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KERMA FACTORS FOR NEUTRON AND PHOTONS WITH ENERGIES BELOW 20 MeV

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**KERMA FACTORS
FOR NEUTRON AND PHOTONS
WITH ENERGIES BELOW 20 MeV**

M. S. Singh

Manuscript date: November 5, 1979

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KERMA FACTORS FOR NEUTRONS AND PHOTONS
WITH ENERGIES BELOW 20 MeV

ABSTRACT

A comprehensive set of kerma factors for neutrons and photons has been computed for the International Commission on Radiological Protection's (ICRP) standard man, ICRP soft tissue, ICRP red bone marrow, ICRP eye lens, H_2O , dry air, Al, Si, ^{32}S , Ar, and four thermoluminescent dosimeter materials. The energy range for neutrons is 10^{-9} to 20 MeV, divided into 175 energy groups. For photons, the energy range is 10^{-3} to 20 MeV, and kerma factors are calculated at 144 energy values. The kerma factors were computed using the neutron group-averaged and photon pointwise Evaluated Nuclear Data Library. Results are compared with those in other works where appropriate. The use of kerma factors to convert fluence to absorbed-dose index for ICRP tissue is discussed.

INTRODUCTION

For biomedical purposes, one often needs to convert from the physical description of particle energy fluence to the nonstochastic quantity called absorbed dose (D). Absorbed dose is defined as the limiting value of the mean of energy imparted $d\bar{e}$ per unit mass (a stochastic quantity), for vanishingly small volumes. The available nuclear data required to calculate the stochastic quantity $\bar{e}$ precisely are far from complete. Calculating the nonstochastic quantity D precisely is therefore impossible. Similarly, one can easily compute the nonstochastic quantity called kerma, but its value can be over- or underestimated depending on the final-state energy taken for the induced charged particles. Kerma and D are nearly equal in magnitude when radiation equilibrium is established. Under this condition, one can directly relate absorbed-dose index to kerma for neutrons and photons in a broad energy range.

This paper reports neutron and photon kerma factors computed for the International Commission on Radiological Protection's (ICRP) standard man, ICRP soft tissue, ICRP red bone marrow, ICRP eye lens, H₂O, dry air, Al, Si, ³²S, Ar, and thermoluminescent dosimeter materials TLD 100, 200, 600, and 700. The results of this study are compared where appropriate with earlier published kerma (and in some cases absorbed-dose) values for neutrons,¹⁻⁵ and photons.⁶

CALCULATION OF KERMA FACTORS

Kerma K , as defined by the International Commission on Radiation Units and Measurements (ICRU), is equal to $\Delta E_k / \Delta M$, where ΔE_k is the sum of the initial kinetic energies of all the charged particles liberated by indirectly ionizing particles in a volume element ΔV of material, and where ΔM is the mass of the matter in ΔV . Kerma per unit fluence K/Φ_0 , for monoenergetic neutrons or photons, is given by

$$\frac{K(E)}{\Phi_0} = \sum_L \sum_J \sum_I C N_L \overline{E_{LJI}}(E) \sigma_{LJ}(E) \quad , \quad (1)$$

where N_L is the number of nuclei or atoms of the L th element or isotope per gram, $\overline{E_{LJI}}(E)$ is the average energy transferred to the kinetic energy of the I th charged particle in J th collision, $\sigma_{LJ}(E)$ is the J th reaction cross section at particle energy E , and C is the unit conversion factor.

NEUTRONS

Kerma factors for neutrons have been computed for 175 energy groups, extending from 10^{-9} to 20 MeV. If we use the Evaluated Nuclear Data Library (ENDL) notation, the mean energy deposition in each energy group (E_g) "locally" per neutron collision is

$$E(E_g) = \frac{\sum_L f_L \sum_J \sigma_{LJ}(E_g) E_{LJ}(E_g)}{\sum_L f_L \sum_J \sigma_{LJ}(E_g)} \quad ,$$

where f_L is the atom fraction of L th element in the material.

The energy deposit is the sum of the energy of the center-of-mass, the recoil energy of the nucleus, and the average energy of any light secondary particles other than neutrons, photons, or decay energies of the residual radioactive nuclei. The average energy of the final-state neutrons in ENDL is taken either from the kinematics of a two-body reaction with a defined Q-value or from tabular representations. The average energy of the final-state charged particles is either taken from the experimentally tabulated data or is estimated to equal x times the square root of the energy that is available after the average neutron energy has been removed, where x is 0.5 for $Z \geq 29$, 0.25 for $7 < Z < 29$, and 1 for $Z \leq 7$.

PHOTONS

The mean energy deposition per photon collision using ENDL notation is

$$E_{\text{dep}}(E) = \frac{\sum_{i=1}^m f_i \sum_{j=1}^4 \sigma_{ij}(E) E_{\text{dep}}(E)_{i,j}}{\sum_{i=1}^m f_i \sum_{j=1}^4 \sigma_{i,j}(E)},$$

where $\sigma_{i,j}$ is the j th reaction cross section of element i , $E_{\text{dep}}(E)_{i,j}$ is the average energy deposition for the j th reaction of i th element, and f_i is the atom fraction of i th element in the material.

Photon-induced reactions considered for energy deposit "locally" include coherent and incoherent scattering, pair production, and photoelectric processes (pure absorption and fluorescence). Photonuclear reactions and secondary bremsstrahlung have been neglected; their influence on energy deposition in the materials considered in this report is rather small.

RESULTS AND DISCUSSION

The computed kerma factors are given in Tables A1 and A2 for neutrons and in Tables A3 and A4 for photons. The factors are given in J/kg per particle per m^2 . To convert to $rad \cdot cm^2$, multiply these values by 10^6 .

Table A5 lists the standard elemental composition of the ICRP standard man, ICRP soft tissue, ICRP red bone marrow, and ICRP eye lens. All are derived from Ref. 7.

In Table A6, the neutron absorbed-dose indices (unrestricted D_I and isotropic ${}_iD_I$) are compared with the kerma factors calculated in this study. The kerma values underestimate the D_I values calculated by Chen and Chilton.³ The ${}_iD_I$ values, on the other hand, are grossly overestimated by the use of kerma factors, assuming the values in Ref. 3 are correct.

In Table A7, the standard-man kerma values given in Ref. 1 are compared with those calculated in this work; in most cases agreement is within a few percent.

From Tables A4 and A5 it is evident that ICRU needs to more closely examine the use of absorbed-dose indices for radiological protection before their future recommendations. Meanwhile, we recommend that D_I values be used for radiological protection since they are likely to give a better estimate of the maximum absorbed-dose in a tissue than do ${}_iD_I$ values.

The neutron kerma factors for some TLD materials calculated by Spurny et al.⁸ are in good agreement with the values in this report. They used the 1974 ENDL cross-sectional library. Since then, the ENDL library has been updated several times, particularly with respect to the energy deposition reactions. The values calculated in this study are therefore more precise.

Figure 1 plots the conversion factors from photon fluence to absorbed dose, as recommended by the ICRP⁹ and as calculated in this study. These factors are for water since ICRP has no data for tissue. The agreement between the results reported here and those of ICRP is quite good. Despite this agreement, Jones's¹⁰ experimental measurements in a phantom show that we can underestimate the absorbed dose for photons by as much as a factor of 2 at low energies. Therefore, we should not encourage unrestricted use of these conversion factors for radiological protection purposes before we have

FIG. 1. Factor for converting photon fluence to absorbed dose for water, as a function of photon energy. ICRP values for energies above 10 keV are also shown.

validated more points experimentally. For D_I calculations, the values computed for the ICRP standard man or soft tissue should be preferred over those for H_2O . Comparison of photon kerma values other than for H_2O and standard tissue is not possible, since there is no published data for other elements or mixtures of materials (except TLD's).

The kerma values computed in this report, along with those tabulated in Ref. 1, provide a rather complete set for radiological protection or biological purposes. It is hoped that future experiments will confirm the accuracy of these values and will indicate areas where modifications or refinements of the theory is needed.

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APPENDIX

TABLE A1. Neutron kerma per unit fluence for four standard tissues and three elements, as a function of neutron energy.

Neutron energy, ^a MeV	kerma per unit fluence, J/kg per n/m ²						
	ICRP standard man	ICRP soft tissue	ICRP red bone marrow	ICRP eye lens	Si	Ar	S
1.31E-09	5.82E-17	6.21E-17	7.98E-17	1.27E-16	2.31E-19	2.23E-19	1.84E-18
5.23E-09	2.69E-17	3.08E-17	3.95E-17	6.29E-17	1.15E-19	1.13E-19	1.64E-18
2.09E-08	1.93E-17	2.06E-17	2.65E-17	4.21E-17	7.68E-20	7.65E-20	1.56E-18
3.27E-08	1.57E-17	1.68E-17	2.16E-17	3.43E-17	6.23E-20	6.42E-20	1.53E-18
4.70E-08	1.24E-17	1.32E-17	1.69E-17	2.69E-17	4.90E-20	4.89E-20	1.51E-18
8.32E-08	9.72E-18	1.04E-17	1.33E-17	2.12E-17	3.82E-20	3.65E-20	1.48E-18
1.31E-07	8.12E-18	8.65E-18	1.11E-17	1.77E-17	3.15E-20	3.11E-20	1.47E-18
1.88E-07	8.69E-18	9.14E-18	9.17E-18	1.46E-17	2.67E-20	2.63E-20	1.46E-18
2.56E-07	5.78E-18	6.17E-18	7.92E-18	1.26E-17	2.32E-20	2.26E-20	1.45E-18
3.35E-07	5.10E-18	5.44E-18	6.98E-18	1.11E-17	2.03E-20	2.01E-20	1.44E-18
4.23E-07	4.62E-18	4.93E-18	6.33E-18	1.01E-17	1.83E-20	1.79E-20	1.44E-18
5.12E-07	3.97E-18	4.23E-18	5.44E-18	8.63E-18	1.58E-20	1.54E-20	1.43E-18
7.53E-07	3.22E-18	3.43E-18	4.41E-18	6.99E-18	1.27E-20	1.28E-20	1.42E-18
1.18E-06	2.81E-18	2.99E-18	3.84E-18	6.10E-18	1.09E-20	1.12E-20	1.42E-18
1.51E-06	2.40E-18	2.56E-18	3.29E-18	5.21E-18	9.59E-21	9.53E-21	1.42E-18
2.09E-06	2.06E-18	2.19E-18	2.81E-18	4.45E-18	8.72E-21	8.12E-21	1.42E-18
2.74E-06	1.81E-18	1.92E-18	2.46E-18	3.89E-18	8.10E-21	7.17E-21	1.42E-18
3.53E-06	1.59E-18	1.69E-18	2.16E-18	3.40E-18	7.47E-21	6.66E-21	1.42E-18
4.70E-06	1.44E-18	1.53E-18	1.95E-18	3.06E-18	6.99E-21	6.16E-21	1.42E-18
5.66E-06	1.32E-18	1.40E-18	1.79E-18	2.79E-18	6.54E-21	5.68E-21	1.42E-18
6.74E-06	1.22E-18	1.29E-18	1.64E-18	2.55E-18	6.05E-21	5.04E-21	1.42E-18
8.32E-06	1.14E-18	1.20E-18	1.52E-18	2.36E-18	5.65E-21	4.36E-21	1.42E-18
9.62E-06	1.08E-18	1.15E-18	1.45E-18	2.23E-18	5.39E-21	3.89E-21	1.42E-18
1.10E-05	1.05E-18	1.11E-18	1.39E-18	2.13E-18	5.15E-21	3.85E-21	1.42E-18
1.31E-05	1.02E-18	1.07E-18	1.34E-18	2.04E-18	5.45E-21	3.85E-21	1.42E-18
1.47E-05	9.90E-19	1.04E-18	1.30E-18	1.96E-18	5.60E-21	3.81E-21	1.42E-18
1.58E-05	9.63E-19	1.01E-18	1.26E-18	1.89E-18	5.66E-21	3.80E-21	1.42E-18
1.76E-05	9.35E-19	9.84E-19	1.22E-18	1.81E-18	5.73E-21	3.78E-21	1.42E-18
1.88E-05	9.09E-19	9.54E-19	1.18E-18	1.73E-18	5.80E-21	3.76E-21	1.42E-18
2.08E-05	9.02E-19	9.45E-19	1.16E-18	1.69E-18	5.88E-21	3.74E-21	1.42E-18
2.28E-05	9.02E-19	9.44E-19	1.15E-18	1.67E-18	5.96E-21	3.72E-21	1.42E-18
2.42E-05	9.02E-19	9.43E-19	1.15E-18	1.66E-18	6.02E-21	3.71E-21	1.42E-18
2.56E-05	9.02E-19	9.42E-19	1.14E-18	1.64E-18	6.09E-21	3.69E-21	1.42E-18
2.71E-05	9.02E-19	9.41E-19	1.14E-18	1.62E-18	6.15E-21	3.68E-21	1.42E-18
2.86E-05	9.02E-19	9.40E-19	1.13E-18	1.61E-18	6.20E-21	3.66E-21	1.42E-18
2.94E-05	9.02E-19	9.39E-19	1.13E-18	1.59E-18	6.26E-21	3.65E-21	1.42E-18
3.10E-05	9.02E-19	9.37E-19	1.12E-18	1.57E-18	6.35E-21	3.63E-21	1.42E-18
3.35E-05	9.02E-19	9.36E-19	1.12E-18	1.54E-18	6.46E-21	3.60E-21	1.42E-18
3.60E-05	9.03E-19	9.34E-19	1.11E-18	1.51E-18	6.57E-21	3.57E-21	1.42E-18
3.87E-05	9.03E-19	9.33E-19	1.10E-18	1.48E-18	6.67E-21	3.55E-21	1.42E-18
4.05E-05	9.11E-19	9.40E-19	1.10E-18	1.47E-18	6.75E-21	3.53E-21	1.42E-18
4.23E-05	9.19E-19	9.47E-19	1.11E-18	1.47E-18	6.81E-21	3.51E-21	1.42E-18
4.33E-05	9.30E-19	9.57E-19	1.12E-18	1.47E-18	6.90E-21	3.49E-21	1.42E-18
4.62E-05	9.41E-19	9.68E-19	1.13E-18	1.47E-18	6.98E-21	3.47E-21	1.42E-18
4.72E-05	9.49E-19	9.75E-19	1.13E-18	1.46E-18	7.05E-21	3.45E-21	1.42E-18
4.92E-05	9.61E-19	9.86E-19	1.14E-18	1.48E-18	7.14E-21	3.43E-21	1.42E-18
5.12E-05	9.73E-19	9.97E-19	1.15E-18	1.48E-18	7.23E-21	3.41E-21	1.42E-18
5.33E-05	9.88E-19	1.01E-18	1.16E-18	1.48E-18	7.35E-21	3.38E-21	1.42E-18
5.65E-05	1.00E-18	1.02E-18	1.17E-18	1.48E-18	7.44E-21	3.36E-21	1.42E-18
5.76E-05	1.01E-18	1.03E-18	1.18E-18	1.48E-18	7.54E-21	3.33E-21	1.42E-18
6.10E-05	1.03E-18	1.05E-18	1.20E-18	1.49E-18	7.66E-21	3.30E-21	1.42E-18
6.23E-05	1.05E-18	1.07E-18	1.22E-18	1.50E-18	7.77E-21	3.28E-21	1.42E-18
6.56E-05	1.06E-18	1.08E-18	1.23E-18	1.50E-18	7.84E-21	3.25E-21	1.42E-18
6.67E-05	1.08E-18	1.10E-18	1.24E-18	1.51E-18	7.95E-21	3.22E-21	1.42E-18
7.03E-05	1.10E-18	1.12E-18	1.26E-18	1.52E-18	8.05E-21	3.20E-21	1.42E-18
7.16E-05	1.12E-18	1.13E-18	1.28E-18	1.53E-18	8.18E-21	3.18E-21	1.42E-18
7.53E-05	1.14E-18	1.16E-18	1.30E-18	1.55E-18	8.30E-21	3.14E-21	1.42E-18

TABLE A1. Continued.

Neutron energy, ^a MeV	kerma per unit fluence, J/kg per n/m ²							
	ICRP standard man	ICRP soft tissue	ICRP red bone marrow	ICRP eye lens	Si	Ar	S	
	man	tissue	marrow	lens	Si	Ar	S	
7.78E-05	1.15E-18	1.17E-18	1.31E-18	1.55E-18	8.38E-21	3.12E-21	1.42E-18	
7.91E-05	1.17E-18	1.19E-18	1.33E-18	1.56E-18	8.47E-21	3.10E-21	1.42E-18	
8.17E-05	1.19E-18	1.21E-18	1.35E-18	1.58E-18	8.59E-21	3.07E-21	1.42E-18	
8.43E-05	1.22E-18	1.23E-18	1.37E-18	1.60E-18	8.73E-21	3.04E-21	1.42E-18	
8.68E-05	1.25E-18	1.26E-18	1.40E-18	1.62E-18	8.88E-21	3.00E-21	1.42E-18	
8.91E-05	1.27E-18	1.28E-18	1.42E-18	1.63E-18	9.00E-21	2.97E-21	1.42E-18	
9.39E-05	1.29E-18	1.31E-18	1.44E-18	1.65E-18	9.13E-21	2.94E-21	1.42E-18	
9.67E-05	1.31E-18	1.32E-18	1.46E-18	1.66E-18	9.22E-21	2.92E-21	1.42E-18	
9.81E-05	1.34E-18	1.35E-18	1.49E-18	1.68E-18	9.35E-21	2.89E-21	1.42E-18	
1.03E-04	1.39E-18	1.40E-18	1.54E-18	1.73E-18	9.64E-21	2.82E-21	1.42E-18	
1.10E-04	1.46E-18	1.47E-18	1.61E-18	1.79E-18	1.00E-20	2.74E-21	1.42E-18	
1.18E-04	1.53E-18	1.54E-18	1.68E-18	1.85E-18	1.04E-20	2.65E-21	1.42E-18	
1.26E-04	1.61E-18	1.61E-18	1.76E-18	1.92E-18	1.08E-20	2.57E-21	1.42E-18	
1.34E-04	1.68E-18	1.68E-18	1.83E-18	1.98E-18	1.12E-20	2.49E-21	1.42E-18	
1.41E-04	1.75E-18	1.76E-18	1.91E-18	2.05E-18	1.16E-20	2.39E-21	1.42E-18	
1.51E-04	1.84E-18	1.85E-18	2.00E-18	2.12E-18	1.21E-20	2.39E-21	1.42E-18	
1.60E-04	1.93E-18	1.93E-18	2.08E-18	2.20E-18	1.25E-20	2.46E-21	1.42E-18	
1.69E-04	2.01E-18	2.02E-18	2.17E-18	2.27E-18	1.30E-20	2.54E-21	1.42E-18	
1.79E-04	2.10E-18	2.10E-18	2.26E-18	2.35E-18	1.35E-20	2.61E-21	1.42E-18	
1.89E-04	2.19E-18	2.19E-18	2.35E-18	2.43E-18	1.40E-20	2.69E-21	1.42E-18	
1.99E-04	2.29E-18	2.29E-18	2.44E-18	2.51E-18	1.45E-20	2.77E-21	1.42E-18	
2.09E-04	2.66E-18	2.65E-18	2.82E-18	2.86E-18	1.63E-20	3.07E-21	1.42E-18	
2.74E-04	3.24E-18	3.23E-18	3.41E-18	3.40E-18	1.58E-20	3.54E-21	1.42E-18	
3.27E-04	3.77E-18	3.76E-18	3.94E-18	3.89E-18	1.58E-20	3.77E-21	1.42E-18	
3.81E-04	4.48E-18	4.45E-18	4.66E-18	4.56E-18	2.84E-20	4.56E-21	1.42E-18	
4.70E-04	5.05E-18	5.02E-18	5.26E-18	5.12E-18	2.83E-20	5.04E-21	1.43E-18	
4.99E-04	5.51E-18	5.48E-18	5.74E-18	5.57E-18	3.08E-20	5.43E-21	1.43E-18	
5.66E-04	6.02E-18	5.98E-18	6.28E-18	6.07E-18	3.32E-20	5.87E-21	1.43E-18	
6.04E-04	6.37E-18	6.33E-18	6.64E-18	6.41E-18	3.50E-20	6.16E-21	1.43E-18	
6.37E-04	6.92E-18	6.87E-18	7.21E-18	6.95E-18	3.77E-20	6.63E-21	1.43E-18	
7.16E-04	7.89E-18	7.83E-18	8.21E-18	7.89E-18	4.25E-20	7.46E-21	1.43E-18	
8.32E-04	8.88E-18	8.82E-18	9.24E-18	8.87E-18	4.75E-20	8.32E-21	1.43E-18	
9.18E-04	1.00E-17	9.92E-17	1.04E-17	9.96E-18	5.31E-20	9.30E-21	1.44E-18	
1.06E-03	1.19E-17	1.18E-17	1.24E-17	1.18E-17	6.27E-20	1.10E-20	1.44E-18	
1.31E-03	1.45E-17	1.44E-17	1.51E-17	1.44E-17	7.57E-20	1.34E-20	1.44E-18	
1.58E-03	1.74E-17	1.72E-17	1.80E-17	1.72E-17	8.99E-20	1.60E-20	1.44E-18	
1.88E-03	2.05E-17	2.03E-17	2.12E-17	2.02E-17	1.05E-19	1.91E-20	1.45E-18	
2.21E-03	2.38E-17	2.36E-17	2.47E-17	2.35E-17	1.22E-19	2.24E-20	1.45E-18	
2.56E-03	2.75E-17	2.72E-17	2.86E-17	2.71E-17	1.40E-19	2.62E-20	1.46E-18	
2.94E-03	3.13E-17	3.11E-17	3.25E-17	3.09E-17	1.60E-19	3.04E-20	1.46E-18	
3.35E-03	3.54E-17	3.51E-17	3.67E-17	3.49E-17	1.80E-19	3.50E-20	1.47E-18	
3.78E-03	3.97E-17	3.94E-17	4.12E-17	3.92E-17	2.02E-19	4.01E-20	1.48E-18	
4.23E-03	4.94E-17	4.90E-17	5.12E-17	4.87E-17	2.29E-19	4.52E-20	1.49E-18	
4.76E-03	6.49E-17	6.44E-17	6.73E-17	6.39E-17	3.29E-19	7.45E-20	1.53E-18	
5.33E-03	8.57E-17	8.50E-17	8.89E-17	8.44E-17	4.17E-19	1.09E-19	1.58E-18	
5.93E-03	1.20E-16	1.19E-16	1.24E-16	1.18E-16	5.27E-19	1.86E-19	1.68E-18	
6.51E-03	1.65E-16	1.63E-16	1.71E-16	1.62E-16	6.60E-19	3.28E-19	1.72E-18	
7.09E-03	2.10E-16	2.08E-16	2.18E-16	2.07E-16	8.05E-19	4.58E-19	1.74E-18	
7.65E-03	2.55E-16	2.53E-16	2.65E-16	2.51E-16	9.86E-19	5.65E-19	1.93E-18	
8.27E-03	3.01E-16	2.99E-16	3.12E-16	2.98E-16	1.16E-18	6.82E-19	2.17E-18	
8.95E-03	3.49E-16	3.46E-16	3.62E-16	3.43E-16	1.45E-18	8.10E-19	2.47E-18	
9.67E-03	4.05E-16	4.02E-16	4.20E-16	3.99E-16	1.84E-18	9.68E-19	2.83E-18	
1.04E-02	4.71E-16	4.67E-16	4.89E-16	4.63E-16	3.02E-18	1.17E-18	3.25E-18	
1.12E-02	5.38E-16	5.33E-16	5.58E-16	5.29E-16	3.11E-18	1.38E-18	3.70E-18	
1.20E-02	6.07E-16	6.02E-16	6.30E-16	5.97E-16	3.57E-18	1.60E-18	4.20E-18	
1.28E-02	6.77E-16	6.71E-16	7.05E-16	6.66E-16	4.07E-18	1.98E-18	4.75E-18	
1.36E-02	7.57E-16	7.50E-16	7.91E-16	7.43E-16	4.69E-18	2.37E-18	5.32E-18	
1.44E-02	8.47E-16	8.39E-16	8.91E-16	8.31E-16	5.45E-18	2.85E-18	6.00E-18	
1.52E-02	9.47E-16	9.38E-16	9.91E-16	9.31E-16	6.35E-18	3.45E-18	6.80E-18	
1.60E-02	1.06E-15	1.05E-15	1.10E-15	1.04E-15	7.45E-18	4.10E-18	7.75E-18	
1.68E-02	1.18E-15	1.17E-15	1.23E-15	1.16E-15	8.75E-18	4.80E-18	8.85E-18	
1.76E-02	1.31E-15	1.30E-15	1.36E-15	1.29E-15	1.02E-17	5.60E-18	1.01E-17	
1.84E-02	1.44E-15	1.43E-15	1.49E-15	1.42E-15	1.18E-17	6.50E-18	1.15E-17	
1.92E-02	1.58E-15	1.57E-15	1.63E-15	1.56E-15	1.35E-17	7.50E-18	1.30E-17	
2.00E-02	1.73E-15	1.72E-15	1.78E-15	1.71E-15	1.54E-17	8.60E-18	1.46E-17	
2.08E-02	1.88E-15	1.87E-15	1.93E-15	1.86E-15	1.74E-17	9.80E-18	1.63E-17	
2.16E-02	2.04E-15	2.03E-15	2.09E-15	2.02E-15	1.96E-17	1.12E-17	1.81E-17	
2.24E-02	2.21E-15	2.20E-15	2.26E-15	2.19E-15	2.20E-17	1.30E-17	2.01E-17	
2.32E-02	2.39E-15	2.38E-15	2.44E-15	2.37E-15	2.45E-17	1.50E-17	2.23E-17	
2.40E-02	2.58E-15	2.57E-15	2.63E-15	2.56E-15	2.72E-17	1.72E-17	2.47E-17	
2.48E-02	2.78E-15	2.77E-15	2.83E-15	2.76E-15	3.02E-17	1.98E-17	2.73E-17	
2.56E-02	2.99E-15	2.98E-15	3.04E-15	2.97E-15	3.34E-17	2.28E-17	3.01E-17	
2.64E-02	3.21E-15	3.20E-15	3.26E-15	3.19E-15	3.69E-17	2.60E-17	3.32E-17	
2.72E-02	3.44E-15	3.43E-15	3.49E-15	3.42E-15	4.07E-17	2.95E-17	3.65E-17	
2.80E-02	3.68E-15	3.67E-15	3.73E-15	3.66E-15	4.48E-17	3.34E-17	4.01E-17	
2.88E-02	3.93E-15	3.92E-15	3.98E-15	3.91E-15	4.92E-17	3.76E-17	4.39E-17	
2.96E-02	4.19E-15	4.18E-15	4.24E-15	4.17E-15	5.39E-17	4.21E-17	4.80E-17	
3.04E-02	4.46E-15	4.45E-15	4.51E-15	4.44E-15	5.89E-17	4.69E-17	5.24E-17	
3.12E-02	4.74E-15	4.73E-15	4.79E-15	4.72E-15	6.42E-17	5.20E-17	5.71E-17	
3.20E-02	5.03E-15	5.02E-15	5.08E-15	5.01E-15	6.98E-17	5.74E-17	6.21E-17	
3.28E-02	5.33E-15	5.32E-15	5.38E-15	5.31E-15	7.57E-17	6.31E-17	6.74E-17	
3.36E-02	5.64E-15	5.63E-15	5.69E-15	5.62E-15	8.19E-17	6.91E-17	7.31E-17	
3.44E-02	5.96E-15	5.95E-15	6.01E-15	5.94E-15	8.84E-17	7.54E-17	7.93E-17	
3.52E-02	6.29E-15	6.28E-15	6.34E-15	6.27E-15	9.52E-17	8.20E-17	8.59E-17	
3.60E-02	6.63E-15	6.62E-15	6.68E-15	6.61E-15	1.02E-16	8.89E-17	9.29E-17	
3.68E-02	6.98E-15	6.97E-15	7.03E-15	6.96E-15	1.10E-16	9.61E-17	1.00E-16	
3.76E-02	7.34E-15	7.33E-15	7.39E-15	7.32E-15	1.18E-16	1.04E-16	1.08E-16	
3.84E-02	7.71E-15	7.70E-15	7.76E-15	7.69E-15	1.27E-16	1.13E-16	1.17E-16	
3.92E-02	8.09E-15	8.08E-15	8.14E-15	8.07E-15	1.36E-16	1.23E-16	1.27E-16	
4.00E-02	8.48E-15	8.47E-15	8.53E-15	8.46E-15	1.46E-16	1.34E-16	1.38E-16	
4.08E-02	8.88E-15	8.87E-15	8.93E-15	8.86E-15	1.56E-16	1.45E-16	1.49E-16	
4.16E-02	9.29E-15	9.28E-15	9.34E-15	9.27E-15	1.67E-16	1.57E-16	1.61E-16	
4.24E-02	9.71E-15	9.70E-15	9.76E-15	9.69E-15	1.78E-16	1.69E-16	1.73E-16	
4.32E-02	1.01E-14	1.01E-14	1.01E-14	1.00E-14	1.90E-16	1.82E-16	1.86E-16	
4.40E-02	1.05E-14	1.05E-14	1.05E-14	1.04E-14	2.02E-16	1.95E-16	1.99E-16	
4.48E-02	1.10E-14	1.10E-14	1.10E-14	1.09E-14	2.15E-16	2.09E-16	2.13E-16	
4.56E-02	1.14E-14	1.14E-14	1.14E-14	1.13E-14	2.29E-16	2.24E-16	2.28E-16	
4.64E-02	1.19E-14	1.19E-14	1.19E-14	1.18E-14	2.43E-16	2.39E-16	2.43E-16	
4.72E-02	1.24E-14	1.24E-14	1.24E-14	1.23E-14	2.58E-16	2.55E-16	2.59E-16	
4.80E-02	1.29E-14	1.29E-14	1.29E-14	1.28E-14	2.73E-16	2.71E-16	2.75E-16	
4.88E-02	1.34E-14	1.34E-14	1.34E-14	1.33E-14	2.89E-16	2.87E-16	2.91E-16	
4.96E-02	1.39E-14	1.39E-14	1.39E-14	1.38E-14	3.05E-16	3.03E-16	3.07E-16	
5.04E-02	1.44E-14	1.44E-14	1.44E-14	1.43E-14	3.22E-16	3.20E-16	3.24E-16	
5.12E-02	1.49E-14	1.49E-14	1.49E-14	1.48E-14	3.39E-16	3.37E-16	3.41E-16	
5.20E-02	1.54E-14	1.54E-14	1.54E-14	1.53E-14	3.57E-16	3.55E-16	3.59E-16	
5.28E-02	1.59E-14	1.59E-14	1.59E-14	1.58E-14	3.75E-16	3.73E-16	3.77E-16	
5.36E-02	1.64E-14	1.64E-14	1.64E-14	1.63E-14	3.94E-16	3.92E-16	3.96E-16	
5.44E-02	1.69E-14	1.69E-14	1.69E-14	1.68E-14	4.13E-16	4.11E-16	4.15E-16	
5.52E-02	1.74E-14	1.74E-14	1.74E-14	1.73E-14	4.33E-16	4.31E-16	4.35E-16	
5.60E-02	1.79E-14	1.79E-14	1.79E-14	1.78E-14	4.53E-16	4.51E-16	4.55E-16	
5.68E-02	1.84E-14	1.84E-14	1.84E-14	1.83E-1				

TABLE A1. Continued.

kerma per unit fluence, J/kg per n/m ²								
Neutron energy, ^a MeV	ICRP standard man	ICRP soft tissue	ICRP red bone marrow	ICRP eye lens	Si	Ar	S	
2.71E-01	1.21E-15	1.20E-15	1.25E-15	1.19E-15	2.95E-17	5.13E-18	1.85E-17	
2.94E-01	1.28E-15	1.27E-15	1.32E-15	1.26E-15	2.87E-17	5.49E-18	1.31E-17	
3.35E-01	1.37E-15	1.36E-15	1.42E-15	1.38E-15	2.89E-17	4.80E-18	9.79E-18	
3.78E-01	1.50E-15	1.49E-15	1.54E-15	1.48E-15	2.98E-17	4.00E-18	2.16E-17	
4.23E-01	1.62E-15	1.61E-15	1.66E-15	1.61E-15	3.10E-17	5.50E-18	1.67E-17	
5.12E-01	1.69E-15	1.68E-15	1.77E-15	1.67E-15	4.43E-17	9.63E-18	2.05E-17	
6.33E-01	1.87E-15	1.85E-15	1.95E-15	1.84E-15	4.00E-17	1.20E-17	2.18E-17	
7.53E-01	2.03E-15	2.02E-15	2.12E-15	2.00E-15	5.62E-17	1.00E-17	2.26E-17	
8.83E-01	2.31E-15	2.29E-15	2.36E-15	2.28E-15	5.88E-17	1.54E-17	2.65E-17	
1.03E+00	2.42E-15	2.41E-15	2.49E-15	2.39E-15	4.22E-17	2.38E-17	2.82E-17	
1.18E+00	2.59E-15	2.57E-15	2.66E-15	2.55E-15	4.73E-17	2.96E-17	3.59E-17	
1.34E+00	2.67E-15	2.65E-15	2.77E-15	2.63E-15	6.59E-17	3.77E-17	4.39E-17	
1.51E+00	2.78E-15	2.76E-15	2.90E-15	2.75E-15	9.65E-17	3.66E-17	4.83E-17	
1.69E+00	2.92E-15	2.90E-15	3.05E-15	2.88E-15	8.94E-17	4.98E-17	7.18E-17	
1.89E+00	3.07E-15	3.05E-15	3.21E-15	3.03E-15	9.23E-17	5.72E-17	1.13E-16	
2.09E+00	3.15E-15	3.12E-15	3.29E-15	3.10E-15	9.38E-17	6.18E-17	1.27E-16	
2.31E+00	3.23E-15	3.21E-15	3.40E-15	3.18E-15	1.01E-16	6.67E-17	1.43E-16	
2.53E+00	3.42E-15	3.40E-15	3.60E-15	3.37E-15	1.00E-16	7.18E-17	1.70E-16	
2.74E+00	3.61E-15	3.59E-15	3.84E-15	3.56E-15	1.00E-16	7.40E-17	2.48E-16	
3.01E+00	3.81E-15	3.78E-15	3.99E-15	3.77E-15	1.06E-16	7.40E-17	2.69E-16	
3.27E+00	4.12E-15	4.10E-15	4.34E-15	4.09E-15	1.07E-16	7.67E-17	2.89E-16	
3.53E+00	4.23E-15	4.20E-15	4.45E-15	4.19E-15	9.42E-17	7.99E-17	3.50E-16	
3.81E+00	4.22E-15	4.19E-15	4.43E-15	4.18E-15	1.23E-16	8.19E-17	3.93E-16	
4.07E+00	4.36E-15	4.33E-15	4.57E-15	4.32E-15	1.36E-16	8.35E-17	3.28E-16	
4.40E+00	4.36E-15	4.33E-15	4.57E-15	4.32E-15	1.58E-16	8.36E-17	3.12E-16	
4.70E+00	4.39E-15	4.36E-15	4.58E-15	4.34E-15	1.79E-16	8.28E-17	3.17E-16	
4.99E+00	4.51E-15	4.48E-15	4.69E-15	4.46E-15	1.69E-16	8.28E-17	3.23E-16	
5.29E+00	4.52E-15	4.49E-15	4.72E-15	4.47E-15	1.69E-16	8.05E-17	3.41E-16	
5.66E+00	4.62E-15	4.59E-15	4.79E-15	4.57E-15	2.14E-16	7.67E-17	3.79E-16	
6.04E+00	4.68E-15	4.64E-15	4.90E-15	4.61E-15	2.34E-16	7.76E-17	4.12E-16	
6.37E+00	4.75E-15	4.72E-15	4.89E-15	4.70E-15	2.81E-16	6.23E-17	4.29E-16	
6.74E+00	4.80E-15	4.77E-15	4.92E-15	4.76E-15	3.57E-16	8.77E-17	1.47E-16	
7.16E+00	5.06E-15	5.02E-15	5.23E-15	5.01E-15	4.36E-16	9.32E-17	4.68E-16	
7.55E+00	5.12E-15	5.08E-15	5.40E-15	5.05E-15	5.63E-16	9.83E-17	4.89E-16	
7.91E+00	5.11E-15	5.07E-15	5.39E-15	5.04E-15	5.79E-16	1.04E-16	5.10E-16	
8.32E+00	5.11E-15	5.07E-15	5.32E-15	5.05E-15	6.63E-16	1.10E-16	5.34E-16	
8.79E+00	5.19E-15	5.15E-15	5.41E-15	5.12E-15	7.63E-16	1.15E-16	5.58E-16	
9.18E+00	5.26E-15	5.22E-15	5.51E-15	5.20E-15	8.46E-16	1.22E-16	5.83E-16	
9.67E+00	5.35E-15	5.31E-15	5.59E-15	5.29E-15	9.32E-16	1.29E-16	6.11E-16	
1.01E+01	5.41E-15	5.38E-15	5.65E-15	5.36E-15	9.95E-16	1.36E-16	6.40E-16	
1.06E+01	5.52E-15	5.48E-15	5.79E-15	5.46E-15	1.04E-15	1.42E-16	6.68E-16	
1.10E+01	5.70E-15	5.66E-15	5.97E-15	5.64E-15	1.07E-15	1.49E-16	6.88E-16	
1.15E+01	5.81E-15	5.77E-15	6.08E-15	5.76E-15	1.11E-15	1.58E-16	7.00E-16	
1.20E+01	5.89E-15	5.85E-15	6.18E-15	5.84E-15	1.12E-15	1.62E-16	7.13E-16	
1.25E+01	5.99E-15	5.96E-15	6.29E-15	5.95E-15	1.14E-15	1.72E-16	7.26E-16	
1.31E+01	6.07E-15	6.04E-15	6.37E-15	6.03E-15	1.17E-15	1.82E-16	7.39E-16	
1.35E+01	6.14E-15	6.11E-15	6.43E-15	6.10E-15	1.17E-15	1.91E-16	7.49E-16	
1.39E+01	6.19E-15	6.15E-15	6.47E-15	6.15E-15	1.17E-15	1.98E-16	7.56E-16	
1.41E+01	6.23E-15	6.20E-15	6.51E-15	6.20E-15	1.16E-15	2.05E-16	7.67E-16	
1.44E+01	6.28E-15	6.25E-15	6.56E-15	6.24E-15	1.15E-15	2.14E-16	7.78E-16	
1.47E+01	6.36E-15	6.33E-15	6.64E-15	6.33E-15	1.13E-15	2.23E-16	7.97E-16	
1.52E+01	6.44E-15	6.41E-15	6.74E-15	6.41E-15	1.11E-15	2.31E-16	8.20E-16	
1.58E+01	6.52E-15	6.49E-15	6.82E-15	6.49E-15	1.08E-15	2.39E-16	8.42E-16	
1.63E+01	6.56E-15	6.53E-15	6.86E-15	6.53E-15	1.06E-15	2.46E-16	8.64E-16	
1.69E+01	6.55E-15	6.52E-15	6.85E-15	6.51E-15	1.04E-15	2.53E-16	8.85E-16	
1.75E+01	6.51E-15	6.48E-15	6.85E-15	6.47E-15	1.01E-15	2.60E-16	9.05E-16	
1.81E+01	6.54E-15	6.50E-15	6.90E-15	6.49E-15	9.82E-16	2.67E-16	9.26E-16	
1.87E+01	6.62E-15	6.59E-15	7.00E-15	6.57E-15	8.77E-16	2.77E-16	9.54E-16	
2.00E+01								

^a Entries in this column are the lower energy values for each energy group.

TABLE A2. Neutron kerma per unit fluence for four TLD materials and three others, as a function of neutron energy.

Neutron energy, ^a MeV	kerma per unit fluence, J/kg per n/m ²						
	TLD 100	TLD 600	TLD 700	TLD 200	H ₂ O	Air	Al
1.31E-09	4.27E-13	4.92E-12	3.94E-15	.87E-19	1.78E-15	1.37E-18	2.80E-19
5.23E-09	2.13E-13	2.46E-12	1.97E-15	9.71E-20	8.84E-16	6.87E-19	1.40E-19
2.09E-08	1.42E-13	1.64E-12	1.31E-15	6.46E-20	5.91E-16	4.59E-19	9.31E-20
3.27E-08	1.16E-13	1.34E-12	1.07E-15	5.30E-20	4.82E-16	3.75E-19	7.61E-20
4.70E-08	9.15E-14	1.06E-12	8.45E-16	4.16E-20	3.78E-16	2.96E-19	6.00E-20
8.32E-08	7.12E-14	8.22E-13	6.57E-16	3.23E-20	2.98E-16	2.21E-19	4.67E-20
1.31E-07	4.92E-14	5.72E-13	4.37E-16	2.65E-20	2.45E-16	1.89E-19	3.82E-20
1.88E-07	6.92E-14	8.68E-13	6.44E-16	2.65E-20	2.05E-16	1.61E-19	3.23E-20
2.56E-07	4.27E-14	4.92E-13	3.94E-16	1.95E-20	1.77E-16	1.41E-19	2.80E-20
3.35E-07	3.76E-14	4.34E-13	3.47E-16	1.72E-20	1.56E-16	1.25E-19	2.47E-20
4.23E-07	3.39E-14	3.91E-13	3.12E-16	1.55E-20	1.41E-16	1.14E-19	2.22E-20
5.12E-07	2.92E-14	3.37E-13	2.70E-16	1.34E-20	1.21E-16	1.01E-19	1.92E-20
7.53E-07	2.37E-14	2.74E-13	2.19E-16	1.09E-20	9.82E-17	8.72E-20	1.56E-20
1.18E-06	2.00E-14	2.31E-13	1.85E-16	9.21E-21	8.56E-17	7.95E-20	1.32E-20
1.51E-06	1.73E-14	2.00E-13	1.60E-16	8.01E-21	7.30E-17	7.60E-20	1.14E-20
2.03E-06	1.43E-14	1.72E-13	1.38E-16	6.99E-21	6.23E-17	7.52E-20	9.87E-21
2.74E-06	1.31E-14	1.51E-13	1.21E-16	6.23E-21	5.42E-17	7.74E-20	8.69E-21
3.53E-06	1.14E-14	1.32E-13	1.05E-16	5.58E-21	4.73E-17	8.31E-20	7.64E-21
4.70E-06	1.02E-14	1.17E-13	9.39E-17	5.15E-21	4.23E-17	9.09E-20	6.85E-21
5.66E-06	9.30E-15	1.07E-13	8.58E-17	4.86E-21	3.83E-17	9.95E-20	6.31E-21
6.74E-06	8.44E-15	9.75E-14	7.79E-17	4.60E-21	3.48E-17	1.12E-19	5.80E-21
8.32E-06	7.73E-15	8.92E-14	7.13E-17	4.42E-21	3.19E-17	1.26E-19	5.38E-21
9.62E-06	7.21E-15	8.32E-14	6.65E-17	4.28E-21	2.99E-17	1.39E-19	5.08E-21
1.10E-05	6.67E-15	7.70E-14	6.16E-17	4.14E-21	2.83E-17	1.57E-19	4.79E-21
1.31E-05	6.21E-15	7.17E-14	5.73E-17	4.04E-21	2.67E-17	1.76E-19	4.55E-21
1.47E-05	5.92E-15	6.74E-14	5.47E-17	4.00E-21	2.55E-17	1.90E-19	4.40E-21
1.58E-05	5.66E-15	6.54E-14	5.23E-17	3.98E-21	2.42E-17	2.06E-19	4.28E-21
1.76E-05	5.42E-15	6.26E-14	5.00E-17	3.98E-21	2.29E-17	2.22E-19	4.18E-21
1.88E-05	5.20E-15	6.01E-14	4.80E-17	3.99E-21	2.16E-17	2.39E-19	4.07E-21
2.08E-05	4.96E-15	5.73E-14	4.58E-17	4.04E-21	2.08E-17	2.60E-19	3.99E-21
2.28E-05	4.77E-15	5.51E-14	4.41E-17	4.11E-21	2.02E-17	2.79E-19	3.92E-21
2.42E-05	4.64E-15	5.35E-14	4.28E-17	4.16E-21	1.98E-17	2.94E-19	3.87E-21
2.56E-05	4.51E-15	5.20E-14	4.16E-17	4.22E-21	1.93E-17	3.10E-19	3.84E-21
2.66E-05	4.38E-15	5.06E-14	4.04E-17	4.29E-21	1.89E-17	3.27E-19	3.82E-21
2.81E-05	4.29E-15	4.96E-14	3.96E-17	4.35E-21	1.85E-17	3.39E-19	3.80E-21
2.94E-05	4.21E-15	4.86E-14	3.89E-17	4.41E-21	1.81E-17	3.52E-19	3.78E-21
3.10E-05	4.08E-15	4.70E-14	3.76E-17	4.52E-21	1.75E-17	3.75E-19	3.75E-21
3.35E-05	3.93E-15	4.53E-14	3.62E-17	4.66E-21	1.67E-17	4.02E-19	3.74E-21
3.60E-05	3.79E-15	4.37E-14	3.49E-17	4.81E-21	1.59E-17	4.31E-19	3.74E-21
3.87E-05	3.68E-15	4.25E-14	3.39E-17	4.95E-21	1.52E-17	4.56E-19	3.73E-21
4.05E-05	3.59E-15	4.15E-14	3.32E-17	5.07E-21	1.49E-17	4.76E-19	3.75E-21
4.23E-05	3.54E-15	4.08E-14	3.26E-17	5.15E-21	1.47E-17	4.92E-19	3.76E-21
4.39E-05	3.46E-15	3.99E-14	3.19E-17	5.27E-21	1.45E-17	5.13E-19	3.77E-21
4.62E-05	3.38E-15	3.91E-14	3.13E-17	5.40E-21	1.42E-17	5.35E-19	3.79E-21
4.72E-05	3.33E-15	3.85E-14	3.08E-17	5.50E-21	1.40E-17	5.51E-19	3.80E-21
4.92E-05	3.26E-15	3.77E-14	3.01E-17	5.64E-21	1.37E-17	5.74E-19	3.82E-21
5.12E-05	3.20E-15	3.69E-14	2.95E-17	5.78E-21	1.34E-17	5.97E-19	3.85E-21
5.33E-05	3.12E-15	3.60E-14	2.88E-17	5.96E-21	1.30E-17	6.26E-19	3.89E-21
5.65E-05	3.06E-15	3.53E-14	2.83E-17	6.11E-21	1.28E-17	6.50E-19	3.92E-21
5.76E-05	3.00E-15	3.47E-14	2.77E-17	6.27E-21	1.25E-17	6.75E-19	3.96E-21
6.10E-05	2.93E-15	3.39E-14	2.71E-17	6.47E-21	1.20E-17	7.06E-19	4.00E-21
6.33E-05	2.88E-15	3.33E-14	2.66E-17	6.63E-21	1.20E-17	7.32E-19	4.05E-21
6.58E-05	2.84E-15	3.28E-14	2.63E-17	6.76E-21	1.18E-17	7.51E-19	4.08E-21
6.67E-05	2.79E-15	3.23E-14	2.58E-17	6.93E-21	1.16E-17	7.76E-19	4.13E-21
7.03E-05	2.75E-15	3.17E-14	2.54E-17	7.11E-21	1.15E-17	8.05E-19	4.18E-21
7.16E-05	2.70E-15	3.12E-14	2.49E-17	7.29E-21	1.12E-17	8.32E-19	4.23E-21
7.33E-05	2.64E-15	3.05E-14	2.44E-17	7.52E-21	1.10E-17	8.67E-19	4.30E-21
7.78E-05	2.61E-15	3.01E-14	2.41E-17	7.67E-21	1.08E-17	8.88E-19	4.34E-21
7.91E-05	2.58E-15	2.98E-14	2.38E-17	7.81E-21	1.07E-17	9.10E-19	4.38E-21
8.17E-05	2.54E-15	2.93E-14	2.34E-17	8.01E-21	1.05E-17	9.39E-19	4.45E-21
8.43E-05	2.49E-15	2.87E-14	2.30E-17	8.25E-21	1.03E-17	9.76E-19	4.53E-21
8.83E-05	2.44E-15	2.82E-14	2.26E-17	8.52E-21	1.02E-17	1.01E-18	4.61E-21
9.11E-05	2.41E-15	2.78E-14	2.22E-17	8.73E-21	1.00E-17	1.05E-18	4.68E-21
9.39E-05	2.37E-15	2.74E-14	2.19E-17	8.94E-21	9.85E-18	1.08E-18	4.75E-21
9.67E-05	2.34E-15	2.71E-14	2.17E-17	9.11E-21	9.73E-18	1.10E-18	4.80E-21
9.81E-05	2.31E-15	2.67E-14	2.13E-17	9.33E-21	9.58E-18	1.13E-18	4.87E-21

TABLE A2. Continued.

Neutron		kerma per unit fluence, J/kg per n/m ²						
energy, ^a		TLD	TLD	TLD	TLD	H ₂ O	Air	Al
MeV		100	600	700	200			
1.03E-04	2.25E-15	2.59E-14	2.08E-17	9.78E-21	9.41E-18	1.20E-18	5.04E-21	
1.10E-04	2.01E-15	2.35E-14	2.00E-17	1.04E-20	9.21E-18	1.28E-18	5.27E-21	
1.16E-04	1.85E-15	2.19E-14	1.88E-17	1.16E-20	9.00E-18	1.37E-18	5.50E-21	
1.26E-04	1.62E-15	2.03E-14	1.68E-17	1.36E-20	8.78E-18	1.46E-18	5.74E-21	
1.34E-04	1.48E-15	1.88E-14	1.43E-17	1.62E-20	8.58E-18	1.54E-18	5.97E-21	
1.41E-04	1.32E-15	1.72E-14	1.27E-17	1.88E-20	8.34E-18	1.64E-18	6.23E-21	
1.51E-04	1.16E-15	1.56E-14	1.12E-17	2.16E-20	8.08E-18	1.75E-18	6.53E-21	
1.60E-04	1.00E-15	1.40E-14	1.00E-17	2.44E-20	7.83E-18	1.85E-18	6.81E-21	
1.69E-04	8.75E-16	1.24E-14	8.75E-17	2.72E-20	7.58E-18	1.95E-18	7.11E-21	
1.79E-04	7.71E-16	1.07E-14	7.71E-17	3.00E-20	7.32E-18	2.06E-18	7.41E-21	
1.89E-04	6.86E-16	9.22E-15	6.86E-17	3.28E-20	7.05E-18	2.17E-18	7.72E-21	
1.99E-04	6.22E-16	8.37E-15	6.22E-17	3.56E-20	6.78E-18	2.28E-18	8.04E-21	
2.09E-04	5.69E-16	7.52E-15	5.69E-17	3.84E-20	6.49E-18	2.40E-18	8.36E-21	
2.24E-04	5.26E-16	6.86E-15	5.26E-17	4.12E-20	6.20E-18	2.52E-18	8.68E-21	
2.37E-04	4.84E-16	6.29E-15	4.84E-17	4.40E-20	5.91E-18	2.64E-18	8.99E-21	
2.51E-04	4.42E-16	5.81E-15	4.42E-17	4.68E-20	5.62E-18	2.76E-18	9.30E-21	
2.66E-04	4.00E-16	5.33E-15	4.00E-17	4.96E-20	5.33E-18	2.88E-18	9.61E-21	
2.81E-04	3.58E-16	4.85E-15	3.58E-17	5.24E-20	5.04E-18	3.00E-18	9.92E-21	
2.97E-04	3.16E-16	4.37E-15	3.16E-17	5.52E-20	4.75E-18	3.12E-18	1.02E-20	
3.14E-04	2.74E-16	3.89E-15	2.74E-17	5.80E-20	4.46E-18	3.24E-18	1.05E-20	
3.32E-04	2.32E-16	3.41E-15	2.32E-17	6.08E-20	4.17E-18	3.36E-18	1.08E-20	
3.51E-04	1.90E-16	2.93E-15	1.90E-17	6.36E-20	3.88E-18	3.48E-18	1.11E-20	
3.71E-04	1.48E-16	2.45E-15	1.48E-17	6.64E-20	3.59E-18	3.60E-18	1.14E-20	
3.92E-04	1.06E-16	1.97E-15	1.06E-17	6.92E-20	3.30E-18	3.72E-18	1.17E-20	
4.14E-04	8.24E-17	1.46E-15	8.24E-17	7.20E-20	3.01E-18	3.84E-18	1.20E-20	
4.37E-04	6.82E-17	1.21E-15	6.82E-17	7.48E-20	2.72E-18	3.96E-18	1.23E-20	
4.61E-04	5.40E-17	9.69E-16	5.40E-17	7.76E-20	2.43E-18	4.08E-18	1.26E-20	
4.86E-04	4.00E-17	7.27E-16	4.00E-17	8.04E-20	2.14E-18	4.20E-18	1.29E-20	
5.12E-04	2.58E-17	4.85E-16	2.58E-17	8.32E-20	1.85E-18	4.32E-18	1.32E-20	
5.39E-04	1.19E-17	2.40E-16	1.19E-17	8.60E-20	1.56E-18	4.44E-18	1.35E-20	
5.67E-04	6.00E-18	1.01E-16	6.00E-18	8.88E-20	1.27E-18	4.56E-18	1.38E-20	
5.96E-04	3.61E-18	5.99E-17	3.61E-18	9.16E-20	9.40E-19	4.68E-18	1.41E-20	
6.26E-04	2.22E-18	3.78E-17	2.22E-18	9.44E-20	8.04E-19	4.80E-18	1.44E-20	
6.57E-04	1.33E-18	2.25E-17	1.33E-18	9.72E-20	6.68E-19	4.92E-18	1.47E-20	
6.89E-04	8.40E-19	1.46E-17	8.40E-19	1.00E-20	5.32E-19	5.04E-18	1.50E-20	
7.22E-04	5.00E-19	8.75E-18	5.00E-19	1.02E-20	4.46E-19	5.16E-18	1.53E-20	
7.56E-04	2.99E-19	5.00E-18	2.99E-19	1.04E-20	3.60E-19	5.28E-18	1.56E-20	
7.91E-04	1.78E-19	2.93E-18	1.78E-19	1.06E-20	2.74E-19	5.40E-18	1.59E-20	
8.27E-04	1.06E-19	1.72E-18	1.06E-19	1.08E-20	1.88E-19	5.52E-18	1.62E-20	
8.64E-04	6.40E-20	1.00E-18	6.40E-20	1.10E-20	1.02E-19	5.64E-18	1.65E-20	
9.02E-04	3.80E-20	5.79E-19	3.80E-20	1.12E-20	8.36E-20	5.76E-18	1.68E-20	
9.41E-04	2.22E-20	3.41E-19	2.22E-20	1.14E-20	6.92E-20	5.88E-18	1.71E-20	
9.81E-04	1.33E-20	2.00E-19	1.33E-20	1.16E-20	5.48E-20	5.99E-18	1.74E-20	
1.02E-03	8.00E-21	1.25E-19	8.00E-21	1.18E-20	4.64E-20	6.10E-18	1.77E-20	
1.06E-03	4.80E-21	7.27E-20	4.80E-21	1.20E-20	3.80E-20	6.22E-18	1.80E-20	
1.10E-03	2.80E-21	4.29E-20	2.80E-21	1.22E-20	3.06E-20	6.34E-18	1.83E-20	
1.14E-03	1.60E-21	2.50E-20	1.60E-21	1.24E-20	2.32E-20	6.46E-18	1.86E-20	
1.18E-03	9.00E-22	1.40E-20	9.00E-22	1.26E-20	1.58E-20	6.58E-18	1.89E-20	
1.22E-03	5.00E-22	7.50E-21	5.00E-22	1.28E-20	9.40E-21	6.70E-18	1.92E-20	
1.26E-03	2.80E-22	4.29E-21	2.80E-22	1.30E-20	7.20E-21	6.82E-18	1.95E-20	
1.30E-03	1.60E-22	2.50E-21	1.60E-22	1.32E-20	5.90E-21	6.94E-18	1.98E-20	
1.34E-03	9.00E-23	1.40E-21	9.00E-23	1.34E-20	4.70E-21	7.06E-18	2.01E-20	
1.38E-03	5.00E-23	7.50E-22	5.00E-23	1.36E-20	3.80E-21	7.18E-18	2.04E-20	
1.42E-03	2.80E-23	4.29E-22	2.80E-23	1.38E-20	3.06E-21	7.30E-18	2.07E-20	
1.46E-03	1.60E-23	2.50E-22	1.60E-23	1.40E-20	2.32E-21	7.42E-18	2.10E-20	
1.50E-03	9.00E-24	1.40E-22	9.00E-24	1.42E-20	1.58E-21	7.54E-18	2.13E-20	
1.54E-03	5.00E-24	7.50E-23	5.00E-24	1.44E-20	9.40E-22	7.66E-18	2.16E-20	
1.58E-03	2.80E-24	4.29E-23	2.80E-24	1.46E-20	7.20E-22	7.78E-18	2.19E-20	
1.62E-03	1.60E-24	2.50E-23	1.60E-24	1.48E-20	5.90E-22	7.90E-18	2.22E-20	
1.66E-03	9.00E-25	1.40E-23	9.00E-25	1.50E-20	4.70E-22	8.02E-18	2.25E-20	
1.70E-03	5.00E-25	7.50E-24	5.00E-25	1.52E-20	3.80E-22	8.14E-18	2.28E-20	
1.74E-03	2.80E-25	4.29E-24	2.80E-25	1.54E-20	3.06E-22	8.26E-18	2.31E-20	
1.78E-03	1.60E-25	2.50E-24	1.60E-25	1.56E-20	2.32E-22	8.38E-18	2.34E-20	
1.82E-03	9.00E-26	1.40E-24	9.00E-26	1.58E-20	1.58E-22	8.50E-18	2.37E-20	
1.86E-03	5.00E-26	7.50E-25	5.00E-26	1.60E-20	9.40E-23	8.62E-18	2.40E-20	
1.90E-03	2.80E-26	4.29E-25	2.80E-26	1.62E-20	7.20E-23	8.74E-18	2.43E-20	
1.94E-03	1.60E-26	2.50E-25	1.60E-26	1.64E-20	5.90E-23	8.86E-18	2.46E-20	
1.98E-03	9.00E-27	1.40E-25	9.00E-27	1.66E-20	4.70E-23	8.98E-18	2.49E-20	
2.02E-03	5.00E-27	7.50E-26	5.00E-27	1.68E-20	3.80E-23	9.10E-18	2.52E-20	
2.06E-03	2.80E-27	4.29E-26	2.80E-27	1.70E-20	3.06E-23	9.22E-18	2.55E-20	
2.10E-03	1.60E-27	2.50E-26	1.60E-27	1.72E-20	2.32E-23	9.34E-18	2.58E-20	
2.14E-03	9.00E-28	1.40E-26	9.00E-28	1.74E-20	1.58E-23	9.46E-18	2.61E-20	
2.18E-03	5.00E-28	7.50E-27	5.00E-28	1.76E-20	9.40E-24	9.58E-18	2.64E-20	
2.22E-03	2.80E-28	4.29E-27	2.80E-28	1.78E-20	7.20E-24	9.70E-18	2.67E-20	
2.26E-03	1.60E-28	2.50E-27	1.60E-28	1.80E-20	5.90E-24	9.82E-18	2.70E-20	
2.30E-03	9.00E-29	1.40E-27	9.00E-29	1.82E-20	4.70E-24	9.94E-18	2.73E-20	
2.34E-03	5.00E-29	7.50E-28	5.00E-29	1.84E-20	3.80E-24	1.01E-17	2.76E-20	
2.38E-03	2.80E-29	4.29E-28	2.80E-29	1.86E-20	3.06E-24	1.03E-17	2.79E-20	
2.42E-03	1.60E-29	2.50E-28	1.60E-29	1.88E-20	2.32E-24	1.05E-17	2.82E-20	
2.46E-03	9.00E-30	1.40E-28	9.00E-30	1.90E-20	1.58E-24	1.07E-17	2.85E-20	
2.50E-03	5.00E-30	7.50E-29	5.00E-30	1.92E-20	9.40E-25	1.09E-17	2.88E-20	
2.54E-03	2.80E-30	4.29E-29	2.80E-30	1.94E-20	7.20E-25	1.11E-17	2.91E-20	
2.58E-03	1.60E-30	2.50E-29	1.60E-30	1.96E-20	5.90E-25	1.13E-17	2.94E-20	
2.62E-03	9.00E-31	1.40E-29	9.00E-31	1.98E-20	4.70E-25	1.15E-17	2.97E-20	
2.66E-03	5.00E-31	7.50E-30	5.00E-31	2.00E-20	3.80E-25	1.17E-17	3.00E-20	
2.70E-03	2.80E-31	4.29E-30	2.80E-31	2.02E-20	3.06E-25	1.19E-17	3.03E-20	
2.74E-03	1.60E-31	2.50E-30	1.60E-31	2.04E-20	2.32E-25	1.21E-17	3.06E-20	
2.78E-03	9.00E-32	1.40E-30	9.00E-32	2.06E-20	1.58E-25	1.23E-17	3.09E-20	
2.82E-03	5.00E-32	7.50E-31	5.00E-32	2.08E-20	9.40E-26	1.25E-17	3.12E-20	
2.86E-03	2.80E-32	4.29E-31	2.80E-32	2.10E-20	7.20E-26	1.27E-17	3.15E-20	
2.90E-03	1.60E-32	2.50E-31	1.60E-32	2.12E-20	5.90E-26	1.29E-17	3.18E-20	
2.94E-03	9.00E-33	1.40E-31	9.00E-33	2.14E-20	4.70E-26	1.31E-17	3.21E-20	
2.98E-03	5.00E-33	7.50E-32	5.00E-33	2.16E-20	3.80E-26	1.33E-17	3.24E-20	
3.02E-03	2.80E-33	4.29E-32	2.80E-33	2.18E-20	3.06E-26	1.35E-17	3.27E-20	
3.06E-03	1.60E-33	2.50E-32	1.60E-33	2.20E-20	2.32E-26	1.37E-17	3.30E-20	
3.10E-03	9.00E-34	1.40E-32	9.00E-34	2.22E-20	1.58E-26	1.39E-17	3.33E-20	
3.14E-03	5.00E-34	7.50E-33	5.00E-34	2.24E-20	9.40E-27	1.41E-17	3.36E-20	
3.18E-03	2.80E-34	4.29E-33	2.80E-34	2.26E-20	7.20E-27	1.43E-17	3.39E-20	
3.22E-03	1.60E-34	2.50E-33	1.60E-34	2.28E-20	5.90E-27	1.45E-17	3.42E-20	
3.26E-03	9.00E-35	1.40E-33	9.00E-35	2.30E-20	4.70E-27	1.47E-17	3.45E-20	
3.30E-03	5.00E-35	7.50E-34	5.00E-35	2.32E-20	3.80E-27	1.49E-17	3.48E-20	
3.34E-03	2.80E-35	4.29E-34	2.80E-35	2.34E-20	3.06E-27	1.51E-17	3.51E-20	
3.38E-03	1.60E-35	2.50E-34	1.60E-35	2.36E-20	2.32E-27	1.53E-17	3.54E-20	
3.42E-03	9.00E-36	1.40E-34	9.00E-36	2.38E-20	1.58E-27	1.55E-17	3.57E-20	
3.46E-03	5.00E-36	7.50E-35	5.00E-36	2.40E-20	9.40E-28	1.57E-17	3.60E-20	
3.50E-03	2.80E-36	4.29E-35	2.80E-36	2.42E-20	7.20E-28	1.59E-17	3.63E-20	
3.54E-03	1.60E-36	2.50E-35	1.60E-36	2.44E-20	5.90E-28	1.61E-17	3.66E-20	
3.58E-03	9.00E-37	1.40E-35	9.00E-37	2.46E-20	4.70E-28	1.63E-17	3.69E-20	
3.62E-03	5.00E-37	7.50E-36	5.00E-37	2.48E-20	3.80E-28	1.65E-17	3.72E-20	
3.66E-03	2.80E-37	4.29E-36	2.80E-37	2.50E-20	3.06E-28	1.67E-17	3.75E-20	
3.70E-03	1.60E-37	2.50E-36	1.60E-37	2.52E-20	2.32E-28	1.69E-17		

TABLE A2. Continued.

Neutron energy, ^a MeV	kerma per unit fluence, J/kg per n/m ²						
	TLD 100	TLD 600	TLD 700	TLD 200	H ₂ O	Air	Al
4.99E+00	1.19E-15	1.60E-15	1.16E-15	5.30E-16	1.09E-15	4.93E-15	1.72E-16
5.35E+00	1.30E-15	1.73E-15	1.25E-15	6.03E-16	1.01E-15	4.89E-15	1.83E-16
5.66E+00	1.43E-15	1.81E-15	1.39E-15	6.58E-16	1.01E-15	5.04E-15	2.05E-16
6.04E+00	1.46E-15	1.82E-15	1.43E-15	6.76E-16	1.01E-15	5.03E-15	2.19E-16
6.37E+00	1.49E-15	1.82E-15	1.46E-15	6.94E-16	1.03E-15	5.29E-15	2.42E-16
6.74E+00	1.58E-15	1.87E-15	1.56E-15	7.42E-16	1.10E-15	5.34E-15	2.68E-16
7.16E+00	1.66E-15	1.90E-15	1.64E-15	7.74E-16	1.35E-15	5.56E-15	2.93E-16
7.55E+00	1.71E-15	1.92E-15	1.69E-15	7.92E-16	1.40E-15	5.48E-15	3.28E-16
7.91E+00	1.77E-15	1.96E-15	1.75E-15	8.18E-16	1.39E-15	5.47E-15	3.58E-16
8.32E+00	1.87E-15	2.00E-15	1.85E-15	8.59E-16	1.34E-15	5.58E-15	4.00E-16
8.79E+00	1.91E-15	1.99E-15	1.90E-15	8.78E-16	1.35E-15	5.66E-15	4.38E-16
9.18E+00	1.96E-15	2.02E-15	1.95E-15	9.06E-16	1.41E-15	5.72E-15	4.87E-16
9.67E+00	2.00E-15	2.06E-15	2.00E-15	9.31E-16	1.54E-15	5.84E-15	5.35E-16
1.01E+01	2.03E-15	2.10E-15	2.03E-15	9.61E-16	1.68E-15	5.92E-15	5.77E-16
1.06E+01	2.05E-15	2.14E-15	2.04E-15	9.93E-16	1.78E-15	6.00E-15	6.21E-16
1.10E+01	2.06E-15	2.17E-15	2.05E-15	1.03E-15	1.93E-15	6.21E-15	6.71E-16
1.15E+01	2.08E-15	2.21E-15	2.07E-15	1.06E-15	2.10E-15	6.36E-15	7.18E-16
1.20E+01	2.09E-15	2.25E-15	2.08E-15	1.09E-15	2.24E-15	6.40E-15	7.61E-16
1.25E+01	2.11E-15	2.29E-15	2.09E-15	1.11E-15	2.42E-15	6.53E-15	8.08E-16
1.31E+01	2.10E-15	2.32E-15	2.08E-15	1.13E-15	2.55E-15	6.62E-15	8.45E-16
1.35E+01	2.10E-15	2.35E-15	2.08E-15	1.14E-15	2.65E-15	6.71E-15	8.67E-16
1.39E+01	2.10E-15	2.36E-15	2.07E-15	1.15E-15	2.71E-15	6.76E-15	8.81E-16
1.41E+01	2.10E-15	2.39E-15	2.08E-15	1.16E-15	2.77E-15	6.82E-15	8.89E-16
1.44E+01	2.11E-15	2.42E-15	2.08E-15	1.18E-15	2.83E-15	6.87E-15	8.97E-16
1.47E+01	2.12E-15	2.47E-15	2.09E-15	1.19E-15	2.92E-15	6.96E-15	9.08E-16
1.52E+01	2.14E-15	2.56E-15	2.11E-15	1.21E-15	3.01E-15	7.05E-15	9.13E-16
1.58E+01	2.17E-15	2.65E-15	2.12E-15	1.24E-15	3.09E-15	7.14E-15	9.11E-16
1.63E+01	2.19E-15	2.75E-15	2.13E-15	1.25E-15	3.17E-15	7.20E-15	9.04E-16
1.69E+01	2.20E-15	2.85E-15	2.14E-15	1.27E-15	3.23E-15	7.19E-15	8.91E-16
1.75E+01	2.21E-15	2.95E-15	2.14E-15	1.29E-15	3.28E-15	7.12E-15	8.73E-16
1.81E+01	2.22E-15	3.05E-15	2.14E-15	1.31E-15	3.37E-15	7.13E-15	8.51E-16
1.87E+01	2.23E-15	3.21E-15	2.14E-15	1.34E-15	3.55E-15	7.21E-15	8.12E-16
2.00E+01							

^a Entries in this column are the lower energy values for each energy group.

TABLE A3. Photon kerma per unit fluence for four standard tissues and three elements, as a function of photon energy.

kerma per unit fluence, J/kg per γ/m^2								
Photon energy, MeV	ICRP standard man	ICRP soft tissue	ICRP red bone marrow	ICRP eye lens	Si	Ar	S	
1.00E-03	5.64E-14	5.64E-14	4.86E-14	5.79E-14	2.57E-14	5.28E-14	4.10E-14	
1.08E-03	4.99E-14	4.98E-14	4.32E-14	5.09E-14	2.26E-14	4.65E-14	3.60E-14	
1.14E-03	4.55E-14	4.55E-14	3.94E-14	4.65E-14	2.06E-14	4.25E-14	3.28E-14	
1.36E-03	3.39E-14	3.39E-14	2.92E-14	3.46E-14	1.53E-14	3.17E-14	2.44E-14	
1.56E-03	2.69E-14	2.68E-14	2.31E-14	2.74E-14	1.22E-14	2.52E-14	1.93E-14	
1.70E-03	2.30E-14	2.30E-14	1.97E-14	2.35E-14	1.06E-14	2.17E-14	1.66E-14	
1.84E-03	2.00E-14	2.00E-14	1.71E-14	2.04E-14	9.37E-15	1.90E-14	1.45E-14	
1.91E-03	1.87E-14	1.86E-14	1.60E-14	1.90E-14	9.28E-15	1.78E-14	1.35E-14	
2.14E-03	1.51E-14	1.51E-14	1.29E-14	1.54E-14	7.88E-15	1.46E-14	1.10E-14	
2.24E-03	1.48E-14	1.46E-14	1.18E-14	1.41E-14	7.37E-15	1.35E-14	1.02E-14	
4.1E-03	1.29E-14	1.28E-14	1.02E-14	1.23E-14	6.91E-15	1.18E-14	8.92E-15	
4.7E-03	1.23E-14	1.22E-14	9.77E-15	1.17E-14	6.38E-15	1.13E-14	8.54E-15	
6.3E-03	1.11E-14	1.10E-14	8.65E-15	1.04E-14	5.31E-15	1.01E-14	8.02E-15	
7.5E-03	1.02E-14	1.01E-14	7.94E-15	9.54E-15	5.44E-15	9.38E-15	7.49E-15	
8.2E-03	9.75E-15	9.64E-15	7.56E-15	9.09E-15	5.24E-15	8.97E-15	7.21E-15	
9.6E-03	8.99E-15	8.89E-15	6.89E-15	8.29E-15	4.88E-15	8.24E-15	6.69E-15	
1.18E-03	7.83E-15	7.73E-15	5.97E-15	7.19E-15	4.34E-15	7.24E-15	5.97E-15	
3.55E-03	6.32E-15	6.24E-15	4.78E-15	5.77E-15	3.63E-15	6.06E-15	5.00E-15	
3.61E-03	6.12E-15	6.05E-15	4.63E-15	5.58E-15	3.53E-15	5.91E-15	4.87E-15	
7.0E-03	5.93E-15	5.86E-15	4.39E-15	5.30E-15	3.39E-15	5.68E-15	4.67E-15	
8.3E-03	5.66E-15	5.49E-15	4.10E-15	5.05E-15	3.20E-15	5.40E-15	4.42E-15	
9.3E-03	5.03E-15	4.96E-15	3.69E-15	4.47E-15	2.94E-15	4.98E-15	4.06E-15	
4.15E-03	6.06E-15	5.52E-15	3.47E-15	4.20E-15	2.79E-15	4.75E-15	3.86E-15	
4.30E-03	5.67E-15	5.15E-15	3.23E-15	3.91E-15	2.63E-15	4.49E-15	3.64E-15	
4.50E-03	5.20E-15	4.73E-15	2.94E-15	3.56E-15	2.43E-15	4.17E-15	3.37E-15	
4.81E-03	4.58E-15	4.15E-15	2.55E-15	3.10E-15	2.16E-15	3.74E-15	3.00E-15	
1.16E-03	4.00E-15	3.61E-15	2.20E-15	2.67E-15	1.90E-15	3.33E-15	2.65E-15	
1.47E-03	3.57E-15	3.22E-15	1.95E-15	2.37E-15	1.72E-15	3.02E-15	2.40E-15	
5.55E-03	3.48E-15	3.13E-15	1.89E-15	2.30E-15	1.67E-15	2.94E-15	2.34E-15	
5.93E-03	3.05E-15	2.74E-15	1.64E-15	1.99E-15	1.48E-15	2.62E-15	2.07E-15	
5.98E-03	2.75E-15	2.46E-15	1.61E-15	1.46E-15	1.39E-15	2.59E-15	2.04E-15	
6.5E-03	2.22E-15	2.05E-15	1.46E-15	1.78E-15	1.34E-15	2.39E-15	1.83E-15	
6.54E-03	2.15E-15	1.98E-15	1.32E-15	1.61E-15	1.23E-15	2.21E-15	1.73E-15	
6.75E-03	2.36E-15	2.11E-15	1.24E-15	1.51E-15	1.16E-15	2.09E-15	1.63E-15	
6.98E-03	2.20E-15	1.97E-15	1.15E-15	1.40E-15	1.09E-15	1.97E-15	1.54E-15	
7.11E-03	2.12E-15	1.90E-15	1.10E-15	1.35E-15	1.05E-15	1.90E-15	1.46E-15	
7.25E-03	2.04E-15	1.83E-15	1.06E-15	1.29E-15	1.01E-15	1.84E-15	1.43E-15	
7.71E-03	1.81E-15	1.61E-15	9.25E-16	1.13E-15	9.98E-16	1.64E-15	1.28E-15	
7.94E-03	1.70E-15	1.52E-15	8.68E-16	1.06E-15	9.50E-16	1.56E-15	1.21E-15	
8.18E-03	1.60E-15	1.43E-15	8.14E-16	9.95E-16	8.02E-16	1.48E-15	1.14E-15	
8.38E-03	1.53E-15	1.36E-15	7.71E-16	9.43E-16	7.64E-16	1.41E-15	1.09E-15	
8.60E-03	1.45E-15	1.28E-15	7.18E-16	8.92E-16	7.27E-16	1.35E-15	1.04E-15	
8.98E-03	1.33E-15	1.18E-15	6.62E-16	8.10E-16	6.67E-16	1.24E-15	9.57E-16	
9.20E-03	1.26E-15	1.12E-15	6.28E-16	7.69E-16	6.36E-16	1.19E-15	9.14E-16	
9.40E-03	1.21E-15	1.07E-15	5.98E-16	7.33E-16	6.09E-16	1.14E-15	8.77E-16	
9.56E-03	1.17E-15	1.03E-15	5.77E-16	7.07E-16	5.90E-16	1.10E-15	8.49E-16	
9.66E-03	1.14E-15	1.01E-15	5.63E-16	6.91E-16	5.77E-16	1.08E-15	8.32E-16	
9.80E-03	1.11E-15	9.82E-16	5.46E-16	6.69E-16	5.61E-16	1.05E-15	8.10E-16	
1.00E-02	1.06E-15	9.80E-16	5.21E-16	6.39E-16	5.38E-16	1.01E-15	7.77E-16	
1.04E-02	9.83E-16	8.48E-16	4.79E-16	5.88E-16	4.99E-16	9.42E-16	7.22E-16	
1.08E-02	9.08E-16	7.78E-16	4.44E-16	5.45E-16	4.65E-16	8.62E-16	6.75E-16	
1.11E-02	8.50E-16	7.49E-16	4.09E-16	5.03E-16	4.32E-16	8.02E-16	6.29E-16	
1.19E-02	7.38E-16	6.49E-16	3.52E-16	4.32E-16	3.76E-16	7.21E-16	5.50E-16	
1.27E-02	6.52E-16	5.72E-16	3.08E-16	3.79E-16	3.33E-16	6.42E-16	4.89E-16	
1.30E-02	6.13E-16	5.38E-16	2.88E-16	3.54E-16	3.13E-16	6.06E-16	4.61E-16	
1.39E-02	5.39E-16	4.72E-16	2.51E-16	3.09E-16	2.76E-16	5.37E-16	4.08E-16	
1.47E-02	4.77E-16	4.17E-16	2.20E-16	2.71E-16	2.45E-16	4.79E-16	3.63E-16	
1.52E-02	4.45E-16	3.89E-16	2.04E-16	2.52E-16	2.28E-16	4.48E-16	3.39E-16	
1.55E-02	4.15E-16	3.59E-16	1.90E-16	2.34E-16	2.13E-16	4.19E-16	3.17E-16	
1.64E-02	3.79E-16	3.30E-16	1.78E-16	2.12E-16	1.95E-16	3.84E-16	2.91E-16	
1.70E-02	3.51E-16	3.06E-16	1.69E-16	1.96E-16	1.80E-16	3.57E-16	2.70E-16	
1.72E-02	3.44E-16	3.00E-16	1.55E-16	1.92E-16	1.77E-16	3.50E-16	2.65E-16	
1.81E-02	3.09E-16	2.69E-16	1.39E-16	1.71E-16	1.58E-16	3.16E-16	2.39E-16	
1.90E-02	2.78E-16	2.42E-16	1.24E-16	1.53E-16	1.43E-16	2.86E-16	2.16E-16	
1.97E-02	2.58E-16	2.24E-16	1.15E-16	1.42E-16	1.32E-16	2.66E-16	2.00E-16	
2.01E-02	2.47E-16	2.14E-16	1.09E-16	1.35E-16	1.26E-16	2.54E-16	1.92E-16	
2.10E-02	2.26E-16	1.96E-16	9.99E-17	1.23E-16	1.16E-16	2.33E-16	1.76E-16	
2.17E-02	2.09E-16	1.81E-16	9.21E-17	1.13E-16	1.07E-16	2.16E-16	1.63E-16	
2.23E-02	1.95E-16	1.72E-16	8.54E-17	1.05E-16	9.91E-17	2.00E-16	1.49E-16	
2.31E-02	1.83E-16	1.59E-16	8.07E-17	9.89E-17	9.31E-17	1.90E-16	1.39E-16	
2.55E-02	1.49E-16	1.29E-16	6.54E-17	8.03E-17	7.54E-17	1.55E-16	1.17E-16	
2.92E-02	1.14E-16	9.83E-17	5.01E-17	6.11E-17	5.66E-17	1.17E-16	8.83E-17	

TABLE A3. Continued.

kerma per unit fluence, J/kg per γ/m^2								
Photon energy, MeV	ICRP standard man	ICRP soft tissue	ICRP red bone marrow	ICRP eye lens	Si	Ar	S	
3.32E-02	8.84E-17	7.65E-17	3.97E-17	4.79E-17	4.30E-16	8.96E-16	6.76E-16	
3.75E-02	7.04E-17	6.12E-17	3.28E-17	3.90E-17	3.31E-16	6.93E-16	5.23E-16	
4.20E-02	5.82E-17	5.08E-17	2.85E-17	3.33E-17	2.60E-16	5.47E-16	4.14E-16	
4.74E-02	4.88E-17	4.31E-17	2.58E-17	2.95E-17	2.03E-16	4.27E-16	3.24E-16	
4.85E-02	4.74E-17	4.19E-17	2.55E-17	2.89E-17	1.94E-16	4.06E-16	3.09E-16	
5.02E-02	4.54E-17	4.03E-17	2.51E-17	2.83E-17	1.81E-16	3.78E-16	2.88E-16	
5.50E-02	4.14E-17	3.72E-17	2.46E-17	2.71E-17	1.66E-16	3.25E-16	2.41E-16	
6.10E-02	3.85E-17	3.51E-17	2.50E-17	2.75E-17	1.50E-16	2.97E-16	1.99E-16	
6.75E-02	3.71E-17	3.43E-17	2.63E-17	2.78E-17	1.06E-16	2.12E-16	1.66E-16	
6.75E-02	3.71E-17	3.43E-17	2.63E-17	2.78E-17	1.06E-16	2.12E-16	1.66E-16	
6.95E-02	3.70E-17	3.44E-17	2.68E-17	2.83E-17	1.02E-16	2.01E-16	1.57E-16	
7.35E-02	3.70E-17	3.47E-17	2.80E-17	2.92E-17	9.38E-17	1.82E-16	1.44E-16	
7.84E-02	3.75E-17	3.55E-17	2.96E-17	3.07E-17	8.64E-17	1.63E-16	1.30E-16	
8.07E-02	3.79E-17	3.60E-17	3.05E-17	3.15E-17	8.35E-17	1.55E-16	1.25E-16	
8.55E-02	3.89E-17	3.72E-17	3.24E-17	3.32E-17	7.85E-17	1.41E-16	1.15E-16	
8.05E-02	3.95E-17	3.79E-17	3.34E-17	3.42E-17	7.65E-17	1.38E-16	1.11E-16	
9.05E-02	4.03E-17	3.88E-17	3.45E-17	3.52E-17	7.37E-17	1.30E-16	1.07E-16	
9.23E-02	4.08E-17	3.94E-17	3.53E-17	3.60E-17	7.36E-17	1.27E-16	1.05E-16	
9.60E-02	4.20E-17	4.07E-17	3.70E-17	3.76E-17	7.17E-17	1.20E-16	1.01E-16	
1.00E-01	4.35E-17	4.23E-17	3.89E-17	3.94E-17	7.01E-17	1.14E-16	9.69E-17	
1.05E-01	4.54E-17	4.43E-17	4.12E-17	4.17E-17	6.88E-17	1.08E-16	9.31E-17	
1.10E-01	4.73E-17	4.63E-17	4.35E-17	4.39E-17	6.81E-17	1.04E-16	9.03E-17	
1.10E-01	4.74E-17	4.63E-17	4.36E-17	4.40E-17	6.81E-17	1.04E-16	9.03E-17	
1.15E-01	4.96E-17	4.86E-17	4.62E-17	4.65E-17	6.77E-17	9.95E-17	8.80E-17	
1.15E-01	4.96E-17	4.86E-17	4.62E-17	4.65E-17	6.77E-17	9.95E-17	8.80E-17	
1.21E-01	5.24E-17	5.15E-17	4.94E-17	4.98E-17	6.79E-17	9.57E-17	8.61E-17	
1.21E-01	5.25E-17	5.16E-17	4.94E-17	4.97E-17	6.79E-17	9.57E-17	8.61E-17	
1.35E-01	5.93E-17	5.86E-17	5.69E-17	5.70E-17	6.99E-17	9.06E-17	8.46E-17	
1.49E-01	6.64E-17	6.58E-17	6.45E-17	6.46E-17	7.34E-17	8.89E-17	8.56E-17	
1.64E-01	7.44E-17	7.39E-17	7.29E-17	7.28E-17	7.82E-17	8.93E-17	8.84E-17	
1.80E-01	8.35E-17	8.30E-17	8.23E-17	8.22E-17	8.45E-17	9.18E-17	9.30E-17	
1.98E-01	9.37E-17	9.33E-17	9.28E-17	9.26E-17	9.22E-17	9.61E-17	9.93E-17	
2.18E-01	1.05E-16	1.05E-16	1.04E-16	1.04E-16	1.01E-16	1.02E-16	1.07E-16	
2.39E-01	1.17E-16	1.17E-16	1.16E-16	1.16E-16	1.11E-16	1.05E-16	1.12E-16	
2.63E-01	1.31E-16	1.31E-16	1.30E-16	1.30E-16	1.23E-16	1.18E-16	1.27E-16	
2.90E-01	1.46E-16	1.46E-16	1.46E-16	1.45E-16	1.36E-16	1.29E-16	1.39E-16	
3.19E-01	1.62E-16	1.62E-16	1.63E-16	1.62E-16	1.50E-16	1.41E-16	1.53E-16	
3.51E-01	1.81E-16	1.80E-16	1.81E-16	1.80E-16	1.66E-16	1.55E-16	1.69E-16	
3.86E-01	2.00E-16	2.00E-16	2.01E-16	2.00E-16	1.84E-16	1.70E-16	1.86E-16	
4.24E-01	2.21E-16	2.21E-16	2.22E-16	2.21E-16	2.02E-16	1.86E-16	2.05E-16	
4.67E-01	2.44E-16	2.44E-16	2.45E-16	2.44E-16	2.23E-16	2.04E-16	2.25E-16	
5.13E-01	2.69E-16	2.68E-16	2.69E-16	2.68E-16	2.45E-16	2.24E-16	2.47E-16	
5.65E-01	2.95E-16	2.95E-16	2.96E-16	2.95E-16	2.69E-16	2.45E-16	2.71E-16	
6.21E-01	3.23E-16	3.23E-16	3.24E-16	3.23E-16	2.94E-16	2.67E-16	2.96E-16	
6.83E-01	3.53E-16	3.53E-16	3.54E-16	3.52E-16	3.21E-16	2.91E-16	3.23E-16	
7.51E-01	3.85E-16	3.85E-16	3.86E-16	3.85E-16	3.50E-16	3.17E-16	3.52E-16	
8.26E-01	4.19E-16	4.19E-16	4.20E-16	4.19E-16	3.81E-16	3.45E-16	3.83E-16	
9.09E-01	4.55E-16	4.54E-16	4.56E-16	4.54E-16	4.13E-16	3.74E-16	4.15E-16	
1.00E+00	4.93E-16	4.93E-16	4.95E-16	4.92E-16	4.48E-16	4.05E-16	4.50E-16	
1.12E+00	5.43E-16	5.43E-16	5.44E-16	5.42E-16	4.93E-16	4.46E-16	4.95E-16	
1.27E+00	5.95E-16	5.95E-16	5.97E-16	5.94E-16	5.40E-16	4.89E-16	5.43E-16	
1.42E+00	6.50E-16	6.50E-16	6.53E-16	6.50E-16	5.91E-16	5.35E-16	5.94E-16	
1.60E+00	7.10E-16	7.09E-16	7.12E-16	7.09E-16	6.46E-16	5.85E-16	6.49E-16	
1.80E+00	7.72E-16	7.72E-16	7.75E-16	7.71E-16	7.04E-16	6.39E-16	7.08E-16	
2.03E+00	8.39E-16	8.38E-16	8.41E-16	8.37E-16	7.68E-16	6.98E-16	7.73E-16	
2.28E+00	9.09E-16	9.08E-16	9.11E-16	9.08E-16	8.37E-16	7.63E-16	8.44E-16	
2.51E+00	9.85E-16	9.84E-16	9.86E-16	9.83E-16	9.14E-16	8.36E-16	9.23E-16	
2.89E+00	1.07E-15	1.07E-15	1.07E-15	1.07E-15	1.01E-15	9.26E-16	1.02E-15	
3.29E+00	1.17E-15	1.16E-15	1.17E-15	1.16E-15	1.10E-15	1.02E-15	1.12E-15	
3.85E+00	1.25E-15	1.25E-15	1.25E-15	1.24E-15	1.18E-15	1.12E-15	1.23E-15	
4.11E+00	1.35E-15	1.35E-15	1.35E-15	1.35E-15	1.32E-15	1.24E-15	1.35E-15	
4.62E+00	1.46E-15	1.46E-15	1.45E-15	1.46E-15	1.46E-15	1.38E-15	1.50E-15	
5.20E+00	1.59E-15	1.58E-15	1.57E-15	1.58E-15	1.61E-15	1.54E-15	1.66E-15	
5.85E+00	1.72E-15	1.71E-15	1.70E-15	1.71E-15	1.78E-15	1.71E-15	1.84E-15	
6.58E+00	1.86E-15	1.86E-15	1.84E-15	1.85E-15	1.97E-15	1.92E-15	2.06E-15	
7.41E+00	2.03E-15	2.02E-15	2.00E-15	2.01E-15	2.20E-15	2.17E-15	2.31E-15	
8.33E+00	2.23E-15	2.22E-15	2.19E-15	2.20E-15	2.48E-15	2.47E-15	2.61E-15	
9.37E+00	2.44E-15	2.43E-15	2.39E-15	2.42E-15	2.81E-15	2.80E-15	2.98E-15	
1.06E+01	2.69E-15	2.68E-15	2.64E-15	2.67E-15	3.17E-15	3.22E-15	3.38E-15	
1.19E+01	2.96E-15	2.94E-15	2.87E-15	2.91E-15	3.58E-15	3.66E-15	3.83E-15	
1.34E+01	3.27E-15	3.25E-15	3.15E-15	3.21E-15	4.05E-15	4.19E-15	4.36E-15	
2.00E+01	4.76E-15	4.73E-15	4.53E-15	4.66E-15	6.46E-15	6.88E-15	7.06E-15	

TABLE A4. Photon kerma per unit fluence for four TLD materials and three others, as a function of photon energy.

Photon energy, MeV	TLD 100	TLD 600	TLD 700	TLD 200	H ₂ O	Air	Al
1.00E-03	6.75E-14	6.99E-14	6.73E-14	8.30E-14	5.88E-14	6.54E-14	1.88E-14
1.08E-03	6.60E-14	6.21E-14	5.98E-14	7.36E-14	5.16E-14	5.76E-14	1.65E-14
1.14E-03	6.52E-14	5.71E-14	5.50E-14	6.76E-14	4.70E-14	5.27E-14	1.50E-14
1.36E-03	4.21E-14	4.36E-14	4.20E-14	5.13E-14	3.48E-14	3.94E-14	1.11E-14
1.56E-03	3.39E-14	3.51E-14	3.38E-14	4.12E-14	2.74E-14	3.13E-14	8.85E-15
1.64E-03	2.57E-14	2.66E-14	2.56E-14	3.14E-14	2.03E-14	2.33E-14	8.34E-14
1.91E-03	2.41E-14	2.49E-14	2.40E-14	2.94E-14	1.89E-14	2.18E-14	7.89E-14
2.14E-03	1.97E-14	2.04E-14	1.96E-14	2.42E-14	1.52E-14	1.76E-14	6.62E-14
2.24E-03	1.62E-14	1.88E-14	1.81E-14	2.23E-14	1.40E-14	1.62E-14	6.16E-14
2.41E-03	1.59E-14	1.65E-14	1.59E-14	1.97E-14	1.21E-14	1.41E-14	5.48E-14
2.47E-03	1.52E-14	1.58E-14	1.52E-14	1.88E-14	1.15E-14	1.35E-14	5.27E-14
2.53E-03	1.36E-14	1.41E-14	1.35E-14	1.89E-14	1.02E-14	1.19E-14	4.77E-14
2.59E-03	1.25E-14	1.30E-14	1.25E-14	1.56E-14	9.37E-15	1.10E-14	4.45E-14
2.82E-03	1.20E-14	1.24E-14	1.19E-14	1.49E-14	8.93E-15	1.05E-14	4.27E-14
2.96E-03	1.10E-14	1.14E-14	1.09E-14	1.37E-14	8.13E-15	9.55E-15	3.95E-14
3.18E-03	9.57E-15	9.90E-15	9.54E-15	1.20E-14	7.03E-15	8.29E-15	3.50E-14
3.55E-03	7.76E-15	8.02E-15	7.73E-15	9.86E-15	6.36E-15	6.67E-15	2.90E-14
3.61E-03	7.51E-15	7.77E-15	7.49E-15	9.56E-15	6.15E-15	6.46E-15	2.82E-14
3.70E-03	7.15E-15	7.40E-15	7.13E-15	9.12E-15	5.85E-15	6.13E-15	2.70E-14
3.83E-03	6.70E-15	6.93E-15	6.68E-15	8.57E-15	5.47E-15	5.73E-15	2.54E-14
4.03E-03	6.06E-15	6.27E-15	6.00E-15	7.80E-15	4.94E-15	5.17E-15	2.33E-14
4.15E-03	5.72E-15	5.91E-15	5.70E-15	7.43E-15	4.65E-15	4.87E-15	2.21E-14
4.30E-03	5.33E-15	5.51E-15	5.31E-15	6.47E-15	4.33E-15	4.53E-15	2.07E-14
4.50E-03	4.87E-15	5.04E-15	4.86E-15	4.16E-14	3.95E-15	4.13E-15	1.91E-14
4.81E-03	4.26E-15	4.40E-15	4.24E-15	3.73E-14	3.45E-15	3.60E-15	1.69E-14
5.16E-03	3.69E-15	3.82E-15	3.68E-15	3.33E-14	2.98E-15	3.10E-15	1.48E-14
5.47E-03	3.28E-15	3.39E-15	3.27E-15	3.02E-14	2.65E-15	2.75E-15	1.33E-14
5.55E-03	3.19E-15	3.30E-15	3.17E-15	2.95E-14	2.57E-15	2.67E-15	1.30E-14
5.93E-03	2.77E-15	2.87E-15	2.76E-15	2.64E-14	2.32E-15	2.32E-15	1.14E-14
5.98E-03	2.73E-15	2.82E-15	2.72E-15	2.60E-14	2.29E-15	2.29E-15	1.13E-14
6.28E-03	2.49E-15	2.58E-15	2.48E-15	2.41E-14	2.00E-15	2.07E-15	1.04E-14
6.54E-03	2.26E-15	2.34E-15	2.25E-15	2.22E-14	1.82E-15	1.88E-15	9.48E-15
6.75E-03	2.12E-15	2.19E-15	2.11E-15	2.11E-14	1.70E-15	1.76E-15	8.92E-15
6.98E-03	1.97E-15	2.04E-15	1.97E-15	1.99E-14	1.58E-15	1.64E-15	8.36E-15
7.11E-03	1.90E-15	1.96E-15	1.89E-15	1.92E-14	1.52E-15	1.57E-15	8.06E-15
7.25E-03	1.82E-15	1.88E-15	1.81E-15	1.86E-14	1.46E-15	1.51E-15	7.77E-15
7.71E-03	1.60E-15	1.65E-15	1.59E-15	1.67E-14	1.28E-15	1.32E-15	6.89E-15
7.94E-03	1.50E-15	1.55E-15	1.50E-15	1.59E-14	1.20E-15	1.24E-15	6.52E-15
8.18E-03	1.41E-15	1.46E-15	1.41E-15	1.50E-14	1.13E-15	1.16E-15	6.15E-15
8.38E-03	1.34E-15	1.38E-15	1.33E-15	1.44E-14	1.07E-15	1.10E-15	5.85E-15
8.60E-03	1.27E-15	1.31E-15	1.26E-15	1.37E-14	1.01E-15	1.04E-15	5.56E-15
8.98E-03	1.15E-15	1.19E-15	1.15E-15	1.27E-14	9.24E-16	9.49E-16	5.10E-15
9.20E-03	1.10E-15	1.13E-15	1.09E-15	1.21E-14	8.77E-16	8.90E-16	4.86E-15
9.40E-03	1.05E-15	1.08E-15	1.04E-15	1.17E-14	8.37E-16	8.59E-16	4.66E-15
9.56E-03	1.01E-15	1.04E-15	1.01E-15	1.13E-14	8.07E-16	8.28E-16	4.50E-15
9.66E-03	9.86E-16	1.02E-15	9.83E-16	1.11E-14	7.89E-16	8.09E-16	4.41E-15
9.80E-03	9.56E-16	9.89E-16	9.53E-16	1.08E-14	7.65E-16	7.84E-16	4.29E-15
1.00E-02	9.14E-16	9.45E-16	9.11E-16	1.04E-14	7.45E-16	7.61E-16	4.15E-15
1.08E-02	7.81E-16	8.08E-16	7.78E-16	9.71E-15	6.74E-16	6.89E-16	3.80E-15
1.11E-02	7.22E-16	7.47E-16	7.19E-16	9.10E-15	6.25E-16	6.39E-16	3.55E-15
1.19E-02	6.22E-16	6.44E-16	6.20E-16	8.51E-15	5.78E-16	5.90E-16	3.30E-15
1.27E-02	5.46E-16	5.65E-16	5.44E-16	7.49E-15	4.98E-16	5.08E-16	2.87E-15
1.30E-02	5.11E-16	5.29E-16	5.10E-16	6.69E-15	4.37E-16	4.45E-16	2.54E-15
1.39E-02	4.47E-16	4.62E-16	4.45E-16	6.32E-15	4.09E-16	4.17E-16	2.39E-15
1.47E-02	3.92E-16	4.05E-16	3.91E-16	5.63E-15	3.58E-16	3.63E-16	2.10E-15
1.52E-02	3.65E-16	3.77E-16	3.63E-16	5.03E-15	3.14E-16	3.19E-16	1.86E-15
1.57E-02	3.39E-16	3.50E-16	3.38E-16	4.72E-15	2.92E-16	2.96E-16	1.74E-15
1.64E-02	3.08E-16	3.19E-16	3.07E-16	4.43E-15	2.67E-16	2.71E-16	1.62E-15
1.72E-02	2.78E-16	2.89E-16	2.76E-16	4.07E-15	2.47E-16	2.50E-16	1.49E-15
1.75E-02	2.78E-16	2.89E-16	2.76E-16	4.07E-15	2.47E-16	2.50E-16	1.49E-15
1.81E-02	2.49E-16	2.57E-16	2.48E-16	3.72E-15	2.23E-16	2.26E-16	1.34E-15
1.90E-02	2.22E-16	2.30E-16	2.22E-16	3.37E-15	1.99E-16	2.02E-16	1.21E-15
1.97E-02	2.06E-16	2.13E-16	2.05E-16	3.06E-15	1.79E-16	1.81E-16	1.09E-15
2.01E-02	1.96E-16	2.03E-16	1.95E-16	2.85E-15	1.65E-16	1.67E-16	1.01E-15
2.10E-02	1.79E-16	1.85E-16	1.78E-16	2.73E-15	1.58E-16	1.59E-16	9.63E-16
2.17E-02	1.64E-16	1.70E-16	1.64E-16	2.51E-15	1.44E-16	1.45E-16	8.91E-16
2.23E-02	1.60E-16	1.66E-16	1.56E-16	2.33E-15	1.36E-16	1.37E-16	8.19E-16
2.31E-02	1.44E-16	1.49E-16	1.43E-16	2.06E-15	1.16E-16	1.17E-16	7.14E-16
2.55E-02	1.16E-16	1.20E-16	1.15E-16	1.69E-15	9.40E-17	9.45E-17	5.77E-16
2.92E-02	8.71E-17	9.01E-17	8.68E-17	1.29E-15	7.12E-17	7.16E-17	4.35E-16
3.32E-02	6.71E-17	6.94E-17	6.68E-17	9.97E-16	5.55E-17	5.59E-17	3.31E-16
3.75E-02	5.30E-17	5.49E-17	5.29E-17	7.77E-16	4.46E-17	4.51E-17	2.56E-16

TABLE A4. Continued.

Photon energy, MeV	kerma per unit fluence, J/kg per γ/m^2						
	TLD 100	TLD 600	TLD 700	TLD 200	H ₂ O	Air	Al
4.20E-02	4.37E-17	4.52E-17	4.36E-17	6.18E-16	3.74E-17	3.81E-17	2.02E-16
4.74E-02	3.67E-17	3.80E-17	3.66E-17	4.86E-16	3.23E-17	3.31E-17	1.59E-16
4.85E-02	3.57E-17	3.69E-17	3.55E-17	4.63E-16	3.15E-17	3.24E-17	1.52E-16
5.02E-02	3.42E-17	3.54E-17	3.41E-17	4.32E-16	3.05E-17	3.15E-17	1.42E-16
5.50E-02	3.14E-17	3.25E-17	3.13E-17	3.62E-16	2.87E-17	2.99E-17	1.20E-16
6.10E-02	2.95E-17	3.05E-17	2.94E-17	2.96E-16	2.77E-17	2.92E-17	1.01E-16
6.75E-02	2.88E-17	2.98E-17	2.87E-17	2.46E-16	2.78E-17	2.97E-17	8.62E-17
6.75E-02	2.88E-17	2.98E-17	2.87E-17	2.46E-16	2.78E-17	2.97E-17	8.61E-17
7.35E-02	2.91E-17	3.01E-17	2.90E-17	2.11E-16	2.81E-17	3.00E-17	8.26E-17
7.84E-02	2.97E-17	3.07E-17	2.96E-17	1.89E-16	2.87E-17	3.08E-17	7.69E-17
8.07E-02	3.01E-17	3.12E-17	3.00E-17	1.81E-16	2.98E-17	3.22E-17	7.15E-17
8.55E-02	3.12E-17	3.22E-17	3.11E-17	1.65E-16	3.04E-17	3.29E-17	6.95E-17
8.80E-02	3.18E-17	3.29E-17	3.17E-17	1.58E-16	3.17E-17	3.45E-17	6.60E-17
9.05E-02	3.25E-17	3.36E-17	3.24E-17	1.52E-16	3.25E-17	3.54E-17	6.47E-17
9.23E-02	3.30E-17	3.41E-17	3.29E-17	1.48E-16	3.34E-17	3.64E-17	6.35E-17
9.60E-02	3.41E-17	3.52E-17	3.40E-17	1.40E-16	3.40E-17	3.71E-17	6.28E-17
1.00E-01	3.54E-17	3.65E-17	3.53E-17	1.33E-16	3.54E-17	3.87E-17	6.17E-17
1.05E-01	3.71E-17	3.84E-17	3.70E-17	1.26E-16	3.69E-17	4.05E-17	6.09E-17
1.10E-01	3.88E-17	4.02E-17	3.87E-17	1.20E-16	3.89E-17	4.27E-17	6.03E-17
1.10E-01	3.89E-17	4.02E-17	3.87E-17	1.20E-16	4.08E-17	4.49E-17	6.01E-17
1.15E-01	4.08E-17	4.22E-17	4.07E-17	1.15E-16	4.09E-17	4.50E-17	6.01E-17
1.15E-01	4.08E-17	4.23E-17	4.07E-17	1.15E-16	4.31E-17	4.75E-17	6.03E-17
1.21E-01	4.33E-17	4.48E-17	4.31E-17	1.10E-16	4.31E-17	4.75E-17	6.03E-17
1.21E-01	4.33E-17	4.48E-17	4.31E-17	1.10E-16	4.58E-17	5.06E-17	6.10E-17
1.35E-01	4.32E-17	4.47E-17	4.31E-17	1.04E-16	4.59E-17	5.07E-17	6.10E-17
1.49E-01	5.32E-17	5.73E-17	5.32E-17	1.01E-16	5.25E-17	5.80E-17	6.39E-17
1.64E-01	6.22E-17	6.44E-17	6.20E-17	1.01E-16	5.92E-17	6.56E-17	7.80E-17
1.80E-01	6.99E-17	7.24E-17	6.97E-17	1.03E-16	6.67E-17	7.39E-17	7.32E-17
1.98E-01	7.86E-17	8.13E-17	7.83E-17	1.07E-16	7.51E-17	8.33E-17	7.97E-17
2.18E-01	8.80E-17	9.11E-17	8.77E-17	1.13E-16	8.45E-17	9.38E-17	8.75E-17
2.39E-01	9.85E-17	1.02E-16	9.82E-17	1.21E-16	9.47E-17	1.05E-16	9.63E-17
2.63E-01	1.10E-16	1.14E-16	1.10E-16	1.30E-16	1.06E-16	1.18E-16	1.06E-16
2.90E-01	1.23E-16	1.27E-16	1.22E-16	1.42E-16	1.19E-16	1.32E-16	1.18E-16
3.19E-01	1.41E-16	1.47E-16	1.38E-16	1.54E-16	1.32E-16	1.47E-16	1.30E-16
3.51E-01	1.52E-16	1.57E-16	1.52E-16	1.69E-16	1.47E-16	1.64E-16	1.44E-16
3.86E-01	1.69E-16	1.74E-16	1.68E-16	1.85E-16	1.64E-16	1.82E-16	1.60E-16
4.24E-01	1.86E-16	1.93E-16	1.86E-16	2.03E-16	1.82E-16	2.02E-16	1.77E-16
4.67E-01	2.06E-16	2.13E-16	2.05E-16	2.23E-16	2.01E-16	2.24E-16	1.95E-16
5.13E-01	2.26E-16	2.34E-16	2.26E-16	2.44E-16	2.22E-16	2.47E-16	2.15E-16
5.65E-01	2.48E-16	2.57E-16	2.48E-16	2.67E-16	2.44E-16	2.71E-16	2.36E-16
6.21E-01	2.72E-16	2.82E-16	2.71E-16	2.91E-16	2.68E-16	2.98E-16	2.59E-16
6.83E-01	3.07E-16	3.08E-16	3.06E-16	3.18E-16	2.94E-16	3.26E-16	2.84E-16
7.51E-01	3.45E-16	3.38E-16	3.23E-16	3.46E-16	3.21E-16	3.57E-16	3.10E-16
8.26E-01	3.83E-16	3.65E-16	3.52E-16	3.76E-16	3.50E-16	3.89E-16	3.36E-16
9.09E-01	4.25E-16	3.97E-16	3.82E-16	4.08E-16	3.81E-16	4.23E-16	3.68E-16
1.00E+00	4.15E-16	4.30E-16	4.14E-16	4.42E-16	4.13E-16	4.60E-16	3.99E-16
1.12E+00	4.57E-16	4.73E-16	4.55E-16	4.86E-16	4.48E-16	4.98E-16	4.33E-16
1.27E+00	5.01E-16	5.19E-16	5.00E-16	5.33E-16	4.93E-16	5.48E-16	4.76E-16
1.42E+00	5.48E-16	5.67E-16	5.46E-16	5.83E-16	5.41E-16	6.01E-16	5.22E-16
1.60E+00	5.98E-16	6.19E-16	5.96E-16	6.37E-16	5.91E-16	6.57E-16	5.71E-16
1.80E+00	6.51E-16	6.74E-16	6.49E-16	6.96E-16	6.45E-16	7.17E-16	6.24E-16
2.03E+00	7.07E-16	7.32E-16	7.05E-16	7.59E-16	7.02E-16	7.81E-16	6.80E-16
2.28E+00	7.67E-16	7.94E-16	7.65E-16	8.29E-16	7.63E-16	8.47E-16	7.41E-16
2.57E+00	8.32E-16	8.61E-16	8.29E-16	9.07E-16	8.28E-16	9.19E-16	8.07E-16
2.89E+00	9.08E-16	9.40E-16	9.05E-16	1.00E-15	8.97E-16	9.95E-16	8.80E-16
3.25E+00	9.87E-16	1.02E-15	9.83E-16	1.10E-15	9.79E-16	1.09E-15	9.68E-16
3.65E+00	1.06E-15	1.10E-15	1.06E-15	1.21E-15	1.06E-15	1.18E-15	1.06E-15
4.11E+00	1.15E-15	1.19E-15	1.14E-15	1.33E-15	1.14E-15	1.26E-15	1.15E-15
4.62E+00	1.25E-15	1.29E-15	1.24E-15	1.48E-15	1.24E-15	1.37E-15	1.26E-15
5.20E+00	1.35E-15	1.40E-15	1.35E-15	1.64E-15	1.34E-15	1.48E-15	1.39E-15
5.85E+00	1.47E-15	1.52E-15	1.47E-15	1.83E-15	1.46E-15	1.60E-15	1.53E-15
6.58E+00	1.60E-15	1.66E-15	1.60E-15	2.04E-15	1.58E-15	1.73E-15	1.69E-15
7.41E+00	1.75E-15	1.81E-15	1.74E-15	2.29E-15	1.72E-15	1.88E-15	1.87E-15
8.33E+00	1.92E-15	1.99E-15	1.92E-15	2.60E-15	1.88E-15	2.05E-15	2.06E-15
9.37E+00	2.13E-15	2.20E-15	2.12E-15	2.97E-15	2.07E-15	2.24E-15	2.34E-15
1.06E+01	2.35E-15	2.43E-15	2.34E-15	3.37E-15	2.28E-15	2.47E-15	2.64E-15
1.19E+01	2.58E-15	2.68E-15	2.58E-15	3.82E-15	2.52E-15	2.72E-15	2.97E-15
1.34E+01	2.87E-15	2.97E-15	2.86E-15	4.36E-15	2.78E-15	2.98E-15	3.34E-15
2.00E+01	4.24E-15	4.39E-15	4.23E-15	7.09E-15	3.98E-15	4.29E-15	5.77E-15
					4.54E-15	4.79E-15	5.96E-15

TABLE A5. Elemental composition of standard biological tissues (derived from Ref. 7).

Element	Atom fraction			
	Standard man	Soft tissue	Red bone marrow	Eye lens
O	2.41 E-01	2.40 E-01	1.60 E-01	2.57 E-01
C	1.19 E-01	1.18 E-01	2.13 E-01	1.01 E-01
H	6.22 E-01	6.30 E-01	6.13 E-01	6.18 E-01
N	1.15 E-02	1.08 E-02	1.41 E-02	2.39 E-02
Ca	2.24 E-03	3.53 E-05		
P	2.56 E-03	2.61 E-04		
S	3.91 E-04	3.78 E-04		
K	3.21 E-04	3.10 E-04		
Na	3.90 E-04	2.99 E-04	1.18 E-04	
Cl	2.40 E-04	2.31 E-04		
Mg	7.00 E-05			
Si	5.74 E-05			
Fe	6.74 E-06			
F	1.23 E-05			
Zn	3.15 E-06			

TABLE A6. Comparison of absorbed-dose indices calculated in Ref. 2 with kerma factors computed in this study.^a

Neutron energy, MeV	Absorbed-dose index, $10^{-9} \text{ rad} \cdot \text{n}^{-1} \text{ cm}^{-2}$		Kerma factor, $10^{-9} \text{ rad} \cdot \text{n}^{-1} \text{ cm}^{-2}$	Ratio	
	Unrestricted, D_I	Isotropic, i_I		D_I/kerma	i_I/kerma
0.1	0.85	0.34	0.640	1.3	0.5
0.5	2.0	9.5	1.63	1.2	0.6
1.0	3.2	1.6	2.34	1.4	0.7
2.5	3.8	2.3	3.30	1.2	0.7
5.0	5.2	3.4	4.50	1.2	0.8
7.5	6.2	4.0	5.11	1.2	0.8
10	6.9	4.5	5.40	1.3	0.8
14	6.9	5.5	6.21	1.1	0.9
17	8.2	5.8	6.55	1.3	0.9
20	8.4	6.5	6.70	1.3	0.97

^aNeutron energy values are pointwise-averaged in Ref. 2 and group-averaged in this study.

TABLE A7. Comparison of neutron group-averaged kerma factors for the ICRP standard man, from Ref. 1 and this study.

Neutron energy, MeV	Kerma factor, $10^{-9} \text{ rad} \cdot \text{n}^{-1} \text{ cm}^{-2}$		Ref. 1/Singh
	Ref. 1	Singh	
0.1	0.640	0.640	1.0
0.5	1.57	1.63	0.96
1.0	2.41	2.34	1.03
2.5	3.27	3.30	0.99
5.0	4.46	4.50	0.99
7.5	5.07	5.11	0.99
10	5.54	5.40	1.03
14	6.39	6.21	1.03
17	6.80	6.55	1.04
20	7.15	6.70	1.07