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Energy Loss and Range of Electrons and Positrons

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Data on Radiation Physics

Graphs of the Compton Energy-Angle Relationship and the Klein-Nishina Formula from 10 Kev to 500 Mev NBS Circular 542

The Compton energy versus angle relationship and the differential and integral Klein-Nishina cross sections are presented graphically as functions of the energy and direction of the scattered photon and of the recoil electron. These graphs are intended to serve the purpose of tables. Unpolarized primary gamma rays in an energy range from 10 Kev to 500 Mev are considered. The accuracy of all curves is estimated at 1 percent. The advantage of this form of presentation is the convenience and accuracy of two-way interpolation. In general, interpolated values may be obtained with an accuracy of 2 percent.

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Energy Loss and Range of Electrons and Positrons

Ann T. Nelms

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Contents

ENERGY LOSS AND RANGE OF ELECTRONS AND POSITRONS

Ann T. Nelms

Tabulations of the mean energy loss due to ionization and excitation and the range derived from this quantity are given for electrons and positrons in several materials.

1. INTRODUCTION

This Circular belongs to a series of surveys and tabulations of data on radiation physics that are being carried out with the support of the Biophysics Branch of the Atomic Energy Commission. Other reports of this series are listed on the inside cover.

The material in this Circular is designed to serve as input for recently developed calculations of electron penetration, which take into account both elastic scattering and slowing down. Most of the earlier reports on stopping powers of matter and ranges of charged particles pertain to heavier particles, for which the penetration process is simpler and the knowledge of basic processes somewhat more advanced than for electrons. The present data gives the energy loss resulting from ionization and excitation. The range is derived from this quantity and represents the actual path length rather than an extrapolated range.

This Circular is presented as a regular publication even though much of its material is in fact preliminary and incomplete, and should be improved and revised at an early date. The main limitations to the completeness and accuracy of the data presented here arise from the following circumstances: a) uncertainty of the value of the constant I for different materials, about which new evidence is being accummulated (see Sect. 3); b) failure to apply "density corrections" in the high energy range, for which standardized procedures of calculation and presentation have not yet been established in this laboratory; c) lack of a theory of inelastic collisions for lower energy electrons, with velocity comparable to those of atomic electrons; and d) limited significance of the very concepts of stopping power and range, in the presence of the straggling that results from occasional extremely large energy loss by an electron in a single process. This last consideration has limited the tabulation to energies at which bremsstrahlung losses are unimportant. In the future, data on stopping powers and ranges might be replaced with data on other parameters of an energy-pathlength distribution (e.g. most probable instead of mean energy losses), which is an extension of the Landau distribution. The inaccuracy arising from item a) is not too large, no more than a few percent under most circumstances and may well be reduced in the next few years. The limitation b) ought to be largely removed at an early date, but c) is of a more fundamental nature, even though it concerns only the lower energy range (below 10 kev), and its removal cannot be easily forecast.

2. GENERAL FORMULATION

The differential cross section for inelastic collisions of an electron with an atomic electron considered free is given by the Rutherford non-relativistic theory [1] as

$$d\sigma = 2\pi r_o^2 \frac{mc^2}{\beta^2} \frac{dQ}{Q^2}, \qquad (1)$$

Figures in brackets indicate literature references at end of this paper.

where $r_o = e^2/mc^2$, $\beta = v/c$, e and m are the charge and mass of an electron, v is the velocity of the incident particle, c is the velocity of light and Q is the recoil energy of the free atomic electron, which is related to the momentum transfer, $\hbar\vec{q}$, by

$$Q = \hbar^2 \left|\vec{q}\right|^2/2m.$$

Because atomic electrons are bound within matter, the momentum, $\vec{q}$, received in a collision does not fix the final state, n, of excitation or ionization of the electrons; that is, the actual energy received, W_n, is not unique. The probability that the momentum transfer $\vec{q}$ will send an atom to the state n is given by $|F_n(\vec{q})|^2$, the square of the generalized form factor,

$$F_n(\vec{q}) = \int \psi_n^* \, \psi_o \sum_i e^{i\vec{q}\cdot\vec{r}_i} \, d\tau \quad , \tag{2}$$

where ψ_o and ψ_n are respectively the wave functions of the ground state and the excited state n, $\vec{r}_i$ is the position vector of the i-th electron with respect to the nucleus and $d\tau = d\vec{r}_1 \, d\vec{r}_2 \ldots d\vec{r}_Z$ is the volume element of the configuration of electrons in the atom. If the atom has spherical symmetry and $|F_n(\vec{q})|^2$ is regarded as a sum over all states of equal energy W_n and different orientation, $|F_n(\vec{q})|^2$ is independent of the direction of $\vec{q}$. For small momentum transfer, $\vec{q} << a$, where a is the size of an electron's orbit,

$$\left|F_n(\vec{q})\right|^2 \sim \frac{Q|x_n|^2}{\hbar^2/2m} \quad ,$$

where $x_n = \int \psi_n^* \, \psi_o \sum_i x_i \, d\tau$ is the electric dipole matrix element. For large momentum transfer, $q >> 1/a$, the electron recoils almost freely and

$$\left|F_n(\vec{q})\right|^2 \sim Z \, \delta \, (W_n - Q).$$

The differential cross section for a collision that gives the atom an energy W_n is therefore

$$d\sigma_n = 2\pi \, r_o^2 \, \frac{mc^2}{\beta} \, \frac{dQ}{Q^2} \left|F_n(\vec{q})\right|^2. \tag{3}$$

For a given W_n, the values of Q are limited by conservation of energy and momentum (see below) and the total cross section may be expressed as

$$\sigma_n = 2\pi \, r_o^2 \, \frac{mc^2}{\beta^2} \int_{Q_{min}}^{Q_{max}} \frac{dQ}{Q^2} \left|F_n(\vec{q})\right|^2. \tag{4}$$

This basic formula of collision theory is derived analytically using the Born approximation [2] or the impulse approximation, both of which assume that the incident electron has a velocity much higher than the initial velocity v_{at} of the atomic electrons,

$$v >> v_{at} \tag{5}$$

The expression for the mean energy loss per unit surface density is then

$$\left(-\frac{dE}{dx}\right) = N_A \sum_n W_n \sigma_n / A = 2C \, \frac{mc^2}{\beta^2} \, \frac{1}{Z} \sum_n W_n \int_{Q_{min}}^{Q_{max}} \frac{dQ}{Q^2} \left|F_n(\vec{q})\right|^2, \tag{6}$$

where N_A is Avagadro's number, Z and A are respectively the atomic number and weight of the material. $C = \pi N_A \, r_o^2 (Z/A) = 0.15(Z/A) \left[g^{-1}cm^2\right]$ is an atomic constant that may be interpreted as

the total "area" covered by the electrons contained in one gram, each considered as a sphere of radius r_o. Assume for a moment that the summation in eq (6) can be performed under the integral even though the limits depend upon the excited state n. Since

$$\sum_n W_n \left|F_n(\vec{q})\right|^2 = ZQ, \quad [3] \ ^{1/}$$

eq (6) may be expressed

$$\left(-\frac{dE}{dx}\right) = 2C\,\frac{mc^2}{\beta^2}\int_{Q_{min}}^{Q_{max}} \frac{dQ}{Q^2}\,Q = 2C\,\frac{mc^2}{\beta^2}\,\ln\frac{Q_{max}}{Q_{min}}\,. \qquad (7)$$

---

1 This sum rule holds for a many-electron atom, provided only that the initial bound state wave function ψ_o is real. Setting $W_n = E_n - E_o$, where E_n and E_o are eigenvalues of the energy operator H, one can write $W_n F_n(\vec{q}) = \int \psi_n^* \sum_i \left[H \exp(i\vec{q}\cdot\vec{r}_i) - \exp(i\vec{q}\cdot\vec{r}_i)H\right] \psi_o \, d\tau$ The potential energy part of H commutes with the exponential, the kinetic energy part yields

$$\left[H \exp(i\vec{q}\cdot\vec{r}_i) - \exp(i\vec{q}\cdot\vec{r}_i)H\right] = \exp(i\vec{q}\cdot\vec{r}_i)\left(\left|\vec{p}_i \times \hbar\vec{q}\right|^2 - \vec{p}_i^{\,2}\right)/2m = \exp(i\vec{q}\cdot\vec{r}_i)Q(1 - 2\vec{q}\cdot\vec{p}_i/\hbar q^2),$$

where $\vec{p}_i$ is the momentum operator of the i-th electron. Application of the closure theorem yields now

$$\sum_n W_n \left|F_n(\vec{q})\right|^2 = \sum_n \int \psi_o^* \sum_j e^{-i\vec{q}\cdot\vec{r}_j} \psi_n \, d\tau \int \psi_n^* \sum_i e^{i\vec{q}\cdot\vec{r}_i} Q\left(1-2\,\frac{\vec{q}\cdot\vec{p}_i}{\hbar q^2}\right) \psi_o \, d\tau$$

$$= Q \sum_{ji} \int \psi_o^* e^{i\vec{q}\cdot(\vec{r}_i - \vec{r}_j)} \left(1-2\,\frac{\vec{q}\cdot\vec{p}_i}{\hbar q}\right)\psi_o \, d\tau \qquad (*)$$

The term containing $\vec{p}_i = (\hbar/i)\,\overrightarrow{\text{grad}}_i$ can be transformed provided $\psi_o^* = \psi_o$ since partial integration shows that

$$\int \psi_o(\vec{r}_1 \ldots \vec{r}_Z) f(\vec{r}_1 \ldots \vec{r}_Z) \frac{\partial \psi_o(\vec{r}_1 \ldots r_Z)}{\partial x_i} \, d\vec{r}_1 \ldots d\vec{r}_Z$$

$$= -\frac{1}{2}\int \left[\psi_o(\vec{r}_1 \ldots r_Z)\right]^2 \frac{\partial f^{(\vec{r}_1 \ldots \vec{r}_Z)}}{\partial x_i} \, d\vec{r}_1 \ldots d\vec{r}_Z \qquad (**)$$

Because $\text{grad}_i \exp[i\vec{q}\cdot(\vec{r}_i - \vec{r}_j)]$ equals $i\vec{q}\exp[i\vec{q}\cdot(\vec{r}_i - \vec{r}_j)]$ for $i \neq j$ and vanishes for $i = j$, the second term in the parentheses of $(*)$ cancels the first except for $i = j$, in which case the integral equals 1 and $\sum_{ij} = Z$.

The result $(**)$ is a special case of a time-parity theorem stating that the product of a time-even operator A (f in this case) and of a time-odd B ($\vec{p}_i$ in this case), averaged over a time-even state, equals the average of (AB-BA)/2. The condition that ψ_o is real means indeed that the initial state contains no net current, i.e. that it is time-even.

The ratio

$$B = (-dE/dx)/2C(mc^2/\beta^2), \tag{8}$$

is equal to the effective value of $\ln(Q_{max}/Q_{min})$ and may be called the "stopping number".[2/]

To make allowance for the dependence of the limits of integration in (6) upon W_n, one must enter into (7) suitable average values for Q_{min} and Q_{max}. In practice, one can set

$$Q_{min} = W_n^2/2mv^2 << W_n ,[3/]$$

so that, eq (7) applies for $Q \sim Q_{min}$. Calculation (ref. [2] , p. 520) shows that the correct average for $\ln Q_{min}$ is obtained by taking as weights the dipole oscillator strength f_n, which represents the fraction of atomic electrons capable of oscillating with natural frequency W_n/h,

$$\left\langle \ln Q_{min} \right\rangle = \left\langle \ln \frac{W_n^2}{2mv^2} \right\rangle = \sum_n f_n \ln \frac{W_n^2}{2mv^2} = \ln \frac{I^2}{2mv^2} ,$$

where

$$I = \prod_n W_n^{f_n} \tag{9}$$

The value of this atomic constant is discussed in section 3.

The upper limit Q_{max} of the integral in (7) is effectively infinity, because $|F_n(\vec{q})|^2$ decreases rapidly for large $\vec{q}$, unless W_n is comparable to the energy of the incident electron. For large W_n the equations (1) through (7) need modification because of exchange effects. Detailed calculations (ref. [2] , p. 521) shows that the effective value of Q_{max} to be entered in (7) is

$$(Q_{max})_{eff} = \frac{2.7182...}{16} mv^2 .$$

Eq (7) is now written

$$\left(-\frac{dE}{dx} \right) = 2C \frac{mc^2}{\beta^2} 2 \ln \left(\frac{mv^2}{2I} \sqrt{\frac{2.7182}{2}} \right) \tag{10}$$

This formula requires some modification when the velocity of the incident electron approaches the light velocity c. Basically, the Rutherford cross section (1) must be replaced with the corresponding Møller relativistic expression [4] for electrons and Bhabha cross section for positrons.

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2 The term stopping number and the symbol B are often defined so as to be only half as large as in this Circular.

3 The equation $Q_{min} = W_n^2/2mv^2$ holds for $W_n << T$ where $T = mv^2/2$ is the incident electron energy. When both T and W_n are much larger than the binding energy of the atomic electrons, $|F_n(\vec{q})|^2$ vanishes for $Q \sim Q_{min}$ and the actual value of Q_{min} is immaterial. When T is comparable to this binding energy, the condition (5) no longer holds and the whole theory breaks down anyhow.

The resulting formula for the energy loss was obtained by Bethe (ref. [2] p. 273) for electrons and by Rohrlich and Carlson [5] for positrons. These expressions may be combined and written as a function of $\tau = (1-\beta^2)^{-1/2}-1$, which is the initial kinetic energy in units of mc^2:

$$\left(\frac{dE}{dx}\right)^{\pm} = 2C\frac{mc^2}{\beta^2}\left\{B_o^{\pm} - 2\left(\ln Z + \ln\frac{I/10}{Z}\right)\right\}, \tag{11}$$

where I is expressed in e.v. and the expressions

$$B_o^{-} = 19.683 + \ln\tau^2(\tau+2) - \left(1+\frac{2\tau+1}{(\tau+1)^2}\right)\ln 2 + \frac{1}{(\tau+1)^2} + 1/8\left(\frac{\tau}{(\tau+1)}\right)^2 \tag{12}$$

$$B_o^{+} = 19.683 + \ln\tau^2(\tau+2) + \ln 2 - \frac{\beta^2}{12}\left(23 + \frac{14}{(\tau+2)} + \frac{10}{(\tau+2)^2} + \frac{4}{(\tau+2)^3}\right) \tag{13}$$

are the same for all materials. The tabulations given in this Circular were obtained from this equation.

The mean energy loss for compounds and mixtures is approximately an average of the mean energy loss of the constituent elements, weighted in proportion to the fraction by weight of each element. For example, for water,

$$\left(-\frac{dE}{dx}\right)^{\pm} = \frac{1}{9}\left(-\frac{dE}{dx}\right)^{\pm}_{H} + \frac{8}{9}\left(-\frac{dE}{dx}\right)^{\pm}_{O}. \tag{14}$$

This additivity rule derives from the circumstance that the chemical aggregation of atoms influences only the valence electrons in a way that does not affect their spectrum of oscillator strengths very profoundly. Therefore, the value of $\ln I = \sum_n f_n \ln W_n$ for a whole atom is not sensitive to changes of chemical binding.

Thompson [6] made an experimental study to determine the validity of the additivity rule. He detected small deviations from strict additivity that were within 1 percent except for hydrogenous compounds where the deviations were larger (up to about 2 percent). He noted also that these departures decreased rapidly with increasing atomic number.

3. EVALUATION OF I

The theoretical evaluation of the mean energy I according to eq (9) requires a knowledge of oscillator strengths, f_n. For atomic hydrogen, the f_n's are well known; and Bethe (ref. [2] , p. 442) has determined I_H and I for hydrogen-like atoms. Williams [7] obtained the mean energy I for molecular hydrogen by assuming that the ratio of I to the ionization potential is the same for H_2 as for H. He also evaluated I_{He} using data for the oscillator strength obtained from Wheeler [8]. A theoretical value of the ratio of the energy loss in H_2 to that in He, 1.18, given by Williams is in excellent agreement with an experimental determination of 1.19 by Gurney [9] .

The energy I for many-electron atoms is difficult to determine theoretically because of the scarcity of information on the oscillator strengths. For this reason, approximation procedures are required.[4] Bloch [10] , using a Fermi-Thomas model of the atom, found the mean excitation energy I to be directly proportional to Z with the proportionality constant assuming a value equal to the ionization potential of atomic hydrogen, I = 13.6 Z.

4 For general reviews see E. A. Uehling, Penetration of heavy charged particles in matter, Annual Review of Nuclear Science, J. B. Beckerley, editor, Annual Reviews, Inc., Stanford, Calif., (1954) and W. Paul and H. Steinwedel, Interaction of electrons with matter, Beta- and Gamma-Ray Spectroscopy, K. Siegbahn, editor, North-Holland Publishing Co., Amsterdam (1955).

The most useful data concerning the evaluation and variation of I with Z have been obtained experimentally. For compounds, all evidence is derived from experimental data.

Experiments to determine I using incident electrons are quite difficult due to straggling and multiple scattering. The best evidence on I comes from experiments on the slowing down of proton beams. It is desirable to have data for high energy protons to minimize the correction for departures from eq (5). The experiments have been designed to measure either the energy loss, from which I may be obtained using an equation alalogous to eq (10), or the range obtained from reciprocal stopping power (RSP) given by

$$R = \int_0^E \left(- \frac{dE'}{dx} \right)^{-1} dE' \ , \tag{15}$$

where E is the initial energy of the incident particle.

The values of I used in this Circular are taken from a plot of data, Fig. 1, from Mather and Segrè [11] . These authors measured, absolutely, the mean range of 340 Mev protons in several materials. Although it is more difficult to obtain I from range data than from energy loss data, this work gave I for more elements than previously available in an energy interval where corrections are minimized. The values of I_{H_2} and I_{He} used in the present report are Williams' theoretical values.

Since the present tabulations were made, Caldwell [12] re-examined the old experimental data together with previously unused and new data. In his treatment, more accurate corrections for multiple scattering were made where applicable; and better corrections from Walske [13] for the non-contribution of K and L shell electrons to the energy loss at low energies which reflect departures from (5) were employed. The results of this study for Al, Cu and emulsions show that data on stopping power at different energies can be fitted with a single value of I with the exception of the Mather-Segrè data.

Because of the present uncertainty in the choice of I, auxiliary tabulations are presented here which will simplify incorporating new and more adequate data on I. The log-log variation of the range R with I,

$$\frac{d\ln R}{d\ln I} = \frac{2}{R-r} \int_r^R B(r')^{-1} \, dr' \ , \tag{16}$$

is tabulated in Table 1. $B(r')$ is the stopping number, evaluated for the energy corresponding to the residual range r', and r is a cut-off range corresponding to a residual energy equal to 10 Kev or the K absorption energy, whichever is larger.

4. LIMITATIONS OF THE DATA

As pointed out in the introduction the formulas presented in Sect. 2 have a range of validity limited by various circumstances.

4.1 Density effect. The rate of energy loss of charged particles depends to some extent on the density of the material traversed. One part of this effect persists at moderate and low energies of the incident particle and is taken into account automatically by the use of an experimental value for the constant I. The other and larger part is important only for relativistic energies. However, no provision is made in this Circular to take it into account, except for reproducing in Fig. 2 the results of reference [14] which provide the best data for this purpose available at this time. These results are expressed as a correction δ to the stopping number B plotted as a function of the electron energy represented by $(1/2)\ln_{10}[\tau\,(\tau+2)]$. This correction remains of the order of 10% within the energy limits allowed by the other considerations mentioned below.

4.2 Radiation losses. For electrons of very high energy, the energy losses incurred during bremsstrahlung (X-ray emission) processes become large compared to the losses due to inelastic collisions which are considered in Sect. 2. The radiation losses are subject to large statistical fluctuations. Therefore, since data on the average radiation loss per unit distance traveled is not informative, it has not been included in the data presented here on the average loss in inelastic collisions. As indicated in Sect. 1, it would be desirable to present data adequate to describe the entire statistical distribution of energy losses in a given length of path, including radiation as well as collision losses. Pending this development, the tabulations presented in this Circular are limited to the energy range where radiation losses constitute a minor effect, less than 5%. For purpose of orientation, a few data on the relative importance of radiation and collision losses are presented in Table 2.

4.3 Low energy limitation. The theoretical formulation of Sect. 2 is limited, for low energies of the incident electron, by the condition (5), that the incident electron be much faster than the atomic electrons with which it interacts. This condition is fulfilled adequately for collisions against external electrons of atoms provided the incident electron has an energy of the order of 1 kev or more. On the other hand, there are internal electrons whose kinetic energy ranges in heavy atoms up to the order of 100 kev. Thus there is an important range of materials and of incident energies where the theoretical basis of calculations is insecure. Experimental data do not provide any firm basis either. This difficulty is made less severe by the circumstance that even in high-Z atoms only a small fraction of the electrons has a high velocity (e.g. in Pb only 2 out of 82 electrons have a kinetic energy approaching 100 kev, and 8 more of the order of 20 kev).

When the condition (5), $v >> v_{at}$, fails to hold, the cross section formula (4) is no longer justified by the Born or the impulse approximation. Nevertheless this formula has been shown to predict correctly the probability of ejecting K electrons from atoms by the impact of electrons with energy barely sufficient to produce this effect [15] . The reason for this is unknown at present.

In this connection the situation is quite different for heavy charged particles for which Mott [16] has shown that the cross section formula (4) is justified irrespective of the condition $v >> v_{at}$. The formulation of Sect. 2 can then be utilized throughout, except that a more elaborate procedure is required to evaluate the effective average $\langle \ln(Q_{max}/Q_{min}) \rangle$. (The equation $Q_{min} \sim W_n^2/2mv^2$ also holds for heavy particles, but not for electrons, irrespective of $v >> v_{at}$.) The results of these more elaborate calculations are usually represented by adding to the left side of (8) corrective terms, called $C_K, C_L \ldots$, which allow for the failure of $v >> v_{at}$ with respect to the K,L... electrons of the materials (see ref [13]). These corrections have been occasionally applied also with regard to incident electrons, but this application has no theoretical basis.

Qualitatively, as the energy of incident electrons decreases and the condition $v >> v_{at}$ begins to fail, the average energy loss should decrease a little below the value given by (11), because electrons presumably behave in this respect like heavier particles. As the incident electron energy decreases further to the point where it is no longer sufficient to excite internal electrons, the value given by (11) must represent an overestimate. This is seen by considering the structure of the expression (8)

$$B = \left\langle \ln \frac{Q_{max}}{Q_{min}} \right\rangle = 2 \ln \left(\frac{mv^2}{2I} \sqrt{\frac{2.7182}{2}} \right)$$

$$= 2 \sum_n f_n \ln \left(\frac{mv^2}{2 W_n} \sqrt{\frac{2.7182}{2}} \right) \qquad (17)$$

Here internal electrons, whose values of W_n are large, yield a negative contribution to B when v is sufficiently small, whereas their actual contribution is zero. Therefore, the corrections are never very large and become effective only at low energies.

5. PREPARATION OF TABLES AND GRAPHS

Tabulations of the energy loss and RSP range of electrons and positrons in several materials are given in Table 3. The data were calculated from eqs (11) and (15); values of I were taken from Fig. 1.

The maximum energy selected for each material is the value at which radiation effects contribute about 5 percent to the total energy loss.

At low energies when condition (5) is no longer fulfilled, the use of eq (11) is not strictly valid. For protons, the corrections C_K, C_L... (see ref. [13]) are applicable. These corrections are initially small and positive. As the energy decreases, they become negative and larger in magnitude. A correction of approximately 1-2 percent for $C_K + C_L$ is attained in the region of 10 Mev for different elements. If a comparison is made between protons and electrons of equal velocity this 1-2 percent contribution corresponds to electron energies of 5 kev. Hence the error should not exceed 5 percent at the low energy limit of 10 kev used in the present tabulation.

Calculations of the RSP range, eq (15) were made by integrating numerically according to Simpson's rule. The function $(-dE/dx)^{-1}$ becomes infinite as $E \rightarrow 0$; however, to evaluate the integral, $(-dE/dx)^{-1}$ was taken as zero at $E = 0$ and interpolated linearly between zero and a calculated value at $E = 5$ kev (see Fig. 3). This procedure was adopted somewhat arbitrarily for expediency. In fact the concept of end of an electron track is ambiguous since the action of an electron on the material it traverses tapers off gradually. Any definition of range which one adopts is necessarily somewhat arbitrary. Of the various reasonable definitions most would probably give range values somewhat larger than those obtained by the procedure adopted here, but the difference would be negligible at energies of the order of 50 kev or more.

Representative graphs of the tabulations are given in Figs. 4, 5, 6 and 7 for H_2O, Al and Cu.

Several tables have been included to facilitate future tabulations of eq (11) as more reliable data for I become available. Table 4 gives values of Z/A and lnZ for several elements and a few compounds. Table 5 contains data for β^2 and $B_0^{\pm}$, which are independent of Z, in the energy range 10 kev to 10 Mev. A graph (Fig. 8) of $B_0^{\pm}$ is given to aid in interpolation and to show the difference in electron-positron energy loss. It is seen that positrons lose energy more rapidly than electrons at low energies, the energy losses become comparable near 1 Mev, and at higher energies electrons lose energy faster. A detailed discussion of this difference is given by Rohrlich and Carlson (see Ref. 5).

6. COMPARISON WITH EXPERIMENTAL DATA

Only a few experiments are available that can be compared directly with the present tabulations. The basic difficulties in making absolute measurements are the contributions of elastic scattering and range straggling. For the most part, measurements are made of the most probable rather than the mean energy loss. The most probable energy loss is less than the mean energy loss and obtaining one from the other requires a theory whose accuracy is comparable to the accuracy of this formulation.

Paul and Reich [17] measured both the most probable and the mean energy loss in several materials at 2.8 and 4.7 Mev. They evaluated a correction for polarization of the medium from data of Halpern and Hall [18] . A contribution to the energy loss from the radiative effect was determined from Heitler [19] . Their corrected results are compared with the present tabulations in Table 6 and show good agreement.

The actual pathlength, which is measured by either photographic plates or cloud chambers, includes range straggling. The tabulated (RSP) ranges for H_2 and He are compared in Figs. 9 and 10 with the cloud chamber measurements of O'Neil and Scott [20] . The scatter of the points gives an estimate of the width of the electron range straggling distribution. Theoretical calculations [21] indicate that the width of this distribution is about that shown by Figs. 9 and 10.

Earlier range data from Klemperer [22] for several gases are given in Table 7. These results in the region of 25 kev show 2-15 percent agreement with the tabulations except for air. Here the erratic variation of range with energy suggests that the data is unreliable. Additional data for air by Buchmann [23] is given in Table 8. The error of his data is difficult to determine since they are derived from energy loss measurements by a method that contains input data of questionable

accuracy. In contrast to the Klemperer data, the general trend is a continuous variation with energy. In this low energy region, 10-25 kev, a comparison of values is not realistic due to the error introduced by the method of extrapolating to zero in the range computation.

A survey of data for emulsions has not been included in this report since it would require a major effort of evaluation. The composition of an emulsion varies with its humidity, which is not often controlled in a vigorous and standard manner, as evidenced by inconsistencies in the density values reported by different laboratories. Calculations for emulsions may be made, using data from Table 3 which contains the energy loss and RSP range separately for "dry" Ilford emulsion and for water.

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TABLE 1. Percentage change of R for 1 percent change of I

R-r \ Z, r	d(ln R⁻)/d(ln I)													
	2	4	6	7	8	11	13	14	16	17	18	19	20	26
	0.0003	0.0003	0.0003	0.0004	0.0003	0.0004	0.0003	0.0005	0.0005	0.0005	0.0004	0.0005	0.0005	0.0005
0.0002	0.226	0.214	0.221	0.230	0.229	0.248	0.262	0.260	0.269	0.274	0.277	0.282	0.284	0.308
.0004	.213	.208	.216	.226	.225	.244	.255	.256	.263	.269	.273	.277	.280	.302
.0006	.206	.205	.212	.224	.221	.240	.250	.252	.260	.265	.267	.273	.275	.297
.0008	.201	.203	.210	.220	.218	.236	.245	.248	.256	.261	.263	.268	.271	.292
.001	.197	.200	.207	.218	.216	.234	.243	.245	.253	.257	.260	.265	.267	.288
.002	.188	.193	.199	.210	.208	.225	.230	.235	.243	.246	.247	.253	.255	.274
.004	.179	.185	.191	.200	.199	.214	.218	.224	.230	.233	.234	.239	.242	.258
.006	.174	.180	.186	.195	.194	.207	.212	.217	.223	.226	.226	.230	.233	.248
.008	.170	.176	.182	.190	.190	.202	.206	.212	.217	.220	.220	.224	.226	.242
.01	.168	.174	.180	.187	.187	.198	.203	.208	.214	.216	.216	.220	.222	.237
.02	.159	.165	.171	.176	.177	.188	.192	.196	.202	.203	.203	.207	.207	.222
.04	.151	.157	.162	.167	.168	.178	.180	.184	.190	.191	.191	.195	.195	.207
.06	.147	.153	.157	.162	.163	.172	.174	.178	.183	.184	.184	.188	.187	.199
.08	.144	.150	.153	.158	.159	.168	.170	.174	.177	.179	.180	.183	.183	.193
.1	.142	.147	.150	.155	.156	.164	.166	.171	.175	.175	.176	.180	.180	.188
.2	.135	.139	.142	.146	.147	.155	.156	.161	.164	.164	.165	.167	.168	.176
.4	.127	.131	.133	.138	.138	.146	.145	.151	.153	.153	.154	.158	.157	.164
.6	.123	.126	.128	.133	.133	.140	.140	.146	.147	.147	.147	.152	.151	.157
.8	.120	.123	.125	.130	.129	.136	.136	.141	.142	.143	.143	.147	.147	.152
1.0	.117	.120	.122	.127	.126	.134	.133	.139	.138	.140	.140	.144	.143	.148
2	.109	.113	.114	.118	.117	.124	.123	.134	.127	.130	.130	.133	.133	.137
4	.101	.104	.105	.108	.108	.114	.113	.131	.117	.118	.118	.121	.122	.125
6		.0999	.0999	.103	.103	.108	.108	.129	.112	.112	.112	.114	.114	.117

R-r \ Z, r	d(ln R⁺)/d(ln I)													
	2	4	6	7	8	11	13	14	16	17	18	19	20	26
	0.0003	0.0003	0.0003	0.0003	0.0003	0.0004	0.0003	0.0004	0.0004	0.0004	0.0003	0.0004	0.0004	0.0005
0.0002	0.187	0.195	0.203	0.213	0.212	0.226	0.233	0.238	0.243	0.246	0.251	0.252	0.255	0.275
.0004	.184	.191	.199	.209	.208	.222	.228	.233	.238	.242	.245	.248	.250	.268
.0006	.182	.188	.196	.206	.204	.219	.224	.230	.235	.238	.240	.244	.245	.259
.0008	.180	.186	.194	.204	.202	.216	.220	.227	.232	.235	.236	.241	.243	.255
.001	.178	.184	.192	.201	.200	.214	.218	.224	.229	.232	.234	.238	.239	.253
.002	.173	.178	.185	.194	.193	.206	.209	.215	.220	.223	.224	.228	.230	.243
.004	.166	.172	.177	.185	.185	.198	.200	.205	.210	.212	.213	.217	.219	.231
.006	.162	.168	.173	.180	.181	.193	.194	.199	.204	.206	.207	.210	.213	.224
.008	.160	.165	.170	.176	.178	.189	.191	.195	.200	.202	.203	.206	.208	.219
.01	.158	.163	.168	.174	.176	.186	.188	.192	.197	.199	.200	.203	.205	.215
.02	.152	.156	.161	.166	.168	.178	.180	.184	.187	.189	.190	.193	.195	.204
.04	.146	.150	.157	.159	.161	.171	.172	.175	.178	.181	.181	.184	.185	.194
.06	.143	.147	.153	.155	.157	.167	.167	.171	.174	.176	.176	.179	.180	.189
.08	.141	.145	.149	.153	.154	.164	.164	.168	.171	.173	.172	.176	.177	.185
.1	.139	.143	.147	.151	.152	.162	.162	.166	.168	.170	.170	.174	.175	.183
.2	.133	.137	.141	.145	.145	.154	.154	.158	.161	.163	.162	.165	.166	.174
.4	.127	.131	.134	.138	.138	.146	.147	.150	.153	.154	.154	.157	.158	.164
.6	.123	.127	.130	.134	.134	.142	.142	.145	.148	.149	.148	.152	.152	.158
.8	.120	.124	.126	.131	.131	.138	.139	.141	.144	.145	.145	.148	.148	.154
1.0	.118	.122	.124	.128	.128	.135	.136	.138	.141	.142	.142	.144	.144	.150
2	.111	.114	.116	.120	.120	.126	.127	.128	.131	.132	.132	.134	.134	.140
4	.104	.106	.108	.113	.111	.116	.117	.119	.121	.122	.121	.123	.124	.130
6	.0990	.101	.102	.111	.105	.111	.111	.113	.115	.116	.116	.117	.117	.122

TABLE 1. Percentage change of R for 1 percent change of I—Continued

		d(ln R^-)/d(ln I)												
R-r	Z / r	29 / 0.0005	30 / 0.0005	35 / 0.001	42 / 0.001	47 / 0.003	50 / 0.004	53 / 0.006	74 / 0.02	78 / 0.03	79 / 0.02	80 / 0.03	82 / 0.03	92 / 0.06
0.0002		0.307	0.310											
.0004		.299	.303											
.0006		.293	.297											
.0008		.288	.292											
.001		.285	.288											
.002		.272	.274	0.284	0.285	0.269	0.270	0.258						
.004		.257	.258	.270	.273	.263	.268	.254						
.006		.248	.249	.260	.264	.257	.264	.250						
.008		.242	.243	.254	.258	.253	.260	.247						
.01		.237	.238	.249	.253	.249	.257	.245						
.02		.222	.223	.234	.238	.237	.245	.236	0.235	0.233	0.237	0.230	0.232	0.224
.04		.207	.208	.219	.222	.223	.232	.225	.228	.227	.228	.225	.226	.221
.06		.200	.201	.210	.214	.216	.224	.219	.222	.222	.223	.220	.223	.218
.08		.194	.195	.204	.208	.210	.218	.214	.218	.218	.219	.217	.219	.216
.1		.190	.192	.200	.204	.205	.214	.210	.214	.216	.215	.214	.216	.213
.2		.177	.178	.186	.189	.192	.200	.196	.202	.205	.203	.204	.205	.204
.4		.165	.166	.174	.175	.177	.185	.181	.190	.194	.190	.191	.193	.193
.6		.158	.158	.166	.167	.169	.176	.173	.182	.186	.182	.183	.185	.186
.8		.152	.153	.161	.162	.164	.170	.167	.176	.180	.176	.178	.179	.180
1.0		.148	.149	.157	.158	.160	.166	.163	.172	.176	.171	.173	.174	.176
2		.137	.137	.144	.145	.146	.152	.149	.156	.161	.156	.158	.158	.161
4		.124	.125	.131	.132	.133	.137	.136	.141	.146	.142	.143	.143	.146
6		.117	.118	.124	.124	.125	.130	.128	.133	.138	.133	.134	.134	.138
8							.125	.123	.128	.132	.128	.129	.128	.132

		d(ln R^+)/d(ln I)												
R-r	Z / r	29 / 0.0004	30 / 0.0004	35 / 0.002	42 / 0.001	47 / 0.003	50 / 0.004	53 / 0.005	74 / 0.02	78 / 0.02	79 / 0.02	80 / 0.02	82 / 0.02	92 / 0.06
0.0002		0.272	0.275											
.0004		.266	.270											
.0006		.262	.265											
.0008		.258	.261											
.001		.255	.258											
.002		.245	.247	0.239	0.253	0.240	0.244	0.237						
.004		.233	.235	.232	.244	.236	.240	.234						
.006		.226	.228	.228	.237	.232	.236	.231						
.008		.221	.223	.224	.233	.228	.233	.229						
.01		.217	.218	.221	.229	.226	.231	.227						
.02		.206	.208	.212	.218	.217	.223	.220	0.221	0.227	0.223	0.224	0.225	0.215
.04		.195	.197	.202	.207	.208	.214	.212	.216	.222	.219	.220	.220	.213
.06		.189	.192	.197	.202	.203	.209	.207	.213	.218	.215	.216	.217	.211
.08		.186	.187	.193	.198	.200	.205	.203	.210	.215	.212	.213	.214	.210
.1		.183	.184	.190	.194	.196	.202	.200	.208	.213	.210	.210	.212	.208
.2		.175	.175	.181	.184	.187	.192	.190	.199	.204	.201	.201	.203	.202
.4		.165	.166	.172	.173	.176	.182	.180	.189	.193	.191	.191	.193	.193
.6		.158	.160	.166	.167	.170	.176	.174	.183	.187	.184	.184	.186	.187
.8		.154	.156	.162	.162	.166	.171	.169	.178	.182	.180	.180	.181	.183
1.0		.151	.152	.158	.159	.162	.167	.165	.174	.178	.176	.176	.177	.179
2		.140	.142	.146	.147	.149	.154	.152	.160	.164	.162	.162	.163	.165
4		.128	.129	.134	.135	.136	.141	.139	.146	.150	.148	.148	.149	.151
6		.122	.122	.127	.128	.129	.133	.132	.138	.142	.139	.139	.140	.143
8				.122	.122	.124	.128	.126	.132	.136	.134	.134	.134	.137

TABLE 2. Average fraction (f) of energy lost by radiation from electrons with kinetic energy T_o (in units of mc^2)

f	T_o				
	H_2O	Al	Fe	Cu	Pb
1.02	6.6	5.0	2.4	2.1	0.5
1.04	13.0	9.7	4.8	4.3	1.3
1.06	19.0	15.0	7.3	6.6	2.1

TABLE 3. Energy loss and range of electrons and positrons.

Hydrogen

Z = 1, I = 17.5 ev

Energy	$-dE^-/dx$	R^-	$-dE^+/dx$	R^+
Mev	Mev cm^2/g	g/cm^2	Mev cm^2/g	g/cm^2
0.01	52.0	0.000105	56.1	0.0000965
.02	29.5	.000369	31.5	.000344
.03	21.4	.000776	22.6	.000726
.04	17.1	.00130	18.0	.00122
.05	14.4	.00194	15.1	.00184
.06	12.6	.00269	13.2	.00255
.07	11.3	.00353	11.7	.00335
.08	10.3	.00446	10.6	.00425
.09	9.47	.00548	9.80	.00523
.10	8.83	.00657	9.12	.00629
.15	6.89	.0131	7.04	.0126
.20	5.91	.0210	5.99	.0204
.25	5.33	.0299	5.37	.0292
.30	4.95	.0397	4.96	.0389
.35	4.68	.0501	4.68	.0493
.40	4.49	.0610	4.47	.0603
.45	4.34	.0723	4.31	.0717
.50	4.23	.0840	4.20	.0834
.55	4.15	.0959	4.10	.0955
.60	4.08	.108	4.03	.108
.65	4.02	.120	3.97	.120
.70	3.98	.133	3.92	.133
.75	3.95	.146	3.89	.146
.80	3.92	.158	3.86	.159
.85	3.89	.171	3.83	.172
.90	3.88	.184	3.81	.185
.95	3.86	.197	3.79	.198
1.0	3.85	.210	3.78	.211
1.2	3.82	.262	3.75	.264
1.4	3.82	.314	3.74	.318
1.6	3.82	.367	3.74	.371
1.8	3.84	.419	3.75	.425
2.0	3.85	.471	3.77	.478
2.2	3.87	.523	3.79	.531
2.4	3.89	.574	3.81	.583
2.6	3.91	.626	3.83	.636
2.8	3.93	.677	3.84	.688
3.0	3.95	.727	3.86	.740
4.0	4.05	.977	3.96	.996
5.0	4.13	1.22	4.04	1.25
6.0	4.20	1.46	4.11	1.49
8.0	4.32	1.93	4.23	1.97
10.0	4.42	2.39	4.32	2.44

TABLE 3. Energy loss and range of electrons and positrons – Continued

Helium

Z = 2, I = 44 ev

Energy	$-dE^-/dx$	R^-	$-dE^+/dx$	R^+
Mev	Mev cm^2/g	g/cm^2	Mev cm^2/g	g/cm^2
0.01	22.5	0.000246	24.5	0.000223
.02	13.0	.000851	14.0	.000783
.03	9.45	.00178	10.1	.00165
.04	7.59	.00296	8.04	.00276
.05	6.43	.00440	6.78	.00412
.06	5.63	.00606	5.91	.00570
.07	5.05	.00795	5.28	.00750
.08	4.61	.0100	4.80	.00949
.09	4.26	.0123	4.43	.0117
.10	3.98	.0147	4.12	.0140
.15	3.12	.0291	3.19	.0280
.20	2.68	.0465	2.72	.0450
.25	2.43	.0662	2.44	.0645
.30	2.26	.0876	2.26	.0858
.35	2.14	.110	2.14	.109
.40	2.05	.134	2.04	.133
.45	1.99	.159	1.98	.157
.50	1.94	.184	1.92	.183
.55	1.90	.210	1.88	.209
.60	1.87	.237	1.85	.236
.65	1.85	.264	1.83	.264
.70	1.83	.291	1.80	.291
.75	1.82	.318	1.79	.319
.80	1.81	.346	1.77	.347
.85	1.80	.374	1.76	.375
.90	1.79	.402	1.76	.404
.95	1.78	.430	1.75	.432
1.0	1.78	.458	1.74	.461
1.2	1.77	.571	1.73	.576
1.4	1.77	.684	1.73	.691
1.6	1.78	.796	1.73	.807
1.8	1.78	.909	1.74	.922
2.0	1.79	1.02	1.75	1.04
2.2	1.80	1.13	1.76	1.15
2.4	1.81	1.24	1.77	1.26
2.6	1.83	1.35	1.78	1.38
2.8	1.84	1.46	1.79	1.49
3.0	1.85	1.57	1.80	1.60
4.0	1.90	2.10	1.85	2.15
5.0	1.94	2.63	1.89	2.68
6.0	1.98	3.14	1.93	3.21
8.0	2.04	4.13	1.99	4.23
10.0	2.08	5.10	2.04	5.22

Beryllium

Z = 4, I = 59 ev

0.01	18.9	0.000294	20.7	0.000265
.02	11.0	.00101	11.8	.000925
.03	8.02	.00210	8.58	.00194
.04	6.45	.00349	6.86	.00325
.05	5.47	.00519	5.78	.00485
.06	4.80	.00714	5.05	.00670
.07	4.31	.00936	4.51	.00881
.08	3.93	.0118	4.10	.0111
.09	3.64	.0144	3.78	.0137
.10	3.40	.0173	3.52	.0164

TABLE 3. Energy loss and range of electrons and positrons – Continued

Beryllium – Continued

Z = 4, I = 59 ev

Energy	$-dE^-/dx$	R^-	$-dE^+/dx$	R^+
Mev	Mev cm^2/g	g/cm^2	Mev cm^2/g	g/cm^2
.15	2.67	.0341	2.73	.0327
.20	2.30	.0544	2.34	.0526
.25	2.08	.0774	2.10	.0753
.30	1.94	.102	1.94	.100
.35	1.84	.129	1.83	.127
.40	1.76	.157	1.76	.155
.45	1.71	.185	1.70	.184
.50	1.67	.215	1.65	.213
.55	1.64	.245	1.62	.244
.60	1.61	.276	1.59	.275
.65	1.59	.307	1.57	.307
.70	1.58	.339	1.55	.339
.75	1.57	.371	1.54	.371
.80	1.56	.403	1.53	.404
.85	1.55	.435	1.52	.437
.90	1.54	.467	1.51	.470
.95	1.54	.500	1.51	.503
1.0	1.53	.532	1.50	.536
1.2	1.53	.663	1.49	.669
1.4	1.53	.794	1.49	.803
1.6	1.53	.925	1.50	.937
1.8	1.54	1.05	1.50	1.07
2.0	1.55	1.18	1.51	1.20
2.2	1.56	1.31	1.52	1.34
2.4	1.57	1.44	1.53	1.47
2.6	1.58	1.57	1.54	1.60
2.8	1.59	1.69	1.55	1.73
3.0	1.60	1.82	1.56	1.85
4.0	1.64	2.44	1.60	2.49
5.0	1.68	3.04	1.64	3.10
6.0	1.71	3.63	1.67	3.71
8.0	1.77	4.78	1.72	4.89

Carbon

Z = 6, I = 77.4 ev

0.01	20.3	0.000274	22.4	0.000246
.02	11.9	.000936	12.9	.000855
.03	8.70	.00194	9.34	.00179
.04	7.01	.00322	7.47	.00299
.05	5.95	.00479	6.31	.00446
.06	5.22	.00658	5.51	.00615
.07	4.69	.00861	4.93	.00809
.08	4.29	.0108	4.48	.0102
.09	3.97	.0133	4.13	.0125
.10	3.71	.0159	3.85	.0150
.15	2.92	.0313	2.99	.0300
.2	2.52	.0500	2.56	.0482
.25	2.28	.0709	2.30	.0689
.30	2.12	.0937	2.13	.0915
.35	2.01	.118	2.01	.116
.40	1.94	.143	1.93	.141
.45	1.88	.169	1.86	.168
.50	1.83	.196	1.82	.195
.55	1.80	.224	1.78	.223
.60	1.77	.252	1.75	.251
.65	1.75	.280	1.72	.280
.70	1.73	.309	1.71	.309
.75	1.72	.338	1.69	.338
.80	1.71	.367	1.68	.368
.85	1.70	.396	1.67	.398

TABLE 3. Energy loss and range of electrons and positrons – Continued

Carbon – Continued

Z = 6, I = 77.4 ev

Energy	$-dE^-/dx$	R^-	$-dE^+/dx$	R^+
Mev	Mev cm^2/g	g/cm^2	Mev cm^2/g	g/cm^2
.90	1.70	.426	1.66	.428
.95	1.69	.455	1.66	.458
1.0	1.69	.485	1.65	.488
1.2	1.68	.604	1.64	.610
1.4	1.68	.723	1.64	.731
1.6	1.69	.841	1.65	.853
1.8	1.70	.960	1.66	.974
2.0	1.71	1.08	1.67	1.09
2.2	1.72	1.19	1.68	1.21
2.4	1.73	1.31	1.69	1.33
2.6	1.74	1.42	1.70	1.45
2.8	1.75	1.54	1.71	1.57
3.0	1.76	1.65	1.72	1.69
4.0	1.81	2.21	1.77	2.26
5.0	1.86	2.76	1.81	2.82
6.0	1.89	3.29	1.85	3.36
8.0	1.95	4.33	1.91	4.43

Nitrogen

Z = 7, I = 87.5 ev

0.01	19.7	0.000283	21.7	0.000254
.02	11.5	.000966	12.5	.000879
.03	8.47	.00200	9.11	.00181
.04	6.83	.00332	7.29	.00307
.05	5.81	.00492	6.16	.00454
.06	5.10	.00675	5.38	.00631
.07	4.58	.00883	4.82	.00825
.08	4.19	.0111	4.39	.0105
.09	3.88	.0136	4.04	.0128
.10	3.63	.0163	3.77	.0154
.15	2.86	.0320	2.93	.0306
.20	2.47	.0510	2.51	.0492
.25	2.23	.0723	2.25	.0703
.30	2.08	.0956	2.09	.0934
.35	1.98	.120	1.97	.118
.40	1.90	.146	1.89	.144
.45	1.84	.173	1.83	.171
.50	1.80	.200	1.78	.199
.55	1.77	.228	1.75	.227
.60	1.74	.257	1.72	.256
.65	1.72	.286	1.69	.285
.70	1.70	.315	1.68	.315
.75	1.69	.344	1.66	.345
.80	1.68	.374	1.65	.375
.85	1.67	.404	1.64	.405
.90	1.67	.434	1.63	.436
.95	1.66	.464	1.63	.467
1.0	1.66	.494	1.62	.497
1.2	1.65	.615	1.62	.621
1.4	1.66	.736	1.62	.745
1.6	1.66	.856	1.62	.868
1.8	1.67	.976	1.63	.991
2.0	1.68	1.10	1.64	1.11
2.2	1.69	1.21	1.65	1.23
2.4	1.71	1.33	1.66	1.36

TABLE 3. Energy loss and range of electrons and positrons — Continued

Nitrogen — Continued

Z = 7, I = 87.5 ev

Energy	$-dE^-/dx$	R^-	$-dE^+/dx$	R^+
Mev	Mev cm^2/g	g/cm^2	Mev cm^2/g	g/cm^2
2.6	1.72	1.45	1.67	1.48
2.8	1.73	1.56	1.68	1.59
3.0	1.74	1.68	1.69	1.71
4.0	1.79	2.25	1.74	2.29
5.0	1.83	2.80	1.79	2.86
6.0	1.87	3.34	1.82	3.42
8.0	1.93	4.39	1.88	4.50

Oxygen

Z = 8, I = 97.8 ev

0.01	19.3	0.000292	21.3	0.000260
.02	11.3	.000987	12.3	.000897
.03	8.32	.00204	8.95	.00187
.04	6.72	.00338	7.17	.00312
.05	5.71	.00501	6.06	.00465
.06	5.02	.00688	5.30	.00641
.07	4.51	.00899	4.75	.00842
.08	4.13	.0113	4.32	.0106
.09	3.82	.0138	3.99	.0130
.10	3.57	.0165	3.72	.0156
.15	2.82	.0325	2.89	.0311
.20	2.43	.0517	2.47	.0499
.25	2.20	.0734	2.22	.0713
.30	2.05	.0969	2.06	.0947
.35	1.95	.122	1.95	.120
.40	1.88	.148	1.87	.146
.45	1.82	.175	1.81	.173
.50	1.78	.203	1.76	.201
.55	1.75	.231	1.72	.230
.60	1.72	.260	1.70	.259
.65	1.70	.289	1.67	.288
.70	1.68	.319	1.66	.319
.75	1.67	.349	1.64	.348
.80	1.66	.379	1.63	.380
.85	1.65	.409	1.62	.410
.90	1.65	.439	1.62	.441
.95	1.64	.470	1.61	.472
1.0	1.64	.500	1.61	.503
1.2	1.64	.622	1.60	.628
1.4	1.64	.744	1.60	.753
1.6	1.65	.866	1.61	.878
1.8	1.66	.987	1.61	1.00
2.0	1.67	1.11	1.62	1.13
2.2	1.68	1.23	1.63	1.25
2.4	1.69	1.35	1.65	1.37
2.6	1.70	1.46	1.66	1.49
2.8	1.71	1.58	1.67	1.61
3.0	1.72	1.70	1.68	1.73
4.0	1.77	2.27	1.73	2.32
5.0	1.82	2.83	1.77	2.89
6.0	1.85	3.37	1.81	3.45
8.0	1.91	4.43	1.87	4.54

TABLE 3. Energy loss and range of electrons and positrons — Continued

Sodium

Z = 11, I = 128 ev

Energy	$-dE^-/dx$	R^-	$-dE^+/dx$	R^+
Mev	Mev cm^2/g	g/cm^2	Mev cm^2/g	g/cm^2
0.01	17.4	0.000325	19.3	0.000288
.02	10.3	.00109	11.2	.000986
.03	7.60	.00225	8.20	.00205
.04	6.14	.00371	6.58	.00341
.05	5.23	.00550	5.57	.00508
.06	4.60	.00753	4.87	.00700
.07	4.14	.00983	4.37	.00918
.08	3.79	.0123	3.98	.0116
.09	3.51	.0151	3.67	.0142
.10	3.29	.0180	3.42	.0170
.15	2.60	.0354	2.67	.0338
.20	2.25	.0562	2.28	.0542
.25	2.04	.0797	2.06	.0773
.30	1.90	.105	1.91	.103
.35	1.81	.132	1.80	.130
.40	1.74	.160	1.73	.158
.45	1.69	.190	1.67	.187
.50	1.65	.220	1.63	.218
.55	1.62	.250	1.60	.249
.60	1.60	.281	1.57	.280
.65	1.58	.313	1.55	.312
.70	1.56	.345	1.54	.344
.75	1.55	.377	1.52	.377
.80	1.54	.409	1.51	.410
.85	1.54	.442	1.51	.443
.90	1.53	.474	1.51	.476
.95	1.53	.507	1.50	.510
1.0	1.53	.540	1.49	.543
1.2	1.52	.671	1.49	.678
1.4	1.53	.802	1.43	.814
1.6	1.53	.933	1.49	.953
1.8	1.54	1.06	1.50	1.08
2.0	1.55	1.19	1.51	1.22
2.2	1.56	1.32	1.52	1.35
2.4	1.58	1.45	1.53	1.48
2.6	1.59	1.57	1.54	1.61
2.8	1.60	1.70	1.55	1.74
3.0	1.61	1.82	1.57	1.83
4.0	1.66	2.44	1.61	2.50
5.0	1.70	3.03	1.65	3.07
6.0	1.73	3.62	1.69	3.71

Aluminum

Z = 13, I = 148 ev

0.01	17.0	0.000335	18.9	0.000295
.02	10.1	.00112	11.0	.00101
.03	7.45	.00230	8.06	.00209
.04	6.04	.00379	6.48	.00348
.05	5.14	.00561	5.49	.00517
.06	4.53	.00767	4.80	.00712
.07	4.08	.0100	4.30	.00933
.08	3.73	.0126	3.92	.0118
.09	3.46	.0154	3.62	.0144
.10	3.24	.0183	3.38	.0173
.15	2.56	.0359	2.63	.0343
.20	2.22	.0570	2.26	.0549
.25	2.01	.0808	2.03	.0783
.30	1.88	.107	1.89	.104
.35	1.79	.134	1.78	.131

TABLE 3. Energy loss and range of electrons and positrons — Continued

Aluminum - Continued

Z = 13, I = 148 ev

Energy	$-dE^-/dx$	R^-	$-dE^+/dx$	R^+
Mev	Mev cm^2/g	g/cm^2	Mev cm^2/g	g/cm^2
.40	1.72	.162	1.71	.160
.45	1.67	.192	1.66	.190
.50	1.63	.222	1.61	.220
.55	1.60	.253	1.58	.252
.60	1.58	.285	1.56	.283
.65	1.56	.316	1.54	.316
.70	1.55	.349	1.52	.348
.75	1.54	.381	1.51	.381
.80	1.53	.414	1.50	.415
.85	1.52	.446	1.49	.448
.90	1.52	.479	1.49	.482
.95	1.52	.512	1.48	.515
1.0	1.51	.545	1.48	.549
1.2	1.51	.678	1.47	.685
1.4	1.51	.810	1.48	.820
1.6	1.52	.942	1.48	.955
1.8	1.53	1.07	1.49	1.09
2.0	1.54	1.20	1.50	1.22
2.2	1.55	1.33	1.51	1.36
2.4	1.57	1.46	1.52	1.49
2.6	1.58	1.59	1.53	1.62
2.8	1.59	1.71	1.54	1.75
3.0	1.60	1.84	1.55	1.88
4.0	1.65	2.46	1.60	2.52
5.0	1.69	3.05	1.64	3.13
6.0	1.72	3.64	1.68	3.74

Silicon

Z = 14, I = 158 ev

0.01	17.3	0.000330	19.3	0.000330
.02	10.3	.00110	11.3	.000986
.03	7.61	.00226	8.24	.00209
.04	6.17	.00371	6.63	.00340
.05	5.26	.00549	5.61	.00510
.06	4.63	.00751	4.92	.00696
.07	4.17	.00980	4.41	.00916
.08	3.82	.0123	4.02	.0115
.09	3.54	.0150	3.71	.0141
.10	3.32	.0179	3.46	.0169
.15	2.63	.0351	2.70	.0335
.20	2.27	.0557	2.31	.0536
.25	2.06	.0789	2.08	.0765
.30	1.93	.104	1.93	.101
.35	1.83	.131	1.83	.128
.40	1.79	.158	1.75	.156
.45	1.71	.187	1.70	.185
.50	1.67	.217	1.66	.215
.55	1.64	.248	1.62	.245
.60	1.62	.277	1.60	.276
.65	1.60	.301	1.58	.308
.70	1.59	.340	1.56	.340
.75	1.58	.364	1.55	.372
.80	1.57	.403	1.54	.404
.85	1.56	.428	1.53	.437
.90	1.56	.467	1.53	.470
.95	1.56	.492	1.52	.502
1.0	1.55	.531	1.52	.535
1.2	1.55	.660	1.51	.667
1.4	1.55	.789	1.52	.799

TABLE 3. Energy loss and range of electrons and positrons — Continued

Silicon - Continued

Z = 14, I = 158 ev

Energy	$-dE^-/dx$	R^-	$-dE^+/dx$	R^+
Mev	Mev cm^2/g	g/cm^2	Mev cm^2/g	g/cm^2
1.6	1.56	.917	1.52	.931
1.8	1.57	1.04	1.53	1.06
2.0	1.58	1.17	1.54	1.19
2.2	1.60	1.30	1.55	1.32
2.4	1.61	1.42	1.56	1.45
2.6	1.62	1.55	1.58	1.58
2.8	1.63	1.67	1.59	1.70
3.0	1.64	1.79	1.60	1.83
4.0	1.69	2.39	1.65	2.44
5.0	1.74	2.97	1.69	3.04
6.0	1.77	3.54	1.73	3.62

Sulphur

Z = 16, I = 178.7 ev

0.01	16.8	0.000340	18.8	0.000298
.02	10.0	.00113	11.0	.00101
.03	7.44	.00231	8.08	.00210
.04	6.04	.00380	6.50	.00348
.05	5.16	.00562	5.51	.00517
.06	4.54	.00767	4.83	.00710
.07	4.09	.0100	4.33	.00930
.08	3.75	.0126	3.95	.0117
.09	3.48	.0153	3.64	.0144
.10	3.26	.0183	3.40	.0172
.15	2.58	.0358	2.65	.0341
.20	2.24	.0567	2.28	.0545
.25	2.03	.0803	2.05	.0778
.30	1.90	.106	1.90	.103
.35	1.80	.133	1.80	.130
.40	1.74	.161	1.73	.159
.45	1.69	.190	1.67	.188
.50	1.65	.220	1.63	.218
.55	1.62	.251	1.60	.249
.60	1.60	.282	1.58	.281
.65	1.58	.313	1.56	.313
.70	1.57	.345	1.54	.345
.75	1.56	.377	1.53	.377
.80	1.55	.409	1.52	.410
.85	1.54	.442	1.51	.443
.90	1.54	.474	1.51	.476
.95	1.54	.507	1.50	.510
1.0	1.53	.539	1.50	.543
1.2	1.53	.670	1.49	.677
1.4	1.54	.800	1.50	.811
1.6	1.54	.930	1.50	.944
1.8	1.56	1.06	1.51	1.08
2.0	1.57	1.19	1.52	1.21
2.2	1.58	1.31	1.54	1.34
2.4	1.59	1.44	1.55	1.47
2.6	1.60	1.57	1.56	1.60
2.8	1.61	1.69	1.57	1.73
3.0	1.62	1.81	1.58	1.85
4.0	1.68	2.42	1.63	2.48
5.0	1.72	3.01	1.67	3.08

TABLE 3. Energy loss and range of electrons and positrons — Continued

Chlorine

Z = 17, I = 189 ev

Energy	$-dE^-/dx$	R^-	$-dE^+/dx$	R^+
Mev	Mev cm^2/g	g/cm^2	Mev cm^2/g	g/cm^2
0.01	15.9	0.000360	17.9	0.000311
.02	9.55	.00119	10.5	.00104
.03	7.08	.00244	7.69	.00219
.04	5.75	.00400	6.19	.00363
.05	4.91	.00591	5.25	.00542
.06	4.33	.00806	4.60	.00743
.07	3.90	.0105	4.12	.00976
.08	3.57	.0132	3.76	.0123
.09	3.31	.0161	3.47	.0151
.10	3.10	.0192	3.22	.0180
.15	2.46	.0376	2.53	.0359
.20	2.13	.0595	2.17	.0572
.25	1.94	.0842	1.96	.0817
.30	1.81	.111	1.82	.108
.35	1.72	.139	1.72	.137
.40	1.66	.169	1.65	.166
.45	1.61	.200	1.60	.197
.50	1.58	.231	1.56	.229
.55	1.55	.263	1.53	.261
.60	1.53	.296	1.50	.294
.65	1.51	.328	1.49	.328
.70	1.50	.362	1.47	.361
.75	1.49	.395	1.46	.396
.80	1.48	.429	1.45	.430
.85	1.47	.463	1.44	.465
.90	1.47	.497	1.44	.499
.95	1.47	.531	1.43	.534
1.0	1.46	.565	1.43	.569
1.2	1.46	.702	1.43	.709
1.4	1.47	.838	1.43	.849
1.6	1.48	.974	1.44	.989
1.8	1.49	1.11	1.45	1.13
2.0	1.50	1.24	1.46	1.27
2.2	1.51	1.38	1.47	1.40
2.4	1.52	1.51	1.48	1.54
2.6	1.53	1.64	1.49	1.67
2.8	1.54	1.77	1.50	1.81
3.0	1.55	1.90	1.51	1.94
4.0	1.60	2.53	1.56	2.59
5.0	1.64	3.15	1.60	3.22

Argon

Z = 18, I = 199 ev

0.01	14.8	0.000388	16.6	0.000339
.02	8.87	.00128	9.76	.00114
.03	6.59	.00262	7.16	.00237
.04	5.35	.00430	5.76	.00393
.05	4.57	.00635	4.89	.00583
.06	4.03	.00867	4.28	.00801
.07	3.63	.0113	3.84	.0105
.08	3.60	.0141	3.50	.0132
.09	3.09	.0170	3.24	.0162
.10	2.89	.0205	3.02	.0194
.15	2.29	.0403	2.36	.0384
.20	1.99	.0637	2.03	.0614
.25	1.81	.0903	1.83	.0875
.30	1.69	.119	1.69	.116
.35	1.61	.149	1.60	.146

TABLE 3. Energy loss and range of electrons and positrons — Continued

Argon - Continued

Z = 18, I = 199 ev

Energy	$-dE^-/dx$	R^-	$-dE^+/dx$	R^+
Mev	Mev cm^2/g	g/cm^2	Mev cm^2/g	g/cm^2
.40	1.55	.181	1.54	.178
.45	1.50	.214	1.49	.211
.50	1.47	.247	1.45	.245
.55	1.45	.282	1.43	.280
.60	1.43	.317	1.40	.315
.65	1.41	.352	1.39	.351
.70	1.40	.387	1.37	.387
.75	1.39	.423	1.36	.424
.80	1.38	.459	1.35	.461
.85	1.38	.496	1.35	.498
.90	1.37	.532	1.34	.535
.95	1.37	.569	1.34	.572
1.0	1.37	.605	1.34	.609
1.2	1.37	.751	1.33	.759
1.4	1.37	.897	1.34	.909
1.6	1.38	1.04	1.34	1.06
1.8	1.39	1.19	1.35	1.21
2.0	1.40	1.33	1.36	1.35
2.2	1.41	1.47	1.37	1.50
2.4	1.42	1.61	1.38	1.65
2.6	1.43	1.75	1.39	1.79
2.8	1.44	1.89	1.40	1.93
3.0	1.45	2.03	1.41	2.08
4.0	1.50	2.71	1.46	2.77
5.0	1.54	3.37	1.50	3.45

Potassium

Z = 19, I = 209 ev

0.01	15.7	0.000365	17.7	0.000318
.02	9.47	.00120	10.4	.00107
.03	7.04	.00246	7.65	.00222
.04	5.72	.00403	6.16	.00367
.05	4.89	.00595	5.23	.00546
.06	4.31	.00811	4.58	.00749
.07	3.89	.0106	4.11	.00981
.08	3.56	.0133	3.75	.0124
.09	3.30	.0162	3.47	.0151
.10	3.10	.0193	2.35	.0181
.15	2.46	.0377	2.53	.0358
.20	2.13	.0597	2.17	.0573
.25	1.94	.0844	1.96	.0817
.30	1.81	.111	1.82	.108
.35	1.72	.140	1.72	.137
.40	1.66	.169	1.65	.166
.45	1.61	.200	1.60	.197
.50	1.58	.231	1.56	.229
.55	1.55	.263	1.53	.261
.60	1.53	.296	1.51	.294
.65	1.51	.329	1.49	.328
.70	1.50	.362	1.47	.361
.75	1.49	.395	1.46	.396
.80	1.48	.429	1.45	.430
.85	1.48	.463	1.45	.464
.90	1.47	.497	1.44	.499
.95	1.47	.531	1.44	.534
1.0	1.47	.565	1.43	.569
1.2	1.47	.701	1.43	.708
1.4	1.47	.837	1.43	.848

TABLE 3. Energy loss and range of electrons and positrons — Continued

Potassium - Continued

Z = 19, I = 209 ev

Energy	$-dE^-/dx$	R^-	$-dE^+/dx$	R^+
Mev	Mev cm^2/g	g/cm^2	Mev cm^2/g	g/cm^2
1.6	1.48	.973	1.44	.988
1.8	1.49	1.11	1.45	1.13
2.0	1.50	1.24	1.46	1.26
2.2	1.51	1.37	1.47	1.40
2.4	1.52	1.51	1.48	1.54
2.6	1.54	1.64	1.49	1.67
2.8	1.55	1.77	1.50	1.80
3.0	1.56	1.89	1.51	1.94
4.0	1.61	2.39	1.56	2.58

Calcium

Z = 20, I = 220 ev

0.01	16.0	0.000360	18.0	0.000313
.02	9.63	.00118	10.6	.00105
.03	7.16	.00242	7.80	.00218
.04	5.82	.00396	6.28	.00361
.05	4.98	.00584	5.33	.00536
.06	4.39	.00797	4.67	.00736
.07	3.96	.0104	4.19	.00963
.08	3.63	.0130	3.82	.0121
.09	3.37	.0159	3.53	.0149
.10	3.16	.0190	3.30	.0178
.15	2.50	.0370	2.58	.0352
.20	2.17	.0585	2.21	.0562
.25	1.98	.0827	2.00	.0801
.30	1.85	.109	1.85	.106
.35	1.76	.137	1.75	.134
.40	1.69	.166	1.68	.163
.45	1.64	.196	1.63	.193
.50	1.61	.227	1.59	.224
.55	1.58	.258	1.56	.256
.60	1.56	.290	1.54	.288
.65	1.54	.322	1.52	.321
.70	1.53	.354	1.50	.354
.75	1.52	.387	1.49	.388
.80	1.51	.420	1.48	.421
.85	1.51	.453	1.48	.455
.90	1.50	.486	1.47	.489
.95	1.50	.520	1.47	.523
1.0	1.50	.533	1.46	.557
1.2	1.50	.687	1.46	.694
1.4	1.50	.820	1.46	.831
1.6	1.51	.953	1.47	.967
1.8	1.52	1.08	1.48	1.10
2.0	1.53	1.22	1.49	1.24
2.2	1.55	1.34	1.50	1.37
2.4	1.56	1.47	1.49	1.50
2.6	1.57	1.60	1.53	1.64
2.8	1.58	1.73	1.54	1.77
3.0	1.59	1.85	1.55	1.90
4.0	1.64	2.47	1.60	2.53

Iron

Z = 26, I = 280 ev

0.01	14.0	0.000416	15.9	0.000358
.02	8.51	.00134	9.43	.00119
.03	6.36	.00274	6.95	.00246
.04	5.18	.00448	5.37	.00409
.05	4.44	.00659	4.77	.00612

TABLE 3. Energy loss and range of electrons and positrons — Continued

Iron - Continued

Z = 26, I = 280 ev

Energy	$-dE^-/dx$	R^-	$-dE^+/dx$	R^+
Mev	Mev cm^2/g	g/cm^2	Mev cm^2/g	g/cm^2
.06	3.92	.00898	4.18	.00830
.07	3.54	.0117	3.76	.0109
.08	3.25	.0146	3.43	.0136
.09	3.02	.0178	3.17	.0167
.10	2.83	.0212	2.96	.0199
.15	2.25	.0413	2.32	.0393
.20	1.95	.0653	1.99	.0627
.25	1.78	.0922	1.80	.0893
.30	1.66	.121	1.67	.118
.35	1.58	.152	1.58	.149
.40	1.53	.184	1.52	.181
.45	1.49	.218	1.47	.215
.50	1.45	.252	1.44	.249
.55	1.43	.286	1.41	.284
.60	1.41	.321	1.39	.320
.65	1.40	.357	1.37	.356
.70	1.39	.393	1.36	.393
.75	1.38	.429	1.35	.429
.80	1.37	.466	1.34	.467
.85	1.37	.502	1.34	.504
.90	1.36	.539	1.33	.541
.95	1.36	.575	1.33	.579
1.0	1.36	.612	1.33	.617
1.2	1.36	.759	1.32	.768
1.4	1.36	.906	1.33	.919
1.6	1.37	1.05	1.34	1.07
1.8	1.38	1.20	1.35	1.22
2.0	1.40	1.34	1.36	1.37
2.2	1.41	1.48	1.37	1.51
2.4	1.42	1.63	1.38	1.66
2.6	1.43	1.77	1.39	1.80
2.8	1.44	1.91	1.40	1.95
3.0	1.45	2.04	1.41	2.09

Copper

Z = 29, I = 310 ev

0.01	13.3	0.000439	15.2	0.000376
.02	8.14	.00141	9.04	.00125
.03	6.09	.00287	6.67	.00257
.04	4.97	.00468	5.39	.00423
.05	4.26	.00689	4.58	.00627
.06	3.77	.00936	4.03	.00859
.07	3.40	.0122	3.62	.0112
.08	3.12	.0152	3.30	.0141
.09	2.90	.0186	3.05	.0173
.10	2.72	.0221	2.85	.0207
.15	2.17	.0430	2.24	.0407
.20	1.88	.0678	1.92	.0650
.25	1.72	.0957	1.73	.0925
.30	1.61	.126	1.61	.122
.35	1.53	.158	1.53	.154
.40	1.48	.191	1.47	.188
.45	1.44	.226	1.42	.222
.50	1.41	.261	1.39	.258
.55	1.38	.297	1.36	.294
.60	1.36	.333	1.34	.331
.65	1.35	.370	1.33	.369
.70	1.34	.407	1.31	.407
.75	1.33	.444	1.31	.445
.80	1.33	.482	1.30	.483
.85	1.32	.520	1.29	.522

TABLE 3. Energy loss and range of electrons and positrons — Continued

Copper - Continued

Z = 29, I = 310 ev

Energy	$-dE^-/dx$	R^-	$-dE^+/dx$	R^+
Mev	Mev cm^2/g	g/cm^2	Mev cm^2/g	g/cm^2
.90	1.32	.558	1.29	.561
.95	1.32	.596	1.29	.599
1.0	1.31	.634	1.28	.638
1.2	1.32	.786	1.28	.794
1.4	1.32	.938	1.29	.950
1.6	1.33	1.09	1.29	1.11
1.8	1.34	1.24	1.30	1.26
2.0	1.35	1.39	1.31	1.41
2.2	1.36	1.53	1.32	1.56
2.4	1.37	1.68	1.33	1.71
2.6	1.39	1.83	1.34	1.86
2.8	1.40	1.97	1.36	2.01

Zinc

Z = 30, I = 320 ev

0.01	13.3	0.000441	15.2	0.000377
.02	8.13	.00141	9.03	.00125
.03	6.09	.00288	6.67	.00257
.04	4.97	.00469	5.39	.00424
.05	4.26	.00689	4.58	.00627
.06	3.77	.00937	4.03	.00859
.07	3.40	.0122	3.62	.0112
.08	3.12	.0152	3.30	.0141
.09	2.90	.0186	3.06	.0173
.10	2.72	.0221	2.85	.0207
.15	2.17	.0430	2.24	.0407
.20	1.89	.0678	1.92	.0650
.25	1.72	.0957	1.74	.0924
.30	1.61	.126	1.61	.122
.35	1.53	.158	1.53	.154
.40	1.48	.191	1.47	.188
.45	1.44	.225	1.42	.222
.50	1.41	.260	1.39	.258
.55	1.38	.296	1.36	.294
.60	1.37	.333	1.34	.331
.65	1.35	.369	1.33	.368
.70	1.34	.407	1.32	.406
.75	1.33	.444	1.31	.444
.80	1.33	.481	1.30	.483
.85	1.32	.519	1.29	.521
.90	1.32	.557	1.29	.560
.95	1.32	.595	1.29	.599
1.0	1.32	.633	1.29	.637
1.2	1.32	.785	1.28	.793
1.4	1.32	.936	1.29	.949
1.6	1.33	1.09	1.30	1.10
1.8	1.34	1.24	1.31	1.26
2.0	1.36	1.38	1.32	1.41
2.2	1.37	1.53	1.33	1.56
2.4	1.38	1.68	1.34	1.71
2.6	1.39	1.82	1.35	1.86

Bromine

Z = 35, I = 368 ev

0.01	12.2	0.000484	14.0	0.000353
.02	7.50	.00154	8.36	.00135
.03	5.63	.00313	6.19	.00272
.04	4.61	.00508	5.01	.00457
.05	3.95	.00746	4.26	.00671

TABLE 3. Energy loss and range of electrons and positrons — Continued

Bromine - Continued

Z = 35, I = 368 ev

Energy	$-dE^-/dx$	R^-	$-dE^+/dx$	R^+
Mev	Mev cm^2/g	g/cm^2	Mev cm^2/g	g/cm^2
.06	3.50	.0101	3.75	.00926
.07	3.16	.0132	3.37	.0120
.08	2.91	.0164	3.08	.0152
.09	2.70	.0200	2.85	.0185
.10	2.54	.0238	2.66	.0222
.15	2.02	.0462	2.09	.0437
.20	1.76	.0728	1.80	.0697
.25	1.61	.103	1.62	.0990
.30	1.50	.135	1.51	.131
.35	1.43	.169	1.43	.165
.40	1.38	.205	1.37	.201
.45	1.35	.241	1.33	.238
.50	1.32	.279	1.30	.276
.55	1.30	.317	1.28	.314
.60	1.28	.356	1.26	.354
.65	1.27	.395	1.25	.394
.70	1.26	.435	1.23	.434
.75	1.25	.475	1.23	.475
.80	1.25	.515	1.22	.516
.85	1.24	.555	1.21	.557
.90	1.24	.595	1.21	.598
.95	1.24	.636	1.21	.640
1.0	1.24	.676	1.21	.681
1.2	1.24	.838	1.20	.847
1.4	1.24	.999	1.21	1.01
1.6	1.25	1.16	1.22	1.18
1.8	1.26	1.32	1.23	1.34
2.0	1.27	1.48	1.24	1.50

Molybdenum

Z = 42, I = 433 ev

0.01	11.6	0.000513	13.4	0.000432
.02	7.20	.00161	8.06	.00141
.03	5.43	.00327	5.98	.00289
.04	4.45	.00528	5.07	.00471
.05	3.82	.00775	4.13	.00689
.06	3.39	.0105	3.63	.00951
.07	3.07	.0136	3.27	.0124
.08	2.82	.0170	2.99	.0156
.09	2.62	.0207	2.77	.0191
.10	2.46	.0246	2.59	.0228
.15	1.97	.0477	2.03	.0449
.20	1.72	.0750	1.75	.0716
.25	1.56	.106	1.58	.102
.30	1.47	.139	1.47	.135
.35	1.40	.174	1.40	.169
.40	1.35	.210	1.34	.206
.45	1.31	.248	1.30	.244
.50	1.29	.286	1.27	.283
.55	1.27	.325	1.25	.322
.60	1.25	.365	1.23	.363
.65	1.24	.405	1.22	.404
.70	1.23	.446	1.21	.445
.75	1.22	.486	1.20	.486
.80	1.22	.527	1.19	.528
.85	1.22	.568	1.19	.570

TABLE 3. Energy loss and range of electrons and positrons — Continued

Molybdenum - Continued

Z = 42, I = 433 ev

Energy	$-dE^-/dx$	R^-	$-dE^+/dx$	R^+
Mev	Mev cm^2/g	g/cm^2	Mev cm^2/g	g/cm^2
.90	1.21	.610	1.18	.613
.95	1.21	.651	1.18	.655
1.0	1.21	.692	1.18	.697
1.2	1.21	.857	1.18	.867
1.4	1.22	1.02	1.18	1.04
1.6	1.23	1.19	1.19	1.20

Silver

Z = 47, I = 480 ev

0.01	11.2	0.000535	13.0	0.000447
.02	6.98	.00167	7.84	.00145
.03	5.27	.00337	5.83	.00298
.04	4.33	.00544	4.73	.00487
.05	3.73	.00798	4.03	.00719
.06	3.30	.0108	3.55	.00982
.07	2.99	.0140	3.19	.0128
.08	2.75	.0175	2.92	.0161
.09	2.56	.0212	2.70	.0197
.10	2.40	.0253	2.53	.0235
.15	1.92	.0489	1.99	.0461
.20	1.68	.0768	1.71	.0733
.25	1.53	.108	1.55	.104
.30	1.44	.142	1.44	.138
.35	1.37	.178	1.37	.173
.40	1.32	.215	1.32	.210
.45	1.29	.253	1.28	.249
.50	1.26	.292	1.25	.289
.55	1.24	.332	1.23	.329
.60	1.23	.372	1.21	.370
.65	1.22	.413	1.19	.412
.70	1.21	.455	1.18	.454
.75	1.20	.496	1.18	.496
.80	1.20	.538	1.17	.539
.85	1.19	.580	1.17	.582
.90	1.19	.621	1.16	.625
.95	1.19	.663	1.16	.668
1.0	1.19	.705	1.16	.711
1.2	1.19	.873	1.16	.883
1.4	1.20	1.04	1.16	1.06

Tin

Z = 50, I = 508 ev

0.01	10.6	0.000568	12.3	0.000473
.02	6.63	.00176	7.46	.00153
.03	5.02	.00356	5.55	.00313
.04	4.12	.00573	4.51	.00512
.05	3.55	.00840	3.85	.00756
.06	3.15	.0114	3.39	.0103
.07	2.85	.0147	3.05	.0135
.08	2.62	.0184	2.79	.0169
.09	2.44	.0224	2.58	.0206
.10	2.29	.0265	2.42	.0246
.15	1.84	.0512	1.90	.0483
.20	1.60	.0805	1.64	.0767
.25	1.47	.113	1.48	.109
.30	1.37	.148	1.38	.144
.35	1.31	.186	1.31	.181

TABLE 3. Energy loss and range of electrons and positrons — Continued

Tin - Continued

Z = 50, I = 508 ev

Energy	$-dE^-/dx$	R^-	$-dE^+/dx$	R^+
Mev	Mev cm^2/g	g/cm^2	Mev cm^2/g	g/cm^2
.40	1.27	.225	1.26	.220
.45	1.23	.265	1.22	.261
.50	1.21	.306	1.19	.302
.55	1.19	.347	1.17	.344
.60	1.18	.389	1.16	.387
.65	1.17	.432	1.14	.431
.70	1.16	.475	1.13	.474
.75	1.15	.519	1.13	.519
.80	1.15	.562	1.12	.563
.85	1.14	.606	1.12	.608
.90	1.14	.649	1.11	.653
.95	1.14	.693	1.11	.698
1.0	1.14	.737	1.11	.743
1.2	1.14	.912	1.00	.923

Iodine

Z = 53, I = 536 ev

0.01	10.3	0.000582	12.1	0.000484
.02	6.50	.00180	7.33	.00156
.03	4.92	.00363	5.45	.00319
.04	4.05	.00585	4.43	.00521
.05	3.49	.00856	3.78	.00769
.06	3.10	.0116	3.33	.0105
.07	2.80	.0150	3.00	.0137
.08	2.58	.0187	2.74	.0172
.09	2.40	.0228	2.54	.0210
.10	2.26	.0270	2.38	.0250
.15	1.81	.0521	1.87	.0490
.20	1.58	.0818	1.61	.0780
.25	1.44	.115	1.46	.111
.30	1.35	.151	1.36	.146
.35	1.29	.189	1.29	.184
.40	1.25	.228	1.24	.224
.45	1.22	.269	1.20	.265
.50	1.19	.310	1.18	.307
.55	1.17	.353	1.16	.349
.60	1.16	.395	1.14	.393
.65	1.15	.439	1.13	.437
.70	1.14	.482	1.12	.482
.75	1.14	.526	1.11	.526
.80	1.13	.570	1.11	.572
.85	1.13	.615	1.10	.617
.90	1.13	.659	1.10	.662
.95	1.12	.703	1.10	.708
1.0	1.12	.748	1.10	.754
1.2	1.13	.926	1.10	.936

Tungsten

Z = 74, I = 734 ev

0.01	8.94	0.000690	10.6	0.000559
.02	5.74	.00207	6.53	.00177
.03	4.38	.00415	4.90	.00360
.04	3.62	.00661	3.99	.00584
.05	3.13	.00965	3.42	.00859
.06	2.79	.0130	3.02	.0117
.07	2.53	.0168	2.72	.0152
.08	2.33	.0209	2.49	.0190
.09	2.17	.0254	2.31	.0232
.10	2.05	.0301	2.16	.0277

TABLE 3. Energy loss and range of electrons and positrons — Continued

Tungsten - Continued

Z = 74, I = 734 ev

Energy	$-dE^-/dx$	R^-	$-dE^+/dx$	R^+
Mev	Mev cm^2/g	g/cm^2	Mev cm^2/g	g/cm^2
.15	1.65	.0577	1.71	.0541
.20	1.44	.0902	1.47	.0858
.25	1.32	.127	1.34	.122
.30	1.24	.166	1.25	.160
.35	1.19	.207	1.18	.202
.40	1.15	.250	1.14	.245
.45	1.12	.294	1.11	.289
.50	1.10	.339	1.08	.335
.55	1.08	.385	1.06	.382
.60	1.07	.432	1.05	.429
.65	1.06	.479	1.04	.477
.70	1.05	.526	1.03	.525
.75	1.05	.574	1.02	.574
.80	1.04	.622	1.02	.623
.85	1.04	.670	1.02	.672
.90	1.04	.718	1.01	.721
.95	1.04	.766	1.01	.771
1.0	1.04	.804	1.01	.820

Platinum

Z = 78, I = 772 ev

0.01	8.71	0.000712	10.3	0.000574
.02	5.61	.00213	6.40	.00181
.03	4.29	.00425	4.80	.00367
.04	3.55	.00676	3.92	.00596
.05	3.07	.00986	3.35	.00877
.06	2.73	.0133	2.96	.0119
.07	2.48	.0172	2.67	.0155
.08	2.29	.0213	2.45	.0194
.09	2.14	.0259	2.27	.0237
.10	2.01	.0307	2.12	.0282
.15	1.62	.0588	1.68	.0550
.20	1.42	.0919	1.45	.0872
.25	1.30	.129	1.31	.124
.30	1.22	.169	1.23	.163
.35	1.17	.211	1.17	.205
.40	1.13	.254	1.12	.249
.45	1.10	.299	1.09	.294
.50	1.08	.345	1.07	.340
.55	1.06	.392	1.05	.388
.60	1.05	.439	1.03	.436
.65	1.04	.487	1.02	.485
.70	1.04	.535	1.01	.534
.75	1.03	.583	1.01	.583
.80	1.03	.631	1.00	.633
.85	1.03	.680	1.00	.683
.90	1.03	.729	.999	.733

Gold

Z = 79, I = 782 ev

0.01	8.70	0.000714	10.3	0.000575
.02	5.61	.00213	6.40	.00181
.03	4.29	.00425	4.80	.00368
.04	3.55	.00677	3.92	.00596
.05	3.07	.00987	3.36	.00876

TABLE 3. Energy loss and range of electrons and positrons — Continued

Gold - Continued

Z = 79, I = 782 ev

Energy	$-dE^-/dx$	R^-	$-dE^+/dx$	R^+
Mev	Mev cm^2/g	g/cm^2	Mev cm^2/g	g/cm^2
.06	2.74	.0133	2.96	.0119
.07	2.49	.0172	2.67	.0155
.08	2.29	.0213	2.45	.0194
.09	2.14	.0259	2.27	.0237
.10	2.01	.0306	2.13	.0282
.15	1.62	.0587	1.68	.0550
.20	1.42	.0918	1.45	.0872
.25	1.30	.129	1.32	.124
.30	1.22	.168	1.23	.163
.35	1.17	.210	1.17	.205
.40	1.13	.254	1.12	.248
.45	1.10	.299	1.09	.294
.50	1.08	.345	1.07	.340
.55	1.07	.391	1.05	.387
.60	1.05	.438	1.03	.435
.65	1.05	.486	1.02	.484
.70	1.04	.534	1.02	.533
.75	1.03	.582	1.01	.582
.80	1.03	.631	1.01	.632
.85	1.03	.679	1.00	.682
.90	1.03	.728	1.00	.732

Mercury

Z = 80, I = 792 ev

0.01	8.62	0.000721	10.3	0.000580
.02	5.56	.00215	6.35	.00183
.03	4.26	.00429	4.77	.00371
.04	3.53	.00682	3.89	.00601
.05	3.05	.00995	3.33	.00883
.06	2.72	.0134	2.94	.0120
.07	2.47	.0173	2.65	.0156
.08	2.27	.0215	2.43	.0195
.09	2.12	.0261	2.25	.0238
.10	2.00	.0309	2.11	.0284
.15	1.61	.0592	1.67	.0554
.20	1.41	.0925	1.44	.0878
.25	1.29	.130	1.31	.124
.30	1.21	.170	1.22	.164
.35	1.16	.212	1.16	.206
.40	1.12	.256	1.12	.250
.45	1.09	.301	1.08	.296
.50	1.07	.347	1.06	.342
.55	1.06	.394	1.04	.390
.60	1.05	.441	1.03	.438
.65	1.04	.489	1.02	.487
.70	1.03	.538	1.01	.537
.75	1.03	.586	1.00	.586
.80	1.02	.635	.999	.636
.85	1.02	.684	.996	.686
.90	1.02	.733	.994	.737

Lead

Z = 82, I = 811 ev

0.01	8.48	0.000735	10.1	0.000590
.02	5.48	.00218	6.26	.00185
.03	4.20	.00435	4.70	.00376
.04	3.48	.00692	3.84	.00609
.05	3.01	.0101	3.29	.00895

TABLE 3. Energy loss and range of electrons and positrons — Continued

Lead - Continued

Z = 82, I = 811 ev

Energy	$-dE^-/dx$	R^-	$-dE^+/dx$	R^+
Mev	Mev cm^2/g	g/cm^2	Mev cm^2/g	g/cm^2
.06	2.68	.0136	2.90	.0122
.07	2.44	.0175	2.62	.0158
.08	2.25	.0218	2.40	.0198
.09	2.10	.0264	2.23	.0242
.10	1.97	.0313	2.09	.0288
.15	1.59	.0599	1.65	.0561
.20	1.39	.0936	1.43	.0889
.25	1.28	.131	1.29	.126
.30	1.20	.172	1.21	.166
.35	1.15	.214	1.15	.209
.40	1.11	.259	1.10	.253
.45	1.08	.305	1.07	.299
.50	1.06	.351	1.05	.346
.55	1.05	.399	1.03	.395
.60	1.04	.447	1.02	.443
.65	1.03	.495	1.01	.493
.70	1.02	.544	.998	.543
.75	1.02	.593	.993	.593
.80	1.01	.642	.988	.643

Uranium

Z = 92, I = 907 ev

0.01	7.93	0.000795	9.51	0.000631
.02	5.17	.00233	5.93	.00196
.03	3.98	.00463	4.47	.00398
.04	3.30	.00733	3.65	.00642
.05	2.86	.0107	3.13	.00943
.06	2.55	.0143	2.77	.0128
.07	2.32	.0185	2.50	.0166
.08	2.14	.0229	2.29	.0208
.09	2.00	.0278	2.13	.0254
.10	1.88	.0329	1.99	.0302
.15	1.52	.0629	1.58	.0588
.20	1.33	.0982	1.36	.0931
.25	1.22	.138	1.24	.132
.30	1.15	.180	1.15	.174
.35	1.10	.224	1.10	.218
.40	1.06	.271	1.06	.265
.45	1.04	.318	1.03	.313
.50	1.02	.367	1.01	.362
.55	1.00	.416	.988	.412
.60	.994	.466	.976	.463
.65	.986	.517	.966	.514
.70	.980	.568	.959	.566
.75	.976	.619	.953	.619
.80	.973	.670	.949	.671

Air

0.755 N, 0.232 O, 0.013 A

0.01	19.5	0.000286	21.6	0.000256
.02	11.5	.000974	12.4	.000886
.03	8.41	.00202	9.05	.00185
.04	6.79	.00334	7.24	.00309
.05	5.77	.00496	6.12	.00460
.06	5.07	.00680	5.35	.00635
.07	4.56	.00890	4.79	.00834
.08	4.17	.0112	4.36	.0105
.09	3.86	.0137	4.02	.0129
.10	3.60	.0164	3.75	.0155

TABLE 3. Energy loss and range of electrons and positrons — Continued

Air - Continued

0.755 N, 0.232 O, 0.013 A

Energy	$-dE^-/dx$	R^-	$-dE^+/dx$	R^+
Mev	Mev cm^2/g	g/cm^2	Mev cm^2/g	g/cm^2
.15	2.84	.0322	2.91	.0308
.20	2.45	.0513	2.49	.0495
.25	2.22	.0728	2.24	.0707
.30	2.07	.0961	2.08	.0940
.35	1.97	.121	1.96	.119
.40	1.89	.147	1.88	.145
.45	1.83	.174	1.82	.172
.50	1.79	.201	1.77	.200
.55	1.76	.230	1.74	.228
.60	1.73	.258	1.71	.257
.65	1.71	.287	1.69	.287
.70	1.70	.317	1.67	.317
.75	1.68	.346	1.65	.347
.80	1.67	.376	1.64	.377
.85	1.67	.406	1.63	.408
.90	1.66	.436	1.63	.438
.95	1.65	.466	1.62	.469
1.0	1.65	.497	1.62	.498
1.2	1.65	.618	1.61	.624
1.4	1.65	.739	1.61	.747
1.6	1.66	.860	1.62	.872
1.8	1.67	.981	1.62	.994
2.0	1.68	1.10	1.63	1.12
2.2	1.69	1.22	1.64	1.24
2.4	1.70	1.34	1.65	1.36
2.6	1.71	1.46	1.67	1.48
2.8	1.72	1.57	1.68	1.60
3.0	1.73	1.69	1.69	1.72
4.0	1.78	2.26	1.74	2.31
5.0	1.82	2.81	1.78	2.87
6.0	1.86	3.35	1.81	3.43
8.0	1.92	4.41	1.87	4.52

Water

H_2O

0.01	23.1	0.000241	25.4	0.000217
.02	13.5	.000824	14.6	.000754
.03	9.85	.00171	10.6	.00158
.04	7.93	.00285	8.44	.00264
.05	6.73	.00423	7.12	.00394
.06	5.90	.00581	6.22	.00545
.07	5.30	.00761	5.56	.00716
.08	4.84	.00958	5.06	.00904
.09	4.48	.0117	4.66	.0111
.10	4.19	.0140	4.34	.0133
.15	3.29	.0277	3.37	.0266
.20	2.84	.0442	2.88	.0427
.25	2.57	.0628	2.59	.0611
.30	2.39	.0830	2.40	.0812
.35	2.27	.105	2.26	.103
.40	2.18	.127	2.17	.125
.45	2.11	.150	2.10	.149
.50	2.06	.174	2.04	.173
.55	2.02	.199	2.00	.198
.60	1.99	.224	1.97	.223
.65	1.97	.249	1.94	.248
.70	1.95	.274	1.92	.274
.75	1.94	.300	1.90	.301
.80	1.92	.326	1.89	.327
.85	1.91	.352	1.88	.354

TABLE 3. Energy loss and range of electrons and positrons — Continued

Water - Continued

H_2O

Energy	$-dE^-/dx$	R^-	$-dE^+/dx$	R^+
Mev	Mev cm^2/g	g/cm^2	Mev cm^2/g	g/cm^2
.90	1.91	.378	1.87	.380
.95	1.90	.405	1.86	.407
1.0	1.90	.431	1.86	.434
1.2	1.89	.537	1.85	.542
1.4	1.89	.643	1.85	.650
1.6	1.90	.748	1.85	.758
1.8	1.91	.853	1.86	.866
2.0	1.92	.958	1.87	.973
2.2	1.93	1.06	1.88	1.08
2.4	1.94	1.17	1.89	1.19
2.6	1.96	1.27	1.91	1.29
2.8	1.97	1.37	1.92	1.40
3.0	1.98	1.47	1.93	1.50
4.0	2.04	1.97	1.98	2.01
5.0	2.08	2.45	2.03	2.51
6.0	2.12	2.93	2.07	3.00
8.0	2.19	3.86	2.14	3.95

Carbon Monoxide

CO

0.01	19.7	0.000284	21.8	0.000254
.02	11.6	.000964	12.5	.000878
.03	8.48	.00200	9.12	.00184
.04	6.84	.00331	7.30	.00306
.05	5.81	.00491	6.17	.00457
.06	5.11	.00674	5.39	.00630
.07	4.59	.00882	4.82	.00827
.08	4.19	.0111	4.39	.0104
.09	3.88	.0136	4.05	.0128
.10	3.63	.0162	3.77	.0154
.15	2.86	.0320	2.93	.0306
.20	2.47	.0509	2.51	.0492
.25	2.24	.0723	2.26	.0703
.30	2.08	.0955	2.09	.0933
.35	1.98	.120	1.98	.118
.40	1.90	.146	1.89	.144
.45	1.84	.173	1.83	.171
.50	1.80	.200	1.78	.198
.55	1.77	.228	1.75	.227
.60	1.74	.257	1.72	.256
.65	1.72	.285	1.70	.285
.70	1.71	.315	1.68	.315
.75	1.69	.344	1.66	.344
.80	1.68	.374	1.65	.375
.85	1.68	.403	1.64	.405
.90	1.67	.433	1.64	.435
.95	1.66	.463	1.63	.466
1.0	1.66	.493	1.63	.497
1.2	1.66	.614	1.62	.620
1.4	1.66	.735	1.62	.744
1.6	1.66	.855	1.62	.867
1.8	1.67	.975	1.63	.990
2.0	1.68	1.09	1.64	1.11
2.2	1.70	1.21	1.65	1.23
2.4	1.71	1.33	1.66	1.35
2.6	1.72	1.45	1.67	1.47
2.8	1.73	1.56	1.68	1.59
3.0	1.74	1.68	1.70	1.71
4.0	1.79	2.24	1.74	2.29
5.0	1.83	2.80	1.79	2.86

TABLE 3. Energy loss and range of electrons and positrons — Continued

Carbon Monoxide - Continued

CO

Energy	$-dE^-/dx$	R^-	$-dE^+/dx$	R^+
Mev	Mev cm^2/g	g/cm^2	Mev cm^2/g	g/cm^2
6.0	1.87	3.34	1.82	3.41
8.0	1.93	4.39	1.88	4.49

Carbon Dioxide

CO_2

0.01	19.6	0.000287	21.6	0.000256
.02	11.5	.000972	12.5	.000885
.03	8.42	.00202	9.06	.00185
.04	6.80	.00334	7.26	.00308
.05	5.78	.00495	6.13	.00460
.06	5.07	.00679	5.36	.00634
.07	4.56	.00888	4.79	.00833
.08	4.17	.0112	4.37	.0105
.09	3.86	.0137	4.03	.0129
.10	3.61	.0163	3.75	.0155
.15	2.84	.0322	2.92	.0308
.20	2.46	.0512	2.50	.0494
.25	2.22	.0727	2.24	.0706
.30	2.07	.0960	2.08	.0938
.35	1.97	.121	1.97	.119
.40	1.89	.147	1.88	.145
.45	1.84	.174	1.82	.172
.50	1.79	.201	1.78	.199
.55	1.76	.229	1.74	.228
.60	1.73	.258	1.71	.257
.65	1.71	.287	1.69	.286
.70	1.70	.316	1.67	.316
.75	1.69	.346	1.66	.346
.80	1.68	.376	1.64	.376
.85	1.67	.405	1.64	.407
.90	1.66	.435	1.63	.438
.95	1.66	.466	1.62	.468
1.0	1.65	.496	1.62	.499
1.2	1.65	.617	1.61	.623
1.4	1.65	.738	1.61	.747
1.6	1.66	.859	1.62	.871
1.8	1.67	.979	1.63	.995
2.0	1.68	1.10	1.64	1.12
2.2	1.69	1.22	1.65	1.24
2.4	1.70	1.34	1.66	1.36
2.6	1.71	1.45	1.67	1.48
2.8	1.72	1.57	1.68	1.60
3.0	1.73	1.69	1.69	1.72
4.0	1.78	2.25	1.74	2.30
5.0	1.83	2.81	1.78	2.87
6.0	1.86	3.35	1.82	3.43
8.0	1.92	4.40	1.88	4.51

Silver Bromide

Ag Br

0.01	11.6	0.000512	13.4	0.000400
.02	7.20	.00161	8.07	.00141
.03	5.43	.00326	5.98	.00286
.04	4.45	.00528	4.85	.00474
.05	3.82	.00775	4.13	.00697
.06	3.39	.0105	3.63	.00957
.07	3.06	.0136	3.27	.0125
.08	2.82	.0170	2.99	.0157
.09	2.62	.0207	2.77	.0192
.10	2.46	.0246	2.59	.0229

TABLE 3. Energy loss and range of electrons and positrons — Continued

Silver Bromide - Continued

Ag Br

Energy	$-dE^-/dx$	R^-	$-dE^+/dx$	R^+
Mev	Mev cm^2/g	g/cm^2	Mev cm^2/g	g/cm^2
.15	1.97	.0477	2.03	.0450
.20	1.71	.0750	1.75	.0717
.25	1.56	.106	1.58	.102
.30	1.47	.139	1.47	.135
.35	1.40	.174	1.40	.170
.40	1.35	.210	1.34	.206
.45	1.31	.248	1.30	.244
.50	1.29	.286	1.27	.283
.55	1.27	.325	1.25	.323
.60	1.25	.365	1.23	.363
.65	1.24	.405	1.22	.404
.70	1.23	.446	1.21	.445
.75	1.22	.487	1.20	.487
.80	1.22	.528	1.19	.529
.85	1.21	.569	1.19	.571
.90	1.21	.610	1.18	.613
.95	1.21	.651	1.18	.655
1.0	1.21	.693	1.18	.698
1.2	1.21	.858	1.18	.868
1.4	1.22	1.02	1.18	1.04
1.6	1.23	1.19	1.19	1.21
1.8	1.24	1.35	1.20	1.37
2.0	1.25	1.51	1.21	1.54

Dry Ilford Emulsion

.01 I, .45 Ag, .33 Br, .07 O, .02 N, .09 C, .03 H

0.01	14.3	0.000407	16.2	0.000334
.02	8.66	.00132	9.58	.00117
.03	6.46	.00270	7.05	.00240
.04	5.26	.00440	5.69	.00400
.05	4.50	.00649	4.83	.00591
.06	3.97	.00884	4.24	.00813
.07	3.59	.0115	3.80	.0106
.08	3.29	.0144	3.47	.0134
.09	3.05	.0176	3.21	.0164
.10	2.86	.0210	3.00	.0196
.15	2.28	.0408	2.35	.0387
.20	1.98	.0645	2.01	.0619
.25	1.80	.0911	1.82	.0881
.30	1.68	.120	1.69	.117
.35	1.60	.150	1.60	.147
.40	1.54	.182	1.53	.179
.45	1.50	.215	1.49	.212
.50	1.47	.249	1.45	.246
.55	1.44	.283	1.42	.281
.60	1.42	.318	1.40	.317
.65	1.41	.353	1.39	.352
.70	1.40	.389	1.37	.389
.75	1.39	.425	1.36	.425
.80	1.38	.461	1.35	.462
.85	1.38	.497	1.35	.499
.90	1.37	.534	1.34	.536
.95	1.37	.570	1.34	.574
1.0	1.37	.607	1.34	.611
1.2	1.37	.753	1.33	.761
1.4	1.38	.898	1.34	.910
1.6	1.38	1.04	1.34	1.06
1.8	1.39	1.19	1.36	1.21
2.0	1.41	1.33	1.37	1.35

TABLE 3. Energy loss and range of electrons and positrons — Continued

Sodium Iodide

NaI

Energy	$-dE^-/dx$	R^-	$-dE^+/dx$	R^+
Mev	Mev cm^2/g	g/cm^2	Mev cm^2/g	g/cm^2
0.01	11.6	0.000513	13.3	0.000433
.02	7.15	.00162	8.00	.00142
.03	5.38	.00328	5.93	.00292
.04	4.41	.00532	4.80	.00478
.05	3.79	.00781	4.09	.00707
.06	3.35	.0106	3.60	.00966
.07	3.03	.0138	3.23	.0126
.08	2.79	.0172	2.96	.0158
.09	2.59	.0243	2.74	.0194
.10	2.43	.0249	2.56	.0231
.15	1.95	.0482	2.01	.0455
.20	1.69	.0759	1.73	.0725
.25	1.55	.107	1.56	.103
.30	1.45	.140	1.45	.136
.35	1.38	.176	1.38	.172
.40	1.33	.213	1.32	.209
.45	1.30	.251	1.29	.247
.50	1.27	.290	1.26	.286
.55	1.25	.329	1.23	.327
.60	1.23	.370	1.21	.368
.65	1.22	.410	1.20	.409
.70	1.21	.451	1.19	.451
.75	1.21	.493	1.18	.493
.80	1.20	.534	1.18	.535
.85	1.20	.576	1.17	.578
.90	1.20	.618	1.17	.621
.95	1.19	.660	1.17	.664
1.0	1.19	.701	1.16	.707
1.2	1.19	.869	1.16	.879

Styrene

C_8H_8

0.01	23.0	0.0002h2	25.2	0.000218
.02	13.3	.000831	14.4	.000762
.03	9.74	.00173	10.4	.00160
.04	7.84	.00288	8.32	.00267
.05	6.64	.00428	7.02	.00399
.06	5.82	.00588	6.13	.00552
.07	5.23	.00771	5.48	.00725
.08	4.77	.00970	4.98	.00916
.09	4.42	.0119	4.59	.0113
.10	4.13	.0142	4.28	.0135
.15	3.24	.0281	3.32	.0270
.20	2.79	.0448	2.84	.0434
.25	2.53	.0637	2.55	.0620
.30	2.35	.0843	2.36	.0825
.35	2.23	.106	2.23	.104
.40	2.14	.129	2.13	.127
.45	2.08	.153	2.06	.151
.50	2.03	.177	2.01	.176
.55	1.99	.202	1.97	.201
.60	1.96	.227	1.93	.227
.65	1.93	.253	1.91	.253
.70	1.92	.279	1.89	.279
.75	1.90	.305	1.87	.306
.80	1.89	.332	1.86	.333
.85	1.88	.358	1.84	.359

TABLE 3. Energy loss and range of electrons and positrons – Continued

Styrene - Continued

C_8H_8

Energy	$-dE^-/dx$	R^-	$-dE^+/dx$	R^+
Mev	Mev cm^2/g	g/cm	Mev cm^2/g	g/cm^2
.90	1.87	.385	1.84	.387
.95	1.87	.412	1.83	.414
1.0	1.86	.439	1.82	.441
1.2	1.85	.546	1.81	.552
1.4	1.85	.654	1.81	.662
1.6	1.86	.762	1.82	.772
1.8	1.87	.869	1.83	.882
2.0	1.88	.976	1.84	.991
2.2	1.89	1.08	1.85	1.10
2.4	1.90	1.19	1.86	1.21
2.6	1.92	1.29	1.87	1.32
2.8	1.93	1.40	1.88	1.42
3.0	1.94	1.50	1.89	1.53
4.0	1.99	2.01	1.94	2.05
5.0	2.04	2.50	1.99	2.56
6.0	2.08	2.99	2.03	3.06
8.0	2.14	3.94	2.09	4.03
10.0	2.20	4.86	2.14	4.97

TABLE 4. Table of ln Z and Z/A.[a]

Z	lnZ	Z/A	Z	lnZ	Z/A
1	0.0000	0.99206	37	3.6109	.43285
2	.6932	.49963	38	3.6376	.43364
3	1.0986	.43228	39	3.6636	.43860
4	1.3863	.44380	40	3.6889	.43850
5	1.6094	.46211	41	3.7136	0.44129
6	1.7918	.49954	42	3.7377	.43773
7	1.9459	.49971	43	3.7612	.43434
8	2.0794	.50000	44	3.7842	.43521
9	2.1972	.47368	45	3.8067	.43728
10	2.3026	.49547	46	3.8286	.43112
11	2.3979	.47845	47	3.8502	.43567
12	2.4849	.49342	48	3.8712	.42701
13	2.5650	.48184	49	3.8918	.42698
14	2.6391	.49840	50	3.9120	.42123
15	2.7081	.48426	51	3.9318	.41886
16	2.7726	.49897	52	3.9512	.40749
17	2.8332	.47945	53	3.9703	.41762
18	2.8904	.45063	54	3.9890	.41127
19	2.9444	.48593	55	4.0073	.41381
20	2.9957	.49900	56	4.0254	.40769
21	3.0445	.46708	57	4.0431	.41031
22	3.0910	.45929	72	4.2767	.40314
23	3.1355	.45142	73	4.2905	.40343
24	3.1781	.46145	74	4.3041	.40235
25	3.2189	.45504	75	4.3175	.40255
26	3.2581	.46553	76	4.3307	.39958
27	3.2958	.45809	77	4.3438	.40062
28	3.3322	.47708	78	4.3567	.39953
29	3.3673	.45641	79	4.3695	.40102
30	3.4012	.45886	80	4.3820	.39878
31	3.4340	.44464	81	4.3945	.39630
32	3.4657	.44077	82	4.4067	.39573
33	3.4965	.44053	83	4.4188	.39713
34	3.5264	.43060	84	4.4308	.40000
35	3.5554	.43796	85	4.4427	.40284
36	3.5835	.42959	86	4.4544	.37739

TABLE 4. Table of lnZ and Z/A.[a] – Continued

Z	lnZ	Z/A	Z	lnZ	Z/A
87	4.4659	.39013	89	4.4886	.39207
88	4.4773	.38929	92	4.5218	.38644

[a] Compiled from William F. Meggers' Key to a periodic chart of the atoms No. 4858, W. M. Welsh Manufacturing Company, Chicago, Illinois, 1954.

TABLE 5. Energy dependent component of the stopping number.

Energy	B_o^-	B_o^+	β^2 [a]
Mev			
0.01	14.0946	15.1074	0.038025
.02	15.4552	16.4057	.073924
.03	16.2431	17.1348	.107847
.04	16.7977	17.6338	.139943
.05	17.2252	18.0088	.170330
.06	17.5729	18.3070	.199148
.07	17.8658	18.5531	.22646
.08	18.1191	18.7621	.252d4
.09	18.3425	18.9433	.27708
.10	18.5421	19.1031	.300589
.15	19.3150	19.7042	.40231
.20	19.8737	20.1272	.483512
.25	20.3181	20.4628	.549155
.30	20.6911	20.7472	.603045
.35	21.0149	20.9979	.647816
.40	21.3026	21.2244	.685418
.45	21.5626	21.4327	.717307
.50	21.8001	21.6261	.744579
.55	22.0194	21.8072	.768077
.56	22.2231	21.9780	.788491
.65	22.4135	22.1394	.806314
.70	22.5925	22.2931	.821978
.75	22.7612	22.4393	.835816
.80	22.9223	22.5793	.848112
.85	23.0724	22.7130	.859069
.90	23.2177	22.8416	.868866
.95	23.3556	22.9650	.877688
1.0	23.4879	23.0841	.885650
1.2	23.9655	23.5194	.910822
1.4	24.3790	23.9023	.928525
1.6	24.7434	24.2437	.941424
1.8	25.0691	24.5516	.951113
2.0	25.3635	24.8317	.958598
2.2	25.6322	25.0888	.964481
2.4	25.8791	25.3260	.969201
2.6	26.1074	25.5463	.973024
2.8	26.3198	25.7518	.976184
3.0	26.5185	25.9444	.978833
4.0	27.3535	26.7587	.987181
5.0	28.0073	27.4002	.991399
6.0	28.5445	27.9293	.993849
8.0	29.3959	28.7704	.996403
10.0	30.0589	29.4278	.997641

[a] Derived from Tables for the analysis of Beta spectra, NBS Applied mathematics series -13, June 2, 1952.

TABLE 6. Comparison of calculated and experimental energy loss of electrons

Energy	Z	$(-dE^-/dx) \times 10^{24}$		Corrections	
		Measured[a]	Calculated	Radiative	Density
Mev		Mev/el/cm^2	Mev/el/cm^2		
2.8 ±3%	Be	5.44 ±0.25	5.94	0.06	0
	C	5.09 ± .26	5.81	.08	0.64
	H_2O	5.48 ± .30	5.88	.14	.25
	Fe	5.09 ± .36	5.14	.36	.11
	Pb	5.52 ± .42	4.58	1.15	.04
4.7 ±3%	Be	6.46 ± .44	6.23	.11	0
	C	6.28 ± .53	6.11	.17	.75
	H_2O	7.27 ± .61	6.20	.28	.40
	Fe	6.92 ± .66	5.35	.72	.20
	Pb	8.55 ± .91	4.91	2.21	.08

[a] W. Paul and H. Reich, Z. Phys. 127, 429 (1950).

TABLE 7. Comparison of calculated and experimental range of electrons

Energy	Range 0°, 760 mm Hg	
	Measured[a]	Calculated
Oxygen		
Kev	cm	cm
16.91	0.49	0.489
19.59	.67	.661
22.13	.87	.819
Nitrogen		
19.7	0.77	0.976
22.24	1.01	1.18
Argon		
17.22	0.48	0.544
19.76	.65	.701
27.19	1.20	1.22
Air		
21.7	1.1	0.870
24.6	1.5	1.09
30.3	0.8	1.58
42.6	1.58	2.89

[a] O. Klemperer, Einführung in die Electronik, S. 272 (Berlin, 1933).

TABLE 8. Comparison of calculated and experimental range of electrons in air

Energy	Range 0°, 760 mm Hg	
	Measured[a]	Calculated
Kev	cm	cm
10	0.193	.219
12	.261	.302
15	.391	.452
20	.701	.758
25	1.12	1.12

[a] E. Buchmann, Ann. Phys., 87, 509 (1928).

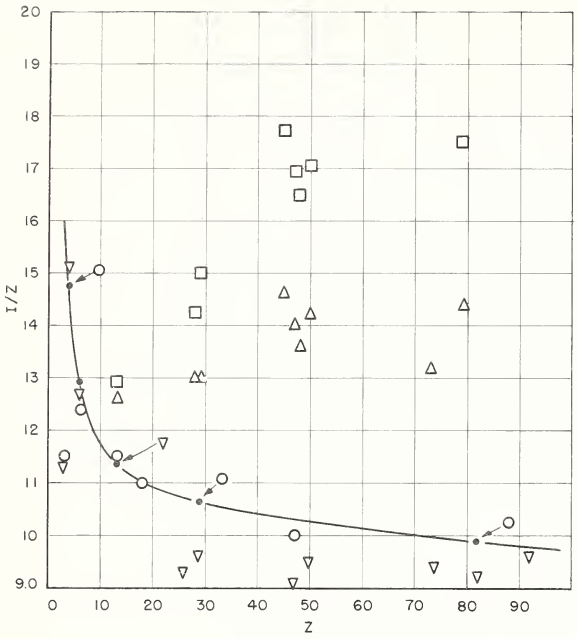


FIGURE 1. Comparison of mean ionization energy I, e.v.

- ● Mather-Segrè, [see reference 11].
- ○ Aron, UCRL-1325 (1951) unpublished.
- ▽ Bakker-Segrè, Phys. Rev. 81, 489 (1951).
- □ Sachs-Richardson, Phys. Rev. 89, 1163 (1953).
- △ Caldwell, [see reference 12].

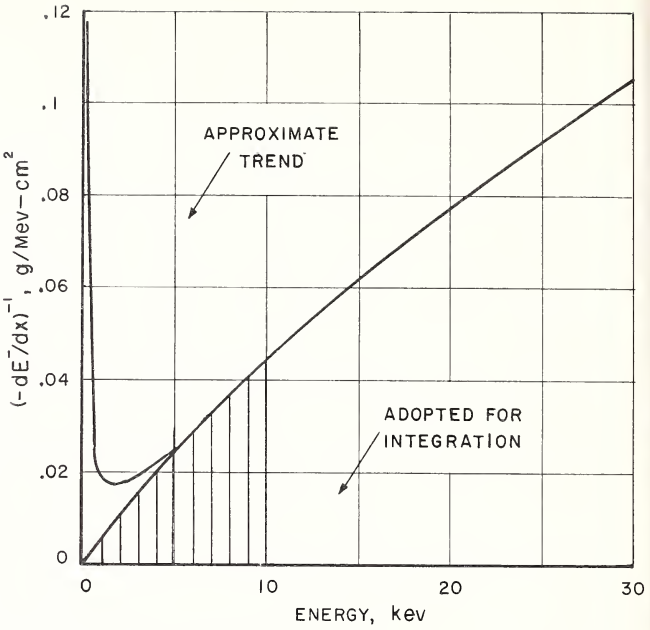


FIGURE 3. Qualitative diagram regarding range calculation.

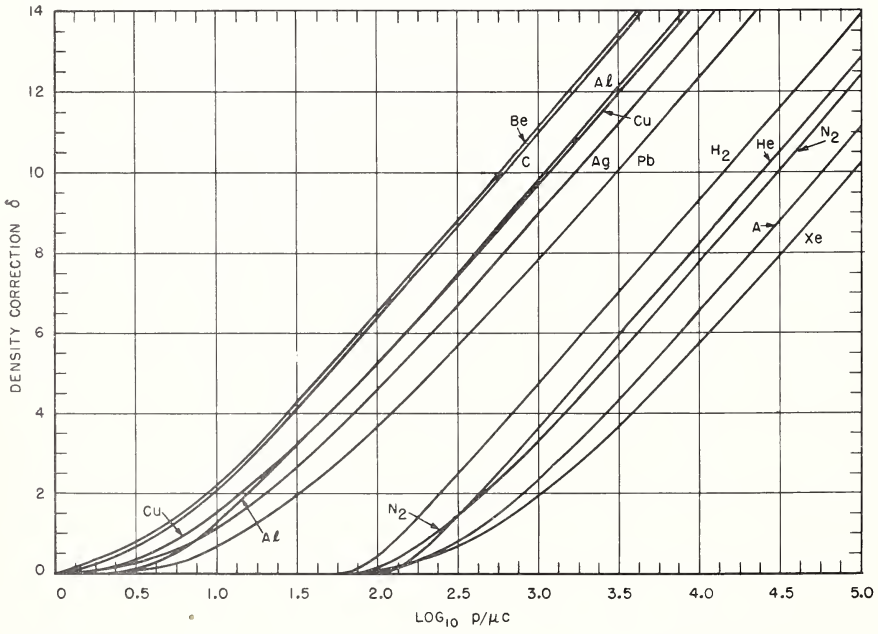


FIGURE 2. Density effect correction. (R.M. Sternheimer, 1953).

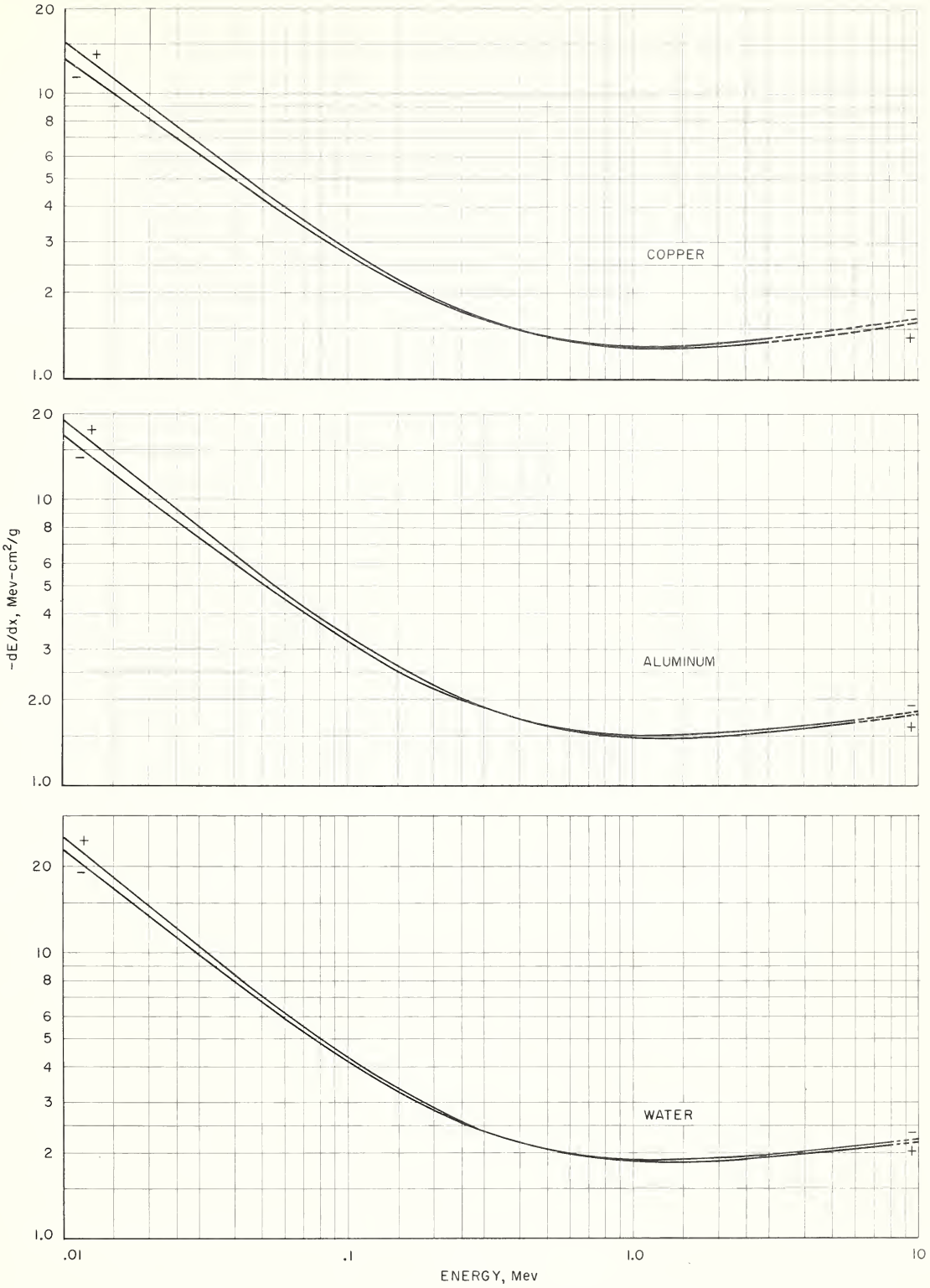


FIGURE 4. Energy loss of electrons and positrons.

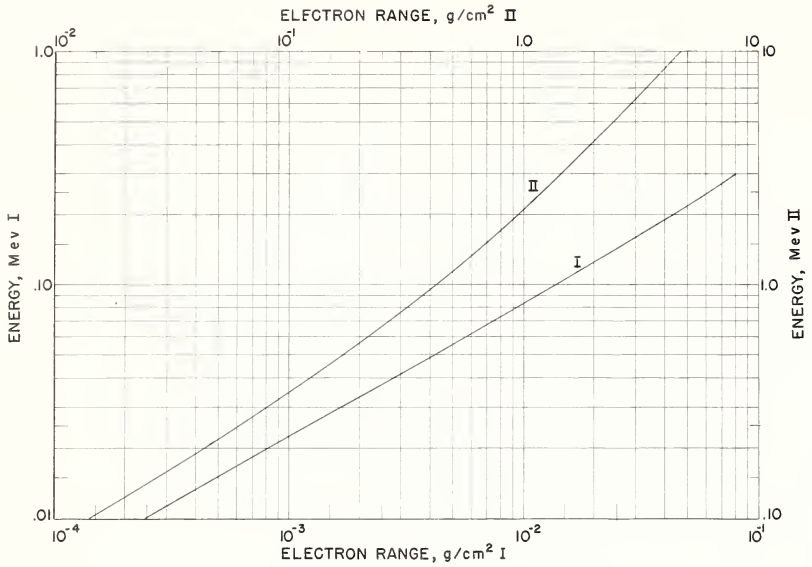
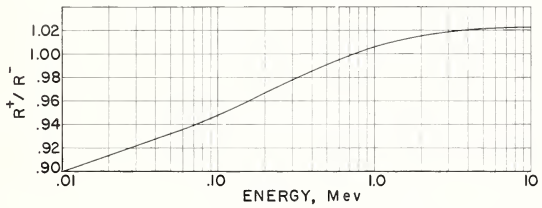
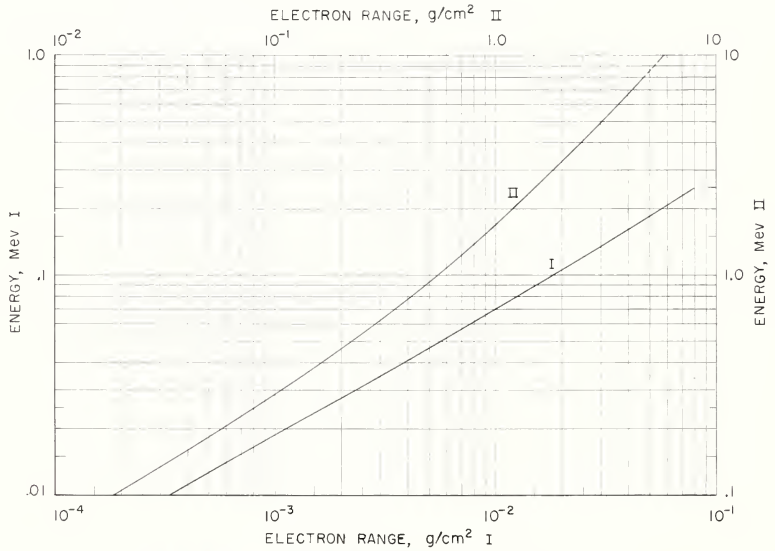


FIGURE 5. Range of electrons and positrons in H_2O.





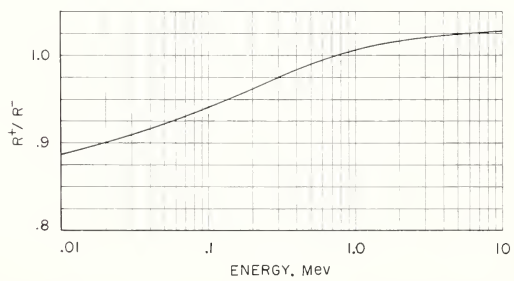


FIGURE 6. Range of electrons and positrons in Al.

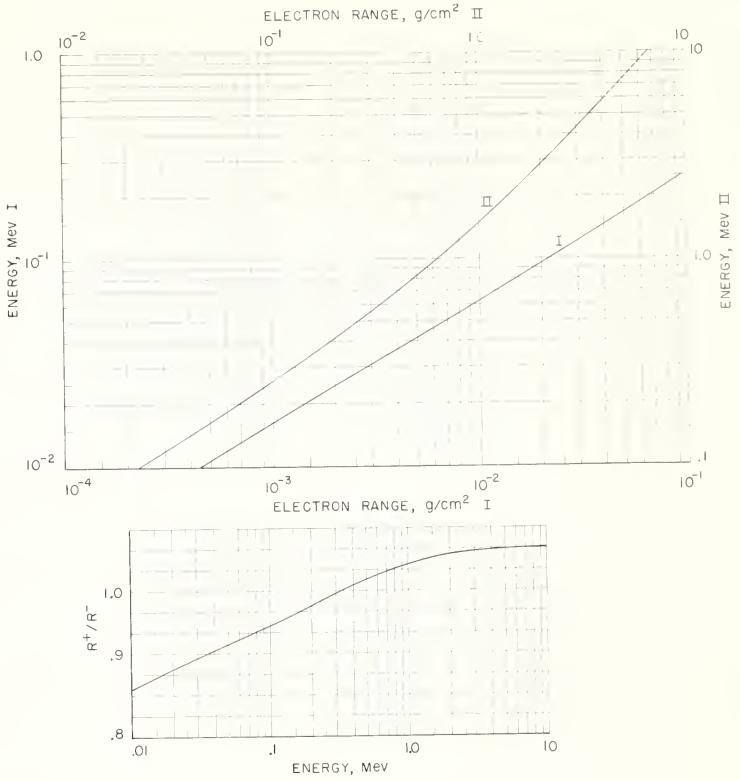


FIGURE 7. Range of electrons and positrons in Cu.

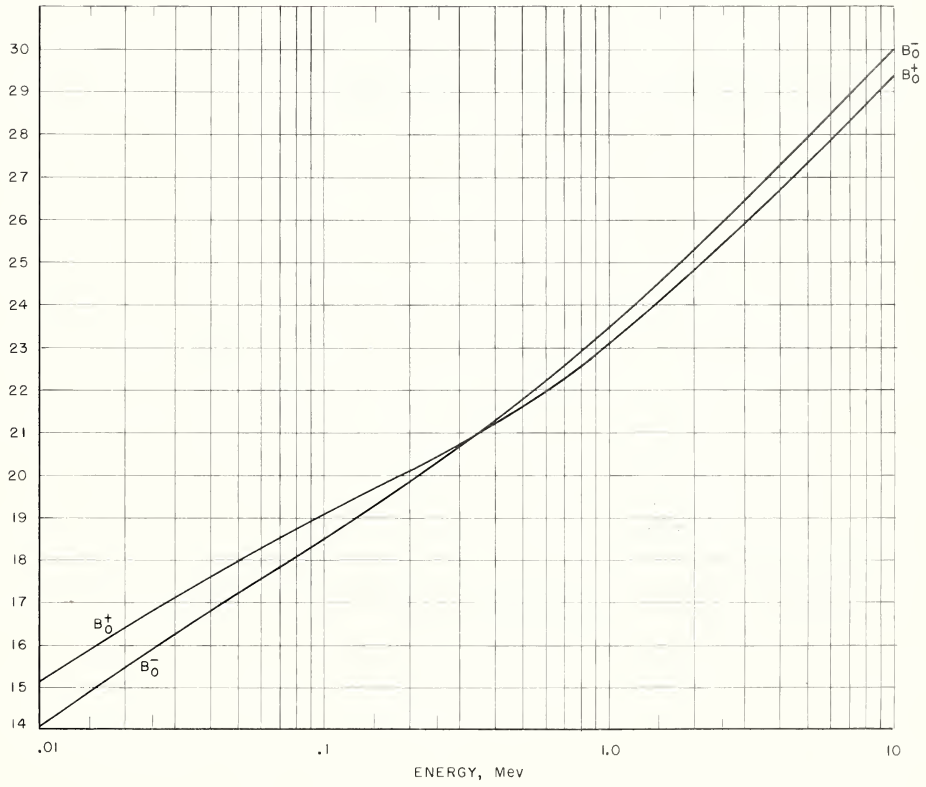


FIGURE 8. Electron-positron difference in energy loss.

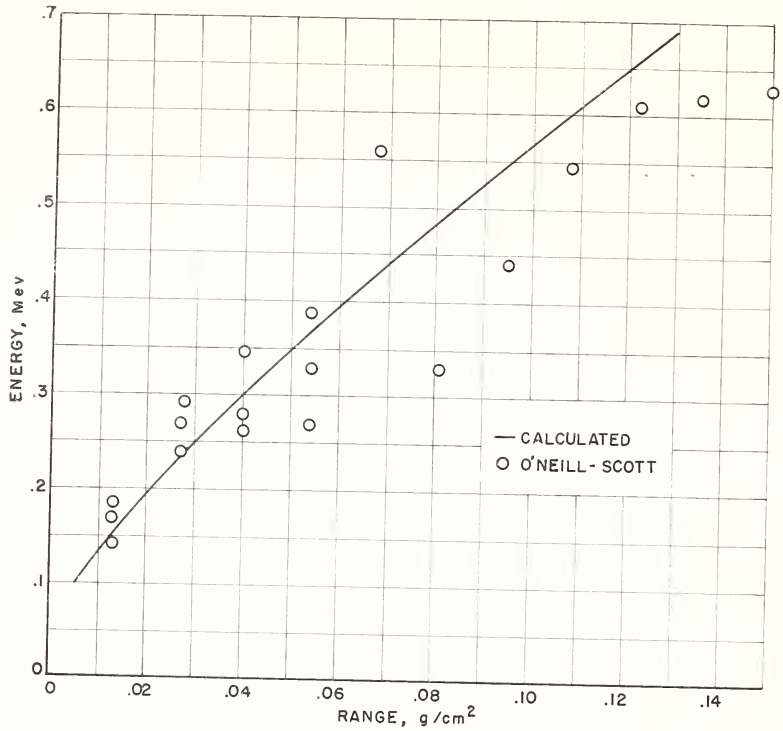


FIGURE 9. Comparison of calculated and experimental range of electrons in H_2.

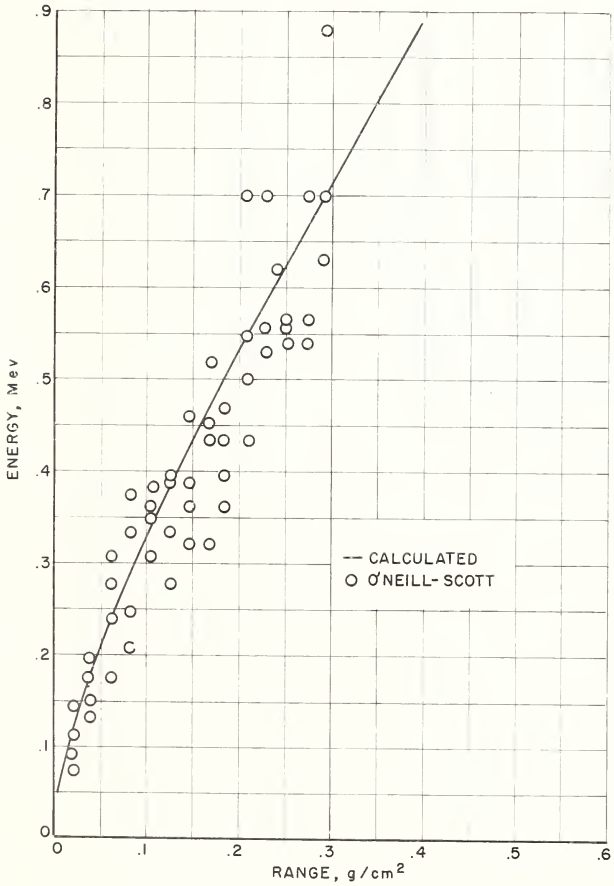


FIGURE 10. Comparison of calculated and experimental range of electrons in He.

WASHINGTON, January 26, 1956.

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DEPARTMENT OF COMMERCE
UNITED STATES OF AMERICA

SUPPLEMENT TO NBS CIRCULAR 577

Energy Loss and Range of Electrons and Positrons

UNITED STATES DEPARTMENT OF COMMERCE

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Energy Loss and Range of Electrons and Positrons

Ann T. Nelms

Supplement to National Bureau of Standards Circular 577

Issued July 30, 1958

For sale by the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C.

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Contents

ENERGY LOSS AND RANGE OF ELECTRONS AND POSITRONS

Ann T. Nelms

Tabulations of the mean energy loss due to ionization and excitation which include the density effect and the range derived from this quantity are given for electrons and positrons in several materials.

1. INTRODUCTION

The material in this publication extends the data in NBS Circular 577 [1][1] by including the effect of the polarization of the medium (density effect) on the mean energy loss and range of incident electrons and positrons. The characteristics of the material are reflected in this correction through values of the density ρ and the mean excitation energy I. Due to the uncertainty in the values of I to be used, data are presented based on two alternative sets of values, namely the Bakker-Segrè [2] and the Caldwell [3] values.

Sternheimer [4, 5] has derived a theoretical approximation for the density effect that contains parameters based on either set of I values. Figures 1 to 4 show the correction δ to the stopping number $B_o^{\pm}$ (reference 1, eq (12) for electrons and eq (13) for positrons) for several materials. The expression for the mean energy loss now becomes

$$\left(-\frac{dE}{dx}\right)^{\pm} = 2C\,\frac{mc^2}{\beta^2}\left\{B_o^{\pm} - 2\left(\ell nZ + \ell n\,\frac{I/10}{Z}\right) - \delta\right\}, \quad (1)$$

where the notation is the same as in reference 1. The data in these figures were calculated from reference 5 [2], eq (13), which is based on Caldwell's evaluation of I. The low energy region of each curve is the least accurate; however, the contribution to the energy loss is small, less than 1 percent, in this region. In the energy range of these figures the density effect is negligible for gases.

The correction given in fig. 1 to 4 along with Caldwell's values of I has been entered in eq (11) and (15) of reference 1 to revise the tabulation of the mean energy loss and "RSP" range for electrons

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1 Figures in brackets indicate literature references at end of this paper.

2 The density for carbon quoted in this reference (ρ = 1.58 g/cc) appeared to be too low. R. M. Sternheimer has informed the author that this value should be 1.66 g/cc; he expects to include this correction in a forthcoming publication. Data derived from ρ = 1.66 g/cc were used in the present Circular.

and positrons. These results appear in table 1. The maximum energy for each material lies in the region in which bremsstrahlung absorption would contribute an additional 5 percent energy loss.

The difference in the range with and without the density effect is tabulated in tables 2 and 3 from the expression

$$\Delta R = \int_0^E dE' \frac{\delta}{BS} ,$$

where B is the stopping number reference 1, eq (8) and S is the mean energy loss.

Sternheimer's [4] 1952 correction δ that is based on Bakker-Segrè I values appears in table 4 for selected materials. The data can be utilized to improve the tabulations in reference 1. The corresponding electron range data for these materials are given in table 5.

The additional calculation of ranges with the two sets of I data affords an estimate of the accuracy of table 1 in reference 1. From the data given here the following expression was evaluated:

$$\frac{R_C - R_{B-S}}{R_C} \cdot \frac{I_C}{I_C - I_{B-S}}$$

This expression may be compared with the estimate based on table 1 of reference 1 namely dlog R/dlog I. The general agreement was within 10 percent even though the percent departures $(I_C - I_{B-S})/I_C$ were by no means small.

2. REFERENCES

1 A. T. Nelms, "Energy Loss and Range of Electrons and Positrons" NBS Circular 577 (1956).

2 C. J. Bakker and E. Segrè, Phys. Rev. 81, 489 (1951).

3 D. O. Caldwell, Phys. Rev. 100, 291 (1955).

4 R. M. Sternheimer, Phys. Rev. 88, 851 (1952); 91, 256 (1953).

5 R. M. Sternheimer, Phys. Rev. 103, 511 (1956).

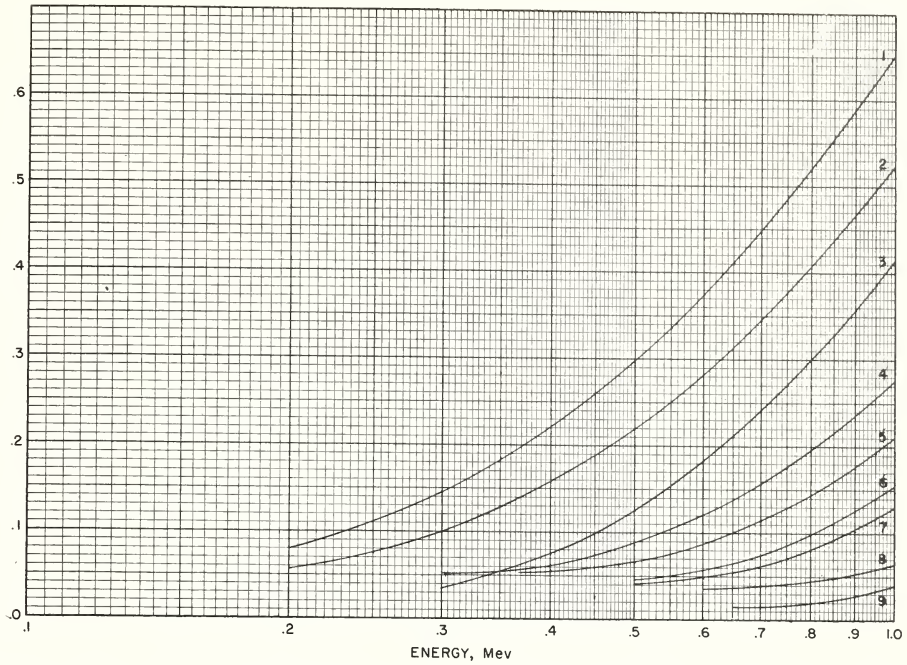

FIGURE 1. The density correction δ_C to the stopping number for energy $\leq$ 1 Mev.

1, Beryllium; 2, graphite; 3, lithium; 4, aluminum; 5, iron; 6 magnesium; 7, copper; 8, tin; 9, silver.

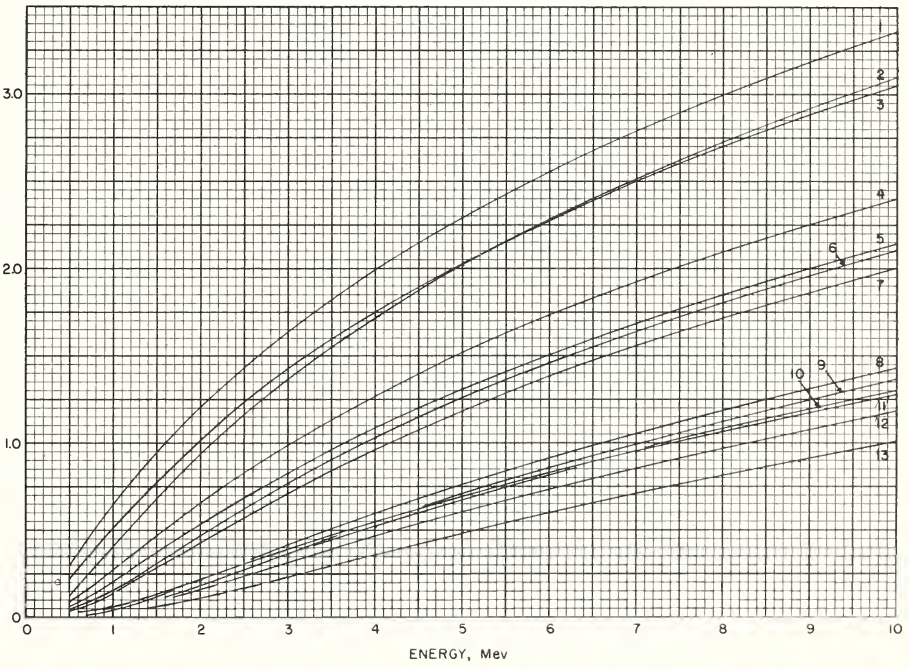

FIGURE 2. The density correction δ_C to the stopping number for energy $\leq$ 10 Mev.

1, Beryllium:, 2, lithium; 3, graphite; 4, aluminum; 5, iron; 6, magnesium; 7, copper; 8, silver; 9, tungsten; 10, gold; 11, tin; 12, uranium; 13, lead.

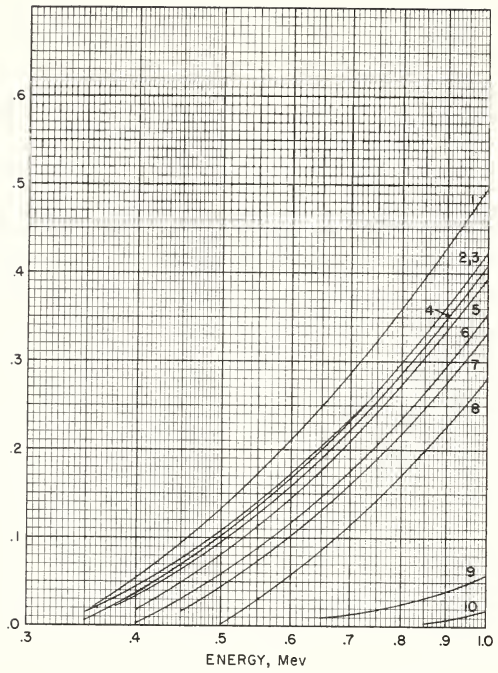

FIGURE 3. The density correction δ_C to the stopping number for energy $\leq$ 1 Mev.

1, Polyethylene; 2, anthracene; 3, stilbene; 4, polystyrene; 5, lucite; 6, xylene; 7, toulene; 8, water; 9, emulsion; 10, sodium iodide.

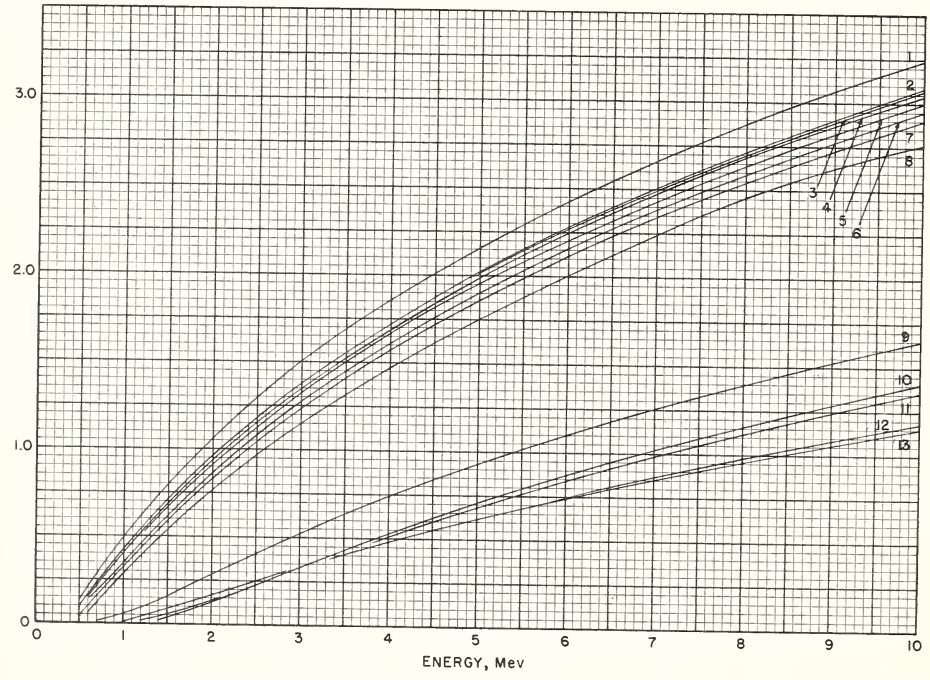

FIGURE 4. The density effect correction δ_C to the stopping number for energy $\leq$ 10 Mev.

1, Polyethylene; 2, anthracene, 3, stilbene; 4, polystyrene; 5, lucite; 6, xylene; 7, toluene; 8, water; 9, emulsion; 10, silver chloride; 11, silver bromide; 12, sodium iodide; 13, lithium iodide.

TABLE 1. Energy loss and range of electrons and positrons (including density correction)

Hydrogen				
Z = 1, I = 19.0 ev				
Energy	$-dE^-/dx$	R^-	$-dE^+/dx$	R^+
Mev	Mev cm^2/g	g/cm^2	Mev cm^2/g	g/cm^2
0.01	51.3	0.000106	55.4	0.0000977
.02	29.2	.000374	31.2	.000348
.03	21.1	.000785	22.4	.000734
.04	16.9	.00132	17.8	.00124
.05	14.3	.00197	15.0	.00186
.06	12.5	.00272	13.0	.00257
.07	11.2	.00357	11.6	.00339
.08	10.2	.00451	10.5	.00429
.09	9.38	.00554	9.71	.00528
.10	8.75	.00664	9.03	.00635
.15	6.83	.0132	6.98	.0127
.20	5.86	.0212	5.94	.0206
.25	5.28	.0302	5.32	.0295
.30	4.90	.0400	4.92	.0393
.35	4.64	.0505	4.64	.0498
.40	4.45	.0615	4.43	.0608
.45	4.31	.0730	4.28	.0723
.50	4.20	.0847	4.16	.0841
.55	4.11	.0968	4.07	.0963
.60	4.05	.109	4.00	.109
.65	3.99	.121	3.94	.121
.70	3.95	.134	3.89	.134
.75	3.92	.147	3.86	.147
.80	3.89	.160	3.83	.160
.85	3.86	.172	3.80	.173
.90	3.85	.185	3.78	.186
.95	3.83	.198	3.76	.200
1.0	3.82	.212	3.75	.213
1.2	3.79	.264	3.72	.266
1.4	3.79	.317	3.71	.320
1.6	3.80	.370	3.72	.374
1.8	3.81	.422	3.73	.428
2.0	3.83	.475	3.74	.481
2.2	3.85	.527	3.76	.535
2.4	3.87	.579	3.78	.588
2.6	3.89	.630	3.80	.641
2.8	3.91	.681	3.82	.693
3.0	3.93	.732	3.84	.745
4.0	4.02	.984	3.93	1.00
5.0	4.11	1.23	4.01	1.25
6.0	4.18	1.47	4.09	1.50
8.0	4.30	1.94	4.20	1.98
10.0	4.40	2.40	4.30	2.45

Helium				
Z = 2, I = 44.1 ev				
Energy	$-dE^-/dx$	R^-	$-dE^+/dx$	R^+
Mev	Mev cm^2/g	g/cm^2	Mev cm^2/g	g/cm^2
0.01	22.4	0.000246	24.5	0.000223
.02	13.0	.000851	13.9	.000783
.03	9.44	.00178	10.1	.00165
.04	7.58	.00296	8.04	.00276
.05	6.42	.00441	6.77	.00413
.06	5.63	.00607	5.91	.00571
.07	5.05	.00796	5.28	.00751
.08	4.60	.0100	4.80	.00949
.09	4.26	.0123	4.42	.0117
.10	3.97	.0147	4.12	.0140
.15	3.12	.0308	3.19	.0280
.20	2.68	.0466	2.72	.0451
.25	2.42	.0679	2.44	.0645
.30	2.25	.0877	2.26	.0858
.35	2.14	.112	2.13	.109
.40	2.05	.134	2.04	.133
.45	1.99	.161	1.97	.158
.50	1.94	.185	1.92	.183
.55	1.90	.212	1.88	.209
.60	1.87	.237	1.85	.236
.65	1.85	.266	1.82	.264
.70	1.83	.291	1.80	.291
.75	1.82	.320	1.79	.319
.80	1.80	.346	1.77	.347
.85	1.80	.376	1.76	.375
.90	1.79	.402	1.75	.404
.95	1.78	.432	1.75	.432
1.0	1.78	.458	1.74	.461
1.2	1.77	.571	1.73	.576
1.4	1.77	.684	1.73	.692
1.6	1.77	.797	1.73	.807
1.8	1.78	.909	1.74	.923
2.0	1.79	1.02	1.75	1.04
2.2	1.80	1.13	1.76	1.15
2.4	1.81	1.24	1.77	1.26
2.6	1.82	1.35	1.78	1.38
2.8	1.83	1.46	1.79	1.49
3.0	1.85	1.57	1.80	1.60
4.0	1.89	2.11	1.85	2.15
5.0	1.94	2.63	1.89	2.68
6.0	1.97	3.14	1.93	3.21
8.0	2.03	4.14	1.99	4.23
10.0	2.08	5.11	2.03	5.22

TABLE 1. Energy loss and range of electrons and positrons (including density correction) - Continued

Nitrogen Z = 7, I = 91.0 ev				
Energy	$-dE^-/dx$	R^-	$-dE^+/dx$	R^+
Mev	Mev cm^2/g	g/cm^2	Mev cm^2/g	g/cm^2
0.01	19.5	0.000287	21.6	0.000256
.02	11.5	.000973	12.5	.000885
.03	8.42	.00202	9.06	.00185
.04	6.80	.00334	7.25	.00308
.05	5.78	.00495	6.13	.00460
.06	5.07	.00679	5.36	.00634
.07	4.56	.00889	4.79	.00833
.08	4.17	.0112	4.36	.0105
.09	3.86	.0137	4.03	.0129
.10	3.61	.0164	3.75	.0155
.15	2.84	.0322	2.92	.0308
.20	2.46	.0512	2.50	.0494
.25	2.22	.0727	2.24	.0706
.30	2.07	.0960	2.08	.0938
.35	1.97	.121	1.97	.119
.40	1.89	.147	1.88	.145
.45	1.84	.174	1.82	.172
.50	1.79	.201	1.78	.199
.55	1.76	.229	1.74	.228
.60	1.73	.258	1.71	.257
.65	1.71	.287	1.69	.286
.70	1.70	.316	1.67	.316
.75	1.69	.346	1.66	.346
.80	1.68	.376	1.64	.376
.85	1.67	.405	1.64	.407
.90	1.66	.435	1.63	.438
.95	1.66	.466	1.62	.468
1.0	1.65	.496	1.62	.499
1.2	1.65	.617	1.61	.623
1.4	1.65	.738	1.61	.747
1.6	1.66	.859	1.62	.871
1.8	1.67	.979	1.63	.995
2.0	1.68	1.10	1.64	1.12
2.2	1.69	1.22	1.65	1.24
2.4	1.70	1.34	1.66	1.36
2.6	1.71	1.45	1.67	1.48
2.8	1.72	1.57	1.68	1.60
3.0	1.73	1.69	1.69	1.72
4.0	1.78	2.25	1.74	2.30
5.0	1.83	2.81	1.78	2.87
6.0	1.86	3.35	1.82	3.43
8.0	1.93	4.40	1.88	4.51

Oxygen Z = 8, I = 104 ev				
Energy	$-de^-/dx$	R^-	$-dE^+/dx$	R^+
Mev	Mev cm^2/g	g/cm^2	Mev cm^2/g	g/cm^2
0.01	19.0	0.000296	21.1	0.000263
.02	11.2	.000999	12.2	.000907
.03	8.23	.00207	8.87	.00189
.04	6.65	.00342	7.11	.00315
.05	5.65	.00507	6.01	.00470
.06	4.97	.00695	5.25	.00648
.07	4.47	.00909	4.70	.00850
.08	4.09	.0114	4.28	.0107
.09	3.79	.0140	3.95	.0131
.10	3.54	.0167	3.68	.0158
.15	2.79	.0328	2.87	.0314
.20	2.41	.0522	2.45	.0504
.25	2.19	.0740	2.21	.0719
.30	2.04	.0978	2.05	.0955
.35	1.94	.123	1.93	.121
.40	1.86	.149	1.85	.147
.45	1.81	.177	1.79	.175
.50	1.77	.205	1.75	.203
.55	1.73	.233	1.71	.232
.60	1.71	.262	1.68	.261
.65	1.69	.292	1.66	.291
.70	1.67	.321	1.65	.321
.75	1.66	.351	1.63	.352
.80	1.65	.382	1.62	.383
.85	1.64	.412	1.61	.414
.90	1.64	.442	1.60	.445
.95	1.63	.473	1.60	.476
1.0	1.63	.504	1.60	.507
1.2	1.63	.627	1.59	.633
1.4	1.63	.750	1.59	.759
1.6	1.64	.872	1.60	.884
1.8	1.65	.994	1.60	1.01
2.0	1.66	1.12	1.61	1.13
2.2	1.67	1.24	1.62	1.26
2.4	1.68	1.35	1.64	1.38
2.6	1.69	1.47	1.65	1.50
2.8	1.70	1.59	1.66	1.62
3.0	1.71	1.71	1.67	1.74
4.0	1.76	2.28	1.72	2.33
5.0	1.81	2.84	1.76	2.91
6.0	1.84	3.39	1.80	3.47
8.0	1.90	4.46	1.86	4.57

TABLE 1. Energy loss and range of electrons and positrons (including density correction) - Continued

Neon Z = 10, I = 130 ev					Argon Z = 18, I = 228 ev				
Energy	$-dE^-/dx$	R^-	$-dE^+/dx$	R^+	Energy	$-dE^-/dx$	R^-	$-dE^+/dx$	R^+
Mev	Mev cm^2/g	g/cm^2	Mev cm^2/g	g/cm^2	Mev	Mev cm^2/g	g/cm^2	Mev cm^2/g	g/cm^2
0.01	17.9	0.000315	20.0	0.000279	0.01	14.3	0.000404	16.1	0.000351
.02	10.6	.00106	11.6	.000955	.02	8.61	.00132	9.50	.00118
.03	7.84	.00218	8.47	.00199	.03	6.41	.00271	6.98	.00244
.04	6.34	.00360	6.80	.00331	.04	5.21	.00443	5.63	.00403
.05	5.40	.00532	5.75	.00492	.05	4.46	.00653	4.77	.00599
.06	4.75	.00729	5.04	.00678	.06	3.93	.00891	4.19	.00821
.07	4.28	.00952	4.51	.00889	.07	3.55	.0116	3.76	.0108
.08	3.92	.0120	4.11	.0112	.08	3.25	.0145	3.43	.0135
.09	3.63	.0146	3.79	.0138	.09	3.02	.0178	3.17	.0166
.10	3.40	.0175	3.54	.0165	.10	2.83	.0212	2.96	.0198
.15	2.68	.0343	2.76	.0327	.15	2.25	.0413	2.31	.0392
.20	2.32	.0544	2.36	.0524	.20	1.95	.0653	1.99	.0627
.25	2.10	.0771	2.12	.0748	.25	1.77	.0923	1.79	.0893
.30	1.96	.102	1.97	.0993	.30	1.66	.122	1.66	.118
.35	1.87	.128	1.86	.125	.35	1.58	.153	1.57	.149
.40	1.80	.155	1.79	.153	.40	1.52	.185	1.51	.182
.45	1.74	.184	1.73	.181	.45	1.48	.218	1.46	.215
.50	1.70	.213	1.69	.211	.50	1.44	.253	1.43	.250
.55	1.67	.242	1.65	.241	.55	1.42	.287	1.40	.285
.60	1.65	.272	1.63	.271	.60	1.40	.323	1.38	.321
.65	1.63	.303	1.61	.302	.65	1.39	.359	1.36	.358
.70	1.62	.334	1.59	.333	.70	1.38	.395	1.35	.395
.75	1.61	.365	1.58	.365	.75	1.37	.432	1.34	.432
.80	1.60	.396	1.57	.397	.80	1.36	.468	1.33	.469
.85	1.59	.427	1.56	.429	.85	1.35	.505	1.33	.507
.90	1.58	.459	1.55	.461	.90	1.35	.542	1.32	.545
.95	1.58	.490	1.55	.493	.95	1.35	.579	1.32	.583
1.0	1.58	.522	1.54	.526	1.0	1.35	.616	1.31	.621
1.2	1.57	.649	1.54	.656	1.2	1.35	.765	1.31	.773
1.4	1.58	.776	1.54	.786	1.4	1.35	.913	1.32	.925
1.6	1.59	.903	1.55	.916	1.6	1.36	1.06	1.32	1.08
1.8	1.60	1.03	1.55	1.04	1.8	1.37	1.21	1.33	1.23
2.0	1.61	1.15	1.56	1.17	2.0	1.38	1.35	1.34	1.38
2.2	1.62	1.28	1.57	1.30	2.2	1.39	1.50	1.35	1.53
2.4	1.63	1.40	1.59	1.43	2.4	1.40	1.64	1.36	1.67
2.6	1.64	1.52	1.60	1.56	2.6	1.41	1.78	1.37	1.82
2.8	1.65	1.64	1.61	1.68	2.8	1.42	1.92	1.38	1.97
3.0	1.66	1.77	1.62	1.80	3.0	1.43	2.06	1.39	2.11
4.0	1.71	2.36	1.67	2.41	4.0	1.48	2.75	1.44	2.82
5.0	1.76	2.93	1.71	3.01	5.0	1.52	3.42	1.48	3.50
6.0	1.79	3.50	1.75	3.58					
8.0	1.85	4.59	1.81	4.71					

TABLE 1. Energy loss and range of electrons and positrons (including density correction) - Continued

Krypton Z = 36, I = 494 ev				
Energy	$-dE^-/dx$	R^-	$-dE^+/dx$	R^+
Mev	Mev cm^2/g	g/cm^2	Mev cm^2/g	g/cm^2
0.01	10.9	0.000547	12.7	0.000457
.02	6.85	.00171	7.70	.00148
.03	5.18	.00344	5.72	.00303
.04	4.25	.00555	4.65	.00496
.05	3.66	.00814	3.96	.00733
.06	3.24	.0110	3.49	.0100
.07	2.94	.0143	3.14	.0131
.08	2.70	.0178	2.87	.0164
.09	2.52	.0217	2.66	.0200
.10	2.36	.0258	2.49	.0239
.15	1.89	.0497	1.96	.0469
.20	1.65	.0781	1.69	.0746
.25	1.51	.110	1.52	.106
.30	1.41	.144	1.42	.140
.35	1.35	.181	1.35	.176
.40	1.30	.218	1.29	.214
.45	1.27	.257	1.26	.253
.50	1.24	.297	1.23	.294
.55	1.22	.338	1.21	.335
.60	1.21	.379	1.19	.376
.65	1.20	.420	1.18	.419
.70	1.19	.462	1.17	.461
.75	1.18	.504	1.16	.505
.80	1.18	.547	1.15	.548
.85	1.18	.589	1.15	.592
.90	1.17	.632	1.14	.635
.95	1.17	.674	1.14	.679
1.0	1.17	.717	1.14	.722
1.2	1.17	.888	1.14	.898
1.4	1.18	1.06	1.15	1.07
1.6	1.19	1.23	1.15	1.25
1.8	1.20	1.39	1.16	1.42
2.0	1.21	1.56	1.17	1.59

CH_4 I = 445 ev				
Energy	$-dE^-/dx$	R^-	$-dE^+/dx$	R^+
Mev	Mev cm^2/g	g/cm^2	Mev cm^2/g	g/cm^2
0.01	28.0	0.000197	30.5	0.000179
.02	16.2	.000683	17.4	.000628
.03	11.8	.00142	12.6	.00132
.04	9.46	.00237	10.0	.00221
.05	8.01	.00353	8.45	.00331
.06	7.02	.00487	7.37	.00458
.07	6.30	.00638	6.59	.00602
.08	5.74	.00804	5.99	.00761
.09	5.31	.00986	5.52	.00936
.10	4.96	.0118	5.14	.0112
.15	3.89	.0233	3.98	.0224
.20	3.35	.0373	3.40	.0361
.25	3.02	.0531	3.05	.0517
.30	2.81	.0702	2.82	.0688
.35	2.67	.0885	2.66	.0871
.40	2.56	.108	2.55	.106
.45	2.48	.128	2.46	.126
.50	2.42	.148	2.40	.147
.55	2.37	.169	2.35	.168
.60	2.34	.190	2.31	.189
.65	2.31	.212	2.28	.211
.70	2.29	.233	2.25	.233
.75	2.27	.255	2.23	.256
.80	2.25	.277	2.21	.278
.85	2.24	.300	2.20	.301
.90	2.23	.322	2.19	.324
.95	2.22	.344	2.18	.346
1.0	2.22	.367	2.17	.369
1.2	2.21	.457	2.16	.462
1.4	2.21	.548	2.16	.554
1.6	2.21	.639	2.16	.647
1.8	2.22	.729	2.17	.739
2.0	2.24	.818	2.18	.831
2.2	2.25	.908	2.20	.922
2.4	2.26	.996	2.21	1.01
2.6	2.28	1.08	2.22	1.10
2.8	2.29	1.17	2.23	1.19
3.0	2.30	1.26	2.25	1.28
4.0	2.36	1.69	2.31	1.72
5.0	2.42	2.11	2.36	2.15
6.0	2.46	2.52	2.40	2.57
8.0	2.54	3.31	2.48	3.39
10.0	2.60	4.09	2.54	4.19

TABLE 1. Energy loss and range of electrons and positrons (including density correction) - Continued

$(CH_2)_2$ I = 54.9 ev				
Energy	$-dE^-/dx$	R^-	$-dE^+/dx$	R^+
Mev	Mev cm^2/g	g/cm^2	Mev cm^2/g	g/cm^2
0.01	24.6	0.000225	27.0	0.000204
.02	14.3	.000775	15.4	.000711
.03	10.4	.00161	11.2	.00149
.04	8.38	.00269	8.91	.00250
.05	7.11	.00399	7.51	.00373
.06	6.23	.00549	6.55	.00516
.07	5.59	.00720	5.86	.00678
.08	5.11	.00907	5.33	.00857
.09	4.72	.0111	4.91	.0105
.10	4.41	.0133	4.57	.0126
.15	3.46	.0263	3.55	.0252
.20	2.98	.0419	3.03	.0406
.25	2.70	.0596	2.72	.0581
.30	2.51	.0788	2.52	.0772
.35	2.38	.0993	2.38	.0977
.40	2.29	.121	2.28	.119
.45	2.22	.143	2.20	.142
.50	2.16	.166	2.14	.165
.55	2.12	.189	2.10	.188
.60	2.09	.213	2.06	.212
.65	2.06	.237	2.04	.237
.70	2.04	.261	2.01	.261
.75	2.03	.286	1.99	.286
.80	2.02	.311	1.98	.311
.85	2.01	.335	1.97	.337
.90	2.00	.360	1.96	.362
.95	1.99	.386	1.95	.388
1.0	1.99	.411	1.95	.413
1.2	1.98	.512	1.93	.517
1.4	1.98	.613	1.93	.620
1.6	1.99	.714	1.94	.723
1.8	2.00	.814	1.95	.826
2.0	2.01	.914	1.96	.929
2.2	2.02	1.01	1.97	1.03
2.4	2.03	1.11	1.98	1.13
2.6	2.04	1.21	1.99	1.23
2.8	2.06	1.31	2.01	1.33
3.0	2.07	1.41	2.02	1.43
4.0	2.12	1.88	2.07	1.92
5.0	2.17	2.35	2.12	2.40
6.0	2.22	2.80	2.16	2.86
8.0	2.28	3.69	2.23	3.78
10.0	2.34	4.56	2.28	4.66

$(CH)_2$ I = 63.8 ev				
Energy	$-dE^-/dx$	R^-	$-dE^+/dx$	R^+
Mev	Mev cm^2/g	g/cm^2	Mev cm^2/g	g/cm^2
0.01	22.6	0.000247	24.8	0.000222
.02	13.1	.000845	14.2	.000773
.03	9.60	.00176	10.3	.00162
.04	7.73	.00292	8.22	.00271
.05	6.56	.00434	6.94	.00405
.06	5.75	.00596	6.06	.00559
.07	5.16	.00781	5.42	.00734
.08	4.72	.00983	4.93	.00928
.09	4.36	.0120	4.54	.0114
.10	4.08	.0144	4.23	.0137
.15	3.20	.0284	3.28	.0273
.20	2.76	.0453	2.81	.0439
.25	2.50	.0644	2.52	.0627
.30	2.33	.0852	2.33	.0834
.35	2.21	.107	2.20	.105
.40	2.12	.130	2.11	.129
.45	2.06	.154	2.04	.153
.50	2.01	.179	1.99	.178
.55	1.97	.204	1.95	.203
.60	1.94	.230	1.91	.229
.65	1.92	.256	1.89	.255
.70	1.90	.282	1.87	.282
.75	1.88	.308	1.85	.309
.80	1.87	.335	1.84	.336
.85	1.86	.362	1.83	.363
.90	1.85	.389	1.82	.391
.95	1.85	.416	1.81	.418
1.0	1.85	.443	1.81	.446
1.2	1.84	.551	1.80	.557
1.4	1.84	.660	1.80	.668
1.6	1.85	.769	1.80	.779
1.8	1.86	.877	1.81	.890
2.0	1.87	.984	1.82	1.00
2.2	1.88	1.09	1.83	1.11
2.4	1.89	1.20	1.84	1.22
2.6	1.90	1.30	1.85	1.33
2.8	1.91	1.41	1.87	1.43
3.0	1.93	1.51	1.88	1.54
4.0	1.98	2.02	1.93	2.07
5.0	2.02	2.52	1.97	2.58
6.0	2.06	3.01	2.01	3.08
8.0	2.13	3.97	2.08	4.06
10.0	2.18	4.89	2.13	5.01

TABLE 1. Energy loss and range of electrons and positrons (including density correction) - Continued

CO_2 I = 96.3 ev				
Energy	$-dE^-/dx$	R^-	$-dE^+/dx$	R^+
Mev	Mev cm^2/g	g/cm^2	Mev cm^2/g	g/cm^2
0.01	19.3	0.000291	21.4	0.000259
.02	11.4	.000984	12.3	.000894
.03	8.34	.00204	8.98	.00187
.04	6.73	.00337	7.19	.00311
.05	5.72	.00500	6.08	.00464
.06	5.03	.00686	5.31	.00640
.07	4.52	.00897	4.76	.00840
.08	4.13	.0113	4.33	.0106
.09	3.83	.0138	4.00	.0130
.10	3.58	.0165	3.72	.0156
.15	2.82	.0324	2.90	.0310
.20	2.44	.0516	2.48	.0498
.25	2.21	.0732	2.23	.0712
.30	2.06	.0967	2.07	.0945
.35	1.95	.122	1.95	.119
.40	1.88	.148	1.87	.146
.45	1.82	.175	1.81	.173
.50	1.78	.203	1.76	.201
.55	1.75	.231	1.73	.230
.60	1.72	.260	1.70	.259
.65	1.70	.289	1.68	.288
.70	1.69	.318	1.66	.318
.75	1.68	.348	1.65	.349
.80	1.67	.378	1.63	.379
.85	1.66	.408	1.63	.410
.90	1.65	.438	1.62	.441
.95	1.65	.469	1.61	.472
1.0	1.64	.499	1.61	.502
1.2	1.64	.621	1.60	.627
1.4	1.64	.743	1.60	.752
1.6	1.65	.865	1.61	.877
1.8	1.66	.986	1.62	1.00
2.0	1.67	1.11	1.63	1.12
2.2	1.68	1.23	1.64	1.25
2.4	1.69	1.34	1.65	1.37
2.6	1.70	1.46	1.66	1.49
2.8	1.71	1.58	1.67	1.61
3.0	1.73	1.69	1.68	1.73
4.0	1.78	2.15	1.73	2.32
5.0	1.82	2.82	1.77	2.89
6.0	1.86	3.25	1.81	3.45
8.0	1.92	4.31	1.87	4.53

Lithium Z = 3, I = 39.0 ev				
Energy	$-dE^-/dx$	R^-	$-dE^+/dx$	R^+
Mev	Mev cm^2/g	g/cm^2	Mev cm^2/g	g/cm^2
0.01	19.8	0.000278	21.6	0.000252
.02	11.4	.000965	12.3	.000888
.03	8.31	.00202	8.87	.00187
.04	6.66	.00336	7.07	.00313
.05	5.64	.00501	5.96	.00469
.06	4.94	.00690	5.20	.00648
.07	4.43	.00905	4.64	.00853
.08	4.04	.0114	4.22	.0108
.09	3.73	.0140	3.89	.0133
.10	3.49	.0168	3.62	.0159
.15	2.72	.0332	2.79	.0329
.20	2.35	.0531	2.39	.0514
.25	2.12	.0756	2.14	.0746
.30	1.97	.100	1.98	.0979
.35	1.87	.126	1.87	.125
.40	1.79	.154	1.79	.151
.45	1.73	.182	1.72	.181
.50	1.69	.211	1.67	.209
.55	1.65	.241	1.64	.241
.60	1.62	.272	1.61	.270
.65	1.60	.303	1.58	.303
.70	1.58	.334	1.56	.334
.75	1.57	.366	1.54	.367
.80	1.55	.398	1.53	.398
.85	1.54	.430	1.52	.432
.90	1.54	.463	1.51	.464
.95	1.53	.496	1.50	.498
1.0	1.52	.528	1.50	.531
1.2	1.51	.660	1.48	.665
1.4	1.50	.794	1.47	.801
1.6	1.50	.927	1.47	.938
1.8	1.50	1.06	1.46	1.07
2.0	1.50	1.19	1.47	1.21
2.2	1.50	1.33	1.47	1.35
2.4	1.51	1.46	1.47	1.48
2.6	1.51	1.59	1.48	1.62
2.8	1.51	1.73	1.48	1.75
3.0	1.52	1.86	1.48	1.89
4.0	1.54	2.51	1.50	2.56
5.0	1.55	3.16	1.52	3.22
6.0	1.57	3.79	1.53	3.88
8.0	1.59	5.06	1.55	5.17
10.0	1.61	6.31	1.57	6.45

TABLE 1. Energy loss and range of electrons and positrons (including density correction) - Continued

Energy	Beryllium Z = 4, I = 64.1 ev			Graphite Z = 6, I = 78.1 ev			
	$-dE^-/dx$	R^-	$-dE^+/dx$	R^+	$-dE^-/dx$	R^-	$-dE^+/dx$	R^+
Mev	Mev cm^2/g	g/cm^2	Mev cm^2/g	g/cm^2	Mev cm^2/g	g/cm^2	Mev cm^2/g	g/cm^2
0.01	18.6	0.000300	20.4	0.000270	20.1	0.000277	22.2	0.000248
.02	10.8	.00103	11.7	.000939	11.8	.000945	12.8	.000861
.03	7.90	.00213	8.47	.00194	8.63	.00196	9.28	.00180
.04	6.36	.00355	6.77	.00329	6.96	.00325	7.42	.00301
.05	5.39	.00527	5.72	.00489	5.91	.00483	6.27	.00449
.06	4.73	.00725	4.99	.00678	5.19	.00663	5.48	.00619
.07	4.25	.00949	4.46	.00889	4.66	.00868	4.90	.00814
.08	3.88	.0119	4.06	.0113	4.26	.0109	4.46	.0103
.09	3.59	.0146	3.74	.0138	3.94	.0134	4.11	.0126
.10	3.36	.0175	3.49	.0166	3.68	.0160	3.83	.0151
.15	2.64	.0345	2.71	.0331	2.90	.0315	2.98	.0302
.20	2.26	.0551	2.30	.0533	2.49	.0502	2.53	.0485
.25	2.04	.0785	2.06	.0763	2.25	.0714	2.28	.0694
.30	1.90	.104	1.91	.102	2.10	.0944	2.11	.0922
.35	1.80	.131	1.80	.129	1.99	.119	1.99	.117
.40	1.72	.159	1.72	.157	1.91	.145	1.90	.143
.45	1.67	.189	1.66	.187	1.85	.171	1.83	.169
.50	1.62	.219	1.61	.217	1.80	.199	1.78	.197
.55	1.59	.251	1.57	.249	1.76	.227	1.74	.225
.60	1.56	.282	1.55	.281	1.73	.255	1.71	.254
.65	1.54	.314	1.52	.313	1.71	.285	1.69	.284
.70	1.53	.347	1.50	.347	1.69	.314	1.67	.314
.75	1.51	.380	1.49	.380	1.68	.344	1.65	.344
.80	1.50	.413	1.47	.414	1.66	.374	1.64	.374
.85	1.49	.447	1.46	.448	1.65	.404	1.62	.405
.90	1.48	.480	1.45	.482	1.65	.434	1.61	.436
.95	1.47	.514	1.45	.517	1.64	.464	1.61	.467
1.0	1.47	.548	1.44	.551	1.63	.495	1.60	.498
1.2	1.45	.685	1.42	.691	1.62	.618	1.58	.624
1.4	1.45	.823	1.41	.832	1.61	.742	1.58	.750
1.6	1.45	.961	1.41	.974	1.61	.866	1.57	.877
1.8	1.45	1.10	1.41	1.12	1.62	.990	1.58	1.00
2.0	1.45	1.24	1.41	1.26	1.62	1.11	1.58	1.13
2.2	1.45	1.38	1.42	1.40	1.62	1.24	1.58	1.26
2.4	1.46	1.51	1.42	1.54	1.63	1.36	1.59	1.38
2.6	1.46	1.65	1.42	1.68	1.63	1.48	1.59	1.51
2.8	1.47	1.79	1.43	1.82	1.64	1.60	1.60	1.64
3.0	1.47	1.92	1.43	1.96	1.65	1.73	1.60	1.76
4.0	1.49	2.60	1.45	2.65	1.67	2.33	1.63	2.38
5.0	1.51	3.26	1.47	3.34	1.69	2.92	1.65	2.99
6.0	1.52	3.92	1.48	4.01	1.71	3.51	1.67	3.59
8.0	1.55	5.22	1.51	5.35	1.74	4.67	1.69	4.78

TABLE 1. Energy loss and range of electrons and positrons (including density correction) - Continued

Magnesium Z = 12, I = 156 ev				
Energy	$-dE^-/dx$	R^-	$-dE^+/dx$	R^+
Mev	Mev cm^2/g	g/cm^2	Mev cm^2/g	g/cm^2
0.01	17.1	0.000333	19.2	0.000292
.02	10.2	.00111	11.2	.00099h
.03	7.53	.00228	8.18	.00207
.0h	6.11	.00375	6.57	.003h3
.05	5.21	.00555	5.57	.00510
.06	h.58	.00758	h.87	.00702
.07	h.13	.00990	h.37	.00920
.08	3.78	.012h	3.98	.0116
.09	3.51	.0152	3.68	.01h2
.10	3.28	.0181	3.h3	.0170
.15	2.60	.0355	2.68	.0338
.20	2.25	.0563	2.29	.05h1
.25	2.0h	.0797	2.07	.0771
.30	1.91	.105	1.92	.102
.35	1.80	.132	1.81	.129
.h0	1.7h	.160	1.73	.158
.h5	1.69	.190	1.68	.187
.50	1.65	.220	1.6h	.217
.55	1.62	.250	1.60	.2h8
.60	1.60	.281	1.58	.279
.65	1.58	.313	1.56	.311
.70	1.57	.3h4	1.5h	.3h3
.75	1.55	.376	1.53	.376
.80	1.5h	.h09	1.52	.h09
.85	1.5h	.h41	1.51	.h42
.90	1.53	.h7h	1.50	.h75
.95	1.53	.507	1.50	.508
1.0	1.52	.539	1.h9	.539
1.2	1.52	.671	1.h8	.677
1.h	1.51	.803	1.h8	.809
1.6	1.52	.935	1.h8	.9h7
1.8	1.52	1.07	1.h9	1.08
2.0	1.53	1.20	1.h9	1.22
2.2	1.5h	1.33	1.50	1.35
2.h	1.5h	1.h6	1.50	1.h8
2.6	1.55	1.59	1.51	1.61
2.8	1.56	1.72	1.52	1.75
3.0	1.56	1.8h	1.52	1.88
h.0	1.60	2.h8	1.55	2.53
5.0	1.62	3.10	1.58	3.16
6.0	1.6h	3.71	1.60	3.80

Aluminum Z = 13, I = 163 ev				
Energy	$-dE^-/dx$	R^-	$-dE^+/dx$	R^+
Mev	Mev cm^2/g	g/cm^2	Mev cm^2/g	g/cm^2
0.01	16.6	0.0003h4	18.5	0.000302
.02	9.88	.0011h	10.8	.00103
.03	7.31	.00235	7.93	.00213
.0h	5.93	.00386	6.37	.003Sh
.05	5.06	.00571	5.h0	.00526
.06	h.h5	.00781	h.73	.0072h
.07	h.01	.0102	h.2h	.009h9
.08	3.67	.0128	3.86	.0120
.09	3.h1	.0156	3.57	.01h7
.10	3.19	.0187	3.33	.0176
.15	2.53	.0365	2.60	.03h8
.20	2.19	.0579	2.23	.0557
.25	1.99	.0820	2.00	.0795
.30	1.85	.108	1.85	.105
.35	1.76	.136	1.75	.133
.h0	1.69	.165	1.68	.162
.h5	1.6h	.195	1.63	.193
.50	1.60	.226	1.59	.22h
.55	1.57	.257	1.55	.256
.60	1.55	.289	1.53	.288
.65	1.53	.322	1.51	.321
.70	1.52	.355	1.h9	.35h
.75	1.51	.388	1.h8	.388
.80	1.50	.h21	1.h7	.h22
.85	1.h9	.h55	1.h6	.h56
.90	1.h8	.h88	1.h5	.h91
.95	1.h8	.522	1.hh	.525
1.0	1.h7	.556	1.hh	.560
1.2	1.h6	.692	1.h3	.700
1.h	1.h6	.829	1.h2	.8h0
1.6	1.h7	.965	1.h3	.980
1.8	1.h7	1.10	1.h3	1.12
2.0	1.h8	1.2h	1.h3	1.26
2.2	1.h8	1.37	1.hh	1.h0
2.h	1.h9	1.51	1.h5	1.5h
2.6	1.h9	1.6h	1.h5	1.68
2.8	1.50	1.78	1.h6	1.81
3.0	1.51	1.91	1.h6	1.95
h.0	1.5h	2.56	1.h9	2.63
5.0	1.56	3.21	1.52	3.29
6.0	1.58	3.85	1.53	3.95

TABLE 1. Energy loss and range of electrons and positrons (including density correction) - Continued

Iron Z = 26, I = 337 ev				
Energy	$-dE^-/dx$	R^-	$-dE^+/dx$	R^+
Mev	Mev cm^2/g	g/cm^2	Mev cm^2/g	g/cm^2
0.01	13.3	0.000442	15.2	0.000377
.02	8.14	.00141	9.06	.00125
.03	6.10	.00288	6.69	.00257
.04	4.99	.00468	5.41	.00422
.05	4.28	.00688	4.61	.00625
.06	3.78	.00934	4.05	.00856
.07	3.42	.0122	3.64	.0112
.08	3.14	.0152	3.32	.0141
.09	2.92	.0185	3.07	.0172
.10	2.74	.0220	2.87	.0206
.15	2.18	.0428	2.25	.0405
.20	1.90	.0675	1.94	.0646
.25	1.73	.0952	1.75	.0919
.30	1.62	.125	1.63	.122
.35	1.54	.157	1.53	.153
.40	1.48	.190	1.47	.187
.45	1.44	.224	1.43	.221
.50	1.41	.243	1.39	.256
.55	1.39	.295	1.37	.293
.60	1.37	.315	1.35	.330
.65	1.35	.368	1.33	.367
.70	1.34	.388	1.32	.405
.75	1.33	.442	1.31	.443
.80	1.33	.463	1.30	.481
.85	1.32	.518	1.29	.520
.90	1.32	.539	1.29	.559
.95	1.31	.594	1.27	.598
1.0	1.31	.615	1.27	.637
1.2	1.31	.768	1.27	.794
1.4	1.31	.921	1.27	.951
1.6	1.31	1.07	1.28	1.11
1.8	1.32	1.23	1.28	1.26
2.0	1.33	1.38	1.29	1.42
2.2	1.33	1.53	1.29	1.58
2.4	1.34	1.68	1.30	1.73
2.6	1.35	1.83	1.31	1.88
2.8	1.36	1.97	1.31	2.04
3.0	1.36	2.12	1.32	2.19

Copper Z = 29, I = 377 ev				
Energy	$-dE^-/dx$	R^-	$-dE^+/dx$	R^+
Mev	Mev cm^2/g	g/cm^2	Mev cm^2/g	g/cm^2
0.01	12.6	0.000468	14.5	0.000397
.02	7.77	.00149	8.67	.00131
.03	5.84	.00302	6.42	.00268
.04	4.78	.00490	5.20	.00441
.05	4.10	.00719	4.42	.00652
.06	3.63	.00976	3.89	.00892
.07	3.28	.0127	3.50	.0117
.08	3.02	.0158	3.19	.0146
.09	2.80	.0193	2.96	.0179
.10	2.63	.0230	2.76	.0214
.15	2.10	.0445	2.17	.0415
.20	1.83	.0702	1.87	.0671
.25	1.67	.0989	1.69	.0949
.30	1.56	.130	1.57	.126
.35	1.49	.163	1.49	.158
.40	1.44	.197	1.43	.193
.45	1.39	.232	1.38	.228
.50	1.36	.269	1.35	.266
.55	1.34	.306	1.32	.303
.60	1.33	.343	1.30	.341
.65	1.31	.381	1.29	.379
.70	1.30	.419	1.28	.419
.75	1.29	.458	1.27	.458
.80	1.29	.497	1.26	.498
.85	1.28	.535	1.25	.537
.90	1.28	.575	1.25	.578
.95	1.28	.614	1.24	.617
1.0	1.27	.653	1.24	.658
1.2	1.27	.810	1.24	.819
1.4	1.27	.968	1.24	.981
1.6	1.28	1.12	1.24	1.15
1.8	1.28	1.28	1.25	1.30
2.0	1.29	1.43	1.25	1.47
2.2	1.30	1.59	1.26	1.62
2.4	1.31	1.74	1.27	1.79
2.6	1.31	1.90	1.27	1.94
2.8	1.32	2.04	1.28	2.10

TABLE 1. Energy loss and range of electrons and positrons (including density correction) - Continued

Silver				
Z = 47, I = 660 ev				
Energy	$-dE^-/dx$	R^-	$-dE^+/dx$	R^+
Mev	Mev cm^2/g	g/cm^2	Mev cm^2/g	g/cm^2
0.01	10.0	0.000210	11.8	0.000497
.02	6.38	.00185	7.26	.00159
.03	4.87	.00332	5.43	.00323
.04	4.02	.00594	4.42	.00525
.05	3.47	.00828	3.78	.00740
.06	3.08	.0117	3.34	.0105
.07	2.80	.0148	3.01	.0134
.08	2.58	.0188	2.75	.0172
.09	2.40	.0225	2.55	.0207
.10	2.26	.0272	2.39	.0250
.15	1.82	.0518	1.88	.0486
.20	1.59	.0818	1.63	.0776
.25	1.45	.114	1.47	.110
.30	1.36	.150	1.37	.145
.35	1.30	.188	1.30	.182
.40	1.26	.227	1.25	.222
.45	1.22	.267	1.22	.262
.50	1.20	.309	1.19	.304
.55	1.18	.350	1.17	.346
.60	1.17	.393	1.15	.389
.65	1.16	.436	1.14	.433
.70	1.15	.479	1.13	.477
.75	1.15	.522	1.12	.521
.80	1.14	.566	1.12	.566
.85	1.14	.610	1.11	.610
.90	1.14	.654	1.11	.656
.95	1.14	.698	1.11	.700
1.0	1.14	.742	1.11	.746
1.2	1.14	.918	1.11	.927
1.4	1.14	1.09	1.11	1.11

Tin				
Z = 50, I = 709 ev				
Energy	$-dE^-/dx$	R^-	$-dE^+/dx$	R^+
Mev	Mev cm^2/g	g/cm^2	Mev cm^2/g	g/cm^2
0.01	9.46	0.000650	11.2	0.000528
.02	6.06	.00196	6.90	.00167
.03	4.62	.00393	5.17	.00340
.04	3.82	.00627	4.21	.00553
.05	3.30	.00915	3.60	.00814
.06	2.93	.0123	3.18	.0111
.07	2.66	.0160	2.87	.0144
.08	2.45	.0198	2.62	.0180
.09	2.29	.0241	2.43	.0220
.10	2.15	.0285	2.28	.0263
.15	1.73	.0548	1.80	.0513
.20	1.52	.0858	1.55	.0814
.25	1.39	.120	1.41	.116
.30	1.30	.158	1.31	.152
.35	1.25	.197	1.25	.192
.40	1.20	.238	1.20	.232
.45	1.17	.280	1.16	.275
.50	1.15	.323	1.14	.318
.55	1.13	.367	1.12	.363
.60	1.12	.412	1.10	.408
.65	1.11	.456	1.09	.454
.70	1.10	.502	1.08	.499
.75	1.10	.547	1.07	.546
.80	1.09	.593	1.07	.592
.85	1.09	.639	1.07	.640
.90	1.09	.685	1.06	.686
.95	1.09	.731	1.06	.734
1.0	1.09	.777	1.06	.781
1.2	1.09	.961	1.06	.970

TABLE 1. Energy loss and range of electrons and positrons (including density correction) - Continued

Xenon Z = 54, I = 758 ev				
Energy	$-dE^-/dx$	R^-	$-dE^+/dx$	R^+
Mev	Mev cm^2/g	g/cm^2	Mev cm^2/g	g/cm^2
0.01	9.04	0.000685	10.7	0.000553
.02	5.81	.00205	6.63	.00175
.03	4.45	.00410	4.97	.00355
.04	3.68	.00653	4.06	.00575
.05	3.18	.00952	3.47	.00847
.06	2.83	.0128	3.06	.0115
.07	2.57	.0166	2.76	.0150
.08	2.37	.0206	2.53	.0187
.09	2.21	.0250	2.35	.0229
.10	2.08	.0296	2.20	.0273
.15	1.67	.0568	1.74	.0532
.20	1.47	.0888	1.50	.0844
.25	1.34	.125	1.36	.120
.30	1.26	.163	1.27	.158
.35	1.21	.204	1.20	.198
.40	1.17	.246	1.16	.241
.45	1.14	.289	1.13	.284
.50	1.12	.334	1.10	.329
.55	1.10	.379	1.08	.375
.60	1.09	.425	1.07	.422
.65	1.08	.471	1.06	.469
.70	1.07	.517	1.05	.516
.75	1.07	.564	1.04	.564
.80	1.06	.611	1.04	.612
.85	1.06	.658	1.03	.660
.90	1.06	.705	1.03	.709
.95	1.06	.753	1.03	.757
1.0	1.06	.800	1.03	.806
1.2	1.06	.988	1.03	1.00

Tungsten Z = 74, I = 991 ev				
Energy	$-dE^-/dx$	$-R^-$	$-dE^+/dx$	R^+
Mev	Mev cm^2/g	g/cm^2	Mev cm^2/g	g/cm^2
0.01	7.95	0.000800	9.61	0.000628
.02	5.22	.00231	6.03	.00194
.03	4.03	.00460	4.55	.00392
.04	3.35	.00725	3.73	.00632
.05	2.91	.0105	3.20	.00927
.06	2.60	.0141	2.83	.0126
.07	2.36	.0182	2.55	.0163
.08	2.18	.0222	2.34	.0204
.09	2.04	.0274	2.17	.0249
.10	1.92	.0321	2.04	.0296
.15	1.55	.0618	1.61	.0575
.20	1.36	.0959	1.40	.0910
.25	1.25	.135	1.27	.129
.30	1.18	.176	1.18	.170
.35	1.13	.220	1.13	.213
.40	1.09	.264	1.08	.258
.45	1.06	.311	1.05	.305
.50	1.04	.358	1.03	.353
.55	1.03	.407	1.02	.402
.60	1.02	.455	1.00	.451
.65	1.01	.505	.992	.501
.70	1.00	.555	.985	.552
.75	.997	.605	.979	.603
.80	.995	.655	.975	.654
.85	.993	.706	.973	.705
.90	.992	.756	.967	.757
.95	.992	.806	.966	.809
1.0	.992	.856	.966	.860

TABLE 1. Energy loss and range of electrons and positrons (including density correction) - Continued

Gold				
Z = 79, I = 1136 ev				
Energy	$-dE^-/dx$	R^-	$-dE^+/dx$	R^+
Mev	Mev cm^2/g	g/cm^2	Mev cm^2/g	g/cm^2
0.01	7.48	0.000865	9.13	0.000669
.02	4.98	.00245	5.77	.00204
.03	3.86	.00485	4.37	.00410
.04	3.22	.00761	3.59	.00659
.05	2.80	.0110	3.09	.00966
.06	2.50	.0147	2.73	.0131
.07	2.28	.0190	2.47	.0170
.08	2.11	.0235	2.27	.0212
.09	1.97	.0285	2.10	.0258
.10	1.86	.0336	1.97	.0307
.15	1.50	.0640	1.57	.0595
.20	1.32	.0995	1.36	.0940
.25	1.21	.139	1.23	.133
.30	1.14	.182	1.15	.175
.35	1.10	.226	1.09	.220
.40	1.06	.273	1.06	.266
.45	1.04	.320	1.03	.314
.50	1.02	.369	1.00	.363
.55	1.00	.419	.988	.414
.60	.995	.469	.976	.465
.65	.984	.519	.967	.516
.70	.979	.570	.960	.568
.75	.975	.621	.955	.620
.80	.973	.673	.951	.673
.85	.971	.724	.948	.725
.90	.971	.776	.945	.778

Lead				
Z = 82, I = 1180 ev				
Energy	$-dE^-/dx$	R^-	$-dE^+/dx$	R^+
Mev	Mev cm^2/g	g/cm^2	Mev cm^2/g	g/cm^2
0.01	7.29	0.000893	8.90	0.000688
.02	4.87	.00251	5.65	.00209
.03	3.78	.00497	4.28	.00420
.04	3.16	.00778	3.52	.00674
.05	2.74	.0113	3.02	.00988
.06	2.45	.0151	2.68	.0133
.07	2.24	.0194	2.42	.0173
.08	2.07	.0240	2.22	.0216
.09	1.93	.0291	2.06	.0263
.10	1.82	.0343	1.93	.0313
.15	1.48	.0652	1.54	.0607
.20	1.30	.101	1.33	.0958
.25	1.19	.142	1.21	.135
.30	1.13	.185	1.13	.178
.35	1.08	.230	1.08	.224
.40	1.04	.277	1.04	.271
.45	1.02	.326	1.01	.320
.50	1.00	.375	.987	.370
.55	.989	.426	.971	.421
.60	.979	.476	.959	.473
.65	.972	.528	.950	.526
.70	.966	.579	.943	.578
.75	.963	.631	.938	.632
.80	.960	.683	.935	.685

TABLE 1. Energy loss and range of electrons and positrons (including density correction) - Continued

Uranium

Z = 92, I = 1325 ev

Energy	$-dE^-/dx$	R^-	$-dE^+/dx$	R^+
Mev	Mev cm^2/g	g/cm^2	Mev cm^2/g	g/cm^2
0.01	6.73	0.000984	8.33	0.000742
.02	4.55	.00271	5.33	.00223
.03	3.55	.00534	4.06	.00447
.04	2.97	.00832	3.34	.00714
.05	2.59	.0121	2.87	.0104
.06	2.32	.0160	2.55	.0141
.07	2.12	.0207	2.30	.0183
.08	1.96	.0255	2.12	.0228
.09	1.83	.0309	1.97	.0277
.10	1.73	.0364	1.84	.0329
.15	1.40	.0689	1.47	.0638
.20	1.24	.107	1.27	.101
.25	1.14	.149	1.16	.142
.30	1.07	.195	1.08	.187
.35	1.03	.242	1.03	.234
.40	.996	.292	.992	.284
.45	.974	.343	.966	.335
.50	.957	.394	.946	.387
.55	.944	.447	.931	.441
.60	.935	.500	.919	.495
.65	.925	.554	.911	.549
.70	.921	.608	.905	.604
.75	.918	.662	.900	.660
.80	.915	.717	.897	.715

Anthracene

I = 67.2 ev

Energy	$-dE^-/dx$	R^-	$-dE^+/dx$	R^+
Mev	Mev cm^2/g	g/cm^2	Mev cm^2/g	g/cm^2
0.01	21.9	0.000254	24.1	0.000229
.02	12.8	.000870	13.8	.000796
.03	9.34	.00181	10.0	.00167
.04	7.52	.00300	8.00	.00279
.05	6.38	.00446	6.75	.00416
.06	5.60	.00613	5.90	.00574
.07	5.03	.00802	5.27	.00755
.08	4.59	.0101	4.80	.00953
.09	4.25	.0124	4.42	.0117
.10	3.97	.0148	4.12	.0140
.15	3.12	.0292	3.20	.0280
.20	2.69	.0466	2.73	.0450
.25	2.44	.0662	2.46	.0644
.30	2.27	.0875	2.28	.0856
.35	2.15	.110	2.15	.108
.40	2.06	.134	2.05	.132
.45	2.00	.159	1.98	.157
.50	1.95	.184	1.93	.182
.55	1.91	.210	1.88	.209
.60	1.87	.236	1.85	.236
.65	1.85	.263	1.82	.263
.70	1.83	.290	1.80	.290
.75	1.81	.318	1.78	.318
.80	1.80	.346	1.76	.347
.85	1.79	.374	1.75	.375
.90	1.78	.402	1.74	.404
.95	1.77	.430	1.73	.432
1.0	1.76	.458	1.72	.461
1.2	1.74	.572	1.70	.578
1.4	1.74	.687	1.70	.696
1.6	1.74	.803	1.69	.814
1.8	1.74	.918	1.69	.932
2.0	1.74	1.03	1.70	1.05
2.2	1.74	1.15	1.70	1.17
2.4	1.75	1.26	1.70	1.29
2.6	1.75	1.38	1.71	1.40
2.8	1.76	1.49	1.71	1.52
3.0	1.77	1.60	1.72	1.64
4.0	1.79	2.17	1.74	2.21
5.0	1.81	2.72	1.76	2.79
6.0	1.83	3.27	1.78	3.35
8.0	1.86	4.35	1.81	4.46
10.0	1.88	5.42	1.83	5.56

TABLE 1. Energy loss and range of electrons and positrons (including density correction) - Continued

	Stilbene I = 65.4 ev				Polystyrene I = 63.8 ev				
Energy	$-dE^-/dx$	R^-	$-dE^+/dx$	R^+	Energy	$-dE^-/dx$	R^-	$-dE^+/dx$	R^+
Mev	Mev cm^2/g	g/cm^2	Mev cm^2/g	g/cm^2	Mev	Mev cm^2/g	g/cm^2	Mev cm^2/g	g/cm^2
0.01	22.2	0.000250	24.4	0.000225	0.01	22.6	0.000247	24.8	0.000222
.02	12.9	.000857	14.0	.000784	.02	13.1	.000845	14.2	.000773
.03	9.47	.00178	10.1	.00164	.03	9.60	.00176	10.3	.00162
.04	7.62	.00296	8.11	.00275	.04	7.73	.00292	8.22	.00271
.05	6.47	.00440	6.84	.00410	.05	6.56	.00434	6.94	.00405
.06	5.68	.00605	5.98	.00567	.06	5.75	.00596	6.06	.00559
.07	5.10	.00792	5.34	.00744	.07	5.16	.00781	5.42	.00734
.08	4.65	.00997	4.86	.00940	.08	4.72	.00983	4.93	.00928
.09	4.31	.0122	4.48	.0116	.09	4.36	.0120	4.54	.0114
.10	4.02	.0146	4.18	.0139	.10	4.08	.0144	4.23	.0137
.15	3.16	.0288	3.24	.0276	.15	3.20	.0284	3.28	.0273
.20	2.73	.0459	2.77	.0444	.20	2.76	.0453	2.81	.0439
.25	2.47	.0653	2.49	.0635	.25	2.50	.0644	2.52	.0627
.30	2.30	.0863	2.30	.0845	.30	2.33	.0852	2.33	.0834
.35	2.18	.109	2.18	.107	.35	2.21	.107	2.20	.105
.40	2.09	.132	2.08	.130	.40	2.12	.130	2.11	.129
.45	2.02	.157	2.01	.155	.45	2.05	.154	2.03	.153
.50	1.97	.182	1.95	.180	.50	2.00	.179	1.98	.178
.55	1.93	.207	1.91	.206	.55	1.96	.205	1.93	.203
.60	1.90	.233	1.87	.233	.60	1.92	.230	1.90	.230
.65	1.87	.260	1.84	.259	.65	1.90	.257	1.87	.256
.70	1.85	.287	1.82	.287	.70	1.88	.283	1.85	.283
.75	1.83	.314	1.80	.314	.75	1.86	.310	1.83	.310
.80	1.82	.341	1.79	.342	.80	1.84	.337	1.81	.338
.85	1.81	.369	1.77	.370	.85	1.83	.364	1.80	.365
.90	1.80	.397	1.76	.399	.90	1.82	.391	1.79	.393
.95	1.79	.424	1.75	.427	.95	1.81	.419	1.78	.421
1.0	1.78	.452	1.75	.456	1.0	1.81	.447	1.77	.450
1.2	1.77	.565	1.73	.571	1.2	1.79	.558	1.75	.563
1.4	1.76	.679	1.72	.687	1.4	1.78	.670	1.74	.678
1.6	1.76	.792	1.71	.804	1.6	1.78	.782	1.74	.793
1.8	1.76	.906	1.71	.920	1.8	1.78	.894	1.74	.908
2.0	1.76	1.02	1.72	1.04	2.0	1.79	1.01	1.74	1.02
2.2	1.77	1.13	1.72	1.15	2.2	1.79	1.12	1.74	1.14
2.4	1.77	1.25	1.72	1.27	2.4	1.80	1.23	1.75	1.25
2.6	1.78	1.36	1.73	1.39	2.6	1.80	1.34	1.75	1.37
2.8	1.78	1.47	1.73	1.50	2.8	1.81	1.45	1.76	1.48
3.0	1.79	1.58	1.74	1.62	3.0	1.81	1.56	1.76	1.59
4.0	1.81	2.14	1.76	2.19	4.0	1.84	2.11	1.79	2.16
5.0	1.83	2.69	1.78	2.75	5.0	1.86	2.65	1.81	2.71
6.0	1.85	3.23	1.80	3.31	6.0	1.88	3.19	1.83	3.26
8.0	1.88	4.30	1.83	4.41	8.0	1.91	4.24	1.86	4.35
10.0	1.90	5.36	1.85	5.49	10.0	1.93	5.29	1.88	5.42

TABLE 1. Energy loss and range of electrons and positrons (including density correction) - Continued

Energy	Polyethylene I = 54.9 ev				Lucite I = 69.1 ev			
	$-dE^-/dx$	R^-	$-dE^+/dx$	R^+	$-dE^-/dx$	R^-	$-dE^+/dx$	R^+
Mev	Mev cm^2/g	g/cm^2	Mev cm^2/g	g/cm^2	Mev cm^2/g	g/cm^2	Mev cm^2/g	g/cm^2
0.01	24.6	0.000225	27.0	0.000204	22.3	0.000250	24.5	0.000224
.02	14.3	.000775	15.4	.000711	13.0	.000854	14.1	.000781
.03	10.4	.00161	11.2	.00149	9.51	.00178	10.2	.00164
.04	8.38	.00269	8.91	.00250	7.66	.00295	8.16	.00273
.05	7.11	.00399	7.51	.00373	6.50	.00438	6.88	.00408
.06	6.23	.00549	6.55	.00516	5.71	.00602	6.01	.00563
.07	5.59	.00720	5.86	.00678	5.13	.00788	5.38	.00740
.08	5.11	.00907	5.33	.00857	4.68	.00992	4.89	.00935
.09	4.72	.0111	4.91	.0105	4.33	.0121	4.51	.0115
.10	4.41	.0133	4.57	.0126	4.05	.0145	4.20	.0138
.15	3.46	.0263	3.55	.0252	3.18	.0286	3.26	.0275
.20	2.98	.0419	3.03	.0406	2.74	.0457	2.79	.0442
.25	2.70	.0596	2.72	.0581	2.48	.0649	2.51	.0631
.30	2.51	.0788	2.52	.0772	2.31	.0858	2.32	.0839
.35	2.38	.0993	2.38	.0977	2.19	.108	2.19	.106
.40	2.28	.121	2.27	.119	2.11	.131	2.10	.129
.45	2.21	.143	2.19	.142	2.04	.155	2.02	.154
.50	2.15	.166	2.13	.165	1.99	.180	1.97	.179
.55	2.10	.190	2.08	.189	1.95	.206	1.92	.205
.60	2.07	.214	2.04	.213	1.91	.232	1.89	.231
.65	2.04	.238	2.01	.238	1.89	.258	1.86	.257
.70	2.01	.263	1.98	.263	1.87	.285	1.84	.284
.75	1.99	.288	1.96	.288	1.85	.311	1.82	.312
.80	1.98	.313	1.94	.314	1.84	.339	1.80	.339
.85	1.96	.338	1.93	.339	1.82	.366	1.79	.367
.90	1.95	.364	1.92	.366	1.81	.393	1.78	.395
.95	1.94	.389	1.91	.392	1.81	.421	1.77	.424
1.0	1.94	.415	1.90	.418	1.80	.449	1.76	.452
1.2	1.92	.519	1.87	.524	1.78	.560	1.74	.566
1.4	1.91	.624	1.86	.631	1.78	.673	1.73	.681
1.6	1.91	.728	1.86	.739	1.77	.786	1.73	.797
1.8	1.91	.833	1.86	.846	1.78	.898	1.73	.912
2.0	1.91	.938	1.86	.954	1.78	1.01	1.73	1.03
2.2	1.91	1.04	1.86	1.06	1.78	1.12	1.74	1.14
2.4	1.92	1.15	1.87	1.17	1.79	1.23	1.74	1.26
2.6	1.92	1.25	1.87	1.28	1.80	1.35	1.75	1.37
2.8	1.93	1.36	1.88	1.38	1.80	1.46	1.75	1.48
3.0	1.93	1.46	1.88	1.49	1.81	1.57	1.76	1.60
4.0	1.96	1.97	1.91	2.02	1.83	2.12	1.78	2.17
5.0	1.98	2.48	1.93	2.54	1.86	2.66	1.80	2.72
6.0	2.00	2.98	1.95	3.05	1.87	3.20	1.82	3.27
8.0	2.03	3.97	1.98	4.07	1.90	4.25	1.85	4.36
10.0	2.06	4.95	2.00	5.08	1.93	5.30	1.88	5.44

TABLE 1. Energy loss and range of electrons and positrons (including density correction) - Continued

Toluene I = 62.3 ev				
Energy	$-dE^-/dx$	R^-	$-dE^+/dx$	R^+
Mev	Mev cm^2/g	g/cm^2	Mev cm^2/g	g/cm^2
0.01	22.9	0.000243	25.1	0.000219
.02	13.3	.000833	14.4	.000763
.03	9.73	.00173	10.4	.00160
.04	7.83	.00288	8.33	.00267
.05	6.64	.00428	7.03	.00399
.06	5.83	.00588	6.13	.00552
.07	5.23	.00771	5.49	.00725
.08	4.78	.00970	4.99	.00916
.09	4.42	.0119	4.60	.0113
.10	4.13	.0142	4.29	.0135
.15	3.25	.0281	3.33	.0269
.20	2.80	.0448	2.84	.0433
.25	2.53	.0636	2.55	.0619
.30	2.36	.0841	2.36	.0823
.35	2.23	.106	2.23	.104
.40	2.15	.129	2.14	.127
.45	2.08	.153	2.06	.151
.50	2.03	.177	2.01	.175
.55	1.99	.202	1.96	.201
.60	1.95	.227	1.93	.226
.65	1.93	.253	1.90	.253
.70	1.90	.279	1.87	.279
.75	1.89	.305	1.86	.306
.80	1.87	.332	1.84	.333
.85	1.86	.359	1.83	.360
.90	1.85	.386	1.81	.388
.95	1.84	.413	1.81	.415
1.0	1.84	.440	1.80	.443
1.2	1.82	.550	1.78	.555
1.4	1.81	.660	1.77	.668
1.6	1.81	.770	1.77	.781
1.8	1.81	.880	1.77	.894
2.0	1.82	.991	1.77	1.01
2.2	1.82	1.10	1.77	1.12
2.4	1.83	1.21	1.78	1.23
2.6	1.83	1.32	1.78	1.35
2.8	1.84	1.43	1.79	1.46
3.0	1.84	1.54	1.79	1.57
4.0	1.87	2.08	1.82	2.12
5.0	1.89	2.61	1.84	2.67
6.0	1.91	3.13	1.86	3.21
8.0	1.94	4.17	1.89	4.28
10.0	1.96	5.20	1.91	5.33

Xylene I = 61.2ev				
Energy	$-dE^-/dx$	R^-	$-dE^+/dx$	R^+
Mev	Mev cm^2/g	g/cm^2	Mev cm^2/g	g/cm^2
0.01	23.1	0.000241	25.3	0.000217
.02	13.4	.000825	14.5	.000756
.03	9.82	.00172	10.5	.00158
.04	7.90	.00285	8.40	.00265
.05	6.70	.00424	7.09	.00396
.06	5.88	.00583	6.19	.00547
.07	5.28	.00764	5.53	.00718
.08	4.82	.00962	5.03	.00908
.09	4.46	.0118	4.64	.0112
.10	4.16	.0141	4.32	.0134
.15	3.27	.0278	3.35	.0267
.20	2.82	.0444	2.86	.0429
.25	2.55	.0631	2.57	.0614
.30	2.37	.0835	2.38	.0817
.35	2.25	.105	2.25	.103
.40	2.16	.128	2.15	.120
.45	2.09	.151	2.08	.150
.50	2.04	.175	2.02	.168
.55	2.00	.200	1.98	.199
.60	1.97	.225	1.94	.218
.65	1.94	.251	1.91	.251
.70	1.92	.277	1.89	.271
.75	1.90	.303	1.87	.304
.80	1.89	.330	1.85	.324
.85	1.87	.356	1.84	.358
.90	1.86	.383	1.83	.379
.95	1.86	.410	1.82	.412
1.0	1.85	.437	1.81	.434
1.2	1.83	.546	1.79	.545
1.4	1.82	.655	1.78	.657
1.6	1.82	.765	1.78	.769
1.8	1.82	.875	1.78	.882
2.0	1.83	.984	1.78	.994
2.2	1.83	1.09	1.78	1.11
2.4	1.84	1.20	1.79	1.22
2.6	1.84	1.31	1.79	1.33
2.8	1.85	1.42	1.80	1.44
3.0	1.85	1.53	1.80	1.55
4.0	1.88	2.06	1.83	2.10
5.0	1.90	2.59	1.85	2.65
6.0	1.92	3.12	1.87	3.18
8.0	1.95	4.15	1.90	4.24
10.0	1.98	5.17	1.92	5.29

TABLE 1. Energy loss and range of electrons and positrons (including density correction) - Continued

	H_2O I = 74.1 ev			
Energy	$-dE^-/dx$	R^-	$-dE^+/dx$	R^+
Mev	Mev cm^2/g	g/cm^2	Mev cm^2/g	g/cm^2
0.01	22.6	0.0002l7	2l.9	0.000221
.02	13.2	.0008l1	1l.3	.000768
.03	9.68	.00175	10.l	.00161
.0l	7.80	.00290	8.31	.00269
.05	6.62	.00l31	7.01	.00l01
.06	5.8l	.00591	6.13	.00553
.07	5.22	.0077l	5.l8	.00727
.08	l.77	.0097l	l.99	.00918
.09	l.l1	.0119	l.60	.0113
.10	l.12	.0ll3	l.28	.0135
.15	3.25	.0281	3.33	.0270
.20	2.80	.0l48	2.8l	.0l33
.25	2.53	.0636	2.56	.0619
.30	2.36	.08l1	2.37	.0823
.35	2.2l	.106	2.2l	.10l
.l0	2.15	.129	2.1l	.127
.l5	2.09	.152	2.07	.151
.50	2.0l	.177	2.02	.175
.55	2.00	.201	1.97	.200
.60	1.96	.227	1.9l	.226
.65	1.9l	.252	1.91	.252
.70	1.92	.278	1.89	.278
.75	1.90	.30l	1.87	.305
.80	1.89	.331	1.85	.332
.85	1.87	.357	1.8l	.359
.90	1.86	.38l	1.83	.386
.95	1.86	.ll1	1.82	.ll1l
1.0	1.85	.l38	1.81	.ll1
1.2	1.83	.5l7	1.79	.552
1.l	1.83	.656	1.78	.66l
1.6	1.83	.766	1.78	.776
1.8	1.83	.875	1.78	.889
2.0	1.83	.98l	1.79	1.00
2.2	1.8l	1.09	1.79	1.11
2.l	1.8l	1.20	1.79	1.22
2.6	1.85	1.31	1.80	1.3l
2.8	1.86	1.l2	1.81	1.l5
3.0	1.86	1.53	1.81	1.56
l.0	1.89	2.06	1.8l	2.10
5.0	1.91	2.58	1.86	2.65
6.0	1.93	3.10	1.88	3.18
8.0	1.97	l.13	1.91	l.23

	AgCl I = l91 ev			
Energy	$-dE^-/dx$	R^-	$-dE^+/dx$	R^+
Mev	Mev cm^2/g	g/cm^2	Mev cm^2/g	g/cm^2
0.01	11.l	0.000526	13.2	0.000l10
.02	7.11	.00161	8.00	.00ll3
.03	5.38	.00331	5.95	.00292
.0l	l.l2	.00531	l.83	.00l78
.05	3.80	.00783	l.12	.00705
.06	3.37	.0106	3.62	.00963
.07	3.05	.0138	3.26	.0126
.08	2.81	.0171	2.98	.0158
.09	2.61	.0209	2.76	.0193
.10	2.l3	.02l8	2.58	.0230
.15	1.97	.0l81	2.03	.0l51
.20	1.71	.0753	1.75	.0718
.25	1.57	.106	1.58	.102
.30	1.l7	.139	1.l7	.135
.35	1.l0	.17l	1.l0	.170
.l0	1.35	.210	1.3l	.206
.l5	1.32	.2l8	1.31	.2l1
.50	1.29	.286	1.28	.283
.55	1.27	.325	1.25	.322
.60	1.26	.365	1.23	.362
.65	1.2l	.l05	1.22	.l03
.70	1.2l	.ll5	1.21	.ll1
.75	1.23	.l86	1.20	.l86
.80	1.22	.526	1.20	.527
.85	1.22	.567	1.19	.569
.90	1.22	.608	1.19	.6ll
.95	1.22	.650	1.19	.653
1.0	1.22	.690	1.18	.696
1.2	1.22	.855	1.18	.865
1.l	1.22	1.02	1.19	1.03
1.6	1.23	1.18	1.20	1.20
1.8	1.2l	1.3l	1.20	1.37
2.0	1.25	1.50	1.21	1.53

TABLE 1. Energy loss and range of electrons and positrons (including density correction) - Continued

	AgBr 571$_4$ ev			
Energy	$-dE^-/dx$	R^-	$-dE^+/dx$	R^+
Mev	Mev cm^2/g	g/cm^2	Mev cm^2/g	g/cm^2
0.01	10.6	0.000572	12.$_4$	0.000$_4$71
.02	6.68	.00176	7.$_5$4	.00152
.03	5.07	.00354	5.62	.00310
.0$_4$	$_4$.17	.00569	$_4$.57	.00506
.05	3.59	.00832	3.90	.007$_4$7
.06	3.19	.0112	3.$_4$4	.0102
.07	2.89	.01$_4$6	3.10	.0133
.08	2.66	.0181	2.83	.0166
.09	2.$_4$8	.0221	2.63	.0203
.10	2.33	.0262	2.$_4$6	.02$_4$2
.15	1.87	.0505	1.9$_4$	.0$_4$75
.20	1.63	.0792	1.67	.0755
.25	1.$_4$9	.111	1.51	.107
.30	1.$_4$0	.1$_4$6	1.$_4$1	.1$_4$1
.35	1.3$_4$	.183	1.3$_4$	.178
.$_4$0	1.29	.221	1.28	.216
.$_4$5	1.26	.260	1.25	.256
.50	1.23	.300	1.22	.296
.55	1.22	.3$_4$1	1.20	.338
.60	1.20	.382	1.18	.380
.65	1.19	.$_4$2$_4$	1.17	.$_4$22
.70	1.18	.$_4$66	1.16	.$_4$65
.75	1.18	.508	1.15	.509
.80	1.17	.551	1.15	.552
.85	1.17	.59$_4$	1.1$_4$	.596
.90	1.17	.636	1.1$_4$	.6$_4$0
.95	1.17	.679	1.1$_4$	.68$_4$
1.0	1.17	.722	1.1$_4$	.728
1.2	1.17	.89$_4$	1.13	.90$_4$
1.$_4$	1.17	1.06	1.1$_4$	1.08
1.6	1.18	1.23	1.15	1.26
1.8	1.19	1.$_4$0	1.15	1.$_4$3
2.0	1.20	1.57	1.16	1.60

	Emulsion I = 373 ev			
Energy	$-dE^-/dx$	R^-	$-dE^+/dx$	R^+
Mev	Mev cm^2/g	g/cm^2	Mev cm^2/g	g/cm^2
0.01	12.6	0.000$_4$68	1$_4$.$_4$	0.000397
.02	7.76	.001$_4$9	8.66	.00131
.03	5.83	.00302	6.$_4$1	.00269
.0$_4$	$_4$.77	.00$_4$90	5.19	.00$_4$$_4$2
.05	$_4$.09	.00720	$_4$.$_4$1	.00653
.06	3.62	.00978	3.88	.00894
.07	3.28	.0127	3.$_4$9	.0117
.08	3.01	.0159	3.19	.01$_4$7
.09	2.80	.019$_4$	2.95	.0180
.10	2.63	.0230	2.76	.02$_4$
.15	2.10	.0$_4$6	2.16	.0$_4$22
.20	1.82	.0703	1.86	.0673
.25	1.66	.0991	1.68	.0957
.30	1.56	.130	1.56	.127
.35	1.$_4$8	.163	1.$_4$8	.159
.$_4$0	1.$_4$3	.197	1.$_4$2	.19$_4$
.$_4$5	1.39	.233	1.38	.230
.50	1.37	.269	1.35	.266
.55	1.3$_4$	.306	1.32	.30$_4$
.60	1.33	.3$_4$3	1.31	.3$_4$2
.65	1.31	.381	1.29	.380
.70	1.30	.$_4$20	1.28	.$_4$19
.75	1.30	.$_4$58	1.27	.$_4$58
.80	1.29	.$_4$97	1.26	.$_4$98
.85	1.28	.536	1.25	.538
.90	1.28	.575	1.25	.578
.95	1.28	.61$_4$	1.25	.618
1.0	1.28	.653	1.2$_4$	.658
1.2	1.27	.810	1.2$_4$	.819
1.$_4$	1.28	.967	1.2$_4$	.980
1.6	1.28	1.12	1.25	1.1$_4$
1.8	1.29	1.28	1.25	1.30
2.0	1.30	1.$_4$3	1.26	1.$_4$6

TABLE 1. Energy loss and range of electrons and positrons (including density correction) - Continued

	LdI I = 636 ev			
Energy	$-dE^-/dx$	R^-	$-dE^+/dx$	R^+
Mev	Mev cm^2/g	g/cm^2	Mev cm^2/g	g/cm^2
0.01	9.79	0.000623	11.5	0.000511
.02	6.22	.00190	7.04	.00163
.03	4.73	.00381	5.26	.00332
.04	3.90	.00611	4.29	.00542
.05	3.37	.00892	3.66	.00798
.06	2.99	.0120	3.23	.0109
.07	2.71	.0156	2.91	.0142
.08	2.50	.0194	2.66	.0177
.09	2.33	.0236	2.47	.0217
.10	2.19	.0280	2.31	.0258
.15	1.76	.0538	1.82	.0505
.20	1.54	.0843	1.57	.0802
.25	1.41	.118	1.42	.114
.30	1.32	.155	1.33	.150
.35	1.26	.194	1.26	.189
.40	1.22	.234	1.21	.229
.45	1.19	.276	1.18	.271
.50	1.17	.318	1.15	.314
.55	1.15	.362	1.13	.358
.60	1.13	.405	1.11	.403
.65	1.12	.450	1.10	.448
.70	1.12	.494	1.09	.493
.75	1.11	.539	1.09	.539
.80	1.11	.584	1.08	.585
.85	1.11	.629	1.08	.632
.90	1.10	.675	1.08	.678
.95	1.10	.720	1.07	.725
1.0	1.10	.765	1.07	.771
1.2	1.10	.947	1.07	.958

	NaI I = 562 ev			
Energy	$-dE^-/dx$	R^-	$-dE^+/dx$	R^+
Mev	Mev cm^2/g	g/cm^2	Mev cm^2/g	g/cm^2
0.01	10.4	0.000580	12.2	0.000480
.02	6.57	.00179	7.41	.00155
.03	4.98	.00360	5.52	.00316
.04	4.10	.00579	4.49	.00515
.05	3.53	.00847	3.83	.00760
.06	3.13	.0114	3.38	.0104
.07	2.84	.0148	3.04	.0135
.08	2.61	.0185	2.78	.0169
.09	2.44	.0225	2.58	.0207
.10	2.29	.0267	2.41	.0247
.15	1.84	.0514	1.90	.0484
.20	1.60	.0807	1.64	.0769
.25	1.46	.113	1.48	.109
.30	1.37	.149	1.38	.144
.35	1.31	.186	1.31	.181
.40	1.27	.225	1.26	.220
.45	1.24	.265	1.22	.261
.50	1.21	.306	1.20	.302
.55	1.19	.347	1.17	.344
.60	1.18	.389	1.16	.387
.65	1.17	.432	1.15	.430
.70	1.16	.475	1.14	.474
.75	1.15	.518	1.13	.518
.80	1.15	.562	1.12	.563
.85	1.15	.605	1.12	.607
.90	1.14	.649	1.12	.652
.95	1.14	.693	1.11	.697
1.0	1.14	.736	1.11	.742
1.2	1.14	.912	1.11	.922

TABLE 2. The difference in range with and without the density correction for electrons - Continued

$$\int_0^E dE \cdot \frac{\delta}{\bar{B}\bar{S}}$$

Energy Mev	Li	Be	C	Mg	Al	Fe	Cu	Ag	Sn
0.20	0.000020								
.25	.000057	0.00020	0.00014						
.30	.000097	.00039	.00028						
.35	.00016	.00065	.00045		0.00016				
.40	.00026	.00098	.00068	0.00017	.00026	0.00021			
.45	.00039	.0014	.00095	.00026	.00039	.00035			
.50	.00056	.0018	.0013	.00034	.00055	.00050	0.00018	0.00019	0.00028
.55	.00078	.0024	.0016	.00043	.00073	.00067	.00030	.00028	.00041
.60	.0010	.0030	.0021	.00053	.00095	.00087	.00042	.00034	.00054
.65	.0013	.0036	.0025	.00065	.0012	.0011	.00057	.00040	.00066
.70	.0017	.0044	.0031	.00078	.0015	.0014	.00073	.00044	.00078
.75	.0021	.0052	.0036	.00093	.0018	.0016	.00092	.00050	.00091
.80	.0025	.0060	.0043	.0011	.0022	.0020	.0011	.00055	.0011
.85	.0030	.0069	.0049	.0013	.0026	.0023	.0014	.00062	.0012
.90	.0036	.0079	.0056	.0015	.0030	.0027	.0016	.00069	.0014
.95	.0042	.0089	.0064	.0018	.0034	.0031	.0020	.00079	.0015
1.0	.0048	.0099	.0072	.0020	.0040	.0036	.0023	.00090	.0017
1.2	.0077	.015	.017	.0033	.0063	.0058	.0039	.0014	.0026
1.4	.011	.020	.015	.0051	.0092	.0085	.0060	.0022	.0039
1.6	.015	.026	.019	.0072	.013	.012	.0086	.0036	.0054
1.8	.020	.033	.024	.0097	.016	.015	.012	.0052	.0073
2.0	.025	.040	.030	.013	.021	.020	.015	.0073	.0094
2.2	.030	.047	.036	.016	.025	.024	.019	.0095	.012
2.4	.036	.055	.042	.019	.030	.029	.023	.012	.015
2.6	.043	.063	.048	.023	.035	.034	.028	.015	.018
2.8	.049	.072	.055	.027	.041	.040	.033	.018	.021
3.0	.056	.081	.062	.031	.047	.046	.038	.022	.025
4.0	.095	.13	.10	.062	.076	.079	.069	.044	.046
5.0	.14	.18	.14	.11	.12	.12	.11	.070	.072
6.0	.19	.24	.19	.13	.16	.16	.15	.10	.10
8.0	.30	.37	.30	.22	.25	.26	.24	.18	.17
10.0	.42	.51	.41	.30	.35	.37	.34	.26	.25

TABLE 2. The difference in range with and without the density correction for electrons - Continued

$$\int_0^E dE \cdot \frac{\delta}{B^{-}S^{-}}$$

Energy Mev	W	Au	Pb	U	Anthracene	Stilbene	Polystyrene	Polyethylene	Lucite
0.40					0.000029	0.000046	0.000023	0.000047	
.45					.00010	.00013	.00089	.00014	0.000058
.50					.00023	.00026	.00020	.00028	.00015
.55					.00039	.00043	.00035	.00048	.00029
.60					.00061	.00065	.00055	.00072	.00047
.65					.00088	.00092	.00080	.0010	.00070
.70	0.00038	0.00026		0.00033	.0012	.0012	.0011	.0014	.00098
.75	.00058	.00039		.00051	.0015	.0016	.0014	.0017	.0013
.80	.00077	.00053		.00067	.0020	.0020	.0018	.0022	.0017
.85	.00094	.00065		.00085	.0024	.0024	.0022	.0027	.0021
.90	.0011	.00079		.0010	.0029	.0029	.0027	.0032	.0025
.95	.0013	.00091	0.00029	.0012	.0034	.0034	.0032	.0037	.0030
1.0	.0015	.0011	.00048	.0013	.0040	.0040	.0037	.0044	.0035
1.2	.0023	.0018	.0012	.0021	.0067	.0067	.0063	.0071	.0060
1.4	.0033	.0028	.0019	.0031	.010	.0099	.0093	.010	.0091
1.6	.0047	.0041	.0027	.0045	.014	.014	.013	.014	.013
1.8	.0065	.0058	.0038	.0061	.017	.018	.017	.019	.017
2.0	.0085	.0078	.0050	.0082	.023	.022	.021	.023	.021
2.2	.011	.010	.0065	.010	.027	.027	.026	.028	.026
2.4	.014	.013	.0081	.013	.033	.032	.031	.034	.031
2.6	.017	.015	.010	.016	.038	.038	.037	.039	.036
2.8	.020	.020	.012	.019	.045	.044	.043	.045	.042
3.0	.024	.022	.015	.023	.050	.050	.049	.051	.048
4.0	.046	.046	.030	.045	.087	.085	.082	.086	.081
5.0	.076	.074	.051	.073	.13	.12	.12	.12	.12
6.0	.11	.11	.077	.11	.17	.17	.16	.17	.16
8.0	.19	.19	.14	.16	.27	.26	.26	.26	.25
10.0	.29	.28	.21	.28	.37	.37	.36	.36	.36

TABLE 2. The difference in range with and without the density correction for electrons - Continued

$$\int_0^E \frac{dE'}{\bar{B}\bar{S}}$$

Energy Mev	Toluene	Xylene	H_2O	AgCl	AgBr	Emulsion	LiI	NaI
0.45		0.000061						
.50	0.000055	.00011						
.55	.00014	.00022	0.000062					
.60	.00026	.00035	.00012					
.65	.00043	.00054	.00023					
.70	.00062	.00075	.00037			0.000046		
.75	.00087	.0010	.00055			.000087		
.80	.0011	.0013	.00076			.00014		
.85	.0015	.0017	.0010			.00021		
.90	.0018	.0020	.0013			.00030		0.000020
.95	.0022	.0025	.0016			.00041	0.000027	.000077
1.0	.0026	.0029	.0020			.00053	.000067	.000090
1.2	.0047	.0051	.0038			.0013	.00036	.00043
1.4	.0073	.0078	.0061		0.00038	.0024	.0011	.0010
1.6	.010	.011	.0089	0.00044	.00099	.0039	.0020	.0020
1.8	.014	.015	.012	.0011	.0019	.0058	.0034	.0032
2.0	.018	.019	.016	.0021	.0031	.0080	.0050	.0047
2.2	.022	.023	.020	.0035	.0046	.011	.0070	.0064
2.4	.027	.028	.024	.0052	.0065	.014	.0091	.0085
2.6	.031	.033	.028	.0072	.0086	.017	.011	.011
2.8	.037	.038	.033	.0095	.011	.020	.014	.013
3.0	.042	.043	.038	.012	.014	.024	.017	.016
4.0	.073	.075	.067	.029	.031	.047	.035	.033
5.0	.011	.11	.10	.051	.054	.075	.058	.055
6.0	.15	.15	.14	.079	.082	.11	.084	.080
8.0	.23	.24	.22	.14	.15	.18	.15	.14
10.0	.33	.33	.31	.22	.23	.27	.22	.21

TABLE 3. The difference in the range with and without the density correction for positrons

$$\int_0^E \frac{\delta}{B^+S^+} dE'$$

Energy Mev	Li	Be	C	Mg	Al	Fe	Cu	Ag	Sn
0.20	0.000090								
.25	.00012	0.00019	0.00014						
.30	.00016	.00038	.00027						
.35	.00023	.00064	.00045		0.00016				
.40	.00032	.00097	.00067	0.00017	.00027	0.00021			
.45	.00045	.0014	.00095	.00035	.00040	.00036			
.50	.00062	.0018	.0013	.00035	.00056	.00051	0.00018		
.55	.00085	.0024	.0017	.00053	.00074	.00068	.00030		
.60	.0011	.0030	.0021	.00054	.00097	.00089	.00044		0.00022
.65	.0014	.0037	.0026	.00075	.0012	.0011	.00058		.00035
.70	.0018	.0044	.0031	.00079	.0015	.0014	.00076	0.000084	.00048
.75	.0022	.0053	.0037	.0010	.0019	.0017	.00096	.00014	.00062
.80	.0027	.0061	.0044	.0011	.0022	.0020	.0012	.00020	.00076
.85	.0032	.0071	.0050	.0014	.0026	.0024	.0014	.00027	.00092
.90	.0037	.0081	.0058	.0016	.0031	.0028	.0017	.00035	.0011
.95	.0043	.0091	.0065	.0019	.0036	.0033	.0020	.00044	.0013
1.0	.0050	.010	.0074	.0021	.0041	.0037	.0024	.00056	.0015
1.2	.0080	.015	.011	.0035	.0064	.0061	.0041	.0012	.0025
1.4	.012	.021	.015	.0053	.0095	.0089	.0063	.0022	.0038
1.6	.016	.027	.021	.0075	.013	.012	.0091	.0036	.0054
1.8	.021	.034	.026	.010	.017	.016	.012	.0054	.0074
2.0	.026	.041	.032	.013	.021	.021	.016	.0075	.0097
2.2	.032	.049	.038	.017	.026	.025	.020	.010	.012
2.4	.038	.058	.044	.020	.031	.031	.025	.013	.015
2.6	.045	.066	.051	.024	.037	.036	.030	.016	.019
2.8	.052	.075	.058	.029	.043	.042	.035	.019	.022
3.0	.059	.085	.065	.033	.049	.048	.040	.023	.026
4.0	.10	.14	.11	.060	.084	.084	.073	.046	.048
5.0	.15	.19	.15	.092	.12	.12	.11	.075	.076
6.0	.20	.26	.20	.13	.17	.17	.16	.11	.11
8.0	.31	.39	.31	.21	.27	.27	.25	.19	.18
10.0	.44	.53	.43	.30	.38	.39	.37	.28	.27

TABLE 3. The difference in the range with and without the density correction for positrons - Continued

$$\int_0^E \frac{\delta}{B^+S^+}\, dE'$$

Energy Mev	W	Au	Pb	U	Anthracene	Stilbene	Polystyrene	Polyethylene	Lucite
0.40					0.000030	0.000046	0.000023	0.000048	
.45					.00011	.00013	.000090	.00014	0.000058
.50					.00023	.00026	.00020	.00029	.00015
.55					.00040	.00044	.00036	.00049	.00029
.60					.00062	.00066	.00056	.00074	.00048
.65					.00090	.00094	.00081	.0010	.00072
.70					.0012	.0013	.0011	.0014	.0010
.75					.0016	.0016	.0015	.0018	.0013
.80					.0020	.0020	.0018	.0022	.0017
.85					.0025	.0025	.0023	.0027	.0021
.90					.0030	.0030	.0028	.0033	.0026
.95	0.00031	0.00022	0.00031		.0035	.0036	.0033	.0039	.0031
1.0	.00050	.00038	.00050	0.00028	.0041	.0042	.0038	.0045	.0028
1.2	.0014	.0011	.0013	.0013	.0070	.0069	.0065	.0074	.0063
1.4	.0025	.0022	.0021	.0022	.010	.010	.0097	.011	.0086
1.6	.0040	.0036	.0029	.0038	.014	.014	.013	.015	.013
1.8	.0058	.0054	.0040	.0054	.019	.019	.018	.019	.017
2.0	.0080	.0076	.0053	.0078	.024	.023	.022	.024	.022
2.2	.011	.010	.0069	.010	.029	.029	.027	.030	.026
2.4	.014	.013	.0087	.013	.035	.034	.033	.035	.032
2.6	.017	.016	.011	.016	.041	.040	.039	.041	.037
2.8	.021	.020	.013	.020	.047	.046	.045	.047	.044
3.0	.025	.024	.016	.024	.054	.053	.051	.054	.049
4.0	.050	.049	.033	.048	.091	.089	.086	.090	.085
5.0	.081	.080	.055	.077	.13	.13	.13	.13	.12
6.0	.12	.12	.082	.11	.18	.18	.17	.18	.17
8.0	.21	.20	.15	.20	.28	.28	.27	.27	.27
10.0	.31	.30	.23	.29	.39	.39	.38	.38	.37

TABLE 3. The difference in the range with and without the density correction for positrons - Continued

$$\int_0^E \frac{\delta}{B^+S^+}$$

Energy Mev	Toluene	Xylene	H_2O	AgCl	AgBr	Emulsion	LiI	NaI
0.45		0.000018						
.50	0.000056	.000079						
.55	.00014	.00018	0.000019					
.60	.00026	.00032	.000083					
.65	.00043	.00051	.00019					
.70	.00064	.00074	.00033			0.000048		
.75	.00089	.0010	.00052			.000090		
.80	.0012	.0013	.00074			.00015		
.85	.0015	.0017	.0010			.00022		
.90	.0019	.0021	.0013			.00031		0.000021
.95	.0023	.0025	.0017			.00042	0.000029	.000038
1.0	.0027	.0030	.0020			.00056	.000071	.000095
1.2	.0049	.0053	.0039			.0013	.00046	.00045
1.4	.0076	.0081	.0064		0.00040	.0025	.0012	.0011
1.6	.011	.011	.0093	0.00047	.0010	.0041	.0023	.0021
1.8	.015	.015	.013	.0012	.0020	.0061	.0037	.0034
2.0	.019	.019	.016	.0023	.0033	.0085	.0054	.0049
2.2	.023	.024	.021	.0037	.0049	.011	.0075	.0068
2.4	.028	.029	.025	.0055	.0069	.014	.0098	.0090
2.6	.033	.034	.030	.0076	.0092	.018	.012	.011
2.8	.038	.040	.035	.010	.012	.022	.015	.014
3.0	.044	.046	.040	.013	.015	.026	.018	.017
4.0	.076	.078	.071	.031	.033	.050	.038	.035
5.0	.11	.12	.11	.051	.058	.080	.062	.058
6.0	.15	.16	.14	.084	.087	.11	.090	.085
8.0	.25	.25	.23	.15	.16	.19	.16	.15
10.0	.35	.35	.33	.24	.24	.29	.23	.22

TABLE 4. The density correction δ_{B-S} to the stopping number

ENERGY MEV	Li	Be	C	Al	Cu	Ag	Sn	Pb	U	Anthracene	Poly-styrene	H_2O	AgBr
.25	0.0381	0.0128	0.0137		0.0172								
.3	.0697	.0316	.0365		.0256					0.000458			
.35	.104	.0572	.0647		.0376					.0365	0.0256	0.00688	
.4	.141	.0871	.0959		.0544					.0733	.0591	.0124	
.45	.178	.119	.129		.0731					.110	.0930	.0234	
.5	.215	.153	.163		.0940		0.00213		0.0156	.147	.128	.0382	
.55	.253	.188	.198		.116	0.00377	.00499		.0175	.184	.163	.0558	0.00402
.6	.290	.224	.233		.138	.0160	.00959		.0204	.221	.197	.0755	.00555
.65	.327	.259	.268		.160	.0291	.0156		.0255	.256	.231	.0964	.00943
.7	.363	.295	.303		.184	.0432	.0226		.0310	.292	.265	.118	.0149
.75	.399	.331	.338		.206	.0581	.0306		.0377	.327	.299	.141	.0217
.8	.435	.366	.372		.230	.0731	.0396		.0454	.361	.332	.165	.0298
.85	.470	.401	.406		.253	.0887	.0489	0.0205	.0537	.395	.365	.189	.0386
.9	.504	.436	.440	0.00232	.276	.105	.0592	.0250	.0623	.428	.397	.214	.0481
.95	.538	.471	.473	.0170	.299	.120	.0693	.0293	.0711	.460	.429	.239	.0580
1.0	.572	.505	.506	.0367	.322	.137	.0805	.0351	.0804	.492	.460	.264	.0689
1.2	.700	.637	.634	.116	.412	.203	.126	.0609	.120	.616	.581	.363	.115
1.4	.821	.763	.754	.197	.499	.268	.174	.0915	.162	.731	.695	.462	.165
1.6	.935	.882	.869	.278	.582	.333	.223	.125	.205	.840	.803	.558	.217
1.8	1.04	.996	.978	.358	.661	.395	.271	.160	.248	.943	.905	.651	.268
2.0	1.15	1.10	1.08	.436	.738	.457	.320	.196	.291	1.04	1.00	.742	.320
2.2	1.24	1.21	1.18	.511	.811	.516	.367	.232	.333	1.13	1.09	.829	.371
2.4	1.33	1.30	1.27	.581	.882	.574	.414	.268	.375	1.22	1.18	.913	.422
2.6	1.42	1.40	1.36	.656	.950	.629	.459	.304	.416	1.31	1.27	.994	.471
2.8	1.51	1.49	1.45	.725	1.01	.684	.504	.340	.455	1.39	1.35	1.07	.519
3.0	1.59	1.57	1.53	.792	1.08	.737	.548	.376	.495	1.47	1.43	1.15	.567
4.0	1.95	1.96	1.90	1.10	1.36	.979	.752	.545	.679	1.82	1.78	1.49	.789
5.0	2.26	2.28	2.22	1.37	1.61	1.19	.934	.701	.845	2.11	2.07	1.79	.989
6.0	2.53	2.56	2.49	1.60	1.83	1.38	1.10	.844	.995	2.38	2.33	2.05	1.17
8.0	2.98	3.04	2.95	2.00	2.20	1.71	1.39	1.10	1.26	2.81	2.77	2.49	1.48
10.0	3.35	3.42	3.32	2.34	2.50	1.99	1.64	1.32	1.49	3.17	3.13	2.86	1.75

TABLE 5. Range of electrons including δ_{B-S}

Energy Mev	Li	Be	C	Al	Cu	Ag	Sn	Pb	U	Anthracene	Polystyrene	H_2O	AgBr
.01	0.000270	0.000294	0.000274	0.000335	0.000438	0.000535	0.000568	0.000735	0.000795	0.000260	0.000242	0.000241	0.000512
.02	.000941	.00101	.000936	.00112	.00141	.00167	.00176	.00218	.00232	.000857	.000831	.000824	.00161
.03	.00197	.00210	.00194	.00230	.00287	.00337	.00356	.00436	.00463	.00179	.00173	.00171	.00327
.04	.00329	.00349	.00323	.00379	.00468	.00544	.00573	.00692	.00720	.00296	.00288	.00285	.00528
.05	.00490	.00520	.00479	.00561	.00688	.00798	.00840	.0101	.0107	.00441	.00428	.00423	.00775
.06	.00675	.00714	.00658	.00767	.00936	.0108	.0114	.0136	.0142	.00605	.00588	.00581	.0105
.07	.00886	.00936	.00861	.0100	.0122	.0140	.0137	.0175	.0185	.00794	.00771	.00761	.0136
.08	.0112	.0118	.0108	.0126	.0152	.0175	.0184	.0218	.0228	.00998	.00970	.00958	.0170
.09	.0137	.0144	.0133	.0154	.0186	.0213	.0214	.0264	.0278	.0123	.0119	.0117	.0207
.10	.0164	.0173	.0159	.0183	.0221	.0253	.0265	.0313	.0328	.0149	.0142	.0140	.0246
.15	.0325	.0341	.0313	.0359	.0430	.0488	.0512	.0599	.0629	.0306	.0281	.0277	.0477
.2	.0520	.0544	.0498	.0570	.0678	.0768	.0805	.0936	.0980	.0489	.0448	.0442	.0750
.25	.0741	.0774	.0708	.0808	.0957	.108	.113	.131	.138	.0702	.0637	.0628	.106
.3	.0982	.102	.0936	.107	.126	.142	.148	.172	.180	.0928	.0843	.0830	.139
.35	.124	.129	.118	.134	.158	.177	.186	.215	.224	.117	.106	.105	.174
.4	.151	.157	.143	.162	.191	.214	.225	.259	.270	.143	.129	.127	.210
.45	.179	.186	.170	.192	.226	.253	.265	.305	.318	.170	.153	.150	.248
.5	.208	.216	.197	.222	.261	.292	.347	.351	.367	.197	.177	.174	.286
.55	.237	.246	.225	.253	.297	.332	.390	.399	.416	.225	.203	.199	.326
.6	.268	.277	.253	.285	.334	.372	.432	.447	.466	.253	.228	.224	.365
.65	.298	.309	.282	.317	.371	.413	.475	.495	.517	.283	.254	.249	.406
.7	.330	.341	.311	.349	.409	.455	.519	.544	.568	.312	.281	.275	.446
.75	.361	.373	.341	.381	.447	.496	.562	.593	.619	.342	.307	.301	.487
.8	.393	.406	.370	.414	.485	.538	.606	.642	.671	.371	.334	.327	.528
.85	.425	.439	.400	.446	.523	.580	.650			.402	.361	.353	.569
.9	.457	.472	.430	.479	.562	.622	.694			.432	.388	.380	.611
.95	.489	.505	.461	.512	.600	.665	.738			.463	.416	.406	.652
1.0	.522	.539	.491	.545	.639	.707	.915			.493	.443	.433	.693
1.2	.653	.673	.613	.678	.794	.877	1.09			.617	.554	.540	.860
1.4	.785	.809	.737	.812	.950	1.05				.742	.665	.649	1.03
1.6	.918	.945	.860	.945	1.11					.867	.777	.757	1.19
1.8	1.05	1.08	.984	1.08	1.26					.993	.888	.865	1.36
2.0	1.18	1.22	1.11	1.21	1.42					1.12	1.00	.973	1.52
2.2	1.32	1.35	1.23	1.34	1.57					1.24	1.11	1.08	
2.4	1.45	1.49	1.35	1.48	1.72					1.37	1.22	1.19	
2.6	1.58	1.62	1.48	1.61	1.87					1.49	1.33	1.30	
2.8	1.71	1.76	1.60	1.74	2.03					1.62	1.44	1.40	
3.	1.84	1.89	1.72	1.87						1.74	1.55	1.51	
4.	2.49	2.56	2.32	2.51						2.36	2.10	2.04	
5.	3.14	3.22	2.92	3.15						2.97	2.64	2.56	
6.	3.78	3.87	3.51	3.77						3.57	3.17	3.07	
8.	5.04	5.16	4.68							4.76	4.22	4.09	
10.	6.28									5.94	5.26		

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