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**INTERPOLATION OF GAMMA-RAY BUILDUP FACTORS  
IN ATOMIC NUMBER, USING THE GEOMETRICAL  
PROGRESSION (G-P) PARAMETERS**

October 1988

Yukio SAKAMOTO, Shun-ichi TANAKA and Yoshiko HARIMA\*

日本原子力研究所  
Japan Atomic Energy Research Institute

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Interpolation of Gamma-Ray Buildup Factors  
in Atomic Number, Using the Geometrical Progression (G-P) Parameters

Yukio SAKAMOTO, Shun-ichi TANAKA<sup>+</sup> and Yoshiko HARIMA<sup>\*</sup>

Department of Fuel Safety Research  
Tokai Research Establishment  
Japan Atomic Energy Research Institute  
Tokai-mura, Naka-gun, Ibaraki-ken

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The values of buildup factors for specified energy above K-edges and penetration distance vary smoothly with respect to atomic number, and the geometrical progression (G-P) parameters behave also similarly. An interpolation of buildup factors for an arbitrary elemental material was examined using the G-P parameters for an equivalent atomic number, where the G-P parameters are data fitted to the proposed American National Standard buildup factor data compilation of 17 elements from Be to Mo calculated by the moments method and those for 8 elements of Fe, Mo, Sn, La, Gd, W, Pb and U, including bremsstrahlung and fluorescence, calculated by the PALLAS code. It has been confirmed through various tests over a wide range of atomic number that the values of the buildup factors generated by interpolated G-P parameters can accurately reproduce the basic data calculated directly over the full range of energy within a few percent.

The values of equivalent atomic number for mixture materials, such as water, air, concrete and lead glass of the density 4.36, are

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+ Department of Reactor Engineering

\* Tokyo Institute of Technology

determined from a ratio of scattering cross section to the total attenuation coefficient. The buildup factors for these materials calculated using the G-P parameters, interpolated by the equivalent atomic number, are in good agreement with the basic data, except the buildup factors for lead glass to  $\gamma$ -ray energy above 3 MeV.

Keywords: Gamma-Ray Buildup Factor, G-P Parameter, Interpolation, Equivalent Atomic Number, Mixture Materials

幾何級数 ( G - P ) パラメータを用いたガンマ線ビルドアップ係数の  
原子番号での内挿

日本原子力研究所東海研究所燃料安全工学部  
坂本 幸夫・田中 俊一<sup>+</sup>・播磨 良子\*

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Kエッジ以上の特定エネルギー及び透過距離に対するビルドアップ係数の値は原子番号の変化に伴い滑らかに変化するとともに、幾何級数 ( G - P ) パラメータも同様な挙動を示す。任意の元素物質に対するビルドアップ係数の内挿を実効原子番号に対するG - Pパラメータを用いて調べた。ここでG - Pパラメータは、モーメント法で計算されたBeからMoまでの17元素に対する米国標準ビルドアップ係数の提案データ及びPALLASコードで計算された制動輻射線と蛍光X線を含むFeからUまでの8元素に対するデータにフィッティングしたものである。内挿したG - Pパラメータで作成したビルドアップ係数の値が直接計算で得られた基礎データを全エネルギー範囲で誤差数%以内で正確に再現できることを種々のテストを通して原子番号の広い範囲で確かめた。

水、空気、コンクリート及び鉛ガラスの混合物に対する実効原子番号の値を全減衰係数に対する散乱断面積の比から決定した。実効原子番号で内挿したG - Pパラメータで計算したこれらの物質に対するビルドアップ係数は、3MeV以上のガンマ線に対する鉛ガラスの場合を除いて基礎データと良く一致した。

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東海研究所 : 〒319-11茨城県那珂郡東海村白方字白根 2-4

+ 原子炉工学部

\* 東京工業大学

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## 1. Introduction

Following the Three Mile Island accident, an American Nuclear Society Standards Committee Working Group, identified as ANS-6.4.3, began developing a set of evaluated gamma-ray isotropic point-source buildup factors and attenuation coefficients for a standard reference data base<sup>1,2</sup>. The 1985 data base was released as part of the CCC-493B/QAD-CGGP code package<sup>3</sup>, and as the DLC-129/ANS643 data package<sup>4</sup> available from the Radiation Shielding Information Center (RSIC). The 1985 data base is represented as coefficients for the G-P fitting function, and it contains data for 19 elements and 3 mixtures (water, air and concrete).

The 1985 data base as calculated by the moments method, concentrates upon the light elements from Z=4 to 29 and does not take into account the bremsstrahlung process. Newer buildup factor data, including bremsstrahlung and fluorescence effects have now been calculated for iron, molybdenum, tin, lanthanum, gadolinium, tungsten, lead and uranium<sup>5,6,7</sup> with the PALLAS code<sup>8</sup>.

It frequently happens that shielding materials will consist of elements not included in the standard data or compounds and homogeneous mixtures of a number of elements. Furthermore, there are significant disagreements in the buildup data using the different approximating techniques in the present computational art for analysis of photon transport<sup>9</sup>. Therefore, it is important to predict consistent buildup factors using the available data.

In this paper the validity of using the G-P parameters to interpolate the buildup factor in the atomic number is tested in the wide range of the distance from the source and the source energy.

The common interpolation methods are based on the use of an equivalent atomic number for mixtures and compounds. There were a few values of the equivalent atomic number Zeq for ordinary concrete following the method to find a value of Zeq. That is, 18 by Obenshain<sup>10</sup>, 13.4 by Berger and Spencer<sup>11</sup>, and 11 - 12 by Walker and Grotenhuis<sup>12</sup>. The values of Zeq in this paper are determined from a ratio of scattering cross section to the total attenuation coefficient for the source energy. The discussions are performed about the method of finding a value of Zeq and the values of adopted buildup factors to interpolate in Zeq before this.

The buildup factor data of Ref. 7 were replaced by the recalculated values over the energy range of 0.5 to 3 Mev. The buildup factors and the G-P parameters including the replaced values are listed the appendix. Also, the buildup factors including fluorescence radiations were compared with the results calculated by the ASFIT code<sup>13</sup>.

## 2. Interpolation of the Buildup Factor for Atomic Number

There are now available buildup factor data of 17 elements for atomic number  $Z = 4, 5, 6, 7, 8, 11, 12, 13, 14, 15, 16, 18, 19, 20, 26, 29$  and 42 calculated with the moments method<sup>1</sup> and of 8 elements for  $Z = 26, 42, 50, 57, 64, 74, 82$  and 92 calculated with the PAILAS code<sup>5,6,7</sup>, for the energy range from 15 keV to 15 MeV up to 40 mfp.

The behavior of the buildup factors at various distances reflects the characteristics of the element and the source energy. As typical examples, the dependence of the exposure buildup factors as a function of  $\log Z$  are plotted for various penetration depths in mean free path lengths for 10-, 3-, and 0.5 MeV sources in Fig. 1.

The geometric progression (G-P) form can accurately reproduce the buildup factor data over the full range of energy and atomic number within a few percent. The G-P function<sup>14</sup> is:

$$\begin{aligned} B(E,x) &= 1 + (B-1)(K^x - 1)/(K-1) \text{ for } K \neq 1 \\ &= 1 + (B-1)x \quad \text{for } K = 1 \\ K &= cx^a + d \{\tanh(x/Xk-2) - \tanh(-2)\}/\{1 - \tanh(-2)\} \end{aligned}$$

where  $x$  = source-detector distance of the medium, and  $a, B, c, d$  and  $Xk$  are parameters. The value of the parameter  $B$  (buildup factor at 1 mfp) monotonically decreases with increasing atomic number as seen in Fig. 1.

The parameter  $K$  represents the photon dose multiplication and the change in the shape of the spectrum.

As seen in Fig. 2, the bahavior of the parameter  $K$  is not monotonic with increasing atomic number, but is smooth. Therefore, the values of the parameter  $K$  for elements not calculated will be approximated by those interpolated in atomic number.

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## 2.1 Interpolation of the G-P Parameters in the Atomic Number

The interpolation of each parameter with respect to  $\log Z$  was performed with parabolic interpolation. At first, four atomic numbers were selected from the calculated data at before and behind an arbitrary  $Z_a$ , where  $Z_1 < Z_2 < Z_a < Z_3 < Z_4$ . The parabolic interpolation was repeated two times, that is, for  $Z_1, Z_2, Z_3$  and  $Z_2, Z_3, Z_4$ . The mean value of the two interpolations was adopted as the parameter.

The validity of using the G-P parameters to interpolate the buildup factor in  $Z$  is investigated in two regions of the atomic numbers. The first is the range of  $Z = 4-29$ , and the second  $Z = 42-92$ . This treatment was confirmed from the comparison between the basic buildup factor data and those by the G-P parameters interpolated in equivalent atomic number<sup>7</sup>. The results were given in Tables 1 and 2. The value of element in Tables corresponds to  $Z_a$ . A large part of the maximum deviations is within 10%. A few large values appear for low  $Z$  and low energy. At deep penetrations, there is a peak formed by an increasing concentration of photons scattered to the vicinity of  $E_{peak}$ . The values of  $E_{peak}$  move to high energy with the atomic number (see Fig. 7). When the source energy comes the  $E_{peak}$  of one among four atomic number applied to interpolate the parameters, the maximum deviations often become above 10%.

For  $Z_a$  located between two regions, it follows that interpolations as performed by parameters fitted to buildup factors calculated with different technique.

The buildup factors calculated with two methods are compared for iron and molybdenum in Figs. 3 and 4. Both results are good agreement. The PALLAS's buildup factors are larger than the moments method's for high energy. This is due to be included bremsstrahlung for high energy. These deviations come from bremsstrahlung contribution.

## 2.2 Other Methods for the Interpolation of Buildup Factors

One of the methods for the interpolation is a polynomial expression for the buildup factors presented by Tobias<sup>15</sup>. That is,  
 $B_r = 1 + A \cdot (\mu_r) + B \cdot (\mu_r)^2 + C \cdot (\mu_r)^3$ . The values of A, B and C were determined from Goldstein and Wilkins data<sup>16</sup>. The present data for beryllium and graphite were compared with Tobias' results and Engholms<sup>17</sup>' ones calculated by DTF-IV code<sup>18</sup> for the source energies 0.5, 1 and 2 MeV in

Figs. 5 and 6. The values of DTF-IV<sup>18</sup> calculations are a little higher than the present ones. Tobias' results are a little lower than other two methods for 0.5 and 1 MeV, and become higher than others for 2 MeV above 10 mfp.

### 3. Interpolation of the Buildup Factor for Mixture Materials

#### 3.1 Calculation of Z<sub>eq</sub>

The values of the buildup factor at 1 mfp are almost entirely based on unscattered and single scattered gamma rays, except for lower source energies and for low Z materials. Besides, the flux spectrum at 1 mfp forms a specified shape for a specified source energy and atomic number. The magnitude of single scattering gamma rays at 1 mfp depends on a ratio of scattering cross section to the total interaction cross section  $\mu_{\text{sca}}/\mu_{\text{tot}}$  for a specified source energy and attenuating rate of scattering gamma rays. Single scattering gamma rays with the energy near to the source energy hold a majority in contribution to a part of scattered gamma rays of buildup factor at 1 mfp. This is clear from the fact that the differential cross section for the Compton effect is predominantly forward scattering for the high source energy, and is near to symmetrical in  $\cos \theta$  for the low source energy, where the fractional energy lost is a quite few. That is, the total interaction cross sections for the effective single scattered gamma rays are almost the same to the one for the source energy. A values of ratio  $\mu_{\text{sca}}/\mu_{\text{tot}}$  for a specified source energy is plotted as a function of atomic number. The curve monotonically decreases with increasing atomic number. The value of  $\mu_{\text{sca}}/\mu_{\text{tot}}$  for mixture is founded out at an atomic number on the curve. It seems to be reasonable to use this atomic number as an equivalent atomic number Z<sub>eq</sub> for mixture. The values of the Z<sub>eq</sub> are given for water, air, concrete and lead glass in Tables 3 and 5.

The value of 1 mfp-buildup factor for mixture is obtained by the interpolation of the 1 mfp-buildup factor as a function of atomic number in the Z<sub>eq</sub> for mixture.

Next step is to estimate the values of mixture's buildup factors for penetration depths above 1 mfp. The flux spectrum at 1 mfp represents a

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Next step is to estimate the values of mixture's buildup factors for penetration depths above 1 mfp. The flux spectrum at 1 mfp represents a

source spectrum with continuous energies for further deep penetration.

In the energy range below 1.5 MeV, the Compton scattering cross section gently increases and the photoelectric absorption cross section steeply increases with decreasing energy and increasing atomic number. The Compton scattering cross section agrees with the photoelectric absorption at a energy  $E_{pe}$ . The value of  $E_{pe}$  changes with the atomic number as seen in Fig. 7 (0.025 MeV for N to 0.56 MeV for Pb). The values of  $E_{pe}$  for mixture are 0.027 MeV for water, 0.028 MeV for air, 0.052 MeV for concrete and 0.39 MeV for lead glass. These values agree with the ones for  $Z_{eq}$  on the  $E_{pe}$ -curve. The gamma rays are almost absorbed in the energy range below  $E_{pe}$ . This suggests the values of  $Z_{eq}$  almost constantly take place in the energy range between the initial and  $E_{pe}$ .

At very deep penetrations, a peak formed from multiple scattering photons appears in the energy spectra. The peak occurs at an energy  $E_{peak}$ , where the ratio of photoelectric effect to the total is  $\sim 20\%$ . This moves from 40 keV oxygen to  $\sim 1.5$  MeV for lead with increasing the atomic number. The value of  $E_{peak}$  is larger than the one of  $E_{pe}$  for a specified atomic number as seen in Fig. 7.

These facts indicate that the buildup factor for mixture can be represented by the interpolation of the ones for elements near to the  $Z_{eq}$  in the energy range below 1.5 MeV.

In the energy range 1.5 MeV or more, the Compton scattering cross section competes with the pair production. Both cross sections have the same value at the energy  $E_{pp}$ . The value of  $E_{pp}$  changes with atomic number (25 MeV for N to 4.6 MeV for Pb). Those for mixtures are 27 MeV for water, 24 MeV for air, 18 MeV for concrete and 7.1 MeV for lead glass. These values agree with the ones for  $Z_{eq}$  on the  $E_{pp}$ -curve. This is due to the fact that an interested energy constantly takes place in the energy range, where the Compton scattering cross section proportion to  $Z$  maintain predominance over the pair production proportion to  $Z^2$ . For light mixtures the values of  $Z_{eq}$  constantly take place in the energy range 1.5 to 15 MeV. However, there are a few deviations between the values of  $Z_{eq}$  defined below 1.5 MeV and above 1.5 MeV. This is due to the difference of  $Z$ -dependence of the absorbed cross section which the Compton scattering cross section competes with. As seen in the spectra for  $E_0=3-$  and 10 MeV of Fig. 1, those for light element are almost flat

curve in the high source energy range, where the maximum deviations of buildup factors are 10% at most for deviations of two atomic number. In the high source energy, the energy spectra for light element decrease uniformly with decreasing energy except annihilation gamma rays. This shows a part of energy spectrum below 1.5 MeV is less important relative to the rest of the spectrum.

The case of lead glass, the predominant cross section alternates at 7.1 MeV. Therefore the corresponding  $Z_{eq}$  values range from 41.3 for 15 MeV to 65.3 for 1.5 MeV. Continuously, the values of  $Z_{eq}$  slowly moves to the value determined in the energy range where the photoelectric absorption cross section competes with the Compton scattering and predominates below that. The peak of energy spectra occurs at 1.5 MeV, and its shape is almost the same as the one of gadolinium. These facts suggest the buildup factor for lead glass cannot be represented by the interpolation of the ones for elements. For such case the buildup factor for mixture cannot exactly estimate by  $Z_{eq}$ .

For heavy material, there is a minimum in the total interaction cross section. The energy corresponding the minimum  $E_{min}$  is lower than the values of  $E_{pp}$ . Saying in other words, in the case that the value of  $E_{min}$  for mixture is smaller than 15 MeV, the buildup factor for the high energy cannot exactly estimate by  $Z_{eq}$ .

### 3.2 Water, Air and Concrete

The proposed standard data contain 3 mixtures of water, air and concrete. The ratio  $\mu_{sca}/\mu_{tot}$  for water, air and concrete were calculated for a source energy range from 15 keV to 15 MeV. By comparison with the values of the ratio corresponding to individual elements, the values of an equivalent atomic number were determined. Next, the values of the buildup factors for 3 mixtures were calculated from the G-P parameters interpolated for the equivalent atomic number. The results were compared with those of the 1985 data. The equivalent atomic number and the maximum deviation of the estimated buildup factors from the 1985 data base are listed in Table 3.

As seen from Table 1, the values of the equivalent atomic number for each mixture are divided into those for the energy range of below 1.5 MeV and of above 1.5 MeV; 7.5 and 6.5 for water, 7.8 and 7.3 for air, and

13.5 and 11.5 for concrete. These phenomena were explained by the fact that in the energy range below 1 MeV, the photoelectric effect with  $Z^4$  dependence is dominant, and above 1 MeV pair production with  $Z^2$  dependence is dominant. The values of the maximum deviations of the buildup factors estimated by the equivalent atomic number from the basic data are within 10% except for a few cases of low source energies at 40 mfp.

Engholm<sup>17</sup> read from the plots of buildup factors to obtain the equivalent atomic number of 6.4, 8.2 and 10.4 for water and of 16, 11 and 9.6 for concrete, at the source energies of 0.5, 1 and 2 MeV, respectively. The data used were water, iron, tin, tungsten and uranium from Goldstein & Wilkins<sup>16</sup> and beryllium, graphite, concrete and iron from calculations made with the DTF-IV code<sup>18</sup>. The differences between their equivalent atomic number and the present ones in Table 3 was caused by merging DTF-IV results with NYO-3075 data as the reference data. That is, DTF-IV results are smaller than those of NYO-3075 at 0.5 MeV, larger than those at 1 and 2 MeV.

In Fig. 8 the new buildup factor data<sup>19</sup> are compared with ones calculated by DTF-IV and Goldstein & Wilkins for 0.5, 1 and 2 MeV.

The water buildup factors by Goldstein & Wilkins are larger than the present ones and the concrete buildup factors by DTF-IV are smaller than the present ones at 0.5 MeV. In the cases of 1 and 2 MeV, water data by Goldstein & Wilkins and concrete data by DTF-IV are good agreement with the present. The differences between their equivalent atomic number come from the difference of reference data.

Walker and Grotenhuis' equivalent atomic number were determined from the comparison of the total cross sections normalized at 2 and 8 MeV with those of individual elements. Their values are the same as the present values above 1 MeV. However, their estimated buildup factor data were larger than Eisenhauer & Simons data<sup>20</sup> in the low energy range, and smaller in the high energy range as seen in Fig. 9. These differences are caused by the deviations of the equivalent atomic numbers in the low energy range and differences of the buildup data between the 1985 data and NYO-3075 data.

### 3.3 Radiation Shielding Lead Glass

Lead glass for direct observation is an indispensable material for radiation shielding in the design of hot cells.

The values of buildup factors of various radiation shielding glasses are given for energies from 0.5 to 10 MeV in Table 9.1-60 and -61 of Ref. 21. Linear attenuation coefficients for lead glass resembles that for lead in shape. However, the values of their buildup factors are significantly larger than those for lead at the source energies 0.5, 1 and 2 MeV.

Initially, a case of buildup factor data for lead glass was calculated by the PALLAS code. The chemical composition of lead glass is given in the Table 4.

The linear attenuation coefficients of the calculated lead glass were compared with those of the RS420G of Ref. 21 in the Table 5. The values are almost the same. The values of the incoherent scattering, photoelectric, pair production and total cross section are listed in  $\text{cm}^2/\text{g}$  units. The values of the exposure buildup factors are listed in Table 6, and given in Fig. 10 as a function of distance from source. Where buildup factors below 0.3 MeV are including of fluorescent radiations treated as 4 X-rays with different energies and corresponding emission efficiencies<sup>7</sup>. These of the G-P fitting parameters are given for them in Table 7, where the cross sections used are from NBS-29<sup>22</sup> for the energy range above 0.3 MeV and from DLC-15<sup>23</sup> below 0.3 MeV.

The PALLAS results without bremsstrahlung are in fairly good agreement with RG420G results of Ref. 21 in the energy range 3-6 MeV, but are not below 2 MeV or above 8 MeV. Furthermore, the present buildup factor data are in good agreement with Penkuhn results<sup>24</sup> in the energy range of 0.5 - 3 MeV. These comparisons are given in Fig. 11.

The equivalent atomic numbers were determined by the method mentioned above and listed in the 8th column of Table 5. The values of the equivalent atomic numbers are about 64 between 2 and 0.15 MeV, and about 35 below 0.08 MeV. However, these are decreasing from 52 to 41 with increasing energy above 3 MeV.

As typical example, the buildup factors for lead glass ( $Z_{\text{eq}} = 41.27$ ) are compared with those of high Z elements in various depths at the source energy of 15 MeV in Fig. 12. The values at 1 and 5 mfp are good agreement with those corresponding to  $Z_{\text{eq}}$ .

However, the values at depths above 10 mfp decrease with increasing depth. This behavior is clearly explained from the comparison of energy spectra for molybdenum, gadolinium and lead glass in Fig. 13.

The energy spectra at 1 and 5 mfp for lead glass are in good agreement with ones for molybdenum. With increasing depth the energy spectra for lead glass become smaller than the ones for molybdenum.

The Z<sub>eq</sub> for lead glass almost equals to gadolinium in the energy range below 1.5 MeV. However, the shape of broad peak at 15 MeV is not the same as gadolinium. It is broader and lower than ones for molybdenum. In Table 5, "Max. dev." is the maximum deviation between the PALLAS results and the interpolated buildup factor for  $0 < X < 40$  mfp. The maximum occurs at X<sub>max</sub>. The shape of the photoeffect is similar to that of gadolinium, but the pair production cross section for lead glass cannot be represented by that of an arbitrary element. The energy corresponding to the minimum in the total cross section is about 6 MeV. In the useful energy range, the buildup data for lead glass were estimated by the G-P parameters interpolated in the equivalent atomic number. However, it is difficult to estimate the values of the buildup factors for lead glass from the present definition of equivalent atomic number for source energies above 3 MeV.

#### 4. Conclusions

Using consistent reference buildup data, the interpolation of buildup factor in atomic number was examined by the G-P parameters interpolated in the equivalent atomic number.

It is confirmed by various test analyses that the interpolation of the buildup factor for elements not calculated and mixtures composed of light elements can be performed using the G-P parameters interpolated by the equivalent atomic number determined from the comparison of a ratio of  $\mu_{\text{sca}}/\mu_{\text{tot}}$  for mixtures with those corresponding to individual elements at a source energy.

The differences between estimated results and the basic data are very small over a wide range of atomic number and low-Z mixtures, when the reference buildup factor data are calculated by the same approximating

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The differences between estimated results and the basic data are very small over a wide range of atomic number and low-Z mixtures, when the reference buildup factor data are calculated by the same approximating

technique or code using the same cross sections. The interpolation of buildup factors for heavy element mixture remains a problem above the source energy in the minimum total cross section.

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Table 1 Percent deviations of values of buildup factors interpolated in the atomic number from the basic data calculated with the moments method.

Element	Na	Mg	Al	Si	P	S	A	K	Ca	Fe
Z	11	12	13	14	15	16	18	19	20	26
E <sub>0</sub> MeV	*M.D. (%)	**X <sub>m</sub> mfp (%)	M.D. (%)	X <sub>m</sub> mfp (%)						
0.015	0.9	0.5	0.8	35	0.6	40	0.7	35	0.9	35
0.02	2.3	40	1.0	10	1.0	0.5	4.9	40	1.2	40
0.03	4.0	35	1.9	0.5	1.7	0.5	0.9	5	0.9	7
0.04	12.1	40	2.4	0.5	1.4	0.5	2.0	0.5	1.6	40
0.05	63.9	40	24.8	40	6.9	40	3.1	40	1.9	30
0.06	18.2	40	21.4	40	14.0	40	5.5	1	2.1	40
0.08	3.3	40	3.5	40	8.0	40	17.4	40	11.8	40
0.1	14.3	35	1.1	40	1.2	35	4.3	35	10.4	40
0.15	15.7	40	9.8	40	2.3	30	11.0	40	9.7	30
0.2	7.2	40	10.6	40	8.6	35	6.2	35	3.9	25
0.3	3.9	30	2.7	40	1.7	35	9.2	40	8.2	35
0.4	4.1	40	1.0	1	1.1	40	1.2	35	3.9	40
0.5	1.0	5	0.8	25	1.3	40	1.0	35	0.7	5
0.6	5.5	40	0.9	20	1.1	40	1.2	40	1.1	40
0.8	2.3	25	0.9	35	1.7	25	1.2	40	0.6	25
1	1.4	25	0.7	0.5	0.5	35	0.8	40	0.9	15
1.5	0.9	35	0.7	25	1.0	35	0.6	25	0.4	35
2	4.5	40	0.7	25	1.8	40	1.7	35	0.8	40
3	1.8	35	0.3	20	1.0	40	0.6	40	1	30
4	0.9	40	2.5	30	3.3	30	2.3	35	5.5	40
5	13.8	40	7.2	40	2.8	35	1.0	40	1.5	40
6	6.9	40	2.4	40	1.5	40	1.4	40	1.7	40
8	2.9	35	1.3	1	1.3	0.5	1.6	0.5	1.8	40
10	1.6	0.5	4.3	40	4.8	35	4.0	40	1.8	35
15	2.2	40	1.8	35	3.9	40	3.1	40	2.7	35

\* M.D. : the maximum deviation, \*\* X<sub>m</sub> : X<sub>maximum</sub>

Table 2 Percent deviations of values of buildup factors interpolated in the atomic number from the basic data calculated with the PALLAS code.

Element Z	Sn		La		Cd		W	
	50		57		64		74	
E <sub>0</sub> (MeV)	Max.Dev. (%)	Xmax (mfp)	Max.Dev. (%)	Xmax (mfp)	Max.Dev. (%)	Xmax (mfp)	Max.Dev. (%)	Xmax (mfp)
15	4.6	(1)	7.1	(35)	6.1	(1)	7.9	(35)
10	5.2	(0.5)	6.7	(35)	13.7	(40)	31.0	(40)
8	9.4	(40)	13.1	(35)	8.7	(40)	15.8	(35)
6	5.0	(35)	5.7	(0.5)	13.7	(40)	5.6	(35)
5	7.9	(40)	10.3	(35)	7.3	(40)	4.6	(35)
4	7.5	(40)	7.9	(35)	4.0	(0.5)	5.8	(4)
3	2.4	(5)	5.6	(35)	2.6	(0.5)	6.8	(35)
2	6.1	(40)	6.1	(35)	4.6	(40)	4.6	(35)
1.5	1.7	(40)	1.6	(15)	1.8	(5)	6.9	(35)
1	5.0	(40)	6.6	(35)	2.7	(40)	7.6	(40)
0.8	7.6	(40)	6.2	(35)	6.3	(40)	3.1	(15)
0.6	2.8	(40)	2.7	(35)	5.0	(40)	7.6	(35)
0.5	7.8	(35)	4.1	(40)	1.9	(5)	6.9	(40)
0.4	1.5	(35)	0.9	(40)	3.5	(25)	4.1	(40)
0.3	2.0	(40)	1.1	(40)	3.6	(40)	5.3	(35)
0.2	5.1	(40)	1.8	(0.5)	40.9	(40)	4.6	(40)

Table 3 The equivalent atomic number for water, air and concrete and the maximum deviation of buildup factors estimated by the equivalent atomic number from the standard data

photon energy (MeV)	water			air			concrete		
	Z-eq	Max.D. (%)	Xm (mfp)	Z-eq	Max.D. (%)	Xm (mfp)	Z-eq	Max.D. (%)	Xm (mfp)
0.015	7.57	1.8	35	7.76	1.9	10	13.05	0.5	4
0.02	7.52	1.9	0.5	7.74	3.3	35	13.13	0.9	0.5
0.03	7.52	13.7	40	7.75	15.6	40	13.23	1.5	0.5
0.04	7.52	2.8	40	7.74	2.7	5	13.29	2.7	35
0.05	7.46	10.3	35	7.76	3.7	25	13.34	2.6	2
0.06	7.54	3.6	25	7.78	5.2	40	13.35	12.7	40
0.08	7.50	7.7	35	7.73	6.4	35	13.33	2.0	35
0.1	7.51	6.1	1	7.78	6.4	25	13.43	4.1	35
0.15	7.51	9.3	35	7.81	3.4	25	13.46	2.0	40
0.2	7.49	9.5	40	7.83	5.3	40	13.54	2.6	30
0.3	7.51	3.2	35	7.84	4.5	25	13.54	2.8	40
0.4	7.50	4.4	35	7.83	2.8	25	13.59	1.0	8
0.5	7.50	2.9	15	7.90	3.9	40	13.59	0.9	5
0.6	7.43	4.1	35	7.86	2.4	25	13.62	1.7	30
0.8	7.50	2.5	10	8.00	3.7	25	13.62	0.9	25
1.0	7.67	2.3	40	8.00	3.0	25	13.64	0.8	30
1.5	6.76	5.6	15	7.37	2.7	35	12.00	3.1	35
2.0	6.62	5.3	35	7.41	2.1	10	11.62	1.7	10
3.0	6.36	3.9	15	7.14	1.7	8	11.43	2.0	40
4.0	6.26	3.0	6	7.37	1.1	30	11.31	1.4	4
5.0	6.41	2.3	4	7.17	0.6	1	11.78	2.4	20
6.0	6.33	8.2	40	7.22	4.6	40	11.75	4.1	40
8.0	6.50	3.1	20	7.30	6.2	40	11.52	2.1	25
10.0	6.66	1.4	4	7.29	1.3	35	11.58	1.7	25
15.0	6.54	1.9	4	7.37	1.2	4	11.50	2.8	40

Table 4 Composition of lead glass

$\text{SiO}_2$	34.5 wt(%)
$\text{B}_2\text{O}_3$	3.0
$\text{BaO}$	5.0
$\text{PbO}$	55.0
$\text{Na}_2\text{O}$	0.5
$\text{K}_2\text{O}$	2.0
density	4.36

Table 5 The gamma-ray cross sections for lead glass, the equivalent atomic number and the maximum deviations of buildup factor estimated by the equivalent atomic number from the PALLAS calculations in lead glass

Photon Energy $E_0$	linear attenuation coefficient ( $\text{cm}^{-1}$ )	total cross section	Scattering	photo-effect	pair production	$Z_{\text{eq}}$	Max. Dev.	Xmax	
(MeV)	=4.36	=4.20	( $\text{cm}^2/\text{g}$ )	( $\text{cm}^2/\text{g}$ )	( $\text{cm}^2/\text{g}$ )	( $\text{cm}^2/\text{g}$ )	(%)	(mfp)	
0.015	2.600+2	5.964+1	1.588-1	5.936+1		37.54			
0.020	1.903+2	4.364+1	1.560-1	4.342+1		33.12			
0.030	6.479+1	1.486+1	1.508-1	1.469+1		33.52			
0.040	2.999+1	6.877+0	1.462-1	6.746+0		33.88			
0.050	1.664+1	3.816+0	1.417-1	3.677+0		34.42			
0.060	1.031+1	2.365+0	1.377-1	2.228+0		34.97			
0.080	4.985+0	1.137+0	1.306-1	1.007+0		35.93			
0.10	1.195+1	1.216+1	2.741+0	1.244-1	2.619+0	---			
0.15	4.467+0	4.38 +0	1.025+0	1.121-1	9.131-1	63.10	27.4	8.0	
0.20	2.339+0	2.25 +0	5.365-1	1.026-1	4.337-1	64.27	4.6	1.0	
0.30	1.056+0	1.00 +0	2.421-1	8.930-2	1.531-1	65.60	20.7	40.0	
0.40	6.707-1	6.49 -1	1.538-1	7.996-2	7.371-2	66.12	11.1	40.0	
0.50	5.079-1	4.92 -1	1.165-1	7.297-2	4.339-2	66.81	15.5	40.0	
0.60	4.199-1	4.11 -1	9.631-2	6.750-2	2.853-2	67.21	13.0	40.0	
0.80	3.247-1	3.23 -1	7.446-2	5.938-2	1.516-2	67.08	11.5	40.0	
1.0	2.742-1	2.76 -1	6.290-2	5.332-2	9.494-3	67.00	16.3	40.0	
1.5	2.118-1	2.15 -1	4.857-2	4.333-2	4.294-3	9.032-4	65.31	7.8	5.0
2.0	1.849-1	1.88 -1	4.241-2	3.695-2	2.630-3	2.773-3	66.62	14.0	40.0
3.0	1.615-1	1.63 -1	3.705-2	2.911-2	1.358-3	6.570-3	52.20	77.5	40.0
4.0	1.521-1	1.55 -1	3.489-2	2.430-2	8.753-4	9.759-3	48.23	77.2	40.0
5.0	1.487-1	1.50 -1	3.411-2	2.097-2	6.449-4	1.246-2	46.19	124.5	40.0
6.0	1.470-1	1.49 -1	3.371-2	1.854-2	4.994-4	1.470-2	45.67	180.5	40.0
8.0	1.476-1	1.48 -1	3.386-2	1.515-2	3.433-4	1.827-2	44.00	261.5	40.0
10.0	1.505-1	1.52 -1	3.451-2	1.291-2	2.646-4	2.135-2	42.00	282.8	40.0
15.0	1.613-1		3.700-2	9.553-3	1.662-4	2.730-2	41.27	326.9	40.0

Table 6 Exposure Buildup Factors in 45-mfp-thick Lead Glass by the PALLAS Code

R(MFP)	ENERGY (MEV)								
	15	10	8	6	5	4	3	2	1.5
0.5	1.32	1.28	1.26	1.23	1.23	1.24	1.23	1.21	1.21
1.0	1.64	1.50	1.46	1.41	1.41	1.44	1.43	1.43	1.43
2.0	2.26	1.92	1.83	1.75	1.76	1.84	1.85	1.89	1.89
3.0	2.95	2.35	2.21	2.12	2.14	2.28	2.32	2.38	2.38
4.0	3.76	2.83	2.62	2.50	2.55	2.74	2.79	2.87	2.86
5.0	4.71	3.35	3.06	2.92	2.98	3.23	3.29	3.39	3.35
6.0	5.83	3.92	3.54	3.38	3.45	3.76	3.83	3.93	3.86
7.0	7.16	4.55	4.06	3.87	3.96	4.32	4.40	4.48	4.37
8.0	8.71	5.25	4.63	4.40	4.50	4.91	4.98	5.04	4.90
10.0	1.27E1	6.86	5.90	5.56	5.68	6.18	6.20	6.20	5.97
15.0	3.01E1	1.25E1	1.01E1	9.16	9.25	9.88	9.58	9.27	8.75
20.0	6.69E1	2.13E1	1.60E1	1.38E1	1.37E1	1.42E1	1.32E1	1.25E1	1.16E1
25.0	1.43E2	3.46E1	2.40E1	1.94E1	1.90E1	1.90E1	1.70E1	1.58E1	1.44E1
30.0	2.97E2	5.42E1	3.45E1	2.62E1	2.51E1	2.42E1	2.10E1	1.91E1	1.73E1
35.0	6.01E2	8.26E1	4.82E1	3.40E1	3.20E1	2.98E1	2.50E1	2.24E1	2.01E1
40.0	1.19E3	1.23E2	6.55E1	4.31E1	3.97E1	3.57E1	2.91E1	2.58E1	2.29E1
R(MFP)	ENERGY (MEV)								
	1	0.8	0.6	0.5	0.4	0.3	0.2	0.15	0.1
0.5	1.21	1.18	1.16	1.14	1.12	1.12	1.15	1.26	1.52
1.0	1.43	1.36	1.32	1.28	1.22	1.19	1.22	1.41	2.05
2.0	1.88	1.74	1.62	1.54	1.41	1.30	1.28	1.58	3.35
3.0	2.35	2.13	1.93	1.80	1.59	1.40	1.32	1.67	5.32
4.0	2.80	2.49	2.21	2.03	1.73	1.47	1.36	1.73	8.68
5.0	3.26	2.84	2.49	2.25	1.87	1.54	1.39	1.77	1.46E1
6.0	3.73	3.20	2.77	2.47	2.00	1.60	1.42	1.80	2.49E1
7.0	4.20	3.56	3.05	2.68	2.13	1.65	1.45	1.83	4.19E1
8.0	4.68	3.92	3.33	2.89	2.25	1.70	1.47	1.86	6.88E1
10.0	5.64	4.62	3.87	3.30	2.49	1.79	1.51	1.91	1.93E2
15.0	8.08	6.36	5.07	4.20	2.98	1.95	1.59	1.99	3.01E3
20.0	1.06E1	8.03	6.20	5.06	3.44	2.08	1.64	2.05	5.50E4
25.0	1.31E1	9.61	7.25	5.86	3.86	2.18	1.69	2.10	1.10E6
30.0	1.56E1	1.11E1	8.26	6.60	4.23	2.27	1.73	2.13	2.27E7
35.0	1.81E1	1.26E1	9.23	7.31	4.56	2.34	1.76	2.15	4.81E8
40.0	2.05E1	1.40E1	1.02E1	7.97	4.88	2.40	1.78	2.16	1.03E10
R(MFP)	ENERGY (MEV)								
	0.08	0.06	0.05	0.04					
0.5	1.04	1.02	1.02	1.01					
1.0	1.06	1.03	1.02	1.01					
2.0	1.08	1.04	1.03	1.02					
3.0	1.10	1.05	1.04	1.02					
4.0	1.12	1.06	1.04	1.02					
5.0	1.14	1.07	1.05	1.03					
6.0	1.16	1.08	1.05	1.03					
7.0	1.17	1.08	1.06	1.03					
8.0	1.18	1.09	1.06	1.04					
10.0	1.21	1.10	1.07	1.04					
15.0	1.25	1.13	1.08	1.05					
20.0	1.29	1.15	1.09	1.06					
25.0	1.32	1.16	1.10	1.06					
30.0	1.35	1.18	1.11	1.07					
35.0	1.38	1.19	1.12	1.07					
40.0	1.40	1.20	1.13	1.08					

Table 7 Parameters for Point Isotropic Source Exposure Buildup Factors up to 40 mfp in 45-mfp-thick Lead Glass and Comparison to Values Calculated by the PALLAS Code

E (MEV)	B	C	A	XK	D	MAX. DEV(%)	XMAX (MFP)	RMS DEV(%)
15	1.597	1.063	0.031	14.24	-0.0451	2.4	1	1.21
10	1.470	0.923	0.055	14.30	-0.0607	2.7	0.5	1.33
8	1.430	0.904	0.056	14.23	-0.0630	3.1	0.5	1.41
6	1.376	0.972	0.030	13.88	-0.0453	3.5	0.5	1.33
5	1.385	0.981	0.026	13.67	-0.0431	2.7	0.5	1.18
4	1.417	1.023	0.010	13.14	-0.0303	2.4	0.5	0.97
3	1.421	1.053	-0.003	12.29	-0.0181	1.7	0.5	0.66
2	1.430	1.079	-0.015	7.83	-0.0030	0.3	35	0.17
1.5	1.433	1.064	-0.014	16.28	0.0017	0.8	3	0.24
1	1.433	1.037	-0.009	11.51	0.0028	0.6	3	0.28
0.8	1.372	0.997	-0.001	12.52	-0.0006	0.7	3	0.30
0.6	1.314	0.976	0.001	16.43	0.0048	0.5	3	0.22
0.5	1.280	0.920	0.016	15.81	-0.0030	0.7	3	0.25
0.4	1.223	0.820	0.043	16.55	-0.0160	0.4	3	0.18
0.3	1.187	0.612	0.107	13.74	-0.0468	0.8	0.5	0.37
0.2	1.212	0.295	0.299	13.28	-0.1781	1.0	3	0.57
0.15	1.409	0.360	0.186	15.10	-0.0849	0.3	0.5	0.14
0.1	2.100	1.268	0.098	16.67	-0.0854	9.9	3	4.41
0.08	1.053	0.537	0.150	13.67	-0.0743	0.8	0.5	0.32
0.06	1.028	0.491	0.178	13.92	-0.1032	0.5	0.5	0.19
0.05	1.021	0.390	0.248	13.64	-0.1591	0.3	0.5	0.15
0.04	1.012	0.411	0.231	14.20	-0.1470	0.2	4	0.08

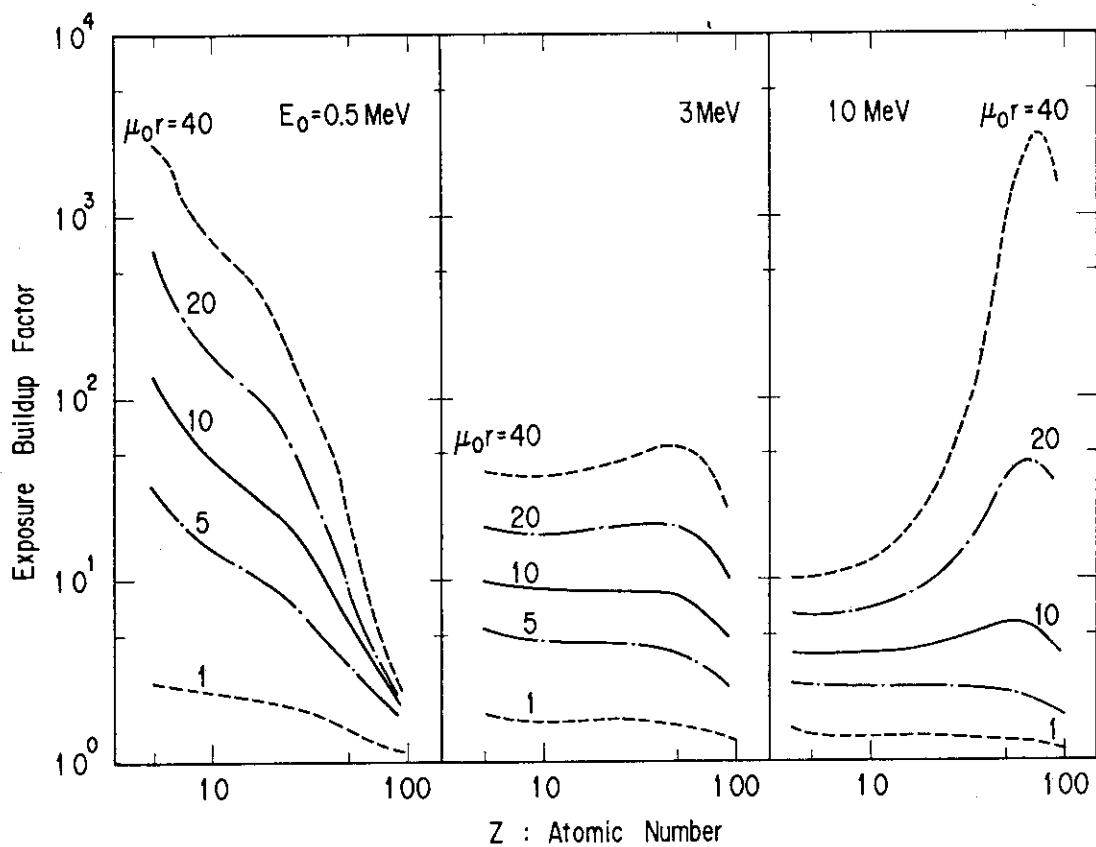


Fig. 1 Dependence of  $\log Z$  for the exposure buildup factors, point isotropic sources in infinite media of 4 - 92 elements.

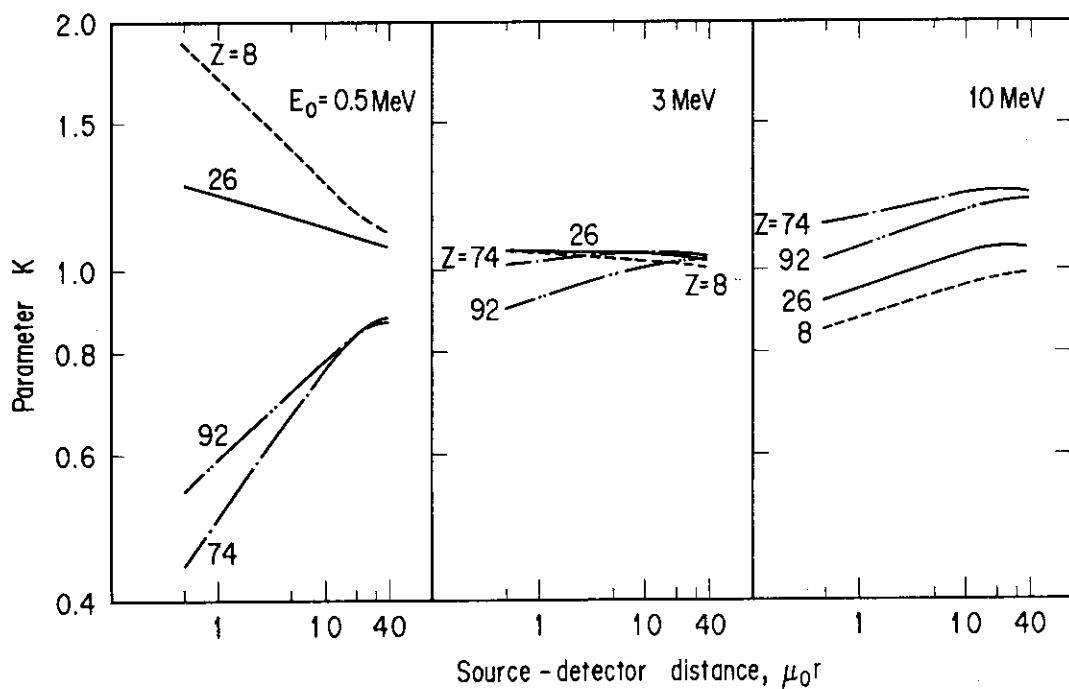


Fig. 2 Dependence of  $\log K$  on  $\log X$  for the exposure buildup factors, point isotropic sources in infinite media of various elements.

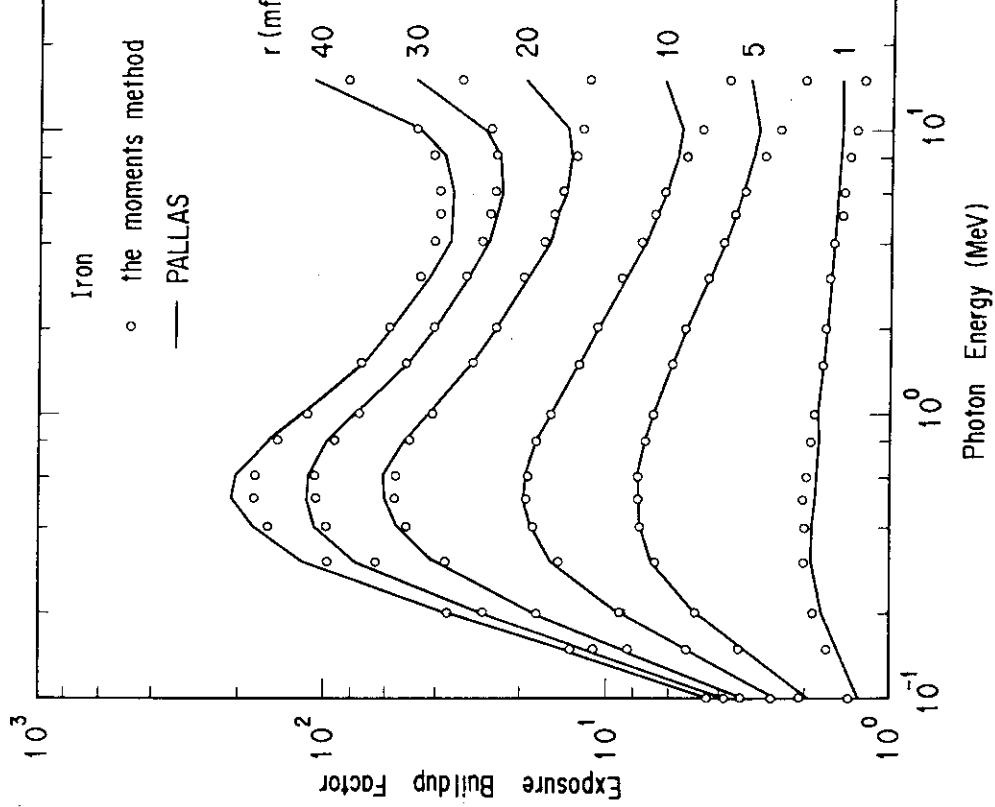


Fig. 3 Comparison of exposure buildup factors in iron using the moments method and the PALLAS codes.

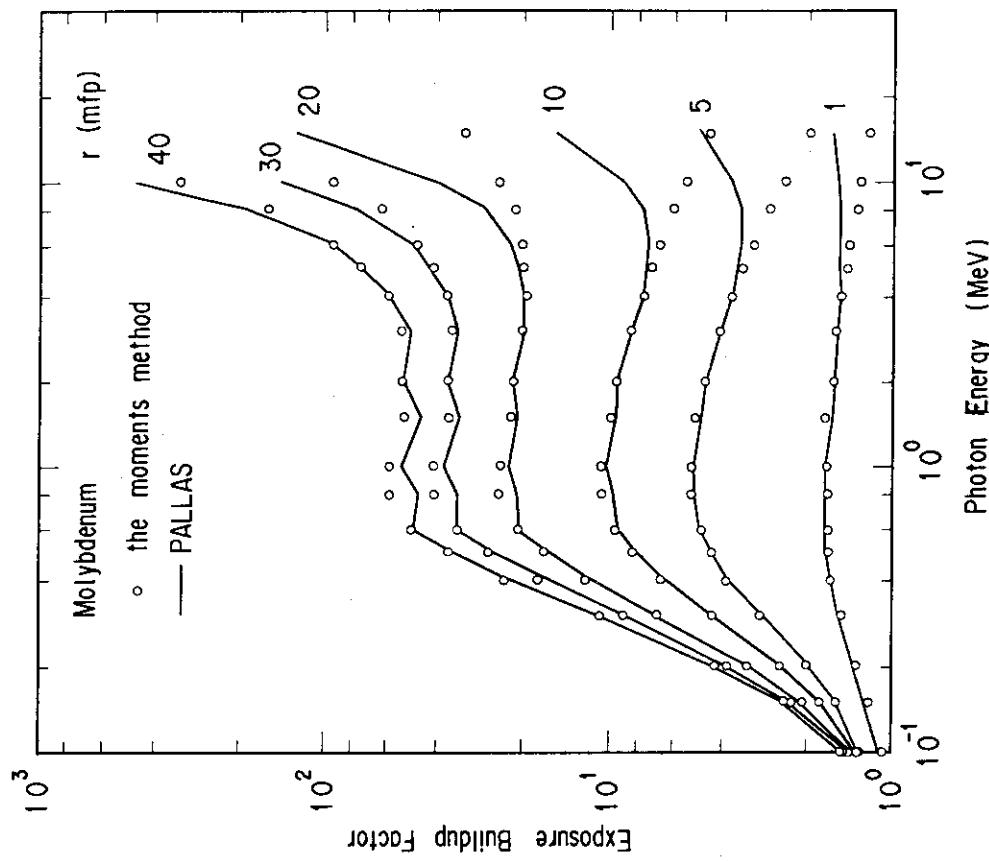


Fig. 4 Comparison of exposure buildup factors in molybdenum using the moments method and the PALLAS codes.

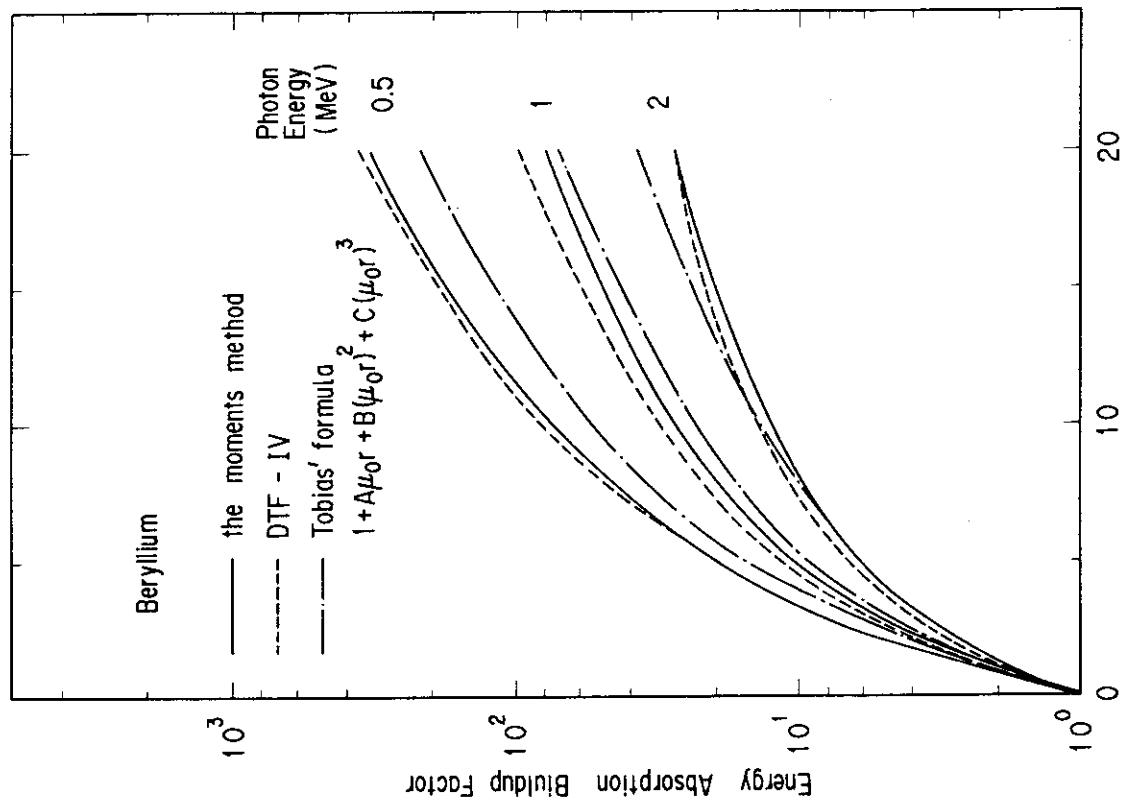
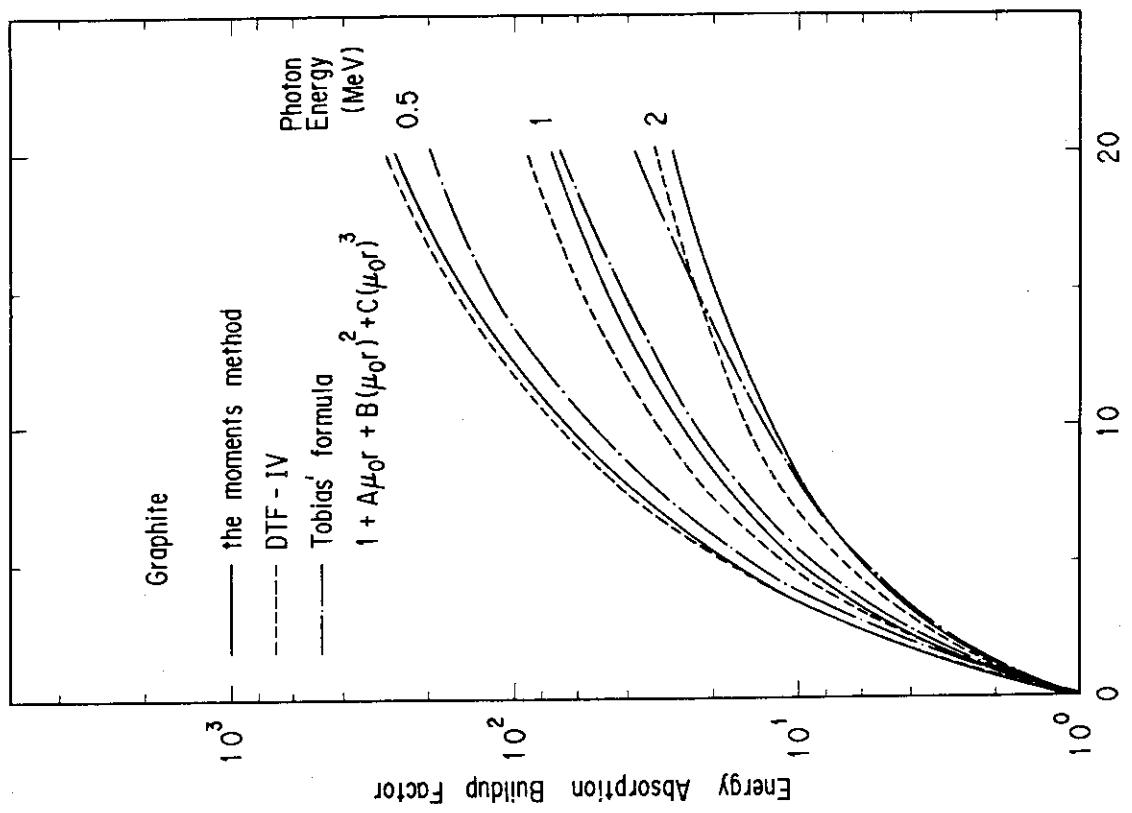


Fig. 5 Comparison of energy absorption buildup factors in beryllium using the moments method, DTF-IV code and Tobias' formula.

Fig. 6 Comparison of energy absorption buildup factors in graphite using the moments method, DTF-IV code and Tobias' formula.

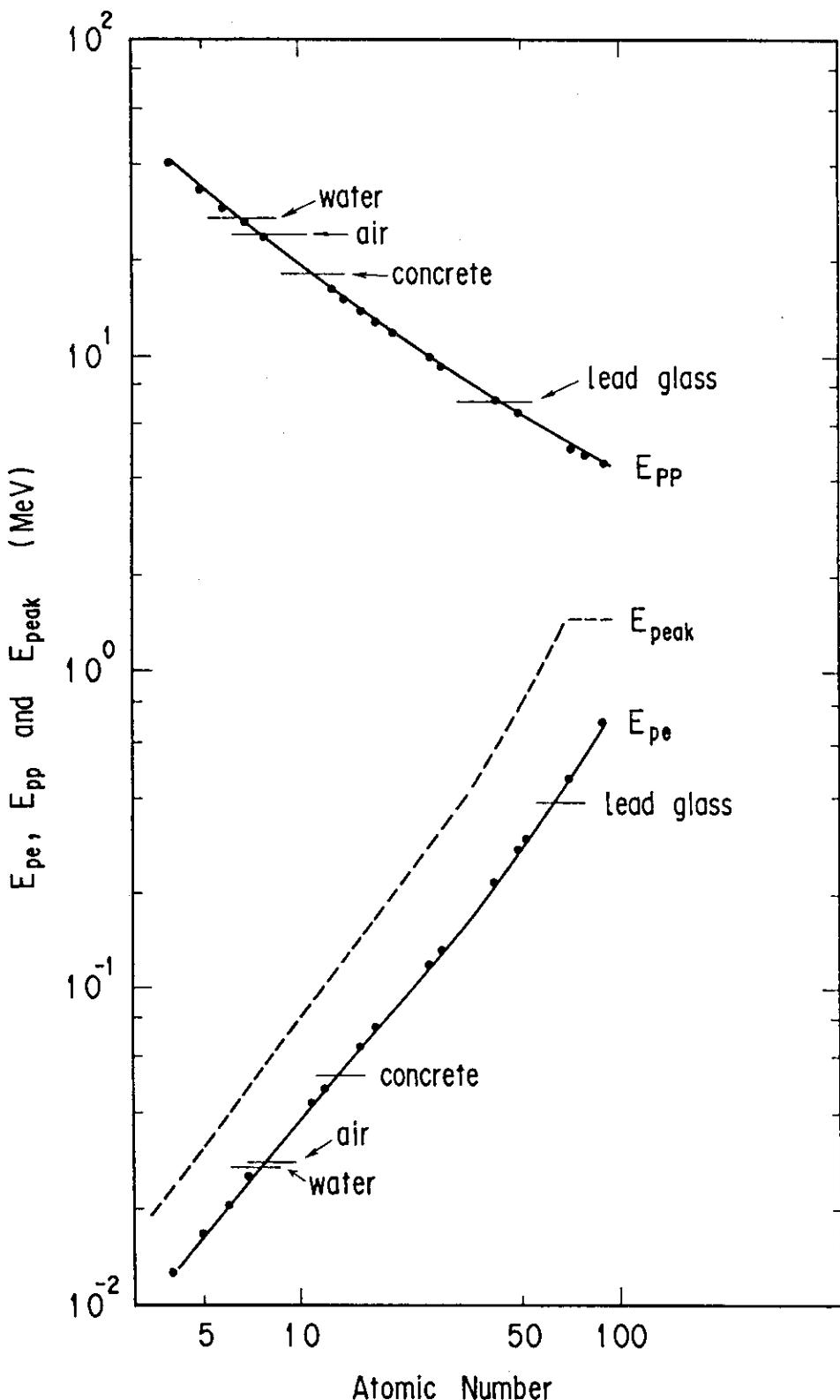


Fig. 7 Energy E<sub>pe</sub>, E<sub>pp</sub> and E<sub>peak</sub> versus atomic number.  
 (E<sub>pp</sub>: the photon energy where the cross section of photoelectric effect and scattering are the same value, E<sub>pp</sub>: the photon energy where the cross section of pair production and scattering are same value, and E<sub>peak</sub>: the energy corresponding to a broad peak by the multiple scattering of photons in an energy spectrum at deep penetration)

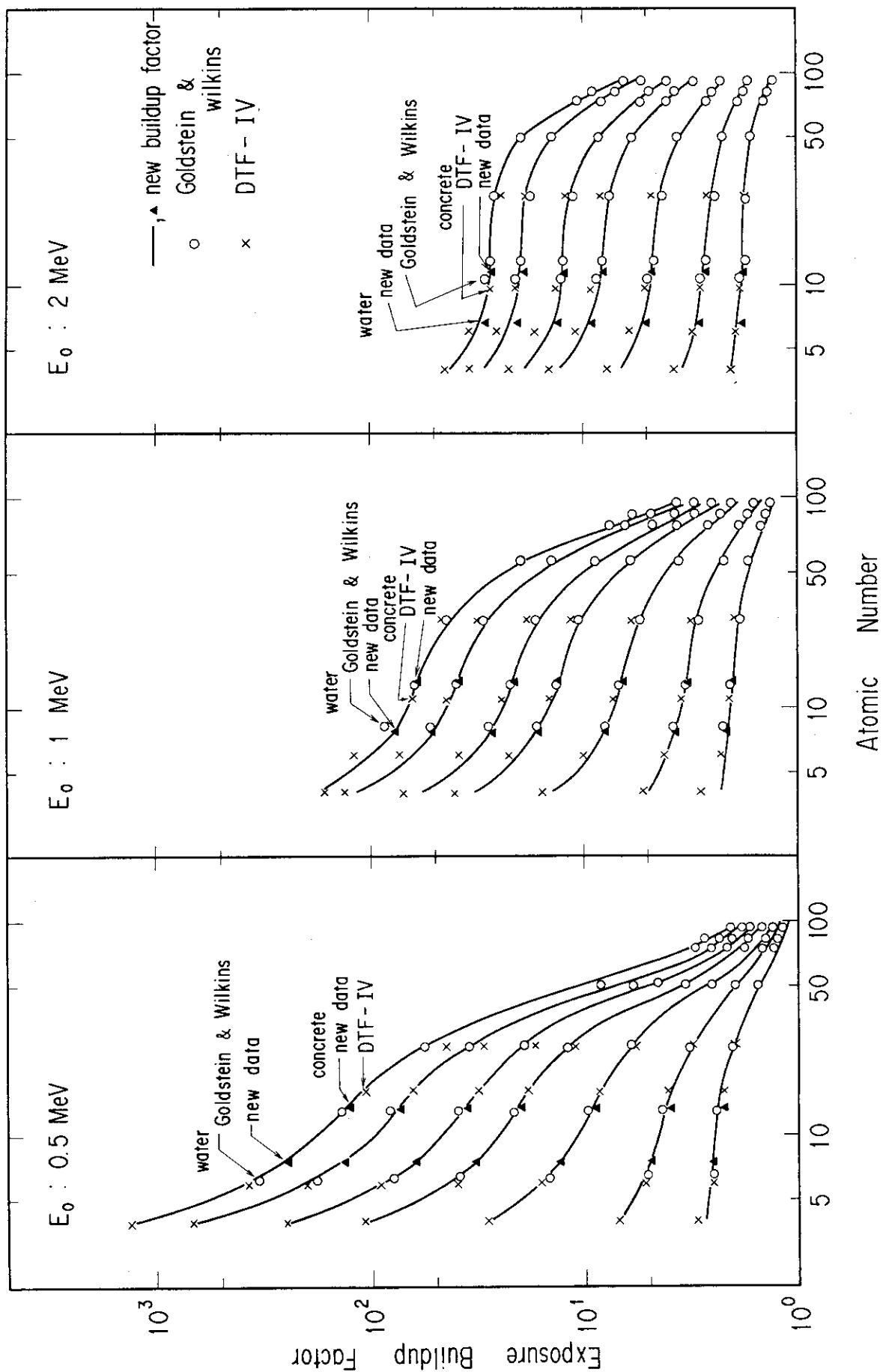


Fig. 8 Comparison of new exposure buildup factor data in various materials with ones calculated by DTF-IV code and Goldstein & Wilkins.

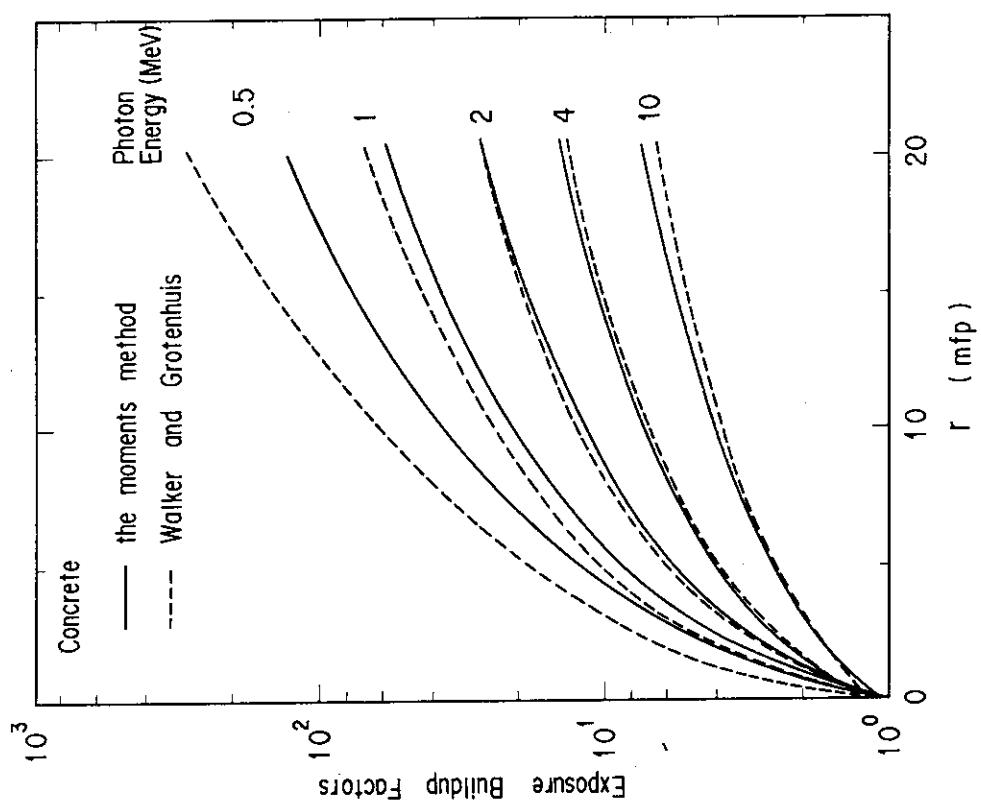


Fig. 9 Comparison of exposure buildup factors in concrete between the moments method and Walker & Grotenhuis' results.

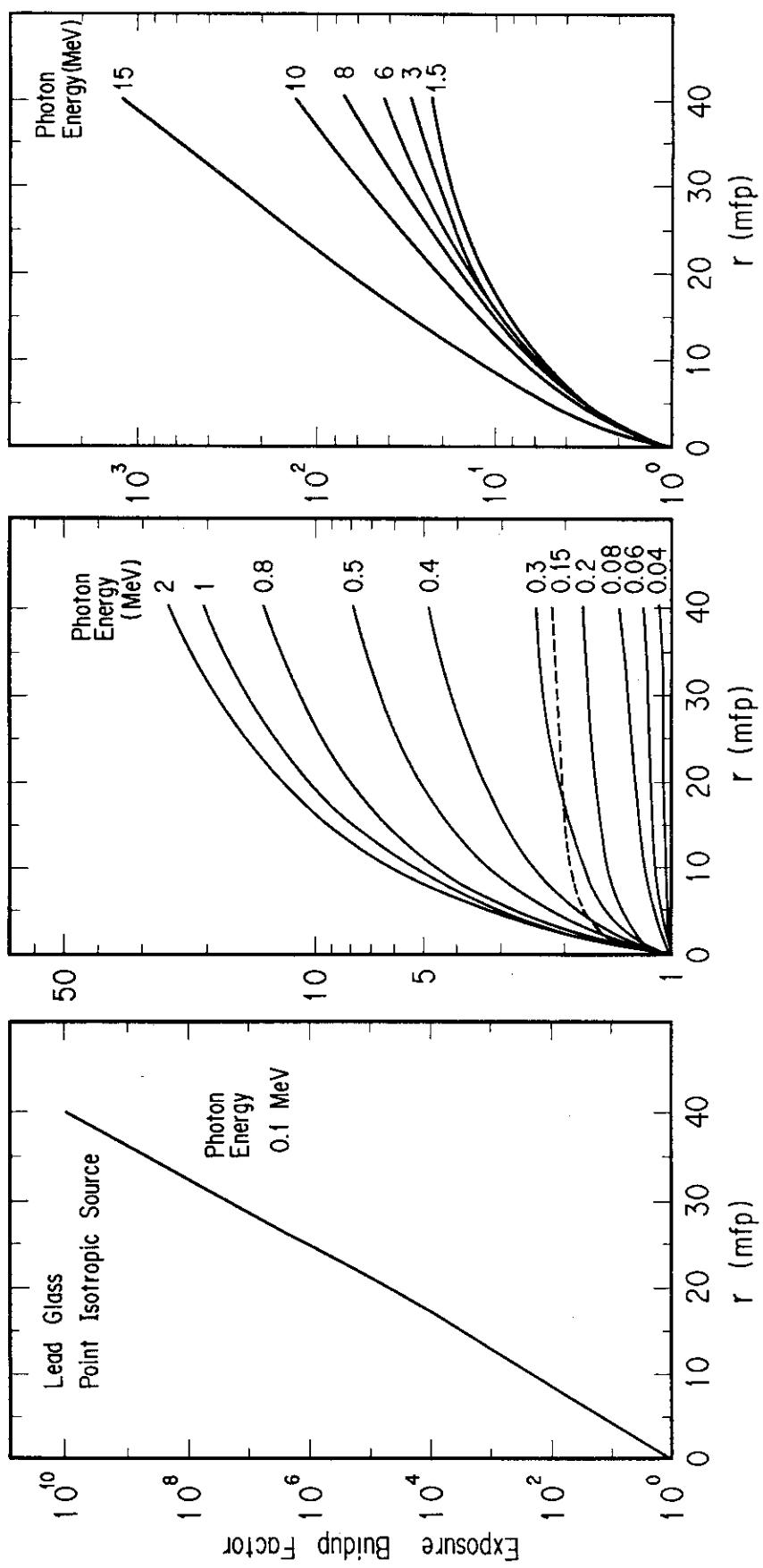


Fig. 10 Exposure buildup factors in lead glass.

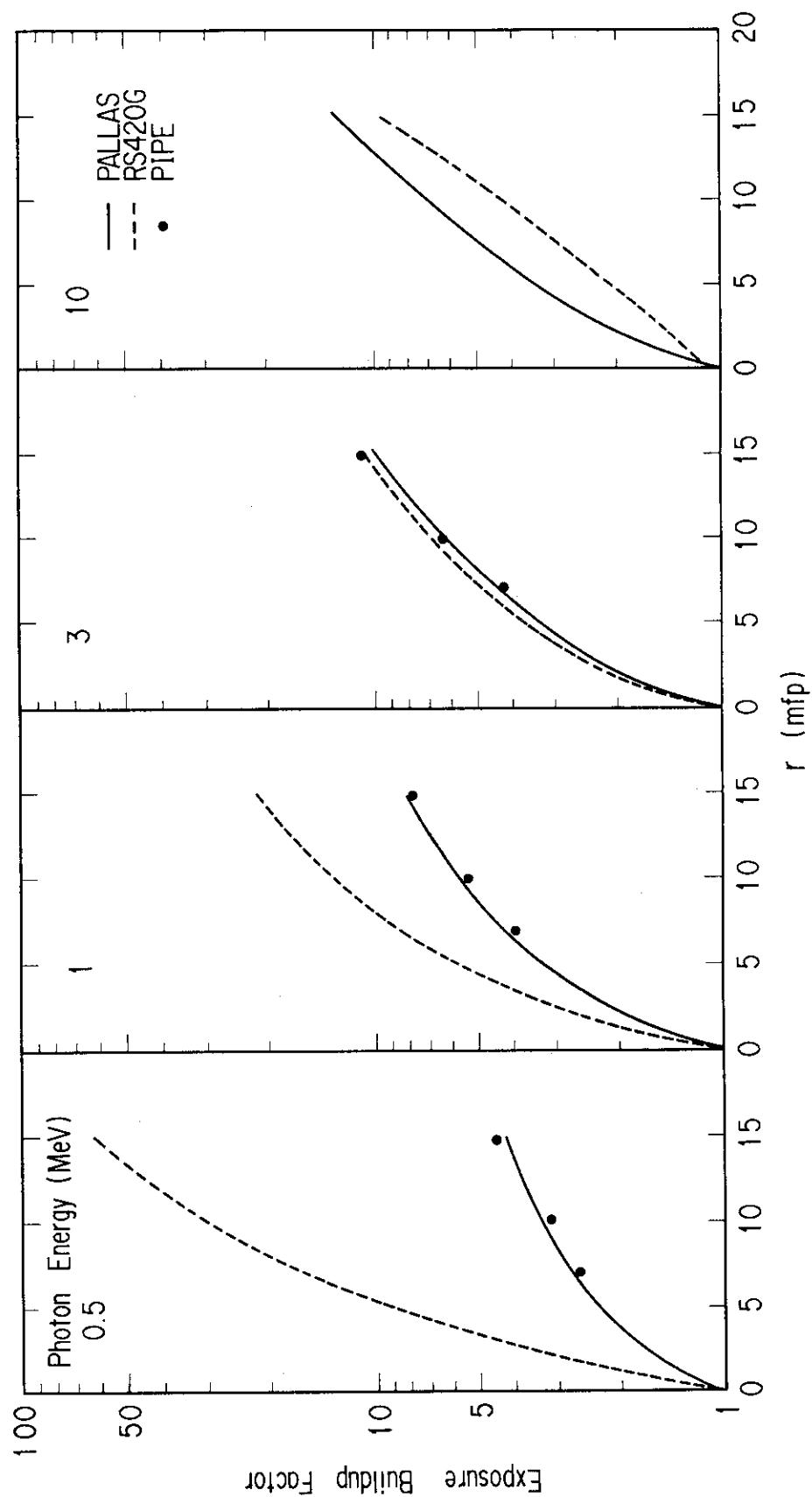


Fig. 11 Comparison of exposure buildup factors in lead glass using the PALLAS and PIPE codes, and RS420G (estimated from Goldstein & Wilkins' data)

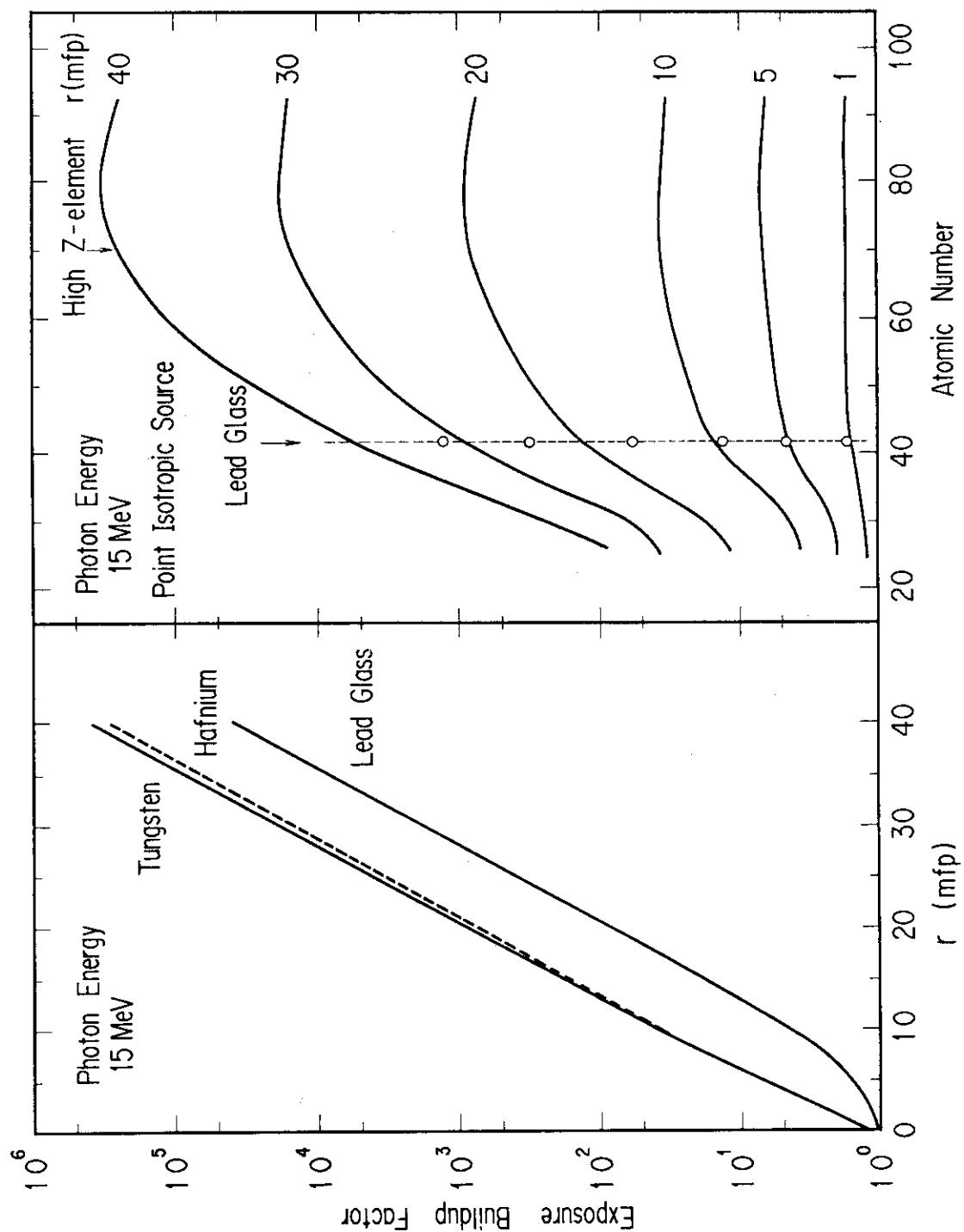


Fig. 12 Comparison of exposure buildup factors in lead glass and the high-Z elements at the source energy of 15 MeV.

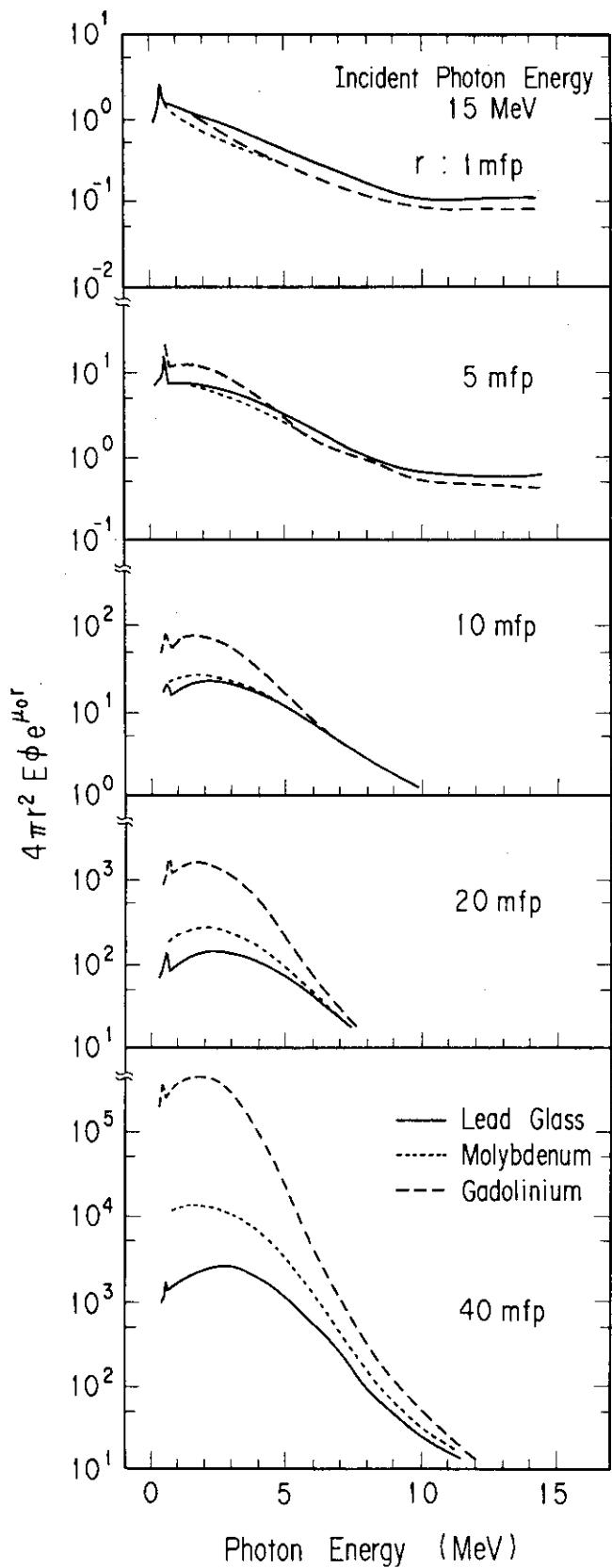


Fig. 13 Comparison of energy spectra for lead glass, molybdenum and gadolinium at the source energy of 15 MeV.

## Appendix

This is data library of gamma-ray buildup factors for a point isotropic source including the contribution of bremsstrahlung, fluorescence and annihilation radiation, and the G-P parameters fitted to these buildup factors. The absorbed-dose, exposure and dose-equivalent buildup factors calculated by the PALLAS code are tabulated for molybdenum, tin, lanthanum, gadolinium, tungsten, lead and uranium, the source energies over an energy range from 0.015 MeV to 15 MeV, for penetration depths up to 40 mfp.

The buildup factor data of Ref. 7 were replaced by the recalculated values over the energy range of 0.5 to 3 MeV. Here are listed the revised buildup factors and the G-P parameters again. The buildup factors including fluorescence radiations were compared with the results of tin, tungsten, lead and uranium, calculated by the ASFIT code<sup>13</sup>. Both values were in good agreement.

Table A.1 Gamma-ray buildup factors for point isotropic source  
in 45-mfp-thick molybdenum

ABSORBED DOSE BUILDUP FACTORS IN 45-MFP THICK MOYBODENUM										
R(MFP)	ENERGY (MEV)									
	15	10	8	6	5	4	3	2	1.5	1
0.5	1.25	1.27	1.33	1.37	1.40	1.34	1.38	1.42	1.44	1.66
1.0	1.47	1.48	1.55	1.62	1.67	1.62	1.72	1.86	1.91	2.28
2.0	1.84	1.81	1.89	2.00	2.12	2.11	2.38	2.80	2.88	3.48
3.0	2.25	2.14	2.21	2.38	2.55	2.57	3.02	3.72	3.93	4.73
4.0	2.76	2.52	2.59	2.79	3.03	3.08	3.68	4.64	4.98	5.95
5.0	3.39	2.97	3.02	3.26	3.57	3.64	4.40	5.61	6.05	7.18
6.0	4.18	3.49	3.51	3.80	4.18	4.28	5.20	6.69	7.24	8.61
7.0	5.16	4.11	4.08	4.41	4.85	4.98	6.05	7.82	8.47	1.01E1
8.0	6.38	4.81	4.77	5.07	5.59	5.73	6.96	9.02	9.69	1.15E1
10.0	9.72	6.56	6.23	6.60	7.25	7.40	8.94	1.16E1	1.23E1	1.46E1
15.0	2.75E1	1.38E1	1.19E1	1.18E1	1.26E1	1.26E1	1.48E1	1.91E1	1.96E1	2.35E1
20.0	7.59E1	2.76E1	2.14E1	1.92E1	1.99E1	1.90E1	2.15E1	2.75E1	2.75E1	3.35E1
25.0	2.03E2	5.30E1	3.65E1	2.93E1	2.90E1	2.66E1	2.88E1	3.65E1	3.56E1	4.41E1
30.0	5.27E2	9.83E1	5.97E1	4.24E1	4.02E1	3.53E1	3.66E1	4.59E1	4.38E1	5.51E1
35.0	1.33E3	1.78E2	9.44E1	5.92E1	5.36E1	4.51E1	4.49E1	5.58E1	5.21E1	6.66E1
40.0	3.30E3	3.13E2	1.45E2	7.99E1	6.93E1	5.57E1	5.34E1	6.59E1	6.03E1	7.81E1
R(MFP)	ENERGY (MEV)									
	0.8	0.6	0.5	0.4	0.3	0.2	0.15	0.1	0.08	0.06
0.5	1.76	1.86	1.92	1.94	1.82	1.48	1.33	1.13	1.07	1.02
1.0	2.43	2.57	2.62	2.58	2.30	1.71	1.42	1.16	1.09	1.03
2.0	3.69	3.86	3.84	3.62	3.01	2.00	1.53	1.19	1.10	1.04
3.0	4.99	5.18	5.04	4.60	3.61	2.23	1.63	1.22	1.12	1.05
4.0	6.23	6.43	6.14	5.46	4.11	2.41	1.72	1.25	1.13	1.06
5.0	7.48	7.68	7.21	6.27	4.56	2.55	1.80	1.28	1.15	1.07
6.0	8.91	9.13	8.44	7.19	5.05	2.71	1.88	1.30	1.16	1.08
7.0	1.04E1	1.06E1	9.66	8.08	5.51	2.85	1.94	1.32	1.17	1.08
8.0	1.18E1	1.20E1	1.08E1	8.92	5.93	2.97	2.00	1.34	1.18	1.09
10.0	1.48E1	1.51E1	1.33E1	1.07E1	6.78	3.21	2.10	1.37	1.20	1.09
15.0	2.32E1	2.40E1	2.02E1	1.52E1	8.89	3.76	2.31	1.43	1.23	1.11
20.0	3.25E1	3.41E1	2.75E1	1.97E1	1.09E1	4.25	2.45	1.47	1.26	1.12
25.0	4.21E1	4.49E1	3.52E1	2.41E1	1.27E1	4.67	2.57	1.51	1.27	1.13
30.0	5.20E1	5.62E1	4.30E1	2.85E1	1.43E1	5.03	2.67	1.53	1.29	1.14
35.0	6.21E1	6.81E1	5.09E1	3.27E1	1.59E1	5.36	2.77	1.56	1.30	1.15
40.0	7.22E1	8.02E1	5.88E1	3.68E1	1.72E1	5.65	2.85	1.58	1.31	1.15
R(MFP)	ENERGY (MEV)									
	0.05	0.04	0.035	0.03	0.028	0.026	0.024	0.022	0.021	0.02
0.5	1.31	1.31	1.31	1.29	1.29	1.28	1.27	1.26	1.26	1.01
1.0	1.38	1.49	1.53	1.55	1.56	1.57	1.57	1.56	1.56	1.01
2.0	1.40	1.66	1.89	2.11	2.22	2.33	2.42	2.48	2.51	1.02
3.0	1.40	1.73	2.19	2.84	3.21	3.60	3.99	4.33	4.50	1.02
4.0	1.39	1.77	2.50	3.93	4.87	5.95	7.16	8.36	8.99	1.02
5.0	1.40	1.79	2.84	5.61	7.70	1.04E1	1.37E1	1.73E1	1.93E1	1.02
6.0	1.40	1.80	3.20	8.16	1.25E1	1.87E1	2.69E1	3.67E1	4.24E1	1.03
7.0	1.40	1.80	3.62	1.21E1	2.05E1	3.32E1	5.07E1	7.28E1	8.70E1	1.03
8.0	1.40	1.81	4.15	1.78E1	3.23E1	5.74E1	9.52E1	1.47E2	1.81E2	1.03
10.0	1.41	1.82	5.39	3.80E1	8.41E1	1.79E2	3.46E2	6.13E2	8.06E2	1.03
15.0	1.41	1.82	1.26E1	3.26E2	1.10E3	3.46E3	9.53E3	2.33E4	3.55E4	1.04
20.0	1.42	1.84	4.03E1	3.60E3	1.76E4	7.74E4	2.91E5	9.55E5	1.67E6	1.05
25.0	1.43	1.84	1.53E2	4.58E4	3.19E5	1.92E6	9.59E6	4.12E7	8.19E7	1.05
30.0	1.44	1.85	6.28E2	6.21E5	6.24E6	5.14E7	3.36E8	1.86E9	4.16E9	1.06
35.0	1.44	1.85	2.64E3	8.69E6	1.27E8	1.44E9	1.24E10	8.72E10	2.18E11	1.06
40.0	1.45	1.85	1.13E4	1.23E8	2.64E9	4.17E10	4.73E11	4.22E12	1.18E13	1.06
R(MFP)	ENERGY (MEV)									
	0.015									
0.5	1.00									
1.0	1.01									
2.0	1.01									
3.0	1.01									
4.0	1.01									
5.0	1.01									
6.0	1.01									
7.0	1.01									
8.0	1.01									
10.0	1.02									
15.0	1.02									
20.0	1.02									
25.0	1.02									
30.0	1.03									
35.0	1.03									
40.0	1.03									

Table A.1 (continued)

## EXPOSURE BUILDUP FACTORS IN 45-MFP THICK MOLYBDENUM

R(MFP)	ENERGY (MEV)									
	15	10	8	6	5	4	3	2	1.5	1
0.5	1.33	1.32	1.32	1.32	1.32	1.29	1.29	1.29	1.30	1.36
1.0	1.64	1.58	1.57	1.57	1.57	1.54	1.58	1.62	1.64	1.75
2.0	2.21	2.02	1.98	2.01	2.04	2.04	2.18	2.34	2.37	2.54
3.0	2.89	2.49	2.41	2.45	2.51	2.54	2.78	3.07	3.15	3.38
4.0	3.73	3.04	2.90	2.93	3.03	3.09	3.40	3.82	3.94	4.21
5.0	4.79	3.68	3.45	3.49	3.61	3.69	4.09	4.61	4.75	5.07
6.0	6.12	4.44	4.10	4.12	4.27	4.37	4.84	5.47	5.65	6.04
7.0	7.78	5.32	4.83	4.82	4.99	5.11	5.65	6.39	6.58	7.03
8.0	9.84	6.34	5.65	5.59	5.78	5.91	6.50	7.36	7.51	8.02
10.0	1.56E1	8.88	7.64	7.38	7.57	7.67	8.36	9.43	9.49	1.02E1
15.0	4.63E1	1.94E1	1.51E1	1.35E1	1.34E1	1.31E1	1.38E1	1.54E1	1.50E1	1.62E1
20.0	1.31E2	3.98E1	2.77E1	2.22E1	2.11E1	1.99E1	2.00E1	2.20E1	2.09E1	2.29E1
25.0	3.54E2	7.77E1	4.78E1	3.41E1	3.10E1	2.80E1	2.68E1	2.92E1	2.70E1	3.01E1
30.0	9.24E2	1.46E2	7.88E1	4.97E1	4.31E1	3.72E1	3.41E1	3.67E1	3.32E1	3.75E1
35.0	2.35E3	2.65E2	1.25E2	6.95E1	5.76E1	4.75E1	4.17E1	4.45E1	3.93E1	4.52E1
40.0	5.83E3	4.69E2	1.94E2	9.42E1	7.45E1	5.87E1	4.96E1	5.25E1	4.55E1	5.29E1
R(MFP)	ENERGY (MEV)									
	0.8	0.6	0.5	0.4	0.3	0.2	0.15	0.1	0.08	0.06
0.5	1.37	1.37	1.37	1.35	1.30	1.20	1.18	1.08	1.05	1.02
1.0	1.76	1.75	1.73	1.66	1.54	1.34	1.25	1.11	1.07	1.03
2.0	2.55	2.50	2.41	2.23	1.95	1.54	1.35	1.15	1.09	1.04
3.0	3.37	3.28	3.09	2.78	2.31	1.71	1.43	1.18	1.10	1.05
4.0	4.18	4.04	3.74	3.28	2.62	1.84	1.51	1.20	1.12	1.06
5.0	4.99	4.81	4.38	3.76	2.91	1.96	1.58	1.23	1.13	1.07
6.0	5.91	5.68	5.10	4.29	3.21	2.07	1.64	1.25	1.14	1.07
7.0	6.84	6.56	5.81	4.80	3.50	2.18	1.69	1.27	1.15	1.08
8.0	7.77	7.45	6.52	5.30	3.77	2.28	1.74	1.29	1.16	1.08
10.0	9.72	9.33	7.99	6.32	4.31	2.46	1.83	1.32	1.18	1.09
15.0	1.52E1	1.47E1	1.20E1	8.95	5.64	2.89	2.00	1.37	1.21	1.11
20.0	2.11E1	2.07E1	1.63E1	1.16E1	6.88	3.26	2.12	1.41	1.24	1.12
25.0	2.72E1	2.72E1	2.08E1	1.42E1	8.01	3.58	2.22	1.44	1.25	1.13
30.0	3.35E1	3.40E1	2.54E1	1.67E1	9.04	3.86	2.31	1.47	1.27	1.14
35.0	4.00E1	4.11E1	3.00E1	1.91E1	9.99	4.11	2.39	1.49	1.28	1.14
40.0	4.64E1	4.82E1	3.46E1	2.15E1	1.09E1	4.33	2.46	1.51	1.29	1.15
R(MFP)	ENERGY (MEV)									
	0.05	0.04	0.035	0.03	0.028	0.026	0.024	0.022	0.021	0.02
0.5	2.66	2.82	2.68	2.45	2.32	2.17	2.03	1.89	1.82	1.01
1.0	3.06	3.83	3.91	3.76	3.59	3.38	3.16	2.90	2.78	1.01
2.0	3.12	4.83	5.86	6.59	6.66	6.58	6.38	6.02	5.82	1.02
3.0	3.06	5.23	7.52	1.03E1	1.12E1	1.19E1	1.23E1	1.23E1	1.22E1	1.02
4.0	3.02	5.42	9.19	1.58E1	1.89E1	2.18E1	2.44E1	2.59E1	2.65E1	1.02
5.0	3.02	5.53	1.10E1	2.43E1	3.20E1	4.05E1	4.91E1	5.61E1	5.92E1	1.02
6.0	3.02	5.57	1.29E1	3.72E1	5.42E1	7.52E1	9.91E1	1.22E2	1.33E2	1.03
7.0	3.01	5.58	1.52E1	5.70E1	9.13E1	1.36E2	1.89E2	2.44E2	2.75E2	1.03
8.0	3.02	5.61	1.80E1	8.57E1	1.46E2	2.38E2	3.57E2	4.94E2	5.74E2	1.03
10.0	3.01	5.62	2.47E1	1.87E2	3.83E2	7.44E2	1.30E3	2.07E3	2.56E3	1.03
15.0	3.00	5.63	6.31E1	1.62E3	5.03E3	1.44E4	3.58E4	7.83E4	1.13E5	1.04
20.0	3.02	5.69	2.10E2	1.77E4	7.96E4	3.19E5	1.09E6	3.20E6	5.27E6	1.05
25.0	3.04	5.72	8.09E2	2.24E5	1.43E6	7.88E6	3.56E7	1.37E8	2.57E8	1.05
30.0	3.06	5.74	3.32E3	3.04E6	2.80E7	2.10E8	1.24E9	6.17E9	1.30E10	1.06
35.0	3.07	5.73	1.40E4	4.25E7	5.68E8	5.87E9	4.56E10	2.88E11	6.80E11	1.06
40.0	3.09	5.72	5.98E4	6.02E8	1.18E10	1.70E11	1.74E12	1.39E13	3.65E13	1.06
R(MFP)	ENERGY (MEV)									
	0.015									
0.5	1.00									
1.0	1.01									
2.0	1.01									
3.0	1.01									
4.0	1.01									
5.0	1.01									
6.0	1.01									
7.0	1.01									
8.0	1.01									
10.0	1.02									
15.0	1.02									
20.0	1.02									
25.0	1.02									
30.0	1.03									
35.0	1.03									
40.0	1.03									

Table A.1 (continued)

## DOSE EQUIVALENT BUILDUP FACTORS IN 45-MFP THICK MOLYBDENUM

R(MFP)	ENERGY (MEV)									
	15	10	8	6	5	4	3	2	1.5	1
0.5	1.39	1.39	1.38	1.37	1.37	1.32	1.32	1.32	1.33	1.40
1.0	1.75	1.69	1.66	1.65	1.66	1.60	1.63	1.67	1.71	1.83
2.0	2.40	2.18	2.11	2.12	2.16	2.12	2.27	2.44	2.50	2.70
3.0	3.14	2.69	2.57	2.58	2.67	2.65	2.90	3.22	3.35	3.62
4.0	4.07	3.29	3.10	3.10	3.23	3.22	3.56	4.01	4.21	4.53
5.0	5.25	4.00	3.70	3.69	3.85	3.85	4.27	4.85	5.09	5.46
6.0	6.72	4.84	4.40	4.36	4.56	4.56	5.07	5.77	6.08	6.52
7.0	8.56	5.81	5.20	5.11	5.35	5.34	5.92	6.74	7.08	7.61
8.0	1.09E1	6.94	6.09	5.94	6.20	6.18	6.81	7.77	8.10	8.69
10.0	1.72E1	9.75	8.25	7.85	8.14	8.03	8.77	9.97	1.03E1	1.10E1
15.0	5.14E1	2.15E1	1.64E1	1.44E1	1.38E1	1.45E1	1.63E1	1.62E1	1.76E1	
20.0	1.45E2	4.41E1	3.02E1	2.38E1	2.29E1	2.10E1	2.11E1	2.34E1	2.27E1	2.50E1
25.0	3.94E2	8.63E1	5.21E1	3.65E1	3.36E1	2.94E1	2.83E1	3.10E1	2.93E1	3.28E1
30.0	1.03E3	1.62E2	8.61E1	5.33E1	4.68E1	3.91E1	3.60E1	3.90E1	3.61E1	4.10E1
35.0	2.62E3	2.95E2	1.37E2	7.47E1	6.25E1	5.00E1	4.41E1	4.73E1	4.28E1	4.94E1
40.0	6.51E3	5.22E2	2.12E2	1.01E2	8.09E1	6.19E1	5.24E1	5.58E1	4.95E1	5.78E1
R(MFP)	ENERGY (MEV)									
	0.8	0.6	0.5	0.4	0.3	0.2	0.15	0.1	0.08	0.06
0.5	1.42	1.41	1.41	1.37	1.32	1.22	1.19	1.09	1.05	1.02
1.0	1.85	1.82	1.80	1.71	1.57	1.36	1.27	1.12	1.07	1.03
2.0	2.71	2.63	2.53	2.31	1.99	1.57	1.37	1.15	1.09	1.04
3.0	3.62	3.47	3.26	2.88	2.36	1.75	1.45	1.18	1.10	1.05
4.0	4.50	4.28	3.96	3.41	2.68	1.88	1.53	1.21	1.12	1.06
5.0	5.39	5.10	4.64	3.91	2.98	2.00	1.60	1.24	1.13	1.07
6.0	6.39	6.04	5.41	4.46	3.29	2.12	1.66	1.26	1.14	1.07
7.0	7.41	6.98	6.17	5.00	3.58	2.23	1.72	1.28	1.16	1.08
8.0	8.42	7.93	6.93	5.52	3.86	2.33	1.77	1.30	1.17	1.08
10.0	1.06E1	9.95	8.50	6.58	4.42	2.52	1.86	1.33	1.18	1.09
15.0	1.65E1	1.57E1	1.28E1	9.33	5.78	2.95	2.03	1.38	1.22	1.11
20.0	2.30E1	2.22E1	1.74E1	1.21E1	7.06	3.33	2.16	1.42	1.24	1.12
25.0	2.97E1	2.91E1	2.22E1	1.48E1	8.22	3.65	2.26	1.45	1.26	1.13
30.0	3.66E1	3.64E1	2.71E1	1.74E1	9.27	3.94	2.35	1.48	1.27	1.14
35.0	4.37E1	4.40E1	3.20E1	2.00E1	1.02E1	4.20	2.43	1.50	1.28	1.14
40.0	5.07E1	5.17E1	3.69E1	2.24E1	1.11E1	4.42	2.51	1.52	1.29	1.15
R(MFP)	ENERGY (MEV)									
	0.05	0.04	0.035	0.03	0.028	0.026	0.024	0.022	0.021	0.02
0.5	2.28	2.36	2.32	2.21	2.13	2.03	1.93	1.82	1.77	1.01
1.0	2.59	3.12	3.30	3.31	3.22	3.09	2.94	2.76	2.67	1.01
2.0	2.64	3.87	4.84	5.69	5.85	5.90	5.84	5.64	5.53	1.02
3.0	2.59	4.18	6.15	8.81	9.79	1.06E1	1.12E1	1.14E1	1.15E1	1.02
4.0	2.57	4.33	7.48	1.35E1	1.64E1	1.93E1	2.21E1	2.41E1	2.49E1	1.02
5.0	2.56	4.41	8.93	2.06E1	2.77E1	3.57E1	4.44E1	5.21E1	5.58E1	1.02
6.0	2.56	4.45	1.05E1	3.15E1	4.68E1	6.64E1	8.96E1	1.13E2	1.25E2	1.03
7.0	2.56	4.46	1.24E1	4.83E1	7.88E1	1.20E2	1.71E2	2.26E2	2.59E2	1.03
8.0	2.57	4.48	1.46E1	7.26E1	1.26E2	2.10E2	3.23E2	4.58E2	5.41E2	1.03
10.0	2.56	4.50	2.00E1	1.59E2	3.32E2	6.58E2	1.18E3	1.92E3	2.41E3	1.03
15.0	2.55	4.51	5.15E1	1.39E3	4.40E3	1.28E4	3.26E4	7.31E4	1.06E5	1.04
20.0	2.57	4.56	1.72E2	1.54E4	7.02E4	2.87E5	9.95E5	3.00E6	5.01E6	1.05
25.0	2.58	4.59	6.64E2	1.95E5	1.27E6	7.13E6	3.28E7	1.30E8	2.46E8	1.05
30.0	2.60	4.60	2.73E3	2.65E6	2.49E7	1.91E8	1.15E9	5.84E9	1.25E10	1.06
35.0	2.61	4.60	1.15E4	3.71E7	5.07E8	5.35E9	4.24E10	2.74E11	6.54E11	1.06
40.0	2.63	4.58	4.92E4	5.27E8	1.05E10	1.55E11	1.62E12	1.33E13	3.53E13	1.06
R(MFP)	ENERGY (MEV)									
	0.015									
0.5	1.00									
1.0	1.01									
2.0	1.01									
3.0	1.01									
4.0	1.01									
5.0	1.01									
6.0	1.01									
7.0	1.01									
8.0	1.01									
10.0	1.02									
15.0	1.02									
20.0	1.02									
25.0	1.02									
30.0	1.03									
35.0	1.03									
40.0	1.03									

Table A.2 Gamma-ray buildup factors for point isotropic source  
in 45-mfp-thick tin

## ABSORBED DOSE BUILDUP FACTORS IN 45-MFP THICK TIN

R(MFP)	ENERGY (MEV)									
	15	10	8	6	5	4	3	2	1.5	1
0.5	1.27	1.30	1.35	1.39	1.42	1.34	1.38	1.42	1.46	1.67
1.0	1.49	1.52	1.56	1.62	1.67	1.58	1.69	1.82	1.93	2.25
2.0	1.87	1.85	1.89	1.98	2.07	2.00	2.27	2.65	2.89	3.36
3.0	2.32	2.21	2.22	2.34	2.48	2.42	2.84	3.45	3.89	4.49
4.0	2.91	2.65	2.62	2.76	2.95	2.89	3.45	4.26	4.88	5.55
5.0	3.68	3.18	3.08	3.24	3.48	3.42	4.12	5.12	5.89	6.62
6.0	4.68	3.82	3.63	3.80	4.09	4.02	4.87	6.06	7.01	7.84
7.0	5.98	4.59	4.26	4.43	4.77	4.68	5.68	7.06	8.16	9.08
8.0	7.66	5.50	4.99	5.14	5.52	5.39	6.54	8.10	9.30	1.03E1
10.0	1.26E1	7.87	6.79	6.83	7.25	7.00	8.43	1.04E1	1.17E1	1.28E1
15.0	4.38E1	1.89E1	1.41E1	1.30E1	1.31E1	1.21E1	1.41E1	1.68E1	1.84E1	1.99E1
20.0	1.49E2	4.35E1	2.79E1	2.27E1	2.15E1	1.87E1	2.08E1	2.39E1	2.55E1	2.73E1
25.0	4.89E2	9.67E1	5.25E1	3.72E1	3.28E1	2.68E1	2.83E1	3.16E1	3.28E1	3.50E1
30.0	1.56E3	2.08E2	9.52E1	5.83E1	4.77E1	3.63E1	3.65E1	3.96E1	4.01E1	4.28E1
35.0	4.84E3	4.38E2	1.68E2	8.80E1	6.66E1	4.73E1	4.53E1	4.79E1	4.75E1	5.06E1
40.0	1.47E4	8.97E2	2.87E2	1.29E2	8.99E1	5.97E1	5.46E1	5.65E1	5.47E1	5.83E1
R(MFP)	ENERGY (MEV)									
	0.8	0.6	0.5	0.4	0.3	0.2	0.15	0.1	0.09	0.08
0.5	1.75	1.81	1.80	1.77	1.61	1.32	1.11	1.10	1.09	1.35
1.0	2.35	2.41	2.35	2.24	1.93	1.46	1.17	1.12	1.11	1.40
2.0	3.47	3.47	3.29	2.97	2.37	1.63	1.26	1.15	1.14	1.41
3.0	4.60	4.51	4.17	3.62	2.74	1.76	1.32	1.18	1.15	1.42
4.0	5.66	5.45	4.96	4.16	3.02	1.86	1.38	1.19	1.17	1.43
5.0	6.71	6.37	5.72	4.66	3.28	1.94	1.42	1.21	1.18	1.44
6.0	7.92	7.42	6.58	5.21	3.55	2.02	1.46	1.22	1.19	1.45
7.0	9.12	8.44	7.41	5.72	3.81	2.10	1.49	1.24	1.20	1.46
8.0	1.03E1	9.43	8.21	6.20	4.03	2.16	1.52	1.25	1.21	1.46
10.0	1.27E1	1.15E1	9.88	7.17	4.49	2.29	1.58	1.26	1.22	1.48
15.0	1.95E1	1.71E1	1.43E1	9.53	5.55	2.56	1.68	1.30	1.25	1.50
20.0	2.67E1	2.28E1	1.88E1	1.17E1	6.50	2.80	1.75	1.32	1.27	1.52
25.0	3.41E1	2.87E1	2.32E1	1.38E1	7.32	3.00	1.81	1.34	1.28	1.54
30.0	4.15E1	3.44E1	2.76E1	1.56E1	8.03	3.16	1.85	1.36	1.30	1.55
35.0	4.90E1	4.02E1	3.20E1	1.74E1	8.66	3.31	1.89	1.37	1.31	1.57
40.0	5.63E1	4.58E1	3.62E1	1.91E1	9.22	3.44	1.93	1.38	1.32	1.58
R(MFP)	ENERGY (MEV)									
	0.07	0.06	0.055	0.05	0.045	0.04	0.035	0.03	0.029	0.02
0.5	1.38	1.38	1.38	1.38	1.37	1.36	1.36	1.35	1.01	1.00
1.0	1.49	1.56	1.61	1.64	1.68	1.70	1.75	1.76	1.02	1.01
2.0	1.52	1.70	1.86	2.05	2.28	2.51	2.81	3.04	1.02	1.01
3.0	1.51	1.73	1.99	2.37	2.96	3.69	4.68	5.66	1.03	1.01
4.0	1.51	1.74	2.07	2.69	3.84	5.62	8.33	1.15E1	1.03	1.01
5.0	1.51	1.74	2.13	3.02	5.05	8.87	1.56E1	2.46E1	1.04	1.01
6.0	1.52	1.74	2.17	3.38	6.70	1.43E1	2.97E1	5.38E1	1.04	1.01
7.0	1.52	1.73	2.21	3.80	9.08	2.32E1	5.45E1	1.10E2	1.04	1.02
8.0	1.53	1.73	2.25	4.33	1.22E1	3.66E1	9.89E1	2.26E2	1.05	1.02
10.0	1.54	1.72	2.34	5.59	2.24E1	9.32E1	3.38E2	9.82E2	1.05	1.02
15.0	1.55	1.71	2.62	1.26E1	1.29E2	1.18E3	8.09E3	4.09E4	1.06	1.02
20.0	1.57	1.71	2.88	3.78E1	9.96E2	1.83E4	2.20E5	1.83E6	1.07	1.03
25.0	1.58	1.71	3.20	1.32E2	8.80E3	3.24E5	6.60E6	8.65E7	1.08	1.03
30.0	1.59	1.72	3.64	4.93E2	8.16E4	6.13E6	2.12E8	4.25E9	1.08	1.03
35.0	1.60	1.72	4.26	1.90E3	7.72E5	1.20E8	7.13E9	2.17E11	1.09	1.03
40.0	1.61	1.73	5.14	7.47E3	7.39E6	2.39E9	2.47E11	1.14E13	1.10	1.04
R(MFP)	ENERGY (MEV)									
	0.015									
0.5	1.00									
1.0	1.00									
2.0	1.00									
3.0	1.01									
4.0	1.01									
5.0	1.01									
6.0	1.01									
7.0	1.01									
8.0	1.01									
10.0	1.01									
15.0	1.01									
20.0	1.01									
25.0	1.01									
30.0	1.02									
35.0	1.02									
40.0	1.02									

Table A.2 (continued)

## EXPOSURE BUILDUP FACTORS IN 45-MFP THICK TIN

R(MFP)	ENERGY (MEV)									
	15	10	8	6	5	4	3	2	1.5	1
0.5	1.33	1.32	1.32	1.32	1.31	1.27	1.28	1.28	1.29	1.33
1.0	1.65	1.57	1.55	1.54	1.54	1.50	1.53	1.57	1.61	1.68
2.0	2.27	2.03	1.96	1.95	1.97	1.94	2.06	2.20	2.28	2.37
3.0	3.05	2.55	2.40	2.39	2.42	2.40	2.61	2.83	2.98	3.09
4.0	4.08	3.17	2.92	2.88	2.93	2.91	3.19	3.48	3.69	3.79
5.0	5.43	3.94	3.53	3.44	3.50	3.49	3.82	4.17	4.42	4.50
6.0	7.21	4.86	4.24	4.10	4.16	4.14	4.53	4.92	5.22	5.29
7.0	9.51	5.96	5.07	4.84	4.89	4.85	5.29	5.72	6.04	6.09
8.0	1.25E1	7.28	6.02	5.67	5.70	5.62	6.10	6.55	6.87	6.88
10.0	2.14E1	1.07E1	8.39	7.65	7.57	7.35	7.86	8.33	8.60	8.54
15.0	7.81E1	2.69E1	1.81E1	1.49E1	1.39E1	1.28E1	1.31E1	1.34E1	1.34E1	1.31E1
20.0	2.71E2	6.35E1	3.66E1	2.64E1	2.30E1	1.99E1	1.93E1	1.90E1	1.84E1	1.79E1
25.0	8.98E2	1.43E2	6.98E1	4.38E1	3.53E1	2.86E1	2.63E1	2.50E1	2.36E1	2.29E1
30.0	2.88E3	3.11E2	1.28E2	6.90E1	5.14E1	3.89E1	3.40E1	3.13E1	2.88E1	2.79E1
35.0	8.97E3	6.57E2	2.26E2	1.05E2	7.20E1	5.07E1	4.22E1	3.78E1	3.40E1	3.29E1
40.0	2.73E4	1.35E3	3.89E2	1.54E2	9.74E1	6.41E1	5.07E1	4.45E1	3.91E1	3.79E1
R(MFP)	ENERGY (MEV)									
	0.8	0.6	0.5	0.4	0.3	0.2	0.15	0.1	0.09	0.08
0.5	1.34	1.33	1.31	1.29	1.23	1.14	1.06	1.09	1.11	1.69
1.0	1.68	1.65	1.61	1.53	1.41	1.23	1.11	1.12	1.14	1.79
2.0	2.35	2.26	2.14	1.96	1.69	1.36	1.17	1.14	1.16	1.79
3.0	3.04	2.86	2.66	2.34	1.92	1.47	1.23	1.16	1.17	1.79
4.0	3.70	3.43	3.14	2.68	2.12	1.55	1.27	1.18	1.19	1.80
5.0	4.37	4.00	3.62	2.99	2.30	1.62	1.31	1.20	1.20	1.81
6.0	5.11	4.62	4.13	3.33	2.49	1.68	1.34	1.21	1.21	1.83
7.0	5.86	5.23	4.63	3.65	2.66	1.75	1.37	1.22	1.22	1.84
8.0	6.60	5.84	5.13	3.95	2.82	1.80	1.40	1.23	1.23	1.85
10.0	8.14	7.09	6.15	4.56	3.14	1.91	1.45	1.25	1.24	1.86
15.0	1.24E1	1.04E1	8.83	6.03	3.87	2.14	1.54	1.28	1.27	1.90
20.0	1.68E1	1.39E1	1.16E1	7.40	4.52	2.33	1.60	1.31	1.29	1.92
25.0	2.14E1	1.74E1	1.43E1	8.66	5.08	2.49	1.65	1.33	1.30	1.95
30.0	2.59E1	2.09E1	1.69E1	9.84	5.57	2.63	1.70	1.34	1.32	1.96
35.0	3.06E1	2.43E1	1.96E1	1.10E1	6.01	2.75	1.73	1.35	1.33	1.98
40.0	3.51E1	2.77E1	2.21E1	1.20E1	6.39	2.86	1.77	1.37	1.34	2.00
R(MFP)	ENERGY (MEV)									
	0.07	0.06	0.055	0.05	0.045	0.04	0.035	0.03	0.029	0.02
0.5	1.96	2.25	2.34	2.40	2.36	2.28	2.08	1.86	1.01	1.00
1.0	2.22	2.83	3.12	3.40	3.50	3.50	3.23	2.86	1.02	1.01
2.0	2.28	3.28	3.99	4.91	5.69	6.39	6.41	5.98	1.02	1.01
3.0	2.25	3.38	4.43	6.12	8.17	1.06E1	1.20E1	1.24E1	1.03	1.01
4.0	2.23	3.38	4.70	7.29	1.14E1	1.75E1	2.29E1	2.66E1	1.03	1.01
5.0	2.23	3.37	4.90	8.54	1.58E1	2.91E1	4.45E1	5.86E1	1.04	1.01
6.0	2.24	3.35	5.04	9.86	2.18E1	4.84E1	8.67E1	1.30E2	1.04	1.01
7.0	2.24	3.32	5.17	1.14E1	3.05E1	7.99E1	1.61E2	2.66E2	1.04	1.02
8.0	2.24	3.31	5.30	1.33E1	4.17E1	1.28E2	2.93E2	5.49E2	1.05	1.02
10.0	2.25	3.28	5.59	1.80E1	7.88E1	3.28E2	1.00E3	2.39E3	1.05	1.02
15.0	2.28	3.23	6.52	4.37E1	4.61E2	4.15E3	2.40E4	9.92E4	1.06	1.02
20.0	2.30	3.20	7.41	1.36E2	3.57E3	6.41E4	6.49E5	4.43E6	1.07	1.03
25.0	2.32	3.19	8.49	4.81E2	3.15E4	1.13E6	1.94E7	2.08E8	1.08	1.03
30.0	2.34	3.20	10.00	1.80E3	2.92E5	2.13E7	6.19E8	1.02E10	1.08	1.03
35.0	2.36	3.20	1.21E1	6.96E3	2.76E6	4.17E8	2.08E10	5.19E11	1.09	1.03
40.0	2.37	3.21	1.52E1	2.73E4	2.64E7	8.30E9	7.20E11	2.73E13	1.10	1.04
R(MFP)	ENERGY (MEV)									
	0.015									
0.5	1.00									
1.0	1.00									
2.0	1.00									
3.0	1.01									
4.0	1.01									
5.0	1.01									
6.0	1.01									
7.0	1.01									
8.0	1.01									
10.0	1.01									
15.0	1.01									
20.0	1.01									
25.0	1.01									
30.0	1.02									
35.0	1.02									
40.0	1.02									

Table A.2 (continued)

## DOSE EQUIVALENT BUILDUP FACTORS IN 45-MFP THICK TIN

R(MFP)	ENERGY (MEV)									
	15	10	8	6	5	4	3	2	1.5	1
0.5	1.39	1.38	1.37	1.36	1.36	1.30	1.30	1.30	1.32	1.37
1.0	1.76	1.67	1.63	1.61	1.61	1.54	1.57	1.61	1.67	1.75
2.0	2.45	2.17	2.07	2.05	2.07	2.01	2.13	2.28	2.39	2.50
3.0	3.31	2.74	2.55	2.51	2.56	2.48	2.70	2.94	3.15	3.28
4.0	4.44	3.43	3.11	3.03	3.10	3.02	3.30	3.62	3.92	4.03
5.0	5.94	4.27	3.77	3.63	3.72	3.61	3.97	4.35	4.70	4.80
6.0	7.90	5.28	4.54	4.32	4.42	4.29	4.70	5.13	5.57	5.66
7.0	1.05E1	6.50	5.43	5.11	5.21	5.03	5.49	5.96	6.45	6.52
8.0	1.38E1	7.95	6.47	6.00	6.07	5.83	6.34	6.83	7.34	7.37
10.0	2.37E1	1.18E1	9.04	8.11	8.09	7.64	8.18	8.70	9.21	9.17
15.0	8.65E1	2.97E1	1.96E1	1.58E1	1.49E1	1.34E1	1.37E1	1.40E1	1.44E1	1.41E1
20.0	3.00E2	7.02E1	3.97E1	2.82E1	2.47E1	2.08E1	2.02E1	1.99E1	1.98E1	1.93E1
25.0	9.97E2	1.59E2	7.59E1	4.67E1	3.80E1	2.99E1	2.75E1	2.62E1	2.54E1	2.47E1
30.0	3.20E3	3.45E2	1.39E2	7.37E1	5.55E1	4.06E1	3.55E1	3.28E1	3.10E1	3.01E1
35.0	9.97E3	7.29E2	2.46E2	1.12E2	7.77E1	5.31E1	4.41E1	3.97E1	3.66E1	3.55E1
40.0	3.03E4	1.50E3	4.24E2	1.64E2	1.05E2	6.71E1	5.31E1	4.67E1	4.21E1	4.09E1
R(MFP)	ENERGY (MEV)									
	0.8	0.6	0.5	0.4	0.3	0.2	0.15	0.1	0.09	0.08
0.5	1.37	1.36	1.34	1.31	1.24	1.15	1.07	1.10	1.11	1.63
1.0	1.75	1.71	1.66	1.57	1.43	1.25	1.11	1.12	1.14	1.72
2.0	2.48	2.35	2.23	2.01	1.71	1.38	1.18	1.15	1.16	1.72
3.0	3.23	3.00	2.78	2.41	1.96	1.49	1.24	1.17	1.18	1.73
4.0	3.94	3.60	3.29	2.76	2.16	1.57	1.28	1.19	1.19	1.74
5.0	4.66	4.20	3.79	3.08	2.34	1.64	1.32	1.21	1.20	1.75
6.0	5.47	4.86	4.34	3.43	2.53	1.71	1.36	1.22	1.21	1.76
7.0	6.27	5.50	4.87	3.76	2.71	1.77	1.39	1.23	1.22	1.77
8.0	7.07	6.14	5.40	4.07	2.87	1.83	1.42	1.24	1.23	1.78
10.0	8.74	7.47	6.48	4.70	3.19	1.93	1.46	1.26	1.24	1.80
15.0	1.33E1	1.10E1	9.31	6.23	3.94	2.17	1.55	1.29	1.27	1.83
20.0	1.81E1	1.47E1	1.22E1	7.64	4.60	2.36	1.62	1.32	1.29	1.86
25.0	2.30E1	1.84E1	1.51E1	8.95	5.18	2.53	1.67	1.34	1.31	1.88
30.0	2.80E1	2.20E1	1.79E1	1.02E1	5.68	2.67	1.72	1.35	1.32	1.89
35.0	3.30E1	2.57E1	2.07E1	1.13E1	6.12	2.79	1.75	1.37	1.33	1.91
40.0	3.79E1	2.93E1	2.34E1	1.24E1	6.51	2.90	1.79	1.38	1.34	1.92
R(MFP)	ENERGY (MEV)									
	0.07	0.06	0.055	0.05	0.045	0.04	0.035	0.03	0.029	0.02
0.5	1.84	2.05	2.14	2.23	2.17	2.08	1.97	1.82	1.01	1.00
1.0	2.07	2.54	2.82	3.10	3.16	3.12	3.00	2.77	1.02	1.01
2.0	2.12	2.92	3.57	4.42	5.05	5.58	5.84	5.74	1.02	1.01
3.0	2.10	3.01	3.95	5.49	7.20	9.17	1.09E1	1.18E1	1.03	1.01
4.0	2.09	3.01	4.18	6.53	1.00E1	1.50E1	2.07E1	2.54E1	1.03	1.01
5.0	2.09	3.01	4.36	7.63	1.39E1	2.49E1	4.01E1	5.59E1	1.04	1.01
6.0	2.09	2.99	4.49	8.81	1.91E1	4.15E1	7.80E1	1.24E2	1.04	1.01
7.0	2.09	2.97	4.60	1.02E1	2.67E1	6.85E1	1.45E2	2.54E2	1.04	1.02
8.0	2.10	2.95	4.72	1.19E1	3.65E1	1.10E2	2.64E2	5.24E2	1.05	1.02
10.0	2.11	2.93	4.98	1.61E1	6.90E1	2.82E2	9.06E2	2.28E3	1.05	1.02
15.0	2.14	2.89	5.81	3.93E1	4.08E2	3.59E3	2.18E4	9.51E4	1.06	1.02
20.0	2.16	2.87	6.60	1.23E2	3.17E3	5.59E4	5.93E5	4.26E6	1.07	1.03
25.0	2.17	2.86	7.56	4.34E2	2.80E4	9.88E5	1.78E7	2.01E8	1.08	1.03
30.0	2.19	2.86	8.90	1.63E3	2.60E5	1.87E7	5.70E8	9.91E9	1.08	1.03
35.0	2.20	2.87	1.08E1	6.30E3	2.46E6	3.67E8	1.92E10	5.06E11	1.09	1.03
40.0	2.22	2.88	1.35E1	2.47E4	2.35E7	7.29E9	6.66E11	2.66E13	1.10	1.04
R(MFP)	ENERGY (MEV)									
	0.015									
0.5	1.00									
1.0	1.00									
2.0	1.00									
3.0	1.01									
4.0	1.01									
5.0	1.01									
6.0	1.01									
7.0	1.01									
8.0	1.01									
10.0	1.01									
15.0	1.01									
20.0	1.01									
25.0	1.01									
30.0	1.02									
35.0	1.02									
40.0	1.02									

Table A.3 Gamma-ray buildup factors for point isotropic source  
in 45-mfp-thick lanthanum

ABSORBED DOSE BUILDUP FACTORS IN 45-MFP THICK LANTHANUM										
R(MFP)	ENERGY (MEV)									
	15	10	8	6	5	4	3	2	1.5	1
0.5	1.28	1.31	1.36	1.41	1.44	1.36	1.41	1.44	1.48	1.64
1.0	1.50	1.52	1.56	1.63	1.67	1.59	1.70	1.83	1.95	2.17
2.0	1.90	1.85	1.87	1.96	2.05	1.98	2.24	2.63	2.86	3.13
3.0	2.38	2.23	2.21	2.32	2.45	2.38	2.79	3.39	3.80	4.09
4.0	3.03	2.69	2.62	2.73	2.91	2.85	3.38	4.15	4.70	4.99
5.0	3.91	3.27	3.11	3.22	3.45	3.37	4.03	4.97	5.62	5.89
6.0	5.08	3.98	3.69	3.78	4.06	3.97	4.76	5.86	6.64	6.91
7.0	6.65	4.85	4.38	4.43	4.76	4.64	5.55	6.80	7.68	7.92
8.0	8.73	5.91	5.18	5.16	5.53	5.37	6.39	7.79	8.69	8.91
10.0	1.52E1	8.76	7.22	6.93	7.37	7.04	8.25	9.89	1.08E1	1.10E1
15.0	6.04E1	2.31E1	1.62E1	1.37E1	1.39E1	1.26E1	1.39E1	1.59E1	1.67E1	1.66E1
20.0	2.35E2	5.89E1	3.46E1	2.50E1	2.39E1	2.01E1	2.06E1	2.25E1	2.27E1	2.24E1
25.0	8.83E2	1.46E2	7.12E1	4.31E1	3.85E1	2.98E1	2.84E1	2.95E1	2.88E1	2.82E1
30.0	3.22E3	3.49E2	1.41E2	7.10E1	5.89E1	4.18E1	3.70E1	3.69E1	3.48E1	3.41E1
35.0	1.14E4	8.15E2	2.73E2	1.13E2	8.67E1	5.64E1	4.63E1	4.46E1	4.07E1	3.99E1
40.0	3.96E4	1.86E3	5.12E2	1.74E2	1.24E2	7.37E1	5.62E1	5.25E1	4.65E1	4.56E1
R(MFP)	ENERGY (MEV)									
	0.8	0.6	0.5	0.4	0.3	0.2	0.15	0.1	0.08	0.07
0.5	1.70	1.72	1.78	1.72	1.58	1.41	1.13	1.38	1.41	1.42
1.0	2.23	2.22	2.25	2.10	1.82	1.51	1.17	1.46	1.60	1.68
2.0	3.18	3.05	3.00	2.65	2.14	1.64	1.23	1.48	1.73	2.00
3.0	4.10	3.82	3.67	3.11	2.39	1.74	1.27	1.49	1.75	2.18
4.0	4.93	4.51	4.23	3.48	2.59	1.81	1.31	1.50	1.76	2.32
5.0	5.75	5.16	4.76	3.82	2.76	1.86	1.34	1.51	1.76	2.43
6.0	6.68	5.89	5.35	4.19	2.94	1.92	1.36	1.52	1.75	2.52
7.0	7.59	6.58	5.90	4.52	3.10	1.98	1.38	1.53	1.75	2.61
8.0	8.46	7.25	6.42	4.82	3.25	2.02	1.40	1.54	1.75	2.72
10.0	1.03E1	8.63	7.48	5.42	3.53	2.11	1.44	1.55	1.74	2.96
15.0	1.50E1	1.21E1	1.01E1	6.83	4.18	2.29	1.50	1.58	1.74	3.70
20.0	1.99E1	1.56E1	1.26E1	8.07	4.74	2.45	1.54	1.61	1.75	4.81
25.0	2.46E1	1.89E1	1.49E1	9.15	5.20	2.58	1.58	1.62	1.76	6.76
30.0	2.92E1	2.21E1	1.71E1	1.01E1	5.59	2.69	1.61	1.64	1.77	1.02E1
35.0	3.37E1	2.52E1	1.92E1	1.10E1	5.93	2.79	1.63	1.65	1.78	1.65E1
40.0	3.81E1	2.81E1	2.11E1	1.19E1	6.23	2.87	1.66	1.66	1.78	2.81E1
R(MFP)	ENERGY (MEV)									
	0.06	0.055	0.05	0.048	0.046	0.044	0.042	0.04	0.039	0.038
0.5	1.41	1.41	1.40	1.40	1.41	1.40	1.40	1.40	1.41	1.02
1.0	1.74	1.77	1.80	1.82	1.83	1.84	1.86	1.86	1.88	1.02
2.0	2.34	2.56	2.78	2.88	3.00	3.09	3.19	3.27	3.36	1.03
3.0	2.97	3.58	4.29	4.64	5.02	5.39	5.77	6.11	6.38	1.04
4.0	3.75	5.09	6.90	7.84	8.88	9.99	1.12E1	1.23E1	1.31E1	1.04
5.0	4.76	7.41	1.15E1	1.38E1	1.64E1	1.94E1	2.27E1	2.60E1	2.83E1	1.05
6.0	6.08	1.09E1	1.96E1	2.47E1	3.10E1	3.84E1	4.69E1	5.59E1	6.19E1	1.05
7.0	7.91	1.64E1	3.34E1	4.36E1	5.74E1	7.24E1	9.22E1	1.12E2	1.27E2	1.06
8.0	1.03E1	2.44E1	5.45E1	7.49E1	1.03E2	1.36E2	1.80E2	2.28E2	2.61E2	1.06
10.0	1.78E1	5.32E1	1.52E2	2.30E2	3.44E2	4.93E2	7.07E2	9.59E2	1.14E3	1.07
15.0	8.63E1	4.82E2	2.36E3	4.37E3	7.90E3	1.36E4	2.33E4	3.72E4	4.77E4	1.08
20.0	5.60E2	5.58E3	4.41E4	9.75E4	2.08E5	4.24E5	8.45E5	1.57E6	2.15E6	1.09
25.0	4.12E3	7.31E4	9.27E5	2.43E6	6.04E6	1.44E7	3.30E7	7.03E7	1.03E8	1.10
30.0	3.17E4	1.01E6	2.08E7	6.48E7	1.88E8	5.19E8	1.36E9	3.30E9	5.11E9	1.11
35.0	2.48E5	1.42E7	4.83E8	1.79E9	6.09E9	1.96E10	5.86E10	1.61E11	2.64E11	1.12
40.0	1.97E6	2.03E8	1.14E10	5.07E10	2.03E11	7.60E11	2.60E12	8.08E12	1.40E13	1.13
R(MFP)	ENERGY (MEV)									
	0.03	0.02	0.015							
0.5	1.01	1.00	1.00							
1.0	1.01	1.00	1.00							
2.0	1.02	1.01	1.00							
3.0	1.02	1.01	1.00							
4.0	1.02	1.01	1.00							
5.0	1.03	1.01	1.00							
6.0	1.03	1.01	1.00							
7.0	1.03	1.01	1.01							
8.0	1.03	1.01	1.01							
10.0	1.04	1.01	1.01							
15.0	1.04	1.02	1.01							
20.0	1.05	1.02	1.01							
25.0	1.06	1.02	1.01							
30.0	1.06	1.02	1.01							
35.0	1.06	1.02	1.01							
40.0	1.07	1.02	1.01							

Table A.3 (continued)

## EXPOSURE BUILDUP FACTORS IN 45-MFP THICK LANTHANUM

R(MFP)	ENERGY (MEV)									
	15	10	8	6	5	4	3	2	1.5	1
0.5	1.34	1.32	1.32	1.31	1.31	1.26	1.27	1.27	1.27	1.31
1.0	1.66	1.58	1.54	1.53	1.52	1.47	1.50	1.54	1.58	1.62
2.0	2.31	2.04	1.95	1.92	1.93	1.88	2.00	2.12	2.18	2.22
3.0	3.16	2.60	2.41	2.35	2.37	2.32	2.51	2.69	2.81	2.84
4.0	4.32	3.29	2.96	2.84	2.87	2.82	3.06	3.29	3.44	3.43
5.0	5.90	4.15	3.62	3.42	3.45	3.38	3.66	3.92	4.08	4.03
6.0	8.02	5.21	4.40	4.08	4.11	4.02	4.33	4.61	4.78	4.69
7.0	1.09E1	6.51	5.32	4.84	4.86	4.72	5.05	5.33	5.49	5.35
8.0	1.47E1	8.10	6.41	5.71	5.71	5.50	5.83	6.08	6.19	6.00
10.0	2.66E1	1.24E1	9.20	7.81	7.69	7.27	7.52	7.69	7.68	7.36
15.0	1.11E2	3.44E1	2.15E1	1.58E1	1.48E1	1.31E1	1.26E1	1.22E1	1.17E1	1.10E1
20.0	4.39E2	8.99E1	4.71E1	2.94E1	2.57E1	2.11E1	1.88E1	1.72E1	1.58E1	1.48E1
25.0	1.66E3	2.25E2	9.83E1	5.13E1	4.16E1	3.14E1	2.58E1	2.25E1	1.99E1	1.86E1
30.0	6.09E3	5.44E2	1.97E2	8.51E1	6.39E1	4.42E1	3.36E1	2.81E1	2.40E1	2.24E1
35.0	2.17E4	1.28E3	3.82E2	1.36E2	9.44E1	5.96E1	4.20E1	3.39E1	2.81E1	2.61E1
40.0	7.53E4	2.91E3	7.20E2	2.10E2	1.35E2	7.79E1	5.10E1	3.98E1	3.21E1	2.98E1
R(MFP)	ENERGY (MEV)									
	0.8	0.6	0.5	0.4	0.3	0.2	0.15	0.1	0.08	0.07
0.5	1.30	1.29	1.27	1.24	1.19	1.13	1.06	1.39	1.69	1.85
1.0	1.60	1.56	1.51	1.43	1.32	1.20	1.09	1.47	2.00	2.38
2.0	2.16	2.04	1.92	1.74	1.52	1.29	1.14	1.48	2.21	3.02
3.0	2.72	2.50	2.30	2.02	1.68	1.36	1.17	1.49	2.25	3.39
4.0	3.25	2.93	2.64	2.25	1.81	1.42	1.20	1.50	2.25	3.65
5.0	3.77	3.34	2.97	2.46	1.94	1.46	1.23	1.51	2.24	3.88
6.0	4.35	3.79	3.31	2.68	2.06	1.51	1.25	1.52	2.23	4.07
7.0	4.92	4.22	3.64	2.89	2.17	1.55	1.27	1.53	2.22	4.25
8.0	5.47	4.64	3.95	3.08	2.27	1.59	1.29	1.54	2.22	4.46
10.0	6.61	5.50	4.59	3.46	2.47	1.65	1.32	1.56	2.21	4.94
15.0	9.59	7.67	6.16	4.34	2.91	1.80	1.38	1.59	2.20	6.46
20.0	1.26E1	9.80	7.63	5.11	3.29	1.92	1.42	1.61	2.20	8.72
25.0	1.55E1	1.19E1	9.02	5.79	3.61	2.02	1.45	1.62	2.21	1.27E1
30.0	1.84E1	1.38E1	1.03E1	6.40	3.88	2.10	1.47	1.64	2.22	1.98E1
35.0	2.13E1	1.57E1	1.16E1	6.97	4.11	2.17	1.50	1.65	2.23	3.26E1
40.0	2.40E1	1.76E1	1.27E1	7.48	4.31	2.24	1.52	1.66	2.24	5.63E1
R(MFP)	ENERGY (MEV)									
	0.06	0.055	0.05	0.048	0.046	0.044	0.042	0.04	0.039	0.038
0.5	2.02	2.04	2.05	2.01	1.98	1.94	1.91	1.86	1.82	1.02
1.0	2.85	2.98	3.08	3.05	3.02	2.97	2.92	2.85	2.78	1.02
2.0	4.36	4.99	5.64	5.74	5.84	5.89	5.92	5.89	5.77	1.03
3.0	5.96	7.62	9.60	1.02E1	1.08E1	1.13E1	1.17E1	1.20E1	1.19E1	1.04
4.0	7.92	1.15E1	1.64E1	1.82E1	2.02E1	2.20E1	2.39E1	2.53E1	2.55E1	1.04
5.0	1.05E1	1.74E1	2.85E1	3.33E1	3.86E1	4.41E1	4.97E1	5.49E1	5.63E1	1.05
6.0	1.38E1	2.65E1	4.95E1	6.08E1	7.40E1	8.85E1	1.04E2	1.19E2	1.24E2	1.05
7.0	1.84E1	4.04E1	8.56E1	1.09E2	1.38E2	1.68E2	2.06E2	2.41E2	2.56E2	1.06
8.0	2.44E1	6.11E1	1.41E2	1.87E2	2.49E2	3.16E2	4.03E2	4.89E2	5.28E2	1.06
10.0	4.33E1	1.35E2	3.96E2	5.78E2	8.36E2	1.15E3	1.59E3	2.06E3	2.30E3	1.07
15.0	2.16E2	1.24E3	6.16E3	1.10E4	1.92E4	3.19E4	5.22E4	8.01E4	9.65E4	1.08
20.0	1.41E3	1.43E4	1.15E5	2.46E5	5.05E5	9.90E5	1.90E6	3.38E6	4.36E6	1.09
25.0	1.04E4	1.87E5	2.42E6	6.12E6	1.47E7	3.35E7	7.39E7	1.51E8	2.08E8	1.10
30.0	8.00E4	2.59E6	5.43E7	1.63E8	4.55E8	1.21E9	3.05E9	7.08E9	1.03E10	1.11
35.0	6.27E5	3.65E7	1.26E9	4.52E9	1.48E10	4.56E10	1.31E11	3.45E11	5.33E11	1.12
40.0	4.96E6	5.20E8	2.98E10	1.28E11	4.92E11	1.77E12	5.83E12	1.74E13	2.83E13	1.13
R(MFP)	ENERGY (MEV)									
	0.03	0.02	0.015							
0.5	1.01	1.00	1.00							
1.0	1.01	1.00	1.00							
2.0	1.02	1.01	1.00							
3.0	1.02	1.01	1.00							
4.0	1.02	1.01	1.00							
5.0	1.03	1.01	1.00							
6.0	1.03	1.01	1.00							
7.0	1.03	1.01	1.01							
8.0	1.03	1.01	1.01							
10.0	1.04	1.01	1.01							
15.0	1.04	1.02	1.01							
20.0	1.05	1.02	1.01							
25.0	1.06	1.02	1.01							
30.0	1.06	1.02	1.01							
35.0	1.06	1.02	1.01							
40.0	1.07	1.02	1.01							

Table A.3 (continued)

## DOSE EQUIVALENT BUILDUP FACTORS IN 45-MFP THICK LANTHANUM

R(MFP)	ENERGY (MEV)									
	15	10	8	6	5	4	3	2	1.5	1
0.5	1.40	1.38	1.37	1.36	1.35	1.29	1.29	1.29	1.30	1.34
1.0	1.77	1.67	1.62	1.59	1.59	1.51	1.54	1.57	1.63	1.67
2.0	2.48	2.18	2.06	2.01	2.03	1.94	2.05	2.18	2.28	2.32
3.0	3.43	2.79	2.56	2.46	2.50	2.39	2.58	2.78	2.95	2.98
4.0	4.71	3.55	3.15	2.98	3.03	2.91	3.16	3.40	3.62	3.61
5.0	6.45	4.49	3.86	3.59	3.65	3.49	3.78	4.06	4.31	4.24
6.0	8.79	5.66	4.70	4.29	4.36	4.15	4.48	4.78	5.06	4.95
7.0	1.19E1	7.09	5.70	5.10	5.17	4.89	5.23	5.53	5.81	5.65
8.0	1.62E1	8.85	6.88	6.02	6.07	5.69	6.03	6.31	6.57	6.34
10.0	2.93E1	1.36E1	9.90	8.25	8.20	7.54	7.80	7.98	8.15	7.79
15.0	1.23E2	3.78E1	2.32E1	1.68E1	1.58E1	1.36E1	1.31E1	1.27E1	1.24E1	1.17E1
20.0	4.86E2	9.92E1	5.11E1	3.13E1	2.76E1	2.19E1	1.95E1	1.79E1	1.68E1	1.57E1
25.0	1.85E3	2.49E2	1.07E2	5.46E1	4.47E1	3.27E1	2.68E1	2.35E1	2.13E1	1.97E1
30.0	6.76E3	6.02E2	2.14E2	9.07E1	6.88E1	4.60E1	3.49E1	2.93E1	2.57E1	2.37E1
35.0	2.41E4	1.41E3	4.16E2	1.45E2	1.02E2	6.22E1	4.38E1	3.53E1	3.00E1	2.78E1
40.0	8.36E4	3.23E3	7.84E2	2.24E2	1.45E2	8.13E1	5.31E1	4.15E1	3.43E1	3.17E1
R(MFP)	ENERGY (MEV)									
	0.8	0.6	0.5	0.4	0.3	0.2	0.15	0.1	0.08	0.07
0.5	1.34	1.31	1.30	1.26	1.20	1.16	1.07	1.44	1.70	1.82
1.0	1.66	1.60	1.55	1.46	1.34	1.23	1.11	1.53	2.01	2.34
2.0	2.27	2.11	1.99	1.78	1.54	1.32	1.15	1.55	2.22	2.95
3.0	2.87	2.60	2.39	2.06	1.71	1.40	1.19	1.55	2.26	3.32
4.0	3.43	3.04	2.74	2.30	1.85	1.45	1.22	1.56	2.26	3.58
5.0	3.99	3.48	3.09	2.53	1.97	1.50	1.25	1.58	2.25	3.81
6.0	4.60	3.94	3.45	2.75	2.09	1.54	1.27	1.59	2.25	4.00
7.0	5.21	4.40	3.79	2.96	2.21	1.59	1.29	1.60	2.23	4.19
8.0	5.80	4.84	4.12	3.16	2.31	1.62	1.31	1.61	2.23	4.40
10.0	7.02	5.74	4.79	3.55	2.51	1.69	1.34	1.62	2.22	4.89
15.0	1.02E1	8.02	6.43	4.46	2.96	1.84	1.40	1.65	2.21	6.43
20.0	1.34E1	1.03E1	7.98	5.25	3.35	1.96	1.44	1.68	2.21	8.71
25.0	1.66E1	1.24E1	9.43	5.94	3.68	2.07	1.47	1.69	2.22	1.27E1
30.0	1.97E1	1.45E1	1.08E1	6.58	3.95	2.15	1.50	1.71	2.23	1.99E1
35.0	2.27E1	1.65E1	1.21E1	7.16	4.19	2.23	1.52	1.72	2.24	3.29E1
40.0	2.56E1	1.84E1	1.33E1	7.69	4.39	2.29	1.54	1.74	2.25	5.69E1
R(MFP)	ENERGY (MEV)									
	0.06	0.055	0.05	0.048	0.046	0.044	0.042	0.04	0.039	0.038
0.5	1.95	1.98	2.01	1.97	1.94	1.90	1.86	1.81	1.78	1.02
1.0	2.71	2.87	3.01	2.97	2.93	2.87	2.81	2.74	2.69	1.02
2.0	4.12	4.78	5.48	5.56	5.62	5.65	5.65	5.59	5.53	1.03
3.0	5.61	7.27	9.31	9.82	1.03E1	1.08E1	1.11E1	1.13E1	1.13E1	1.04
4.0	7.45	1.10E1	1.59E1	1.76E1	1.93E1	2.10E1	2.26E1	2.39E1	2.43E1	1.04
5.0	9.86	1.66E1	2.76E1	3.21E1	3.70E1	4.20E1	4.71E1	5.16E1	5.35E1	1.05
6.0	1.30E1	2.53E1	4.81E1	5.88E1	7.10E1	8.44E1	9.87E1	1.12E2	1.18E2	1.05
7.0	1.74E1	3.87E1	8.33E1	1.05E2	1.33E2	1.60E2	1.95E2	2.27E2	2.44E2	1.06
8.0	2.30E1	5.85E1	1.37E2	1.82E2	2.40E2	3.02E2	3.83E2	4.61E2	5.03E2	1.06
10.0	4.10E1	1.30E2	3.87E2	5.61E2	8.06E2	1.10E3	1.51E3	1.95E3	2.20E3	1.07
15.0	2.08E2	1.20E3	6.09E3	1.08E4	1.87E4	3.08E4	5.00E4	7.61E4	9.25E4	1.08
20.0	1.36E3	1.40E4	1.15E5	2.43E5	4.95E5	9.62E5	1.83E6	3.22E6	4.20E6	1.09
25.0	1.01E4	1.84E5	2.42E6	6.09E6	1.45E7	3.28E7	7.16E7	1.45E8	2.01E8	1.10
30.0	7.75E4	2.55E6	5.45E7	1.63E8	4.51E8	1.19E9	2.97E9	6.83E9	1.01E10	1.11
35.0	6.07E5	3.60E7	1.27E9	4.52E9	1.47E10	4.50E10	1.28E11	3.34E11	5.21E11	1.12
40.0	4.81E6	5.13E8	3.00E10	1.28E11	4.90E11	1.75E12	5.72E12	1.69E13	2.78E13	1.12
R(MFP)	ENERGY (MEV)									
	0.03	0.02	0.015							
0.5	1.01	1.00	1.00							
1.0	1.01	1.00	1.00							
2.0	1.02	1.01	1.00							
3.0	1.02	1.01	1.00							
4.0	1.02	1.01	1.00							
5.0	1.03	1.01	1.00							
6.0	1.03	1.01	1.00							
7.0	1.03	1.01	1.01							
8.0	1.03	1.01	1.01							
10.0	1.04	1.01	1.01							
15.0	1.04	1.02	1.01							
20.0	1.05	1.02	1.01							
25.0	1.06	1.02	1.01							
30.0	1.06	1.02	1.01							
35.0	1.06	1.02	1.01							
40.0	1.07	1.02	1.01							

Table A.4 Gamma-ray buildup factors for point isotropic source  
in 45-mfp-thick gadolinium

## ABSORBED DOSE BUILDUP FACTORS IN 45-MFP THICK GADOLINIUM

R(MFP)	ENERGY (MEV)									
	15	10	8	6	5	4	3	2	1.5	1
0.5	1.30	1.33	1.37	1.42	1.45	1.37	1.42	1.45	1.48	1.59
1.0	1.52	1.54	1.57	1.63	1.67	1.57	1.68	1.81	1.92	2.05
2.0	1.93	1.88	1.88	1.94	2.03	1.92	2.17	2.53	2.74	2.86
3.0	2.46	2.28	2.23	2.30	2.41	2.29	2.67	3.20	3.55	3.63
4.0	3.18	2.79	2.65	2.71	2.86	2.73	3.22	3.88	4.32	4.33
5.0	4.17	3.42	3.16	3.18	3.38	3.22	3.82	4.60	5.10	5.02
6.0	5.51	4.21	3.76	3.74	3.97	3.78	4.49	5.38	5.95	5.80
7.0	7.33	5.18	4.48	4.38	4.64	4.41	5.22	6.20	6.81	6.55
8.0	9.79	6.38	5.33	5.11	5.40	5.10	6.00	7.05	7.64	7.28
10.0	1.76E1	9.68	7.52	6.89	7.20	6.69	7.71	8.83	9.37	8.78
15.0	7.67E1	2.72E1	1.74E1	1.38E1	1.37E1	1.20E1	1.29E1	1.38E1	1.39E1	1.27E1
20.0	3.26E2	7.41E1	3.88E1	2.60E1	2.41E1	1.94E1	1.92E1	1.92E1	1.85E1	1.65E1
25.0	1.34E3	1.96E2	8.35E1	4.63E1	3.96E1	2.93E1	2.65E1	2.48E1	2.30E1	2.02E1
30.0	5.33E3	5.04E2	1.74E2	7.91E1	6.21E1	4.18E1	3.47E1	3.06E1	2.74E1	2.39E1
35.0	2.07E4	1.26E3	3.53E2	1.31E2	9.38E1	5.75E1	4.38E1	3.66E1	3.16E1	2.74E1
40.0	7.82E4	3.08E3	6.98E2	2.09E2	1.37E2	7.64E1	5.35E1	4.26E1	3.57E1	3.08E1
R(MFP)	ENERGY (MEV)									
	0.8	0.6	0.5	0.4	0.3	0.2	0.15	0.1	0.09	0.08
0.5	1.63	1.60	1.67	1.60	1.49	1.40	1.37	1.44	1.45	1.44
1.0	2.07	1.99	2.03	1.88	1.65	1.47	1.42	1.64	1.71	1.77
2.0	2.82	2.61	2.57	2.26	1.87	1.56	1.46	1.80	2.02	2.31
3.0	3.51	3.16	3.03	2.56	2.04	1.63	1.49	1.84	2.19	2.79
4.0	4.12	3.62	3.40	2.80	2.16	1.67	1.52	1.85	2.31	3.31
5.0	4.70	4.06	3.75	3.01	2.27	1.71	1.55	1.86	2.41	3.91
6.0	5.35	4.53	4.13	3.23	2.39	1.75	1.57	1.86	2.48	4.61
7.0	5.96	4.98	4.47	3.43	2.49	1.79	1.59	1.85	2.56	5.50
8.0	6.55	5.40	4.79	3.61	2.58	1.82	1.60	1.85	2.64	6.67
10.0	7.73	6.25	5.44	3.96	2.75	1.87	1.63	1.85	2.81	9.74
15.0	1.07E1	8.30	6.94	4.74	3.14	2.00	1.69	1.85	3.38	3.20E1
20.0	1.34E1	1.02E1	8.29	5.39	3.45	2.09	1.73	1.85	4.02	1.38E2
25.0	1.60E1	1.19E1	9.48	5.94	3.71	2.18	1.76	1.86	4.97	6.70E2
30.0	1.85E1	1.35E1	1.06E1	6.42	3.93	2.25	1.78	1.87	6.49	3.43E3
35.0	2.08E1	1.50E1	1.16E1	6.86	4.11	2.31	1.80	1.88	8.93	1.80E4
40.0	2.30E1	1.64E1	1.25E1	7.25	4.27	2.36	1.82	1.89	1.30E1	9.60E4
R(MFP)	ENERGY (MEV)									
	0.075	0.07	0.065	0.06	0.058	0.056	0.054	0.052	0.051	0.05
0.5	1.44	1.44	1.44	1.43	1.43	1.44	1.44	1.44	1.45	1.02
1.0	1.81	1.84	1.86	1.87	1.89	1.91	1.93	1.94	1.95	1.03
2.0	2.48	2.67	2.86	3.03	3.14	3.25	3.35	3.44	3.50	1.04
3.0	3.22	3.75	4.34	4.97	5.31	5.68	6.04	6.37	6.58	1.05
4.0	4.16	5.31	6.78	8.53	9.47	1.05E1	1.16E1	1.26E1	1.32E1	1.06
5.0	5.41	7.69	1.09E1	1.53E1	1.76E1	2.03E1	2.31E1	2.60E1	2.78E1	1.07
6.0	7.08	1.13E1	1.80E1	2.78E1	3.33E1	3.98E1	4.70E1	5.46E1	5.92E1	1.07
7.0	9.47	1.68E1	2.96E1	4.97E1	6.18E1	7.45E1	9.11E1	1.10E2	1.19E2	1.08
8.0	1.26E1	2.49E1	4.75E1	8.66E1	1.11E2	1.39E2	1.75E2	2.17E2	2.39E2	1.09
10.0	2.30E1	5.40E1	1.25E2	2.73E2	3.75E2	4.97E2	6.67E2	8.76E2	9.91E2	1.10
15.0	1.28E2	4.86E2	1.72E3	5.58E3	8.83E3	1.34E4	2.06E4	3.08E4	3.71E4	1.12
20.0	9.39E2	5.61E3	2.91E4	1.34E5	2.39E5	4.12E5	7.09E5	1.19E6	1.52E6	1.13
25.0	7.75E3	7.27E4	5.54E5	3.57E6	7.17E6	1.38E7	2.65E7	4.93E7	6.65E7	1.15
30.0	6.66E4	9.87E5	1.12E7	1.01E8	2.29E8	4.93E8	1.05E9	2.16E9	3.06E9	1.16
35.0	5.83E5	1.37E7	2.32E8	2.98E9	7.59E9	1.83E10	4.33E10	9.84E10	1.47E11	1.17
40.0	5.16E6	1.91E8	4.88E9	8.95E10	2.58E11	7.00E11	1.84E12	4.63E12	7.24E12	1.18
R(MFP)	ENERGY (MEV)									
	0.04	0.03	0.02	0.015						
0.5	1.01	1.01	1.00	1.00						
1.0	1.02	1.01	1.00	1.00						
2.0	1.02	1.01	1.00	1.00						
3.0	1.03	1.01	1.01	1.00						
4.0	1.03	1.02	1.01	1.00						
5.0	1.04	1.02	1.01	1.00						
6.0	1.04	1.02	1.01	1.00						
7.0	1.04	1.02	1.01	1.00						
8.0	1.05	1.02	1.01	1.00						
10.0	1.05	1.02	1.01	1.00						
15.0	1.06	1.03	1.01	1.01						
20.0	1.07	1.04	1.01	1.01						
25.0	1.08	1.04	1.01	1.01						
30.0	1.09	1.04	1.01	1.01						
35.0	1.09	1.04	1.02	1.01						
40.0	1.10	1.05	1.02	1.01						

Table A.4 (continued)

## EXPOSURE BUILDUP FACTORS IN 45-MFP THICK GADOLINIUM

R(MFP)	ENERGY (MEV)									
	15	10	8	6	5	4	3	2	1.5	1
0.5	1.34	1.32	1.31	1.30	1.29	1.25	1.25	1.25	1.26	1.27
1.0	1.67	1.57	1.53	1.50	1.49	1.43	1.46	1.50	1.53	1.54
2.0	2.35	2.05	1.93	1.88	1.87	1.81	1.91	2.02	2.06	2.04
3.0	3.28	2.65	2.41	2.30	2.29	2.21	2.38	2.52	2.60	2.54
4.0	4.58	3.39	2.97	2.78	2.77	2.67	2.88	3.04	3.12	3.00
5.0	6.36	4.33	3.65	3.34	3.32	3.20	3.43	3.59	3.66	3.47
6.0	8.79	5.50	4.46	3.99	3.95	3.79	4.04	4.18	4.23	3.97
7.0	1.21E1	6.96	5.43	4.73	4.67	4.45	4.70	4.79	4.81	4.47
8.0	1.67E1	8.76	6.58	5.59	5.45	5.18	5.41	5.43	5.38	4.95
10.0	3.12E1	1.38E1	9.56	7.69	7.40	6.85	6.96	6.77	6.56	5.95
15.0	1.42E2	4.06E1	2.31E1	1.59E1	1.44E1	1.25E1	1.16E1	1.05E1	9.64	8.49
20.0	6.13E2	1.13E2	5.29E1	3.04E1	2.55E1	2.03E1	1.73E1	1.45E1	1.27E1	1.10E1
25.0	2.54E3	3.04E2	1.15E2	5.49E1	4.23E1	3.07E1	2.39E1	1.86E1	1.58E1	1.35E1
30.0	1.02E4	7.85E2	2.43E2	9.43E1	6.66E1	4.40E1	3.13E1	2.30E1	1.87E1	1.58E1
35.0	3.94E4	1.97E3	4.94E2	1.56E2	1.01E2	6.05E1	3.94E1	2.74E1	2.16E1	1.82E1
40.0	1.50E5	4.83E3	9.80E2	2.51E2	1.48E2	8.05E1	4.81E1	3.19E1	2.44E1	2.04E1
R(MFP)	ENERGY (MEV)									
	0.8	0.6	0.5	0.4	0.3	0.2	0.15	0.1	0.09	0.08
0.5	1.27	1.24	1.22	1.19	1.15	1.11	1.14	1.41	1.51	1.64
1.0	1.52	1.46	1.41	1.34	1.24	1.16	1.17	1.60	1.82	2.12
2.0	1.97	1.83	1.72	1.56	1.38	1.23	1.20	1.75	2.18	2.90
3.0	2.39	2.17	1.99	1.75	1.49	1.27	1.23	1.79	2.38	3.61
4.0	2.79	2.47	2.22	1.90	1.58	1.31	1.25	1.80	2.52	4.37
5.0	3.17	2.77	2.45	2.04	1.66	1.34	1.27	1.81	2.63	5.27
6.0	3.58	3.07	2.67	2.18	1.74	1.37	1.29	1.81	2.72	6.33
7.0	3.97	3.36	2.89	2.31	1.81	1.40	1.30	1.81	2.81	7.69
8.0	4.35	3.63	3.09	2.43	1.88	1.42	1.32	1.81	2.91	9.45
10.0	5.11	4.19	3.50	2.66	2.00	1.47	1.34	1.80	3.13	1.42E1
15.0	6.99	5.52	4.44	3.17	2.28	1.56	1.38	1.80	3.82	4.84E1
20.0	8.77	6.76	5.28	3.60	2.50	1.63	1.41	1.81	4.61	2.11E2
25.0	1.04E1	7.89	6.03	3.96	2.68	1.70	1.44	1.81	5.78	1.04E3
30.0	1.20E1	8.93	6.72	4.28	2.84	1.75	1.46	1.82	7.64	5.31E3
35.0	1.35E1	9.91	7.35	4.57	2.97	1.80	1.47	1.83	1.07E1	2.79E4
40.0	1.49E1	1.08E1	7.93	4.83	3.08	1.84	1.49	1.84	1.56E1	1.49E5
R(MFP)	ENERGY (MEV)									
	0.075	0.07	0.065	0.06	0.058	0.056	0.054	0.052	0.051	0.05
0.5	1.68	1.72	1.77	1.81	1.81	1.80	1.80	1.78	1.78	1.02
1.0	2.24	2.37	2.51	2.65	2.66	2.68	2.68	2.67	2.67	1.03
2.0	3.29	3.76	4.29	4.87	5.00	5.14	5.25	5.32	5.38	1.04
3.0	4.44	5.54	6.92	8.58	9.08	9.62	1.01E1	1.05E1	1.08E1	1.05
4.0	5.91	8.16	1.13E1	1.54E1	1.69E1	1.85E1	2.01E1	2.16E1	2.24E1	1.06
5.0	7.89	1.22E1	1.87E1	2.84E1	3.23E1	3.66E1	4.11E1	4.54E1	4.80E1	1.06
6.0	1.06E1	1.82E1	3.13E1	5.25E1	6.20E1	7.29E1	8.45E1	9.62E1	1.03E2	1.07
7.0	1.44E1	2.75E1	5.22E1	9.49E1	1.16E2	1.37E2	1.65E2	1.95E2	2.09E2	1.08
8.0	1.94E1	4.12E1	8.46E1	1.66E2	2.10E2	2.57E2	3.18E2	3.87E2	4.21E2	1.08
10.0	3.61E1	9.09E1	2.25E2	5.30E2	7.13E2	9.27E2	1.22E3	1.57E3	1.75E3	1.09
15.0	2.07E2	8.38E2	3.16E3	1.10E4	1.70E4	2.53E4	3.79E4	5.54E4	6.62E4	1.11
20.0	1.53E3	9.76E3	5.40E4	2.66E5	4.66E5	7.84E5	1.32E6	2.16E6	2.73E6	1.13
25.0	1.27E4	1.27E5	1.03E6	7.14E6	1.41E7	2.65E7	4.97E7	9.03E7	1.20E8	1.14
30.0	1.09E5	1.73E6	2.09E7	2.04E8	4.51E8	9.51E8	1.98E9	3.98E9	5.58E9	1.15
35.0	9.58E5	2.39E7	4.35E8	6.01E9	1.50E10	3.55E10	8.21E10	1.82E11	2.69E11	1.16
40.0	8.49E6	3.35E8	9.15E9	1.81E11	5.11E11	1.36E12	3.50E12	8.60E12	1.33E13	1.17
R(MFP)	ENERGY (MEV)									
	0.04	0.03	0.02	0.015						
0.5	1.01	1.01	1.00	1.00						
1.0	1.02	1.01	1.00	1.00						
2.0	1.02	1.01	1.00	1.00						
3.0	1.03	1.01	1.01	1.00						
4.0	1.03	1.02	1.01	1.00						
5.0	1.04	1.02	1.01	1.00						
6.0	1.04	1.02	1.01	1.00						
7.0	1.04	1.02	1.01	1.00						
8.0	1.05	1.02	1.01	1.00						
10.0	1.05	1.02	1.01	1.00						
15.0	1.06	1.03	1.01	1.01						
20.0	1.07	1.04	1.01	1.01						
25.0	1.08	1.04	1.01	1.01						
30.0	1.09	1.04	1.01	1.01						
35.0	1.09	1.04	1.02	1.01						
40.0	1.10	1.05	1.02	1.01						

Table A.4 (continued)

## DOSE EQUIVALENT BUILDUP FACTORS IN 45-MFP THICK GADOLINIUM

R(MFP)	ENERGY (MEV)									
	15	10	8	6	5	4	3	2	1.5	1
0.5	1.40	1.37	1.36	1.34	1.33	1.27	1.27	1.27	1.28	1.30
1.0	1.77	1.66	1.60	1.56	1.55	1.47	1.50	1.53	1.57	1.59
2.0	2.52	2.18	2.04	1.96	1.96	1.85	1.96	2.07	2.14	2.12
3.0	3.54	2.83	2.54	2.40	2.41	2.27	2.44	2.59	2.71	2.64
4.0	4.97	3.65	3.15	2.90	2.92	2.75	2.96	3.13	3.26	3.13
5.0	6.93	4.68	3.88	3.49	3.50	3.29	3.53	3.69	3.83	3.62
6.0	9.61	5.96	4.75	4.18	4.18	3.90	4.16	4.30	4.44	4.15
7.0	1.33E1	7.56	5.80	4.97	4.94	4.58	4.84	4.93	5.05	4.67
8.0	1.83E1	9.55	7.04	5.88	5.81	5.34	5.57	5.59	5.66	5.18
10.0	3.43E1	1.51E1	1.03E1	8.10	7.87	7.07	7.17	6.98	6.91	6.23
15.0	1.57E2	4.45E1	2.49E1	1.68E1	1.54E1	1.29E1	1.20E1	1.08E1	1.02E1	8.91
20.0	6.77E2	1.25E2	5.71E1	3.23E1	2.73E1	2.10E1	1.79E1	1.49E1	1.35E1	1.16E1
25.0	2.80E3	3.34E2	1.25E2	5.82E1	4.53E1	3.18E1	2.47E1	1.93E1	1.67E1	1.41E1
30.0	1.12E4	8.66E2	2.63E2	1.00E2	7.14E1	4.56E1	3.24E1	2.38E1	1.98E1	1.66E1
35.0	4.36E4	2.18E3	5.36E2	1.66E2	1.08E2	6.28E1	4.08E1	2.84E1	2.28E1	1.91E1
40.0	1.66E5	5.33E3	1.06E3	2.67E2	1.59E2	8.36E1	4.98E1	3.30E1	2.58E1	2.14E1
R(MFP)	ENERGY (MEV)									
	0.8	0.6	0.5	0.4	0.3	0.2	0.15	0.1	0.09	0.08
0.5	1.29	1.26	1.24	1.20	1.16	1.14	1.19	1.49	1.58	1.67
1.0	1.56	1.49	1.44	1.36	1.26	1.19	1.23	1.72	1.93	2.18
2.0	2.04	1.88	1.76	1.59	1.40	1.26	1.26	1.90	2.33	3.00
3.0	2.50	2.23	2.05	1.78	1.51	1.31	1.29	1.94	2.55	3.75
4.0	2.91	2.55	2.29	1.94	1.61	1.35	1.31	1.95	2.71	4.56
5.0	3.32	2.85	2.53	2.08	1.69	1.38	1.33	1.96	2.83	5.50
6.0	3.75	3.17	2.76	2.23	1.77	1.41	1.35	1.96	2.94	6.61
7.0	4.16	3.47	2.99	2.36	1.84	1.44	1.36	1.95	3.04	8.03
8.0	4.57	3.76	3.20	2.48	1.91	1.46	1.38	1.95	3.15	9.88
10.0	5.38	4.33	3.62	2.72	2.04	1.51	1.40	1.95	3.39	1.48E1
15.0	7.37	5.72	4.60	3.24	2.31	1.60	1.45	1.94	4.16	5.05E1
20.0	9.24	7.00	5.47	3.68	2.54	1.68	1.48	1.95	5.03	2.20E2
25.0	1.10E1	8.17	6.25	4.05	2.73	1.74	1.51	1.95	6.34	1.08E3
30.0	1.27E1	9.26	6.97	4.37	2.88	1.80	1.53	1.96	8.41	5.54E3
35.0	1.43E1	1.03E1	7.63	4.67	3.02	1.85	1.54	1.97	1.18E1	2.91E4
40.0	1.58E1	1.12E1	8.23	4.93	3.13	1.89	1.56	1.98	1.73E1	1.55E5
R(MFP)	ENERGY (MEV)									
	0.075	0.07	0.065	0.06	0.058	0.056	0.054	0.052	0.051	0.05
0.5	1.70	1.74	1.77	1.79	1.79	1.80	1.80	1.79	1.79	1.02
1.0	2.29	2.40	2.51	2.62	2.64	2.66	2.68	2.68	2.69	1.03
2.0	3.38	3.81	4.28	4.78	4.94	5.10	5.25	5.36	5.44	1.04
3.0	4.57	5.62	6.90	8.39	8.95	9.54	1.01E1	1.06E1	1.09E1	1.05
4.0	6.09	8.28	1.12E1	1.51E1	1.67E1	1.84E1	2.01E1	2.17E1	2.27E1	1.06
5.0	8.13	1.23E1	1.87E1	2.77E1	3.17E1	3.63E1	4.11E1	4.58E1	4.86E1	1.07
6.0	1.09E1	1.85E1	3.12E1	5.12E1	6.09E1	7.22E1	8.44E1	9.69E1	1.05E2	1.07
7.0	1.48E1	2.79E1	5.19E1	9.25E1	1.14E2	1.36E2	1.64E2	1.96E2	2.11E2	1.08
8.0	2.00E1	4.17E1	8.41E1	1.62E2	2.06E2	2.54E2	3.17E2	3.89E2	4.26E2	1.08
10.0	3.71E1	9.20E1	2.24E2	5.15E2	6.99E2	9.16E2	1.21E3	1.57E3	1.77E3	1.09
15.0	2.12E2	8.45E2	3.12E3	1.06E4	1.66E4	2.50E4	3.77E4	5.57E4	6.67E4	1.11
20.0	1.57E3	9.82E3	5.33E4	2.57E5	4.54E5	7.71E5	1.31E6	2.17E6	2.75E6	1.13
25.0	1.30E4	1.28E5	1.02E6	6.89E6	1.37E7	2.60E7	4.92E7	9.03E7	1.21E8	1.14
30.0	1.12E5	1.73E6	2.06E7	1.97E8	4.38E8	9.33E8	1.96E9	3.97E9	5.60E9	1.16
35.0	9.80E5	2.40E7	4.28E8	5.79E9	1.46E10	3.48E10	8.11E10	1.82E11	2.69E11	1.17
40.0	8.69E6	3.37E8	9.00E9	1.74E11	4.96E11	1.33E12	3.46E12	8.57E12	1.33E13	1.17
R(MFP)	ENERGY (MEV)									
	0.04	0.03	0.02	0.015						
0.5	1.01	1.01	1.00	1.00						
1.0	1.02	1.01	1.00	1.00						
2.0	1.02	1.01	1.00	1.00						
3.0	1.03	1.01	1.01	1.00						
4.0	1.03	1.02	1.01	1.00						
5.0	1.04	1.02	1.01	1.00						
6.0	1.04	1.02	1.01	1.00						
7.0	1.04	1.02	1.01	1.00						
8.0	1.05	1.02	1.01	1.00						
10.0	1.05	1.02	1.01	1.00						
15.0	1.06	1.03	1.01	1.01						
20.0	1.07	1.04	1.01	1.01						
25.0	1.08	1.04	1.01	1.01						
30.0	1.09	1.04	1.01	1.01						
35.0	1.09	1.04	1.02	1.01						
40.0	1.10	1.05	1.02	1.01						

Table A.5 Gamma-ray buildup factors for point isotropic source  
in 45-mfp-thick tungsten

ABSORBED DOSE BUILDUP FACTORS IN 45-MFP THICK TUNGSTEN										
R(MFP)	ENERGY (MEV)									
	15	10	8	6	5	4	3	2	1.5	1
0.5	1.28	1.31	1.35	1.40	1.42	1.38	1.43	1.45	1.47	1.52
1.0	1.51	1.51	1.53	1.58	1.60	1.54	1.64	1.77	1.87	1.89
2.0	1.91	1.84	1.82	1.87	1.91	1.84	2.07	2.39	2.55	2.48
3.0	2.45	2.24	2.16	2.20	2.25	2.18	2.52	2.96	3.20	3.03
4.0	3.21	2.76	2.58	2.58	2.64	2.57	3.01	3.53	3.79	3.50
5.0	4.25	3.41	3.07	3.03	3.08	3.02	3.54	4.13	4.39	3.95
6.0	5.70	4.23	3.66	3.55	3.60	3.53	4.13	4.77	5.04	4.45
7.0	7.71	5.26	4.38	4.15	4.18	4.09	4.76	5.43	5.66	4.91
8.0	1.05E1	6.56	5.23	4.83	4.84	4.71	5.43	6.11	6.28	5.36
10.0	1.96E1	1.02E1	7.47	6.54	6.42	6.15	6.91	7.52	7.51	6.23
15.0	9.40E1	3.11E1	1.80E1	1.34E1	1.23E1	1.10E1	1.14E1	1.13E1	1.06E1	8.34
20.0	4.42E2	9.31E1	4.25E1	2.60E1	2.18E1	1.79E1	1.67E1	1.53E1	1.36E1	1.03E1
25.0	2.01E3	2.71E2	9.74E1	4.85E1	3.67E1	2.72E1	2.29E1	1.94E1	1.64E1	1.20E1
30.0	8.87E3	7.69E2	2.17E2	8.69E1	5.91E1	3.94E1	2.99E1	2.35E1	1.90E1	1.36E1
35.0	3.82E4	2.13E3	4.73E2	1.51E2	9.21E1	5.50E1	3.76E1	2.77E1	2.16E1	1.52E1
40.0	1.61E5	5.74E3	1.01E3	2.56E2	1.39E2	7.44E1	4.59E1	3.18E1	2.40E1	1.66E1
R(MFP)	ENERGY (MEV)									
	0.8	0.6	0.5	0.4	0.3	0.2	0.15	0.14	0.13	0.12
0.5	1.57	1.49	1.55	1.49	1.44	1.45	1.45	1.47	1.47	1.48
1.0	1.93	1.77	1.80	1.68	1.55	1.52	1.62	1.67	1.72	1.78
2.0	2.48	2.19	2.15	1.92	1.68	1.57	1.71	1.81	1.95	2.14
3.0	2.97	2.53	2.43	2.10	1.78	1.61	1.72	1.85	2.04	2.36
4.0	3.38	2.81	2.65	2.24	1.85	1.63	1.73	1.86	2.09	2.52
5.0	3.76	3.08	2.85	2.36	1.90	1.66	1.74	1.86	2.11	2.65
6.0	4.18	3.35	3.05	2.49	1.96	1.69	1.74	1.86	2.13	2.77
7.0	4.56	3.60	3.24	2.60	2.01	1.71	1.75	1.86	2.13	2.89
8.0	4.92	3.83	3.41	2.70	2.05	1.73	1.76	1.87	2.14	3.02
10.0	5.63	4.29	3.74	2.89	2.13	1.76	1.77	1.87	2.15	3.31
15.0	7.28	5.33	4.46	3.29	2.29	1.84	1.81	1.89	2.17	4.27
20.0	8.73	6.24	5.08	3.62	2.42	1.90	1.84	1.91	2.17	5.64
25.0	1.00E1	7.02	5.60	3.89	2.52	1.94	1.86	1.92	2.16	8.01
30.0	1.12E1	7.71	6.05	4.12	2.61	1.98	1.88	1.94	2.17	1.23E1
35.0	1.23E1	8.34	6.46	4.33	2.69	2.02	1.89	1.96	2.17	2.00E1
40.0	1.33E1	8.91	6.82	4.51	2.77	2.05	1.91	1.97	2.17	3.47E1
R(MFP)	ENERGY (MEV)									
	0.11	0.1	0.09	0.08	0.075	0.07	0.069	0.06	0.05	0.04
0.5	1.47	1.47	1.47	1.47	1.48	1.49	1.03	1.02	1.01	1.01
1.0	1.82	1.86	1.91	1.96	2.00	2.05	1.04	1.03	1.02	1.01
2.0	2.35	2.60	2.92	3.25	3.47	3.70	1.06	1.04	1.03	1.02
3.0	2.80	3.42	4.31	5.40	6.11	6.91	1.07	1.05	1.03	1.02
4.0	3.25	4.47	6.50	9.38	1.14E1	1.37E1	1.08	1.06	1.04	1.02
5.0	3.74	5.89	1.01E1	1.69E1	2.19E1	2.82E1	1.09	1.06	1.04	1.02
6.0	4.29	7.82	1.58E1	3.10E1	4.29E1	5.88E1	1.10	1.07	1.04	1.02
7.0	4.97	1.06E1	2.51E1	5.61E1	8.14E1	1.18E2	1.11	1.08	1.05	1.03
8.0	5.83	1.43E1	3.93E1	9.82E1	1.51E2	2.32E2	1.12	1.08	1.05	1.03
10.0	8.01	2.66E1	9.60E1	3.13E2	5.41E2	9.23E2	1.13	1.09	1.06	1.03
15.0	2.13E1	1.57E2	1.13E3	6.52E3	1.45E4	3.16E4	1.16	1.11	1.07	1.04
20.0	7.37E1	1.20E3	1.64E4	1.58E5	4.40E5	1.20E6	1.18	1.13	1.08	1.05
25.0	2.88E2	1.03E4	2.66E5	4.26E6	1.46E7	4.85E7	1.20	1.14	1.09	1.05
30.0	1.19E3	9.11E4	4.52E6	1.22E8	5.17E8	2.08E9	1.22	1.15	1.10	1.05
35.0	5.07E3	8.24E5	7.84E7	3.60E9	1.90E10	9.28E10	1.23	1.16	1.10	1.06
40.0	2.20E4	7.53E6	1.38E9	1.08E11	7.15E11	4.26E12	1.24	1.17	1.11	1.06
R(MFP)	ENERGY (MEV)									
	0.03	0.02	0.015							
0.5	1.00	1.00	1.00							
1.0	1.01	1.00	1.00							
2.0	1.01	1.00	1.00							
3.0	1.01	1.00	1.00							
4.0	1.01	1.00	1.00							
5.0	1.01	1.00	1.00							
6.0	1.01	1.00	1.00							
7.0	1.01	1.00	1.00							
8.0	1.01	1.01	1.00							
10.0	1.02	1.01	1.00							
15.0	1.02	1.01	1.00							
20.0	1.02	1.01	1.00							
25.0	1.02	1.01	1.00							
30.0	1.03	1.01	1.01							
35.0	1.03	1.01	1.01							
40.0	1.03	1.01	1.01							

Table A.5 (continued)

## EXPOSURE BUILDUP FACTORS IN 45-MFP THICK TUNGSTEN

R(MFP)	ENERGY (MEV)									
	15	10	8	6	5	4	3	2	1.5	1
0.5	1.30	1.27	1.26	1.25	1.24	1.22	1.23	1.23	1.23	1.23
1.0	1.62	1.51	1.46	1.43	1.42	1.38	1.41	1.44	1.47	1.45
2.0	2.27	1.97	1.85	1.77	1.75	1.71	1.80	1.88	1.90	1.83
3.0	3.22	2.56	2.30	2.15	2.13	2.07	2.21	2.30	2.32	2.19
4.0	4.55	3.32	2.84	2.59	2.55	2.48	2.64	2.73	2.73	2.51
5.0	6.41	4.28	3.50	3.10	3.04	2.94	3.12	3.18	3.14	2.83
6.0	9.01	5.49	4.29	3.70	3.60	3.47	3.64	3.65	3.57	3.15
7.0	1.26E1	7.04	5.25	4.39	4.24	4.05	4.20	4.14	3.99	3.47
8.0	1.77E1	8.99	6.40	5.19	4.97	4.70	4.80	4.63	4.41	3.77
10.0	3.44E1	1.46E1	9.44	7.17	6.71	6.19	6.11	5.67	5.24	4.37
15.0	1.72E2	4.66E1	2.39E1	1.52E1	1.32E1	1.12E1	1.00E1	8.43	7.33	5.79
20.0	8.23E2	1.43E2	5.79E1	3.01E1	2.38E1	1.84E1	1.48E1	1.13E1	9.31	7.09
25.0	3.77E3	4.20E2	1.35E2	5.68E1	4.05E1	2.81E1	2.02E1	1.43E1	1.12E1	8.28
30.0	1.67E4	1.20E3	3.03E2	1.03E2	6.57E1	4.09E1	2.64E1	1.74E1	1.30E1	9.39
35.0	7.21E4	3.32E3	6.62E2	1.79E2	1.03E2	5.71E1	3.32E1	2.04E1	1.47E1	1.04E1
40.0	3.04E5	9.00E3	1.41E3	3.04E2	1.56E2	7.73E1	4.05E1	2.34E1	1.63E1	1.14E1
R(MFP)	ENERGY (MEV)									
	0.8	0.6	0.5	0.4	0.3	0.2	0.15	0.14	0.13	0.12
0.5	1.22	1.19	1.17	1.14	1.11	1.12	1.19	1.22	1.26	1.31
1.0	1.41	1.35	1.30	1.24	1.17	1.16	1.26	1.32	1.40	1.51
2.0	1.74	1.61	1.51	1.39	1.26	1.20	1.31	1.40	1.53	1.75
3.0	2.04	1.83	1.68	1.51	1.33	1.23	1.33	1.42	1.59	1.90
4.0	2.31	2.03	1.83	1.60	1.38	1.25	1.34	1.43	1.62	2.02
5.0	2.56	2.21	1.96	1.69	1.42	1.27	1.35	1.44	1.64	2.12
6.0	2.82	2.39	2.09	1.77	1.46	1.29	1.35	1.45	1.66	2.22
7.0	3.07	2.57	2.21	1.85	1.49	1.30	1.36	1.45	1.67	2.31
8.0	3.30	2.73	2.33	1.92	1.53	1.32	1.37	1.46	1.67	2.41
10.0	3.76	3.04	2.55	2.05	1.58	1.35	1.38	1.46	1.69	2.65
15.0	4.82	3.75	3.02	2.33	1.70	1.40	1.41	1.48	1.70	3.42
20.0	5.76	4.37	3.43	2.55	1.79	1.44	1.43	1.50	1.71	4.50
25.0	6.59	4.91	3.77	2.74	1.86	1.48	1.45	1.51	1.71	6.38
30.0	7.36	5.39	4.07	2.90	1.93	1.51	1.46	1.52	1.71	9.76
35.0	8.07	5.83	4.34	3.04	1.98	1.53	1.47	1.53	1.71	1.60E1
40.0	8.73	6.22	4.58	3.16	2.04	1.56	1.48	1.54	1.72	2.77E1
R(MFP)	ENERGY (MEV)									
	0.11	0.1	0.09	0.08	0.075	0.07	0.069	0.06	0.05	0.04
0.5	1.37	1.44	1.52	1.61	1.63	1.65	1.03	1.02	1.01	1.01
1.0	1.64	1.82	2.00	2.24	2.31	2.38	1.04	1.03	1.02	1.01
2.0	2.06	2.53	3.12	3.91	4.23	4.58	1.05	1.04	1.03	1.02
3.0	2.43	3.34	4.69	6.74	7.72	8.85	1.06	1.05	1.03	1.02
4.0	2.80	4.40	7.18	1.20E1	1.47E1	1.79E1	1.08	1.05	1.04	1.02
5.0	3.23	5.85	1.13E1	2.21E1	2.88E1	3.74E1	1.08	1.06	1.04	1.02
6.0	3.72	7.87	1.80E1	4.10E1	5.71E1	7.89E1	1.09	1.07	1.04	1.02
7.0	4.33	1.08E1	2.90E1	7.50E1	1.09E2	1.59E2	1.10	1.07	1.05	1.03
8.0	5.12	1.48E1	4.60E1	1.33E2	2.05E2	3.15E2	1.11	1.08	1.05	1.03
10.0	7.13	2.82E1	4.31E2	7.44E2	1.27E3	1.12	1.09	1.06	1.03	
15.0	1.97E1	1.76E2	1.43E3	9.39E3	2.07E4	4.49E4	1.15	1.11	1.07	1.04
20.0	6.92E1	1.38E3	2.15E4	2.37E5	6.51E5	1.75E6	1.17	1.12	1.08	1.05
25.0	2.73E2	1.19E4	3.53E5	6.51E6	2.22E7	7.31E7	1.19	1.14	1.09	1.05
30.0	1.14E3	1.06E5	6.05E6	1.89E8	8.00E8	3.20E9	1.20	1.15	1.09	1.05
35.0	4.85E3	9.63E5	1.05E8	5.63E9	2.98E10	1.45E11	1.22	1.16	1.10	1.06
40.0	2.11E4	8.84E6	1.86E9	1.70E11	1.13E12	6.73E12	1.23	1.17	1.11	1.06
R(MFP)	ENERGY (MEV)									
	0.03	0.02	0.015							
0.5	1.00	1.00	1.00							
1.0	1.01	1.00	1.00							
2.0	1.01	1.00	1.00							
3.0	1.01	1.00	1.00							
4.0	1.01	1.00	1.00							
5.0	1.01	1.00	1.00							
6.0	1.01	1.00	1.00							
7.0	1.01	1.00	1.00							
8.0	1.01	1.01	1.00							
10.0	1.02	1.01	1.00							
15.0	1.02	1.01	1.00							
20.0	1.02	1.01	1.00							
25.0	1.02	1.01	1.00							
30.0	1.03	1.01	1.01							
35.0	1.03	1.01	1.01							
40.0	1.03	1.01	1.01							

Table A.5 (continued)

DOSE EQUIVALENT BUILDUP FACTORS IN 45-MFP THICK TUNGSTEN										
R(MFP)	ENERGY (MEV)									
	15	10	8	6	5	4	3	2	1.5	1
0.5	1.35	1.32	1.30	1.29	1.28	1.25	1.25	1.25	1.25	1.25
1.0	1.70	1.58	1.52	1.48	1.46	1.41	1.44	1.47	1.50	1.48
2.0	2.43	2.09	1.93	1.83	1.82	1.74	1.84	1.92	1.96	1.88
3.0	3.46	2.73	2.42	2.23	2.22	2.11	2.25	2.35	2.40	2.25
4.0	4.91	3.55	3.00	2.70	2.67	2.54	2.70	2.78	2.83	2.59
5.0	6.96	4.60	3.70	3.23	3.19	3.01	3.19	3.24	3.26	2.92
6.0	9.81	5.93	4.55	3.86	3.78	3.55	3.73	3.73	3.71	3.26
7.0	1.38E1	7.62	5.58	4.59	4.46	4.16	4.30	4.23	4.15	3.59
8.0	1.93E1	9.75	6.82	5.43	5.24	4.82	4.92	4.74	4.59	3.90
10.0	3.77E1	1.59E1	1.01E1	7.52	7.09	6.36	6.27	5.80	5.46	4.52
15.0	1.89E2	5.09E1	2.57E1	1.60E1	1.40E1	1.15E1	1.03E1	8.64	7.65	6.00
20.0	9.04E2	1.56E2	6.23E1	3.18E1	2.53E1	1.90E1	1.52E1	1.16E1	9.74	7.35
25.0	4.14E3	4.61E2	1.45E2	6.00E1	4.31E1	2.90E1	2.08E1	1.47E1	1.17E1	8.59
30.0	1.83E4	1.32E3	3.26E2	1.08E2	7.01E1	4.22E1	2.71E1	1.78E1	1.36E1	9.74
35.0	7.94E4	3.65E3	7.14E2	1.90E2	1.10E2	5.89E1	3.41E1	2.09E1	1.54E1	1.08E1
40.0	3.35E5	9.89E3	1.53E3	3.22E2	1.67E2	7.98E1	4.16E1	2.41E1	1.71E1	1.18E1
R(MFP)	ENERGY (MEV)									
	0.8	0.6	0.5	0.4	0.3	0.2	0.15	0.14	0.13	0.12
0.5	1.24	1.21	1.19	1.15	1.13	1.16	1.26	1.30	1.35	1.40
1.0	1.45	1.37	1.33	1.26	1.19	1.20	1.36	1.44	1.53	1.65
2.0	1.79	1.64	1.54	1.41	1.28	1.24	1.42	1.54	1.71	1.97
3.0	2.11	1.87	1.72	1.53	1.35	1.27	1.44	1.57	1.78	2.16
4.0	2.39	2.07	1.87	1.63	1.40	1.30	1.45	1.58	1.82	2.31
5.0	2.65	2.26	2.01	1.72	1.44	1.32	1.46	1.58	1.84	2.43
6.0	2.93	2.45	2.15	1.80	1.48	1.34	1.46	1.59	1.86	2.55
7.0	3.18	2.63	2.27	1.88	1.52	1.36	1.47	1.59	1.87	2.66
8.0	3.43	2.79	2.39	1.95	1.55	1.37	1.48	1.60	1.88	2.79
10.0	3.91	3.12	2.61	2.09	1.61	1.40	1.49	1.60	1.89	3.09
15.0	5.01	3.85	3.11	2.37	1.73	1.46	1.52	1.62	1.90	4.04
20.0	6.00	4.49	3.52	2.60	1.82	1.50	1.55	1.63	1.90	5.38
25.0	6.87	5.05	3.88	2.79	1.90	1.54	1.56	1.65	1.90	7.71
30.0	7.67	5.54	4.19	2.95	1.96	1.57	1.58	1.66	1.91	1.19E1
35.0	8.41	5.99	4.47	3.10	2.02	1.60	1.59	1.67	1.91	1.96E1
40.0	9.09	6.39	4.72	3.22	2.07	1.62	1.60	1.69	1.91	3.41E1
R(MFP)	ENERGY (MEV)									
	0.11	0.1	0.09	0.08	0.075	0.07	0.069	0.06	0.05	0.04
0.5	1.46	1.54	1.59	1.64	1.67	1.69	1.03	1.02	1.01	1.01
1.0	1.80	1.98	2.14	2.31	2.39	2.47	1.04	1.03	1.02	1.01
2.0	2.32	2.84	3.40	4.09	4.43	4.81	1.05	1.04	1.03	1.01
3.0	2.78	3.81	5.17	7.08	8.14	9.35	1.07	1.05	1.03	1.02
4.0	3.24	5.06	7.98	1.27E1	1.55E1	1.90E1	1.08	1.05	1.04	1.02
5.0	3.76	6.79	1.26E1	2.33E1	3.05E1	3.97E1	1.09	1.06	1.04	1.02
6.0	4.36	9.17	2.01E1	4.32E1	6.03E1	8.36E1	1.10	1.07	1.04	1.02
7.0	5.10	1.26E1	3.24E1	7.89E1	1.15E2	1.68E2	1.10	1.07	1.05	1.03
8.0	6.05	1.73E1	5.13E1	1.39E2	2.16E2	3.33E2	1.11	1.08	1.05	1.03
10.0	8.48	3.30E1	1.28E2	4.51E2	7.81E2	1.34E3	1.13	1.09	1.06	1.03
15.0	2.35E1	2.04E2	1.57E3	9.72E3	2.16E4	4.70E4	1.15	1.11	1.07	1.04
20.0	8.30E1	1.59E3	2.34E4	2.43E5	6.73E5	1.82E6	1.17	1.12	1.08	1.05
25.0	3.27E2	1.37E4	3.84E5	6.65E6	2.28E7	7.55E7	1.19	1.14	1.09	1.05
30.0	1.36E3	1.22E5	6.56E6	1.92E8	8.17E8	3.29E9	1.21	1.15	1.09	1.05
35.0	5.80E3	1.11E6	1.14E8	5.71E9	3.03E10	1.49E11	1.22	1.16	1.10	1.06
40.0	2.52E4	1.02E7	2.01E9	1.73E11	1.15E12	6.88E12	1.23	1.17	1.11	1.06
R(MFP)	ENERGY (MEV)									
	0.03	0.02	0.015							
0.5	1.00	1.00	1.00							
1.0	1.01	1.00	1.00							
2.0	1.01	1.00	1.00							
3.0	1.01	1.00	1.00							
4.0	1.01	1.00	1.00							
5.0	1.01	1.00	1.00							
6.0	1.01	1.00	1.00							
7.0	1.01	1.00	1.00							
8.0	1.01	1.01	1.00							
10.0	1.02	1.01	1.00							
15.0	1.02	1.01	1.00							
20.0	1.02	1.01	1.00							
25.0	1.02	1.01	1.00							
30.0	1.03	1.01	1.01							
35.0	1.03	1.01	1.01							
40.0	1.03	1.01	1.01							

Table A.6 Gamma-ray buildup factors for point isotropic source  
in 45-mfp-thick lead

ABSORBED DOSE BUILDUP FACTORS IN 45-MFP THICK LEAD										
R(MFP)	ENERGY (MEV)									
	15	10	8	6	5	4	3	2	1.5	1
0.5	1.32	1.36	1.39	1.44	1.47	1.51	1.43	1.42	1.37	1.32
1.0	1.53	1.54	1.55	1.59	1.62	1.69	1.63	1.69	1.66	1.58
2.0	1.91	1.86	1.83	1.87	1.92	2.03	2.01	2.20	2.19	2.06
3.0	2.43	2.26	2.16	2.19	2.26	2.42	2.43	2.70	2.67	2.47
4.0	3.16	2.77	2.56	2.55	2.64	2.84	2.85	3.17	3.08	2.80
5.0	4.17	3.41	3.04	2.97	3.07	3.30	3.31	3.64	3.49	3.12
6.0	5.56	4.20	3.61	3.45	3.56	3.81	3.80	4.13	3.89	3.43
7.0	7.48	5.21	4.30	4.00	4.12	4.37	4.33	4.65	4.31	3.74
8.0	1.01E1	6.45	5.12	4.64	4.75	4.99	4.89	5.17	4.72	4.05
10.0	1.89E1	9.95	7.25	6.19	6.24	6.40	6.11	6.23	5.50	4.64
15.0	9.01E1	2.94E1	1.72E1	1.23E1	1.17E1	1.10E1	9.69	9.00	7.36	5.99
20.0	4.23E2	8.59E1	4.02E1	2.35E1	2.06E1	1.75E1	1.39E1	1.18E1	9.06	7.24
25.0	1.94E3	2.45E2	9.17E1	4.32E1	3.44E1	2.61E1	1.86E1	1.46E1	1.07E1	8.44
30.0	8.63E3	6.82E2	2.04E2	7.66E1	5.52E1	3.73E1	2.38E1	1.75E1	1.22E1	9.57
35.0	3.75E4	1.85E3	4.45E2	1.32E2	8.58E1	5.13E1	2.95E1	2.03E1	1.36E1	1.06E1
40.0	1.60E5	4.94E3	9.52E2	2.22E2	1.30E2	6.84E1	3.54E1	2.31E1	1.50E1	1.16E1
R(MFP)	ENERGY (MEV)									
	0.8	0.6	0.5	0.4	0.3	0.2	0.16	0.15	0.14	0.13
0.5	1.30	1.25	1.20	1.15	1.40	1.46	1.48	1.48	1.49	1.50
1.0	1.52	1.42	1.32	1.23	1.48	1.60	1.74	1.78	1.83	1.88
2.0	1.93	1.71	1.55	1.38	1.58	1.67	2.00	2.13	2.32	2.55
3.0	2.26	1.94	1.72	1.49	1.66	1.69	2.11	2.33	2.70	3.19
4.0	2.51	2.11	1.84	1.57	1.72	1.71	2.16	2.48	3.05	3.93
5.0	2.75	2.27	1.95	1.63	1.77	1.73	2.20	2.60	3.40	4.83
6.0	2.97	2.41	2.05	1.69	1.81	1.75	2.22	2.70	3.77	5.94
7.0	3.20	2.55	2.16	1.75	1.85	1.76	2.24	2.80	4.20	7.42
8.0	3.42	2.68	2.26	1.81	1.89	1.78	2.25	2.91	4.72	9.41
10.0	3.83	2.93	2.44	1.90	1.94	1.80	2.28	3.14	6.04	1.49E1
15.0	4.70	3.44	2.81	2.10	2.06	1.85	2.32	3.89	1.22E1	6.08E1
20.0	5.49	3.87	3.14	2.26	2.14	1.89	2.33	4.78	3.10E1	3.18E2
25.0	6.19	4.23	3.43	2.40	2.20	1.92	2.34	6.13	9.00E1	1.85E3
30.0	6.82	4.57	3.69	2.54	2.26	1.95	2.35	8.32	2.81E2	1.12E4
35.0	7.40	4.89	3.93	2.66	2.31	1.97	2.35	1.19E1	9.11E2	6.90E4
40.0	7.95	5.20	4.15	2.76	2.36	1.99	2.36	1.81E1	3.03E3	4.33E5
R(MFP)	ENERGY (MEV)									
	0.12	0.11	0.1	0.09	0.089	0.088	0.08	0.06	0.05	0.04
0.5	1.50	1.50	1.48	1.51	1.51	1.07	1.03	1.02	1.01	1.01
1.0	1.93	1.97	1.98	2.07	2.08	1.09	1.04	1.02	1.01	1.01
2.0	2.79	3.05	3.28	3.68	3.73	1.10	1.06	1.03	1.02	1.01
3.0	3.81	4.58	5.38	6.66	6.81	1.12	1.08	1.04	1.02	1.01
4.0	5.21	7.00	9.19	1.27E1	1.31E1	1.13	1.09	1.04	1.03	1.01
5.0	7.20	1.10E1	1.62E1	2.51E1	2.62E1	1.15	1.10	1.04	1.03	1.02
6.0	1.01E1	1.75E1	2.91E1	5.02E1	5.29E1	1.16	1.11	1.05	1.03	1.02
7.0	1.44E1	2.81E1	5.22E1	9.66E1	1.03E2	1.17	1.11	1.05	1.03	1.02
8.0	2.02E1	4.42E1	8.98E1	1.83E2	1.97E2	1.18	1.12	1.06	1.04	1.02
10.0	4.09E1	1.11E2	2.77E2	6.81E2	7.44E2	1.20	1.14	1.06	1.04	1.02
15.0	2.99E2	1.36E3	3.53E3	1.99E4	2.26E4	1.24	1.16	1.08	1.05	1.03
20.0	2.80E3	2.05E4	1.22E5	6.53E5	7.67E5	1.26	1.18	1.09	1.06	1.03
25.0	2.89E4	3.44E5	3.06E6	2.33E7	2.82E7	1.28	1.20	1.10	1.07	1.04
30.0	3.09E5	6.04E6	8.17E7	8.77E8	1.10E9	1.29	1.21	1.11	1.08	1.04
35.0	3.38E6	1.09E8	2.25E9	3.44E10	4.44E10	1.31	1.22	1.11	1.08	1.04
40.0	3.72E7	1.97E9	6.30E10	1.38E12	1.84E12	1.32	1.24	1.12	1.09	1.04
R(MFP)	ENERGY (MEV)									
	0.03									
0.5	1.00									
1.0	1.00									
2.0	1.01									
3.0	1.01									
4.0	1.01									
5.0	1.01									
6.0	1.01									
7.0	1.01									
8.0	1.01									
10.0	1.01									
15.0	1.01									
20.0	1.02									
25.0	1.02									
30.0	1.02									
35.0	1.02									
40.0	1.02									

Table A.6 (continued)

## EXPOSURE BUILDUP FACTORS IN 45-MFP THICK LEAD

R(MFP)	ENERGY (MEV)									
	15	10	8	6	5	4	3	2	1.5	1
0.5	1.32	1.29	1.27	1.26	1.25	1.25	1.24	1.21	1.19	1.16
1.0	1.62	1.51	1.46	1.42	1.40	1.41	1.41	1.39	1.37	1.31
2.0	2.26	1.97	1.82	1.74	1.71	1.74	1.77	1.76	1.73	1.61
3.0	3.16	2.54	2.26	2.10	2.06	2.11	2.13	2.12	2.05	1.87
4.0	4.43	3.26	2.78	2.51	2.45	2.49	2.51	2.47	2.34	2.10
5.0	6.21	4.17	3.40	2.98	2.89	2.92	2.91	2.83	2.63	2.32
6.0	8.69	5.32	4.15	3.52	3.39	3.40	3.34	3.20	2.92	2.54
7.0	1.21E1	6.78	5.05	4.14	3.96	3.92	3.81	3.58	3.21	2.75
8.0	1.69E1	8.60	6.13	4.86	4.61	4.50	4.30	3.97	3.50	2.96
10.0	3.28E1	1.38E1	8.97	6.64	6.14	5.80	5.37	4.76	4.05	3.37
15.0	1.64E2	4.28E1	2.24E1	1.37E1	1.18E1	1.01E1	8.43	6.80	5.35	4.30
20.0	7.83E2	1.28E2	5.36E1	2.66E1	2.10E1	1.61E1	1.20E1	8.89	6.56	5.17
25.0	3.61E3	3.69E2	1.24E2	4.94E1	3.53E1	2.42E1	1.61E1	1.10E1	7.70	6.00
30.0	1.61E4	1.03E3	2.78E2	8.83E1	5.70E1	3.46E1	2.06E1	1.31E1	8.78	6.80
35.0	7.03E4	2.82E3	6.10E2	1.53E2	8.89E1	4.77E1	2.56E1	1.52E1	9.81	7.53
40.0	3.00E5	7.51E3	1.31E3	2.59E2	1.35E2	6.37E1	3.10E1	1.73E1	1.08E1	8.21
R(MFP)	ENERGY (MEV)									
	0.8	0.6	0.5	0.4	0.3	0.2	0.16	0.15	0.14	0.13
0.5	1.14	1.12	1.09	1.07	1.08	1.14	1.22	1.25	1.29	1.33
1.0	1.28	1.22	1.18	1.13	1.12	1.19	1.34	1.41	1.49	1.59
2.0	1.53	1.41	1.32	1.23	1.19	1.23	1.47	1.60	1.79	2.05
3.0	1.74	1.57	1.44	1.31	1.24	1.25	1.53	1.72	2.03	2.50
4.0	1.91	1.69	1.53	1.37	1.28	1.26	1.57	1.82	2.26	3.03
5.0	2.08	1.80	1.61	1.42	1.31	1.28	1.59	1.90	2.50	3.70
6.0	2.24	1.90	1.69	1.47	1.34	1.29	1.61	1.96	2.76	4.55
7.0	2.39	2.00	1.77	1.52	1.37	1.31	1.62	2.03	3.06	5.70
8.0	2.54	2.10	1.85	1.56	1.39	1.32	1.64	2.11	3.44	7.27
10.0	2.83	2.28	1.98	1.64	1.43	1.34	1.66	2.27	4.41	1.17E1
15.0	3.44	2.65	2.27	1.79	1.51	1.37	1.69	2.77	8.96	4.96E1
20.0	4.00	2.97	2.52	1.92	1.57	1.40	1.70	3.36	2.29E1	2.66E2
25.0	4.49	3.24	2.74	2.04	1.62	1.42	1.71	4.26	6.68E1	1.56E3
30.0	4.94	3.50	2.94	2.15	1.65	1.44	1.72	5.71	2.09E2	9.48E3
35.0	5.35	3.74	3.13	2.25	1.69	1.45	1.72	8.13	6.83E2	5.89E4
40.0	5.74	3.97	3.31	2.33	1.72	1.47	1.73	1.22E1	2.28E3	3.71E5
R(MFP)	ENERGY (MEV)									
	0.12	0.11	0.1	0.09	0.089	0.088	0.08	0.06	0.05	0.04
0.5	1.38	1.45	1.52	1.58	1.59	1.05	1.02	1.01	1.01	1.01
1.0	1.71	1.87	2.05	2.23	2.25	1.07	1.03	1.02	1.01	1.01
2.0	2.39	2.85	3.44	4.09	4.17	1.08	1.05	1.03	1.02	1.01
3.0	3.21	4.26	5.72	7.55	7.77	1.10	1.06	1.03	1.02	1.01
4.0	4.34	6.53	9.90	1.46E1	1.52E1	1.11	1.08	1.04	1.02	1.01
5.0	6.01	1.03E1	1.77E1	2.93E1	3.08E1	1.13	1.09	1.04	1.03	1.02
6.0	8.44	1.66E1	3.22E1	5.92E1	6.28E1	1.14	1.09	1.05	1.03	1.02
7.0	1.22E1	2.70E1	5.83E1	1.15E2	1.23E2	1.15	1.10	1.05	1.03	1.02
8.0	1.73E1	4.30E1	1.02E2	2.20E2	2.38E2	1.16	1.11	1.06	1.04	1.02
10.0	3.58E1	1.11E2	3.20E2	8.32E2	9.14E2	1.18	1.12	1.06	1.04	1.02
15.0	2.78E2	1.45E3	6.55E3	2.54E4	2.90E4	1.21	1.15	1.08	1.05	1.03
20.0	2.68E3	2.26E4	1.55E5	8.67E5	1.02E6	1.23	1.17	1.09	1.06	1.03
25.0	2.80E4	3.86E5	4.01E6	3.19E7	3.88E7	1.25	1.18	1.10	1.07	1.04
30.0	3.02E5	6.85E6	1.09E8	1.23E9	1.55E9	1.27	1.20	1.10	1.08	1.04
35.0	3.31E6	1.24E8	3.02E9	4.89E10	6.35E10	1.28	1.21	1.11	1.08	1.04
40.0	3.66E7	2.26E9	8.51E10	1.98E12	2.66E12	1.29	1.22	1.12	1.09	1.04
R(MFP)	ENERGY (MEV)									
	0.03									
0.5	1.00									
1.0	1.00									
2.0	1.00									
3.0	1.01									
4.0	1.01									
5.0	1.01									
6.0	1.01									
7.0	1.01									
8.0	1.01									
10.0	1.01									
15.0	1.01									
20.0	1.02									
25.0	1.02									
30.0	1.02									
35.0	1.02									
40.0	1.02									

Table A.6 (continued)

## DOSE EQUIVALENT BUILDUP FACTORS IN 45-MFP THICK LEAD

R(MFP)	ENERGY (MEV)									
	15	10	8	6	5	4	3	2	1.5	1
0.5	1.37	1.33	1.31	1.29	1.28	1.27	1.24	1.22	1.20	1.17
1.0	1.71	1.58	1.51	1.46	1.44	1.44	1.41	1.41	1.39	1.33
2.0	2.40	2.07	1.90	1.79	1.77	1.78	1.76	1.79	1.77	1.65
3.0	3.38	2.69	2.37	2.17	2.14	2.15	2.13	2.16	2.10	1.92
4.0	4.77	3.48	2.92	2.60	2.55	2.55	2.51	2.51	2.41	2.16
5.0	6.71	4.47	3.58	3.09	3.02	2.99	2.92	2.88	2.71	2.38
6.0	9.41	5.72	4.38	3.66	3.55	3.48	3.36	3.25	3.01	2.61
7.0	1.32E1	7.30	5.35	4.31	4.15	4.02	3.83	3.65	3.31	2.83
8.0	1.84E1	9.29	6.50	5.07	4.84	4.61	4.33	4.04	3.61	3.05
10.0	3.58E1	1.49E1	9.54	6.93	6.47	5.96	5.42	4.85	4.18	3.47
15.0	1.79E2	4.65E1	2.39E1	1.43E1	1.24E1	1.04E1	8.58	6.93	5.54	4.43
20.0	8.57E2	1.39E2	5.74E1	2.79E1	2.22E1	1.66E1	1.23E1	9.05	6.80	5.33
25.0	3.95E3	4.02E2	1.33E2	5.19E1	3.75E1	2.49E1	1.65E1	1.12E1	7.98	6.20
30.0	1.77E4	1.13E3	2.99E2	9.30E1	6.05E1	3.56E1	2.11E1	1.33E1	9.10	7.02
35.0	7.71E4	3.06E3	6.55E2	1.61E2	9.44E1	4.91E1	2.61E1	1.55E1	1.02E1	7.78
40.0	3.29E5	8.21E3	1.40E3	2.73E2	1.43E2	6.56E1	3.13E1	1.76E1	1.12E1	8.48
R(MFP)	ENERGY (MEV)									
	0.8	0.6	0.5	0.4	0.3	0.2	0.16	0.15	0.14	0.13
0.5	1.15	1.12	1.10	1.07	1.10	1.19	1.30	1.34	1.38	1.42
1.0	1.29	1.23	1.19	1.14	1.15	1.26	1.46	1.55	1.64	1.75
2.0	1.56	1.43	1.34	1.24	1.21	1.30	1.63	1.81	2.03	2.33
3.0	1.78	1.59	1.46	1.32	1.26	1.32	1.71	1.97	2.34	2.91
4.0	1.96	1.71	1.56	1.38	1.31	1.34	1.76	2.08	2.64	3.58
5.0	2.13	1.83	1.64	1.44	1.34	1.36	1.79	2.19	2.95	4.42
6.0	2.30	1.93	1.72	1.48	1.37	1.37	1.81	2.28	3.28	5.48
7.0	2.46	2.04	1.80	1.53	1.40	1.38	1.82	2.36	3.66	6.91
8.0	2.62	2.14	1.88	1.57	1.42	1.39	1.84	2.46	4.14	8.86
10.0	2.91	2.32	2.02	1.65	1.46	1.41	1.86	2.66	5.37	1.44E1
15.0	3.55	2.70	2.31	1.81	1.54	1.45	1.89	3.31	1.12E1	6.11E1
20.0	4.12	3.03	2.57	1.94	1.60	1.48	1.91	4.08	2.88E1	3.27E2
25.0	4.63	3.30	2.79	2.06	1.65	1.50	1.92	5.25	8.45E1	1.91E3
30.0	5.10	3.56	3.00	2.17	1.69	1.52	1.92	7.14	2.65E2	1.16E4
35.0	5.53	3.81	3.19	2.27	1.73	1.54	1.93	1.03E1	8.63E2	7.21E4
40.0	5.93	4.05	3.37	2.36	1.76	1.55	1.93	1.56E1	2.88E3	4.54E5
R(MFP)	ENERGY (MEV)									
	0.12	0.11	0.1	0.09	0.089	0.088	0.08	0.06	0.05	0.04
0.5	1.47	1.53	1.59	1.63	1.64	1.06	1.02	1.01	1.01	1.00
1.0	1.88	2.04	2.20	2.32	2.34	1.07	1.03	1.02	1.01	1.01
2.0	2.72	3.21	3.78	4.32	4.39	1.09	1.05	1.02	1.02	1.01
3.0	3.72	4.88	6.39	8.05	8.24	1.10	1.06	1.03	1.02	1.01
4.0	5.11	7.56	1.11E1	1.56E1	1.62E1	1.12	1.07	1.03	1.02	1.01
5.0	7.14	1.20E1	2.00E1	3.13E1	3.27E1	1.13	1.08	1.04	1.03	1.01
6.0	1.01E1	1.94E1	3.64E1	6.33E1	6.68E1	1.14	1.09	1.04	1.03	1.02
7.0	1.46E1	3.17E1	6.60E1	1.23E2	1.31E2	1.15	1.10	1.05	1.03	1.02
8.0	2.08E1	5.04E1	1.15E2	2.35E2	2.53E2	1.16	1.11	1.05	1.03	1.02
10.0	4.31E1	1.29E2	3.61E2	8.86E2	9.68E2	1.18	1.12	1.06	1.04	1.02
15.0	3.33E2	1.67E3	7.30E3	2.68E4	3.04E4	1.22	1.14	1.07	1.05	1.03
20.0	3.19E3	2.60E4	1.72E5	9.09E5	1.07E6	1.24	1.16	1.08	1.06	1.03
25.0	3.32E4	4.42E5	4.42E6	3.32E7	4.03E7	1.26	1.18	1.09	1.07	1.03
30.0	3.58E5	7.83E6	1.20E8	1.28E9	1.60E9	1.27	1.19	1.10	1.07	1.04
35.0	3.92E6	1.41E8	3.32E9	5.07E10	6.54E10	1.29	1.21	1.11	1.08	1.04
40.0	4.34E7	2.57E9	9.33E10	2.05E12	2.73E12	1.30	1.22	1.11	1.08	1.04
R(MFP)	ENERGY (MEV)									
	0.03									
0.5	1.00									
1.0	1.00									
2.0	1.00									
3.0	1.01									
4.0	1.01									
5.0	1.01									
6.0	1.01									
7.0	1.01									
8.0	1.01									
10.0	1.01									
15.0	1.01									
20.0	1.02									
25.0	1.02									
30.0	1.02									
35.0	1.02									
40.0	1.02									

Table A.7 Gamma-ray buildup factors for point isotropic source  
in 45-mfp-thick uranium

## ABSORBED DOSE BUILDUP FACTORS IN 45-MFP THICK URANIUM

R(MFP)	ENERGY (MEV)									
	15	10	8	6	5	4	3	2	1.5	1
0.5	1.33	1.36	1.40	1.44	1.46	1.48	1.49	1.46	1.38	1.35
1.0	1.53	1.54	1.55	1.58	1.61	1.62	1.68	1.70	1.63	1.58
2.0	1.91	1.86	1.83	1.82	1.86	1.92	2.03	2.15	2.10	1.99
3.0	2.42	2.26	2.15	2.10	2.15	2.25	2.41	2.57	2.49	2.29
4.0	3.13	2.76	2.54	2.41	2.47	2.61	2.80	2.97	2.83	2.55
5.0	4.10	3.38	2.99	2.77	2.83	2.99	3.21	3.37	3.14	2.80
6.0	5.43	4.14	3.52	3.18	3.23	3.41	3.65	3.79	3.46	3.04
7.0	7.25	5.09	4.14	3.65	3.69	3.88	4.12	4.23	3.78	3.28
8.0	9.76	6.27	4.89	4.17	4.20	4.38	4.61	4.66	4.10	3.51
10.0	1.79E1	9.53	6.80	5.45	5.39	5.51	5.67	5.53	4.70	3.93
15.0	8.26E1	2.71E1	1.54E1	1.03E1	9.64	9.14	8.67	7.76	6.13	4.85
20.0	3.77E2	7.64E1	3.42E1	1.89E1	1.63E1	1.40E1	1.21E1	9.98	7.47	5.69
25.0	1.68E3	2.11E2	7.47E1	3.35E1	2.65E1	2.04E1	1.59E1	1.22E1	8.72	6.45
30.0	7.32E3	5.70E2	1.60E2	5.76E1	4.16E1	2.85E1	1.99E1	1.44E1	9.96	7.18
35.0	3.12E4	1.51E3	3.35E2	9.67E1	6.33E1	3.84E1	2.43E1	1.66E1	1.13E1	7.83
40.0	1.30E5	3.92E3	6.92E2	1.59E2	9.41E1	5.05E1	2.88E1	1.88E1	1.27E1	8.43
R(MFP)	ENERGY (MEV)									
	0.8	0.6	0.5	0.4	0.3	0.25	0.2	0.19	0.18	0.17
0.5	1.35	1.34	1.35	1.38	1.43	1.46	1.48	1.49	1.49	1.49
1.0	1.55	1.48	1.46	1.45	1.54	1.63	1.76	1.80	1.83	1.87
2.0	1.90	1.73	1.64	1.58	1.61	1.73	2.06	2.19	2.32	2.48
3.0	2.14	1.90	1.77	1.66	1.66	1.75	2.21	2.42	2.68	3.03
4.0	2.34	2.03	1.87	1.73	1.70	1.77	2.29	2.60	3.01	3.61
5.0	2.53	2.16	1.96	1.79	1.73	1.80	2.36	2.75	3.34	4.28
6.0	2.71	2.28	2.04	1.84	1.77	1.81	2.40	2.88	3.68	5.07
7.0	2.88	2.40	2.12	1.89	1.79	1.83	2.44	3.01	4.06	6.06
8.0	3.04	2.52	2.19	1.94	1.82	1.84	2.47	3.15	4.51	7.35
10.0	3.35	2.73	2.33	2.02	1.86	1.87	2.54	3.47	5.68	1.08E1
15.0	3.97	3.13	2.59	2.18	1.94	1.93	2.68	4.52	1.08E1	3.47E1
20.0	4.52	3.47	2.82	2.32	1.99	1.97	2.80	5.96	2.51E1	1.42E2
25.0	4.98	3.75	3.02	2.44	2.04	2.00	2.86	8.40	6.64E1	6.55E2
30.0	5.40	4.00	3.19	2.55	2.08	2.03	2.92	1.26E1	1.90E2	3.17E3
35.0	5.78	4.22	3.35	2.65	2.11	2.06	2.98	2.03E1	5.65E2	1.57E4
40.0	6.16	4.43	3.51	2.74	2.15	2.09	3.04	3.42E1	1.73E3	7.93E4
R(MFP)	ENERGY (MEV)									
	0.16	0.15	0.14	0.13	0.12	0.116	0.115	0.1	0.08	0.06
0.5	1.49	1.49	1.50	1.51	1.51	1.51	1.10	1.06	1.02	1.01
1.0	1.90	1.92	1.98	2.03	2.06	2.07	1.12	1.08	1.03	1.01
2.0	2.65	2.82	3.07	3.32	3.56	3.64	1.14	1.09	1.04	1.02
3.0	3.44	3.91	4.58	5.35	6.14	6.47	1.16	1.11	1.05	1.02
4.0	4.41	5.45	6.95	8.87	1.11E1	1.20E1	1.18	1.12	1.06	1.03
5.0	5.68	7.71	1.08E1	1.52E1	2.07E1	2.33E1	1.20	1.13	1.06	1.03
6.0	7.36	1.10E1	1.70E1	2.63E1	3.92E1	4.55E1	1.21	1.14	1.07	1.03
7.0	9.69	1.61E1	2.74E1	4.61E1	7.28E1	8.75E1	1.23	1.16	1.07	1.04
8.0	1.28E1	2.32E1	4.31E1	7.74E1	1.32E2	1.63E2	1.24	1.16	1.08	1.04
10.0	2.28E1	4.87E1	1.07E2	2.25E2	4.45E2	5.84E2	1.26	1.18	1.09	1.04
15.0	1.18E2	3.92E2	1.26E3	3.82E3	1.06E4	1.58E4	1.30	1.21	1.11	1.05
20.0	7.87E2	3.98E3	1.83E4	7.68E4	2.87E5	4.80E5	1.33	1.23	1.12	1.06
25.0	5.83E3	4.47E4	2.95E5	1.72E6	8.55E6	1.59E7	1.35	1.24	1.13	1.07
30.0	4.49E4	5.23E5	5.01E6	4.05E7	2.70E8	5.58E8	1.37	1.26	1.14	1.07
35.0	3.52E5	6.25E6	8.71E7	9.83E8	8.81E9	2.03E10	1.39	1.27	1.15	1.08
40.0	2.80E6	7.54E7	1.53E9	2.43E10	2.94E11	7.54E11	1.40	1.28	1.16	1.08
R(MFP)	ENERGY (MEV)									
	0.05	0.04	0.03							
0.5	1.01	1.00	1.00							
1.0	1.01	1.01	1.00							
2.0	1.01	1.01	1.00							
3.0	1.02	1.01	1.00							
4.0	1.02	1.01	1.01							
5.0	1.02	1.01	1.01							
6.0	1.02	1.01	1.01							
7.0	1.02	1.01	1.01							
8.0	1.03	1.01	1.01							
10.0	1.03	1.02	1.01							
15.0	1.03	1.02	1.01							
20.0	1.04	1.02	1.01							
25.0	1.04	1.03	1.01							
30.0	1.05	1.03	1.01							
35.0	1.05	1.03	1.01							
40.0	1.05	1.03	1.02							

Table A.7 (continued)

## EXPOSURE BUILDUP FACTORS IN 45-MFP THICK URANIUM

R(MFP)	ENERGY (MEV)									
	15	10	8	6	5	4	3	2	1.5	1
0.5	1.31	1.27	1.25	1.25	1.23	1.21	1.21	1.19	1.16	1.14
1.0	1.60	1.48	1.42	1.39	1.37	1.35	1.36	1.35	1.31	1.27
2.0	2.21	1.92	1.77	1.66	1.63	1.63	1.66	1.66	1.61	1.50
3.0	3.07	2.46	2.17	1.97	1.93	1.94	1.97	1.96	1.86	1.69
4.0	4.27	3.14	2.65	2.32	2.25	2.26	2.29	2.25	2.09	1.86
5.0	5.94	3.98	3.21	2.72	2.62	2.61	2.63	2.54	2.31	2.03
6.0	8.24	5.04	3.87	3.17	3.03	3.00	2.99	2.84	2.53	2.19
7.0	1.14E1	6.36	4.66	3.69	3.49	3.43	3.38	3.15	2.74	2.34
8.0	1.59E1	8.01	5.60	4.28	4.01	3.90	3.79	3.45	2.95	2.49
10.0	3.02E1	1.26E1	8.03	5.71	5.22	4.94	4.66	4.08	3.36	2.77
15.0	1.46E2	3.76E1	1.90E1	1.12E1	9.56	8.28	7.12	5.66	4.34	3.38
20.0	6.77E2	1.09E2	4.35E1	2.09E1	1.64E1	1.28E1	9.93	7.24	5.25	3.94
25.0	3.04E3	3.03E2	9.63E1	3.76E1	2.69E1	1.87E1	1.30E1	8.82	6.11	4.46
30.0	1.33E4	8.24E2	2.08E2	6.52E1	4.25E1	2.62E1	1.64E1	1.04E1	6.96	4.94
35.0	5.67E4	2.19E3	4.38E2	1.10E2	6.50E1	3.54E1	1.99E1	1.20E1	7.91	5.39
40.0	2.37E5	5.69E3	9.07E2	1.82E2	9.70E1	4.66E1	2.36E1	1.35E1	8.85	5.79
R(MFP)	ENERGY (MEV)									
	0.8	0.6	0.5	0.4	0.3	0.25	0.2	0.19	0.18	0.17
0.5	1.12	1.10	1.09	1.08	1.10	1.13	1.21	1.23	1.25	1.29
1.0	1.23	1.18	1.15	1.13	1.14	1.19	1.33	1.38	1.44	1.51
2.0	1.43	1.32	1.26	1.21	1.19	1.24	1.47	1.58	1.70	1.87
3.0	1.58	1.43	1.34	1.26	1.22	1.27	1.55	1.70	1.91	2.21
4.0	1.71	1.52	1.41	1.31	1.25	1.29	1.60	1.81	2.11	2.59
5.0	1.83	1.60	1.47	1.35	1.28	1.30	1.64	1.90	2.32	3.05
6.0	1.95	1.68	1.52	1.38	1.30	1.32	1.68	1.98	2.54	3.60
7.0	2.06	1.76	1.57	1.42	1.32	1.33	1.70	2.07	2.80	4.31
8.0	2.17	1.84	1.62	1.45	1.34	1.34	1.73	2.16	3.11	5.26
10.0	2.37	1.98	1.72	1.51	1.36	1.36	1.77	2.37	3.92	7.85
15.0	2.78	2.25	1.90	1.62	1.42	1.40	1.87	3.05	7.51	2.63E1
20.0	3.15	2.48	2.06	1.72	1.46	1.43	1.94	3.98	1.78E1	1.11E2
25.0	3.46	2.68	2.20	1.81	1.49	1.45	1.99	5.55	4.69E1	5.16E2
30.0	3.74	2.85	2.32	1.89	1.52	1.48	2.02	8.30	1.35E2	2.52E3
35.0	4.01	3.00	2.44	1.96	1.54	1.49	2.06	1.32E1	4.05E2	1.26E4
40.0	4.26	3.16	2.55	2.03	1.56	1.51	2.10	2.23E1	1.25E3	6.37E4
R(MFP)	ENERGY (MEV)									
	0.16	0.15	0.14	0.13	0.12	0.116	0.115	0.1	0.08	0.06
0.5	1.32	1.36	1.40	1.45	1.50	1.52	1.06	1.04	1.02	1.01
1.0	1.59	1.68	1.78	1.90	2.04	2.09	1.08	1.06	1.02	1.01
2.0	2.08	2.35	2.67	3.06	3.51	3.71	1.10	1.07	1.03	1.02
3.0	2.63	3.20	3.92	4.89	6.09	6.66	1.12	1.09	1.04	1.02
4.0	3.32	4.41	5.93	8.14	1.11E1	1.26E1	1.14	1.10	1.05	1.03
5.0	4.26	6.25	9.26	1.41E1	2.09E1	2.46E1	1.16	1.11	1.06	1.03
6.0	5.53	9.01	1.48E1	2.47E1	4.02E1	4.87E1	1.17	1.12	1.06	1.03
7.0	7.35	1.34E1	2.41E1	4.38E1	7.56E1	9.45E1	1.18	1.13	1.07	1.03
8.0	9.85	1.95E1	3.85E1	7.45E1	1.38E2	1.78E2	1.20	1.14	1.07	1.04
10.0	1.79E1	4.23E1	9.85E1	2.24E2	4.81E2	6.55E2	1.22	1.16	1.08	1.04
15.0	9.97E1	3.69E2	1.26E3	4.10E3	1.22E4	1.88E4	1.26	1.19	1.10	1.05
20.0	6.87E2	3.90E3	1.93E4	8.71E4	3.50E5	6.04E5	1.28	1.21	1.11	1.06
25.0	5.16E3	4.47E4	3.20E5	2.01E6	1.09E7	2.09E7	1.30	1.22	1.13	1.07
30.0	4.01E4	5.29E5	5.50E6	4.83E7	3.51E8	7.52E8	1.32	1.23	1.14	1.07
35.0	3.16E5	6.35E6	9.63E7	1.19E9	1.17E10	2.78E10	1.34	1.25	1.15	1.08
40.0	2.53E6	7.71E7	1.70E9	2.95E10	3.93E11	1.05E12	1.35	1.26	1.15	1.08
R(MFP)	ENERGY (MEV)									
	0.05	0.04	0.03							
0.5	1.01	1.00	1.00							
1.0	1.01	1.01	1.00							
2.0	1.01	1.01	1.00							
3.0	1.02	1.01	1.00							
4.0	1.02	1.01	1.01							
5.0	1.02	1.01	1.01							
6.0	1.02	1.01	1.01							
7.0	1.02	1.01	1.01							
8.0	1.02	1.01	1.01							
10.0	1.03	1.02	1.01							
15.0	1.03	1.02	1.01							
20.0	1.04	1.02	1.01							
25.0	1.04	1.03	1.01							
30.0	1.05	1.03	1.01							
35.0	1.05	1.03	1.01							
40.0	1.05	1.03	1.02							

Table A.7 (continued)

## DOSE EQUIVALENT BUILDUP FACTORS IN 45-MFP THICK URANIUM

R(MFP)	ENERGY (MEV)									
	15	10	8	6	5	4	3	2	1.5	1
0.5	1.35	1.31	1.29	1.28	1.26	1.23	1.23	1.20	1.17	1.15
1.0	1.67	1.54	1.47	1.43	1.41	1.37	1.38	1.36	1.33	1.28
2.0	2.34	2.01	1.84	1.71	1.69	1.66	1.69	1.68	1.64	1.53
3.0	3.27	2.60	2.27	2.03	2.00	1.97	2.00	1.98	1.91	1.72
4.0	4.58	3.33	2.77	2.40	2.34	2.31	2.33	2.27	2.14	1.90
5.0	6.39	4.25	3.37	2.81	2.72	2.67	2.68	2.57	2.37	2.07
6.0	8.90	5.39	4.07	3.28	3.16	3.07	3.05	2.87	2.59	2.23
7.0	1.24E1	6.83	4.92	3.83	3.64	3.51	3.44	3.19	2.82	2.39
8.0	1.72E1	8.61	5.92	4.44	4.19	3.98	3.86	3.51	3.04	2.55
10.0	3.29E1	1.36E1	8.51	5.94	5.47	5.05	4.75	4.14	3.46	2.83
15.0	1.59E2	4.08E1	2.03E1	1.17E1	1.01E1	8.48	7.26	5.75	4.47	3.46
20.0	7.39E2	1.18E2	4.64E1	2.19E1	1.74E1	1.31E1	1.01E1	7.36	5.41	4.03
25.0	3.32E3	3.30E2	1.03E2	3.94E1	2.85E1	1.92E1	1.33E1	8.96	6.30	4.57
30.0	1.45E4	8.96E2	2.22E2	6.84E1	4.50E1	2.68E1	1.67E1	1.06E1	7.18	5.07
35.0	6.19E4	2.38E3	4.69E2	1.16E2	6.89E1	3.63E1	2.03E1	1.22E1	8.15	5.52
40.0	2.59E5	6.20E3	9.71E2	1.91E2	1.03E2	4.78E1	2.41E1	1.37E1	9.13	5.94
R(MFP)	ENERGY (MEV)									
	0.8	0.6	0.5	0.4	0.3	0.25	0.2	0.19	0.18	0.17
0.5	1.13	1.11	1.10	1.10	1.12	1.17	1.26	1.29	1.32	1.35
1.0	1.25	1.19	1.16	1.14	1.17	1.24	1.42	1.48	1.54	1.62
2.0	1.45	1.34	1.28	1.22	1.22	1.30	1.60	1.72	1.87	2.07
3.0	1.61	1.45	1.36	1.28	1.26	1.32	1.69	1.88	2.13	2.48
4.0	1.75	1.54	1.43	1.33	1.29	1.34	1.75	2.00	2.37	2.94
5.0	1.87	1.63	1.49	1.37	1.31	1.36	1.80	2.11	2.62	3.49
6.0	2.00	1.71	1.55	1.41	1.34	1.37	1.84	2.21	2.89	4.14
7.0	2.11	1.79	1.60	1.44	1.35	1.39	1.87	2.32	3.20	4.99
8.0	2.22	1.87	1.66	1.47	1.37	1.40	1.90	2.43	3.57	6.13
10.0	2.43	2.02	1.75	1.53	1.40	1.42	1.95	2.68	4.54	9.20
15.0	2.86	2.30	1.94	1.65	1.46	1.46	2.06	3.50	8.84	3.10E1
20.0	3.24	2.53	2.10	1.75	1.50	1.49	2.15	4.62	2.09E1	1.31E2
25.0	3.55	2.73	2.24	1.84	1.53	1.52	2.20	6.52	5.60E1	6.09E2
30.0	3.85	2.90	2.37	1.92	1.56	1.54	2.24	9.85	1.61E2	2.97E3
35.0	4.12	3.06	2.49	2.00	1.58	1.56	2.28	1.58E1	4.84E2	1.48E4
40.0	4.39	3.22	2.60	2.07	1.61	1.57	2.33	2.68E1	1.49E3	7.50E4
R(MFP)	ENERGY (MEV)									
	0.16	0.15	0.14	0.13	0.12	0.116	0.115	0.1	0.08	0.06
0.5	1.39	1.43	1.46	1.50	1.54	1.56	1.07	1.05	1.02	1.01
1.0	1.71	1.81	1.91	2.02	2.12	2.17	1.08	1.06	1.02	1.01
2.0	2.31	2.61	2.93	3.31	3.72	3.90	1.10	1.08	1.03	1.02
3.0	2.96	3.61	4.38	5.36	6.51	7.04	1.13	1.09	1.04	1.02
4.0	3.79	5.05	6.69	8.98	1.19E1	1.33E1	1.14	1.11	1.05	1.03
5.0	4.91	7.20	1.05E1	1.56E1	2.25E1	2.60E1	1.16	1.12	1.06	1.03
6.0	6.41	1.04E1	1.68E1	2.74E1	4.32E1	5.16E1	1.18	1.13	1.06	1.03
7.0	8.56	1.55E1	2.75E1	4.85E1	8.11E1	1.00E2	1.19	1.14	1.07	1.03
8.0	1.15E1	2.26E1	4.38E1	8.25E1	1.48E2	1.88E2	1.20	1.15	1.07	1.04
10.0	2.10E1	4.91E1	1.12E2	2.47E2	5.14E2	6.90E2	1.22	1.16	1.08	1.04
15.0	1.16E2	4.25E2	1.42E3	4.46E3	1.29E4	1.96E4	1.26	1.19	1.10	1.05
20.0	7.99E2	4.47E3	2.15E4	9.42E4	3.67E5	6.25E5	1.29	1.21	1.11	1.06
25.0	5.99E3	5.10E4	3.55E5	2.16E6	1.13E7	2.15E7	1.31	1.22	1.13	1.07
30.0	4.65E4	6.03E5	6.09E6	5.19E7	3.65E8	7.71E8	1.33	1.24	1.14	1.07
35.0	3.66E5	7.23E6	1.07E8	1.27E9	1.21E10	2.84E10	1.34	1.25	1.15	1.07
40.0	2.93E6	8.77E7	1.88E9	3.16E10	4.06E11	1.07E12	1.36	1.26	1.16	1.08
R(MFP)	ENERGY (MEV)									
	0.05	0.04	0.03							
0.5	1.01	1.00	1.00							
1.0	1.01	1.01	1.00							
2.0	1.01	1.01	1.00							
3.0	1.02	1.01	1.00							
4.0	1.02	1.01	1.01							
5.0	1.02	1.01	1.01							
6.0	1.02	1.01	1.01							
7.0	1.02	1.01	1.01							
8.0	1.02	1.01	1.01							
10.0	1.03	1.02	1.01							
15.0	1.03	1.02	1.01							
20.0	1.04	1.02	1.01							
25.0	1.04	1.03	1.01							
30.0	1.05	1.03	1.01							
35.0	1.05	1.03	1.01							
40.0	1.05	1.03	1.02							

Table B.1 G-P parameters for gamma-ray buildup factors  
in molybdenum medium

PARAMETERS FOR POINT SOURCE ABSORBED DOSE BUILDUP FACTORS UP TO 40 MFP  
IN 45-MFP THICK MOLYBDENUM AND COMPARISON TO VALUES CALCULATED  
BY THE PALLAS CODE

E (MEV)	B	C	A	XK	D	MAX. DEV(%)	XMAX (MFP)	RMS DEV(%)
15	1.404	0.984	0.072	14.18	-0.0947	4.7	1	2.44
10	1.411	0.863	0.091	14.31	-0.1056	4.9	1	2.59
8	1.465	0.805	0.105	14.27	-0.1188	5.9	0.5	2.98
6	1.545	0.784	0.107	13.97	-0.1249	5.5	0.5	3.02
5	1.596	0.819	0.090	13.79	-0.1087	5.6	0.5	2.86
4	1.563	0.900	0.057	13.51	-0.0796	3.3	0.5	2.06
3	1.690	0.950	0.035	13.30	-0.0570	2.0	0.5	1.40
2	1.860	1.032	0.006	13.22	-0.0281	1.6	2	0.73
1.5	1.906	1.079	-0.012	12.97	-0.0095	0.7	3	0.34
1	2.263	0.958	0.026	13.62	-0.0389	1.5	5	0.75
0.8	2.408	0.908	0.040	13.62	-0.0467	2.1	0.5	1.03
0.6	2.549	0.847	0.063	13.82	-0.0655	2.5	0.5	1.34
0.5	2.594	0.774	0.085	13.93	-0.0750	3.1	0.5	1.48
0.4	2.555	0.675	0.119	13.99	-0.0919	3.5	0.5	1.62
0.3	2.294	0.527	0.182	14.13	-0.1276	2.9	0.5	1.41
0.2	1.709	0.389	0.248	14.25	-0.1467	2.2	0.5	1.00
0.15	1.422	0.291	0.330	12.85	-0.2300	3.5	0.5	1.69
0.1	1.156	0.252	0.363	13.03	-0.2549	1.8	0.5	0.85
0.08	1.085	0.240	0.379	13.14	-0.2715	0.9	0.5	0.50
0.06	1.028	0.505	0.150	13.57	-0.0706	0.1	0.5	0.07
0.05	1.380	0.053	-0.090	9.94	0.1063	0.4	4	0.23
0.04	1.486	0.349	0.064	29.63	-0.0674	0.4	15	0.18
0.035	1.545	0.529	0.259	17.17	-0.2122	1.5	0.5	0.74
0.03	1.511	1.111	0.103	28.91	-0.1158	4.3	8	2.41
0.028	1.553	1.275	0.087	36.00	-0.2236	7.3	40	4.05
0.026	1.595	1.413	0.083	10.64	-0.0623	9.5	3	5.48
0.024	1.594	1.632	0.057	9.15	-0.0313	10.8	3	4.61
0.022	1.596	1.785	0.049	10.68	-0.0390	11.7	3	4.84
0.021	1.531	1.997	0.022	20.26	-0.0122	7.6	3	4.31
0.02	1.011	0.365	0.261	14.32	-0.1599	0.1	0.5	0.05
0.015	1.005	0.347	0.282	13.56	-0.1759	0.1	10	0.04

Table B.1 (continued)

PARAMETERS FOR POINT SOURCE EXPOSURE BUILDUP FACTORS UP TO 40 MFP  
IN 45-MFP THICK MOLYBDENUM AND COMPARISON TO VALUES CALCULATED  
BY THE PALLAS CODE

E (MEV)	B	C	A	XK	D	MAX. DEV(%)	XMAX (MFP)	RMS DEV(%)
15	1.567	1.081	0.044	13.97	-0.0699	4.4	1	2.12
10	1.510	0.936	0.067	14.16	-0.0860	4.5	0.5	2.37
8	1.496	0.904	0.070	14.12	-0.0891	4.9	0.5	2.37
6	1.517	0.901	0.064	13.82	-0.0869	4.2	0.5	2.27
5	1.524	0.940	0.047	13.63	-0.0713	3.9	0.5	1.99
4	1.509	1.003	0.023	13.32	-0.0502	2.4	0.5	1.40
3	1.566	1.042	0.006	12.98	-0.0329	1.2	35	0.81
2	1.628	1.097	-0.013	12.41	-0.0128	1.3	2	0.61
1.5	1.649	1.117	-0.023	12.45	-0.0005	1.2	0.5	0.44
1	1.743	1.061	-0.006	13.68	-0.0129	0.9	5	0.39
0.8	1.757	1.032	0.0	13.85	-0.0143	0.8	5	0.37
0.6	1.747	0.997	0.012	14.14	-0.0237	1.0	5	0.39
0.5	1.716	0.940	0.025	14.30	-0.0275	1.0	5	0.44
0.4	1.654	0.856	0.047	14.13	-0.0369	1.0	5	0.49
0.3	1.533	0.733	0.084	14.45	-0.0549	1.0	35	0.49
0.2	1.334	0.582	0.136	14.63	-0.0734	0.6	25	0.38
0.15	1.241	0.462	0.192	12.98	-0.1125	2.4	0.5	1.05
0.1	1.108	0.373	0.250	13.00	-0.1638	1.4	0.5	0.62
0.08	1.065	0.341	0.275	13.17	-0.1833	0.8	0.5	0.39
0.06	1.025	0.556	0.123	14.26	-0.0506	0.1	0.5	0.07
0.05	2.981	0.038	-0.226	16.53	0.0483	2.6	1	1.04
0.04	3.839	0.345	0.050	30.30	-0.0921	0.8	15	0.40
0.035	3.897	0.545	0.248	17.68	-0.1994	2.1	15	1.04
0.03	3.621	1.090	0.110	36.26	-0.3084	5.8	0.5	3.41
0.028	3.577	1.275	0.087	25.69	-0.1113	9.1	3	5.57
0.026	3.252	1.519	0.057	26.56	-0.0687	12.8	40	6.29
0.024	3.272	1.606	0.063	10.16	-0.0447	12.8	3	5.60
0.022	2.935	1.820	0.043	10.51	-0.0326	11.4	3	4.89
0.021	2.758	1.945	0.031	10.77	-0.0230	10.3	3	4.64
0.02	1.011	0.376	0.250	14.35	-0.1476	0.1	10	0.06
0.015	1.005	0.377	0.249	15.04	-0.1493	0.1	0.5	0.04

Table B.1 (continued)

PARAMETERS FOR POINT SOURCE DOSE EQUIVALENT BUILDUP FACTORS UP TO 40  
MFP IN 45-MFP THICK MOLYBDENUM AND COMPARISON TO VALUES CALCULATED  
BY THE PALLAS CODE

E (MEV)	B	C	A	XK	D	MAX. DEV(%)	XMAX (MFP)	RMS DEV(%)
15	1.660	1.048	0.054	13.98	-0.0807	5.1	1	2.49
10	1.600	0.894	0.082	14.14	-0.1014	5.2	0.5	2.75
8	1.583	0.850	0.090	14.09	-0.1092	5.2	0.5	2.74
6	1.578	0.873	0.074	13.84	-0.0961	5.2	0.5	2.59
5	1.597	0.903	0.060	13.63	-0.0832	4.5	0.5	2.30
4	1.558	0.972	0.033	13.41	-0.0590	2.8	0.5	1.63
3	1.615	1.019	0.013	13.10	-0.0387	1.6	35	0.97
2	1.665	1.121	-0.025	5.00	0.0116	1.9	2	0.63
1.5	1.706	1.119	-0.024	5.51	0.0015	1.1	3	0.46
1	1.835	1.038	0.001	13.63	-0.0188	1.0	5	0.44
0.8	1.849	1.015	0.005	13.99	-0.0180	1.1	5	0.40
0.6	1.818	0.984	0.016	14.04	-0.0266	1.2	5	0.45
0.5	1.787	0.922	0.031	14.19	-0.0323	1.1	5	0.48
0.4	1.700	0.842	0.052	14.10	-0.0405	1.1	5	0.54
0.3	1.566	0.712	0.093	14.31	-0.0618	0.9	35	0.52
0.2	1.357	0.564	0.144	15.11	-0.0801	0.8	0.5	0.48
0.15	1.260	0.430	0.215	12.81	-0.1339	2.5	0.5	1.13
0.1	1.115	0.353	0.266	12.93	-0.1764	1.4	0.5	0.66
0.08	1.067	0.330	0.285	13.17	-0.1932	0.9	0.5	0.40
0.06	1.025	0.542	0.132	13.73	-0.0581	0.1	0.5	0.06
0.05	2.539	0.038	-0.310	15.80	0.0557	2.0	1	0.82
0.04	3.127	0.346	0.055	25.76	-0.0643	0.7	15	0.36
0.035	3.310	0.542	0.251	17.37	-0.2035	2.4	0.5	0.94
0.03	3.201	1.101	0.106	28.78	-0.1329	5.4	3	3.15
0.028	3.101	1.310	0.079	32.82	-0.1454	8.7	40	4.90
0.026	3.308	1.377	0.089	11.87	-0.0574	14.5	3	6.93
0.024	3.019	1.624	0.059	10.67	-0.0388	12.3	3	5.60
0.022	2.780	1.831	0.041	11.36	-0.0300	11.3	3	5.01
0.021	2.586	1.986	0.024	35.45	-0.0642	8.1	3	4.69
0.02	1.011	0.365	0.261	14.32	-0.1599	0.1	0.5	0.05
0.015	1.005	0.347	0.282	13.56	-0.1759	0.1	10	0.04

Table B.2 G-P parameters for gamma-ray buildup factors  
in tin medium

PARAMETERS FOR POINT SOURCE ABSORBED DOSE BUILDUP FACTORS UP TO 40 MFP  
IN 45-MFP THICK TIN AND COMPARISON TO VALUES CALCULATED  
BY THE PALLAS CODE

E (MEV)	B	C	A	XK	D	MAX. DEV(%)	XMAX (MFP)	RMS DEV(%)
15	1.398	1.055	0.064	14.06	-0.0929	6.0	1	2.81
10	1.435	0.895	0.088	14.80	-0.1043	5.8	0.5	3.32
8	1.469	0.807	0.112	14.26	-0.1297	7.2	0.5	3.38
6	1.568	0.732	0.136	14.03	-0.1584	5.7	0.5	3.70
5	1.575	0.814	0.096	13.88	-0.1167	7.8	0.5	3.42
4	1.517	0.891	0.063	13.52	-0.0873	5.1	0.5	2.52
3	1.643	0.933	0.043	13.32	-0.0665	3.7	0.5	1.85
2	1.814	0.981	0.021	13.33	-0.0392	1.5	35	0.86
1.5	1.929	1.030	0.001	13.25	-0.0179	0.9	5	0.36
1	2.236	0.901	0.041	13.52	-0.0463	1.6	5	0.95
0.8	2.332	0.852	0.057	13.76	-0.0574	2.7	0.5	1.23
0.6	2.391	0.769	0.085	13.78	-0.0736	3.1	0.5	1.44
0.5	2.337	0.702	0.110	13.90	-0.0892	3.3	0.5	1.60
0.4	2.224	0.589	0.151	13.88	-0.1057	3.5	0.5	1.51
0.3	1.924	0.460	0.213	14.10	-0.1426	2.5	0.5	1.25
0.2	1.456	0.356	0.263	14.22	-0.1497	1.7	0.5	0.75
0.15	1.170	0.504	0.152	13.45	-0.0750	0.9	0.5	0.40
0.1	1.123	0.245	0.342	12.99	-0.2053	1.1	0.5	0.44
0.09	1.115	0.192	0.403	13.17	-0.2361	0.7	2	0.37
0.08	1.393	0.033	0.741	14.35	-0.2278	0.5	3	0.24
0.07	1.476	0.064	0.125	8.62	0.1096	0.6	1	0.33
0.06	1.566	0.258	-0.080	21.22	0.0579	0.5	0.5	0.27
0.055	1.610	0.315	0.243	15.34	0.1054	1.5	0.5	0.81
0.05	1.636	0.496	0.276	16.81	-0.2316	1.9	20	0.91
0.045	1.647	0.881	0.152	17.98	-0.1158	2.6	4	1.52
0.04	1.691	1.229	0.096	29.62	-0.1824	6.3	3	3.78
0.035	1.671	1.705	0.030	13.79	0.0447	5.5	3	2.92
0.03	1.787	1.859	0.042	11.10	-0.0316	11.3	3	4.82
0.029	1.017	0.366	0.260	14.11	-0.1578	0.1	3	0.08
0.02	1.006	0.381	0.252	13.99	-0.1592	0.1	15	0.03
0.015	1.003	0.405	0.215	26.26	-0.3092	0.1	4	0.04

Table B.2 (continued)

PARAMETERS FOR POINT SOURCE EXPOSURE BUILDUP FACTORS UP TO 40 MFP  
IN 45-MFP THICK TIN AND COMPARISON TO VALUES CALCULATED  
BY THE PALLAS CODE

E (MeV)	B	C	A	XK	D	I	MAX. DEV(%)	XMAX (MFP)	RMS DEV(%)
15	1.573	1.170	0.033	13.84	-0.0640	I	4.8	1	2.25
10	1.509	0.987	0.061	14.01	-0.0850	I	4.8	0.5	2.49
8	1.478	0.945	0.063	14.24	-0.0840	I	5.5	0.5	2.49
6	1.486	0.924	0.062	13.89	-0.0870	I	5.1	0.5	2.44
5	1.480	0.970	0.041	13.72	-0.0672	I	5.1	0.5	2.19
						I			
4	1.459	1.018	0.021	13.31	-0.0504	I	3.4	0.5	1.58
3	1.506	1.058	0.003	13.05	-0.0314	I	2.0	0.5	0.97
2	1.567	1.073	-0.007	12.77	-0.0162	I	1.3	2	0.49
1.5	1.612	1.085	-0.015	12.40	-0.0057	I	0.9	0.5	0.36
1	1.674	1.021	0.002	13.56	-0.0151	I	0.9	5	0.37
						I			
0.8	1.670	0.994	0.009	13.88	-0.0182	I	0.9	5	0.38
0.6	1.643	0.929	0.027	13.89	-0.0286	I	0.8	5	0.40
0.5	1.601	0.877	0.042	13.86	-0.0357	I	1.0	5	0.49
0.4	1.525	0.780	0.067	14.18	-0.0432	I	1.0	35	0.49
0.3	1.405	0.659	0.109	14.33	-0.0678	I	0.9	35	0.49
						I			
0.2	1.229	0.543	0.149	14.61	-0.0779	I	0.6	35	0.32
0.15	1.104	0.640	0.091	13.89	-0.0357	I	0.3	3	0.15
0.1	1.117	0.229	0.366	13.11	-0.2253	I	1.0	0.5	0.46
0.09	1.139	0.134	0.498	13.46	-0.2889	I	0.8	2	0.39
0.08	1.765	0.018	0.810	15.18	-0.1613	I	1.1	1	0.35
						I			
0.07	2.215	0.050	-0.558	9.48	0.1018	I	0.8	2	0.40
0.06	2.848	0.236	-0.030	5.00	-0.0542	I	0.6	40	0.38
0.055	3.104	0.326	0.225	14.57	0.1272	I	2.1	2	1.31
0.05	3.386	0.491	0.279	16.78	-0.2340	I	2.3	0.5	1.18
0.045	3.407	0.867	0.157	17.52	-0.1194	I	3.4	4	2.02
						I			
0.04	3.472	1.233	0.094	27.06	-0.1217	I	8.2	3	4.12
0.035	3.122	1.612	0.052	27.11	-0.0716	I	12.6	25	6.73
0.03	2.901	1.854	0.044	9.47	-0.0403	I	11.5	3	4.87
0.029	1.016	0.401	0.234	14.00	-0.1396	I	0.2	0.5	0.08
0.02	1.006	0.377	0.255	14.12	-0.1620	I	0.1	10	0.03
						I			
0.015	1.003	0.382	0.234	28.06	-0.4056	I	0.1	4	0.04

Table B.2 (continued)

PARAMETERS FOR POINT SOURCE DOSE EQUIVALENT BUILDUP FACTORS UP TO 40  
MFP IN 45-MFP THICK TIN AND COMPARISON TO VALUES CALCULATED  
BY THE PALLAS CODE

E (MEV)	B	C	A	XK	D	MAX. DEV(%)	XMAX (MFP)	RMS DEV(%)
15	1.663	1.135	0.043	13.78	-0.0756	5.4	1	2.63
10	1.578	0.969	0.067	14.03	-0.0913	6.2	0.5	2.88
8	1.551	0.898	0.080	14.07	-0.1022	6.1	0.5	2.87
6	1.543	0.891	0.074	13.88	-0.0990	5.9	0.5	2.80
5	1.552	0.918	0.059	13.67	-0.0845	5.5	0.5	2.53
4	1.497	0.990	0.030	13.34	-0.0588	3.9	0.5	1.85
3	1.553	1.022	0.014	13.21	-0.0410	2.0	0.5	1.14
2	1.609	1.056	-0.002	12.97	-0.0205	1.1	2	0.52
1.5	1.665	1.079	-0.013	11.82	-0.0077	0.9	3	0.39
1	1.746	1.004	0.007	14.18	-0.0191	1.0	5	0.41
0.8	1.744	0.975	0.015	13.72	-0.0229	1.0	5	0.43
0.6	1.693	0.922	0.029	13.93	-0.0293	0.9	5	0.46
0.5	1.648	0.868	0.045	13.89	-0.0378	1.0	35	0.53
0.4	1.557	0.769	0.071	14.18	-0.0456	1.0	35	0.52
0.3	1.419	0.656	0.110	14.35	-0.0681	0.8	35	0.50
0.2	1.242	0.529	0.156	14.58	-0.0821	0.8	0.5	0.37
0.15	1.110	0.631	0.094	13.87	-0.0374	0.4	0.5	0.17
0.1	1.125	0.220	0.374	13.07	-0.2271	1.0	0.5	0.48
0.09	1.141	0.137	0.492	13.31	-0.2847	0.8	2	0.39
0.08	1.702	0.019	0.806	15.22	-0.1694	0.9	1	0.33
0.07	2.070	0.051	-0.550	9.12	0.1074	0.7	2	0.38
0.06	2.553	0.238	-0.022	5.00	-0.0544	0.6	8	0.34
0.055	2.811	0.323	0.232	14.60	0.1162	2.1	0.5	1.26
0.05	3.091	0.495	0.277	16.76	-0.2333	2.1	0.5	1.10
0.045	3.067	0.874	0.155	17.21	-0.1148	3.5	0.5	2.02
0.04	3.132	1.222	0.098	19.11	-0.0717	8.8	3	4.84
0.035	3.097	1.535	0.068	13.19	-0.0466	13.0	3	6.88
0.03	2.807	1.862	0.042	10.55	-0.0344	11.6	3	4.96
0.029	1.017	0.366	0.260	14.11	-0.1578	0.1	3	0.08
0.02	1.006	0.381	0.252	13.99	-0.1592	0.1	15	0.03
0.015	1.003	0.405	0.215	26.26	-0.3092	0.1	4	0.04

Table B.3 G-P parameters for gamma-ray buildup factors  
in lanthanum medium

PARAMETERS FOR POINT SOURCE ABSORBED DOSE BUILDUP FACTORS UP TO 40 MFP  
IN 45-MFP THICK LANTHANUM AND COMPARISON TO VALUES CALCULATED  
BY THE PALLAS CODE

E (MEV)	B	C	A	XK	D	MAX.	XMAX	RMS
						DEV(%)	(MFP)	DEV(%)
15	1.400	1.096	0.061	13.99	-0.0938	6.9	1	3.10
10	1.422	0.919	0.089	14.18	-0.1121	7.3	0.5	3.36
8	1.404	0.924	0.073	14.62	-0.0883	10.9	0.5	4.13
6	1.518	0.788	0.115	14.12	-0.1361	9.1	0.5	3.85
5	1.574	0.797	0.107	13.96	-0.1293	8.8	0.5	3.80
4	1.513	0.873	0.073	13.60	-0.0989	6.6	0.5	3.00
3	1.647	0.899	0.056	13.34	-0.0789	5.1	0.5	2.30
2	1.822	0.942	0.033	13.34	-0.0477	1.6	0.5	1.09
1.5	1.937	0.977	0.015	13.37	-0.0258	1.2	5	0.50
1	2.143	0.854	0.055	13.58	-0.0542	2.2	0.5	1.14
0.8	2.212	0.786	0.077	13.61	-0.0670	2.9	0.5	1.35
0.6	2.202	0.690	0.112	13.78	-0.0874	3.0	0.5	1.46
0.5	2.235	0.599	0.149	13.87	-0.1084	3.9	0.5	1.68
0.4	2.094	0.488	0.199	13.77	-0.1338	3.4	0.5	1.55
0.3	1.820	0.369	0.269	14.03	-0.1785	3.2	0.5	1.35
0.2	1.524	0.216	0.390	14.02	-0.2232	2.3	0.5	1.02
0.15	1.170	0.338	0.259	12.95	-0.1506	1.4	0.5	0.60
0.1	1.450	0.043	0.646	14.35	-0.1780	0.6	1	0.24
0.08	1.604	0.214	-0.058	14.49	0.0680	0.4	1	0.16
0.07	1.699	0.288	0.358	26.36	-0.3037	3.7	0.5	1.73
0.06	1.694	0.794	0.175	16.64	-0.1387	2.4	1	1.27
0.055	1.794	1.018	0.134	17.05	-0.1003	6.9	3	3.37
0.05	1.768	1.347	0.080	33.49	-0.1719	6.4	20	3.96
0.048	1.811	1.434	0.072	25.88	-0.0836	13.4	40	5.43
0.046	1.809	1.558	0.059	26.72	-0.0842	15.0	40	5.75
0.044	1.848	1.646	0.054	18.45	-0.0407	11.1	25	6.26
0.042	1.856	1.753	0.046	13.62	-0.0330	10.1	20	6.07
0.04	1.907	1.787	0.050	11.12	-0.0373	12.1	3	5.13
0.039	1.912	1.854	0.043	11.56	-0.0330	11.7	3	5.07
0.038	1.021	0.399	0.237	13.92	-0.1449	0.3	0.5	0.12
0.03	1.012	0.371	0.256	14.48	-0.1601	0.1	4	0.08
0.02	1.004	0.385	0.242	15.44	-0.1504	0.1	5	0.03
0.015	1.002	0.351	0.272	14.37	-0.1700	0.1	6	0.02

Table B.3 (continued)

PARAMETERS FOR POINT SOURCE EXPOSURE BUILDUP FACTORS UP TO 40 MFP  
IN 45-MFP THICK LANTHANUM AND COMPARISON TO VALUES CALCULATED  
BY THE PALLAS CODE

E (MEV)	B	C	A	XK	D	MAX. DEV(%)	XMAX (MFP)	RMS DEV(%)
15	1.581	1.220	0.029	13.69	-0.0637	4.9	1	2.35
10	1.493	1.055	0.047	13.98	-0.0734	5.7	0.5	2.54
8	1.468	0.974	0.060	14.13	-0.0838	5.9	0.5	2.56
6	1.467	0.938	0.061	13.94	-0.0871	5.5	0.5	2.49
5	1.466	0.966	0.047	13.73	-0.0749	5.2	0.5	2.33
4	1.431	1.026	0.022	13.38	-0.0535	3.7	0.5	1.72
3	1.481	1.051	0.006	13.03	-0.0342	2.3	0.5	1.09
2	1.536	1.053	-0.002	12.93	-0.0187	0.9	2	0.49
1.5	1.574	1.053	-0.008	12.66	-0.0081	0.7	0.5	0.32
1	1.608	0.990	0.009	13.65	-0.0172	0.9	5	0.40
0.8	1.592	0.942	0.021	13.82	-0.0224	0.9	5	0.43
0.6	1.547	0.868	0.042	13.95	-0.0331	0.9	5	0.45
0.5	1.500	0.805	0.060	14.09	-0.0407	0.8	5	0.49
0.4	1.426	0.709	0.089	13.99	-0.0526	0.8	35	0.47
0.3	1.310	0.619	0.121	14.43	-0.0711	0.8	0.5	0.45
0.2	1.197	0.452	0.195	14.41	-0.1048	1.1	0.5	0.45
0.15	1.089	0.537	0.135	13.64	-0.0636	0.8	0.5	0.29
0.1	1.455	0.040	0.661	14.48	-0.1748	0.7	1	0.25
0.08	2.014	0.216	-0.123	16.23	0.0673	0.7	1	0.32
0.07	2.381	0.305	0.340	24.83	-0.2257	4.1	0.5	2.25
0.06	2.786	0.778	0.182	16.42	-0.1492	2.7	4	1.57
0.0551	2.849	1.084	0.114	20.72	-0.0981	5.6	0.5	3.00
0.05	3.178	1.269	0.100	18.88	-0.1095	12.8	40	6.98
0.0481	3.042	1.426	0.075	26.95	-0.1311	12.5	40	5.63
0.0461	3.095	1.510	0.070	16.32	-0.0550	12.4	3	7.17
0.0441	2.970	1.647	0.054	19.11	-0.0472	11.3	25	6.63
0.0421	3.029	1.684	0.059	10.66	-0.0434	12.9	3	5.68
0.04	2.900	1.811	0.046	11.12	-0.0333	11.8	3	5.15
0.0391	2.812	1.867	0.041	10.66	-0.0308	11.4	3	5.07
0.0381	1.022	0.380	0.251	13.91	-0.1574	0.2	0.5	0.11
0.03	1.012	0.367	0.263	13.73	-0.1674	0.1	0.5	0.06
0.02	1.004	0.385	0.242	15.44	-0.1504	0.1	5	0.03
0.0151	1.002	0.351	0.272	14.37	-0.1700	0.1	6	0.02

Table B.3 (continued)

PARAMETERS FOR POINT SOURCE DOSE EQUIVALENT BUILDUP FACTORS UP TO 40  
MFP IN 45-MFP THICK LANTHANUM AND COMPARISON TO VALUES CALCULATED  
BY THE PALLAS CODE

E (MEV)	B	C	A	XK	D	MAX. DEV(%)	XMAX (MFP)	RMS DEV(%)
15	1.666	1.191	0.037	13.65	-0.0732	5.7	1	2.73
10	1.576	1.011	0.061	13.97	-0.0888	6.5	0.5	2.97
8	1.532	0.939	0.072	14.08	-0.0965	6.8	0.5	2.97
6	1.516	0.912	0.070	13.97	-0.0958	6.6	0.5	2.87
5	1.520	0.939	0.056	13.77	-0.0834	6.3	0.5	2.66
4	1.462	1.004	0.029	13.40	-0.0598	4.6	0.5	1.99
3	1.511	1.032	0.012	13.14	-0.0399	2.9	0.5	1.26
2	1.568	1.040	0.002	13.01	-0.0222	1.1	2	0.55
1.5	1.624	1.040	-0.004	12.87	-0.0116	0.8	0.5	0.34
1	1.667	0.968	0.016	13.67	-0.0228	1.1	5	0.43
0.8	1.653	0.921	0.028	13.69	-0.0280	1.1	5	0.46
0.6	1.587	0.856	0.046	13.97	-0.0356	0.9	5	0.51
0.5	1.544	0.784	0.068	14.02	-0.0467	1.0	25	0.56
0.4	1.448	0.703	0.091	14.03	-0.0534	0.9	35	0.50
0.3	1.329	0.600	0.130	14.36	-0.0775	1.0	0.5	0.51
0.2	1.224	0.411	0.221	14.29	-0.1221	1.3	0.5	0.54
0.15	1.102	0.486	0.163	13.30	-0.0843	1.0	0.5	0.36
0.1	1.518	0.037	0.657	14.68	-0.1509	0.7	1	0.27
0.08	2.019	0.218	-0.118	16.77	0.0677	0.7	1	0.33
0.07	2.339	0.306	0.342	27.94	-0.3397	4.1	0.5	2.06
0.06	2.635	0.792	0.177	16.33	-0.1431	2.8	1	1.65
0.055	2.760	1.087	0.113	19.94	-0.0848	5.1	0.5	2.80
0.05	3.048	1.295	0.093	20.58	-0.0948	9.5	3	5.27
0.048	2.765	1.508	0.059	29.90	-0.0961	11.0	40	5.97
0.046	2.946	1.538	0.064	10.18	-0.0246	10.9	3	4.82
0.044	2.970	1.599	0.064	13.03	-0.0451	13.0	3	6.37
0.042	2.911	1.690	0.058	10.98	-0.0418	12.8	3	5.65
0.04	2.813	1.787	0.051	10.34	-0.0409	12.3	3	5.28
0.039	2.738	1.853	0.044	10.83	-0.0343	11.9	3	5.12
0.038	1.021	0.401	0.235	14.15	-0.1456	0.3	0.5	0.12
0.03	1.012	0.371	0.256	14.48	-0.1601	0.1	4	0.08
0.02	1.004	0.385	0.242	15.44	-0.1504	0.1	5	0.03
0.015	1.002	0.351	0.272	14.37	-0.1700	0.1	6	0.02

Table B.4 G-P parameters for gamma-ray buildup factors  
in gadolinium medium

PARAMETERS FOR POINT SOURCE ABSORBED DOSE BUILDUP FACTORS UP TO 40 MFP  
IN 45-MFP THICK GADOLINIUM AND COMPARISON TO VALUES CALCULATED  
BY THE PALLAS CODE

E (MEV)	B	C	A	XK	D	MAX. DEV(%)	XMAX (MFP)	RMS DEV(%)
15	1.415	1.120	0.060	13.92	-0.0949	7.0	0.5	3.26
10	1.433	0.938	0.087	14.14	-0.1117	8.2	0.5	3.54
8	1.466	0.820	0.116	14.21	-0.1362	9.0	0.5	3.85
6	1.482	0.828	0.100	14.26	-0.1177	11.6	0.5	4.23
5	1.616	0.713	0.145	14.15	-0.1708	7.7	0.5	4.29
4	1.490	0.854	0.081	13.71	-0.1057	8.0	0.5	3.34
3	1.625	0.866	0.068	13.44	-0.0887	6.3	0.5	2.67
2	1.795	0.889	0.049	13.34	-0.0585	2.5	0.5	1.35
1.5	1.899	0.912	0.033	13.36	-0.0360	1.2	5	0.72
1	2.025	0.790	0.074	13.55	-0.0629	2.6	0.5	1.28
0.8	2.054	0.709	0.101	13.64	-0.0763	2.8	0.5	1.34
0.6	1.975	0.625	0.134	13.80	-0.0948	3.0	0.5	1.38
0.5	2.022	0.516	0.186	13.77	-0.1282	3.6	0.5	1.60
0.4	1.883	0.408	0.242	13.70	-0.1576	3.0	0.5	1.40
0.3	1.664	0.303	0.316	14.00	-0.2044	2.8	0.5	1.25
0.2	1.488	0.148	0.479	13.91	-0.2602	2.2	0.5	0.96
0.15	1.433	0.076	0.629	13.32	-0.3336	1.5	2	0.75
0.1	1.648	0.242	-0.006	19.35	0.0590	0.4	0.5	0.17
0.09	1.710	0.330	0.268	10.53	0.0625	1.6	2	0.95
0.08	1.739	0.609	0.235	16.12	-0.2033	2.2	35	1.23
0.075	1.757	0.830	0.169	16.56	-0.1377	2.7	1	1.42
0.07	1.771	1.069	0.117	20.36	-0.0956	3.8	0.5	2.10
0.065	1.821	1.261	0.093	37.31	-0.3050	5.3	3	3.12
0.06	1.903	1.408	0.085	18.32	-0.0988	15.2	40	7.47
0.058	1.849	1.603	0.049	13.03	0.0133	7.7	3	3.51
0.056	2.022	1.508	0.080	12.29	-0.0541	14.0	3	6.30
0.054	2.026	1.603	0.070	11.81	-0.0505	13.9	3	6.18
0.052	1.990	1.736	0.053	12.46	-0.0402	12.4	3	5.86
0.051	1.997	1.769	0.051	10.56	-0.0359	11.8	3	5.13
0.05	1.030	0.408	0.228	13.76	-0.1346	0.4	0.5	0.17
0.04	1.017	0.393	0.238	14.15	-0.1412	0.2	0.5	0.10
0.03	1.008	0.370	0.262	14.04	-0.1718	0.1	3	0.06
0.02	1.003	0.304	0.321	14.04	-0.2144	0.0	4	0.02
0.015	1.001	0.623	0.099	11.85	-0.0272	0.1	4	0.03

Table B.4 (continued)

PARAMETERS FOR POINT SOURCE EXPOSURE BUILDUP FACTORS UP TO 40 MFP  
IN 45-MFP THICK GADOLINIUM AND COMPARISON TO VALUES CALCULATED  
BY THE PALLAS CODE

E (MeV)	B	C	A	XK	D	MAX. DEV(%)	XMAX (MFP)	RMS DEV(%)
15	1.590	1.269	0.022	13.68	-0.0562	4.8	1	2.25
10	1.503	1.074	0.046	13.91	-0.0738	5.2	0.5	2.42
8	1.457	0.995	0.056	14.08	-0.0790	5.9	0.5	2.48
6	1.443	0.949	0.059	14.02	-0.0835	5.6	0.5	2.43
5	1.438	0.967	0.048	13.80	-0.0749	5.4	0.5	2.27
4	1.392	1.036	0.020	13.47	-0.0510	4.2	0.5	1.73
3	1.444	1.038	0.010	13.33	-0.0365	2.5	0.5	1.13
2	1.496	1.016	0.007	13.01	-0.0237	1.0	35	0.54
1.5	1.524	1.009	0.002	13.00	-0.0122	0.8	5	0.31
1	1.533	0.935	0.022	13.53	-0.0218	0.9	5	0.44
0.8	1.507	0.875	0.037	13.71	-0.0272	0.9	5	0.43
0.6	1.450	0.806	0.058	13.74	-0.0379	0.8	35	0.44
0.5	1.399	0.749	0.075	14.07	-0.0448	0.7	15	0.48
0.4	1.328	0.658	0.104	13.96	-0.0569	0.7	25	0.43
0.3	1.235	0.576	0.136	14.60	-0.0779	0.8	0.5	0.43
0.2	1.160	0.389	0.232	14.05	-0.1256	1.1	0.5	0.46
0.15	1.175	0.182	0.427	13.11	-0.2640	1.2	2	0.60
0.1	1.607	0.246	-0.005	19.62	0.0612	0.3	0.5	0.18
0.09	1.822	0.331	0.270	9.77	0.0566	1.9	0.5	1.02
0.08	2.066	0.621	0.230	16.01	-0.1998	2.4	1	1.40
0.075	2.171	0.836	0.168	16.31	-0.1389	3.0	1	1.69
0.07	2.336	1.043	0.126	17.83	-0.0956	5.5	3	2.62
0.065	2.476	1.255	0.095	26.75	-0.1659	9.4	40	4.18
0.06	2.651	1.449	0.076	19.01	-0.0762	10.5	40	6.14
0.058	2.835	1.445	0.086	12.65	-0.0598	14.2	3	6.59
0.056	2.758	1.580	0.066	13.26	-0.0444	12.5	3	6.28
0.054	2.760	1.659	0.060	12.87	-0.0430	12.9	3	6.47
0.052	2.749	1.729	0.055	11.49	-0.0404	12.8	3	5.66
0.051	2.752	1.762	0.053	11.10	-0.0399	12.6	3	5.45
0.05	1.029	0.419	0.220	13.78	-0.1281	0.4	0.5	0.17
0.04	1.017	0.393	0.238	14.15	-0.1412	0.2	0.5	0.10
0.03	1.008	0.380	0.252	14.05	-0.1597	0.1	0.5	0.05
0.02	1.003	0.304	0.321	14.04	-0.2144	0.0	4	0.02
0.015	1.001	0.673	0.069	23.28	0.0179	0.1	7	0.03

Table B.4 (continued)

PARAMETERS FOR POINT SOURCE DOSE EQUIVALENT BUILDUP FACTORS UP TO 40 MFP IN 45-MFP THICK GADOLINIUM AND COMPARISON TO VALUES CALCULATED BY THE PALLAS CODE

E (MEV)	B	C	A	XK	D	I	MAX. DEV(%)	XMAX (MFP)	RMS DEV(%)
15	1.670	1.243	0.029	13.57	-0.0652	I	5.6	0.5	2.63
10	1.572	1.048	0.054	13.91	-0.0825	I	6.3	0.5	2.82
8	1.519	0.959	0.068	14.09	-0.0916	I	6.8	0.5	2.88
6	1.494	0.912	0.072	13.99	-0.0967	I	6.4	0.5	2.80
5	1.487	0.940	0.057	13.82	-0.0832	I	6.3	0.5	2.63
4	1.423	1.004	0.030	13.52	-0.0598	I	4.8	0.5	2.02
3	1.467	1.026	0.014	13.21	-0.0406	I	3.3	0.5	1.32
2	1.520	1.009	0.009	13.17	-0.0248	I	0.8	2	0.57
1.5	1.563	1.002	0.004	12.81	-0.0133	I	0.8	5	0.38
1	1.581	0.909	0.031	13.54	-0.0296	I	1.0	5	0.50
0.8	1.549	0.863	0.041	13.63	-0.0296	I	0.9	5	0.50
0.6	1.478	0.797	0.061	13.99	-0.0400	I	0.8	1	0.49
0.5	1.431	0.731	0.082	14.06	-0.0494	I	0.8	5	0.53
0.4	1.345	0.650	0.107	13.99	-0.0584	I	0.8	0.5	0.47
0.3	1.251	0.553	0.148	14.34	-0.0863	I	0.9	0.5	0.48
0.2	1.191	0.335	0.272	13.98	-0.1517	I	1.4	0.5	0.57
0.15	1.232	0.137	0.495	13.19	-0.2937	I	1.3	2	0.66
0.1	1.726	0.245	-0.021	20.47	0.0624	I	0.4	0.5	0.22
0.09	1.925	0.331	0.269	9.98	0.0590	I	2.0	0.5	1.06
0.08	2.150	0.606	0.238	15.93	-0.2101	I	2.3	35	1.37
0.075	2.226	0.828	0.171	16.23	-0.1421	I	2.9	4	1.70
0.07	2.346	1.043	0.126	17.57	-0.0938	I	4.7	3	2.47
0.065	2.425	1.273	0.091	36.15	-0.3023	I	6.1	40	3.61
0.06	2.539	1.487	0.067	35.25	-0.1837	I	8.7	40	4.62
0.058	2.629	1.553	0.061	9.99	-0.0163	I	10.4	35	6.02
0.056	2.661	1.624	0.058	14.55	-0.0400	I	12.5	20	6.64
0.054	2.679	1.701	0.052	13.79	-0.0365	I	11.3	20	6.25
0.052	2.763	1.728	0.055	11.19	-0.0402	I	12.7	3	5.67
0.051	2.768	1.767	0.052	11.25	-0.0378	I	12.5	3	5.48
0.05	1.029	0.416	0.224	13.82	-0.1355	I	0.4	0.5	0.16
0.04	1.016	0.419	0.222	13.82	-0.1330	I	0.2	0.5	0.09
0.03	1.008	0.370	0.262	14.04	-0.1718	I	0.1	3	0.06
0.02	1.003	0.304	0.321	14.04	-0.2144	I	0.0	4	0.02
0.015	1.001	0.623	0.099	11.85	-0.0272	I	0.1	4	0.03

Table B.5 G-P parameters for gamma-ray buildup factors  
in tungsten medium

PARAMETERS FOR POINT SOURCE ABSORBED DOSE BUILDUP FACTORS UP TO 40 MFP  
IN 45-MFP THICK TUNGSTEN AND COMPARISON TO VALUES CALCULATED  
BY THE PALLAS CODE

E (MEV)	B	C	A	XK	D	MAX. DEV(%)	XMAX (MFP)	RMS DEV(%)
15	1.396	1.164	0.054	13.90	-0.0885	7.3	1	3.17
10	1.481	0.844	0.128	14.12	-0.1624	7.0	3	4.40
8	1.431	0.839	0.112	14.28	-0.1304	8.9	0.5	3.71
6	1.480	0.768	0.127	14.27	-0.1441	9.7	0.5	3.95
5	1.509	0.756	0.126	14.11	-0.1441	9.9	0.5	4.02
4	1.460	0.828	0.091	13.78	-0.1126	9.5	0.5	3.67
3	1.582	0.840	0.076	13.53	-0.0922	8.2	0.5	3.01
2	1.748	0.827	0.068	13.39	-0.0694	4.0	0.5	1.72
1.5	1.840	0.818	0.061	13.42	-0.0512	1.7	0.5	1.02
1	1.869	0.689	0.106	13.54	-0.0760	2.2	0.5	1.27
0.8	1.910	0.607	0.139	13.57	-0.0952	2.9	0.5	1.40
0.6	1.759	0.534	0.171	13.78	-0.1124	2.9	0.5	1.28
0.5	1.802	0.416	0.237	13.74	-0.1550	3.0	0.5	1.43
0.4	1.683	0.327	0.294	13.68	-0.1857	2.9	0.5	1.29
0.3	1.563	0.204	0.395	13.29	-0.2179	2.4	0.5	1.04
0.2	1.528	0.073	0.634	13.97	-0.2997	1.2	2	0.61
0.15	1.613	0.124	0.194	8.36	0.0659	0.5	0.5	0.27
0.14	1.670	0.202	0.055	11.85	0.0626	0.2	20	0.10
0.13	1.722	0.302	0.098	10.26	-0.0495	0.1	40	0.09
0.12	1.784	0.314	0.334	24.73	-0.2381	2.9	0.5	1.46
0.11	1.800	0.536	0.262	16.25	-0.2280	2.1	30	1.20
0.1	1.809	0.852	0.164	16.39	-0.1348	2.6	1	1.54
0.09	1.903	1.149	0.111	17.41	-0.0776	6.6	3	3.09
0.08	1.956	1.461	0.073	27.21	-0.1584	17.9	40	6.37
0.075	2.075	1.544	0.072	11.76	-0.0407	12.4	3	5.50
0.07	2.106	1.710	0.056	11.56	-0.0415	12.4	3	5.95
0.069	1.042	0.417	0.220	13.25	-0.1249	0.6	0.5	0.23
0.06	1.029	0.415	0.224	13.44	-0.1325	0.5	0.5	0.18
0.05	1.018	0.407	0.230	13.80	-0.1384	0.3	0.5	0.11
0.04	1.011	0.346	0.279	14.35	-0.1832	0.1	8	0.06
0.03	1.004	0.554	0.136	15.36	-0.0677	0.2	0.5	0.06
0.02	1.002	0.246	0.414	13.11	-0.3510	0.1	2	0.03
0.015	1.001	0.277	0.342	19.18	-0.3351	0.1	3	0.03

Table B.5 (continued)

PARAMETERS FOR POINT SOURCE EXPOSURE BUILDUP FACTORS UP TO 40 MFP  
IN 45-MFP THICK TUNGSTEN AND COMPARISON TO VALUES CALCULATED  
BY THE PALLAS CODE

E (MEV)	I	B	C	A	XK	D	I	MAX. DEV(%)	XMAX (MFP)	RMS DEV(%)
15		1.544	1.332	0.013	13.57	-0.0464	1	4.4	1	1.87
10		1.442	1.156	0.028	14.05	-0.0537	1	4.6	0.5	1.97
8		1.416	1.024	0.050	14.34	-0.0707	1	4.3	0.5	2.12
6		1.395	0.953	0.060	14.15	-0.0823	1	4.0	0.5	2.13
5		1.365	1.010	0.035	13.97	-0.0597	1	4.8	0.5	1.92
4		1.346	1.039	0.019	13.73	-0.0470	1	4.3	0.5	1.68
3		1.392	1.028	0.012	13.29	-0.0362	1	2.8	0.5	1.11
2		1.435	0.985	0.013	13.24	-0.0234	1	1.0	0.5	0.57
1.5		1.456	0.948	0.016	13.24	-0.0168	1	0.7	1	0.36
1		1.443	0.849	0.043	13.54	-0.0282	1	0.8	5	0.44
0.8		1.405	0.799	0.057	13.63	-0.0340	1	0.7	5	0.43
0.6		1.339	0.743	0.074	14.08	-0.0417	1	0.8	1	0.43
0.5		1.294	0.681	0.094	14.19	-0.0502	1	0.7	1	0.42
0.4		1.234	0.611	0.118	14.19	-0.0609	1	0.6	0.5	0.37
0.3		1.169	0.497	0.162	13.63	-0.0757	1	0.8	0.5	0.33
0.2		1.155	0.253	0.340	13.68	-0.1903	1	1.1	0.5	0.47
0.15		1.257	0.152	0.335	15.57	-0.0722	1	0.3	0.5	0.15
0.14		1.318	0.222	0.147	11.41	0.0326	1	0.1	2	0.07
0.13		1.397	0.317	0.128	10.81	-0.0628	1	0.2	30	0.10
0.12		1.509	0.347	0.310	22.77	-0.2041	1	1.8	0.5	0.79
0.11		1.610	0.582	0.239	15.94	-0.2054	1	2.2	25	1.40
0.1		1.755	0.894	0.152	16.07	-0.1271	1	3.4	1	1.78
0.09		1.980	1.174	0.108	15.93	-0.0795	1	6.4	3	3.06
0.08		2.054	1.649	0.034	12.02	0.0348	1	8.8	0.5	3.70
0.075		2.304	1.636	0.056	20.17	-0.0584	1	10.4	3	6.07
0.07		2.441	1.732	0.054	12.72	-0.0403	1	12.5	3	5.73
0.069		1.034	0.495	0.172	13.26	-0.0911	1	0.4	0.5	0.19
0.06		1.026	0.448	0.203	13.55	-0.1178	1	0.3	0.5	0.15
0.05		1.017	0.432	0.213	13.80	-0.1254	1	0.2	0.5	0.10
0.04		1.011	0.346	0.279	14.35	-0.1832	1	0.1	8	0.06
0.03		1.005	0.408	0.224	14.86	-0.1299	1	0.1	0.5	0.03
0.02		1.002	0.258	0.394	13.12	-0.3192	1	0.0	4	0.02
0.015		1.001	0.277	0.342	19.18	-0.3351	1	0.1	3	0.03

Table B.5 (continued)

PARAMETERS FOR POINT SOURCE DOSE EQUIVALENT BUILDUP FACTORS UP TO 40 MFP IN 45-MFP THICK TUNGSTEN AND COMPARISON TO VALUES CALCULATED BY THE PALLAS CODE

E (MEV)	B	C	A	XK	D	MAX. DEV(%)	XMAX (MFP)	RMS DEV(%)
15	1.611	1.312	0.018	13.52	-0.0524	5.2	1	2.19
10	1.501	1.128	0.036	14.00	-0.0627	5.4	0.5	2.32
8	1.469	0.980	0.065	14.05	-0.0877	4.9	0.5	2.46
6	1.415	0.959	0.058	14.11	-0.0799	5.7	0.5	2.36
5	1.413	0.964	0.050	13.97	-0.0739	5.3	0.5	2.23
4	1.363	1.024	0.024	13.55	-0.0521	5.3	0.5	1.94
3	1.409	1.018	0.015	13.30	-0.0383	3.5	0.5	1.29
2	1.464	0.955	0.023	13.22	-0.0322	1.1	4	0.70
1.5	1.488	0.938	0.019	13.49	-0.0188	0.8	5	0.41
1	1.472	0.837	0.047	13.61	-0.0308	0.9	5	0.48
0.8	1.434	0.790	0.060	13.73	-0.0356	0.8	5	0.47
0.6	1.362	0.725	0.081	14.06	-0.0465	0.8	1	0.47
0.5	1.316	0.664	0.101	14.17	-0.0545	0.8	0.5	0.47
0.4	1.250	0.594	0.125	14.43	-0.0648	0.9	0.5	0.43
0.3	1.188	0.458	0.185	13.50	-0.0917	0.9	0.5	0.40
0.2	1.203	0.190	0.414	13.68	-0.2315	1.2	0.5	0.54
0.15	1.356	0.136	0.314	21.14	-0.0514	0.4	1	0.22
0.14	1.435	0.214	0.107	11.86	0.0490	0.1	20	0.07
0.13	1.529	0.313	0.116	10.66	-0.0613	0.2	3	0.12
0.12	1.656	0.341	0.314	23.43	-0.2148	2.1	0.5	0.99
0.11	1.768	0.570	0.245	15.96	-0.2115	3.0	35	1.38
0.1	1.917	0.881	0.156	16.07	-0.1305	3.3	1	1.82
0.09	2.008	1.246	0.088	29.13	-0.1509	6.4	0.5	2.87
0.08	2.304	1.471	0.074	17.47	-0.0728	10.5	20	6.11
0.075	2.453	1.575	0.067	12.10	-0.0363	11.7	3	5.20
0.07	2.552	1.713	0.057	11.74	-0.0422	12.7	3	5.57
0.069	1.036	0.475	0.183	13.43	-0.0980	0.4	0.5	0.19
0.06	1.025	0.465	0.193	13.56	-0.1123	0.4	0.5	0.15
0.05	1.017	0.444	0.202	13.99	-0.1125	0.3	0.5	0.10
0.04	1.010	0.401	0.237	13.66	-0.1458	0.2	0.5	0.07
0.03	1.005	0.401	0.231	14.64	-0.1381	0.1	3	0.04
0.02	1.002	0.258	0.394	13.12	-0.3192	0.0	4	0.02
0.015	1.001	0.277	0.342	19.18	-0.3351	0.1	3	0.03

Table B.6 G-P parameters for gamma-ray buildup factors  
in lead medium

PARAMETERS FOR POINT SOURCE ABSORBED DOSE BUILDUP FACTORS UP TO 40 MFP  
IN 45-MFP THICK LEAD AND COMPARISON TO VALUES CALCULATED  
BY THE PALLAS CODE

E (MEV)	B	C	A	XK	D	MAX. DEV(%)	XMAX (MFP)	RMS DEV(%)
15	1.404	1.124	0.065	13.91	-0.0991	9.2	0.5	3.79
10	1.424	0.940	0.090	14.20	-0.1121	10.4	0.5	3.92
8	1.443	0.808	0.123	14.30	-0.1385	10.9	0.5	4.15
6	1.497	0.721	0.145	14.37	-0.1578	11.5	0.5	4.26
5	1.530	0.722	0.139	14.19	-0.1526	12.1	0.5	4.36
4	1.612	0.706	0.137	14.11	-0.1471	11.3	0.5	4.14
3	1.575	0.778	0.096	13.78	-0.1032	8.4	0.5	3.06
2	1.670	0.785	0.079	13.58	-0.0696	4.2	0.5	1.66
1.5	1.656	0.778	0.069	13.61	-0.0452	1.4	0.5	0.73
1	1.589	0.744	0.076	14.76	-0.0406	0.8	10	0.53
0.8	1.533	0.682	0.094	14.43	-0.0455	0.9	10	0.53
0.6	1.424	0.621	0.113	13.77	-0.0478	0.7	0.5	0.42
0.5	1.332	0.590	0.127	14.62	-0.0572	0.9	1	0.52
0.4	1.237	0.552	0.134	15.25	-0.0504	1.0	0.5	0.43
0.3	1.494	0.183	0.421	12.80	-0.2485	2.4	0.5	1.20
0.2	1.588	0.097	0.441	14.49	-0.1076	0.8	1	0.27
0.16	1.742	0.317	0.124	12.50	-0.0510	0.1	40	0.09
0.15	1.783	0.318	0.310	26.45	-0.1233	2.8	0.5	1.29
0.14	1.824	0.456	0.292	16.71	-0.2395	1.9	20	1.07
0.13	1.840	0.689	0.209	15.78	-0.1834	2.9	35	1.44
0.12	1.863	0.953	0.141	16.79	-0.1122	3.3	1	1.78
0.11	1.862	1.242	0.090	28.31	-0.1473	5.4	0.5	2.94
0.1	2.014	1.393	0.083	20.93	-0.0912	10.0	3	5.32
0.09	2.056	1.679	0.052	14.62	-0.0356	12.3	20	6.32
0.0891	2.026	1.730	0.045	58.63	-0.4542	10.8	40	5.38
0.0881	1.086	0.227	0.400	13.28	-0.2937	1.1	0.5	0.56
0.08	1.044	0.403	0.227	13.24	-0.1318	0.6	0.5	0.25
0.06	1.020	0.413	0.226	13.73	-0.1353	0.2	0.5	0.10
0.05	1.013	0.368	0.273	13.99	-0.1844	0.2	0.5	0.07
0.04	1.007	0.414	0.227	13.71	-0.1370	0.1	5	0.05
0.03	1.003	0.506	0.167	14.21	-0.0950	0.1	0.5	0.04

Table B.6 (continued)

PARAMETERS FOR POINT SOURCE EXPOSURE BUILDUP FACTORS UP TO 40 MFP  
IN 45-MFP THICK LEAD AND COMPARISON TO VALUES CALCULATED  
BY THE PALLAS CODE

E (MEV)	B	C	A	XK	D	MAX. DEV(%)	XMAX (MFP)	RMS DEV(%)
15	1.548	1.287	0.024	13.50	-0.0571	4.7	0.5	2.21
10	1.448	1.121	0.036	13.98	-0.0599	5.5	0.5	2.20
8	1.424	0.968	0.068	13.98	-0.0874	4.2	0.5	2.35
6	1.377	0.941	0.062	14.14	-0.0795	5.3	0.5	2.15
5	1.361	0.956	0.051	13.95	-0.0709	5.3	0.5	2.06
4	1.378	0.954	0.042	14.04	-0.0603	4.6	0.5	1.72
3	1.385	0.960	0.029	13.48	-0.0421	3.6	0.5	1.31
2	1.388	0.939	0.024	13.33	-0.0266	1.0	0.5	0.51
1.5	1.375	0.891	0.029	13.29	-0.0168	0.5	2	0.35
1	1.318	0.860	0.035	16.49	-0.0154	0.7	3	0.38
0.8	1.283	0.800	0.050	15.20	-0.0191	0.9	0.5	0.43
0.6	1.228	0.744	0.064	14.47	-0.0184	0.9	3	0.40
0.5	1.179	0.725	0.072	14.89	-0.0244	0.7	3	0.36
0.4	1.135	0.670	0.085	19.56	-0.0325	0.5	0.5	0.26
0.3	1.122	0.533	0.137	13.69	-0.0612	0.8	0.5	0.32
0.2	1.184	0.190	0.381	13.27	-0.1868	0.5	3	0.26
0.16	1.339	0.343	0.151	12.54	-0.0682	0.2	4	0.11
0.15	1.408	0.362	0.281	21.46	-0.0964	1.2	0.5	0.66
0.14	1.474	0.512	0.259	16.39	-0.2077	1.6	35	1.07
0.13	1.549	0.746	0.187	15.62	-0.1639	2.6	1	1.64
0.12	1.652	0.999	0.130	16.27	-0.1064	3.6	1	1.87
0.11	1.850	1.204	0.103	16.88	-0.0848	6.5	3	3.22
0.1	2.037	1.432	0.079	18.37	-0.0935	10.5	40	5.97
0.09	2.168	1.728	0.045	16.92	-0.0346	10.9	40	5.81
0.089	2.368	1.604	0.071	12.64	-0.0578	13.9	3	6.19
0.088	1.062	0.350	0.272	13.10	-0.1845	1.0	0.5	0.44
0.08	1.033	0.523	0.153	13.30	-0.0777	0.4	0.5	0.17
0.06	1.017	0.487	0.180	13.37	-0.1037	0.3	0.5	0.11
0.05	1.012	0.405	0.244	14.18	-0.1624	0.1	0.5	0.07
0.04	1.007	0.438	0.204	14.26	-0.1093	0.1	3	0.05
0.03	1.003	0.396	0.248	14.56	-0.1696	0.1	5	0.04

Table B.6 (continued)

PARAMETERS FOR POINT SOURCE DOSE EQUIVALENT BUILDUP FACTORS UP TO 40  
MFP IN 45-MFP THICK LEAD AND COMPARISON TO VALUES CALCULATED  
BY THE PALLAS CODE

E (MEV)	B	C	A	XK	D	MAX. DEV(%)	XMAX (MFP)	RMS DEV(%)
15	1.612	1.271	0.028	13.58 -0.0619	5.9	0.5	2.65	
10	1.510	1.084	0.047	13.94 -0.0721	5.9	0.5	2.48	
8	1.457	0.967	0.068	14.14 -0.0876	5.9	0.5	2.57	
6	1.443	0.847	0.097	14.03 -0.1166	4.3	0.5	2.85	
5	1.395	0.935	0.058	14.04 -0.0774	6.0	0.5	2.28	
4	1.403	0.928	0.051	13.93 -0.0686	5.0	0.5	1.95	
3	1.384	0.963	0.029	13.61 -0.0456	3.6	0.5	1.34	
2	1.401	0.935	0.025	13.24 -0.0266	1.3	0.5	0.63	
1.5	1.395	0.889	0.029	13.75 -0.0156	0.7	2	0.36	
1	1.341	0.842	0.041	15.93 -0.0189	0.8	1	0.47	
0.8	1.297	0.803	0.048	15.95 -0.0168	1.1	3	0.48	
0.6	1.237	0.741	0.065	13.82 -0.0184	0.9	3	0.43	
0.5	1.189	0.718	0.074	15.14 -0.0253	0.6	3	0.34	
0.4	1.139	0.667	0.086	16.78 -0.0250	0.7	0.5	0.27	
0.3	1.143	0.474	0.170	13.23 -0.0852	1.2	0.5	0.47	
0.2	1.251	0.154	0.411	13.45 -0.1739	0.4	3	0.24	
0.16	1.462	0.334	0.144	12.40 -0.0675	0.2	35	0.11	
0.15	1.551	0.347	0.293	22.96 -0.1245	1.7	0.5	0.82	
0.14	1.628	0.496	0.269	16.36 -0.2196	2.3	35	1.14	
0.13	1.710	0.731	0.193	15.63 -0.1704	2.5	1	1.70	
0.12	1.818	0.982	0.135	16.17 -0.1115	3.4	0.5	1.97	
0.11	1.994	1.210	0.101	17.48 -0.0845	5.6	3	3.02	
0.1	2.256	1.393	0.085	16.20 -0.0622	11.3	3	5.02	
0.09	2.197	1.754	0.040	29.31 -0.0769	11.3	40	5.47	
0.089	2.342	1.702	0.052	13.94 -0.0374	10.6	3	5.87	
0.088	1.067	0.318	0.299	13.25 -0.2057	1.0	0.5	0.48	
0.08	1.031	0.541	0.144	13.42 -0.0714	0.4	0.5	0.14	
0.06	1.015	0.530	0.157	13.50 -0.0890	0.2	0.5	0.11	
0.05	1.009	0.553	0.151	14.26 -0.0870	0.2	0.5	0.07	
0.04	1.006	0.452	0.206	14.38 -0.1351	0.1	4	0.04	
0.03	1.003	0.422	0.231	13.42 -0.1520	0.1	3	0.02	

Table B.7 G-P parameters for gamma-ray buildup factors  
in uranium medium

PARAMETERS FOR POINT SOURCE ABSORBED DOSE BUILDUP FACTORS UP TO 40 MFP  
IN 45-MFP THICK URANIUM AND COMPARISON TO VALUES CALCULATED  
BY THE PALLAS CODE

E (MEV)	B	C	A	XK	D	MAX.	XMAX	RMS
						DEV(%)	(MFP)	DEV(%)
15	1.411	1.096	0.071	13.88	-0.1035	9.6	0.5	3.87
10	1.435	0.915	0.096	14.23	-0.1155	10.0	0.5	3.79
8	1.449	0.783	0.129	14.39	-0.1393	11.2	0.5	4.10
6	1.479	0.677	0.161	14.46	-0.1666	11.7	0.5	4.38
5	1.506	0.669	0.159	14.38	-0.1641	11.8	0.5	4.34
4	1.554	0.677	0.147	14.11	-0.1506	11.1	0.5	4.01
3	1.624	0.681	0.135	13.81	-0.1336	9.5	0.5	3.49
2	1.674	0.698	0.113	13.58	-0.0938	5.6	0.5	2.13
1.5	1.639	0.680	0.107	13.23	-0.0624	1.7	0.5	0.90
1	1.578	0.641	0.114	14.32	-0.0605	1.8	0.5	0.86
0.8	1.558	0.547	0.155	13.52	-0.0864	1.8	0.5	0.88
0.6	1.487	0.450	0.209	13.34	-0.1284	2.9	0.5	1.20
0.5	1.469	0.346	0.274	13.50	-0.1558	3.2	0.5	1.19
0.4	1.474	0.217	0.392	13.47	-0.2187	2.9	0.5	1.27
0.3	1.539	0.121	0.494	13.05	-0.2398	1.4	2	0.70
0.25	1.617	0.129	0.356	14.93	-0.0606	0.6	1	0.25
0.2	1.759	0.336	0.183	15.97	-0.0460	0.8	20	0.35
0.19	1.804	0.339	0.311	27.44	-0.2754	2.6	0.5	1.29
0.18	1.839	0.436	0.300	16.83	-0.2422	2.4	0.5	1.12
0.17	1.839	0.611	0.232	15.95	-0.2006	2.2	35	1.36
0.16	1.839	0.810	0.172	16.12	-0.1429	3.2	1	1.54
0.15	1.858	1.007	0.129	17.25	-0.0990	3.4	0.5	1.93
0.14	1.890	1.219	0.093	23.66	-0.0969	4.7	0.5	2.64
0.13	2.006	1.362	0.082	19.14	-0.0699	7.3	3	4.54
0.12	2.081	1.518	0.070	17.94	-0.0719	11.2	40	6.58
0.116	2.112	1.584	0.065	13.81	-0.0481	11.7	3	5.98
0.115	1.119	0.207	0.420	13.13	-0.2998	1.4	0.5	0.72
0.1	1.076	0.248	0.367	13.01	-0.2542	0.9	2	0.51
0.08	1.028	0.417	0.220	13.29	-0.1242	0.4	0.5	0.18
0.06	1.013	0.446	0.202	13.86	-0.1161	0.3	0.5	0.10
0.05	1.009	0.379	0.255	13.55	-0.1651	0.1	0.5	0.07
0.04	1.005	0.448	0.191	19.76	-0.1466	0.1	0.5	0.05
0.03	1.003	0.270	0.357	14.60	-0.2551	0.1	3	0.04

Table B.7 (continued)

PARAMETERS FOR POINT SOURCE EXPOSURE BUILDUP FACTORS UP TO 40 MFP  
IN 45-MFP THICK URANIUM AND COMPARISON TO VALUES CALCULATED  
BY THE PALLAS CODE

E (MEV)	B	C	A	XK	D	MAX. DEV(%)	XMAX (MFP)	RMS DEV(%)
15	1.526	1.285	0.022	13.61 -0.0515	4.8	0.5	2.17	
10	1.429	1.111	0.036	14.05 -0.0565	4.7	0.5	1.91	
8	1.376	1.009	0.050	14.37 -0.0633	4.9	0.5	1.90	
6	1.335	0.930	0.062	14.27 -0.0740	6.2	0.5	2.26	
5	1.338	0.889	0.071	14.10 -0.0838	4.4	0.5	2.33	
4	1.317	0.963	0.036	14.07 -0.0506	4.1	0.5	1.52	
3	1.335	0.948	0.031	13.63 -0.0436	3.3	0.5	1.27	
2	1.341	0.911	0.030	13.96 -0.0258	1.2	0.5	0.61	
1.5	1.317	0.849	0.041	12.50 -0.0154	1.0	2	0.42	
1	1.271	0.796	0.053	15.45 -0.0219	0.7	0.5	0.37	
0.8	1.235	0.746	0.067	13.79 -0.0264	0.6	2	0.32	
0.6	1.177	0.724	0.073	13.34 -0.0304	0.8	10	0.40	
0.5	1.149	0.660	0.094	14.55 -0.0343	0.5	2	0.25	
0.4	1.129	0.556	0.136	14.89 -0.0530	0.5	0.5	0.29	
0.3	1.138	0.358	0.242	13.01 -0.1319	0.9	0.5	0.44	
0.25	1.189	0.228	0.323	13.26 -0.1347	0.3	10	0.21	
0.2	1.329	0.369	0.197	14.10 -0.0755	0.4	20	0.18	
0.19	1.377	0.401	0.269	20.45 -0.1382	1.1	15	0.58	
0.18	1.421	0.514	0.253	16.30 -0.1962	1.9	35	1.06	
0.17	1.457	0.704	0.191	15.76 -0.1599	3.2	1	1.66	
0.16	1.533	0.874	0.153	15.65 -0.1309	3.3	1	1.78	
0.15	1.606	1.080	0.112	16.63 -0.0875	4.4	1	2.02	
0.14	1.719	1.250	0.090	16.51 -0.0597	4.8	4	2.59	
0.13	1.957	1.313	0.100	13.21 -0.0889	10.6	3	5.22	
0.12	2.027	1.566	0.064	17.89 -0.0695	9.3	25	5.74	
0.116	2.128	1.602	0.064	13.21 -0.0410	11.1	3	4.84	
0.115	1.074	0.374	0.248	12.98 -0.1601	1.2	0.5	0.50	
0.1	1.053	0.362	0.270	12.21 -0.1943	0.7	1	0.38	
0.08	1.021	0.550	0.139	13.56 -0.0621	0.4	0.5	0.12	
0.06	1.012	0.457	0.198	13.92 -0.1168	0.2	0.5	0.08	
0.05	1.008	0.451	0.199	14.63 -0.1175	0.1	0.5	0.05	
0.04	1.005	0.448	0.191	19.76 -0.1466	0.1	0.5	0.05	
0.03	1.003	0.275	0.355	14.80 -0.2744	0.1	3	0.04	

Table B.7 (continued)

PARAMETERS FOR POINT SOURCE DOSE EQUIVALENT BUILDUP FACTORS UP TO 40  
MFP IN 45-MFP THICK URANIUM AND COMPARISON TO VALUES CALCULATED  
BY THE PALLAS CODE

E (MEV)	B	C	A	XK	D	MAX. DEV(%)	XMAX (MFP)	RMS DEV(%)
15	1.588	1.262	0.028	13.54	-0.0587	5.4	0.5	2.43
10	1.481	1.087	0.043	14.11	-0.0638	5.3	0.5	2.21
8	1.473	0.876	0.097	13.99	-0.1156	5.0	35	3.11
6	1.349	0.938	0.059	14.39	-0.0702	7.6	0.5	2.67
5	1.360	0.888	0.071	14.15	-0.0840	6.0	0.5	2.33
4	1.341	0.928	0.048	13.96	-0.0616	4.6	0.5	1.73
3	1.350	0.933	0.036	13.58	-0.0474	3.9	0.5	1.39
2	1.358	0.884	0.040	13.49	-0.0350	1.3	0.5	0.72
1.5	1.337	0.838	0.044	13.49	-0.0159	0.7	2	0.44
1	1.284	0.788	0.056	15.01	-0.0240	0.8	2	0.37
0.8	1.247	0.747	0.066	13.98	-0.0253	1.0	2	0.34
0.6	1.192	0.691	0.087	13.41	-0.0411	1.0	10	0.43
0.5	1.165	0.624	0.110	14.24	-0.0451	0.5	10	0.26
0.4	1.142	0.528	0.150	14.45	-0.0617	1.0	0.5	0.37
0.3	1.169	0.301	0.286	13.03	-0.1573	1.0	0.5	0.53
0.25	1.237	0.200	0.338	13.53	-0.1237	0.3	3	0.20
0.2	1.419	0.357	0.199	14.32	-0.0722	0.5	20	0.22
0.19	1.480	0.382	0.283	20.43	-0.1498	1.4	0.5	0.68
0.18	1.529	0.500	0.261	16.40	-0.2043	2.2	35	1.11
0.17	1.580	0.681	0.201	15.75	-0.1706	2.6	6	1.70
0.16	1.648	0.864	0.156	15.69	-0.1330	3.5	1	1.84
0.15	1.737	1.058	0.118	16.40	-0.0933	4.0	1	2.08
0.14	1.871	1.207	0.101	16.84	-0.0858	5.9	4	3.24
0.13	1.982	1.394	0.078	18.00	-0.0661	7.0	3	3.89
0.12	2.063	1.601	0.056	22.83	-0.0804	11.5	40	5.09
0.116	2.225	1.581	0.068	12.91	-0.0481	11.8	3	5.16
0.115	1.079	0.350	0.267	12.94	-0.1744	1.3	0.5	0.53
0.1	1.059	0.355	0.256	12.95	-0.1525	1.1	0.5	0.45
0.08	1.022	0.522	0.155	13.45	-0.0750	0.3	0.5	0.13
0.06	1.012	0.453	0.202	13.62	-0.1228	0.2	0.5	0.07
0.05	1.009	0.372	0.259	14.15	-0.1693	0.1	25	0.07
0.04	1.005	0.448	0.191	19.76	-0.1466	0.1	0.5	0.05
0.03	1.003	0.270	0.357	14.60	-0.2551	0.1	3	0.04

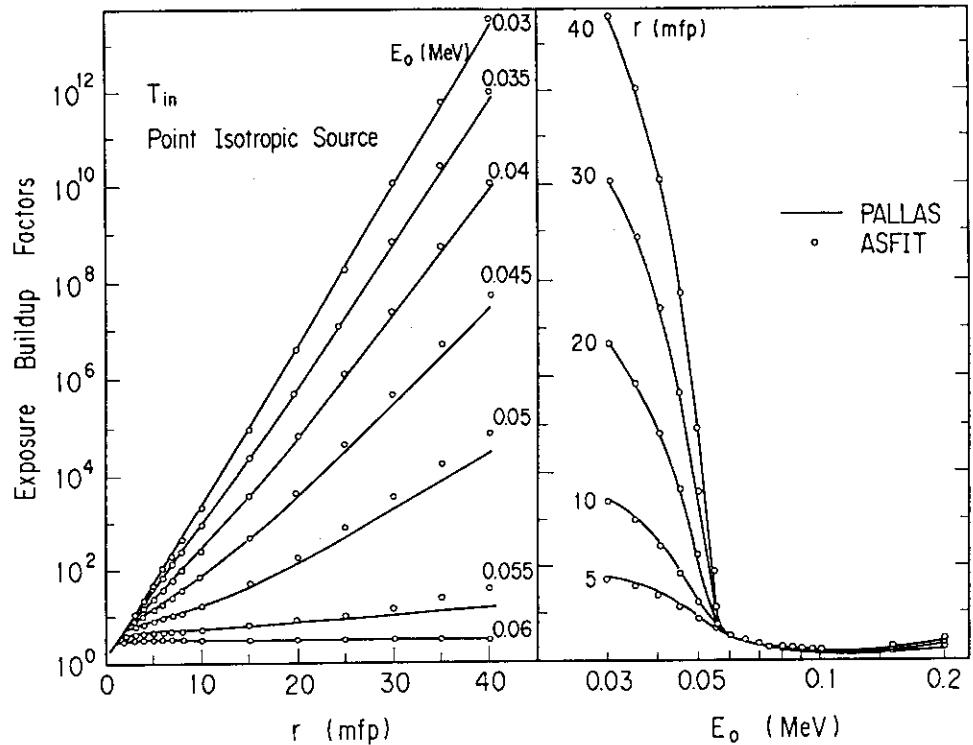


Fig. A.1 Comparison of exposure buildup factors in tin using the PALLAS and the ASFIT codes.

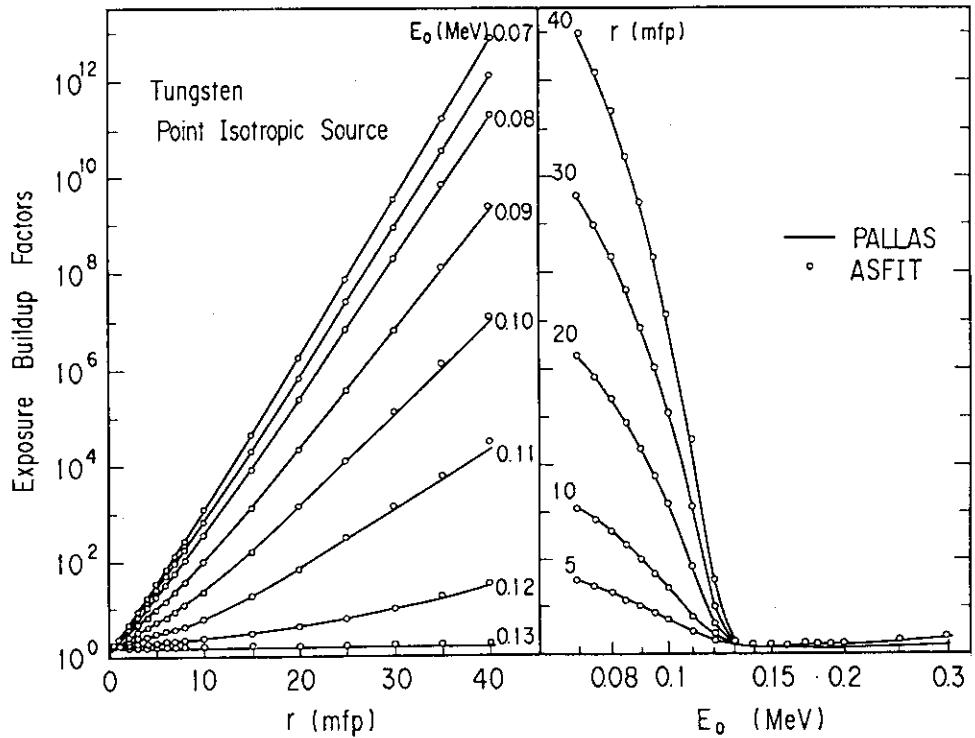


Fig. A.2 Comparison of exposure buildup factors in tungsten using the PALLAS and the ASFIT codes.

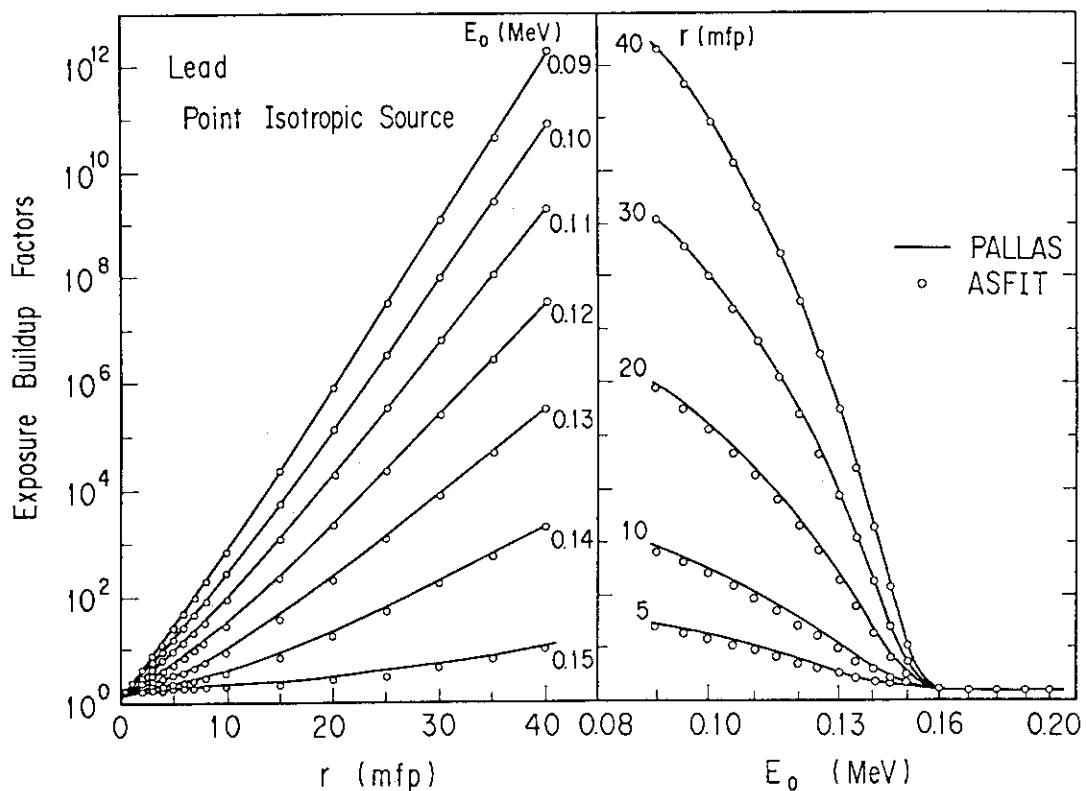


Fig. A.3 Comparison of exposure buildup factors in lead using the PALLAS and the ASFIT codes.

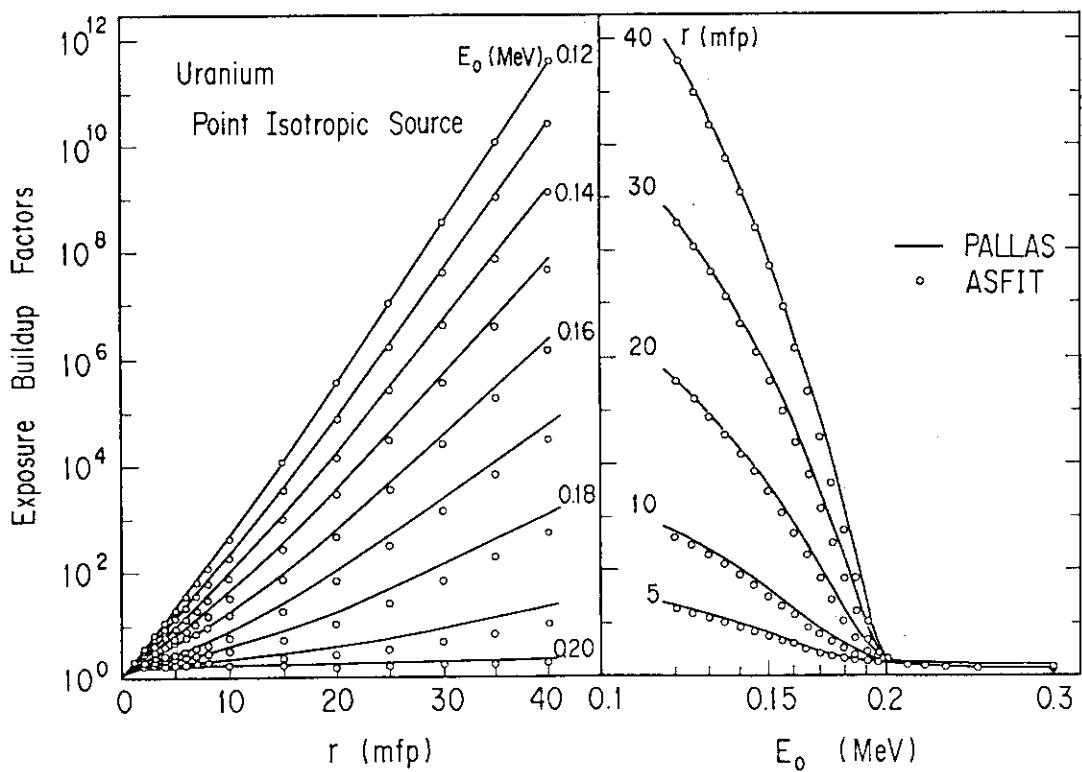


Fig. A.4 Comparison of exposure buildup factors in uranium using the PALLAS and the ASFIT codes.