77E-04	1.77E-03	4.67E-04	2.24E-03	6.87E-05	9.58E-06	7.83E-05
26	1.30E+02	6.70E-06	4.24E-11	3.37E-09	3.41E-09	6.32E-06	5.03E-04	5.10E-04	5.39E-07	6.47E-04	6.47E-04	1.24E-03	3.53E-04	1.59E-03	4.11E-05	5.97E-06	4.70E-05
27	1.35E+02	6.21E-06	2.39E-11	2.58E-09	2.61E-09	3.85E-06	4.16E-04	4.20E-04	3.05E-07	5.39E-04	5.39E-04	8.66E-04	2.66E-04	1.13E-03	2.45E-05	3.71E-06	2.82E-05
28	1.40E+02	5.78E-06	1.35E-11	1.98E-09	2.00E-09	2.34E-06	3.44E-04	3.46E-04	1.72E-07	4.49E-04	4.49E-04	6.04E-04	2.00E-04	8.04E-04	1.46E-05	2.31E-06	1.69E-05
29	1.45E+02	5.38E-06	7.68E-12	1.53E-09	1.54E-09	1.43E-06	2.84E-04	2.85E-04	9.74E-08	3.73E-04	3.73E-04	4.20E-04	1.51E-04	5.71E-04	8.72E-06	1.43E-06	1.02E-05
30	1.50E+02	5.03E-06	4.37E-12	1.18E-09	1.18E-09	8.68E-07	2.35E-04	2.35E-04	5.51E-08	3.10E-04	3.11E-04	2.92E-04	1.13E-04	4.05E-04	5.19E-06	8.84E-07	6.08E-06
31	1.55E+02	4.71E-06	2.49E-12	9.14E-10	9.16E-10	5.28E-07	1.94E-04	1.95E-04	3.12E-08	2.58E-04	2.58E-04	2.03E-04	8.50E-05	2.88E-04	3.09E-06	5.47E-07	3.63E-06
32	1.60E+02	4.42E-06	1.42E-12	7.09E-10	7.11E-10	3.21E-07	1.60E-04	1.61E-04	1.77E-08	2.15E-04	2.15E-04	1.41E-04	6.38E-05	2.05E-04	1.83E-06	3.37E-07	2.17E-06
33	1.65E+02	4.16E-06	8.13E-13	5.52E-10	5.53E-10	1.96E-07	1.33E-04	1.33E-04	1.00E-08	1.78E-04	1.78E-04	9.77E-05	4.79E-05	1.46E-04	1.09E-06	2.08E-07	1.30E-06
34	1.70E+02	3.92E-06	4.66E-13	4.31E-10	4.31E-10	1.19E-07	1.10E-04	1.10E-04	5.69E-09	1.48E-04	1.48E-04	6.77E-05	3.59E-05	1.04E-04	6.45E-07	1.28E-07	7.73E-07
35	1.75E+02	3.70E-06	2.68E-13	3.37E-10	3.37E-10	7.24E-08	9.11E-05	9.12E-05	3.23E-09	1.23E-04	1.23E-04	4.68E-05	2.70E-05	7.38E-05	3.82E-07	7.88E-08	4.61E-07
36	1.80E+02	3.49E-06	1.54E-13	2.64E-10	2.64E-10	4.41E-08	7.56E-05	7.57E-05	1.83E-09	1.02E-04	1.02E-04	3.24E-05	2.02E-05	5.26E-05	2.26E-07	4.84E-08	2.75E-07
37	1.85E+02	3.31E-06	8.87E-14	2.08E-10	2.08E-10	2.68E-08	6.28E-05	6.28E-05	1.04E-09	8.52E-05	8.52E-05	2.24E-05	1.52E-05	3.76E-05	1.34E-07	2.97E-08	1.64E-07
38	1.90E+02	3.14E-06	5.12E-14	1.64E-10	1.64E-10	1.63E-08	5.22E-05	5.22E-05	5.90E-10	7.08E-05	7.08E-05	1.54E-05	1.14E-05	2.69E-05	7.91E-08	1.82E-08	9.73E-08
39	1.95E+02	2.98E-06	2.96E-14	1.29E-10	1.29E-10	9.93E-09	4.35E-05	4.35E-05	3.35E-10	5.89E-05	5.89E-05	1.06E-05	8.60E-06	1.92E-05	4.67E-08	1.12E-08	5.79E-08
40	2.00E+02	2.83E-06	1.71E-14	1.03E-10	1.03E-10	6.05E-09	3.62E-05	3.63E-05	1.90E-10	4.90E-05	4.90E-05	7.34E-06	6.47E-06	1.38E-05	2.76E-08	6.85E-09	3.44E-08
41	2.05E+02	2.69E-06	9.91E-15	8.15E-11	8.15E-11	3.68E-09	3.03E-05	3.03E-05	1.08E-10	4.08E-05	4.08E-05	5.05E-06	4.87E-06	9.92E-06	1.63E-08	4.19E-09	2.04E-08
42	2.10E+02	2.57E-06	5.75E-15	6.49E-11	6.49E-11	2.24E-09	2.53E-05	2.53E-05	6.14E-11	3.39E-05	3.39E-05	3.48E-06	3.67E-06	7.15E-06	9.58E-09	2.56E-09	1.21E-08
43	2.15E+02	2.45E-06	3.34E-15	5.19E-11	5.19E-11	1.36E-09	2.12E-05	2.12E-05	3.49E-11	2.83E-05	2.83E-05	2.39E-06	2.77E-06	5.16E-06	5.64E-09	1.57E-09	7.21E-09
44	2.20E+02	2.34E-06	1.94E-15	4.16E-11	4.16E-11	8.29E-10	1.78E-05	1.78E-05	1.98E-11	2.35E-05	2.35E-05	1.64E-06	2.09E-06	3.73E-06	3.32E-09	9.57E-10	4.28E-09

Table 5.5.5 Neutron and secondary gamma-ray ambient dose equivalent rates for D-D

	r [cm]	H_0	Water						Polyethylene			Ordinary Concrete			Heavy Concrete		
			H_n	H_g	H_t	F_n	F_g	F_t	F_n	F_g	F_t	F_n	F_g	F_t	F_n	F_g	F_t
1	5.00E+00	4.77E-03	4.93E-03	2.53E-05	4.95E-03	1.03E+00	5.31E-03	1.04E+00	9.79E-01	7.68E-03	9.87E-01	1.50E+00	2.64E-03	1.50E+00	1.74E+00	5.44E-03	1.75E+00
2	1.00E+01	1.19E-03	7.91E-04	1.69E-05	8.08E-04	6.64E-01	1.42E-02	6.78E-01	5.15E-01	1.80E-02	5.33E-01	1.57E+00	6.96E-03	1.58E+00	1.84E+00	1.25E-02	1.85E+00
3	1.50E+01	5.29E-04	1.93E-04	1.02E-05	2.04E-04	3.65E-01	1.92E-02	3.84E-01	2.24E-01	2.17E-02	2.45E-01	1.45E+00	1.20E-02	1.47E+00	1.60E+00	1.87E-02	1.62E+00
4	2.00E+01	2.98E-04	5.49E-05	5.94E-06	6.08E-05	1.84E-01	2.00E-02	2.04E-01	8.82E-02	2.07E-02	1.09E-01	1.23E+00	1.66E-02	1.24E+00	1.24E+00	2.21E-02	1.26E+00
5	2.50E+01	1.91E-04	1.68E-05	3.51E-06	2.03E-05	8.79E-02	1.84E-02	1.06E-01	3.27E-02	1.83E-02	5.10E-02	9.72E-01	1.98E-02	9.92E-01	8.89E-01	2.23E-02	9.12E-01
6	3.00E+01	1.32E-04	5.35E-06	2.13E-06	7.47E-06	4.04E-02	1.61E-02	5.64E-02	1.16E-02	1.58E-02	2.74E-02	7.41E-01	2.15E-02	7.62E-01	6.03E-01	1.99E-02	6.23E-01
7	3.50E+01	9.72E-05	1.75E-06	1.33E-06	3.08E-06	1.80E-02	1.37E-02	3.17E-02	4.00E-03	1.36E-02	1.76E-02	5.48E-01	2.16E-02	5.69E-01	3.92E-01	1.64E-02	4.09E-01
8	4.00E+01	7.45E-05	5.87E-07	8.60E-07	1.45E-06	7.88E-03	1.16E-02	1.94E-02	1.35E-03	1.17E-02	1.31E-02	3.96E-01	2.05E-02	4.17E-01	2.48E-01	1.27E-02	2.61E-01
9	4.50E+01	5.88E-05	1.99E-07	5.72E-07	7.71E-07	3.39E-03	9.72E-03	1.31E-02	4.47E-04	1.01E-02	1.05E-02	2.82E-01	1.86E-02	3.01E-01	1.53E-01	9.31E-03	1.62E-01
10	5.00E+01	4.77E-05	6.85E-08	3.89E-07	4.57E-07	1.44E-03	8.16E-03	9.60E-03	1.46E-04	8.66E-03	8.81E-03	1.99E-01	1.63E-02	2.15E-01	9.28E-02	6.58E-03	9.93E-02
11	5.50E+01	3.94E-05	2.37E-08	2.70E-07	2.93E-07	6.03E-04	6.85E-03	7.45E-03	4.70E-05	7.42E-03	7.46E-03	1.38E-01	1.38E-02	1.52E-01	5.54E-02	4.51E-03	6.00E-02
12	6.00E+01	3.31E-05	8.28E-09	1.90E-07	1.98E-07	2.50E-04	5.74E-03	5.99E-03	1.50E-05	6.33E-03	6.35E-03	9.56E-02	1.15E-02	1.07E-01	3.28E-02	3.02E-03	3.58E-02
13	6.50E+01	2.82E-05	2.91E-09	1.35E-07	1.38E-07	1.03E-04	4.80E-03	4.90E-03	4.76E-06	5.38E-03	5.39E-03	6.57E-02	9.36E-03	7.51E-02	1.92E-02	1.99E-03	2.12E-02
14	7.00E+01	2.43E-05	1.03E-09	9.74E-08	9.84E-08	4.22E-05	4.01E-03	4.05E-03	1.50E-06	4.57E-03	4.57E-03	4.49E-02	7.51E-03	5.24E-02	1.12E-02	1.29E-03	1.25E-02
15	7.50E+01	2.12E-05	3.63E-10	7.06E-08	7.10E-08	1.72E-05	3.34E-03	3.35E-03	4.68E-07	3.86E-03	3.86E-03	3.06E-02	5.94E-03	3.65E-02	6.46E-03	8.23E-04	7.28E-03
16	8.00E+01	1.86E-05	1.29E-10	5.16E-08	5.17E-08	6.94E-06	2.77E-03	2.78E-03	1.46E-07	3.25E-03	3.25E-03	2.08E-02	4.65E-03	2.54E-02	3.72E-03	5.22E-04	4.24E-03
17	8.50E+01	1.65E-05	4.60E-11	3.79E-08	3.80E-08	2.79E-06	2.30E-03	2.30E-03	4.51E-08	2.73E-03	2.73E-03	1.41E-02	3.60E-03	1.77E-02	2.13E-03	3.28E-04	2.46E-03
18	9.00E+01	1.47E-05	1.65E-11	2.80E-08	2.80E-08	1.12E-06	1.90E-03	1.90E-03	1.39E-08	2.29E-03	2.29E-03	9.50E-03	2.77E-03	1.23E-02	1.22E-03	2.05E-04	1.42E-03
19	9.50E+01	1.32E-05	5.90E-12	2.08E-08	2.08E-08	4.47E-07	1.57E-03	1.57E-03	4.27E-09	1.92E-03	1.92E-03	6.40E-03	2.12E-03	8.52E-03	6.95E-04	1.27E-04	8.22E-04
20	1.00E+02	1.19E-05	2.12E-12	1.55E-08	1.55E-08	1.78E-07	1.30E-03	1.30E-03	1.31E-09	1.60E-03	1.60E-03	4.31E-03	1.61E-03	5.92E-03	3.95E-04	7.88E-05	4.74E-04
21	1.05E+02	1.08E-05	7.61E-13	1.15E-08	1.15E-08	7.05E-08	1.07E-03	1.07E-03	3.99E-10	1.34E-03	1.34E-03	2.90E-03	1.22E-03	4.11E-03	2.25E-04	4.86E-05	2.73E-04
22	1.10E+02	9.85E-06	2.74E-13	8.64E-09	8.64E-09	2.79E-08	8.78E-04	8.78E-04	1.22E-10	1.11E-03	1.11E-03	1.94E-03	9.17E-04	2.86E-03	1.28E-04	2.99E-05	1.57E-04
23	1.15E+02	9.01E-06	9.89E-14	6.49E-09	6.49E-09	1.10E-08	7.21E-04	7.21E-04	3.68E-11	9.24E-04	9.24E-04	1.30E-03	6.89E-04	1.99E-03	7.23E-05	1.84E-05	9.06E-05
24	1.20E+02	8.27E-06	3.57E-14	4.89E-09	4.89E-09	4.32E-09	5.91E-04	5.91E-04	1.13E-11	7.67E-04	7.67E-04	8.72E-04	5.17E-04	1.39E-03	4.09E-05	1.13E-05	5.22E-05
25	1.25E+02	7.62E-06	1.29E-14	3.69E-09	3.69E-09	1.70E-09	4.84E-04	4.84E-04	3.34E-12	6.36E-04	6.36E-04	5.83E-04	3.86E-04	9.70E-04	2.32E-05	6.89E-06	3.01E-05
26	1.30E+02	7.05E-06	4.68E-15	2.79E-09	2.79E-09	6.64E-10	3.95E-04	3.95E-04	1.05E-12	5.27E-04	5.27E-04	3.90E-04	2.89E-04	6.79E-04	1.31E-05	4.21E-06	1.73E-05
27	1.35E+02	6.54E-06	1.70E-15	2.11E-09	2.11E-09	2.60E-10	3.23E-04	3.23E-04	3.08E-13	4.35E-04	4.35E-04	2.60E-04	2.16E-04	4.76E-04	7.41E-06	2.57E-06	9.98E-06
28	1.40E+02	6.08E-06	6.16E-16	1.60E-09	1.60E-09	1.01E-10	2.63E-04	2.63E-04	9.40E-14	3.60E-04	3.60E-04	1.74E-04	1.61E-04	3.35E-04	4.19E-06	1.57E-06	5.76E-06
29	1.45E+02	5.67E-06	2.24E-16	1.22E-09	1.22E-09	3.95E-11	2.15E-04	2.15E-04	2.85E-14	2.97E-04	2.97E-04	1.16E-04	1.20E-04	2.36E-04	2.36E-06	9.57E-07	3.32E-06
30	1.50E+02	5.29E-06	8.12E-17	9.25E-10	9.25E-10	1.53E-11	1.75E-04	1.75E-04	8.37E-15	2.45E-04	2.45E-04	7.72E-05	8.96E-05	1.67E-04	1.34E-06	5.83E-07	1.92E-06
31	1.55E+02	4.96E-06	2.95E-17	7.04E-10	7.04E-10	5.96E-12	1.42E-04	1.42E-04	2.61E-15	2.02E-04	2.02E-04	5.14E-05	6.68E-05	1.18E-04	7.54E-07	3.55E-07	1.11E-06
32	1.60E+02	4.65E-06	1.08E-17	5.37E-10	5.37E-10	2.31E-12	1.15E-04	1.15E-04	7.59E-16	1.66E-04	1.66E-04	3.42E-05	4.99E-05	8.41E-05	4.25E-07	2.16E-07	6.42E-07
33	1.65E+02	4.38E-06	3.92E-18	4.10E-10	4.10E-10	8.95E-13	9.37E-05	9.37E-05	2.33E-16	1.37E-04	1.37E-04	2.28E-05	3.73E-05	6.01E-05	2.40E-07	1.32E-07	3.72E-07
34	1.70E+02	4.12E-06	1.43E-18	3.13E-10	3.13E-10	3.46E-13	7.60E-05	7.60E-05	6.91E-17	1.12E-04	1.12E-04	1.51E-05	2.79E-05	4.30E-05	1.35E-07	8.02E-08	2.16E-07
35	1.75E+02	3.89E-06	5.20E-19	2.40E-10	2.40E-10	1.34E-13	6.16E-05	6.16E-05	2.06E-17	9.24E-05	9.24E-05	1.01E-05	2.09E-05	3.10E-05	7.64E-08	4.88E-08	1.25E-07
36	1.80E+02	3.68E-06	1.90E-19	1.84E-10	1.84E-10	5.16E-14	4.99E-05	4.99E-05	6.21E-18	7.59E-05	7.59E-05	6.68E-06	1.57E-05	2.23E-05	4.31E-08	2.97E-08	7.27E-08
37	1.85E+02	3.48E-06	6.93E-20	1.41E-10	1.41E-10	1.99E-14	4.04E-05	4.04E-05	1.81E-18	6.23E-05	6.23E-05	4.43E-06	1.18E-05	1.62E-05	2.43E-08	1.80E-08	4.23E-08
38	1.90E+02	3.30E-06	2.53E-20	1.08E-10	1.08E-10	7.67E-15	3.27E-05	3.27E-05	5.60E-19	5.11E-05	5.11E-05	2.94E-06	8.84E-06	1.18E-05	1.37E-08	1.10E-08	2.47E-08
39	1.95E+02	3.13E-06	9.25E-21	8.27E-11	8.27E-11	2.95E-15	2.64E-05	2.64E-05	1.56E-19	4.19E-05	4.19E-05	1.95E-06	6.65E-06	8.60E-06	7.71E-09	6.67E-09	1.44E-08
40	2.00E+02	2.98E-06	3.38E-21	6.35E-11	6.35E-11	1.13E-15	2.13E-05	2.13E-05	4.91E-20	3.44E-05	3.44E-05	1.29E-06	5.01E-06	6.30E-06	4.34E-09	4.05E-09	8.40E-09
41	2.05E+02	2.83E-06	1.24E-21	4.88E-11	4.88E-11	4.36E-16	1.72E-05	1.72E-05	1.46E-20	2.82E-05	2.82E-05	8.57E-07	3.78E-06	4.64E-06	2.45E-09	2.46E-09	4.91E-09
42	2.10E+02	2.70E-06	4.52E-22	3.76E-11	3.76E-11	1.67E-16	1.39E-05	1.39E-05	4.33E-21	2.31E-05	2.31E-05	5.67E-07	2.85E-06	3.42E-06	1.38E-09	1.50E-09	2.87E-09
43	2.15E+02	2.58E-06	1.65E-22	2.89E-11	2.89E-11	6.42E-17	1.12E-05	1.12E-05	1.29E-21	1.89E-05	1.89E-05	3.75E-07	2.16E-06	2.53E-06	7.76E-10	9.08E-10	1.68E-09
44	2.20E+02	2.46E-06	6.06E-23	2.22E-11	2.22E-11	2.46E-17	9.03E-06	9.03E-06	3.76E-22	1.55E-05	1.55E-05	2.48E-07	1.63E-06	1.88E-06	4.37E-10	5.51E-10	9.88E-10

Table 5.5.6 Neutron and secondary gamma-ray ambient dose equivalent rates for D-T

	r [cm]	H_0	Water						Polyethylene			Ordinary Concrete			Heavy Concrete		
			H_n	H_g	H_t	F_n	F_g	F_t	F_n	F_g	F_t	F_n	F_g	F_t	F_n	F_g	F_t
1	5.00E+00	5.96E-03	6.52E-03	6.77E-04	7.20E-03	1.10E+00	1.14E-01	1.21E+00	1.10E+00	4.23E-03	1.10E+00	1.21E+00	1.82E-01	1.39E+00	1.40E+00	1.38E-01	1.54E+00
2	1.00E+01	1.49E-03	1.46E-03	3.66E-04	1.83E-03	9.83E-01	2.46E-01	1.23E+00	9.67E-01	9.82E-03	9.77E-01	1.23E+00	3.36E-01	1.56E+00	1.44E+00	1.94E-01	1.63E+00
3	1.50E+01	6.62E-04	5.51E-04	2.17E-04	7.68E-04	8.33E-01	3.28E-01	1.16E+00	7.90E-01	1.40E-02	8.04E-01	1.16E+00	3.84E-01	1.55E+00	1.29E+00	1.81E-01	1.47E+00
4	2.00E+01	3.72E-04	2.51E-04	1.34E-04	3.85E-04	6.73E-01	3.61E-01	1.03E+00	6.13E-01	1.63E-02	6.29E-01	1.04E+00	3.63E-01	1.41E+00	1.06E+00	1.46E-01	1.20E+00
5	2.50E+01	2.38E-04	1.25E-04	8.48E-05	2.10E-04	5.26E-01	3.56E-01	8.82E-01	4.58E-01	1.69E-02	4.75E-01	8.97E-01	3.11E-01	1.21E+00	8.16E-01	1.10E-01	9.25E-01
6	3.00E+01	1.65E-04	6.61E-05	5.43E-05	1.20E-04	4.00E-01	3.28E-01	7.28E-01	3.33E-01	1.65E-02	3.49E-01	7.47E-01	2.51E-01	9.99E-01	6.02E-01	7.90E-02	6.81E-01
7	3.50E+01	1.22E-04	3.62E-05	3.50E-05	7.12E-05	2.98E-01	2.88E-01	5.86E-01	2.37E-01	1.54E-02	2.53E-01	6.08E-01	1.96E-01	8.04E-01	4.31E-01	5.55E-02	4.86E-01
8	4.00E+01	9.31E-05	2.04E-05	2.27E-05	4.31E-05	2.19E-01	2.44E-01	4.63E-01	1.67E-01	1.40E-02	1.81E-01	4.85E-01	1.49E-01	6.34E-01	3.01E-01	3.81E-02	3.39E-01
9	4.50E+01	7.35E-05	1.17E-05	1.47E-05	2.64E-05	1.59E-01	2.01E-01	3.59E-01	1.16E-01	1.25E-02	1.28E-01	3.81E-01	1.12E-01	4.92E-01	2.06E-01	2.58E-02	2.32E-01
10	5.00E+01	5.96E-05	6.79E-06	9.62E-06	1.64E-05	1.14E-01	1.62E-01	2.76E-01	7.93E-02	1.10E-02	9.03E-02	2.95E-01	8.28E-02	3.78E-01	1.39E-01	1.72E-02	1.56E-01
11	5.50E+01	4.92E-05	3.99E-06	6.29E-06	1.03E-05	8.11E-02	1.28E-01	2.09E-01	5.39E-02	9.55E-03	6.35E-02	2.26E-01	6.09E-02	2.87E-01	9.23E-02	1.14E-02	1.04E-01
12	6.00E+01	4.14E-05	2.37E-06	4.12E-06	6.49E-06	5.73E-02	9.97E-02	1.57E-01	3.64E-02	8.27E-03	4.47E-02	1.72E-01	4.45E-02	2.16E-01	6.08E-02	7.48E-03	6.83E-02
13	6.50E+01	3.52E-05	1.42E-06	2.71E-06	4.13E-06	4.02E-02	7.69E-02	1.17E-01	2.44E-02	7.12E-03	3.16E-02	1.29E-01	3.25E-02	1.62E-01	3.97E-02	4.87E-03	4.45E-02
14	7.00E+01	3.04E-05	8.53E-07	1.78E-06	2.64E-06	2.81E-02	5.87E-02	8.68E-02	1.63E-02	6.10E-03	2.24E-02	9.68E-02	2.36E-02	1.20E-01	2.57E-02	3.15E-03	2.88E-02
15	7.50E+01	2.65E-05	5.16E-07	1.18E-06	1.70E-06	1.95E-02	4.45E-02	6.40E-02	1.08E-02	5.21E-03	1.60E-02	7.19E-02	1.72E-02	8.91E-02	1.65E-02	2.02E-03	1.85E-02
16	8.00E+01	2.33E-05	3.14E-07	7.82E-07	1.10E-06	1.35E-02	3.36E-02	4.71E-02	7.15E-03	4.44E-03	1.16E-02	5.31E-02	1.25E-02	6.56E-02	1.06E-02	1.29E-03	1.19E-02
17	8.50E+01	2.06E-05	1.91E-07	5.20E-07	7.12E-07	9.29E-03	2.52E-02	3.45E-02	4.70E-03	3.78E-03	8.48E-03	3.91E-02	9.05E-03	4.81E-02	6.71E-03	8.25E-04	7.54E-03
18	9.00E+01	1.84E-05	1.17E-07	3.48E-07	4.65E-07	6.37E-03	1.89E-02	2.53E-02	3.08E-03	3.21E-03	6.29E-03	2.86E-02	6.57E-03	3.52E-02	4.25E-03	5.24E-04	4.77E-03
19	9.50E+01	1.65E-05	7.19E-08	2.34E-07	3.06E-07	4.36E-03	1.42E-02	1.86E-02	2.01E-03	2.73E-03	4.74E-03	2.09E-02	4.78E-03	2.56E-02	2.68E-03	3.32E-04	3.01E-03
20	1.00E+02	1.49E-05	4.42E-08	1.59E-07	2.03E-07	2.97E-03	1.07E-02	1.36E-02	1.31E-03	2.31E-03	3.62E-03	1.51E-02	3.48E-03	1.86E-02	1.68E-03	2.09E-04	1.89E-03
21	1.05E+02	1.35E-05	2.73E-08	1.08E-07	1.36E-07	2.02E-03	8.02E-03	1.00E-02	8.52E-04	1.96E-03	2.81E-03	1.10E-02	2.54E-03	1.35E-02	1.05E-03	1.32E-04	1.18E-03
22	1.10E+02	1.23E-05	1.69E-08	7.46E-08	9.15E-08	1.37E-03	6.06E-03	7.43E-03	5.51E-04	1.66E-03	2.21E-03	7.91E-03	1.85E-03	9.76E-03	6.55E-04	8.28E-05	7.38E-04
23	1.15E+02	1.13E-05	1.04E-08	5.19E-08	6.23E-08	9.26E-04	4.61E-03	5.54E-03	3.56E-04	1.41E-03	1.76E-03	5.69E-03	1.35E-03	7.04E-03	4.07E-04	5.19E-05	4.59E-04
24	1.20E+02	1.03E-05	6.47E-09	3.65E-08	4.30E-08	6.25E-04	3.53E-03	4.16E-03	2.29E-04	1.19E-03	1.42E-03	4.08E-03	9.91E-04	5.07E-03	2.52E-04	3.24E-05	2.85E-04
25	1.25E+02	9.53E-06	4.01E-09	2.60E-08	3.00E-08	4.21E-04	2.73E-03	3.15E-03	1.48E-04	1.01E-03	1.15E-03	2.92E-03	7.27E-04	3.65E-03	1.56E-04	2.03E-05	1.76E-04
26	1.30E+02	8.81E-06	2.50E-09	1.88E-08	2.12E-08	2.83E-04	2.13E-03	2.41E-03	9.46E-05	8.53E-04	9.47E-04	2.09E-03	5.34E-04	2.62E-03	9.62E-05	1.26E-05	1.09E-04
27	1.35E+02	8.17E-06	1.55E-09	1.37E-08	1.53E-08	1.90E-04	1.68E-03	1.87E-03	6.06E-05	7.22E-04	7.82E-04	1.49E-03	3.93E-04	1.88E-03	5.92E-05	7.86E-06	6.71E-05
28	1.40E+02	7.60E-06	9.67E-10	1.01E-08	1.11E-08	1.27E-04	1.34E-03	1.46E-03	3.87E-05	6.11E-04	6.50E-04	1.06E-03	2.90E-04	1.35E-03	3.64E-05	4.88E-06	4.12E-05
29	1.45E+02	7.08E-06	6.03E-10	7.61E-09	8.21E-09	8.52E-05	1.07E-03	1.16E-03	2.47E-05	5.17E-04	5.42E-04	7.50E-04	2.14E-04	9.63E-04	2.23E-05	3.03E-06	2.53E-05
30	1.50E+02	6.62E-06	3.76E-10	5.78E-09	6.16E-09	5.69E-05	8.74E-04	9.31E-04	1.57E-05	4.38E-04	4.54E-04	5.31E-04	1.58E-04	6.89E-04	1.36E-05	1.88E-06	1.55E-05
31	1.55E+02	6.20E-06	2.35E-10	4.45E-09	4.68E-09	3.79E-05	7.18E-04	7.56E-04	1.00E-05	3.71E-04	3.81E-04	3.75E-04	1.17E-04	4.92E-04	8.32E-06	1.16E-06	9.48E-06
32	1.60E+02	5.82E-06	1.47E-10	3.46E-09	3.61E-09	2.53E-05	5.95E-04	6.20E-04	6.35E-06	3.15E-04	3.21E-04	2.65E-04	8.68E-05	3.52E-04	5.07E-06	7.20E-07	5.79E-06
33	1.65E+02	5.47E-06	9.19E-11	2.72E-09	2.81E-09	1.68E-05	4.97E-04	5.14E-04	4.02E-06	2.67E-04	2.71E-04	1.87E-04	6.45E-05	2.51E-04	3.08E-06	4.45E-07	3.53E-06
34	1.70E+02	5.15E-06	5.75E-11	2.16E-09	2.21E-09	1.12E-05	4.18E-04	4.29E-04	2.55E-06	2.26E-04	2.29E-04	1.32E-04	4.80E-05	1.79E-04	1.87E-06	2.75E-07	2.15E-06
35	1.75E+02	4.86E-06	3.60E-11	1.72E-09	1.76E-09	7.41E-06	3.54E-04	3.62E-04	1.61E-06	1.92E-04	1.94E-04	9.24E-05	3.57E-05	1.28E-04	1.14E-06	1.69E-07	1.31E-06
36	1.80E+02	4.60E-06	2.26E-11	1.39E-09	1.41E-09	4.91E-06	3.02E-04	3.07E-04	1.02E-06	1.63E-04	1.64E-04	6.49E-05	2.67E-05	9.16E-05	6.89E-07	1.04E-07	7.93E-07
37	1.85E+02	4.35E-06	1.41E-11	1.13E-09	1.14E-09	3.25E-06	2.59E-04	2.62E-04	6.41E-07	1.38E-04	1.39E-04	4.55E-05	1.99E-05	6.54E-05	4.17E-07	6.43E-08	4.81E-07
38	1.90E+02	4.12E-06	8.86E-12	9.18E-10	9.27E-10	2.15E-06	2.23E-04	2.25E-04	4.04E-07	1.18E-04	1.18E-04	3.19E-05	1.49E-05	4.68E-05	2.52E-07	3.95E-08	2.91E-07
39	1.95E+02	3.92E-06	5.56E-12	7.52E-10	7.58E-10	1.42E-06	1.92E-04	1.94E-04	2.54E-07	1.00E-04	1.00E-04	2.23E-05	1.12E-05	3.35E-05	1.52E-07	2.43E-08	1.76E-07
40	2.00E+02	3.72E-06	3.49E-12	6.19E-10	6.23E-10	9.37E-07	1.66E-04	1.67E-04	1.60E-07	8.51E-05	8.53E-05	1.56E-05	8.39E-06	2.40E-05	9.15E-08	1.49E-08	1.06E-07
41	2.05E+02	3.54E-06	2.19E-12	5.12E-10	5.14E-10	6.18E-07	1.44E-04	1.45E-04	1.00E-07	7.24E-05	7.25E-05	1.09E-05	6.30E-06	1.72E-05	5.51E-08	9.17E-09	6.43E-08
42	2.10E+02	3.38E-06	1.38E-12	4.24E-10	4.26E-10	4.07E-07	1.26E-04	1.26E-04	6.28E-08	6.17E-05	6.17E-05	7.57E-06	4.74E-06	1.23E-05	3.31E-08	5.63E-09	3.88E-08
43	2.15E+02	3.22E-06	8.64E-13	3.53E-10	3.54E-10	2.68E-07	1.10E-04	1.10E-04	3.93E-08	5.25E-05	5.26E-05	5.27E-06	3.57E-06	8.84E-06	1.99E-08	3.45E-09	2.34E-08
44	2.20E+02	3.08E-06	5.43E-13	2.94E-10	2.95E-10	1.76E-07	9.57E-05	9.58E-05	2.46E-08	4.47E-05	4.48E-05	3.66E-06	2.69E-06	6.36E-06	1.19E-08	2.11E-09	1.41E-08

Table 5.5.7 Typical activation reactions and cross section data, half-lives, gamma-ray energies of produced radionuclides [81Mug], [88Mcl], [02Nak].

Material	Reaction	Half life	γ-ray energy [MeV]	Cross section [barn]
Stainless steel	$^{58}Ni(n, p)^{58}Co$	70.8 d	0.811, 0.511	$1.1 \cdot 10^{-1}$ (Fission spectrum averaged)
	$^{54}Fe(n, p)^{54}Mn$	312 d	0.835	$8.2 \cdot 10^{-2}$ (Fission spectrum averaged)
	$^{59}Co(n, \gamma)^{60}Co$	5.27 y	1.17, 1.33	$3.7 \cdot 10^{1}$ (at 0.0253 eV)
Water	$^{16}O(n, p)^{16}N$	7.13 s	6.13	$2.0 \cdot 10^{-5}$ (Fission spectrum averaged)
Air	$^{40}Ar(n, \gamma)^{41}Ar$	1.83 h	1.29	$6.6 \cdot 10^{-1}$ (at 0.0253 eV)

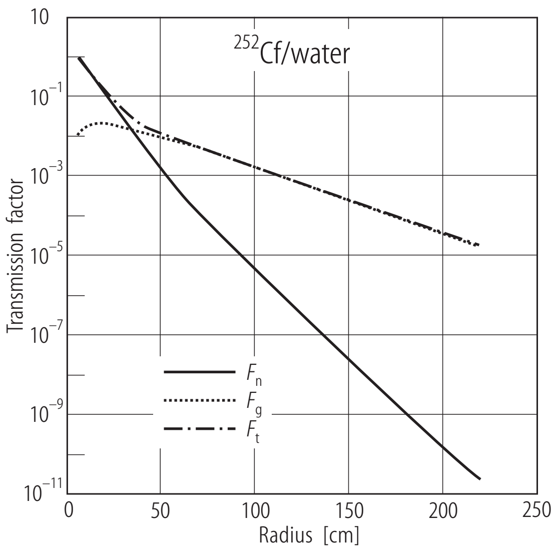

Fig. 5.5.2. Transmission factor of water for ^{252}Cf source.

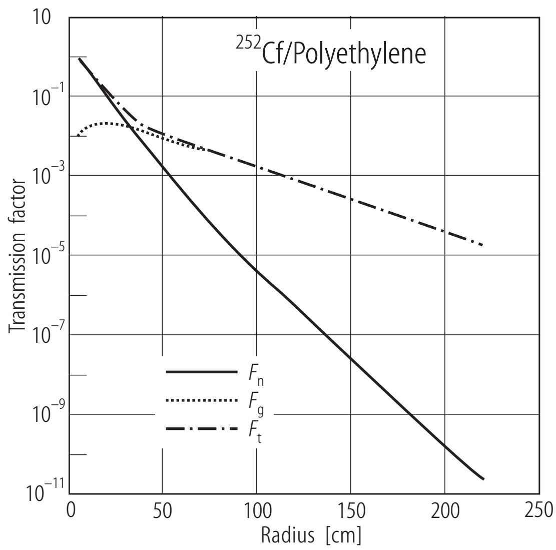

Fig. 5.5.3. Transmission factor of polyethylene for ^{252}Cf source.

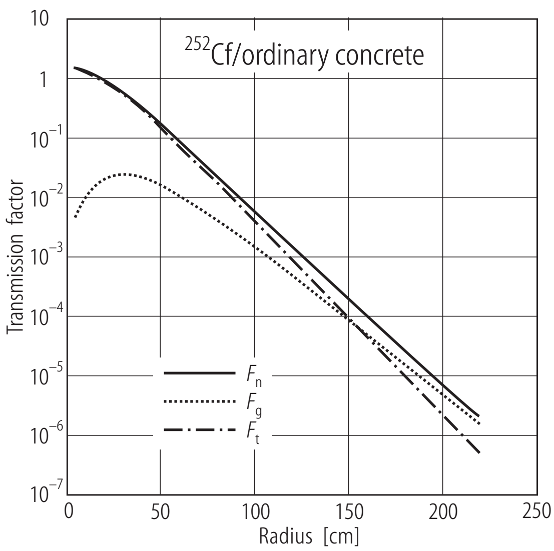

Fig. 5.5.4. Transmission factor of ordinary concrete for ^{252}Cf source.

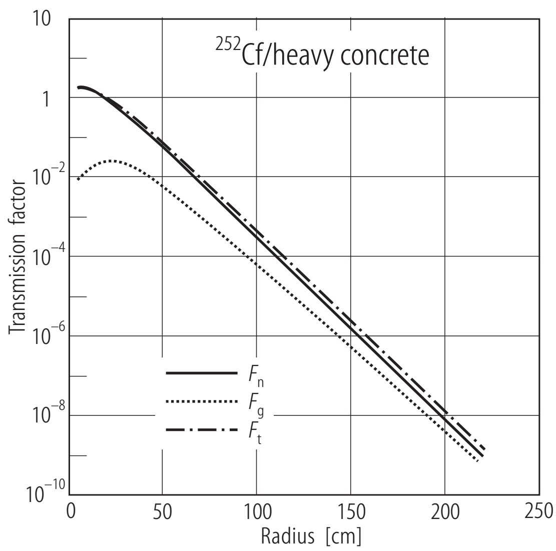

Fig. 5.5.5. Transmission factor of heavy concrete for ^{252}Cf source.

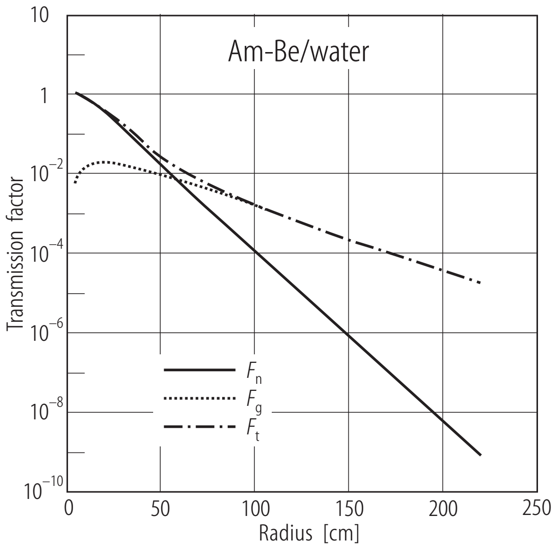

Fig. 5.5.6. Transmission factor of water for Am-Be source.

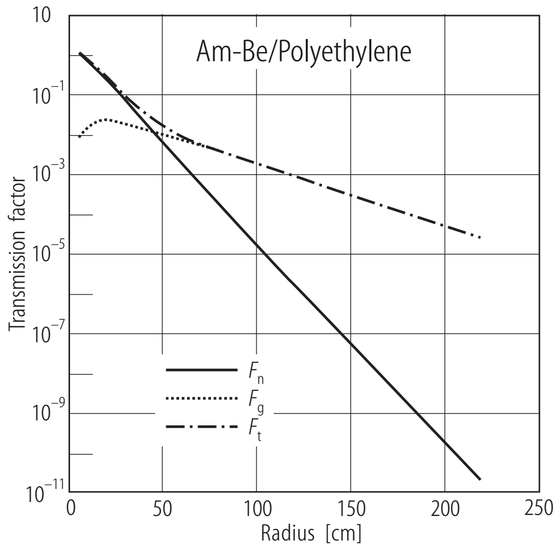

Fig. 5.5.7. Transmission factor of polyethylene for Am-Be source.

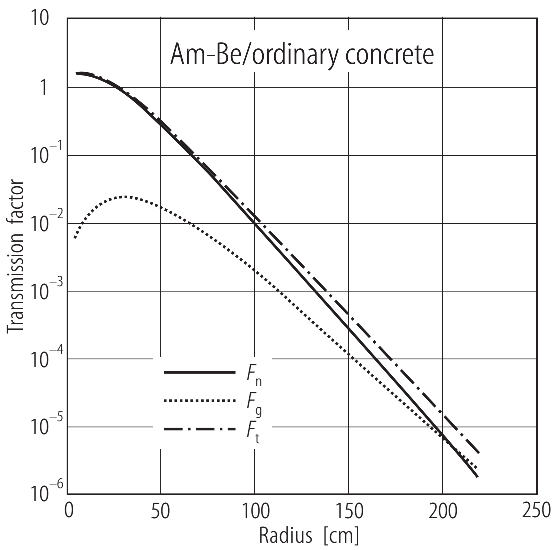

Fig. 5.5.8. Transmission factor of ordinary concrete for Am-Be source.

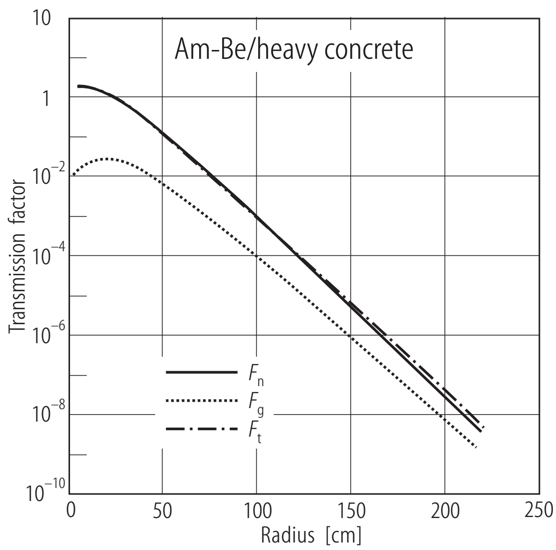

Fig. 5.5.9. Transmission factor of heavy concrete for Am-Be source.

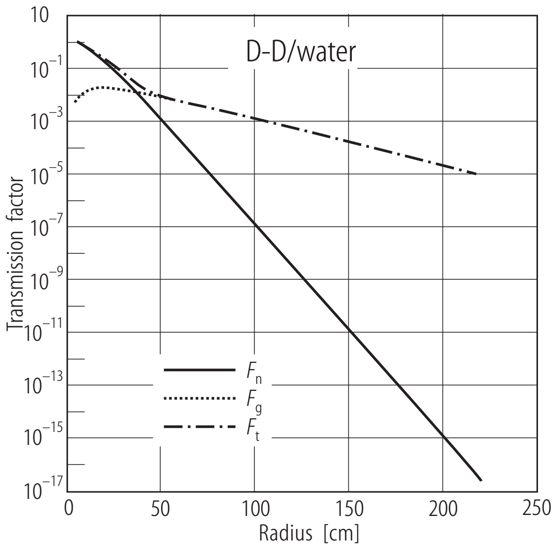

Fig. 5.5.10. Transmission factor of water for D-D source.

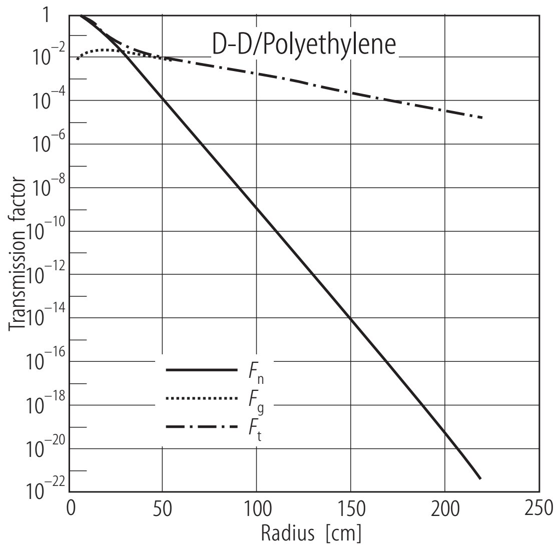

Fig. 5.5.11. Transmission factor of polyethylene for D-D source.

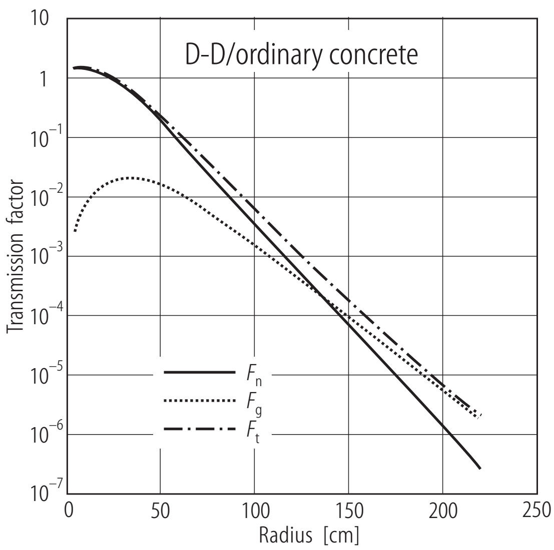

Fig. 5.5.12. Transmission factor of ordinary concrete for D-D source.

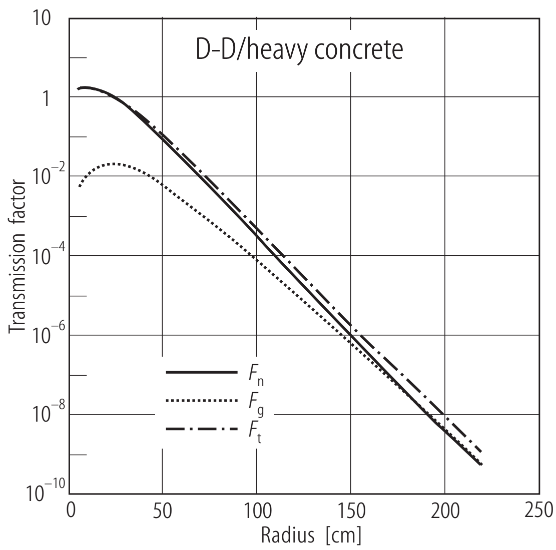

Fig. 5.5.13. Transmission factor of heavy concrete for D-D source.

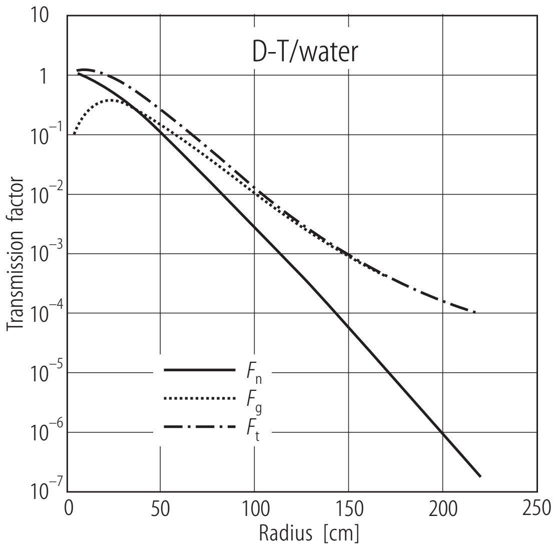

Fig. 5.5.14. Transmission factor of water for D-T source.

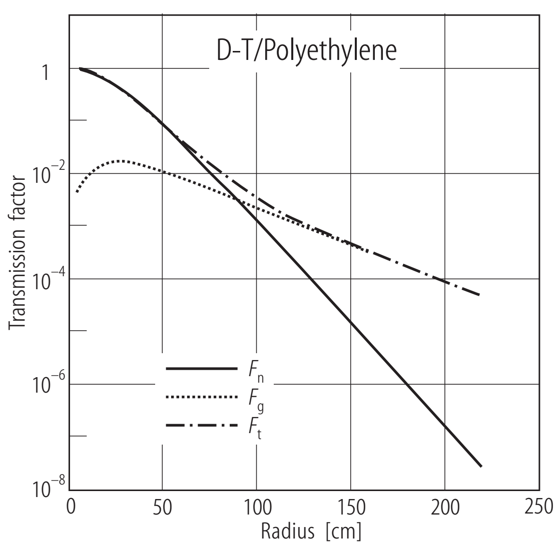

Fig. 5.5.15. Transmission factor of polyethylene for D-T source.

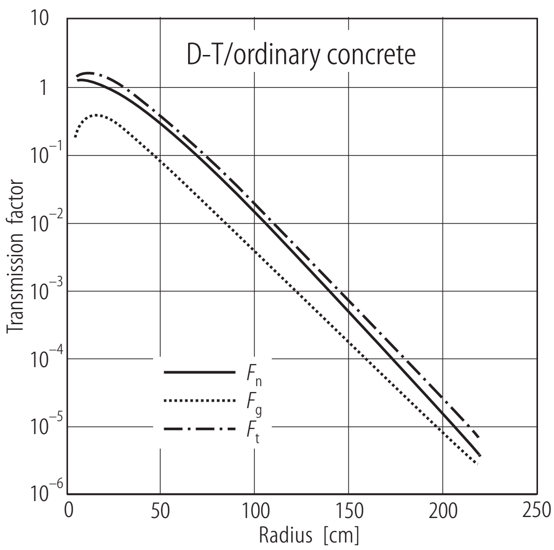

Fig. 5.5.16. Transmission factor of ordinary concrete for D-T source.

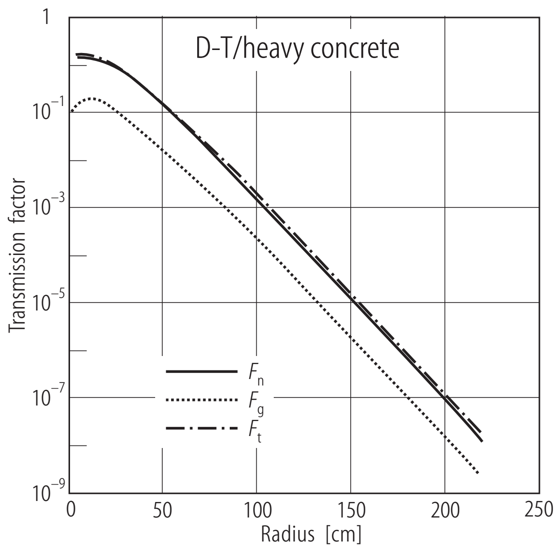

Fig. 5.5.17. Transmission factor of heavy concrete for D-T source.

5.6 Computer codes and online nuclear data services

Table 5.6.1 gives a collection of typical computer codes for transport calculations of gamma-rays, neutrons and charged particles with regard to shielding problems. The programs are collected and distributed by different Data Centres, as for example NEA or NNDC. The necessary data in specified formats for program testing and evaluation are provided by the centres as well. Some Online Nuclear Data Services for basic nuclear data and evaluated nuclear data are listed in Table 5.6.2.

Table 5.6.1 Computer codes for shielding and source calculations

Computer Codes	
ANISN	Engle Jr., W.W.: A Users Manual for ANISN, A One Dimensional Discrete Ordinates Transport Code with Anisotropic Scattering. K-1693, 1973
BERMUDA	Suzuki, T. et al.: Development of: A Radiation Transport Code System Part I. Neutron Transport Codes, JAERI 1327, JAERI, 1992 A Radiation Transport Code System Part II. Gamma Rays Transport Codes. JAERI-M 93-143, JAERI, 1993
DOORS	DOORS includes: TORT Three-dimensional neutron/photon transport DORT Two-dimensional neutron/photon transport ANISN One-dimensional neutron/photon transport Rhoades, W.A., D.B. Simpson: The TORT Three-Dimensional Discrete Ordinates Neutron/Photon Transport Code. ORNL/TM-13221, 1997
DOT-4.2	Rhoades, W.A., D.B. Simpson, R.L. Childs, W.W. Engle Jr.: The DOT-4 Two Dimensional, Discrete-Ordinates Transport Code with Space-Dependent Mesh and Quadrature. ORNL/TM-6529, 1978
DUCT-III	Tayama, R., H. Nakano, H. Handa, K. Hayashi, H. Hirayama, K. Shin, F. Masukawa, H. Nakashima, N. Sasamoto: DUCT-III, A Simple Design Code for Duct-Streaming Radiations. KEK Internal 2001-8, 2001
EGS4	Nelson, W.R., H. Hirayama, W.O. Rogers: The EGS4 Code System. SLAC-265, 1985 (Electron Photon Shower Simulation by Monte-Carlo)
ETRAN	Berger, M.J., S.M. Seltzer: Electron and Photon Transport Programs – 1. Introduction and Notes on Program DATAPAC-4. NBS 9836, 1968; 2. Notes on Program ETRAN-15. NBS 9837, 1968 (Monte Carlo Code System for Electron and Photon Transport Through Extended Media)
ISO-PC	Revision of ISOSHLD Engle, R.L., J. Greenborg, N.M. Hendrickson: ISOSHLD - A Computer Code for General Purpose Isotope Shielding Analysis. BNWL-236, 1966 (X-Ray, Gamma-Ray, Bremsstrahlung Dose-Rates)

Computer Codes	
MCNP-4C	Briesmeister, J. F.: MCNP - A General Monte Carlo N-Particle Transport Code. Version 4C, LA-13709-M, 2000 (Coupled Neutron, Electron, Gamma 3-D Time-Dependent Monte Carlo Transport Calculation Code)
MORSE-CGA	Emmett, M.B.: MORSE-CGA, A Monte Carlo Radiation Transport Code with Array Geometry Capability. ORNL-6174, 1985
NAC	Weinstein, Suzanne T.: NAC - Neutron Activation Code. NASA TM X-5260, 1968
ORIGEN2	Croff, A.G.: A User’s Manual for the ORIGEN2 Computer Code. ORNL/TM-7175, 1980
PALLAS	Takeuchi, K., S. Tanaka: PALLAS-1D(VII): A Code for Direct Integration of Transport Equation in One-Dimensional Plane and Spherical Geometries. JAERI-M 84-214, 1984
PENELOPE2001	Salvat, F., J.M. Fernandez-Varea, E. Acosta, J. Sempau: PENELOPE, A Code System for Monte Carlo Simulation of Electron and Photon Transport. Proceedings of a Workshop/Training Course, OECD/NEA 5-7 November, 2001, NEA/NSC/DOC, 2001
PUTZ	Ingersoll, D.T.: User's Manual for PUTZ - A Point-kernel Photon Shielding Code. ORNL/TM-9803, 1986
QAD-CGGP	Sakamoto, Y., S. Tanaka: QAD-CGGP2 and G33-GP2- Revised Versions of QAD-CGGP and G33-GP Codes with Conversion Factors from Exposure to Ambient and Maximum Dose Equivalents. JAERI-M 90-110, 1990
RAID	Moore, J.A., J.B. Eggen, F.O. Leopard: Monte Carlo Procedure for Analysis of Radiation in Ducts (RAID). AFWL-TR 67-9, 1967 (Gamma, Neutron Scattering in Cylindrical or Multibend Ducts)
SAM-CE	Steinberg, H.A. et al.: SAM-CE - A Monte Carlo Code for Three Dimensional Neutron, Gamma Ray and Electron Transport (Revision 5). MR-7052-5, 1977
SKYSHINE	Lampley, C.M., M.C. Andrew, M.B. Wells: The SKYSHINE-III Procedure: Calculation of the Effects of a Structure Design on Neutron, Primary Gamma-Ray and Secondary Gamma-Ray Dose Rates in Air. RRA-T8209A, 1988
SRNA-2KG	Ilic, R.D.: SRNA, Protons Transport Simulation by Monte Carlo Techniques User's Guide. Version 2KG, 2001

Table 5.6.2 Online Nuclear Data Services and Code Services

Address	Information
Atomic Mass Data Center (AMDC) http://csnwww.in2p3.fr/AMDC/	Atomic Mass Data, Q-Values
Gesellschaft für Schwerionenforschung (GSI) http://www.gsi.de/	Links to Data Banks, Literature-Research
International Atomic Energy Agency (IAEA) Nuclear Data Center http://www-nds.iaea.or.at	Nuclear Structure and Decay Data, Cross Section Data (Photons, Neutrons, charged Particles) (ENSDF, ENDF), Nuclear Science References
Nuclear Data Center **Japan Atomic Energy Research Institute** http://wwwndc.tokai.jaeri.go.jp/	Chart of Nuclides, Evaluated Nuclear Data Library, Tables of Nuclear Data
Korea Atomic Energy Research Institute (KAERI) Nuclear Data Evaluation Lab http://atom.kaeri.re.kr	Nuclear Structure and Decay Data, Photon Cross Section Data
Lawrence Berkeley National Laboratory (LBNL) Isotopes Project http://isotopes.lbl.gov	Nuclide-Table, Nuclide-Chart, Isotope Explorer, Internet Isotope Explorer
Los Alamos National Laboratory (LANL) T-2 Nuclear Information Service http://t2.lanl.gov/data/decayd.html	Nuclear Structure and Decay Data, Cross Section Data (Photons, charged Particles, thermal Neutrons) (ENSDF, ENDF) Nuclide-Chart, Nuclear Data Viewer
Lunds Universitet LUND Nuclear Data Service http://nucleardata.nuclear.lu.se/nucleardata	Nuclear Structure and Decay Data (ENSDF), Literature, References, Isotope Explorer, Internet Isotope Explorer
www-tech.mit.edu/Chemicool	Periodical System of Elements
Nuclear Energy Agency (NEA) http://www.nea.fr/html/dbdata/	Nuclear Data, Computer Codes, Experimental Nuclear Reaction Data Retrievals, Evaluated Nuclear Data Retrievals, Bibliographical Research
National Institute of Standards and Technology (NIST) http://physics.nist.gov/PhysRefData/contents.html	Physical Constants, X-ray and gamma ray data, X-Ray Attenuation and Absorption for Materials of Dosimetric Interest, XCOM: Photon Cross Sections Database, Stopping-Power and Range Tables for Electrons, Protons, and Helium Ions, Radionuclide Half-life Measurements Made at NIST, Atomic Weights and Isotopic Compositions

Address	Information
National Nuclear Data Center (NNDC) http://www.nndc.bnl.gov	Nuclear Structure and Decay Data, Neutron Cross Sections, Online-Service, Literature, References, Documentation of Data Banks and Computer Codes (ENSDF, ENDF,...), Nuclear Science References
PhysicsWeb http://physicsweb.org/TIPTOP/paw/	Information, Links
Radiation Safety Information Computational Center (RSICC) http://www-rsicc.ornl.gov/rsicc.html	Codes and Data, Newsletter, Workshops
Triangle Universities Nuclear Laboratory (TUNL) http://www.tunl.duke.edu/NuclData	Nuclear Data for light Nuclides (A = 3 to 20)
Department of Computer Science University of Columbia (UBC) http://www.cs.ubc.ca/elements/periodic-table	Periodical System of Elements
US Nuclear Data Program (USNDP) http://www.nndc.bnl.gov/usndp/	Links to Nuclear Data Banks
WebElements http://www.webelements.com/	Periodical System of Elements

5.7 References

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88DLC Radiation Shielding Information Center Data Package DLC-136/PHOTX, Photon Interaction Cross Section Library, contributed by National Institute of Standards and Technology, 1988.

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92ICR International Commission on Radiation Units and Measurements, ICRU Report 47, Measurements of dose equivalents from external photon and electron radiations, ICRU Publications, 1992.

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97ICR International Commission on Radiation Units and Measurements, ICRU Report 56, Dosimetry of external Beta-rays for radiation protection, ICRU Publications, 1997.

01JRI The Japan Radioisotope Association, Radioisotope Pocket Data Book (Revised Edition 10), 2001 (in Japanese).

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5.8 Appendix: Tables and Figures for 5

Table A5.3.1 Average penetration depth $R\rho$ [g/cm^2] of protons [93ICR].

Energy [MeV]	ICRP adipose tissue	Air	Water	Aluminum	Iron	Lead	Tungsten
	Average penetration depth $R\rho$ [g/cm^2]						
0.1	1.14E-04	1.63E-04	1.46E-04	2.23E-04	3.91E-04	7.09E-04	7.28E-04
0.15	1.66E-04	2.33E-04	2.09E-04	3.38E-04	5.53E-04	1.03E-03	1.07E-03
0.2	2.25E-04	3.12E-04	2.81E-04	4.65E-04	7.19E-04	1.37E-03	1.42E-03
0.3	3.70E-04	5.00E-04	4.46E-04	7.51E-04	1.09E-03	2.10E-03	2.21E-03
0.4	5.50E-04	7.29E-04	6.42E-04	1.08E-03	1.51E-03	2.96E-03	3.11E-03
0.5	7.61E-04	9.95E-04	8.68E-04	1.45E-03	1.99E-03	3.92E-03	4.14E-03
0.6	1.00E-03	1.30E-03	1.12E-03	1.86E-03	2.53E-03	5.01E-03	5.27E-03
0.7	1.27E-03	1.63E-03	1.41E-03	2.30E-03	3.12E-03	6.20E-03	6.48E-03
0.8	1.57E-03	2.00E-03	1.72E-03	2.79E-03	3.76E-03	7.48E-03	7.78E-03
0.9	1.89E-03	2.40E-03	2.07E-03	3.31E-03	4.44E-03	8.85E-03	9.15E-03
1	2.24E-03	2.83E-03	2.43E-03	3.87E-03	5.17E-03	1.03E-02	1.06E-02
1.5	4.36E-03	5.44E-03	4.67E-03	7.19E-03	9.44E-03	1.86E-02	1.88E-02
2	7.07E-03	8.74E-03	7.52E-03	1.13E-02	1.47E-02	2.84E-02	2.85E-02
3	1.41E-02	1.73E-02	1.49E-02	2.19E-02	2.78E-02	5.19E-02	5.17E-02
4	2.33E-02	2.83E-02	2.45E-02	3.54E-02	4.43E-02	8.04E-02	7.97E-02
5	3.44E-02	4.16E-02	3.61E-02	5.16E-02	6.39E-02	1.13E-01	1.12E-01
6	4.75E-02	5.71E-02	4.97E-02	7.03E-02	8.64E-02	1.51E-01	1.49E-01
7	6.23E-02	7.49E-02	6.52E-02	9.16E-02	1.12E-01	1.92E-01	1.89E-01
8	7.90E-02	9.47E-02	8.26E-02	1.15E-01	1.40E-01	2.37E-01	2.34E-01
9	9.75E-02	1.17E-01	1.02E-01	1.41E-01	1.71E-01	2.86E-01	2.82E-01
10	1.18E-01	1.40E-01	1.23E-01	1.70E-01	2.04E-01	3.39E-01	3.33E-01
15	2.44E-01	2.89E-01	2.53E-01	3.45E-01	4.09E-01	6.55E-01	6.43E-01
20	4.10E-01	4.85E-01	4.25E-01	5.73E-01	6.73E-01	1.05E+00	1.03E+00
25	6.14E-01	7.24E-01	6.36E-01	8.50E-01	9.93E-01	1.53E+00	1.50E+00
30	8.54E-01	1.01E+00	8.84E-01	1.18E+00	1.37E+00	2.07E+00	2.03E+00
35	1.13E+00	1.33E+00	1.17E+00	1.55E+00	1.79E+00	2.69E+00	2.64E+00
40	1.44E+00	1.69E+00	1.49E+00	1.96E+00	2.26E+00	3.37E+00	3.30E+00
45	1.78E+00	2.09E+00	1.84E+00	2.42E+00	2.78E+00	4.12E+00	4.03E+00
50	2.15E+00	2.52E+00	2.22E+00	2.92E+00	3.35E+00	4.93E+00	4.82E+00
55	2.56E+00	3.00E+00	2.64E+00	3.46E+00	3.96E+00	5.80E+00	5.67E+00
60	2.99E+00	3.50E+00	3.09E+00	4.04E+00	4.62E+00	6.74E+00	6.57E+00
65	3.46E+00	4.05E+00	3.57E+00	4.65E+00	5.31E+00	7.73E+00	7.52E+00
70	3.95E+00	4.62E+00	4.07E+00	5.31E+00	6.05E+00	8.77E+00	8.54E+00
75	4.47E+00	5.23E+00	4.61E+00	6.00E+00	6.83E+00	9.88E+00	9.60E+00
80	5.02E+00	5.87E+00	5.18E+00	6.73E+00	7.65E+00	1.10E+01	1.07E+01
85	5.60E+00	6.54E+00	5.77E+00	7.49E+00	8.51E+00	1.22E+01	1.19E+01
90	6.20E+00	7.24E+00	6.39E+00	8.28E+00	9.40E+00	1.35E+01	1.31E+01
95	6.83E+00	7.97E+00	7.04E+00	9.11E+00	1.03E+01	1.48E+01	1.43E+01
100	7.48E+00	8.73E+00	7.71E+00	9.98E+00	1.13E+01	1.62E+01	1.56E+01

Table A5.3.2 Average penetration depth R [cm] of protons, deuterons and alpha particles in air ($\rho = 1.205 \cdot 10^{-3}$ g/cm^3), and of alpha particles in water ($\rho = 1.0$ g/cm^3) [93ICR].

Energy [MeV]	Air			Water
	Proton	Deuteron	Alpha particle	Alpha particle
	Average penetration depth R [cm]			
0.1	1.4E-01	1.6E-01	1.1E-01	1.2E-04
0.2	2.6E-01	2.7E-01	1.8E-01	1.9E-04
0.3	4.2E-01	3.9E-01	2.3E-01	2.5E-04
0.4	6.0E-01	5.2E-01	2.8E-01	3.0E-04
0.5	8.3E-01	6.7E-01	3.2E-01	3.5E-04
0.6	1.1E+00	8.3E-01	3.6E-01	3.9E-04
0.7	1.4E+00	1.0E+00	4.0E-01	4.4E-04
0.8	1.7E+00	1.2E+00	4.4E-01	4.8E-04
0.9	2.0E+00	1.4E+00	4.9E-01	5.3E-04
1.0	2.4E+00	1.7E+00	5.3E-01	5.7E-04
1.5	4.5E+00	3.0E+00	7.6E-01	8.1E-04
2.0	7.3E+00	4.7E+00	1.0E+00	1.1E-03
3.0	1.4E+01	9.0E+00	1.7E+00	1.8E-03
4.0	2.3E+01	1.5E+01	2.6E+00	2.7E-03
5.0	3.5E+01	2.1E+01	3.6E+00	3.7E-03
6.0	4.7E+01	2.9E+01	4.8E+00	4.9E-03
7.0	6.2E+01	3.7E+01	6.1E+00	6.3E-03
8.0	7.9E+01	4.7E+01	7.5E+00	7.8E-03
9.0	9.7E+01	5.8E+01	9.1E+00	9.5E-03
10.0	1.2E+02	6.9E+01	1.1E+01	1.1E-02
15.0	2.4E+02	1.4E+02	2.1E+01	2.2E-02
20.0	4.0E+02	2.3E+02	3.5E+01	3.7E-02
30.0	8.3E+02	4.8E+02	7.1E+01	7.4E-02
40.0	1.4E+03	8.0E+02	1.2E+02	1.2E-01
50.0	2.1E+03	1.2E+03	1.7E+02	1.8E-01
60.0	2.9E+03	1.7E+03	2.4E+02	2.6E-01
70.0	3.8E+03	2.2E+03	3.2E+02	3.4E-01
80.0	4.9E+03	2.8E+03	4.1E+02	4.3E-01
90.0	6.0E+03	3.5E+03	5.0E+02	5.3E-01
100.0	7.2E+03	4.2E+03	6.1E+02	6.4E-01

Table A5.3.3 Electron range R_{max} [cm] evaluated by Eq. (5.3.3) [97ICR].

Material density	Air	Wood	Water	Acrylic glass	Glass	concrete	Aluminum	Iron	Lead
g/cm^3	0.001205	0.7	1.0	1.18	2.23	2.3	2.7	7.874	11.35
Energy [MeV]	Electron range R_{max} [cm]								
0.1	9.72E+00	1.67E-02	1.17E-02	9.92E-03	5.25E-03	5.09E-03	4.34E-03	1.49E-03	1.03E-03
0.15	2.07E+01	3.56E-02	2.49E-02	2.11E-02	1.12E-02	1.08E-02	9.23E-03	3.16E-03	2.20E-03
0.2	3.44E+01	5.93E-02	4.15E-02	3.52E-02	1.86E-02	1.80E-02	1.54E-02	5.27E-03	3.66E-03
0.4	1.04E+02	1.79E-01	1.26E-01	1.06E-01	5.63E-02	5.46E-02	4.65E-02	1.59E-02	1.11E-02
0.6	1.84E+02	3.16E-01	2.21E-01	1.88E-01	9.92E-02	9.62E-02	8.20E-02	2.81E-02	1.95E-02
0.8	2.66E+02	4.58E-01	3.21E-01	2.72E-01	1.44E-01	1.40E-01	1.19E-01	4.08E-02	2.83E-02
1	3.50E+02	6.03E-01	4.22E-01	3.58E-01	1.89E-01	1.84E-01	1.56E-01	5.36E-02	3.72E-02
1.5	5.63E+02	9.70E-01	6.79E-01	5.75E-01	3.04E-01	2.95E-01	2.51E-01	8.62E-02	5.98E-02
2	7.78E+02	1.34E+00	9.37E-01	7.94E-01	4.20E-01	4.08E-01	3.47E-01	1.19E-01	8.26E-02
4	1.64E+03	2.82E+00	1.98E+00	1.67E+00	8.86E-01	8.59E-01	7.32E-01	2.51E-01	1.74E-01
6	2.50E+03	4.31E+00	3.02E+00	2.56E+00	1.35E+00	1.31E+00	1.12E+00	3.83E-01	2.66E-01
8	3.37E+03	5.80E+00	4.06E+00	3.44E+00	1.82E+00	1.76E+00	1.50E+00	5.15E-01	3.58E-01
10	4.23E+03	7.28E+00	5.10E+00	4.32E+00	2.29E+00	2.22E+00	1.89E+00	6.48E-01	4.49E-01
15	6.39E+03	1.10E+01	7.70E+00	6.53E+00	3.45E+00	3.35E+00	2.85E+00	9.78E-01	6.79E-01
20	8.55E+03	1.47E+01	1.03E+01	8.73E+00	4.62E+00	4.48E+00	3.82E+00	1.31E+00	9.08E-01
40	1.72E+04	2.96E+01	2.07E+01	1.76E+01	9.29E+00	9.01E+00	7.68E+00	2.63E+00	1.83E+00
60	2.58E+04	4.45E+01	3.11E+01	2.64E+01	1.40E+01	1.35E+01	1.15E+01	3.95E+00	2.74E+00
80	3.45E+04	5.94E+01	4.16E+01	3.52E+01	1.86E+01	1.81E+01	1.54E+01	5.28E+00	3.66E+00
100	4.31E+04	7.42E+01	5.20E+01	4.40E+01	2.33E+01	2.26E+01	1.92E+01	6.60E+00	4.58E+00

Table A5.3.4 Electron range $R\rho$ [g/cm^2] (csda-approximation) [84ICR2].

Energy [MeV]	Air	Water	Beryllium	Aluminum	Iron	Lead
	Electron range $R\rho$ [g/cm^2]					
0.1	1.62E-02	1.43E-02	1.75E-02	1.87E-02	2.14E-02	3.11E-02
0.15	3.19E-02	2.82E-02	3.45E-02	3.66E-02	4.15E-02	5.91E-02
0.2	5.08E-02	4.49E-02	5.51E-02	5.80E-02	6.56E-02	9.18E-02
0.4	1.46E-01	1.29E-01	1.59E-01	1.65E-01	1.85E-01	2.49E-01
0.6	2.56E-01	2.27E-01	2.81E-01	2.89E-01	3.23E-01	4.25E-01
0.8	3.72E-01	3.30E-01	4.12E-01	4.21E-01	4.68E-01	6.05E-01
1.0	4.91E-01	4.37E-01	5.46E-01	5.55E-01	6.16E-01	7.84E-01
1.5	7.90E-01	7.08E-01	8.87E-01	8.91E-01	9.85E-01	1.22E+00
2.0	1.09E+00	9.79E-01	1.23E+00	1.22E+00	1.35E+00	1.63E+00
4.0	2.21E+00	2.04E+00	2.56E+00	2.49E+00	2.70E+00	3.06E+00
6.0	3.26E+00	3.05E+00	3.85E+00	3.68E+00	3.92E+00	4.24E+00
8.0	4.25E+00	4.03E+00	5.09E+00	4.80E+00	5.04E+00	5.25E+00
10.0	5.19E+00	4.98E+00	6.30E+00	5.86E+00	6.08E+00	6.13E+00
15.0	7.41E+00	7.22E+00	9.22E+00	8.33E+00	8.37E+00	7.95E+00
20.0	9.45E+00	9.32E+00	1.20E+01	1.06E+01	1.04E+01	9.40E+00
40.0	1.65E+01	1.67E+01	2.20E+01	1.79E+01	1.63E+01	1.33E+01
60.0	2.23E+01	2.28E+01	3.07E+01	2.36E+01	2.05E+01	1.57E+01
80.0	2.73E+01	2.80E+01	3.84E+01	2.82E+01	2.38E+01	1.75E+01
100.0	3.17E+01	3.25E+01	4.52E+01	3.21E+01	2.64E+01	1.89E+01

Table A5.4.1 Elemental composition of ordinary concrete, NBS concrete (ρ = 2.35 g/cm^3) and type 02-a concrete from ANL-5800 (ρ = 2.10 g/cm^3)

material	NBS concrete		type 02-a concrete from ANL-5800	
density	2.35 g/cm^3		2.10 g/cm^3	
element	atomic density [10^{24} atoms cm^{-3}]	weight fraction	atomic density [10^{24} atoms cm^{-3}]	weight fraction.
H	7.863E-3	0.0056	1.299E-2	0.0100
C	-	-	1.082E-4	0.0010
O	4.408E-2	0.4983	4.305E-2	0.5298
Na	1.053E-3	0.0171	-	0.0160
Mg	1.398E-4	0.0024	1.161E-4	0.0022
Al	2.392E-3	0.0456	1.632E-3	0.0339
Si	1.591E-2	0.3158	1.558E-2	0.3367
S	5.296E-5	0.0012	-	-
K	6.950E-4	0.0192	-	0.0130
Ca	2.917E-3	0.0826	1.409E-3	0.0435
Fe	3.092E-4	0.0122	3.235E-4	0.0139

Table A5.4.2 Photon mass attenuation coefficients for iron, lead, concrete (ρ = 2.10 g/cm^3) and water

Photon energy [MeV]	Photon mass attenuation coefficients [cm^2/g]				
	iron	lead		concrete	water
0.015	56.41		108.4	6.809	1.579
0.0152			104.6		
0.0152		82L2	145.4		
0.01553			138.3		
0.015861			131.3		
0.015861		82L1	151.8		
0.02	25.22		84.11	2.973	0.7505
0.03	7.930		29.00	0.9830	0.3455
0.04	3.478		13.49	0.5026	0.2503
0.05	1.855		7.426	0.3324	0.2149
0.06	1.131		4.562	0.2566	0.1973
0.08	0.5510		2.136	0.1934	0.1787
0.088005			1.668		
0.088005		82K	7.442		
0.1	0.3426		5.355	0.1673	0.1675
0.15	0.1829		1.920	0.1394	0.1490
0.2	0.1383		0.9432	0.1252	0.1362
0.3	0.1064		0.3772	0.1077	0.1182
0.4	0.09200		0.2172	0.09625	0.1059
0.5	0.08283		0.1515	0.08779	0.09667
0.6	0.07611		0.1178	0.08118	0.08943
0.8	0.06644		0.08472	0.07127	0.07856
1	0.05956		0.06843	0.06406	0.07062
1.022	0.05892		0.06713	0.06338	0.06987
1.25	0.05323		0.05705	0.05729	0.06315
1.5	0.04862		0.05102	0.05218	0.05747
2	0.04249		0.04536	0.04497	0.04932
2.044	0.04209		0.04506	0.04446	0.04873
3	0.03611		0.04199	0.03658	0.03960
4	0.03303		0.04176	0.03186	0.03395
5	0.03139		0.04256	0.02885	0.03024
6	0.03050		0.04379	0.02680	0.02763
7	0.03005		0.04518	0.02534	0.02571
8	0.02985		0.04666	0.02426	0.02423
9	0.02982		0.04815	0.02344	0.02307
10	0.02990		0.04965	0.02280	0.02213

Table A5.4.3 Conversion coefficients of the exposure dose rate, air absorbed dose rate and ambient dose equivalent rate for flux density together with the air mass energy coefficient

E [MeV]	μ_{en} / ρ [cm^2/g]	$\dot{X} / \phi$ [μR h^{-1} cm^{2}s]	$\dot{K}_a / \phi$ [nGy h^{-1} cm^{2}s]	$\dot{H}^*(10) / \phi_\gamma$ [nSv h^{-1} cm^{2}s]
0.01	4.742	3.05	27.4	0.220
0.015	1.334	1.29	11.6	2.99
0.02	0.5389	0.691	6.23	3.78
0.03	0.1537	0.296	2.66	2.92
0.04	0.06833	0.176	1.58	2.30
0.05	0.04098	0.133	1.18	1.98
0.06	0.03041	0.119	1.05	1.84
0.08	0.02407	0.126	1.11	1.91
0.1	0.02325	0.153	1.34	2.20
0.15	0.02496	0.248	2.16	3.20
0.2	0.02672	0.353	3.08	4.32
0.3	0.02872	0.565	4.97	6.48
0.4	0.02949	0.778	6.80	8.57
0.5	0.02966	0.976	8.57	10.5
0.6	0.02953	1.17	10.2	12.4
0.8	0.02882	1.52	13.3	15.8
1	0.02789	1.83	16.1	18.7
1.5	0.02547	2.52	22.0	24.8
2	0.02345	3.09	27.0	31.0
3	0.02057	4.06	35.6	40.0
4	0.01870	-	43.2	48.2
5	0.01740	-	50.0	55.8
6	0.01647	-	56.9	63.4
8	0.01525	-	70.2	77.8
10	0.01450	-	83.5	92.2

Table A5.4.4 Ambient dose equivalent transmission factor of ^{18}F for iron, lead, concrete and water

t [cm]	iron T(t)	t [cm]	lead T(t)	t [cm]	concrete T(t)	t [cm]	water T(t)
0	1.00E+0	0	1.00E+0	0	1.00E+0	0	1.00E+0
0.5	9.47E-1	0.2	7.86E-1	10	6.46E-1	20	7.57E-1
1	8.62E-1	0.3	6.90E-1	15	4.01E-1	30	4.92E-1
2	6.56E-1	0.4	6.03E-1	20	2.30E-1	40	2.90E-1
3	4.62E-1	0.5	5.26E-1	25	1.25E-1	50	1.60E-1
5	2.02E-1	0.7	3.97E-1	30	6.54E-2	60	8.43E-2
7	7.96E-2	1	2.57E-1	35	3.33E-2	70	4.28E-2
10	1.77E-2	1.5	1.22E-1	40	1.65E-2	80	2.10E-2
12	6.18E-3	2	5.68E-2	45	8.06E-3	90	1.01E-2
15	1.22E-3	3	1.19E-2	50	3.87E-3	100	4.76E-3
17	4.03E-4	4	2.45E-3	55	1.84E-3	110	2.20E-3
20	7.45E-5	5	4.95E-4	60	8.60E-4	120	1.00E-3
22	2.38E-5	6	9.92E-5	65	3.99E-4	130	4.50E-4
25	4.20E-6	7	1.98E-5	70	1.83E-4	140	2.00E-4
27	1.31E-6	8	3.92E-6	80	3.79E-5	160	3.83E-5
30	2.23E-7	9	7.76E-7	90	7.64E-6	180	7.12E-6
32	6.81E-8	10	1.53E-7	100	1.51E-6	200	1.29E-6
35	1.14E-8	15	4.34E-11	110	2.92E-7	220	2.30E-7
37	3.42E-9	20	1.16E-14	120	5.59E-8	240	4.06E-8
39	1.03E-9	25	3.08E-18	130	1.06E-8	260	7.09E-9

Table A5.4.5 Ambient dose equivalent transmission factor of ^{24}Na for iron, lead, concrete and water

t [cm]	iron T(t)	t [cm]	lead T(t)	t [cm]	concrete T(t)	t [cm]	water T(t)
0	1.00E+0	0	1.00E+0	0	1.00E+0	0	1.00E+0
0.5	9.42E-1	0.2	9.37E-1	10	6.97E-1	20	7.12E-1
5	4.28E-1	0.3	9.06E-1	15	5.42E-1	30	5.53E-1
10	1.37E-1	0.5	8.46E-1	20	4.10E-1	40	4.15E-1
15	3.96E-2	0.7	7.88E-1	25	3.04E-1	50	3.05E-1
20	1.10E-2	1	7.08E-1	30	2.22E-1	60	2.20E-1
25	3.02E-3	1.5	5.88E-1	35	1.61E-1	70	1.57E-1
30	8.15E-4	2	4.86E-1	40	1.15E-1	80	1.12E-1
32	4.82E-4	3	3.28E-1	50	5.84E-2	100	5.50E-2
35	2.18E-4	4	2.19E-1	60	2.92E-2	120	2.67E-2
40	5.77E-5	5	1.45E-1	70	1.44E-2	140	1.29E-2
42	3.38E-5	6	9.51E-2	80	7.12E-3	160	6.18E-3
45	1.51E-5	8	4.07E-2	90	3.49E-3	180	2.95E-3
47	8.84E-6	10	1.73E-2	100	1.70E-3	200	1.40E-3
50	3.94E-6	15	1.99E-3	120	4.03E-4	240	3.13E-4
52	2.29E-6	20	2.26E-4	140	9.39E-5	280	6.88E-5
55	1.02E-6	25	2.54E-5	160	2.16E-5	320	1.49E-5
57	5.91E-7	30	2.81E-6	180	4.93E-6	360	3.21E-6
60	2.61E-7	35	3.06E-7	200	1.11E-6	400	6.81E-7
64	8.74E-8	40	3.29E-8	220	2.49E-7	440	1.44E-7

Table A5.4.6 Ambient dose equivalent transmission factor of ^{51}Cr for iron, lead, concrete and water

t [cm]	iron T(t)	t [cm]	lead T(t)	t [cm]	concrete T(t)	t [cm]	water T(t)
0	1.00E+0	0	1.00E+0	0	1.00E+0	0	1.00E+0
0.5	9.40E-1	0.1	7.45E-1	5	9.53E-1	10	1.12E+0
1	8.19E-1	0.5	1.91E-1	10	6.19E-1	20	8.39E-1
2.5	4.28E-1	0.8	6.55E-2	20	1.68E-1	40	2.69E-1
5	1.03E-1	1	3.18E-2	25	7.87E-2	50	1.32E-1
10	3.85E-3	1.3	1.07E-2	30	3.52E-2	60	6.10E-2
12.5	6.72E-4	1.5	5.13E-3	35	1.53E-2	70	2.69E-2
15	1.13E-4	1.8	1.71E-3	40	6.44E-3	80	1.15E-2
17.5	1.85E-5	2	8.19E-4	45	2.66E-3	90	4.73E-3
20	2.95E-6	2.5	1.30E-4	50	1.08E-3	100	1.91E-3
22.5	4.62E-7	3	2.06E-5	55	4.33E-4	110	7.51E-4
25	7.11E-8	3.5	3.26E-6	60	1.71E-4	120	2.91E-4
27.5	1.08E-8	4	5.14E-7	65	6.69E-5	130	1.11E-4
		4.5	8.09E-8	70	2.59E-5	140	4.16E-5
				75	9.95E-6	150	1.55E-5
				80	3.79E-6	160	5.69E-6
				90	5.38E-7	180	7.53E-7

Table A5.4.7 Ambient dose equivalent transmission factor of ^{54}Mn for iron, lead, concrete and water

t [cm]	iron T(t)	t [cm]	lead T(t)	t [cm]	concrete T(t)	t [cm]	water T(t)
0	1.00E+0	0	1.00E+0	0	1.00E+0	0	1.00E+0
1	8.65E-1	0.3	8.40E-1	5	8.67E-1	10	9.11E-1
5	2.93E-1	0.5	7.39E-1	10	6.52E-1	20	7.09E-1
10	4.62E-2	0.8	6.04E-1	20	2.88E-1	40	3.20E-1
12.5	1.68E-2	1	5.25E-1	30	1.07E-1	60	1.17E-1
15	5.87E-3	2.5	1.70E-1	40	3.60E-2	80	3.83E-2
17.5	2.00E-3	5	2.21E-2	50	1.14E-2	100	1.16E-2
20	6.65E-4	7.5	2.64E-3	60	3.43E-3	120	3.33E-3
22.5	2.18E-4	10	3.03E-4	70	1.00E-3	140	9.15E-4
25	7.02E-5	12.5	3.40E-5	80	2.85E-4	160	2.44E-4
27.5	2.24E-5	15	3.74E-6	90	7.92E-5	180	6.32E-5
30	7.05E-6	17.5	4.08E-7	100	2.16E-5	200	1.61E-5
32.5	2.20E-6	20	4.40E-8	120	1.55E-6	240	9.92E-7
35	6.82E-7			140	1.06E-7	280	5.87E-8
40	6.41E-8						

Table A5.4.8 Ambient dose equivalent transmission factor of ^{59}Fe for iron, lead, concrete and water

t [cm]	iron T(t)	t [cm]	lead T(t)	t [cm]	concrete T(t)	t [cm]	water T(t)
0	1.00E+0	0	1.00E+0	0	1.00E+0	0	1.00E+0
0.5	9.39E-1	0.5	8.04E-1	5	8.59E-1	10	8.92E-1
1	8.71E-1	1	6.37E-1	10	6.65E-1	20	7.04E-1
5	3.50E-1	2.5	2.95E-1	30	1.45E-1	60	1.49E-1
10	7.66E-2	5	7.26E-2	40	5.82E-2	80	5.78E-2
15	1.40E-2	7.5	1.67E-2	50	2.23E-2	100	2.11E-2
20	2.33E-3	10	3.74E-3	60	8.21E-3	120	7.42E-3
25	3.68E-4	12.5	8.24E-4	70	2.95E-3	140	2.52E-3
30	5.58E-5	15	1.80E-4	80	1.04E-3	160	8.39E-4
35	8.26E-6	17.5	3.90E-5	100	1.23E-4	200	8.81E-5
40	1.20E-6	20	8.45E-6	120	1.39E-5	240	8.82E-6
45	1.71E-7	22.5	1.83E-6	140	1.53E-6	280	8.56E-7
50	2.42E-8	25	3.94E-7	160	1.65E-7	320	8.15E-8
		27.5	8.50E-8				

Table A5.4.9 Ambient dose equivalent transmission factor of ^{56}Co for iron, lead, concrete and water

t [cm]	iron T(t)	t [cm]	lead T(t)	t [cm]	concrete T(t)	t [cm]	water T(t)
0	1.00E+0	0	1.00E+0	0	1.00E+0	0	1.00E+0
1	8.74E-1	0.5	7.89E-1	10	6.75E-1	20	7.12E-1
5	3.61E-1	1	6.17E-1	20	3.50E-1	40	3.68E-1
10	9.21E-2	5	8.74E-2	30	1.65E-1	60	1.69E-1
15	2.26E-2	7.5	2.72E-2	40	7.55E-2	80	7.47E-2
20	5.68E-3	10	8.68E-3	50	3.46E-2	100	3.30E-2
25	1.46E-3	12.5	2.82E-3	70	7.50E-3	140	6.72E-3
30	3.85E-4	15	9.26E-4	80	3.56E-3	160	3.11E-3
35	1.02E-4	17.5	3.05E-4	100	8.29E-4	200	6.90E-4
40	2.73E-5	20	1.01E-4	120	1.98E-4	240	1.58E-4
45	7.32E-6	25	1.10E-5	140	4.77E-5	280	3.66E-5
50	1.96E-6	30	1.20E-6	160	1.16E-5	320	8.52E-6
55	5.25E-7	35	1.30E-7	180	2.82E-6	360	1.99E-6
60	1.41E-7	40	1.39E-8	200	6.88E-7	400	4.65E-7
65	3.75E-8			220	1.67E-7	440	1.09E-7

Table A5.4.10 Ambient dose equivalent transmission factor of ^{57}Co for iron, lead, concrete and water

t [cm]	iron T(t)	t [cm]	lead T(t)	t [cm]	concrete T(t)	t [cm]	water T(t)
0	1.00E+0	0	1.00E+0	0	1.00E+0	0	1.00E+0
0.2	8.57E-1	0.1	1.28E-1	5	8.79E-1	10	1.60E+0
0.5	6.02E-1	0.2	1.95E-2	10	3.61E-1	20	1.01E+0
1	2.98E-1	0.3	8.74E-3	15	1.21E-1	30	4.73E-1
3	1.58E-2	0.4	6.91E-3	20	3.75E-2	40	1.88E-1
4	5.39E-3	0.5	6.13E-3	25	1.13E-2	50	6.74E-2
5	2.71E-3	0.7	5.07E-3	30	3.47E-3	60	2.27E-2
7	1.08E-3	1	3.84E-3	35	1.15E-3	70	7.28E-3
10	2.98E-4	1.5	2.38E-3	40	4.23E-4	80	2.29E-3
12	1.22E-4	2	1.45E-3	45	1.75E-4	90	7.23E-4
14	4.86E-5	3	5.27E-4	50	7.96E-5	100	2.36E-4
15	3.05E-5	4	1.87E-4	55	3.83E-5	110	8.15E-5
16	1.90E-5	5	6.53E-5	60	1.90E-5	120	3.05E-5
18	7.34E-6	6	2.26E-5	65	9.50E-6	130	1.24E-5
20	2.79E-6	7	7.75E-6	70	4.77E-6	140	5.36E-6
22	1.05E-6	8	2.65E-6	75	2.39E-6	150	2.42E-6
23	6.43E-7	10	3.06E-7	80	1.19E-6	160	1.12E-6
25	2.39E-7	11	1.03E-7	85	5.92E-7	170	5.25E-7
26	1.45E-7			90	2.93E-7	180	2.47E-7
27	8.81E-8						

Table A5.4.11 Ambient dose equivalent transmission factor of ^{60}Co for iron, lead, concrete and water

t [cm]	iron T(t)	t [cm]	lead T(t)	t [cm]	concrete T(t)	t [cm]	water T(t)
0	1.00E+0	0	1.00E+0	0	1.00E+0	0	1.00E+0
1	8.74E-1	0.1	9.63E-1	5	8.56E-1	10	8.84E-1
5	3.62E-1	0.2	9.25E-1	10	6.68E-1	20	7.01E-1
10	8.28E-2	0.3	8.88E-1	15	4.88E-1	30	5.14E-1
12	4.34E-2	0.4	8.52E-1	20	3.41E-1	40	3.57E-1
15	1.59E-2	0.5	8.17E-1	25	2.31E-1	50	2.39E-1
18	5.62E-3	0.7	7.49E-1	30	1.52E-1	60	1.56E-1
20	2.77E-3	1	6.54E-1	40	6.30E-2	80	6.20E-2
22	1.36E-3	2	4.05E-1	50	2.47E-2	100	2.33E-2
25	4.58E-4	3	2.43E-1	60	9.37E-3	120	8.41E-3
27	2.20E-4	4	1.43E-1	70	3.46E-3	140	2.95E-3
30	7.26E-5	5	8.29E-2	80	1.25E-3	160	1.01E-3
32	3.45E-5	6	4.75E-2	90	4.43E-4	180	3.38E-4
35	1.12E-5	8	1.53E-2	100	1.55E-4	200	1.12E-4
37	5.27E-6	9	8.61E-3	110	5.38E-5	220	3.64E-5
40	1.69E-6	10	4.82E-3	120	1.85E-5	240	1.18E-5
42	7.90E-7	15	2.56E-4	130	6.29E-6	260	3.77E-6
45	2.51E-7	20	1.31E-5	140	2.13E-6	280	1.20E-6
47	1.17E-7	25	6.57E-7	150	7.15E-7	300	3.80E-7
48	7.95E-8	30	3.26E-8	155	4.14E-7	310	2.13E-7

Table A5.4.12 Ambient dose equivalent transmission factor of ^{64}Cu for iron, lead, concrete and water

t [cm]	iron T(t)	t [cm]	lead T(t)	t [cm]	concrete T(t)	t [cm]	water T(t)
0	1.00E+0	0	1.00E+0	0	1.00E+0	0	1.00E+0
0.5	9.47E-1	0.2	7.90E-1	10	6.46E-1	20	7.55E-1
1	8.62E-1	0.3	6.95E-1	15	4.04E-1	30	4.93E-1
2	6.58E-1	0.4	6.11E-1	20	2.33E-1	40	2.93E-1
3	4.66E-1	0.5	5.35E-1	25	1.28E-1	50	1.63E-1
5	2.07E-1	0.7	4.08E-1	30	6.82E-2	60	8.66E-2
7	8.36E-2	1	2.69E-1	35	3.54E-2	70	4.46E-2
10	1.98E-2	1.5	1.34E-1	40	1.80E-2	80	2.24E-2
12	7.40E-3	2	6.74E-2	45	9.10E-3	90	1.10E-2
15	1.71E-3	3	1.92E-2	50	4.57E-3	100	5.37E-3
17	6.63E-4	4	6.98E-3	55	2.29E-3	110	2.60E-3
20	1.70E-4	5	3.23E-3	60	1.15E-3	120	1.25E-3
22	7.20E-5	6	1.72E-3	65	5.82E-4	130	6.07E-4
25	2.11E-5	7	9.72E-4	70	2.98E-4	140	2.96E-4
27	9.64E-6	8	5.58E-4	80	8.15E-5	160	7.32E-5
30	3.06E-6	9	3.21E-4	90	2.38E-5	180	1.94E-5
32	1.45E-6	10	1.84E-4	100	7.37E-6	200	5.51E-6
35	4.72E-7	15	1.10E-5	110	2.39E-6	220	1.66E-6
37	2.24E-7	20	6.21E-7	120	7.98E-7	240	5.17E-7
39	1.07E-7	25	3.38E-8	130	2.70E-7	260	1.64E-7

Table A5.4.13 Ambient dose equivalent transmission factor of ^{65}Zn for iron, lead, concrete and water

t [cm]	iron T(t)	t [cm]	lead T(t)	t [cm]	concrete T(t)	t [cm]	water T(t)
0	1.00E+0	0	1.00E+0	0	1.00E+0	0	1.00E+0
0.5	9.40E-1	0.5	7.96E-1	5	8.61E-1	10	8.94E-1
1	8.72E-1	1	6.19E-1	10	6.64E-1	20	7.04E-1
5	3.40E-1	2.5	2.72E-1	20	3.24E-1	40	3.44E-1
10	6.98E-2	5	6.12E-2	30	1.37E-1	60	1.42E-1
15	1.19E-2	7.5	1.27E-2	40	5.31E-2	80	5.32E-2
20	1.84E-3	10	2.53E-3	50	1.95E-2	100	1.87E-2
25	2.67E-4	12.5	4.90E-4	60	6.92E-3	120	6.30E-3
30	3.70E-5	15	9.34E-5	70	2.38E-3	140	2.05E-3
35	4.97E-6	17.5	1.75E-5	80	8.02E-4	160	6.51E-4
40	6.51E-7	20	3.26E-6	90	2.65E-4	180	2.02E-4
45	8.34E-8	22.5	6.01E-7	100	8.62E-5	200	6.18E-5
50	1.05E-8	25	1.10E-7	120	8.79E-6	240	5.53E-6
		27.5	2.00E-8	140	8.63E-7	280	4.75E-7
		30	3.61E-9	160	8.23E-8	320	3.97E-8

Table A5.4.14 Ambient dose equivalent transmission factor of ^{67}Ga for iron, lead, concrete and water

t [cm]	iron T(t)	t [cm]	lead T(t)	t [cm]	concrete T(t)	t [cm]	water T(t)
0	1.00E+0	0	1.00E+0	0	1.00E+0	0	1.00E+0
0.5	7.49E-1	0.1	4.62E-1	5	8.86E-1	10	1.35E+0
1	5.69E-1	0.3	1.90E-1	10	4.83E-1	20	9.05E-1
2	3.32E-1	0.5	9.83E-2	15	2.34E-1	30	4.76E-1
3	1.86E-1	0.7	5.44E-2	20	1.07E-1	40	2.24E-1
4	1.02E-1	1	2.48E-2	25	4.76E-2	50	9.94E-2
5	5.52E-2	2	4.09E-3	30	2.07E-2	60	4.24E-2
6	2.97E-2	3	1.42E-3	35	8.91E-3	70	1.77E-2
7	1.59E-2	4	6.07E-4	40	3.81E-3	80	7.25E-3
8	8.57E-3	5	2.70E-4	45	1.63E-3	90	2.95E-3
10	2.51E-3	6	1.20E-4	50	6.96E-4	100	1.19E-3
12	7.60E-4	7	5.32E-5	55	3.01E-4	110	4.81E-4
15	1.38E-4	8	2.34E-5	60	1.31E-4	120	1.95E-4
17	4.75E-5	9	1.03E-5	65	5.82E-5	130	8.01E-5
20	1.04E-5	10	4.50E-6	70	2.62E-5	140	3.33E-5
22	3.95E-6	11	1.97E-6	75	1.21E-5	150	1.41E-5
25	9.62E-7	12	8.56E-7	80	5.66E-6	160	6.09E-6
27	3.80E-7	13	3.72E-7	85	2.70E-6	170	2.69E-6
30	9.53E-8	14	1.62E-7	90	1.31E-6	180	1.21E-6
		15	7.01E-8	100	3.23E-7	200	2.62E-7

Table A5.4.15 Ambient dose equivalent transmission factor of ^{68}Ge/ ^{68}Ga for iron, lead, concrete and water

t [cm]	iron T(t)	t [cm]	lead T(t)	t [cm]	concrete T(t)	t [cm]	water T(t)
0	1.00E+0	0	1.00E+0	0	1.00E+0	0	1.00E+0
0.5	9.46E-1	0.5	5.35E-1	5	9.08E-1	10	9.86E-1
1	8.62E-1	1	2.70E-1	10	6.46E-1	20	7.55E-1
5	2.07E-1	2.5	3.46E-2	20	2.33E-1	40	2.92E-1
10	1.95E-2	5	2.61E-3	30	6.79E-2	60	8.64E-2
15	1.61E-3	7.5	4.76E-4	40	1.78E-2	80	2.22E-2
20	1.43E-4	10	1.04E-4	50	4.44E-3	100	5.26E-3
25	1.56E-5	12.5	2.38E-5	60	1.09E-3	120	1.20E-3
30	2.10E-6	15	5.78E-6	70	2.68E-4	140	2.72E-4
35	3.30E-7	17.5	1.48E-6	80	6.90E-5	160	6.35E-5
40	5.65E-8	20	3.95E-7	90	1.88E-5	180	1.58E-5
45	1.02E-8	22.5	1.09E-7	100	5.54E-6	200	4.24E-6
50	1.90E-9	25	3.08E-8	120	5.85E-7	240	3.92E-7
		27.5	8.82E-9	140	7.45E-8	280	4.52E-8
		30	2.54E-9	160	1.05E-8	320	5.85E-9

Table A5.4.16 Ambient dose equivalent transmission factor of ^{75}Se for iron, lead, concrete and water

t [cm]	iron T(t)	t [cm]	lead T(t)	t [cm]	concrete T(t)	t [cm]	water T(t)
0	1.00E+0	0	1.00E+0	0	1.00E+0	0	1.00E+0
0.5	8.51E-1	0.1	5.27E-1	5	9.43E-1	10	1.28E+0
1	6.70E-1	0.2	3.25E-1	7.5	7.38E-1	15	1.13E+0
2.5	2.89E-1	0.5	9.48E-2	10	5.45E-1	20	9.10E-1
5	6.04E-2	1	1.79E-2	20	1.23E-1	40	2.46E-1
7.5	1.14E-2	1.5	4.75E-3	30	2.28E-2	60	4.77E-2
10	2.09E-3	2	1.42E-3	40	3.89E-3	80	7.95E-3
12.5	3.81E-4	2.5	4.40E-4	45	1.58E-3	90	3.13E-3
15	7.02E-5	3	1.40E-4	50	6.32E-4	100	1.22E-3
17.5	1.31E-5	3.5	4.55E-5	60	9.94E-5	120	1.76E-4
20	2.47E-6	4	1.55E-5	70	1.54E-5	140	2.48E-5
22.5	4.68E-7	4.5	5.54E-6	80	2.36E-6	160	3.42E-6
25	8.90E-8	5	2.12E-6	90	3.62E-7	180	4.70E-7
		6	3.81E-7				
		7	8.43E-8				

Table A5.4.17 Ambient dose equivalent transmission factor of ^{81}Rb/ ^{81m}Kr for iron, lead, concrete and water

t [cm]	iron T[t]	t [cm]	lead T[t]	t [cm]	concrete T[t]	t [cm]	water T[t]
0	1.00E+0	0	1.00E+0	0	1.00E+0	0	1.00E+0
0.5	9.27E-1	0.2	6.48E-1	10	6.23E-1	20	8.03E-1
1	8.15E-1	0.3	5.55E-1	15	3.69E-1	30	5.00E-1
2	5.82E-1	0.4	4.81E-1	20	2.05E-1	40	2.82E-1
3	3.95E-1	0.5	4.19E-1	25	1.09E-1	50	1.50E-1
5	1.68E-1	0.7	3.19E-1	30	5.70E-2	60	7.72E-2
7	6.72E-2	1	2.11E-1	35	2.93E-2	70	3.87E-2
10	1.62E-2	1.5	1.08E-1	40	1.49E-2	80	1.91E-2
12	6.20E-3	2	5.72E-2	45	7.57E-3	90	9.34E-3
15	1.50E-3	3	1.88E-2	50	3.83E-3	100	4.54E-3
17	6.01E-4	4	7.67E-3	55	1.95E-3	110	2.21E-3
20	1.60E-4	5	3.64E-3	60	9.94E-4	120	1.08E-3
22	6.89E-5	6	1.88E-3	65	5.12E-4	130	5.28E-4
25	2.04E-5	7	1.01E-3	70	2.67E-4	140	2.61E-4
27	9.25E-6	8	5.50E-4	80	7.53E-5	160	6.68E-5
30	2.91E-6	9	3.04E-4	90	2.24E-5	180	1.81E-5
32	1.36E-6	10	1.69E-4	100	6.99E-6	200	5.22E-6
35	4.41E-7	15	9.42E-6	110	2.27E-6	220	1.57E-6
37	2.09E-7	20	5.49E-7	120	7.53E-7	240	4.90E-7
39	9.94E-8	25	3.25E-8	130	2.55E-7	260	1.56E-7

Table A5.4.18 Ambient dose equivalent transmission factor of ^{85}Kr for iron, lead, concrete and water

t [cm]	iron T(t)	t [cm]	lead T(t)	t [cm]	concrete T(t)	t [cm]	water T(t)
0	1.00E+0	0	1.00E+0	0	1.00E+0	0	1.00E+0
0.5	9.46E-1	0.2	7.87E-1	10	6.45E-1	20	7.55E-1
1	8.62E-1	0.3	6.92E-1	15	4.01E-1	30	4.92E-1
2	6.56E-1	0.4	6.06E-1	20	2.30E-1	40	2.90E-1
3	4.63E-1	0.5	5.29E-1	25	1.26E-1	50	1.61E-1
5	2.03E-1	0.7	4.01E-1	30	6.58E-2	60	8.46E-2
7	8.03E-2	1	2.61E-1	35	3.35E-2	70	4.30E-2
10	1.79E-2	1.5	1.24E-1	40	1.67E-2	80	2.12E-2
12	6.28E-3	2	5.84E-2	45	8.16E-3	90	1.02E-2
15	1.25E-3	3	1.24E-2	50	3.93E-3	100	4.81E-3
17	4.14E-4	4	2.59E-3	55	1.86E-3	110	2.23E-3
20	7.68E-5	5	5.31E-4	60	8.75E-4	120	1.02E-3
22	2.46E-5	6	1.08E-4	65	4.07E-4	130	4.57E-4
25	4.37E-6	7	2.19E-5	70	1.87E-4	140	2.04E-4
27	1.36E-6	8	4.40E-6	80	3.89E-5	160	3.92E-5
30	2.34E-7	9	8.82E-7	90	7.87E-6	180	7.31E-6
32	7.17E-8	10	1.76E-7	100	1.56E-6	200	1.33E-6
35	1.20E-8	15	5.37E-11	110	3.04E-7	220	2.38E-7
37	3.63E-9			120	5.83E-8	240	4.22E-8
39	1.09E-9			130	1.10E-8	260	7.40E-9

Table A5.4.19 Ambient dose equivalent transmission factor of ^{85}Sr for iron, lead, concrete and water

t [cm]	iron T(t)	t [cm]	lead T(t)	t [cm]	concrete T(t)	t [cm]	water T(t)
0	1.00E+0	0	1.00E+0	0	1.00E+0	0	1.00E+0
1	8.62E-1	0.5	5.29E-1	5	9.08E-1	10	9.88E-1
2.5	5.56E-1	1	2.61E-1	10	6.46E-1	20	7.56E-1
5	2.03E-1	2	5.84E-2	20	2.31E-1	40	2.91E-1
7.5	6.30E-2	3	1.25E-2	30	6.59E-2	60	8.47E-2
10	1.79E-2	4	2.60E-3	40	1.67E-2	80	2.12E-2
12.5	4.82E-3	5	5.37E-4	50	3.93E-3	100	4.81E-3
15	1.25E-3	6	1.10E-4	60	8.76E-4	120	1.02E-3
17.5	3.14E-4	7	2.29E-5	70	1.88E-4	140	2.04E-4
20	7.70E-5	8	4.85E-6	80	3.90E-5	160	3.92E-5
22.5	1.85E-5	9	1.08E-6	90	7.89E-6	180	7.32E-6
25	4.39E-6	10	2.61E-7	100	1.56E-6	200	1.34E-6
27.5	1.02E-6	11	7.19E-8	110	3.05E-7	220	2.39E-7
30	2.36E-7						

Table A5.4.20 Ambient dose equivalent transmission factor of $^{99}Mo/^{99m}Tc$ for iron, lead, concrete and water

t [cm]	iron T(t)	t [cm]	lead T(t)	t [cm]	concrete T(t)	t [cm]	water T(t)
0	1.00E+0	0	1.00E+0	0	1.00E+0	0	1.00E+0
0.5	8.14E-1	0.2	4.15E-1	5	9.03E-1	10	1.25E+0
1	6.25E-1	0.5	3.21E-1	10	5.29E-1	20	8.73E-1
2	3.88E-1	1	2.14E-1	15	2.87E-1	30	4.92E-1
3	2.61E-1	1.5	1.40E-1	20	1.55E-1	40	2.55E-1
5	1.27E-1	2	9.09E-2	25	8.50E-2	50	1.29E-1
7	5.95E-2	3	3.70E-2	30	4.70E-2	60	6.48E-2
10	1.76E-2	4	1.47E-2	35	2.59E-2	70	3.30E-2
12	7.51E-3	5	5.77E-3	40	1.42E-2	80	1.69E-2
15	2.00E-3	6	2.24E-3	45	7.73E-3	90	8.73E-3
17	8.11E-4	7	8.61E-4	50	4.17E-3	100	4.50E-3
20	2.04E-4	8	3.31E-4	55	2.22E-3	110	2.31E-3
22	8.01E-5	9	1.27E-4	60	1.18E-3	120	1.18E-3
25	1.94E-5	10	4.85E-5	65	6.18E-4	130	6.00E-4
30	1.76E-6	11	1.86E-5	70	3.22E-4	140	3.02E-4
32	6.67E-7	12	7.12E-6	80	8.60E-5	160	7.51E-5
35	1.54E-7	13	2.74E-6	90	2.24E-5	180	1.82E-5
36	9.46E-8	15	4.13E-7	100	5.76E-6	200	4.34E-6
		16	1.62E-7	110	1.46E-6	220	1.02E-6
		17	6.37E-8	120	3.64E-7	240	2.35E-7

Table A5.4.21 Ambient dose equivalent transmission factor of ^{99m}Tc for iron, lead, concrete and water

t [cm]	iron T(t)	t [cm]	lead T(t)	t [cm]	concrete T(t)	t [cm]	water T(t)
0	1.00E+0	0	1.00E+0	0	1.00E+0	0	1.00E+0
0.1	9.63E-1	0.01	9.25E-1	5	9.31E-1	10	1.55E+0
0.5	7.00E-1	0.02	8.00E-1	10	4.22E-1	20	1.02E+0
1	4.06E-1	0.03	6.72E-1	15	1.54E-1	30	4.96E-1
2	1.14E-1	0.04	5.55E-1	20	5.08E-2	40	2.06E-1
3	2.91E-2	0.05	4.54E-1	25	1.57E-2	50	7.72E-2
4	7.06E-3	0.06	3.68E-1	30	4.64E-3	60	2.69E-2
4.4	3.98E-3	0.07	2.97E-1	35	1.33E-3	70	8.85E-3
5	1.67E-3	0.1	1.52E-1	40	3.72E-4	80	2.78E-3
5.4	9.33E-4	0.2	1.46E-2	45	1.02E-4	90	8.43E-4
6	3.88E-4	0.25	4.45E-3	50	2.76E-5	100	2.48E-4
6.4	2.16E-4	0.3	1.35E-3	55	7.36E-6	110	7.12E-5
7	8.93E-5	0.35	4.09E-4	60	1.94E-6	120	2.00E-5
7.4	4.95E-5	0.4	1.25E-4	65	5.06E-7	130	5.55E-6
8	2.04E-5	0.45	3.83E-5				
8.4	1.12E-5	0.5	1.19E-5				
9	4.61E-6	0.55	3.70E-6				
9.4	2.54E-6	0.6	1.16E-6				
10	1.04E-6	0.65	3.68E-7				
12	5.18E-8	0.7	1.17E-7				

Table A5.4.22 Ambient dose equivalent transmission factor of $^{103}Pd/^{103m}Rh$ for iron, lead, concrete and water

t [cm]	iron T(t)	t [cm]	lead T(t)	t [cm]	concrete T(t)	t [cm]	water T(t)
0	1.00E+0	0	9.99E-1	0	1.00E+0	0	1.00E+0
0.5	1.11E-3	0.2	1.06E-3	10	7.71E-4	20	9.30E-4
1	1.02E-3	0.3	9.96E-4	15	5.30E-4	30	5.94E-4
2	8.30E-4	0.4	9.37E-4	20	3.44E-4	40	3.81E-4
3	6.43E-4	0.5	8.81E-4	25	2.14E-4	50	2.36E-4
5	3.51E-4	0.7	7.75E-4	30	1.29E-4	60	1.41E-4
7	1.76E-4	1.0	6.34E-4	35	7.63E-5	70	8.21E-5
10	5.68E-5	1.5	4.46E-4	40	4.41E-5	80	4.67E-5
12	2.56E-5	2	3.10E-4	45	2.51E-5	90	2.61E-5
15	7.43E-6	3	1.45E-4	50	1.41E-5	100	1.43E-5
17	3.18E-6	4	6.59E-5	55	7.87E-6	110	7.78E-6
20	8.68E-7	5	2.95E-5	60	4.34E-6	120	4.18E-6
22	3.60E-7	6	1.30E-5	65	2.37E-6	130	2.22E-6
25	9.44E-8	7	5.70E-6	70	1.29E-6	140	1.17E-6
27	3.83E-8	8	2.47E-6	80	3.71E-7	160	3.16E-7
30	9.77E-9	9	1.07E-6	90	1.05E-7	180	8.36E-8
32	3.90E-9	10	4.59E-7	100	2.91E-8	200	2.16E-8
35	9.75E-10	15	6.43E-9	110	7.97E-9	220	5.51E-9
37	3.84E-10	20	8.56E-11	120	2.15E-9	240	1.38E-9
39	1.51E-10	25	1.10E-12	130	5.76E-10	260	3.44E-10

Table A5.4.23 Ambient dose equivalent transmission factor of ^{110m}Ag for iron, lead, concrete and water

t [cm]	iron T(t)	t [cm]	lead T(t)	t [cm]	concrete T(t)	t [cm]	water T(t)
0	1.00E+0	0	1.00E+0	0	1.00E+0	0	1.00E+0
0.5	9.39E-1	0.5	7.33E-1	5	8.69E-1	10	9.13E-1
1	8.67E-1	1	5.23E-1	10	6.55E-1	20	7.12E-1
5	3.00E-1	2.5	1.85E-1	20	2.95E-1	40	3.26E-1
10	5.27E-2	5	3.57E-2	30	1.14E-1	60	1.24E-1
15	8.26E-3	7.5	7.83E-3	40	4.11E-2	80	4.28E-2
20	1.28E-3	10	1.86E-3	50	1.43E-2	100	1.42E-2
25	2.00E-4	12.5	4.59E-4	60	4.90E-3	120	4.58E-3
30	3.20E-5	15	1.15E-4	70	1.68E-3	140	1.48E-3
35	5.17E-6	17.5	2.91E-5	80	5.76E-4	160	4.76E-4
40	8.40E-7	20	7.32E-6	90	1.99E-4	180	1.54E-4
45	1.36E-7	22.5	1.84E-6	100	6.90E-5	200	5.05E-5
50	2.21E-8	25	4.61E-7	120	8.43E-6	240	5.50E-6
		27.5	1.15E-7	140	1.04E-6	280	6.08E-7
		30	2.85E-8	160	1.30E-7	320	6.75E-8

Table A5.4.24 Ambient dose equivalent transmission factor of ^{111}In for iron, lead, concrete and water

t [cm]	iron T(t)	t [cm]	lead T(t)	t [cm]	concrete T(t)	t [cm]	water T(t)
0	1.00E+0	0	1.00E+0	0	1.00E+0	0	1.00E+0
0.5	8.74E-1	0.1	4.69E-1	5	9.69E-1	10	1.33E+0
1	6.78E-1	0.2	2.17E-1	10	5.50E-1	20	9.46E-1
5	3.53E-2	0.3	1.07E-1	15	2.58E-1	30	5.18E-1
10	5.63E-4	0.4	5.46E-2	20	1.10E-1	40	2.46E-1
11	2.41E-4	0.5	2.83E-2	25	4.40E-2	50	1.07E-1
12	1.03E-4	0.6	1.47E-2	30	1.70E-2	60	4.36E-2
13	4.36E-5	0.7	7.67E-3	35	6.38E-3	70	1.70E-2
14	1.84E-5	0.8	4.00E-3	40	2.34E-3	80	6.35E-3
15	7.74E-6	0.9	2.09E-3	50	3.02E-4	100	8.16E-4
16	3.24E-6	1	1.09E-3	55	1.06E-4	110	2.83E-4
17	1.36E-6	1.5	4.20E-5	60	3.70E-5	120	9.68E-5
18	5.64E-7	2	1.63E-6	70	4.39E-6	140	1.09E-5
19	2.34E-7	2.5	6.32E-8	75	1.49E-6	150	3.58E-6
20	9.68E-8			80	5.05E-7	160	1.17E-6

Table A5.4.25 Ambient dose equivalent transmission factor of ^{124}Sb for iron, lead, concrete and water

t [cm]	iron T(t)	t [cm]	lead T(t)	t [cm]	concrete T(t)	t [cm]	water T(t)
0	1.00E+0	0	1.00E+0	0	1.00E+0	0	1.00E+0
0.5	9.41E-1	0.5	7.41E-1	5	8.69E-1	10	9.10E-1
1	8.71E-1	1	5.46E-1	10	6.64E-1	20	7.16E-1
5	3.27E-1	5	7.03E-2	20	3.19E-1	40	3.47E-1
10	7.32E-2	10	6.67E-3	30	1.38E-1	60	1.45E-1
15	1.58E-2	12.5	2.00E-3	40	5.77E-2	80	5.79E-2
20	3.38E-3	15	5.92E-4	50	2.40E-2	100	2.28E-2
25	7.09E-4	17.5	1.73E-4	60	9.92E-3	120	8.98E-3
30	1.46E-4	20	5.03E-5	70	4.10E-3	140	3.54E-3
35	2.97E-5	22.5	1.45E-5	80	1.69E-3	160	1.39E-3
40	5.94E-6	25	4.17E-6	100	2.83E-4	200	2.12E-4
45	1.18E-6	30	3.40E-7	120	4.65E-5	240	3.18E-5
50	2.32E-7	35	2.75E-8	140	7.51E-6	280	4.68E-6
55	4.57E-8			160	1.20E-6	320	6.85E-7
				180	1.91E-7	360	9.96E-8

Table A5.4.26 Ambient dose equivalent transmission factor of ^{123}I for iron, lead, concrete and water

t [cm]	iron T(t)	t [cm]	lead T(t)	t [cm]	concrete T(t)	t [cm]	water T(t)
0	1.00E+0	0	1.00E+0	0	1.00E+0	0	1.00E+0
0.5	6.95E-1	0.1	2.64E-1	3	9.88E-1	5	1.28E+0
1	4.77E-1	0.2	1.01E-1	5	8.35E-1	10	1.28E+0
3	1.32E-1	0.5	4.72E-2	8	6.20E-1	15	1.10E+0
5	2.25E-2	1	2.40E-2	10	4.29E-1	20	8.60E-1
8	5.99E-3	2	6.18E-3	20	7.38E-2	40	2.00E-1
10	1.72E-3	3	1.65E-3	30	1.17E-2	60	3.25E-2
13	4.83E-4	4	4.69E-4	40	2.10E-3	80	4.79E-3
15	1.33E-4	5	1.44E-4	50	4.28E-4	100	7.37E-4
18	3.59E-5	6	4.74E-5	60	9.33E-5	120	1.26E-4
20	9.62E-6	7	1.66E-5	70	2.07E-5	140	2.34E-5
23	2.57E-6	8	6.10E-6	80	4.60E-6	160	4.57E-6
25	6.86E-7	9	2.32E-6	90	1.02E-6	180	9.11E-7
28	1.84E-7	10	9.08E-7	100	2.25E-7	200	1.83E-7
30	4.96E-8	12	1.48E-7				

Table A5.4.27 Ambient dose equivalent transmission factor of ^{125}I for iron, lead, concrete and water

t [cm]	iron T(t)	t [cm]	lead T(t)	t [cm]	concrete T(t)	t [cm]	water T(t)
0	1.00E+0	0	1.00E+0	0	1.00E+0	0	1.00E+0
0.01	4.96E-1	0.001	6.91E-1	0.5	3.64E-1	2	8.54E-1
0.03	1.19E-1	0.002	4.72E-1	1	1.22E-1	4	5.43E-1
0.04	6.01E-2	0.003	3.23E-1	1.5	4.20E-2	6	3.17E-1
0.05	3.11E-2	0.004	2.21E-1	2	1.52E-2	8	1.77E-1
0.06	1.65E-2	0.005	1.52E-1	2.5	5.85E-3	10	9.72E-2
0.08	5.07E-3	0.006	1.05E-1	3	2.39E-3	15	2.11E-2
0.1	1.74E-3	0.007	7.33E-2	3.5	1.02E-3	20	4.61E-3
0.12	6.52E-4	0.008	5.13E-2	4	4.58E-4	25	1.04E-3
0.14	2.61E-4	0.009	3.61E-2	4.5	2.12E-4	30	2.43E-4
0.16	1.09E-4	0.01	2.56E-2	5	1.01E-4	35	5.88E-5
0.18	4.73E-5	0.02	1.18E-3	5.5	4.87E-5	40	1.46E-5
0.2	2.09E-5	0.03	9.44E-5	6	2.39E-5	45	3.71E-6
0.22	9.37E-6	0.04	9.75E-6	6.5	1.18E-5	50	9.55E-7
0.24	4.24E-6	0.05	1.11E-6	7	5.90E-6	55	2.48E-7
0.26	1.93E-6	0.06	1.32E-7	7.5	2.96E-6	60	6.49E-8
0.28	8.85E-7	0.07	1.60E-8	8	1.50E-6	65	1.70E-8
0.3	4.07E-7						
0.32	1.87E-7						
0.34	8.65E-8						

Table A5.4.28 Ambient dose equivalent transmission factor of ^{131}I for iron, lead, concrete and water

t [cm]	iron T(t)	t [cm]	lead T(t)	t [cm]	concrete T(t)	t [cm]	water T(t)
0	1.00E+0	0	1.00E+0	0	1.00E+0	0	1.00E+0
0.5	9.36E-1	0.1	8.06E-1	5	9.29E-1	10	1.07E+0
1	8.32E-1	0.2	6.46E-1	10	6.28E-1	20	8.05E-1
2	5.92E-1	0.3	5.17E-1	15	3.64E-1	30	5.00E-1
3	3.87E-1	0.5	3.32E-1	20	1.94E-1	40	2.78E-1
5	1.46E-1	1	1.20E-1	25	9.84E-2	50	1.44E-1
6	8.63E-2	1.5	5.11E-2	30	4.82E-2	60	7.10E-2
8	2.94E-2	2	2.52E-2	35	2.30E-2	70	3.38E-2
10	9.84E-3	3	7.60E-3	40	1.09E-2	80	1.57E-2
12	3.30E-3	4	2.49E-3	45	5.06E-3	90	7.11E-3
14	1.11E-3	5	8.23E-4	50	2.34E-3	100	3.18E-3
16	3.80E-4	6	2.72E-4	55	1.08E-3	110	1.41E-3
18	1.31E-4	7	9.00E-5	60	4.99E-4	120	6.23E-4
20	4.58E-5	8	2.98E-5	65	2.30E-4	130	2.74E-4
22	1.61E-5	9	9.90E-6	70	1.07E-4	140	1.20E-4
24	5.67E-6	10	3.30E-6	75	4.94E-5	150	5.28E-5
26	2.01E-6	11	1.10E-6	80	2.29E-5	160	2.33E-5
28	7.09E-7	12	3.70E-7	90	5.00E-6	180	4.56E-6
30	2.51E-7	13	1.25E-7	100	1.10E-6	200	9.05E-7
32	8.85E-8	14	4.23E-8	110	2.43E-7	220	1.82E-7

Table A5.4.29 Ambient dose equivalent transmission factor of ^{133}Xe for iron, lead, concrete and water

t [cm]	iron T(t)	t [cm]	lead T(t)	t [cm]	concrete T(t)	t [cm]	water T(t)
0	1.00E+0	0	1.00E+0	0	1.00E+0	0	1.00E+0
0.1	2.68E-1	0.01	3.23E-1	1	5.33E-1	4	1.07E+0
0.2	1.88E-1	0.02	2.30E-1	2	3.85E-1	6	9.48E-1
0.3	1.31E-1	0.04	1.45E-1	4	2.45E-1	10	7.10E-1
0.4	9.06E-2	0.06	9.17E-2	7	1.10E-1	15	4.76E-1
0.5	6.20E-2	0.08	5.78E-2	10	4.42E-2	20	3.05E-1
0.7	2.87E-2	0.1	3.64E-2	15	8.60E-3	25	1.86E-1
1	9.12E-3	0.2	3.62E-3	20	1.58E-3	30	1.09E-1
2	4.81E-4	0.4	1.05E-4	25	2.91E-4	40	3.36E-2
3	1.53E-4	0.6	3.99E-5	30	5.74E-5	50	9.43E-3
4	6.95E-5	0.8	2.17E-5	35	1.30E-5	60	2.47E-3
6	1.69E-5	1	1.21E-5	40	3.54E-6	70	6.13E-4
8	4.46E-6	1.2	6.80E-6	45	1.13E-6	90	3.44E-5
10	1.20E-6	1.5	2.95E-6	50	4.03E-7	100	7.99E-6
12	3.21E-7	2	7.64E-7	55	1.52E-7	110	1.87E-6
15	4.34E-8	2.5	2.04E-7	60	5.86E-8	120	4.49E-7
						130	1.13E-7

Table A5.4.30 Ambient dose equivalent transmission factor of ^{134}Cs for iron, lead, concrete and water

t [cm]	iron T(t)	t [cm]	lead T(t)	t [cm]	concrete T(t)	t [cm]	water T(t)
0	1.00E+0	0	1.00E+0	0	1.00E+0	0	1.00E+0
0.5	9.25E-1	0.2	8.40E-1	5	8.66E-1	10	9.28E-1
1	8.49E-1	0.3	7.71E-1	10	6.36E-1	20	7.14E-1
2	6.72E-1	0.4	7.06E-1	15	4.18E-1	30	4.82E-1
5	2.47E-1	0.5	6.45E-1	20	2.56E-1	40	2.99E-1
8	7.31E-2	1	4.02E-1	25	1.50E-1	50	1.76E-1
10	3.05E-2	2	1.45E-1	30	8.45E-2	60	9.88E-2
12	1.23E-2	3	5.01E-2	35	4.65E-2	70	5.38E-2
14	4.81E-3	4	1.68E-2	40	2.50E-2	80	2.85E-2
16	1.85E-3	5	5.54E-3	45	1.32E-2	90	1.48E-2
18	7.01E-4	6	1.81E-3	50	6.91E-3	100	7.56E-3
20	2.62E-4	7	5.84E-4	55	3.56E-3	110	3.80E-3
22	9.66E-5	8	1.88E-4	60	1.81E-3	120	1.88E-3
24	3.53E-5	9	6.01E-5	65	9.16E-4	130	9.21E-4
26	1.28E-5	10	1.92E-5	70	4.59E-4	140	4.47E-4
28	4.60E-6	11	6.09E-6	80	1.13E-4	160	1.02E-4
30	1.64E-6	12	1.93E-6	90	2.71E-5	180	2.27E-5
32	5.83E-7	13	6.10E-7	100	6.37E-6	200	4.95E-6
34	2.06E-7	14	1.92E-7	110	1.47E-6	220	1.06E-6
36	6.99E-8	15	6.05E-8	120	3.33E-7	240	2.08E-7

Table A5.4.31 Ambient dose equivalent transmission factor of ^{192}Ir for iron, lead, concrete and water

t [cm]	iron T(t)	t [cm]	lead T(t)	t [cm]	concrete T(t)	t [cm]	water T(t)
0	1.00E+0	0	1.00E+0	0	1.00E+0	0	1.00E+0
0.5	9.29E-1	0.2	6.18E-1	5	9.27E-1	10	1.08E+0
1	8.21E-1	0.3	4.89E-1	7.5	7.78E-1	15	9.66E-1
2	5.76E-1	0.4	3.91E-1	10	6.20E-1	20	8.08E-1
3	3.73E-1	0.5	3.15E-1	15	3.57E-1	30	4.97E-1
4	2.31E-1	1	1.23E-1	20	1.89E-1	40	2.75E-1
5	1.40E-1	2	2.62E-2	25	9.54E-2	50	1.41E-1
8	2.84E-2	3	6.52E-3	30	4.66E-2	60	6.94E-2
10	9.56E-3	4	1.76E-3	35	2.23E-2	70	3.29E-2
12	3.20E-3	5	5.16E-4	40	1.05E-2	80	1.52E-2
14	1.07E-3	6	1.63E-4	45	4.88E-3	90	6.89E-3
16	3.59E-4	7	5.55E-5	50	2.26E-3	100	3.08E-3
18	1.20E-4	8	2.04E-5	55	1.04E-3	110	1.36E-3
20	4.04E-5	9	8.06E-6	60	4.76E-4	120	5.98E-4
22	1.36E-5	10	3.37E-6	65	2.18E-4	130	2.61E-4
24	4.61E-6	11	1.48E-6	70	9.98E-5	140	1.14E-4
26	1.57E-6	12	6.67E-7	80	2.09E-5	160	2.16E-5
28	5.37E-7	13	3.08E-7	90	4.39E-6	180	4.10E-6
30	1.86E-7	14	1.45E-7	100	9.31E-7	200	7.85E-7
32	6.49E-8	15	6.90E-8	105	4.31E-7	210	3.46E-7

Table A5.4.32 Ambient dose equivalent transmission factor of ^{198}Au for iron, lead, concrete and water

t [cm]	iron T(t)	t [cm]	lead T(t)	t [cm]	concrete T(t)	t [cm]	water T(t)
0	1.00E+0	0	1.00E+0	0	1.00E+0	0	1.00E+0
0.5	9.42E-1	0.2	6.95E-1	5	9.29E-1	10	1.05E+0
1	8.46E-1	0.3	5.72E-1	8	7.89E-1	15	9.45E-1
2	6.15E-1	0.4	4.69E-1	10	6.37E-1	20	7.97E-1
3	4.10E-1	0.5	3.83E-1	15	3.76E-1	30	5.00E-1
4	2.59E-1	0.7	2.54E-1	20	2.03E-1	40	2.82E-1
6	9.44E-2	1	1.36E-1	25	1.04E-1	50	1.48E-1
8	3.18E-2	2	1.72E-2	30	5.11E-2	60	7.37E-2
10	1.02E-2	3	2.91E-3	35	2.44E-2	70	3.53E-2
12	3.21E-3	4	8.01E-4	40	1.14E-2	80	1.64E-2
14	9.94E-4	5	3.17E-4	45	5.22E-3	90	7.41E-3
16	3.07E-4	6	1.45E-4	50	2.36E-3	100	3.28E-3
18	9.57E-5	7	6.99E-5	55	1.06E-3	110	1.43E-3
20	3.04E-5	8	3.45E-5	60	4.69E-4	120	6.15E-4
22	1.00E-5	9	1.72E-5	65	2.08E-4	130	2.62E-4
24	3.42E-6	10	8.67E-6	70	9.17E-5	140	1.11E-4
26	1.22E-6	12	2.21E-6	80	1.80E-5	160	1.98E-5
28	4.58E-7	14	5.66E-7	90	3.65E-6	180	3.58E-6
30	1.79E-7	16	1.44E-7	100	7.81E-7	200	6.79E-7
32	7.19E-8	17	7.26E-8	105	3.71E-7	210	3.03E-7

Table A5.4.33 Ambient dose equivalent transmission factor of ^{197}Hg for iron, lead, concrete and water

t [cm]	iron T(t)	t [cm]	lead T(t)	t [cm]	concrete T(t)	t [cm]	water T(t)
0	1.00E+0	0	1.00E+0	0	1.00E+0	0	1.00E+0
0.1	6.49E-1	0.1	4.92E-2	2	9.19E-1	4	1.71E+0
0.2	3.99E-1	0.2	4.14E-3	3	7.32E-1	6	1.78E+0
0.5	9.30E-2	0.3	7.89E-4	4	5.58E-1	8	1.73E+0
0.7	3.90E-2	0.4	2.69E-4	5	4.13E-1	10	1.59E+0
1	1.43E-2	0.5	1.18E-4	7.5	1.83E-1	15	1.14E+0
2	3.74E-3	0.6	5.85E-5	10	7.73E-2	20	7.22E-1
3	1.61E-3	0.7	3.11E-5	15	1.37E-2	30	2.40E-1
4	6.70E-4	1	5.71E-6	20	2.74E-3	40	6.87E-2
5	2.72E-4	1.2	1.94E-6	25	6.66E-4	50	1.80E-2
7	4.38E-5	1.5	3.90E-7	30	1.93E-4	60	4.50E-3
8	1.76E-5	1.7	1.34E-7	40	2.05E-5	80	2.65E-4
10	2.88E-6	2	2.70E-8	50	2.29E-6	100	1.65E-5
12.5	3.14E-7			55	7.59E-7	110	4.35E-6
15	3.60E-8			60	2.50E-7	120	1.19E-6

Table A5.4.34 Ambient dose equivalent transmission factor of ^{201}Tl for iron, lead, concrete and water

t [cm]	iron T(t)	t [cm]	lead T(t)	t [cm]	concrete T(t)	t [cm]	water T(t)
0	1.00E+0	0	1.00E+0	0	1.00E+0	0	1.00E+0
0.5	2.29E-1	0.01	7.81E-1	3	8.94E-1	5	1.69E+0
1	1.10E-1	0.02	6.07E-1	5	5.27E-1	10	1.57E+0
2	3.90E-2	0.03	4.71E-1	8	2.88E-1	15	1.17E+0
3	1.33E-2	0.04	3.67E-1	10	1.56E-1	20	7.85E-1
4	4.35E-3	0.05	2.87E-1	15	4.81E-2	30	2.96E-1
5	1.39E-3	0.07	1.78E-1	20	1.54E-2	40	9.98E-2
6	4.35E-4	0.1	8.97E-2	25	4.99E-3	50	3.19E-2
7	1.35E-4	0.15	3.14E-2	30	1.60E-3	60	9.92E-3
8	4.15E-5	0.2	1.20E-2	35	5.01E-4	70	3.04E-3
9	1.27E-5	0.25	4.84E-3	40	1.54E-4	80	9.26E-4
10	3.84E-6	0.3	2.02E-3	45	4.67E-5	90	2.80E-4
11	1.16E-6	0.35	8.61E-4	50	1.39E-5	100	8.36E-5
12	3.48E-7	0.4	3.71E-4	55	4.10E-6	110	2.48E-5
13	1.04E-7	0.5	7.02E-5	60	1.19E-6	120	7.28E-6
		0.6	1.35E-5	65	3.44E-7	130	2.12E-6
		0.7	2.59E-6				
		0.8	4.99E-7				
		0.9	9.63E-8				

Table A5.4.35 Ambient dose equivalent transmission factor of ^{226}Ra/daughter for iron, lead, concrete and water

t [cm]	iron T(t)	t [cm]	lead T(t)	t [cm]	concrete T(t)	t [cm]	water T(t)
0	1.00E+0	0	1.00E+0	0	1.00E+0	0	1.00E+0
0.5	9.28E-1	0.2	8.33E-1	5	8.73E-1	10	9.47E-1
1	8.51E-1	0.4	7.20E-1	10	6.52E-1	20	7.34E-1
5	3.04E-1	0.7	5.94E-1	20	3.04E-1	40	3.39E-1
10	6.89E-2	1	4.99E-1	30	1.30E-1	60	1.39E-1
15	1.51E-2	1.5	3.80E-1	40	5.47E-2	80	5.51E-2
20	3.28E-3	2	2.93E-1	50	2.29E-2	100	2.19E-2
22	1.78E-3	3	1.77E-1	60	9.62E-3	120	8.72E-3
25	7.09E-4	4	1.09E-1	70	4.04E-3	140	3.49E-3
27	3.83E-4	5	6.71E-2	80	1.70E-3	160	1.40E-3
30	1.52E-4	6	4.15E-2	90	7.12E-4	180	5.64E-4
32	8.24E-5	7	2.57E-2	100	2.99E-4	200	2.27E-4
35	3.27E-5	8	1.59E-2	110	1.26E-4	220	9.17E-5
37	1.77E-5	9	9.87E-3	120	5.29E-5	240	3.70E-5
40	7.03E-6	10	6.11E-3	130	2.23E-5	260	1.50E-5
42	3.80E-6	15	5.52E-4	140	9.38E-6	280	6.07E-6
45	1.51E-6	20	4.97E-5	150	3.96E-6	300	2.47E-6
47	8.17E-7	25	4.46E-6	160	1.67E-6	320	1.00E-6
50	3.25E-7	30	3.99E-7	170	7.08E-7	340	4.09E-7
54	9.54E-8	35	3.56E-8	180	3.00E-7	360	1.67E-7

Table A5.4.36 Ambient dose equivalent transmission factor of ^{241}Am for iron, lead, concrete and water

t [cm]	iron T(t)	t [cm]	lead T(t)	t [cm]	concrete T(t)	t [cm]	water T(t)
0	1.00E+0	0	1.00E+0	0	1.00E+0	0	1.00E+0
0.05	6.90E-1	0.01	6.04E-1	1	9.54E-1	2	1.45E+0
0.1	4.60E-1	0.02	3.60E-1	2	7.22E-1	4	1.65E+0
0.2	1.97E-1	0.03	2.14E-1	3	5.04E-1	6	1.65E+0
0.3	8.25E-2	0.04	1.27E-1	4	3.36E-1	8	1.53E+0
0.4	3.45E-2	0.05	7.53E-2	5	2.19E-1	10	1.35E+0
0.5	1.45E-2	0.07	2.65E-2	6	1.40E-1	12	1.15E+0
0.6	6.21E-3	0.1	5.53E-3	7	8.85E-2	15	8.69E-1
0.7	2.76E-3	0.15	4.27E-4	8	5.54E-2	20	4.97E-1
0.8	1.31E-3	0.2	3.98E-5	9	3.45E-2	25	2.65E-1
0.9	6.76E-4	0.25	6.01E-6	10	2.14E-2	30	1.35E-1
1	3.91E-4	0.3	1.62E-6	13	6.37E-3	40	3.16E-2
1.5	8.01E-5	0.35	5.80E-7	15	1.89E-3	50	6.75E-3
2	2.65E-5	0.4	2.26E-7	18	5.64E-4	60	1.36E-3
2.5	9.21E-6	0.45	9.03E-8	20	1.72E-4	70	2.61E-4
3	3.31E-6			23	5.44E-5	80	4.87E-5
3.5	1.23E-6			25	1.82E-5	90	8.90E-6
4	4.70E-7			30	2.51E-6	100	1.61E-6
				35	4.45E-7	110	2.88E-7

Table A5.4.37 Effective conversion coefficients $\bar{f}^*_{10}$ of iron from air absorbed dose to ambient dose equivalent

μt[mfp]	Photon energy [MeV]								
	0.015	0.02	0.03	0.04	0.05	0.06	0.08	0.1	0.15
0.5	0.2673	0.6277	1.126	1.496	1.691	1.753	1.727	1.663	1.515
1	0.2673	0.6276	1.125	1.495	1.690	1.752	1.728	1.666	1.524
2	0.2673	0.6276	1.125	1.494	1.689	1.752	1.728	1.669	1.531
3	0.2672	0.6276	1.125	1.494	1.689	1.752	1.729	1.670	1.534
4	0.2672	0.6275	1.125	1.494	1.689	1.752	1.729	1.671	1.535
5	0.2672	0.6276	1.125	1.495	1.689	1.752	1.729	1.671	1.536
6	0.2672	0.6276	1.125	1.495	1.689	1.752	1.729	1.671	1.537
7	0.2672	0.6276	1.125	1.495	1.689	1.752	1.730	1.671	1.537
8	0.2672	0.6276	1.125	1.495	1.689	1.752	1.730	1.671	1.538
10	0.2672	0.6276	1.125	1.495	1.689	1.752	1.730	1.672	1.539
15	0.2672	0.6276	1.125	1.495	1.689	1.753	1.730	1.672	1.539
20	0.2672	0.6276	1.125	1.495	1.690	1.753	1.730	1.672	1.540
25	0.2672	0.6276	1.125	1.495	1.690	1.753	1.730	1.672	1.540
30	0.2672	0.6276	1.125	1.495	1.690	1.753	1.730	1.672	1.540
35	0.2672	0.6276	1.125	1.495	1.690	1.753	1.730	1.672	1.540
40	0.2672	0.6276	1.125	1.495	1.690	1.753	1.730	1.672	1.540
μt[mfp]	0.2	0.3	0.4	0.5	0.6	0.8	1	1.5	2
0.5	1.432	1.342	1.292	1.260	1.233	1.211	1.190	1.162	1.150
1	1.444	1.356	1.309	1.275	1.249	1.225	1.204	1.175	1.161
2	1.454	1.370	1.324	1.291	1.267	1.240	1.220	1.189	1.173
3	1.459	1.377	1.333	1.300	1.276	1.249	1.229	1.197	1.180
4	1.463	1.381	1.338	1.306	1.282	1.255	1.234	1.202	1.184
5	1.465	1.384	1.342	1.309	1.287	1.259	1.238	1.205	1.187
6	1.466	1.387	1.345	1.312	1.290	1.262	1.241	1.208	1.189
7	1.468	1.389	1.347	1.315	1.292	1.264	1.244	1.210	1.191
8	1.469	1.390	1.349	1.316	1.295	1.266	1.245	1.211	1.192
10	1.470	1.392	1.352	1.319	1.298	1.269	1.248	1.214	1.194
15	1.472	1.396	1.356	1.323	1.302	1.273	1.252	1.217	1.197
20	1.473	1.397	1.358	1.326	1.305	1.275	1.254	1.219	1.198
25	1.474	1.399	1.360	1.327	1.306	1.276	1.255	1.220	1.199
30	1.474	1.399	1.361	1.328	1.307	1.277	1.256	1.220	1.199
35	1.474	1.400	1.362	1.329	1.308	1.278	1.256	1.221	1.200
40	1.474	1.400	1.362	1.330	1.309	1.278	1.257	1.221	1.200
μt[mfp]	3	4	5	6	8	10			
0.5	1.136	1.124	1.111	1.107	1.092	1.080			
1	1.146	1.133	1.121	1.116	1.101	1.089			
2	1.155	1.142	1.130	1.124	1.108	1.096			
3	1.161	1.147	1.135	1.128	1.113	1.100			
4	1.164	1.150	1.138	1.131	1.116	1.104			
5	1.166	1.153	1.141	1.134	1.119	1.107			
6	1.168	1.155	1.143	1.136	1.122	1.110			
7	1.169	1.156	1.145	1.137	1.124	1.113			
8	1.170	1.157	1.146	1.139	1.126	1.115			
10	1.172	1.159	1.148	1.141	1.129	1.119			
15	1.175	1.162	1.152	1.145	1.134	1.126			
20	1.176	1.163	1.154	1.147	1.137	1.130			
25	1.177	1.164	1.155	1.148	1.139	1.133			
30	1.177	1.165	1.156	1.149	1.140	1.135			
35	1.177	1.165	1.156	1.150	1.141	1.137			
40	1.178	1.165	1.157	1.150	1.142	1.138			

μt: thickness of shield (unit: mean free path)

Table A5.4.38 Effective conversion coefficients $\bar{f}_{10}^{*}$ of lead from air absorbed dose to ambient dose equivalent

μt[mfp]	Photon energy [MeV]								
	0.015	0.02	0.03	0.04	0.05	0.06	0.08	0.1	0.15
0.5			1.127	1.499	1.695	1.755	1.725	1.683	1.540
1			1.127	1.499	1.695	1.755	1.725	1.695	1.558
2			1.127	1.499	1.695	1.755	1.725	1.708	1.573
3			1.127	1.499	1.695	1.755	1.725	1.716	1.579
4			1.127	1.499	1.695	1.755	1.725	1.720	1.583
5			1.127	1.499	1.695	1.755	1.725	1.723	1.585
6			1.127	1.499	1.695	1.755	1.725	1.724	1.587
7			1.127	1.499	1.695	1.755	1.725	1.724	1.588
8			1.127	1.499	1.695	1.755	1.725	1.723	1.590
10			1.127	1.499	1.695	1.755	1.725	1.721	1.594
15			1.127	1.499	1.695	1.755	1.726	1.716	1.604
20			1.127	1.499	1.695	1.756	1.726	1.712	1.616
25			1.127	1.499	1.695	1.756	1.726	1.709	1.630
30			1.127	1.499	1.695	1.756	1.726	1.707	1.644
35			1.127	1.499	1.695	1.756	1.726	1.706	1.658
40			1.127	1.499	1.695	1.756	1.726	1.706	1.670
μt[mfp]	0.2	0.3	0.4	0.5	0.6	0.8	1	1.5	2
0.5	1.436	1.323	1.269	1.234	1.210	1.191	1.172	1.149	1.139
1	1.441	1.324	1.270	1.236	1.212	1.193	1.175	1.152	1.142
2	1.442	1.324	1.272	1.238	1.215	1.196	1.179	1.156	1.146
3	1.441	1.325	1.273	1.239	1.216	1.197	1.181	1.158	1.148
4	1.440	1.325	1.273	1.239	1.217	1.198	1.182	1.160	1.149
5	1.440	1.325	1.274	1.240	1.218	1.199	1.183	1.161	1.150
6	1.439	1.325	1.274	1.240	1.218	1.200	1.184	1.162	1.151
7	1.439	1.326	1.274	1.240	1.219	1.200	1.185	1.162	1.152
8	1.439	1.326	1.274	1.241	1.219	1.200	1.185	1.163	1.152
10	1.439	1.326	1.274	1.241	1.220	1.201	1.186	1.163	1.153
15	1.439	1.326	1.274	1.241	1.220	1.202	1.187	1.165	1.155
20	1.439	1.326	1.274	1.241	1.221	1.202	1.187	1.165	1.155
25	1.439	1.326	1.275	1.242	1.222	1.203	1.188	1.166	1.156
30	1.439	1.326	1.274	1.242	1.222	1.203	1.188	1.166	1.156
35	1.439	1.326	1.274	1.242	1.222	1.203	1.188	1.166	1.156
40	1.439	1.326	1.274	1.242	1.222	1.203	1.188	1.166	1.156
μt[mfp]	3	4	5	6	8	10			
0.5	1.128	1.117	1.104	1.100	1.086	1.075			
1	1.131	1.119	1.107	1.103	1.089	1.078			
2	1.134	1.123	1.111	1.106	1.092	1.081			
3	1.136	1.126	1.115	1.110	1.095	1.084			
4	1.138	1.128	1.118	1.113	1.099	1.088			
5	1.139	1.130	1.120	1.115	1.103	1.092			
6	1.140	1.131	1.123	1.118	1.106	1.096			
7	1.141	1.133	1.124	1.120	1.109	1.101			
8	1.141	1.134	1.126	1.122	1.112	1.105			
10	1.143	1.135	1.129	1.125	1.117	1.112			
15	1.144	1.138	1.134	1.131	1.127	1.125			
20	1.146	1.140	1.137	1.135	1.132	1.132			
25	1.146	1.141	1.138	1.137	1.136	1.136			
30	1.147	1.142	1.140	1.139	1.138	1.138			
35	1.147	1.143	1.141	1.140	1.140	1.140			
40	1.147	1.143	1.142	1.141	1.141	1.141			

μt: thickness of shield (unit: mean free path)

Table A5.4.39 Effective conversion coefficients $\bar{f}_{10}^{*}$ of concrete from air absorbed dose to ambient dose equivalent

μt[mfp]	Photon energy [MeV]								
	0.015	0.02	0.03	0.04	0.05	0.06	0.08	0.1	0.15
0.5	0.2738	0.6316	1.115	1.466	1.652	1.727	1.728	1.671	1.544
1	0.2734	0.6308	1.110	1.453	1.637	1.713	1.727	1.685	1.576
2	0.2732	0.6302	1.107	1.444	1.626	1.703	1.724	1.695	1.607
3	0.2730	0.6300	1.106	1.442	1.622	1.699	1.724	1.700	1.621
4	0.2730	0.6299	1.106	1.441	1.620	1.698	1.723	1.703	1.630
5	0.2729	0.6299	1.106	1.441	1.620	1.697	1.723	1.705	1.635
6	0.2729	0.6299	1.106	1.441	1.620	1.697	1.723	1.706	1.640
7	0.2728	0.6299	1.107	1.441	1.620	1.697	1.724	1.707	1.643
8	0.2728	0.6299	1.107	1.442	1.620	1.697	1.724	1.708	1.645
10	0.2728	0.6299	1.107	1.442	1.620	1.697	1.724	1.709	1.649
15	0.2726	0.6299	1.108	1.443	1.620	1.697	1.724	1.711	1.655
20	0.2726	0.6299	1.108	1.444	1.620	1.697	1.724	1.712	1.659
25	0.2725	0.6299	1.108	1.444	1.620	1.697	1.724	1.713	1.662
30	0.2725	0.6298	1.108	1.444	1.621	1.697	1.724	1.713	1.664
35	0.2725	0.6298	1.109	1.444	1.621	1.697	1.724	1.714	1.665
40	0.2724	0.6298	1.109	1.445	1.621	1.697	1.724	1.714	1.666

μt[mfp]	0.2	0.3	0.4	0.5	0.6	0.8	1	1.5	2
0.5	1.437	1.354	1.311	1.275	1.246	1.221	1.199	1.170	1.156
1	1.482	1.395	1.349	1.309	1.279	1.249	1.226	1.191	1.174
2	1.527	1.442	1.392	1.349	1.318	1.283	1.257	1.216	1.194
3	1.551	1.466	1.415	1.370	1.339	1.301	1.273	1.229	1.204
4	1.565	1.481	1.430	1.384	1.353	1.312	1.283	1.237	1.210
5	1.574	1.491	1.439	1.392	1.361	1.320	1.290	1.242	1.214
6	1.580	1.499	1.447	1.399	1.368	1.325	1.295	1.246	1.217
7	1.586	1.505	1.452	1.404	1.373	1.330	1.299	1.248	1.219
8	1.590	1.509	1.456	1.408	1.377	1.333	1.301	1.251	1.221
10	1.596	1.516	1.463	1.414	1.383	1.338	1.306	1.254	1.224
15	1.605	1.528	1.474	1.424	1.392	1.345	1.312	1.258	1.227
20	1.611	1.535	1.481	1.430	1.398	1.349	1.315	1.261	1.229
25	1.615	1.540	1.486	1.434	1.401	1.352	1.318	1.262	1.230
30	1.618	1.544	1.489	1.436	1.404	1.353	1.319	1.263	1.230
35	1.621	1.546	1.492	1.438	1.405	1.355	1.320	1.264	1.231
40	1.622	1.549	1.493	1.440	1.407	1.356	1.320	1.264	1.231

μt[mfp]	3	4	5	6	8	10
0.5	1.140	1.126	1.113	1.107	1.091	1.079
1	1.154	1.139	1.125	1.118	1.101	1.087
2	1.169	1.151	1.136	1.127	1.108	1.094
3	1.176	1.157	1.142	1.132	1.113	1.098
4	1.180	1.161	1.145	1.135	1.116	1.101
5	1.183	1.163	1.148	1.137	1.118	1.104
6	1.185	1.165	1.150	1.139	1.121	1.106
7	1.187	1.167	1.151	1.140	1.122	1.108
8	1.188	1.168	1.152	1.141	1.123	1.109
10	1.190	1.170	1.154	1.143	1.125	1.111
15	1.193	1.172	1.157	1.146	1.128	1.114
20	1.194	1.173	1.158	1.147	1.130	1.116
25	1.195	1.174	1.159	1.148	1.131	1.118
30	1.195	1.175	1.160	1.148	1.131	1.118
35	1.195	1.175	1.160	1.149	1.132	1.119
40	1.196	1.175	1.160	1.149	1.133	1.120

μt: thickness of shield (unit: mean free path)

Table A5.4.40 Effective conversion coefficients $\bar{f}^*_{10}$ of water from air absorbed dose to ambient dose equivalent

μt[mfp]	Photon energy [MeV]								
	0.015	0.02	0.03	0.04	0.05	0.06	0.08	0.1	0.15
0.5	0.2701	0.6218	1.067	1.385	1.575	1.666	1.702	1.665	1.551
1	0.2686	0.6171	1.042	1.335	1.512	1.604	1.664	1.658	1.583
2	0.2672	0.6130	1.019	1.287	1.448	1.535	1.609	1.625	1.597
3	0.2665	0.6113	1.009	1.265	1.415	1.498	1.574	1.599	1.594
4	0.2660	0.6104	1.004	1.252	1.396	1.476	1.551	1.580	1.587
5	0.2657	0.6099	1.002	1.244	1.383	1.461	1.535	1.566	1.580
6	0.2654	0.6097	1.000	1.239	1.375	1.450	1.523	1.555	1.575
7	0.2653	0.6097	1.000	1.236	1.369	1.442	1.515	1.546	1.570
8	0.2652	0.6097	0.9991	1.233	1.364	1.436	1.508	1.540	1.566
10	0.2651	0.6098	0.9991	1.230	1.358	1.428	1.498	1.530	1.559
15	0.2649	0.6102	0.9992	1.225	1.348	1.416	1.483	1.515	1.549
20	0.2648	0.6104	1.000	1.223	1.343	1.409	1.474	1.507	1.544
25	0.2646	0.6105	0.9994	1.221	1.339	1.404	1.468	1.501	1.539
30	0.2645	0.6106	1.000	1.220	1.336	1.400	1.464	1.497	1.536
35	0.2644	0.6106	1.000	1.218	1.334	1.397	1.460	1.493	1.534
40	0.2644	0.6106	1.000	1.217	1.332	1.395	1.457	1.491	1.532

μt[mfp]	0.2	0.3	0.4	0.5	0.6	0.8	1.5	1	2
0.5	1.447	1.362	1.318	1.281	1.252	1.226	1.174	1.204	1.160
1	1.499	1.414	1.367	1.325	1.293	1.263	1.202	1.238	1.183
2	1.545	1.472	1.425	1.378	1.347	1.310	1.236	1.282	1.211
3	1.560	1.500	1.456	1.406	1.375	1.335	1.254	1.304	1.224
4	1.564	1.514	1.473	1.422	1.392	1.350	1.263	1.318	1.231
5	1.565	1.522	1.483	1.432	1.403	1.359	1.269	1.326	1.236
6	1.565	1.527	1.490	1.439	1.410	1.366	1.274	1.332	1.239
7	1.564	1.531	1.496	1.444	1.416	1.371	1.277	1.336	1.242
8	1.563	1.533	1.499	1.448	1.420	1.375	1.280	1.339	1.244
10	1.561	1.537	1.505	1.454	1.426	1.380	1.283	1.344	1.247
15	1.557	1.542	1.514	1.463	1.436	1.388	1.289	1.352	1.251
20	1.554	1.544	1.519	1.468	1.441	1.393	1.291	1.355	1.252
25	1.552	1.546	1.522	1.472	1.445	1.396	1.293	1.358	1.254
30	1.551	1.547	1.524	1.474	1.447	1.397	1.294	1.359	1.254
35	1.550	1.548	1.525	1.475	1.449	1.399	1.295	1.361	1.255
40	1.549	1.548	1.527	1.477	1.450	1.400	1.295	1.361	1.255

μt[mfp]	3	4	5	6	8	10
0.5	1.142	1.128	1.114	1.108	1.092	1.079
1	1.161	1.144	1.129	1.121	1.102	1.088
2	1.180	1.159	1.142	1.131	1.111	1.095
3	1.189	1.166	1.148	1.137	1.115	1.099
4	1.194	1.170	1.152	1.140	1.119	1.102
5	1.197	1.173	1.155	1.142	1.121	1.105
6	1.199	1.175	1.156	1.144	1.123	1.107
7	1.201	1.177	1.158	1.145	1.124	1.108
8	1.202	1.178	1.159	1.146	1.125	1.109
10	1.205	1.180	1.161	1.148	1.127	1.111
15	1.207	1.182	1.164	1.150	1.130	1.114
20	1.209	1.183	1.165	1.151	1.131	1.115
25	1.210	1.184	1.166	1.152	1.132	1.116
30	1.210	1.185	1.166	1.152	1.132	1.117
35	1.211	1.185	1.167	1.153	1.133	1.117
40	1.211	1.185	1.167	1.153	1.133	1.118

μt: thickness of shield (unit: mean free path)

Table A5.4.41 Exposure buildup factors for a point isotropic source in iron

μt[mfp]	Photon energy [MeV]								
	0.015	0.02	0.03	0.04	0.05	0.06	0.08	0.1	0.15
0.5	1.00	1.01	1.02	1.04	1.07	1.11	1.19	1.26	1.40
1	1.00	1.01	1.03	1.06	1.10	1.15	1.27	1.40	1.68
2	1.01	1.01	1.04	1.08	1.14	1.21	1.39	1.61	2.15
3	1.01	1.02	1.04	1.09	1.16	1.25	1.49	1.78	2.59
4	1.01	1.02	1.05	1.10	1.18	1.29	1.57	1.94	3.00
5	1.01	1.02	1.05	1.11	1.20	1.32	1.64	2.07	3.39
6	1.01	1.02	1.06	1.12	1.22	1.34	1.70	2.20	3.77
7	1.01	1.02	1.06	1.13	1.23	1.37	1.75	2.31	4.13
8	1.01	1.02	1.06	1.13	1.24	1.39	1.81	2.41	4.49
10	1.01	1.02	1.07	1.14	1.26	1.42	1.90	2.61	5.17
15	1.01	1.03	1.07	1.16	1.30	1.49	2.08	3.01	6.75
20	1.01	1.03	1.08	1.17	1.33	1.54	2.22	3.33	8.21
25	1.01	1.03	1.08	1.18	1.35	1.58	2.34	3.61	9.58
30	1.01	1.03	1.09	1.19	1.37	1.62	2.45	3.86	10.9
35	1.01	1.03	1.09	1.20	1.38	1.64	2.53	4.07	12.1
40	1.01	1.04	1.09	1.21	1.39	1.66	2.59	4.23	13.2
μt[mfp]	0.2	0.3	0.4	0.5	0.6	0.8	1	1.5	2
0.5	1.47	1.51	1.50	1.48	1.46	1.43	1.41	1.37	1.35
1	1.86	1.99	2.01	1.99	1.96	1.90	1.85	1.76	1.71
2	2.59	3.00	3.12	3.12	3.07	2.96	2.85	2.62	2.49
3	3.33	4.12	4.40	4.44	4.39	4.20	4.00	3.59	3.34
4	4.08	5.34	5.86	5.96	5.90	5.62	5.30	4.65	4.25
5	4.85	6.66	7.48	7.68	7.61	7.21	6.74	5.79	5.22
6	5.64	8.08	9.27	9.58	9.51	8.96	8.31	7.01	6.25
7	6.44	9.59	11.2	11.7	11.6	10.9	10.0	8.30	7.33
8	7.25	11.2	13.3	14.0	13.9	13.0	11.8	9.65	8.45
10	8.90	14.7	18.1	19.1	19.0	17.5	15.8	12.5	10.8
15	13.2	24.7	32.6	35.1	34.8	31.4	27.5	20.6	17.4
20	17.6	36.4	50.8	55.4	54.8	48.5	41.3	29.7	24.6
25	22.2	49.6	72.5	79.9	78.8	68.4	57.0	39.7	32.5
30	26.9	64.3	97.7	108	107	91.0	74.5	50.4	40.9
35	31.7	80.3	126	141	138	116	93.5	61.8	49.8
40	36.4	97.4	158	177	173	144	114	73.8	59.1
μt[mfp]	3	4	5	6	8	10			
0.5	1.32	1.30	1.27	1.25	1.22	1.19			
1	1.64	1.57	1.51	1.47	1.39	1.33			
2	2.28	2.12	1.97	1.87	1.71	1.59			
3	2.96	2.68	2.46	2.30	2.04	1.86			
4	3.68	3.29	2.98	2.76	2.41	2.16			
5	4.45	3.93	3.53	3.25	2.81	2.50			
6	5.25	4.60	4.11	3.78	3.24	2.87			
7	6.09	5.31	4.73	4.33	3.71	3.27			
8	6.96	6.05	5.38	4.92	4.20	3.71			
10	8.80	7.60	6.75	6.18	5.30	4.69			
15	13.8	11.9	10.7	9.85	8.64	7.88			
20	19.4	16.8	15.2	14.2	12.9	12.3			
25	25.4	22.1	20.3	19.3	18.2	18.1			
30	31.7	27.9	25.9	25.1	24.5	25.7			
35	38.4	34.0	32.0	31.5	32.0	35.3			
40	45.5	40.6	38.8	38.8	40.9	47.6			

μt: thickness of shield (unit: mean free path)

Table A5.4.42 Exposure buildup factors for a point isotropic source in lead

μt[mfp]	Photon energy [MeV]								
	0.015	0.02	0.03	0.04	0.05	0.06	0.08	0.1	0.15
0.5			1.01	1.01	1.02	1.02	1.04	1.51	1.25
1			1.01	1.01	1.02	1.03	1.06	2.04	1.40
2			1.01	1.02	1.03	1.05	1.08	3.39	1.59
3			1.01	1.02	1.04	1.05	1.10	5.60	1.69
4			1.01	1.02	1.04	1.06	1.11	9.59	1.77
5			1.01	1.03	1.04	1.06	1.12	17.0	1.84
6			1.01	1.03	1.04	1.07	1.13	30.6	1.90
7			1.01	1.03	1.05	1.07	1.13	54.9	1.95
8			1.02	1.03	1.05	1.07	1.14	94.7	2.01
10			1.02	1.03	1.05	1.08	1.15	294	2.13
15			1.02	1.04	1.06	1.09	1.17	5800	2.47
20			1.02	1.04	1.06	1.10	1.19	1.33E+5	2.88
25			1.02	1.04	1.07	1.11	1.21	3.34E+6	3.34
30			1.02	1.05	1.07	1.11	1.22	8.77E+7	4.03
35			1.02	1.05	1.08	1.12	1.23	2.36E+9	5.06
40			1.02	1.05	1.08	1.12	1.24	6.43E+10	6.65
μt[mfp]	0.2	0.3	0.4	0.5	0.6	0.8	1	1.5	2
0.5	1.15	1.10	1.12	1.14	1.15	1.18	1.20	1.19	1.21
1	1.20	1.15	1.19	1.24	1.28	1.34	1.38	1.38	1.40
2	1.24	1.21	1.30	1.39	1.46	1.59	1.68	1.73	1.76
3	1.26	1.26	1.39	1.52	1.62	1.82	1.95	2.07	2.14
4	1.28	1.30	1.45	1.62	1.76	2.01	2.20	2.40	2.52
5	1.29	1.33	1.51	1.71	1.88	2.19	2.43	2.74	2.91
6	1.30	1.36	1.57	1.80	2.00	2.37	2.67	3.08	3.33
7	1.31	1.38	1.62	1.88	2.10	2.53	2.89	3.42	3.74
8	1.33	1.40	1.67	1.95	2.20	2.69	3.10	3.77	4.17
10	1.35	1.44	1.75	2.10	2.39	2.99	3.51	4.47	5.07
15	1.39	1.52	1.93	2.39	2.79	3.65	4.45	6.26	7.45
20	1.42	1.59	2.08	2.64	3.11	4.20	5.27	8.11	9.98
25	1.45	1.64	2.19	2.85	3.38	4.67	5.99	9.94	12.6
30	1.47	1.68	2.29	3.02	3.61	5.10	6.64	11.7	15.4
35	1.49	1.72	2.38	3.18	3.82	5.49	7.24	13.4	18.2
40	1.50	1.75	2.45	3.31	4.02	5.84	7.79	15.0	21.0
μt[mfp]	3	4	5	6	8	10			
0.5	1.23	1.21	1.25	1.26	1.30	1.28			
1	1.40	1.37	1.41	1.42	1.51	1.51			
2	1.73	1.67	1.71	1.73	1.90	2.01			
3	2.10	2.02	2.05	2.08	2.36	2.63			
4	2.50	2.40	2.44	2.49	2.92	3.42			
5	2.93	2.82	2.88	2.96	3.59	4.45			
6	3.40	3.29	3.38	3.51	4.41	5.73			
7	3.89	3.79	3.93	4.13	5.39	7.37			
8	4.41	4.35	4.56	4.84	6.58	9.44			
10	5.56	5.61	6.03	6.61	9.73	15.4			
15	8.91	9.74	11.4	13.7	25.1	50.8			
20	12.9	15.4	19.9	26.6	62.0	161			
25	17.5	23.0	33.0	49.6	148	495			
30	22.5	32.6	52.2	88.9	344	1470			
35	28.1	44.6	79.9	155	780	4280			
40	34.0	59.2	119	262	1730	1.22E+4			

μt: thickness of shield (unit: mean free path)

Table A5.4.43 Exposure buildup factors for a point isotropic source in concrete

μt[mfp]	Photon energy [MeV]								
	0.015	0.02	0.03	0.04	0.05	0.06	0.08	0.1	0.15
0.5	1.02	1.05	1.15	1.30	1.42	1.68	1.84	1.89	1.84
1	1.03	1.07	1.21	1.46	1.74	2.15	2.58	2.78	2.82
2	1.04	1.09	1.30	1.69	2.26	2.89	3.96	4.63	5.13
3	1.05	1.11	1.37	1.87	2.63	3.54	5.31	6.63	7.92
4	1.05	1.13	1.43	2.01	2.95	4.17	6.69	8.80	11.2
5	1.06	1.14	1.47	2.14	3.25	4.77	8.09	11.1	15.0
6	1.06	1.15	1.51	2.25	3.53	5.34	9.52	13.6	19.3
7	1.07	1.16	1.54	2.35	3.79	5.90	11.0	16.3	24.2
8	1.07	1.17	1.57	2.45	4.04	6.44	12.5	19.2	29.7
10	1.08	1.18	1.63	2.62	4.51	7.52	15.7	25.6	42.7
15	1.09	1.21	1.74	2.98	5.57	10.2	24.3	44.9	87.6
20	1.10	1.22	1.82	3.27	6.52	12.7	33.8	69.1	153
25	1.10	1.24	1.89	3.51	7.38	15.2	44.3	97.9	240
30	1.11	1.25	1.94	3.73	8.18	18.2	55.4	131	353
35	1.11	1.26	1.99	3.91	8.87	21.9	66.8	170	494
40	1.11	1.27	2.02	4.03	9.44	26.5	78.1	214	664
μt[mfp]	0.2	0.3	0.4	0.5	0.6	0.8	1	1.5	2
0.5	1.78	1.68	1.61	1.57	1.53	1.48	1.45	1.39	1.37
1	2.72	2.52	2.37	2.27	2.18	2.06	1.98	1.85	1.77
2	5.05	4.66	4.31	4.03	3.80	3.47	3.24	2.86	2.65
3	8.00	7.42	6.80	6.26	5.82	5.18	4.72	4.00	3.60
4	11.6	10.8	9.85	8.97	8.25	7.18	6.42	5.25	4.61
5	15.9	15.0	13.5	12.2	11.1	9.47	8.33	6.60	5.68
6	20.9	19.9	17.8	15.9	14.3	12.0	10.4	8.05	6.80
7	26.7	25.6	22.8	20.2	18.0	14.9	12.7	9.58	7.97
8	33.4	32.2	28.5	25.0	22.2	18.1	15.2	11.2	9.18
10	49.6	48.2	42.1	36.4	31.8	25.1	20.7	14.6	11.7
15	109	107	90.7	75.6	63.6	47.4	37.2	24.2	18.6
20	201	198	162	131	107	75.7	57.1	35.0	26.0
25	331	326	259	203	161	110	80.1	46.9	33.9
30	507	497	383	292	226	149	106	59.6	42.2
35	734	716	536	399	302	193	134	73.0	50.9
40	1020	985	719	523	389	242	164	87.1	59.8
μt[mfp]	3	4	5	6	8	10			
0.5	1.33	1.31	1.27	1.26	1.22	1.19			
1	1.67	1.61	1.53	1.49	1.41	1.35			
2	2.38	2.18	2.04	1.93	1.76	1.64			
3	3.09	2.77	2.53	2.37	2.11	1.93			
4	3.84	3.37	3.03	2.80	2.45	2.22			
5	4.61	3.98	3.54	3.25	2.81	2.51			
6	5.40	4.60	4.05	3.69	3.16	2.80			
7	6.20	5.23	4.57	4.14	3.51	3.10			
8	7.03	5.86	5.09	4.60	3.87	3.40			
10	8.71	7.15	6.15	5.52	4.59	4.01			
15	13.1	10.5	8.85	7.86	6.43	5.57			
20	17.7	13.9	11.6	10.2	8.31	7.19			
25	22.5	17.4	14.4	12.7	10.2	8.86			
30	27.4	20.9	17.3	15.2	12.2	10.6			
35	32.4	24.6	20.5	17.8	14.1	12.3			
40	37.4	28.4	24.8	20.5	16.2	14.5			

μt: thickness of shield (unit: mean free path)

Table A5.4.44 Exposure buildup factors for a point isotropic source in water

μt[mfp]	Photon energy [MeV]								
	0.015	0.02	0.03	0.04	0.05	0.06	0.08	0.1	0.15
0.5	1.13	1.28	1.77	2.22	2.52	2.62	2.55	2.37	2.07
1	1.18	1.43	2.35	3.47	4.42	4.90	4.95	4.55	3.89
2	1.27	1.67	3.32	6.18	9.25	11.4	12.6	11.8	9.49
3	1.33	1.86	4.21	9.14	15.3	20.4	24.5	23.8	19.0
4	1.38	2.02	5.07	12.3	22.6	32.0	41.1	41.3	33.3
5	1.43	2.16	5.89	15.7	31.0	46.4	63.3	65.2	53.4
6	1.46	2.28	6.68	19.2	40.5	63.6	91.4	96.7	80.1
7	1.50	2.39	7.45	22.9	51.3	83.9	126	137	115
8	1.53	2.50	8.20	26.8	63.2	107	169	187	158
10	1.58	2.68	9.69	35.1	90.9	165	281	321	277
15	1.68	3.08	13.5	59.2	185	386	762	938	834
20	1.75	3.42	17.2	88.5	323	751	1660	2170	1960
25	1.82	3.71	21.2	123	511	1310	3200	4360	3980
30	1.87	3.97	25.7	163	759	2110	5630	7970	7320
35	1.91	4.19	30.7	208	1080	3240	9300	1.35E+4	1.25E+4
40	1.94	4.36	36.3	259	1470	4740	1.46E+4	2.11E+4	2.03E+4
μt[mfp]	0.2	0.3	0.4	0.5	0.6	0.8	1	1.5	2
0.5	1.92	1.75	1.66	1.60	1.56	1.50	1.47	1.41	1.38
1	3.42	2.85	2.61	2.44	2.33	2.17	2.08	1.92	1.83
2	8.31	6.30	5.44	4.88	4.49	3.96	3.62	3.10	2.81
3	16.0	11.7	9.66	8.35	7.44	6.26	5.50	4.43	3.87
4	27.0	19.3	15.3	12.8	11.2	9.00	7.68	5.88	4.98
5	42.2	29.4	22.5	18.4	15.6	12.2	10.1	7.44	6.15
6	62.5	42.1	31.4	25.0	20.8	15.8	12.8	9.11	7.38
7	88.5	57.8	41.9	32.7	26.7	19.8	15.8	10.9	8.65
8	121	76.8	54.3	41.5	33.5	24.2	19.0	12.7	9.97
10	208	126	85.0	62.9	49.3	34.2	26.1	16.7	12.7
15	600	327	202	139	104	66.3	47.7	27.8	20.1
20	1350	676	387	252	179	108	74.0	40.4	28.0
25	2670	1220	649	403	276	157	104	54.0	36.5
30	4810	1990	999	594	395	215	139	68.7	45.2
35	8170	3040	1440	828	534	281	177	84.3	54.4
40	1.33E+4	4410	1990	1110	695	353	218	101	63.7
μt[mfp]	3	4	5	6	8	10			
0.5	1.34	1.31	1.28	1.27	1.23	1.20			
1	1.71	1.63	1.56	1.51	1.43	1.37			
2	2.46	2.24	2.08	1.97	1.80	1.68			
3	3.23	2.85	2.58	2.41	2.15	1.97			
4	4.00	3.46	3.08	2.84	2.49	2.25			
5	4.80	4.07	3.58	3.27	2.82	2.53			
6	5.61	4.68	4.08	3.70	3.15	2.80			
7	6.43	5.30	4.58	4.12	3.48	3.07			
8	7.27	5.92	5.07	4.54	3.80	3.34			
10	8.97	7.16	6.05	5.37	4.44	3.86			
15	13.3	10.3	8.49	7.41	5.99	5.14			
20	17.8	13.4	10.9	9.42	7.49	6.38			
25	22.4	16.5	13.3	11.4	8.96	7.59			
30	27.1	19.7	15.7	13.3	10.4	8.78			
35	31.8	22.8	18.0	15.0	11.9	9.96			
40	36.5	25.9	20.4	16.4	13.4	11.2			

μt: thickness of shield (unit: mean free path)

Table A5.5.1 Neutron and secondary gamma-ray effective dose rates for ^{252}Cf

	r [cm]	H_0	Water						Polyethylene			Ordinary Concrete			Heavy Concrete		
			H_n	H_g	H_t	F_n	F_g	F_t	F_n	F_g	F_t	F_n	F_g	F_t	F_n	F_g	F_t
1	5.00E+00	4.01E-03	3.56E-03	3.07E-05	3.59E-03	8.88E-01	7.67E-03	8.96E-01	8.27E-01	9.11E-03	8.36E-01	1.44E+00	4.65E-03	1.44E+00	1.55E+00	8.69E-03	1.56E+00
2	1.00E+01	1.00E-03	5.38E-04	1.75E-05	5.56E-04	5.37E-01	1.75E-02	5.54E-01	4.32E-01	1.94E-02	4.52E-01	1.34E+00	1.04E-02	1.35E+00	1.42E+00	1.79E-02	1.44E+00
3	1.50E+01	4.45E-04	1.38E-04	9.68E-06	1.48E-04	3.10E-01	2.17E-02	3.32E-01	2.12E-01	2.22E-02	2.34E-01	1.13E+00	1.62E-02	1.15E+00	1.12E+00	2.46E-02	1.15E+00
4	2.00E+01	2.51E-04	4.36E-05	5.43E-06	4.90E-05	1.74E-01	2.17E-02	1.96E-01	1.02E-01	2.09E-02	1.22E-01	8.95E-01	2.08E-02	9.16E-01	8.10E-01	2.67E-02	8.36E-01
5	2.50E+01	1.60E-04	1.54E-05	3.16E-06	1.86E-05	9.61E-02	1.97E-02	1.16E-01	4.84E-02	1.84E-02	6.68E-02	6.84E-01	2.35E-02	7.08E-01	5.51E-01	2.47E-02	5.75E-01
6	3.00E+01	1.11E-04	5.89E-06	1.91E-06	7.80E-06	5.29E-02	1.71E-02	7.00E-02	2.33E-02	1.59E-02	3.93E-02	5.11E-01	2.42E-02	5.35E-01	3.60E-01	2.05E-02	3.81E-01
7	3.50E+01	8.18E-05	2.39E-06	1.19E-06	3.58E-06	2.92E-02	1.46E-02	4.38E-02	1.15E-02	1.37E-02	2.52E-02	3.76E-01	2.33E-02	3.99E-01	2.29E-01	1.58E-02	2.45E-01
8	4.00E+01	6.26E-05	1.02E-06	7.70E-07	1.79E-06	1.63E-02	1.23E-02	2.86E-02	5.76E-03	1.18E-02	1.75E-02	2.73E-01	2.13E-02	2.94E-01	1.43E-01	1.15E-02	1.54E-01
9	4.50E+01	4.95E-05	4.53E-07	5.11E-07	9.64E-07	9.16E-03	1.03E-02	1.95E-02	2.96E-03	1.01E-02	1.31E-02	1.97E-01	1.88E-02	2.15E-01	8.79E-02	8.00E-03	9.59E-02
10	5.00E+01	4.01E-05	2.09E-07	3.47E-07	5.55E-07	5.21E-03	8.65E-03	1.39E-02	1.56E-03	8.66E-03	1.02E-02	1.41E-01	1.60E-02	1.57E-01	5.35E-02	5.43E-03	5.89E-02
11	5.50E+01	3.31E-05	9.94E-08	2.39E-07	3.39E-07	3.00E-03	7.22E-03	1.02E-02	8.33E-04	7.40E-03	8.23E-03	1.00E-01	1.33E-02	1.13E-01	3.23E-02	3.60E-03	3.59E-02
12	6.00E+01	2.78E-05	4.86E-08	1.68E-07	2.16E-07	1.75E-03	6.02E-03	7.77E-03	4.53E-04	6.30E-03	6.75E-03	7.09E-02	1.08E-02	8.17E-02	1.94E-02	2.36E-03	2.18E-02
13	6.50E+01	2.37E-05	2.43E-08	1.19E-07	1.43E-07	1.03E-03	5.01E-03	6.04E-03	2.50E-04	5.35E-03	5.60E-03	4.99E-02	8.70E-03	5.86E-02	1.16E-02	1.52E-03	1.31E-02
14	7.00E+01	2.05E-05	1.24E-08	8.52E-08	9.76E-08	6.07E-04	4.16E-03	4.77E-03	1.39E-04	4.53E-03	4.66E-03	3.51E-02	6.90E-03	4.20E-02	6.91E-03	9.73E-04	7.89E-03
15	7.50E+01	1.78E-05	6.46E-09	6.16E-08	6.80E-08	3.62E-04	3.46E-03	3.82E-03	7.84E-05	3.82E-03	3.90E-03	2.45E-02	5.40E-03	3.00E-02	4.11E-03	6.18E-04	4.72E-03
16	8.00E+01	1.57E-05	3.41E-09	4.48E-08	4.82E-08	2.18E-04	2.86E-03	3.08E-03	4.45E-05	3.22E-03	3.26E-03	1.71E-02	4.20E-03	2.13E-02	2.43E-03	3.90E-04	2.82E-03
17	8.50E+01	1.39E-05	1.82E-09	3.28E-08	3.47E-08	1.31E-04	2.37E-03	2.50E-03	2.55E-05	2.70E-03	2.73E-03	1.19E-02	3.24E-03	1.52E-02	1.44E-03	2.45E-04	1.68E-03
18	9.00E+01	1.24E-05	9.85E-10	2.42E-08	2.52E-08	7.96E-05	1.95E-03	2.03E-03	1.47E-05	2.27E-03	2.28E-03	8.29E-03	2.48E-03	1.08E-02	8.49E-04	1.53E-04	1.00E-03
19	9.50E+01	1.11E-05	5.38E-10	1.79E-08	1.84E-08	4.84E-05	1.61E-03	1.66E-03	8.48E-06	1.90E-03	1.91E-03	5.74E-03	1.89E-03	7.64E-03	5.01E-04	9.56E-05	5.96E-04
20	1.00E+02	1.00E-05	2.96E-10	1.33E-08	1.36E-08	2.96E-05	1.33E-03	1.36E-03	4.94E-06	1.59E-03	1.59E-03	3.97E-03	1.44E-03	5.41E-03	2.95E-04	5.95E-05	3.54E-04
21	1.05E+02	9.09E-06	1.65E-10	9.93E-09	1.01E-08	1.81E-05	1.09E-03	1.11E-03	2.89E-06	1.32E-03	1.33E-03	2.75E-03	1.09E-03	3.83E-03	1.73E-04	3.69E-05	2.10E-04
22	1.10E+02	8.28E-06	9.20E-11	7.44E-09	7.53E-09	1.11E-05	8.98E-04	9.09E-04	1.70E-06	1.10E-03	1.10E-03	1.89E-03	8.20E-04	2.71E-03	1.02E-04	2.29E-05	1.25E-04
23	1.15E+02	7.58E-06	5.18E-11	5.59E-09	5.64E-09	6.83E-06	7.37E-04	7.44E-04	1.00E-06	9.17E-04	9.18E-04	1.30E-03	6.17E-04	1.92E-03	5.98E-05	1.41E-05	7.39E-05
24	1.20E+02	6.96E-06	2.93E-11	4.21E-09	4.24E-09	4.21E-06	6.05E-04	6.09E-04	5.92E-07	7.62E-04	7.62E-04	8.97E-04	4.64E-04	1.36E-03	3.51E-05	8.73E-06	4.38E-05
25	1.25E+02	6.41E-06	1.67E-11	3.18E-09	3.19E-09	2.60E-06	4.95E-04	4.98E-04	3.52E-07	6.32E-04	6.32E-04	6.17E-04	3.48E-04	9.65E-04	2.06E-05	5.38E-06	2.60E-05
26	1.30E+02	5.93E-06	9.55E-12	2.41E-09	2.41E-09	1.61E-06	4.06E-04	4.07E-04	2.10E-07	5.24E-04	5.24E-04	4.23E-04	2.61E-04	6.84E-04	1.21E-05	3.31E-06	1.54E-05
27	1.35E+02	5.50E-06	5.49E-12	1.82E-09	1.83E-09	9.98E-07	3.32E-04	3.33E-04	1.25E-07	4.34E-04	4.34E-04	2.90E-04	1.95E-04	4.86E-04	7.06E-06	2.04E-06	9.10E-06
28	1.40E+02	5.11E-06	3.17E-12	1.39E-09	1.39E-09	6.20E-07	2.71E-04	2.72E-04	7.52E-08	3.59E-04	3.59E-04	1.99E-04	1.46E-04	3.45E-04	4.14E-06	1.25E-06	5.39E-06
29	1.45E+02	4.77E-06	1.84E-12	1.06E-09	1.06E-09	3.85E-07	2.22E-04	2.22E-04	4.52E-08	2.97E-04	2.97E-04	1.36E-04	1.10E-04	2.46E-04	2.42E-06	7.68E-07	3.19E-06
30	1.50E+02	4.45E-06	1.07E-12	8.06E-10	8.07E-10	2.40E-07	1.81E-04	1.81E-04	2.72E-08	2.45E-04	2.45E-04	9.33E-05	8.20E-05	1.75E-04	1.42E-06	4.71E-07	1.89E-06
31	1.55E+02	4.17E-06	6.25E-13	6.16E-10	6.16E-10	1.50E-07	1.48E-04	1.48E-04	1.65E-08	2.03E-04	2.03E-04	6.38E-05	6.14E-05	1.25E-04	8.29E-07	2.89E-07	1.12E-06
32	1.60E+02	3.91E-06	3.66E-13	4.71E-10	4.72E-10	9.35E-08	1.20E-04	1.21E-04	9.97E-09	1.67E-04	1.67E-04	4.36E-05	4.60E-05	8.96E-05	4.84E-07	1.77E-07	6.61E-07
33	1.65E+02	3.68E-06	2.15E-13	3.61E-10	3.62E-10	5.85E-08	9.82E-05	9.82E-05	6.04E-09	1.38E-04	1.38E-04	2.98E-05	3.45E-05	6.43E-05	2.83E-07	1.08E-07	3.91E-07
34	1.70E+02	3.47E-06	1.27E-13	2.77E-10	2.78E-10	3.67E-08	8.00E-05	8.01E-05	3.67E-09	1.14E-04	1.14E-04	2.03E-05	2.59E-05	4.62E-05	1.65E-07	6.62E-08	2.32E-07
35	1.75E+02	3.27E-06	7.53E-14	2.13E-10	2.13E-10	2.30E-08	6.52E-05	6.52E-05	2.24E-09	9.38E-05	9.38E-05	1.39E-05	1.95E-05	3.33E-05	9.67E-08	4.05E-08	1.37E-07
36	1.80E+02	3.09E-06	4.47E-14	1.64E-10	1.64E-10	1.45E-08	5.31E-05	5.31E-05	1.36E-09	7.73E-05	7.73E-05	9.45E-06	1.46E-05	2.41E-05	5.65E-08	2.47E-08	8.12E-08
37	1.85E+02	2.93E-06	2.66E-14	1.27E-10	1.27E-10	9.09E-09	4.33E-05	4.33E-05	8.33E-10	6.37E-05	6.37E-05	6.44E-06	1.10E-05	1.74E-05	3.30E-08	1.51E-08	4.81E-08
38	1.90E+02	2.78E-06	1.59E-14	9.79E-11	9.79E-11	5.73E-09	3.53E-05	3.53E-05	5.09E-10	5.24E-05	5.24E-05	4.39E-06	8.29E-06	1.27E-05	1.92E-08	9.22E-09	2.85E-08
39	1.95E+02	2.64E-06	9.52E-15	7.57E-11	7.57E-11	3.61E-09	2.87E-05	2.87E-05	3.12E-10	4.32E-05	4.32E-05	2.99E-06	6.25E-06	9.24E-06	1.12E-08	5.62E-09	1.68E-08
40	2.00E+02	2.51E-06	5.71E-15	5.86E-11	5.86E-11	2.28E-09	2.34E-05	2.34E-05	1.91E-10	3.56E-05	3.56E-05	2.03E-06	4.72E-06	6.75E-06	6.55E-09	3.43E-09	9.98E-09
41	2.05E+02	2.38E-06	3.44E-15	4.55E-11	4.55E-11	1.44E-09	1.91E-05	1.91E-05	1.17E-10	2.93E-05	2.93E-05	1.38E-06	3.57E-06	4.95E-06	3.82E-09	2.09E-09	5.91E-09
42	2.10E+02	2.27E-06	2.07E-15	3.53E-11	3.53E-11	9.12E-10	1.55E-05	1.56E-05	7.22E-11	2.41E-05	2.41E-05	9.40E-07	2.70E-06	3.64E-06	2.23E-09	1.27E-09	3.50E-09
43	2.15E+02	2.17E-06	1.25E-15	2.75E-11	2.75E-11	5.78E-10	1.27E-05	1.27E-05	4.44E-11	1.99E-05	1.99E-05	6.39E-07	2.04E-06	2.68E-06	1.30E-09	7.75E-10	2.07E-09
44	2.20E+02	2.07E-06	7.59E-16	2.14E-11	2.14E-11	3.67E-10	1.03E-05	1.03E-05	2.73E-11	1.63E-05	1.63E-05	4.34E-07	1.55E-06	1.98E-06	7.56E-10	4.72E-10	1.23E-09

Table A5.5.2 Neutron and secondary gamma-ray effective dose rates for Am-Be

	r [cm]	H_0	Water						Polyethylene			Ordinary Concrete			Heavy Concrete		
			H_n	H_g	H_t	F_n	F_g	F_t	F_n	F_g	F_t	F_n	F_g	F_t	F_n	F_g	F_t
1	5.00E+00	4.77E-03	4.76E-03	2.37E-05	4.78E-03	9.98E-01	4.98E-03	1.00E+00	9.62E-01	6.66E-03	9.68E-01	1.38E+00	4.57E-03	1.39E+00	1.48E+00	1.04E-02	1.49E+00
2	1.00E+01	1.19E-03	8.48E-04	1.43E-05	8.63E-04	7.12E-01	1.20E-02	7.24E-01	6.09E-01	1.48E-02	6.24E-01	1.37E+00	9.12E-03	1.38E+00	1.42E+00	1.73E-02	1.43E+00
3	1.50E+01	5.29E-04	2.54E-04	8.50E-06	2.62E-04	4.79E-01	1.61E-02	4.95E-01	3.59E-01	1.82E-02	3.77E-01	1.24E+00	1.33E-02	1.25E+00	1.19E+00	2.17E-02	1.21E+00
4	2.00E+01	2.98E-04	9.18E-05	5.07E-06	9.69E-05	3.08E-01	1.70E-02	3.25E-01	2.02E-01	1.81E-02	2.20E-01	1.05E+00	1.67E-02	1.07E+00	9.17E-01	2.28E-02	9.40E-01
5	2.50E+01	1.91E-04	3.68E-05	3.08E-06	3.99E-05	1.93E-01	1.62E-02	2.09E-01	1.11E-01	1.65E-02	1.28E-01	8.60E-01	1.87E-02	8.78E-01	6.66E-01	2.13E-02	6.87E-01
6	3.00E+01	1.32E-04	1.58E-05	1.92E-06	1.77E-05	1.19E-01	1.45E-02	1.34E-01	6.05E-02	1.45E-02	7.51E-02	6.80E-01	1.94E-02	7.00E-01	4.64E-01	1.81E-02	4.82E-01
7	3.50E+01	9.73E-05	7.08E-06	1.23E-06	8.31E-06	7.28E-02	1.27E-02	8.54E-02	3.30E-02	1.26E-02	4.56E-02	5.26E-01	1.90E-02	5.45E-01	3.13E-01	1.44E-02	3.28E-01
8	4.00E+01	7.45E-05	3.30E-06	8.09E-07	4.11E-06	4.43E-02	1.09E-02	5.52E-02	1.80E-02	1.08E-02	2.88E-02	4.01E-01	1.77E-02	4.18E-01	2.07E-01	1.09E-02	2.18E-01
9	4.50E+01	5.88E-05	1.58E-06	5.42E-07	2.13E-06	2.69E-02	9.22E-03	3.61E-02	9.83E-03	9.30E-03	1.91E-02	3.01E-01	1.60E-02	3.17E-01	1.34E-01	7.95E-03	1.42E-01
10	5.00E+01	4.77E-05	7.78E-07	3.71E-07	1.15E-06	1.63E-02	7.78E-03	2.41E-02	5.39E-03	7.96E-03	1.34E-02	2.23E-01	1.39E-02	2.37E-01	8.59E-02	5.62E-03	9.15E-02
11	5.50E+01	3.94E-05	3.90E-07	2.58E-07	6.48E-07	9.91E-03	6.54E-03	1.65E-02	2.97E-03	6.79E-03	9.76E-03	1.65E-01	1.19E-02	1.76E-01	5.44E-02	3.89E-03	5.83E-02
12	6.00E+01	3.31E-05	1.99E-07	1.81E-07	3.81E-07	6.02E-03	5.48E-03	1.15E-02	1.64E-03	5.78E-03	7.42E-03	1.20E-01	9.92E-03	1.30E-01	3.41E-02	2.64E-03	3.68E-02
13	6.50E+01	2.82E-05	1.03E-07	1.29E-07	2.32E-07	3.66E-03	4.59E-03	8.24E-03	9.10E-04	4.91E-03	5.82E-03	8.73E-02	8.15E-03	9.54E-02	2.12E-02	1.77E-03	2.30E-02
14	7.00E+01	2.43E-05	5.41E-08	9.31E-08	1.47E-07	2.22E-03	3.83E-03	6.05E-03	5.06E-04	4.16E-03	4.67E-03	6.30E-02	6.60E-03	6.96E-02	1.31E-02	1.17E-03	1.43E-02
15	7.50E+01	2.12E-05	2.87E-08	6.76E-08	9.63E-08	1.35E-03	3.19E-03	4.55E-03	2.82E-04	3.52E-03	3.80E-03	4.53E-02	5.28E-03	5.06E-02	8.08E-03	7.65E-04	8.85E-03
16	8.00E+01	1.86E-05	1.53E-08	4.95E-08	6.48E-08	8.24E-04	2.66E-03	3.48E-03	1.57E-04	2.97E-03	3.13E-03	3.24E-02	4.19E-03	3.66E-02	4.95E-03	4.97E-04	5.45E-03
17	8.50E+01	1.65E-05	8.27E-09	3.64E-08	4.47E-08	5.02E-04	2.21E-03	2.71E-03	8.79E-05	2.50E-03	2.59E-03	2.31E-02	3.29E-03	2.64E-02	3.02E-03	3.20E-04	3.34E-03
18	9.00E+01	1.47E-05	4.49E-09	2.70E-08	3.15E-08	3.05E-04	1.84E-03	2.14E-03	4.92E-05	2.10E-03	2.15E-03	1.64E-02	2.56E-03	1.90E-02	1.84E-03	2.05E-04	2.04E-03
19	9.50E+01	1.32E-05	2.46E-09	2.01E-08	2.26E-08	1.86E-04	1.52E-03	1.71E-03	2.76E-05	1.77E-03	1.79E-03	1.16E-02	1.99E-03	1.36E-02	1.11E-03	1.31E-04	1.24E-03
20	1.00E+02	1.19E-05	1.35E-09	1.50E-08	1.64E-08	1.13E-04	1.26E-03	1.38E-03	1.55E-05	1.48E-03	1.50E-03	8.23E-03	1.53E-03	9.76E-03	6.74E-04	8.30E-05	7.57E-04
21	1.05E+02	1.08E-05	7.46E-10	1.13E-08	1.20E-08	6.90E-05	1.05E-03	1.12E-03	8.71E-06	1.24E-03	1.25E-03	5.81E-03	1.17E-03	6.98E-03	4.06E-04	5.24E-05	4.59E-04
22	1.10E+02	9.85E-06	4.14E-10	8.53E-09	8.94E-09	4.20E-05	8.66E-04	9.08E-04	4.91E-06	1.04E-03	1.04E-03	4.09E-03	8.97E-04	4.98E-03	2.45E-04	3.30E-05	2.78E-04
23	1.15E+02	9.01E-06	2.31E-10	6.45E-09	6.68E-09	2.56E-05	7.16E-04	7.42E-04	2.76E-06	8.67E-04	8.70E-04	2.87E-03	6.83E-04	3.55E-03	1.47E-04	2.07E-05	1.68E-04
24	1.20E+02	8.27E-06	1.29E-10	4.90E-09	5.03E-09	1.56E-05	5.92E-04	6.08E-04	1.56E-06	7.24E-04	7.25E-04	2.01E-03	5.18E-04	2.53E-03	8.82E-05	1.30E-05	1.01E-04
25	1.25E+02	7.62E-06	7.24E-11	3.73E-09	3.81E-09	9.49E-06	4.90E-04	4.99E-04	8.80E-07	6.04E-04	6.05E-04	1.41E-03	3.92E-04	1.80E-03	5.28E-05	8.11E-06	6.09E-05
26	1.30E+02	7.05E-06	4.08E-11	2.85E-09	2.89E-09	5.78E-06	4.05E-04	4.11E-04	4.97E-07	5.03E-04	5.04E-04	9.84E-04	2.96E-04	1.28E-03	3.16E-05	5.05E-06	3.66E-05
27	1.35E+02	6.54E-06	2.30E-11	2.19E-09	2.21E-09	3.52E-06	3.35E-04	3.38E-04	2.81E-07	4.19E-04	4.19E-04	6.86E-04	2.23E-04	9.10E-04	1.89E-05	3.14E-06	2.20E-05
28	1.40E+02	6.08E-06	1.30E-11	1.68E-09	1.69E-09	2.14E-06	2.77E-04	2.79E-04	1.59E-07	3.49E-04	3.49E-04	4.78E-04	1.68E-04	6.46E-04	1.13E-05	1.95E-06	1.32E-05
29	1.45E+02	5.67E-06	7.40E-12	1.30E-09	1.30E-09	1.31E-06	2.29E-04	2.30E-04	9.00E-08	2.90E-04	2.90E-04	3.33E-04	1.27E-04	4.59E-04	6.71E-06	1.21E-06	7.91E-06
30	1.50E+02	5.29E-06	4.21E-12	1.00E-09	1.01E-09	7.95E-07	1.89E-04	1.90E-04	5.10E-08	2.42E-04	2.42E-04	2.31E-04	9.51E-05	3.26E-04	3.99E-06	7.48E-07	4.74E-06
31	1.55E+02	4.96E-06	2.40E-12	7.75E-10	7.78E-10	4.84E-07	1.56E-04	1.57E-04	2.89E-08	2.01E-04	2.01E-04	1.61E-04	7.14E-05	2.32E-04	2.37E-06	4.62E-07	2.83E-06
32	1.60E+02	4.65E-06	1.37E-12	6.02E-10	6.04E-10	2.95E-07	1.29E-04	1.30E-04	1.64E-08	1.67E-04	1.67E-04	1.11E-04	5.36E-05	1.65E-04	1.41E-06	2.85E-07	1.69E-06
33	1.65E+02	4.38E-06	7.85E-13	4.69E-10	4.70E-10	1.79E-07	1.07E-04	1.07E-04	9.29E-09	1.39E-04	1.39E-04	7.72E-05	4.03E-05	1.17E-04	8.36E-07	1.76E-07	1.01E-06
34	1.70E+02	4.12E-06	4.50E-13	3.66E-10	3.67E-10	1.09E-07	8.88E-05	8.89E-05	5.27E-09	1.15E-04	1.15E-04	5.34E-05	3.02E-05	8.36E-05	4.96E-07	1.08E-07	6.04E-07
35	1.75E+02	3.89E-06	2.59E-13	2.87E-10	2.87E-10	6.65E-08	7.37E-05	7.37E-05	2.99E-09	9.60E-05	9.60E-05	3.70E-05	2.27E-05	5.96E-05	2.94E-07	6.66E-08	3.60E-07
36	1.80E+02	3.68E-06	1.49E-13	2.25E-10	2.25E-10	4.05E-08	6.12E-05	6.12E-05	1.70E-09	7.98E-05	7.99E-05	2.55E-05	1.70E-05	4.26E-05	1.74E-07	4.09E-08	2.15E-07
37	1.85E+02	3.48E-06	8.57E-14	1.77E-10	1.77E-10	2.46E-08	5.08E-05	5.09E-05	9.64E-10	6.64E-05	6.64E-05	1.76E-05	1.28E-05	3.04E-05	1.03E-07	2.51E-08	1.28E-07
38	1.90E+02	3.30E-06	4.95E-14	1.40E-10	1.40E-10	1.50E-08	4.23E-05	4.23E-05	5.47E-10	5.52E-05	5.52E-05	1.22E-05	9.62E-06	2.18E-05	6.07E-08	1.54E-08	7.61E-08
39	1.95E+02	3.13E-06	2.86E-14	1.10E-10	1.10E-10	9.13E-09	3.53E-05	3.53E-05	3.11E-10	4.60E-05	4.60E-05	8.39E-06	7.24E-06	1.56E-05	3.59E-08	9.44E-09	4.53E-08
40	2.00E+02	2.98E-06	1.65E-14	8.76E-11	8.76E-11	5.56E-09	2.94E-05	2.94E-05	1.77E-10	3.83E-05	3.83E-05	5.78E-06	5.45E-06	1.12E-05	2.12E-08	5.78E-09	2.69E-08
41	2.05E+02	2.83E-06	9.59E-15	6.97E-11	6.97E-11	3.38E-09	2.46E-05	2.46E-05	1.00E-10	3.19E-05	3.19E-05	3.98E-06	4.10E-06	8.08E-06	1.25E-08	3.54E-09	1.60E-08
42	2.10E+02	2.70E-06	5.56E-15	5.56E-11	5.56E-11	2.06E-09	2.06E-05	2.06E-05	5.70E-11	2.65E-05	2.65E-05	2.74E-06	3.09E-06	5.83E-06	7.35E-09	2.16E-09	9.52E-09
43	2.15E+02	2.58E-06	3.23E-15	4.45E-11	4.45E-11	1.25E-09	1.73E-05	1.73E-05	3.24E-11	2.21E-05	2.21E-05	1.88E-06	2.33E-06	4.21E-06	4.33E-09	1.32E-09	5.65E-09
44	2.20E+02	2.46E-06	1.88E-15	3.57E-11	3.57E-11	7.63E-10	1.45E-05	1.45E-05	1.84E-11	1.84E-05	1.84E-05	1.29E-06	1.76E-06	3.05E-06	2.55E-09	8.08E-10	3.36E-09

Table A5.5.3 Neutron and secondary gamma-ray effective dose rates for D-D

	r [cm]	H_0	Water						Polyethylene			Ordinary Concrete			Heavy Concrete		
			H_n	H_g	H_t	F_n	F_g	F_t	F_n	F_g	F_t	F_n	F_g	F_t	F_n	F_g	F_t
1	5.00E+00	4.69E-03	4.22E-03	2.21E-05	4.24E-03	9.00E-01	4.70E-03	9.05E-01	8.34E-01	6.80E-03	8.41E-01	1.35E+00	2.35E-03	1.36E+00	1.54E+00	4.83E-03	1.54E+00
2	1.00E+01	1.17E-03	6.42E-04	1.47E-05	6.57E-04	5.48E-01	1.26E-02	5.61E-01	4.15E-01	1.59E-02	4.30E-01	1.34E+00	6.22E-03	1.35E+00	1.51E+00	1.12E-02	1.53E+00
3	1.50E+01	5.21E-04	1.53E-04	8.83E-06	1.62E-04	2.94E-01	1.70E-02	3.11E-01	1.76E-01	1.90E-02	1.95E-01	1.21E+00	1.08E-02	1.22E+00	1.28E+00	1.70E-02	1.30E+00
4	2.00E+01	2.93E-04	4.29E-05	5.15E-06	4.81E-05	1.47E-01	1.76E-02	1.64E-01	6.85E-02	1.81E-02	8.66E-02	1.00E+00	1.49E-02	1.02E+00	9.79E-01	2.01E-02	9.99E-01
5	2.50E+01	1.88E-04	1.30E-05	3.03E-06	1.60E-05	6.93E-02	1.61E-02	8.55E-02	2.52E-02	1.59E-02	4.11E-02	7.87E-01	1.78E-02	8.05E-01	6.95E-01	2.02E-02	7.16E-01
6	3.00E+01	1.30E-04	4.12E-06	1.83E-06	5.95E-06	3.16E-02	1.40E-02	4.57E-02	8.91E-03	1.37E-02	2.26E-02	5.96E-01	1.93E-02	6.15E-01	4.69E-01	1.81E-02	4.87E-01
7	3.50E+01	9.57E-05	1.35E-06	1.14E-06	2.49E-06	1.41E-02	1.19E-02	2.60E-02	3.06E-03	1.17E-02	1.47E-02	4.38E-01	1.94E-02	4.57E-01	3.05E-01	1.49E-02	3.20E-01
8	4.00E+01	7.33E-05	4.49E-07	7.35E-07	1.18E-06	6.13E-03	1.00E-02	1.62E-02	1.03E-03	9.98E-03	1.10E-02	3.16E-01	1.84E-02	3.34E-01	1.92E-01	1.15E-02	2.04E-01
9	4.50E+01	5.79E-05	1.52E-07	4.87E-07	6.40E-07	2.63E-03	8.42E-03	1.11E-02	3.40E-04	8.55E-03	8.89E-03	2.24E-01	1.67E-02	2.41E-01	1.19E-01	8.45E-03	1.27E-01
10	5.00E+01	4.69E-05	5.22E-08	3.31E-07	3.83E-07	1.11E-03	7.06E-03	8.17E-03	1.11E-04	7.31E-03	7.42E-03	1.57E-01	1.46E-02	1.72E-01	7.19E-02	5.97E-03	7.79E-02
11	5.50E+01	3.88E-05	1.81E-08	2.29E-07	2.47E-07	4.66E-04	5.91E-03	6.37E-03	3.57E-05	6.24E-03	6.27E-03	1.09E-01	1.24E-02	1.21E-01	4.30E-02	4.10E-03	4.71E-02
12	6.00E+01	3.26E-05	6.29E-09	1.61E-07	1.67E-07	1.93E-04	4.94E-03	5.14E-03	1.14E-05	5.31E-03	5.32E-03	7.52E-02	1.03E-02	8.55E-02	2.54E-02	2.74E-03	2.82E-02
13	6.50E+01	2.77E-05	2.21E-09	1.15E-07	1.17E-07	7.95E-05	4.13E-03	4.21E-03	3.61E-06	4.51E-03	4.51E-03	5.16E-02	8.40E-03	6.00E-02	1.49E-02	1.80E-03	1.67E-02
14	7.00E+01	2.39E-05	7.77E-10	8.23E-08	8.31E-08	3.25E-05	3.44E-03	3.47E-03	1.13E-06	3.81E-03	3.81E-03	3.52E-02	6.74E-03	4.19E-02	8.66E-03	1.17E-03	9.83E-03
15	7.50E+01	2.08E-05	2.75E-10	5.97E-08	6.00E-08	1.32E-05	2.86E-03	2.88E-03	3.54E-07	3.22E-03	3.22E-03	2.39E-02	5.33E-03	2.92E-02	5.01E-03	7.47E-04	5.75E-03
16	8.00E+01	1.83E-05	9.77E-11	4.36E-08	4.37E-08	5.33E-06	2.38E-03	2.38E-03	1.10E-07	2.71E-03	2.71E-03	1.62E-02	4.17E-03	2.04E-02	2.88E-03	4.73E-04	3.36E-03
17	8.50E+01	1.62E-05	3.48E-11	3.20E-08	3.20E-08	2.14E-06	1.97E-03	1.97E-03	3.41E-08	2.27E-03	2.27E-03	1.09E-02	3.23E-03	1.42E-02	1.65E-03	2.97E-04	1.95E-03
18	9.00E+01	1.45E-05	1.24E-11	2.36E-08	2.36E-08	8.59E-07	1.63E-03	1.63E-03	1.05E-08	1.90E-03	1.90E-03	7.38E-03	2.49E-03	9.87E-03	9.45E-04	1.86E-04	1.13E-03
19	9.50E+01	1.30E-05	4.45E-12	1.75E-08	1.75E-08	3.43E-07	1.35E-03	1.35E-03	3.23E-09	1.59E-03	1.59E-03	4.97E-03	1.90E-03	6.87E-03	5.39E-04	1.15E-04	6.54E-04
20	1.00E+02	1.17E-05	1.60E-12	1.30E-08	1.30E-08	1.36E-07	1.11E-03	1.11E-03	9.89E-10	1.33E-03	1.33E-03	3.34E-03	1.44E-03	4.78E-03	3.07E-04	7.14E-05	3.78E-04
21	1.05E+02	1.06E-05	5.74E-13	9.72E-09	9.72E-09	5.40E-08	9.14E-04	9.14E-04	3.01E-10	1.11E-03	1.11E-03	2.24E-03	1.09E-03	3.33E-03	1.74E-04	4.40E-05	2.18E-04
22	1.10E+02	9.69E-06	2.07E-13	7.27E-09	7.27E-09	2.13E-08	7.51E-04	7.51E-04	9.21E-11	9.21E-04	9.21E-04	1.50E-03	8.24E-04	2.32E-03	9.89E-05	2.71E-05	1.26E-04
23	1.15E+02	8.86E-06	7.46E-14	5.46E-09	5.46E-09	8.41E-09	6.16E-04	6.16E-04	2.78E-11	7.65E-04	7.65E-04	1.00E-03	6.19E-04	1.62E-03	5.61E-05	1.66E-05	7.27E-05
24	1.20E+02	8.14E-06	2.69E-14	4.11E-09	4.11E-09	3.31E-09	5.05E-04	5.05E-04	8.53E-12	6.35E-04	6.35E-04	6.72E-04	4.64E-04	1.14E-03	3.18E-05	1.02E-05	4.20E-05
25	1.25E+02	7.50E-06	9.74E-15	3.10E-09	3.10E-09	1.30E-09	4.13E-04	4.13E-04	2.52E-12	5.26E-04	5.26E-04	4.49E-04	3.47E-04	7.96E-04	1.80E-05	6.23E-06	2.42E-05
26	1.30E+02	6.94E-06	3.52E-15	2.34E-09	2.34E-09	5.08E-10	3.38E-04	3.38E-04	7.91E-13	4.35E-04	4.35E-04	3.00E-04	2.60E-04	5.59E-04	1.02E-05	3.81E-06	1.40E-05
27	1.35E+02	6.43E-06	1.28E-15	1.77E-09	1.77E-09	1.99E-10	2.76E-04	2.76E-04	2.32E-13	3.60E-04	3.60E-04	2.00E-04	1.94E-04	3.94E-04	5.75E-06	2.33E-06	8.08E-06
28	1.40E+02	5.98E-06	4.63E-16	1.34E-09	1.34E-09	7.74E-11	2.25E-04	2.25E-04	7.09E-14	2.97E-04	2.97E-04	1.33E-04	1.45E-04	2.78E-04	3.25E-06	1.42E-06	4.67E-06
29	1.45E+02	5.58E-06	1.68E-16	1.02E-09	1.02E-09	3.02E-11	1.83E-04	1.83E-04	2.15E-14	2.45E-04	2.45E-04	8.88E-05	1.08E-04	1.97E-04	1.84E-06	8.65E-07	2.70E-06
30	1.50E+02	5.21E-06	6.11E-17	7.77E-10	7.77E-10	1.17E-11	1.49E-04	1.49E-04	6.32E-15	2.02E-04	2.02E-04	5.91E-05	8.05E-05	1.40E-04	1.04E-06	5.27E-07	1.56E-06
31	1.55E+02	4.88E-06	2.22E-17	5.92E-10	5.92E-10	4.55E-12	1.21E-04	1.21E-04	1.97E-15	1.67E-04	1.67E-04	3.93E-05	6.01E-05	9.95E-05	5.85E-07	3.21E-07	9.06E-07
32	1.60E+02	4.58E-06	8.08E-18	4.51E-10	4.51E-10	1.77E-12	9.85E-05	9.85E-05	5.73E-16	1.37E-04	1.37E-04	2.62E-05	4.49E-05	7.11E-05	3.30E-07	1.96E-07	5.26E-07
33	1.65E+02	4.31E-06	2.94E-18	3.44E-10	3.44E-10	6.84E-13	7.99E-05	7.99E-05	1.75E-16	1.13E-04	1.13E-04	1.74E-05	3.36E-05	5.10E-05	1.86E-07	1.19E-07	3.05E-07
34	1.70E+02	4.06E-06	1.07E-18	2.63E-10	2.63E-10	2.64E-13	6.48E-05	6.48E-05	5.22E-17	9.28E-05	9.28E-05	1.15E-05	2.51E-05	3.67E-05	1.05E-07	7.24E-08	1.78E-07
35	1.75E+02	3.83E-06	3.91E-19	2.01E-10	2.01E-10	1.02E-13	5.26E-05	5.26E-05	1.55E-17	7.63E-05	7.63E-05	7.67E-06	1.88E-05	2.65E-05	5.93E-08	4.41E-08	1.03E-07
36	1.80E+02	3.62E-06	1.43E-19	1.54E-10	1.54E-10	3.94E-14	4.26E-05	4.26E-05	4.68E-18	6.26E-05	6.26E-05	5.09E-06	1.41E-05	1.92E-05	3.34E-08	2.68E-08	6.02E-08
37	1.85E+02	3.42E-06	5.20E-20	1.18E-10	1.18E-10	1.52E-14	3.44E-05	3.44E-05	1.37E-18	5.14E-05	5.14E-05	3.38E-06	1.06E-05	1.40E-05	1.88E-08	1.63E-08	3.51E-08
38	1.90E+02	3.25E-06	1.90E-20	9.05E-11	9.05E-11	5.85E-15	2.79E-05	2.79E-05	4.22E-19	4.22E-05	4.22E-05	2.24E-06	7.96E-06	1.02E-05	1.06E-08	9.90E-09	2.05E-08
39	1.95E+02	3.08E-06	6.94E-21	6.94E-11	6.94E-11	2.25E-15	2.25E-05	2.25E-05	1.18E-19	3.46E-05	3.46E-05	1.48E-06	5.99E-06	7.48E-06	5.98E-09	6.02E-09	1.20E-08
40	2.00E+02	2.93E-06	2.54E-21	5.33E-11	5.33E-11	8.66E-16	1.82E-05	1.82E-05	3.71E-20	2.84E-05	2.84E-05	9.84E-07	4.52E-06	5.50E-06	3.37E-09	3.66E-09	7.03E-09
41	2.05E+02	2.79E-06	9.28E-22	4.10E-11	4.10E-11	3.33E-16	1.47E-05	1.47E-05	1.10E-20	2.33E-05	2.33E-05	6.51E-07	3.41E-06	4.06E-06	1.90E-09	2.22E-09	4.12E-09
42	2.10E+02	2.66E-06	3.39E-22	3.15E-11	3.15E-11	1.28E-16	1.18E-05	1.18E-05	3.27E-21	1.91E-05	1.91E-05	4.31E-07	2.57E-06	3.01E-06	1.07E-09	1.35E-09	2.42E-09
43	2.15E+02	2.54E-06	1.24E-22	2.42E-11	2.42E-11	4.90E-17	9.55E-06	9.55E-06	9.70E-22	1.56E-05	1.56E-05	2.85E-07	1.95E-06	2.23E-06	6.02E-10	8.19E-10	1.42E-09
44	2.20E+02	2.42E-06	4.55E-23	1.86E-11	1.86E-11	1.88E-17	7.70E-06	7.70E-06	2.84E-22	1.28E-05	1.28E-05	1.88E-07	1.47E-06	1.66E-06	3.39E-10	4.97E-10	8.36E-10

Table A5.5.4 Neutron and secondary gamma-ray effective dose rates for D-T

r [cm]		H_0	Water						Polyethylene			Ordinary Concrete			Heavy Concrete		
			H_n	H_g	H_t	F_n	F_g	F_t	F_n	Fg	F_t	F_n	F_g	F_t	F_n	F_g	F_t
1	5.00E+00	5.69E-03	6.32E-03	5.68E-04	6.88E-03	1.11E+00	9.99E-02	1.21E+00	1.12E+00	3.91E-03	1.12E+00	1.21E+00	1.61E-01	1.38E+00	1.34E+00	1.23E-01	1.47E+00
2	1.00E+01	1.42E-03	1.42E-03	3.05E-04	1.73E-03	1.00E+00	2.14E-01	1.21E+00	9.87E-01	9.00E-03	9.96E-01	1.22E+00	2.96E-01	1.51E+00	1.33E+00	1.73E-01	1.51E+00
3	1.50E+01	6.32E-04	5.36E-04	1.80E-04	7.16E-04	8.48E-01	2.85E-01	1.13E+00	8.08E-01	1.28E-02	8.21E-01	1.14E+00	3.38E-01	1.48E+00	1.17E+00	1.61E-01	1.33E+00
4	2.00E+01	3.55E-04	2.44E-04	1.11E-04	3.55E-04	6.87E-01	3.12E-01	9.98E-01	6.27E-01	1.48E-02	6.42E-01	1.01E+00	3.20E-01	1.33E+00	9.52E-01	1.30E-01	1.08E+00
5	2.50E+01	2.27E-04	1.22E-04	6.96E-05	1.92E-04	5.37E-01	3.06E-01	8.43E-01	4.69E-01	1.53E-02	4.85E-01	8.65E-01	2.74E-01	1.14E+00	7.29E-01	9.78E-02	8.27E-01
6	3.00E+01	1.58E-04	6.45E-05	4.44E-05	1.09E-04	4.09E-01	2.81E-01	6.90E-01	3.42E-01	1.48E-02	3.57E-01	7.16E-01	2.22E-01	9.38E-01	5.36E-01	7.07E-02	6.07E-01
7	3.50E+01	1.16E-04	3.54E-05	2.85E-05	6.39E-05	3.05E-01	2.46E-01	5.51E-01	2.44E-01	1.38E-02	2.58E-01	5.79E-01	1.73E-01	7.52E-01	3.82E-01	4.97E-02	4.32E-01
8	4.00E+01	8.88E-05	1.99E-05	1.84E-05	3.83E-05	2.24E-01	2.07E-01	4.31E-01	1.72E-01	1.25E-02	1.84E-01	4.60E-01	1.32E-01	5.92E-01	2.66E-01	3.43E-02	3.00E-01
9	4.50E+01	7.02E-05	1.14E-05	1.19E-05	2.34E-05	1.63E-01	1.70E-01	3.33E-01	1.19E-01	1.11E-02	1.30E-01	3.60E-01	9.88E-02	4.58E-01	1.81E-01	2.32E-02	2.05E-01
10	5.00E+01	5.69E-05	6.65E-06	7.77E-06	1.44E-05	1.17E-01	1.37E-01	2.54E-01	8.17E-02	9.73E-03	9.15E-02	2.78E-01	7.33E-02	3.51E-01	1.22E-01	1.56E-02	1.38E-01
11	5.50E+01	4.70E-05	3.91E-06	5.07E-06	8.99E-06	8.33E-02	1.08E-01	1.91E-01	5.56E-02	8.45E-03	6.41E-02	2.12E-01	5.40E-02	2.66E-01	8.11E-02	1.03E-02	9.14E-02
12	6.00E+01	3.95E-05	2.32E-06	3.32E-06	5.64E-06	5.89E-02	8.41E-02	1.43E-01	3.76E-02	7.29E-03	4.49E-02	1.61E-01	3.96E-02	2.00E-01	5.33E-02	6.77E-03	6.01E-02
13	6.50E+01	3.36E-05	1.39E-06	2.18E-06	3.57E-06	4.13E-02	6.48E-02	1.06E-01	2.52E-02	6.26E-03	3.15E-02	1.21E-01	2.89E-02	1.49E-01	3.47E-02	4.41E-03	3.91E-02
14	7.00E+01	2.90E-05	8.37E-07	1.43E-06	2.27E-06	2.89E-02	4.95E-02	7.83E-02	1.68E-02	5.36E-03	2.22E-02	8.99E-02	2.11E-02	1.11E-01	2.25E-02	2.86E-03	2.53E-02
15	7.50E+01	2.53E-05	5.07E-07	9.47E-07	1.45E-06	2.01E-02	3.75E-02	5.76E-02	1.12E-02	4.57E-03	1.58E-02	6.66E-02	1.53E-02	8.20E-02	1.44E-02	1.84E-03	1.63E-02
16	8.00E+01	2.22E-05	3.08E-07	6.28E-07	9.36E-07	1.39E-02	2.83E-02	4.22E-02	7.39E-03	3.89E-03	1.13E-02	4.91E-02	1.11E-02	6.03E-02	9.22E-03	1.18E-03	1.04E-02
17	8.50E+01	1.97E-05	1.88E-07	4.19E-07	6.07E-07	9.56E-03	2.13E-02	3.08E-02	4.86E-03	3.30E-03	8.17E-03	3.60E-02	8.11E-03	4.42E-02	5.85E-03	7.52E-04	6.61E-03
18	9.00E+01	1.75E-05	1.15E-07	2.80E-07	3.95E-07	6.56E-03	1.60E-02	2.25E-02	3.19E-03	2.80E-03	5.99E-03	2.63E-02	5.91E-03	3.22E-02	3.70E-03	4.78E-04	4.18E-03
19	9.50E+01	1.57E-05	7.06E-08	1.89E-07	2.60E-07	4.49E-03	1.20E-02	1.65E-02	2.08E-03	2.38E-03	4.46E-03	1.92E-02	4.30E-03	2.35E-02	2.33E-03	3.03E-04	2.63E-03
20	1.00E+02	1.42E-05	4.35E-08	1.28E-07	1.72E-07	3.06E-03	9.03E-03	1.21E-02	1.36E-03	2.02E-03	3.37E-03	1.39E-02	3.14E-03	1.70E-02	1.46E-03	1.91E-04	1.65E-03
21	1.05E+02	1.29E-05	2.68E-08	8.79E-08	1.15E-07	2.08E-03	6.82E-03	8.90E-03	8.82E-04	1.71E-03	2.59E-03	1.00E-02	2.29E-03	1.23E-02	9.14E-04	1.21E-04	1.03E-03
22	1.10E+02	1.17E-05	1.66E-08	6.08E-08	7.74E-08	1.41E-03	5.18E-03	6.59E-03	5.71E-04	1.45E-03	2.02E-03	7.22E-03	1.68E-03	8.90E-03	5.69E-04	7.58E-05	6.45E-04
23	1.15E+02	1.07E-05	1.03E-08	4.25E-08	5.27E-08	9.55E-04	3.95E-03	4.91E-03	3.69E-04	1.22E-03	1.59E-03	5.19E-03	1.23E-03	6.41E-03	3.54E-04	4.76E-05	4.01E-04
24	1.20E+02	9.87E-06	6.36E-09	3.00E-08	3.64E-08	6.45E-04	3.04E-03	3.69E-03	2.38E-04	1.04E-03	1.27E-03	3.72E-03	9.01E-04	4.62E-03	2.19E-04	2.98E-05	2.49E-04
25	1.25E+02	9.10E-06	3.95E-09	2.15E-08	2.54E-08	4.34E-04	2.36E-03	2.80E-03	1.53E-04	8.77E-04	1.03E-03	2.65E-03	6.62E-04	3.32E-03	1.35E-04	1.86E-05	1.54E-04
26	1.30E+02	8.41E-06	2.46E-09	1.56E-08	1.80E-08	2.92E-04	1.85E-03	2.14E-03	9.80E-05	7.43E-04	8.41E-04	1.89E-03	4.87E-04	2.38E-03	8.34E-05	1.16E-05	9.50E-05
27	1.35E+02	7.80E-06	1.53E-09	1.14E-08	1.30E-08	1.96E-04	1.47E-03	1.66E-03	6.28E-05	6.29E-04	6.92E-04	1.35E-03	3.59E-04	1.71E-03	5.13E-05	7.23E-06	5.85E-05
28	1.40E+02	7.25E-06	9.52E-10	8.52E-09	9.47E-09	1.31E-04	1.18E-03	1.31E-03	4.01E-05	5.33E-04	5.73E-04	9.56E-04	2.65E-04	1.22E-03	3.15E-05	4.50E-06	3.60E-05
29	1.45E+02	6.76E-06	5.94E-10	6.43E-09	7.02E-09	8.78E-05	9.51E-04	1.04E-03	2.56E-05	4.51E-04	4.77E-04	6.77E-04	1.96E-04	8.73E-04	1.93E-05	2.79E-06	2.21E-05
30	1.50E+02	6.32E-06	3.71E-10	4.91E-09	5.28E-09	5.87E-05	7.77E-04	8.36E-04	1.63E-05	3.82E-04	3.99E-04	4.79E-04	1.45E-04	6.24E-04	1.18E-05	1.73E-06	1.35E-05
31	1.55E+02	5.92E-06	2.31E-10	3.79E-09	4.02E-09	3.91E-05	6.41E-04	6.80E-04	1.04E-05	3.24E-04	3.34E-04	3.38E-04	1.08E-04	4.46E-04	7.19E-06	1.07E-06	8.27E-06
32	1.60E+02	5.55E-06	1.45E-10	2.96E-09	3.11E-09	2.61E-05	5.34E-04	5.60E-04	6.58E-06	2.75E-04	2.81E-04	2.39E-04	7.98E-05	3.18E-04	4.38E-06	6.64E-07	5.05E-06
33	1.65E+02	5.22E-06	9.05E-11	2.34E-09	2.43E-09	1.73E-05	4.48E-04	4.65E-04	4.17E-06	2.33E-04	2.37E-04	1.68E-04	5.94E-05	2.27E-04	2.66E-06	4.11E-07	3.08E-06
34	1.70E+02	4.92E-06	5.66E-11	1.86E-09	1.92E-09	1.15E-05	3.78E-04	3.90E-04	2.64E-06	1.98E-04	2.00E-04	1.18E-04	4.42E-05	1.62E-04	1.62E-06	2.54E-07	1.87E-06
35	1.75E+02	4.64E-06	3.55E-11	1.49E-09	1.53E-09	7.64E-06	3.21E-04	3.29E-04	1.67E-06	1.68E-04	1.70E-04	8.29E-05	3.30E-05	1.16E-04	9.81E-07	1.56E-07	1.14E-06
36	1.80E+02	4.39E-06	2.22E-11	1.20E-09	1.23E-09	5.06E-06	2.75E-04	2.80E-04	1.05E-06	1.43E-04	1.44E-04	5.82E-05	2.46E-05	8.28E-05	5.94E-07	9.65E-08	6.91E-07
37	1.85E+02	4.15E-06	1.39E-11	9.79E-10	9.93E-10	3.35E-06	2.36E-04	2.39E-04	6.65E-07	1.21E-04	1.22E-04	4.07E-05	1.84E-05	5.91E-05	3.59E-07	5.94E-08	4.19E-07
38	1.90E+02	3.94E-06	8.73E-12	8.00E-10	8.09E-10	2.22E-06	2.03E-04	2.05E-04	4.19E-07	1.03E-04	1.04E-04	2.85E-05	1.38E-05	4.23E-05	2.17E-07	3.66E-08	2.54E-07
39	1.95E+02	3.74E-06	5.48E-12	6.57E-10	6.62E-10	1.47E-06	1.76E-04	1.77E-04	2.63E-07	8.77E-05	8.80E-05	1.99E-05	1.03E-05	3.03E-05	1.31E-07	2.25E-08	1.53E-07
40	2.00E+02	3.55E-06	3.44E-12	5.41E-10	5.45E-10	9.67E-07	1.52E-04	1.53E-04	1.66E-07	7.46E-05	7.48E-05	1.39E-05	7.77E-06	2.17E-05	7.88E-08	1.38E-08	9.27E-08
41	2.05E+02	3.38E-06	2.16E-12	4.48E-10	4.50E-10	6.38E-07	1.32E-04	1.33E-04	1.04E-07	6.36E-05	6.37E-05	9.69E-06	5.84E-06	1.55E-05	4.74E-08	8.49E-09	5.59E-08
42	2.10E+02	3.22E-06	1.35E-12	3.72E-10	3.73E-10	4.20E-07	1.15E-04	1.16E-04	6.51E-08	5.42E-05	5.42E-05	6.75E-06	4.40E-06	1.11E-05	2.85E-08	5.21E-09	3.37E-08
43	2.15E+02	3.07E-06	8.51E-13	3.10E-10	3.10E-10	2.77E-07	1.01E-04	1.01E-04	4.08E-08	4.62E-05	4.62E-05	4.69E-06	3.32E-06	8.01E-06	1.71E-08	3.20E-09	2.03E-08
44	2.20E+02	2.94E-06	5.35E-13	2.58E-10	2.59E-10	1.82E-07	8.80E-05	8.82E-05	2.55E-08	3.93E-05	3.94E-05	3.26E-06	2.50E-06	5.76E-06	1.03E-08	1.96E-09	1.22E-08

Table A5.5.5 Constant Γ (effective dose; AP geometry) for various neutron sources

Source	Γ [µSv h^{-1} m^2 s]
^{252}Cf	1.00E-05
Am-Be	1.19E-05
D-D	1.17E-05
D-T	1.42E-05

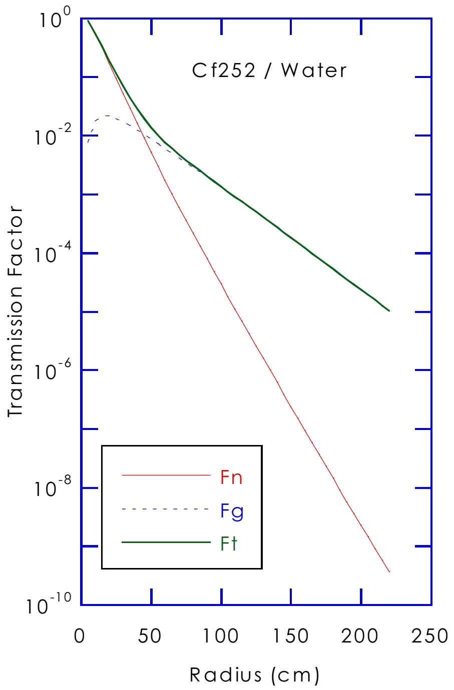

Fig. 5.5.20. Transmission factor of water for ^{252}Cf source (Effective Dose)

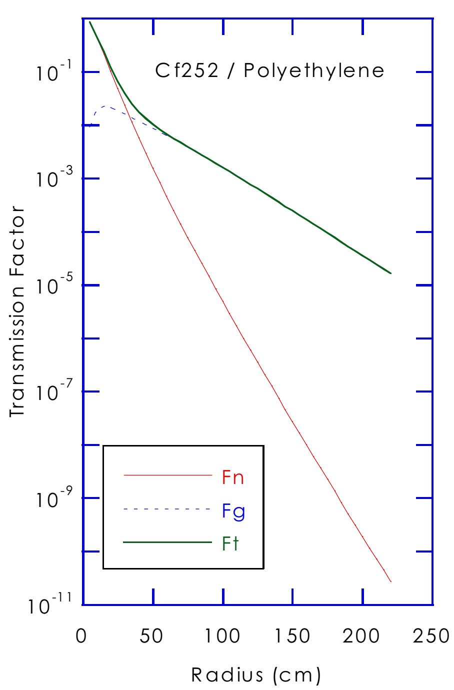

Fig. 5.5.21. Transmission factor of polyethylene for ^{252}Cf source (Effective Dose)

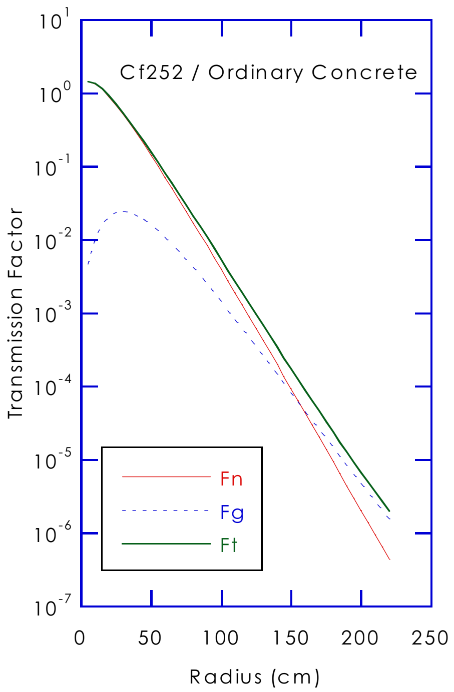

Fig. 5.5.22. Transmission factor of ordinary concrete for ^{252}Cf source (Effective Dose)

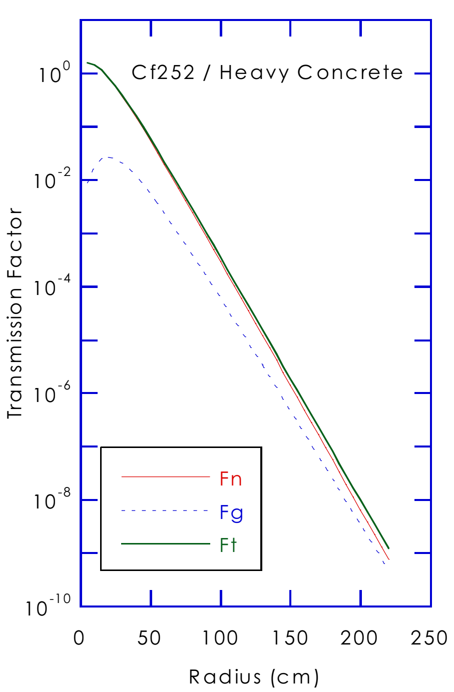

Fig. 5.5.23. Transmission factor of heavy concrete for ^{252}Cf source (Effective Dose)

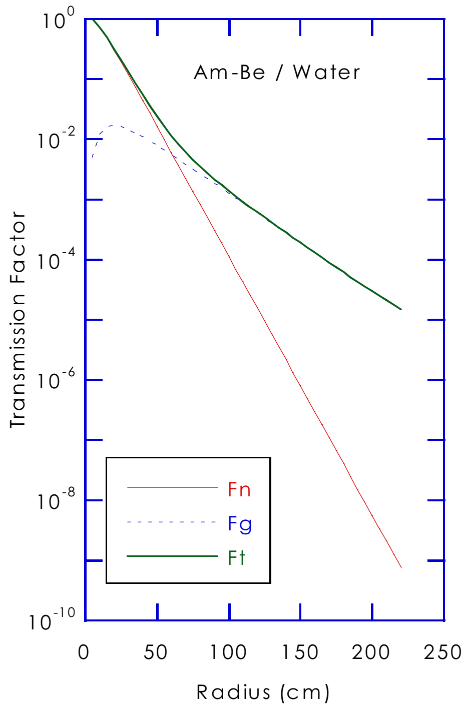

Fig. A5.5.24. Transmission factor of water for Am-Be source (Effective Dose)

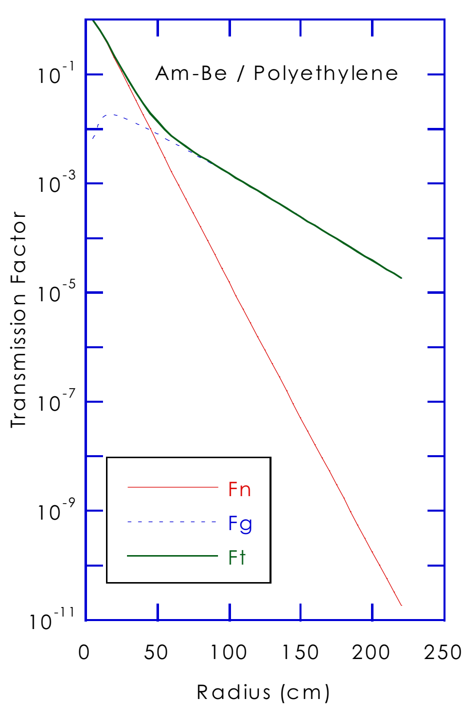

Fig. A5.5.25. Transmission factor of polyethylene for Am-Be source (Effective Dose)

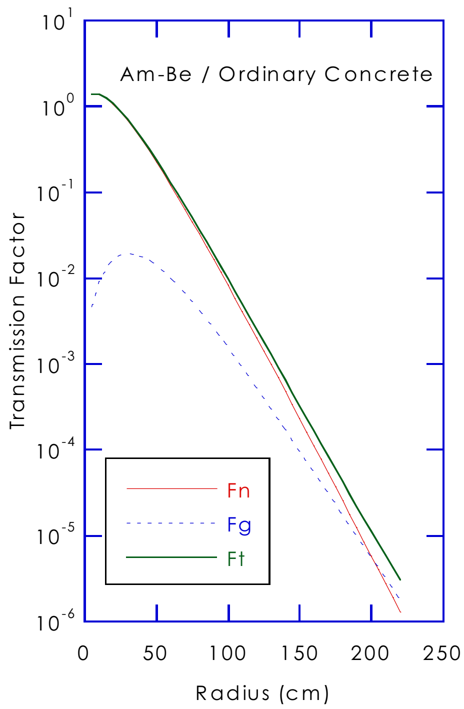

Fig. A5.5.26. Transmission factor of ordinary concrete for Am-Be source (Effective Dose)

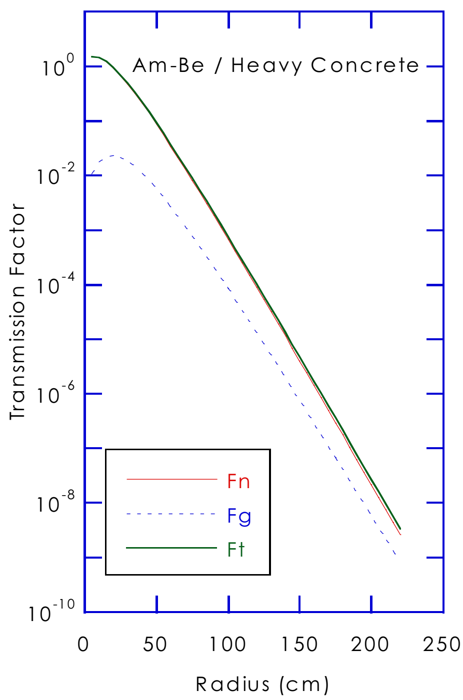

Fig. A5.5.27. Transmission factor of heavy concrete for Am-Be source (Effective Dose)

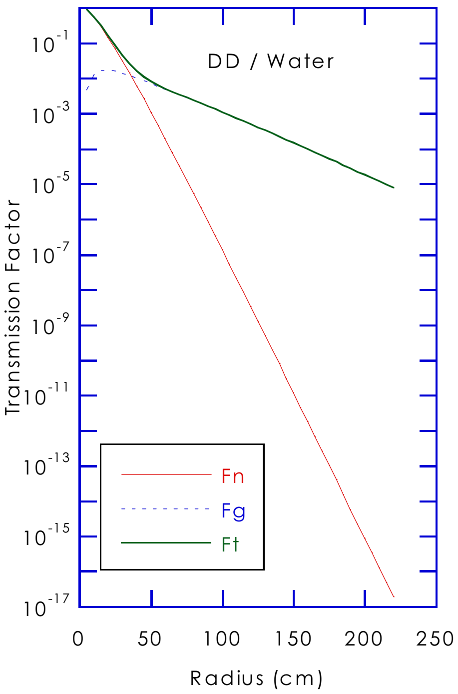

Fig. A5.5.28. Transmission factor of water for D-D source (Effective Dose)

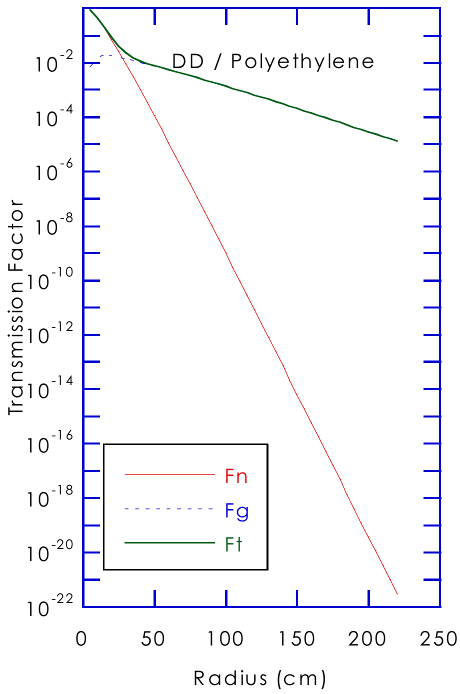

Fig. A5.5.29. Transmission factor of polyethylene for D-D source (Effective Dose)

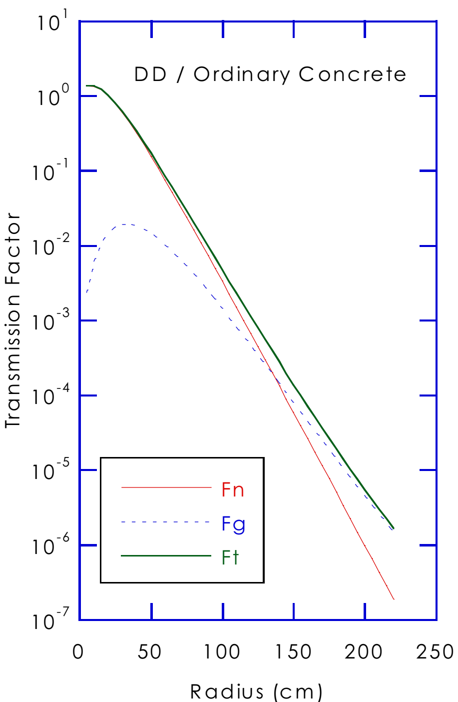

Fig. A5.5.30. Transmission factor of ordinary concrete for D-D source (Effective Dose)

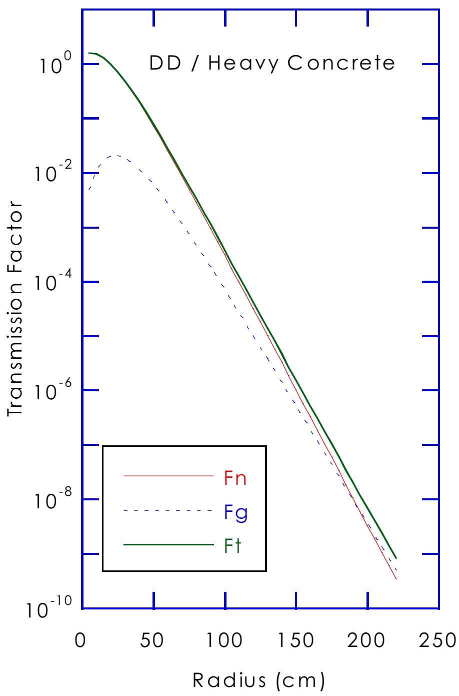

Fig. A5.5.31. Transmission factor of heavy concrete for D-D source (Effective Dose)

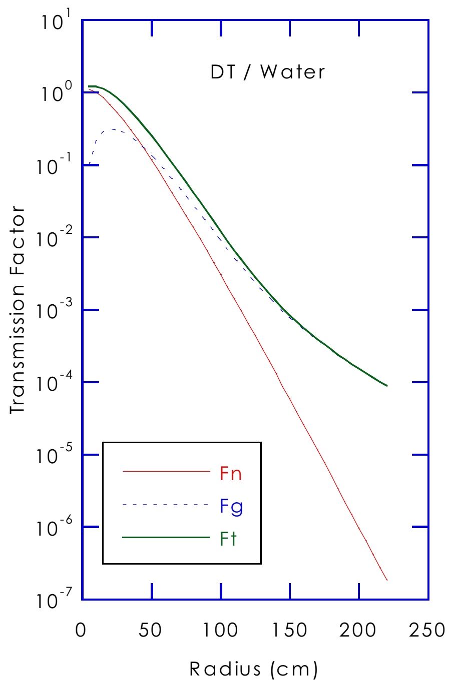

Fig. A5.5.32. Transmission factor of water for D-T source (Effective Dose)

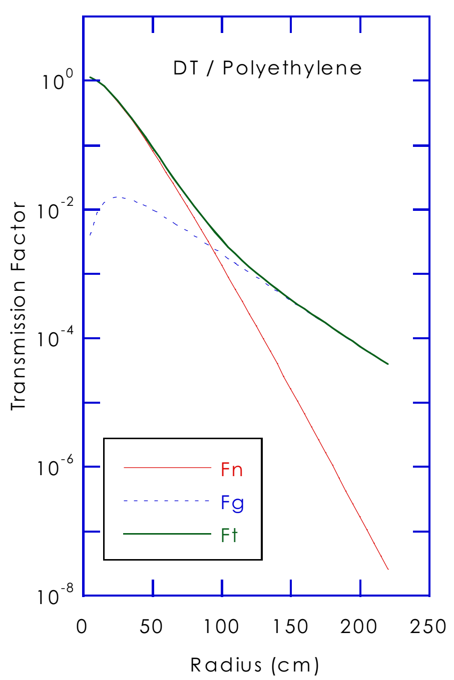

Fig. A5.5.33. Transmission factor of polyethylene for D-T source (Effective Dose)

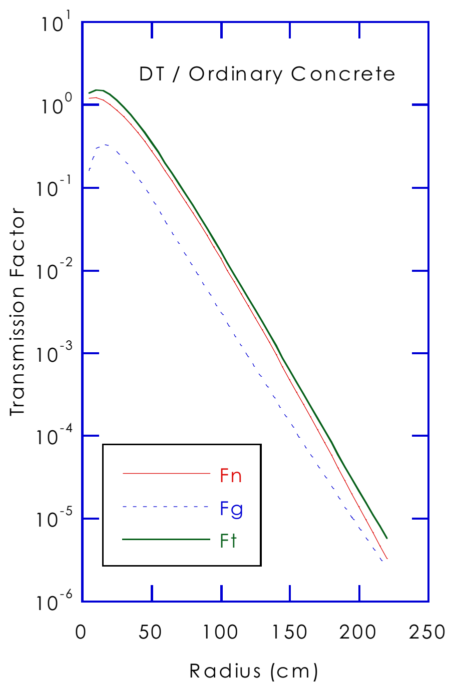

Fig. A5.5.34. Transmission factor of ordinary concrete for D-T source (Effective Dose)

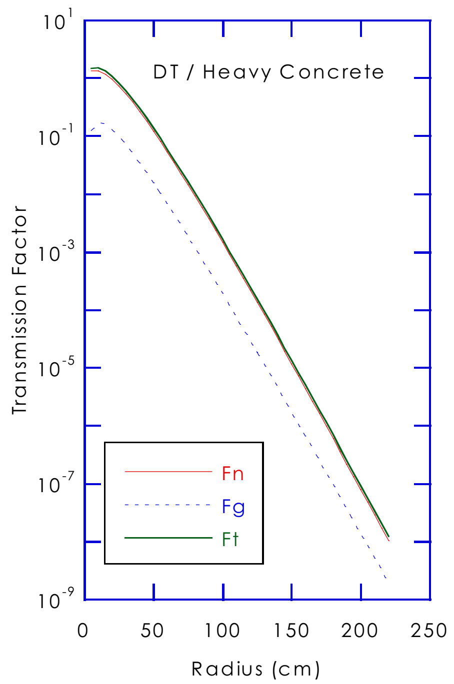

Fig. A5.5.35. Transmission factor of heavy concrete for D-T source (Effective Dose)