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EXPOSURE, DOSE-EQUIVALENT AND ABSORBED-DOSE
BUILDUP FACTORS OF GAMMA RAYS FOR PLANE
NORMAL AND ISOTROPIC INCIDENCES ON WATER,
CONCRETE, IRON AND LEAD

February 1984

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Exposure, Dose-Equivalent and Absorbed-Dose Buildup Factors of
Gamma Rays for Plane Normal and Isotropic Incidences on Water,
Concrete, Iron and Lead

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Exposure, dose-equivalent and absorbed-dose buildup factors are calculated using a discrete-ordinates direct integration code, PALLAS-PL, SP-Br, for water, concrete, iron and lead, typifying materials of low, medium, high atomic number for gamma-ray sources at plane normal and isotropic incidences. These data include the effects of secondary photon sources arising from Compton scattering, Bremsstrahlung and annihilation. Inclusion of Bremsstrahlung source has great influence on these buildup factors for high energy photons in materials of high atomic number.

The calculated buildup factors are tabulated for incident energies of 0.1 to 15 MeV (0.4 to 15 MeV only for lead) and penetration depths up to 40 mean-free-paths in each material.

Keyword : Exposure, Dose-equivalent, Absorbed-dose Buildup
Factors, PALLAS-PL Code, SP-Br, Water, Concrete,
Iron, Lead, Plane Normal, Isotropic Incidences,
Bremsstrahlung, Annihilation, Gamma-ray

*On leave from Ship Research Institute

水, コンクリート, 鉄, 鉛に平板垂直入射
および平板等方入射の場合のガンマ線照射
再生係数, 線量当量再生係数, 吸収線量再
生係数

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(1984年1月23日受理)

平板垂直入射および等方入射ガンマ線について, 小, 中および大の原子番号をもつ典型的な物質である水, コンクリート, 鉄, 鉛に対して, ディスクリット・オーディネイト直接積分コード PALLAS-PL, SP-Br を用いて, 照射再生係数, 線量当量再生係数および吸収線量再生係数を計算した。これらのデータはコンプトン散乱, 制動放射および消滅ガンマ線に起因する二次光子線源を考慮して求められている。制動放射線は大きな原子番号の物質におけるエネルギーの高い光子の場合にこれらの再生係数に大きな影響を及ぼす。

計算された再生係数は各物質毎に深さ40平均自由行程までについて, 入射エネルギーが0.1 MeVから1.5 MeV(ただし, 鉛のみについては0.4 MeVから1.5 MeV)までの各エネルギーに対して表の形にまとめられている。

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目 次

1. 序 言	1
2. 線量再生係数の計算結果	2
参考文献	4
表1 再生係数計算に使用した各種変換係数の値	5
表2 線減衰係数と物質密度	6
表3 普通コンクリートの原子密度構成	7
表4～6 平板垂直入射線源に対する 43-mfp 厚の水の再生係数	8
表7～9 平板等方入射線源に対する 43-mfp 厚の水の再生係数	11
表10～12 平板垂直入射線源に対する 43-mfp 厚のコンクリートの再生係数	14
表13～15 平板等方入射線源に対する 43-mfp 厚のコンクリートの再生係数	17
表16～18 平板垂直入射線源に対する 43-mfp 厚の鉄の再生係数	20
表19～21 平板等方入射線源に対する 43-mfp 厚の鉄の再生係数	23
表22～24 平板垂直入射線源に対する 43-mfp 厚の鉛の再生係数	26
表25～27 平板等方入射線源に対する 43-mfp 厚の鉛の再生係数	29

Contents

1. Introduction	1
2. Calculated Dose Buildup Factors	2
References	4
Table 1 Energy Flux to Dose Rate Conversion Factors Used for the Buildup Factors	5
Table 2 Linear Attenuation Coefficients and Material Densities	6
Table 3 Atomic Composition of the Ordinary Concrete	7
Tables 4 ~ 6 Buildup Factors-Plane Normal Incidence on 43-mfp-thick Water	8
Tables 7 ~ 9 Buildup Factors-Plane Isotropic Incidence on 43-mfp-thick Water	11
Tables 10~12 Buildup Factors-Plane Normal Incidence on 43-mfp-thick Concrete	14
Tables 13~15 Buildup Factors-Plane Isotropic Incidence on 43-mfp-thick Concrete	17
Tables 16~18 Buildup Factors-Plane Normal Incidence on 43-mfp-thick Iron	20
Tables 19~21 Buildup Factors-Plane Isotropic Incidence on 43-mfp-thick Iron	23
Tables 22~24 Buildup Factors-Plane Normal Incidence on 43-mfp-thick Lead	26
Tables 25~27 Buildup Factors-Plane Isotropic Incidence on 43-mfp-thick Lead	29

1. INTRODUCTION

Buildup factors are always effective for practical calculations in gamma-ray shield design. The data calculated using a moments-method by Goldstein and Wilkins¹ have been extensively utilized throughout the world in gamma-ray shield calculations. However, these data are not only old (1954) but also limited up to 15 mean free path in depth. In addition, only Compton scattering was taken into account as secondary photon sources for these data.

The contribution of Bremsstrahlung and annihilation photons to the buildup factors is exceedingly large at high energies in materials of high atomic number. In a previous paper², we presented an approach to transport calculation of photons including those arising from the Bremsstrahlung and annihilation, and provided some comparisons of calculations with experiments in energy spectra in iron and lead as well as in transmitted dose through lead to test the validity of a discrete ordinates PALLAS-PL,SP-Br code³ designed based on the presented approach.

The object of the present work is to provide exposure, dose-equivalent and absorbed-dose buildup factors for typical shielding materials such as water, concrete, iron and lead for general use in gamma-ray shield design calculations. Our systematic calculations using the PALLAS-PL,SP-Br code include the effects of secondary sources arising from Compton scattering, Bremsstrahlung and annihilation. Plane normal and isotropic incidences are taken into account as gamma-ray sources with the incident energies of 0.1~15.0 MeV except for lead, in which the incident energies are limited to the range of 0.4~15.0 MeV because of neglect of fluorescence contribution. The effect of fluorescence on the dose buildup factor has been studied by Subbaiah, et al.⁴ to be spectacular for source energies close to the K edge.

2. CALCULATED DOSE BUILDUP FACTORS

Calculated three types of dose buildup factors are tabulated in tables 4~27. We define the types of dose buildup factor in the following: If the flux in a medium M is given as $\Phi(x, E)$, then

(1) dose equivalent rate, $D(x)$, is defined as

$$D(x) = \int_0^{E_{\max}} \Phi(x, E) \cdot K(E) dE,$$

where $K(E)$ is the flux to dose equivalent rate conversion factor ($\text{mrem} \cdot \text{hr}^{-1} / \text{n} \cdot \text{cm}^2 \cdot \text{sec}$),

(2) exposure dose rate, $De(x)$, is defined as

$$De(x) = \int_0^{E_{\max}} \Phi(x, E) \cdot Ke(E) dE,$$

where $Ke(E)$ is the flux to exposure dose rate conversion factor ($\text{mr} \cdot \text{hr}^{-1} / \text{n} \cdot \text{cm}^2 \cdot \text{sec}$),

and

(3) absorbed dose rate, $Da(x)$, is defined as

$$Da = \int_0^{E_{\max}} E \cdot \Phi(x, E) \frac{\mu_{\text{en}}(E)}{\rho} dE,$$

where $\mu_{\text{en}}(E)/\rho$ is the conversion coefficient from the energy flux to the energy absorbed dose rate when the Bremsstrahlung is taken into account in the calculations, while for exclusion of the Bremsstrahlung the energy transfer coefficient $\mu_k(E)/\rho$ is used instead of $\mu_{\text{en}}(E)/\rho$. These conversion factors are summarized in Table 1 for the present calculations. Table 2 gives the linear attenuation coefficients and the material

densities, which is convenient for shielding designers to calculate mfp of shield. These data are taken from Hubbell's compilation⁵. Table 3 gives the atomic composition of the ordinary concrete, which is taken from ANL-5800⁶.

The blanks in the item "with brems." mean that the buildup factors with taking the Bremsstrahlung into account are almost the same as those without it. The reason for lack of data for lead at the source energies of 0.1~0.3 MeV is due to that our calculations exclude the effect of the fluorescence photons. The fluorescence contribution to the buildup factors is considerably large at these low energies for heavy materials like lead: The data increase by ~13% at 0.3 MeV source, by ~80% at 0.2 MeV source and by a factor of 16 at 0.1 MeV source at 8-mfp depth⁴.

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Table 1 Energy Flux to Dose Rate Conversion Factors Used for the Buildup Factors

Photon Energy E γ (MeV)	Energy Flux to Dose Rate Conversion Factors		Energy Transfer and Energy Absorption Coefficients (cm ² /g)							
	K ₁ (mrem-hr ⁻¹ /E $\gamma\phi$)		Lead		Iron		Water		Concrete	
	K ₂ (mK-hr ⁻¹ /E $\gamma\phi$)	K ₁ (mrem-hr ⁻¹ /E $\gamma\phi$)	μ_K/ρ	μ_{en}/ρ	μ_K/ρ	μ_{en}/ρ	μ_K/ρ	μ_{en}/ρ	μ_K/ρ	μ_{en}/ρ
15.0	8.84-04	9.29-04	4.95-02	3.49-02	2.62-02	2.25-02	1.51-02	1.46-02	1.71-02	1.60-02
10.0	9.55	1.00-03	4.19	3.10	2.38	2.09	1.62	1.57	1.72	1.62
8.0	1.01-03	1.04	3.78	2.94	2.26	2.04	1.70	1.66	1.75	1.67
6.0	1.10	1.11	3.31	2.72	2.15	1.99	1.85	1.80	1.82	1.75
5.0	1.16	1.18	3.06	2.59	2.11	1.98	1.95	1.91	1.88	1.82
4.0	1.27	1.25	2.81	2.45	2.09	1.99	2.09	2.06	1.98	1.93
3.0	1.40	1.37	2.60	2.34	2.12	2.04	2.29	2.27	2.12	2.09
2.0	1.62	1.57	2.59	2.40	2.25	2.20	2.62	2.60	2.38	2.36
1.5	1.75	1.71	2.88	2.71	2.41	2.37	2.85	2.82	2.58	2.55
1.0	1.98	1.86	3.96	3.77	2.64	2.62	3.11	3.09	2.82	2.80
0.8	2.10	1.92	5.03	4.81	2.75	2.73	3.21	3.21	2.91	2.91
0.6	2.27	1.96	7.37	7.10	2.87	2.86	3.29	3.29	2.98	2.98
0.5	2.34	1.97	9.84	9.51	2.95	2.95	3.30	3.30	3.01	3.01
0.4	2.46	1.96	1.47-01	1.43-01	3.08	3.08	3.28	3.28	3.00	3.00
0.3	2.53	1.91	2.65	2.59	3.35	3.35	3.19	3.19	2.95	2.95
0.2	2.51	1.78	6.37	6.29	4.95	4.95	2.97	2.97	2.88	2.88
0.15	2.53	1.66	1.16+00	1.15+00	8.14	8.14	2.77	2.77	2.97	2.97
0.1	2.83	1.55	2.28	2.28	2.19-01	2.19-01	2.56	2.56	3.95	3.95
0.08	3.25	1.61	1.87	1.86	4.14	4.14	2.62	2.62	5.66	5.66
0.06	4.42	2.02	4.11	4.08	9.61	9.61	3.20	3.20	1.09-01	1.09-01
0.05	5.80	2.69	6.57	6.54	1.64+00	1.64+00	4.19	4.19	1.79	1.79
0.04	9.13	4.44	1.18+01	1.18+01	3.17	3.17	6.78	6.78	3.43	3.43
0.03	1.94-02	9.82	2.46	2.46	7.28	7.28	1.49-01	1.49-01	8.15	8.15
0.02	5.90	3.39-02	6.92	6.91	2.28+01	2.28+01	5.12	5.12	2.80+00	2.80+00
0.015	1.30-01	8.43	9.17	9.17	4.93	4.93	1.28+00	1.28+00	6.68	6.68
0.01	3.96	3.06-01	1.27+02	1.27+02	1.42+02	1.42	4.79	4.79	2.24+01	2.28+01

Table 2 Linear Attenuation Coefficients and Material Densities

Material	Lead	Iron	Water	Concrete
$\rho(\text{g/cm}^3)$	11.34	7.86	1.00	2.302
E (MeV)	Linear Attenuation coefficients (cm^{-1})			
15.0	6.21-01	2.41-01	1.94-02	4.87-02
10.0	5.49	2.34	2.22	5.27
8.0	5.21	2.34	2.43	5.60
6.0	4.92	2.40	2.77	6.19
5.0	4.81	2.47	3.03	6.67
4.0	4.69	2.60	3.40	7.35
3.0	4.72	2.84	3.97	8.44
2.0	5.10	3.34	4.94	1.04-01
1.0	7.82	4.68	7.07	1.48
0.8	9.71	5.23	7.86	1.64
0.6	1.36+00	5.99	8.95	1.87
0.5	1.75	6.51	9.67	2.02
0.4	2.49	7.24	1.06-01	2.21
0.3	4.34	8.41	1.18	2.48
0.2	1.07+01	1.09+00	1.36	2.89
0.1	5.93	2.69	1.68	3.87

Table 3 Atomic Composition of the Ordinary Concrete

Element	Atomic density (atoms/cm ³)
H	1.374-02
C	1.154-04
O	4.592-02
Na	9.641-04
Al	1.852-03
Si	1.661-02
Ca	1.952-03
Fe	3.451-04

* 02-a Ordinary Concrete
in ANL-5800

Table 4 Exposure Buildup Factors-Plane Normal Incidence on 43-mfp-thick Water

Penetration (mfp)	Photon energy (MeV)															
	0.1	0.2	0.3	0.4	0.5	0.6	0.8	1.0	2.0	3.0	4.0	5.0	6.0	8.0	10.0	15.0
0.5 without brems. with brems.	3.15	2.40	2.12	1.97	1.86	1.79	1.69	1.61	1.45	1.38	1.33	1.29	1.27	1.22	1.19	1.14
1.0 without brems. with brems.	4.60	3.43	2.97	2.72	2.54	2.42	2.24	2.12	1.83	1.71	1.60	1.54	1.49	1.41	1.35	1.26
2.0 without brems. with brems.	8.20	6.05	5.04	4.51	4.13	3.85	3.48	3.23	2.62	2.36	2.14	2.00	1.90	1.75	1.64	1.47
3.0 without brems. with brems.	12.9	9.61	7.77	6.79	6.10	5.56	4.93	4.51	3.46	3.02	2.67	2.46	2.30	2.08	1.91	1.67
4.0 without brems. with brems.	19.1	14.3	11.2	9.62	8.49	7.58	6.60	5.94	4.34	3.69	3.19	2.91	2.70	2.39	2.18	1.87
5.0 without brems. with brems.	26.9	20.3	15.6	13.0	11.3	9.94	8.52	7.55	5.26	4.38	3.72	3.35	3.09	2.71	2.44	2.06
6.0 without brems. with brems.	36.2	27.8	20.7	16.8	14.7	12.7	10.7	9.37	6.26	5.10	4.28	3.81	3.49	3.02	2.70	2.25
7.0 without brems. with brems.	47.9	37.0	27.3	21.8	18.7	15.8	13.1	11.3	7.29	5.83	4.83	4.26	3.88	3.34	2.96	2.44
8.0 without brems. with brems.	62.0	48.4	34.9	27.3	23.2	19.3	15.8	13.4	8.35	6.56	5.38	4.71	4.27	3.64	3.22	2.62
10.0 without brems. with brems.	98.3	78.0	54.1	40.8	34.0	27.4	21.9	18.1	10.5	8.04	6.48	5.60	5.03	4.24	3.72	2.98
15.0 without brems. with brems.	252	205	130	89.9	71.9	54.1	41.3	32.4	16.4	11.8	9.27	7.78	6.89	5.70	4.93	3.84
20.0 without brems. with brems.	535	436	254	164	126	90.2	66.3	49.8	22.7	15.6	12.0	9.91	8.68	7.10	6.09	4.65
25.0 without brems. with brems.	1010	815	438	265	198	135	96.8	70.0	29.3	19.5	14.8	12.0	10.4	8.46	7.21	5.42
30.0 without brems. with brems.	1750	1390	690	394	288	189	132	92.8	36.2	23.5	17.7	14.0	12.1	9.77	8.29	6.15
35.0 without brems. with brems.	2850	2210	1020	553	395	252	173	117	43.3	27.4	20.5	16.0	13.7	11.0	9.34	6.85
40.0 without brems. with brems.	4420	3340	1430	741	519	324	218	145	50.5	31.3	23.2	18.0	15.3	12.2	10.4	7.53
											23.4	18.1	15.5	12.5	10.6	8.03

Table 5 Dose-Equivalent Buildup Factors--Plane Normal Incidence on 43-mfp-thick Water

Penetration (mfp)	Photon energy (MeV)															
	0.1	0.2	0.3	0.4	0.5	0.6	0.8	1.0	2.0	3.0	4.0	5.0	6.0	8.0	10.0	15.0
0.5 without brems. with brems.	3.41	2.74	2.36	2.19	2.08	1.98	1.87	1.76	1.54	1.45	1.37	1.34	1.30	1.26	1.27	1.16
1.0 without brems. with brems.	5.05	4.05	3.42	3.13	2.94	2.77	2.57	2.41	1.99	1.82	1.68	1.61	1.54	1.46	1.39	1.28
2.0 without brems. with brems.	9.10	7.45	6.09	5.44	5.02	4.63	4.19	3.84	2.92	2.56	2.27	2.13	1.99	1.83	1.71	1.50
3.0 without brems. with brems.	14.5	12.2	9.73	8.49	7.68	6.92	6.13	5.51	3.93	3.33	2.85	2.64	2.43	2.19	2.01	1.72
4.0 without brems. with brems.	21.5	18.6	14.5	12.3	10.9	9.69	8.41	7.43	4.99	4.10	3.43	3.14	2.85	2.53	2.29	1.92
5.0 without brems. with brems.	30.2	26.9	20.5	17.1	14.9	12.9	11.0	9.60	6.12	4.90	4.02	3.64	3.27	2.87	2.58	2.12
6.0 without brems. with brems.	40.7	37.3	27.7	22.5	19.8	16.8	14.1	12.1	7.35	5.75	4.64	4.15	3.71	3.22	2.84	2.33
7.0 without brems. with brems.	54.0	50.1	36.8	29.5	25.5	21.3	17.6	14.8	8.61	6.60	5.25	4.66	4.13	3.56	3.12	2.52
8.0 without brems. with brems.	70.0	66.0	47.6	37.4	32.0	26.3	21.4	17.7	9.91	7.46	5.86	5.16	4.55	3.89	3.39	2.72
10.0 without brems. with brems.	111	107	75.0	56.8	47.8	38.0	30.1	24.3	12.6	9.19	7.09	6.15	5.38	4.55	3.93	3.10
15.0 without brems. with brems.	285	287	184	129	103	77.3	58.2	44.4	19.9	13.6	10.1	8.58	7.39	6.13	5.23	3.99
20.0 without brems. with brems.	606	617	366	238	185	130	94.9	69.2	27.7	18.1	13.2	10.9	9.34	7.65	6.47	4.84
25.0 without brems. with brems.	1140	1160	636	389	294	198	139	98.2	35.9	22.6	16.4	13.3	11.2	9.12	7.67	5.65
30.0 without brems. with brems.	1980	1980	1010	583	431	280	192	130	44.5	27.2	19.5	15.5	13.0	10.5	8.83	6.41
35.0 without brems. with brems.	3230	3160	1500	822	594	375	253	167	53.3	31.9	22.6	17.8	14.8	11.9	9.95	7.15
40.0 without brems. with brems.	5000	4780	2110	1100	784	482	320	206	62.4	36.5	25.7	20.0	16.5	13.2	11.0	7.85
											25.9	20.2	16.7	13.5	11.4	8.46

Table 6 Absorbed-Dose Buildup Factors-Plane Normal Incidence on 43-mfp-thick Water

Penetration (mfp)	Photon energy (MeV)															
	0.1	0.2	0.3	0.4	0.5	0.6	0.8	1.0	2.0	3.0	4.0	5.0	6.0	8.0	10.0	15.0
0.5 without brems. with brems.	3.07	2.37	2.10	1.96	1.85	1.78	1.68	1.61	1.45	1.38	1.33	1.30	1.27	1.23	1.20	1.14
1.0 without brems. with brems.	4.47	3.38	2.93	2.69	2.52	2.40	2.23	2.11	1.83	1.70	1.60	1.54	1.49	1.41	1.36	1.26
2.0 without brems. with brems.	7.89	5.90	4.95	4.44	4.08	3.80	3.46	3.22	2.62	2.35	2.13	2.01	1.90	1.76	1.65	1.47
3.0 without brems. with brems.	12.4	9.32	7.59	6.65	5.99	5.48	4.89	4.48	3.45	3.01	2.66	2.47	2.31	2.09	1.93	1.68
4.0 without brems. with brems.	18.2	13.8	10.9	9.39	8.31	7.45	6.53	5.89	4.33	3.67	3.19	2.92	2.70	2.41	2.20	1.88
5.0 without brems. with brems.	25.6	19.6	15.1	12.6	11.0	9.75	8.42	7.48	5.25	4.36	3.71	3.37	3.09	2.73	2.47	2.07
6.0 without brems. with brems.	34.3	26.7	20.0	16.4	14.4	12.4	10.5	9.27	6.24	5.07	4.27	3.84	3.49	3.04	2.74	2.26
7.0 without brems. with brems.	45.4	35.4	26.3	21.1	18.2	15.4	12.9	11.2	7.26	5.80	4.81	4.29	3.88	3.37	3.00	2.45
8.0 without brems. with brems.	58.6	46.2	33.5	26.4	22.6	18.8	15.6	13.3	8.31	6.52	5.36	4.75	4.27	3.68	3.26	2.64
10.0 without brems. with brems.	92.7	74.2	51.8	39.3	32.9	26.7	21.5	17.9	10.5	7.99	6.46	5.64	5.03	4.29	3.77	3.00
15.0 without brems. with brems.	237	193	124	86.2	69.3	52.5	40.5	31.9	16.3	11.7	9.24	7.84	6.90	5.76	5.01	3.87
20.0 without brems. with brems.	502	411	241	156	121	87.3	64.9	49.0	22.6	15.5	12.0	9.99	8.70	7.18	6.19	4.68
25.0 without brems. with brems.	945	766	414	252	190	131	94.7	68.9	29.2	19.4	14.8	12.1	10.4	8.55	7.33	5.45
30.0 without brems. with brems.	1640	1300	653	375	276	183	129	91.2	36.0	23.3	17.6	14.1	12.1	9.88	8.43	6.19
35.0 without brems. with brems.	2670	2070	964	526	379	244	169	115	43.0	27.2	20.4	16.2	13.7	11.1	9.50	6.90
40.0 without brems. with brems.	4130	3120	1350	705	497	312	213	142	50.2	31.1	23.1	18.2	15.3	12.4	10.5	7.58

Table 7 Exposure Buildup Factors-Plane Isotropic Incidence on 43-mfp-thick Water

Penetration (mfp)	Photon energy (MeV)															
	0.1	0.2	0.3	0.4	0.5	0.6	0.8	1.0	2.0	3.0	4.0	5.0	6.0	8.0	10.0	15.0
0.5 without brems. with brems.	4.18	3.18	2.80	2.60	2.44	2.33	2.20	2.10	1.85	1.74	1.67	1.59	1.54	1.45	1.38	1.28
1.0 without brems. with brems.	7.79	5.62	4.73	4.24	3.89	3.64	3.32	3.10	2.54	2.29	2.13	1.98	1.88	1.72	1.60	1.43
2.0 without brems. with brems.	19.1	13.3	10.5	9.01	7.91	7.17	6.20	5.55	4.01	3.37	2.98	2.67	2.47	2.18	1.98	1.70
3.0 without brems. with brems.	37.5	26.1	19.7	16.1	13.5	11.9	9.90	8.56	5.59	4.47	3.80	3.34	3.04	2.62	2.34	1.95
4.0 without brems. with brems.	64.6	45.4	33.0	25.8	21.0	18.1	14.3	12.0	7.24	5.58	4.61	3.99	3.58	3.04	2.68	2.19
5.0 without brems. with brems.	101	71.7	50.3	38.0	30.3	25.5	19.5	16.0	8.99	6.72	5.42	4.63	4.12	3.45	3.01	2.42
6.0 without brems. with brems.	149	107	71.2	52.0	42.0	34.7	25.7	20.5	10.9	7.96	6.28	5.31	4.68	3.88	3.35	2.65
7.0 without brems. with brems.	213	154	101	71.8	55.6	45.2	32.5	25.5	12.8	9.19	7.11	5.96	5.22	4.29	3.68	2.88
8.0 without brems. with brems.	293	213	137	94.0	71.4	57.1	40.0	30.9	14.9	10.4	7.94	6.60	5.75	4.69	4.00	3.11
10.0 without brems. with brems.	515	377	229	149	109	85.0	57.0	42.7	19.0	12.9	9.58	7.88	6.79	5.48	4.64	3.54
15.0 without brems. with brems.	1550	1140	615	359	243	178	110	78.0	30.2	19.3	13.6	10.9	9.31	7.37	6.17	4.59
20.0 without brems. with brems.	3660	2630	1280	683	434	306	178	120	42.1	25.9	17.6	14.0	11.7	9.18	7.64	5.59
25.0 without brems. with brems.	7410	5180	2290	1130	681	467	259	169	54.6	32.6	21.5	16.9	14.1	10.9	9.07	6.55
30.0 without brems. with brems.	13600	9150	3690	1710	983	658	351	223	67.6	39.4	25.4	19.8	16.3	12.6	10.4	7.48
35.0 without brems. with brems.	23000	14900	5540	2430	1330	877	455	282	80.8	46.2	29.2	22.7	18.6	14.2	11.8	8.37
40.0 without brems. with brems.	36800	22900	7860	3290	1730	1120	568	346	94.3	52.9	32.9	25.5	20.8	15.8	13.1	9.24
											33.1	25.6	20.9	16.1	13.4	9.66

Table 8 Dose-Equivalent Buildup Factors-Plane Isotropic Incidence on 43-mfp-thick Water

Penetration (mfp)	Photon energy (MeV)															
	0.1	0.2	0.3	0.4	0.5	0.6	0.8	1.0	2.0	3.0	4.0	5.0	6.0	8.0	10.0	15.0
0.5 without brems. with brems.	4.56	3.66	3.14	2.91	2.75	2.61	2.47	2.34	1.99	1.84	1.75	1.68	1.60	1.51	1.43	1.31
1.0 without brems. with brems.	8.64	6.81	5.60	5.02	4.65	4.32	3.95	3.65	2.83	2.50	2.28	2.13	1.98	1.81	1.68	1.47
2.0 without brems. with brems.	21.5	17.1	13.3	11.4	10.1	9.12	7.92	6.99	4.68	3.80	3.26	2.93	2.64	2.33	2.08	1.75
3.0 without brems. with brems.	42.4	34.6	26.0	21.3	18.1	15.9	13.1	11.1	6.67	5.12	4.20	3.69	3.27	2.82	2.47	2.02
4.0 without brems. with brems.	73.1	61.3	44.6	35.2	28.9	24.6	19.5	16.0	8.75	6.44	5.11	4.42	3.87	3.28	2.83	2.27
5.0 without brems. with brems.	114	97.9	69.1	52.6	42.6	35.5	27.1	21.7	10.9	7.80	6.03	5.15	4.45	3.73	3.19	2.51
6.0 without brems. with brems.	169	147	101	74.4	59.8	49.0	36.1	28.3	13.4	9.30	7.00	5.93	5.08	4.21	3.57	2.77
7.0 without brems. with brems.	241	213	142	102	80.2	64.5	46.2	35.4	15.9	10.7	7.95	6.67	5.67	4.66	3.92	3.01
8.0 without brems. with brems.	332	297	193	135	103	82.1	57.3	43.1	18.4	12.2	8.88	7.40	6.25	5.10	4.27	3.24
10.0 without brems. with brems.	583	529	328	217	160	123	82.5	60.2	23.7	15.2	10.7	8.84	7.39	5.97	4.96	3.71
15.0 without brems. with brems.	1760	1620	893	529	363	264	162	111	37.7	22.8	15.3	12.3	10.1	8.05	6.62	4.81
20.0 without brems. with brems.	4140	3750	1870	1020	655	457	263	173	52.7	30.6	19.8	15.7	12.8	10.0	8.20	5.87
25.0 without brems. with brems.	8390	7410	3370	1690	1030	700	384	244	68.5	38.6	24.2	19.1	15.3	11.9	9.74	6.88
30.0 without brems. with brems.	15300	13100	5460	2570	1490	990	523	322	84.7	46.6	28.5	22.3	17.8	13.8	11.4	7.85
35.0 without brems. with brems.	26000	21500	8210	3660	2040	1320	678	408	101	54.6	32.8	25.6	20.3	15.6	12.7	8.79
40.0 without brems. with brems.	41600	33000	11700	4960	2660	1690	848	500	118	62.6	37.0	28.7	22.7	17.3	14.1	9.70

Table 9 Absorbed-Dose Buildup Factors--Plane Isotropic Incidence on 43-mfp-thick Water

Penetration (mfp)	Photon energy (MeV)															
	0.1	0.2	0.3	0.4	0.5	0.6	0.8	1.0	2.0	3.0	4.0	5.0	6.0	8.0	10.0	15.0
0.5 without brems. with brems.	4.07	3.14	2.77	2.58	2.42	2.32	2.19	2.09	1.85	1.74	1.67	1.60	1.54	1.46	1.39	1.29
1.0 without brems. with brems.	7.53	5.51	4.66	4.19	3.85	3.61	3.31	3.08	2.54	2.28	2.13	1.99	1.88	1.73	1.62	1.44
2.0 without brems. with brems.	18.3	12.9	10.3	8.82	7.76	7.06	6.14	5.50	3.99	3.35	2.97	2.69	2.47	2.20	2.00	1.71
3.0 without brems. with brems.	35.7	25.2	19.1	15.7	13.2	11.7	9.76	8.46	5.57	4.45	3.79	3.37	3.04	2.64	2.37	1.96
4.0 without brems. with brems.	61.2	43.5	31.8	25.0	20.4	17.6	14.1	11.8	7.21	5.55	4.60	4.02	3.59	3.07	2.72	2.20
5.0 without brems. with brems.	95.6	68.4	48.3	36.7	29.4	24.9	19.2	15.7	8.95	6.68	5.40	4.67	4.12	3.48	3.05	2.43
6.0 without brems. with brems.	140	101	69.4	51.0	40.6	33.7	25.2	20.2	10.8	7.91	6.25	5.35	4.68	3.92	3.40	2.67
7.0 without brems. with brems.	200	146	96.8	69.0	53.7	43.9	31.9	25.1	12.8	9.13	7.09	6.01	5.23	4.33	3.73	2.90
8.0 without brems. with brems.	276	202	130	90.2	68.8	55.3	39.2	30.4	14.8	10.3	7.91	6.66	5.76	4.74	4.07	3.13
10.0 without brems. with brems.	483	356	217	143	105	82.2	55.8	42.0	18.9	12.8	9.54	7.94	6.80	5.54	4.71	3.57
15.0 without brems. with brems.	1460	1070	582	342	233	172	107	76.6	30.0	19.2	13.5	11.0	9.33	7.45	6.28	4.63
20.0 without brems. with brems.	3420	2470	1210	650	415	295	174	118	41.9	25.7	17.5	14.1	11.7	9.29	7.78	5.64
25.0 without brems. with brems.	6920	4850	2160	1080	651	450	252	166	54.3	32.4	21.4	17.1	14.1	11.0	9.23	6.60
30.0 without brems. with brems.	12700	8560	3480	1630	939	633	343	219	67.2	39.1	25.3	20.0	16.4	12.7	10.6	7.54
35.0 without brems. with brems.	21500	14000	5220	2310	1270	844	443	277	80.3	45.8	29.1	22.9	18.6	14.4	12.0	8.44
40.0 without brems. with brems.	34400	21400	7390	3120	1650	1080	554	339	93.7	52.5	32.8	25.7	20.8	16.0	13.4	9.31

Table 10 Exposure Buildup Factors-Plane Normal Incidence on 43-mfp-thick Concrete

Penetration (mfp)	Photon energy (MeV)															
	0.1	0.2	0.3	0.4	0.5	0.6	0.8	1.0	2.0	3.0	4.0	5.0	6.0	8.0	10.0	15.0
0.5 without brems. with brems.	2.15	2.05	1.93	1.84	1.76	1.71	1.63	1.56	1.43	1.36	1.32	1.29	1.27	1.22	1.18	1.14
1.0 without brems. with brems.	2.74	2.72	2.56	2.43	2.32	2.24	2.11	2.01	1.79	1.66	1.59	1.52	1.48	1.39	1.33	1.24
2.0 without brems. with brems.	3.85	4.16	3.92	3.73	3.54	3.38	3.14	2.96	2.52	2.26	2.10	1.97	1.88	1.71	1.60	1.44
3.0 without brems. with brems.	4.99	5.78	5.48	5.21	4.95	4.66	4.31	4.02	3.28	2.87	2.61	2.42	2.28	2.04	1.87	1.63
4.0 without brems. with brems.	6.16	7.60	7.28	6.90	6.55	6.09	5.61	5.17	4.08	3.49	3.13	2.87	2.68	2.35	2.14	1.83
5.0 without brems. with brems.	7.40	9.68	9.33	8.83	8.38	7.71	7.06	6.43	4.92	4.13	3.65	3.31	3.07	2.67	2.41	2.02
6.0 without brems. with brems.	8.76	12.1	11.7	11.1	10.5	9.54	8.69	7.82	5.82	4.80	4.20	3.78	3.49	3.00	2.69	2.23
7.0 without brems. with brems.	10.2	14.7	14.4	13.6	12.8	11.5	10.5	9.30	6.75	5.48	4.75	4.24	3.90	3.33	2.97	2.43
8.0 without brems. with brems.	11.7	17.7	17.3	16.3	15.4	13.7	12.4	10.9	7.71	6.17	5.31	4.70	4.31	3.66	3.24	2.63
10.0 without brems. with brems.	14.9	24.5	24.2	22.7	21.4	18.7	16.7	14.3	9.70	7.58	6.43	5.63	5.13	4.31	3.80	3.05
15.0 without brems. with brems.	24.3	48.0	47.7	44.2	41.0	34.2	30.0	24.3	15.1	11.2	9.30	7.96	7.19	5.95	5.22	4.10
20.0 without brems. with brems.	35.8	82.0	81.0	74.1	67.5	54.2	46.9	36.1	21.0	15.1	12.2	10.3	9.26	7.59	6.65	5.17
25.0 without brems. with brems.	49.1	128	125	113	101	78.7	67.0	49.4	27.2	19.0	15.2	12.6	11.3	9.23	8.10	6.26
30.0 without brems. with brems.	64.3	189	181	161	142	108	90.4	63.9	33.8	23.1	18.2	14.9	13.3	10.8	9.55	7.36
35.0 without brems. with brems.	81.0	264	249	220	189	141	117	79.3	40.6	27.2	21.2	17.2	15.3	12.4	11.0	8.47
40.0 without brems. with brems.	99.2	357	330	288	242	177	146	95.6	47.5	31.4	24.3	19.5	17.3	14.0	12.4	9.57

Table 11 Dose-Equivalent Buildup Factors-Plane Normal Incidence on 43-mfp-thick Concrete

Penetration (mfp)	Photon energy (MeV)															
	0.1	0.2	0.3	0.4	0.5	0.6	0.8	1.0	2.0	3.0	4.0	5.0	6.0	8.0	10.0	15.0
0.5 without brems. with brems.	2.67	2.24	2.07	1.97	1.90	1.84	1.75	1.67	1.49	1.40	1.36	1.33	1.30	1.25	1.21	1.16
1.0 without brems. with brems.	2.92	3.03	2.80	2.67	2.56	2.46	2.33	2.20	1.89	1.73	1.64	1.58	1.53	1.43	1.37	1.27
2.0 without brems. with brems.	4.15	4.74	4.39	4.18	4.02	3.81	3.56	3.33	2.70	2.39	2.19	2.08	1.96	1.79	1.67	1.48
3.0 without brems. with brems.	5.39	6.70	6.25	5.95	5.71	5.34	4.97	4.59	3.56	3.04	2.75	2.57	2.39	2.13	1.96	1.68
4.0 without brems. with brems.	6.69	8.92	8.40	7.98	7.67	7.09	6.56	5.98	4.47	3.72	3.31	3.06	2.82	2.47	2.25	1.89
5.0 without brems. with brems.	8.07	11.5	10.9	10.3	9.93	9.07	8.35	7.51	5.42	4.42	3.87	3.55	3.24	2.82	2.54	2.10
6.0 without brems. with brems.	9.57	14.4	13.8	13.1	12.5	11.3	10.4	9.22	6.45	5.16	4.47	4.06	3.69	3.17	2.84	2.31
7.0 without brems. with brems.	11.1	17.7	17.0	16.1	15.5	13.8	12.6	11.1	7.51	5.91	5.06	4.57	4.13	3.53	3.14	2.53
8.0 without brems. with brems.	12.8	21.4	20.7	19.5	1.87	16.5	15.0	13.0	8.60	6.67	5.66	5.08	4.57	3.88	3.44	2.74
10.0 without brems. with brems.	16.4	30.0	29.2	27.5	26.2	22.7	20.4	17.3	10.9	8.22	6.87	6.10	5.46	4.58	4.05	3.18
15.0 without brems. with brems.	26.9	59.7	58.5	54.4	51.1	42.3	37.3	29.8	17.1	12.2	9.97	8.66	7.68	6.35	5.57	4.29
20.0 without brems. with brems.	39.7	103	101	92.3	85.1	67.8	58.7	44.6	23.8	16.4	13.1	11.2	9.90	8.12	7.12	5.43
25.0 without brems. with brems.	54.7	162	157	142	128	99.2	84.5	61.3	31.0	20.8	16.4	13.8	12.1	9.89	8.69	6.58
30.0 without brems. with brems.	71.7	240	228	204	181	136	115	79.5	38.6	25.3	19.6	16.3	14.3	11.6	10.2	7.75
35.0 without brems. with brems.	90.5	337	315	278	242	178	149	99.1	46.4	29.8	22.9	18.9	16.4	13.3	11.8	8.92
40.0 without brems. with brems.	111	457	418	365	311	226	186	120	54.3	34.4	26.2	21.4	18.6	15.0	13.3	10.0

Table 12 Absorbed-Dose Buildup Factors-Plane Normal Incidence on 43-mfp-thick Concrete

Penetration (mfp)	Photon energy (MeV)															
	0.1	0.2	0.3	0.4	0.5	0.6	0.8	1.0	2.0	3.0	4.0	5.0	6.0	8.0	10.0	15.0
0.5 without brems. with brems.	2.76	2.51	2.19	2.02	1.89	1.81	1.71	1.62	1.46	1.37	1.32	1.29	1.26	1.21	1.18	1.12
1.0 without brems. with brems.	3.67	3.50	3.03	2.76	2.57	2.43	2.25	2.12	1.84	1.68	1.59	1.52	1.47	1.38	1.31	1.22
2.0 without brems. with brems.	5.41	5.71	4.90	4.42	4.06	3.78	3.44	3.19	2.61	2.29	2.10	1.97	1.86	1.69	1.57	1.40
3.0 without brems. with brems.	7.19	8.28	7.12	6.36	5.82	5.34	4.80	4.38	3.43	2.91	2.62	2.42	2.25	2.00	1.83	1.58
4.0 without brems. with brems.	9.05	11.3	9.71	8.64	7.86	7.11	6.34	5.70	4.29	3.55	3.14	2.86	2.63	2.31	2.09	1.76
5.0 without brems. with brems.	11.0	14.7	12.8	11.3	10.2	9.13	8.07	7.16	5.19	4.20	3.66	3.31	3.02	2.61	2.34	1.94
6.0 without brems. with brems.	13.2	18.7	16.3	14.4	13.0	11.5	10.0	8.78	6.17	4.90	4.22	3.78	3.42	2.93	2.61	2.12
7.0 without brems. with brems.	15.5	23.3	20.4	17.9	16.1	14.0	12.2	10.5	7.17	5.60	4.77	4.24	3.82	3.24	2.87	2.31
8.0 without brems. with brems.	17.9	28.4	25.0	21.8	19.5	16.8	14.5	12.4	8.20	6.31	5.32	4.70	4.22	3.56	3.14	2.49
10.0 without brems. with brems.	23.2	40.3	35.7	31.0	27.5	23.2	19.8	16.4	10.4	7.76	6.45	5.63	5.02	4.19	3.67	2.87
15.0 without brems. with brems.	38.7	82.2	73.1	62.3	54.3	43.5	36.3	28.3	16.2	11.5	9.33	7.95	7.02	5.77	5.01	3.83
20.0 without brems. with brems.	57.8	144	127	107	91.0	70.1	57.2	42.4	22.6	15.4	12.2	10.2	9.03	7.35	6.38	4.82
25.0 without brems. with brems.	80.3	229	200	165	138	103	82.5	58.2	29.4	19.5	15.2	12.6	11.0	8.92	7.75	5.81
30.0 without brems. with brems.	106	342	293	238	195	142	112	75.6	36.5	23.7	18.3	14.9	13.0	10.4	9.13	6.82
35.0 without brems. with brems.	134	484	407	327	262	186	145	94.2	43.9	28.0	21.3	17.2	14.9	12.0	10.5	7.83
40.0 without brems. with brems.	165	658	543	431	338	236	162	114	51.4	32.3	24.4	19.5	16.9	13.5	11.8	8.83

Table 13 Exposure Buildup Factors-Plane Isotropic Incidence on 43-mfp-thick Concrete

Penetration (mfp)	Photon energy (MeV)															
	0.1	0.2	0.3	0.4	0.5	0.6	0.8	1.0	2.0	3.0	4.0	5.0	6.0	8.0	10.0	15.0
0.5 without brems. with brems.	2.76	2.68	2.52	2.40	2.30	2.22	2.11	2.02	1.82	1.71	1.65	1.58	1.53	1.43	1.36	1.26
1.0 without brems. with brems.	4.17	4.21	3.90	3.67	3.46	3.30	3.07	2.89	2.44	2.21	2.09	1.95	1.86	1.68	1.57	1.41
2.0 without brems. with brems.	7.32	8.05	7.40	6.81	6.32	5.92	5.32	4.86	3.74	3.20	2.90	2.62	2.44	2.14	1.94	1.66
3.0 without brems. with brems.	10.9	13.0	12.0	10.9	9.94	9.17	8.03	7.18	5.13	4.22	3.70	3.28	3.01	2.58	2.30	1.91
4.0 without brems. with brems.	15.0	19.1	17.6	15.8	14.3	13.1	11.2	9.81	6.59	5.26	4.49	3.93	3.57	3.01	2.66	2.16
5.0 without brems. with brems.	19.6	26.6	24.6	21.8	19.5	17.6	14.8	12.7	8.13	6.32	5.29	4.58	4.13	3.43	3.01	2.40
6.0 without brems. with brems.	24.8	35.7	33.0	29.0	25.7	23.0	18.9	16.1	9.83	7.48	6.14	5.27	4.72	3.88	3.38	2.66
7.0 without brems. with brems.	30.5	46.3	42.8	37.3	32.7	29.0	23.5	19.7	11.6	8.64	6.98	5.95	5.29	4.32	3.74	2.92
8.0 without brems. with brems.	36.7	58.6	54.1	46.7	40.6	35.7	28.5	23.6	13.4	9.82	7.82	6.62	5.87	4.76	4.11	3.18
10.0 without brems. with brems.	50.5	88.4	81.6	69.2	59.0	51.1	39.7	32.0	17.1	12.2	9.50	7.97	7.01	5.63	4.84	3.70
15.0 without brems. with brems.	93.8	199	182	148	121	101	74.4	57.0	27.1	18.5	13.7	11.3	9.85	7.81	6.68	5.04
20.0 without brems. with brems.	149	371	333	262	205	168	118	86.6	38.0	25.0	17.9	14.7	12.6	9.98	8.55	6.41
25.0 without brems. with brems.	217	615	541	412	311	250	170	120	49.4	31.6	22.1	18.0	15.5	12.1	10.4	7.82
30.0 without brems. with brems.	295	942	810	600	437	347	229	157	61.3	38.4	26.3	21.3	18.3	14.2	12.3	9.26
35.0 without brems. with brems.	384	1360	1140	826	582	457	294	196	73.5	45.2	30.4	24.6	21.0	16.5	14.2	10.7
40.0 without brems. with brems.	482	1870	1540	1090	745	579	365	237	85.9	52.1	34.5	27.9	23.8	18.4	16.1	12.1
											34.7	28.1	24.1	18.9	16.7	13.2

Table 14 Dose-Equivalent Buildup Factors-Plane Isotropic Incidence on 43-mfp-thick Concrete

Penetration (mfp)	Photon energy (MeV)																
	0.1	0.2	0.3	0.4	0.5	0.6	0.8	1.0	2.0	3.0	4.0	5.0	6.0	8.0	10.0	15.0	
0.5 without brems. with brems.	2.94	2.96	2.73	2.60	2.52	2.42	2.31	2.20	1.92	1.79	1.72	1.65	1.59	1.48	1.41	1.29	
1.0 without brems. with brems.	4.50	4.80	4.36	4.11	3.93	3.72	3.48	3.25	2.64	2.35	2.20	2.07	1.95	1.76	1.64	1.45	
2.0 without brems. with brems.	8.01	9.49	8.58	7.92	7.45	6.93	6.27	5.69	4.14	3.47	3.10	2.83	2.59	2.26	2.05	1.72	
3.0 without brems. with brems.	12.0	15.6	14.1	12.9	12.0	11.0	9.68	8.58	5.76	4.61	3.98	3.56	3.22	2.74	2.44	1.99	
4.0 without brems. with brems.	16.6	23.3	21.1	19.0	17.5	15.8	13.7	11.9	7.45	5.77	4.85	4.29	3.82	2.21	2.83	2.25	
5.0 without brems. with brems.	21.7	32.7	29.7	26.5	24.1	21.6	18.2	15.6	9.25	6.97	5.72	5.01	4.43	3.68	3.21	2.51	
6.0 without brems. with brems.	27.6	44.2	40.2	35.5	32.0	28.4	23.6	19.8	11.2	8.27	6.66	5.78	5.07	4.17	3.62	2.79	
7.0 without brems. with brems.	33.9	57.6	52.5	45.9	40.9	36.1	29.4	24.3	13.2	9.57	7.58	6.53	5.70	4.65	4.00	3.97	
8.0 without brems. with brems.	40.8	73.1	66.7	57.8	51.0	44.6	35.8	29.2	15.3	10.9	8.49	7.28	6.32	5.12	4.41	3.34	
10.0 without brems. with brems.	56.3	111	101	86.3	74.7	64.3	50.2	39.9	19.7	13.6	10.3	8.78	7.56	6.07	5.21	3.90	
15.0 without brems. with brems.	105	253	229	187	155	129	95.0	71.6	31.3	20.6	14.9	12.5	10.6	8.44	7.21	5.32	
20.0 without brems. with brems.	168	474	422	332	264	215	151	109	43.9	27.9	19.5	16.2	13.7	10.7	9.24	6.78	
25.0 without brems. with brems.	244	790	689	526	402	321	218	152	57.2	35.3	24.1	19.9	16.7	13.1	11.2	8.28	
30.0 without brems. with brems.	332	1210	1030	768	567	446	294	198	70.9	42.9	28.7	23.6	19.7	15.4	13.3	9.80	
35.0 without brems. with brems.	432	1760	1460	1060	758	588	379	248	85.1	50.5	33.2	27.2	22.7	17.7	15.4	11.3	
40.0 without brems. with brems.	542	2430	1980	1400	972	748	472	301	99.5	58.2	37.7	30.9	25.7	20.0	17.5	12.9	

Table 15 Absorbed-Dose Buildup Factors-Plane Isotropic Incidence on 43-mfp-thick Concrete

Penetration (mfp)	Photon energy (MeV)																
	0.1	0.2	0.3	0.4	0.5	0.6	0.8	1.0	2.0	3.0	4.0	5.0	6.0	8.0	10.0	15.0	
0.5 without brems. with brems.	3.66	3.35	2.90	2.66	2.49	2.37	2.23	2.11	1.86	1.73	1.65	1.58	1.52	1.42	1.35	1.24	
1.0 without brems. with brems.	5.91	5.72	4.82	4.29	3.93	3.67	3.34	3.10	2.54	2.26	2.10	1.95	1.84	1.66	1.55	1.37	
2.0 without brems. with brems.	11.0	12.0	9.90	8.55	7.62	6.94	6.05	5.41	3.96	3.30	2.92	2.63	2.41	2.10	1.90	1.60	
3.0 without brems. with brems.	17.0	20.3	16.8	14.2	12.4	11.1	9.36	8.15	5.48	4.36	3.73	3.30	2.97	2.52	2.24	1.83	
4.0 without brems. with brems.	23.8	30.9	25.5	21.2	18.3	16.1	13.2	11.3	7.07	5.44	4.53	3.95	3.51	2.93	2.57	2.05	
5.0 without brems. with brems.	31.4	44.0	36.3	29.8	25.3	22.1	17.7	14.8	8.77	6.55	5.34	4.60	4.05	3.34	2.91	2.28	
6.0 without brems. with brems.	40.2	60.2	49.7	40.3	33.8	29.1	22.9	18.8	10.6	7.76	6.20	5.29	4.63	3.78	3.26	2.51	
7.0 without brems. with brems.	49.7	79.1	65.4	52.5	43.5	37.1	28.6	23.1	12.5	8.98	7.04	5.97	5.19	4.20	3.61	2.75	
8.0 without brems. with brems.	60.0	101	83.6	66.4	54.4	46.0	34.9	27.8	14.5	10.2	7.89	6.64	5.74	4.62	3.95	2.98	
10.0 without brems. with brems.	83.3	155	128	99.8	80.1	66.6	49.0	37.9	18.6	12.7	9.58	7.99	6.85	5.46	4.64	3.46	
15.0 without brems. with brems.	157	359	293	218	167	134	92.8	68.1	29.6	19.2	13.8	11.3	9.62	7.55	6.39	4.67	
20.0 without brems. with brems.	252	680	546	392	287	224	148	104	41.4	26.0	18.0	14.7	12.3	9.63	8.16	5.92	
25.0 without brems. with brems.	367	1140	897	623	438	336	214	144	53.9	32.9	22.3	18.0	15.1	11.7	9.95	7.20	
30.0 without brems. with brems.	502	1760	1350	913	619	467	289	188	66.9	40.0	26.5	21.4	17.8	13.7	11.7	8.51	
35.0 without brems. with brems.	654	2560	1920	1260	829	617	372	236	80.2	47.1	30.7	24.7	20.5	15.7	13.5	9.84	
40.0 without brems. with brems.	823	3550	2600	1670	1060	784	463	286	93.8	54.3	34.8	27.9	23.1	17.8	15.3	11.1	

Table 16 Exposure Buildup Factors-Plane Normal Incidence on 43-mfp-thick Iron

Penetration (mfp)	Photon energy (MeV)															
	0.1	0.2	0.3	0.4	0.5	0.6	0.8	1.0	2.0	3.0	4.0	5.0	6.0	8.0	10.0	15.0
0.5 without brems. with brems.	1.40	1.88	2.03	2.07	2.05	2.02	1.96	1.91	1.77	1.70	1.62	1.55	1.50	1.39	1.32	1.23
1.0 without brems. with brems.	1.61	2.48	2.80	2.89	2.86	2.82	2.72	2.62	2.32	2.18	2.03	1.90	1.80	1.62	1.51	1.35
2.0 without brems. with brems.	1.97	3.65	4.43	4.69	4.68	4.61	4.39	4.17	3.46	3.12	2.81	2.55	2.38	2.05	1.86	1.59
3.0 without brems. with brems.	2.28	4.87	6.24	6.75	6.76	6.67	6.31	5.93	4.69	4.09	3.60	3.22	2.97	2.51	2.23	1.84
4.0 without brems. with brems.	2.56	6.11	8.22	9.06	9.12	9.00	8.47	7.87	5.98	5.09	4.43	3.91	3.58	2.99	2.63	2.12
5.0 without brems. with brems.	2.82	7.37	10.3	11.6	11.8	11.6	10.9	10.0	7.36	6.14	5.28	4.64	4.22	3.50	3.06	2.43
6.0 without brems. with brems.	3.05	8.58	12.5	14.2	14.8	14.6	13.6	12.4	8.86	7.26	6.21	5.42	4.93	4.07	3.54	2.79
7.0 without brems. with brems.	3.28	9.86	14.8	17.0	18.0	17.8	16.5	15.0	10.4	8.41	7.15	6.23	5.65	4.66	4.06	3.19
8.0 without brems. with brems.	3.50	11.2	17.2	20.1	21.5	21.3	19.7	17.7	12.0	9.59	8.13	7.06	6.41	5.29	4.61	3.63
10.0 without brems. with brems.	3.92	13.9	22.5	26.9	29.3	29.1	26.6	23.6	15.4	12.0	10.1	8.80	8.01	6.64	5.83	4.66
15.0 without brems. with brems.	4.91	21.0	37.6	47.1	53.2	53.0	47.5	40.6	24.7	18.5	15.5	13.5	12.5	10.6	9.65	8.34
20.0 without brems. with brems.	5.83	28.6	55.1	71.7	82.7	82.7	72.8	60.5	34.9	25.6	21.5	18.9	17.7	15.5	14.7	14.2
25.0 without brems. with brems.	6.71	36.5	74.6	100	117	118	102	82.6	45.7	32.9	27.7	24.6	23.6	21.4	21.3	23.5
30.0 without brems. with brems.	7.56	44.6	95.6	132	156	157	135	106	57.1	40.6	34.3	30.8	30.1	28.3	29.7	37.7
35.0 without brems. with brems.	8.39	53.0	118	167	199	201	171	132	68.9	48.4	41.1	37.4	37.2	36.2	40.1	59.0
40.0 without brems. with brems.	9.22	61.4	141	205	245	248	210	159	80.9	56.4	48.1	44.3	44.8	45.2	52.9	90.7
										56.8	48.6	45.1	46.0	47.6	57.6	119

Table 17 Dose-Equivalent Buildup Factors--Plane Normal Incidence on 43-mfp-thick Iron

Penetration (mfp)	Photon energy (MeV)															
	0.1	0.2	0.3	0.4	0.5	0.6	0.8	1.0	2.0	3.0	4.0	5.0	6.0	8.0	10.0	15.0
0.5 without brems. with brems.	1.43	1.96	2.11	2.17	2.16	2.13	2.09	2.03	1.83	1.76	1.67	1.61	1.55	1.43	1.37	1.26
1.0 without brems. with brems.	1.65	2.61	2.94	3.06	3.08	3.03	2.96	2.84	2.44	2.28	2.11	2.00	1.88	1.69	1.57	1.40
2.0 without brems. with brems.	2.02	3.89	4.70	5.04	5.12	5.04	4.87	4.61	3.70	3.30	2.95	2.72	2.50	2.16	1.96	1.65
3.0 without brems. with brems.	2.35	5.21	6.67	7.31	7.47	7.37	7.08	6.63	5.05	4.35	3.81	3.45	3.14	2.66	2.37	1.93
4.0 without brems. with brems.	2.65	6.56	8.80	9.85	10.1	10.0	9.56	8.86	6.47	5.43	4.69	4.21	3.80	3.18	2.80	2.23
5.0 without brems. with brems.	2.92	7.92	11.1	12.6	13.1	13.0	12.3	11.3	7.98	6.55	5.60	5.00	4.49	3.74	3.27	2.57
6.0 without brems. with brems.	3.15	9.23	13.4	15.5	16.5	16.4	15.5	14.1	9.64	7.77	6.59	5.86	5.25	4.35	3.80	2.96
7.0 without brems. with brems.	3.39	10.6	15.9	18.6	20.2	20.0	18.9	17.0	11.3	9.01	7.61	6.74	6.03	5.00	4.36	3.39
8.0 without brems. with brems.	3.62	12.0	18.5	22.0	24.2	24.0	22.5	20.2	13.1	10.2	8.64	7.65	6.85	5.67	4.96	3.86
10.0 without brems. with brems.	4.07	14.9	24.2	29.4	33.0	32.9	30.6	27.0	16.9	12.9	10.8	9.56	8.57	7.14	6.30	4.98
15.0 without brems. with brems.	5.09	22.7	40.6	51.7	60.2	60.0	54.8	46.7	27.1	19.9	16.6	14.7	13.4	11.4	10.5	8.99
20.0 without brems. with brems.	6.05	30.9	59.6	78.9	93.7	93.9	84.3	69.7	38.2	27.5	22.9	20.5	19.0	16.8	16.1	15.4
25.0 without brems. with brems.	6.97	39.4	80.6	110	133	134	118	95.4	50.2	35.4	29.6	26.9	25.3	23.2	23.3	25.6
30.0 without brems. with brems.	7.86	48.2	103	146	178	179	157	123	62.7	43.6	36.6	33.7	32.3	30.7	32.5	41.1
35.0 without brems. with brems.	8.73	57.2	128	184	226	229	198	153	75.6	52.1	43.9	40.8	39.9	39.3	44.0	64.6
40.0 without brems. with brems.	9.59	66.4	153	226	279	283	244	184	88.9	60.7	51.4	48.4	48.2	49.1	58.0	99.4
										61.2	52.0	49.3	49.6	52.0	63.7	132

Table 18 Absorbed-Dose Buildup Factors-Plane Normal Incidence on 43-mfp-thick Iron

Penetration (mfp)	Photon energy (MeV)															
	0.1	0.2	0.3	0.4	0.5	0.6	0.8	1.0	2.0	3.0	4.0	5.0	6.0	8.0	10.0	15.0
0.5 without brems. with brems.	1.62	2.82	3.04	2.85	2.66	2.50	2.32	2.18	1.88	1.74	1.61	1.52	1.44	1.32	1.25	1.16
1.0 without brems. with brems.	1.92	4.02	4.59	4.32	4.00	3.74	3.39	3.14	2.54	2.26	2.02	1.85	1.72	1.52	1.40	1.26
2.0 without brems. with brems.	2.41	6.36	7.87	7.55	7.00	6.52	5.79	5.24	3.89	3.25	2.79	2.45	2.22	1.87	1.67	1.42
3.0 without brems. with brems.	2.84	8.75	11.5	11.3	10.5	9.56	8.56	7.64	5.33	4.28	3.56	3.07	2.73	2.24	1.96	1.60
4.0 without brems. with brems.	3.23	11.2	15.5	15.5	14.4	13.4	11.7	10.3	6.86	5.33	4.36	3.71	3.25	2.62	2.26	1.80
5.0 without brems. with brems.	3.57	13.6	19.8	20.0	18.9	17.6	15.2	13.2	8.48	6.45	5.19	4.37	3.81	3.03	2.59	2.02
6.0 without brems. with brems.	3.87	15.6	24.0	24.7	24.0	22.4	19.2	16.6	10.3	7.62	6.09	5.09	4.42	3.48	2.96	2.26
7.0 without brems. with brems.	4.17	18.4	28.6	29.8	29.6	27.6	23.5	20.1	12.1	8.82	7.01	5.83	5.04	3.96	3.34	2.54
8.0 without brems. with brems.	4.47	20.9	33.6	35.4	35.6	33.2	28.1	23.9	14.0	10.0	7.95	6.59	5.69	4.45	3.76	2.84
10.0 without brems. with brems.	5.04	26.0	44.2	47.7	49.0	45.8	38.4	32.0	18.0	12.6	9.91	8.19	7.07	5.53	4.67	3.53
15.0 without brems. with brems.	6.35	39.7	74.9	84.8	90.2	84.5	69.2	55.7	28.9	19.4	15.1	12.5	10.9	8.69	7.53	5.99
20.0 without brems. with brems.	7.58	54.2	110	130	141	133	107	83.4	40.9	26.8	20.8	17.4	15.3	12.5	11.3	9.86
25.0 without brems. with brems.	8.75	69.4	150	182	202	190	150	114	53.6	34.5	26.9	22.6	20.3	17.1	16.1	15.8
30.0 without brems. with brems.	9.89	85.0	193	241	270	254	199	148	67.0	42.4	33.2	28.3	25.9	22.5	22.3	24.9
35.0 without brems. with brems.	11.0	101	238	306	345	326	253	183	80.9	50.6	39.8	34.3	31.9	28.7	29.9	38.4
40.0 without brems. with brems.	12.1	117	286	376	426	404	311	220	95.1	58.9	46.5	40.5	38.5	35.8	39.1	58.4

Table 19 Exposure Buildup Factors-Plane Isotropic Incidence on 43-mfp-thick Iron

Penetration (mfp)	Photon energy (MeV)															
	0.1	0.2	0.3	0.4	0.5	0.6	0.8	1.0	2.0	3.0	4.0	5.0	6.0	8.0	10.0	15.0
0.5 without brems. with brems.	1.26	1.53	1.60	1.61	1.59	1.57	1.53	1.49	1.40	1.35	1.32	1.28	1.26	1.20	1.17	1.12
1.0 without brems. with brems.	1.36	1.83	1.99	2.03	2.02	2.00	1.93	1.88	1.73	1.63	1.56	1.50	1.45	1.35	1.29	1.21
2.0 without brems. with brems.	1.51	2.36	2.73	2.87	2.88	2.85	2.77	2.68	2.39	2.19	2.05	1.92	1.83	1.64	1.53	1.37
3.0 without brems. with brems.	1.64	2.86	3.48	3.75	3.82	3.76	3.68	3.54	3.09	2.77	2.55	2.36	2.22	1.95	1.79	1.55
4.0 without brems. with brems.	1.74	3.34	4.25	4.68	4.82	4.74	4.66	4.46	3.82	3.38	3.07	2.82	2.62	2.28	2.06	1.74
5.0 without brems. with brems.	1.84	3.80	5.03	5.66	5.91	5.87	5.72	5.44	4.58	4.01	3.61	3.29	3.06	2.63	2.35	1.96
6.0 without brems. with brems.	1.91	4.22	5.78	6.63	7.11	7.07	6.89	6.51	5.40	4.69	4.19	3.80	3.52	3.01	2.68	2.20
7.0 without brems. with brems.	1.99	4.64	6.57	7.68	8.38	8.35	8.14	7.63	6.24	5.39	4.79	4.32	4.01	3.41	3.02	2.46
8.0 without brems. with brems.	2.06	5.06	7.38	8.77	9.74	9.71	9.47	8.82	7.12	6.10	5.41	4.86	4.51	3.83	3.39	2.76
10.0 without brems. with brems.	2.19	5.90	9.07	11.1	12.7	12.6	12.4	11.3	8.95	7.59	6.69	5.99	5.58	4.74	4.20	3.43
15.0 without brems. with brems.	2.48	8.01	13.6	17.9	21.5	21.5	21.0	18.5	13.9	11.6	10.2	9.08	8.58	7.42	6.72	5.78
20.0 without brems. with brems.	2.74	10.1	18.6	25.7	32.3	32.4	31.4	26.8	19.4	16.0	14.0	12.5	12.0	10.7	10.0	9.40
25.0 without brems. with brems.	2.97	12.3	23.9	34.7	44.9	45.2	43.5	35.8	25.4	20.8	18.2	16.2	15.9	14.6	14.2	14.8
30.0 without brems. with brems.	3.18	14.5	29.7	44.7	59.1	60.0	57.3	45.6	31.6	25.8	22.7	20.2	20.2	19.1	19.4	22.7
35.0 without brems. with brems.	3.38	16.7	35.7	55.6	74.8	76.7	72.6	55.9	38.1	31.0	27.4	24.4	24.8	24.3	25.8	34.1
40.0 without brems. with brems.	3.58	19.0	42.0	67.4	91.8	95.1	89.2	66.6	44.9	36.4	32.2	28.8	29.8	30.1	33.4	50.3

Table 20 Dose-Equivalent Buildup Factors-Plane Isotropic Incidence on 43-mfp-thick Iron

Penetration (mfp)	Photon energy (MeV)															
	0.1	0.2	0.3	0.4	0.5	0.6	0.8	1.0	2.0	3.0	4.0	5.0	6.0	8.0	10.0	15.0
0.5 without brems. with brems.	1.28	1.58	1.66	1.67	1.67	1.65	1.61	1.56	1.44	1.38	1.35	1.32	1.29	1.23	1.20	1.15
1.0 without brems. with brems.	1.38	1.90	2.07	2.12	2.13	2.11	2.06	1.99	1.80	1.68	1.61	1.55	1.50	1.39	1.33	1.24
2.0 without brems. with brems.	1.54	2.47	2.85	3.03	3.09	3.05	3.00	2.89	2.51	2.28	2.12	2.01	1.90	1.71	1.59	1.41
3.0 without brems. with brems.	1.67	3.01	3.66	3.98	4.12	4.06	4.01	3.86	3.26	2.90	2.65	2.49	2.32	2.04	1.87	1.60
4.0 without brems. with brems.	1.78	3.52	4.48	5.00	5.24	5.21	5.12	4.89	4.05	3.54	3.20	2.98	2.75	2.39	2.16	1.81
5.0 without brems. with brems.	1.87	4.01	5.31	6.06	6.45	6.42	6.33	6.00	4.87	4.22	3.78	3.50	3.21	2.77	2.48	2.04
6.0 without brems. with brems.	1.95	4.46	6.12	7.12	7.79	7.75	7.66	7.22	5.76	4.94	4.40	4.05	3.71	3.18	2.83	2.30
7.0 without brems. with brems.	2.03	4.91	6.96	8.26	9.21	9.18	9.09	8.49	6.68	5.68	5.03	4.62	4.22	3.61	3.21	2.59
8.0 without brems. with brems.	2.10	5.37	7.83	9.45	10.7	10.7	10.6	9.84	7.63	6.45	5.68	5.20	4.76	4.06	3.61	2.90
10.0 without brems. with brems.	2.24	6.27	9.64	12.0	14.1	14.0	13.9	12.7	9.62	8.04	7.05	6.43	5.90	5.04	4.49	3.63
15.0 without brems. with brems.	2.54	8.52	14.5	19.4	24.0	24.0	23.8	20.9	15.1	12.3	10.7	9.79	9.12	7.94	7.24	6.17
20.0 without brems. with brems.	2.80	10.8	19.9	28.1	36.2	36.3	35.8	30.4	21.1	17.1	14.8	13.5	12.8	11.4	10.8	10.1
25.0 without brems. with brems.	3.04	13.1	25.7	37.9	50.4	50.9	49.9	40.8	27.5	22.2	19.3	17.5	16.9	15.7	15.4	15.9
30.0 without brems. with brems.	3.26	15.5	31.8	48.9	66.6	67.7	65.8	52.1	34.4	27.5	24.0	21.9	21.5	20.6	21.1	24.6
35.0 without brems. with brems.	3.46	17.9	38.3	60.9	84.4	86.6	83.4	63.9	41.5	33.1	29.0	26.5	26.5	26.2	28.1	37.1
40.0 without brems. with brems.	3.66	20.3	45.1	73.9	104	107.6	103	76.3	48.8	38.9	34.2	31.3	31.9	32.5	36.5	54.8
										39.4	34.8	32.1	33.1	35.0	41.0	78.1

Table 21 Absorbed-Dose Buildup Factors-Plane Isotropic Incidence on 43-mfp-thick Iron

Penetration (mfp)	Photon energy (MeV)															
	0.1	0.2	0.3	0.4	0.5	0.6	0.8	1.0	2.0	3.0	4.0	5.0	6.0	8.0	10.0	15.0
0.5 without brems. with brems.	1.41	2.13	2.25	2.11	1.98	1.88	1.76	1.66	1.48	1.37	1.32	1.27	1.23	1.17	1.14	1.09
1.0 without brems. with brems.	1.54	2.67	2.94	2.79	2.62	2.48	2.29	2.15	1.85	1.66	1.56	1.47	1.40	1.29	1.23	1.15
2.0 without brems. with brems.	1.74	3.63	4.28	4.15	3.93	3.71	3.40	3.17	2.60	2.24	2.02	1.86	1.73	1.54	1.42	1.27
3.0 without brems. with brems.	1.89	4.52	5.66	5.62	5.37	5.04	4.63	4.28	3.39	2.84	2.51	2.26	2.07	1.79	1.62	1.40
4.0 without brems. with brems.	2.02	5.38	7.09	7.19	6.93	6.55	5.97	5.47	4.22	3.47	3.01	2.68	2.43	2.06	1.84	1.54
5.0 without brems. with brems.	2.13	6.19	8.54	8.83	8.66	8.19	7.44	6.77	5.10	4.12	3.54	3.12	2.80	2.34	2.07	1.70
6.0 without brems. with brems.	2.23	6.93	9.95	10.5	10.6	10.0	9.08	8.19	6.04	4.82	4.10	3.59	3.20	2.65	2.32	1.87
7.0 without brems. with brems.	2.32	7.69	11.4	12.3	12.6	11.9	10.8	9.68	7.01	5.54	4.67	4.06	3.62	2.97	2.58	2.06
8.0 without brems. with brems.	2.40	8.45	13.0	14.2	14.8	14.0	12.7	11.3	8.02	6.29	5.26	4.56	4.06	3.31	2.87	2.27
10.0 without brems. with brems.	2.57	9.97	16.2	18.3	19.7	18.6	16.8	14.7	10.1	7.83	6.51	5.59	4.98	4.05	3.49	2.74
15.0 without brems. with brems.	2.92	13.8	25.0	30.1	34.4	32.5	29.2	24.4	15.9	12.0	9.89	8.42	7.57	6.20	5.40	4.35
20.0 without brems. with brems.	3.22	17.6	34.7	44.2	52.5	49.8	44.3	35.6	22.3	16.6	13.6	11.5	10.5	8.81	7.89	6.77
25.0 without brems. with brems.	3.50	21.6	45.3	60.3	73.8	70.3	62.1	48.0	29.2	21.5	17.6	14.9	13.8	11.9	11.0	10.3
30.0 without brems. with brems.	3.75	25.6	56.5	78.3	98.1	94.1	82.2	61.4	36.5	26.7	21.9	18.6	17.5	15.4	14.8	15.5
35.0 without brems. with brems.	3.99	29.6	68.4	98.1	125	120	105	75.6	44.1	32.1	26.4	22.4	21.5	19.5	19.5	22.8
40.0 without brems. with brems.	4.22	33.7	80.9	120	154	150	129	90.4	51.9	37.8	31.1	26.4	25.8	24.1	25.2	33.2
										39.4	32.8	28.4	28.2	27.7	30.7	50.8

Table 22 Exposure Buildup Factors-Plane Normal Incidence on 43-mfp-thick Lead

Penetration (mfp)	Photon energy (MeV)															
	0.1	0.2	0.3	0.4	0.5	0.6	0.8	1.0	2.0	3.0	4.0	5.0	6.0	8.0	10.0	15.0
0.5 without brems. with brems.	1.11	1.14	1.16	1.20	1.21	1.24	1.23	1.21	1.24	1.23	1.21	1.19	1.17	1.12	1.10	1.07
1.0 without brems. with brems.	1.17	1.22	1.27	1.33	1.37	1.43	1.40	1.36	1.43	1.44	1.43	1.36	1.28	1.20	1.16	1.11
2.0 without brems. with brems.	1.26	1.35	1.43	1.53	1.63	1.78	1.73	1.65	1.78	1.78	1.74	1.57	1.50	1.36	1.29	1.20
3.0 without brems. with brems.	1.33	1.46	1.57	1.75	1.87	2.11	2.06	1.96	2.11	2.06	1.96	1.84	1.75	1.55	1.45	1.30
4.0 without brems. with brems.	1.39	1.55	1.68	1.92	2.08	2.45	2.41	2.29	2.45	2.41	2.29	2.14	2.02	1.77	1.62	1.42
5.0 without brems. with brems.	1.44	1.63	1.79	2.08	2.28	2.77	2.77	2.64	2.77	2.77	2.64	2.47	2.32	2.02	1.83	1.58
6.0 without brems. with brems.	1.49	1.70	1.89	2.23	2.48	3.11	3.15	3.02	3.11	3.15	3.02	2.84	2.66	2.31	2.08	1.78
7.0 without brems. with brems.	1.53	1.77	1.98	2.37	2.66	3.45	3.54	3.42	3.45	3.54	3.42	3.24	3.04	2.65	2.38	2.03
8.0 without brems. with brems.	1.57	1.83	2.06	2.51	2.84	3.81	4.04	4.02	3.81	4.04	4.02	4.08	4.22	4.92	6.30	15.1
10.0 without brems. with brems.	1.64	1.94	2.21	2.76	3.17	4.45	4.79	4.77	4.45	4.79	4.77	4.66	4.45	3.98	3.62	3.25
15.0 without brems. with brems.	1.78	2.17	2.54	3.33	3.92	6.13	7.14	7.59	6.13	7.14	7.59	7.94	8.00	7.87	7.78	8.98
20.0 without brems. with brems.	1.89	2.37	2.82	3.84	4.59	7.83	9.80	11.1	4.59	7.83	9.80	12.7	13.7	15.5	17.5	29.5
25.0 without brems. with brems.	1.99	2.56	3.07	4.30	5.22	9.54	12.7	15.6	5.22	9.54	12.7	19.5	22.8	30.3	40.4	105
30.0 without brems. with brems.	2.08	2.73	3.31	4.72	5.81	11.2	16.0	21.1	5.81	11.2	16.0	28.9	36.8	58.8	94.3	387
35.0 without brems. with brems.	2.16	2.89	3.53	5.12	6.37	13.0	19.5	27.7	6.37	13.0	19.5	41.8	58.3	112	220	1440
40.0 without brems. with brems.	2.24	3.05	3.74	5.49	6.91	14.7	23.3	35.5	6.91	14.7	23.3	59.3	90.6	215	516	5410

Table 23 Dose-Equivalent Buildup Factors--Plane Normal Incidence on 43-mfp-thick Lead

Penetration (mfp)	Photon energy (MeV)															
	0.1	0.2	0.3	0.4	0.5	0.6	0.8	1.0	2.0	3.0	4.0	5.0	6.0	8.0	10.0	15.0
0.5 without brems. with brems.				1.11	1.15	1.17	1.21	1.23	1.26	1.24	1.23	1.21	1.19	1.14	1.12	1.08
1.0 without brems. with brems.				1.18	1.24	1.28	1.35	1.39	1.45	1.42	1.38	1.34	1.31	1.22	1.18	1.13
2.0 without brems. with brems.				1.27	1.37	1.45	1.59	1.67	1.80	1.75	1.68	1.61	1.54	1.39	1.32	1.22
3.0 without brems. with brems.				1.34	1.48	1.59	1.79	1.91	2.15	2.10	2.00	1.90	1.79	1.59	1.48	1.32
4.0 without brems. with brems.				1.40	1.57	1.71	1.97	2.13	2.48	2.45	2.33	2.22	2.07	1.82	1.67	1.46
5.0 without brems. with brems.				1.46	1.65	1.82	2.13	2.34	2.82	1.82	2.69	2.57	2.39	2.08	1.90	1.62
6.0 without brems. with brems.				1.50	1.73	1.92	2.29	2.54	3.16	3.21	3.08	2.95	2.74	2.39	2.16	1.83
7.0 without brems. with brems.				1.55	1.79	2.01	2.44	2.73	3.50	3.61	3.49	3.37	3.14	2.74	2.48	2.10
8.0 without brems. with brems.				1.58	1.86	2.09	2.58	2.91	3.84	4.02	3.93	3.83	3.58	3.15	2.85	2.43
10.0 without brems. with brems.				1.65	1.97	2.25	2.84	3.26	4.53	4.89	4.88	4.87	4.61	4.15	3.81	3.41
15.0 without brems. with brems.				1.79	2.21	2.58	3.43	4.04	6.24	7.29	7.77	8.34	8.32	8.28	8.28	9.57
20.0 without brems. with brems.				1.91	2.42	2.87	3.95	4.74	7.97	10.0	11.4	13.3	14.3	16.4	18.8	31.8
25.0 without brems. with brems.				2.01	2.60	3.13	4.43	5.38	9.72	13.0	16.0	20.5	23.8	32.2	43.6	114
30.0 without brems. with brems.				2.10	2.78	3.37	4.87	5.99	11.4	16.3	21.6	30.5	38.5	62.6	102	421
35.0 without brems. with brems.				2.19	2.95	3.60	5.28	6.60	13.3	20.4	29.3	46.7	67.9	182	676	24600
40.0 without brems. with brems.				2.27	3.11	3.81	5.67	7.13	15.0	23.9	36.4	62.8	95.1	230	562	5910
								7.16	15.1	24.3	37.5	65.9	104	340	1570	95300

Table 24 Absorbed-Dose Buildup Factors-Plane Normal Incidence on 43-mfp-thick Lead

Penetration (mfp)	Photon energy (MeV)															
	0.1	0.2	0.3	0.4	0.5	0.6	0.8	1.0	2.0	3.0	4.0	5.0	6.0	8.0	10.0	15.0
0.5 without brems. with brems.				1.22	1.29	1.35	1.42	1.44	1.44	1.44	1.36	1.30	1.24	1.20	1.14	1.07
							1.47	1.53	1.53	1.53	1.52	1.61	1.64	1.72	1.79	2.76
1.0 without brems. with brems.				1.31	1.42	1.51	1.63	1.68	1.70	1.56	1.45	1.36	1.30	1.20	1.15	1.09
							1.73	1.80	1.80	1.76	1.70	1.77	1.79	1.86	1.94	2.95
2.0 without brems. with brems.				1.44	1.61	1.75	1.97	2.08	2.16	1.93	1.74	1.59	1.48	1.32	1.24	1.15
							2.14	2.30	2.30	2.17	2.04	2.07	2.06	2.13	2.23	3.36
3.0 without brems. with brems.				1.53	1.75	1.94	2.25	2.43	2.60	2.30	2.03	1.83	1.67	1.46	1.35	1.21
							2.50	2.77	2.77	2.59	2.39	2.39	2.35	2.42	2.56	3.87
4.0 without brems. with brems.				1.61	1.87	2.10	2.50	2.74	3.03	2.68	2.35	2.09	1.89	1.61	1.47	1.29
							2.82	3.23	3.23	3.02	2.76	2.72	2.66	2.74	2.93	4.52
5.0 without brems. with brems.				1.67	1.98	2.24	2.73	3.02	3.46	3.08	2.69	2.38	2.13	1.79	1.61	1.38
							3.12	3.69	3.69	3.46	3.16	3.09	3.01	3.10	3.36	5.37
6.0 without brems. with brems.				1.73	2.07	2.38	2.95	3.31	3.91	3.50	3.05	2.70	2.40	1.99	1.77	1.50
							3.42	4.17	4.17	3.93	3.59	3.49	3.39	3.51	3.87	6.47
7.0 without brems. with brems.				1.79	2.16	2.50	3.15	3.57	4.35	3.93	3.44	3.04	2.70	2.22	1.96	1.64
							3.69	4.64	4.64	4.42	4.03	3.92	3.80	3.97	4.47	7.89
8.0 without brems. with brems.				1.83	2.24	2.62	3.34	3.82	4.78	4.38	3.85	3.42	3.02	2.48	2.17	1.81
							3.95	5.11	5.11	4.91	4.54	4.39	4.26	4.49	5.17	9.74
10.0 without brems. with brems.				1.92	2.38	2.82	3.71	4.30	5.66	5.32	4.74	4.26	3.79	3.12	2.72	2.28
							4.45	6.05	6.05	5.96	5.55	5.44	5.31	5.75	6.96	15.3
15.0 without brems. with brems.				2.09	2.68	3.26	4.50	5.37	7.86	7.92	7.43	7.06	6.49	5.67	5.17	5.06
							5.56	8.41	8.41	8.85	8.66	8.88	8.95	10.6	15.1	54.0
20.0 without brems. with brems.				2.22	2.94	3.63	5.21	6.33	10.0	10.8	10.8	11.1	10.8	10.5	10.6	14.4
							6.56	10.7	12.1	12.6	12.6	13.7	14.6	19.8	34.0	205
25.0 without brems. with brems.				2.34	3.17	3.97	5.85	7.21	12.3	14.1	15.1	16.8	17.5	19.7	23.2	47.5
							7.48	13.2	15.8	17.5	20.6	23.4	37.0	77.7	801	
30.0 without brems. with brems.				2.45	3.39	4.28	6.45	8.04	14.6	17.7	20.3	24.6	27.8	37.2	52.1	167
							8.34	15.6	19.8	23.5	30.1	36.7	68.8	178	3110	
35.0 without brems. with brems.				2.55	3.60	4.57	7.00	8.84	16.8	21.7	26.5	35.4	43.5	70.1	119	610
							9.17	18.0	24.1	30.7	43.1	56.9	127	412	12000	
40.0 without brems. with brems.				2.65	3.80	4.85	7.52	9.60	19.1	25.9	33.9	49.9	67.1	131	274	2250
							9.97	20.5	28.8	39.2	60.4	86.8	236	952	46600	

Table 25 Exposure Buildup Factors-Plane Isotropic Incidence on 43-mfp-thick Lead

Penetration (mfp)	Photon energy (MeV)															
	0.1	0.2	0.3	0.4	0.5	0.6	0.8	1.0	2.0	3.0	4.0	5.0	6.0	8.0	10.0	15.0
0.5 without brems. with brems.				1.19	1.24	1.29	1.35	1.42	1.48	1.44	1.40	1.35	1.31	1.22	1.18	1.12
								1.42	1.48	1.45	1.43	1.41	1.41	1.42	1.50	1.89
1.0 without brems. with brems.				1.29	1.37	1.44	1.55	1.66	1.77	1.70	1.63	1.54	1.48	1.34	1.28	1.19
								1.66	1.77	1.72	1.67	1.63	1.63	1.65	1.76	2.35
2.0 without brems. with brems.				1.44	1.57	1.70	1.89	2.08	2.29	2.20	2.07	1.93	1.82	1.60	1.48	1.32
								2.08	2.30	2.23	2.13	2.05	2.04	2.08	2.29	3.37
3.0 without brems. with brems.				1.56	1.75	1.93	2.20	2.47	2.81	2.72	2.55	2.36	2.20	1.90	1.72	1.48
								2.47	2.83	2.76	2.63	2.52	2.50	2.58	2.90	4.64
4.0 without brems. with brems.				1.67	1.91	2.14	2.49	2.83	3.33	3.26	3.07	2.83	2.64	2.25	2.02	1.70
								2.83	3.35	3.31	3.16	3.03	3.01	3.14	3.62	6.30
5.0 without brems. with brems.				1.78	2.07	2.34	2.76	3.17	3.85	3.83	3.62	3.36	3.13	2.67	2.38	1.98
								3.18	3.87	3.88	3.73	3.60	3.58	3.79	4.49	8.53
6.0 without brems. with brems.				1.87	2.21	2.53	3.03	3.52	4.39	4.44	4.24	3.96	3.70	3.17	2.82	2.34
								3.53	4.42	4.50	4.36	4.24	4.24	4.56	5.56	11.5
7.0 without brems. with brems.				1.96	2.35	2.72	3.29	3.85	4.94	5.07	4.90	4.63	4.35	3.75	3.36	2.83
								3.86	4.96	5.14	5.04	4.95	4.98	5.46	6.85	15.6
8.0 without brems. with brems.				2.05	2.49	2.89	3.54	4.17	5.48	5.73	5.61	5.37	5.08	4.44	4.02	3.46
								4.18	5.51	5.81	5.77	5.73	5.81	6.51	8.42	21.1
10.0 without brems. with brems.				2.20	2.73	3.23	4.02	4.79	6.58	7.12	7.17	7.09	6.84	6.21	5.81	5.43
								4.80	6.62	7.22	7.37	7.55	7.80	9.16	12.6	38.6
15.0 without brems. with brems.				2.53	3.30	3.99	5.12	6.23	9.39	11.0	12.0	13.1	13.5	14.1	15.1	19.9
								6.24	9.45	11.1	12.3	13.8	15.2	20.7	34.4	175
20.0 without brems. with brems.				2.80	3.82	4.68	6.12	7.56	12.2	15.5	18.5	22.4	25.3	31.6	40.6	82.5
								7.58	12.3	15.7	18.9	23.6	28.1	45.4	92.4	788
25.0 without brems. with brems.				3.04	4.31	5.34	7.07	8.83	15.1	20.5	26.7	36.6	45.5	69.5	109	352
								8.85	15.3	20.8	27.4	38.3	49.9	97.4	244	3480
30.0 without brems. with brems.				3.26	4.79	5.96	7.97	10.0	18.1	26.0	37.0	57.4	78.9	149	291	1510
								10.1	18.2	26.4	37.9	59.8	85.8	205	639	15100
35.0 without brems. with brems.				3.45	5.25	6.56	8.83	11.2	21.1	32.0	49.7	87.6	133	316	768	6410
								11.2	21.2	32.5	50.8	90.9	144	425	1640	65000
40.0 without brems. with brems.				3.63	5.71	7.15	9.66	12.3	24.0	38.5	65.0	130	221	658	1999	26900
								12.4	24.2	39.0	66.4	134	237	869	4200	274000

Table 26 Dose-Equivalent Buildup Factors-Plane Isotropic Incidence on 43-mfp-thick Lead

Penetration (mfp)	Photon energy (MeV)															
	0.1	0.2	0.3	0.4	0.5	0.6	0.8	1.0	2.0	3.0	4.0	5.0	6.0	8.0	10.0	15.0
0.5 without brems. with brems.				1.20	1.25	1.30	1.38	1.44	1.50	1.46	1.42	1.38	1.34	1.24	1.20	1.14
							1.45	1.51	1.51	1.48	1.46	1.45	1.45	1.47	1.56	1.99
1.0 without brems. with brems.				1.30	1.39	1.46	1.59	1.70	1.80	1.73	1.66	1.59	1.52	1.37	1.31	1.21
								1.70	1.80	1.75	1.70	1.68	1.68	1.71	1.85	2.51
2.0 without brems. with brems.				1.46	1.60	1.73	1.95	2.15	2.34	2.25	2.12	2.00	1.87	1.64	1.52	1.35
								2.15	2.35	2.28	2.18	2.14	2.11	2.18	2.43	3.61
3.0 without brems. with brems.				1.59	1.79	1.97	2.27	2.55	2.87	2.78	2.61	2.45	2.27	1.96	1.78	1.52
								2.56	2.89	2.82	2.69	2.63	2.59	2.70	3.09	4.99
4.0 without brems. with brems.				1.70	1.96	2.19	2.57	2.93	3.40	3.34	3.14	2.95	2.72	2.34	2.10	1.75
								2.94	3.42	3.38	3.24	3.17	3.13	3.30	3.87	6.81
5.0 without brems. with brems.				1.80	2.12	2.39	2.86	3.30	3.94	3.94	3.71	3.51	3.24	2.78	2.49	2.05
								3.30	3.96	3.97	3.83	3.77	3.73	4.00	4.82	9.24
6.0 without brems. with brems.				1.91	2.27	2.60	3.15	3.66	4.49	4.54	4.34	4.15	3.84	3.30	2.96	2.44
								3.67	4.52	4.61	4.48	4.46	4.42	4.83	5.98	12.5
7.0 without brems. with brems.				2.00	2.42	2.79	3.42	4.01	5.05	5.19	5.02	4.85	4.51	3.93	3.54	2.96
								4.02	5.08	5.27	5.18	5.21	5.20	5.79	7.38	16.9
8.0 without brems. with brems.				2.08	2.55	2.97	3.68	4.35	5.61	5.87	5.75	5.64	5.28	4.66	4.25	3.65
								4.36	5.65	5.96	5.93	6.04	6.08	6.91	9.09	22.9
10.0 without brems. with brems.				2.24	2.81	3.32	4.18	4.99	6.74	7.29	7.36	7.45	7.12	6.54	6.18	5.77
								5.01	6.78	7.40	7.59	7.97	8.16	9.75	13.7	42.0
15.0 without brems. with brems.				2.58	3.40	4.11	5.33	6.50	9.62	11.3	12.3	13.8	14.1	15.0	16.3	21.5
								6.52	9.69	11.4	12.7	14.6	16.0	22.1	37.4	191
20.0 without brems. with brems.				2.86	3.94	4.83	6.39	7.90	12.5	15.9	19.0	23.7	26.5	33.7	44.0	89.5
								7.93	12.6	16.1	19.5	25.0	29.6	48.7	100	862
25.0 without brems. with brems.				3.11	4.46	5.50	7.38	9.23	15.5	21.0	27.5	38.7	47.6	74.2	118	384
								9.26	15.6	21.3	28.2	40.6	52.5	104	266	3819
30.0 without brems. with brems.				3.33	4.95	6.15	8.32	10.5	18.5	26.7	38.1	60.9	82.9	160	317	1648
								10.5	18.7	27.1	39.0	63.5	90.3	220	698	16600
35.0 without brems. with brems.				3.52	5.43	6.77	9.22	11.7	21.6	32.8	51.1	92.9	140	338	837	7010
								11.7	21.7	33.4	52.3	96.6	151	456	1800	71200
40.0 without brems. with brems.				3.70	5.91	7.38	10.1	12.9	24.6	39.4	66.8	138	233	706	2170	29400
								12.9	24.8	40.0	68.4	143	250	934	4590	300000

Table 27 Absorbed-Dose Buildup Factors-Plane Isotropic Incidence on 43-mfp-thick Lead

Penetration (mfp)	Photon energy (MeV)															
	0.1	0.2	0.3	0.4	0.5	0.6	0.8	1.0	2.0	3.0	4.0	5.0	6.0	8.0	10.0	15.0
0.5 without brems. with brems.				1.42	1.47	1.57	1.70	1.84	1.87	1.64	1.50	1.40	1.33	1.22	1.17	1.10
1.0 without brems. with brems.				1.58	1.69	1.83	2.05	2.27	2.24	1.95	1.74	1.58	1.47	1.31	1.23	1.49
2.0 without brems. with brems.				1.83	2.02	2.27	2.62	3.01	3.00	2.54	2.18	1.93	1.74	1.49	1.37	1.22
3.0 without brems. with brems.				2.04	2.31	2.64	3.13	3.66	3.75	3.14	2.65	2.30	2.05	1.70	1.53	1.32
4.0 without brems. with brems.				2.22	2.57	2.98	3.60	4.27	4.47	3.75	3.16	2.71	2.38	1.94	1.71	1.44
5.0 without brems. with brems.				2.38	2.80	3.29	4.04	4.84	5.20	4.40	3.70	3.17	2.77	2.22	1.94	1.59
6.0 without brems. with brems.				2.53	3.04	3.60	4.48	5.42	5.96	5.10	4.30	3.69	3.21	2.56	2.21	1.78
7.0 without brems. with brems.				2.67	3.26	3.89	4.89	5.97	6.72	5.81	4.94	4.27	3.71	2.95	2.53	2.03
8.0 without brems. with brems.				2.80	3.46	4.17	5.29	6.49	7.47	6.56	5.62	4.90	4.27	3.40	2.92	2.35
10.0 without brems. with brems.				3.04	3.85	4.70	6.05	7.50	8.99	8.13	7.12	6.36	5.64	4.55	3.96	3.30
15.0 without brems. with brems.				3.54	4.73	5.89	7.78	9.84	12.8	12.5	11.8	11.4	10.6	9.58	9.21	9.89
20.0 without brems. with brems.				3.97	5.53	6.98	9.37	12.0	16.8	17.5	17.9	19.2	19.3	20.4	23.0	37.0
25.0 without brems. with brems.				4.33	6.30	8.00	10.8	14.0	20.7	23.2	25.7	31.0	34.0	43.4	59.6	151
30.0 without brems. with brems.				4.66	7.04	8.98	12.2	16.0	24.8	29.4	35.5	48.3	58.4	91.7	155	632
35.0 without brems. with brems.				4.95	7.76	9.93	13.6	17.9	28.8	36.1	47.5	73.3	98.0	191	403	2650
40.0 without brems. with brems.				5.22	8.48	10.9	14.9	19.8	32.8	43.3	62.0	108	161	395	1040	11000
								20.5	35.0	47.9	71.1	129	204	642	2780	146000