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QAD-CGGP2 AND G33-GP2 : REVISED VERSIONS OF QAD-CGGP AND G33-GP

(CODES WITH THE CONVERSION FACTORS FROM EXPOSURE TO AMBIENT AND MAXIMUM DOSE EQUIVALENTS)

July 1990

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QAD-CGGP2 and G33-GP2:Revised Versions of QAD-CGGP and G33-GP

(Codes with the Conversion Factors from Exposure to Ambient and Maximum Dose Equivalents)

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(Received June 16, 1990)

QAD-CGGP2 and G33-GP2 are the revised versions of the point kernel codes of QAD-CGGP and G33-GP. With the revised versions, the ambient dose equivalent $H^*(10)$, $H^*(3)$ and $H^*(0.07)$, and the maximum dose equivalent which are needed for the radiation protection are estimated using the effective conversion factors. Besides, the GP buildup factor coefficients for Mo, Sn, La, Gd, W, Pb and U were replaced by those for the buildup factors using the PHOTX photon cross section, resulting all of the data used in the codes were based on the PHOTX.

Keywords: QAD-CGGP2, G33-GP2, Geometric Progression (G-P) Form, Photon, Buildup Factor, Effective Conversion Factor, Ambient Dose Equivalent, Maximum Dose Equivalent Computer Code, Revised Versions

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ＱＡＤ－ＣＧＧＰ２及びＧ33－ＧＰ２：照射線量から周辺線量当量及び最大線量当量への換算係数を有するＱＡＤ－ＣＧＧＰ及びＧ33－ＧＰコードの改良バージョン

日本原子力研究所むつ事業所原子力船技術部
坂本　幸夫・田中　俊一[+]

（1990年6月16日受理）

ＱＡＤ－ＣＧＧＰ２及びＧ33－ＧＰ２は，点減衰核コードＱＡＤ－ＣＧＧＰ及びＧ33－ＧＰの改良版である。改良コードによって，放射線防護に必要な周辺線量当量$H^*(10)$，$H^*(3)$，$H^*(0.07)$及び最大線量当量が実行換算係数を用いることにより推定される。さらに，モリブデン，スズ，ランタン，ガドリニウム，タングステン，鉛及びウランに対するＧＰビルドアップ係数パラメータをＰＨＯＴＸ光子断面積を用いたビルドアップ係数に対するデータに置換した。この結果，コード内で用いるデータは全てＰＨＯＴＸに基づいている。

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The point kernel calculation codes: QAD and G33 and their revised versions[1,2] have been used for the shielding design of reactors, nuclear facilities and transport casks of nuclear fuel and radioisotopes. The QAD-CGGP2 and G33-GP2 are the revised versions of QAD-CGGP[3] and G33-GP[4]. In these versions, the buildup factors for Mo, Sn, La, Gd, W, Pb and U calculated with the DLC-15 photon cross section[5] were replaced by those calculated with the PHOTX photon cross section[6]. Subsequently, the GP buildup factor coefficients for above 7 elements incorporated in the codes were based on the PHOTX data. Furthermore, a modification of the codes was made to estimate the dose equivalent from the exposure using the effective conversion factors.

2. Characteristics of GP2 Version

2.1 Effective Conversion Factor

The effective dose equivalent and/or other practical doses becoming the index of the effective dose equivalent should be estimated for the external radiation protection according to the ICRP recommendation[7]. It is generally impossible to estimate the effective dose equivalent. So, the ANSI[8] recommends the maximum dose in a ICRU plane phantom, and the ICRP[9] recommends the ambient dose equivalent at 1 cm depth in the ICRU sphere as a dosimetric quantity for the effective dose equivalent, and gives the conversion factors from fluence to the quantities. It has been known that the ANSI dose H_{max} and the ambient dose equivalent $H^*(10)$ are conservative quantity for the effective dose equivalent in a large space where a charge equilibrium might be kept. While, the situation is more complicated at the radiation field behind the shields, because there are the backscattering of radiations with the phantom and no charge equilibrium of the fields. Hirayama and Tanaka[10] studied the relations between the 1 cm depth dose H(10) in a phantom behind the finite shields of water, concrete, iron, and lead and the ambient dose equivalent and the maximum dose equivalent (ANSI dose) for different energy photons of 0.1, 1, 10 MeV in a plane geometry. As a result, it was demonstrated that the ambient dose equivalent and the ANSI dose calculated using each conversion factor of fluence to dose equivalent would estimate the 1 cm depth dose equivalent within 10 % behind the shields, as

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well. In addition, Tanaka et al.[11,12] defined the concept of the effective conversion factor based on the above consideration and tabulated the data from the absorbed dose in air kerma to the ambient dose equivalent $H^*(10)$, $H^*(3)$ and $H^*(0.07)$, and the ANSI dose behind the shields.

When the photon fluence $\phi(E,t)$ behind a shield is given, the absorbed dose in air D(Gy) and ambient dose equivalent $H^*(10)$ are represented by the followings,

$$D = \int (Da(E)/\phi) \times \phi(E,t)\, dE \quad \cdots\cdots(1)$$

$$H^*(10) = \int (Ho(E)/\phi) \times \phi(E,t)\, dE \quad \cdots\cdots(2)$$

where $Da(E)/\phi$ and $Ho(E)/\phi$ are the conversion factors from unit photon fluence of energy E to the absorbed dose in air and the ambient dose equivalent, and it is assumed that there are radiation and charge equilibrium at the point of interest. Using the ratio fx(E) of the factor $Ho(E)/\phi$ to $Da(E)/\phi$ are given in Table 10 in ICRP Pub.51, Eq.(2) is written as

$$H^*(10) = \int fx(E)\, (Da(E)/\phi) \times \phi(E,t)\, dE \quad \cdots\cdots(3)$$

Next, let's define an effective conversion factor <fx> averaged by the energy spectrum by the following equation.

$$\overline{f_x} = \frac{\int fx(E)\, (Da(E)/\phi) \times \phi(E,t)\, dE}{\int (Da(E)/\phi) \times \phi(E,t)\, dE} \quad \cdots\cdots(4)$$

Using the effective conversion factor, the ambient dose equivalent $H^*(10)$ is presented by

$$H^*(10) = \overline{fx} \int (Da(E)/\phi) \times \phi(E,t)\, dE$$

$$= \overline{fx} \times D \quad \cdots\cdots(5)$$

The effective conversion factors for other quantities, $H^*(3)$, $H^*(0.07)$ and H_{max} are defined similarly.

The effective conversion factor is dependent upon the incident photon energy, the shield material, the thickness and the geometry. Tanaka et al.[11] showed that the factor changes insensitively with the thickness of shield and

becomes nearly constant above a few mfp, in addition, the difference of factor is less than 1 % for plane normal and point isotropic geometries from the systematic calculations from 0.03 to 10 MeV photons incident to the water, concrete, iron and lead shields from 1 mfp up to 30 mfp with PALLAS code.[13]

In the GP2 versions, the maximum value of the effective conversion factor up to 30 mfp is used, and the factors for 7 materials of carbon, aluminum and air in addition to water, concrete, iron and lead for 0.03 to 10 MeV photons are prepared as shown in Appendix A. The effective conversion factors changes slightly with the atomic number so that the factors for other materials can be represented with those for the 7 materials. The effective conversion factor $\overline{fx}$ are multiplied to the absorbed dose of air converted from the exposure for each source energy E, where absorbed dose in air D(Gy) is obtained by multiplying the factor 0.00873 to the exposure (R).

2.2 GP Buildup Factor Coefficients

The buildup factors in GP2 version, as well as in GP version, are calculated by Geometric Progression formula (GP form)[14] represented followings,

$$B(E,x) = 1 + (B-1)\frac{K^X - 1}{K - 1} \quad \text{for } K \neq 1 \qquad \cdots\cdots\cdots(6)$$

$$= 1 + (B-1)X \quad \text{for } K = 1$$

$$K = c X^a + d \frac{\tanh(X/Xk) - \tanh(-2)}{1 - \tanh(-2)} \qquad \cdots\cdots\cdots(7)$$

where X is the source-detector distance in mean free path (mfp), B is the value of the buildup factor at 1 mfp, and K is the multiplication per mfp. B, c, a ,Xk and d are the fitting parameters of GP form. When the source-detector distance is over 40 mfp, the K parameter is approximated by next,[15]

$$K(X) = 1 + (K35 - 1)\left|\frac{K_{40} - 1}{K_{35} - 1}\right|^{\xi(X)} \quad \text{for } 0 < \frac{K_{40} - 1}{K_{35} - 1} < 1$$

$$\xi(X)^{0.8} = K_{35}\left|\frac{K_{40}}{K_{35}}\right|$$

$$\text{for } \frac{K_{40}-1}{K_{35}-1} \leqq 0 \text{ or } 1 \leqq \frac{K_{40}-1}{K_{35}-1}$$

$$\xi(X) = \frac{(X/35)^{0.1}-1}{(X/40)^{0.1}-1} \qquad \cdots\cdots\cdots(8)$$

where K_{35} and K_{40} are the values of K parameter at 35mfp and 40mfp source-detector distance.

In the GP2 version, the buildup factors for Molybdenum (Mo), Tin (Sn), Lanthanum (La), Gadolinium (Gd), Tungsten (W), Lead (Pb) and Uranium (U) calculated with the DLC-15 photon cross section were replaced by those calculated with the PHOTX photon cross section by PALLAS code. In Appendix B the cross section data used for PALLAS calculation are tabulated that contain total cross section, partial cross section and flux-to-dose conversion factors.

Exposure and energy absorption buildup factors for above 7 materials are tabulated from 0.5 mfp to 40 mfp in Appendix C. Furthermore, the GP buildup factor coefficients for all materials incorporated in GP2 version are tabulated in Appendix D.

2.3 Energy Interpolation of Attenuation Coefficients and GP Buildup Factor Coefficients

In GP2 version, the Akima's method[16,17] is adopted for the energy interpolation technique of attenuation coefficients and GP buildup factor coefficients. The curve obtained by the Akima's method that uses a piecewise function composed of a set of polynomials, each of degree three, and determines curve slope at each given point locally is closely to manually drawn curve than those drawn by other mathematical methods.[16]

There is no increase of CPU time in QAD-CGGP2 calculation. On the other hand, CPU time in G33-GP2 calculation of sample problem with mono-energy incident photon is 2.5 times as large as in G33-GP calculation because the data are interpolated corresponding to the scattered photon energy. If the incident photon has multi-group energy, the difference of calculating time between these codes becomes smaller.

3. Information of QAD-CGGP2 for Users

3.1 Input Specification

Much of the input to the QAD-CGGP2 code is identical to that for the original QAD-CG code.

The input to QAD-CGGP2 consists of the following:

Note: Variables marked (*) have a new meaning compared to QAD-CG.

Variable Names and Format

Card A Title Information — Format(12A6)

ID - Problem Title.

Card B Control data — Free Format

① LSO - Number of increments along the R(cyl.), X(cart.) or ρ (spher.) axis which specify the divisions of source volume. ($1 \leqq LSO \leqq 100$)

② MSO - Number of increments along the Z(cyl.), Z(cart.) or θ (spher.) axis which specify the divisions of source volume. ($1 \leqq MSO \leqq 100$)

③ NSO - Number of increments along the ϕ (cyl.), Y(cart.) or ϕ (spher.) axis which specify the divisions of source volume. ($1 \leqq NSO \leqq 100$)

④ MAT - Total number of elements used in problem. ($1 \leqq MAT \leqq 20$)
(If MAT $\leqq$ 0, Cards O through W not needed; cards of previous case are used).

⑤ NCOMP - Number of compositions. ($1 \leqq NCOMP \leqq 40$)

⑥ NREG - Geometry input switch.
If NREG $\leqq$ 0, use previous geometry input,
otherwise NREG equals any dummy positive number.

⑦ NRGY - Number of gamma-ray energy groups. ($1 \leqq NRGY \leqq 30$)

⑧ NBOUND- Not used with Combinatorial Geometry.

⑨ NSOPT - Geometry of source:
Set NSOPT=0 for Cylindrical,
NSOPT=1 for Cartesian,
NSOPT=2 for Spherical.

⑩ NZSO - The most probable source region, i.e., the region most likely to contain the source points.

⑪ ISRC - Type of source:
ISRC=0; source of the previous case used.
ISRC=1; cosine-distributed source used.
ISRC=2; source is computed using the weighting values input along each coordinate axis.

⑫ INEUT - If INEUT >0, neutron calculation will be made, and INEUT is the No. of neutron moments data sets to be used. ($\leqq 3$)

⑬ NGPF - First source point for which ray geometry printout is desired.

⑭ NGPL - Last source point for which ray geometry printout is desired.

⑮ NGPI -The incremental step size used to select additional source points for ray geometry printout.

⑯ NGINT - Number of additional gamma calculations to be made.

NOTE: The ray geometry printout will give the distance traveled through each region from the specified source point to the detector. The first source point for which this is done is NGPF. The next source point is selected by adding NGPI to NGPF. This is continued until the last source point, NGPL, is reached. (The ray geometry from the coordinate origin is always printed out.) This is useful for finding errors in the geometry input.

Card C Source information (1) Free Format

① ASO - The total source strength in fissions/sec, captures/sec or decays/sec.

② XISO(1,1), ③ XISO(2,1) - Constants for cosine source distribution (if ISRC=1) as a function of the R(cyl.), X(cart.) or ρ (spher.) coordinate.

④ XISO(1,2), ⑤ XISO(2,2) - Constants for cosine source distribution (if ISRC=1) as a function of the ϕ (cyl.), Y(cart.) or ϕ (spher.) coordinate.

⑥ XISO(1,3), ⑦ XISO(2,3) - Constants for cosine source distribution (if ISRC=1) as a function of the Z(cyl.), Z(cart.) or θ (spher.) coordinate.

NOTE: Using this cosine-distributed source OPTION (ISRC=1), the code calculates the source strength as a point (A,B,C) as

Source Strength (A,B,C) = ASO * cos[XISO(1,1)*(A - XISO(2,1))]
* cos[XISO(1,2)*(B - XISO(2,2))] * cos[XISO(1,3)*(C - XISO(2,3))]

where A, B, C are the coordinates of the point in the appropriate coordinates system. If all values of XISO are input as zero, a flat or uniformly distributed source will be obtained when using this source option.

Card(s) D Source information (2) Free Format

RSO - Coordinates of source volume divisions along R(cyl.), X(cart.) or ρ (spher.). (LSO + 1 values)

Card(s) E Source information (3) Free Format

ZSO - Coordinates of source volume divisions along Z(cyl.), Z(cart.) or θ (spher.). (MSO + 1 values)

Card(s) F Source information (4) Free Format

PHISO - Coordinates of source volume divisions along ϕ (cyl.), Y(cart.) or ϕ (spher.). (NSO + 1 values)

NOTE: The QAD code will select a point midway between the coordinates specified as the midpoint of the source volume.

Card(s) G Source information (5) (If ISRC=2) Free Format

FL - Weighting factors for source strength at each point specified on Card D.

Card(s) H Source information (6) (If ISRC=2) Free Format

FM - Weighting factors for source strength at each point specified on Card E.

Card(s) I Source information (7) (If ISRC=2) Free Format

FN - Weighting factors for source strength at each point specified on Card F.

Combinatorial Geometry Input

Card CGA Geometry information (1) Format(2I5,10X,15A4)

① IVOPT - Set to zero for QAD input.

② IDBG - Set to zero for QAD input.

③ JTY - Alphanumeric title for geometry input.

Cards CGB Geometry information (2) Format(2X,A3,1X,I4,6E10.3)

One set of CGB cards is required for each body and for the END card. Leave columns 1-6 blank on all continuation cards.

① ITYPE -Specifies body type or END to terminate reading of body data (for example BOX,RPP, ARB, etc.). Leave blank for continuation cards.

② IALP -Body number assigned by user (all input body number must form a sequence set beginning at 1). If left blank, numbers are assigned sequentially. Either assign all or none of the numbers. Leave blank for continuation cards.

③ FPD(I) - Real data required for the given body.

Cards CGC Geometry information (3) Format(2X,A3,I5,9(A2,I5))

Input zone specification cards. One set of cards required for each input zone, with input zone numbers being assigned sequentially.

① IALP - IALP must be a nonblank for the first card of each set of cards defining an input zone. If IALP is blank, this card is treated as a continuation of the previous zone card,
IALP = END denotes the end of zone description.

② NAZ - Total number of zones that can be entered upon leaving any of the bodies defined for this input region (some zones may be counted more than once). Leave blank for continuation cards for a given zone. (If NAZ $\leqq$ 0 on the first card of the zone card set, then it is set to 5). This is used to allocate blank common.

Alternate IIBLAS(I) and JTY(I) for all bodies defining this input zone.

③ IIBLAS(I)- Specify the "OR" operator if required for the JTY(I) body.

④ JTY(I) -Body number with the (+) or (-) sign as required for the zone description.

Card CGD Geometry Information (4) Format(14I5)

MRIZ(I) -Not needed for QAD - Input all one's. Number of input values is the number of input zones, as defined in cards CGC.

Card CGE Geometry Information (5) Format(1415)

MMIZ(I) -MMIZ(I) is the medium number in which the "Ith" input zone is contained (I=1, to the number of input zones). Medium numbers must be in the range from 1 to NCOMP, else 0 for external void, or 1000 for internal void. More than one zone can have the same medium number.

Card(s) M Identification of Buildup Factor and Elements Free Format

①NBLD* - Buildup factor selection.

If NBLD=1 ～ 8, the buildup factor is calculated by Capo's formula as in earlier versions of QAD.

1:Water dose buildup factor, 2:Aluminum dose buildup factor,
3:Iron dose buildup factor, 4:Lead dose buildup factor,
5:Water energy absorption buildup factor,
6:Concrete dose buildup factor,
7:Iron energy absorption buildup factor,
8:Lead energy absorption buildup factor,

If NBLD > 10, the buildup factor is calculated by Geometric Progression (G-P) form.

② MATZ1,MATZ2,...MATZn - Atomic number of first, second, ... and last element used.

Card M'* Identification of Buildup Factor(2) (If NBLD > 10) Free Format

①MATGP*- Index of medium.

②ICGP* - Index of response.

③CONGY*- Conversion factor from exposure to energy absorption in air : 8.73 if Card Q is given by the conversion factor to exposure represented by mR or mR/h.

1.0 if Card Q is given by the conversion factor to energy absorption in air represented by μGy or μGy/h .

④ MATDOS*-Index of medium to convert energy absorption in air to ambient dose equivalents.

MATDOS	medium	Z
CARB	Carbon	6
ALUM	Aluminum	13
IRON	Iron	26
LEAD	Lead	82
WATE	Water	-
CONC	Concrete	-
AIR_	Air	-

Index of Material and Response used in QAD-CGGP2

MATGP	Material	ICGP	Response	ICGP	Response
BERY	Beryllium	_ABS	Beryllium	_EXP	Air
BORO	Boron	_ABS	Boron	_EXP	Air
CARB	Carbon	_ABS	Carbon	_EXP	Air
NITR	Nitrogen	_ABS	Nitrogen	_EXP	Air
OXYG	Oxygen	_ABS	Oxygen	_EXP	Air
SODI	Sodium	_ABS	Sodium	_EXP	Air
MAGN	Magnesium	_ABS	Magnesium	_EXP	Air
ALUM	Aluminum	_ABS	Aluminum	_EXP	Air
SILI	Silicon	_ABS	Silicon	_EXP	Air
PHOS	Phosphorus	_ABS	Phosphorus	_EXP	Air
SULP	Sulphur	_ABS	Sulphur	_EXP	Air
ARGO	Argon	_ABS	Argon	_EXP	Air
POTA	Potassium	_ABS	Potassium	_EXP	Air
CALC	Calcium	_ABS	Calcium	_EXP	Air
IRON	Iron	_ABS	Iron	_EXP	Air
COPP	Copper	_ABS	Copper	_EXP	Air
MOLY	Molybdenum	_ABS	Molybdenum	_EXP	Air
TIN_	Tin	_ABS	Tin	_EXP	Air
LANT	Lanthanum	_ABS	Lanthanum	_EXP	Air
GADO	Gadolinium	_ABS	Gadolinium	_EXP	Air
TUNG	Tungsten	_ABS	Tungsten	_EXP	Air
LEAD	Lead	_ABS	Lead	_EXP	Air
URAN	Uranium	_ABS	Uranium	_EXP	Air
WATE	Water	_ABS	Water	_EXP	Air
CONC	Concrete	_ABS	Concrete	_EXP	Air
AIR_	Air	_ABS	Air	_EXP	Air

Note: The ABS and EXP buildup factors for air are same.
A blank is indicated by " ".

Card(s) N Material Identification (NCOMP cards or sets of cards) Free Format
COMP1,COMP2,....,COMPn - Partial density of first, second, ... and last element in this composition.

NOTE: A similar list of the densities (in g/cm^3) must be included for each composition. The density for each of the elements specified on Card M must be listed even though it may be zero for the particular composition. The order of these cards must correspond to the composition numbers. The list of densities for a particular composition must begin on a new Card N.

Card(s) O Source Energy Free Format
EBAR -Mean gamma energy (MeV) for each group . (NRGY values).

Card(s) P Source Spectrum Free Format

GAMEN -The gamma-ray source energy spectrum, i.e., MeV/fission, MeV/capture or MeV/decay in each gamma-ray energy group. (The units here depend upon the units on Card C for ASO.). (NRGY values)

Card(s) Q Response Function (1) Free Format

CONV - Gamma flux-to-dose conversion factor for each gamma-ray energy group. For example, (rads/hr)/(MeV/cm^2 • sec). (NRGY values)

Card(s) R Response Function (2) Free Format

FEABSG-Gamma flux-to-heat conversion factor in Fe for each gamma-ray energy group. For example, (W/g)/(MeV/cm^2 • sec). (NRGY values)

Card S Response Function (3) Format(2A6)

WIDTHT -Total width of gamma-ray energy range. (Example, 0.1 - 4.0)

Card(s) T Response Function (4) (NRGY Titles) Format(2A6)

WIDTHG - Width of first, second, ..., and last gamma group. (Example, 3.0 - 4.0)

Card U Response Function (5) Format(3(4A6)

①UNITG, ②UNITG - Units of gamma flux. (Example, MeV/cm^2 • sec)

③UNITG, ④UNITG -Units of gamma dose according to Card Q. (Example, rads/sec)

⑤UNITG, ⑥UNITG - Units of gamma heating in iron according to Card R. (Example, W/g)

Card(s) V Response Function (6) (Use only if NGINT > 0 on Card B) Free Format (NRGY values per set)

WTG - Conversion factor for first, second, ..., and last gamma-ray energy group.

NOTE: There are conversion factors to convert from gamma energy flux to any other units one may wish to obtain. There must be NGINT sets of these factors.

Card W Response Function (7) (If NGINT > 0) Format(3(4A6))

UNITGI - The units for each of these additional quantities according to the conversion factors of Card V; these units will be used to title the output. Format is the same for Card U.

Card(s) X Detector Point or Evaluated Point Free Format

① RRC - The R, X or ρ detector coordinate. (cm)

② ZRC - The Z, Z or θ detector coordinate. (cm or radians)

③ PHIRC - The ϕ, Y or ϕ detector coordinate. (cm or radians)

④ NRCOPT-Receiver Geometry Option:

0=Cylindrical, 1=Cartesian, 2=Spherical.

⑤ NGPF, ⑥ NGPL, ⑦ NGPI-Same meaning as Card B:

If these values are greater than zero, they override the values on Card B. (Optional)

NOTE: One Card X must be used for each detector: any number of detectors may be used.

Card Y Terminate Card Free Format

A "-1" in these columns signals the end of problem set; additional problems may be stacked after this card.

NOTE: Receiver cards are read until a "-1" is encountered; then the program returns to read Card A of the next case.

3.2 JCL Specification

JCL for QAD-CGGP2 calculation is shown below.

```
//JCLG JOB
//JCLG EXEC JCLG
//SYSIN DD DATA,DLM='++'
// JUSER
  T.4 C.1 W.4 I.3 SRP
  OPTP PASSWORD=???  NOTIFY=J****
//***** RSIC2.CNTL(QADCGGP2) *****
// EXEC FORT77,SO=J3631.RSIC2,Q='.FORT77',
//      A='ELM(QADGP2,QADCOM,COMBGE),NOSOURCE'
// EXEC LKED77
// EXEC GO
//FT10F001 DD DSN=J3631.RSIC2.DATA(ATTFACT),DISP=SHR
//FT11F001 DD DSN=J3631.RSIC2.DATA(BFSET@),DISP=SHR
//FT12F001 DD DSN=J3631.RSIC2.DATA(DOSECON),DISP=SHR
//FT16F001 DD UNIT=WK10,DSN=&&JOMIN,DISP=(NEW,DELETE),
//   DCB=(RECFM=FB,LRECL=120,BLKSIZE=4800),SPACE=(TRK,(10,10),RLSE)
//SYSIN  DD *
```

input data

```
++
//
```

The following external data files are given,

Logical Unit:10 .... Data library of photon attenuation coefficients
Logical Unit:11 .... Data library of GP buildup factor coefficients
Logical Unit:12 .... Data library of conversion factors from energy absorption in air to ambient dose equivalents.

3.3 Sample Problem

(1) Sample Problem 1 : Calculation of ambient dose equivalents, $H^*(10)$, $H^*(3)$ and $H^*(0.07)$ outside the ^{60}Co treating facility with 100 cm thick concrete shielding wall where there is the source of 1000 Ci (3.7×10^{13} Bq).[11]

The input data are shown below, in which the sequential numbers on the left side represent those of the input cards.

```
 1  TEST RUN OF QAD-CGGP2(T)
 2    1  1    1  10    1  1    1  1    1  1    1  0    1     1    1 0
 3  3.7E+10 0.0  0.0  0.0  0.0  0.0  0.0
 4     0.      0.1
 5     0.      0.1
 6     0.      0.1
 7                      GEOMETR DATA
 8     RCC    1         0         0     -5.E3         0         0      1.E4
 9                   500.
10     RCC    2         0         0     -5.E3         0         0      1.E4
11                   600.
12     SPH    3         0         0         0      1.E5
13     END
14     ZON           1
15     ZON          -1       2
16     ZON          -2       3
17     END
18       1    2    3
19    1000    1 1000
20      11   1    8  11   12  13   14  16   19   20  26
21   CONC EXP  8.73  CONC
22    0.0129   1.1461   0.0393   0.0055   0.1049   0.7263   0.0028   0.0442
23    0.1900   0.0281
24    1.25
25      2.0E+3
26     2.19E-3
27    0
28    1.25
29       1.25
30     PHOTONS    /CM**2/SEC      MR       PER HOUR
31    600.1    0.       0          0   0    0   0
32    0        0        0         -1   0    0   0
```

In the card 3, the value of 3.7E+10 indicates the disintegration rate in isotope with source strength of 1 Ci. Cards 4-6 represent the spatial meshes for integration of source, in this problem the source is approximated to the point geometry. Cards 7-19 mean the geometry information of shielding concrete wall with thickness of 100 cm that exists 500 cm apart from source.

The value 11 of the first item in card 20 means usage of GP form for buildup factor calculation. The first and second items in card 21, CONC EXP, indicate exposure buildup factor of concrete medium. The third item in it, 8.73, is the conversion factor from exposure (mR/h) to energy absorption in air (μ Gy/h). The last item in card 21, CONC, means the index of concrete medium whose conversion factor is used from energy absorption in air to ambient dose equivalents. The second to last items of card 21 mean the atomic numbers of elements contained in concrete and cards 22-23 indicate the weight of elements in concrete. Cards 24-26 mean the source energy, source intensity for 1 Ci source and flux-to-exposure conversion factor at source energy. Card 31 indicates the detector position.

The output of sample problem 1 is shown in Fig.3.1 and Fig.3.2. Figure 3.1 shows the GP buildup factor coefficients, exposure buildup factors and conversion factor from energy absorption in air to ambient dose equivalents of concrete medium corresponding to the source energy. Figure 3.2 indicates the exposure, ambient dose equivalents, $H^*(10)$, $H^*(3)$ and $H^*(0.07)$, and maximum dose equivalent H_{max}.

(2) Sample Problem 2: Benchmark problem of gamma-ray shielding for the facility treating the radwaste proposed in ANS Standard Committee 6.2.1

The input data are shown below.

```
 1  TEST RUN OF QAD-CG *** G-III-1 *** D-2
 2   32  28   52   9    3   1    7   1    0   1    1   0 0 0 0 0
 3  8.069E6 0.0  0.0  0.0  0.0  0.0  0.0
 4     0.     25.      50.      66.6667  83.3333  100.     102.     104.
 5   106.     108.     110.     112.     114.     116.     118.     120.
 6   122.     124.     126.     128.     130.     132.     134.     136.
 7   138.     140.     142.     144.     146.     148.     150.     152.
 8   154.
 9   249.15   251.08   253.02   254.95   256.89   258.82   260.75   262.69
10   264.62   266.56   268.49   270.42   272.36   274.29   276.22   278.16
11   280.09   282.03   283.96   285.89   287.83   289.76   291.70   293.63
12   295.56   297.5    299.43   301.37   303.30
13   0.       0.025323 0.050645 0.075968 0.10129  0.12661  0.15194  0.17726
14   0.20258  0.22790  0.25323  0.27855  0.30387  0.32919  0.35452  0.37984
15   0.40516  0.43048  0.45581  0.48113  0.50645  0.53177  0.55710  0.58242
16   0.60774  0.63306  0.65839  0.68371  0.70903  0.73435  0.75968  0.78500
17   0.83411  0.88322  0.93234  0.98145  1.0306   1.0797   1.1288   1.1779
18   1.2270   1.2761   1.3252   1.3743   1.4235   1.4726   1.5217   1.5708
19   1.8850   2.1991   2.5133   2.8274   3.1416
20                    GEOMETR DATA
```

```
21    RCC   1       0        0     -5.E3        0        0      1.E4
22                154.
23    RCC   2       0        0-5.001  E3        0        0  1.0002E4
24           156.54
25    RPP   3 -220.     220.     -220.     220.     -5002.     5002.
26    RPP   4 -311.     311.     -311.     311.     -5003.     5003.
27    SPH   5       0       0         0     1.E5
28    END
29    ZON          1
30    ZON         -1      2
31    ZON         -2      3
32    ZON         -3      4
33    ZON         -4      5
34    END
35      1    2    3    4    5
36      1    2 1000    3 1000
37     11    1    8  11   12  13   14  19   20  26
38   WATE EXP  8.73  WATE
39    0.1118   0.8882   0       0       0       0       0       0
40    0
41    0       0       0       0       0       0       0       0
42    7.85
43    0.013098 1.1645   0.039967 6.0149-3 1.0949-1 0.7366   4.4994-2 1.9393-1
44    2.9025-2
45    0.4      0.8      1.3      1.7      2.2      2.5      3.5
46       4.E6     7.E6    2.8E6    8.2E5    4.E4     3.E4    1.2E1
47    7.79E-4  1.52E-3  2.26E-3  2.75E-3  3.30E-3  3.60E-3  4.51E-3
48    0       0       0       0       0       0       0
49    0.4-3.5
50          0.4        0.8        1.3        1.7        2.2        2.5
51          3.5
52     PHOTONS    /CM**2/SEC      MR      PER HOUR  **************************
53    219.     249.     0          0  0   0   0
54     0        0        0         -1  0   0   0
```

Cards 4-19 represent the spatial meshes for integration of volume source with cylindrical geometry. Cards 20-36 mean the geometry information for 100 cm thick storage tank that contains the radwaste. The value 11 of the first item in card 37 means usage of GP form for buildup factor calculation. The first and second items in card 38, WATE EXP, indicate exposure buildup factor of water medium. The third item in it, 8.73, is the conversion factor from exposure (mR/h) to energy absorption in air (μ Gy/h). The last item in card 38, WATE, means the index of water medium whose conversion factor is used from energy absorption in air to dose equivalent. The second to last items in card 37 mean the atomic numbers of elements contained in water, iron and concrete and cards 39-44 indicate the weight of the elements in each

material. Cards 45-47 mean the source energy with 7 groups , source intensity and flux-to-exposure conversion factor at each source energy. Card 53 indicates the position of detector denoted D_2 in this benchmark problem.

The output of sample problem 2 is shown in Fig.3.3 and Fig.3.4. In these figures, data and final results are shown for the multi-energy incident photons.

```
***** CONVERSION FACTORS AND BUILD FACTORS

***** BUILDUP FACTORS OF GEOMETRIC-PROGRESSION METHOD ARE USED
*****  CONCRETE MEDIUM, AIR RESPONSE

   GRP        ENERGY       CONV.         B        C        A        XK        D
    1       2.0000E+03  2.1900E-03   1.9031   1.2741  -0.0553   16.092  0.01791   1.25

   GRP     EG     0.5MFP     1.0MFP     2.0MFP     4.0MFP     8.0MFP    10.0MFP    20.0MFP    40.0MFP    60.0MFP
    1     1.25  1.420E+00  1.903E+00  3.011E+00  5.712E+00  1.279E+01  1.704E+01  4.351E+01  1.153E+02  2.046E+02


     E      1CM DEPTH    3MM DEPTH    70MU DEPTH  ANSI 6.1.1
   (MEV)    (A)   (B)    (A)   (B)    (A)   (B)    (A)   (B)
    1.25    1.13 1.09    1.15 1.08    1.15 1.06    1.20 1.14

    NOTE  (A)... CONVERSION GY TO SV
          (B)... (BF-DOS/BF-EXP) MAX

 ALBERT-WELTON COEFFICIENTS

     7.7200E-09  3.4900E-01  4.2200E-01  6.9800E-01

EG-
  1.2500E+00
FE ABS G-
  0.0
EN-
  1.0000E+01  8.0000E+00  6.0000E+00  5.0000E+00  4.0000E+00  3.0000E+00  2.0000E+00  1.0000E+00  6.7000E-01
  3.3000E-01
FE ABS N-
  2.2500E-15  9.2700E-16  5.4700E-16  4.6800E-16  3.8000E-16  3.0700E-16  2.1600E-16  1.0400E-16  8.3500E-17
  4.6700E-17
WIDTH T-            1.25        12.0-0.10
WIDTH G-                1.25
WIDTH N-            12.0-9.00   9.00-7.00   7.00-5.50   5.50-4.50   4.50-3.50   3.50-2.50
                    2.50-1.50   1.50-0.835  0.835-0.50  0.50-0.10
UNIT G-              PHOTONS    /CM**2/SEC      MR        PER HOUR
UNIT N-                RAD      WATTS PER    PER HOUR      GRAM       RAD PER  R
```

Fig.3.1 Output list (1) of sample problem 1 for QAD-CGGP2 code. GP buildup factor coefficients, exposure buildup factors and conversion factors to ambient dose equivalents for concrete medium corresponding to the photon energy emitted from ^{60}Co.

TEST RUN OF QAD-CGGP2(T)

RECEIVER NUMBER 1 COORDINATES - R 6.0010E+02 PHI 0.0 Z 0.0

GRP NO	MEAN ENERGY MEV	ENERGY GROUP LIMIT MEV	DIR. BEAM FLUX PHOTONS /CM**2/SEC	MEAN B - F	DOSE RATE DIR. BEAM MR PER HOUR	WITH B-F	HEATING RATES IN IRON DIR. BEAM	WITH B-F	DOSE EQUIVALENT RATE WITH B-F MICRO SV PER HOUR 1 CM DEPTH	3 MM DEPTH	70 MU DEPTH	ANSI 6.1.1
TOTAL	1.2500	1.25	3.364E+01	2.441E+01	7.367E-02	1.798E+00	0.0	0.0	1.933E+01	1.940E+01	1.921E+01	2.148E+01
W/BU	1.2500											
1	1.2500	1.25	3.364E+01	2.441E+01	7.367E-02	1.798E+00	0.0	0.0	1.933E+01	1.940E+01	1.921E+01	2.148E+01

Fig.3.2 Output list (2) of sample problem 1 for QAD-CGGP2 code. Exposure rate and ambient dose equivalent rates outside the concrete wall.

```
***** CONVERSION FACTORS AND BUILD FACTORS
***** BUILDUP FACTORS OF GEOMETRIC-PROGRESSION METHOD ARE USED
*****  WATER MEDIUM, AIR RESPONSE

 GRP        ENERGY      CONV.        B        C        A        XK       D
  1      4.0000E+06  7.7900E-04   2.6600   1.8820  -0.1490   14.240  0.05950   0.40
  2      7.0000E+06  1.5200E-03   2.2120   1.5440  -0.1050   14.360  0.04370   0.80
  3      2.8000E+06  2.2600E-03   1.9933   1.3261  -0.0686   14.419  0.02920   1.30
  4      8.2000E+05  2.7500E-03   1.8941   1.2244  -0.0496   14.414  0.02085   1.70
  5      4.0000E+04  3.3000E-03   1.8083   1.1437  -0.0328   13.642  0.01339   2.20
  6      3.0000E+04  3.6000E-03   1.7675   1.1053  -0.0246   12.713  0.00982   2.50
  7      1.2000E+01  4.5100E-03   1.6622   1.0196  -0.0039   12.572  0.00006   3.50

 GRP   EG     0.5MFP      1.0MFP      2.0MFP      4.0MFP      8.0MFP      10.0MFP     20.0MFP     40.0MFP     60.0MFP
  1   0.40  1.679E+00   2.660E+00   5.478E+00   1.506E+01   5.462E+01   8.663E+01   3.839E+02   1.974E+03   4.769E+03
  2   0.80  1.530E+00   2.212E+00   3.952E+00   8.878E+00   2.441E+01   3.483E+01   1.071E+02   3.519E+02   6.638E+02
  3   1.30  1.456E+00   1.993E+00   3.249E+00   6.380E+00   1.468E+01   1.964E+01   4.959E+01   1.322E+02   2.276E+02
  4   1.70  1.421E+00   1.894E+00   2.952E+00   5.422E+00   1.142E+01   1.481E+01   3.384E+01   8.002E+01   1.291E+02
  5   2.20  1.388E+00   1.808E+00   2.712E+00   4.713E+00   9.258E+00   1.172E+01   2.504E+01   5.533E+01   8.567E+01
  6   2.50  1.372E+00   1.767E+00   2.601E+00   4.399E+00   8.345E+00   1.044E+01   2.155E+01   4.579E+01   6.903E+01
  7   3.50  1.329E+00   1.662E+00   2.336E+00   3.705E+00   6.513E+00   7.944E+00   1.527E+01   3.033E+01   4.556E+01

   E      1CM DEPTH    3MM DEPTH    70MU DEPTH   ANSI 6.1.1
 (MEV)   (A)   (B)    (A)   (B)    (A)   (B)    (A)   (B)
  0.40   1.26  1.19   1.25  1.14   1.24  1.13   1.45  1.40
  0.80   1.16  1.15   1.18  1.11   1.18  1.11   1.26  1.28
  1.30   1.13  1.10   1.15  1.08   1.15  1.08   1.20  1.18
  1.70   1.13  1.06   1.14  1.06   1.15  1.05   1.19  1.13
  2.20   1.13  1.05   1.13  1.05   1.14  1.04   1.20  1.09
  2.50   1.13  1.04   1.13  1.04   1.13  1.03   1.19  1.08
  3.50   1.11  1.04   1.12  1.03   1.13  1.03   1.18  1.06

 NOTE  (A)... CONVERSION GY TO SV
       (B)... (BF-DOS/BF-EXP) MAX

 ALBERT-WELTON COEFFICIENTS
    7.7200E-09  3.4900E-01  4.2200E-01  6.9800E-01

EG-
  4.0000E-01  8.0000E-01  1.3000E+00  1.7000E+00  2.2000E+00  2.5000E+00  3.5000E+00
FE ABS G-
  0.0         0.0         0.0         0.0         0.0         0.0         0.0
EN-
  1.0000E+01  8.0000E+00  6.0000E+00  5.0000E+00  4.0000E+00  3.0000E+00  2.0000E+00  1.0000E+00  6.7000E-01
  3.3000E-01
FE ABS N-
  2.2500E-15  9.2700E-16  5.4700E-16  4.6800E-16  3.8000E-16  3.0700E-16  2.1600E-16  1.0400E-16  8.3500E-17
  4.6700E-17
WIDTH T-              0.4-3.5     12.0-0.10
WIDTH G-                     0.4         0.8         1.3         1.7         2.2         2.5
                             3.5
WIDTH N-
                     12.0-9.00   9.00-7.00   7.00-5.50   5.50-4.50   4.50-3.50   3.50-2.50
                     2.50-1.50   1.50-0.835  0.835-0.50  0.50-0.18
UNIT G-               PHOTONS    /CM**2/SEC      MR       PER HOUR  ......................
UNIT N-                 RAD      WATTS PER    PER HOUR     GRAM      RAD PER  H
```

Fig.3.3 Output list (1) of sample problem 2 for QAD-CGGP2 code.
Printout data for 7 group photon energies.

TEST RUN OF QAD-CG ••• G-III-1 ••• D-2

RECEIVER NUMBER 1 COORDINATES - R 2.1900E+02 PHI 0.0 Z 2.4900E+02

GRP NO	MEAN ENERGY MEV	ENERGY GROUP LIMIT MEV	DIR. BEAM FLUX PHOTONS /CM••2/SEC	MEAN B - F	DOSE RATE DIR. BEAM MR PER HOUR	WITH B-F	HEATING RATES IN IRON DIR. BEAM •••••••••••• ••••••••••••	WITH B-F	DOSE EQUIVALENT RATE WITH B-F MICRO SV PER HOUR 1 CM DEPTH	3 MM DEPTH	70 MU DEPTH	ANSI 6.1.1
TOTAL	0.8990	0.4-3.5	4.469E+06	4.478E+00	8.291E+03	3.713E+04	0.0	0.0	4.231E+05	4.185E+05	4.184E+05	5.055E+05
W/BU	1.0490											
1	0.4000	0.4	4.619E+05	1.117E+01	3.598E+02	4.020E+03	0.0	0.0	5.276E+04	4.980E+04	4.923E+04	7.111E+04
2	0.8000	0.8	1.986E+06	5.406E+00	3.819E+03	1.632E+04	0.0	0.0	1.905E+05	1.869E+05	1.871E+05	2.299E+05
3	1.3000	1.3	1.485E+06	3.656E+00	3.175E+03	1.161E+04	0.0	0.0	1.257E+05	1.255E+05	1.258E+05	1.441E+05
4	1.7000	1.7	5.524E+05	3.039E+00	1.519E+03	4.616E+03	0.0	0.0	4.837E+04	4.848E+04	4.845E+04	5.411E+04
5	2.2000	2.2	3.459E+04	2.641E+00	1.141E+02	3.015E+02	0.0	0.0	3.107E+03	3.107E+03	3.104E+03	3.429E+03
6	2.5000	2.5	2.985E+04	2.482E+00	1.046E+02	2.596E+02	0.0	0.0	2.658E+03	2.664E+03	2.656E+03	2.904E+03
7	3.5000	3.5	1.523E+01	2.142E+00	6.867E-02	1.471E-01	0.0	0.0	1.482E+00	1.486E+00	1.490E+00	1.607E+00

Fig.3.4 Output list (2) of sample problem 2 for QAD-CGGP2 code.
Exposure rates and ambient dose equivalent rates outside the iron tank wall.

4. Information of G33-GP2 for Users

4.1 Input Specification

Much of the input to the G33-GP2 code is identical to that for the original G33 code.

The input to G33-GP2 consists of the following:

Note: Variables marked (*) have a new meaning compared to G33.

Variable Names and Format

Set 1 Title Information Format(12A4) one card

ID - Any alphanumeric information desired.

Set 2 Control data Format(8(I5,I4)) one card

① NGEOM-Specifies scattering geometry: 1-rectangular, 2-cylindrical, 3-spherical.

② LU -Number of x_1, r_2 or ρ_3 divisions in scattering volume. ($1 \leqq LU \leqq 20$)

③ MU -Number of y_1, ϕ_2 or ϕ_3 divisions in scattering volume. ($1 \leqq MU \leqq 20$)

④ NU -Number of z_1, z_2 or θ_3 divisions in scattering volume. ($1 \leqq NU \leqq 20$)

⑤ MAT -Number of elements. ($1 \leqq MAT \leqq 20$)

⑥ NCMP -Number of compositions. ($1 \leqq NCMP \leqq 20$)

⑦ NINC -Number of incident gamma source energy groups. ($1 \leqq NINC \leqq 30$)

⑧ NSC -Number of scattered gamma energy groups. ($1 \leqq NSC \leqq 30$)

⑨ NREG -Number of regions. ($1 \leqq NREG \leqq 50$)

⑩ NB -Number of bounding surfaces. ($1 \leqq NB \leqq 50$)

⑪ NZSO -Region number where point source is most probably located.

⑫ STYP -Selection of anisotropic source:

3 - anisotropic source in spherical geometry.

Otherwise - normal (isotropic source).

Set 2' Control data Format(I5,I4,2X,2A4,1X,F8.0,A4) one card

① IBUILD*-Buildup factor selection:

$\neq 0$ Specifies the reading of GP buildup factor coefficient data file from unit 10.

$= 0$ Specifies no use of GP buildup factor coefficient data.

② ISPEC* -Gamma group intensity selection:

= 0 Specifies the reading SINC as described in the original manual.

= 1 Specifies reading (ENERGD(I), I=1, NINC) and (ANGD(M), M=1, NU) (both format 8E9.4) and defining SINC (I,M)= ENERGD(I) * ANGD(M).

= 2 Specifies reading (SINC(I,M), M=1, NU), I=1, NINC), format (10E12.3) from unit 2.

③ MATGP*-Material identification of buildup factor from table below.

④ ICGP* -Buildup factor response, i.e., _ABS for absorption buildup factor, _EXP for exposure (air response) buildup factor.

⑤ CONGY*-Conversion factor from exposure to energy absorption in air : 8.73 if Set_14 card is given by the conversion factor to exposure represented by mR or mR/h.

1.0 if Set 14 card is given by the conversion factor to energy absorption in air represented by μ Gy or μ Gy/h.

⑥ MATDOS*-Index of material to convert energy absorption in air for to ambient dose equivalents.

MATDOS	medium	Z
CARB	Carbon	6
ALUM	Aluminum	13
IRON	Iron	26
LEAD	Lead	82
WATE	Water	-
CONC	Concrete	-
AIR_	Air	-

Set 3 - x_1, r_2 or ρ_3 divisions Format(8E9.4) Int(LU/8)* + 1 cards

XR - (LU+1) values of x_1, r_2 or ρ_3. The values specified are the coordinates values of the volume scattering elements along either the x_1, r_2 or ρ_3.

Set 4 - y_1, ϕ_2 or ϕ_3 divisions Format(8E9.4) Int(MU/8) + 1 cards

YPH -(MU+1) values of y_1, ϕ_2 or ϕ_3. The values specified are the coordinates values of the volume scattering elements along either the y_1, ϕ_2 or ϕ_3.

---

*The function Int(X) equals the greatest integer less than X. For example, Int(1.01)=1, Int(0.9)=0 and Int(1.0)=0.

Index of Materials and Response used in G33-GP2

MATGP	Material	ICGP	Response	ICGP	Response
BERY	Beryllium	_ABS	Beryllium	_EXP	Air
BORO	Boron	_ABS	Boron	_EXP	Air
CARB	Carbon	_ABS	Carbon	_EXP	Air
NITR	Nitrogen	_ABS	Nitrogen	_EXP	Air
OXYG	Oxygen	_ABS	Oxygen	_EXP	Air
SODI	Sodium	_ABS	Sodium	_EXP	Air
MAGN	Magnesium	_ABS	Magnesium	_EXP	Air
ALUM	Aluminum	_ABS	Aluminum	_EXP	Air
SILI	Silicon	_ABS	Silicon	_EXP	Air
PHOS	Phosphorus	_ABS	Phosphorus	_EXP	Air
SULP	Sulphur	_ABS	Sulphur	_EXP	Air
ARGO	Argon	_ABS	Argon	_EXP	Air
POTA	Potassium	_ABS	Potassium	_EXP	Air
CALC	Calcium	_ABS	Calcium	_EXP	Air
IRON	Iron	_ABS	Iron	_EXP	Air
COPP	Copper	_ABS	Copper	_EXP	Air
MOLY	Molybdenum	_ABS	Molybdenum	_EXP	Air
TIN_	Tin	_ABS	Tin	_EXP	Air
LANT	Lanthanum	_ABS	Lanthanum	_EXP	Air
GADO	Gadolinium	_ABS	Gadolinium	_EXP	Air
TUNG	Tungsten	_ABS	Tungsten	_EXP	Air
LEAD	Lead	_ABS	Lead	_EXP	Air
URAN	Uranium	_ABS	Uranium	_EXP	Air
WATE	Water	_ABS	Water	_EXP	Air
CONC	Concrete	_ABS	Concrete	_EXP	Air
AIR_	Air	_ABS	Air	_EXP	Air

Note: A blank is indicated by "_". AIR ABS selects the buildup factor for air exposure buildup factor. This would be the typical selection for an air-scattering problem.

Set 5 - z_1, z_2 or θ_3 divisions Format(8E9.4) Int(NU/8) + 1 cards

ZYH -(NU+1) values of z_1, z_2 or θ_3. The values specified are the coordinates values of the volume scattering elements along either the z_1, z_2 or θ_3.

Set 6 - Region description Format(8(I5,I4)) G cards

① Bo (NBNDZN) - Number of boundaries of region.

② h (NCMPIN) - Composition in the region described.

③ $\pm\lambda$ ($\pm$LBD) - j. λ for the first boundary to consider for this zone.

④ p (NTRYZN) - The zone that is likely to be entered by crossing boundary λ from zone.

(There are Bo pairs of ($\pm\lambda$,p) for each zone)

Set 7 - Boundary description Format(I5,I4,7E9.4) B cards

① λ (I) - Boundary number.

② S (NEQBD) - Boundary type number.

③ A (ABD), ④ B (BBD), ⑤ C (CBD), ⑥ xo (XOBD), ⑦ yo (YOBD), ⑧ zo (ZOBD),

⑨ k (DBD) - Boundary equation coefficients as required.

Set 8 - Composition Matrix Format(8E9.4) H [Int(N/8) + 1] cards

θ i,j (COMP) - The densities in g/cm^3 of the i-th composition (rows) and the J-th element (columns).

Set 9 - Element atomic numbers Format(8E9.4) Int(Mo/8)+1 cards

ZMAT - Element atomic numbers in the same order as columns in Set 8, must be floating point integer.

Set 10 - Element atomic weights Format(8E9.4) Int(Mo/8)+1 cards

AMAT - Element atomic weights in order as on Set 8.

Set 11 - Source energies Format(8E9.4) Int(I/8)+1 cards

EINC - Source energies in MeV, input on ascending order of energy.

Set 12 - Source group intensities Format(8E9.4) Int(I/8)+1 cards

SINC - Gamma group intensities in photons/sec in same order as Set 11.

Set 13 - Scattered energy group bounds Format(8E9.4) Int(J/8)+1 cards

ESC - Lower bounds for each scattered group, input in ascending order of energy. A lower bound of zwro should be entered for the first group as this is understood.

Set 14 - Conversion factors Format(8E9.4) Int(J/8)+1 cards

CONV - Unit conversion factors in one-to-one correspondence with ESC(j).

Set 15 - Constants

① EPSLN-A small number used in region testing.

② FUDGE-A small number in geometry routines, must be greater than EPSLN.

③ SFACT-The symmetry factor.

Set 16 - Source locations Format(3E9.4,2(I5,I4)) one card

① XSO, ② YSO, ③ ZSO - Source coordinates consistent with coordinate system specified by NCOORD.

④ NCOORD - Coordinate system specification:
1-Cartiesian, 2-Cylindrical, 3-Spherical.

⑤ N1, ⑥ N2 - A distance print will be obtained for the N1 trough the N2 source - scatter point rays.

Set 17 - Receiver locations Format(3E9.4,2(I5,I4)) any number of cards

① XRC, ② YRC, ③ ZRC- The detector coordinates consistent with coordinate system specified by NCOORD.

④ NCOORD - Coordinate system specification:
1-Cartiesian, 2-Cylindrical, 3-Spherical.

⑤ N1, ⑥ N2 - A distance print will be obtained for the N1 trough the N2 source - scatter point rays.

Set 18 - Last card Format(3E9.4,2(I5,I4)) one card

N$<$0 - denotes end of problem, i.e., NCOORD $<$0.

Set 19 - Final card

STOP - STOP written in columns 1-4 with column 5-6 blank, denotes end of problem set.

4.2 JCL Specification

JCL for G33-GP2 calculation is shown below.

```
//JCLG JOB
//JCLG EXEC JCLG
//SYSIN DD DATA,DLM='++'
// JUSER
  T.2 C.2  I.4 W.4 SRP
  OPTP PASSWORD=???  NOTIFY=J****
//***** RSIC2.CNTL(G33GP2) *****
// EXEC FORT77,SO=J3631.RSIC2,Q='.FORT77',
//      A='ELM(G33GP2),NOSOURCE'
// EXEC LKED77
// EXEC GO
//FT03F001 DD DSN=&&SCR1,UNIT=WK10,DISP=(NEW,DELETE),
//   DCB=(RECFM=VBS,BLKSIZE=6447),SPACE=(TRK,(10,10),RLSE)
//FT04F001 DD DSN=&&SCR2,UNIT=WK10,DISP=(NEW,DELETE),
//   DCB=(RECFM=VBS,BLKSIZE=6447),SPACE=(TRK,(10,10),RLSE)
//FT10F001 DD DSN=J3631.RSIC2.DATA(ATTFACT),DISP=SHR
//FT11F001 DD DSN=J3631.RSIC2.DATA(BFSET@),DISP=SHR
//FT12F001 DD DSN=J3631.RSIC2.DATA(DOSECON),DISP=SHR
//SYSIN  DD *
```

input data

```
++
//
```

The folling external data files are given, next.

Logical Unit:10 ... Data library of photon attenuation coefficients

Logical Unit:11 ... Data library of GP buildup factor coefficients

Logical Unit:12 ...Data library of conversion factors from energy absorption in air to ambient dose equivalents

4.3 Sample Problem

1) Sample Problem 1 : Calculation of ^{60}Co gamma-ray skyshine measurements performed at Kansas State University.[18] A point source is located on the axis of an approximately cylindrical-shell collimator. There is azimuthal symmetry about the vertical and the collimator restricts emission to a cone of polar angle 1.3134 radians measured from vertical. Detectors are at elevations 1 meter below the source and are at radial distances from 50 to 700 meters from the collimator axis.[19]

The input data are shown below, in which the sequential number on the right side represents those of the input cards.

```
G33GP SAMPLE PROBLEM, KSU SKYSHINE EXPERIMENT - NO OVERHEAD SHIELDING  01
   3  20   20  20    9   2    1  14    4   3    1   0                   02
   1   0  AIR  ABS  8.73  AIR                                           03
57.3      75.     110.     150.0    210.0    315.0    465.0    680.0    04
1000.    1470.    2155.    3160.    4640.    6810.    10000.   14760.   05
21550.   31660.   46410.   68130.   100000.                            06
0.0      .025     .05      .075     .1       .15      .2       .25      07
.3       .4       .5       .6       .8       1.0      1.2      1.4      08
1.6      1.8      2.0      2.4      3.1416                             09
0.       .1       .2       .3       .4       .5       .6       .70      10
.75      .8       .85      .9       .95      1.0      1.05     1.10     11
1.125    1.25     1.275    1.3      1.3134                             12
   2   1    1   2    3   4                                             13
   3   2   -1   1    2   3    3   4                                    14
   2   1    3   4   -2   2                                             15
   1   1   -3   3                                                      16
   1   3                          0.0      0.0          15625+04       17
   2   3                          0.0      0.0          47306+04       18
   3   6                                               3.10E+01       19
0.0      85723-04 26277-04 0.0      0.0      0.0      0.0      0.0      20
0.0                                                                    21
0.01193  0.0      1.063    0.0364   0.0978   0.6731   0.0411   0.1798   22
0.02663                                                                23
1.0      7.0      8.0      11.0     13.0     14.0     19.0     20.0     24
26.0                                                                   25
1.00797  14.007   15.995   22.990   26.98    28.086   39.102   40.08    26
55.847                                                                 27
1.25                                                                   28
7.40E+10                                                               29
0.05     0.06     0.08     0.10     0.15     0.20     0.30     0.40     30
0.50     0.60     0.80     1.00     1.50     2.0                        31
```

```
1.235-04 1.122-04 1.221-04 1.500-04 2.448-04 3.501-04 5.688-04 7.769-04      32
9.843-04 1.169-03 1.517-03 1.836-03 2.517-03 3.092-03                        33
1.000E-6 3.000E-1 2.0                                                        34
  0.0      0.0       0.0                                                     35
 50.0E+2   0.0      -100.                                                    36
 100.E+2   0.0      -100.                                                    37
 200.E+2   0.0      -100.                                                    37
 300.E+2   0.0      -100.                                                    37
 400.E+2   0.0      -100.                                                    37
 500.E+2   0.0      -100.                                                    37
 600.E+2   0.0      -100.                                                    37
 700.E+2   0.0      -100.                                                    37
                                                                           44
*END                                                                       45
```

The value 1 of the first item in card 3 means usage of GP form for buildup factor calculation. The third and fourth items in card 3, AIR ABS, indicate exposure buildup factor of air medium. The fifth itemp in it,8.73, is the conversion factor from exposure(mR/h) to energy absorption in air(μ Gy/h). The last item in card 3, AIR, means the index of air medium whose conversion factor is used from energy absorption in air to ambient dose equivalents. Cards 28-29 mean the source energy and source intensity. Cards 30-33 indicate the scattered photon energy and flux-to-exposure conversion factor at scattered energy. Cards 35 and 36-37 indicate the position of source and detector respectively.

The output of sample problem 1 is shown in Fig.4.1 and Fig.4.2. Figure 4.1 shows the GP buildup factor coefficients, exposure buildup factors and conversion factor from energy absorption in air to ambient dose equivalents of air medium corresponding to source energy. Figure 4.2 indicates total dose and partial dose to scattered energy bin of the exposure, ambients dose equivalents, $H^*(10)$ $H^*(3)$ $H^*(0.07)$, maximum dose equivalent H_{max}.

```
   G33GP SAMPLE PROBLEM. KSU SKYSHINE EXPERIMENT -
COMP     MAT      1            2            3            4            5            6            7            8            9
    Z          1.0000D+00   7.0000D+00   8.0000D+00   1.1000D+01   1.3000D+01   1.4000D+01   1.9000D+01   2.0000D+01   2.6000D+01
    A          1.0080D+00   1.4007D+01   1.5995D+01   2.2990D+01   2.6980D+01   2.8086D+01   3.9102D+01   4.0080D+01   5.5847D+01
  1            0.0          8.5723D-04   2.8277D-04   0.0          0.0          0.0          0.0          0.0          0.0
  2            1.1930D-02   0.0          1.0630D+00   3.6400D-02   9.7800D-02   6.7310D-01   4.1100D-02   1.7980D-01   2.6630D-02

**** BUILDUP FACTORS ****

  -- GP PARAMETER OF  AIR MEDIUM. AIR RESPONSE

  GRP    ENERGY      B         C         A          XK        D
   1      1.25    2.0102    1.3328   -0.0698    14.313   0.02811


  -- CHECK OF BUILDUP FACTORS BY GP-METHOD --

  GRP      EG       0.5MFP      1.0MFP      2.0MFP      4.0MFP      8.0MFP      10.0MFP     20.0MFP     40.0MFP     60.0MFP
   1      1.25   1.463D+00   2.010D+00   3.293D+00   6.503D+00   1.506D+01   2.020D+01   5.125D+01   1.344D+02   2.251D+02



    E       1CM DEPTH    3MM DEPTH    70MU DEPTH   ANSI 6.1.1
  (MEV)    (A)   (B)    (A)   (B)    (A)   (B)    (A)   (B)
   1.25    1.13  1.10   1.15  1.09   1.15  1.09   1.20  1.20

  NOTE  (A)... CONVERSION GY TO SV
        (B)... (BF-DOS/BF-EXP) MAX
```

Fig.4.1 Output list (1) of sample problem 1 for G33-GP2 code.
GP buildup factor coefficients, exposure buildup factors and conversion factor to ambient dose equivalents for air medium corresponding to the photon energy emitted from ^{60}Co.

G33GP SAMPLE PROBLEM, KSU SKYSHINE EXPERIMENT -

1 X= 5.0000D+03 Y= 0.0 Z= -1.0000D+02

SOURCE X= 0.0 Y= 0.0 Z= 0.0

GROUP	ENERGY	SOURCE	MIN DIRECT	MAX DIRECT	MIN SCATTR	MAX SCATTR	MIND+MAXSC	GROUP
1	1.2500D+00	7.4000D+10	5.0566D-06	1.2355D-04	1.0638D-02	1.7323D-02	1.7329D-02	1
TOTAL(EXPOSURE MR,MUGY/HR)			5.0566D-06	1.2355D-04	1.0638D-02	1.7323D-02	1.7329D-02	
1	1.2500D+00	7.4000D+10	4.9957D-05	1.3468D-03	1.1409D-01	2.1941D-01	2.1946D-01	1
TOTAL (1CM DOSE	MUSV/HR)		4.9957D-05	1.3468D-03	1.1409D-01	2.1941D-01	2.1946D-01	
1	1.2500D+00	7.4000D+10	5.0669D-05	1.3542D-03	1.1437D-01	2.1503D-01	2.1508D-01	1
TOTAL (3MM DOSE	MUSV/HR)		5.0669D-05	1.3542D-03	1.1437D-01	2.1503D-01	2.1508D-01	
1	1.2500D+00	7.4000D+10	5.0966D-05	1.3537D-03	1.1357D-01	2.0977D-01	2.0982D-01	1
TOTAL (70MU DOSE	MUSV/HR)		5.0966D-05	1.3537D-03	1.1357D-01	2.0977D-01	2.0982D-01	
1	1.2500D+00	7.4000D+10	5.3189D-05	1.5584D-03	1.2895D-01	2.9589D-01	2.9594D-01	1
TOTAL (ANSI DOSE	MUSV/HR)		5.3189D-05	1.5584D-03	1.2895D-01	2.9589D-01	2.9594D-01	

BIN	E-LOW	FACTOR	EXPOSURE(MR,MUGY/HR)		1CM DOSE(MUSV/HR)		3MM DOSE(MUSV/HR)		70MU DOSE(MUSV/HR)		ANSI DOSE(MUSV/HR)		BIN
			MIN SCAT	MAX SCAT	MIN SCAT	MAX SCAT	MIN SCAT	MAX SCAT	MIN SCAT	MAX SCAT	MIN SCAT	MAX SCAT	
7	2.00D-01	3.501D-04	2.140D-03	5.309D-03	2.502D-02	7.135D-02	2.466D-02	6.939D-02	2.437D-02	6.726D-02	2.938D-02	1.048D-01	7
8	3.00D-01	5.688D-04	1.456D-03	2.450D-03	1.632D-02	3.247D-02	1.619D-02	3.163D-02	1.601D-02	3.084D-02	1.893D-02	4.539D-02	8
9	4.00D-01	7.769D-04	1.520D-03	2.210D-03	1.637D-02	2.836D-02	1.638D-02	2.773D-02	1.625D-02	2.701D-02	1.869D-02	3.772D-02	9
10	5.00D-01	9.843D-04	1.256D-03	1.740D-03	1.315D-02	2.159D-02	1.326D-02	2.118D-02	1.314D-02	2.067D-02	1.479D-02	2.777D-02	10
11	6.00D-01	1.169D-03	2.126D-03	2.852D-03	2.180D-02	3.411D-02	2.208D-02	3.365D-02	2.198D-02	3.305D-02	2.399D-02	4.235D-02	11
12	8.00D-01	1.517D-03	1.743D-03	2.252D-03	1.749D-02	2.583D-02	1.780D-02	2.574D-02	1.780D-02	2.547D-02	1.893D-02	3.113D-02	12
13	1.00D+00	1.836D-03	3.971D-04	5.104D-04	3.944D-03	5.704D-03	4.012D-03	5.709D-03	4.017D-03	5.667D-03	4.247D-03	6.776D-03	13

Fig.4.2 Output list (2) of sample problem 1 for G33-GP2 code.
Exposure rate and ambient dose equivalent rates of skyshine gamma at the point 50m apart from the source.

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References

1) Cain,V.R., "A Users Manual for QAD-CG, the Combinatorial Geometry Version of the QAD-P5A Point Kernel Shielding Code" Bechtel Computer Code-NE007 (1977).
2) Malenfant,R.E., "G^3: A General Purpose Gamma-Ray Scattering Code", LA-5176 (1973).
3) Oak Ridge National Laboratory Radiation Shielding Information Center Code Package CCC-493, "QAD-CGGP, A Combinatorial Geometry Version of QAD-P5A, A Point Kernel Code System for Neutron and Gamma-Ray Shielding Calculations Using the GP Buildup Factor" (1986).
4) Oak Ridge National Laboratory Radiation Shielding Information Center Code Package CCC-494, "G33-GP, Kernel Integration Code System -- Multigroup Gamma-Ray Scattering Using the GP Buildup Factor" (1986).
5) Oak Ridge National Laboratory Radiation Shielding Information Center Data Library Collection DLC-15, "Evaluated Photon Interaction Library ENDF/B File 23 Format" (1971).
6) Oak Ridge National Laboratory Radiation Shielding Information Center Data Package DLC-136, "PHOTX, Photon Interaction Cross Section Library".
7) ICRP Publ.26, "Recommendation of International Commission on Radiological Protection", (1975), Pergamon Press, Oxford.
8) American Nuclear Society, "Neutron and Gamma-Ray Flux-Dose-Rate Factors", ANSI/ANS-6.1.1-1977.
9) ICRP Publ.51, "Data for Use in Protection Against External Radiation", (1987), Pergamon Press, Oxford.
10) Hirayama,H. and Tanaka,S., "Investigation of 1 cm Dose Equivalent for Photons behind Shielding Materials", J. At. Energy Soc. Jpn. 31, 841 (1989) (in Japanese).
11) Tanaka,S. and Suzuki,T., "A Calculation Method of Photon Dose Equivalent Based on the Revised Technical Standards of Radiation Protection Law (No.1) - Conversion from Absorbed Dose in Air to Dose Equivalent in Shielding Calculation -", Radioisotopes, 38 (2) 90 (1989) (in Japanese).
12) Nuclear Safety Technical Center, "Practical Manual for Shielding Calculations of Gamma (X) Ray Radiation Facility" (1989) (in Japanese)
13) Takeuchi,K. and Tanaka,S., "PALLAS-PL,SP-Br: A Code for Direct Integration of Transport Equation in One-Dimensional Plane and Spherical Geometries", JAERI-M 9695 (1981).

14) Harima,Y., Sakamoto,Y., Tanaka,S. and Kawai,M., "Validity of the Geometric-Progression Formula in Approximating Gamma-Ray Buildup Factors", Nucl. Sci. Eng. 94, 24 (1986).

15) Harima,Y., Tanaka,S., Sakamoto,Y. and Hirayama,H., "New Gamma-Ray Buildup Factor Data Base for Point Kernel Method and Application to Shielding Calculation", J. At. Energy Soc. Jpn. 31, 477 (1989) (in Japanese).

16) Akima,A., "A New Method of Interpolation and Smooth Curve Fitting Based on Local Procedures", J. ACM, 17, 4 (1970).

17) Akima,A., "Algorithm 433, Interpolation and Smooth Curve Fitting Based on Local Procedures", Comm. ACM, 15, 914 (1972).

18) Nason,R.R., Shultis,J.K., Faw,R.E. and Clifford,C.E., "A Benchmark Gamma-Ray Skyshine Experiment", Nucl. Sci. Eng. 79, 404 (1981).

19) Faw,R.E., private communication.

Appendix A

Conversion Factor Data from Air Kerma to Dose Equivalents

Table A.1 Conversion Factor fx from Air Kerma (Gy) to Dose Equivalent (Sv)

E (MeV)	1 cm	3 mm	70 μ m	ANSI
0.01	0.0103	0.271	0.930	1.48
0.015	0.271	0.686	0.974	1.74
0.02	0.601	0.917	1.02	1.95
0.03	1.09	1.19	1.19	2.24
0.04	1.43	1.42	1.38	2.36
0.05	1.63	1.59	1.52	2.49
0.06	1.74	1.67	1.58	2.55
0.08	1.73	1.66	1.59	2.35
0.10	1.65	1.60	1.55	2.12
0.15	1.49	1.46	1.42	1.76
0.20	1.38	1.36	1.34	1.63
0.30	1.31	1.30	1.28	1.53
0.40	1.26	1.25	1.24	1.45
0.50	1.21	1.22	1.21	1.37
0.60	1.19	1.20	1.19	1.33
0.80	1.16	1.18	1.18	1.26
1.0	1.14	1.16	1.16	1.23
1.5	1.13	1.14	1.15	1.19
2.0	1.13	1.13	1.14	1.20
3.0	1.12	1.13	1.13	1.18
4.0	1.11	1.12	1.13	1.18
5.0	1.11	1.12	1.12	1.16
6.0	1.10	1.11	1.11	1.17
8.0	1.09	1.10	1.11	1.15
10.0	1.09	1.11	1.11	1.15
15.0	1.09	1.11	1.11	1.14

Table A.2 Ratio $\overline{fxm}$ / fx of the Maximum Effective Conversion Factors to Conversion Factors from Air Kerma to Dose Equivalent for Shielding Materials up to 30 mfp Thickness

Carbon

E (MeV)	1 cm	3 mm	70 μm	ANSI
0.03	1.00	1.00	1.00	1.00
0.06	1.00	1.00	1.00	1.00
0.08	1.00	1.00	1.00	1.02
0.1	1.01	1.01	1.00	1.05
0.2	1.04	1.04	1.03	1.40
0.5	1.16	1.15	1.13	1.43
1.0	1.14	1.12	1.10	1.28
2.0	1.06	1.06	1.06	1.11
5.0	1.02	1.02	1.02	1.05
10.0	1.02	1.01	1.01	1.03

Aluminum

E (MeV)	1 cm	3 mm	70 μm	ANSI
0.03	1.00	1.00	1.00	1.00
0.06	1.00	1.00	1.00	1.00
0.08	1.00	1.00	1.00	1.03
0.1	1.03	1.02	1.01	1.10
0.2	1.13	1.12	1.10	1.21
0.5	1.14	1.12	1.10	1.21
1.0	1.10	1.08	1.07	1.17
2.0	1.04	1.05	1.05	1.08
5.0	1.02	1.02	1.02	1.05
10.0	1.02	1.01	1.02	1.03

Table A.2 (Continued)

Iron

E (MeV)	1 cm	3 mm	70 μm	ANSI
0.03	1.00	1.00	1.00	1.00
0.06	1.00	1.00	1.00	1.00
0.08	1.00	1.00	1.00	1.00
0.1	1.01	1.01	1.01	1.02
0.2	1.04	1.04	1.04	1.05
0.5	1.07	1.06	1.06	1.11
1.0	1.07	1.06	1.05	1.11
2.0	1.04	1.04	1.03	1.06
5.0	1.03	1.03	1.03	1.05
10.0	1.04	1.03	1.03	1.08

Lead

E (MeV)	1 cm	3 mm	70 μm	ANSI
0.03	1.00	1.00	1.00	1.00
0.06	1.00	1.00	1.00	1.00
0.08	1.00	1.01	1.00	1.00
0.1	1.04	1.03	1.02	1.10
0.2	1.02	1.02	1.02	1.03
0.5	1.02	1.01	1.01	1.02
1.0	1.02	1.02	1.02	1.03
2.0	1.01	1.02	1.01	1.01
5.0	1.02	1.02	1.02	1.04
10.0	1.04	1.03	1.03	1.05

Table A.2 (Continued)

Water

E (MeV)	1 cm	3 mm	70 μm	ANSI
0.03	1.00	1.00	1.00	1.00
0.06	1.00	1.00	1.00	1.00
0.08	1.00	1.00	1.00	1.03
0.1	1.01	1.01	1.00	1.13
0.2	1.13	1.12	1.10	1.40
0.5	1.19	1.13	1.13	1.36
1.0	1.13	1.10	1.10	1.24
2.0	1.05	1.05	1.04	1.10
5.0	1.03	1.02	1.02	1.05
10.0	1.02	1.01	1.01	1.03

Concrete

E (MeV)	1 cm	3 mm	70 μm	ANSI
0.03	1.00	1.00	1.00	1.00
0.06	1.00	1.00	1.00	1.00
0.08	1.00	1.00	1.00	1.04
0.1	1.03	1.03	1.01	1.10
0.2	1.14	1.13	1.10	1.22
0.5	1.14	1.12	1.11	1.21
1.0	1.11	1.09	1.07	1.16
2.0	1.04	1.05	1.04	1.08
5.0	1.03	1.03	1.02	1.05
10.0	1.03	1.02	1.02	1.08

Table A.2 (Continued)

Air

E (MeV)	1 cm	3 mm	70 μ m	ANSI
0.03	1.00	1.00	1.00	1.00
0.06	1.00	1.00	1.00	1.00
0.08	1.00	1.00	1.00	1.03
0.1	1.01	1.01	1.00	1.13
0.2	1.12	1.11	1.09	1.40
0.5	1.19	1.16	1.14	1.37
1.0	1.13	1.11	1.10	1.25
2.0	1.05	1.06	1.06	1.10
5.0	1.02	1.02	1.02	1.05
10.0	1.02	1.01	1.01	1.03

Appendix B

Cross section Data used in PALLAS Calculation

Material: Molybdenum, Tin, Lanthanum, Gadolinium, Tungsten, Lead and Uranium

Notation (unit)

E : Photon energy (MeV)

TOT : Total cross section, Mass attenuation coefficient(cm^2/g)

(TOT) = (PHOTO ELECTRIC) + (PAIR CREATION)
+ (INCOHERENT SCATTERING)

PHOTO ELECTRIC : Photo electric absorption cross section (cm^2/g)

PAIR CREATION : Pair production cross section (cm^2/g)

K-SHELL ABSORP : Photo electric absorption cross section of K-shell (cm^2/g)

MASS E ABSORP. : Mass energy absorption coefficient(cm^2/g)

TISSUE RESPONSE : flux-to-maximum dose conversion factor (mrem/hr)/(photons*MeV/ cm^2/sec)

AIR RESPONSE : flux-to-exposure conversion factor (mR/hr)/(photons*MeV/ cm^2/sec)

42 - MO MAT=1420 A= 95.94

E (MEV) UNIT ¥	TOT (A)	PHOTO ELECTRIC (A)	PAIR CREATION (A)	K-SHELL ABSORP (A)	MASS E ABSORP. (A)	TISSUE RESPONSE (B)	AIR RESPONSE (C)
0.01	8.358E+1	8.342E+1			8.062E+1	3.961E-1	3.055E-1
0.015	2.716E+1	2.700E+1			2.624E+1	1.301E-1	8.559E-2
0.019999	1.216E+1	1.200E+1			1.183E+1	5.906E-2	3.460E-2
0.02	7.862E+1	7.846E+1		6.647E+1	7.749E+1	5.906E-2	3.460E-2
0.02	7.862E+1	7.846E+1		6.647E+1	7.749E+1	5.906E-2	3.460E-2
0.03	2.759E+1	2.743E+1		2.366E+1	1.679E+1	1.940E-2	9.882E-3
0.04	1.261E+1	1.246E+1		1.082E+1	8.823E+0	9.032E-3	4.407E-3
0.05	6.812E+0	6.666E+0		5.807E+0	5.106E+0	5.808E-3	2.654E-3
0.06	4.110E+0	3.966E+0		3.464E+0	3.194E+0	4.409E-3	1.978E-3
0.08	1.864E+0	1.728E+0		1.513E+0	1.487E+0	3.259E-3	1.575E-3
0.1	1.031E+0	9.007E-1		7.896E-1	8.114E-1	2.826E-3	1.526E-3
0.15	3.902E-1	2.732E-1		2.399E-1	2.716E-1	2.529E-3	1.642E-3
0.2	2.246E-1	1.175E-1		1.033E-1	1.327E-1	2.506E-3	1.759E-3
0.3	1.298E-1	3.665E-2		3.221E-2	5.987E-2	2.529E-3	1.891E-3
0.4	1.001E-1	1.661E-2		1.460E-2	4.154E-2	2.462E-3	1.941E-3
0.5	8.553E-2	9.265E-3		8.147E-3	3.468E-2	2.340E-3	1.953E-3
0.6	7.638E-2	5.891E-3		5.180E-3	3.125E-2	2.263E-3	1.944E-3
0.8	6.497E-2	3.030E-3		2.666E-3	2.775E-2	2.103E-3	1.897E-3
1	5.757E-2	1.888E-3		1.661E-3	2.573E-2	1.979E-3	1.835E-3
1.022	5.688E-2	1.796E-3			2.555E-2	1.967E-3	1.826E-3
1.25	5.112E-2	1.213E-3	1.340E-4		2.396E-2	1.856E-3	1.745E-3
1.5	4.674E-2	8.700E-4	6.371E-4		2.261E-2	1.757E-3	1.676E-3
2	4.138E-2	5.318E-4	2.261E-3		2.112E-2	1.604E-3	1.542E-3
2.044	4.104E-2	5.132E-4	2.422E-3		2.108E-2	1.592E-3	1.531E-3
3	3.660E-2	2.842E-4	5.977E-3		2.038E-2	1.397E-3	1.352E-3
4	3.485E-2	1.894E-4	9.358E-3		2.073E-2	1.258E-3	1.228E-3
5	3.430E-2	1.406E-4	1.232E-2		2.140E-2	1.160E-3	1.144E-3
6	3.433E-2	1.114E-4	1.491E-2		2.214E-2	1.093E-3	1.082E-3
7	3.467E-2	9.189E-5	1.723E-2		2.294E-2	1.042E-3	1.038E-3
8	3.518E-2	7.815E-5	1.931E-2		2.366E-2	1.004E-3	1.001E-3
9	3.579E-2	6.792E-5	2.121E-2		2.431E-2	9.746E-4	9.750E-4
10	3.645E-2	6.000E-5	2.295E-2		2.490E-2	9.515E-4	9.520E-4
11	3.712E-2	5.372E-5	2.454E-2		2.535E-2	9.330E-4	9.368E-4
12	3.781E-2	4.862E-5	2.600E-2		2.578E-2	9.180E-4	9.230E-4
13	3.847E-2	4.439E-5	2.736E-2		2.617E-2	9.057E-4	9.098E-4
14	3.912E-2	4.083E-5	2.860E-2		2.654E-2	8.957E-4	8.987E-4
15	3.973E-2	3.780E-5	2.975E-2		2.689E-2	8.867E-4	8.881E-4

¥ UNIT (A) : CM**2 / G
(B) : (MREM/HR) / (PHOTONS*MEV/CM**2/SEC)
(C) : (MR/HR) / (PHOTONS*MEV/CM**2/SEC)

50 - SN MAT=1500 A=118.69

E (MEV) UNIT ¥	TOT (A)	PHOTO ELECTRIC (A)	PAIR CREATION (A)	K-SHELL ABSORP (A)	MASS E ABSORP. (A)	TISSUE RESPONSE (B)	AIR RESPONSE (C)
0.01	1.359E+2	1.357E+2			1.293E+2	3.961E-1	3.055E-1
0.015	4.499E+1	4.483E+1			4.313E+1	1.301E-1	8.559E-2
0.02	2.030E+1	2.015E+1			1.946E+1	5.906E-2	3.460E-2
0.0292	7.094E+0	6.941E+0			6.860E+0	2.089E-2	1.074E-2
0.0292	4.292E+1	4.277E+1		3.583E+1	1.567E+1	2.089E-2	1.074E-2
0.03	4.058E+1	4.043E+1		3.399E+1	1.516E+1	1.940E-2	9.882E-3
0.04	1.902E+1	1.887E+1		1.603E+1	9.989E+0	9.032E-3	4.407E-3
0.05	1.041E+1	1.027E+1		8.778E+0	6.410E+0	5.808E-3	2.654E-3
0.06	6.355E+0	6.215E+0		5.333E+0	4.264E+0	4.409E-3	1.978E-3
0.08	2.901E+0	2.770E+0		2.388E+0	2.124E+0	3.259E-3	1.575E-3
0.1	1.592E+0	1.467E+0		1.267E+0	1.200E+0	2.826E-3	1.526E-3
0.15	5.690E-1	4.564E-1		3.953E-1	4.170E-1	2.529E-3	1.642E-3
0.2	3.026E-1	1.996E-1		1.730E-1	2.015E-1	2.506E-3	1.759E-3
0.3	1.532E-1	6.352E-2		5.515E-2	8.292E-2	2.529E-3	1.891E-3
0.4	1.095E-1	2.915E-2		2.531E-2	5.209E-2	2.462E-3	1.941E-3
0.5	8.976E-2	1.639E-2		1.424E-2	4.028E-2	2.340E-3	1.953E-3
0.6	7.831E-2	1.048E-2		9.107E-3	3.455E-2	2.263E-3	1.944E-3
0.8	6.503E-2	5.419E-3		4.709E-3	2.900E-2	2.103E-3	1.897E-3
1	5.696E-2	3.381E-3		2.941E-3	2.611E-2	1.979E-3	1.835E-3
1.022	5.624E-2	3.218E-3			2.589E-2	1.967E-3	1.826E-3
1.25	5.024E-2	2.170E-3	1.721E-4		2.395E-2	1.856E-3	1.745E-3
1.5	4.588E-2	1.555E-3	7.996E-4		2.232E-2	1.757E-3	1.676E-3
2	4.081E-2	9.468E-4	2.734E-3		2.079E-2	1.604E-3	1.542E-3
2.044	4.051E-2	9.138E-4	2.923E-3		2.077E-2	1.592E-3	1.531E-3
3	3.670E-2	5.032E-4	6.997E-3		2.035E-2	1.397E-3	1.352E-3
4	3.550E-2	3.338E-4	1.081E-2		2.102E-2	1.258E-3	1.228E-3
5	3.539E-2	2.471E-4	1.412E-2		2.195E-2	1.160E-3	1.144E-3
6	3.576E-2	1.951E-4	1.699E-2		2.288E-2	1.093E-3	1.082E-3
7	3.640E-2	1.608E-4	1.955E-2		2.383E-2	1.042E-3	1.038E-3
8	3.718E-2	1.365E-4	2.185E-2		2.469E-2	1.004E-3	1.001E-3
9	3.803E-2	1.185E-4	2.394E-2		2.542E-2	9.746E-4	9.750E-4
10	3.890E-2	1.046E-4	2.587E-2		2.610E-2	9.515E-4	9.520E-4
11	3.979E-2	9.351E-5	2.764E-2		2.661E-2	9.330E-4	9.368E-4
12	4.066E-2	8.458E-5	2.927E-2		2.709E-2	9.180E-4	9.230E-4
13	4.152E-2	7.717E-5	3.079E-2		2.753E-2	9.057E-4	9.098E-4
14	4.234E-2	7.093E-5	3.219E-2		2.795E-2	8.957E-4	8.987E-4
15	4.312E-2	6.565E-5	3.348E-2		2.835E-2	8.867E-4	8.881E-4

¥ UNIT (A) : CM**2 / G
(B) : (MREM/HR) / (PHOTONS*MEV/CM**2/SEC)
(C) : (MR/HR) / (PHOTONS*MEV/CM**2/SEC)

57 - LA MAT=1570 A=138.91

E (MEV) UNIT ¥	TOT (A)	PHOTO ELECTRIC (A)	PAIR CREATION (A)	K-SHELL ABSORP (A)	MASS E ABSORP. (A)	TISSUE RESPONSE (B)	AIR RESPONSE (C)
0.01	1.939E+2	1.937E+2			1.834E+2	3.961E-1	3.055E-1
0.015	6.545E+1	6.529E+1			6.279E+1	1.301E-1	8.559E-2
0.02	2.985E+1	2.970E+1			2.862E+1	5.906E-2	3.460E-2
0.03	9.763E+0	9.616E+0			9.304E+0	1.940E-2	9.882E-3
0.038924	4.761E+0	4.617E+0			4.588E+0	9.711E-3	4.758E-3
0.038925	2.722E+1	2.707E+1		2.245E+1	9.342E+0	9.711E-3	4.758E-3
0.04	2.530E+1	2.515E+1		2.088E+1	9.212E+0	9.032E-3	4.407E-3
0.05	1.413E+1	1.399E+1		1.172E+1	6.789E+0	5.808E-3	2.654E-3
0.06	8.706E+0	8.571E+0		7.223E+0	4.947E+0	4.409E-3	1.978E-3
0.08	4.021E+0	3.894E+0		3.302E+0	2.658E+0	3.259E-3	1.575E-3
0.1	2.211E+0	2.090E+0		1.779E+0	1.560E+0	2.826E-3	1.526E-3
0.15	7.747E-1	6.650E-1		5.684E-1	5.673E-1	2.529E-3	1.642E-3
0.2	3.952E-1	2.947E-1		2.523E-1	2.752E-1	2.506E-3	1.759E-3
0.3	1.829E-1	9.551E-2		8.185E-2	1.096E-1	2.529E-3	1.891E-3
0.4	1.226E-1	4.431E-2		3.801E-2	6.442E-2	2.462E-3	1.941E-3
0.5	9.654E-2	2.510E-2		2.154E-2	4.713E-2	2.340E-3	1.953E-3
0.6	8.223E-2	1.612E-2		1.384E-2	3.843E-2	2.263E-3	1.944E-3
0.8	6.643E-2	8.376E-3		7.201E-3	3.037E-2	2.103E-3	1.897E-3
1	5.743E-2	5.237E-3		4.504E-3	2.637E-2	1.979E-3	1.835E-3
1.022	5.664E-2	5.007E-3			2.611E-2	1.967E-3	1.826E-3
1.25	5.024E-2	3.378E-3	2.094E-4		2.387E-2	1.856E-3	1.745E-3
1.5	4.578E-2	2.416E-3	9.677E-4		2.200E-2	1.757E-3	1.676E-3
2	4.084E-2	1.468E-3	3.204E-3		1.997E-2	1.604E-3	1.542E-3
2.044	4.056E-2	1.416E-3	3.419E-3		1.993E-2	1.592E-3	1.531E-3
3	3.716E-2	7.769E-4	7.948E-3		1.924E-2	1.397E-3	1.352E-3
4	3.633E-2	5.133E-4	1.210E-2		1.974E-2	1.258E-3	1.228E-3
5	3.654E-2	3.791E-4	1.568E-2		2.041E-2	1.160E-3	1.144E-3
6	3.717E-2	2.988E-4	1.878E-2		2.103E-2	1.093E-3	1.082E-3
7	3.803E-2	2.459E-4	2.153E-2		2.158E-2	1.042E-3	1.038E-3
8	3.901E-2	2.084E-4	2.400E-2		2.207E-2	1.004E-3	1.001E-3
9	4.003E-2	1.807E-4	2.625E-2		2.242E-2	9.746E-4	9.750E-4
10	4.107E-2	1.594E-4	2.831E-2		2.274E-2	9.515E-4	9.520E-4
11	4.211E-2	1.425E-4	3.022E-2		2.289E-2	9.330E-4	9.368E-4
12	4.313E-2	1.288E-4	3.199E-2		2.303E-2	9.180E-4	9.230E-4
13	4.413E-2	1.174E-4	3.363E-2		2.315E-2	9.057E-4	9.098E-4
14	4.508E-2	1.079E-4	3.516E-2		2.327E-2	8.957E-4	8.987E-4
15	4.599E-2	9.980E-5	3.657E-2		2.338E-2	8.867E-4	8.881E-4

¥ UNIT
(A) : CM**2 / G
(B) : (MREM/HR) / (PHOTONS*MEV/CM**2/SEC)
(C) : (MR/HR) / (PHOTONS*MEV/CM**2/SEC)

64 - GD MAT=1640 A=157.25

E (MEV) UNIT ¥	TOT (A)	PHOTO ELECTRIC (A)	PAIR CREATION (A)	K-SHELL ABSORP (A)	MASS E ABSORP. (A)	TISSUE RESPONSE (B)	AIR RESPONSE (C)
0.01	2.659E+2	2.657E+2			2.473E+2	3.961E-1	3.055E-1
0.015	9.115E+1	9.099E+1			8.571E+1	1.301E-1	8.559E-2
0.02	4.205E+1	4.190E+1			3.976E+1	5.906E-2	3.460E-2
0.03	1.393E+1	1.378E+1			1.321E+1	1.940E-2	9.882E-3
0.04	6.334E+0	6.192E+0			5.964E+0	9.032E-3	4.407E-3
0.05	3.449E+0	3.311E+0			3.205E+0	5.808E-3	2.654E-3
0.050239	3.405E+0	3.267E+0			3.162E+0	5.766E-3	2.634E-3
0.05024	1.823E+1	1.809E+1		1.482E+1	5.707E+0	5.766E-3	2.634E-3
0.06	1.145E+1	1.131E+1		9.333E+0	4.917E+0	4.409E-3	1.978E-3
0.08	5.385E+0	5.258E+0		4.381E+0	3.054E+0	3.259E-3	1.575E-3
0.1	2.983E+0	2.862E+0		2.397E+0	1.906E+0	2.826E-3	1.526E-3
0.15	1.040E+0	9.310E-1		7.847E-1	7.288E-1	2.529E-3	1.642E-3
0.2	5.182E-1	4.186E-1		3.534E-1	3.598E-1	2.506E-3	1.759E-3
0.3	2.246E-1	1.380E-1		1.168E-1	1.409E-1	2.529E-3	1.891E-3
0.4	1.424E-1	6.476E-2		5.488E-2	8.027E-2	2.462E-3	1.941E-3
0.5	1.078E-1	3.694E-2		3.134E-2	5.641E-2	2.340E-3	1.953E-3
0.6	8.941E-2	2.384E-2		2.024E-2	4.480E-2	2.263E-3	1.944E-3
0.8	7.005E-2	1.245E-2		1.059E-2	3.406E-2	2.103E-3	1.897E-3
1	5.958E-2	7.801E-3		6.641E-3	2.908E-2	1.979E-3	1.835E-3
1.022	5.867E-2	7.464E-3			2.870E-2	1.967E-3	1.826E-3
1.25	5.155E-2	5.032E-3	2.538E-4		2.553E-2	1.856E-3	1.745E-3
1.5	4.682E-2	3.594E-3	1.173E-3		2.345E-2	1.757E-3	1.676E-3
2	4.183E-2	2.181E-3	3.774E-3		2.152E-2	1.604E-3	1.542E-3
2.044	4.155E-2	2.103E-3	4.017E-3		2.141E-2	1.592E-3	1.531E-3
3	3.841E-2	1.149E-3	9.052E-3		2.155E-2	1.397E-3	1.352E-3
4	3.786E-2	7.575E-4	1.358E-2		2.300E-2	1.258E-3	1.228E-3
5	3.832E-2	5.580E-4	1.745E-2		2.478E-2	1.160E-3	1.144E-3
6	3.919E-2	4.389E-4	2.080E-2		2.606E-2	1.093E-3	1.082E-3
7	4.025E-2	3.606E-4	2.376E-2		2.750E-2	1.042E-3	1.038E-3
8	4.140E-2	3.054E-4	2.642E-2		2.902E-2	1.004E-3	1.001E-3
9	4.259E-2	2.645E-4	2.884E-2		3.066E-2	9.746E-4	9.750E-4
10	4.379E-2	2.331E-4	3.106E-2		3.220E-2	9.515E-4	9.520E-4
11	4.497E-2	2.083E-4	3.311E-2		3.327E-2	9.330E-4	9.368E-4
12	4.613E-2	1.881E-4	3.501E-2		3.428E-2	9.180E-4	9.230E-4
13	4.726E-2	1.715E-4	3.680E-2		3.528E-2	9.057E-4	9.098E-4
14	4.834E-2	1.575E-4	3.845E-2		3.627E-2	8.957E-4	8.987E-4
15	4.939E-2	1.456E-4	4.000E-2		3.722E-2	8.867E-4	8.881E-4

¥ UNIT (A) : CM**2 / G
(B) : (MREM/HR) / (PHOTONS*MEV/CM**2/SEC)
(C) : (MR/HR) / (PHOTONS*MEV/CM**2/SEC)

74 - W MAT=1740 A=183.85

E (MEV) UNIT ¥	TOT (A)	PHOTO ELECTRIC (A)	PAIR CREATION (A)	K-SHELL ABSORP (A)	MASS E ABSORP. (A)	TISSUE RESPONSE (B)	AIR RESPONSE (C)
0.01	9.256E+1	9.240E+1			9.242E+1	3.961E-1	3.055E-1
0.010206	8.774E+1	8.759E+1			8.906E+1	3.741E-1	2.862E-1
0.010207	2.291E+2	2.290E+2			2.020E+2	3.741E-1	2.862E-1
0.011543	1.651E+2	1.650E+2			1.459E+2	2.673E-1	1.949E-1
0.011544	2.274E+2	2.273E+2			1.951E+2	2.673E-1	1.949E-1
0.012099	2.029E+2	2.028E+2			1.728E+2	2.347E-1	1.680E-1
0.0121	2.346E+2	2.344E+2			1.966E+2	2.347E-1	1.680E-1
0.015	1.361E+2	1.359E+2			1.177E+2	1.301E-1	8.559E-2
0.02	6.376E+1	6.361E+1			5.732E+1	5.906E-2	3.460E-2
0.03	2.158E+1	2.144E+1			1.998E+1	1.940E-2	9.882E-3
0.04	9.921E+0	9.781E+0			9.289E+0	9.032E-3	4.407E-3
0.05	5.426E+0	5.290E+0			5.100E+0	5.808E-3	2.654E-3
0.06	3.323E+0	3.191E+0			3.095E+0	4.409E-3	1.978E-3
0.06952	2.246E+0	2.118E+0			2.080E+0	3.777E-3	1.760E-3
0.06952	1.093E+1	1.080E+1		8.680E+0	3.619E+0	3.777E-3	1.760E-3
0.08	7.567E+0	7.442E+0		6.011E+0	3.164E+0	3.259E-3	1.575E-3
0.1	4.273E+0	4.153E+0		3.387E+0	2.254E+0	2.826E-3	1.526E-3
0.15	1.503E+0	1.395E+0		1.148E+0	9.833E-1	2.529E-3	1.642E-3
0.2	7.382E-1	6.397E-1		5.287E-1	5.133E-1	2.506E-3	1.759E-3
0.3	3.023E-1	2.166E-1		1.796E-1	2.056E-1	2.529E-3	1.891E-3
0.4	1.800E-1	1.033E-1		8.585E-2	1.146E-1	2.462E-3	1.941E-3
0.5	1.297E-1	5.961E-2		4.962E-2	7.722E-2	2.340E-3	1.953E-3
0.6	1.036E-1	3.875E-2		3.231E-2	5.882E-2	2.263E-3	1.944E-3
0.8	7.738E-2	2.042E-2		1.706E-2	4.151E-2	2.103E-3	1.897E-3
1	6.403E-2	1.283E-2		1.074E-2	3.360E-2	1.979E-3	1.835E-3
1.022	6.292E-2	1.228E-2			3.309E-2	1.967E-3	1.826E-3
1.25	5.436E-2	8.281E-3	3.227E-4		2.873E-2	1.856E-3	1.745E-3
1.5	4.902E-2	5.906E-3	1.510E-3		2.528E-2	1.757E-3	1.676E-3
2	4.373E-2	3.574E-3	4.684E-3		2.286E-2	1.604E-3	1.542E-3
2.044	4.347E-2	3.449E-3	4.969E-3		2.284E-2	1.592E-3	1.531E-3
3	4.045E-2	1.875E-3	1.068E-2		2.253E-2	1.397E-3	1.352E-3
4	4.018E-2	1.231E-3	1.569E-2		2.368E-2	1.258E-3	1.228E-3
5	4.090E-2	9.044E-4	1.991E-2		2.503E-2	1.160E-3	1.144E-3
6	4.200E-2	7.098E-4	2.354E-2		2.631E-2	1.093E-3	1.082E-3
7	4.328E-2	5.821E-4	2.675E-2		2.748E-2	1.042E-3	1.038E-3
8	4.464E-2	4.923E-4	2.963E-2		2.853E-2	1.004E-3	1.001E-3
9	4.603E-2	4.258E-4	3.226E-2		2.940E-2	9.746E-4	9.750E-4
10	4.741E-2	3.747E-4	3.467E-2		3.021E-2	9.515E-4	9.520E-4
11	4.876E-2	3.344E-4	3.690E-2		3.078E-2	9.330E-4	9.368E-4
12	5.011E-2	3.019E-4	3.900E-2		3.131E-2	9.180E-4	9.230E-4
13	5.138E-2	2.750E-4	4.093E-2		3.181E-2	9.057E-4	9.098E-4
14	5.264E-2	2.524E-4	4.276E-2		3.228E-2	8.957E-4	8.987E-4
15	5.380E-2	2.332E-4	4.442E-2		3.272E-2	8.867E-4	8.881E-4

¥ UNIT (A) : CM**2 / G
(B) : (MREM/HR) / (PHOTONS*MEV/CM**2/SEC)
(C) : (MR/HR) / (PHOTONS*MEV/CM**2/SEC)

82 - PB MAT=1820 A=207.20

E (MEV) UNIT Y	TOT (A)	PHOTO ELECTRIC (A)	PAIR CREATION (A)	K-SHELL ABSORP (A)	MASS E ABSORP. (A)	TISSUE RESPONSE (B)	AIR RESPONSE (C)
0.01	1.258E+2	1.256E+2			1.256E+2	3.961E-1	3.055E-1
0.013035	6.325E+1	6.310E+1			6.368E+1	1.913E-1	1.330E-1
0.013036	1.583E+2	1.582E+2			1.285E+2	1.913E-1	1.330E-1
0.015	1.084E+2	1.082E+2			8.939E+1	1.301E-1	8.559E-2
0.015199	1.046E+2	1.045E+2			8.733E+1	1.255E-1	8.211E-2
0.0152	1.454E+2	1.452E+2			1.156E+2	1.255E-1	8.211E-2
0.01586	1.313E+2	1.312E+2			1.054E+2	1.116E-1	7.181E-2
0.01586	1.518E+2	1.517E+2			1.202E+2	1.116E-1	7.181E-2
0.02	8.411E+1	8.397E+1			6.923E+1	5.906E-2	3.460E-2
0.03	2.900E+1	2.886E+1			2.550E+1	1.940E-2	9.882E-3
0.04	1.349E+1	1.335E+1			1.221E+1	9.032E-3	4.407E-3
0.05	7.426E+0	7.292E+0			6.796E+0	5.808E-3	2.654E-3
0.06	4.562E+0	4.432E+0			4.177E+0	4.409E-3	1.978E-3
0.08	2.136E+0	2.012E+0			1.936E+0	3.259E-3	1.575E-3
0.088	1.668E+0	1.547E+0			1.508E+0	3.066E-3	1.554E-3
0.088	7.442E+0	7.321E+0		5.772E+0	2.495E+0	3.066E-3	1.554E-3
0.1	5.355E+0	5.237E+0		4.150E+0	2.229E+0	2.826E-3	1.526E-3
0.15	1.920E+0	1.815E+0		1.459E+0	1.135E+0	2.529E-3	1.642E-3
0.2	9.432E-1	8.463E-1		6.842E-1	6.229E-1	2.506E-3	1.759E-3
0.3	3.772E-1	2.930E-1		2.381E-1	2.581E-1	2.529E-3	1.891E-3
0.4	2.172E-1	1.417E-1		1.156E-1	1.439E-1	2.462E-3	1.941E-3
0.5	1.515E-1	8.257E-2		6.752E-2	9.564E-2	2.340E-3	1.953E-3
0.6	1.178E-1	5.406E-2		4.429E-2	7.132E-2	2.263E-3	1.944E-3
0.8	8.472E-2	2.871E-2		2.359E-2	4.838E-2	2.103E-3	1.897E-3
1	6.843E-2	1.810E-2		1.490E-2	3.787E-2	1.979E-3	1.835E-3
1.022	6.713E-2	1.732E-2			3.720E-2	1.967E-3	1.826E-3
1.25	5.705E-2	1.168E-2	3.781E-4		3.153E-2	1.856E-3	1.745E-3
1.5	5.102E-2	8.321E-3	1.806E-3		2.714E-2	1.757E-3	1.676E-3
2	4.536E-2	5.034E-3	5.449E-3		2.407E-2	1.604E-3	1.542E-3
2.044	4.506E-2	4.854E-3	5.769E-3		2.404E-2	1.592E-3	1.531E-3
3	4.199E-2	2.631E-3	1.193E-2		2.351E-2	1.397E-3	1.352E-3
4	4.176E-2	1.723E-3	1.716E-2		2.463E-2	1.258E-3	1.228E-3
5	4.256E-2	1.263E-3	2.155E-2		2.600E-2	1.160E-3	1.144E-3
6	4.379E-2	9.893E-4	2.535E-2		2.730E-2	1.093E-3	1.082E-3
7	4.518E-2	8.103E-4	2.869E-2		2.845E-2	1.042E-3	1.038E-3
8	4.666E-2	6.845E-4	3.171E-2		2.948E-2	1.004E-3	1.001E-3
9	4.815E-2	5.915E-4	3.445E-2		3.034E-2	9.746E-4	9.750E-4
10	4.965E-2	5.202E-4	3.698E-2		3.114E-2	9.515E-4	9.520E-4
11	5.111E-2	4.642E-4	3.931E-2		3.169E-2	9.330E-4	9.368E-4
12	5.254E-2	4.185E-4	4.149E-2		3.219E-2	9.180E-4	9.230E-4
13	5.392E-2	3.810E-4	4.353E-2		3.267E-2	9.057E-4	9.098E-4
14	5.527E-2	3.496E-4	4.545E-2		3.311E-2	8.957E-4	8.987E-4
15	5.653E-2	3.229E-4	4.722E-2		3.353E-2	8.867E-4	8.881E-4

Y UNIT (A) : CM**2 / G
(B) : (MREM/HR) / (PHOTONS*MEV/CM**2/SEC)
(C) : (MR/HR) / (PHOTONS*MEV/CM**2/SEC)

92 - U MAT=1920 A=238.05

E (MEV) UNIT ¥	TOT (A)	PHOTO ELECTRIC (A)	PAIR CREATION (A)	K-SHELL ABSORP (A)	MASS E ABSORP. (A)	TISSUE RESPONSE (B)	AIR RESPONSE (C)
0.01	1.737E+2	1.735E+2			1.735E+2	3.961E-1	3.055E-1
0.015	6.162E+1	6.147E+1			6.148E+1	1.301E-1	8.559E-2
0.017166	4.348E+1	4.333E+1			4.377E+1	8.984E-2	5.598E-2
0.017167	1.038E+2	1.037E+2			8.100E+1	8.984E-2	5.598E-2
0.02	6.845E+1	6.830E+1			5.586E+1	5.906E-2	3.460E-2
0.020947	6.053E+1	6.038E+1			4.977E+1	5.201E-2	2.999E-2
0.020948	8.590E+1	8.576E+1			6.645E+1	5.201E-2	2.999E-2
0.021757	7.788E+1	7.774E+1			6.108E+1	4.687E-2	2.667E-2
0.021758	8.985E+1	8.970E+1			6.919E+1	4.687E-2	2.667E-2
0.03	3.975E+1	3.962E+1			3.293E+1	1.940E-2	9.882E-3
0.04	1.881E+1	1.868E+1			1.632E+1	9.032E-3	4.407E-3
0.05	1.048E+1	1.035E+1			9.303E+0	5.808E-3	2.654E-3
0.06	6.489E+0	6.362E+0			5.830E+0	4.409E-3	1.978E-3
0.08	3.057E+0	2.937E+0			2.767E+0	3.259E-3	1.575E-3
0.1	1.722E+0	1.607E+0			1.541E+0	2.826E-3	1.526E-3
0.1156	1.196E+0	1.086E+0			1.055E+0	2.716E-3	1.567E-3
0.1156	4.712E+0	4.602E+0		3.516E+0	1.645E+0	2.716E-3	1.567E-3
0.15	2.476E+0	2.373E+0		1.836E+0	1.218E+0	2.529E-3	1.642E-3
0.2	1.230E+0	1.136E+0		8.872E-1	7.352E-1	2.506E-3	1.759E-3
0.3	4.873E-1	4.050E-1		3.190E-1	3.250E-1	2.529E-3	1.891E-3
0.4	2.735E-1	1.998E-1		1.583E-1	1.847E-1	2.462E-3	1.941E-3
0.5	1.854E-1	1.181E-1		9.388E-2	1.226E-1	2.340E-3	1.953E-3
0.6	1.403E-1	7.807E-2		6.226E-2	9.025E-2	2.263E-3	1.944E-3
0.8	9.661E-2	4.192E-2		3.357E-2	5.917E-2	2.103E-3	1.897E-3
1	7.569E-2	2.654E-2		2.133E-2	4.473E-2	1.979E-3	1.835E-3
1.022	7.405E-2	2.542E-2			4.380E-2	1.967E-3	1.826E-3
1.25	6.157E-2	1.718E-2	4.455E-4		3.605E-2	1.856E-3	1.745E-3
1.5	5.436E-2	1.222E-2	2.199E-3		3.022E-2	1.757E-3	1.676E-3
2	4.790E-2	7.379E-3	6.441E-3		2.612E-2	1.604E-3	1.542E-3
2.044	4.756E-2	7.114E-3	6.800E-3		2.605E-2	1.592E-3	1.531E-3
3	4.404E-2	3.845E-3	1.340E-2		2.493E-2	1.397E-3	1.352E-3
4	4.365E-2	2.509E-3	1.881E-2		2.585E-2	1.258E-3	1.228E-3
5	4.445E-2	1.834E-3	2.333E-2		2.711E-2	1.160E-3	1.144E-3
6	4.569E-2	1.435E-3	2.721E-2		2.835E-2	1.093E-3	1.082E-3
7	4.715E-2	1.173E-3	3.066E-2		2.940E-2	1.042E-3	1.038E-3
8	4.869E-2	9.894E-4	3.376E-2		3.034E-2	1.004E-3	1.001E-3
9	5.030E-2	8.543E-4	3.663E-2		3.115E-2	9.746E-4	9.750E-4
10	5.187E-2	7.508E-4	3.925E-2		3.190E-2	9.515E-4	9.520E-4
11	5.345E-2	6.691E-4	4.171E-2		3.238E-2	9.330E-4	9.368E-4
12	5.495E-2	6.031E-4	4.397E-2		3.282E-2	9.180E-4	9.230E-4
13	5.642E-2	5.487E-4	4.610E-2		3.324E-2	9.057E-4	9.098E-4
14	5.785E-2	5.032E-4	4.810E-2		3.362E-2	8.957E-4	8.987E-4
15	5.921E-2	4.647E-4	4.997E-2		3.399E-2	8.867E-4	8.881E-4

¥ UNIT (A) : CM**2 / G
(B) : (MREM/HR) / (PHOTONS*MEV/CM**2/SEC)
(C) : (MR/HR) / (PHOTONS*MEV/CM**2/SEC)

Appendix C

Buildup Factor Data of Material from Molybdenum to Uranium

(1) Absorbed dose buildup factors in 45-mfp thick molybdenum
(2) Exposure buildup factors in 45-mfp thick molybdenum
(3) Absorbed dose buildup factors in 45-mfp thick tin
(4) Exposure buildup factors in 45-mfp thick tin
(5) Absorbed dose buildup factors in 45-mfp thick lanthanum
(6) Exposure buildup factors in 45-mfp thick lanthanum
(7) Absorbed dose buildup factors in 45-mfp thick gadolinium
(8) Exposure buildup factors in 45-mfp thick gadolinium
(9) Absorbed dose buildup factors in 45-mfp thick tungsten
(10) Exposure buildup factors in 45-mfp thick tungsten
(11) Absorbed dose buildup factors in 45-mfp thick lead
(12) Exposure buildup factors in 45-mfp thick lead
(13) Absorbed dose buildup factors in 45-mfp thick uranium
(14) Exposure buildup factors in 45-mfp thick uranium

(1) ABSORBED DOSE BUILDUP FACTORS IN 45-MFP THICK MOLYBDENUM

R(MFP)	ENERGY (MEV) 15	10	8	6	5	4	3	2	1.5	1	0.8	0.6	0.5
0.5	1.24	1.27	1.32	1.34	1.37	1.37	1.41	1.44	1.46	1.70	1.78	1.90	1.95
1.0	1.46	1.49	1.58	1.59	1.65	1.67	1.77	1.87	1.95	2.39	2.53	2.68	2.73
2.0	1.86	1.82	1.91	1.96	2.07	2.15	2.42	2.74	2.96	3.74	3.96	4.13	4.12
3.0	2.30	2.16	2.25	2.33	2.50	2.67	3.09	3.67	4.08	5.17	5.48	5.63	5.52
4.0	2.84	2.56	2.62	2.74	2.96	3.22	3.80	4.63	5.21	6.58	6.96	7.06	6.83
5.0	3.53	3.02	3.06	3.20	3.49	3.83	4.57	5.63	6.39	8.03	8.46	8.50	8.13
6.0	4.38	3.58	3.57	3.75	4.10	4.53	5.45	6.78	7.75	9.71	1.02E1	1.02E1	9.62
7.0	5.45	4.22	4.15	4.34	4.75	5.28	6.39	7.98	9.16	1.15E1	1.20E1	1.19E1	1.11E1
8.0	6.76	4.95	4.79	4.98	5.46	6.06	7.35	9.20	1.06E1	1.32E1	1.38E1	1.35E1	1.26E1
10.0	1.04E1	6.81	6.35	6.48	7.05	7.81	9.47	1.18E1	1.37E1	1.69E1	1.77E1	1.71E1	1.57E1
15.0	3.06E1	1.46E1	1.23E1	1.16E1	1.22E1	1.32E1	1.57E1	1.95E1	2.28E1	2.77E1	2.90E1	2.73E1	2.46E1
20.0	8.75E1	2.99E1	2.23E1	1.89E1	1.91E1	2.00E1	2.31E1	2.83E1	3.34E1	4.01E1	4.19E1	3.87E1	3.46E1
25.0	2.43E2	5.90E1	3.84E1	2.89E1	2.77E1	2.79E1	3.12E1	3.80E1	4.51E1	5.33E1	5.59E1	5.10E1	4.52E1
30.0	6.53E2	1.13E2	6.36E1	4.21E1	3.83E1	3.70E1	3.99E1	4.84E1	5.74E1	6.72E1	7.07E1	6.38E1	5.63E1
35.0	1.71E3	2.09E2	1.02E2	5.90E1	5.08E1	4.71E1	4.93E1	5.94E1	7.04E1	8.17E1	8.62E1	7.71E1	6.79E1
40.0	4.39E3	3.78E2	1.59E2	8.81E1	6.54E1	5.81E1	5.90E1	7.08E1	8.38E1	9.63E1	1.02E2	9.06E1	7.96E1

R(MFP)	ENERGY (MEV) 0.4	0.3	0.2	0.15	0.1	0.08	0.06	0.05	0.04	0.035	0.03	0.028	0.026
0.5	1.98	1.86	1.93	1.32	1.14	1.26	1.30	1.31	1.32	1.31	1.29	1.25	1.21
1.0	2.69	2.39	2.26	1.45	1.19	1.29	1.33	1.39	1.49	1.53	1.55	1.49	1.42
2.0	3.89	3.20	2.69	1.60	1.25	1.32	1.34	1.40	1.66	1.88	2.10	2.06	1.98
3.0	5.03	3.89	3.02	1.72	1.28	1.35	1.34	1.40	1.73	2.17	2.83	2.90	2.91
4.0	6.06	4.44	3.28	1.80	1.31	1.36	1.35	1.40	1.77	2.46	3.91	4.30	4.61
5.0	7.04	4.93	3.50	1.87	1.33	1.37	1.35	1.40	1.79	2.78	5.57	6.69	7.79
6.0	8.15	5.47	3.73	1.94	1.35	1.39	1.36	1.40	1.80	3.13	8.10	1.07E1	1.37E1
7.0	9.25	5.97	3.94	2.01	1.37	1.40	1.37	1.40	1.80	3.54	1.20E1	1.74E1	2.40E1
8.0	1.03E1	6.41	4.12	2.06	1.39	1.41	1.37	1.41	1.81	4.05	1.76E1	2.72E1	4.09E1
10.0	1.25E1	7.30	4.49	2.17	1.42	1.43	1.38	1.41	1.82	5.27	3.75E1	7.00E1	1.25E2
15.0	1.83E1	9.43	5.31	2.40	1.48	1.47	1.40	1.42	1.85	1.25E1	3.22E2	9.04E2	2.36E3
20.0	2.44E1	1.14E1	6.04	2.59	1.53	1.50	1.41	1.43	1.88	4.00E1	3.56E3	1.42E4	5.17E4
25.0	3.05E1	1.32E1	6.89	2.75	1.57	1.52	1.43	1.44	1.89	1.51E2	4.52E4	2.55E5	1.26E6
30.0	3.66E1	1.49E1	7.26	2.89	1.60	1.54	1.44	1.45	1.90	6.17E2	6.15E5	4.94E6	3.31E7
35.0	4.27E1	1.66E1	7.78	3.02	1.63	1.56	1.45	1.45	1.90	2.59E3	8.59E6	9.94E7	9.14E8
40.0	4.86E1	1.81E1	8.23	3.12	1.65	1.58	1.46	1.46	1.90	1.10E4	1.22E8	2.04E9	2.59E10

R(MFP)	ENERGY (MEV) 0.024	0.022	0.021	0.02	0.019	0.015
0.5	1.17	1.14	1.12	1.11	1.01	1.01
1.0	1.36	1.30	1.27	1.23	1.02	1.01
2.0	1.89	1.77	1.71	1.65	1.02	1.01
3.0	2.85	2.72	2.64	2.52	1.03	1.02
4.0	4.78	4.77	4.70	4.54	1.03	1.02
5.0	8.71	9.27	9.39	9.25	1.03	1.02
6.0	1.66E1	1.90E1	1.98E1	2.01E1	1.04	1.02
7.0	3.07E1	3.68E1	3.97E1	4.14E1	1.04	1.02
8.0	5.67E1	7.30E1	8.14E1	8.73E1	1.04	1.02
10.0	2.02E2	2.98E2	3.54E2	4.01E2	1.04	1.02
15.0	5.36E3	1.09E4	1.50E4	1.93E4	1.05	1.03
20.0	1.59E5	4.29E5	6.76E5	9.89E5	1.05	1.03
25.0	5.09E6	1.79E7	3.20E7	5.25E7	1.06	1.03
30.0	1.75E8	7.86E8	1.58E9	2.87E9	1.06	1.03
35.0	6.29E9	3.59E10	8.04E10	1.62E11	1.06	1.03
40.0	2.35E11	1.69E12	4.23E12	9.33E12	1.06	1.03

(2) EXPOSURE BUILDUP FACTORS IN 45-MFP THICK MOLYBDENUM

	ENERGY (MEV)												
R(MFP)	15	10	8	6	5	4	3	2	1.5	1	0.8	0.6	0.5
0.5	1.31	1.30	1.33	1.31	1.31	1.29	1.30	1.29	1.28	1.37	1.39	1.39	1.39
1.0	1.63	1.56	1.60	1.56	1.57	1.54	1.59	1.61	1.62	1.79	1.81	1.80	1.78
2.0	2.25	2.02	2.04	1.98	2.02	2.02	2.15	2.27	2.34	2.64	2.67	2.62	2.54
3.0	2.97	2.51	2.48	2.42	2.49	2.55	2.76	3.00	3.14	3.57	3.60	3.48	3.32
4.0	3.88	3.08	2.98	2.90	3.01	3.11	3.41	3.76	3.97	4.50	4.52	4.32	4.08
5.0	5.03	3.75	3.55	3.45	3.59	3.73	4.12	4.56	4.84	5.46	5.48	5.18	4.83
6.0	6.47	4.55	4.22	4.08	4.25	4.43	4.91	5.47	5.83	6.56	6.57	6.15	5.68
7.0	8.28	5.47	4.98	4.78	4.97	5.18	5.75	6.41	6.85	7.69	7.69	7.14	6.55
8.0	1.05E1	6.54	5.83	5.54	5.74	5.97	6.63	7.37	7.89	8.83	8.81	8.13	7.41
10.0	1.68E1	9.24	7.91	7.30	7.49	7.73	8.54	9.45	1.02E1	1.13E1	1.12E1	1.02E1	9.22
15.0	5.18E1	2.07E1	1.58E1	1.34E1	1.32E1	1.32E1	1.42E1	1.55E1	1.68E1	1.84E1	1.82E1	1.62E1	1.43E1
20.0	1.51E2	4.36E1	2.93E1	2.21E1	2.07E1	1.99E1	2.07E1	2.24E1	2.45E1	2.63E1	2.62E1	2.29E1	2.00E1
25.0	4.25E2	8.73E1	5.12E1	3.40E1	3.03E1	2.79E1	2.80E1	3.00E1	3.29E1	3.49E1	3.48E1	3.00E1	2.60E1
30.0	1.15E3	1.68E2	8.54E1	4.98E1	4.19E1	3.70E1	3.59E1	3.81E1	4.18E1	4.38E1	4.39E1	3.74E1	3.23E1
35.0	3.03E3	3.14E2	1.38E2	7.01E1	5.58E1	4.72E1	4.42E1	4.67E1	5.12E1	5.31E1	5.33E1	4.51E1	3.89E1
40.0	7.80E3	5.71E2	2.15E2	9.55E1	7.19E1	5.83E1	5.29E1	5.56E1	6.08E1	6.25E1	6.29E1	5.29E1	4.55E1

	ENERGY (MEV)											
R(MFP)	0.4	0.3	0.2	0.15	0.1	0.08	0.06	0.05	0.04	0.035	0.03	0.028	0.026
0.5	1.37	1.32	1.31	1.16	1.12	1.61	2.34	2.75	2.89	2.72	2.48	2.34	2.19
1.0	1.72	1.59	1.48	1.25	1.16	1.64	2.44	3.18	3.93	3.97	3.82	3.63	3.40
2.0	2.36	2.04	1.73	1.37	1.21	1.67	2.42	3.24	4.96	5.91	6.70	6.71	6.59
3.0	3.00	2.44	1.94	1.46	1.24	1.70	2.41	3.18	5.38	7.55	1.05E1	1.13E1	1.19E1
4.0	3.58	2.78	2.10	1.54	1.27	1.72	2.42	3.14	5.57	9.18	1.61E1	1.89E1	2.16E1
5.0	4.16	3.09	2.24	1.60	1.29	1.74	2.43	3.13	5.67	1.10E1	2.46E1	3.19E1	3.98E1
6.0	4.79	3.41	2.39	1.66	1.31	1.76	2.44	3.13	5.71	1.29E1	3.76E1	5.37E1	7.33E1
7.0	5.41	3.72	2.52	1.72	1.33	1.78	2.45	3.13	5.73	1.52E1	5.76E1	8.99E1	1.32E2
8.0	6.01	3.99	2.64	1.76	1.35	1.79	2.46	3.13	5.75	1.80E1	8.64E1	1.43E2	2.28E2
10.0	7.27	4.55	2.88	1.86	1.38	1.81	2.48	3.14	5.80	2.47E1	1.88E2	3.73E2	7.06E2
15.0	1.06E1	5.86	3.40	2.05	1.44	1.87	2.52	3.16	5.95	6.41E1	1.63E3	4.82E3	1.33E4
20.0	1.41E1	7.08	3.87	2.22	1.49	1.91	2.55	3.19	6.08	2.14E2	1.79E4	7.54E4	2.89E5
25.0	1.75E1	8.20	4.28	2.36	1.52	1.94	2.58	3.20	6.13	8.23E2	2.27E5	1.35E6	7.02E6
30.0	2.10E1	9.25	4.64	2.48	1.56	1.97	2.60	3.22	6.17	3.37E3	3.08E6	2.60E7	1.84E8
35.0	2.45E1	1.03E1	4.97	2.58	1.58	1.99	2.62	3.24	6.18	1.41E4	4.30E7	5.22E8	5.05E9
40.0	2.79E1	1.12E1	5.26	2.68	1.61	2.02	2.64	3.26	6.18	6.00E4	6.09E8	1.07E10	1.43E11

	ENERGY (MEV)					
R(MFP)	0.024	0.022	0.021	0.02	0.019	0.015
0.5	2.04	1.89	1.81	1.73	1.01	1.01
1.0	3.16	2.89	2.76	2.61	1.02	1.01
2.0	6.34	5.95	5.72	5.42	1.02	1.01
3.0	1.22E1	1.20E1	1.18E1	1.14E1	1.03	1.02
4.0	2.38E1	2.52E1	2.55E1	2.52E1	1.03	1.02
5.0	4.75E1	5.40E1	5.65E1	5.75E1	1.03	1.02
6.0	9.51E1	1.16E2	1.26E2	1.32E2	1.04	1.02
7.0	1.88E2	2.30E2	2.57E2	2.77E2	1.04	1.02
8.0	3.37E2	4.62E2	5.32E2	5.91E2	1.04	1.02
10.0	1.21E3	1.90E3	2.33E3	2.74E3	1.04	1.02
15.0	3.21E4	6.91E4	9.83E4	1.32E5	1.05	1.03
20.0	9.43E5	2.72E6	4.43E6	6.71E6	1.05	1.03
25.0	3.01E7	1.13E8	2.09E8	3.55E8	1.06	1.03
30.0	1.03E9	4.93E9	1.03E10	1.94E10	1.06	1.03
35.0	3.69E10	2.24E11	5.21E11	1.09E12	1.06	1.03
40.0	1.37E12	1.06E13	2.73E13	8.24E13	1.06	1.03

(3) ABSORBED DOSE BUILDUP FACTORS IN 45-MFP THICK TIN

	ENERGY (MEV)											
R(MFP)	15	10	8	6	5	4	3	2	1.5	1	0.8	0.6	0.5
0.5	1.25	1.29	1.33	1.36	1.39	1.39	1.43	1.46	1.47	1.68	1.74	1.81	1.81
1.0	1.48	1.50	1.57	1.60	1.65	1.67	1.78	1.88	1.93	2.28	2.37	2.42	2.39
2.0	1.91	1.84	1.92	1.95	2.05	2.11	2.37	2.68	2.87	3.42	3.52	3.49	3.35
3.0	2.40	2.21	2.27	2.31	2.46	2.60	3.01	3.55	3.87	4.58	4.69	4.54	4.26
4.0	3.05	2.66	2.66	2.72	2.92	3.14	3.69	4.43	4.87	5.70	5.78	5.49	5.06
5.0	3.91	3.20	3.13	3.19	3.44	3.74	4.43	5.36	5.92	6.83	6.88	6.42	5.83
6.0	5.03	3.86	3.70	3.75	4.05	4.43	5.29	6.43	7.11	8.12	8.13	7.47	6.70
7.0	6.48	4.65	4.35	4.37	4.73	5.18	6.20	7.53	8.34	9.43	9.39	8.50	7.54
8.0	8.37	5.59	5.10	5.05	5.46	5.97	7.14	8.66	9.57	1.07E1	1.06E1	9.49	8.34
10.0	1.41E1	8.07	6.98	6.70	7.17	7.77	9.25	1.11E1	1.22E1	1.34E1	1.32E1	1.16E1	1.00E1
15.0	5.14E1	1.98E1	1.48E1	1.27E1	1.30E1	1.36E1	1.56E1	1.82E1	1.99E1	2.11E1	2.03E1	1.71E1	1.44E1
20.0	1.84E2	4.70E1	2.99E1	2.22E1	2.14E1	2.12E1	2.32E1	2.63E1	2.88E1	2.93E1	2.80E1	2.28E1	1.88E1
25.0	6.35E2	1.08E2	5.76E1	3.65E1	3.29E1	3.07E1	3.18E1	3.52E1	3.84E1	3.78E1	3.58E1	2.85E1	2.31E1
30.0	2.12E3	2.40E2	1.07E2	5.73E1	4.79E1	4.21E1	4.14E1	4.48E1	4.84E1	4.64E1	4.36E1	3.41E1	2.74E1
35.0	6.93E3	5.20E2	1.93E2	8.65E1	6.71E1	5.54E1	5.18E1	5.50E1	5.89E1	5.52E1	5.16E1	3.96E1	3.16E1
40.0	2.20E4	1.10E3	3.38E2	1.27E2	9.10E1	7.06E1	6.28E1	6.55E1	6.95E1	6.39E1	5.95E1	4.51E1	3.56E1

	ENERGY (MEV)											
R(MFP)	0.4	0.3	0.2	0.15	0.1	0.09	0.08	0.07	0.06	0.055	0.05	0.045	0.04
0.5	1.78	1.60	1.46	1.34	1.30	1.32	1.35	1.37	1.38	1.38	1.38	1.37	1.36
1.0	2.27	1.92	1.62	1.43	1.32	1.35	1.40	1.48	1.56	1.61	1.64	1.68	1.70
2.0	3.02	2.36	1.81	1.52	1.36	1.37	1.41	1.51	1.70	1.86	2.05	2.28	2.50
3.0	3.70	2.72	1.96	1.59	1.38	1.39	1.42	1.50	1.73	1.99	2.37	2.95	3.68
4.0	4.26	2.98	2.06	1.64	1.40	1.41	1.43	1.50	1.74	2.07	2.69	3.83	5.59
5.0	4.79	3.21	2.15	1.68	1.42	1.42	1.44	1.50	1.74	2.13	3.03	5.04	8.81
6.0	5.36	3.46	2.25	1.72	1.44	1.44	1.45	1.51	1.74	2.17	3.39	6.68	1.42E1
7.0	5.90	3.68	2.33	1.75	1.45	1.45	1.46	1.51	1.73	2.21	3.81	9.05	2.30E1
8.0	6.41	3.87	2.40	1.78	1.46	1.46	1.47	1.52	1.73	2.26	4.34	1.21E1	3.63E1
10.0	7.43	4.25	2.54	1.84	1.49	1.47	1.48	1.53	1.72	2.35	5.63	2.24E1	9.22E1
15.0	9.95	5.10	2.84	1.97	1.53	1.51	1.51	1.54	1.72	2.64	1.29E1	1.30E2	1.17E3
20.0	1.23E1	5.83	3.10	2.07	1.56	1.53	1.53	1.56	1.71	2.92	3.94E1	1.01E3	1.83E4
25.0	1.45E1	6.46	3.31	2.16	1.58	1.55	1.54	1.57	1.71	3.27	1.39E2	9.03E3	3.24E5
30.0	1.66E1	7.03	3.50	2.23	1.60	1.57	1.55	1.58	1.72	3.76	5.28E2	8.44E4	6.17E6
35.0	1.86E1	7.57	3.67	2.29	1.62	1.58	1.57	1.59	1.72	4.45	2.06E3	8.03E5	1.21E8
40.0	2.04E1	8.06	3.81	2.35	1.63	1.59	1.58	1.60	1.73	5.45	8.19E3	7.73E6	2.42E9

	ENERGY (MEV)				
R(MFP)	0.035	0.03	0.029	0.02	0.015
0.5	1.36	1.35	1.02	1.01	1.00
1.0	1.74	1.75	1.03	1.01	1.01
2.0	2.79	3.00	1.04	1.02	1.01
3.0	4.65	5.57	1.05	1.02	1.01
4.0	8.26	1.13E1	1.05	1.02	1.01
5.0	1.54E1	2.42E1	1.06	1.02	1.01
6.0	2.94E1	5.29E1	1.08	1.02	1.01
7.0	5.36E1	1.08E2	1.06	1.02	1.01
8.0	9.73E1	2.23E2	1.07	1.03	1.01
10.0	3.32E2	9.70E2	1.07	1.03	1.01
15.0	8.00E3	4.06E4	1.08	1.03	1.02
20.0	2.19E5	1.83E6	1.09	1.03	1.02
25.0	6.62E6	8.71E7	1.09	1.04	1.02
30.0	2.14E8	4.32E9	1.10	1.04	1.02
35.0	7.27E9	2.22E11	1.10	1.04	1.02
40.0	2.54E11	1.18E13	1.11	1.04	1.02

(4) EXPOSURE BUILDUP FACTORS IN 45-MFP THICK TIN

	ENERGY (MEV)											
R(MFP)	15	10	8	6	5	4	3	2	1.5	1	0.8	0.6	0.5
0.5	1.32	1.31	1.33	1.31	1.31	1.28	1.29	1.27	1.26	1.33	1.34	1.33	1.32
1.0	1.65	1.57	1.60	1.54	1.55	1.51	1.56	1.57	1.57	1.69	1.69	1.66	1.62
2.0	2.34	2.05	2.04	1.94	1.97	1.96	2.07	2.17	2.21	2.40	2.37	2.26	2.16
3.0	3.20	2.61	2.51	2.38	2.43	2.45	2.64	2.82	2.90	3.14	3.08	2.87	2.68
4.0	4.33	3.27	3.05	2.87	2.94	3.00	3.25	3.51	3.61	3.86	3.76	3.44	3.16
5.0	5.85	4.09	3.69	3.43	3.52	3.60	3.92	4.23	4.36	4.60	4.45	4.01	3.63
6.0	7.82	5.07	4.45	4.09	4.19	4.29	4.68	5.04	5.19	5.43	5.22	4.63	4.14
7.0	1.04E1	6.26	5.34	4.83	4.93	5.04	5.48	5.88	6.04	6.27	6.00	5.25	4.64
8.0	1.38E1	7.69	6.36	5.66	5.74	5.84	6.32	6.74	6.92	7.11	6.76	5.85	5.13
10.0	2.41E1	1.15E1	8.94	7.63	7.63	7.65	8.19	8.61	8.80	8.88	8.37	7.10	6.13
15.0	9.24E1	2.96E1	1.97E1	1.49E1	1.41E1	1.35E1	1.38E1	1.40E1	1.42E1	1.38E1	1.28E1	1.04E1	8.75
20.0	3.37E2	7.21E1	4.08E1	2.64E1	2.35E1	2.11E1	2.05E1	2.01E1	2.04E1	1.91E1	1.75E1	1.38E1	1.14E1
25.0	1.17E3	1.68E2	7.97E1	4.39E1	3.62E1	3.06E1	2.81E1	2.69E1	2.71E1	2.45E1	2.23E1	1.72E1	1.40E1
30.0	3.95E3	3.77E2	1.50E2	6.93E1	5.30E1	4.21E1	3.66E1	3.42E1	3.41E1	3.00E1	2.71E1	2.05E1	1.65E1
35.0	1.29E4	8.21E2	2.71E2	1.05E2	7.44E1	5.54E1	4.57E1	4.19E1	4.13E1	3.56E1	3.20E1	2.38E1	1.90E1
40.0	4.12E4	1.74E3	4.77E2	1.54E2	1.01E2	7.06E1	5.54E1	4.98E1	4.88E1	4.11E1	3.68E1	2.71E1	2.14E1

	ENERGY (MEV)												
R(MFP)	0.4	0.3	0.2	0.15	0.1	0.09	0.08	0.07	0.06	0.055	0.05	0.045	0.04
0.5	1.29	1.23	1.17	1.16	1.35	1.50	1.73	1.98	2.31	2.40	2.47	2.41	2.31
1.0	1.54	1.41	1.27	1.22	1.38	1.54	1.83	2.25	2.93	3.22	3.51	3.59	3.57
2.0	1.97	1.69	1.40	1.29	1.41	1.55	1.83	2.31	3.40	4.13	5.07	5.86	6.54
3.0	2.36	1.91	1.51	1.35	1.43	1.57	1.83	2.28	3.50	4.59	6.34	8.42	1.09E1
4.0	2.71	2.10	1.59	1.39	1.45	1.59	1.84	2.27	3.50	4.87	7.56	1.18E1	1.79E1
5.0	3.04	2.26	1.66	1.43	1.47	1.61	1.86	2.27	3.50	5.08	8.86	1.63E1	2.98E1
6.0	3.39	2.43	1.73	1.46	1.49	1.62	1.87	2.27	3.47	5.23	1.03E1	2.25E1	4.95E1
7.0	3.72	2.58	1.79	1.49	1.50	1.63	1.88	2.27	3.44	5.37	1.19E1	3.15E1	8.17E1
8.0	4.03	2.71	1.85	1.52	1.52	1.65	1.89	2.28	3.43	5.51	1.39E1	4.31E1	1.31E2
10.0	4.67	2.98	1.96	1.57	1.54	1.67	1.91	2.29	3.39	5.83	1.88E1	8.15E1	3.35E2
15.0	6.22	3.57	2.19	1.68	1.58	1.70	1.94	2.31	3.34	6.85	4.65E1	4.31E2	4.24E3
20.0	7.68	4.07	2.39	1.76	1.61	1.73	1.97	2.34	3.32	7.84	1.47E2	3.76E3	6.57E4
25.0	9.04	4.51	2.55	1.83	1.64	1.76	1.99	2.36	3.30	9.07	5.28E2	3.34E4	1.16E6
30.0	1.03E1	4.90	2.69	1.89	1.66	1.78	2.01	2.37	3.31	1.08E1	2.01E3	3.12E5	2.21E7
35.0	1.15E1	5.27	2.82	1.95	1.68	1.79	2.03	2.39	3.31	1.33E1	7.83E3	2.97E6	4.33E8
40.0	1.27E1	5.61	2.93	1.99	1.69	1.81	2.04	2.40	3.32	1.68E1	3.11E4	2.85E7	8.63E9

	ENERGY (MEV)				
R(MFP)	0.035	0.03	0.029	0.02	0.015
0.5	2.10	1.87	1.02	1.01	1.00
1.0	3.27	2.87	1.03	1.01	1.01
2.0	6.51	6.02	1.04	1.02	1.01
3.0	1.22E1	1.25E1	1.05	1.02	1.01
4.0	2.34E1	2.68E1	1.05	1.02	1.01
5.0	4.54E1	5.91E1	1.06	1.02	1.01
6.0	8.84E1	1.31E2	1.06	1.02	1.01
7.0	1.63E2	2.69E2	1.06	1.03	1.01
8.0	2.97E2	5.55E2	1.07	1.03	1.01
10.0	1.02E3	2.42E3	1.07	1.03	1.01
15.0	2.44E4	1.01E5	1.08	1.03	1.02
20.0	6.65E5	4.54E6	1.09	1.03	1.02
25.0	2.00E7	2.15E8	1.09	1.04	1.02
30.0	6.43E8	1.06E10	1.10	1.04	1.02
35.0	2.17E10	5.44E11	1.10	1.04	1.02
40.0	7.58E11	2.88E13	1.11	1.04	1.02

(5) ABSORBED DOSE BUILDUP FACTORS IN 45-MFP THICK LANTHANUM

	ENERGY (MEV)												
R(MFP)	15	10	8	6	5	4	3	2	1.5	1	0.8	0.6	0.5
0.5	1.56	1.57	1.61	1.58	1.61	1.57	1.61	1.59	1.56	1.66	1.70	1.71	1.68
1.0	2.08	1.99	2.02	1.93	1.96	1.89	1.99	2.03	2.03	2.20	2.24	2.20	2.12
2.0	3.16	2.75	2.66	2.44	2.48	2.40	2.63	2.85	2.93	3.17	3.18	3.02	2.81
3.0	4.51	3.60	3.32	2.96	3.00	2.96	3.30	3.70	3.86	4.14	4.10	3.77	3.42
4.0	6.35	4.64	4.08	3.53	3.58	3.56	4.03	4.58	4.79	5.04	4.93	4.43	3.94
5.0	8.84	5.91	4.97	4.19	4.23	4.23	4.82	5.50	5.76	5.94	5.74	5.06	4.43
6.0	1.22E1	7.47	6.02	4.95	4.98	5.00	5.73	6.54	6.84	6.96	6.65	5.76	4.97
7.0	1.67E1	9.38	7.24	5.80	5.81	5.84	6.69	7.62	7.94	7.96	7.55	6.42	5.47
8.0	2.27E1	1.17E1	8.66	6.74	6.72	6.73	7.70	8.73	9.05	8.94	8.40	7.05	5.94
10.0	4.17E1	1.80E1	1.23E1	9.01	8.85	8.78	9.94	1.11E1	1.14E1	1.10E1	1.02E1	8.34	6.90
15.0	1.82E2	5.02E1	2.79E1	1.75E1	1.63E1	1.55E1	1.68E1	1.79E1	1.82E1	1.65E1	1.48E1	1.16E1	9.27
20.0	7.57E2	1.33E2	6.02E1	3.17E1	2.76E1	2.46E1	2.51E1	2.57E1	2.58E1	2.21E1	1.95E1	1.47E1	1.15E1
25.0	3.02E3	3.38E2	1.24E2	5.43E1	4.37E1	3.63E1	3.47E1	3.43E1	3.39E1	2.77E1	2.40E1	1.76E1	1.36E1
30.0	1.16E4	8.32E2	2.48E2	8.91E1	6.59E1	5.09E1	4.55E1	4.35E1	4.22E1	3.32E1	2.84E1	2.03E1	1.55E1
35.0	4.38E4	2.00E3	4.81E2	1.42E2	9.59E1	6.85E1	5.74E1	5.32E1	5.08E1	3.87E1	3.27E1	2.30E1	1.73E1
40.0	1.61E5	4.68E3	9.12E2	2.19E2	1.35E2	8.92E1	7.01E1	6.32E1	5.96E1	4.40E1	3.68E1	2.55E1	1.91E1

	ENERGY (MEV)												
R(MFP)	0.4	0.3	0.2	0.15	0.1	0.09	0.08	0.07	0.06	0.055	0.05	0.048	0.046
0.5	1.72	1.57	1.40	1.36	1.39	1.40	1.41	1.42	1.41	1.41	1.40	1.40	1.40
1.0	2.09	1.80	1.51	1.41	1.46	1.52	1.60	1.68	1.73	1.77	1.80	1.81	1.82
2.0	2.63	2.11	1.63	1.48	1.48	1.57	1.72	1.99	2.33	2.55	2.77	2.87	2.97
3.0	3.08	2.34	1.73	1.52	1.49	1.57	1.75	2.17	2.95	3.56	4.27	4.60	4.96
4.0	3.45	2.51	1.79	1.55	1.50	1.57	1.75	2.30	3.71	5.05	6.85	7.75	8.74
5.0	3.78	2.65	1.85	1.58	1.51	1.57	1.75	2.41	4.70	7.33	1.14E1	1.36E1	1.61E1
6.0	4.13	2.81	1.91	1.61	1.52	1.58	1.75	2.50	5.99	1.08E1	1.94E1	2.43E1	3.03E1
7.0	4.46	2.94	1.96	1.63	1.53	1.58	1.74	2.60	7.77	1.61E1	3.30E1	4.31E1	5.59E1
8.0	4.76	3.06	2.00	1.65	1.54	1.59	1.74	2.70	1.01E1	2.40E1	5.40E1	7.39E1	1.00E2
10.0	5.35	3.28	2.08	1.69	1.56	1.60	1.74	2.94	1.74E1	5.25E1	1.51E2	2.26E2	3.34E2
15.0	6.73	3.76	2.26	1.77	1.59	1.62	1.74	3.70	8.54E1	4.80E2	2.36E3	4.31E3	7.63E3
20.0	7.95	4.16	2.41	1.84	1.61	1.64	1.75	4.84	5.60E2	5.65E3	4.48E4	9.69E4	2.01E5
25.0	9.02	4.49	2.53	1.89	1.62	1.65	1.75	6.84	4.15E3	7.48E4	9.56E5	2.44E6	5.88E6
30.0	9.99	4.78	2.63	1.94	1.64	1.67	1.76	1.04E1	3.21E4	1.04E6	2.18E7	6.55E7	1.84E8
35.0	1.09E1	5.06	2.72	1.97	1.65	1.68	1.77	1.70E1	2.52E5	1.48E7	5.11E8	1.83E9	5.99E9
40.0	1.17E1	5.31	2.79	2.01	1.66	1.69	1.78	2.93E1	2.00E6	2.13E8	1.22E10	5.20E10	2.00E11

	ENERGY (MEV)							
R(MFP)	0.044	0.042	0.04	0.039	0.038	0.03	0.02	0.015
0.5	1.40	1.40	1.39	1.40	1.03	1.01	1.01	1.00
1.0	1.83	1.85	1.85	1.86	1.04	1.02	1.01	1.00
2.0	3.06	3.16	3.23	3.31	1.05	1.03	1.01	1.01
3.0	5.31	5.67	5.98	6.27	1.06	1.03	1.01	1.01
4.0	9.80	1.09E1	1.20E1	1.28E1	1.07	1.04	1.01	1.01
5.0	1.90E1	2.21E1	2.52E1	2.76E1	1.07	1.04	1.01	1.01
6.0	3.73E1	4.55E1	5.38E1	6.03E1	1.08	1.04	1.02	1.01
7.0	7.01E1	8.90E1	1.09E2	1.23E2	1.08	1.05	1.02	1.01
8.0	1.31E2	1.73E2	2.19E2	2.53E2	1.08	1.05	1.02	1.01
10.0	4.73E2	6.75E2	9.15E2	1.10E3	1.09	1.05	1.02	1.01
15.0	1.30E4	2.20E4	3.49E4	4.57E4	1.10	1.06	1.02	1.01
20.0	4.03E5	7.90E5	1.46E6	2.06E6	1.11	1.06	1.02	1.01
25.0	1.37E7	3.07E7	6.45E7	9.79E7	1.12	1.07	1.02	1.01
30.0	4.94E8	1.27E9	3.01E9	4.87E9	1.13	1.07	1.03	1.01
35.0	1.87E10	5.44E10	1.46E11	2.52E11	1.13	1.07	1.03	1.01
40.0	7.24E11	2.41E12	7.30E12	1.34E13	1.14	1.08	1.03	1.01

(6) EXPOSURE BUILDUP FACTORS IN 45-MFP THICK LANTHANUM

R(MFP)	ENERGY (MEV) 15	10	8	6	5	4	3	2	1.5	1	0.8	0.6	0.5
0.5	1.56	1.50	1.50	1.40	1.38	1.32	1.32	1.28	1.26	1.30	1.30	1.28	1.26
1.0	2.22	1.97	1.91	1.71	1.68	1.57	1.59	1.57	1.55	1.61	1.60	1.55	1.50
2.0	3.74	2.94	2.67	2.24	2.17	2.03	2.09	2.12	2.12	2.20	2.15	2.01	1.90
3.0	5.74	4.08	3.47	2.80	2.69	2.54	2.64	2.72	2.73	2.80	2.70	2.46	2.27
4.0	8.49	5.48	4.40	3.43	3.27	3.09	3.23	3.34	3.35	3.38	3.22	2.87	2.60
5.0	1.23E1	7.21	5.50	4.14	3.92	3.71	3.88	4.00	4.00	3.96	3.73	3.26	2.91
6.0	1.73E1	9.31	6.78	4.95	4.66	4.40	4.60	4.73	4.70	4.60	4.29	3.69	3.24
7.0	2.41E1	1.19E1	8.29	5.87	5.48	5.16	5.37	5.48	5.43	5.24	4.84	4.09	3.56
8.0	3.34E1	1.51E1	1.00E1	6.88	6.38	5.97	6.19	6.26	6.16	5.87	5.38	4.49	3.86
10.0	6.27E1	2.37E1	1.45E1	9.34	8.50	7.82	8.00	7.94	7.74	7.17	6.48	5.29	4.47
15.0	2.81E2	6.81E1	3.39E1	1.86E1	1.59E1	1.39E1	1.35E1	1.27E1	1.22E1	1.06E1	9.35	7.27	5.97
20.0	1.18E3	1.83E2	7.40E1	3.40E1	2.71E1	2.21E1	2.02E1	1.82E1	1.72E1	1.42E1	1.22E1	9.16	7.37
25.0	4.71E3	4.68E2	1.54E2	5.87E1	4.32E1	3.28E1	2.78E1	2.41E1	2.25E1	1.77E1	1.50E1	1.10E1	8.67
30.0	1.82E4	1.16E3	3.08E2	9.69E1	6.54E1	4.60E1	3.65E1	3.05E1	2.80E1	2.12E1	1.77E1	1.27E1	9.90
35.0	6.86E4	2.78E3	5.99E2	1.55E2	9.53E1	6.19E1	4.59E1	3.72E1	3.36E1	2.47E1	2.04E1	1.43E1	1.11E1
40.0	2.52E5	6.53E3	1.14E3	2.39E2	1.35E2	8.07E1	5.61E1	4.42E1	3.94E1	2.80E1	2.29E1	1.58E1	1.22E1

R(MFP)	ENERGY (MEV) 0.4	0.3	0.2	0.15	0.1	0.09	0.08	0.07	0.06	0.055	0.05	0.048	0.046
0.5	1.23	1.18	1.13	1.15	1.40	1.54	1.72	1.88	2.05	2.07	2.07	2.03	1.99
1.0	1.42	1.31	1.20	1.19	1.48	1.69	2.03	2.42	2.91	3.03	3.12	3.08	3.04
2.0	1.73	1.58	1.29	1.24	1.50	1.75	2.25	3.07	4.45	5.09	5.73	5.81	5.89
3.0	2.00	1.65	1.36	1.28	1.50	1.74	2.29	3.45	6.08	7.76	9.75	1.03E1	1.08E1
4.0	2.22	1.77	1.41	1.31	1.51	1.74	2.28	3.72	8.07	1.17E1	1.67E1	1.84E1	2.03E1
5.0	2.43	1.87	1.45	1.33	1.53	1.74	2.28	3.94	1.07E1	1.77E1	2.89E1	3.35E1	3.86E1
6.0	2.65	1.97	1.50	1.35	1.54	1.75	2.27	4.14	1.40E1	2.69E1	5.03E1	6.13E1	7.39E1
7.0	2.85	2.06	1.54	1.37	1.55	1.75	2.26	4.33	1.87E1	4.10E1	8.68E1	1.10E2	1.38E2
8.0	3.04	2.14	1.57	1.39	1.55	1.76	2.25	4.54	2.47E1	6.19E1	1.43E2	1.89E2	2.48E2
10.0	3.41	2.30	1.64	1.42	1.57	1.77	2.24	5.04	4.37E1	1.37E2	4.02E2	5.82E2	8.27E2
15.0	4.27	2.63	1.77	1.49	1.60	1.79	2.24	6.64	2.21E2	1.26E3	6.31E3	1.11E4	1.89E4
20.0	5.03	2.90	1.89	1.54	1.62	1.81	2.24	9.02	1.45E3	1.49E4	1.19E5	2.49E5	4.98E5
25.0	5.70	3.13	1.98	1.58	1.64	1.83	2.25	1.32E1	1.08E4	1.97E5	2.55E6	6.25E6	1.45E7
30.0	6.30	3.33	2.06	1.62	1.65	1.84	2.26	2.08E1	8.33E4	2.74E6	5.79E7	1.68E8	4.54E8
35.0	6.86	3.52	2.12	1.65	1.67	1.85	2.27	3.46E1	6.55E5	3.90E7	1.36E9	4.68E9	1.48E10
40.0	7.36	3.69	2.18	1.68	1.68	1.86	2.28	6.05E1	5.21E6	5.60E8	3.25E10	1.33E11	4.93E11

R(MFP)	ENERGY (MEV) 0.044	0.042	0.04	0.039	0.038	0.03	0.02	0.015
0.5	1.95	1.92	1.86	1.82	1.03	1.02	1.01	1.00
1.0	2.99	2.93	2.85	2.78	1.04	1.02	1.01	1.00
2.0	5.92	5.94	5.88	5.77	1.05	1.03	1.01	1.01
3.0	1.13E1	1.17E1	1.19E1	1.19E1	1.06	1.04	1.01	1.01
4.0	2.20E1	2.38E1	2.51E1	2.54E1	1.07	1.04	1.01	1.01
5.0	4.39E1	4.94E1	5.40E1	5.58E1	1.07	1.04	1.02	1.01
6.0	8.78E1	1.03E2	1.17E2	1.23E2	1.08	1.04	1.02	1.01
7.0	1.66E2	2.03E2	2.37E2	2.52E2	1.08	1.05	1.02	1.01
8.0	3.12E2	3.95E2	4.79E2	5.20E2	1.08	1.05	1.02	1.01
10.0	1.13E3	1.54E3	2.00E3	2.26E3	1.09	1.05	1.02	1.01
15.0	3.09E4	5.02E4	7.65E4	9.39E4	1.10	1.06	1.02	1.01
20.0	9.58E5	1.80E6	3.18E6	4.22E6	1.11	1.06	1.02	1.01
25.0	3.24E7	7.00E7	1.41E8	2.01E8	1.12	1.07	1.02	1.01
30.0	1.17E9	2.88E9	6.55E9	9.98E9	1.13	1.07	1.03	1.01
35.0	4.42E10	1.24E11	3.18E11	5.16E11	1.13	1.07	1.03	1.01
40.0	1.72E12	5.48E12	1.59E13	2.75E13	1.14	1.08	1.03	1.01

(7) ABSORBED DOSE BUILDUP FACTORS IN 45-MFP THICK GADOLINIUM

R(MFP)	ENERGY (MEV) 15	10	8	6	5	4	3	2	1.5	1	0.8	0.6	0.5
0.5	1.35	1.40	1.46	1.47	1.50	1.49	1.54	1.54	1.51	1.61	1.63	1.60	1.67
1.0	1.66	1.68	1.75	1.73	1.77	1.74	1.86	1.93	1.93	2.09	2.08	1.99	2.03
2.0	2.31	2.19	2.22	2.13	2.17	2.16	2.39	2.63	2.71	2.91	2.84	2.60	2.56
3.0	3.15	2.79	2.72	2.54	2.60	2.63	2.97	3.37	3.50	3.69	3.54	3.13	3.02
4.0	4.31	3.54	3.30	3.01	3.07	3.14	3.60	4.13	4.28	4.39	4.15	3.58	3.39
5.0	5.93	4.48	4.00	3.55	3.61	3.71	4.28	4.92	5.09	5.09	4.74	4.00	3.72
6.0	8.12	5.65	4.84	4.18	4.24	4.37	5.06	5.81	5.98	5.86	5.39	4.46	4.09
7.0	1.12E1	7.10	5.83	4.90	4.94	5.09	5.89	6.72	6.87	6.62	6.01	4.88	4.42
8.0	1.53E1	8.90	7.00	5.70	5.70	5.85	6.76	7.66	7.76	7.34	6.60	5.28	4.73
10.0	2.89E1	1.39E1	1.00E1	7.66	7.52	7.62	8.71	9.67	9.67	8.82	7.79	6.07	5.35
15.0	1.38E2	4.14E1	2.40E1	1.53E1	1.41E1	1.35E1	1.46E1	1.53E1	1.49E1	1.26E1	1.08E1	7.95	6.79
20.0	6.36E2	1.19E2	5.49E1	2.86E1	2.43E1	2.17E1	2.19E1	2.17E1	2.07E1	1.63E1	1.35E1	9.64	8.07
25.0	2.82E3	3.31E2	1.21E2	5.12E1	3.96E1	3.25E1	3.04E1	2.87E1	2.68E1	1.99E1	1.61E1	1.11E1	9.21
30.0	1.21E4	8.93E2	2.60E2	8.80E1	6.15E1	4.62E1	4.00E1	3.61E1	3.30E1	2.33E1	1.86E1	1.25E1	1.02E1
35.0	5.08E4	2.35E3	5.43E2	1.47E2	9.23E1	6.33E1	5.07E1	4.39E1	3.93E1	2.66E1	2.09E1	1.38E1	1.12E1
40.0	2.08E5	6.04E3	1.11E3	2.38E2	1.34E2	8.38E1	6.22E1	5.19E1	4.55E1	2.97E1	2.31E1	1.50E1	1.21E1

R(MFP)	ENERGY (MEV) 0.4	0.3	0.2	0.15	0.1	0.09	0.08	0.075	0.07	0.065	0.06	0.058	0.056
0.5	1.60	1.48	1.40	1.41	1.44	1.44	1.44	1.44	1.44	1.43	1.42	1.42	1.43
1.0	1.88	1.65	1.47	1.46	1.64	1.71	1.76	1.79	1.82	1.84	1.85	1.87	1.89
2.0	2.26	1.86	1.56	1.50	1.79	2.01	2.28	2.45	2.64	2.81	2.98	3.08	3.20
3.0	2.56	2.01	1.62	1.53	1.83	2.17	2.74	3.16	3.67	4.24	4.84	5.18	5.54
4.0	2.80	2.12	1.67	1.55	1.84	2.28	3.22	4.04	5.15	6.56	8.25	9.17	1.02E1
5.0	3.01	2.21	1.70	1.57	1.85	2.37	3.78	5.21	7.40	1.05E1	1.46E1	1.69E1	1.95E1
6.0	3.23	2.31	1.74	1.59	1.84	2.44	4.43	6.77	1.08E1	1.71E1	2.65E1	3.18E1	3.81E1
7.0	3.43	2.39	1.78	1.61	1.84	2.50	5.25	8.97	1.60E1	2.79E1	4.74E1	5.87E1	7.09E1
8.0	3.61	2.46	1.80	1.62	1.84	2.58	6.32	1.18E1	2.35E1	4.45E1	8.19E1	1.05E2	1.32E2
10.0	3.96	2.60	1.86	1.65	1.84	2.74	9.10	2.13E1	5.06E1	1.16E2	2.56E2	3.51E2	4.67E2
15.0	4.74	2.89	1.98	1.71	1.84	3.25	2.89E1	1.15E2	4.48E2	1.56E3	5.12E3	8.11E3	1.24E4
20.0	5.41	3.11	2.07	1.75	1.84	3.82	1.20E2	8.27E2	5.09E3	2.60E4	1.21E5	2.17E5	3.76E5
25.0	5.98	3.30	2.15	1.79	1.85	4.62	5.68E2	6.65E3	6.46E4	4.88E5	3.18E6	6.43E6	1.25E7
30.0	6.47	3.47	2.21	1.82	1.86	5.87	2.82E3	5.57E4	8.58E5	9.67E6	8.90E7	2.03E8	4.42E8
35.0	6.91	3.62	2.27	1.85	1.87	7.83	1.43E4	4.75E5	1.16E7	1.97E8	2.58E9	6.66E9	1.63E10
40.0	7.31	3.76	2.32	1.87	1.87	1.10E1	7.42E4	4.09E6	1.59E8	4.06E9	7.63E10	2.23E11	6.15E11

R(MFP)	ENERGY (MEV) 0.054	0.052	0.051	0.05	0.04	0.03	0.02	0.015
0.5	1.43	1.44	1.44	1.04	1.02	1.01	1.00	1.00
1.0	1.91	1.93	1.93	1.05	1.03	1.02	1.01	1.00
2.0	3.30	3.39	3.44	1.07	1.04	1.02	1.01	1.00
3.0	5.90	6.23	6.42	1.08	1.05	1.02	1.01	1.00
4.0	1.12E1	1.23E1	1.28E1	1.09	1.05	1.03	1.01	1.01
5.0	2.23E1	2.52E1	2.68E1	1.10	1.06	1.03	1.01	1.01
6.0	4.51E1	5.26E1	5.69E1	1.10	1.06	1.03	1.01	1.01
7.0	8.70E1	1.05E2	1.14E2	1.11	1.06	1.03	1.01	1.01
8.0	1.67E2	2.08E2	2.28E2	1.11	1.07	1.03	1.01	1.01
10.0	6.29E2	8.31E2	9.40E2	1.12	1.07	1.03	1.01	1.01
15.0	1.91E4	2.87E4	3.47E4	1.14	1.08	1.04	1.01	1.01
20.0	6.52E5	1.10E6	1.41E6	1.15	1.09	1.04	1.02	1.01
25.0	2.41E7	4.51E7	6.11E7	1.16	1.10	1.05	1.02	1.01
30.0	9.47E8	1.96E9	2.80E9	1.17	1.10	1.05	1.02	1.01
35.0	3.88E10	8.87E10	1.33E11	1.18	1.11	1.05	1.02	1.01
40.0	1.64E12	4.14E12	6.53E12	1.18	1.11	1.05	1.02	1.01

(8) EXPOSURE BUILDUP FACTORS IN 45-MFP THICK GADOLINIUM

	ENERGY (MEV)											
R(MFP)	15	10	8	6	5	4	3	2	1.5	1	0.8	0.6	0.5
0.5	1.49	1.44	1.44	1.36	1.35	1.29	1.29	1.26	1.24	1.27	1.26	1.24	1.22
1.0	2.06	1.85	1.80	1.63	1.60	1.51	1.53	1.52	1.50	1.54	1.51	1.45	1.40
2.0	3.37	2.70	2.46	2.10	2.04	1.92	1.98	2.01	2.00	2.03	1.96	1.81	1.70
3.0	5.16	3.73	3.19	2.61	2.51	2.39	2.48	2.54	2.53	2.51	2.39	2.14	1.97
4.0	7.67	5.02	4.05	3.19	3.05	2.90	3.02	3.09	3.05	2.97	2.78	2.43	2.20
5.0	1.12E1	6.66	5.09	3.85	3.65	3.46	3.61	3.68	3.60	3.42	3.16	2.71	2.42
6.0	1.60E1	8.70	6.32	4.62	4.34	4.11	4.27	4.31	4.19	3.91	3.56	3.00	2.64
7.0	2.27E1	1.13E1	7.79	5.50	5.12	4.81	4.97	4.96	4.78	4.38	3.95	3.27	2.84
8.0	3.20E1	1.44E1	9.53	6.49	5.97	5.57	5.72	5.64	5.39	4.85	4.33	3.53	3.04
10.0	6.25E1	2.34E1	1.41E1	8.91	8.01	7.32	7.37	7.09	6.67	5.80	5.09	4.05	3.42
15.0	3.11E2	7.30E1	3.51E1	1.84E1	1.54E1	1.31E1	1.24E1	1.11E1	1.02E1	8.21	6.95	5.26	4.32
20.0	1.45E3	2.14E2	8.22E1	3.52E1	2.69E1	2.12E1	1.86E1	1.57E1	1.41E1	1.06E1	8.70	6.35	5.12
25.0	6.48E3	6.02E2	1.84E2	6.37E1	4.42E1	3.20E1	2.58E1	2.07E1	1.82E1	1.28E1	1.03E1	7.32	5.83
30.0	2.80E4	1.63E3	3.97E2	1.10E2	6.91E1	4.56E1	3.39E1	2.60E1	2.23E1	1.50E1	1.19E1	8.22	6.47
35.0	1.17E5	4.31E3	8.32E2	1.85E2	1.04E2	6.25E1	4.29E1	3.16E1	2.65E1	1.71E1	1.34E1	9.05	7.06
40.0	4.82E5	1.11E4	1.70E3	3.01E2	1.52E2	8.29E1	5.27E1	3.73E1	3.06E1	1.91E1	1.47E1	9.84	7.60

	ENERGY (MEV)												
R(MFP)	0.4	0.3	0.2	0.15	0.1	0.09	0.08	0.075	0.07	0.065	0.06	0.058	0.056
0.5	1.19	1.14	1.11	1.16	1.42	1.52	1.65	1.69	1.74	1.78	1.83	1.82	1.82
1.0	1.33	1.24	1.16	1.19	1.61	1.83	2.14	2.26	2.40	2.53	2.68	2.68	2.69
2.0	1.55	1.37	1.22	1.23	1.76	2.19	2.92	3.32	3.79	4.31	4.90	5.03	5.17
3.0	1.74	1.47	1.27	1.25	1.80	2.39	3.62	4.45	5.56	6.93	8.59	9.10	9.63
4.0	1.89	1.55	1.31	1.27	1.81	2.52	4.36	5.89	8.12	1.12E1	1.54E1	1.69E1	1.85E1
5.0	2.03	1.62	1.34	1.29	1.82	2.63	5.23	7.80	1.20E1	1.85E1	2.81E1	3.20E1	3.64E1
6.0	2.17	1.69	1.37	1.30	1.81	2.72	6.23	1.04E1	1.79E1	3.08E1	5.16E1	6.11E1	7.19E1
7.0	2.30	1.75	1.39	1.32	1.81	2.80	7.52	1.40E1	2.78E1	5.09E1	9.33E1	1.14E2	1.35E2
8.0	2.42	1.80	1.42	1.33	1.81	2.90	9.19	1.87E1	4.02E1	8.18E1	1.63E2	2.05E2	2.51E2
10.0	2.65	1.90	1.46	1.35	1.81	3.10	1.36E1	3.44E1	8.79E1	2.15E2	5.12E2	6.89E2	8.99E2
15.0	3.16	2.10	1.55	1.40	1.81	3.75	4.49E1	1.92E2	7.96E2	2.96E3	1.04E4	1.61E4	2.41E4
20.0	3.60	2.26	1.62	1.44	1.81	4.45	1.90E2	1.39E3	9.12E3	4.97E4	2.48E5	4.35E5	7.37E5
25.0	3.97	2.39	1.68	1.47	1.82	5.47	9.02E2	1.12E4	1.16E5	9.37E5	6.55E6	1.30E7	2.47E7
30.0	4.29	2.51	1.73	1.49	1.83	7.04	4.49E3	9.41E4	1.54E6	1.86E7	1.84E8	4.12E8	8.77E8
35.0	4.58	2.62	1.77	1.51	1.83	9.52	2.28E4	8.03E5	2.09E7	3.80E8	5.36E9	1.35E10	3.24E10
40.0	4.84	2.72	1.81	1.53	1.84	1.35E1	1.18E5	6.93E6	2.86E8	7.83E9	1.59E11	4.55E11	1.23E12

	ENERGY (MEV)							
R(MFP)	0.054	0.052	0.051	0.05	0.04	0.03	0.02	0.015
0.5	1.81	1.79	1.79	1.03	1.02	1.01	1.00	1.00
1.0	2.69	2.68	2.68	1.05	1.03	1.02	1.01	1.00
2.0	5.28	5.35	5.40	1.07	1.04	1.02	1.01	1.00
3.0	1.01E1	1.05E1	1.08E1	1.08	1.05	1.02	1.01	1.00
4.0	2.01E1	2.16E1	2.24E1	1.09	1.05	1.03	1.01	1.01
5.0	4.09E1	4.52E1	4.78E1	1.10	1.06	1.03	1.01	1.01
6.0	8.36E1	9.54E1	1.02E2	1.10	1.06	1.03	1.01	1.01
7.0	1.62E2	1.92E2	2.06E2	1.11	1.06	1.03	1.01	1.01
8.0	3.12E2	3.80E2	4.14E2	1.11	1.07	1.03	1.01	1.01
10.0	1.18E3	1.53E3	1.71E3	1.12	1.07	1.03	1.01	1.01
15.0	3.63E4	5.33E4	6.37E4	1.14	1.08	1.04	1.01	1.01
20.0	1.25E6	2.05E6	2.61E6	1.15	1.09	1.04	1.02	1.01
25.0	4.65E7	8.50E7	1.14E8	1.16	1.10	1.05	1.02	1.01
30.0	1.84E9	3.71E9	5.23E9	1.17	1.10	1.05	1.02	1.01
35.0	7.56E10	1.69E11	2.50E11	1.18	1.11	1.05	1.02	1.01
40.0	3.20E12	7.91E12	1.23E13	1.18	1.11	1.05	1.02	1.01

(9) ABSORBED DOSE BUILDUP FACTORS IN 45-MFP THICK TUNGSTEN

	ENERGY (MEV)												
R(MFP)	15	10	8	6	5	4	3	2	1.5	1	0.8	0.6	0.5
0.5	1.30	1.34	1.38	1.40	1.43	1.43	1.48	1.48	1.45	1.52	1.51	1.46	1.55
1.0	1.54	1.53	1.60	1.59	1.64	1.63	1.74	1.81	1.81	1.89	1.85	1.73	1.80
2.0	1.98	1.88	1.91	1.88	1.94	1.96	2.18	2.39	2.45	2.49	2.38	2.12	2.14
3.0	2.57	2.30	2.26	2.20	2.29	2.36	2.67	3.01	3.09	3.04	2.84	2.45	2.42
4.0	3.41	2.84	2.69	2.58	2.69	2.81	3.20	3.63	3.69	3.52	3.23	2.71	2.63
5.0	4.59	3.53	3.22	3.02	3.15	3.30	3.79	4.27	4.32	3.98	3.59	2.95	2.83
6.0	6.22	4.41	3.86	3.54	3.68	3.86	4.44	4.98	4.99	4.47	3.98	3.20	3.03
7.0	8.51	5.51	4.63	4.13	4.28	4.48	5.14	5.70	5.65	4.94	4.34	3.43	3.21
8.0	1.17E1	6.88	5.54	4.81	4.94	5.14	5.87	6.44	6.30	5.39	4.68	3.64	3.38
10.0	2.24E1	1.08E1	7.99	6.49	6.53	6.68	7.49	8.00	7.69	6.28	5.34	4.05	3.71
15.0	1.14E2	3.38E1	1.98E1	1.33E1	1.24E1	1.18E1	1.24E1	1.23E1	1.14E1	8.42	6.87	4.96	4.42
20.0	5.72E2	1.04E2	4.80E1	2.58E1	2.19E1	1.91E1	1.83E1	1.69E1	1.53E1	1.04E1	8.21	5.72	5.02
25.0	2.77E3	3.14E2	1.13E2	4.79E1	3.65E1	2.87E1	2.53E1	2.19E1	1.92E1	1.21E1	9.40	6.36	5.53
30.0	1.30E4	9.18E2	2.60E2	8.59E1	5.83E1	4.13E1	3.31E1	2.72E1	2.32E1	1.38E1	1.05E1	6.93	5.98
35.0	5.99E4	2.62E3	5.83E2	1.50E2	8.99E1	5.71E1	4.17E1	3.26E1	2.70E1	1.53E1	1.15E1	7.44	6.37
40.0	2.69E5	7.32E3	1.28E3	2.53E2	1.35E2	7.66E1	5.11E1	3.81E1	3.08E1	1.67E1	1.24E1	7.91	6.73

	ENERGY (MEV)												
R(MFP)	0.4	0.3	0.2	0.15	0.14	0.13	0.12	0.11	0.1	0.09	0.08	0.075	0.07
0.5	1.49	1.43	1.45	1.45	1.46	1.47	1.47	1.47	1.46	1.46	1.46	1.47	1.48
1.0	1.67	1.54	1.51	1.61	1.66	1.71	1.77	1.80	1.84	1.89	1.94	1.98	2.02
2.0	1.91	1.68	1.56	1.69	1.79	1.93	2.11	2.32	2.56	2.86	3.18	3.40	3.64
3.0	2.09	1.77	1.60	1.70	1.82	2.01	2.31	2.74	3.33	4.19	5.24	5.94	6.75
4.0	2.23	1.84	1.63	1.71	1.83	2.04	2.45	3.15	4.32	6.25	9.01	1.10E1	1.33E1
5.0	2.35	1.89	1.65	1.72	1.84	2.07	2.57	3.60	5.65	9.57	1.61E1	2.10E1	2.73E1
6.0	2.47	1.95	1.68	1.73	1.84	2.08	2.67	4.10	7.44	1.49E1	2.92E1	4.09E1	5.66E1
7.0	2.58	2.00	1.70	1.73	1.84	2.08	2.77	4.70	9.99	2.34E1	5.24E1	7.70E1	1.13E2
8.0	2.67	2.04	1.72	1.74	1.84	2.09	2.88	5.47	1.34E1	3.64E1	9.10E1	1.42E2	2.22E2
10.0	2.86	2.12	1.76	1.76	1.85	2.09	3.13	7.43	2.46E1	8.75E1	2.86E2	5.04E2	8.78E2
15.0	3.26	2.28	1.83	1.79	1.87	2.10	3.92	1.88E1	1.40E2	9.96E2	5.77E3	1.32E4	2.97E4
20.0	3.58	2.41	1.89	1.82	1.89	2.10	4.90	6.17E1	1.04E3	1.41E4	1.37E5	3.95E5	1.11E6
25.0	3.85	2.51	1.94	1.84	1.90	2.10	6.50	2.29E2	8.62E3	2.23E5	3.59E6	1.29E7	4.49E7
30.0	4.07	2.59	1.98	1.86	1.92	2.10	9.21	9.02E2	7.42E4	3.68E6	1.00E8	4.49E8	1.91E9
35.0	4.27	2.67	2.01	1.88	1.93	2.10	1.39E1	3.66E3	6.51E5	6.20E7	2.88E9	1.63E10	8.45E10
40.0	4.45	2.75	2.04	1.89	1.95	2.11	2.22E1	1.52E4	5.77E6	1.06E9	8.46E10	6.03E11	3.85E12

	ENERGY (MEV)						
R(MFP)	0.069	0.06	0.05	0.04	0.03	0.02	0.015
0.5	1.05	1.04	1.02	1.01	1.01	1.00	1.00
1.0	1.08	1.06	1.03	1.02	1.01	1.00	1.00
2.0	1.10	1.07	1.05	1.03	1.01	1.01	1.00
3.0	1.11	1.08	1.05	1.03	1.02	1.01	1.00
4.0	1.12	1.09	1.06	1.03	1.02	1.01	1.00
5.0	1.13	1.09	1.06	1.04	1.02	1.01	1.00
6.0	1.14	1.10	1.06	1.04	1.02	1.01	1.00
7.0	1.15	1.11	1.07	1.04	1.02	1.01	1.00
8.0	1.15	1.11	1.07	1.04	1.02	1.01	1.00
10.0	1.17	1.12	1.07	1.04	1.02	1.01	1.00
15.0	1.19	1.13	1.08	1.05	1.03	1.01	1.01
20.0	1.21	1.14	1.09	1.06	1.03	1.01	1.01
25.0	1.22	1.15	1.10	1.06	1.03	1.01	1.01
30.0	1.23	1.16	1.10	1.06	1.03	1.01	1.01
35.0	1.24	1.17	1.11	1.07	1.03	1.01	1.01
40.0	1.25	1.18	1.11	1.07	1.03	1.01	1.01

(10) EXPOSURE BUILDUP FACTORS IN 45-MFP THICK TUNGSTEN

	ENERGY (MEV)											
R(MFP)	15	10	8	6	5	4	3	2	1.5	1	0.8	0.6	0.5
0.5	1.32	1.29	1.31	1.27	1.27	1.23	1.24	1.23	1.21	1.23	1.22	1.19	1.17
1.0	1.65	1.53	1.54	1.46	1.45	1.40	1.44	1.44	1.43	1.44	1.41	1.34	1.30
2.0	2.38	2.04	1.95	1.79	1.78	1.74	1.81	1.86	1.84	1.82	1.74	1.59	1.50
3.0	3.41	2.67	2.43	2.17	2.16	2.13	2.24	2.30	2.25	2.17	2.03	1.81	1.67
4.0	4.89	3.49	3.01	2.61	2.59	2.56	2.69	2.75	2.66	2.49	2.29	2.00	1.82
5.0	6.99	4.53	3.73	3.13	3.08	3.03	3.18	3.22	3.08	2.81	2.54	2.17	1.95
6.0	9.92	5.86	4.59	3.73	3.65	3.57	3.73	3.72	3.52	3.13	2.80	2.34	2.08
7.0	1.41E1	7.54	5.63	4.43	4.28	4.17	4.32	4.24	3.96	3.44	3.04	2.50	2.20
8.0	1.99E1	9.67	6.89	5.23	5.00	4.81	4.93	4.77	4.40	3.75	3.27	2.65	2.31
10.0	3.94E1	1.58E1	1.03E1	7.22	6.71	6.30	6.30	5.89	5.33	4.34	3.71	2.94	2.52
15.0	2.10E2	5.20E1	2.67E1	1.53E1	1.30E1	1.13E1	1.04E1	8.94	7.78	5.77	4.74	3.57	2.99
20.0	1.07E3	1.64E2	6.64E1	3.03E1	2.33E1	1.83E1	1.54E1	1.23E1	1.04E1	7.06	5.64	4.10	3.39
25.0	5.20E3	4.99E2	1.59E2	5.71E1	3.93E1	2.77E1	2.12E1	1.59E1	1.30E1	8.24	6.44	4.56	3.72
30.0	2.45E4	1.47E3	3.68E2	1.03E2	6.30E1	3.98E1	2.77E1	1.96E1	1.57E1	9.34	7.17	4.96	4.02
35.0	1.13E5	4.21E3	8.27E2	1.81E2	9.76E1	5.52E1	3.50E1	2.35E1	1.82E1	1.04E1	7.84	5.32	4.28
40.0	5.08E5	1.18E4	1.82E3	3.07E2	1.46E2	7.40E1	4.28E1	2.74E1	2.08E1	1.13E1	8.46	5.66	4.52

	ENERGY (MEV)												
R(MFP)	0.4	0.3	0.2	0.15	0.14	0.13	0.12	0.11	0.1	0.09	0.08	0.075	0.07
0.5	1.14	1.11	1.12	1.19	1.22	1.26	1.31	1.37	1.45	1.52	1.61	1.62	1.65
1.0	1.24	1.17	1.15	1.26	1.32	1.39	1.50	1.63	1.82	2.00	2.23	2.30	2.38
2.0	1.38	1.26	1.19	1.30	1.39	1.52	1.74	2.05	2.52	3.10	3.89	4.20	4.56
3.0	1.50	1.32	1.22	1.32	1.41	1.58	1.88	2.40	3.31	4.63	6.64	7.63	8.79
4.0	1.60	1.37	1.25	1.33	1.42	1.60	1.99	2.75	4.32	7.03	1.17E1	1.44E1	1.77E1
5.0	1.68	1.41	1.27	1.34	1.43	1.62	2.08	3.15	5.71	1.10E1	2.14E1	2.81E1	3.69E1
6.0	1.76	1.46	1.29	1.35	1.44	1.63	2.16	3.60	7.62	1.73E1	3.94E1	5.54E1	7.75E1
7.0	1.84	1.49	1.30	1.35	1.44	1.64	2.24	4.15	1.04E1	2.76E1	7.15E1	1.06E2	1.56E2
8.0	1.91	1.52	1.32	1.36	1.44	1.65	2.33	4.88	1.41E1	4.34E1	1.26E2	1.97E2	3.08E2
10.0	2.04	1.58	1.34	1.38	1.45	1.65	2.53	6.70	2.65E1	1.07E2	4.02E2	7.07E2	1.24E3
15.0	2.31	1.69	1.40	1.40	1.47	1.66	3.16	1.76E1	1.60E2	1.29E3	8.49E3	1.93E4	4.32E4
20.0	2.53	1.78	1.44	1.42	1.49	1.67	3.95	5.85E1	1.22E3	1.88E4	2.08E5	5.96E5	1.67E6
25.0	2.71	1.86	1.48	1.44	1.50	1.67	5.23	2.20E2	1.02E4	3.01E5	5.60E6	2.00E7	6.89E7
30.0	2.87	1.92	1.51	1.45	1.51	1.67	7.40	8.69E2	8.79E4	5.01E6	1.58E8	7.08E8	2.99E9
35.0	3.01	1.98	1.53	1.46	1.52	1.67	1.12E1	3.54E3	7.73E5	8.47E7	4.59E9	2.59E10	1.35E11
40.0	3.13	2.03	1.55	1.48	1.53	1.68	1.78E1	1.47E4	6.88E6	1.45E9	1.35E11	9.69E11	6.19E12

	ENERGY (MEV)						
R(MFP)	0.069	0.06	0.05	0.04	0.03	0.02	0.015
0.5	1.04	1.03	1.02	1.01	1.01	1.00	1.00
1.0	1.06	1.05	1.03	1.02	1.01	1.00	1.00
2.0	1.08	1.07	1.04	1.03	1.01	1.01	1.00
3.0	1.10	1.08	1.05	1.03	1.02	1.01	1.00
4.0	1.11	1.08	1.06	1.03	1.02	1.01	1.00
5.0	1.12	1.09	1.06	1.04	1.02	1.01	1.00
6.0	1.13	1.09	1.06	1.04	1.02	1.01	1.00
7.0	1.13	1.10	1.07	1.04	1.02	1.01	1.00
8.0	1.14	1.10	1.07	1.04	1.02	1.01	1.00
10.0	1.15	1.11	1.07	1.04	1.02	1.01	1.00
15.0	1.17	1.13	1.08	1.05	1.03	1.01	1.01
20.0	1.19	1.14	1.09	1.06	1.03	1.01	1.01
25.0	1.21	1.15	1.10	1.06	1.03	1.01	1.01
30.0	1.22	1.16	1.10	1.06	1.03	1.01	1.01
35.0	1.23	1.16	1.11	1.07	1.03	1.01	1.01
40.0	1.24	1.17	1.11	1.07	1.03	1.01	1.01

(11) ABSORBED DOSE BUILDUP FACTORS IN 45-MFP THICK LEAD

R(MFP)	ENERGY (MEV) 15	10	8	6	5	4	3	2	1.5	1	0.8	0.6	0.5
0.5	1.32	1.35	1.40	1.41	1.44	1.43	1.49	1.48	1.43	1.46	1.43	1.36	1.48
1.0	1.55	1.54	1.59	1.58	1.62	1.60	1.71	1.78	1.75	1.76	1.70	1.57	1.67
2.0	1.99	1.88	1.89	1.84	1.89	1.91	2.11	2.29	2.29	2.23	2.09	1.85	1.92
3.0	2.58	2.30	2.24	2.15	2.22	2.28	2.56	2.82	2.82	2.64	2.43	2.07	2.12
4.0	3.42	2.85	2.66	2.50	2.59	2.68	3.03	3.35	3.31	2.99	2.70	2.25	2.26
5.0	4.61	3.54	3.17	2.92	3.00	3.12	3.55	3.90	3.82	3.32	2.95	2.41	2.40
6.0	6.26	4.41	3.79	3.40	3.48	3.62	4.12	4.50	4.34	3.68	3.22	2.58	2.54
7.0	8.56	5.50	4.53	3.94	4.02	4.15	4.72	5.08	4.85	4.00	3.45	2.72	2.65
8.0	1.18E1	6.87	5.41	4.56	4.61	4.73	5.34	5.68	5.36	4.30	3.67	2.86	2.76
10.0	2.26E1	1.08E1	7.76	6.08	6.01	6.06	6.73	6.96	6.40	4.90	4.10	3.11	2.97
15.0	1.17E2	3.38E1	1.90E1	1.21E1	1.11E1	1.04E1	1.08E1	1.03E1	9.08	6.26	5.03	3.65	3.41
20.0	5.94E2	1.05E2	4.59E1	2.32E1	1.91E1	1.64E1	1.57E1	1.39E1	1.18E1	7.44	5.82	4.08	3.77
25.0	2.93E3	3.19E2	1.08E2	4.26E1	3.13E1	2.43E1	2.12E1	1.77E1	1.46E1	8.48	6.49	4.44	4.07
30.0	1.41E4	9.44E2	2.49E2	7.57E1	4.93E1	3.44E1	2.74E1	2.15E1	1.72E1	9.41	7.09	4.75	4.33
35.0	6.63E4	2.73E3	5.62E2	1.31E2	7.52E1	4.70E1	3.41E1	2.55E1	1.98E1	1.03E1	7.64	5.03	4.56
40.0	3.05E5	7.75E3	1.24E3	2.21E2	1.12E2	6.24E1	4.14E1	2.94E1	2.22E1	1.11E1	8.13	5.29	4.78

R(MFP)	ENERGY (MEV) 0.4	0.3	0.2	0.16	0.15	0.14	0.13	0.12	0.11	0.1	0.09	0.089	0.088
0.5	1.45	1.43	1.47	1.45	1.45	1.45	1.46	1.46	1.45	1.44	1.48	1.48	1.07
1.0	1.58	1.51	1.60	1.69	1.72	1.77	1.81	1.85	1.88	1.89	2.00	2.01	1.10
2.0	1.76	1.61	1.66	1.91	2.03	2.20	2.41	2.62	2.85	3.05	3.49	3.54	1.12
3.0	1.88	1.67	1.68	2.00	2.20	2.52	2.96	3.52	4.20	4.92	6.24	6.39	1.14
4.0	1.98	1.72	1.69	2.05	2.32	2.81	3.59	4.71	6.30	8.25	1.18E1	1.22E1	1.16
5.0	2.06	1.76	1.70	2.08	2.42	3.10	4.33	6.40	9.71	1.44E1	2.31E1	2.41E1	1.17
6.0	2.15	1.80	1.72	2.09	2.49	3.39	5.24	8.77	1.52E1	2.54E1	4.59E1	4.85E1	1.18
7.0	2.22	1.84	1.73	2.10	2.56	3.72	6.41	1.23E1	2.41E1	4.50E1	8.78E1	9.38E1	1.19
8.0	2.29	1.87	1.75	2.11	2.64	4.11	7.98	1.72E1	3.77E1	7.67E1	1.66E2	1.79E2	1.19
10.0	2.41	1.92	1.77	2.13	2.80	5.14	1.22E1	3.39E1	9.20E1	2.32E2	6.11E2	6.71E2	1.21
15.0	2.66	2.03	1.83	2.15	3.28	9.52	4.57E1	2.34E2	1.08E3	4.33E3	1.75E4	2.00E4	1.24
20.0	2.87	2.12	1.87	2.16	3.85	2.17E1	2.20E2	2.06E3	1.55E4	9.54E4	5.66E5	6.71E5	1.26
25.0	3.04	2.19	1.91	2.16	4.50	5.66E1	1.19E3	2.01E4	2.49E5	2.33E6	1.99E7	2.44E7	1.28
30.0	3.18	2.25	1.94	2.17	5.45	1.60E2	6.68E3	2.04E5	4.19E6	6.02E7	7.40E8	9.37E8	1.30
35.0	3.30	2.30	1.97	2.17	6.89	4.73E2	3.85E4	2.10E6	7.21E7	1.61E9	2.86E10	3.74E10	1.31
40.0	3.41	2.35	1.99	2.18	9.10	1.44E3	2.25E5	2.19E7	1.25E9	4.35E10	1.13E12	1.53E12	1.32

R(MFP)	ENERGY (MEV) 0.08	0.06	0.05	0.04	0.03
0.5	1.05	1.03	1.02	1.01	1.01
1.0	1.08	1.04	1.02	1.01	1.01
2.0	1.10	1.05	1.03	1.02	1.01
3.0	1.11	1.06	1.04	1.02	1.01
4.0	1.13	1.06	1.04	1.02	1.01
5.0	1.13	1.07	1.04	1.03	1.01
6.0	1.14	1.07	1.05	1.03	1.01
7.0	1.15	1.07	1.05	1.03	1.01
8.0	1.16	1.08	1.05	1.03	1.02
10.0	1.17	1.08	1.05	1.03	1.02
15.0	1.19	1.09	1.06	1.04	1.02
20.0	1.21	1.10	1.07	1.04	1.02
25.0	1.22	1.11	1.07	1.04	1.02
30.0	1.24	1.12	1.07	1.04	1.02
35.0	1.25	1.12	1.08	1.05	1.02
40.0	1.26	1.13	1.08	1.05	1.02

(12) EXPOSURE BUILDUP FACTORS IN 45-MFP THICK LEAD

	ENERGY (MEV)												
R(MFP)	15	10	8	6	5	4	3	2	1.5	1	0.8	0.6	0.5
0.5	1.31	1.28	1.30	1.26	1.25	1.21	1.23	1.21	1.19	1.20	1.18	1.15	1.14
1.0	1.63	1.51	1.51	1.42	1.41	1.37	1.40	1.40	1.38	1.38	1.34	1.28	1.24
2.0	2.34	2.01	1.90	1.73	1.71	1.67	1.73	1.76	1.73	1.68	1.59	1.46	1.39
3.0	3.34	2.63	2.36	2.08	2.05	2.02	2.10	2.14	2.07	1.95	1.82	1.62	1.52
4.0	4.78	3.42	2.92	2.49	2.44	2.40	2.50	2.52	2.40	2.20	2.01	1.76	1.62
5.0	6.83	4.45	3.59	2.96	2.88	2.82	2.93	2.91	2.74	2.43	2.19	1.88	1.71
6.0	9.70	5.73	4.41	3.51	3.38	3.29	3.40	3.33	3.08	2.67	2.37	2.00	1.80
7.0	1.37E1	7.37	5.39	4.13	3.93	3.79	3.89	3.74	3.42	2.89	2.53	2.10	1.88
8.0	1.94E1	9.44	6.58	4.84	4.56	4.35	4.41	4.17	3.77	3.10	2.69	2.20	1.95
10.0	3.87E1	1.54E1	9.73	6.61	6.03	5.61	5.56	5.07	4.47	3.51	2.99	2.39	2.10
15.0	2.08E2	5.08E1	2.51E1	1.37E1	1.14E1	9.74	8.91	7.45	6.26	4.45	3.65	2.79	2.39
20.0	1.07E3	1.61E2	6.20E1	2.66E1	1.99E1	1.54E1	1.29E1	9.98	8.11	5.27	4.20	3.11	2.64
25.0	5.33E3	4.95E2	1.48E2	4.96E1	3.30E1	2.30E1	1.75E1	1.26E1	9.94	5.99	4.67	3.38	2.85
30.0	2.57E4	1.47E3	3.44E2	8.89E1	5.22E1	3.26E1	2.25E1	1.54E1	1.17E1	6.64	5.10	3.61	3.02
35.0	1.21E5	4.28E3	7.80E2	1.55E2	7.99E1	4.46E1	2.81E1	1.82E1	1.34E1	7.24	5.49	3.82	3.18
40.0	5.59E5	1.22E4	1.73E3	2.62E2	1.19E2	5.92E1	3.40E1	2.10E1	1.50E1	7.79	5.84	4.02	3.31

	ENERGY (MEV)												
R(MFP)	0.4	0.3	0.2	0.16	0.15	0.14	0.13	0.12	0.110.1	0.09	0.089	0.088	
0.5	1.12	1.10	1.15	1.22	1.25	1.28	1.33	1.38	1.44	1.51	1.58	1.59	1.05
1.0	1.19	1.15	1.20	1.34	1.40	1.48	1.58	1.71	1.86	2.04	2.22	2.24	1.07
2.0	1.30	1.21	1.24	1.46	1.59	1.77	2.02	2.36	2.82	3.39	4.05	4.12	1.10
3.0	1.39	1.26	1.26	1.51	1.69	1.99	2.44	3.13	4.16	5.60	7.44	7.66	1.11
4.0	1.45	1.30	1.28	1.54	1.77	2.19	2.93	4.19	6.30	9.59	1.43E1	1.49E1	1.13
5.0	1.51	1.33	1.29	1.56	1.84	2.40	3.53	5.71	9.83	1.70E1	2.85E1	3.00E1	1.14
6.0	1.57	1.36	1.30	1.58	1.90	2.62	4.27	7.90	1.56E1	3.06E1	5.75E1	6.11E1	1.15
7.0	1.62	1.38	1.31	1.59	1.95	2.87	5.26	1.12E1	2.51E1	5.49E1	1.11E2	1.19E2	1.16
8.0	1.67	1.40	1.33	1.60	2.01	3.18	6.60	1.58E1	3.97E1	9.47E1	2.12E2	2.29E2	1.17
10.0	1.75	1.44	1.35	1.61	2.13	3.99	1.03E1	3.21E1	9.99E1	2.94E2	7.94E2	8.75E2	1.18
15.0	1.93	1.52	1.39	1.64	2.47	7.47	4.01E1	2.35E2	1.24E3	5.80E3	2.38E4	2.73E4	1.21
20.0	2.08	1.59	1.42	1.65	2.88	1.71E1	1.99E2	2.14E3	1.86E4	1.33E5	8.01E5	9.51E5	1.23
25.0	2.19	1.64	1.45	1.65	3.34	4.50E1	1.08E3	2.11E4	3.05E5	3.34E6	2.91E7	3.57E7	1.25
30.0	2.29	1.68	1.47	1.66	4.03	1.28E2	6.11E3	2.15E5	5.17E6	8.77E7	1.11E9	1.40E9	1.27
35.0	2.38	1.72	1.49	1.66	5.06	3.81E2	3.54E4	2.22E6	8.94E7	2.36E9	4.35E10	5.70E10	1.28
40.0	2.45	1.75	1.50	1.67	6.65	1.16E3	2.08E5	2.33E7	1.56E9	6.43E10	1.74E12	2.36E12	1.29

	ENERGY (MEV)				
R(MFP)	0.08	0.06	0.05	0.04	0.03
0.5	1.04	1.02	1.02	1.01	1.01
1.0	1.06	1.03	1.02	1.01	1.01
2.0	1.08	1.05	1.03	1.02	1.01
3.0	1.10	1.05	1.04	1.02	1.01
4.0	1.11	1.06	1.04	1.02	1.01
5.0	1.12	1.06	1.04	1.03	1.01
6.0	1.13	1.07	1.04	1.03	1.01
7.0	1.13	1.07	1.05	1.03	1.01
8.0	1.14	1.07	1.05	1.03	1.02
10.0	1.15	1.08	1.05	1.03	1.02
15.0	1.17	1.09	1.06	1.04	1.02
20.0	1.19	1.10	1.06	1.04	1.02
25.0	1.21	1.11	1.07	1.04	1.02
30.0	1.22	1.11	1.07	1.05	1.02
35.0	1.23	1.12	1.08	1.05	1.02
40.0	1.24	1.12	1.08	1.05	1.02

(13) ABSORBED DOSE BUILDUP FACTORS IN 45-MFP THICK URANIUM

R(MFP)	ENERGY (MEV) 15	10	8	6	5	4	3	2	1.5	1	0.8	0.6	0.5
0.5	1.35	1.37	1.42	1.43	1.46	1.44	1.49	1.47	1.40	1.37	1.38	1.32	1.45
1.0	1.57	1.56	1.60	1.58	1.61	1.58	1.68	1.72	1.67	1.61	1.58	1.47	1.58
2.0	2.03	1.90	1.89	1.82	1.86	1.87	2.02	2.14	2.10	1.94	1.87	1.67	1.76
3.0	2.64	2.33	2.23	2.11	2.16	2.19	2.41	2.58	2.51	2.23	2.10	1.82	1.89
4.0	3.48	2.87	2.64	2.44	2.49	2.54	2.81	3.01	2.88	2.47	2.28	1.94	1.99
5.0	4.67	3.54	3.12	2.80	2.86	2.91	3.24	3.45	3.25	2.69	2.45	2.05	2.08
6.0	6.28	4.37	3.69	3.22	3.27	3.33	3.70	3.90	3.63	2.92	2.62	2.16	2.17
7.0	8.54	5.40	4.37	3.69	3.72	3.77	4.18	4.35	4.00	3.12	2.77	2.25	2.24
8.0	1.17E1	6.67	5.16	4.22	4.21	4.24	4.68	4.80	4.35	3.31	2.91	2.33	2.31
10.0	2.20E1	1.03E1	7.22	5.40	5.35	5.29	5.75	5.74	5.08	3.68	3.16	2.49	2.44
15.0	1.09E2	3.04E1	1.67E1	1.02E1	9.27	8.57	8.76	8.12	6.84	4.47	3.71	2.81	2.71
20.0	5.34E2	9.00E1	3.79E1	1.84E1	1.52E1	1.28E1	1.22E1	1.05E1	8.60	5.12	4.15	3.06	2.93
25.0	2.55E3	2.61E2	8.48E1	3.20E1	2.37E1	1.82E1	1.59E1	1.30E1	1.03E1	5.67	4.53	3.26	3.10
30.0	1.20E4	7.43E2	1.86E2	5.40E1	3.56E1	2.47E1	1.99E1	1.55E1	1.18E1	6.16	4.85	3.44	3.25
35.0	5.48E4	2.07E3	4.01E2	8.92E1	5.22E1	3.26E1	2.42E1	1.79E1	1.33E1	6.59	5.14	3.59	3.38
40.0	2.47E5	5.68E3	8.50E2	1.44E2	7.45E1	4.18E1	2.86E1	2.03E1	1.47E1	7.00	5.40	3.72	3.49

R(MFP)	ENERGY (MEV) 0.4	0.3	0.25	0.2	0.19	0.18	0.17	0.16	0.15	0.14	0.13	0.12	0.116
0.5	1.46	1.48	1.50	1.49	1.49	1.49	1.49	1.49	1.48	1.49	1.49	1.49	1.49
1.0	1.56	1.58	1.67	1.76	1.80	1.83	1.86	1.89	1.90	1.95	1.99	2.01	2.02
2.0	1.67	1.65	1.76	2.04	2.16	2.29	2.44	2.60	2.75	2.98	3.21	3.42	3.49
3.0	1.76	1.69	1.78	2.17	2.38	2.62	2.94	3.32	3.77	4.39	5.10	5.83	6.12
4.0	1.83	1.72	1.79	2.25	2.53	2.91	3.46	4.19	5.16	6.56	8.35	1.04E1	1.13E1
5.0	1.89	1.75	1.81	2.30	2.65	3.19	4.04	5.31	7.15	1.00E1	1.41E1	1.92E1	2.16E1
6.0	1.94	1.78	1.83	2.33	2.75	3.46	4.69	6.74	1.00E1	1.55E1	2.41E1	3.60E1	4.18E1
7.0	1.99	1.80	1.85	2.36	2.85	3.76	5.50	8.69	1.43E1	2.46E1	4.17E1	6.63E1	8.02E1
8.0	2.04	1.82	1.86	2.38	2.95	4.11	6.54	1.13E1	2.04E1	3.81E1	6.91E1	1.19E2	1.48E2
10.0	2.12	1.86	1.89	2.42	3.18	5.01	9.30	1.91E1	4.16E1	9.13E1	1.97E2	3.96E2	5.24E2
15.0	2.29	1.94	1.96	2.50	3.85	8.50	2.65E1	8.97E1	3.08E2	1.01E3	3.19E3	9.08E3	1.37E4
20.0	2.42	2.00	2.01	2.54	4.69	1.71E1	9.60E1	5.37E2	2.86E3	1.38E4	6.14E4	2.39E5	4.06E5
25.0	2.52	2.05	2.06	2.57	5.78	3.88E1	3.91E2	3.58E3	2.95E4	2.10E5	1.31E6	6.92E6	1.31E7
30.0	2.61	2.09	2.09	2.60	7.44	9.60E1	1.68E3	2.49E4	3.16E5	3.33E6	2.95E7	2.11E8	4.47E8
35.0	2.69	2.13	2.13	2.62	1.00E1	2.49E2	7.41E3	1.76E5	3.45E6	5.41E7	6.83E8	6.68E9	1.58E10
40.0	2.76	2.17	2.16	2.64	1.41E1	6.68E2	3.33E4	1.27E6	3.81E7	8.90E8	1.60E10	2.15E11	5.69E11

R(MFP)	ENERGY (MEV) 0.115	0.1	0.08	0.06	0.05	0.04	0.03
0.5	1.08	1.06	1.04	1.02	1.01	1.01	1.00
1.0	1.11	1.08	1.05	1.03	1.02	1.01	1.01
2.0	1.15	1.11	1.07	1.03	1.02	1.01	1.01
3.0	1.17	1.13	1.08	1.04	1.03	1.02	1.01
4.0	1.19	1.14	1.08	1.04	1.03	1.02	1.01
5.0	1.20	1.15	1.09	1.04	1.03	1.02	1.01
6.0	1.22	1.16	1.09	1.05	1.03	1.02	1.01
7.0	1.23	1.16	1.10	1.05	1.03	1.02	1.01
8.0	1.24	1.17	1.10	1.05	1.03	1.02	1.01
10.0	1.26	1.18	1.11	1.06	1.04	1.02	1.01
15.0	1.30	1.21	1.13	1.06	1.04	1.03	1.01
20.0	1.34	1.23	1.14	1.07	1.04	1.03	1.01
25.0	1.36	1.25	1.15	1.07	1.05	1.03	1.02
30.0	1.39	1.26	1.16	1.08	1.05	1.03	1.02
35.0	1.41	1.27	1.16	1.08	1.05	1.03	1.02
40.0	1.42	1.28	1.17	1.08	1.05	1.03	1.02

(14) EXPOSURE BUILDUP FACTORS IN 45-MFP THICK URANIUM

	ENERGY (MEV)											
R(MFP)	15	10	8	6	5	4	3	2	1.5	1	0.8	0.6	0.5
0.5	1.31	1.27	1.28	1.24	1.23	1.19	1.20	1.19	1.17	1.17	1.15	1.12	1.12
1.0	1.61	1.49	1.48	1.38	1.37	1.33	1.35	1.35	1.33	1.31	1.27	1.21	1.19
2.0	2.31	1.97	1.85	1.66	1.64	1.60	1.64	1.65	1.61	1.53	1.46	1.35	1.30
3.0	3.28	2.57	2.27	1.98	1.94	1.89	1.95	1.95	1.87	1.73	1.62	1.46	1.39
4.0	4.65	3.31	2.78	2.33	2.27	2.21	2.28	2.25	2.12	1.91	1.75	1.55	1.46
5.0	6.58	4.26	3.39	2.74	2.63	2.55	2.62	2.57	2.38	2.07	1.87	1.63	1.52
6.0	9.23	5.43	4.11	3.19	3.04	2.93	2.99	2.88	2.63	2.23	1.99	1.71	1.58
7.0	1.30E1	6.90	4.96	3.71	3.49	3.33	3.38	3.20	2.87	2.38	2.10	1.78	1.63
8.0	1.82E1	8.73	5.97	4.28	3.99	3.76	3.78	3.51	3.11	2.52	2.20	1.84	1.68
10.0	3.55E1	1.39E1	8.61	5.68	5.14	4.72	4.64	4.17	3.61	2.78	2.39	1.96	1.77
15.0	1.83E2	4.34E1	2.08E1	1.10E1	9.10	7.72	7.06	5.84	4.79	3.35	2.78	2.20	1.96
20.0	9.87E2	1.31E2	4.86E1	2.01E1	1.51E1	1.16E1	9.80	7.54	5.98	3.83	3.10	2.39	2.11
25.0	4.37E3	3.85E2	1.10E2	3.54E1	2.37E1	1.65E1	1.28E1	9.27	7.12	4.23	3.37	2.55	2.23
30.0	2.05E4	1.10E3	2.44E2	6.04E1	3.60E1	2.25E1	1.60E1	1.10E1	8.18	4.59	3.61	2.68	2.33
35.0	9.42E4	3.08E3	5.28E2	1.00E2	5.29E1	2.97E1	1.94E1	1.27E1	9.19	4.91	3.82	2.80	2.42
40.0	4.25E5	8.46E3	1.12E3	1.63E2	7.57E1	3.82E1	2.29E1	1.44E1	1.01E1	5.21	4.01	2.90	2.50

	ENERGY (MEV)												
R(MFP)	0.4	0.3	0.25	0.2	0.19	0.18	0.17	0.16	0.15	0.14	0.13	0.12	0.116
0.5	1.11	1.12	1.15	1.21	1.23	1.25	1.28	1.32	1.35	1.40	1.44	1.49	1.51
1.0	1.16	1.16	1.21	1.33	1.37	1.43	1.50	1.57	1.67	1.77	1.89	2.02	2.08
2.0	1.24	1.21	1.26	1.46	1.56	1.68	1.84	2.05	2.30	2.62	3.00	3.45	3.65
3.0	1.30	1.24	1.28	1.53	1.67	1.87	2.15	2.54	3.09	3.80	4.75	5.93	6.49
4.0	1.35	1.27	1.30	1.57	1.76	2.04	2.48	3.16	4.18	5.65	7.80	1.07E1	1.21E1
5.0	1.39	1.29	1.31	1.61	1.83	2.21	2.87	3.97	5.80	8.67	1.33E1	2.00E1	2.35E1
6.0	1.43	1.31	1.33	1.63	1.90	2.39	3.32	5.04	8.18	1.36E1	2.30E1	3.80E1	4.63E1
7.0	1.46	1.33	1.34	1.65	1.96	2.59	3.90	6.55	1.19E1	2.18E1	4.03E1	7.08E1	8.95E1
8.0	1.49	1.34	1.35	1.67	2.03	2.83	4.65	8.56	1.71E1	3.42E1	6.77E1	1.29E2	1.68E2
10.0	1.55	1.37	1.38	1.70	2.17	3.43	6.66	1.48E1	3.58E1	8.46E1	1.99E2	4.40E2	6.06E2
15.0	1.67	1.43	1.43	1.75	2.59	5.80	1.95E1	7.36E1	2.84E2	1.01E3	3.45E3	1.07E4	1.68E4
20.0	1.76	1.47	1.46	1.78	3.12	1.16E1	7.22E1	4.55E2	2.75E3	1.44E4	6.98E4	2.97E5	5.23E5
25.0	1.83	1.50	1.50	1.80	3.79	2.65E1	2.97E2	3.07E3	2.87E4	2.24E5	1.53E6	8.89E6	1.75E7
30.0	1.90	1.53	1.52	1.82	4.82	6.57E1	1.29E3	2.15E4	3.11E5	3.60E6	3.51E7	2.78E8	6.11E8
35.0	1.95	1.56	1.55	1.84	6.43	1.72E2	5.71E3	1.53E5	3.41E6	5.88E7	8.20E8	8.89E9	2.19E10
40.0	2.00	1.58	1.56	1.85	8.99	4.62E2	2.58E4	1.11E6	3.78E7	9.71E8	1.94E10	2.89E11	7.99E11

	ENERGY (MEV)						
R(MFP)	0.115	0.1	0.08	0.06	0.05	0.04	0.03
0.5	1.05	1.04	1.03	1.02	1.01	1.01	1.00
1.0	1.07	1.06	1.04	1.02	1.02	1.01	1.01
2.0	1.11	1.08	1.05	1.03	1.02	1.01	1.01
3.0	1.13	1.10	1.06	1.04	1.03	1.02	1.01
4.0	1.15	1.11	1.07	1.04	1.03	1.02	1.01
5.0	1.16	1.12	1.08	1.04	1.03	1.02	1.01
6.0	1.17	1.13	1.08	1.05	1.03	1.02	1.01
7.0	1.19	1.14	1.09	1.05	1.03	1.02	1.01
8.0	1.20	1.14	1.09	1.05	1.03	1.02	1.01
10.0	1.22	1.16	1.10	1.05	1.04	1.02	1.01
15.0	1.26	1.18	1.12	1.06	1.04	1.03	1.01
20.0	1.29	1.20	1.13	1.07	1.04	1.03	1.01
25.0	1.32	1.22	1.14	1.07	1.05	1.03	1.02
30.0	1.34	1.23	1.15	1.08	1.05	1.03	1.02
35.0	1.36	1.24	1.15	1.08	1.05	1.03	1.02
40.0	1.37	1.25	1.16	1.08	1.05	1.03	1.02

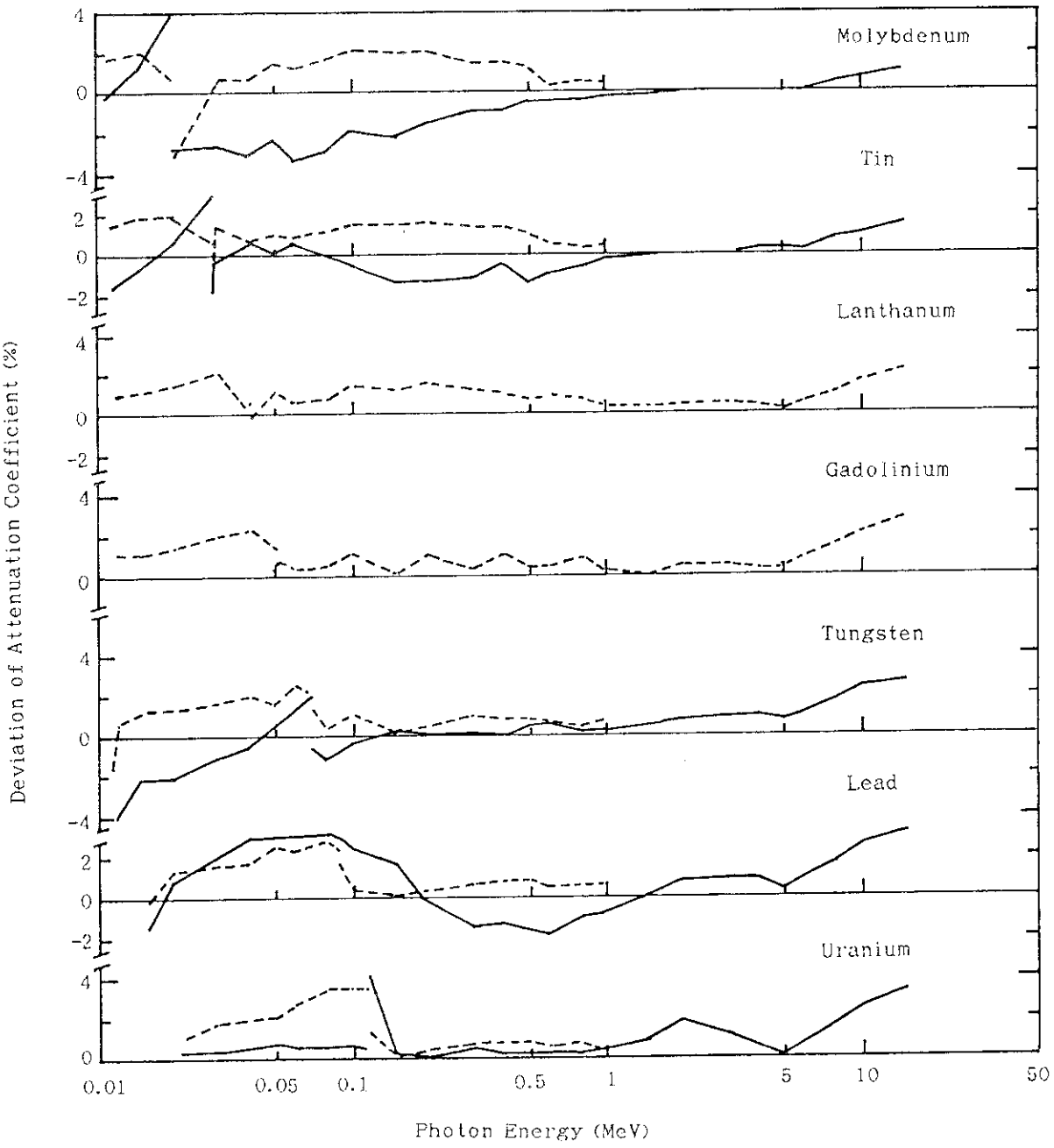

Fig.C.1 Comparison of attenuation coefficients.
The solid and broken lines represent the deviations of NBS-29 and DLC-15 data from new, PHOTX data, respectively. There is a large discrepancy in high energy above 10 MeV and lower energy below 0.1 MeV between the new and old data.

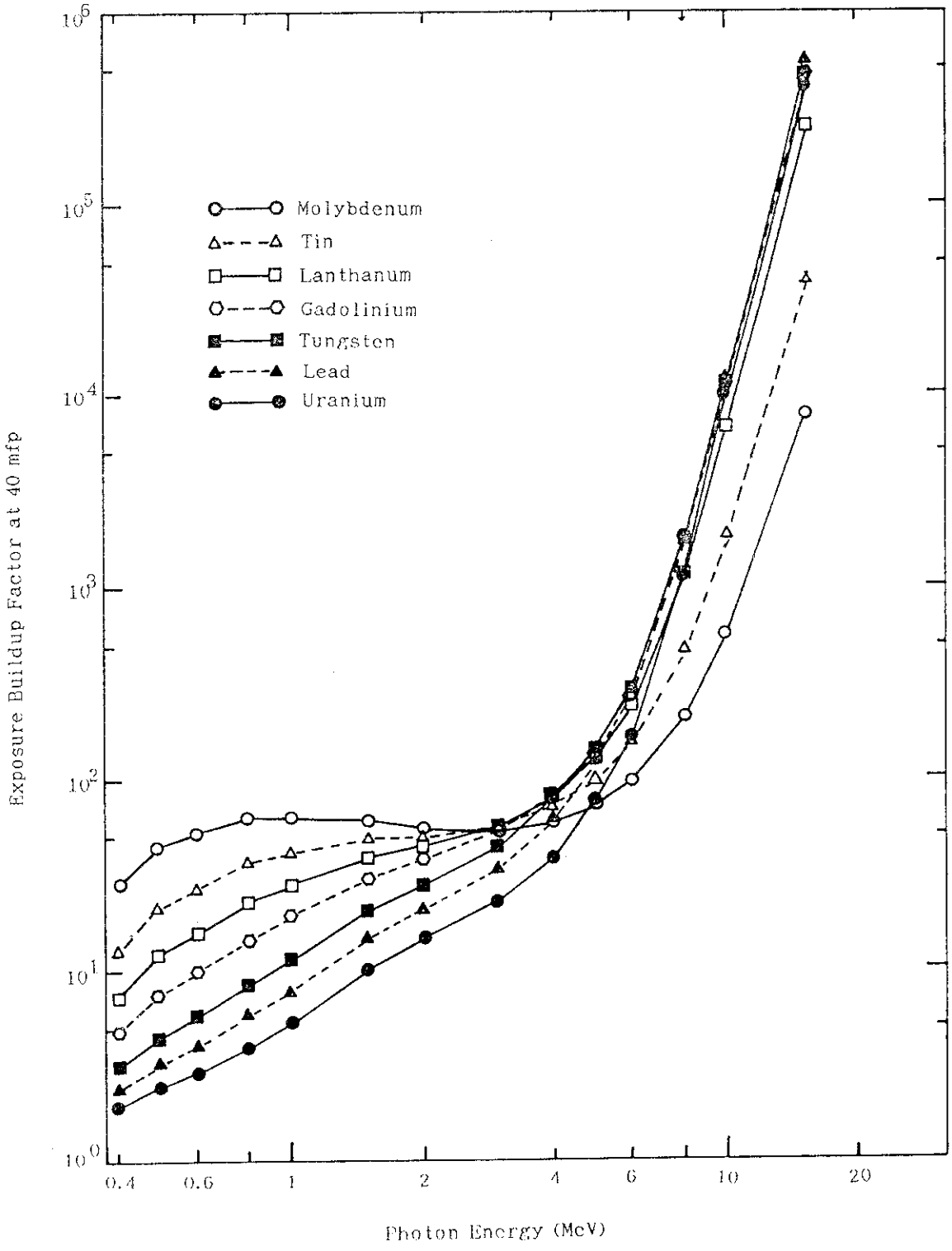

Fig.C.2 Comparison of exposure buildup factors at 40 mfp for each material.

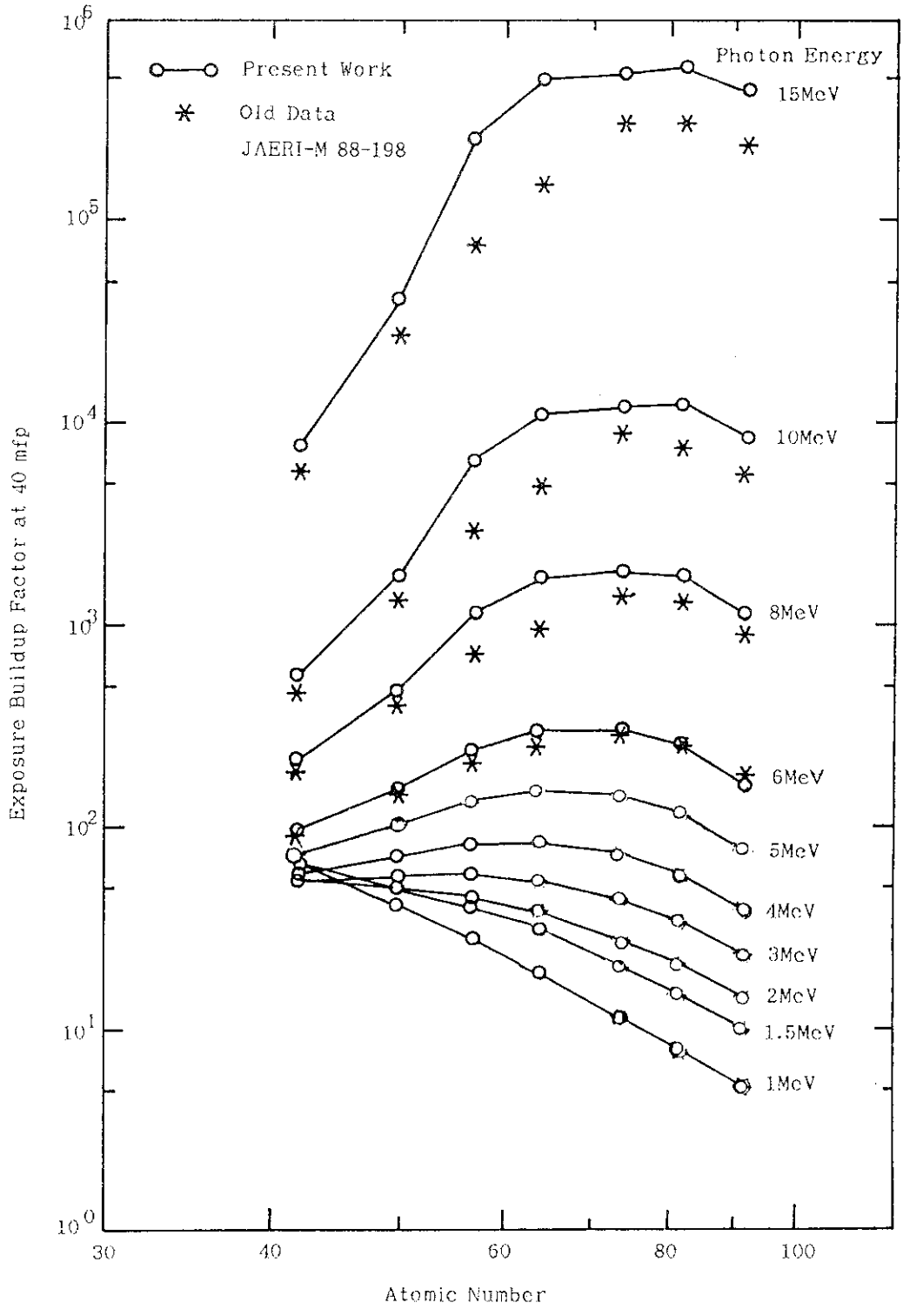

Fig.C.3 Comparison of exposure buildup factors at 40 mfp for various energies.
There is a large discrepancy between new and old buildup factors above 8 MeV.

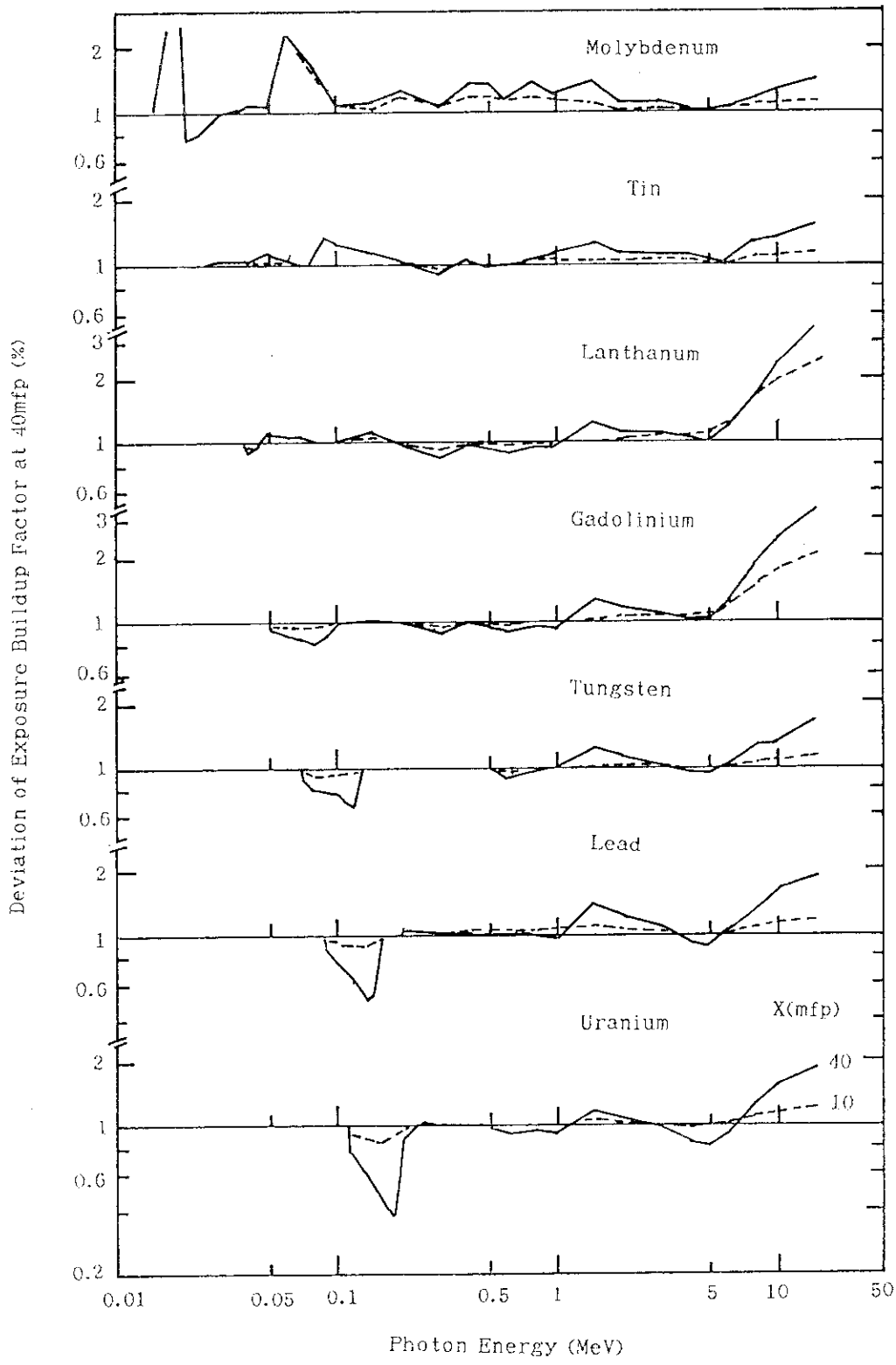

Fig.C.4 Comparison of exposure buildup factors at 10 and 40 mfp.
The ratio of new buildup factor of present work and old data listed in JAERI-M 88-198 is plotted about photon energy. There is a large difference between new and old buildup factors above 8 MeV and in the vicinity of K-edge.

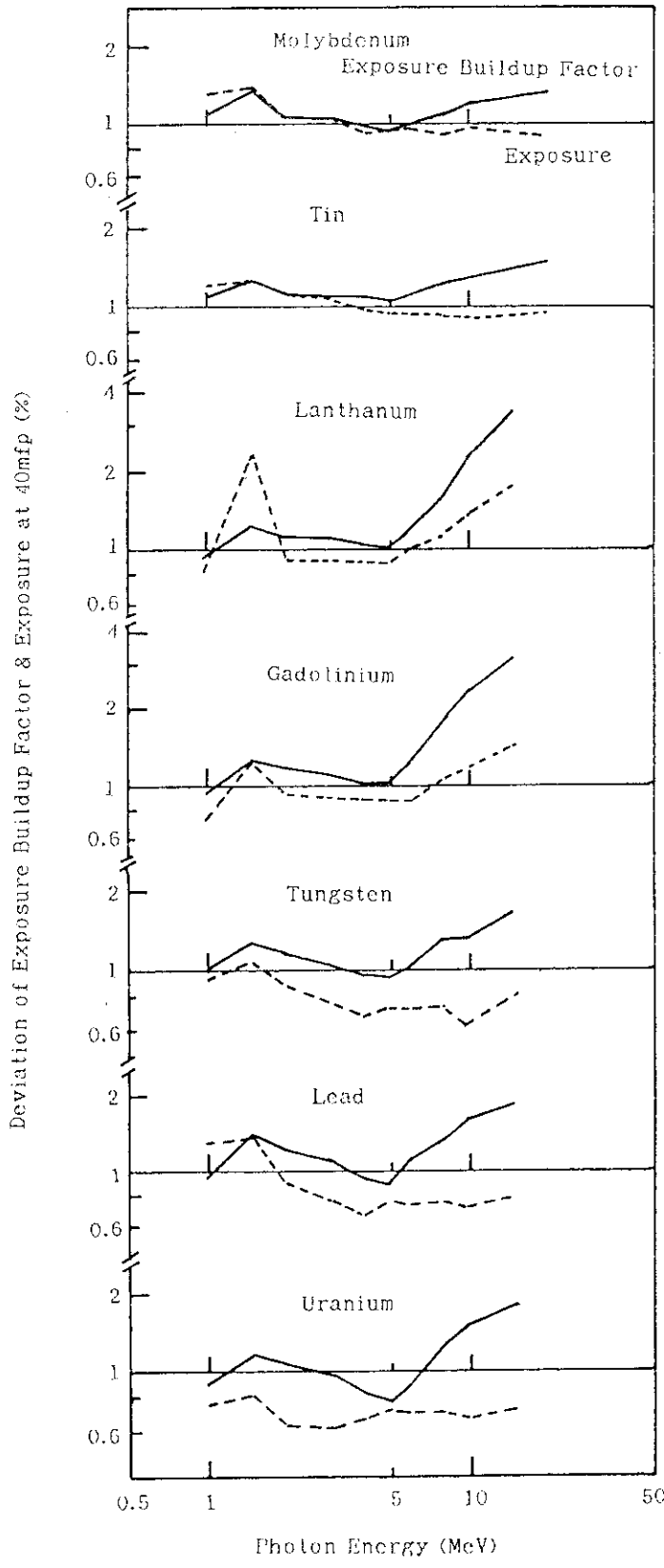

Fig.C.5 Comparison of exposure buildup factor and exposure at 40 mfp above 1 MeV.

The solid line represents the ratio of 40 mfp new and old buildup factor. The broken line represents the ratio of new and old exposure at 40 mfp using new attenutaion coefficient. The difference of exposure is smaller than that of exposure buildup factor.

Appendix D

GP Buildup Factor Coefficients Data

Material:

(1)Beryllium, (2)Boron, (3)Carbon, (4)Nitrogen, (5)Oxygen (6)Sodium, (7)Magnesium, (8)Aluminum, (9)Silicon, (10)Phosphorus, (11)Sulphur, (12)Argon, (13)Potassium, (14)Calcium, (15)Iron, (16)Copper, (17)Molybdenum, (18)Tin, (19)Lanthanum, (20)Gadolinium, (21)Tungsten, (22)Lead, (23)Uranium, (24)Water, (25)Concrete and (26)Air

Notation (unit)

E : Photon energy (MeV)

B, C, A, XK , D :GP buildup factor coefficients(B, c, a, Xk and d).

MAX.D :maximum deviation (%) from moments method results or PALLAS's ones for $0 \leqq X \leqq 40$mfp.

XMAX :source-detector distance (mfp) where maximum deviation appeared.

S.D :standard deviation (%) of 16 data from moments method results or PALLAS's ones for $0 \leqq X \leqq 40$mfp.

(1)Beryllium

BERYLLIUM MEDIUM, BERYLLIUM RESPONSE

E(MEV)	B	C	A	XK	D	MAX.D	XMAX	S.D
0.015	2.597	0.964	0.020	12.81	-0.0195	2.76%	0.5	1.234%
0.020	3.819	1.501	-0.086	16.20	0.0274	2.77%	0.5	0.869%
0.030	5.682	2.348	-0.190	14.96	0.0674	1.84%	15.0	1.153%
0.040	5.706	2.771	-0.222	14.91	0.0771	2.04%	15.0	1.289%
0.050	5.186	2.923	-0.229	15.43	0.0747	2.00%	15.0	1.126%
0.060	4.750	2.950	-0.227	16.03	0.0689	2.03%	0.5	0.971%
0.080	4.196	2.877	-0.217	17.74	0.0596	2.75%	0.5	1.034%
0.100	3.842	2.783	-0.210	19.63	0.0630	2.56%	0.5	1.019%
0.150	3.212	2.600	-0.199	19.35	0.0582	1.58%	0.5	0.660%
0.200	3.098	2.416	-0.189	17.56	0.0573	1.71%	0.5	0.625%
0.300	2.722	2.183	-0.175	15.88	0.0592	1.47%	15.0	0.807%
0.400	2.519	2.060	-0.168	15.38	0.0640	2.88%	0.5	1.251%
0.500	2.395	1.912	-0.154	14.75	0.0605	2.20%	15.0	1.160%
0.600	2.287	1.810	-0.144	14.46	0.0619	2.26%	15.0	1.300%
0.800	2.159	1.632	-0.121	13.99	0.0528	1.74%	25.0	1.176%
1.000	2.081	1.491	-0.099	14.06	0.0439	1.51%	1.0	1.016%
1.500	1.933	1.296	-0.065	13.59	0.0291	1.49%	0.5	0.758%
2.000	1.837	1.182	-0.042	13.81	0.0193	1.30%	0.5	0.622%
3.000	1.712	1.060	-0.015	13.20	0.0073	0.74%	0.5	0.298%
4.000	1.639	0.978	0.006	13.80	-0.0039	0.89%	0.5	0.316%
5.000	1.575	0.941	0.015	13.97	-0.0071	0.39%	2.0	0.196%
6.000	1.535	0.897	0.028	13.94	-0.0143	0.49%	25.0	0.304%
8.000	1.455	0.869	0.036	10.77	-0.0140	0.58%	30.0	0.287%
10.000	1.405	0.842	0.044	13.44	-0.0218	0.64%	35.0	0.371%
15.000	1.313	0.818	0.051	13.60	-0.0256	1.21%	0.5	0.474%

BERYLLIUM MEDIUM, AIR RESPONSE

E(MEV)	B	C	A	XK	D	MAX.D	XMAX	S.D
0.015	2.527	0.957	0.023	12.01	-0.0216	3.01%	0.5	1.237%
0.020	3.834	1.517	-0.089	16.27	0.0300	2.25%	0.5	0.788%
0.030	6.543	2.464	-0.204	14.71	0.0774	2.52%	25.0	1.471%
0.040	8.672	3.150	-0.260	14.20	0.1068	3.59%	10.0	2.348%
0.050	9.770	3.613	-0.292	14.02	0.1238	4.49%	10.0	2.847%
0.060	9.823	3.916	-0.311	13.93	0.1334	4.85%	10.0	3.133%
0.080	8.582	4.200	-0.328	14.01	0.1398	4.98%	25.0	3.145%
0.100	7.303	4.252	-0.333	14.11	0.1406	4.64%	25.0	2.996%
0.150	4.983	4.136	-0.331	14.43	0.1391	4.28%	35.0	2.596%
0.200	4.396	3.877	-0.323	14.44	0.1425	4.45%	35.0	2.612%
0.300	3.448	3.442	-0.304	14.20	0.1422	4.80%	25.0	2.833%
0.400	3.218	3.046	-0.280	14.18	0.1370	4.37%	15.0	2.652%
0.500	2.793	2.934	-0.281	13.44	0.1494	5.92%	35.0	3.826%
0.600	2.654	2.672	-0.261	13.20	0.1435	5.82%	10.0	3.747%
0.800	2.505	2.225	-0.215	13.24	0.1211	6.14%	1.0	3.848%
1.000	2.330	1.997	-0.190	12.98	0.1115	7.37%	1.0	4.366%
1.500	2.150	1.549	-0.122	13.00	0.0757	6.41%	0.5	3.260%
2.000	2.061	1.284	-0.069	13.26	0.0434	4.27%	0.5	1.857%
3.000	1.863	1.087	-0.024	13.06	0.0168	2.95%	0.5	1.072%
4.000	1.740	0.986	0.002	9.42	0.0022	1.59%	0.5	0.593%
5.000	1.641	0.932	0.017	17.21	-0.0085	1.30%	0.5	0.487%
6.000	1.584	0.886	0.031	14.51	-0.0159	0.96%	0.5	0.450%
8.000	1.480	0.851	0.041	14.63	-0.0207	0.69%	25.0	0.393%
10.000	1.437	0.772	0.071	14.24	-0.0469	3.49%	0.5	1.311%
15.000	1.306	0.802	0.057	12.34	-0.0247	0.83%	35.0	0.445%

(2)Boron

BORON MEDIUM, BORON RESPONSE

E(MEV)	B	C	A	XK	D	MAX.D	XMAX	S.D
0.015	1.752	0.678	0.097	15.02	-0.0473	2.16%	0.5	0.813%
0.020	2.694	0.953	0.023	15.10	-0.0242	2.59%	0.5	1.018%
0.030	4.721	1.627	-0.110	14.85	0.0449	1.31%	15.0	0.705%
0.040	5.549	2.219	-0.182	14.33	0.0778	2.46%	35.0	1.455%
0.050	5.727	2.489	-0.204	14.75	0.0837	2.43%	15.0	1.228%
0.060	5.340	2.667	-0.218	14.84	0.0878	2.40%	15.0	1.140%
0.080	4.566	2.791	-0.226	14.99	0.0860	2.05%	15.0	1.065%
0.100	4.037	2.781	-0.224	15.38	0.0818	1.92%	15.0	0.989%
0.150	3.648	2.431	-0.189	17.16	0.0543	7.34%	3.0	3.542%
0.200	3.253	2.328	-0.183	17.94	0.0629	6.91%	3.0	3.361%
0.300	2.723	2.212	-0.183	15.15	0.0714	2.54%	3.0	1.109%
0.400	2.533	2.027	-0.167	14.34	0.0653	2.02%	15.0	1.129%
0.500	2.430	1.860	-0.148	14.53	0.0607	2.02%	15.0	1.062%
0.600	2.358	1.720	-0.129	14.73	0.0510	2.14%	2.0	1.067%
0.800	2.186	1.588	-0.113	14.15	0.0485	1.86%	25.0	1.030%
1.000	2.086	1.475	-0.096	13.96	0.0419	1.76%	1.0	1.118%
1.500	1.935	1.285	-0.062	14.35	0.0279	1.65%	0.5	0.798%
2.000	1.833	1.183	-0.042	14.13	0.0192	1.16%	0.5	0.572%
3.000	1.715	1.054	-0.013	12.91	0.0054	0.90%	0.5	0.292%
4.000	1.630	0.986	0.004	14.96	-0.0035	0.48%	0.5	0.186%
5.000	1.571	0.938	0.017	13.83	-0.0100	0.57%	1.0	0.233%
6.000	1.525	0.903	0.027	13.17	-0.0144	0.75%	0.5	0.329%
8.000	1.451	0.856	0.043	11.15	-0.0230	0.59%	20.0	0.316%
10.000	1.389	0.856	0.040	14.51	-0.0208	0.79%	1.0	0.395%
15.000	1.295	0.834	0.047	14.05	-0.0265	1.25%	0.5	0.516%

BORON MEDIUM, AIR RESPONSE

E(MEV)	B	C	A	XK	D	MAX.D	XMAX	S.D
0.015	1.728	0.683	0.095	15.02	-0.0460	1.78%	0.5	0.740%
0.020	2.629	0.959	0.021	13.74	-0.0179	2.87%	0.5	1.125%
0.030	4.699	1.665	-0.117	14.48	0.0497	1.44%	35.0	0.854%
0.040	6.906	2.243	-0.184	14.61	0.0788	2.32%	35.0	1.257%
0.050	8.247	2.657	-0.223	14.47	0.0972	2.83%	25.0	1.611%
0.060	8.580	2.947	-0.247	14.36	0.1080	3.27%	15.0	1.842%
0.080	8.089	3.170	-0.262	14.66	0.1119	2.83%	15.0	1.645%
0.100	8.262	2.951	-0.238	16.05	0.0956	1.77%	3.0	1.043%
0.150	5.943	3.081	-0.256	15.38	0.1057	0.0 %	0.0	0.0 %
0.200	3.927	3.222	-0.279	14.14	0.1225	3.73%	15.0	2.159%
0.300	3.156	2.928	-0.265	13.98	0.1270	5.20%	1.0	2.668%
0.400	2.862	2.630	-0.245	12.58	0.1109	3.08%	10.0	2.092%
0.500	2.679	2.375	-0.222	12.68	0.1043	3.44%	1.0	2.261%
0.600	2.547	2.161	-0.198	13.69	0.1020	4.06%	10.0	2.710%
0.800	2.359	1.894	-0.167	13.38	0.0876	4.38%	1.0	2.824%
1.000	2.258	1.674	-0.135	13.53	0.0718	3.65%	0.5	2.392%
1.500	2.075	1.372	-0.083	13.78	0.0470	3.29%	0.5	1.539%
2.000	1.955	1.213	-0.050	14.44	0.0278	2.86%	0.5	1.202%
3.000	1.785	1.069	-0.018	12.74	0.0106	1.82%	0.5	0.638%
4.000	1.684	0.978	0.006	17.12	-0.0045	1.07%	0.5	0.342%
5.000	1.599	0.933	0.018	14.95	-0.0099	0.70%	2.0	0.275%
6.000	1.541	0.904	0.026	14.92	-0.0142	0.58%	1.0	0.260%
8.000	1.447	0.873	0.035	14.16	-0.0200	0.75%	35.0	0.332%
10.000	1.383	0.853	0.041	13.43	-0.0179	0.79%	0.5	0.369%
15.000	1.286	0.830	0.048	14.00	-0.0243	1.08%	1.0	0.469%

(3)Carbon

CARBON MEDIUM, CARBON RESPONSE

E(MEV)	B	C	A	XK	D	MAX.D	XMAX	S.D
0.015	1.398	0.526	0.153	14.42	-0.0777	1.92%	0.5	0.819%
0.020	1.900	0.739	0.076	16.46	-0.0363	0.74%	25.0	0.327%
0.030	3.725	1.153	-0.027	12.57	0.0085	0.96%	0.5	0.373%
0.040	5.068	1.735	-0.127	14.10	0.0554	1.91%	15.0	1.207%
0.050	5.594	2.066	-0.164	14.48	0.0692	2.68%	2.0	1.395%
0.060	5.424	2.287	-0.186	14.66	0.0790	2.17%	25.0	1.300%
0.080	4.862	2.488	-0.204	14.81	0.0832	2.38%	15.0	1.307%
0.100	4.305	2.548	-0.209	14.88	0.0834	2.34%	15.0	1.197%
0.150	3.523	2.491	-0.205	14.96	0.0796	1.90%	15.0	1.028%
0.200	3.173	2.365	-0.196	14.77	0.0757	1.95%	15.0	0.989%
0.300	2.797	2.129	-0.175	14.96	0.0694	2.62%	35.0	1.397%
0.400	2.629	1.925	-0.153	14.84	0.0631	1.64%	35.0	0.904%
0.500	2.456	1.801	-0.138	16.05	0.0618	2.75%	2.0	1.200%
0.600	2.399	1.663	-0.119	14.98	0.0457	1.15%	2.0	0.650%
0.800	2.198	1.563	-0.109	14.09	0.0461	1.76%	1.0	1.105%
1.000	2.087	1.461	-0.093	14.20	0.0406	2.31%	0.5	1.149%
1.500	1.941	1.275	-0.060	14.29	0.0266	1.92%	0.5	0.809%
2.000	1.843	1.167	-0.037	14.53	0.0143	1.63%	0.5	0.596%
3.000	1.715	1.050	-0.011	14.52	0.0027	0.93%	0.5	0.285%
4.000	1.626	0.990	0.003	12.82	-0.0020	0.57%	2.0	0.262%
5.000	1.564	0.947	0.014	15.05	-0.0068	0.49%	5.0	0.271%
6.000	1.519	0.900	0.030	12.35	-0.0186	1.73%	0.5	0.607%
8.000	1.430	0.884	0.033	12.11	-0.0158	0.69%	1.0	0.359%
10.000	1.378	0.859	0.040	14.32	-0.0221	1.03%	0.5	0.500%
15.000	1.283	0.838	0.047	15.91	-0.0324	0.96%	0.5	0.512%

CARBON MEDIUM, AIR RESPONSE

E(MEV)	B	C	A	XK	D	MAX.D	XMAX	S.D
0.015	1.386	0.539	0.146	14.31	-0.0718	1.81%	0.5	0.692%
0.020	1.877	0.732	0.079	16.57	-0.0395	0.77%	0.5	0.411%
0.030	3.511	1.153	-0.027	12.82	0.0087	0.84%	2.0	0.399%
0.040	5.260	1.745	-0.129	13.91	0.0571	2.28%	35.0	1.397%
0.050	6.706	2.108	-0.170	14.34	0.0735	2.96%	2.0	1.506%
0.060	7.209	2.383	-0.198	14.53	0.0878	2.66%	15.0	1.551%
0.080	6.765	2.691	-0.227	14.44	0.0998	3.28%	15.0	1.834%
0.100	5.890	2.824	-0.239	14.40	0.1046	3.32%	15.0	1.784%
0.150	4.381	2.866	-0.246	14.14	0.1067	3.22%	15.0	1.856%
0.200	3.750	2.698	-0.233	15.08	0.1060	4.12%	35.0	2.212%
0.300	3.147	2.413	-0.211	14.41	0.0944	4.33%	3.0	1.973%
0.400	2.843	2.197	-0.192	13.47	0.0805	3.04%	2.0	1.664%
0.500	2.657	2.011	-0.171	14.19	0.0795	4.22%	2.0	1.885%
0.600	2.543	1.851	-0.151	13.60	0.0610	4.40%	2.0	1.971%
0.800	2.312	1.691	-0.133	13.80	0.0643	2.76%	1.0	1.814%
1.000	2.192	1.544	-0.110	13.78	0.0533	2.91%	1.0	1.654%
1.500	2.011	1.311	-0.069	13.69	0.0332	2.47%	0.5	1.140%
2.000	1.898	1.192	-0.044	13.99	0.0206	1.85%	0.5	0.739%
3.000	1.752	1.058	-0.014	11.98	0.0060	1.47%	0.5	0.468%
4.000	1.653	0.986	0.004	25.64	-0.0080	0.60%	0.5	0.302%
5.000	1.575	0.939	0.017	14.50	-0.0109	0.85%	35.0	0.313%
6.000	1.525	0.908	0.026	14.36	-0.0149	0.97%	1.0	0.380%
8.000	1.440	0.868	0.038	17.08	-0.0351	0.69%	1.0	0.402%
10.000	1.373	0.855	0.042	12.35	-0.0208	0.63%	4.0	0.351%
15.000	1.276	0.841	0.046	15.27	-0.0296	1.29%	0.5	0.614%

(4)Nitrogen

NITROGEN MEDIUM, NITROGEN RESPONSE

E(MEV)	B	C	A	XK	D	MAX.D	XMAX	S.D
0.015	1.236	0.485	0.163	14.57	-0.0784	1.52%	0.5	0.646%
0.020	1.559	0.578	0.134	14.90	-0.0661	1.93%	0.5	0.753%
0.030	2.712	0.843	0.052	16.05	-0.0373	2.05%	0.5	0.809%
0.040	3.984	1.272	-0.051	13.80	0.0170	0.82%	5.0	0.457%
0.050	4.894	1.630	-0.111	13.96	0.0473	1.78%	10.0	1.095%
0.060	5.144	1.919	-0.151	13.77	0.0689	2.96%	35.0	1.732%
0.080	4.913	2.225	-0.186	13.43	0.0824	2.80%	25.0	1.867%
0.100	4.661	2.248	-0.183	14.48	0.0770	2.62%	15.0	1.454%
0.150	3.749	2.299	-0.189	14.41	0.0764	2.64%	35.0	1.472%
0.200	3.365	2.195	-0.179	14.80	0.0761	2.28%	1.0	1.188%
0.300	2.841	2.056	-0.168	14.21	0.0668	2.53%	25.0	1.404%
0.400	2.620	1.898	-0.151	14.21	0.0602	2.10%	35.0	1.282%
0.500	2.462	1.785	-0.138	14.12	0.0555	1.96%	35.0	1.206%
0.600	2.363	1.680	-0.124	14.24	0.0499	1.85%	1.0	1.167%
0.800	2.202	1.544	-0.105	14.20	0.0434	1.94%	1.0	1.138%
1.000	2.108	1.429	-0.086	14.72	0.0355	1.84%	1.0	0.949%
1.500	1.931	1.277	-0.060	14.38	0.0261	1.58%	0.5	0.725%
2.000	1.835	1.176	-0.040	13.95	0.0172	1.28%	0.5	0.490%
3.000	1.708	1.057	-0.013	12.50	0.0042	0.62%	0.5	0.262%
4.000	1.629	0.980	0.007	14.32	-0.0070	0.49%	0.5	0.227%
5.000	1.567	0.931	0.021	13.51	-0.0148	0.68%	25.0	0.353%
6.000	1.495	0.935	0.018	17.14	-0.0156	0.65%	30.0	0.274%
8.000	1.430	0.869	0.040	12.04	-0.0237	0.68%	3.0	0.329%
10.000	1.364	0.870	0.038	14.33	-0.0223	1.16%	1.0	0.507%
15.000	1.272	0.839	0.049	15.00	-0.0355	1.46%	0.5	0.645%

NITROGEN MEDIUM, AIR RESPONSE

E(MEV)	B	C	A	XK	D	MAX.D	XMAX	S.D
0.015	1.234	0.475	0.171	14.27	-0.0858	1.56%	0.5	0.677%
0.020	1.543	0.586	0.130	15.00	-0.0632	1.97%	0.5	0.762%
0.030	2.621	0.842	0.053	15.71	-0.0398	1.97%	0.5	0.831%
0.040	3.945	1.279	-0.053	13.58	0.0191	0.86%	25.0	0.490%
0.050	5.039	1.640	-0.113	13.85	0.0489	1.60%	25.0	1.099%
0.060	5.510	1.937	-0.154	13.68	0.0714	2.81%	0.5	1.892%
0.080	5.432	2.283	-0.194	13.30	0.0892	3.31%	35.0	2.192%
0.100	5.208	2.311	-0.191	14.39	0.0825	2.88%	15.0	1.572%
0.150	3.970	2.453	-0.209	14.11	0.0943	3.41%	35.0	1.982%
0.200	3.395	2.408	-0.208	13.32	0.0891	3.19%	1.0	2.001%
0.300	2.962	2.142	-0.180	14.06	0.0755	2.66%	25.0	1.645%
0.400	2.700	1.976	-0.163	14.05	0.0690	2.47%	35.0	1.626%
0.500	2.538	1.835	-0.146	14.13	0.0612	2.34%	1.0	1.499%
0.600	2.406	1.737	-0.134	14.11	0.0572	2.16%	10.0	1.434%
0.800	2.241	1.580	-0.112	14.03	0.0484	1.86%	1.0	1.326%
1.000	2.123	1.474	-0.096	13.97	0.0426	3.56%	1.0	1.417%
1.500	1.968	1.270	-0.058	14.81	0.0246	2.13%	0.5	0.806%
2.000	1.858	1.176	-0.040	13.95	0.0175	1.34%	0.5	0.575%
3.000	1.718	1.061	-0.014	13.95	0.0047	0.96%	0.5	0.343%
4.000	1.631	0.989	0.004	15.65	-0.0044	0.58%	2.0	0.275%
5.000	1.562	0.940	0.018	13.58	-0.0128	0.51%	1.0	0.260%
6.000	1.517	0.901	0.030	12.46	-0.0186	1.05%	0.5	0.488%
8.000	1.423	0.887	0.033	11.67	-0.0159	0.89%	0.5	0.463%
10.000	1.361	0.873	0.037	14.21	-0.0221	1.38%	1.0	0.521%
15.000	1.271	0.841	0.048	15.04	-0.0339	1.51%	0.5	0.710%

(5)Oxygen

OXYGEN MEDIUM, OXYGEN RESPONSE

E(MEV)	B	C	A	XK	D	MAX.D	XMAX	S.D
0.015	1.154	0.425	0.198	13.15	-0.1036	1.28%	0.5	0.538%
0.020	1.361	0.502	0.164	14.47	-0.0845	1.91%	0.5	0.784%
0.030	2.173	0.657	0.116	11.54	-0.0467	2.95%	0.5	1.256%
0.040	3.219	0.990	0.012	13.23	-0.0133	1.19%	0.5	0.385%
0.050	4.168	1.313	-0.058	13.41	0.0204	1.01%	35.0	0.610%
0.060	4.739	1.577	-0.103	13.67	0.0436	1.93%	35.0	1.215%
0.080	4.943	1.912	-0.150	13.71	0.0674	2.85%	10.0	1.865%
0.100	4.628	2.082	-0.170	13.71	0.0770	2.93%	35.0	1.926%
0.150	3.921	2.118	-0.170	14.40	0.0691	2.53%	15.0	1.465%
0.200	3.365	2.126	-0.174	13.98	0.0714	2.58%	35.0	1.568%
0.300	2.901	1.974	-0.158	14.10	0.0623	2.37%	25.0	1.462%
0.400	2.650	1.846	-0.144	14.09	0.0569	1.92%	1.0	1.303%
0.500	2.479	1.746	-0.132	14.28	0.0526	1.86%	10.0	1.206%
0.600	2.367	1.656	-0.120	14.31	0.0476	1.59%	35.0	1.135%
0.800	2.214	1.519	-0.100	14.38	0.0396	2.23%	0.5	1.137%
1.000	2.104	1.427	-0.086	14.20	0.0347	1.69%	0.5	0.882%
1.500	1.943	1.261	-0.056	14.31	0.0223	1.38%	0.5	0.614%
2.000	1.839	1.167	-0.037	14.62	0.0144	1.49%	0.5	0.468%
3.000	1.710	1.052	-0.011	14.36	0.0018	0.73%	0.5	0.241%
4.000	1.621	0.986	0.006	12.97	-0.0070	0.55%	1.0	0.251%
5.000	1.556	0.942	0.018	13.28	-0.0128	0.58%	35.0	0.345%
6.000	1.506	0.906	0.029	15.08	-0.0259	0.90%	3.0	0.509%
8.000	1.411	0.896	0.031	12.33	-0.0166	0.64%	0.5	0.329%
10.000	1.356	0.867	0.041	13.90	-0.0273	1.20%	0.5	0.588%
15.000	1.259	0.848	0.048	14.75	-0.0365	1.23%	0.5	0.696%

OXYGEN MEDIUM, AIR RESPONSE

E(MEV)	B	C	A	XK	D	MAX.D	XMAX	S.D
0.015	1.153	0.432	0.189	14.49	-0.0965	1.38%	0.5	0.519%
0.020	1.355	0.505	0.162	14.65	-0.0825	2.23%	0.5	0.804%
0.030	2.054	0.718	0.086	16.37	-0.0456	3.17%	0.5	1.147%
0.040	3.137	0.990	0.012	13.45	-0.0134	1.27%	0.5	0.412%
0.050	4.063	1.305	-0.056	13.54	0.0184	0.97%	4.0	0.590%
0.060	4.610	1.562	-0.100	13.75	0.0412	1.73%	0.5	1.177%
0.080	4.783	1.887	-0.146	13.73	0.0643	2.71%	35.0	1.754%
0.100	4.492	2.043	-0.164	13.85	0.0718	2.61%	25.0	1.781%
0.150	3.877	2.069	-0.163	14.48	0.0637	2.50%	2.0	1.380%
0.200	3.320	2.090	-0.169	14.03	0.0678	2.38%	25.0	1.446%
0.300	2.870	1.948	-0.154	14.20	0.0595	2.32%	25.0	1.344%
0.400	2.629	1.828	-0.141	14.19	0.0546	1.85%	10.0	1.165%
0.500	2.475	1.723	-0.128	14.20	0.0488	1.85%	1.0	1.146%
0.600	2.362	1.635	-0.116	14.32	0.0439	1.81%	1.0	1.056%
0.800	2.185	1.532	-0.103	14.24	0.0427	1.95%	0.5	1.174%
1.000	2.098	1.418	-0.084	14.35	0.0333	1.58%	0.5	0.829%
1.500	1.929	1.265	-0.057	14.45	0.0235	1.61%	0.5	0.633%
2.000	1.837	1.164	-0.036	15.40	0.0137	1.45%	0.5	0.483%
3.000	1.711	1.052	-0.011	12.88	0.0020	0.77%	0.5	0.247%
4.000	1.624	0.990	0.004	20.49	-0.0070	0.55%	4.0	0.297%
5.000	1.553	0.947	0.016	14.42	-0.0111	0.70%	0.5	0.379%
6.000	1.505	0.917	0.025	15.64	-0.0229	0.99%	1.0	0.467%
8.000	1.417	0.891	0.033	12.30	-0.0194	1.16%	0.5	0.467%
10.000	1.358	0.872	0.039	13.99	-0.0252	1.14%	0.5	0.542%
15.000	1.265	0.842	0.050	15.03	-0.0387	1.19%	3.0	0.728%

(6)Sodium

SODIUM MEDIUM, SODIUM RESPONSE

E(MEV)	B	C	A	XK	D	MAX.D	XMAX	S.D
0.015	1.051	0.409	0.197	11.44	-0.0913	0.78%	0.5	0.267%
0.020	1.121	0.410	0.202	14.55	-0.1108	1.31%	0.5	0.464%
0.030	1.401	0.472	0.180	14.69	-0.0944	2.07%	0.5	0.757%
0.040	1.849	0.629	0.114	16.17	-0.0596	1.35%	2.0	0.566%
0.050	2.535	0.737	0.088	14.98	-0.0626	2.26%	0.5	1.051%
0.060	3.171	0.922	0.033	14.39	-0.0303	1.23%	0.5	0.557%
0.080	4.169	1.220	-0.038	11.66	0.0065	1.44%	0.5	0.567%
0.100	4.509	1.444	-0.079	13.36	0.0260	2.39%	0.5	1.110%
0.150	4.045	1.730	-0.124	13.53	0.0491	2.84%	0.5	1.686%
0.200	3.614	1.784	-0.131	13.78	0.0503	2.97%	0.5	1.587%
0.300	3.024	1.769	-0.130	13.87	0.0478	2.03%	10.0	1.397%
0.400	2.721	1.702	-0.122	14.15	0.0440	1.80%	10.0	1.206%
0.500	2.538	1.635	-0.114	14.25	0.0410	1.84%	0.5	1.065%
0.600	2.402	1.569	-0.104	14.56	0.0366	1.89%	0.5	0.958%
0.800	2.227	1.469	-0.090	14.86	0.0327	1.66%	0.5	0.833%
1.000	2.112	1.387	-0.077	14.85	0.0282	1.57%	0.5	0.697%
1.500	1.936	1.253	-0.054	14.28	0.0205	1.22%	0.5	0.505%
2.000	1.845	1.154	-0.034	14.75	0.0125	1.07%	0.5	0.379%
3.000	1.706	1.050	-0.009	10.63	-0.0012	0.61%	0.5	0.215%
4.000	1.614	0.983	0.009	13.16	-0.0120	0.63%	35.0	0.323%
5.000	1.542	0.946	0.019	12.67	-0.0150	1.15%	1.0	0.589%
6.000	1.479	0.929	0.024	15.97	-0.0271	1.20%	0.5	0.536%
8.000	1.388	0.903	0.033	12.28	-0.0233	0.86%	1.0	0.472%
10.000	1.324	0.894	0.036	13.93	-0.0286	1.19%	1.0	0.619%
15.000	1.225	0.892	0.038	14.72	-0.0327	2.07%	0.5	0.768%

SODIUM MEDIUM, AIR RESPONSE

E(MEV)	B	C	A	XK	D	MAX.D	XMAX	S.D
0.015	1.052	0.379	0.223	11.69	-0.1146	0.66%	0.5	0.279%
0.020	1.122	0.398	0.212	13.54	-0.1140	1.20%	0.5	0.432%
0.030	1.388	0.480	0.176	14.60	-0.0921	1.99%	0.5	0.765%
0.040	1.779	0.662	0.099	16.41	-0.0479	2.05%	2.0	0.747%
0.050	2.394	0.740	0.087	14.31	-0.0552	2.23%	0.5	1.153%
0.060	2.836	0.910	0.038	13.27	-0.0339	1.23%	0.5	0.609%
0.080	3.300	1.183	-0.028	13.57	-0.0025	0.30%	1.0	0.141%
0.100	3.388	1.368	-0.062	14.35	0.0115	0.83%	4.0	0.394%
0.150	3.190	1.575	-0.095	14.71	0.0260	0.95%	1.0	0.621%
0.200	2.968	1.627	-0.103	14.63	0.0281	0.95%	1.0	0.550%
0.300	2.658	1.633	-0.106	14.12	0.0279	0.73%	25.0	0.485%
0.400	2.481	1.587	-0.101	15.09	0.0285	0.98%	15.0	0.559%
0.500	2.350	1.548	-0.098	14.86	0.0307	1.02%	25.0	0.542%
0.600	2.253	1.498	-0.090	15.42	0.0264	0.89%	0.5	0.496%
0.800	2.117	1.421	-0.080	15.18	0.0250	0.89%	25.0	0.464%
1.000	2.023	1.356	-0.070	15.70	0.0234	0.65%	1.0	0.346%
1.500	1.879	1.234	-0.049	15.21	0.0168	0.91%	0.5	0.331%
2.000	1.795	1.154	-0.034	14.43	0.0122	0.80%	0.5	0.332%
3.000	1.684	1.056	-0.011	10.47	0.0009	0.50%	0.5	0.214%
4.000	1.606	0.992	0.006	12.86	-0.0089	0.54%	3.0	0.326%
5.000	1.536	0.956	0.016	15.20	-0.0205	0.70%	25.0	0.383%
6.000	1.494	0.914	0.031	11.38	-0.0247	0.54%	8.0	0.345%
8.000	1.406	0.902	0.033	13.53	-0.0260	0.99%	1.0	0.657%
10.000	1.347	0.876	0.043	13.19	-0.0335	1.62%	0.5	0.735%
15.000	1.263	0.823	0.064	14.35	-0.0562	1.79%	3.0	1.064%

(7)Magnesium

MAGNESIUM MEDIUM, MAGNESIUM RESPONSE

E(MEV)	B	C	A	XK	D	MAX.D	XMAX	S.D
0.015	1.037	0.401	0.211	13.33	-0.1332	0.65%	0.5	0.330%
0.020	1.087	0.426	0.185	14.50	-0.0945	0.57%	0.5	0.331%
0.030	1.294	0.445	0.191	14.26	-0.1008	1.58%	0.5	0.655%
0.040	1.644	0.557	0.142	15.31	-0.0745	0.97%	0.5	0.517%
0.050	2.216	0.623	0.130	13.60	-0.0692	2.70%	0.5	1.395%
0.060	2.778	0.780	0.077	13.14	-0.0522	1.71%	0.5	0.904%
0.080	3.778	1.058	-0.001	14.35	-0.0150	0.44%	15.0	0.239%
0.100	4.260	1.285	-0.049	12.62	0.0081	1.79%	0.5	0.731%
0.150	4.099	1.591	-0.103	13.28	0.0364	3.22%	0.5	1.461%
0.200	3.649	1.684	-0.116	13.69	0.0411	3.24%	0.5	1.540%
0.300	3.056	1.704	-0.120	14.17	0.0423	2.23%	0.5	1.327%
0.400	2.751	1.649	-0.113	14.51	0.0377	2.32%	0.5	1.119%
0.500	2.552	1.597	-0.107	14.44	0.0365	1.92%	0.5	0.976%
0.600	2.416	1.544	-0.100	14.58	0.0343	1.84%	0.5	0.876%
0.800	2.238	1.449	-0.086	14.82	0.0299	1.48%	0.5	0.749%
1.000	2.115	1.378	-0.075	15.12	0.0268	1.74%	0.5	0.705%
1.500	1.940	1.249	-0.053	14.51	0.0202	1.38%	0.5	0.497%
2.000	1.834	1.165	-0.036	14.42	0.0130	0.65%	2.0	0.304%
3.000	1.696	1.061	-0.012	14.79	0.0004	0.48%	2.0	0.180%
4.000	1.607	0.992	0.006	14.46	-0.0093	0.80%	1.0	0.345%
5.000	1.549	0.922	0.029	13.02	-0.0274	2.18%	0.5	0.917%
6.000	1.474	0.929	0.025	15.42	-0.0285	0.79%	3.0	0.519%
8.000	1.380	0.909	0.032	11.96	-0.0231	1.19%	0.5	0.522%
10.000	1.309	0.918	0.029	14.57	-0.0249	1.82%	0.5	0.754%
15.000	1.231	0.844	0.058	14.16	-0.0516	1.77%	4.0	0.970%

MAGNESIUM MEDIUM, AIR RESPONSE

E(MEV)	B	C	A	XK	D	MAX.D	XMAX	S.D
0.015	1.037	0.401	0.211	13.33	-0.1332	0.65%	0.5	0.330%
0.020	1.085	0.439	0.178	14.34	-0.0910	0.72%	0.5	0.379%
0.030	1.288	0.449	0.189	14.38	-0.1020	1.92%	0.5	0.756%
0.040	1.617	0.557	0.143	15.17	-0.0757	1.39%	0.5	0.632%
0.050	2.099	0.633	0.125	14.15	-0.0657	2.77%	0.5	1.542%
0.060	2.467	0.794	0.071	14.91	-0.0563	2.47%	0.5	1.088%
0.080	2.950	1.039	0.005	13.70	-0.0201	0.72%	10.0	0.454%
0.100	3.102	1.229	-0.035	12.29	-0.0037	0.49%	6.0	0.202%
0.150	3.032	1.454	-0.075	15.08	0.0138	0.73%	1.0	0.314%
0.200	2.856	1.537	-0.088	15.99	0.0200	0.78%	4.0	0.411%
0.300	2.599	1.564	-0.094	15.96	0.0228	0.89%	15.0	0.373%
0.400	2.437	1.541	-0.093	15.45	0.0236	0.70%	1.0	0.332%
0.500	2.315	1.505	-0.089	16.00	0.0236	0.64%	15.0	0.284%
0.600	2.221	1.473	-0.086	15.28	0.0246	0.69%	35.0	0.291%
0.800	2.100	1.401	-0.076	15.64	0.0233	0.48%	1.0	0.247%
1.000	2.004	1.350	-0.069	15.69	0.0235	0.70%	15.0	0.330%
1.500	1.867	1.233	-0.049	14.52	0.0168	0.51%	0.5	0.292%
2.000	1.787	1.155	-0.033	16.11	0.0108	0.52%	0.5	0.248%
3.000	1.674	1.064	-0.013	16.49	0.0022	0.36%	1.0	0.150%
4.000	1.598	0.997	0.005	13.02	-0.0091	0.80%	0.5	0.382%
5.000	1.538	0.941	0.024	10.17	-0.0216	0.51%	30.0	0.338%
6.000	1.484	0.934	0.024	12.01	-0.0192	1.02%	0.5	0.447%
8.000	1.405	0.902	0.034	13.85	-0.0285	1.06%	1.0	0.684%
10.000	1.342	0.886	0.041	13.09	-0.0332	1.88%	0.5	0.828%
15.000	1.253	0.847	0.057	14.24	-0.0511	1.69%	4.0	1.093%

(8)Aluminum

ALUMINUM MEDIUM, ALUMINUM RESPONSE

E(MEV)	B	C	A	XK	D	MAX.D	XMAX	S.D
0.015	1.029	0.364	0.240	14.12	-0.1704	0.46%	25.0	0.236%
0.020	1.072	0.349	0.241	14.25	-0.1280	0.33%	8.0	0.168%
0.030	1.226	0.415	0.206	14.06	-0.1131	1.61%	0.5	0.690%
0.040	1.504	0.492	0.172	14.83	-0.0948	1.99%	0.5	0.750%
0.050	1.935	0.570	0.148	14.64	-0.0888	4.07%	0.5	1.411%
0.060	2.436	0.683	0.109	14.74	-0.0784	2.72%	0.5	1.314%
0.080	3.399	0.926	0.033	14.11	-0.0328	0.89%	35.0	0.541%
0.100	3.991	1.148	-0.020	13.53	-0.0085	0.84%	2.0	0.401%
0.150	4.141	1.441	-0.076	14.24	0.0185	1.99%	0.5	0.779%
0.200	3.690	1.585	-0.100	14.16	0.0316	3.23%	0.5	1.309%
0.300	3.101	1.636	-0.109	14.26	0.0349	2.83%	0.5	1.263%
0.400	2.791	1.593	-0.103	14.76	0.0306	1.05%	3.0	0.656%
0.500	2.609	1.528	-0.093	15.47	0.0249	2.47%	0.5	0.832%
0.600	2.428	1.521	-0.096	14.79	0.0322	1.73%	0.5	0.750%
0.800	2.237	1.439	-0.084	14.68	0.0284	1.53%	0.5	0.642%
1.000	2.119	1.368	-0.073	15.07	0.0257	1.26%	0.5	0.531%
1.500	1.940	1.245	-0.052	14.72	0.0196	1.41%	0.5	0.527%
2.000	1.835	1.160	-0.034	14.89	0.0107	0.69%	0.5	0.237%
3.000	1.694	1.059	-0.011	10.74	-0.0011	0.35%	1.0	0.179%
4.000	1.605	0.992	0.006	12.74	-0.0087	0.93%	1.0	0.444%
5.000	1.533	0.945	0.021	14.17	-0.0223	2.36%	1.0	0.782%
6.000	1.464	0.936	0.024	15.05	-0.0290	1.08%	1.0	0.525%
8.000	1.374	0.913	0.031	14.15	-0.0269	1.47%	0.5	0.721%
10.000	1.308	0.904	0.036	14.30	-0.0322	1.79%	0.5	0.797%
15.000	1.228	0.833	0.064	14.20	-0.0587	2.12%	3.0	1.186%

ALUMINUM MEDIUM, AIR RESPONSE

E(MEV)	B	C	A	XK	D	MAX.D	XMAX	S.D
0.015	1.029	0.394	0.206	15.51	-0.1388	0.45%	6.0	0.223%
0.020	1.067	0.384	0.220	13.81	-0.1204	0.71%	0.5	0.312%
0.030	1.223	0.422	0.198	15.10	-0.1042	1.83%	0.5	0.635%
0.040	1.480	0.503	0.166	14.78	-0.0893	1.72%	0.5	0.697%
0.050	1.765	0.666	0.099	16.34	-0.0493	2.10%	2.0	0.722%
0.060	2.189	0.697	0.104	12.90	-0.0580	3.00%	0.5	1.356%
0.080	2.640	0.924	0.035	12.99	-0.0351	1.54%	0.5	0.666%
0.100	2.847	1.110	-0.009	12.98	-0.0187	0.63%	0.5	0.413%
0.150	2.877	1.357	-0.058	21.73	0.0071	0.48%	4.0	0.243%
0.200	2.762	1.455	-0.074	17.02	0.0114	0.44%	1.0	0.196%
0.300	2.546	1.510	-0.085	16.22	0.0172	0.48%	4.0	0.215%
0.400	2.403	1.498	-0.085	16.45	0.0189	0.54%	1.0	0.237%
0.500	2.287	1.474	-0.083	16.41	0.0194	0.31%	1.0	0.181%
0.600	2.197	1.448	-0.081	17.03	0.0227	0.67%	15.0	0.293%
0.800	2.080	1.384	-0.072	16.24	0.0202	0.64%	0.5	0.283%
1.000	1.994	1.336	-0.066	15.85	0.0215	0.60%	6.0	0.282%
1.500	1.855	1.230	-0.048	16.01	0.0171	0.45%	15.0	0.226%
2.000	1.781	1.153	-0.032	15.32	0.0091	0.32%	0.5	0.142%
3.000	1.673	1.057	-0.010	10.79	-0.0025	0.42%	1.0	0.202%
4.000	1.607	0.974	0.013	12.22	-0.0164	1.05%	0.5	0.498%
5.000	1.529	0.957	0.018	10.90	-0.0157	0.92%	0.5	0.413%
6.000	1.481	0.933	0.026	12.33	-0.0239	1.13%	0.5	0.524%
8.000	1.396	0.917	0.030	13.88	-0.0262	1.37%	0.5	0.677%
10.000	1.334	0.902	0.038	13.03	-0.0332	1.48%	0.5	0.719%
15.000	1.244	0.869	0.050	14.91	-0.0476	1.97%	0.5	1.098%

(9)Silicon

SILICON MEDIUM, SILICON RESPONSE

E(MEV)	B	C	A	XK	D	MAX.D	XMAX	S.D
0.015	1.022	0.415	0.190	11.16	-0.0775	0.62%	0.5	0.288%
0.020	1.051	0.426	0.179	17.64	-0.1078	0.81%	0.5	0.298%
0.030	1.180	0.395	0.215	14.40	-0.1170	1.44%	0.5	0.588%
0.040	1.401	0.455	0.189	14.61	-0.1049	1.91%	0.5	0.760%
0.050	1.677	0.604	0.119	16.85	-0.0604	1.81%	2.0	0.694%
0.060	2.178	0.604	0.139	13.56	-0.0780	3.08%	0.5	1.521%
0.080	3.059	0.820	0.064	13.99	-0.0488	1.41%	10.0	0.887%
0.100	3.712	1.027	0.009	13.77	-0.0262	0.87%	4.0	0.514%
0.150	4.043	1.348	-0.060	13.94	0.0100	2.24%	0.5	0.798%
0.200	3.678	1.506	-0.087	14.36	0.0243	2.46%	0.5	1.120%
0.300	3.110	1.582	-0.100	14.45	0.0290	2.49%	0.5	1.051%
0.400	2.781	1.571	-0.100	14.57	0.0299	2.02%	0.5	0.870%
0.500	2.570	1.541	-0.097	14.87	0.0301	1.65%	0.5	0.785%
0.600	2.433	1.497	-0.091	15.01	0.0283	1.45%	0.5	0.706%
0.800	2.242	1.424	-0.081	15.08	0.0267	1.81%	0.5	0.622%
1.000	2.124	1.358	-0.071	14.98	0.0243	1.49%	0.5	0.521%
1.500	1.941	1.241	-0.051	14.38	0.0185	1.48%	0.5	0.479%
2.000	1.838	1.155	-0.033	14.32	0.0100	0.83%	0.5	0.305%
3.000	1.699	1.051	-0.008	11.58	-0.0039	0.43%	2.0	0.221%
4.000	1.596	0.998	0.006	12.80	-0.0112	0.87%	1.0	0.375%
5.000	1.528	0.948	0.021	14.62	-0.0256	1.67%	0.5	0.794%
6.000	1.456	0.944	0.022	15.19	-0.0273	0.95%	1.0	0.553%
8.000	1.367	0.907	0.036	11.96	-0.0307	0.94%	1.0	0.533%
10.000	1.298	0.916	0.033	13.36	-0.0293	1.67%	1.0	0.751%
15.000	1.202	0.913	0.037	14.31	-0.0360	1.48%	1.0	0.713%

SILICON MEDIUM, AIR RESPONSE

E(MEV)	B	C	A	XK	D	MAX.D	XMAX	S.D
0.015	1.023	0.349	0.262	11.98	-0.1791	0.50%	0.5	0.266%
0.020	1.051	0.426	0.179	17.64	-0.1078	0.81%	0.5	0.298%
0.030	1.179	0.395	0.216	13.99	-0.1163	1.50%	0.5	0.591%
0.040	1.385	0.460	0.188	14.33	-0.1065	1.95%	0.5	0.788%
0.050	1.640	0.579	0.135	15.12	-0.0715	0.94%	4.0	0.582%
0.060	1.894	0.702	0.092	15.29	-0.0516	3.02%	0.5	1.219%
0.080	2.400	0.838	0.058	14.66	-0.0505	2.36%	0.5	1.133%
0.100	2.627	1.018	0.012	13.65	-0.0298	1.54%	0.5	0.805%
0.150	2.733	1.273	-0.042	10.39	-0.0062	0.66%	0.5	0.237%
0.200	2.669	1.390	-0.063	20.50	0.0073	0.49%	15.0	0.294%
0.300	2.483	1.469	-0.078	16.89	0.0136	0.57%	0.5	0.225%
0.400	2.355	1.473	-0.081	15.82	0.0161	0.50%	35.0	0.226%
0.500	2.252	1.455	-0.080	16.30	0.0182	0.44%	40.0	0.155%
0.600	2.177	1.424	-0.076	18.67	0.0215	0.41%	5.0	0.215%
0.800	2.053	1.385	-0.073	15.28	0.0211	0.44%	35.0	0.203%
1.000	1.980	1.323	-0.063	15.81	0.0184	0.51%	1.0	0.192%
1.500	1.842	1.230	-0.048	15.12	0.0161	0.43%	35.0	0.227%
2.000	1.771	1.155	-0.033	14.57	0.0100	0.45%	40.0	0.167%
3.000	1.669	1.058	-0.010	10.43	-0.0026	0.40%	4.0	0.174%
4.000	1.585	1.011	0.002	15.91	-0.0125	0.94%	1.0	0.351%
5.000	1.522	0.967	0.016	11.03	-0.0170	1.26%	0.5	0.414%
6.000	1.474	0.953	0.019	14.09	-0.0190	1.54%	0.5	0.637%
8.000	1.389	0.930	0.027	13.47	-0.0249	1.73%	0.5	0.758%
10.000	1.331	0.908	0.036	13.36	-0.0319	1.64%	0.5	0.829%
15.000	1.236	0.887	0.047	13.39	-0.0432	2.39%	0.5	0.993%

(10)Phosphorus

PHOSPHORUS MEDIUM, PHOSPHORUS RESPONSE

E(MEV)	B	C	A	XK	D	MAX.D	XMAX	S.D
0.015	1.018	0.398	0.212	12.01	-0.1279	0.52%	4.0	0.286%
0.020	1.041	0.411	0.194	13.58	-0.0962	0.59%	8.0	0.244%
0.030	1.141	0.390	0.219	13.87	-0.1228	0.97%	0.5	0.390%
0.040	1.321	0.439	0.194	14.66	-0.1070	1.79%	0.5	0.702%
0.050	1.573	0.525	0.156	15.24	-0.0836	1.49%	0.5	0.645%
0.060	1.984	0.535	0.168	13.70	-0.0873	3.52%	0.5	1.820%
0.080	2.767	0.726	0.096	13.52	-0.0655	2.06%	0.5	1.165%
0.100	3.452	0.924	0.036	13.69	-0.0410	1.27%	35.0	0.836%
0.150	3.949	1.255	-0.042	20.00	0.0	1.28%	0.5	0.523%
0.200	3.711	1.410	-0.069	16.17	0.0124	1.52%	0.5	0.589%
0.300	3.132	1.528	-0.091	14.16	0.0233	2.48%	0.5	0.942%
0.400	2.805	1.527	-0.092	15.23	0.0252	2.47%	0.5	0.853%
0.500	2.590	1.504	-0.090	15.30	0.0253	1.91%	0.5	0.734%
0.600	2.443	1.475	-0.087	14.94	0.0257	1.92%	0.5	0.654%
0.800	2.245	1.410	-0.078	15.21	0.0241	1.35%	0.5	0.535%
1.000	2.115	1.358	-0.071	15.01	0.0242	1.22%	0.5	0.522%
1.500	1.943	1.234	-0.049	14.99	0.0169	0.89%	0.5	0.361%
2.000	1.837	1.155	-0.033	13.92	0.0100	0.79%	0.5	0.281%
3.000	1.693	1.056	-0.009	11.30	-0.0040	0.43%	25.0	0.228%
4.000	1.596	0.994	0.008	12.63	-0.0141	0.87%	1.0	0.444%
5.000	1.524	0.948	0.022	14.53	-0.0280	1.82%	0.5	0.755%
6.000	1.452	0.946	0.022	15.59	-0.0289	1.22%	1.0	0.580%
8.000	1.361	0.911	0.036	11.74	-0.0309	1.38%	1.0	0.691%
10.000	1.298	0.903	0.039	13.70	-0.0358	1.38%	0.5	0.798%
15.000	1.193	0.930	0.033	14.49	-0.0333	2.21%	1.0	0.866%

PHOSPHORUS MEDIUM, AIR RESPONSE

E(MEV)	B	C	A	XK	D	MAX.D	XMAX	S.D
0.015	1.018	0.398	0.212	12.01	-0.1279	0.52%	4.0	0.286%
0.020	1.041	0.432	0.175	13.83	-0.0771	0.45%	0.5	0.249%
0.030	1.141	0.394	0.213	14.41	-0.1150	0.99%	0.5	0.372%
0.040	1.314	0.439	0.195	14.43	-0.1084	2.14%	0.5	0.811%
0.050	1.533	0.520	0.162	14.69	-0.0901	1.72%	0.5	0.773%
0.060	1.751	0.633	0.117	14.78	-0.0635	0.99%	0.5	0.582%
0.080	2.204	0.757	0.084	12.94	-0.0516	2.79%	0.5	1.399%
0.100	2.434	0.940	0.031	14.07	-0.0402	2.70%	0.5	1.169%
0.150	2.611	1.198	-0.027	11.68	-0.0137	0.82%	0.5	0.496%
0.200	2.590	1.319	-0.048	9.03	-0.0088	0.68%	3.0	0.383%
0.300	2.431	1.433	-0.072	19.17	0.0125	1.06%	0.5	0.328%
0.400	2.325	1.440	-0.075	17.17	0.0139	0.39%	0.5	0.246%
0.500	2.224	1.433	-0.076	16.31	0.0157	0.70%	0.5	0.250%
0.600	2.147	1.416	-0.075	16.44	0.0180	0.30%	6.0	0.153%
0.800	2.035	1.375	-0.071	15.64	0.0205	0.67%	0.5	0.226%
1.000	1.959	1.323	-0.063	17.02	0.0204	0.37%	15.0	0.165%
1.500	1.834	1.226	-0.047	15.36	0.0155	0.37%	10.0	0.184%
2.000	1.763	1.156	-0.033	14.97	0.0099	0.40%	0.5	0.190%
3.000	1.664	1.059	-0.010	13.40	-0.0030	0.36%	1.0	0.231%
4.000	1.590	1.003	0.005	15.05	-0.0156	0.74%	4.0	0.419%
5.000	1.521	0.968	0.016	11.99	-0.0176	1.30%	0.5	0.503%
6.000	1.470	0.958	0.018	14.30	-0.0190	1.73%	0.5	0.742%
8.000	1.389	0.928	0.029	13.67	-0.0279	1.71%	0.5	0.840%
10.000	1.330	0.907	0.038	13.34	-0.0349	1.67%	0.5	0.890%
15.000	1.235	0.879	0.053	13.06	-0.0508	2.40%	0.5	1.027%

(11)Sulphur

SULPHUR MEDIUM, SULPHUR RESPONSE

E(MEV)	B	C	A	XK	D	MAX.D	XMAX	S.D
0.015	1.016	0.294	0.302	11.36	-0.1627	0.51%	8.0	0.286%
0.020	1.040	0.303	0.264	28.62	-0.5075	0.43%	2.0	0.214%
0.030	1.115	0.387	0.215	13.89	-0.1155	0.73%	3.0	0.396%
0.040	1.267	0.405	0.213	14.75	-0.1239	1.86%	0.5	0.734%
0.050	1.476	0.480	0.178	14.71	-0.0989	1.66%	0.5	0.731%
0.060	1.733	0.578	0.136	15.24	-0.0744	5.01%	0.5	1.779%
0.080	2.529	0.648	0.126	13.15	-0.0819	2.43%	0.5	1.373%
0.100	3.177	0.841	0.060	13.60	-0.0536	1.97%	0.5	1.137%
0.150	3.835	1.165	-0.023	12.88	-0.0107	0.90%	2.0	0.425%
0.200	3.680	1.339	-0.056	19.72	0.0054	1.34%	0.5	0.539%
0.300	3.151	1.473	-0.081	16.17	0.0191	1.91%	0.5	0.735%
0.400	2.840	1.475	-0.082	16.92	0.0191	1.00%	0.5	0.325%
0.500	2.599	1.477	-0.085	15.49	0.0223	1.79%	0.5	0.589%
0.600	2.444	1.455	-0.083	15.62	0.0234	1.50%	0.5	0.531%
0.800	2.252	1.395	-0.075	15.38	0.0225	1.68%	0.5	0.512%
1.000	2.130	1.336	-0.066	15.62	0.0209	1.18%	0.5	0.394%
1.500	1.938	1.234	-0.049	14.81	0.0167	0.73%	0.5	0.325%
2.000	1.840	1.146	-0.030	15.78	0.0070	0.97%	0.5	0.304%
3.000	1.691	1.059	-0.010	11.88	-0.0022	0.53%	1.0	0.253%
4.000	1.591	0.998	0.007	13.09	-0.0130	1.18%	1.0	0.447%
5.000	1.513	0.962	0.018	14.66	-0.0251	1.75%	1.0	0.774%
6.000	1.444	0.953	0.021	15.16	-0.0294	1.17%	0.5	0.599%
8.000	1.351	0.931	0.029	13.09	-0.0258	1.71%	0.5	0.777%
10.000	1.291	0.908	0.039	13.43	-0.0369	1.71%	0.5	0.851%
15.000	1.190	0.922	0.038	14.24	-0.0391	2.00%	0.5	0.902%

SULPHUR MEDIUM, AIR RESPONSE

E(MEV)	B	C	A	XK	D	MAX.D	XMAX	S.D
0.015	1.017	0.293	0.325	10.44	-0.2521	0.43%	6.0	0.245%
0.020	1.039	0.340	0.228	27.88	-0.3834	0.52%	8.0	0.264%
0.030	1.115	0.387	0.215	13.89	-0.1155	0.73%	3.0	0.396%
0.040	1.257	0.418	0.204	14.60	-0.1126	1.66%	0.5	0.686%
0.050	1.440	0.487	0.176	14.61	-0.0988	1.89%	0.5	0.786%
0.060	1.635	0.576	0.140	14.63	-0.0781	1.54%	0.5	0.786%
0.080	1.965	0.763	0.074	14.91	-0.0445	3.72%	0.5	1.329%
0.100	2.276	0.868	0.051	12.99	-0.0441	2.56%	0.5	1.275%
0.150	2.492	1.133	-0.014	12.60	-0.0196	1.66%	0.5	0.723%
0.200	2.500	1.269	-0.039	10.97	-0.0123	1.14%	0.5	0.506%
0.300	2.385	1.393	-0.065	25.71	0.0135	1.36%	0.5	0.526%
0.400	2.285	1.417	-0.071	20.45	0.0155	0.70%	0.5	0.306%
0.500	2.201	1.415	-0.073	16.28	0.0148	0.58%	0.5	0.318%
0.600	2.135	1.392	-0.070	18.06	0.0158	0.44%	3.0	0.269%
0.800	2.029	1.353	-0.066	16.59	0.0166	0.28%	3.0	0.156%
1.000	1.951	1.313	-0.061	15.85	0.0173	0.32%	40.0	0.175%
1.500	1.832	1.215	-0.044	16.11	0.0131	0.34%	8.0	0.158%
2.000	1.761	1.149	-0.031	15.18	0.0082	0.39%	0.5	0.167%
3.000	1.660	1.059	-0.009	10.21	-0.0054	0.60%	1.0	0.248%
4.000	1.587	0.995	0.010	10.20	-0.0171	0.54%	4.0	0.300%
5.000	1.515	0.979	0.013	12.27	-0.0161	1.61%	0.5	0.605%
6.000	1.468	0.957	0.020	13.46	-0.0224	1.80%	0.5	0.742%
8.000	1.388	0.927	0.031	13.43	-0.0316	1.74%	0.5	0.901%
10.000	1.325	0.919	0.035	13.72	-0.0335	1.94%	0.5	0.975%
15.000	1.228	0.898	0.048	13.24	-0.0471	2.78%	0.5	1.079%

(12)Argon

ARGON MEDIUM, ARGON RESPONSE

E(MEV)	B	C	A	XK	D	MAX.D	XMAX	S.D
0.015	1.009	0.495	0.141	29.38	-0.2851	0.46%	0.5	0.285%
0.020	1.022	0.465	0.151	30.59	-0.3021	0.65%	0.5	0.280%
0.030	1.081	0.344	0.252	13.45	-0.1508	0.69%	0.5	0.281%
0.040	1.180	0.397	0.211	14.36	-0.1139	1.46%	0.5	0.537%
0.050	1.337	0.420	0.209	14.32	-0.1214	1.60%	0.5	0.747%
0.060	1.522	0.509	0.162	15.42	-0.0887	1.37%	0.5	0.643%
0.080	2.134	0.540	0.170	13.50	-0.1007	3.47%	0.5	1.811%
0.100	2.716	0.699	0.107	13.30	-0.0760	3.45%	0.5	1.602%
0.150	3.558	1.007	0.014	13.47	-0.0308	1.24%	4.0	0.814%
0.200	3.599	1.199	-0.027	12.18	-0.0147	0.78%	5.0	0.488%
0.300	3.161	1.378	-0.064	21.31	0.0125	1.16%	2.0	0.439%
0.400	2.829	1.426	-0.074	16.70	0.0152	1.22%	0.5	0.441%
0.500	2.615	1.424	-0.075	17.17	0.0174	0.93%	0.5	0.343%
0.600	2.456	1.410	-0.074	17.12	0.0183	1.00%	0.5	0.354%
0.800	2.248	1.375	-0.071	15.67	0.0202	1.08%	0.5	0.374%
1.000	2.118	1.334	-0.066	14.93	0.0208	0.83%	35.0	0.387%
1.500	1.943	1.222	-0.046	15.07	0.0146	0.99%	0.5	0.330%
2.000	1.831	1.154	-0.032	15.62	0.0088	0.60%	0.5	0.251%
3.000	1.692	1.052	-0.007	12.91	-0.0061	0.47%	1.0	0.263%
4.000	1.592	0.985	0.013	12.56	-0.0204	1.12%	1.0	0.631%
5.000	1.501	0.970	0.017	15.63	-0.0287	0.94%	10.0	0.518%
6.000	1.437	0.944	0.027	13.04	-0.0330	0.94%	4.0	0.566%
8.000	1.342	0.924	0.035	12.28	-0.0338	1.32%	1.0	0.730%
10.000	1.280	0.911	0.041	13.91	-0.0434	1.54%	1.0	0.980%
15.000	1.176	0.948	0.033	14.53	-0.0363	2.00%	1.0	0.964%

ARGON MEDIUM, AIR RESPONSE

E(MEV)	B	C	A	XK	D	MAX.D	XMAX	S.D
0.015	1.009	0.495	0.141	29.38	-0.2851	0.46%	0.5	0.285%
0.020	1.027	0.318	0.252	18.88	-0.1913	0.70%	2.0	0.291%
0.030	1.081	0.344	0.252	13.45	-0.1508	0.69%	0.5	0.281%
0.040	1.179	0.392	0.216	14.54	-0.1227	1.48%	0.5	0.661%
0.050	1.313	0.433	0.202	14.23	-0.1149	2.13%	0.5	0.866%
0.060	1.456	0.508	0.168	14.35	-0.0942	2.10%	0.5	0.898%
0.080	1.737	0.655	0.111	14.39	-0.0625	1.78%	0.5	0.821%
0.100	1.950	0.814	0.059	14.51	-0.0408	1.04%	0.5	0.663%
0.150	2.255	1.040	0.004	13.40	-0.0244	0.38%	2.0	0.170%
0.200	2.347	1.175	-0.021	12.06	-0.0193	1.56%	0.5	0.858%
0.300	2.314	1.322	-0.053	19.85	0.0016	1.66%	4.0	0.943%
0.400	2.213	1.375	-0.064	23.47	0.0154	1.80%	0.5	0.653%
0.500	2.145	1.378	-0.066	22.25	0.0179	1.29%	0.5	0.425%
0.600	2.088	1.369	-0.066	18.91	0.0152	0.98%	0.5	0.385%
0.800	1.994	1.341	-0.064	16.54	0.0166	0.42%	3.0	0.230%
1.000	1.925	1.303	-0.059	16.03	0.0166	0.46%	35.0	0.239%
1.500	1.814	1.211	-0.043	16.27	0.0125	0.33%	0.5	0.162%
2.000	1.749	1.147	-0.030	15.16	0.0065	0.40%	40.0	0.134%
3.000	1.657	1.052	-0.006	11.62	-0.0089	0.78%	1.0	0.355%
4.000	1.579	1.005	0.007	10.97	-0.0144	0.69%	1.0	0.405%
5.000	1.513	0.978	0.015	13.38	-0.0213	1.67%	0.5	0.742%
6.000	1.461	0.966	0.019	13.70	-0.0235	2.12%	0.5	0.812%
8.000	1.380	0.938	0.030	13.39	-0.0333	2.13%	0.5	1.040%
10.000	1.321	0.919	0.039	13.42	-0.0414	2.15%	1.0	1.040%
15.000	1.244	0.842	0.072	13.87	-0.0710	3.00%	3.0	1.737%

(13)Potassium

POTASSIUM MEDIUM, POTASSIUM RESPONSE

E(MEV)	B	C	A	XK	D	MAX.D	XMAX	S.D
0.015	1.010	0.224	0.422	12.99	-0.4354	0.47%	3.0	0.220%
0.020	1.023	0.248	0.365	12.39	-0.2533	0.45%	7.0	0.270%
0.030	1.069	0.351	0.244	12.59	-0.1388	0.70%	2.0	0.323%
0.040	1.157	0.362	0.238	14.60	-0.1453	1.15%	2.0	0.490%
0.050	1.289	0.400	0.218	14.85	-0.1282	1.48%	0.5	0.706%
0.060	1.451	0.466	0.185	14.80	-0.1055	1.93%	0.5	0.782%
0.080	1.987	0.491	0.193	13.35	-0.1052	3.84%	0.5	1.997%
0.100	2.527	0.634	0.133	13.00	-0.0899	3.74%	0.5	1.871%
0.150	3.411	0.935	0.033	13.43	-0.0406	1.49%	35.0	1.021%
0.200	3.529	1.139	-0.014	12.77	-0.0218	1.21%	10.0	0.727%
0.300	3.188	1.309	-0.048	9.23	-0.0099	1.08%	0.5	0.393%
0.400	2.840	1.389	-0.067	20.01	0.0139	0.77%	0.5	0.336%
0.500	2.627	1.397	-0.070	17.55	0.0148	0.92%	0.5	0.282%
0.600	2.456	1.397	-0.072	16.30	0.0173	0.88%	2.0	0.322%
0.800	2.264	1.352	-0.066	16.77	0.0175	1.11%	0.5	0.306%
1.000	2.128	1.313	-0.061	15.50	0.0170	0.64%	0.5	0.276%
1.500	1.939	1.222	-0.046	14.93	0.0143	0.86%	0.5	0.296%
2.000	1.835	1.147	-0.030	16.46	0.0074	0.79%	0.5	0.243%
3.000	1.685	1.057	-0.008	12.35	-0.0057	0.88%	1.0	0.337%
4.000	1.589	0.983	0.015	11.87	-0.0235	1.30%	1.0	0.713%
5.000	1.501	0.956	0.024	12.99	-0.0361	0.86%	10.0	0.452%
6.000	1.432	0.945	0.028	12.78	-0.0350	1.24%	1.0	0.562%
8.000	1.334	0.934	0.033	12.11	-0.0332	1.61%	0.5	0.715%
10.000	1.283	0.890	0.050	13.89	-0.0525	1.73%	4.0	1.093%
15.000	1.175	0.934	0.040	14.39	-0.0436	2.08%	1.0	0.985%

POTASSIUM MEDIUM, AIR RESPONSE

E(MEV)	B	C	A	XK	D	MAX.D	XMAX	S.D
0.015	1.012	0.130	0.620	11.39	-0.6162	0.43%	2.0	0.219%
0.020	1.024	0.289	0.289	12.38	-0.1453	0.41%	6.0	0.269%
0.030	1.067	0.384	0.215	12.44	-0.1141	0.71%	0.5	0.326%
0.040	1.151	0.382	0.222	13.92	-0.1229	1.26%	0.5	0.554%
0.050	1.269	0.408	0.217	14.20	-0.1274	1.77%	0.5	0.778%
0.060	1.392	0.483	0.178	14.36	-0.0988	1.82%	0.5	0.803%
0.080	1.644	0.609	0.129	14.32	-0.0742	2.23%	0.5	1.020%
0.100	1.853	0.757	0.077	14.33	-0.0502	2.55%	0.5	1.021%
0.150	2.146	1.005	0.010	13.70	-0.0216	0.96%	4.0	0.617%
0.200	2.235	1.166	-0.022	11.91	-0.0143	0.67%	1.0	0.438%
0.300	2.253	1.282	-0.043	10.15	-0.0111	1.68%	0.5	0.591%
0.400	2.199	1.343	-0.058	25.46	0.0094	1.31%	0.5	0.656%
0.500	2.122	1.361	-0.063	20.95	0.0137	1.19%	0.5	0.485%
0.600	2.070	1.353	-0.063	18.25	0.0123	0.74%	0.5	0.402%
0.800	1.979	1.328	-0.061	16.89	0.0137	0.71%	0.5	0.313%
1.000	1.914	1.294	-0.057	15.83	0.0146	0.54%	40.0	0.245%
1.500	1.804	1.214	-0.044	15.26	0.0131	0.45%	35.0	0.203%
2.000	1.744	1.144	-0.029	16.51	0.0061	0.34%	1.0	0.157%
3.000	1.658	1.047	-0.004	11.27	-0.0108	1.31%	1.0	0.488%
4.000	1.579	1.002	0.009	11.56	-0.0183	0.78%	0.5	0.492%
5.000	1.508	0.986	0.013	13.41	-0.0200	1.44%	1.0	0.683%
6.000	1.463	0.958	0.023	13.42	-0.0288	1.99%	0.5	0.865%
8.000	1.382	0.931	0.034	13.47	-0.0389	2.00%	0.5	0.978%
10.000	1.316	0.927	0.038	13.53	-0.0427	2.35%	0.5	1.085%
15.000	1.218	0.920	0.047	13.48	-0.0518	2.56%	1.0	1.163%

(14)Calcium

CALCIUM MEDIUM, CALCIUM RESPONSE

E(MEV)	B	C	A	XK	D	MAX.D	XMAX	S.D
0.015	1.007	0.585	0.034	9.72	0.1113	0.60%	0.5	0.296%
0.020	1.017	0.370	0.247	11.26	-0.1771	0.44%	2.0	0.257%
0.030	1.056	0.363	0.237	12.80	-0.1459	0.53%	35.0	0.356%
0.040	1.127	0.380	0.222	13.84	-0.1211	0.84%	0.5	0.458%
0.050	1.240	0.389	0.225	14.22	-0.1325	1.52%	0.5	0.601%
0.060	1.382	0.450	0.190	14.77	-0.1058	2.01%	0.5	0.802%
0.080	1.741	0.573	0.136	15.85	-0.0738	1.90%	2.0	0.750%
0.100	2.203	0.685	0.099	15.97	-0.0680	1.43%	2.0	0.670%
0.150	3.245	0.871	0.051	13.42	-0.0502	2.20%	0.5	1.297%
0.200	3.471	1.072	0.002	12.89	-0.0317	1.53%	3.0	0.998%
0.300	3.172	1.273	-0.042	10.25	-0.0103	0.79%	5.0	0.415%
0.400	2.848	1.356	-0.061	27.24	0.0185	0.84%	4.0	0.469%
0.500	2.615	1.380	-0.067	17.03	0.0123	0.78%	2.0	0.381%
0.600	2.477	1.364	-0.065	21.16	0.0171	0.79%	0.5	0.282%
0.800	2.258	1.346	-0.065	16.21	0.0164	0.34%	2.0	0.207%
1.000	2.129	1.304	-0.059	16.33	0.0164	0.75%	0.5	0.251%
1.500	1.936	1.222	-0.046	15.60	0.0151	0.76%	0.5	0.289%
2.000	1.834	1.144	-0.029	17.20	0.0068	0.78%	0.5	0.279%
3.000	1.687	1.050	-0.005	11.95	-0.0099	0.76%	1.0	0.346%
4.000	1.589	0.978	0.017	12.17	-0.0250	1.30%	1.0	0.683%
5.000	1.498	0.963	0.021	14.58	-0.0317	1.45%	1.0	0.830%
6.000	1.429	0.944	0.029	12.99	-0.0361	0.97%	20.0	0.615%
8.000	1.330	0.932	0.035	12.38	-0.0364	1.77%	0.5	0.854%
10.000	1.274	0.903	0.047	13.91	-0.0513	1.84%	4.0	1.136%
15.000	1.167	0.957	0.034	14.47	-0.0375	2.26%	0.5	0.966%

CALCIUM MEDIUM, AIR RESPONSE

E(MEV)	B	C	A	XK	D	MAX.D	XMAX	S.D
0.015	1.010	0.177	0.470	15.29	-0.4373	0.48%	4.0	0.260%
0.020	1.016	0.441	0.180	10.89	-0.0845	0.39%	1.0	0.262%
0.030	1.057	0.372	0.226	11.52	-0.1182	0.64%	3.0	0.277%
0.040	1.129	0.364	0.234	14.07	-0.1357	0.66%	3.0	0.344%
0.050	1.226	0.405	0.213	14.14	-0.1172	1.55%	0.5	0.669%
0.060	1.335	0.456	0.192	14.25	-0.1107	2.01%	0.5	0.871%
0.080	1.564	0.574	0.142	14.35	-0.0801	2.38%	0.5	1.070%
0.100	1.760	0.708	0.093	14.30	-0.0580	2.82%	0.5	1.112%
0.150	2.062	0.949	0.024	13.69	-0.0280	1.90%	0.5	0.795%
0.200	2.175	1.118	-0.012	12.58	-0.0188	1.88%	0.5	0.799%
0.300	2.204	1.257	-0.039	10.26	-0.0113	1.04%	0.5	0.521%
0.400	2.167	1.305	-0.049	9.80	-0.0059	1.30%	0.5	0.612%
0.500	2.101	1.344	-0.060	24.54	0.0172	1.04%	0.5	0.542%
0.600	2.058	1.333	-0.059	23.64	0.0150	1.03%	3.0	0.523%
0.800	1.963	1.322	-0.060	18.99	0.0166	1.17%	0.5	0.369%
1.000	1.904	1.289	-0.056	17.12	0.0159	0.77%	0.5	0.307%
1.500	1.796	1.210	-0.043	15.77	0.0128	0.33%	8.0	0.167%
2.000	1.737	1.148	-0.030	17.57	0.0079	0.45%	0.5	0.224%
3.000	1.640	1.070	-0.011	13.24	-0.0067	0.66%	40.0	0.317%
4.000	1.574	1.009	0.007	12.05	-0.0167	1.03%	0.5	0.579%
5.000	1.508	0.983	0.015	13.21	-0.0231	1.12%	0.5	0.665%
6.000	1.459	0.962	0.023	13.19	-0.0303	2.17%	0.5	0.918%
8.000	1.376	0.943	0.031	13.52	-0.0363	2.31%	0.5	1.091%
10.000	1.313	0.934	0.037	13.60	-0.0424	2.51%	0.5	1.147%
15.000	1.219	0.916	0.050	13.91	-0.0551	2.48%	1.0	1.277%

(15)Iron

IRON MEDIUM, IRON RESPONSE

E(MEV)	B	C	A	XK	D	MAX.D	XMAX	S.D
0.015	1.004	1.561	-0.554	5.60	0.3524	0.40%	1.0	0.129%
0.020	1.010	0.258	0.319	18.22	-0.2950	0.49%	3.0	0.247%
0.030	1.027	0.318	0.252	18.88	-0.1913	0.70%	2.0	0.291%
0.040	1.058	0.331	0.248	13.93	-0.1315	0.38%	35.0	0.249%
0.050	1.105	0.344	0.243	14.40	-0.1356	1.09%	0.5	0.383%
0.060	1.167	0.372	0.229	14.70	-0.1365	1.18%	0.5	0.530%
0.080	1.340	0.442	0.191	15.11	-0.1085	1.66%	0.5	0.685%
0.100	1.600	0.484	0.178	15.00	-0.1050	1.40%	3.0	0.880%
0.150	2.426	0.572	0.161	12.70	-0.1086	5.11%	0.5	2.318%
0.200	2.887	0.788	0.080	13.12	-0.0720	5.51%	0.5	2.306%
0.300	3.035	1.034	0.010	12.47	-0.0359	2.86%	0.5	1.456%
0.400	2.823	1.164	-0.020	11.68	-0.0210	1.90%	0.5	0.962%
0.500	2.626	1.225	-0.034	10.32	-0.0132	1.28%	0.5	0.685%
0.600	2.486	1.241	-0.038	10.26	-0.0113	1.01%	20.0	0.612%
0.800	2.277	1.241	-0.039	8.31	-0.0126	0.63%	40.0	0.404%
1.000	2.130	1.256	-0.049	18.40	0.0121	0.73%	4.0	0.343%
1.500	1.938	1.193	-0.039	15.35	0.0096	0.62%	1.0	0.280%
2.000	1.827	1.135	-0.026	25.39	0.0074	0.71%	1.0	0.238%
3.000	1.684	1.035	0.002	12.45	-0.0184	0.94%	1.0	0.587%
4.000	1.565	0.996	0.014	13.95	-0.0296	2.03%	0.5	0.976%
5.000	1.476	0.969	0.024	14.14	-0.0384	1.66%	4.0	0.981%
6.000	1.394	0.977	0.023	14.33	-0.0380	1.83%	1.0	0.919%
8.000	1.299	0.958	0.033	14.00	-0.0446	2.38%	0.5	1.123%
10.000	1.235	0.958	0.037	14.27	-0.0483	2.76%	1.0	1.262%
15.000	1.148	0.955	0.047	14.63	-0.0535	2.71%	1.0	1.268%

IRON MEDIUM, AIR RESPONSE

E(MEV)	B	C	A	XK	D	MAX.D	XMAX	S.D
0.015	1.004	1.561	-0.554	5.60	0.3524	0.40%	1.0	0.129%
0.020	1.012	0.130	0.620	11.39	-0.6162	0.43%	2.0	0.219%
0.030	1.028	0.374	0.190	29.34	-0.3170	0.65%	3.0	0.281%
0.040	1.058	0.336	0.248	11.65	-0.1188	0.50%	7.0	0.238%
0.050	1.099	0.366	0.232	14.01	-0.1354	0.65%	3.0	0.343%
0.060	1.148	0.405	0.208	14.17	-0.1142	1.53%	0.5	0.577%
0.080	1.267	0.470	0.180	14.48	-0.0974	2.32%	0.5	0.892%
0.100	1.389	0.557	0.144	14.11	-0.0791	2.58%	0.5	1.040%
0.150	1.660	0.743	0.079	14.12	-0.0476	2.93%	0.5	1.143%
0.200	1.839	0.911	0.034	13.23	-0.0334	2.60%	0.5	1.169%
0.300	1.973	1.095	-0.009	11.86	-0.0183	2.34%	0.5	0.955%
0.400	1.992	1.187	-0.027	10.72	-0.0140	1.84%	0.5	0.777%
0.500	1.957	1.261	-0.046	24.77	0.0084	2.23%	0.5	0.837%
0.600	1.932	1.274	-0.049	22.82	0.0097	1.79%	0.5	0.674%
0.800	1.884	1.270	-0.050	20.30	0.0120	1.27%	0.5	0.513%
1.000	1.841	1.250	-0.048	19.49	0.0140	1.16%	0.5	0.400%
1.500	1.750	1.197	-0.040	15.90	0.0110	1.05%	0.5	0.318%
2.000	1.703	1.143	-0.028	20.42	0.0070	0.88%	0.5	0.309%
3.000	1.627	1.059	-0.005	11.99	-0.0132	0.85%	0.5	0.507%
4.000	1.553	1.026	0.005	12.93	-0.0191	1.93%	0.5	0.791%
5.000	1.483	1.009	0.012	13.12	-0.0258	2.24%	0.5	0.939%
6.000	1.442	0.980	0.023	13.37	-0.0355	2.16%	0.5	1.120%
8.000	1.354	0.974	0.029	13.65	-0.0424	3.36%	0.5	1.370%
10.000	1.297	0.949	0.042	13.97	-0.0561	3.23%	0.5	1.500%
15.000	1.199	0.957	0.049	14.37	-0.0594	3.38%	0.5	1.553%

(16)Copper

COPPER MEDIUM, COPPER RESPONSE

E(MEV)	B	C	A	XK	D	MAX.D	XMAX	S.D
0.015	1.001	2.044	-0.310	11.15	0.2519	0.46%	3.0	0.175%
0.020	1.006	0.230	0.442	12.61	-0.5099	0.49%	10.0	0.234%
0.030	1.017	0.370	0.247	11.26	-0.1771	0.44%	2.0	0.257%
0.040	1.038	0.392	0.197	25.45	-0.2886	0.58%	0.5	0.283%
0.050	1.071	0.353	0.243	12.89	-0.1407	0.39%	0.5	0.163%
0.060	1.121	0.340	0.250	14.53	-0.1501	1.02%	0.5	0.446%
0.080	1.246	0.395	0.217	14.39	-0.1226	2.08%	0.5	0.792%
0.100	1.381	0.539	0.133	19.42	-0.0874	2.07%	2.0	0.680%
0.150	2.120	0.472	0.208	13.51	-0.1372	5.43%	0.5	2.600%
0.200	2.603	0.671	0.120	13.45	-0.0928	6.52%	0.5	2.781%
0.300	2.926	0.921	0.039	12.80	-0.0495	4.82%	0.5	2.001%
0.400	2.795	1.070	0.002	12.19	-0.0331	3.45%	0.5	1.529%
0.500	2.612	1.158	-0.020	11.56	-0.0190	2.55%	0.5	1.093%
0.600	2.479	1.191	-0.028	10.74	-0.0147	2.09%	0.5	0.878%
0.800	2.270	1.210	-0.033	8.79	-0.0131	1.16%	0.5	0.587%
1.000	2.129	1.211	-0.036	7.13	-0.0090	1.03%	0.5	0.444%
1.500	1.952	1.149	-0.025	8.18	-0.0085	0.56%	2.0	0.300%
2.000	1.835	1.113	-0.019	9.49	-0.0052	0.81%	1.0	0.328%
3.000	1.673	1.041	0.001	12.27	-0.0174	1.97%	0.5	0.834%
4.000	1.542	1.016	0.010	14.08	-0.0286	2.41%	1.0	1.046%
5.000	1.451	0.993	0.019	14.15	-0.0372	1.96%	1.0	1.015%
6.000	1.381	0.984	0.023	14.30	-0.0395	2.29%	0.5	1.076%
8.000	1.289	0.959	0.036	14.05	-0.0494	2.35%	1.0	1.217%
10.000	1.226	0.958	0.041	14.33	-0.0536	2.70%	1.0	1.258%
15.000	1.142	0.944	0.057	14.81	-0.0634	2.39%	1.0	1.209%

COPPER MEDIUM, AIR RESPONSE

E(MEV)	B	C	A	XK	D	MAX.D	XMAX	S.D
0.015	1.001	2.044	-0.310	11.15	0.2519	0.46%	3.0	0.175%
0.020	1.009	0.103	0.764	10.78	-1.0613	0.48%	7.0	0.243%
0.030	1.020	0.359	0.205	12.00	-0.0510	0.37%	8.0	0.247%
0.040	1.042	0.330	0.239	14.45	-0.0962	0.38%	4.0	0.215%
0.050	1.071	0.353	0.243	12.89	-0.1407	0.39%	0.5	0.163%
0.060	1.109	0.364	0.237	13.54	-0.1349	0.92%	0.5	0.410%
0.080	1.189	0.446	0.192	13.97	-0.1094	2.08%	0.5	0.748%
0.100	1.287	0.507	0.165	13.89	-0.0924	2.37%	0.5	0.921%
0.150	1.518	0.675	0.100	13.99	-0.0555	3.10%	0.5	1.109%
0.200	1.695	0.835	0.052	13.62	-0.0364	3.10%	0.5	1.163%
0.300	1.865	1.023	0.005	12.51	-0.0197	2.69%	0.5	1.004%
0.400	1.908	1.135	-0.018	11.46	-0.0137	2.16%	0.5	0.862%
0.500	1.899	1.215	-0.038	16.22	0.0026	2.42%	0.5	0.986%
0.600	1.882	1.235	-0.042	23.77	0.0062	2.44%	0.5	0.834%
0.800	1.854	1.239	-0.044	17.25	0.0057	1.35%	0.5	0.700%
1.000	1.813	1.226	-0.043	21.74	0.0120	1.23%	0.5	0.469%
1.500	1.733	1.185	-0.037	18.36	0.0106	0.84%	0.5	0.302%
2.000	1.694	1.128	-0.024	24.48	0.0026	1.10%	0.5	0.408%
3.000	1.617	1.059	-0.004	12.21	-0.0146	1.22%	0.5	0.608%
4.000	1.546	1.022	0.009	12.92	-0.0258	2.16%	0.5	0.976%
5.000	1.479	1.008	0.015	13.26	-0.0310	2.39%	0.5	1.105%
6.000	1.428	0.995	0.021	13.23	-0.0371	2.80%	0.5	1.201%
8.000	1.353	0.960	0.038	13.50	-0.0547	3.32%	0.5	1.576%
10.000	1.289	0.962	0.042	13.91	-0.0577	3.62%	0.5	1.627%
15.000	1.191	0.969	0.052	14.48	-0.0640	3.95%	1.0	1.757%

(17)Molybdenum

MOLYBDENUM MEDIUM, MOLYBDENUM RESPONSE

E(MEV)	B	C	A	XK	D	MAX.D	XMAX	S.D
0.015	1.009	0.381	0.200	14.36	-0.0830	0.10%	10.0	0.027%
0.020	1.001	1.745	0.078	16.81	-0.1352	6.20%	40.0	2.140%
0.030	1.514	1.100	0.106	28.01	-0.1191	4.40%	8.0	2.352%
0.040	1.489	0.320	0.107	23.22	-0.0448	0.50%	10.0	0.226%
0.050	1.383	0.052	-0.154	8.30	0.1218	0.40%	40.0	0.263%
0.060	1.327	0.023	0.799	14.91	-0.1910	0.40%	2.0	0.158%
0.080	1.300	0.081	0.573	14.04	-0.2282	1.60%	0.5	0.559%
0.100	1.194	0.253	0.328	13.79	-0.1685	0.90%	0.5	0.424%
0.150	1.447	0.321	0.287	14.10	-0.1596	1.60%	0.5	0.747%
0.200	2.280	0.307	0.318	14.03	-0.1986	3.80%	0.5	1.677%
0.300	2.386	0.559	0.159	14.06	-0.0975	2.30%	0.5	1.158%
0.400	2.678	0.714	0.106	13.91	-0.0868	2.80%	0.5	1.533%
0.500	2.696	0.830	0.067	13.90	-0.0645	2.70%	0.5	1.316%
0.600	2.652	0.892	0.047	13.76	-0.0533	2.10%	0.5	1.132%
0.800	2.504	0.966	0.025	13.66	-0.0397	1.50%	5.0	0.825%
1.000	2.369	1.001	0.014	13.55	-0.0314	1.80%	5.0	0.724%
1.500	1.941	1.093	-0.011	13.47	-0.0147	0.90%	5.0	0.323%
2.000	1.850	1.048	0.002	13.07	-0.0244	1.40%	5.0	0.726%
3.000	1.720	0.956	0.034	13.21	-0.0571	3.10%	0.5	1.751%
4.000	1.600	0.906	0.054	13.52	-0.0749	4.50%	0.5	2.240%
5.000	1.570	0.833	0.084	13.78	-0.1024	4.80%	0.5	2.687%
6.000	1.514	0.811	0.096	14.00	-0.1130	4.90%	1.0	2.775%
8.000	1.480	0.792	0.111	14.29	-0.1246	5.10%	1.0	2.767%
10.000	1.413	0.878	0.087	14.35	-0.1013	5.00%	1.0	2.494%
15.000	1.406	1.018	0.063	14.28	-0.0848	3.80%	1.0	2.024%

MOLYBDENUM MEDIUM, AIR RESPONSE

E(MEV)	B	C	A	XK	D	MAX.D	XMAX	S.D
0.015	1.009	0.366	0.223	12.62	-0.1086	0.0 %	10.0	0.018%
0.020	1.005	1.897	0.055	14.24	-0.0822	2.70%	6.0	1.560%
0.030	3.642	1.092	0.109	32.14	-0.2177	6.60%	0.5	3.404%
0.040	3.941	0.322	0.088	23.37	-0.0321	0.90%	10.0	0.446%
0.050	3.109	0.038	-0.317	11.96	0.0558	2.20%	1.0	0.949%
0.060	2.408	0.004	1.103	17.52	-0.1479	1.30%	1.0	0.417%
0.080	1.661	0.033	0.767	14.40	-0.2560	1.80%	0.5	0.760%
0.100	1.158	0.300	0.290	13.75	-0.1554	1.10%	0.5	0.445%
0.150	1.241	0.490	0.174	14.42	-0.0901	0.80%	0.5	0.408%
0.200	1.474	0.514	0.173	14.29	-0.0993	2.10%	0.5	0.843%
0.300	1.589	0.733	0.080	14.49	-0.0428	0.90%	5.0	0.391%
0.400	1.711	0.891	0.038	14.18	-0.0333	1.00%	5.0	0.476%
0.500	1.773	0.978	0.016	14.33	-0.0238	1.20%	5.0	0.433%
0.600	1.796	1.024	0.004	13.94	-0.0183	0.90%	5.0	0.384%
0.800	1.804	1.073	-0.008	14.02	-0.0129	0.90%	5.0	0.385%
1.000	1.784	1.092	-0.013	13.43	-0.0103	0.90%	3.0	0.394%
1.500	1.624	1.161	-0.030	7.13	0.0009	1.30%	0.5	0.459%
2.000	1.601	1.127	-0.021	12.62	-0.0054	0.70%	5.0	0.292%
3.000	1.557	1.065	0.0	12.84	-0.0283	1.90%	1.0	0.953%
4.000	1.505	1.023	0.016	13.36	-0.0428	2.70%	0.5	1.335%
5.000	1.519	0.942	0.046	13.59	-0.0702	3.40%	0.5	1.957%
6.000	1.497	0.921	0.057	13.82	-0.0796	4.00%	1.0	2.155%
8.000	1.531	0.878	0.080	14.15	-0.0985	4.40%	1.0	2.381%
10.000	1.502	0.965	0.059	14.21	-0.0784	3.90%	1.0	2.024%
15.000	1.573	1.118	0.035	14.16	-0.0599	3.30%	1.0	1.603%

(18)Tin

TIN MEDIUM, TIN RESPONSE

E(MEV)	B	C	A	XK	D	MAX.D	XMAX	S.D
0.015	1.005	0.420	0.170	18.40	-0.0827	0.10%	5.0	0.024%
0.020	1.011	0.363	0.217	13.09	-0.0857	0.10%	20.0	0.025%
0.030	1.770	1.862	0.042	11.05	-0.0312	11.20%	3.0	4.908%
0.040	1.660	1.261	0.088	13.32	-0.0262	6.00%	15.0	3.455%
0.050	1.639	0.492	0.280	16.68	-0.2376	2.20%	20.0	0.954%
0.060	1.568	0.257	-0.078	21.17	0.0538	0.60%	0.5	0.277%
0.080	1.393	0.034	0.733	14.24	-0.2271	0.50%	1.0	0.245%
0.100	1.337	0.069	0.659	13.41	-0.3590	1.30%	2.0	0.709%
0.150	1.438	0.181	0.428	13.86	-0.2354	1.70%	0.5	0.843%
0.200	1.624	0.283	0.326	13.92	-0.1909	2.50%	0.5	1.085%
0.300	1.917	0.456	0.205	13.82	-0.1165	2.10%	0.5	1.022%
0.400	2.260	0.590	0.152	13.87	-0.1081	3.00%	0.5	1.520%
0.500	2.364	0.706	0.107	13.87	-0.0848	3.30%	0.5	1.488%
0.600	2.396	0.775	0.082	13.73	-0.0710	2.90%	0.5	1.377%
0.800	2.348	0.865	0.053	13.63	-0.0547	2.10%	0.5	1.137%
1.000	2.259	0.914	0.038	13.50	-0.0462	1.80%	0.5	0.988%
1.500	1.917	1.035	0.004	13.66	-0.0240	1.00%	5.0	0.518%
2.000	1.849	0.993	0.019	13.12	-0.0385	1.90%	0.5	1.124%
3.000	1.713	0.924	0.047	13.27	-0.0708	4.70%	0.5	2.278%
4.000	1.585	0.891	0.063	13.64	-0.0860	6.30%	0.5	2.764%
5.000	1.558	0.825	0.092	13.89	-0.1131	6.50%	0.5	3.156%
6.000	1.513	0.796	0.108	14.10	-0.1277	5.90%	0.5	3.189%
8.000	1.477	0.810	0.112	14.34	-0.1294	6.00%	1.0	3.114%
10.000	1.418	0.914	0.085	14.29	-0.1043	5.60%	1.0	2.818%
15.000	1.413	1.082	0.059	14.09	-0.0884	4.70%	1.0	2.323%

TIN MEDIUM, AIR RESPONSE

E(MEV)	B	C	A	XK	D	MAX.D	XMAX	S.D
0.015	1.005	0.432	0.160	26.10	-0.1522	0.0 %	2.0	0.021%
0.020	1.011	0.389	0.192	14.26	-0.0695	0.10%	6.0	0.026%
0.030	2.897	1.873	0.040	10.77	-0.0311	11.30%	3.0	4.998%
0.040	3.574	1.221	0.097	26.32	-0.1252	8.80%	3.0	4.316%
0.050	3.487	0.491	0.280	16.80	-0.2372	2.30%	0.5	1.207%
0.060	2.945	0.234	-0.028	5.00	-0.0557	0.60%	40.0	0.363%
0.080	1.808	0.017	0.811	15.45	-0.1526	1.10%	1.0	0.364%
0.100	1.396	0.056	0.688	13.79	-0.3221	1.70%	2.0	0.774%
0.150	1.219	0.326	0.279	13.95	-0.1554	1.40%	0.5	0.599%
0.200	1.261	0.500	0.171	14.62	-0.0918	1.10%	0.5	0.484%
0.300	1.405	0.647	0.106	14.23	-0.0501	0.80%	5.0	0.391%
0.400	1.531	0.788	0.065	14.14	-0.0424	0.90%	5.0	0.475%
0.500	1.610	0.871	0.043	14.06	-0.0355	1.00%	5.0	0.476%
0.600	1.645	0.935	0.024	14.02	-0.0249	0.90%	5.0	0.427%
0.800	1.683	0.999	0.008	14.09	-0.0183	1.00%	5.0	0.393%
1.000	1.685	1.029	0.001	13.43	-0.0162	0.90%	5.0	0.362%
1.500	1.570	1.122	-0.021	14.30	-0.0045	0.90%	0.5	0.346%
2.000	1.556	1.108	-0.016	13.10	-0.0087	0.80%	1.0	0.352%
3.000	1.523	1.058	0.004	12.99	-0.0331	2.20%	0.5	1.149%
4.000	1.470	1.035	0.016	13.43	-0.0449	3.40%	0.5	1.516%
5.000	1.490	0.957	0.046	13.69	-0.0729	4.30%	0.5	2.163%
6.000	1.479	0.933	0.059	13.92	-0.0842	4.50%	0.5	2.328%
8.000	1.525	0.913	0.076	14.16	-0.0983	4.70%	1.0	2.538%
10.000	1.504	1.033	0.048	14.18	-0.0710	4.10%	1.0	2.083%
15.000	1.592	1.207	0.026	13.91	-0.0566	3.60%	1.0	1.671%

(19)Lanthanum

LANTHANUM MEDIUM, LANTHANUM RESPONSE

E(MEV)	B	C	A	XK	D	MAX.D	XMAX	S.D
0.015	1.003	0.464	0.161	11.39	-0.0760	0.0 %	2.0	0.025%
0.020	1.007	0.390	0.194	13.63	-0.0649	0.10%	0.5	0.029%
0.030	1.021	0.349	0.221	14.76	-0.0813	0.10%	10.0	0.034%
0.040	1.891	1.773	0.052	10.42	-0.0383	12.10%	3.0	5.206%
0.050	1.820	1.285	0.095	21.62	-0.1009	9.10%	3.0	4.835%
0.060	1.693	0.781	0.181	16.56	-0.1494	2.30%	1.0	1.224%
0.080	1.602	0.212	-0.056	14.11	0.0650	0.30%	1.0	0.156%
0.100	1.453	0.043	0.640	14.28	-0.1659	0.60%	1.0	0.245%
0.150	1.429	0.109	0.549	13.75	-0.2886	1.80%	0.5	0.796%
0.200	1.518	0.212	0.394	13.84	-0.2265	2.30%	0.5	0.999%
0.300	1.809	0.349	0.271	13.54	-0.1550	2.50%	0.5	1.151%
0.400	2.080	0.487	0.199	13.86	-0.1328	3.60%	0.5	1.555%
0.500	2.102	0.617	0.139	13.88	-0.0990	3.00%	0.5	1.414%
0.600	2.185	0.687	0.111	13.71	-0.0842	2.90%	0.5	1.419%
0.800	2.211	0.786	0.076	13.61	-0.0650	2.70%	0.5	1.283%
1.000	2.173	0.841	0.059	13.53	-0.0569	2.20%	0.5	1.175%
1.500	2.007	0.923	0.038	13.54	-0.0498	2.80%	0.5	1.224%
2.000	1.987	0.886	0.054	13.32	-0.0668	4.80%	0.5	2.089%
3.000	1.910	0.803	0.092	13.49	-0.1107	7.60%	0.5	3.350%
4.000	1.795	0.768	0.111	13.85	-0.1284	8.80%	0.5	3.717%
5.000	1.855	0.700	0.145	14.11	-0.1596	8.40%	0.5	3.922%
6.000	1.823	0.710	0.145	14.27	-0.1574	8.00%	0.5	3.769%
8.000	1.906	0.777	0.129	14.28	-0.1449	7.20%	0.5	3.568%
10.000	1.887	0.930	0.087	14.06	-0.1104	6.90%	0.5	3.236%
15.000	1.987	1.151	0.050	13.77	-0.0849	4.90%	0.5	2.611%

LANTHANUM MEDIUM, AIR RESPONSE

E(MEV)	B	C	A	XK	D	MAX.D	XMAX	S.D
0.015	1.003	0.501	0.128	11.60	-0.0387	0.10%	6.0	0.028%
0.020	1.007	0.414	0.172	17.10	-0.0603	0.10%	0.5	0.028%
0.030	1.022	0.322	0.244	13.95	-0.0909	0.10%	35.0	0.029%
0.040	2.921	1.788	0.049	10.98	-0.0358	12.30%	3.0	5.336%
0.050	3.127	1.311	0.089	20.24	-0.0771	9.10%	3.0	5.153%
0.060	2.825	0.774	0.184	16.36	-0.1517	2.80%	1.0	1.540%
0.080	2.048	0.212	-0.124	16.38	0.0663	0.70%	1.0	0.319%
0.100	1.470	0.039	0.661	14.46	-0.1664	0.70%	1.0	0.270%
0.150	1.194	0.236	0.361	13.74	-0.2061	1.40%	0.5	0.587%
0.200	1.194	0.450	0.195	14.20	-0.1044	1.10%	0.5	0.441%
0.300	1.308	0.580	0.131	13.84	-0.0623	0.60%	5.0	0.385%
0.400	1.416	0.713	0.087	14.12	-0.0505	0.80%	5.0	0.459%
0.500	1.488	0.803	0.060	14.10	-0.0399	0.90%	5.0	0.464%
0.600	1.534	0.865	0.041	13.81	-0.0304	0.90%	5.0	0.445%
0.800	1.588	0.934	0.023	13.66	-0.0234	0.90%	5.0	0.394%
1.000	1.602	0.974	0.014	13.24	-0.0222	0.70%	25.0	0.412%
1.500	1.538	1.072	-0.009	13.64	-0.0108	0.60%	1.0	0.277%
2.000	1.553	1.044	0.002	13.08	-0.0225	0.90%	4.0	0.628%
3.000	1.543	1.009	0.019	13.39	-0.0447	3.40%	0.5	1.518%
4.000	1.523	0.970	0.037	13.74	-0.0609	4.10%	0.5	1.821%
5.000	1.611	0.888	0.070	13.96	-0.0893	4.80%	0.5	2.332%
6.000	1.650	0.884	0.076	14.19	-0.0919	4.50%	0.5	2.307%
8.000	1.847	0.929	0.073	14.18	-0.0906	4.00%	0.5	2.245%
10.000	1.918	1.097	0.035	14.06	-0.0582	2.90%	0.5	1.639%
15.000	2.180	1.316	0.008	13.68	-0.0396	1.90%	1.0	1.063%

(20)Gadolinium

GADOLINIUM MEDIUM, GADOLINIUM RESPONSE

E(MEV)	B	C	A	XK	D	MAX.D	XMAX	S.D
0.015	1.002	0.539	0.111	11.48	-0.0337	0.10%	0.5	0.032%
0.020	1.005	0.393	0.191	10.33	-0.0581	0.10%	4.0	0.025%
0.030	1.015	0.325	0.239	14.39	-0.0881	0.10%	2.0	0.031%
0.040	1.031	0.310	0.258	14.22	-0.1014	0.10%	2.0	0.026%
0.050	1.053	0.323	0.243	14.30	-0.0957	0.10%	2.0	0.061%
0.060	1.777	1.500	0.063	29.33	-0.1035	10.20%	40.0	5.175%
0.080	1.734	0.587	0.245	16.07	-0.2151	2.10%	35.0	1.262%
0.100	1.643	0.237	-0.007	18.36	0.0556	0.30%	0.5	0.166%
0.150	1.467	0.060	0.678	14.02	-0.3125	1.20%	0.5	0.558%
0.200	1.485	0.144	0.486	13.76	-0.2671	2.10%	0.5	0.942%
0.300	1.657	0.287	0.316	13.38	-0.1787	2.40%	0.5	1.089%
0.400	1.879	0.411	0.240	13.78	-0.1558	3.10%	0.5	1.413%
0.500	2.022	0.511	0.187	13.85	-0.1264	3.40%	0.5	1.551%
0.600	1.976	0.614	0.137	13.66	-0.0950	2.70%	0.5	1.340%
0.800	2.062	0.711	0.100	13.60	-0.0757	2.60%	0.5	1.317%
1.000	2.067	0.772	0.080	13.51	-0.0669	2.40%	0.5	1.293%
1.500	1.903	0.891	0.046	13.68	-0.0522	2.90%	0.5	1.244%
2.000	1.884	0.865	0.060	13.37	-0.0694	5.10%	0.5	2.174%
3.000	1.785	0.801	0.093	13.53	-0.1111	7.90%	0.5	3.415%
4.000	1.650	0.788	0.104	13.87	-0.1217	9.40%	0.5	3.696%
5.000	1.667	0.727	0.135	14.15	-0.1502	8.90%	0.5	3.901%
6.000	1.631	0.740	0.135	14.30	-0.1487	8.40%	0.5	3.754%
8.000	1.648	0.814	0.119	14.28	-0.1368	7.50%	0.5	3.548%
10.000	1.586	0.976	0.077	14.14	-0.1007	7.00%	0.5	3.072%
15.000	1.581	1.190	0.046	13.74	-0.0810	5.00%	0.5	2.512%

GADOLINIUM MEDIUM, AIR RESPONSE

E(MEV)	B	C	A	XK	D	MAX.D	XMAX	S.D
0.015	1.003	0.261	0.299	21.25	-0.2771	0.10%	1.0	0.034%
0.020	1.005	0.393	0.195	12.95	-0.0802	0.10%	15.0	0.028%
0.030	1.015	0.326	0.241	13.87	-0.0885	0.10%	35.0	0.022%
0.040	1.031	0.312	0.256	14.14	-0.0997	0.10%	8.0	0.032%
0.050	1.051	0.324	0.248	14.02	-0.1050	0.10%	10.0	0.065%
0.060	2.512	1.510	0.062	28.83	-0.1054	10.40%	20.0	5.657%
0.080	2.104	0.593	0.243	15.93	-0.2151	2.40%	35.0	1.390%
0.100	1.617	0.241	-0.007	19.33	0.0608	0.30%	0.5	0.173%
0.150	1.198	0.149	0.473	13.83	-0.2602	1.00%	0.5	0.498%
0.200	1.159	0.389	0.229	14.18	-0.1218	1.10%	0.5	0.442%
0.300	1.233	0.544	0.143	13.81	-0.0659	0.50%	0.5	0.335%
0.400	1.321	0.669	0.099	14.23	-0.0534	0.70%	35.0	0.413%
0.500	1.394	0.744	0.076	14.15	-0.0447	0.70%	5.0	0.443%
0.600	1.442	0.800	0.058	13.75	-0.0359	0.80%	5.0	0.461%
0.800	1.506	0.872	0.038	13.69	-0.0279	0.90%	5.0	0.431%
1.000	1.527	0.929	0.023	13.52	-0.0222	0.90%	5.0	0.414%
1.500	1.495	1.023	0.003	14.01	-0.0176	0.60%	35.0	0.279%
2.000	1.496	1.042	0.001	13.15	-0.0192	1.50%	0.5	0.657%
3.000	1.488	1.014	0.018	13.26	-0.0438	3.60%	0.5	1.536%
4.000	1.466	0.987	0.033	13.74	-0.0572	4.20%	0.5	1.804%
5.000	1.533	0.915	0.063	13.98	-0.0835	5.40%	0.5	2.377%
6.000	1.563	0.915	0.069	14.16	-0.0873	5.20%	0.5	2.378%
8.000	1.726	0.966	0.066	14.13	-0.0861	5.00%	0.5	2.398%
10.000	1.793	1.127	0.033	13.96	-0.0587	3.40%	0.5	1.736%
15.000	2.000	1.358	0.005	13.71	-0.0370	2.70%	1.0	1.253%

(21)Tungsten

TUNGSTEN MEDIUM, TUNGSTEN RESPONSE

E(MEV)	B	C	A	XK	D	MAX.D	XMAX	S.D
0.015	1.002	0.293	0.254	28.31	-0.3727	0.10%	2.0	0.034%
0.020	1.003	0.468	0.137	25.30	-0.0820	0.10%	3.0	0.028%
0.030	1.009	0.357	0.220	13.52	-0.0868	0.10%	7.0	0.029%
0.040	1.019	0.320	0.251	13.89	-0.1026	0.10%	0.5	0.029%
0.050	1.034	0.296	0.263	14.01	-0.0992	0.10%	2.0	0.050%
0.060	1.054	0.284	0.277	13.97	-0.1120	0.30%	0.5	0.103%
0.080	1.984	1.385	0.089	12.82	-0.0580	10.30%	3.0	4.997%
0.100	1.790	0.836	0.168	16.34	-0.1388	2.80%	1.0	1.488%
0.150	1.594	0.107	0.313	24.26	-0.0182	0.90%	2.0	0.399%
0.200	1.521	0.074	0.631	13.95	-0.3015	1.20%	2.0	0.621%
0.300	1.559	0.203	0.396	13.31	-0.2181	2.30%	0.5	1.027%
0.400	1.678	0.326	0.294	13.71	-0.1849	2.90%	0.5	1.289%
0.500	1.793	0.418	0.235	13.74	-0.1529	3.20%	0.5	1.426%
0.600	1.715	0.537	0.166	13.58	-0.1058	2.20%	0.5	1.134%
0.800	1.834	0.627	0.128	13.58	-0.0851	2.50%	0.5	1.228%
1.000	1.872	0.692	0.105	13.53	-0.0762	2.50%	0.5	1.292%
1.500	1.784	0.841	0.059	13.85	-0.0560	2.60%	0.5	1.180%
2.000	1.764	0.842	0.065	13.44	-0.0686	5.40%	0.5	2.169%
3.000	1.659	0.813	0.087	13.54	-0.1032	8.80%	0.5	3.424%
4.000	1.542	0.800	0.100	13.85	-0.1176	9.90%	0.5	3.744%
5.000	1.527	0.756	0.125	14.14	-0.1422	10.20%	0.5	4.125%
6.000	1.485	0.758	0.131	14.29	-0.1478	9.70%	0.5	4.062%
8.000	1.482	0.803	0.128	14.31	-0.1487	8.90%	0.5	4.023%
10.000	1.432	0.957	0.088	14.21	-0.1128	8.60%	0.5	3.548%
15.000	1.432	1.160	0.059	13.89	-0.0949	7.10%	0.5	3.222%

TUNGSTEN MEDIUM, AIR RESPONSE

E(MEV)	B	C	A	XK	D	MAX.D	XMAX	S.D
0.015	1.002	0.317	0.228	33.67	-0.4556	0.10%	2.0	0.032%
0.020	1.003	0.468	0.137	25.30	-0.0820	0.10%	3.0	0.028%
0.030	1.009	0.388	0.187	19.12	-0.0843	0.10%	1.0	0.031%
0.040	1.019	0.320	0.251	13.89	-0.1026	0.10%	1.0	0.038%
0.050	1.033	0.299	0.264	13.96	-0.1066	0.10%	7.0	0.053%
0.060	1.048	0.314	0.257	14.20	-0.1100	0.10%	35.0	0.088%
0.080	2.238	1.442	0.079	17.80	-0.0858	10.90%	25.0	6.249%
0.100	1.764	0.867	0.160	15.88	-0.1366	2.90%	4.0	1.753%
0.150	1.253	0.145	0.353	15.12	-0.0845	0.40%	0.5	0.152%
0.200	1.155	0.248	0.347	13.68	-0.1966	0.90%	0.5	0.466%
0.300	1.170	0.487	0.168	13.62	-0.0812	0.60%	0.5	0.326%
0.400	1.234	0.601	0.123	14.14	-0.0647	0.60%	25.0	0.378%
0.500	1.293	0.672	0.098	14.13	-0.0532	0.60%	25.0	0.405%
0.600	1.338	0.722	0.080	13.69	-0.0438	0.70%	5.0	0.415%
0.800	1.402	0.797	0.057	13.71	-0.0334	0.70%	25.0	0.410%
1.000	1.436	0.853	0.042	13.34	-0.0285	0.80%	5.0	0.426%
1.500	1.421	0.977	0.013	14.30	-0.0205	0.50%	4.0	0.258%
2.000	1.428	1.012	0.007	13.40	-0.0200	1.30%	0.5	0.665%
3.000	1.406	1.023	0.014	13.42	-0.0385	3.30%	0.5	1.351%
4.000	1.363	1.037	0.018	13.72	-0.0437	4.20%	0.5	1.555%
5.000	1.393	0.964	0.049	13.94	-0.0723	5.40%	0.5	2.246%
6.000	1.397	0.963	0.056	14.34	-0.0769	5.50%	0.5	2.371%
8.000	1.465	0.990	0.063	14.15	-0.0848	5.80%	0.5	2.583%
10.000	1.475	1.151	0.031	14.10	-0.0561	4.50%	0.5	1.890%
15.000	1.589	1.335	0.016	13.60	-0.0494	3.40%	0.5	1.708%

(22)Lead

LEAD MEDIUM, LEAD RESPONSE

E(MEV)	B	C	A	XK	D	MAX.D	XMAX	S.D
0.015	0.000	0.000	0.000	0.00	0.0000	0.00%	0.0	0.000%
0.020	0.000	0.000	0.000	0.00	0.0000	0.00%	0.0	0.000%
0.030	1.007	0.309	0.264	13.16	-0.1229	0.10%	2.0	0.023%
0.040	1.014	0.304	0.262	13.53	-0.0970	0.10%	35.0	0.026%
0.050	1.024	0.294	0.267	14.35	-0.1097	0.10%	0.5	0.033%
0.060	1.036	0.300	0.272	13.88	-0.1245	0.10%	2.0	0.058%
0.080	1.076	0.277	0.297	13.69	-0.1425	0.30%	2.0	0.140%
0.100	1.934	1.336	0.096	12.88	-0.0695	9.40%	3.0	4.893%
0.150	1.728	0.304	0.298	27.59	-0.0003	2.70%	0.5	1.087%
0.200	1.589	0.078	0.489	17.42	-0.1064	0.80%	1.0	0.315%
0.300	1.530	0.144	0.476	13.28	-0.2522	2.00%	0.5	0.959%
0.400	1.594	0.262	0.347	13.60	-0.2151	2.90%	0.5	1.225%
0.500	1.674	0.352	0.276	13.67	-0.1762	3.10%	0.5	1.343%
0.600	1.555	0.496	0.181	13.55	-0.1093	2.00%	0.5	0.976%
0.800	1.685	0.570	0.149	13.53	-0.0930	2.20%	0.5	1.127%
1.000	1.741	0.635	0.124	13.51	-0.0829	2.50%	0.5	1.235%
1.500	1.719	0.784	0.076	13.99	-0.0636	3.20%	0.5	1.311%
2.000	1.730	0.784	0.084	13.50	-0.0798	6.20%	0.5	2.379%
3.000	1.642	0.764	0.104	13.62	-0.1140	9.50%	0.5	3.604%
4.000	1.524	0.764	0.112	13.91	-0.1241	10.30%	0.5	3.789%
5.000	1.521	0.714	0.141	14.20	-0.1537	10.50%	0.5	4.202%
6.000	1.475	0.737	0.138	14.36	-0.1503	10.50%	0.5	4.142%
8.000	1.480	0.791	0.132	14.35	-0.1495	9.70%	0.5	4.150%
10.000	1.428	0.963	0.086	14.23	-0.1084	9.60%	0.5	3.630%
15.000	1.437	1.152	0.062	13.87	-0.0968	8.10%	0.5	3.454%

LEAD MEDIUM, AIR RESPONSE

E(MEV)	B	C	A	XK	D	MAX.D	XMAX	S.D
0.015	0.000	0.000	0.000	0.00	0.0000	0.00%	0.0	0.000%
0.020	0.000	0.000	0.000	0.00	0.0000	0.00%	0.0	0.000%
0.030	1.007	0.322	0.246	13.67	-0.1030	0.0 %	0.5	0.020%
0.040	1.014	0.317	0.245	14.95	-0.0867	0.10%	0.5	0.035%
0.050	1.023	0.312	0.252	14.17	-0.1005	0.10%	0.5	0.044%
0.060	1.033	0.320	0.260	13.89	-0.1223	0.10%	4.0	0.058%
0.080	1.058	0.362	0.233	13.91	-0.1127	0.20%	0.5	0.115%
0.100	1.930	1.499	0.061	29.65	-0.1162	10.10%	40.0	4.366%
0.150	1.402	0.352	0.269	17.09	-0.0247	1.10%	0.5	0.581%
0.200	1.201	0.158	0.426	14.12	-0.1873	0.30%	10.0	0.202%
0.300	1.148	0.422	0.203	13.49	-0.1013	0.80%	0.5	0.364%
0.400	1.187	0.562	0.137	14.19	-0.0706	0.60%	0.5	0.351%
0.500	1.233	0.634	0.109	14.20	-0.0556	0.60%	0.5	0.380%
0.600	1.269	0.685	0.089	13.78	-0.0440	0.60%	1.0	0.360%
0.800	1.329	0.759	0.065	13.69	-0.0317	0.80%	1.0	0.394%
1.000	1.367	0.811	0.051	13.67	-0.0283	0.80%	1.0	0.416%
1.500	1.369	0.942	0.020	14.65	-0.0207	0.90%	1.0	0.336%
2.000	1.384	0.980	0.014	13.51	-0.0216	1.70%	0.5	0.675%
3.000	1.367	1.006	0.017	13.33	-0.0377	3.40%	0.5	1.304%
4.000	1.337	1.009	0.024	14.15	-0.0455	3.70%	0.5	1.464%
5.000	1.360	0.957	0.049	14.04	-0.0683	5.40%	0.5	2.117%
6.000	1.363	0.965	0.054	14.21	-0.0716	5.70%	0.5	2.211%
8.000	1.441	0.994	0.061	14.18	-0.0800	5.80%	0.5	2.450%
10.000	1.464	1.148	0.032	14.08	-0.0554	4.10%	0.5	1.733%
15.000	1.573	1.337	0.016	13.54	-0.0463	3.50%	0.5	1.755%

(23)Uranium

URANIUM MEDIUM, URANIUM RESPONSE

E(MEV)	B	C	A	XK	D	MAX.D	XMAX	S.D
0.015	0.000	0.000	0.000	0.00	0.0000	0.00%	0.0	0.000%
0.020	0.000	0.000	0.000	0.00	0.0000	0.00%	0.0	0.000%
0.030	1.005	0.336	0.224	25.06	-0.2039	0.0 %	8.0	0.021%
0.040	1.010	0.301	0.257	14.81	-0.0871	0.10%	2.0	0.032%
0.050	1.016	0.323	0.235	15.31	-0.0834	0.10%	1.0	0.040%
0.060	1.025	0.287	0.282	14.53	-0.1333	0.10%	2.0	0.035%
0.080	1.051	0.269	0.303	13.80	-0.1469	0.20%	0.5	0.125%
0.100	1.083	0.275	0.301	13.80	-0.1524	0.30%	0.5	0.172%
0.150	1.832	0.976	0.134	16.75	-0.1034	3.70%	1.0	1.872%
0.200	1.759	0.334	0.147	13.39	-0.0426	0.20%	0.5	0.095%
0.300	1.587	0.089	0.563	13.59	-0.2424	1.10%	2.0	0.508%
0.400	1.571	0.179	0.441	13.56	-0.2670	2.50%	0.5	1.152%
0.500	1.592	0.272	0.339	13.60	-0.2137	2.90%	0.5	1.298%
0.600	1.464	0.420	0.220	13.49	-0.1309	2.10%	0.5	0.981%
0.800	1.571	0.493	0.183	13.47	-0.1102	2.30%	0.5	1.104%
1.000	1.591	0.574	0.146	13.46	-0.0912	2.10%	0.5	1.114%
1.500	1.643	0.702	0.104	14.01	-0.0780	3.30%	0.5	1.417%
2.000	1.677	0.715	0.107	13.60	-0.0909	6.70%	0.5	2.502%
3.000	1.612	0.707	0.123	13.68	-0.1233	10.00%	0.5	3.600%
4.000	1.518	0.704	0.132	14.03	-0.1340	10.50%	0.5	3.770%
5.000	1.514	0.674	0.153	14.30	-0.1542	11.50%	0.5	4.230%
6.000	1.487	0.680	0.158	14.45	-0.1618	10.80%	0.5	4.147%
8.000	1.492	0.762	0.139	14.43	-0.1499	10.80%	0.5	4.226%
10.000	1.461	0.911	0.100	14.26	-0.1188	9.80%	0.5	3.690%
15.000	1.468	1.114	0.070	13.88	-0.1022	8.60%	0.5	3.562%

URANIUM MEDIUM, AIR RESPONSE

E(MEV)	B	C	A	XK	D	MAX.D	XMAX	S.D
0.015	0.000	0.000	0.000	0.00	0.0000	0.00%	0.0	0.000%
0.020	0.000	0.000	0.000	0.00	0.0000	0.00%	0.0	0.000%
0.030	1.005	0.336	0.224	25.06	-0.2039	0.0 %	8.0	0.021%
0.040	1.010	0.296	0.272	14.23	-0.1199	0.10%	2.0	0.028%
0.050	1.016	0.313	0.248	13.81	-0.0893	0.10%	10.0	0.029%
0.060	1.022	0.336	0.244	14.48	-0.1157	0.10%	2.0	0.036%
0.080	1.039	0.357	0.236	13.87	-0.1154	0.20%	0.5	0.093%
0.100	1.057	0.390	0.217	13.78	-0.1096	0.20%	3.0	0.125%
0.150	1.598	1.030	0.122	16.02	-0.0996	4.00%	1.0	2.002%
0.200	1.324	0.366	0.167	13.28	-0.0655	0.20%	3.0	0.108%
0.300	1.160	0.284	0.304	13.28	-0.1643	0.80%	0.5	0.419%
0.400	1.157	0.490	0.171	13.96	-0.0911	0.90%	0.5	0.417%
0.500	1.185	0.577	0.131	14.05	-0.0682	0.70%	0.5	0.389%
0.600	1.207	0.643	0.101	13.80	-0.0473	0.60%	1.0	0.332%
0.800	1.261	0.705	0.080	13.89	-0.0362	0.70%	1.0	0.353%
1.000	1.298	0.754	0.066	13.69	-0.0325	0.70%	1.0	0.404%
1.500	1.320	0.873	0.038	14.78	-0.0282	0.60%	10.0	0.345%
2.000	1.338	0.923	0.028	13.56	-0.0274	1.60%	0.5	0.691%
3.000	1.326	0.968	0.024	13.45	-0.0372	3.20%	0.5	1.172%
4.000	1.299	0.984	0.027	13.84	-0.0418	3.50%	0.5	1.280%
5.000	1.327	0.932	0.052	14.08	-0.0638	5.10%	0.5	1.903%
6.000	1.339	0.935	0.058	14.53	-0.0676	5.10%	0.5	1.982%
8.000	1.422	0.973	0.063	14.26	-0.0761	5.30%	0.5	2.190%
10.000	1.451	1.133	0.032	14.31	-0.0502	3.70%	0.5	1.486%
15.000	1.557	1.328	0.015	13.75	-0.0405	3.60%	0.5	1.573%

(24)Water

WATER MEDIUM, WATER RESPONSE

E(MEV)	B	C	A	XK	D	MAX.D	XMAX	S.D
0.015	1.188	0.464	0.172	14.00	-0.0829	1.37%	0.5	0.508%
0.020	1.449	0.532	0.152	14.61	-0.0764	1.91%	0.5	0.730%
0.030	2.411	0.741	0.084	14.62	-0.0452	2.29%	0.5	1.065%
0.040	3.587	1.114	-0.018	12.48	0.0013	0.68%	0.5	0.248%
0.050	4.554	1.457	-0.084	13.69	0.0341	1.47%	35.0	0.977%
0.060	5.018	1.735	-0.127	13.70	0.0676	2.37%	35.0	1.564%
0.080	5.030	2.054	-0.167	13.84	0.0763	3.00%	35.0	1.982%
0.100	4.627	2.207	-0.184	13.27	0.0799	2.98%	10.0	1.885%
0.150	3.888	2.206	-0.180	14.27	0.0738	2.37%	0.5	1.478%
0.200	3.462	2.132	-0.173	14.51	0.0750	2.36%	0.5	1.335%
0.300	2.897	2.008	-0.162	14.18	0.0641	2.40%	35.0	1.412%
0.400	2.646	1.874	-0.148	14.16	0.0591	2.41%	35.0	1.377%
0.500	2.499	1.749	-0.132	14.36	0.0517	2.00%	1.0	1.195%
0.600	2.383	1.662	-0.121	14.19	0.0482	1.97%	35.0	1.224%
0.800	2.223	1.524	-0.101	14.31	0.0403	1.97%	1.0	1.078%
1.000	2.106	1.436	-0.088	14.19	0.0367	1.68%	0.5	0.970%
1.500	1.948	1.265	-0.057	14.98	0.0245	1.51%	0.5	0.616%
2.000	1.843	1.169	-0.038	14.22	0.0157	1.61%	0.5	0.551%
3.000	1.716	1.050	-0.011	13.63	0.0027	0.97%	0.5	0.314%
4.000	1.633	0.979	0.007	14.23	-0.0060	0.65%	0.5	0.252%
5.000	1.571	0.928	0.022	13.20	-0.0157	0.62%	4.0	0.336%
6.000	1.521	0.893	0.033	11.92	-0.0208	1.87%	1.0	0.636%
8.000	1.432	0.873	0.038	11.56	-0.0204	0.59%	3.0	0.355%
10.000	1.378	0.849	0.045	14.34	-0.0280	0.98%	0.5	0.574%
15.000	1.280	0.829	0.052	14.85	-0.0367	1.23%	3.0	0.688%

WATER MEDIUM, AIR RESPONSE

E(MEV)	B	C	A	XK	D	MAX.D	XMAX	S.D
0.015	1.182	0.463	0.175	14.23	-0.0908	1.69%	0.5	0.634%
0.020	1.427	0.549	0.143	14.86	-0.0707	2.31%	0.5	0.780%
0.030	2.335	0.736	0.087	13.28	-0.0419	2.34%	0.5	1.180%
0.040	3.477	1.117	-0.019	11.67	0.0026	0.89%	0.5	0.298%
0.050	4.461	1.457	-0.084	13.62	0.0341	1.26%	10.0	0.850%
0.060	4.983	1.730	-0.126	13.64	0.0561	2.22%	10.0	1.563%
0.080	5.059	2.059	-0.168	13.67	0.0770	2.94%	35.0	1.946%
0.100	4.663	2.221	-0.186	13.33	0.0826	3.02%	10.0	1.925%
0.150	3.897	2.242	-0.185	14.19	0.0777	2.55%	15.0	1.584%
0.200	3.478	2.154	-0.176	14.50	0.0774	2.50%	0.5	1.492%
0.300	2.920	2.022	-0.164	14.21	0.0655	2.46%	1.0	1.471%
0.400	2.660	1.882	-0.149	14.24	0.0595	2.17%	35.0	1.372%
0.500	2.500	1.766	-0.135	14.33	0.0546	2.46%	1.0	1.380%
0.600	2.377	1.679	-0.124	14.23	0.0503	2.02%	1.0	1.265%
0.800	2.212	1.544	-0.105	14.36	0.0437	1.97%	0.5	1.186%
1.000	2.103	1.441	-0.089	14.22	0.0378	1.55%	0.5	0.895%
1.500	1.939	1.269	-0.058	14.52	0.0246	1.91%	0.5	0.757%
2.000	1.839	1.173	-0.039	14.07	0.0161	1.45%	0.5	0.522%
3.000	1.710	1.056	-0.013	11.82	0.0047	0.70%	0.5	0.239%
4.000	1.621	0.989	0.004	13.45	-0.0041	0.55%	1.0	0.211%
5.000	1.554	0.939	0.018	13.55	-0.0122	0.51%	30.0	0.333%
6.000	1.507	0.903	0.029	16.13	-0.0272	0.85%	25.0	0.475%
8.000	1.422	0.879	0.035	13.36	-0.0191	0.89%	0.5	0.445%
10.000	1.362	0.859	0.042	13.37	-0.0247	0.90%	0.5	0.453%
15.000	1.267	0.843	0.047	15.08	-0.0336	1.02%	1.0	0.604%

(25)Concrete

CONCRETE MEDIUM, CONCRETE RESPONSE

E(MEV)	B	C	A	XK	D	MAX.D	XMAX	S.D
0.015	1.028	0.429	0.174	27.56	-0.2976	0.58%	4.0	0.282%
0.020	1.067	0.396	0.204	13.32	-0.0960	0.74%	0.5	0.414%
0.030	1.220	0.403	0.212	14.44	-0.1160	1.01%	0.5	0.558%
0.040	1.472	0.489	0.172	14.92	-0.0943	1.94%	0.5	0.766%
0.050	1.826	0.602	0.127	15.51	-0.0687	1.30%	2.0	0.638%
0.060	2.249	0.723	0.087	16.62	-0.0622	1.30%	2.0	0.563%
0.080	3.263	0.885	0.045	14.03	-0.0402	1.15%	10.0	0.700%
0.100	3.867	1.101	-0.009	13.91	-0.0161	0.80%	2.0	0.367%
0.150	4.066	1.413	-0.072	13.89	0.0174	2.67%	0.5	1.007%
0.200	3.682	1.552	-0.095	13.73	0.0285	2.96%	0.5	1.182%
0.300	3.090	1.617	-0.106	14.23	0.0331	2.21%	0.5	1.085%
0.400	2.774	1.593	-0.104	14.36	0.0323	2.22%	0.5	1.000%
0.500	2.572	1.552	-0.099	14.76	0.0315	1.61%	0.5	0.799%
0.600	2.433	1.507	-0.093	14.78	0.0296	1.99%	0.5	0.833%
0.800	2.243	1.429	-0.082	14.85	0.0270	1.79%	0.5	0.687%
1.000	2.124	1.359	-0.071	15.31	0.0243	1.48%	0.5	0.563%
1.500	1.934	1.249	-0.053	14.53	0.0201	1.18%	0.5	0.497%
2.000	1.834	1.161	-0.035	13.88	0.0117	0.75%	2.0	0.332%
3.000	1.701	1.051	-0.009	10.11	-0.0021	0.42%	0.5	0.180%
4.000	1.613	0.981	0.010	12.99	-0.0133	0.64%	4.0	0.331%
5.000	1.551	0.919	0.030	11.99	-0.0263	2.82%	0.5	0.979%
6.000	1.475	0.930	0.024	15.87	-0.0273	0.80%	10.0	0.475%
8.000	1.383	0.909	0.031	12.43	-0.0218	1.21%	1.0	0.573%
10.000	1.320	0.902	0.033	14.83	-0.0258	1.49%	1.0	0.710%
15.000	1.229	0.866	0.048	15.03	-0.0426	1.25%	10.0	0.806%

CONCRETE MEDIUM, AIR RESPONSE

E(MEV)	B	C	A	XK	D	MAX.D	XMAX	S.D
0.015	1.029	0.364	0.240	14.12	-0.1704	0.46%	25.0	0.236%
0.020	1.067	0.389	0.214	12.68	-0.1126	0.72%	0.5	0.359%
0.030	1.212	0.421	0.201	14.12	-0.1079	1.56%	0.5	0.610%
0.040	1.455	0.493	0.171	14.53	-0.0925	2.01%	0.5	0.831%
0.050	1.737	0.628	0.115	15.82	-0.0600	0.97%	2.0	0.499%
0.060	2.125	0.664	0.118	11.90	-0.0615	2.90%	0.5	1.389%
0.080	2.557	0.895	0.042	14.37	-0.0413	1.86%	0.5	0.958%
0.100	2.766	1.069	0.001	12.64	-0.0251	1.14%	35.0	0.623%
0.150	2.812	1.319	-0.050	8.75	-0.0040	0.41%	5.0	0.269%
0.200	2.716	1.430	-0.070	18.52	0.0108	0.50%	0.5	0.164%
0.300	2.522	1.492	-0.082	16.59	0.0161	0.49%	40.0	0.246%
0.400	2.372	1.494	-0.085	15.96	0.0194	0.40%	25.0	0.195%
0.500	2.271	1.466	-0.082	16.25	0.0195	0.28%	15.0	0.163%
0.600	2.192	1.434	-0.078	17.02	0.0199	0.55%	1.0	0.242%
0.800	2.066	1.386	-0.073	15.07	0.0202	0.68%	35.0	0.296%
1.000	1.982	1.332	-0.065	15.38	0.0193	0.46%	35.0	0.189%
1.500	1.848	1.227	-0.047	16.41	0.0160	0.64%	0.5	0.317%
2.000	1.775	1.154	-0.033	14.35	0.0100	0.64%	40.0	0.194%
3.000	1.671	1.054	-0.010	10.47	-0.0008	0.31%	3.0	0.152%
4.000	1.597	0.988	0.008	12.53	-0.0115	0.81%	1.0	0.433%
5.000	1.531	0.945	0.022	10.26	-0.0199	0.59%	40.0	0.335%
6.000	1.478	0.940	0.021	13.11	-0.0163	1.30%	0.5	0.560%
8.000	1.395	0.917	0.028	13.45	-0.0213	1.42%	0.5	0.604%
10.000	1.334	0.901	0.035	12.56	-0.0267	1.48%	0.5	0.623%
15.000	1.260	0.823	0.065	14.28	-0.0581	1.96%	3.0	1.151%

(26)Air

AIR MEDIUM, AIR RESPONSE

E(MEV)	B	C	A	XK	D	MAX.D	XMAX	S.D
0.015	1.170	0.459	0.175	13.73	-0.0862	1.45%	0.5	0.512%
0.020	1.407	0.512	0.161	14.40	-0.0819	2.15%	0.5	0.830%
0.030	2.292	0.693	0.102	13.34	-0.0484	2.48%	0.5	1.240%
0.040	3.390	1.052	-0.004	19.76	-0.0068	0.95%	0.5	0.383%
0.050	4.322	1.383	-0.071	13.51	0.0270	1.19%	4.0	0.782%
0.060	4.837	1.653	-0.115	13.66	0.0511	2.37%	0.5	1.422%
0.080	4.929	1.983	-0.159	13.74	0.0730	2.73%	10.0	1.909%
0.100	4.580	2.146	-0.178	12.83	0.0759	2.69%	1.0	1.733%
0.150	3.894	2.148	-0.173	14.46	0.0698	2.51%	35.0	1.506%
0.200	3.345	2.147	-0.176	14.08	0.0719	2.51%	35.0	1.540%
0.300	2.887	1.990	-0.160	14.13	0.0633	2.29%	25.0	1.450%
0.400	2.635	1.860	-0.146	14.24	0.0583	2.17%	35.0	1.377%
0.500	2.496	1.736	-0.130	14.32	0.0505	2.30%	1.0	1.267%
0.600	2.371	1.656	-0.120	14.27	0.0472	1.80%	25.0	1.198%
0.800	2.207	1.532	-0.103	14.12	0.0425	1.92%	0.5	1.131%
1.000	2.102	1.428	-0.086	14.35	0.0344	1.63%	0.5	0.858%
1.500	1.939	1.265	-0.057	14.24	0.0232	1.22%	0.5	0.610%
2.000	1.835	1.173	-0.039	14.07	0.0161	1.31%	0.5	0.534%
3.000	1.712	1.051	-0.011	13.67	0.0024	0.81%	0.5	0.254%
4.000	1.627	0.983	0.006	13.51	-0.0051	0.44%	5.0	0.257%
5.000	1.558	0.943	0.017	13.82	-0.0117	0.76%	1.0	0.371%
6.000	1.505	0.915	0.025	16.37	-0.0231	0.99%	1.0	0.513%
8.000	1.418	0.891	0.032	12.06	-0.0167	1.12%	0.5	0.418%
10.000	1.358	0.875	0.037	14.01	-0.0226	1.16%	0.5	0.547%
15.000	1.267	0.844	0.048	14.55	-0.0344	1.08%	4.0	0.651%