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**Analytic Flux Formulas
and Tables of Shielding Functions**

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MASTER

**Bettis Atomic Power Laboratory
West Mifflin, Pennsylvania 15122**

June 1981

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ABSTRACT

Hand calculations of radiation flux and dose rates are often useful in evaluating radiation shielding and in determining the scope of a problem. The flux formulas appropriate to such calculations are almost always based on the point kernel and allow for at most the consideration of laminar slab shields. These formulas often require access to tables of values of integral functions for effective use. This report gives flux formulas and function tables appropriate to calculations involving homogeneous source regions with the shapes of lines, disks, slabs, truncated cones, cylinders, and spheres. Slab shields may be included in most of these calculations, and the effect of a cylindrical shield surrounding a cylindrical source may be estimated. Detector points may be located axially, laterally, or interior to a cylindrical source. Line sources may be tilted with respect to a slab shield. All function tables are given for a wide range of arguments.

PREFACE

Hand calculations of radiation fluxes, dose rates, and energy absorption rates are still necessary even in the present age of digital computers. Such calculations are often done in order to obtain a quick answer to a simplified problem. Hand calculations also have a definite place in the preliminary scoping studies which define the rough outlines of a shield design problem.

Hand calculations are appropriate to problems involving both gamma-ray and neutron sources, provided that the shields are laminar and regular, and that, in the case of a neutron source, the detector points lie in homogeneous material outside any other shields.

For many years two standard references for hand calculation methods have been the Reactor Shielding Design Manual, edited by T. Rockwell, and the Engineering Compendium on Radiation Shielding, edited by R. Jaeger. However, a considerable amount of work has been done in this field in recent years, including contributions by H. Ono and A. Tsuru and by Bettis Laboratory personnel. Thus, more accurate and more convenient cylindrical source approximations are available from the work of Foderaro and from the work of Ono and Tsuru than are given by either Rockwell or Jaeger. Further, tables of shielding functions are now available that cover greater ranges in more detail than those given by Jaeger and that are free of the errors found in the Engineering Compendium.

This report is therefore an effort to supply the shielding engineer with a relatively complete; up-to-date, and convenient reference for radiation hand calculations. It includes a set of semi-analytic flux and dose rate calculation formulas (based on the point kernel), the shielding function tables required by these formulas, and a minimally adequate set of library-type shielding data.

These latter data include, for gamma rays, total attenuation coefficients, energy absorption coefficients, flux-to-dose conversion factors, buildup factors, and source energy and yield data; and for neutrons, removal cross section kernel data are given. Data for only a few materials such as water, iron, and lead are given because of space limitations.

The flux calculation formulas given here assume that source strength distributions are uniform and that, in general, the shields are laminar slabs.* The shielding functions required by these formulas have at most three arguments. More complicated formulas and function tables are not given because they become voluminous and are therefore more difficult and time-consuming to use. Calculations requiring such refinements are better done by computers.

* Nomograms are given for estimating the effect of converting a slab shield of a given thickness to a cylindrical shield, and an approximate method of finding the effect of a spherical shield versus a slab shield is also given.

Interpolation of shielding function tables to find accurate function values for intermediate values of the arguments may also be time-consuming. Therefore, the most useful function tables in this report are given in a compact form with exponential dependence removed, so that they may be interpolated linearly with acceptable accuracy.

The flux formulas given here are appropriate to radiation sources having the shapes of lines, disks, rectangular planes, slabs, truncated cones, cylinders, and spheres. The formulas for rectangular plane sources and for a cylindrical source with a lateral detector point are approximations. Since this cylindrical source approximation is a very useful tool, considerable information about its accuracy is also given. Cylindrical source flux formulas are also given for detector points located on the cylindrical axis both internal and external to the source volume. Detector points may also be located internally or externally with respect to slab and spherical sources. Line sources may be tilted with respect to their shields.

The truncated cone source may be used as a basis for several approximations, and approximations to some surface sources may be achieved by using either a truncated cone surface source or line sources.

The formulas given in the main section of this report are set up to calculate uncollided or scalar gamma-ray fluxes. In order to find, for example, a total gamma-ray dose rate, both a gamma-ray flux-to-dose conversion factor and a gamma-ray buildup factor must be included in the calculation. In order to expedite such calculations, a set of dose rate (or energy absorption rate) formulas containing gamma-ray buildup factors, expressed in terms of Taylor Exponential Coefficients, is included in an appendix.

TABLE OF CONTENTS

	<u>Page</u>
A. Introduction	1
1. General Information	1
2. The Point Kernel	2
3. Radiation Sources	5
a. Activation Gammas	5
b. Gammas from U^{235} Fission Products	7
c. Capture Gammas	10
d. Prompt Fission Gammas in Core	10
e. Neutrons in the Core	10
f. Fission Gammas	11
B. Flux Formulas	11
1. Uniform Disk Source, No Shield	12
2. Uniform Disk Source with Shield	12
3. Infinite Slab Source of Infinite Depth, Self-Absorbing, No Shield	13
4. Infinite Slab Source of Infinite Depth, Self-Absorbing with Shield	13
5. Infinite Slab Source, Self-Absorbing, No Shield	13
6. Infinite Slab Source, No Self-Absorption, with Shield	14
7. Infinite Slab Source, Self-Absorbing, with Shield	14
8. Cylindrical Source, No Self-Absorption, No Shield, Axial Detector Point	14
9. Cylindrical Source, Self-Absorbing, No Shield, Axial Detector Point	15
10. Cylindrical Source, Non-Absorbing, with Shield, Axial Detector Point	15
11. Cylindrical Source, Self-Absorbing, with Shield, Axial Detector Point	16
12. Cylindrical Source Interior, Self-Absorbing, Detector Point on Axis	16
13. Cylindrical Source Approximation, Self-Absorbing with Shield, Lateral Detector Point	17
14. Cylindrical Surface Source with Lateral Detector Point, No Shield	20
15. Cylindrical Surface Source with Axial Detector Point	20
16. Cylindrical Surface Source with Interior Detector Point, No Exponential Attenuation	20
17. Cylindrical Surface Source with Axial Detector Point, No Self-Attenuation, and an Intervening Slab Shield	21
18. Truncated Cone Source, Self-Absorbing with Shield, Apex Point	21
19. Truncated Cone Surface Source, Detector Point at Apex	22

TABLE OF CONTENTS (Continued)

	<u>Page</u>
20. Approximations Using Truncated Cone and Cylindrical Sources	22
a. Cylinder with Axial Point	22
b. Finite Slab with Exterior Detector Point	23
c. Annulus with Exterior Point	23
d. Sphere with Exterior Point	23
21. Truncated Cone Source, Not Self-Absorbing, with Shield, Apex Point	24
22. Truncated Cone Source, Self-Absorbing, No Shield, Apex Point	24
23. Truncated Cone Source, Not Self-Absorbing, No Shield, Apex Point	24
24. Spherical Source, No Self-Absorption, No Shield	25
25. Spherical Source, Self-Absorbing, No Shield	25
26. Spherical Source, Self-Absorbing with Slab Shield	26
27. A Special Case of a Spherical Source with a Spherical Shield	27
28. Line Source with Parallel Shield	27
29. Line Source without Shield	28
30. Line Source with Perpendicular Slab Shield	29
31. Line Source with Slab Shield Tilted Out at Bottom, and Lateral Detector Point	30
32. Line Source with Slab Shield Tilted Out at Top and Lateral Detector Point	30
33. Circular Line Source with Exterior Detector Point, No Shield	30
34. Circular Line Source with Interior Detector Point	30
35. Annular Disk Source with Interior Detector Point	31
36. Disk Source with Exterior Lateral Detector Point	31
37. Rectangular Surface Source with Detector Point on Perpendicular to Corner, No Shield	32
38. Rectangular Surface Source with Lateral Detector Point	32
39. Spherical Surface Source, No Shield	33
 C. Shielding Functions - Tables and Plots	 53
1. The Compact Exponential Integral Functions $\bar{E}_1(b)$ and $\bar{E}_2(b)$	53
2. The Exponential Function e^{-x}	57
3. The Function $D(\mu R, \mu a, \mu h)$	60
4. The Function $Z(b', a/l, R/l)$	68
5. The Function $Z(b', R/l)$	76
6. The Function $C(R/l, b, a/l)$	78
7. The Function $G(\mu_{gh}, \mu_{gR})$	88
8. The Function $L_0(\phi_0, b)$	88
9. The Compact Function $\bar{G}(\theta_0, b)$	95
10. The Compact Function $\bar{F}(\theta_0, b)$	95
11. The Function $S(a/R, \mu_{gR})$	102
12. The Function $S(b, a/R, \mu_{gR})$	104

TABLE OF CONTENTS (Continued)

	<u>Page</u>
13. M_C - The Factor which Equalizes the Areas of the Bases of the Cylinder and the Annular Sector	113
14. M_S - The Factor which Equalizes the Volumes of the Sphere and the Conical Sector of a Spherical Shell	113
15. Relation of ϕ_0 and θ_0 to the Geometry of the Cylinder	115
16. Conditions for Accurate Results from the Cylindrical Source Approximation	118
17. Estimating the Effect of a Cylindrical Shield	119
D. Information About Shielding Functions	120
1. Exponential Integral Functions	120
2. Sievert's Integral of the First Kind	123
3. The G-Function Defined by Ono and Tsuru	123
4. The L_0 Function Defined by Ono and Tsuru	124
5. The G-Function Defined by Rockwell	125
6. Relations Between Functions	125
E. Total Flux Formulas Using Taylor Exponential Build-Up Factor Coefficients	127
1. Uniform Disk Source, with Shield	127
2. Infinite Slab Source of Infinite Depth, Self-Absorbing, No Shield	128
3. Infinite Slab Source of Infinite Depth, Self-Absorbing, with Shield	128
4. Infinite Slab Source, Self-Absorbing, No Shield	128
5. Infinite Slab Source, No Self-Absorption, with Shield	128
6. Infinite Slab Source, Self-Absorbing, with Shield	128
7. Cylindrical Source, Self-Absorbing, No Shield, Axial Detector Point	129
8. Cylindrical Source, Non-Absorbing, with Shield, Axial Detector Point	129
9. Cylindrical Source, Self-Absorbing, with Shield, Axial Point	129
10. Cylindrical Source, Self-Absorbing, Detector Point on Axis	129
11. Cylindrical Source Approximation, Self-Absorbing, with Shield, Lateral Detector Point	130
12. Truncated Cone Source, Self-Absorbing with Shield, Apex Point	130
13. Truncated Cone Source, Self-Absorbing, No Shield, Apex Point	130
14. Spherical Source, Self-Absorbing, No Shield	130
15. Spherical Source, Self-Absorbing with Shield	131
16. Line Source with Shield	131

TABLE OF CONTENTS (Continued)

	<u>Page</u>
F. Library Data	133
1. Taylor Exponential Coefficients for Gamma-Ray Build-Up for Water, Iron and Lead	134
2. Gamma-Ray Dose Rate Conversion Factors	142
3. Neutron Removal Cross Section Kernels	143
4. Neutron Removal Cross Section Data	146
5. Gamma-Ray Cross Section Data for Some Common Shielding Materials	148
6. Nomograms for Estimating the Effects of Slab Shields Versus Cylindrical Shields	151
7. Activation, Capture and Fission Gamma Sources	154
G. Sample Problems	158
H. References	160
I. Acknowledgement	163
J. Appendix - A. Foderaro's Approximations of Cylindrical Sources.	164

LIST OF FIGURES

	<u>Page</u>
1. Decay-Gamma Calculation	6
2. Uniform Disk Source	34
3. Uniform Disk Source Detail	34
4. Infinite Slab Source of Infinite Depth	34
5. Infinite Slab Source of Finite Depth	35
6. Cylindrical Source with Axial Point	35
7. Cylindrical Source with Shield and Axial Point	35
8. Cylindrical Source Interior	36
9. Cylindrical Source-Volume Approximation Using a Section of an Annulus with a Curved Top Surface	36
10. Cylindrical Source with Exterior Detector Points	37
11a. Accuracy of the Cylindrical Source Approximation of Ono and Tsuro	38
11b. Accuracy of the Cylindrical Source Approximation of Ono and Tsuro	38
12. Cylindrical Surface Source with Lateral Detector Point	39
13. Cylindrical Surface Source with Interior Detector Point, No Attenuation	40
14. Cylindrical Surface Source with Axial Point and Slab Shield	40
15. Truncated Cone Source with Detector Point at Apex	41
16. Truncated Cone Surface Source with Slab Shield, Detector Point at Apex	41
17. Approximation of a Cylinder with Axial Detector Point Using Truncated Cones	42
18a. Annular Source	42
18b. Approximation of an Annular Source Using a Truncated Cone	42

LIST OF FIGURES (Continued)

	<u>Page</u>
19. Spherical Source Approximated as a Conical Section of a Spherical Cell	43
20. Accuracy of Spherical Source Approximation	44
21. Spherical Source	45
22. Line Source	45
23a. Line Source with Perpendicular Slab Shield	46
23b. Line Source with Perpendicular Slab Shield	46
24. Line Source with Slab Shield, and Equivalent Circular Arc Source	46
25a. Line Source with Tilted Slab Shield	47
25b. Line Source with Tilted Slab Shield	47
26. Circular Line Source with Exterior Detector Point	48
27. Circular Line Source with Detector Point in Center	48
28. Circular Line Source with Detector Point at End of a Diameter	49
29. Circular Line Source with Arbitrary Interior Detector Point	49
30. Annular Disk Source with Detector Point at Center	50
31. Annular Disk Source with Detector Point Arbitrarily Located Inside the Annulus	50
32. Disk Source with Exterior Lateral Detector Point	51
33. Rectangular Surface Source with Detector Point on Perpendicular	51
34. Rectangular Surface Source with Lateral Detector Point	52
35. Spherical Surface Source with No Shield	52
36. $\bar{E}_1(b) = be^b E_1(b)$	55
37. $\bar{E}_2(b) = be^b E_2(b)$	56
38. $L_0(\phi_0, b)$	91
39. $L_0(\phi_0, b)$	92

LIST OF FIGURES (Continued)

	<u>Page</u>
40. $G(\mu_s h, \mu_s R)$	93
41. $G(\mu_s h, \mu_s R)$	94
42. $\bar{F}(\theta_0, b) = (e_b/\theta_0) F(\theta_0, b)$	98
43. $\bar{F}(\theta_0, b) = (e_b/\theta_0) F(\theta_0, b)$	99
44. $\bar{G}(\theta_0, b) = (e_b/\theta_0) G(\theta_0, b)$	100
45. $\bar{G}(\theta_0, b) = (e_b/\theta_0) G(\theta_0, b)$	101
46. Effective Macroscopic Fast Neutron Dose Rate Removal Cross Section as a Function of Thickness of Hydrogenous Material (Polyethylene) Intervening Between Iron or Lead Shield and the Detector Point	147
47. Cylindrical vs Flat Shield for $l/R \geq 2$ and $\mu_s R \geq 4$	152
48. Cylindrical vs Flat Slab Shield: Additional Factor for $\mu_s R < 4$	153

LIST OF TABLES

	<u>Page</u>
1. The Compact Exponential Integral Functions $\bar{E}_1(b)$ and $\bar{E}_2(b)$	53
2. The Exponential Function e^{-x}	58
3. The Function $D(\bar{\mu}R, \bar{\mu}a, \bar{\mu}h)$	61
4. The Function $Z(b', a/l, R/l)$	69
5. The Function $Z(b', R/l)$	77
6. The Function $C(R/l, b, a/l)$	79
7. The Function $G(\mu_s h, \mu_s R)$	89
8. The Function $L_0(\phi_0, b)$	90
9. The Compact Function $\bar{G}(\theta_0, b)$	96
10. The Compact Function $\bar{F}(\theta_0, b)$	97
11. The Function $S(a/R, \mu_s R)$	103
12. The Function $S(b, a/R, \mu_s R)$	105
13. M_C - The Factor which Equalizes the Areas of the Bases of the Cylinder and the Annular Sector	114
14. M_s - The Factor which Equalizes the Volumes of the Sphere and the Conical Sector of a Spherical Shell	114
15. Relation of ϕ_0 and θ_0 to the Geometry of the Cylinder	116
16. Conditions for Accurate Results from the Cylindrical Source Approximation	118
17. Gamma-Ray Dose Build-Up Factors for Water	135
18. Detailed Evaluation of Taylor Exponential Coefficient Representation of Dose Build-Up Factors for Water	136
19. Gamma-Ray Energy Absorption Build-Up Factors for Water	137
20. Gamma-Ray Dose Build-Up Factors for Iron	138
21. Gamma-Ray Energy Absorption Build-Up Factors for Iron	139
22. Gamma-Ray Dose Build-Up Factors for Lead	140

LIST OF TABLES (Continued)

	<u>Page</u>
23. Gamma-Ray Energy Absorption Build-Up Factors for Lead	141
24. Gamma-Ray Dose-Rate Conversion Factors	142
25. Microscopic Neutron Removal Cross Sections and Multipliers	146
26. Nominal Number Densities of Common Shielding Materials	148
27. Gamma-Ray Nominal Macroscopic Attenuation Coefficients	149
28. Gamma-Ray Nominal Macroscopic Energy Absorption Coefficients	150
29. Activation Gamma Sources	155
30. Capture Gamma Sources	156
31. Fission Gamma Sources	157

Analytic Flux Formulas and
Tables of Shielding Functions

O. J. Wallace

A. Introduction

1. General Information

The information in the tables of functions given here was generated on a CDC-6600 computer using 32-point Gauss-Legendre quadrature. Except for spot checks against tabular data given in References (1) through (6), no error analysis of these data has been made. A detailed error analysis for one function is given in Reference (4), which applies also to much of the work reported here. Gauss quadrature is discussed in Reference (6).

Tables of various shielding functions are given in References (1) through (6); but in none of these publications are the set of functions as complete as those given here, except in Reference (2), and the tables in Reference (2) contain many errors. Also, in many cases, the tables given here are more detailed and span a greater range of arguments than those given in the references. The most useful tables given here are displayed in compact form (see Reference (7)) which makes interpolation between values very easy.

Only slab shields are considered in the functions tabulated here because interpolation of function tables having more than three arguments is tedious and error prone. However, nomograms are given which enable the user to estimate the flux from a cylindrical source with a cylindrical shield of thickness t if the flux from the same source with a slab shield of the same thickness is known.

Most of the flux formulas given here have been programmed as part of the SPAR1 point-kernel computer program for shielding (Reference (8)), and values from these function tables have been spot checked against SPAR1 calculations.

This report also includes formulas for total gamma ray fluxes in which the Taylor exponential coefficient representing the build-up factors appear explicitly, and a limited amount of cross section and other data for common shielding materials is included for the convenience of users of this report.

2. The Point Kernel

The basis for all the flux formulas treated in this report is the point kernel

$$\phi(\vec{r}) = \frac{S(\vec{r}') e^{-b}}{4\pi |\vec{r} - \vec{r}'|^2} \quad (1)$$

where $\phi(\vec{r})$ is the uncollided flux at the detector point \vec{r} from a point source of strength S located at \vec{r}' . That is, if $S(\vec{r}')$ is given in gammas/second, $\phi(\vec{r})$ has units of gammas/cm²-sec in Equation (1). In the process of tracing a straight line from \vec{r}' to \vec{r} , various materials are encountered, and we may define $b = \sum_{i=1}^N \mu_i t_i$ as the total optical distance through N shielding material having thicknesses t_i and corresponding macroscopic attenuation coefficients μ_i . Equation (1) is valid for gamma ray calculations and for those neutron calculations in which the use of a neutron point kernel with removal cross sections Σ_{r_i} replacing the μ_i is permissible. Such neutron kernels may be used if the shields are uniform and at least fifteen centimeters of hydrogenous material lies between the last non-hydrogenous shield and the detector point. More information on neutron point kernels, including spectral information, their use when less than fifteen centimeters of following hydrogenous material is present, and a data table, is given in Sections F.3 and F.4 of this report. This material comes from References (9) and (10).

The μ_i are functions of material and (source radiation) energy group, and the Σ_{r_i} are functions of material.

The integration of the point kernel over an extended volume yields

$$\phi(\vec{r}) = \int_V \frac{S(\vec{r}') e^{-b} dV}{4\pi |\vec{r} - \vec{r}'|^2}, \quad (2)$$

$$\text{where } b = \sum_{i=1}^N \mu_i t_i + \mu_s z(\vec{r}, \vec{r}', a).$$

Here μ_s is the macroscopic attenuation coefficient of the source material and $\mu_s z(\vec{r}, \vec{r}', a)$ is the optical distance within the source volume and depends on \vec{r}' , the distance a from the source boundary to the detector point \vec{r}' , and the geometry of the source. If $S(\vec{r}')$ is given in gammas/cm³-sec, the units of $\phi(\vec{r})$ in Equation (2) are gammas/cm²-sec.

In all formulas considered here, the source strength distribution $S(\vec{r}')$ is assumed to be a constant such that

$$\int_V S(\vec{r}') dV = S_V \int_V dV = VS_V \quad (3)$$

so that Equation (2) becomes

$$\phi(\vec{r}) = \frac{S_V}{4\pi} \int_V \frac{e^{-b}}{|\vec{r} - \vec{r}'|^2} dV \quad (4)$$

Further, we also assume that the source radiation is isotropic, giving the factor

$$\frac{1}{4\pi |\vec{r} - \vec{r}'|^2} \text{ in Equations (2) and (4).}$$

The uncollided gamma flux ϕ from Equation (4) may be converted to an uncollided dose rate D_{un} or an uncollided energy absorption rate EA_{un} by multiplication by the appropriate dose conversion factor k_D or energy absorption coefficient k_{ea} giving,

$$D_{un} = k_D \frac{S_V}{4\pi} \int_V \frac{e^{-b} dV}{|\vec{r} - \vec{r}'|^2} \quad (5)$$

and

$$EA_{un} = k_{ea} \frac{S_V}{4\pi} \int_V \frac{e^{-b} dV}{|\vec{r} - \vec{r}'|^2} \quad (6)$$

k_D is a function of energy, and k_{ea} is a function of material and energy.

The units of k_D are $\frac{\text{millirem/hour}}{\text{gammas/cm}^2\text{-sec}}$.

The units of k_{ea} are watt-seconds/cm at energy E , so that $k_{ea} \phi$ has units of $\frac{\text{watts/cm}^3}{\text{cm}^2\text{-sec}}$, where ϕ has units of $\frac{1}{\text{cm}^2\text{-sec}}$. k_{ea} is defined by

$$k_{ea}(E,Z) = N(Z) \sigma_{ea}(E,Z) kE$$

where:

$\sigma_{ea}(E,Z)$ = microscopic gamma-ray energy absorption cross section of material Z at energy E, in barns/atom, barns/molecule, or cm^2/gm .

E = gamma-ray energy group central energy, in MeV.

N(Z) = number density of material Z, in atoms/barn-cm, molecules/barn-cm, or gm/cm^3 , and

k = 1.6×10^{-13} watt-second/MeV.

The total dose rate D and the total energy absorption rate EA may be found by applying the appropriate gamma-ray buildup factor B(b) to Equation (5) or (6). For good results, B(b) should appear under the integral sign. The most analytically convenient form of B(b) is the Taylor exponential form

$$B(b) = A e^{-\alpha_1 b} + (1-A) e^{-\alpha_2 b} \quad (7)$$

which converts Equation (5) to the form

$$D = k_D \frac{S_V}{4\pi} \left[A \int_V \frac{e^{-b(1+\alpha_1)}}{|\vec{r} - \vec{r}'|^2} dV + (1-A) \int_V \frac{e^{-b(1+\alpha_2)}}{|\vec{r} - \vec{r}'|^2} dV \right] \quad (8)$$

which gives the total dose rate D. Likewise for the total energy absorption rate EA, we have

$$EA = k_{ea} \frac{S_V}{4\pi} \left[A \int_V \frac{e^{-b(1+\alpha_1)}}{|\vec{r} - \vec{r}'|^2} dV + (1-A) \int_V \frac{e^{-b(1+\alpha_2)}}{|\vec{r} - \vec{r}'|^2} dV \right] \quad (9)$$

These formulas have certain computational advantages. In Equations (8) and (9) the coefficients A, α_1 , and α_2 are empirical numbers found by fitting a set of buildup factor data $B(b_i)$ to the formula of Equation (7). (See Reference (11).) For Equation (8), the fit would have been done for gamma-ray dose buildup factors, and, for Equation (9), the fit would have been done for energy absorption buildup factors. In all cases the formulas given in this report assume that total attenuation coefficients will be used to describe the self-absorption of the source.

The buildup factors are functions of material (atomic number), energy, and optical distance b .

For more information and for attenuation cross section data, dose conversion factor data, energy absorption cross section data, gamma-ray buildup factor data, and neutron removal cross section data, see References (1), (2), (8), (9), (10) and (11) and Section F of this report.

3. Radiation Sources

The radiation source strength per unit volume S_v is assumed to be constant over any extended source volume treated here. A detailed description of the source strength equations will now be given, since they are important factors in Equations (2) and (4) and in the formulas given in Section II of this report. Some data for activation and capture gamma source for specific nuclides is given in Section F, as well as fission gamma source data.

- a. Activation Gammas (in core and in shields, built up during reactor operation, important after shutdown) (See Table 29.)

$$S_v = N \sigma_a \phi \left(1 - e^{-\lambda t_i} \right) e^{-\lambda t_s} Y(E) \quad (10)$$

S_v = $\gamma/\text{cm}^3\text{-sec}$ at energy E .

N = atoms/barn-cm (number density of activation material).

σ_a = microscopic activation cross section in barns/atom.

ϕ = thermal neutron activating flux in neutrons/ $\text{cm}^2\text{-sec}$.

λ = $\frac{\ln 2}{T_{1/2}}$ where $T_{1/2}$ is the half-life of the activated nuclide, in the same time units as t_i and t_s .

t_i = irradiation time.

t_s = shutdown or decay time.

$Y(E)$ = the yield, in gammas/disintegration, at some specific energy E .

$N \sigma_a \phi \left(1 - e^{-\lambda t_i} \right) e^{-\lambda t_s}$ = specific activity of the activation nuclide.

$N \sigma_a \phi$ = reaction rate.

More precisely, for nuclide j , the source strength in $\text{gammas/cm}^2\text{-sec}$ at energy E is

$$S_v^j(t_i, t_s, E) = N^j \sigma_a^j \phi \left(1 - e^{-\lambda^j t_i}\right) e^{-\lambda^j t_s} s_{Y^j}(E) \text{ gammas/cm}^3\text{-sec}$$

while the source strength in $\text{MeV/cm}^3\text{-sec}$ is

$$S_v^j(t_i, t_s) = E S_v^j(t_i, t_s, E) \text{ MeV/cm}^3\text{-sec} . \quad (11)$$

In an activation-gamma calculation, the dose rate at some time after shutdown of the reactor is of primary interest. Figure 1 shows a sample reactor-operation history, in which each (f_i, T_i) pair specifies a level of source output and the time during which this output was maintained.

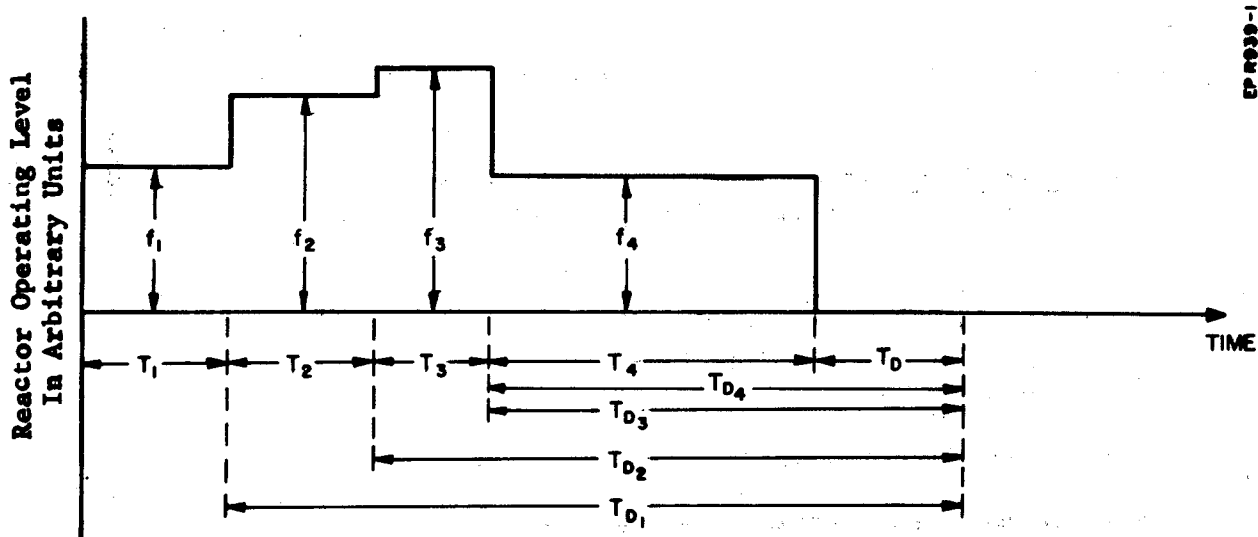


FIGURE 1
DECAY-GAMMA CALCULATION

It is assumed that the decay of the radioactivity which is produced by each source output f_i begins at the end of time T_i . If the total number of operating times is N , then for the last operating time (T_N) the decay time (T_{DN}) equals the decay time after shutdown (T_D). For the previous operating times T_1, T_2, \dots, T_{N-1} , the decay times are given by:

$$T_{Dn} = T_D + \sum_{i=n+1}^N T_i . \quad (12)$$

At the end of time T_D , the dose or flux may be integrated over a sample time T_s , and the integrated dose or flux is found.

The source at the end of the time T_D is then given by

$$S_v = N \sigma_a \phi \sum_{i=1}^N f_i \left[1 - e^{-\lambda T_i} \right] e^{-\lambda T_{Di}} \quad (13)$$

where f_i is the fraction of the thermal neutron activating flux which corresponds to the operative time step T_i . The time integrated source \bar{S}_v for the sample time T_s is:

$$\bar{S}_v = S_v \left(\frac{1 - e^{-\lambda T_s}}{\lambda} \right) \quad (14)$$

where

$$\lambda = \frac{\ln 2}{T_{1/2}} = \frac{0.69315}{T_{1/2}}, \quad (15)$$

and where $T_{1/2}$ is the half-life of the radioactive nuclide. All data regarding half-life and operating decay and sample times must be given in consistent units.

b. Gamma from U^{235} Fission Products (Built up during operation, important after shutdown)

About a thousand different radioactive nuclides are produced as by-products of the fission of U^{235} . As these nuclides decay, they release significant amounts of energy in the form of beta- and gamma-radiation, both of which contribute to heating of reactor components after shutdown. This gamma radiation is also important in that it affects refueling shielding design and is present in any irradiated reactor components which must be moved, so that shielded containers are required.

The following discussion of fission product energy release assumes that neutron capture in fission product nuclides is unimportant; therefore the production and decay of nuclides such as C_s^{137} is not included.

The U^{235} fission product nuclide concentrations in a reactor build up during operation and then decay after shutdown. Since many nuclides are involved, tables of functions have been prepared which sum up the yields of all of the important nuclides for infinite irradiation time t_i and a wide range of shutdown times t_s . See References (2) and (12) through (24). The formulas used in calculating these tables are given below. They take account of the fact that the abundance of a nuclide depends on the activity

and decay of its precursor. In these formulas, for nuclide n , λ_{2n} and λ_{1n} are the decay constants of the nuclide and its precursor, respectively; Y_{1n} is the independent fission yield and Y_{2n} is the total yield; $E_{B,n}$, $E_{GT,n}$, and $E_{G1,n}$ through $E_{G7,n}$ are the average beta energy, the total gamma energy, and the gamma energies in each of seven energy groups, all given in MeV/decay. The central energies of the seven groups are 0.3, 0.63, 1.10, 1.55, 1.99, 2.38, and 3.10 MeV. See Reference (12).

$$D_n(t_s, t_i) = F \left[A_n e^{-\lambda_{1n} t_s} + B_n e^{-\lambda_{2n} t_s} \right] \quad (16)$$

where F is the fission rate in fissions/sec and $D_n(t_s, t_i)$ is the decay rate of nuclide n , and

$$A_n = - \left[\frac{Y_{2n} - Y_{1n}}{\lambda_{1n} - \lambda_{2n}} \right] \cdot \lambda_{2n} \cdot \left[1 - e^{-\lambda_{1n} t_i} \right] \quad (17)$$

$$B_n = \left[\left(\frac{Y_{2n} - Y_{1n}}{\lambda_{1n} - \lambda_{2n}} \right) \cdot \lambda_{1n} + Y_{1n} \right] \cdot \left[1 - e^{-\lambda_{2n} t_i} \right] \quad (18)$$

$$D(t_s, t_i) = \sum_n D_n(t_s, t_i) \quad \text{(total decay rate in disintegrations/sec)} \quad (19)$$

$$B(t_s, t_i) = \sum_n D_n(t_s, t_i) * E_{B,n} \quad \text{(total beta yield, MeV/fission)} \quad (20)$$

$$G(t_s, t_i) = \sum_n D_n(t_s, t_i) * E_{GT,n} \quad \text{(total gamma yield, MeV/fission)} \quad (21)$$

$$F_j(t_s, t_i, E_j) = \sum_n D_n(t_s, t_i) * E_{GJ,n} \quad \text{(from gamma energy groups } E_j, \text{ (22) } \\ J = 1, 7, \text{ yield in MeV/fission)}$$

$$M(t_s, t_i) = B(t_s, t_i) + G(t_s, t_i) \quad \text{(total energy yield in MeV/fission)} \quad (23)$$

Now, the corresponding source strength is

$$S_v(t_i, t_s) = \frac{P}{V} c G(t_s, t_i) \text{ MeV/cm}^3\text{-sec} \quad (24)$$

$$\text{and} \quad G(t_i, t_s) = [G(\infty, t_s) - G(\infty, t_i + t_s)] \quad (25)$$

where t_i and t_s are obtained from a reactor operating history (see the discussion in Section A.3.a).

The total fission product gamma source strength is then

$$S_v(t_i, t_s) = \frac{P}{V} c [G(\infty, t_s) - G(\infty, t_i + t_s)] \text{ MeV/cm}^3\text{-sec} \quad (26)$$

and the fission product gamma source strength for gamma energy group J is

$$G(t_i, t_s, E_J) = [G(\infty, t_s) * F_J(\infty, t_s, E_J) - G(\infty, t_s + t_i) * F_J(\infty, t_i + t_s, E_J)] \text{ MeV/fission} \quad (27)$$

where $J = 1, 7$. $G(t_i, t_s, E_J)/E_J$ then gives yields in gammas/fission at energy E_J . Therefore,

$$\frac{S_v(t_i, t_s, E_J)}{E_J} = \frac{1}{E_J} [G(\infty, t_s) * F_J(\infty, t_s, E_J) - G(\infty, t_i + t_s) * F_J(\infty, t_i + t_s, E_J)] \text{ gammas/fission at energy } E_J \quad (28)$$

The total number of gammas per cm^3 at energy E_J is given by

$$S'_v(E_J) = N^{U^{235}} \sigma_f^{U^{235}} \phi \frac{S_v(t_i, t_s, E_J)}{E_J} \text{ gammas/cm}^3\text{-sec} \quad (29)$$

where

$N^{U^{235}}$ = number density of U^{235} in atoms/bar-cm.

$\sigma_f^{U^{235}}$ = fission cross section (microscopic) of U^{235} in barns/atom.

ϕ = thermal neutron activating flux in neutrons/ cm^2 -sec.

and

$$\Sigma_f = N^{U^{235}} \sigma_f^{U^{235}} = \text{the macroscopic } U^{235} \text{ fission cross section in cm}^{-1}. \quad (30)$$

Thus $\Sigma_f \phi$ is the fission density in fissions/ cm^3 -sec.

If the source volume V and source power output P are known, we may write

$$N^{U^{235}} \sigma_f^{U^{235}} \phi = \frac{P}{V} c \quad (31)$$

where P has units of watts, V is given in cm^3 , and $c = 3.1 \times 10^{10}$ fissions/watt-sec, based on the measured energy release of 200 MeV/fission for U^{235} . Typical values of $\sigma_f^{U^{235}}$ and Σ_f are 580 barns/atom and 0.174 cm^{-1} , but these values may vary for specific situations and ϕ is not a constant throughout the volume V . Therefore, Equation (31) should be treated as an approximation,

the accuracy of which is dependent on local conditions which affect the value of ϕ (and of Σ_f).

- c. Capture Gammas (in core and in shields during reactor operation)
(See Table 30.)

$$S_v = N \sigma_c \phi Y(E) \text{ gammas/cm}^3\text{-sec at energy E} \quad (32)$$

N = number density of capture material,

σ_c = capture cross section, and

Y(E) = yield in gammas/capture.

ϕ is defined in Section A.3.a.

- d. Prompt Fission Gammas in Core (important during operation)

$$S_v = \frac{P}{V} c Y(E) \text{ gammas/cm}^3\text{-sec at energy E} \quad (33)$$

Y(E) = yield in gammas/fission at energy E.

c = 3.1×10^{10} fissions per watt-sec.

P = source output in watts, and

V = source volume in cm^3 .

- e. Neutrons in the Core

$$S_v = \frac{P}{V} c \nu \text{ fission neutrons/cm}^3\text{-sec} \quad (34)$$

where

P = source power in watts.

V = source volume in cm^3 .

$\frac{P}{V}$ = watts/ cm^3 = power density.

c = 3.1×10^{10} fission neutrons/watt-sec.

ν = 2.43 fission neutrons/fission.

The power associated with a fission neutron flux of ϕ fission neutrons/ $\text{cm}^2\text{-sec}$ may be found, in ideal cases, from

$$P = \frac{\Sigma_f \phi V}{c} \text{ watts}$$

where Σ_f is the macroscopic U^{235} fission cross section in cm^{-1} . This of course assumes that ϕ is constant over the source volume V and so takes no account of local conditions. A typical value of Σ_f is 0.174 cm^{-1} but this value may vary from problem to problem.

f. Fission Gammas (See Table 31.)

$$S_v = \frac{P}{V} c Y(E) \quad (35)$$

where

- P = source power in watts.
- V = source volume in cm^3 .
- c = 3.1×10^{10} fissions/watt-second.
- Y(E) = yield in gammas/fission at energy E.

B. Flux Formulas

The derivations of most of the equations or flux formulas given here may be found in References (1), (2), and (5). These derivations have all been checked, and a number of extensions and special cases have been derived in Reference (25) which are not explicitly given in References (1), (2), and (5). All equations given in this section give results in terms of the uncollided flux ϕ . Inclusion of gamma-ray buildup factors and conversion factors in these equations allows the calculation of total dose rates and total energy absorption rates. (See Section A, Equations (2) through (9), and Section E of this report.)

Note that only slab shields are assumed by these formulas and that separate formulas are given for those cases which do not involve external shields. The geometry, nomenclature, and shield placement assumed by each formula should be clear from the referenced figures. S_v = source strength per unit volume, S_a = source strength per unit area, and S_l = source strength per unit length.

The flux formulas included here are all either analytic or include a limited number of integral functions which are readily available in tabular form. See Section C of this report.

1. Uniform Disk Source, No Shield (References (1), (2), (25))
(See Figures 2 and 3.)

$$\phi_{P_1} = \frac{S}{2} \ln \sec \theta \quad (36)$$

$$\sec \theta = \sqrt{1 + (R/a)^2}$$

$$\phi_{P_2} = \frac{S}{4} \ln \left(\frac{a^2 + R^2 - h^2 + \sqrt{R^4 + 2R^2(a^2 - h^2) + (a^2 - h^2)^2}}{2a^2} \right) \quad (37)$$

2. Uniform Disk Source with Shield (References (1), (2), (25))
(See Figures 2 and 3.)

$$\phi_{P_1} = \frac{S}{2} [E_1(b) - E_1(b \sec \theta)] \quad (38)$$

where

$$b = \mu t \text{ or } b = \sum_{i=1}^N \mu_i t_i \quad (39)$$

$$\sec \theta = \sqrt{1 + (R/a)^2} \quad (40)$$

$$E_1(b) = \int_b^{\infty} \frac{e^{-t}}{t} dt. \text{ See Tables 1 and 2.}$$

$$E_1(b) = \bar{E}_1(b) \frac{e^{-b}}{b} \quad (41)$$

$$\phi_{P_2} = \frac{S}{4\pi} D(\bar{\mu}R, \bar{\mu}a, \bar{\mu}h) \quad (42)$$

where

$$\bar{\mu} = \frac{\sum \mu_i t_i}{\sum t_i} = \frac{b}{\sum t_i} \quad (43)$$

$$D(\bar{\mu}R, \bar{\mu}a, \bar{\mu}h) = 2 \int_0^R \int_0^{\pi} \frac{e^{-\bar{\mu}\rho}}{\rho^2} r dr d\alpha \quad (44)$$

$$\rho^2 = r^2 + h^2 + a^2 - 2rh \cos \alpha \quad (45)$$

See Table 3.

3. Infinite Slab Source of Infinite Depth, Self Absorbing, No Shield
(References (1), (2), (25)) (See Figure 4.)

$$\phi_{P_1} = \frac{S}{2\mu_s} \quad (46)$$

$$\phi_{P_2} = \frac{S}{2\mu_s} \quad (47)$$

$$\phi_{P_3} = \frac{S}{2\mu_s} [2 - E_2(\mu_s a')] \quad (48)$$

where

$$E_2(b) = b \int_b^{\infty} \frac{e^{-t}}{t^2} dt = \bar{E}_2(b) \frac{e^{-b}}{b} \quad (49)$$

See Tables 1 and 2.

4. Infinite Slab Source of Infinite Depth, Self-Absorbing with Shield
(References (1), (2), (25)) (See Figure 4.)

$$\phi_{P_1} = \frac{S}{2\mu_s} E_2(b) \quad (50)$$

where

$$b = \mu t = \sum_1 \mu_1 t_1$$

See Tables 1 and 2.

$$E_2(b) = \bar{E}_2(b) \frac{e^{-b}}{b} \quad (51)$$

5. Infinite Slab Source, Self-Absorbing, No Shield (References (1), (2), (25)) (See Figure 5.)

$$\phi_{P_1} = \frac{S}{2\mu_s} [1 - E_2(\mu_s l)] \quad (52)$$

$$\phi_{P_2} = \frac{S}{2\mu_s} [1 - E_2(\mu_s l)] \quad (53)$$

$$\phi_{P_3} = \frac{S}{2\mu_s} \left[2 - E_2(\mu_s a') - E_2(\mu_s \{l-a'\}) \right] \quad (54)$$

See Tables 1 and 2.

Note that the geometry of a detector point on or very close to the surface of a source of any shape may be approximated by replacing that source with an infinite slab source of finite depth. Note also that an upper limit on the flux at a detector point interior to a source may always be found by using Equation (54).

6. Infinite Slab Source, No Self-Absorption, with Shield (References (1), (2), (25)) (See Figure 5.)

$$\phi_{P_1} = \frac{S}{2} E_1(b) \quad (55)$$

See Tables 1 and 2.

If $l = 1$, this gives an infinite plane surface source.

7. Infinite Slab Source, Self-Absorbing, with Shield (References (1), (2), (25)) (See Figure 5.)

$$\phi_{P_1} = \frac{S}{2\mu_s} \left[E_2(b) - E_2(b + \mu_s l) \right] \quad (56)$$

See Tables 1 and 2.

8. Cylindrical Source, No Self-Absorption, No Shield, Axial Detector Point (References (1), (2), (25)) (See Figure 6.)

$$\phi_{P_2} = \frac{S}{2} C(l, 0, R) \quad (57)$$

$$\phi_{P_1} = \frac{S}{2} C(l, a, R) \quad (58)$$

$$C(l, a, R) = \frac{a+l}{2} \ln \left[1 + \left(\frac{R}{a+l} \right)^2 \right] + R \tan^{-1} \frac{R}{a}$$

$$- \frac{a}{2} \ln \left[1 + \left(\frac{R}{a} \right)^2 \right] - R \tan^{-1} \frac{R}{a+l}$$

$$C(l, 0, R) = \frac{l}{2} \ln \left[1 + \left(\frac{R}{l} \right)^2 \right] + R \tan^{-1} \frac{l}{R}$$

9. Cylindrical Source, Self-Absorbing, No Shield, Axial Detector Point
(References (1), (2), (25)) (See Figure 6.)

$$\phi_{P_1} = \frac{S \nu}{2\mu_s} [1 - E_2(\mu_s l) - Z(\mu_s l, a/l, R/l)] \quad (59)$$

$$\phi_{P_2} = \frac{S \nu}{2\mu_s} [1 - E_2(\mu_s l) - Z(\mu_s l, R/l)] \quad (60)$$

$$Z(b', a/l, R/l) = \int_0^{b'} E_1 \left(y \sqrt{1 + \left\{ \frac{R}{l} b' / \left(y + \frac{a}{l} b' \right) \right\}^2} \right) dy$$

$$Z(b', R/l) = \int_0^{b'} E_1 \left(\sqrt{y^2 + \left(b' \frac{R}{l} \right)^2} \right) dy$$

where $b' = \mu_s l$.

See Tables 1, 2, 4 and 5.

10. Cylindrical Source, Non-Absorbing, with Shield, Axial Detector Point
(References (1), (2), (25)) (See Figure 7.)

$$\phi_{P_1} = \frac{S \nu}{2} l C(R/l, b, a/l) \quad (61)$$

where

$$b = \mu t = \sum_i \mu_i t_i.$$

See Table 6.

$$\begin{aligned} l C(R/l, b, a/l) &= C(l, b, a, R) = l E_1(b) + a E_1 \left(b \sqrt{1 + (R/a)^2} \right) \\ &\quad - (a+l) E_1 \left(b \sqrt{1 + (R/(a+l))^2} \right) \\ &\quad - R \cdot F \left[\tan^{-1} (R/(a+l)), b \right] \\ &\quad + R \cdot F \left[\tan^{-1} (R/a), b \right] \end{aligned}$$

11. Cylindrical Source, Self-Absorbing, with Shield, Axial Detector Point
(References (1), (2), (25)) (See Figure 7.)

$$\phi_{P_1} = \frac{S}{2\mu_s} Z(b', b, a/l, R/l), \quad (62)$$

where

$$b = \mu t = \sum \mu_1 t_1 \quad \text{and}$$

$$b' = \mu_s l.$$

$$Z(b', b, a/l, R/l) = E_2(b) - E_2(b+tb') - \int_0^{b'} E_1[g_2(y)] dy$$

where

$$g_2(y) = (y+tb) \sqrt{1 + \left(\frac{R}{l} b' / \left(y + \frac{a}{l} b'\right)\right)^2}$$

See Tables 1, 2 and 4. The function table for $Z(b', b, a/l, R/l)$ is not given here because it is too voluminous and difficult to use. An approximation of ϕ_{P_1} may be obtained by using only the first two terms of the equation which define $Z(b', b, a/l, R/l)$ just above or by using the approximation discussed under Section 20.a.

12. Cylindrical Source Interior, Self-Absorbing, Detector Point on Axis
(References (1), (2), (25)) (See Figure 8.)

$$\phi_{P_1} = \frac{S}{2\mu_s} [G(\mu_s h, b) + G(\mu_s \{l-h\}, b)] \quad (63)$$

where

$$b = \mu_s R.$$

$$\phi_{P_2} = \frac{S}{2\mu_s} G(\mu_s l, b). \quad (64)$$

See Table 7.

$$G(\mu_s h, b) = \int_0^b F(\theta, b') db' ,$$

where

$$b' = \mu_s r, F(\theta_0, b) = \int_0^{\theta_0} e^{-b \sec \theta} d\theta, \text{ and } \theta = \tan^{-1} \frac{\mu_s h}{b'} = \tan^{-1} \frac{h}{r} .$$

13. Cylindrical Source Approximation, Self-Absorbing with Shield, Lateral Detector Point (References (5), (25)) (See Figures 9, 10, 11a, 11b.)

Assume that slab shields with thicknesses t_i and macroscopic attenuation coefficients μ_i intervene between P_1 and the source in Figure 9.

Then

$$b = \mu t = \sum_i \mu_i t_i , \quad (65)$$

$$M_c = \sqrt{\left(\frac{a}{R}\right)^2 + \frac{\pi}{\phi_0}} - \frac{a}{R} , \text{ and} \quad (66)$$

$$b' = b + \mu_s M_c R . \quad (67)$$

See Figure 10 for the detector point positions. We have

$$\phi_{P_1} = \frac{S_v \phi_0}{2\pi\mu_s} L_0(\phi_0, b) \{G(\theta_1, b) - G(\theta_1, b')\} \quad (68)$$

See also the Appendix.

$$\phi_{P_3} = \frac{S_v \phi_0}{2\pi\mu_s} L_0(\phi_0, b) \{G(\theta_3, b) + G(\theta_2, b) - G(\theta_3, b') - G(\theta_2, b')\} \quad (69)$$

$$\phi_{P_5} = \frac{S_v \phi_0}{2\pi\mu_s} L_0(\phi_0, b) \{G(\theta_5, b) - G(\theta_4, b) - G(\theta_5, b') + G(\theta_4, b')\} \quad (70)$$

From Figure 10, the definitions of the angles may be seen to be:

$$\phi_0 = \sin^{-1} \frac{R}{a+R} , \theta_1 = \tan^{-1} \frac{h}{a} , \theta_2 = \tan^{-1} \frac{h-h_3}{a} ,$$

$$\theta_3 = \tan^{-1} \frac{h_3}{a}, \theta_4 = \tan^{-1} \frac{h'_3 - l}{a}, \theta_5 = \tan^{-1} \frac{h'_3}{a}.$$

The functions L_0 and G used in Equations (68) to (70) are defined as follows:

$$G(\theta_0, b) = \int_0^{\theta_0} \cos \theta e^{-b \sec \theta} d\theta = G(\theta_0, b) * \theta_0 e^{-b}$$

See Figures 44 and 45 and Table 9.

$$H(b) = G(\pi/2, b), \text{ and}$$

$$L_0(\phi_0, b) = \frac{\int_0^{\phi_0} H(b \sec \phi) d\phi}{\phi_0 H(b)} \text{ and is given by Figures 38 and 39 or Table 8.}$$

See also Tables 2, 13, 15 and 16.

If $h > l$ find θ_p ; the answer may be very low because of the approximation. The use of $l' = l \frac{2R}{2R+a} (h-l)$ in place of l to get an upper limit is discussed below.

The method of solution given here is an approximation based on substituting an annular section for the cylinder as shown in Figure 9. This approximation is satisfactory for calculating the fluxes at P_1 and P_3 in Figure 10, so long as $R > 10$ cm, $\mu_s > 0$, $\mu_t \geq 1$, $\frac{a}{R} > .2$, and $l/a > .5$. For these conditions the error introduced by the approximation is less than 15%, and the error goes down rapidly as $\frac{a}{R}$ increases. See Table 16 for details. See also Figures 11a and 11b.

We may note in passing that the function $L_0(\phi_0, b)$ is almost independent of the value of ϕ_0 . For ϕ_0 in the range (0.0872 - 1.5708) the value of $L_0(\phi_0, b)$ changes by less than 5%.

The flux at a point opposite a cylindrical source, such as P_3 in Figure 10, may be found from Equation (69), which is the additive rule:

$$\begin{aligned} \Phi_{un}(P_3) = \frac{S_v \phi_0}{2\pi \mu_s} L_0(\phi_0, b) \{ & G(\tan^{-1} \frac{h_3}{a}, b) - G(\tan^{-1} \frac{h_3}{a}, b') \\ & + G(\tan^{-1} \frac{l-h_3}{a}, b) - G(\tan^{-1} \frac{l-h_3}{a}, b') \} . \end{aligned} \quad (71)$$

Using a similar rule (Equation (70)) to find the flux at a point such as P_5 in Figure 10 unfortunately gives an answer which may be low by an order of magnitude or more. Consideration of the shape of the annular section which is substituted for the cylindrical source by this approximation (Figure 9) will show why this is so.

Therefore, at locations outside the height of the cylindrical source (such as P_5 in Figure 10), the best course to follow is to make calculations using this approximation which bracket the true flux. The procedure is to first find the lower bracketing value using a subtractive rule:

$$\begin{aligned} \Phi_{un}(P_5)_{low} = \frac{S \phi_0}{2\pi\mu_s} L_0(\phi_0, b) \{ & G(\tan^{-1} \frac{h'}{a}, b) - G(\tan^{-1} \frac{h'}{a}, b') \\ & - G(\tan^{-1} \frac{h'-l}{a}, b) + G(\tan^{-1} \frac{h'-l}{a}, b') \} . \end{aligned} \quad (72)$$

If the source height l is then replaced by

$$l' = l + z = l + \frac{2R}{2R+a} (h'-l) \quad (73)$$

and we have

$$\begin{aligned} \Phi_{un}(P_5)_{high} = \frac{S \phi_0}{2\pi\mu_s} L_0(\phi_0, b) \{ & G(\tan^{-1} \frac{h'}{a}, b) - G(\tan^{-1} \frac{h'}{a}, b') \\ & - G(\tan^{-1} \frac{h'-l'}{a}, b) + G(\tan^{-1} \frac{h'-l'}{a}, b') \} \end{aligned} \quad (74)$$

which gives an upper limit on the value of the flux at P_5 . These limiting values should be compared and the conservative upper limit value given the most weight in any averaging of these results.

The approximate effect of replacing the slab shield with a cylindrical shield of the same thickness and attenuation may be found by use of the nomograms given in Figures 47 and 48. As is intuitively obvious, a cylindrical shield is always more effective than the corresponding slab shield.

14. Cylindrical Surface Source with Lateral Detector Point, No Shield
(Reference (25)) (See Figure 12.)

$$\phi_{un}(P_1) = \frac{S R}{2(a+2R)} \int_0^{\tan^{-1} \frac{l}{a}} \frac{d\theta}{\sqrt{1 - k^2 \sin^2 \theta}} \quad (75)$$

where

$$k = \frac{2\sqrt{R(a+R)}}{2R+a}$$

This integral is an elliptic function of the first kind and is not given in the function tables of this report since it is readily available in Reference (6) and in other handbooks of mathematical functions.

15. Cylindrical Surface Source with Axial Detector Point (Reference (25))
(See Figure 12.)

If P_2 is located at the end of the axis but there is self-attenuation,

$$\phi_{un}(P_2) = \frac{S a}{2} \int_0^{\tan^{-1} \frac{l}{R}} \frac{e^{-\mu_h R \sec \theta}}{R} d\theta = \frac{S a}{2} F(\tan^{-1} \frac{l}{R}, \mu_h R) \quad (76)$$

If P_2 is not located at the end of the axis, an additive or subtractive rule may be used to find the flux. If $l \rightarrow \infty$ also,

$$\phi_{un}(P_2) = \frac{S a}{2} F\left(\frac{\pi}{2}, \mu_h R\right) \quad (77)$$

If there is no attenuation,

$$\phi_{un}(P_2) = \frac{S a}{2} \tan^{-1} \frac{l}{R} \quad (78)$$

16. Cylindrical Surface Source with Interior Detector Point, No Exponential Attenuation (Reference (25)) (See Figure 13.)

If $a \neq 0$,

$$\phi_{un} = \frac{S a}{2} \frac{R}{(R+a)} \int_0^{\tan^{-1} \frac{l}{R-a}} \frac{d\theta}{\sqrt{1 - k^2 \sin^2 \theta}} \quad (79)$$

where

$$k = \frac{2\sqrt{aR}}{a+R}$$

This integral function is the Legendre normal form of the elliptic integral of the first kind. Tables of the function are not given in this report but are available in Reference (6) and elsewhere.

17. Cylindrical Surface Source with Axial Detector Point, No Self-Attenuation, and an Intervening Slab Shield (Reference (25))
(See Figure 14.)

$$\phi_P = \frac{S}{2} \left[F\left(\tan^{-1} \frac{R}{a}, \mu t\right) - F\left(\tan^{-1} \frac{R}{a+l}, \mu t\right) \right] \quad (80)$$

18. Truncated Cone Source, Self-Absorbing with Shield, Apex Point
(References (1), (2), (25)) (See Figure 15.)

$$\theta_0 = \tan^{-1} \frac{R}{a}$$

$$\sec \theta_0 = \sqrt{1 + \left(\frac{R}{a}\right)^2}$$

$$b = \mu t$$

$$b' = b + \mu_s l$$

$$\phi_{P_1} = \frac{S}{2\mu_s} \left[E_2(b) - E_2(b') + \cos \theta_0 E_2(b' \sec \theta_0) - \cos \theta_0 E_2(b \sec \theta_0) \right] \quad (81)$$

See Tables 1 and 2.

$$\text{Volume of a truncated cone} = \frac{\pi}{3} R^2 \left\{ \frac{(a+l)^3 - a^3}{a^2} \right\}$$

19. Truncated Cone Surface Source, Detector Point at Apex (Reference (25))
(See Figure 16.)

$$\phi_P = \frac{S}{2} e^{-[\mu t - \mu_s a] \sec \alpha} \left[E_1(\mu_s a \sec \alpha) - E_1(\mu_s (a+l) \sec \alpha) \right] \sin \alpha \quad (82)$$

where

$$\sin \alpha = \frac{R_1}{\sqrt{R_1^2 + a^2}}$$

and

$$\sec \alpha = \sqrt{1 + \left(\frac{R_1}{a}\right)^2}.$$

If $\mu_s = 0$,

$$\phi_P = \frac{S}{2} e^{-\mu t \sec \alpha} \sin \alpha \log \left(\frac{a+l}{a}\right), \quad (83)$$

and if $\mu t = 0$ also,

$$\phi_P = \frac{S}{2} \frac{R_1}{\sqrt{R_1^2 + a^2}} \log \left(\frac{a+l}{a}\right). \quad (84)$$

Equation (82) may be used to approximate a cylindrical surface source with both self-attenuation and a slab shield and an axial detector point, as in Figure 14.

20. Approximations Using Truncated Cone and Cylindrical Sources (References (1), (25))

The truncated cone source may be used to give several useful approximations.

a. Cylinder with Axial Point

The flux at a point on the axis of a cylindrical source, such as P in Figure 17, may be bracketed by two calculations using truncated cone sources subtending the angles θ_1 and θ_2 , respectively. If $\mu_s l \leq 3$, we use the full height of the source cylinder, and the two bracketing truncated cones are then those defined by the angles θ_1 and θ_2 in Figure 17. If $\mu_s l > 3$, a better answer is obtained if $\frac{l}{2}$ is used in defining the cones; that is, only the nearer half of the cylinder need be considered in the calculation, so that $\theta_1 = \tan^{-1} \frac{R}{a+\frac{l}{2}}$, and $\theta_2 = \tan^{-1} \frac{R}{a}$.

This approximation may be used whether or not a slab shield intervenes between the source and the detector point. For a refinement of this approximation see the appendix.

b. Finite Slab Source with Exterior Detector Point

Upper and lower limits on the flux from a finite slab or rectangular solid source at an external detector point may be obtained by replacing the slab by inscribed and circumscribed truncated cone sources. This approximation of course is most accurate for a square slab source with detector points located on a perpendicular to the center. For a slab source which is long in comparison to its width, the slab may be replaced by a cylindrical source with the correct diameter/height ratio if the detector point is not too close to the source.

c. Annulus with Exterior Point

A rough approximation of an annular source can also be obtained using a truncated cone. The flux at the point P in Figure 18a is conservatively approximated by the flux from a truncated cone with apex at P, angle $\theta_0 = \tan^{-1} \frac{h'}{a}$, and thickness $l = R_2 - R_1$, where $h' = \sqrt{4R_2^2 + h^2}$, as shown in Figure 18b. An annular source may also be approximated by the superposition of two cylindrical source calculations.

d. Sphere with Exterior Point

This approximation comes from References (5) and (7).

The nomenclature is shown in Figure 19, and accuracy estimates are shown in Figure 20. The spherical source volume is approximated as a conical section of a spherical shell.

$$\phi_{un} = \frac{S_v}{2\mu_s} \left(1 - e^{-m_s \mu_s R} \right) \left\{ E_2(b) - \cos \phi_0 E_2(b \sec \phi_0) \right\} \text{ or}$$

$$\phi_{un} = \frac{S_v}{2\mu_s} \left(1 - e^{-m_s \mu_s R} \right) \left\{ \frac{e^{-b}}{b} \bar{E}_2(b) - \frac{e^{-b \sec \phi_0}}{b \sec^2 \phi_0} \bar{E}_2(b \sec \phi_0) \right\} \quad (85)$$

where

$$\phi_0 = \sin^{-1} \frac{R}{a+R}$$

and

$$m_s = \left\{ \frac{2}{1 - \cos \phi_0} + \left(\frac{a}{R} \right)^3 \right\}^{\frac{1}{3}} - \frac{a}{R}$$

m_s is so chosen as to make the volume of the conical section of the spherical shell equal the volume of the spherical source being approximated. See Tables 1, 2, 14 and 15.

21. Truncated Cone Source, Not Self-Absorbing, with Shield, Apex Point
(References (1), (2), (25)) (See Figure 15.)

$$\phi_P = \frac{S}{2} l \left[E_1(b) - E_1(b \sec \theta_0) \right] \quad (86)$$

where

$$b = \mu t$$

See Tables 1 and 2.

22. Truncated Cone Source, Self-Absorbing, No Shield, Apex Point
(References (1), (2), (25)) (See Figure 15.)

$$\phi_{P_1} = \frac{S}{2\mu_s} \left[1 - E_2(\mu_s l) + \cos \theta_0 E_2(\mu_s l \sec \theta_0) - \cos \theta_0 \right] \quad (87)$$

See Tables 1 and 2.

23. Truncated Cone Source, Not Self-Absorbing, No Shield, Apex Point
(References (1), (2), (25)) (See Figure 15.)

$$\phi_{P_1} = \frac{S}{2} l \cdot \ln \sec \theta_0 \quad (88)$$

24. Spherical Source, No Self-Absorption, No Shield (References (1), (2), (3), (25)) (See Figure 21.)

$$A = R + a$$

$$A' = R - a'$$

$$A' < R$$

$$\sin \phi_0 = \frac{R}{R+a}$$

$$\phi_{P_1} = \frac{S}{4A} \left[2RA - (A^2 - R^2) \ln \left| \frac{A+R}{A-R} \right| \right] \quad (89)$$

$$\phi_{P_2} = \frac{S}{2} \frac{R}{v} \quad (90)$$

$$\phi_{P_3} = \frac{S}{4A'} \left[2RA' + (R^2 - A'^2) \ln \left| \frac{R+A'}{R-A'} \right| \right] \quad (91)$$

$$\phi_{P_4} = \frac{S}{v} R \quad (92)$$

25. Spherical Source, Self-Absorbing, No Shield (References (1), (2), (3), (25)) (See Figure 21.)

$$A = R + a$$

$$A' = R - a'$$

$$\sin \phi_0 = \frac{R}{R+a}$$

$$\cos \phi_0 = \frac{\sqrt{a^2 + 2Ra}}{R + a}$$

$$b_4 = \mu_s |a'|$$

$$b_5 = \mu_s [2R - |a'|]$$

$$\phi_{P_1} = \frac{S_v}{2\mu_s} [1 - \cos \phi_0 - S(a/R, \mu_s R)] \quad (93)$$

See Table 11.

$$\phi_{P_2} = \frac{S_v}{2\mu_s} \left[1 - \frac{1}{2\mu_s R} (1 - e^{-2\mu_s R}) \right] \quad (94)$$

$$\begin{aligned} \phi_{P_3} = \frac{S_v}{\mu_s} \left[1 - \frac{e^{-b_4}}{2} - \frac{e^{-b_5}}{2} - \frac{1}{4\mu_s A'} \left\{ e^{-b_4(1+b_4)} - e^{-b_5(1+b_5)} \right\} \right. \\ \left. + \frac{b_4 b_5}{4\mu_s A'} \{ E_1(b_4) - E_1(b_5) \} \right] \quad (95) \end{aligned}$$

$$\phi_{P_4} = \frac{S_v}{\mu_s} (1 - e^{-\mu_s R}) \quad (96)$$

$$S(a/R, \mu_s R) = \int_0^{\phi_0} \sin \phi e^{-2\mu_s R \sqrt{1 - \left(1 + \frac{a}{R}\right)^2 \sin^2 \phi}} d\phi \quad (97)$$

See Tables 1, 2 and 11.

26. Spherical Source Self-Absorbing with Slab Shield (References (3), (25))
(See Figure 21.)

$$b = \mu t = \sum_i \mu_i t_i$$

$$\sin \phi_0 = \frac{R}{R+a}$$

$$\phi_{P_1} = \frac{S_v}{2\mu_s} S(b, a/R, \mu_s R) \quad (98)$$

$$S(b, a/R, \mu_s R) = \int_0^{\phi_0} e^{-b \sec \phi} \sin \phi \, d\phi$$

$$- \int_0^{\phi_0} e^{-\left(b \sec \phi + 2\mu_s R \sqrt{1 - \left(1 + \frac{a}{R}\right)^2 \sin^2 \phi}\right)} \sin \phi \, d\phi \quad (99)$$

Note that

$$\int_0^{\phi_0} e^{-b \sec \phi} \sin \phi \, d\phi = E_2(b) - \cos \phi_0 E_2(b \sec \phi_0)$$

See Tables 1, 2 and 12.

27. A Special Case of a Spherical Source with a Spherical Shield (Reference (25)) (See Figure 21.)

If we assume in Figure 21 that P_2 lies on the outer edge of a spherical shield of thickness c , so that the distance of P_2 from P_4 is $R+c$, and that the source and spherical shield have the same attenuation coefficient μ_s , then the flux at P_2 is given by

$$\phi_{un} = \frac{S R}{2\mu_s (R+c)} \left\{ E_2(\mu_s c) + E_2[\mu_s (2R+c)] - \frac{1}{\mu_s R} E_3(\mu_s c) + \frac{1}{\mu_s R} E_3[\mu_s (2R+c)] \right\} \quad (100)$$

If we use the relation

$$E_3(x) = \frac{1}{2}(e^{-x} - x E_2(x)) \quad (101)$$

and assume $c = 0$, (100) reduces to (94). (100) may be used to approximate the effect of a spherical shield versus a slab shield. The following approximation, derived from (98) and (99), assuming that $\mu_1 = \mu_s$ and that

$$\sqrt{1 - \left(1 + \frac{a}{R}\right)^2 \sin^2 \phi} = 1,$$

may be used to find the flux when the slab shield is in place:

$$\phi_{P_1} = \frac{S}{2\mu_s} \left(1 - e^{-2\mu_s R} \right) \left[E_2(\mu_s t) - \cos \phi_0 E_2(\mu_s t \sec \phi_0) \right] \quad (102)$$

See Tables 1 and 2. See also Section B.20.d.

28. Line Source with Parallel Shield (References (1), (2), (25)) (See Figure 22.)

$$\theta_1 = \tan^{-1} \frac{l}{a}, \quad \theta_2 = \tan^{-1} \frac{l-h}{a}, \quad \theta_3 = \tan^{-1} \frac{h}{a}, \quad \theta_4 = \tan^{-1} \frac{h'-l}{a},$$

$$\theta_5 = \tan^{-1} \frac{h'}{h}$$

$$\phi_{P_1} = \frac{S_L}{4\pi a} F(\theta_1, \mu t) \quad (103)$$

$$\phi_{P_3} = \frac{S_L}{4\pi a} [F(\theta_2, \mu t) + F(\theta_3, \mu t)] \quad (104)$$

$$\phi_{P_5} = \frac{S_L}{4\pi a} [F(\theta_5, \mu t) - F(\theta_4, \mu t)] \quad (105)$$

See Tables 2 and 10.

Equation (103) also applies to an arc of a circular line source behind a slab shield, as shown in Figure 24. Note that if

$$\theta = \tan^{-1} \frac{l}{a}$$

$$\text{and } l' = a \theta$$

where l is the length of the straight line source and l' is the arc length of the circular line source, then

$$\phi_P = \frac{S_L}{4\pi a} F(\tan^{-1} \frac{l}{a}, \mu t) \quad \text{for both } l \text{ and } l' .$$

29. Line Source without Shield (References (1), (2), (25)) (See Figure 22.)

$$\phi_{P_1} = \frac{S_L}{4\pi a} \theta_1 \quad (106)$$

$$\phi_{P_3} = \frac{S_L}{4\pi a} [\theta_2 + \theta_3] \quad (107)$$

$$\phi_{P_4} = \frac{S_L}{4\pi a} [\theta_5 - \theta_4] \quad (108)$$

30. Line Source with Perpendicular Slab Shield (Reference (25) (See Figures 23a and 23b.)

$$b = \mu t$$

If the detector point lies opposite the end of the line source,

$$\phi_P = \frac{S_L}{4\pi} e^{(\mu_s a - b)} \left[\frac{E_2(\mu_s a)}{a} - \frac{E_2(\mu_s a + \mu_s l')}{a+l'} \right] \quad (109)$$

See Tables 1 and 2.

If $\mu_s = 0$,

$$\phi_P = \frac{S_L}{4\pi} e^{-b} \left[\frac{1}{a} - \frac{1}{a+l} \right] \quad (110)$$

A more general case of a line source with a perpendicular slab shield is shown in Figure 23b.

Let

$$\psi = \frac{\pi}{2} - \theta,$$

$$\psi_1 = \frac{\pi}{2} - \theta_1, \text{ and}$$

$$\psi_2 = \frac{\pi}{2} - \theta_2.$$

Then

$$\phi_P = \frac{S_L}{4\pi a} [F(\psi_1, mt) - F(\psi_2, mt)] \quad (111)$$

and if $l \rightarrow \infty$,

$$\phi_P = \frac{S_L}{4\pi a} F(\psi_1, mt) \quad (112)$$

See Tables 2 and 10.

31. Line Source with Slab Shield Tilted Out at Bottom, and Lateral Detector Point (Reference (25)) (See Figure 25a.)

$$\phi_{un} = \frac{S_L}{4\pi a} [F(\alpha + \theta_0, b) - F(\alpha, b)] \quad (113)$$

Here, $a = (l + t \csc \alpha) \tan \alpha$.

See Tables 2 and 10.

32. Line Source with Slab Shield Tilted Out at Top and Lateral Detector Point (Reference (25)) (See Figure 25b.)

$$\phi_{un} = \frac{S_L}{4\pi a} [F(\alpha, b) + F(\theta_0 - \alpha, b)] \quad (114)$$

where $a \geq t \sec \alpha$, and $\theta_0 = \tan^{-1} \left(\frac{a}{l} \right)$.

See Tables 2 and 10.

33. Circular Line Source with Exterior Detector Point, No Shield (Reference (25)) (See Figure 26.)

$$\phi_P = \frac{S_L}{2} \frac{R}{a(2R + a)} \quad (115)$$

34. Circular Line Source with Interior Detector Point (Reference (25)) (See Figures 27 and 28.)

If the detector point is at the center, and we assume attenuation, the uncollided flux at the point P in Figure 27 is

$$\phi_P = \frac{S_L}{2R} e^{-\mu_s R} \quad (116)$$

If the point P lies a distance h above the plane of the circular line source, we have

$$\phi_{un} = \frac{S_L R}{2(R^2 + h^2)} e^{-\mu_s \sqrt{R^2 + h^2}} \quad (117)$$

In Figure 28, the detector point P lies at the end of a diameter.

If there is no attenuation,

$$\phi_P = \frac{S_L}{4\pi R} \tan \phi \quad (118)$$

Obviously, ϕ cannot approach 90° , and so defines an arc which is a portion of a circular line source.

If the detector point is interior to the circular line source, but arbitrarily located as in Figure 29, and there is no attenuation,

$$\phi_P = \frac{S_L R}{2(R^2 - a^2)}, \quad a < R \quad (119)$$

35. Annular Disk Source with Interior Detector Point (Reference (25))
(See Figures 30 and 31.)

For a detector point at the center of the annulus,

$$\phi_{un} = \frac{S_a}{2} e^{-(\mu - \mu_s)R_0} \left[E_1(\mu_s R_0) - E_1(\mu_s R) \right] \quad (120)$$

which holds so long as $R_0 > 0$.

If there is no self-attenuation ($\mu_s = 0$),

$$\phi_{un} = \frac{S_a}{2} e^{-\mu R_0} \log \frac{R}{R_0} \quad (121)$$

and if $\mu = 0$ also,

$$\phi_{un} = \frac{S_a}{2} \log \frac{R}{R_0} \quad (122)$$

If the detector point is arbitrarily located inside the annular disk as in Figure 31, with $a < R_0 < R$, and there is no attenuation,

$$\phi_P = \frac{S_a}{4} \log \left(\frac{R^2 - a^2}{R_0^2 - a^2} \right) \quad (123)$$

36. Disk Source with Exterior Lateral Detector Point (Reference (25))
(See Figure 32.)

If there is no attenuation,

$$\phi_P = \frac{S_a}{2\pi} \phi_0 \log \left[\frac{(a+R)^2}{a^2 + 2aR} \right]$$

$$+ \frac{S_a}{\pi} \int_0^{\phi_0} \log \left[\cos \phi + \sqrt{\left(\frac{R}{a+R}\right)^2 - \sin^2 \phi} \right] d\phi \quad (124)$$

where $\phi_0 = \sin^{-1} \frac{R}{a+R}$. If we assume $\phi = 0$, a conservative approximation of (124) may be obtained.

The second term of Equation (124) is then approximated as $\frac{S}{\pi} \phi_0 \log \frac{a+2R}{a+R}$ so that an upper limit on the flux value is given by

$$\phi_P = \frac{S}{2\pi} \phi_0 \log \left(\frac{a+2R}{a} \right) \quad (125)$$

37. Rectangular Surface Source with Detector Point on Perpendicular to Corner, No Shield (Reference (25)) (See Figure 33.)

An upper limit in the flux from this source is given by

$$\phi_P = \frac{S}{4\pi} \tan^{-1} \frac{l_2}{a} \log \left[\sqrt{1 + \left(\frac{l_1}{a} \right)^2} + \frac{l_1}{a} \right] \text{ or}$$

$$\phi_P = \frac{S}{4\pi} \phi_0 \log [\sec \theta_0 + \tan \theta_0] \quad (126)$$

A circumscribed disk source may also be used to obtain an estimate of the flux from a rectangular surface source.

38. Rectangular Surface Source with Lateral Detector Point (Reference (25)) (See Figure 34.)

$$\theta_1 = \tan^{-1} \frac{l_2}{a+l_1}$$

$$\theta_2 = \tan^{-1} \frac{l_2}{a}$$

If $\mu_s = 0$.

$$\phi_P = \frac{S}{4\pi} \log \left(\frac{a+l_1}{a} \right) F(\theta_1, \mu t) + \frac{S}{4\pi} \int_{\theta_1}^{\theta_2} \log \left(\frac{l_2 \cot \theta}{a} \right) e^{-\mu t \sec \theta} d\theta \quad (127)$$

This may be conservatively approximated by setting $\cot \theta = \cot \theta_1 = \frac{a+l_1}{l_2}$

and integrating, which gives

$$\phi_P = \frac{S}{4\pi} \log \left(\frac{a+l_1}{a} \right) F(\theta_2, \mu t) \quad (128)$$

39. Spherical Surface Source, No Shield (Reference (25)) (See Figure 35.)

$$\phi_{P_1} = \frac{S}{2} \frac{R}{a+R} \log \left(\frac{a+2R}{a} \right) \quad (129)$$

$$\phi_{P_2} = S_a$$

If self-attenuation μ_s is present,

$$P_2 = S_a e^{-\mu_s R} \quad (130)$$

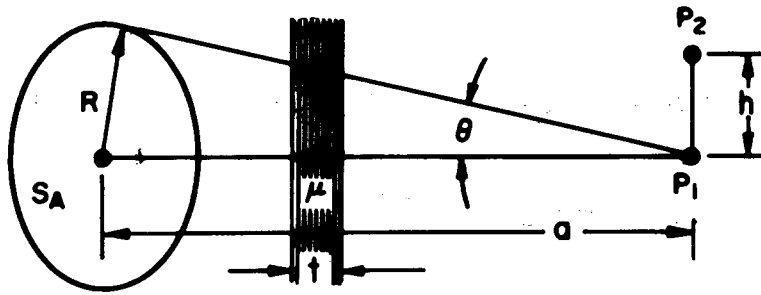


FIGURE 2
UNIFORM DISK SOURCE

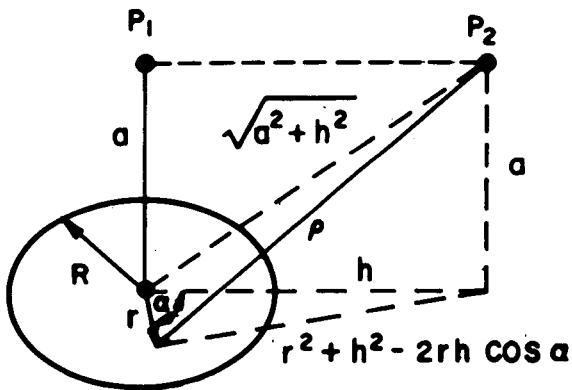


FIGURE 3
UNIFORM DISK SOURCE DETAIL

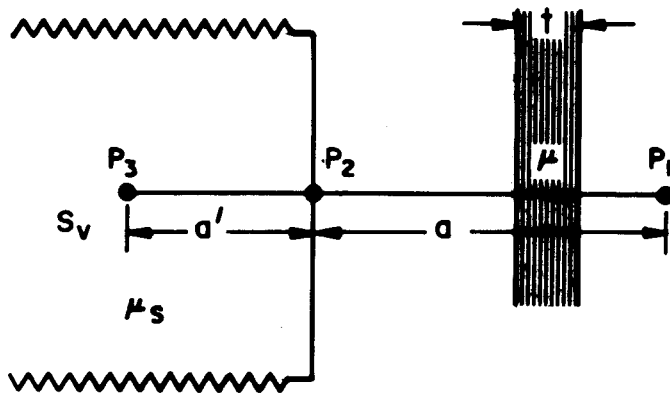


FIGURE 4
INFINITE SLAB SOURCE OF INFINITE DEPTH

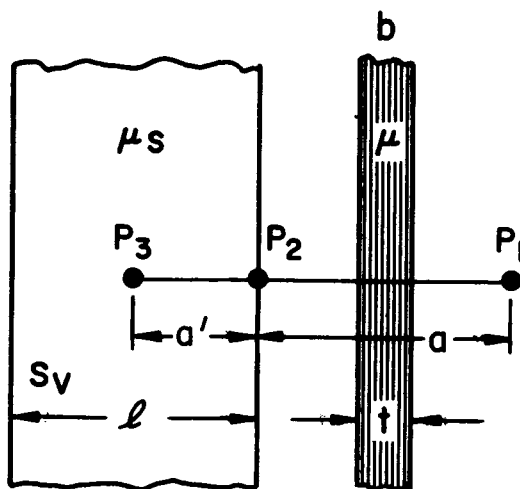


FIGURE 5

INFINITE SLAB SOURCE OF
FINITE DEPTH

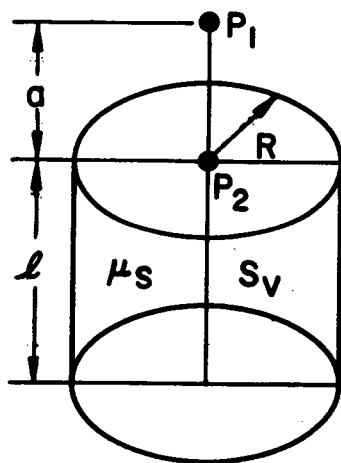


FIGURE 6

CYLINDRICAL SOURCE
WITH AXIAL POINT

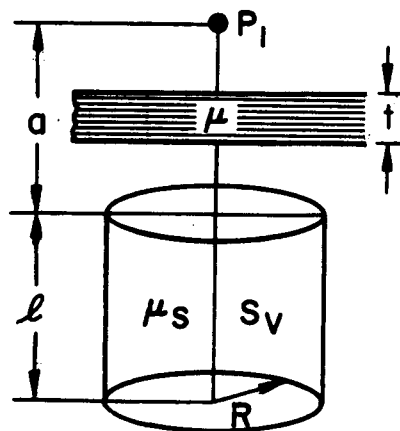


FIGURE 7

CYLINDRICAL SOURCE
WITH SHIELD
AND AXIAL POINT

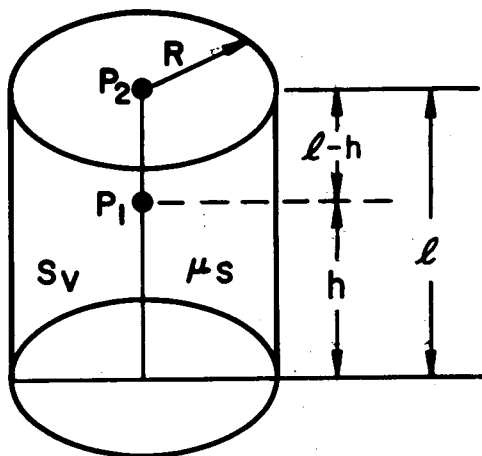


FIGURE 8
CYLINDRICAL SOURCE INTERIOR

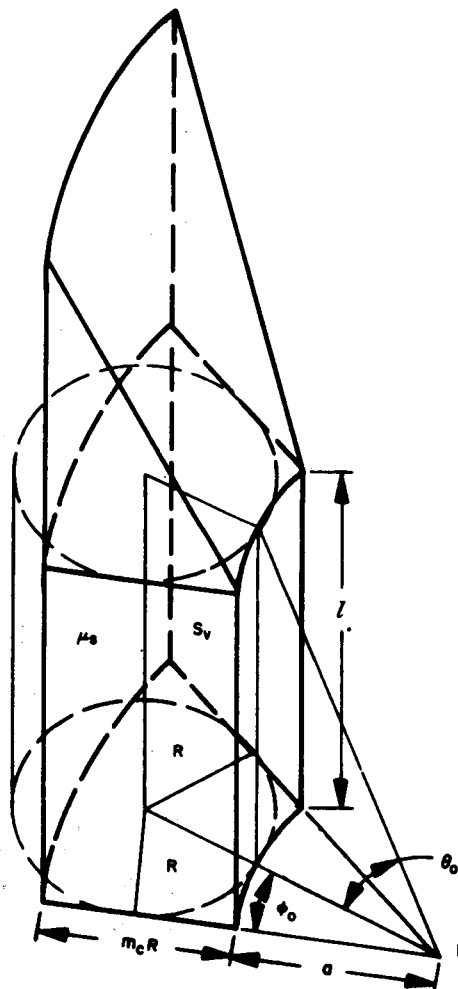


FIGURE 9
CYLINDRICAL SOURCE-VOLUME APPROXIMATION
USING A SECTION OF AN ANNULUS WITH A
CURVED TOP SURFACE

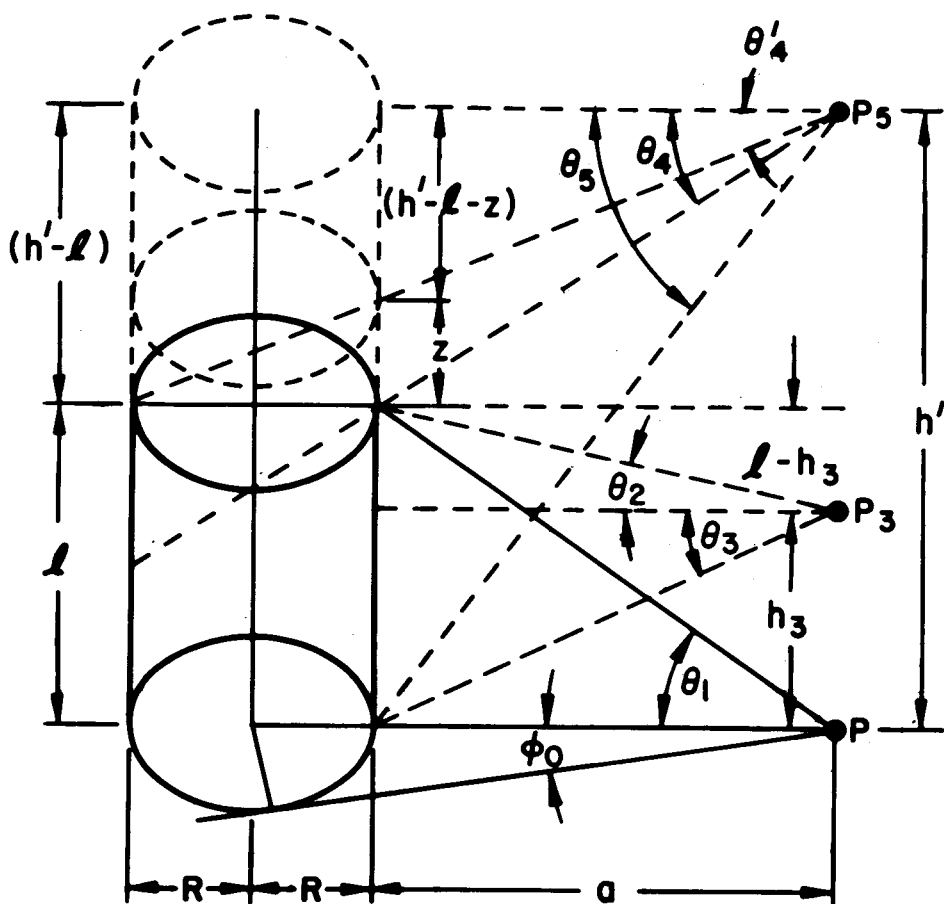


FIGURE 10
CYLINDRICAL SOURCE WITH
EXTERIOR DETECTOR POINTS

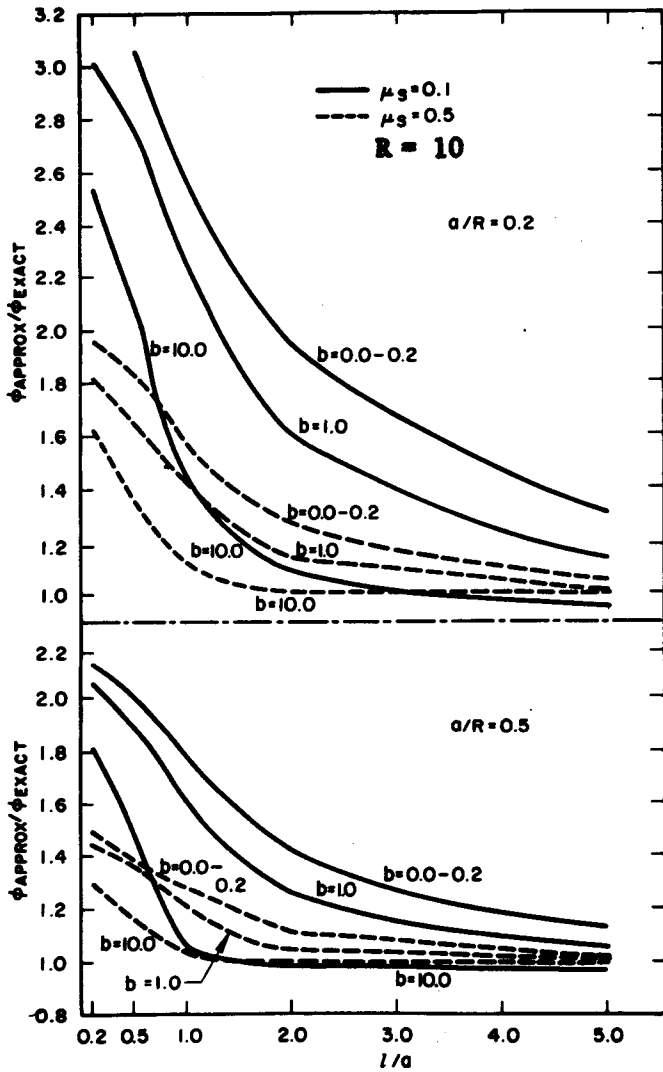


FIGURE 11a

ACCURACY OF THE CYLINDRICAL SOURCE
APPROXIMATION OF ONO AND TSURO

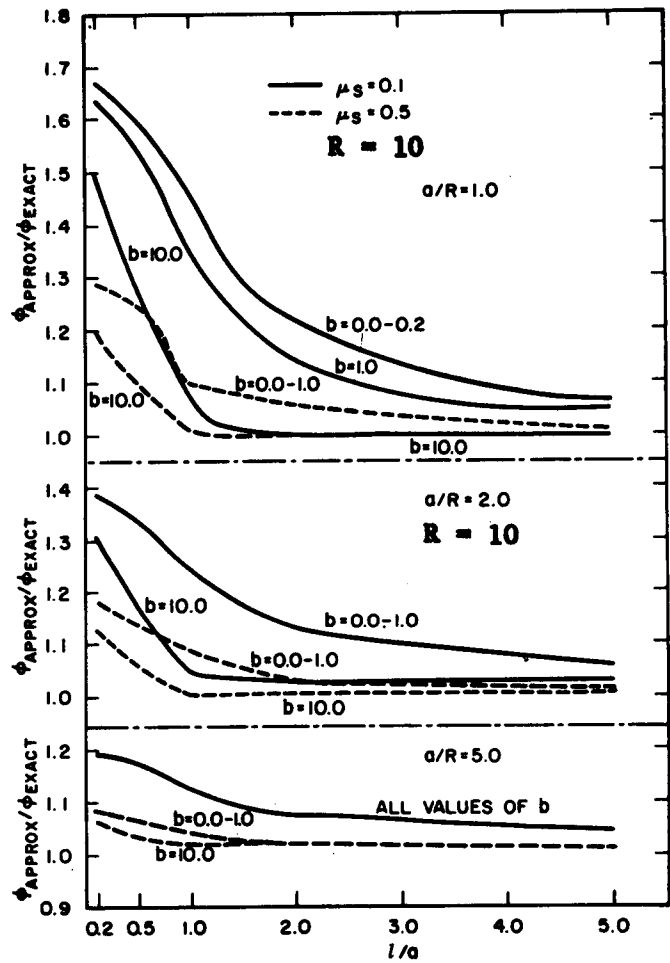


FIGURE 11b

ACCURACY OF THE CYLINDRICAL SOURCE
APPROXIMATION OF ONO AND TSURO

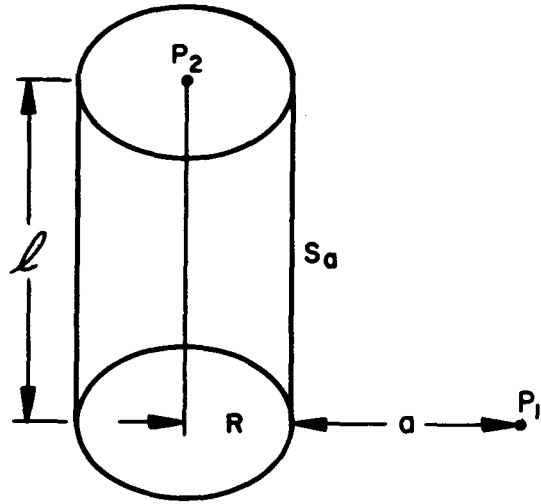


FIGURE 12
CYLINDRICAL SURFACE SOURCE WITH
LATERAL DETECTOR POINT

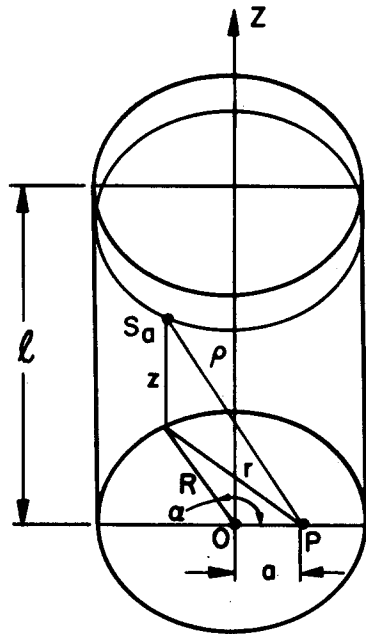


FIGURE 13
CYLINDRICAL SURFACE SOURCE
WITH INTERIOR DETECTOR POINT
NO ATTENUATION

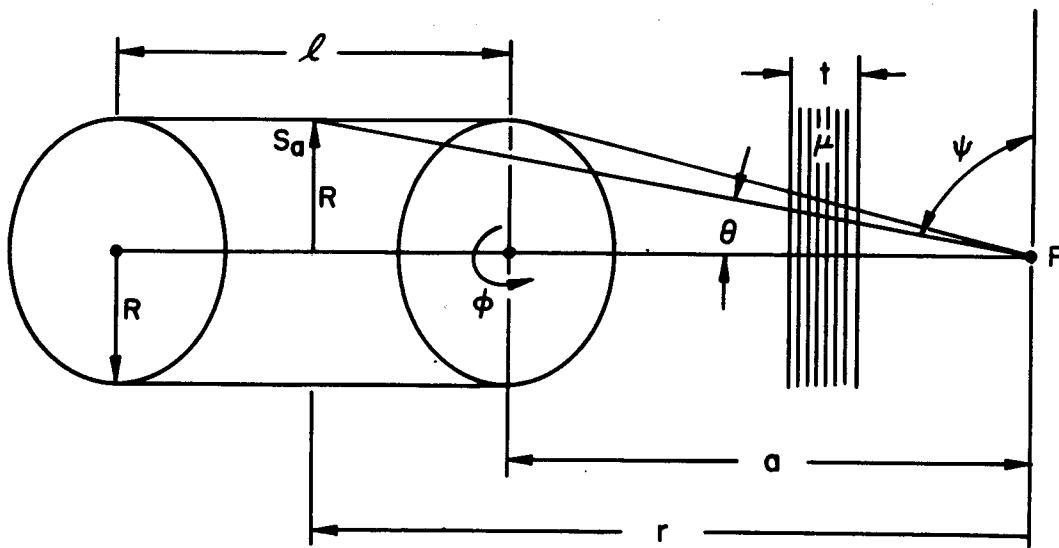


FIGURE 14
CYLINDRICAL SURFACE SOURCE WITH AXIAL
POINT AND SLAB SHIELD

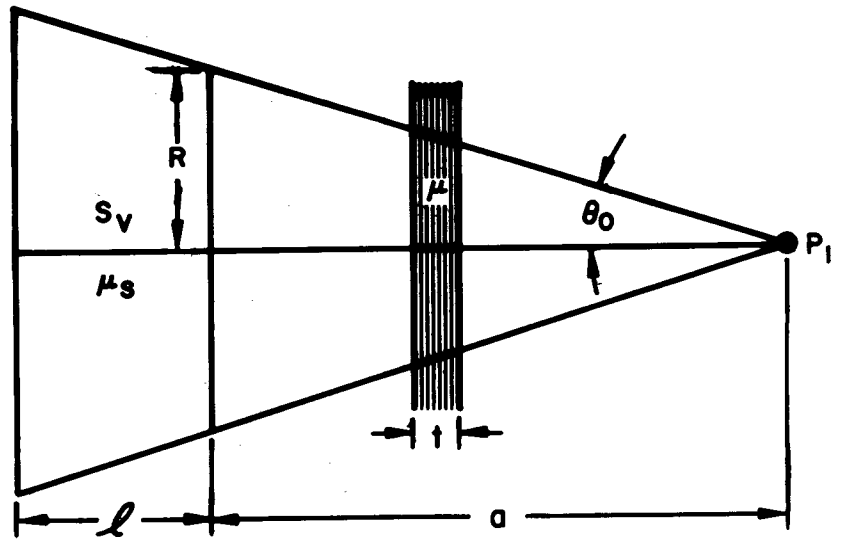


FIGURE 15

TRUNCATED CONE SOURCE WITH
DETECTOR POINT AT APEX

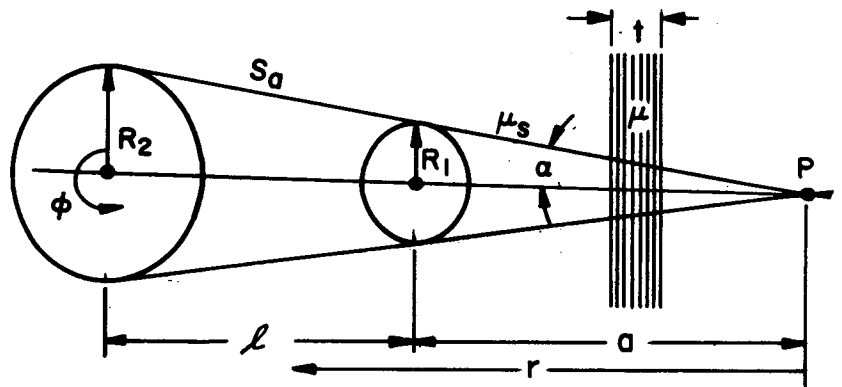


FIGURE 16

TRUNCATED CONE SURFACE SOURCE
WITH SLAB SHIELD, DETECTOR
POINT AT APEX

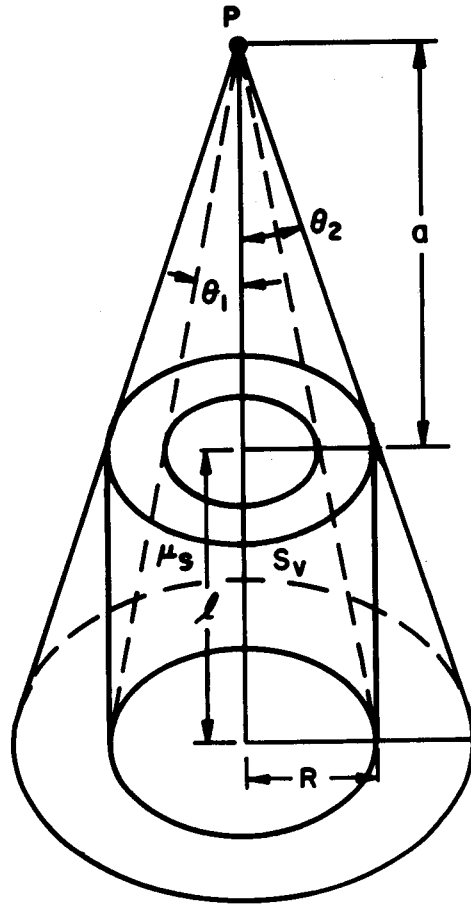


FIGURE 17

APPROXIMATION OF A CYLINDER WITH AXIAL DETECTOR POINT USING TRUNCATED CONES

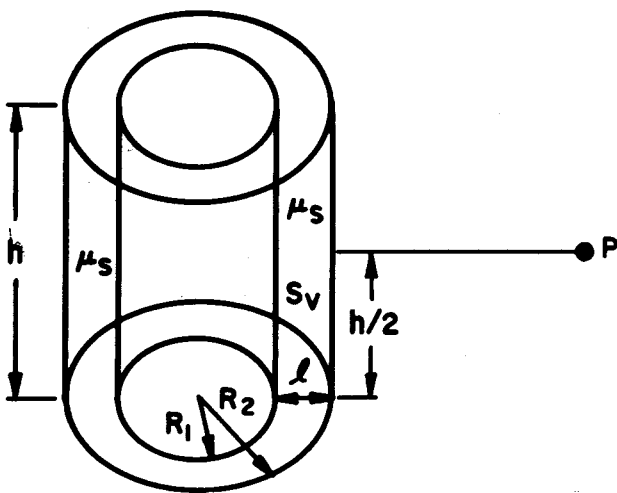


FIGURE 18a

ANNULAR SOURCE

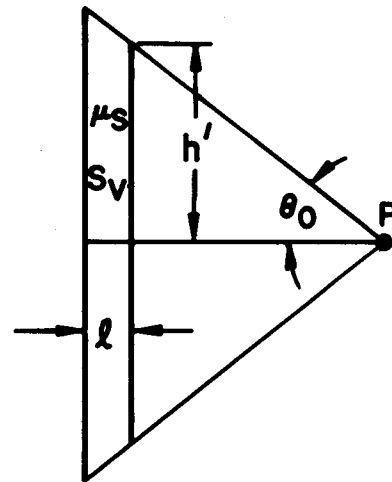


FIGURE 18b

APPROXIMATION OF AN ANNULAR SOURCE USING A TRUNCATED CONE

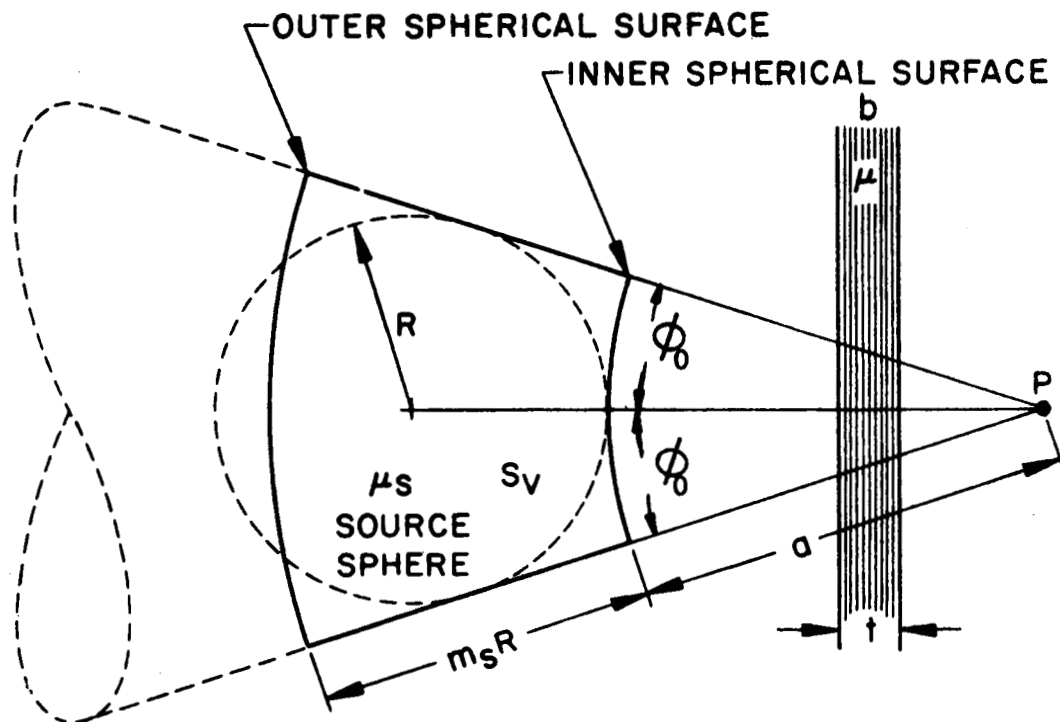


FIGURE 19

SPHERICAL SOURCE APPROXIMATED AS A CONICAL SECTION OF A SPHERICAL SHELL

ACCURACY OF SPHERICAL SOURCE APPROXIMATION

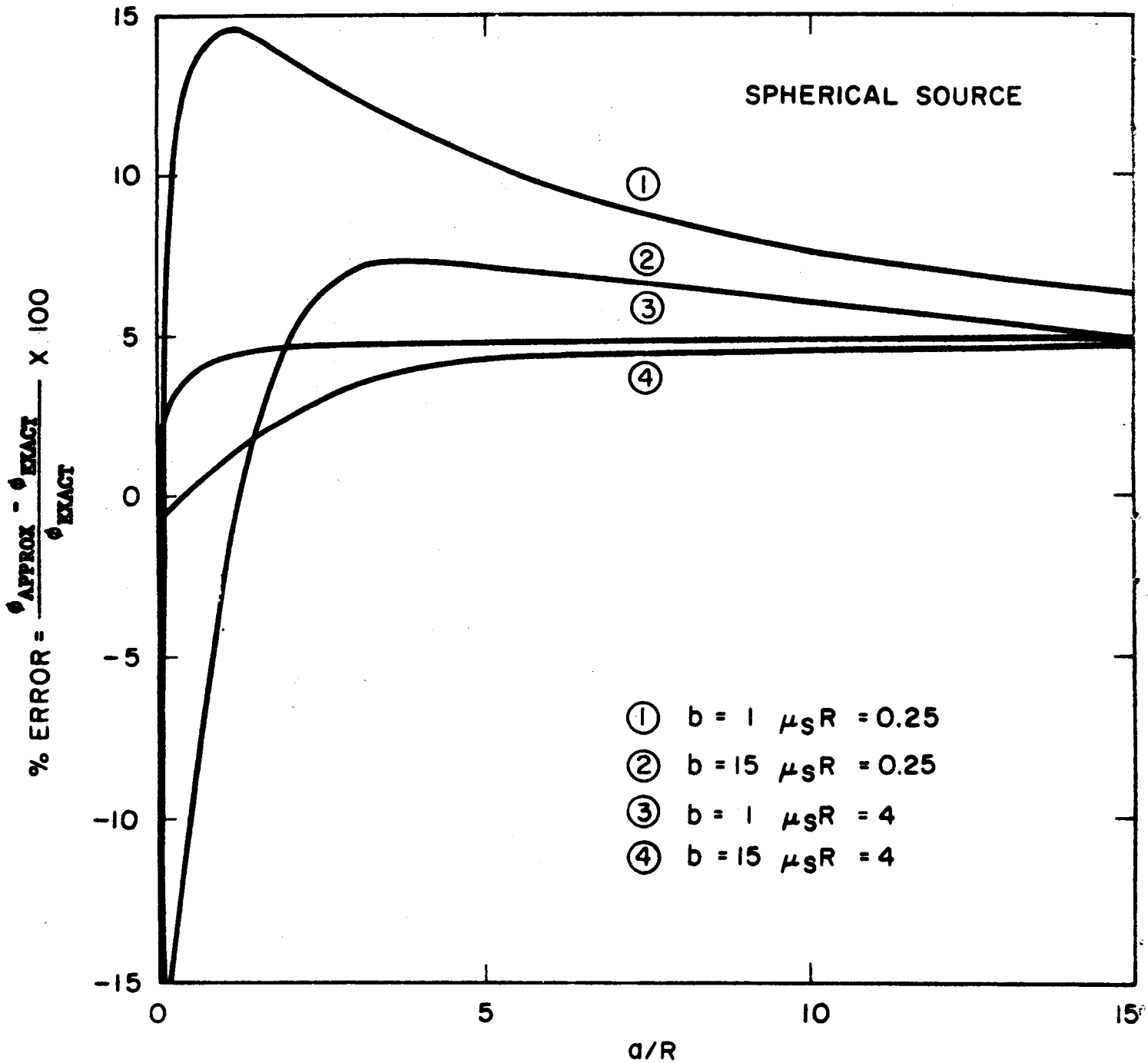


FIGURE 20

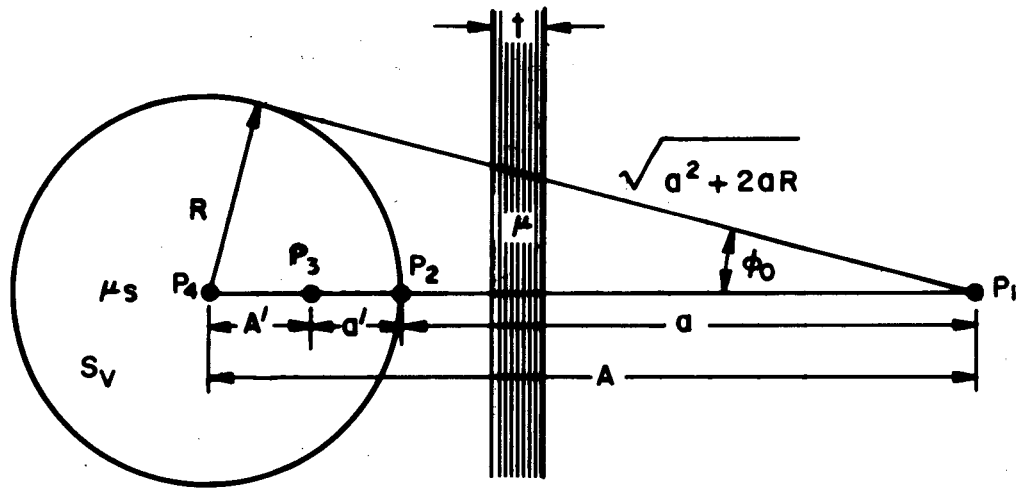


FIGURE 21
SPHERICAL SOURCE

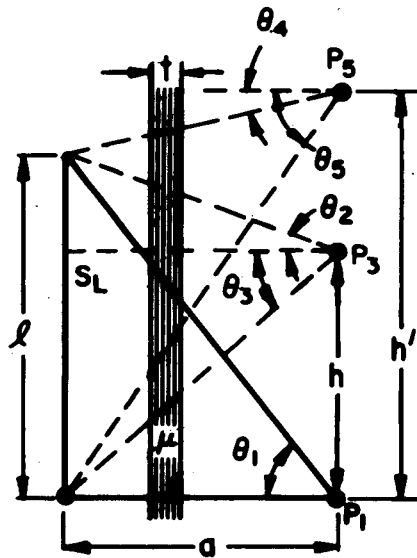
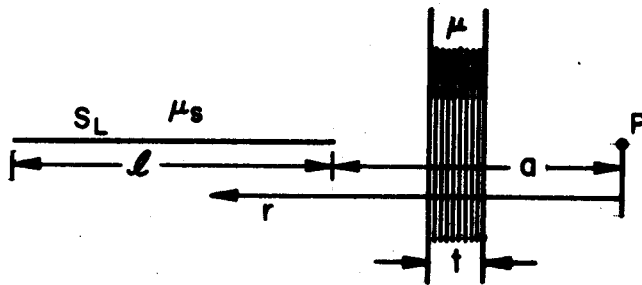


FIGURE 22
LINE SOURCE



μ_s = SELF ATTENUATION
COEFFICIENT OF MEDIUM
CONTAINING THE LINE
SOURCE

FIGURE 23a LINE SOURCE WITH PERPENDICULAR
SLAB SHIELD

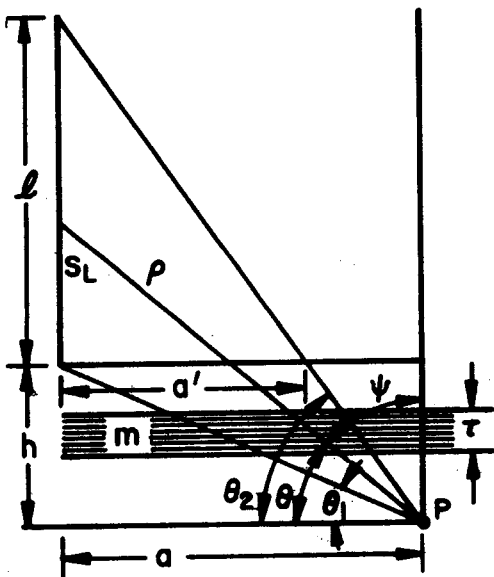


FIGURE 23b LINE SOURCE
WITH PERPENDICULAR SLAB SHIELD

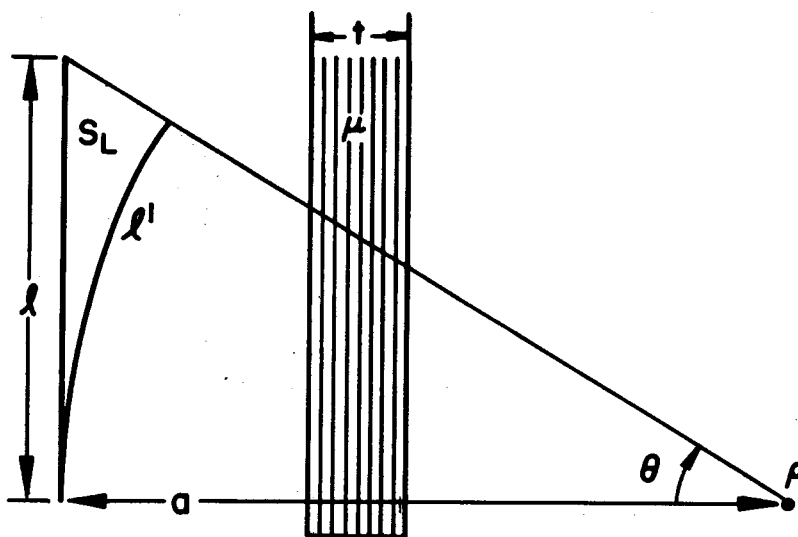


FIGURE 24 CLASSIC LINE SOURCE WITH SLAB
SHIELD, AND EQUIVALENT CIRCULAR ARC SOURCE

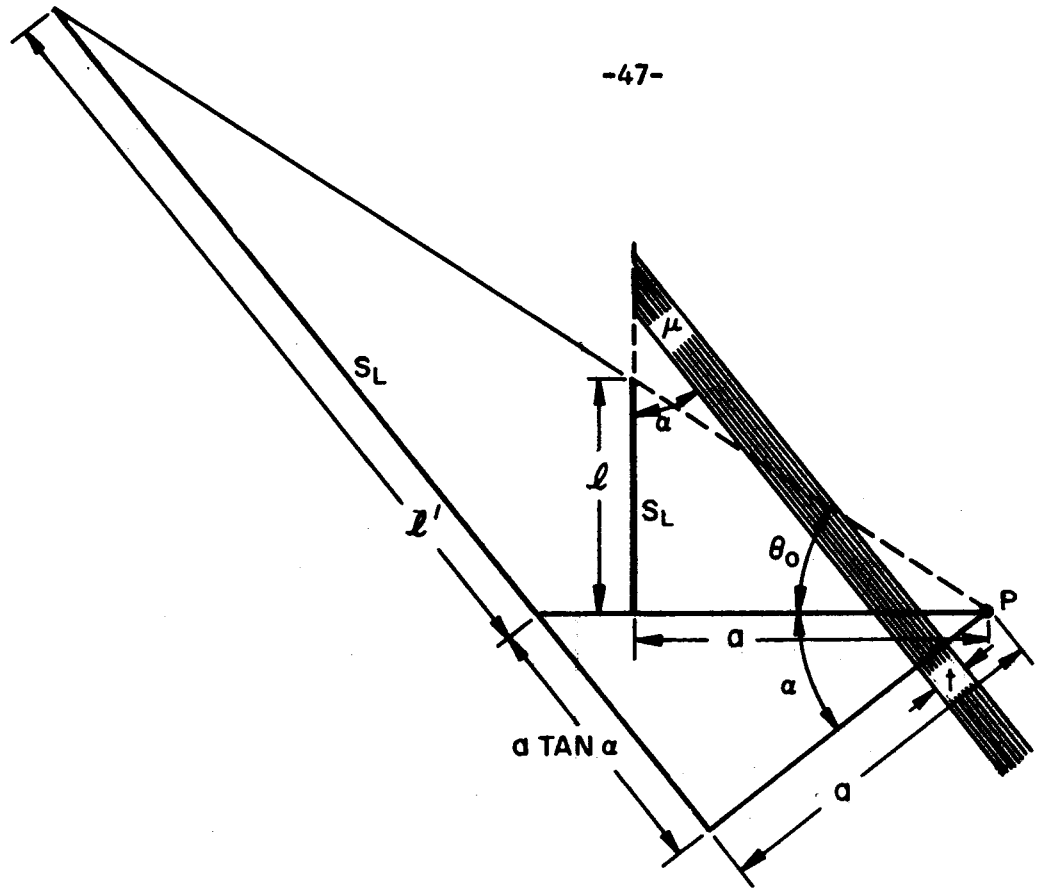


FIGURE 25a LINE SOURCE WITH TILTED SLAB SHIELD

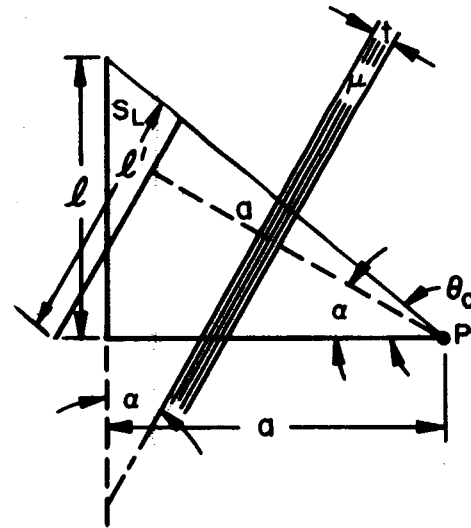


FIGURE 25b LINE SOURCE WITH TILTED SLAB SHIELD

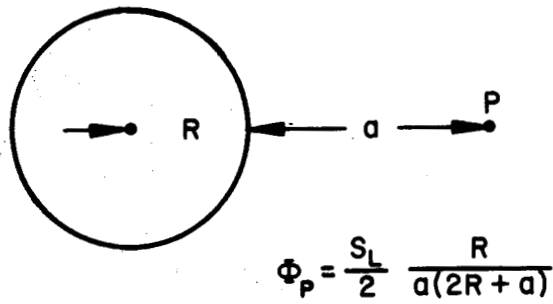


FIGURE 26
CIRCULAR LINE SOURCE WITH
EXTERIOR DETECTOR POINT

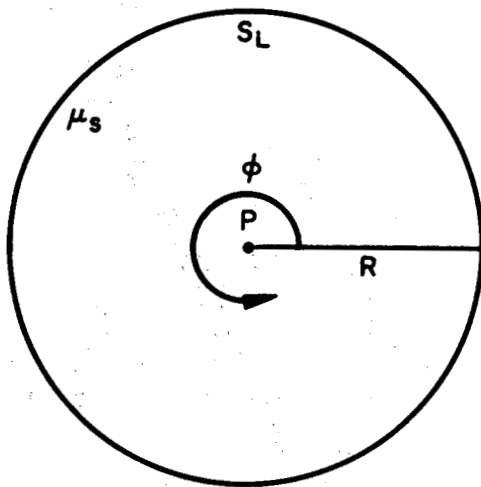


FIGURE 27 CIRCULAR LINE SOURCE
WITH DETECTOR POINT IN CENTER

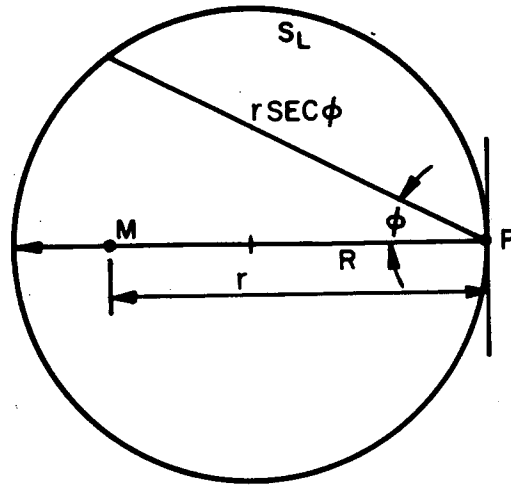


FIGURE 28 CIRCULAR LINE SOURCE WITH DETECTOR POINT AT END OF A DIAMETER

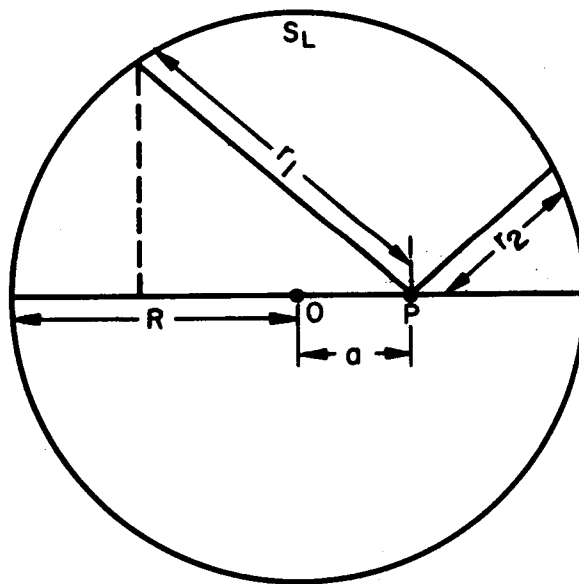


FIGURE 29 CIRCULAR LINE SOURCE WITH ARBITRARY INTERIOR DETECTOR POINT

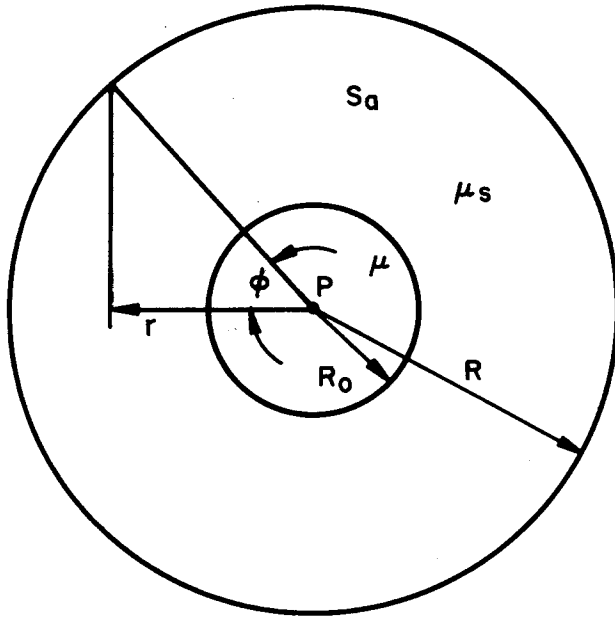


FIGURE 30 ANNULAR DISK SOURCE WITH DETECTOR POINT AT CENTER

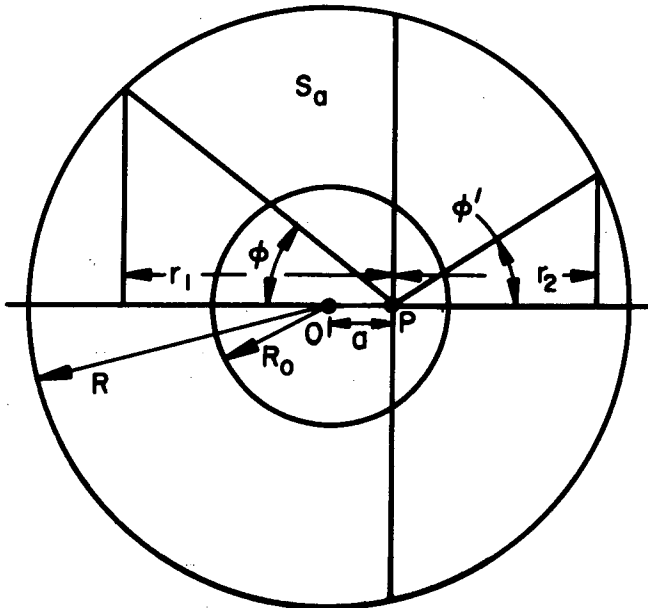


FIGURE 31. ANNULAR DISK SOURCE WITH DETECTOR POINT ARBITRARILY LOCATED INSIDE THE ANNULUS

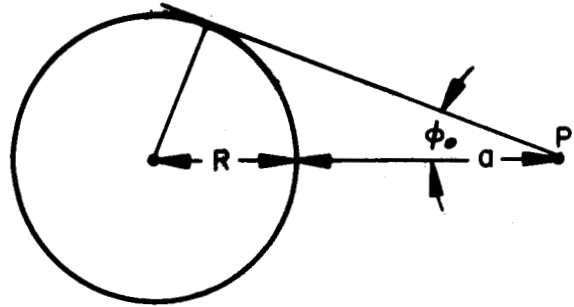


FIGURE 32
DISK SOURCE WITH EXTERIOR
LATERAL DETECTOR POINT

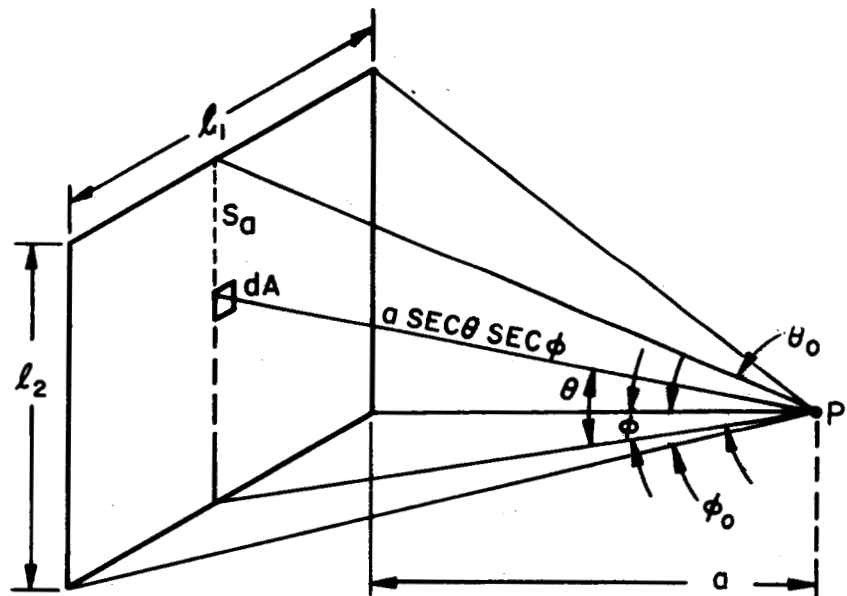


FIGURE 33 RECTANGULAR SURFACE SOURCE
WITH DETECTOR POINT ON PERPENDICULAR

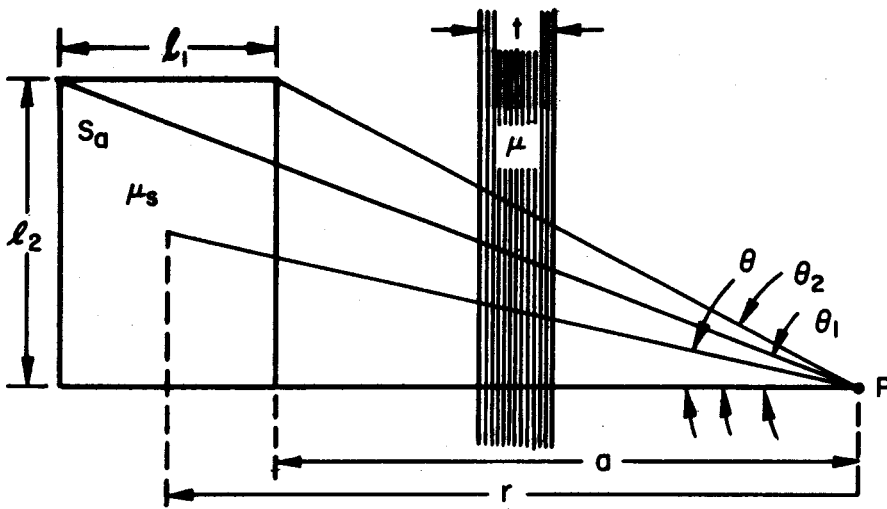


FIGURE 34 RECTANGULAR SURFACE SOURCE WITH LATERAL DETECTOR POINT

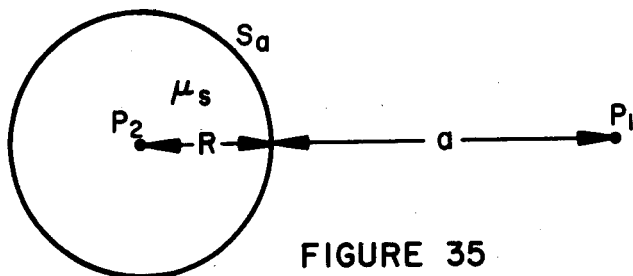


FIGURE 35 SPHERICAL SURFACE SOURCE WITH NO SHIELD

C. Shielding Functions - Tables and Plots

1. The Compact Exponential Integral Functions $\bar{E}_1(b)$ and $\bar{E}_2(b)$

The exponential integral functions $E_1(b)$ and $E_2(b)$ are defined in terms of $\bar{E}_1(b)$ and $\bar{E}_2(b)$ as follows.

$$E_1(b) = \bar{E}_1(b) \frac{e^{-b}}{b} \quad (131)$$

$$E_2(b) = \bar{E}_2(b) \frac{e^{-b}}{b} \quad (132)$$

These tables are given in this form because of their compactness and ease of interpolation. See Reference (7).

Values of the exponential function e^{-b} may be read from Table 2.

TABLE 1

THE COMPACT EXPONENTIAL INTEGRAL FUNCTIONS $\bar{E}_1(b)$ AND $\bar{E}_2(b)$

<u>b(mfp)</u>	<u>$\bar{E}_1(b)$</u>	<u>$\bar{E}_2(b)$</u>
.01	.04078	.00954
.02	.06845	.01863
.03	.09148	.02726
.04	.11163	.03553
.05	.12972	.04351
.06	.14622	.05123
.08	.17566	.06595
.10	.20146	.07985
.20	.29867	.14027
.40	.41913	.23235
.60	.49676	.30194
.80	.55300	.35760
1.00	.59635	.40365
1.25	.63879	.45151
1.50	.67239	.49142
1.75	.69979	.52537
1.90	.71398	.54345
2.00	.72266	.55469
2.50	.75881	.60296
3.00	.78625	.64125
3.50	.80787	.67246

TABLE 1 (Continued)

<u>b(mfp)</u>	<u>\bar{E}_1(b)</u>	<u>\bar{E}_2(b)</u>
4.00	.82538	.69847
5.00	.85211	.73945
6.00	.87161	.77037
8.00	.89824	.81410
10.00	.91563	.84367
12.00	.92791	.86504
15.00	.94080	.88794
19.00	.95218	.90856
20.00	.95437	.91258
25.00	.96287	.92831
35.00	.97294	.94726
50.00	.98076	.96223
60.00	.98386	.96823
75.00	.98701	.97435
100.00	.99019	.98058
150.00	.99342	.98693
190.00	.99479	.98964
200.00	.99505	.99015

$$\bar{E}_1(b) = be^b E_1(b)$$

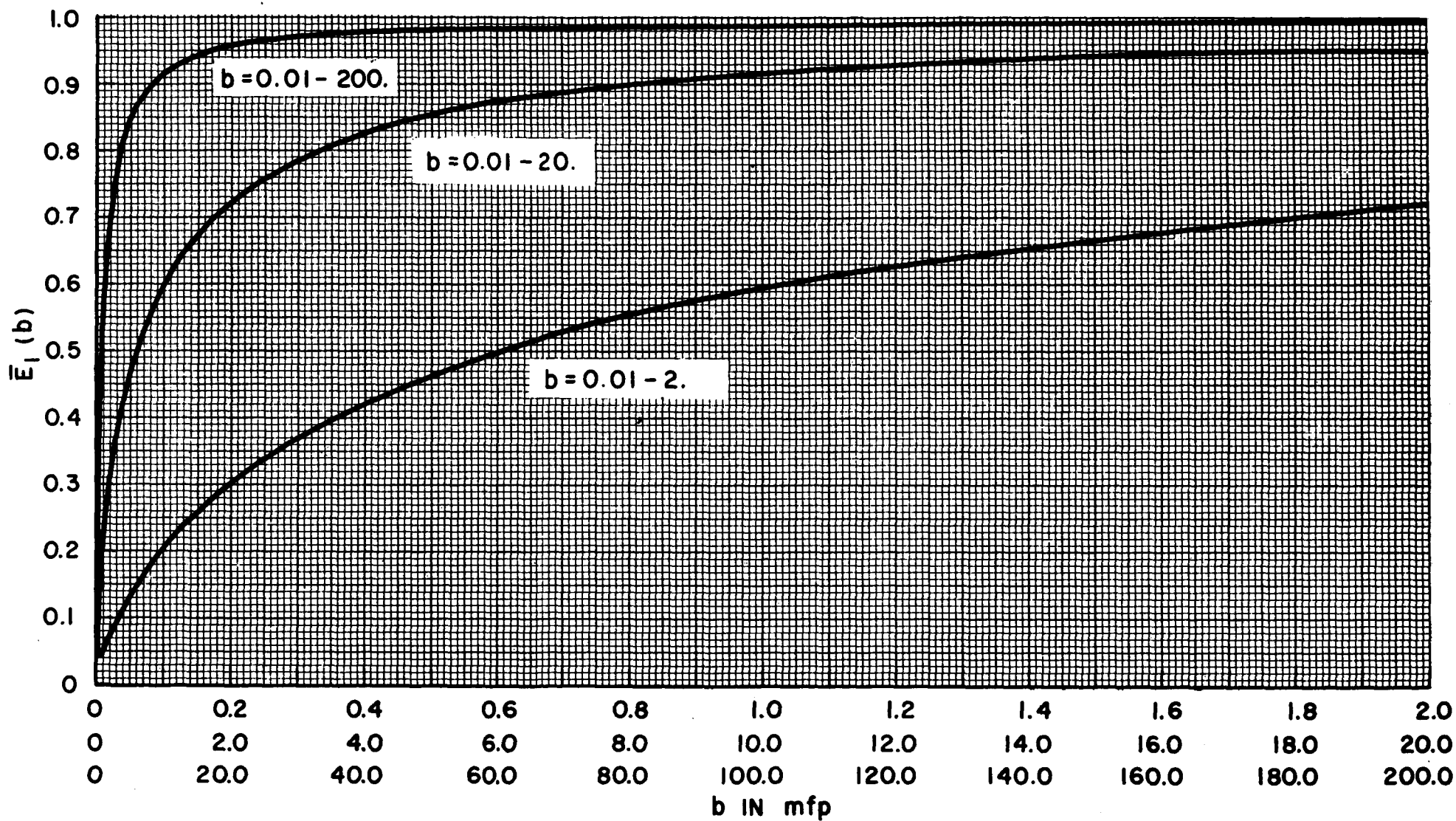


FIGURE 36

$$\bar{E}_2(b) = be^b E_2(b)$$

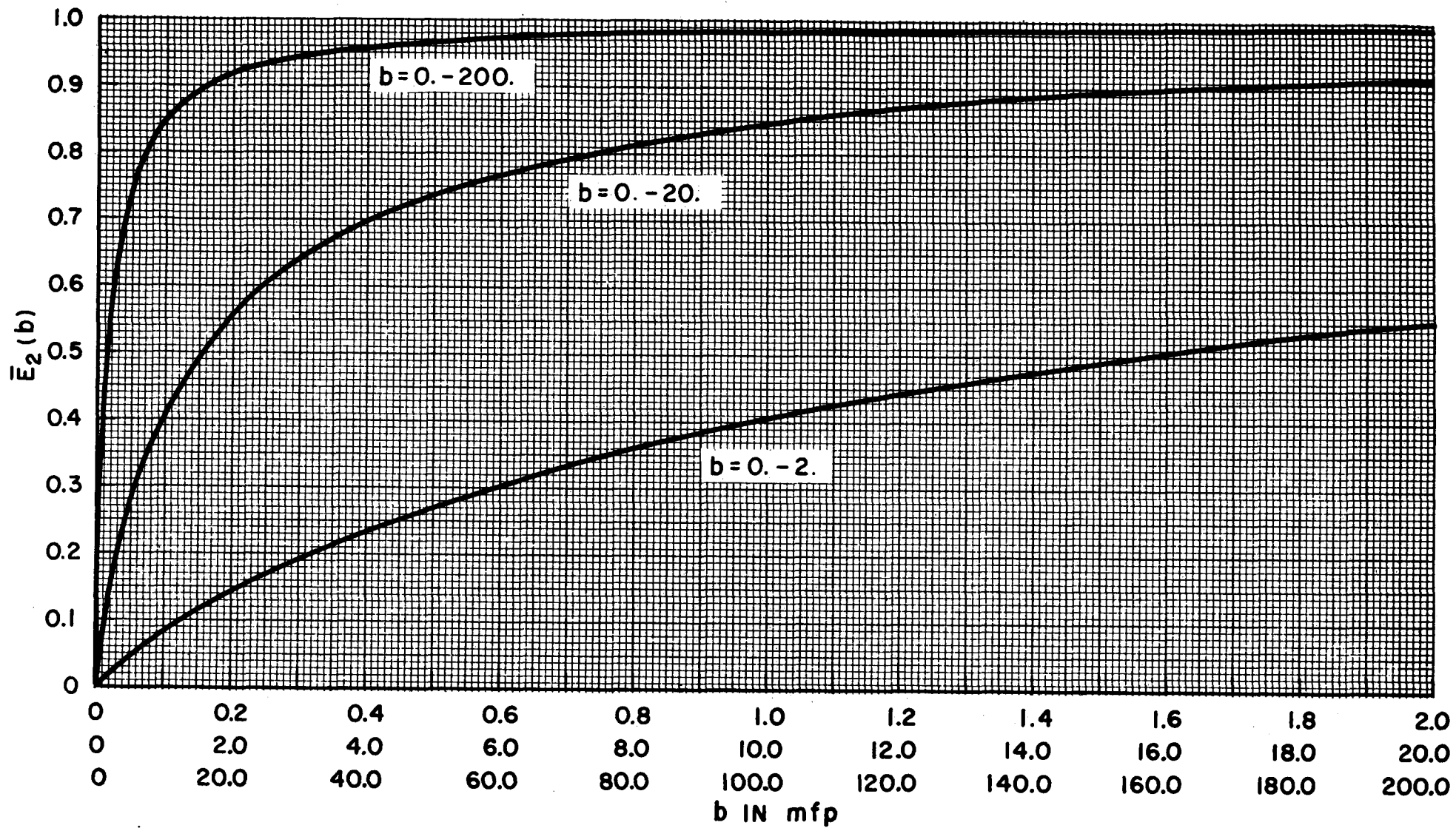


FIGURE 37

2. The Exponential Function e^{-x}

This function is needed for convenient use of the tables of the functions $\bar{E}_1(b)$, $\bar{E}_2(b)$, $\bar{G}(\theta_0, b)$, and $\bar{F}(\theta_0, b)$ which are given in compact form. e^{-x} also appears in various flux formulas.

TABLE 2

THE EXPONENTIAL FUNCTION EXP(-X)

X	0	.1	.2	.3	.4	.5	.6	.7	.8	.9
0.0	1.00000+01	904837+00	818731+00	740818+00	670320+00	606531+00	548812+00	496585+00	449329+00	406570+00
1.0	367879+00	332871+00	301194+00	272532+00	246597+00	223130+00	201897+00	182684+00	165299+00	149569+00
2.0	135335+00	122456+00	110403+00	100259+00	907180-01	820850-01	742736-01	672055-01	608101-01	550232-01
3.0	497871-01	450492-01	407622-01	368832-01	333733-01	301974-01	273237-01	247235-01	223708-01	202419-01
4.0	183156-01	165727-01	149956-01	135686-01	122773-01	111090-01	100518-01	909528-02	822975-02	744658-02
5.0	673795-02	609675-02	551656-02	499159-02	451658-02	408677-02	369796-02	334597-02	302755-02	273944-02
6.0	247875-02	224287-02	202943-02	183630-02	166156-02	150344-02	136037-02	123091-02	111378-02	100779-02
7.0	911882-03	825105-03	746586-03	675539-03	611253-03	553084-03	500451-03	452827-03	409735-03	370744-03
8.0	335463-03	303539-03	274454-03	248517-03	224867-03	203468-03	184106-03	166586-03	150733-03	136389-03
9.0	123410-03	111666-03	101439-03	914242-04	827241-04	748518-04	677297-04	612835-04	554519-04	501747-04
10.0	453999-04	410796-04	371703-04	336331-04	304325-04	275364-04	249190-04	225449-04	203995-04	184582-04
11.0	167017-04	151123-04	136742-04	123729-04	111955-04	101301-04	916649-05	829382-05	750456-05	679040-05
12.0	614421-05	555951-05	503446-05	455174-05	411859-05	372665-05	337202-05	305113-05	276077-05	249805-05
13.0	226033-05	204523-05	185100-05	167449-05	151514-05	137096-05	124050-05	112245-05	101563-05	918981-06
14.0	831529-06	752398-06	680798-06	616012-06	557390-06	504348-06	456353-06	412925-06	373630-06	338074-06
15.0	305902-06	274792-06	250452-06	226618-06	205052-06	185539-06	167883-06	151907-06	137451-06	124371-06
16.0	112535-06	101826-06	921390-07	833681-07	754346-07	682560-07	617606-07	558833-07	505653-07	457534-07
17.0	413994-07	374597-07	338949-07	306694-07	277508-07	251100-07	227205-07	205583-07	186019-07	168317-07
18.0	152300-07	137807-07	124643-07	112826-07	102090-07	923745-08	835839-08	756298-08	684327-08	619205-08
19.0	560280-08	506962-08	458718-08	415065-08	375567-08	339827-08	307488-08	278227-08	251750-08	227793-08
20.0	206115-08	186501-08	168753-08	152694-08	138163-08	125015-08	113119-08	102354-08	926136-09	838003-09
21.0	758256-09	686098-09	620808-09	561730-09	508274-09	459906-09	416140-09	376539-09	340706-09	308284-09
22.0	278947-09	252402-09	228342-09	206649-09	186984-09	169190-09	153089-09	138521-09	125339-09	113411-09
23.0	102619-09	928533-10	840172-10	760219-10	687874-10	622414-10	563184-10	509590-10	461096-10	417217-10
24.0	377513-10	341588-10	309082-10	279669-10	253055-10	228973-10	207184-10	187468-10	169628-10	153486-10
25.0	138879-10	125663-10	113705-10	102884-10	930937-11	842346-11	762187-11	689655-11	624026-11	564642-11
26.0	510909-11	462289-11	418297-11	378491-11	342472-11	309082-11	280393-11	253710-11	229566-11	207720-11
27.0	187953-11	170067-11	153883-11	139239-11	125989-11	113999-11	103151-11	933346-12	844527-12	764159-12
28.0	691440-12	625641-12	566103-12	512231-12	463486-12	419380-12	379470-12	343359-12	310684-12	281119-12
29.0	254367-12	230160-12	208258-12	188439-12	170507-12	154281-12	139599-12	126315-12	114294-12	103418-12
30.0	935762-13	846718-13	766137-13	693230-13	627260-13	567569-13	513557-13	464686-13	420465-13	380453-13
31.0	344248-13	311488-13	281846-13	255025-13	230756-13	208797-13	188927-13	170948-13	154680-13	139961-13
32.0	126642-13	114590-13	103685-13	938184-14	848904-14	768120-14	695024-14	628884-14	569038-14	514887-14
33.0	465889-14	421553-14	381437-14	345139-14	312294-14	282576-14	255685-14	231353-14	209337-14	189416-14
34.0	171391-14	155081-14	140323-14	126969-14	114887-14	103954-14	940613-15	851102-15	770109-15	696823-15
35.0	630512-15	570511-15	516219-15	467095-15	422645-15	382425-15	346022-15	313103-15	283307-15	256347-15
36.0	231952-15	209879-15	189906-15	171834-15	155482-15	140686-15	127298-15	115184-15	104223-15	943048-16
37.0	853305-16	772102-16	698427-16	632144-16	571987-16	517556-16	468304-16	423739-16	383415-16	346928-16
38.0	313913-16	284040-16	257010-16	232553-16	210422-16	190398-16	172279-16	155885-16	141050-16	127628-16
39.0	115482-16	104492-16	945489-17	855513-17	774101-17	700435-17	633780-17	573468-17	518895-17	469516-17
40.0	424835-17	384407-17	347826-17	314726-17	284776-17	257676-17	233155-17	210967-17	190891-17	172725-17
41.0	156288-17	141415-17	127958-17	115781-17	104763-17	947936-18	857728-18	776104-18	702248-18	635420-18
42.0	574952-18	520238-18	470731-18	425935-18	385402-18	348726-18	315540-18	285513-18	258343-18	233758-18
43.0	211513-18	191385-18	173172-18	156693-18	141781-18	128289-18	116081-18	105034-18	950390-19	859948-19
44.0	778113-19	704066-19	637065-19	576440-19	521585-19	471950-19	427038-19	386400-19	349629-19	316357-19
45.0	286252-19	259011-19	234303-19	212061-19	191880-19	173621-19	157098-19	142148-19	128621-19	116381-19
46.0	105306-19	952850-20	862174-20	780127-20	705888-20	638714-20	577933-20	522935-20	473171-20	428143-20
47.0	387400-20	350534-20	317176-20	286993-20	259682-20	234970-20	212609-20	192377-20	174070-20	157505-20
48.0	142516-20	128954-20	116483-20	105579-20	955316-21	864406-21	782147-21	707716-21	640368-21	579428-21
49.0	524289-21	474396-21	429251-21	388403-21	351441-21	317997-21	287736-21	260354-21	235578-21	213160-21
50.0	192875-21	174521-21	157913-21	142885-21	129288-21	116985-21	105852-21	957789-22	866643-22	784171-22

TABLE 2 (Continued)

X	0	.1	.2	.3	.4	.5	.6	.7	.8	.9
51.0	709547-22	642026-22	580428-22	525646-22	475624-22	430362-22	389408-22	352351-22	318820-22	288480-22
52.0	261028-22	236188-22	213712-22	193374-22	174972-22	158321-22	143255-22	129623-22	117287-22	106126-22
53.0	960268-22	868886-22	786201-23	711384-23	643687-23	582432-23	527006-23	476855-23	431476-23	390416-23
54.0	353263-23	319645-23	289227-23	261704-23	236799-23	214265-23	193875-23	175425-23	158731-23	143626-23
55.0	129958-23	117591-23	106401-23	962754-24	871135-24	788236-24	713225-24	645353-24	583940-24	528370-24
56.0	478089-24	432593-24	391426-24	354177-24	320473-24	289976-24	262381-24	237412-24	214819-24	194377-24
57.0	175879-24	159142-24	143998-24	130295-24	117895-24	106076-24	965246-25	873390-25	790276-25	715072-25
58.0	647023-25	585451-25	529758-25	479327-25	433713-25	392440-25	355094-25	321302-25	290726-25	263060-25
59.0	238027-25	215375-25	194800-25	176334-25	159554-25	144370-25	130632-25	118201-25	106952-25	967744-26
60.0	875651-26	792322-26	716922-26	648698-26	586966-26	531109-26	480507-26	434835-26	393455-26	356013-26
61.0	322134-26	291479-26	263741-26	238643-26	215933-26	195384-26	176791-26	159967-26	144744-26	130970-26
62.0	118506-26	107229-26	970249-27	877918-27	794373-27	718778-27	650377-27	588486-27	532484-27	481811-27
63.0	435961-27	394474-27	356935-27	322968-27	292233-27	264424-27	239260-27	216492-27	195890-27	177249-27
64.0	160381-27	145119-27	131309-27	118813-27	107507-27	972760-28	880190-28	796429-28	720639-28	652061-28
65.0	590009-28	533862-28	48359-28	437089-28	395495-28	357859-28	323804-28	292990-28	265108-28	239880-28
66.0	217052-28	196397-28	177707-28	160796-28	145494-28	131649-28	119121-28	107785-28	975278-29	882468-29
67.0	798490-29	722504-29	653749-29	591536-29	535244-29	484309-29	438221-29	396519-29	358785-29	324642-29
68.0	293748-29	265794-29	240501-29	217614-29	196905-29	178167-29	161212-29	145871-29	131990-29	119429-29
69.0	108064-29	977803-30	884753-30	800557-30	724374-30	655441-30	593007-30	536630-30	485563-30	439355-30
70.0	397545-30	359714-30	325482-30	294509-30	266482-30	241123-30	218177-30	197415-30	178628-30	161630-30
71.0	146249-30	132331-30	119738-30	108344-30	980334-31	887043-31	802629-31	726249-31	657137-31	594603-31
72.0	538019-31	486819-31	440492-31	398574-31	360645-31	326325-31	295271-31	267172-31	241747-31	218742-31
73.0	197926-31	179091-31	162048-31	146627-31	132674-31	120048-31	108624-31	982871-32	889339-32	804707-32
74.0	728129-32	658838-32	596142-32	539411-32	488079-32	441033-32	399606-32	361578-32	327169-32	296035-32
75.0	267864-32	242373-32	219308-32	198438-32	179554-32	162468-32	147007-32	133017-32	120359-32	108905-32
76.0	985415-32	891641-33	806790-33	730014-33	660544-33	597685-33	540807-33	489343-33	442776-33	400640-33
77.0	362514-33	328016-33	296801-33	268557-33	243000-33	219876-33	198952-33	180019-33	162888-33	147387-33
78.0	133361-33	120670-33	109187-33	987966-34	893949-34	808878-34	731903-34	662254-34	599232-34	542207-34
79.0	490609-34	443922-34	401477-34	363452-34	328865-34	297570-34	269252-34	243629-34	220445-34	199467-34
80.0	180485-34	163310-34	147769-34	133707-34	120983-34	109470-34	990523-35	896263-35	810972-35	733798-35
81.0	663968-35	600783-35	543011-35	491879-35	445071-35	402717-35	364393-35	329717-35	298340-35	269949-35
82.0	244260-35	221016-35	199983-35	180952-35	163732-35	148151-35	134053-35	121296-35	109753-35	993087-36
83.0	898583-36	813071-36	735697-36	665686-36	602338-36	545018-36	493153-36	446223-36	403759-36	365336-36
84.0	330570-36	299112-36	270548-36	244892-36	221588-36	200501-36	181421-36	164156-36	148535-36	134400-36
85.0	121610-36	110037-36	995658-37	900909-37	815176-37	737602-37	667409-37	603897-37	546429-37	494429-37
86.0	447378-37	404804-37	366282-37	331426-37	299886-37	271348-37	245526-37	222161-37	201020-37	181890-37
87.0	164581-37	148919-37	134748-37	121925-37	110322-37	998235-38	903240-38	817286-38	739511-38	669137-38
88.0	605460-38	547843-38	495709-38	448536-38	405852-38	367230-38	332284-38	300663-38	272051-38	246162-38
89.0	222736-38	201540-38	182361-38	165007-38	149305-38	135096-38	122240-38	110608-38	100082-38	905578-39
90.0	819401-39	741425-39	670869-39	607027-39	549261-39	496992-39	449697-39	406903-39	368181-39	333144-39
91.0	301441-39	272755-39	246799-39	223313-39	202062-39	182833-39	165434-39	149691-39	135446-39	122557-39
92.0	110894-39	100341-39	907922-40	821522-40	743344-40	672606-40	608599-40	550683-40	498278-40	450861-40
93.0	407956-40	369134-40	334006-40	302221-40	273461-40	247438-40	223891-40	202585-40	183306-40	165862-40
94.0	150079-40	135797-40	122874-40	111181-40	100601-40	910273-41	823649-41	745268-41	674347-41	610174-41
95.0	552108-41	499568-41	452028-41	409012-41	370089-41	334871-41	303003-41	274169-41	248078-41	224470-41
96.0	203109-41	183781-41	166292-41	150467-41	136148-41	123192-41	111469-41	100861-41	912629-42	825781-42
97.0	747197-42	676092-42	611753-42	553537-42	500861-42	453198-42	410071-42	371047-42	335737-42	303788-42
98.0	274879-42	248720-42	225051-42	203635-42	184257-42	166722-42	150857-42	136501-42	123511-42	111757-42
99.0	101122-42	914991-43	827918-43	749131-43	677842-43	613337-43	554970-43	502158-43	454371-43	411132-43

3. The Function $D(\bar{\mu}_R, \bar{\mu}_a, \bar{\mu}_h)$

The function $D(\bar{\mu}_R, \bar{\mu}_a, \bar{\mu}_h)$ is useful for finding the flux at points opposite a disk source but not on the disk axis. See Figures 2 and 3.

TABLE 3 (Continued)

TABLE OF THE FUNCTION		D(MU•R, MU•A, MU•H)								
MU•A(MFP)	=	.25000	.50000	.75000	1.00000	1.50000	2.00000	3.00000	5.00000	7.50000
MU•H(MFP)	=	.50000	.50000	.58000	.50000	.50000	.50000	.50000	.50000	.50000
MU•R(MFP)										
.10000	5834952-01	3102385-01	1565689-01	8189574-02	2978544-02	9387976-03	1620364-03	8171387-05	3023317-06	
.25000	3933155+00	1946503+00	9640528-01	5030221-01	1589309-01	5806485-02	1006153-02	5089290-04	1885502-05	
.50000	1859642+01	7563211+00	3617239+00	1887247+00	6052596-01	2238650-01	3932912-02	2010562-03	7484281-05	
.75000	3704393+01	1485955+01	7180598+00	3808889+00	1257868+00	4745577-01	8521704-02	4431825-03	1662643-04	
1.00000	4813036+01	2107827+01	1067948+01	5845721+00	2012192+00	7789329-01	1439195-01	7658524-03	2903843-04	
1.50000	5812321+01	2847882+01	1573358+01	9199013+00	3469999+00	1425118+00	2821068-01	1592913-02	6216885-04	
2.00000	6206285+01	3187291+01	1844920+01	1126465+01	4568664+00	1981577+00	4214300-01	2551168-02	1033013-03	
3.00000	6469415+01	3429005+01	2056218+01	1303679+01	5705920+00	2655727+00	6328218-01	4397437-02	1940011-03	
5.00000	6553586+01	3509422+01	2130972+01	1371358+01	6223359+00	3022456+00	7903952-01	6514798-02	3346108-03	
7.50000	6561675+01	3516718+01	2137991+01	1378011+01	6280606+00	3069165+00	8175178-01	7133365-02	3995927-03	
10.00000	6564687+01	3517127+01	2138396+01	1378403+01	6284163+00	3072281+00	8196797-01	7207244-02	4117967-03	
15.00000	6565826+01	3517075+01	2138424+01	1378429+01	6284412+00	3072507+00	8198526-01	7214895-02	4136079-03	
20.00000	6543755+01	3517547+01	2138425+01	1378429+01	6284413+00	3072508+00	8198535-01	7214949-02	4136273-03	
MU•A(MFP)	=	10.00000	15.00000	20.00000	.10000	.25000	.50000	.75000	1.00000	1.50000
MU•H(MFP)	=	.50000	.50000	.58000	.75000	.75000	.75000	.75000	.75000	.75000
MU•R(MFP)										
.10000	1404647-07	4230271-10	1607518-12	2612673-01	2306333-01	1578075-01	9679969-02	5756721-02	2084701-02	
.25000	8765478-07	2641328-09	1003978-11	1766790+00	1531947+00	1012553+00	6082524-01	3584024-01	1292198-01	
.50000	3486915-06	1052840-08	4005658-11	9775432+00	7635572+00	4366570+00	2451481+00	1406482+00	5014285-01	
.75000	7774044-06	2355140-08	8974468-11	4205480+01	2279793+01	1032096+01	5393292+00	3021241+00	1070448+00	
1.00000	1364535-05	4153032-08	1586008-10	8509167+01	4035196+01	1726822-01	8851357+00	4940007+00	1764417+00	
1.50000	2961546-05	9131275-08	3508681-10	1044151+02	5595555+01	2684766-01	1463792+01	8505764+00	3209367+00	
2.00000	5011001-05	1572383-07	6092917-10	1101442+02	6127207+01	3119578-01	1791593+01	1887019+01	4376480+00	
3.00000	9850480-05	3237210-07	1283538-09	1137898+02	6454126+01	3414794+01	2043597+01	1292922+01	8635874+00	
5.00000	1876718-04	6921884-07	2922328-09	1124500+02	6352015+01	3508446+01	2130047+01	1370500+01	6216873+00	
7.50000	2432702-04	1018111-06	4677454-09	1190621+02	6565307+01	3516669+01	2137949+01	1377966+01	6280288+00	
10.00000	2580698-04	1155364-06	5648412-09	1228236+02	6572357+01	3517115+01	2138394+01	1378400+01	6284139+00	
15.00000	2611383-04	1203710-06	6145378-09	1283942+02	6609926+01	3517272+01	2138419+01	1378429+01	6284412+00	
20.00000	2611893-04	1205473-06	6178688-09	1059030+02	6490168+01	3515705+01	2138429+01	1378431+01	6284414+00	
MU•A(MFP)	=	2.00000	3.00000	5.00000	7.50000	10.00000	15.00000	20.00000	.10000	.25000
MU•H(MFP)	=	.75000	.75000	.75000	.75000	.75000	.75000	.75000	1.00000	1.00000
MU•R(MFP)										
.10000	8121756-03	1489803-03	7825438-05	2944957-06	1378625-07	4180684-10	1593770-12	1149786-01	1063910-01	
.25000	5036771-02	9258841-03	4874848-04	1836765-05	8603395-07	2610401-09	9954000-12	7571364-01	6960232-01	
.50000	1959536-01	3630034-02	1927272-03	7292685-05	3422863-06	1040561-08	3971531-11	3698938-00	3296180-00	
.75000	4210292-01	7902492-02	4253338-03	1620760-04	7832805-06	2327855-08	8898361-11	1243387-01	9978806-00	
1.00000	7022396-01	1342651-01	7361955-03	2832419-04	1340124-05	4105362-08	1572643-10	4807816-01	8255524-01	
1.50000	1327367+00	2669134-01	1937698-02	6073282-04	2910849-05	9029210-08	3479674-10	9968582-01	5182095+01	
2.00000	1894688+00	4044128-01	2475202-02	1011193-03	4930358-05	1555422-07	6043861-10	1885513-02	8990996+01	
3.00000	2613925+00	6204723-01	4311074-02	1908195-03	9717623-05	3205900-07	1273962-09	1139081-02	6429789+01	
5.00000	3017159+00	7878317-01	6476275-02	3321167-03	1862358-04	6874721-07	2905336-09	1164766-02	6552421+01	
7.50000	3068827+00	8173026-01	7127558-02	3988971-03	2426527-04	1014696-06	4661100-09	1220184-02	6970337+01	
10.00000	3072259+00	8196638-01	7206638-02	4116843-03	2579236-04	1153973-06	5639078-09	1249593-02	6589889+01	
15.00000	3072507+00	8198526-01	7214891-02	4136065-03	2611351-04	1203631-06	6144302-09	1048672-02	6543924+01	
20.00000	3072509+00	8198536-01	7214950-02	4136273-03	2611893-04	1205472-06	6178632-09	1403353+02	6742054+01	

TABLE 3 (Continued)

TABLE OF THE FUNCTION		D(MU+R, MU+A, MU+H)								
MU+A(MFP) =	.50000	.75000	1.00000	1.50000	2.00000	3.00000	5.00000	7.50000	10.00000	
MU+H(MFP) =	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	
MU+R(MFP)										
.10000	8262808-02	5777144-02	3822902-02	1592576-02	6709225-03	1328657-03	7369728-05	2839067-06	1343079-07	
.25000	5317574-01	3664097-01	2401776-01	9924768-02	4173152-02	8266364-03	4592268-04	1770897-05	8381974-07	
.50000	2349533+00	1534391+00	9741888-01	3923133-01	1640190+01	3253241-02	1817368-03	7033639-05	3335345-06	
.75000	6076637+00	3636601+00	2209448+00	8615177-01	3579723-01	7124733-02	4017298-03	1564093-04	7439760-06	
1.00000	1205818+01	6610010+00	3865207+00	1469381+00	6087081+01	1219889-01	6968605-03	2735556-04	1306744-05	
1.50000	2407998+01	1295872+01	7514581+00	2861356+00	1199543+00	2470284-01	1463892-02	5878291-04	2841440-05	
2.00000	3007033+01	1706810+01	1026928+01	4101682+00	1774732+00	3814836-01	2372687-02	9814627-04	4819765-05	
3.00000	3392307+01	2023853+01	1276326+01	5929705+00	2952931+00	6030692-01	4192117-02	1864470-03	9534620-05	
5.00000	3506960+01	2128641+01	1369198+01	6205862+00	3009260+00	7840809-01	6421460-02	3286229-03	1842352-04	
7.50000	3516599+01	2137875+01	1377899+01	6279613+00	3068323+00	8169846-01	7119078-02	3979043-03	2417801-04	
10.00000	3517204+01	2138389+01	1378396+01	6284103+00	3072227+00	8196403-01	7205752-02	4115220-03	2977147-04	
15.00000	3517802+01	2138443+01	1378438+01	6284413+00	3072507+00	8198525-01	7214885-02	4136044-03	2611305-04	
20.00000	3520218+01	2138419+01	1378425+01	6284414+00	3072509+00	8198537-01	7214950-02	4136273-03	2611893-04	
MU+A(MFP) =	15.00000	20.00000	.10000	.25000	.50000	.75000	1.00000	1.50000	2.00000	
MU+H(MFP) =	1.00000	1.00000	1.50000	1.50000	1.50000	1.50000	1.50000	1.50000	1.50000	
MU+R(MFP)										
.10000	4112301-10	1574733-12	3109737-02	2985939-02	2597595-02	2095399-02	1597356-02	8376398-03	4126552-03	
.25000	2567749-09	9835196-12	2005258-01	1922313-01	1864051-01	1334153-01	1011219-01	5259952-02	2980638-02	
.50000	1023627-08	3924262-11	8989423-01	8961488-01	7268091-01	5693648-01	4226010-01	2136635-01	1033708-01	
.75000	2290219-08	8792948-11	2470888+00	2319461+00	1891137+00	1418442+00	1015602+00	4908913-01	2325699-01	
1.00000	4039598-08	1554135-10	5991298+00	5438964+00	4094632+00	2861950+00	1948270+00	8901048-01	4119273-01	
1.50000	8888344-08	3439485-10	5124799+01	2786930+01	1397226+01	8014058+00	4892390+00	2012632+00	8923255-01	
2.00000	1532039-07	5975874-10	1013168+02	5334284+01	2935645+01	1397294+01	8299003+00	3311854+00	1450447+00	
3.00000	3162586-07	1260680-09	1113078+02	6335661+01	3307450+01	1951638+01	1217780+01	5182941+00	2364826+00	
5.00000	6809160-07	2881707-09	1140256+02	6544586+01	3501829+01	2123817+01	1364762+01	6170682+00	2983376+00	
7.50000	1009913-06	4638254-09	1209181+02	6581616+01	3516453+01	2137642+01	1377676+01	6277649+00	3066674+00	
10.00000	1152008-06	5625971-09	9951071+01	6492032+01	3516664+01	2138376+01	1378383+01	6283984+00	3072121+00	
15.00000	1203517-06	6142776-09	1399141+02	6751507+01	3521193+01	2138498+01	1378429+01	6284413+00	3072507+00	
20.00000	1205469-06	6178562-09	1601236+02	6926056+01	3527230+01	2138607+01	1378418+01	6284414+00	3072509+00	
MU+A(MFP) =	3.00000	5.00000	7.50000	10.00000	15.00000	20.00000	.10000	.25000	.50000	
MU+H(MFP) =	1.50000	1.50000	1.50000	1.50000	1.50000	1.50000	2.00000	2.00000	2.00000	
MU+R(MFP)										
.10000	9753484-04	6230351-05	2559398-06	1246939-07	3923405-10	1521645-12	1062238-02	1034780-02	9443084-03	
.25000	6083397-03	3885189-04	1596888-05	7783033-07	2449929-09	9503883-12	6792731-02	6613037-02	6022881-02	
.50000	2415160-02	1541599-03	6348665-05	3098510-06	9768393-09	3792433-11	2950223-01	2865386-01	2989512-01	
.75000	5363785-02	3422340-03	1414027-04	6916992-06	2186212-06	8498924-11	7631632-01	7378404-01	6871914-01	
1.00000	9354257-02	5971015-03	2478518-04	1216262-05	3857796-08	1502501-10	1659743+00	1591643+00	1382502+00	
1.50000	1982693-01	1273630-02	5357898-04	2652787-05	8498538-08	3327311-10	7132421+00	6515171+00	4997379+00	
2.00000	3217736-01	2103043-02	9018174-04	4518067-05	1467248-07	5785983-10	5282736+01	2917469+01	1493842+01	
3.00000	5530322-01	3865071-02	1744657-03	9030505-05	3042115-07	1223509-09	1105624+02	6109096+01	3113908+01	
5.00000	7723009-01	6259475-02	3186392-03	1785847-04	6624822-07	2815198-09	1089306+02	6528418+01	3491934+01	
7.50000	8159625-01	7092882-02	3949458-03	2392363-04	9962322-07	4573304-09	1017161+02	6512726+01	3515676+01	
10.00000	8195643-01	7202960-02	4110255-03	2670902-04	1146288-06	5588271-09	1256136+02	6643498+01	3518436+01	
15.00000	8198522-01	7214865-02	4135978-03	2611161-04	1203176-06	6138282-09	1569926+02	6886095+01	3529850+01	
20.00000	8198538-01	7214951-02	4136278-03	2611891-04	1205460-06	6178350-09	1550591+02	7072227+01	3542926+01	

TABLE 3 (Continued)

TABLE OF THE FUNCTION		D(MU*R, MU*A, MU*H)								
MU*A(MFP) =	.75000	1.00000	1.50000	2.00000	3.00000	5.00000	7.50000	10.00000	15.00000	
MU*H(MFP) =	2.00000	2.00000	2.00000	2.00000	2.00000	2.00000	2.00000	2.00000	2.00000	
MU*R(MFP)										
.10000	8160807-03	6733599-03	4132737-03	2323036-03	6567018-04	4964696-05	2218446-06	1124785-07	3674326-10	
.25000	5189880-02	4268701-02	2604879-02	1458278-02	4105950-03	3098750-04	1384655-05	7021871-07	2294559-09	
.50000	2207745-01	1794894-01	1072909-01	5921218-02	1644199-02	1233503-03	5511936-05	2797308-06	9151244-09	
.75000	5494167-01	4376230-01	2526821-01	1362886-01	3703133-02	2792761-03	1230246-04	6251340-06	2048961-08	
1.00000	1119922+00	8648543-01	4757102-01	2489753-01	6581487-02	4837091-03	2162615-04	1100896-05	3617737-08	
1.50000	3579351+00	2503256+00	1209038+00	5894247-01	1465733-01	1051535-02	4712076-04	2411027-05	7982930-08	
2.00000	8736235+00	5434602+00	2319247+00	1065126+00	2521543-01	1777652-02	8010232-04	4128966-05	1381341-07	
3.00000	1798783+01	1103234+01	4592009+00	2073374+00	4838698-01	3439893-02	1589104-03	8369272-05	2881323-07	
5.00000	2114603+01	1356400+01	6106527+00	2937925+00	7530892-01	6020710-02	3047022-03	1708443-04	6374062-07	
7.50000	2137218+01	1377274+01	6274147+00	3063772+00	8142189-01	7051040-02	3905031-03	2355546-04	9770573-07	
10.00000	2138377+01	1378361+01	6283774+00	3071936+00	8194340-01	7198355-02	4102459-03	2561461-04	1138022-06	
15.00000	2138651+01	1378431+01	6284412+00	3072507+00	8198516-01	7214830-02	4135873-03	2610933-04	1202659-06	
20.00000	2139874+01	1378499+01	6284412+00	3072509+00	8198538-01	7214952-02	4136272-03	2611889-04	1205447-06	
MU*A(MFP) =	20.00000	.10000	.25000	.50000	.75000	1.00000	1.50000	2.00000	3.00000	
MU*H(MFP) =	2.00000	3.00000	3.00000	3.00000	3.00000	3.00000	3.00000	3.00000	3.00000	
MU*R(MFP)										
.10000	1450456-12	1738369-03	1713216-03	1827100-03	1495487-03	1333156-03	9776929-04	6876501-04	2509902-04	
.25000	9059591-12	1104001-02	1087848-02	1032549-02	9481594-03	8442662-03	8175259-03	4143104-03	1575025-03	
.50000	3615626-11	4675064-02	4603738-02	4360312-02	3990618-02	3538532-02	2563725-02	1704262-02	6389720-03	
.75000	8104497-11	1156313-01	1137415-01	1073206-01	9765313-02	8596862-02	6128870-02	4012097-02	1470564-02	
1.00000	1433215-10	2345741-01	2303528-01	2161055-01	1949363-01	1697952-01	1182687-01	7577554-02	2693303-02	
1.50000	3176654-10	7697729-01	7513758-01	6908314-01	6050144-01	5090341-01	3302927-01	1991236-01	6822766-02	
2.00000	5530636-10	2361040+00	2272628+00	1999101+00	1650683+00	1305400+00	7591085-01	4218982-01	1253153-01	
3.00000	1173356-09	5435838+01	3043319+01	1586466+01	9426990+00	5953931+00	2617018+00	1237559+00	3104294+01	
5.00000	2724536-09	1084470+02	6467598+01	3434495+01	2062737+01	1311166+01	9790557+00	2734916+00	6806191+01	
7.50000	4483195-09	9993916+01	6486315+01	3513108+01	2135137+01	1375315+01	6257479+00	3050375+00	8067330+01	
10.00000	5534894-09	1100486+02	6545975+01	3516023+01	2138195+01	1378252+01	6282811+00	3071098+00	8188638+01	
15.00000	6131656-09	1318408+02	6892628+01	3536094+01	2139658+01	1378512+01	6284412+00	3072503+00	8198487+01	
20.00000	6178026-09	7238978+01	5737598+01	3455025+01	2133468+01	1378045+01	6284409+00	3072510+00	8198939+01	
MU*A(MFP) =	5.00000	7.50000	10.00000	15.00000	20.00000	.10000	.25000	.50000	.75000	
MU*H(MFP) =	3.00000	3.00000	3.00000	3.00000	3.00000	5.00000	5.00000	5.00000	5.00000	
MU*R(MFP)										
.10000	2712508-05	1494207-06	8423667-08	3051081-10	1265669-12	8473909-05	8411851-05	8194561-05	7846985-05	
.25000	1696344-04	9334570-06	5261333-07	1905731-09	7906236-12	5357576-04	5318137-04	5180064-04	4959263-04	
.50000	6799527-04	3727739-05	2099591-06	7605886-09	3156514-11	2232564-03	2219826-03	2157255-03	2063683-03	
.75000	1534796-03	8364131-05	4705539-06	1704956-08	7079800-11	5373858-03	5332344-03	5187193-03	4955876-03	
1.00000	2739260-03	1481002-04	8319248-06	3015260-08	1253094-10	1048442-02	1040004-02	1810534-02	9636365-03	
1.50000	6212245-03	3291896-04	1842152-05	6684065-08	2784244-10	3051663-02	3024177-02	2928502-02	2777287-02	
2.00000	1108557-02	5743628-04	3201245-05	1163816-07	4863780-10	7655282-02	7575064-02	7297299-02	6862908-02	
3.00000	2432856-02	1214821-03	6736458-05	2468362-07	1041402-09	4347023-01	4276343-01	4836914-01	3678354-01	
5.00000	5283497-02	2657225-03	1499048-04	5703097-07	2480603-09	5549607-01	3139774-01	1656675-01	9945297-00	
7.50000	6895416-02	3759521-03	2243512-04	9223384-07	4231281-09	1324347-02	6589402-01	3480828-01	2104117-01	
10.00000	7179878-02	4074243-03	2529891-04	1112821-06	5378926-09	8756771-01	6277166-01	3507799-01	2136648-01	
15.00000	7214683-02	4135451-03	2610079-04	1200900-06	6110535-09	1921044-02	7493164-01	3576816-01	2143124-01	
20.00000	7214952-02	4136269-03	2611878-04	1205398-06	6176919-09	1806887-02	7822347-01	3635688-01	2151111-01	

TABLE 3 (Continued)

TABLE OF THE FUNCTION D(MU+R, MU+A, MU+H)

MU+A(MFP) =	1.00000	1.50000	2.00000	3.00000	5.00000	7.50000	10.00000	15.00000	20.00000
MU+H(MFP) =	5.00000	5.00000	5.00000	5.00000	5.00000	5.00000	5.00000	5.00000	5.00000
MU+R(MFP)									
.10000	7389209-05	6245003-05	4974610-05	2715848-05	5340273-06	4707361-07	3505332-08	1707681-10	8232523-13
.25000	4668570-04	3942981-04	3137581-04	1709428-04	3350161-05	2946679-06	2192143-07	1067246-09	5144239-12
.50000	1940665-03	1634327-03	1296234-03	7010842-04	1357900-04	1185176-05	8787126-07	4268191-09	2056138-11
.75000	4652021-03	3899927-03	3075455-03	1643432-03	3122087-04	2690765-05	1983939-06	9600296-09	4620455-11
1.00000	9023314-03	7514433-03	5879904-03	3089863-03	5716321-04	4842581-05	3543558-06	1705881-08	8199508-11
1.50000	2581551-02	2109309-02	1613569-02	8089614-03	1392123-03	1126018-04	8072957-06	3832023-08	1635400-10
2.00000	6309044-02	5012181-02	3712006-02	1744804-02	2733670-03	2085883-04	1457296-05	6793568-08	3238979-10
3.00000	3247631-01	2344092-01	1569248-01	6167356-02	7692278-03	5139193-04	3384011-05	1511914-07	7129558-10
5.00000	6340013+00	2835120+00	1362768+00	3529171-01	2949913-02	1596661-03	9546864-05	3962963-07	1833246-09
7.50000	1347242+01	6043127+00	2898538+00	7413071-01	5998897-02	3144150-03	1842409-04	7526697-07	3485935-09
10.00000	1376960+01	6271596+00	3061787+00	8132252-01	7039376-02	3912490-03	2381918-04	1018830-06	4855532-09
15.00000	1378820+01	6284397+00	3072466+00	8198196-01	7213363-02	4132237-03	2604515-04	1191992-06	6019926-09
20.00000	1379894+01	6284563+00	3072508+00	8198538-01	7214943-02	4136238-03	2611792-04	1205095-06	6171134-09
MU+A(MFP) =	.10000	.25000	.50000	.75000	1.00000	1.50000	2.00000	3.00000	5.00000
MU+H(MFP) =	7.50000	7.50000	7.50000	7.50000	7.50000	7.50000	7.50000	7.50000	7.50000
MU+R(MFP)									
.10000	3092074-06	3078394-06	3038091-06	2951473-06	2845239-06	2564690-06	2222723-06	1496564-06	4711103-07
.25000	1951255-05	1942598-05	1912038-05	1862282-05	1795068-05	1617612-05	1401402-05	9426867-06	2961332-06
.50000	8076603-05	8040405-05	7912615-05	7704700-05	7423912-05	6683272-05	5782327-05	3876743-05	1208829-05
.75000	1922522-04	1913762-04	1882845-04	1832568-04	1764717-04	1586022-04	1369218-04	9129785-05	2812254-05
1.00000	3693173-04	3675964-04	3619247-04	3516573-04	3383941-04	3033925-04	2611282-04	1728067-04	5234304-05
1.50000	1028733-03	1023640-03	1005689-03	9765688-04	9374176-04	8351369-04	7127333-04	4618447-04	1335599-04
2.00000	2425519-03	2412533-03	2366818-03	2292845-03	2193773-03	1937063-03	1634068-03	1029084-03	2798424-04
3.00000	1133771-02	1126339-02	1100272-02	1058425-02	1003014-02	8628833-03	7040440-03	4895218-03	9471417-04
5.00000	2285633-01	2257203-01	2159508-01	2009028-01	1821189-01	1398727-01	9992758-02	4414188-02	6507528-03
7.50000	5611073+01	3187145+01	1690888+01	1019640+01	6525944+00	2938864+00	1421574+00	3723798-01	3178006-02
10.00000	1378451+02	6666198+01	3484998+01	2106617+01	1349501+01	6060806+00	2911463+00	7473342-01	6098829-02
15.00000	7017907+01	5637299+01	3439588+01	2131285+01	1377672+01	6283673+00	3071915+00	8194288-01	7199088-02
20.00000	1621619+02	7959722+01	3698094+01	2165579+01	1382813+01	6285693+00	3072548+00	8198519-01	7214841-02
MU+A(MFP) =	7.50000	10.00000	15.00000	20.00000	.10000	.25000	.50000	.75000	1.00000
MU+H(MFP) =	7.50000	7.50000	7.50000	7.50000	10.00000	10.00000	10.00000	10.00000	10.00000
MU+R(MFP)									
.10000	6916802-08	7496030-09	5818208-11	3642844-13	1427813-07	1423322-07	1407408-07	1381316-07	1345676-07
.25000	4338524-07	4695370-08	3639519-10	2277552-12	9002499-07	8974126-07	8873595-07	8708779-07	8483653-07
.50000	1757635-06	1892931-07	1468287-09	9121237-12	3714977-06	3703189-06	3661423-06	3592959-06	3499460-06
.75000	4038418-06	4314497-07	3302355-09	2056383-11	8798793-06	8770561-06	8670547-06	8506635-06	8282859-06
1.00000	7389257-06	7807965-07	5912119-09	3665890-11	1678640-05	1673172-05	1653805-05	1622072-05	1578770-05
1.50000	1799465-05	1845097-06	1356284-08	8311518-11	4987515-05	4971954-05	4516857-05	4426698-05	4303721-05
2.00000	3547781-05	3498539-06	2473945-08	1492627-10	1054265-04	1050499-04	1037170-04	1015372-04	9857114-05
3.00000	1031556-04	9244867-06	5940048-08	3444919-10	4591938-04	4572867-04	4506884-04	4399304-04	4253557-04
5.00000	4989142-04	3640918-05	1902878-07	1008896-09	7140420-03	7099110-03	6953878-03	6719602-03	6407186-03
7.50000	1763926-03	1082192-04	4739666-07	2312805-09	2482903-01	2452194-01	2346652-01	2184032-01	1988940-01
10.00000	3232569-03	1916266-04	8021788-07	3812662-09	5669855+01	3209270+01	1707894+01	1032084+01	6617958+00
15.00000	4106421-03	2570448-04	1155707-06	5735468-09	1962342+02	7479687+01	3575356+01	2141836+01	1377595+01
20.00000	4135919-03	2611081-04	1203308-06	6145111-09	5712860+01	4899142+01	3270357+01	2099653+01	1372052+01

TABLE 3 (Continued)

TABLE OF THE FUNCTION D(MU*A, MU*H, MU*H)										
MU*A(MFP) =	1,50000	2,00000	3,00000	5,00000	7,50000	10,00000	15,00000	20,00000	10,00000	15,00000
MU*H(MFP) =	10,00000	10,00000	10,00000	10,00000	10,00000	10,00000	10,00000	10,00000	10,00000	15,00000
MU*R(MFP)										
.10000	1249284-07	1126820-07	8437321-08	3209306-08	7499837-09	1133858-09	1432391-11	1222197-13	4276088-10	
.25000	7874865-07	7101572-07	5314799-07	2207705-07	4710278-08	7111517-09	8968735-11	7646274-13	2693960-09	
.50000	3246730-06	2925947-06	2185883-06	9038274-07	1916988-07	2880302-08	3610776-10	3069272-12	1108546-08	
.75000	7678410-06	6912143-06	5148767-06	2112909-06	4438008-07	6615438-08	8211622-10	6946153-12	2613378-08	
1.00000	1461917-05	1314031-05	9748784-06	3959336-06	8205989-07	1209954-07	1481615-09	1244873-11	4954191-08	
1.50000	3972853-05	3556040-05	2609151-05	1029884-05	2057829-06	2944998-07	3473913-09	2864870-11	1330565-07	
2.00000	9061655-05	8065702-05	5831318-05	2216597-05	4221657-06	5810639-07	6526171-09	5250405-11	2988727-07	
3.00000	3866439-04	3389755-04	2355661-04	8111786-05	1367145-05	1706367-06	1694555-08	1279811-10	1226350-06	
5.00000	5605125-03	4672893-03	2862998-03	7400174-04	9087740-05	8969154-06	6688835-08	4349534-10	1596459-05	
7.50000	1523711-01	1090652-01	4840247-02	7213852-03	5613927-04	4162699-05	2252491-07	1239891-09	3584780-04	
10.00000	2990034+00	1450477+00	3818728-01	3287327-02	1842080+03	1140269-04	5082020-07	2524950-09	8570093-03	
15.00000	6273591+00	3063433+00	8142512-01	7067152-02	3949056+03	2420802-04	1052620-06	5111239-09	5784125+01	
20.00000	6282478+00	3072412+00	8198268-01	7213681-02	4133052+03	2606023-04	1194826-06	6054472-09	1895206+02	
MU*A(MFP) =	.25000	.50000	.75000	1,00000	1,50000	2,00000	3,00000	5,00000	7,50000	
MU*H(MFP) =	15,00000	15,00000	15,00000	15,00000	15,00000	15,00000	15,00000	15,00000	15,00000	
MU*R(MFP)										
.10000	4267614-10	4237497-10	4187808-10	4119275-10	3929980-10	3680382-10	3055875-10	1709984-10	5823991-11	
.25000	2688616-09	2669620-09	2638278-09	2595057-09	2475673-09	2318270-09	1924503-09	1076265-09	3662190-10	
.50000	1106338-08	1098490-08	1085542-08	1067687-08	1016377-08	9533805-09	7908763-09	4413703-09	1496864-09	
.75000	2608138-08	2589515-08	2558791-08	2516430-08	2399469-08	2245369-08	1860449-08	1034728-08	3490103-09	
1.00000	4944168-08	4908549-08	4849792-08	4768791-08	4545220-08	4250834-08	3516444-08	1946606-08	6517028-09	
1.50000	1327808-07	1318011-07	1301858-07	1279590-07	1218195-07	1137483-07	9368369-08	5120255-08	1679658-08	
2.00000	2982342-07	2959659-07	2922268-07	2870761-07	2728908-07	2542818-07	2082286-07	1119265-07	3575497-08	
3.00000	1223528-06	1213506-06	1197008-06	1174299-06	1111964-06	1030626-06	8316382-07	4284124-07	1279508-07	
5.00000	1592042-05	1576373-05	1550634-05	1515370-05	1419376-05	1296009-05	1003778-05	4604612-06	1151911-06	
7.50000	3571388-04	3524018-04	3446638-04	3341509-04	3060542-04	2710838-04	1935521-04	7149343-05	1325256-05	
10.00000	8520802-03	8347501-03	8067901-03	7894954-03	6736992-03	5622535-03	3454796-03	9001934-04	1119562-04	
15.00000	3228808+01	1724921+01	1044518+01	6709523+00	3040914+00	1479177+00	3912728-01	3394916-02	1918340-03	
20.00000	7838724+01	3640287+01	2151438+01	1378944+01	6274497+00	3064031+00	8146222-01	7077146-02	3962102-03	
MU*A(MFP) =	10,00000	15,00000	20,00000	10,0000	.25000	.50000	.75000	1,00000	1,50000	
MU*H(MFP) =	15,00000	15,00000	15,00000	20,00000	20,00000	20,00000	20,00000	20,00000	20,00000	
MU*R(MFP)										
.10000	1433288-11	4280002-13	6983893-15	1820728-12	1618389-12	1610066-12	1596295-12	1977221-12	1524033-12	
.25000	9003844-11	2684198-12	4374967-14	1020682-11	1019208-11	1013962-11	1005283-11	9932618-12	9597397-12	
.50000	3667416-10	1086869-11	1764352-13	4194421-11	4188347-11	4166729-11	4130959-11	4081422-11	3943294-11	
.75000	8502319-10	2495332-11	4023898-13	9866626-11	9852271-11	9801183-11	9716654-11	9599598-11	9273241-11	
1.00000	1575258-09	4561830-11	7289158-13	1864833-10	1862103-10	1852386-10	1836310-10	1814049-10	1751996-10	
1.50000	3974125-09	1109464-10	1728499-12	4967947-10	4960550-10	4934225-10	4890677-10	4830389-10	4662406-10	
2.00000	8227205-09	2189207-10	3298698-12	1104231-09	1102552-09	1096574-09	1086688-09	1073004-09	1034899-09	
3.00000	2744287-08	6470371-10	8955288-12	4412360-09	4405290-09	4380140-09	4338559-09	4281049-09	4121121-09	
5.00000	2066461-07	3616891-09	4067778-11	5351508-08	5341797-08	5307267-08	5250245-08	5171508-08	4953400-08	
7.50000	1808192-06	2091696-08	1794769-10	1055707-06	1053398-06	1045194-06	1031675-06	1013064-06	9618571-07	
10.00000	1120950-05	8633441-08	5819468-10	2036538-05	2030924-05	2011010-05	1978296-05	1933473-05	1811436-05	
15.00000	1196386-04	5405047-07	2719841-09	9205762-03	9152911-03	8967087-03	8667271-03	8267326-03	7239800-03	
20.00000	2434529-04	1064247-06	5196768-09	5839351+01	3249478+01	1732092+01	1050816+01	6755502+00	3066200+00	

TABLE 3 (Continued)

TABLE OF THE FUNCTION D(MU+R, MU+A, MU+H)

MU+A(MFP) =	2,00000	3,00000	5,00000	7,50000	10,00000	15,00000	20,00000
MU+H(MFP) =	20,00000	20,00000	20,00000	20,00000	20,00000	20,00000	20,00000
MU+R(MFP)							
.10000	1452712-12	1267986-12	8243982-13	3647140-13	1223334-13	6986857-15	2044738-16
.25000	9147909-12	7981293-12	5189103-12	2294371-12	7690774-13	4386574-14	1282306-15
.50000	3758104-11	3277598-11	2128513-11	9392548-12	3141056-12	1783074-13	5191554-15
.75000	8835786-11	7701273-11	4991911-11	2195622-11	7314530-12	4119967-13	1191684-14
1.00000	1668844-10	1453333-10	9396258-11	4114433-11	1363527-11	7598535-13	2178038-14
1.50000	4437485-10	3855565-10	2475431-10	1070895-10	3498703-11	1893633-12	5294582-14
2.00000	9839319-10	8523637-10	5423428-10	2909714-10	7407726-11	3859781-12	1044550-13
3.00000	3907759-09	3360068-09	2090165-09	8558742-10	2620788-10	1241395-11	3093719-13
5.00000	4664365-08	3933221-08	2307292-08	8542999-09	2327311-09	8701147-11	1770555-12
7.50000	8948014-07	7294879-07	3873193-07	1216022-07	2758463-08	7277321-10	1116593-11
10.00000	1654555-05	1282705-05	5901478-06	1484200-06	2680571-07	4770391-09	5472520-11
15.00000	6044181-03	3717127-03	9708558-04	1211797-04	1217999-05	9455398-08	6424042-10
20.00000	1493475-00	3959488-01	3448278-02	1956017-03	1223997-04	5562546-07	2813863-09

4. The Function $Z(b', a/l, R/l)$

The function $Z(b', a/l, R/l)$ is useful in finding the flux at points on the axis of a cylindrical source without intervening shields.

TABLE OF THE FUNCTION Z(RP, A/L, R/L)

TABLE 4 THE FUNCTION Z(b⁴, a/L, R/L)

A/L	=	.01000	.05000	.07500	.10000	.25000	.50000	.75000	1.00000	2.50000
R/L	=	.01000	.01000	.01000	.01000	.01000	.01000	.01000	.01000	.01000
BP (MFP)										
.10000	2769631+00	2773016+00	2773342+00	2773505+00	2773796+00	2773887+00	2773915+00	2773928+00	2773946+00	
.25000	4810466+00	4818902+00	4819710+00	4820114+00	4820828+00	4821050+00	4821117+00	4821147+00	4821191+00	
.50000	6709301+00	6726083+00	6727678+00	6728472+00	6729862+00	6730286+00	6730411+00	6730468+00	6730549+00	
.75000	7792790+00	7817832+00	7820195+00	7821366+00	7823399+00	7824007+00	7824184+00	7824263+00	7824375+00	
1.00000	8467277+00	8500496+00	8503609+00	8505145+00	8507789+00	8508567+00	8508791+00	8508889+00	8509027+00	
2.00000	9531744+00	9596892+00	9602841+00	9605735+00	9610573+00	9611912+00	9612278+00	9612434+00	9612645+00	
4.00000	9790612+00	9916307+00	9927297+00	9932523+00	9940882+00	9942999+00	9943537+00	9943757+00	9944038+00	
7.00000	9705565+00	9915150+00	9932543+00	9940606+00	9952915+00	9955771+00	9956451+00	9956718+00	9957043+00	
10.00000	9600272+00	9886904+00	9909701+00	9920061+00	9935357+00	9938699+00	9939462+00	9939756+00	9940104+00	
20.00000	9294366+00	9800747+00	9837035+00	9852809+00	9874522+00	9878745+00	9879643+00	9879976+00	9880355+00	
A/L	=	5.00000	7.50000	10.00000	25.00000	50.00000	100.00000	.01000	.05000	.07500
R/L	=	.01000	.01000	.01000	.01000	.01000	.01000	.05000	.05000	.05000
BP (MFP)										
.10000	2773950+00	2773951+00	2773951+00	2773952+00	2773952+00	2773952+00	2723210+00	2753453+00	2759714+00	
.25000	4821200+00	4821202+00	4821203+00	4821204+00	4821204+00	4821204+00	4695801+00	4770862+00	4786361+00	
.50000	6730565+00	6730569+00	6730570+00	6730572+00	6730572+00	6730572+00	6484355+00	6632710+00	6683215+00	
.75000	7824398+00	7824402+00	7824404+00	7824406+00	7824406+00	7824407+00	7461548+00	7681512+00	7726566+00	
1.00000	8509055+00	8509060+00	8509062+00	8509065+00	8509065+00	8509065+00	8033383+00	8323351+00	8382525+00	
2.00000	9612685+00	9612693+00	9612696+00	9612699+00	9612700+00	9612700+00	8718405+00	9273668+00	9385546+00	
4.00000	9944087+00	9944097+00	9944100+00	9944104+00	9944105+00	9944105+00	8332612+00	9358178+00	9561042+00	
7.00000	9957096+00	9957107+00	9957111+00	9957115+00	9957115+00	9957115+00	7477397+00	9090648+00	9404192+00	
10.00000	9940159+00	9940169+00	9940173+00	9940177+00	9940178+00	9940178+00	6764879+00	8858660+00	9261340+00	
20.00000	9880413+00	9880424+00	9880427+00	9880432+00	9880432+00	9880432+00	5134097+00	8329235+00	8937255+00	
A/L	=	.10000	.25000	.50000	.75000	1.00000	2.50000	5.00000	7.50000	10.00000
R/L	=	.05000	.05000	.05000	.05000	.05000	.05000	.05000	.05000	.05000
BP (MFP)										
.10000	2763244+00	2770083+00	2772342+00	2773034+00	2773351+00	2773815+00	2773912+00	2773933+00	2773941+00	
.25000	4795079+00	4811880+00	4817363+00	4819027+00	4819783+00	4820884+00	4821111+00	4821160+00	4821179+00	
.50000	6680314+00	6712981+00	6723443+00	6726567+00	6727973+00	6729994+00	6730405+00	6730494+00	6730527+00	
.75000	7751736+00	7799435+00	7814443+00	7818858+00	7820826+00	7823621+00	7824182+00	7824301+00	7824346+00	
1.00000	8415482+00	8477462+00	8496642+00	8502204+00	8504661+00	8508112+00	8508794+00	8508939+00	8508992+00	
2.00000	9447180+00	9560879+00	9593065+00	9602169+00	9606069+00	9611331+00	9612319+00	9612524+00	9612599+00	
4.00000	9670940+00	9864527+00	9916559+00	9929942+00	9935431+00	9942434+00	9943654+00	9943899+00	9943987+00	
7.00000	9571087+00	9853641+00	9923653+00	9940536+00	9947199+00	9955313+00	9956642+00	9956901+00	9956994+00	
10.00000	9473016+00	9821685+00	9903394+00	9922337+00	9929648+00	9938322+00	9939697+00	9939961+00	9940055+00	
20.00000	9249082+00	9735502+00	9838497+00	9860755+00	9869044+00	9878508+00	9879942+00	9880213+00	9880389+00	
A/L	=	25.00000	50.00000	100.00000	.01000	.05000	.07500	.10000	.25000	.50000
R/L	=	.05000	.05000	.05000	.07500	.07500	.07500	.07500	.07500	.07500
BP (MFP)										
.10000	2773950+00	2773951+00	2773952+00	2689952+00	2732942+00	2744122+00	2750963+00	2765335+00	2770340+00	
.25000	4821200+00	4821203+00	4821204+00	4614275+00	4720680+00	4748301+00	4765172+00	4800443+00	4812588+00	
.50000	6730564+00	6730570+00	6730571+00	6326391+00	6535741+00	6589937+00	6622948+00	6691421+00	6714584+00	
.75000	7824396+00	7824404+00	7824406+00	7231712+00	7540742+00	7620543+00	7669024+00	7768855+00	7802067+00	
1.00000	8509053+00	8509062+00	8509065+00	7735800+00	8141418+00	8245924+00	8309258+00	8438792+00	8481214+00	
2.00000	9612683+00	9612696+00	9612699+00	8184271+00	8948265+00	9143714+00	9261179+00	9495875+00	9568705+00	
4.00000	9944085+00	9944100+00	9944104+00	7445309+00	8814861+00	9162525+00	9369000+00	9767879+00	9882435+00	
7.00000	9957096+00	9957110+00	9957114+00	6248596+00	8319790+00	8844358+00	9152467+00	9728592+00	9882260+00	
10.00000	9940158+00	9940173+00	9940177+00	5332108+00	7928752+00	8588843+00	8973973+00	9678822+00	9857936+00	
20.00000	9880412+00	9880427+00	9880431+00	3490198+00	7104065+00	8050446+00	8597813+00	9562254+00	9786764+00	

TABLE OF THE FUNCTION Z(BP,A/L,R/L)

TABLE 4 (Continued)

A/L	=	.75000	1.00000	2.50000	5.00000	7.50000	10.00000	25.00000	50.00000	100.00000
R/L	=	.07500	.07500	.07500	.07500	.07500	.07500	.07500	.07500	.07500
BP (MFP)										
.10000		2771890+00	2772601+00	2773644+00	2773862+00	2773910+00	2773927+00	2773948+00	2773951+00	2773951+00
.25000		4816313+00	4818010+00	4820483+00	4820995+00	4821106+00	4821147+00	4821194+00	4821201+00	4821203+00
.50000		6721576+00	6724731+00	6729272+00	6730197+00	6730396+00	6730470+00	6730555+00	6730568+00	6730571+00
.75000		7811944+00	7816359+00	7822640+00	7823901+00	7824170+00	7824270+00	7824384+00	7824401+00	7824405+00
1.00000		8493655+00	8499167+00	8506921+00	8508455+00	8508781+00	8508901+00	8509038+00	8509058+00	8509064+00
2.00000		9589054+00	9597798+00	9609621+00	9611842+00	9612303+00	9612472+00	9612662+00	9612690+00	9612698+00
4.00000		9912319+00	9924618+00	9940347+00	9943091+00	9943642+00	9943841+00	9944061+00	9944094+00	9944102+00
7.00000		9919917+00	9934842+00	9953062+00	9956051+00	9956634+00	9956842+00	9957071+00	9957104+00	9957113+00
10.00000		9900160+00	9916528+00	9936003+00	9939095+00	9939691+00	9939902+00	9940133+00	9940167+00	9940175+00
20.00000		9836313+00	9854860+00	9876105+00	9879329+00	9879939+00	9880154+00	9880388+00	9880421+00	9880430+00

A/L	=	.01000	.05000	.07500	.10000	.25000	.50000	.75000	1.00000	2.50000
R/L	=	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000
BP (MFP)										
.10000		2656288+00	2709198+00	2724998+00	2735320+00	2758841+00	2767558+00	2770294+00	2771553+00	2773405+00
.25000		4532211+00	4662796+00	4701749+00	4727159+00	4784813+00	4805954+00	4812528+00	4815533+00	4819923+00
.50000		6168812+00	6424549+00	6500709+00	6550282+00	6661990+00	6702200+00	6714616+00	6720202+00	6728262+00
.75000		7004441+00	7380239+00	7491997+00	7564599+00	7727156+00	7784882+00	7802304+00	7810121+00	7821267+00
1.00000		7444041+00	7935119+00	8080990+00	8175579+00	8386115+00	8459800+00	8481738+00	8491496+00	8505254+00
2.00000		7677172+00	8586727+00	8856154+00	9029828+00	9408742+00	9534936+00	9570784+00	9586255+00	9607228+00
4.00000		6649708+00	8231629+00	8700584+00	9000649+00	9637497+00	9835225+00	9887792+00	9909535+00	9937428+00
7.00000		5225854+00	7525989+00	8214624+00	8653073+00	9560972+00	9825105+00	9891249+00	9917614+00	9949912+00
10.00000		4215742+00	7003200+00	7850309+00	8388985+00	9488311+00	9795249+00	9869341+00	9898243+00	9932759+00
20.00000		2420830+00	5981421+00	7129875+00	7864327+00	9333250+00	9715587+00	9802378+00	9835099+00	9872743+00

A/L	=	5.00000	7.50000	10.00000	25.00000	50.00000	100.00000	.01000	.05000	.07500
R/L	=	.10000	.10000	.10000	.10000	.10000	.10000	.25000	.25000	.25000
BP (MFP)										
.10000		2773793+00	2773877+00	2773908+00	2773944+00	2773950+00	2773951+00	2461099+00	2546811+00	2581057+00
.25000		4820833+00	4821030+00	4821103+00	4821187+00	4821200+00	4821203+00	4064146+00	4272099+00	4355293+00
.50000		6729906+00	6730260+00	6730392+00	6730542+00	6730564+00	6730570+00	5293897+00	5689920+00	5848735+00
.75000		7823507+00	7823986+00	7824164+00	7824366+00	7824396+00	7824404+00	5775297+00	6341587+00	6569296+00
1.00000		8507980+00	8508559+00	8508774+00	8509016+00	8509053+00	8509062+00	5906116+00	6626683+00	6917289+00
2.00000		9611176+00	9611995+00	9612295+00	9612633+00	9612683+00	9612696+00	5251154+00	6458197+00	6951853+00
4.00000		9942304+00	9943282+00	9943635+00	9944028+00	9944085+00	9944100+00	3441327+00	5201128+00	5945822+00
7.00000		9955223+00	9956259+00	9956629+00	9957036+00	9957096+00	9957110+00	1896201+00	3958395+00	4880569+00
10.00000		9938254+00	9939312+00	9939688+00	9940098+00	9940158+00	9940173+00	1171006+00	3281843+00	4275377+00
20.00000		9878472+00	9879555+00	9879937+00	9880353+00	9880412+00	9880427+00	4662562-01	2404006+00	3426615+00

A/L	=	.10000	.25000	.50000	.75000	1.00000	2.50000	5.00000	7.50000	10.00000
R/L	=	.25000	.25000	.25000	.25000	.25000	.25000	.25000	.25000	.25000
BP (MFP)										
.10000		2607676+00	2691449+00	2735855+00	2751651+00	2759186+00	2770547+00	2772959+00	2773485+00	2773681+00
.25000		4419969+00	4623288+00	4730484+00	4768348+00	4786320+00	4813225+00	4818885+00	4820115+00	4820573+00
.50000		5972256+00	6359966+00	6562690+00	6633503+00	6666838+00	6716185+00	6726416+00	6728624+00	6729446+00
.75000		6746509+00	7302109+00	7590447+00	7690118+00	7736676+00	7804855+00	7818792+00	7821781+00	7822898+00
1.00000		7143620+00	7852656+00	8218132+00	8343239+00	8401252+00	8485335+00	8502291+00	8505905+00	8507242+00
2.00000		7337926+00	8547017+00	9157327+00	9359472+00	9450865+00	9578646+00	9603184+00	9608296+00	9610171+00
4.00000		6535053+00	8395486+00	9314646+00	9606103+00	9733361+00	9902577+00	9932863+00	9938966+00	9941172+00
7.00000		5625044+00	8025814+00	9203402+00	9564122+00	9717117+00	9912335+00	9945302+00	9951768+00	9954080+00
10.00000		5093044+00	7790858+00	9119381+00	9519071+00	9685895+00	9894071+00	9928172+00	9934769+00	9937115+00
20.00000		4307969+00	7398196+00	8960103+00	9419223+00	9606402+00	9832658+00	9868197+00	9874954+00	9877333+00

TABLE OF THE FUNCTION Z(BP,A/L,R/L)

TABLE 4 (Continued)

A/L	= 25.0000	50.0000	100.0000	.01000	.05000	.07500	.10000	.25000	.50000
R/L	= .25000	.25000	.25000	.50000	.50000	.50000	.50000	.50000	.50000
BP (MFP)									
.10000	2773906+00	2773940+00	2773949+00	2178138+00	2285721+00	2333793+00	2373996+00	2527685+00	2641322+00
.25000	4821097+00	4821177+00	4821197+00	3406615+00	3660500+00	3774405+00	3869843+00	4235787+00	4506842+00
.50000	6730382+00	6730524+00	6730560+00	4127218+00	4589378+00	4798203+00	4973733+00	5650353+00	6153179+00
.75000	7824152+00	7824342+00	7824390+00	4218751+00	4851274+00	5139214+00	5382057+00	6323393+00	7025525+00
1.00000	8508760+00	8508988+00	8509046+00	4055603+00	4826951+00	5180817+00	5480299+00	6647972+00	7522455+00
2.00000	9612279+00	9612593+00	9612673+00	2857881+00	3962355+00	4486055+00	4935842+00	6733739+00	8105718+00
4.00000	9943623+00	9943983+00	9944074+00	1244418+00	2495564+00	3130247+00	3691817+00	6054010+00	7934803+00
7.00000	9956621+00	9956991+00	9957084+00	4610862-01	1611011+00	2244273+00	2825345+00	5431892+00	7630349+00
10.00000	9939682+00	9940053+00	9940147+00	2550806-01	1295199+00	1897705+00	2463778+00	5119336+00	7457960+00
20.00000	9879934+00	9880308+00	9880401+00	1165444-01	1001326+00	1544324+00	2069091+00	4696980+00	7189639+00

A/L	= .75000	1.00000	2.50000	5.00000	7.50000	10.00000	25.00000	50.00000	100.00000
R/L	= .50000	.50000	.50000	.50000	.50000	.50000	.50000	.50000	.50000
BP (MFP)									
.10000	2691558+00	2717848+00	2760485+00	2769992+00	2772086+00	2772870+00	2773769+00	2773905+00	2773940+00
.25000	4626458+00	4688894+00	4789655+00	4811959+00	4816853+00	4818683+00	4820778+00	4821095+00	4821177+00
.50000	6374493+00	6489535+00	6673723+00	6714006+00	6722794+00	6726071+00	6729813+00	6730379+00	6730523+00
.75000	7333865+00	7493522+00	7747196+00	7802033+00	7813924+00	7818348+00	7823387+00	7824147+00	7824341+00
1.00000	7905745+00	8103490+00	8415404+00	8482072+00	8496445+00	8501780+00	8507842+00	8508755+00	8508987+00
2.00000	8704281+00	9009374+00	9478531+00	9574888+00	9595121+00	9602594+00	9611017+00	9612274+00	9612593+00
4.00000	8755893+00	9168304+00	9780856+00	9899354+00	9923594+00	9932388+00	9942177+00	9943618+00	9943983+00
7.00000	8600279+00	9083105+00	9781353+00	9910106+00	9935777+00	9944989+00	9955140+00	9956619+00	9956991+00
10.00000	8501772+00	9019861+00	9759348+00	9892405+00	9918595+00	9927943+00	9938194+00	9939680+00	9940053+00
20.00000	8331668+00	8898057+00	9693254+00	9831757+00	9858572+00	9868078+00	9878441+00	9879933+00	9880387+00

A/L	= .01000	.05000	.07500	.10000	.25000	.50000	.75000	1.00000	2.50000
R/L	= .75000	.75000	.75000	.75000	.75000	.75000	.75000	.75000	.75000
BP (MFP)									
.10000	1945191+00	2062068+00	2116441+00	2163114+00	2355599+00	2522299+00	2607909+00	2656956+00	2744198+00
.25000	2884853+00	3152563+00	3278306+00	3386589+00	3836053+00	4228230+00	4430255+00	4546028+00	4751546+00
.50000	3253032+00	3721033+00	3942695+00	4134631+00	4940056+00	5651685+00	6020156+00	6231411+00	6609188+00
.75000	3119205+00	3733537+00	4027922+00	4284260+00	5371892+00	6345003+00	6851449+00	7141951+00	7654264+00
1.00000	2823215+00	3543837+00	3892108+00	4197792+00	5509318+00	6697505+00	7319050+00	7675755+00	8302853+00
2.00000	1596446+00	2491753+00	2947472+00	3355694+00	5185840+00	6926297+00	7855007+00	8389276+00	9318160+00
4.00000	4993467-01	1339745+00	1805734+00	2239838+00	4339268+00	6507184+00	7705330+00	8398808+00	9586999+00
7.00000	1684751-01	8675558-01	12884692+00	1686934+00	3775318+00	6113893+00	7456859+00	8241425+00	9573581+00
10.00000	1058752-01	7366038-01	1123728+00	1502329+00	3536373+00	5919539+00	7322386+00	8148855+00	9546858+00
20.00000	4552509-02	5970746-01	9514511-01	1301307+00	3241176+00	5644046+00	7113256+00	7989967+00	9473134+00

A/L	= 5.00000	7.50000	10.00000	25.00000	50.00000	100.00000	.01000	.05000	.07500
R/L	= .75000	.75000	.75000	.75000	.75000	.75000	1.00000	1.00000	1.00000
BP (MFP)									
.10000	2765089+00	2769764+00	2771521+00	2773540+00	2773847+00	2773925+00	1752714+00	1873740+00	1931224+00
.25000	4800516+00	4811440+00	4815541+00	4820246+00	4820960+00	4821142+00	2466611+00	2737415+00	2867212+00
.50000	6693515+00	6713118+00	6720461+00	6728865+00	6730137+00	6730462+00	2592947+00	3045418+00	3265659+00
.75000	7774370+00	7800888+00	7810797+00	7822114+00	7823823+00	7824259+00	2334426+00	2905098+00	3187264+00
1.00000	8448712+00	8480754+00	8492700+00	8506314+00	8508366+00	8508889+00	1991722+00	2635750+00	2959250+00
2.00000	9528030+00	9573278+00	9590005+00	9608915+00	9611741+00	9612458+00	9145955-01	1622490+00	2000503+00
4.00000	9844217+00	9898126+00	9917799+00	9939770+00	9943011+00	9943830+00	2279231-01	8157479-01	1159396+00
7.00000	9852239+00	9909291+00	9929892+00	9952673+00	9955998+00	9956835+00	8688831-02	5708089-01	8688829-01
10.00000	9833619+00	9891810+00	9912712+00	9935717+00	9939057+00	9939897+00	5842391-02	5046265-01	7842119-01
20.00000	9771888+00	9831445+00	9852699+00	9875953+00	9879310+00	9880151+00	1981709-02	4077472-01	6697289-01

TABLE OF THE FUNCTION Z(BP,A/L,R/L)

TABLE 4 (Continued)

A/L	=	.10000	.25000	.50000	.75000	1.00000	2.50000	5.00000	7.50000	10.00000
R/L	=	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
BP (MFP)										
.10000		1981225+00	2195748+00	2398573+00	2513415+00	2584161+00	2722342+00	2758312+00	2766532+00	2769639+00
.25000		2980627+00	3471900+00	3942231+00	4210503+00	4376274+00	4700482+00	4784706+00	4803909+00	4811158+00
.50000		3459577+00	4313100+00	5147217+00	5628693+00	5927670+00	6513558+00	6665222+00	6699662+00	6712636+00
.75000		3437614+00	4557198+00	5673550+00	6325381+00	6732036+00	7530321+00	7736200+00	7782762+00	7800267+00
1.00000		3248473+00	4562383+00	5898369+00	6687097+00	<u>7181343+00</u>	8152057+00	8402708+00	8458943+00	8480042+00
2.00000		2348380+00	4024456+00	5854381+00	6978154+00	7693407+00	9106180+00	9463652+00	9542942+00	9572462+00
4.00000		1489218+00	3221097+00	5317088+00	6680521+00	7568393+00	9332876+00	9768480+00	9862786+00	9897478+00
7.00000		1162240+00	2794652+00	4930502+00	6389637+00	7360141+00	9302746+00	9772845+00	9872555+00	9908868+00
10.00000		1061107+00	2631747+00	4756760+00	6246254+00	7249414+00	9268775+00	9753005+00	9854664+00	9891504+00
20.00000		9300774-01	2426714+00	4519384+00	6034499+00	7073855+00	9188000+00	9689838+00	9793834+00	9831287+00

A/L	=	25.00000	50.00000	100.00000	.01000	.05000	.07500	.10000	.25000	.50000
R/L	=	1.00000	1.00000	1.00000	2.50000	2.50000	2.50000	2.50000	2.50000	2.50000
BP (MFP)										
.10000		2773220+00	2773765+00	2773905+00	1069060+00	1187236+00	1245597+00	1297604+00	1537326+00	1804246+00
.25000		4819501+00	4820770+00	4821094+00	1129123+00	1355980+00	1470668+00	1574093+00	2063680+00	2630017+00
.50000		6727538+00	6729799+00	6730377+00	7976640-01	1097639+00	1255202+00	1400019+00	2114920+00	2991898+00
.75000		7820332+00	7823370+00	7824145+00	5047488-01	8133158-01	9813225-01	1138454+00	1944137+00	2985088+00
1.00000		8504176+00	8507822+00	8508752+00	3138182-01	6072447-01	7722376-01	9289300-01	1759340+00	2881112+00
2.00000		9605974+00	9610994+00	9612271+00	6652698-02	2880003-01	4228432-01	5557141-01	1319027+00	2471070+00
4.00000		9936402+00	9942160+00	9943616+00	2345323-02	2024536-01	3153365-01	4280086-01	1096822+00	2164275+00
7.00000		9949221+00	9955129+00	9956617+00	1042944-02	1711538-01	2775211-01	3837900-01	1016718+00	2037404+00
10.00000		9932251+00	9938186+00	9939679+00	4531281-03	1490993-01	2531643-01	3572957-01	9779174-01	1981150+00
20.00000		9872474+00	9878437+00	9879933+00	2477851-04	9092193-02	1877640-01	2886677-01	8958788-01	1879958+00

A/L	=	.75000	1.00000	2.50000	5.00000	7.50000	10.00000	25.00000	50.00000	100.00000
R/L	=	2.50000	2.50000	2.50000	2.50000	2.50000	2.50000	2.50000	2.50000	2.50000
BP (MFP)										
.10000		1989842+00	2127956+00	2519493+00	2683931+00	2729420+00	2747635+00	2769396+00	2772787+00	2773657+00
.25000		3035006+00	3341608+00	4231081+00	4611740+00	4717546+00	4759949+00	4810606+00	4818494+00	4820519+00
.50000		3646384+00	4155025+00	5683889+00	6357221+00	6545721+00	6621351+00	6711695+00	6725749+00	6729354+00
.75000		3791619+00	4433098+00	6423404+00	7322571+00	7575865+00	7677583+00	7799058+00	7817934+00	7822773+00
1.00000		3778795+00	4507319+00	6832133+00	7906269+00	8210479+00	8332723+00	8478656+00	8501305+00	8507107+00
2.00000		3474112+00	4334344+00	7310911+00	8778029+00	9199528+00	9369038+00	9570888+00	9602055+00	9610017+00
4.00000		3144931+00	4021474+00	7275186+00	8973119+00	9465301+00	9662694+00	9896247+00	9931968+00	9941052+00
7.00000		2989661+00	3854089+00	7168401+00	8945383+00	9460669+00	9666370+00	9908079+00	9944720+00	9954004+00
10.00000		2921263+00	3778941+00	7109637+00	8915357+00	9438658+00	9647007+00	9890939+00	9927751+00	9937061+00
20.00000		2805996+00	3655253+00	7001110+00	8840417+00	9373170+00	9584589+00	9830999+00	9867980+00	9877312+00

A/L	=	.01000	.05000	.07500	.10000	.25000	.50000	.75000	1.00000	2.50000
R/L	=	5.00000	5.00000	5.00000	5.00000	5.00000	5.00000	5.00000	5.00000	5.00000
BP (MFP)										
.10000		5925118-01	6932464-01	7440748-01	7899128-01	1007848+00	1265542+00	1457795+00	1611214+00	2146106+00
.25000		4125178-01	5652696-01	6459653-01	7204319-01	1093185+00	1567627+00	1941784+00	2251229+00	3392394+00
.50000		1646236-01	3136315-01	3978286-01	4780908-01	9095446-01	1515869+00	2031115+00	2478706+00	4267681+00
.75000		6839317-02	1957548-01	2713032-01	3449688-01	7610116-01	1387045+00	1948172+00	2453840+00	4609602+00
1.00000		3449242-02	1459036-01	2139317-01	2811456-01	6720719-01	1285733+00	1855590+00	2382662+00	4744797+00
2.00000		1174258-02	1012894-01	1578161-01	2143056-01	5521143-01	1107897+00	1649432+00	2171682+00	4759102+00
4.00000		3964218-03	8170187-02	1344588-01	1872258-01	5032689-01	1025735+00	1538999+00	2039022+00	4614250+00
7.00000		7188323-04	6179598-02	1127564-01	1641862-01	4726238-01	9828902-01	1484920+00	1975819+00	4524081+00
10.00000		1238992-04	4547592-02	9393630-02	1444640-01	4499607-01	9556653-01	1453446+00	1939735+00	4477480+00
20.00000		3212926-07	1411900-02	4598963-02	8830093-02	3849132-01	8854638-01	1378455+00	1860417+00	4384850+00

TABLE OF THE FUNCTION Z(BP,A/L,R/L)

TABLE 4 (Continued)

A/L	=	5.00000	7.50000	10.00000	25.00000	50.00000	100.00000	.01000	.05000	.07500
R/L	=	5.00000	5.00000	5.00000	5.00000	5.00000	5.00000	7.50000	7.50000	7.50000
BP (MFP)										
.10000		2487589+00	2616975+00	2676632+00	2755991+00	2769309+00	2772775+00	3691137-01	4542454-01	4979255-01
.25000		4160426+00	4457443+00	4595303+00	4779443+00	4810408+00	4818469+00	1769695-01	2819918-01	3395437-01
.50000		5567881+00	6086394+00	6329504+00	6656245+00	6711357+00	6725705+00	4604732-02	1311395-01	1816534-01
.75000		6279676+00	6963748+00	7287357+00	7724671+00	7798626+00	7817878+00	1797154-02	8865331-02	1322167-01
1.00000		6672858+00	7481010+00	7866319+00	8389494+00	8478161+00	8501241+00	1108911-02	7501316-02	1149719-01
2.00000		7148904+00	8214704+00	8734108+00	9448615+00	9570331+00	9601983+00	4554316-03	5991761-02	9584616-02
4.00000		7162910+00	8351180+00	8939915+00	9756634+00	9895817+00	9931912+00	8539356-04	4532214-02	7967821-02
7.00000		7099759+00	8318025+00	8924263+00	9765156+00	9907808+00	9944685+00	6147993-05	2872835-02	6065941-02
10.00000		7060849+00	8288649+00	8900189+00	9747455+00	9890747+00	9927727+00	4245855-06	1722649-02	4459796-02
20.00000		6976401+00	8215813+00	8832628+00	9686974+00	9830902+00	9867968+00	5341766-10	2668718-03	1368773-02
A/L	=	.10000	.25000	.50000	.75000	1.00000	2.50000	5.00000	7.50000	10.00000
R/L	=	7.50000	7.50000	7.50000	7.50000	7.50000	7.50000	7.50000	7.50000	7.50000
BP (MFP)										
.10000		5376600-01	7304771-01	9660951-01	1147349+00	1295787+00	1853256+00	2278778+00	2475226+00	2578273+00
.25000		3936244-01	6756899-01	1057402+00	1374639+00	1647945+00	2764364+00	3690145+00	4133228+00	4368824+00
.50000		2309406-01	5100671-01	9335653-01	1318286+00	1670644+00	3277676+00	4770597+00	5523694+00	5932401+00
.75000		1754487-01	4297664-01	8377113-01	1226544+00	1595931+00	3413846+00	5255041+00	6225481+00	6761600+00
1.00000		1548465-01	3925606-01	7824314-01	1162529+00	1530806+00	3434685+00	5490195+00	6613375+00	7243456+00
2.00000		1317726-01	3471395-01	7046362-01	1058976+00	1408661+00	3340458+00	5690832+00	7090358+00	7908285+00
4.00000		1141821-01	3211419-01	6649138-01	1006144+00	1343620+00	3232788+00	5629300+00	7123923+00	8022002+00
7.00000		9422615-02	2978886-01	6364280-01	9725897-01	1305239+00	3173287+00	5566410+00	7076429+00	7990437+00
10.00000		7631958-02	2779209-01	6144556-01	9486738-01	1279464+00	3139188+00	5530027+00	7044444+00	7963024+00
20.00000		3318085-02	2163372-01	5500837-01	8820865-01	1210756+00	3060876+00	5448786+00	6968120+00	7891888+00
A/L	=	25.00000	50.00000	100.00000	.01000	.05000	.07500	.10000	.25000	.50000
R/L	=	7.50000	7.50000	7.50000	10.00000	10.00000	10.00000	10.00000	10.00000	10.00000
BP (MFP)										
.10000		2734476+00	2763569+00	2771309+00	2436169-01	3157696-01	3533773-01	3878619-01	5582803-01	7723132-01
.25000		4729493+00	4797068+00	4815060+00	8337302-02	1581949-01	2085292-01	2409262-01	4589305-01	7686926-01
.50000		6567549+00	6687630+00	6719640+00	1742395-02	7322537-02	1073247-01	1410404-01	3377968-01	6500517-01
.75000		7605906+00	7766807+00	7809743+00	8322810-03	5627162-02	8624754-02	1161639-01	2946282-01	5880572-01
1.00000		8247380+00	8448039+00	8491493+00	5873816-03	5065350-02	7892805-02	1071927-01	2765402-01	5574290-01
2.00000		9254718+00	9518142+00	9588637+00	1982122-03	4085332-02	6723747-02	9363203-02	2519322-01	5152258-01
4.00000		9536283+00	9836419+00	9916733+00	2006839-04	2799271-02	5314281-02	7872824-02	2325870-01	4885675-01
7.00000		9539956+00	9847182+00	9929212+00	5777534-06	1452479-02	3591811-02	6010737-02	2117452-01	4648037-01
10.00000		9521454+00	9829974+00	9912228+00	1606503-07	7060469-03	2299995-02	4416466-02	1927002-01	4446669-01
20.00000		9460201+00	9778010+00	9852453+00	9881759-13	5502197-04	4415660-03	1347454-02	1338685-01	3823404-01
A/L	=	.75000	1.00000	2.50000	5.00000	7.50000	10.00000	25.00000	50.00000	100.00000
R/L	=	10.00000	10.00000	10.00000	10.00000	10.00000	10.00000	10.00000	10.00000	10.00000
BP (MFP)										
.10000		9407813-01	1081147+00	1630889+00	2091555+00	2330660+00	2468665+00	2705943+00	2755652+00	2769264+00
.25000		1036546+00	1274125+00	2310260+00	3278658+00	3807336+00	4118835+00	4663376+00	4778675+00	4810306+00
.50000		9454603-01	1225046+00	2609536+00	4097941+00	4970432+00	5500418+00	6450498+00	6654939+00	6711184+00
.75000		8754900-01	1155736+00	2649301+00	4417163+00	5513597+00	6197059+00	7449598+00	7723001+00	7798404+00
1.00000		8356627-01	1110136+00	2630538+00	4548283+00	5790843+00	6582307+00	8868803+00	8387587+00	8477988+00
2.00000		7733332-01	1037678+00	2532865+00	4604323+00	6073316+00	7060202+00	9002028+00	9446479+00	9570045+00
4.00000		7435108-01	9969131-01	2459220+00	4529717+00	6051252+00	7104156+00	9251018+00	9755002+00	9895598+00
7.00000		7169549-01	9675959-01	2415912+00	4476579+00	6002105+00	7064689+00	9249073+00	9764130+00	9907670+00
10.00000		6956800-01	9452502-01	2388091+00	4444634+00	5970979+00	7036185+00	9229680+00	9746727+00	9890649+00
20.00000		6320724-01	8804147-01	2316950+00	4368636+00	5895800+00	6963971+00	9167564+00	9686607+00	9830853+00

TABLE OF THE FUNCTION Z(BP,A/L,R/L)

TABLE 4 (Continued)

A/L	= .01000	.05000	.07500	.10000	.25000	.50000	.75000	1.00000	2.50000
R/L	= 25.00000	25.00000	25.00000	25.00000	25.00000	25.00000	25.00000	25.00000	25.00000
BP(MFP)									
.10000	3347115-02	6343651-02	8039743-02	9658686-02	1840519-01	3087281-01	4170871-01	5137968-01	9477765-01
.25000	4427532-03	2479025-02	3742280-02	4999628-02	1245415-01	2459993-01	3640920-01	4786922-01	1091234+00
.50000	1784845-03	1896759-02	2994397-02	4092016-02	1067642-01	2164191-01	3258793-01	4350150-01	1074362+00
.75000	9098248-04	1672379-02	2732226-02	3792390-02	1015302-01	2075048-01	3133986-01	4191683-01	1047898+00
1.00000	4531459-04	1491468-02	2533249-02	3576762-02	9838160-02	2027056-01	3069577-01	4111011-01	1031550+00
2.00000	2478026-05	9096143-03	1879074-02	2890114-02	9012256-02	1921697-01	2941514-01	3960356-01	1083494+00
4.00000	6426058-08	2824296-03	9200554-03	1766745-02	7710740-02	1780851-01	2790069-01	3798351-01	9811219-01
7.00000	7965517-12	4208219-04	2701562-03	7350946-03	5913877-02	1592673-01	2597461-01	3601347-01	9588515-01
10.00000	9704061-16	5965256-05	7464407-04	2860121-03	4339336-02	1410483-01	2412880-01	3415022-01	9392033-01
20.00000	8464836-29	8109777-08	9158704-06	1077494-04	1309494-02	8624985-02	1817309-01	2810340-01	8774332-01

A/L	= 5.00000	7.50000	10.00000	25.00000	50.00000	100.00000	.01000	.05000	.07500
R/L	= 25.00000	25.00000	25.00000	25.00000	25.00000	25.00000	50.00000	50.00000	50.00000
BP(MFP)									
.10000	1396641+00	1688968+00	1897960+00	2456158+00	2669904+00	2745399+00	3496638-03	1466329-02	2148879-02
.25000	1869794+00	2438934+00	2869439+00	4091476+00	4580201+00	4754891+00	8924249-04	9483826-03	1497207-02
.50000	2030780+00	2822934+00	3466500+00	5456386+00	6304170+00	6612761+00	2265730-04	7457356-03	1266631-02
.75000	2040766+00	2919329+00	3668093+00	6143529+00	7255338+00	7666598+00	5374249-05	5884820-03	1095037-02
1.00000	2028096+00	2939181+00	3739624+00	6524042+00	7830177+00	8320186+00	1239013-05	4548086-03	9395423-03
2.00000	1987512+00	2912680+00	3758218+00	7004421+00	8695135+00	9355003+00	3213032-08	1412156-03	4600318-03
4.00000	1956075+00	2875203+00	3720065+00	7068137+00	8911359+00	9651939+00	1976383-13	1100526-04	8832413-04
7.00000	1929986+00	2846183+00	3689164+00	7043437+00	8906587+00	9659569+00	2906120-21	2146905-06	6494575-05
10.00000	1908824+00	2823855+00	3666067+00	7021263+00	8887662+00	9642166+00	4232438-29	4054980-08	4579510-06
20.00000	1845301+00	2758971+00	3600293+00	6956490+00	8826296+00	9582133+00	3147025-55	6900587-14	6172749-10

A/L	= .10000	.25000	.50000	.75000	1.00000	2.50000	5.00000	7.50000	10.00000
R/L	= 50.00000	50.00000	50.00000	50.00000	50.00000	50.00000	50.00000	50.00000	50.00000
BP(MFP)									
.10000	2823913-02	6767589-02	1304891-01	1902845-01	2473224-01	5405508-01	8988817-01	1160733+00	1364419+00
.25000	2046028-02	5338513-02	1082334-01	1630188-01	2176920-01	5397422-01	1831655+00	1455249+00	1817174+00
.50000	1788396-02	4919305-02	1013709-01	1535397-01	2056946-01	5179971-01	1030762+00	1520407+00	1975740+00
.75000	1608191-02	4692616-02	9833209-02	1497296-01	2011145-01	5089216-01	1017817+00	1515583+00	1993996+00
1.00000	1445070-02	4506332-02	9610120-02	1471308-01	1981483-01	5037684-01	1009440+00	1506683+00	1989914+00
2.00000	8833840-03	3855565-02	8905819-02	1395561-01	1900424-01	4924960-01	9930792-01	1486068+00	1968012+00
4.00000	2695374-03	2678848-02	7659024-02	1268259-01	1770549-01	4779744-01	9760728-01	1466731+00	1946576+00
7.00000	3906276-04	1371531-02	5882267-02	1085903-01	1586858-01	4589554-01	9560032-01	1445676+00	1924622+00
10.00000	5387721-05	6548344-03	4313855-02	9091564-02	1406375-01	4405890-01	9372196-01	1426498+00	1905086+00
20.00000	6691077-08	4808366-04	1296959-02	4410109-02	8599599-02	3803202-01	8764472-01	1365270+00	1843442+00

A/L	= 25.00000	50.00000	100.00000	.01000	.05000	.07500	.10000	.25000	.50000
R/L	= 50.00000	50.00000	50.00000	100.00000	100.00000	100.00000	100.00000	100.00000	100.00000
BP(MFP)									
.10000	2041418+00	2451775+00	2668999+00	5874709-04	5065652-03	7893481-03	1072061-02	2767018-02	5586050-02
.25000	3176091+00	4081917+00	4578172+00	1132865-04	3728680-03	6333161-03	8941996-03	2459681-02	5068768-02
.50000	3949242+00	5441865+00	6300777+00	6195068-06	2274045-03	4697718-03	7225365-03	2253192-02	4805264-02
.75000	4252839+00	6124980+00	7251061+00	3184427-07	1292070-03	3345206-03	5724877-03	2085865-02	4620056-02
1.00000	4384150+00	6503927+00	7825362+00	1606516-08	7060789-04	2300164-03	4416934-03	1927887-02	4453185-02
2.00000	4482074+00	6985399+00	8689996+00	9881918-14	5502643-05	4416223-04	1347694-03	1339443-02	3829703-02
4.00000	4464216+00	7056012+00	8907656+00	3550427-24	2864222-07	1345035-05	1012257-04	5386307-03	2664339-02
7.00000	4439452+00	7036320+00	8904326+00	7493316-40	1003648-10	6527072-08	1869963-06	1170076-03	1361552-02
10.00000	4418761+00	7016274+00	8886071+00	1573516-55	3450331-14	3086425-10	3345613-08	2404327-04	6485657-03
20.00000	4355768+00	6953992+00	8825498+00	859578-108	9528063-26	5251775-18	4755102-14	1113210-06	4726196-04

TABLE OF THE FUNCTION Z(BP,A/L,R/L)

A/L	=	.75000	1.00000	2.50000
R/L	=	100.00000	100.00000	100.00000
BP(MFP)				
.10000		8394211-02	1118643-01	2733816-01
.25000		7677745-02	1028654-01	2592788-01
.50000		7357229-02	9909047-02	2521388-01
.75000		7154163-02	9688114-02	2488594-01
1.00000		6978466-02	9503683-02	2464916-01
2.00000		6341943-02	8854275-02	2392258-01
4.00000		5131281-02	7633571-02	2266347-01
7.00000		3471061-02	5866583-02	2084293-01
10.00000		2205536-02	4301155-02	1903948-01
20.00000		4107703-03	1290713-02	1325687-01

TABLE 4 (Continued)

		5.00000	7.50000	10.00000	25.00000	50.00000	100.00000
		100.00000	100.00000	100.00000	100.00000	100.00000	100.00000
		5100899-01	7073375-01	8735917-01	1515286+00	2034685+00	2449542+00
		5175374-01	7669791-01	1002574+00	2103949+00	3162471+00	4077050+00
		5067401-01	7600083-01	1010420+00	2365409+00	3929832+00	5433279+00
		5017082-01	7535609-01	1003826+00	2422005+00	4231705+00	6115568+00
		4984747-01	7494865-01	9990457-01	2433146+00	4363303+00	6493735+00
		4899317-01	7396870-01	9880301-01	2424470+00	4466990+00	6975808+00
		4767117-01	7258481-01	9735858-01	2407002+00	4456176+00	7049928+00
		4582386-01	7071119-01	9545910-01	2386676+00	4434863+00	7032757+00
		4400885-01	6888565-01	9362836-01	2367789+00	4415552+00	7013777+00
		3800700-01	6286982-01	8759556-01	2306892+00	4354166+00	6952743+00

5. The Function $Z(b', R/L)$

The function $Z(b', R/L)$ gives the flux at an axial point on the end of a cylindrical source with self-absorption.

TABLE OF THE FUNCTION Z(BP, R/L)

R/L	=	.01000	.05000	.07500	.10000	.25000	.50000	.75000	1.00000	2.50000
BP (MFP)										
.10000		2758921+00	2697777+00	2660600+00	2624186+00	2420714+00	2132739+00	1897960+00	1704929+00	1024555+00
.25000		4783732+00	4632652+00	4541640+00	4453032+00	3966476+00	3300232+00	2776733+00	2361277+00	1047022+00
.50000		6655970+00	6359480+00	6183548+00	6013954+00	5108951+00	3935959+00	3069553+00	2421523+00	6965951-01
.75000		7712997+00	7276326+00	7020991+00	6777229+00	5512449+00	3960432+00	2883245+00	2124184+00	4084958-01
1.00000		8361155+00	7789153+00	7459440+00	7147647+00	5573839+00	3744971+00	2552651+00	1761353+00	2293842-01
2.00000		9321602+00	8250807+00	7666163+00	7132967+00	4710821+00	2440019+00	1290667+00	6922401-01	1989333-02
4.00000		9378408+00	7472761+00	6529855+00	5725253+00	2707932+00	8349749-01	2675172-01	8741600-02	1289359-04
7.00000		9004206+00	6142584+00	4904646+00	3940596+00	1136430+00	1607217-01	2413722-02	3732506-03	6393804-08
10.00000		8625225+00	5063700+00	3706002+00	2736172+00	4866802-01	3177211-02	2233558-03	1627348-04	3174718-11
20.00000		7504677+00	2736208+00	1517609+00	8549057-01	3178386-02	1633897-04	9252342-07	5483829-09	3326933-22

TABLE 5 THE FUNCTION Z(BP, R/L)

R/L	=	5.00000	7.50000	10.00000	25.00000	50.00000	100.00000
BP (MFP)							
.10000		5957898-01	3389510-01	2187737-01	2489303-02	1147847-03	4155782-06
.25000		3613492-01	1444018-01	6194751-02	6749059-04	6927501-07	1336496-12
.50000		1219102-01	2527735-02	5685914-03	1381790-06	2669528-12	1889949-23
.75000		3729410-02	4080744-03	4869157-04	2723645-09	1006227-17	2640440-34
1.00000		1105191-02	6423276-04	4082217-05	5311506-12	3770292-23	3677363-45
2.00000		7748777-05	3663265-07	1900335-09	7464629-23	7317808-45	1372442-88
4.00000		3449346-09	1106457-13	3880611-18	1434694-44	2717621-88	189771-175
7.00000		9876590-16	1786377-23	3502363-31	3784989-77	193489-153	0000000+00
10.00000		2815175-22	2870734-33	3147858-44	996364-110	137597-218	0000000+00
20.00000		4397583-44	6537882-66	1027457-87	250589-218	0000000+00	0000000+00

6. The Function $C(R/l, b, a/l)$

The function $C(R/l, b, a/l)$ is useful in finding the flux at a point on the axis of a non-absorbing cylindrical source with an intervening slab shield.

TABLE 6

TABLE OF THE FUNCTION C(R/L, B, A/L)

THE FUNCTION C(R/L, b, a/L)

B (MFP)	.10000	.25000	.50000	.75000	1.00000	2.00000	3.00000	4.00000	5.00000
A/L	.01000	.01000	.01000	.01000	.01000	.01000	.01000	.01000	.01000
R/L									
.01000	3900445-02	3324927-02	2548939-02	1954772-02	1499615-02	5211255-03	1819561-03	6379815-04	2249175-04
.05000	4438179-01	3608765-01	2588518-01	1879200-01	1376684-01	4199670-02	1350373-02	4469041-03	1506366-03
.07500	7262274-01	5814350-01	4100018-01	2944165-01	2140470-01	6418867-02	2044812-02	6723504-03	2254844-03
.10000	1008668+00	7991303-01	5577657-01	3980761-01	2881806-01	8555253-02	2708870-02	8866516-03	2962435-03
.25000	2612763+00	2011152+00	1347926+00	9604148-01	6866490-01	1968648-01	6078986-02	1948814-02	6393660-03
.50000	4884829+00	3679709+00	2446596+00	1688225+00	1189295+00	3253044-01	9676946-02	3004685-02	9583233-03
.75000	6713670+00	4972941+00	3241267+00	2201108+00	1529273+00	4003026-01	1151586-01	3480506-02	1085662-02
1.00000	8189327+00	5973012+00	3820974+00	2556339+00	1753603+00	4417411-01	1237761-01	3670841-02	1129319-02
2.50000	1304068+01	8836178+00	5201505+00	3279309+00	2150295+00	4879090-01	1304444-01	3779186-02	1148288-02
5.00000	1587539+01	1001160+01	5546853+00	3395323+00	2192365+00	4890016-01	1304839-01	3779355-02	1148296-02
7.50000	1697362+01	1029961+01	5589298+00	3402709+00	2193774+00	4890046-01	1304839-01	3779355-02	1148296-02
10.00000	1750277+01	1038985+01	5506144+00	3403336+00	2193838+00	4890046-01	1304839-01	3779355-02	1148296-02
25.00000	1817585+01	1044250+01	5597739+00	3403405+00	2193841+00	4890046-01	1304839-01	3779355-02	1148296-02
50.00000	1822798+01	1044285+01	5597740+00	3403405+00	2193841+00	4890046-01	1304839-01	3779355-02	1148296-02
100.00000	1822999+01	1044288+01	5597741+00	3403405+00	2193841+00	4890046-01	1304839-01	3779355-02	1148296-02
B (MFP)	7.50000	10.00000	15.00000	20.00000	50.00000	100.00000	.10000	.25000	.50000
A/L	.01000	.01000	.01000	.01000	.01000	.01000	.05000	.05000	.05000
R/L									
.01000	1671793-05	1263883-06	7455264-09	4523381-11	2903442-24	4081375-46	8555255-03	7359768-03	5728844-03
.05000	1043223-04	7531395-06	4193220-08	2452076-10	1414555-23	1828979-45	1864942-01	1589065-01	1217310-01
.07500	1546882-04	1108835-05	6106380-08	3539957-10	1970425-23	2448478-45	3714552-01	3139175-01	2373762-01
.10000	2017214-04	1437362-04	7839010-08	4507890-10	2423054-23	2894529-45	5840060-01	4895853-01	3656888-01
.25000	4187655-04	2887078-05	1489317-07	8172644-10	3626958-23	3662629-45	2008371+00	1623173+00	1153338+00
.50000	5915211-04	3887183-05	1843884-07	9705079-10	3782343-23	3683552-45	4228969+00	3297041+00	2247745+00
.75000	6431764-04	4113957-05	1914014-07	9828972-10	3783110-23	3683553-45	6074038+00	4620953+00	3066136+00
1.00000	6553533-04	4151111-05	1918062-07	9833993-10	3783110-23	3683553-45	7583806+00	5654157+00	3670589+00
2.50000	6583093-04	4156539-05	1918299-07	9834117-10	3783110-23	3683553-45	1263817+01	8673578+00	5148367+00
5.00000	6583093-04	4156539-05	1918299-07	9834117-10	3783110-23	3683553-45	1564931+01	9952023+00	5536593+00
7.50000	6583093-04	4156539-05	1918299-07	9834117-10	3783110-23	3683553-45	1683358+01	1027506+01	5587049+00
10.00000	6583093-04	4156539-05	1918299-07	9834117-10	3783110-23	3683553-45	1741135+01	1037905+01	5595614+00
25.00000	6583093-04	4156539-05	1918299-07	9834117-10	3783110-23	3683553-45	1816491+01	1044237+01	5597739+00
50.00000	6583093-04	4156539-05	1918299-07	9834117-10	3783110-23	3683553-45	1822750+01	1044285+01	5597740+00
100.00000	6583093-04	4156539-05	1918299-07	9834117-10	3783110-23	3683553-45	1823009+01	1044288+01	5597741+00
B (MFP)	.75000	1.00000	2.00000	3.00000	4.00000	5.00000	7.50000	10.00000	15.00000
A/L	.05000	.05000	.05000	.05000	.05000	.05000	.05000	.05000	.05000
R/L									
.01000	4456199-03	3467504-03	1271263-03	4660709-04	1708764-04	6264959-05	5099532-06	4151569-07	2752205-09
.05000	9328732-02	7151428-02	2478133-02	8628891-03	3017444-03	1059156-03	7838604-05	5892501-06	3440286-08
.07500	1797134-01	1362111-01	4540350-02	1533867-02	5237081-03	1803300-03	1289391-04	9473163-06	5370796-08
.10000	2738276-01	2054977-01	6642274-02	2197226-02	7389508-03	2515666-03	1764092-04	1279426-05	7127141-08
.25000	8300103-01	6031166-01	1788108-01	5611665-02	1817448-02	6006188-03	3981275-04	2765972-05	1441014-07
.50000	1571288+00	1116291+00	3188885-01	9334625-02	2916287-02	9343548-03	5811617-04	3837812-05	1850872-07
.75000	2101915+00	1469508+00	3899904-01	1130090-01	3431690-02	1074010-02	6395073-04	4101203-05	1912220-07
1.00000	2474971+00	1706678+00	4348904-01	1225615-01	3647336-02	1124533-02	6543384-04	4148730-05	1917909-07
2.50000	3258884+00	2141836+00	4875659-01	1304270-01	3779089-02	1148282-02	6583092-04	4156539-05	1918299-07
5.00000	3393188+00	2191881+00	4889998-01	1304839-01	3779355-02	1148296-02	6583093-04	4156539-05	1918299-07
7.50000	3402456+00	2193743+00	4890046-01	1304839-01	3779355-02	1148296-02	6583093-04	4156539-05	1918299-07
10.00000	3403303+00	2193836+00	4890046-01	1304839-01	3779355-02	1148296-02	6583093-04	4156539-05	1918299-07
25.00000	3403405+00	2193841+00	4890046-01	1304839-01	3779355-02	1148296-02	6583093-04	4156539-05	1918299-07
50.00000	3403405+00	2193841+00	4890046-01	1304839-01	3779355-02	1148296-02	6583093-04	4156539-05	1918299-07
100.00000	3403405+00	2193841+00	4890046-01	1304839-01	3779355-02	1148296-02	6583093-04	4156539-05	1918299-07

TABLE 6 (Continued)

TABLE OF THE FUNCTION C(R/L, B, A/L)										
B (MFP)	= 20.00000	50.00000	100.00000	.10000	.25000	.50000	.75000	1.00000	2.00000	
A/L	= .05000	.05000	.05000	.07500	.07500	.07500	.07500	.07500	.07500	
R/L										
.01000	1824943-11	1561929-24	2654610-46	5592821-03	4812646-03	3746608-03	2916684-03	2270618-03	8440002-04	
.05000	2068311-10	1272051-23	1698163-45	1302752-01	1115436-01	8612188-02	6650109-02	5135457-02	1828031-02	
.07500	3167835-10	1838215-23	2335714-45	2722397-01	2319039-01	1775697-01	1360170-01	1042239-01	3605185-02	
.10000	4151455-10	2303993-23	2828996-45	4455051-01	3773631-01	2863665-01	2175033-01	1653363-01	5562248-02	
.25000	7958562-10	3592509-23	3654768-45	1728516+00	1419354+00	1028849+00	7511035-01	5515990-01	1674830-01	
.50000	9666938-10	3781826-23	3683550-45	3872362+00	3067371+00	2123578+00	1497673+00	1070197+00	3017208-01	
.75000	9826164-10	3783109-23	3683553-45	5702987+00	4400678+00	2955356+00	2038873+00	1431383+00	4303199-01	
1.00000	9833883-10	3783110-23	3683553-45	7220254+00	5453221+00	3574751+00	2422800+00	1676419+00	4303754-01	
2.50000	9834117-10	3783110-23	3683553-45	1238249+01	8568494+00	5113345+00	3245172+00	2136054+00	4873144-01	
5.00000	9834117-10	3783110-23	3683553-45	1550348+01	9912592+00	5529533+00	3391663+00	2191522+00	4889982-01	
7.50000	9834117-10	3783110-23	3683553-45	1674238+01	1025847+01	5585440+00	3402265+00	2193718+00	4890046-01	
10.00000	9834117-10	3783110-23	3683553-45	1735128+01	1037161+01	5595221+00	3403278+00	2193834+00	4890046-01	
25.00000	9834117-10	3783110-23	3683553-45	1815733+01	1044227+01	5597738+00	3403405+00	2193841+00	4890046-01	
50.00000	9834117-10	3783110-23	3683553-45	1822710+01	1044285+01	5597740+00	3403405+00	2193841+00	4890046-01	
100.00000	9834117-10	3783110-23	3683553-45	1823012+01	1044288+01	5597741+00	3403405+00	2193841+00	4890046-01	
B (MFP)	= 3.00000	4.00000	5.00000	7.50000	10.00000	15.00000	20.00000	50.00000	100.00000	
A/L	= .07500	.07500	.07500	.07500	.07500	.07500	.07500	.07500	.07500	
R/L										
.01000	3063261-04	1125146-04	4132706-05	3379070-06	2763106-07	1847635-09	1235406-11	1105735-24	1991163-46	
.05000	6516010-03	2325642-03	8310612-04	6374854-05	4920552-06	2976244-08	1829182-10	1182663-23	1615813-45	
.07500	1253162-02	4374834-03	1533111-03	1130231-04	8465566-06	4910038-08	2934486-10	1754907-23	2264090-45	
.10000	1890807-02	6482691-03	2238363-03	1605706-04	1180428-05	6680208-08	3927356-10	2228497-23	2743963-45	
.25000	5317678-02	1734656-02	5761554-03	3850403-04	2688839-05	1409981-07	7819826-10	3568999-23	3688924-45	
.50000	9115466-02	2859319-02	9188074-03	5743323-04	3804735-05	1841872-07	9639700-10	3781380-23	3683548-45	
.75000	1115997-01	3399258-02	1066166-02	6369554-04	4092041-05	1910847-07	9823871-10	3783108-23	3683553-45	
1.00000	1217440-01	3631181-02	1121175-02	6535889-04	4146879-05	1917778-07	9833779-10	3783110-23	3683553-45	
2.50000	1304134-01	3779008-02	1148277-02	6583092-04	4156539-05	1918299-07	9834117-10	3783110-23	3683553-45	
5.00000	1304839-01	3779355-02	1148296-02	6583093-04	4156539-05	1918299-07	9834117-10	3783110-23	3683553-45	
7.50000	1304839-01	3779355-02	1148296-02	6583093-04	4156539-05	1918299-07	9834117-10	3783110-23	3683553-45	
10.00000	1304839-01	3779355-02	1148296-02	6583093-04	4156539-05	1918299-07	9834117-10	3783110-23	3683553-45	
25.00000	1304839-01	3779355-02	1148296-02	6583093-04	4156539-05	1918299-07	9834117-10	3783110-23	3683553-45	
50.00000	1304839-01	3779355-02	1148296-02	6583093-04	4156539-05	1918299-07	9834117-10	3783110-23	3683553-45	
100.00000	1304839-01	3779355-02	1148296-02	6583093-04	4156539-05	1918299-07	9834117-10	3783110-23	3683553-45	
B (MFP)	= .10000	.25000	.50000	.75000	1.00000	2.00000	3.00000	4.00000	5.00000	
A/L	= .10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000	
R/L										
.01000	4105057-03	3532773-03	2750698-03	2141739-03	1667608-03	6129216-04	2252745-04	8279890-05	3043247-05	
.05000	9832159-02	8435755-02	6535186-02	5063023-02	3922594-02	1413773-02	5097999-03	1839228-03	6638576-04	
.07500	2107405-01	1801946-01	1388185-01	1069599-01	8242314-02	2910462-02	1029815-02	3650743-03	1296488-03	
.10000	3534538-01	3010024-01	2303739-01	1763849-01	1350953-01	4664775-02	1618678-02	5641371-03	1973724-03	
.25000	1502828+00	1247116+00	9173144-01	6775492-01	5022968-01	1561989-01	5022648-02	1651386-02	5515167-03	
.50000	3556255+00	2851743+00	2001604+00	1424155+00	1023872+00	2924393-01	8892925-02	2801097-02	9028432-03	
.75000	5360150+00	4186479+00	2844116+00	1975123+00	1392701+00	3764831-01	1101413-01	3365376-02	1057894-02	
1.00000	6875785+00	5253290+00	3477672+00	2369665+00	1645472+00	4256848-01	1208817-01	3613883-02	1117525-02	
2.50000	1212596+01	8460831+00	5076940+00	3230725+00	2129881+00	4870319-01	1303973-01	3778907-02	1148270-02	
5.00000	1535433+01	9871469+00	5521959+00	3389982+00	2191116+00	4889962-01	1304839-01	3779355-02	1148296-02	
7.50000	1664839+01	1024090+01	5583663+00	3402044+00	2193688+00	4890046-01	1304839-01	3779355-02	1148296-02	
10.00000	1728897+01	1036362+01	5594773+00	3403247+00	2193831+00	4890046-01	1304839-01	3779355-02	1148296-02	
25.00000	1814916+01	1044214+01	5597738+00	3403405+00	2193841+00	4890046-01	1304839-01	3779355-02	1148296-02	
50.00000	1822662+01	1044285+01	5597740+00	3403405+00	2193841+00	4890046-01	1304839-01	3779355-02	1148296-02	
100.00000	1823014+01	1044288+01	5597741+00	3403405+00	2193841+00	4890046-01	1304839-01	3779355-02	1148296-02	

TABLE 6 (Continued)

TABLE OF THE FUNCTION C(H/L, B, A/L)

B (MFP)	7.50000	10.00000	15.00000	20.00000	50.00000	100.00000	.10000	.25000	.50000
A/L	.10000	.10000	.10000	.10000	.10000	.10000	.25000	.25000	.25000
R/L									
.01000	2492374-06	2041366-07	1349430-09	9185669-12	8370919-25	1547865-46	1447251-03	1245630-03	9700579-04
.05000	5206260-05	4093880-06	2548864-08	1599674-10	1093111-23	1533044-45	3588471-02	3086736-02	2401498-02
.07500	9811478-05	7489090-06	4452045-08	2701027-10	1671117-23	2191644-45	7990151-02	6867861-02	5336611-02
.10000	1449400-04	1081669-05	6232047-08	3702323-10	2152225-23	2683825-45	1400515-01	1202588-01	932977-02
.25000	3718180-04	2610669-05	1378336-07	7677484-10	3543974-23	3642310-45	7616564-01	6476048-01	4943495-01
.50000	5672384-04	3769981-05	1832196-07	9609741-10	3780817-23	3683544-45	2254104+00	1876174+00	1485951+00
.75000	6342002-04	4081915-05	1909256-07	9821089-10	3783106-23	3683553-45	3796523+00	3094419+00	2414019+00
1.00000	6527433-04	4144714-05	1917612-07	9833638-10	3783110-23	3683553-45	5204108+00	4159797+00	2495062+00
2.50000	6583091-04	4156539-05	1918299-07	9834117-10	3783110-23	3683553-45	1065900+01	7775151+00	4830352+00
5.00000	6583093-04	4156539-05	1918299-07	9834117-10	3783110-23	3683553-45	1441700+01	9589594+00	5464970+00
7.50000	6583093-04	4156539-05	1918299-07	9834117-10	3783110-23	3683553-45	1603258+01	1011419+01	558951+00
10.00000	6583093-04	4156539-05	1918299-07	9834117-10	3783110-23	3683553-45	1686965+01	1030316+01	5590706+00
25.00000	6583093-04	4156539-05	1918299-07	9834117-10	3783110-23	3683553-45	1808754+01	1044094+01	5597734+00
50.00000	6583093-04	4156539-05	1918299-07	9834117-10	3783110-23	3683553-45	1822215+01	1044283+01	5597739+00
100.00000	6583093-04	4156539-05	1918299-07	9834117-10	3783110-23	3683553-45	1823002+01	1044287+01	5597741+00

B (MFP)	.75000	1.00000	2.00000	3.00000	4.00000	5.00000	7.50000	10.00000	15.00000
A/L	.25000	.25000	.25000	.25000	.25000	.25000	.25000	.25000	.25000
R/L									
.01000	7554438-04	5883162-04	2143941-04	7959334-05	2927607-05	1076833-05	8835472-07	7250032-08	4881566-10
.05000	1868371-02	1453607-02	5325897-03	1951352-03	7149785-04	2619728-04	2129058-05	1730575-06	1143676-08
.07500	4146784-02	3222257-02	1174863-02	4283832-03	1562141-03	5696890-04	4576907-05	3678996-06	2379990-08
.10000	7237021-02	5614234-02	2043708-02	7368432-03	2670333-03	9679419-04	7664104-05	6076498-06	3833029-08
.25000	3775108-01	2883896-01	9856361-02	3386071-02	1168626-02	4049874-03	2907208-04	1223955-05	1177207-07
.50000	1025167+00	7607110-01	2355446-01	7489770-02	2428564-02	7991884-03	5195306-04	3527917-05	1759886-07
.75000	1594628+00	1155128+00	3323670-01	1004354-01	3133182-02	9995347-03	6132898-04	3999196-05	1894166-07
1.00000	2037827+00	1447839+00	3940542-01	1147845-01	3485679-02	1089168-02	6453425-04	4123320-05	1915816-07
2.50000	3128441+00	2084296+00	4845657-01	1302309-01	3777666-02	1148172-02	6583071-04	4156538-05	1918299-07
5.00000	3376133+00	2187452+00	4889703-01	1304837-01	3779354-02	1148296-02	6583093-04	4156539-05	1918299-07
7.50000	3399950+00	2193361+00	4800043-01	1304839-01	3779355-02	1148296-02	6583093-04	4156539-05	1918299-07
10.00000	3402906+00	2193800+00	4890046-01	1304839-01	3779355-02	1148296-02	6583093-04	4156539-05	1918299-07
25.00000	3403405+00	2193841+00	4890046-01	1304839-01	3779355-02	1148296-02	6583093-04	4156539-05	1918299-07
50.00000	3403405+00	2193841+00	4890046-01	1304839-01	3779355-02	1148296-02	6583093-04	4156539-05	1918299-07
100.00000	3403405+00	2193841+00	4890046-01	1304839-01	3779355-02	1148296-02	6583093-04	4156539-05	1918299-07

B (MFP)	20.00000	50.00000	100.00000	.10000	.25000	.50000	.75000	1.00000	2.00000
A/L	.25000	.25000	.25000	.50000	.50000	.50000	.50000	.50000	.50000
R/L									
.01000	3286382-12	3059820-25	5853457-47	6031696-04	5191495-04	4043091-04	3148696-04	2452179-04	9020644-05
.05000	7560024-11	6353141-24	1048776-45	1504280-02	1294514-02	1007866-02	7846844-03	6109297-03	2444800-03
.07500	1542017-10	1174713-23	1743048-45	3374054-02	2902905-02	2259262-02	1758320-02	1368460-02	5020824-03
.10000	2428198-10	1682451-23	2370743-45	5972316-02	5136754-02	3995746-02	3108174-02	2417774-02	8452541-03
.25000	6755808-10	3362865-23	3584410-45	3553977-01	3046048-01	2355677-01	1821864-01	1409050-01	5043499-02
.50000	9369326-10	3773772-23	3683444-45	1232619+00	1045668+00	7952100-01	6049924-01	4604478-01	1550705-01
.75000	9790336-10	3783055-23	3683553-45	2327703+00	1949522+00	1452435+00	1083581+00	8094611-01	2551055-01
1.00000	9831328-10	3783110-23	3683553-45	3454403+00	2854169+00	2081742+00	1522887+00	1117164+00	3314222-01
2.50000	9834117-10	3783110-23	3683553-45	8653537+00	6628610+00	4339652+00	2902311+00	1974695+00	4766138-01
5.00000	9834117-10	3783110-23	3683553-45	1288696+01	9010607+00	5322050+00	3335264+00	2174800+00	4880034-01
7.50000	9834117-10	3783110-23	3683553-45	1491511+01	9821396+00	5525000+00	3392001+00	2191785+00	4890006-01
10.00000	9834117-10	3783110-23	3683553-45	1604906+01	1014960+01	5576367+00	3401255+00	2193590+00	4890045-01
25.00000	9834117-10	3783110-23	3683553-45	1793079+01	1043594+01	5597703+00	3403404+00	2193841+00	4890046-01
50.00000	9834117-10	3783110-23	3683553-45	1820703+01	1044279+01	5597738+00	3403405+00	2193841+00	4890046-01
100.00000	9834117-10	3783110-23	3683553-45	1822932+01	1044285+01	5597740+00	3403405+00	2193841+00	4890046-01

TABLE 6 (Continued)

TABLE OF THE FUNCTION C(R/L, B, A/L)										
B (MFP)	3.00000	4.00000	5.00000	7.50000	10.00000	15.00000	20.00000	50.00000	100.00000	
A/L	.50000	.50000	.50000	.50000	.50000	.50000	.50000	.50000	.50000	
R/L										
.01000	3318332-05	1220693-05	4490482-06	3685542-07	3025091-08	2038035-10	1372853-12	1282674-25	2467953-47	
.05000	8248212-04	3030733-04	1113617-04	9113811-06	7459271-07	4996801-09	3346884-11	3024009-24	5513059-46	
.07500	1842098-03	6758640-04	2479748-04	2021998-05	1448913-06	1096635-08	7293334-11	6327607-24	1085720-45	
.10000	3241280-03	1186807-03	4345603-04	3525728-05	2861019-06	1884400-08	1241482-10	1022896-23	1036369-45	
.25000	1806204-02	6471904-03	2320157-03	1789219-04	1383836-05	8342422-08	5076069-10	2954377-23	3408281-45	
.50000	5251541-02	1787377-02	6111056-03	4249165-04	3014859-05	1587474-07	8726937-10	3736545-23	3081775-45	
.75000	8174511-02	2655714-02	8727466-03	5618822-04	3770008-05	1841160-07	9653353-10	3782107-23	3683552-45	
1.00000	1014535-01	3180984-02	1016215-02	6222166-04	4042209-05	1903808-07	9812300-10	3783101-23	3683553-45	
2.50000	1295180-01	3770599-02	1147429-02	6582759-04	4156523-05	1918299-07	9834117-10	3783110-23	3683553-45	
5.00000	1304808-01	3779349-02	1148296-02	6583093-04	4156539-05	1918299-07	9834117-10	3783110-23	3683553-45	
7.50000	1304839-01	3779355-02	1148296-02	6583093-04	4156539-05	1918299-07	9834117-10	3783110-23	3683553-45	
10.00000	1304839-01	3779355-02	1148296-02	6583093-04	4156539-05	1918299-07	9834117-10	3783110-23	3683553-45	
25.00000	1304839-01	3779355-02	1148296-02	6583093-04	4156539-05	1918299-07	9834117-10	3783110-23	3683553-45	
50.00000	1304839-01	3779355-02	1148296-02	6583093-04	4156539-05	1918299-07	9834117-10	3783110-23	3683553-45	
100.00000	1304839-01	3779355-02	1148296-02	6583093-04	4156539-05	1918299-07	9834117-10	3783110-23	3683553-45	
B (MFP)	.10000	.25000	.50000	.75000	1.00000	2.00000	3.00000	4.00000	5.00000	
A/L	.75000	.75000	.75000	.75000	.75000	.75000	.75000	.75000	.75000	
R/L										
.01000	3446859-04	2966730-04	2310478-04	1799375-04	1401347-04	5155154-05	1896419-05	6976406-06	2569425-06	
.05000	8606795-03	7407279-03	5767933-03	4491362-03	3497356-03	1285842-03	4727501-04	1738123-04	6390418-05	
.07500	1933509-02	1663853-02	1295375-02	1008493-02	7851524-03	2884563-03	1059745-03	3893397-04	1430396-04	
.10000	3429875-02	2951070-02	2296929-02	1787774-02	1391493-02	5106917-03	1874267-03	6878784-04	2524602-04	
.25000	2089927-01	1794912-01	1392826-01	1080826-01	8387190-02	3041646-02	1103156-02	4001547-03	1451669-03	
.50000	7705487-01	6579056-01	5055956-01	3885962-01	2986958-01	1043773-01	3653184-02	1280518-02	4494990-03	
.75000	1548284+00	1311077+00	9940611-01	7540262-01	5721788-01	1904761-01	6378727-02	2147780-02	7268011-03	
1.00000	2421047+00	2030665+00	1516147+00	1133173+00	8477939-01	2681379-01	8597073-02	2789301-02	9143869-03	
2.50000	7119062+00	5617398+00	3823160+00	2631613+00	1829629+00	4625358-01	1279099-01	3750501-02	1144774-02	
5.00000	1152859+04	8368605+00	5121602+00	3267467+00	2150539+00	4882616-01	1304654-01	3779300-02	1148296-02	
7.50000	1382318+01	9446756+00	5450952+00	3375345+00	2187735+00	4889800-01	1304838-01	3779354-02	1148296-02	
10.00000	1518246+01	9930348+00	5548172+00	3396973+00	2192878+00	4890037-01	1304839-01	3779355-02	1148296-02	
25.00000	1770579+01	1042453+01	5597566+00	3403402+00	2193841+00	4890046-01	1304839-01	3779355-02	1148296-02	
50.00000	1817740+01	1044265+01	5597738+00	3403405+00	2193841+00	4890046-01	1304839-01	3779355-02	1148296-02	
100.00000	1822824+01	1044283+01	5597739+00	3403405+00	2193841+00	4890046-01	1304839-01	3779355-02	1148296-02	
B (MFP)	7.50000	10.00000	15.00000	20.00000	50.00000	100.00000	.10000	.25000	.50000	
A/L	.75000	.75000	.75000	.75000	.75000	.75000	1.00000	1.00000	1.00000	
R/L										
.01000	2106510-07	1729127-08	1165072-10	7849061-13	7338809-26	1413743-47	2262045-04	1946957-04	1516287-04	
.05000	5237738-06	4293266-07	2844527-09	1937778-11	1781345-24	3337320-46	5659962-03	4863565-03	3787403-03	
.07500	1170224-05	9574458-07	6409250-09	4289965-11	3860040-24	6989159-46	1270253-02	1093183-02	8511975-03	
.10000	2060132-05	1681264-06	1119785-08	7457845-11	6519858-24	1129712-45	2255218-02	1940662-02	1510839-02	
.25000	1151312-04	9138152-06	5768272-08	3650443-10	2459246-23	3128886-45	1387495-01	1192624-01	9267362-02	
.50000	3301074-04	2443302-05	1365590-07	7806532-10	3646372-23	3672677-45	5265072-01	4508482-01	3481366-01	
.75000	4935232-04	3429408-05	1745611-07	9357029-10	3776329-23	3683508-45	1095783+00	9330155-01	7137623-01	
1.00000	5838813-04	3885157-05	1873267-07	9745953-10	3782938-23	3683553-45	1773234+00	1499397+00	1134137+00	
2.50000	6580820-04	4156363-05	1918297-07	9834117-10	3783110-23	3683553-45	5926627+00	4768777+00	3337683+00	
5.00000	6583093-04	4156539-05	1918299-07	9834117-10	3783110-23	3683553-45	1034897+01	7725663+00	4879236+00	
7.50000	6583093-04	4156539-05	1918299-07	9834117-10	3783110-23	3683553-45	1281194+01	9025424+00	5345294+00	
10.00000	6583093-04	4156539-05	1918299-07	9834117-10	3783110-23	3683553-45	1433623+01	9659312+00	5502191+00	
25.00000	6583093-04	4156539-05	1918299-07	9834117-10	3783110-23	3683553-45	1742579+01	1040348+01	5597141+00	
50.00000	6583093-04	4156539-05	1918299-07	9834117-10	3783110-23	3683553-45	1812862+01	1044221+01	5597738+00	
100.00000	6583093-04	4156539-05	1918299-07	9834117-10	3783110-23	3683553-45	1822618+01	1044282+01	5597738+00	

TABLE 6 (Continued)

TABLE OF THE FUNCTION C(R/L, B, A/L)										
B (MFP)	1.00000	2.00000	3.00000	4.00000	5.00000	7.50000	10.00000	15.00000		
A/L	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
R/L										
.01000	1180870-04	9196596-05	3383196-05	1244583-05	4578522-06	1684326-06	1382519-07	1134866-08	7646994-11	
.05000	2949337-03	2296738-03	8446170-04	3106022-04	1142232-04	4200522-05	3444839-06	2825292-07	1900426-09	
.07500	6627718-03	5160617-03	1896937-03	6972688-04	2563024-04	9421171-05	7717535-06	6322404-07	4243151-09	
.10000	1176205-02	9156966-03	3343783-03	1235662-03	4539178-04	1667458-04	1363778-05	1115488-06	7462936-09	
.25000	7201278-02	5595835-02	2040379-02	7439700-03	2712876-03	9892823-04	7945504-05	6383543-06	4123179-08	
.50000	2688396-01	2076090-01	7386411-02	2629520-02	9366268-03	3338099-03	2537278-04	1934937-05	1135367-07	
.75000	5461366-01	4179354-01	1435663-01	4944022-02	1706600-02	5904291-03	4195331-04	3017095-05	1608754-07	
1.00000	8582463-01	6497419-01	2143336-01	7115520-02	2376190-02	7978618-03	5324239-04	3646063-05	1015684-07	
2.50000	2351081+00	1666001+00	4420017-01	1250618-01	3708175-02	1138176-02	6573619-04	4155483-05	1918282-07	
5.00000	3172452+00	2112052+00	4849665-01	1304120-01	3779055-02	1148282-02	6583093-04	4156539-05	1918299-07	
7.50000	3346781+00	2179573+00	4889054-01	1304829-01	3779353-02	1148296-02	6583093-04	4156539-05	1918299-07	
10.00000	3388261+00	2191103+00	4889993-01	1304839-01	3779355-02	1148296-02	6583093-04	4156539-05	1918299-07	
25.00000	3403391+00	2193841+00	4890046-01	1304839-01	3779355-02	1148296-02	6583093-04	4156539-05	1918299-07	
50.00000	3403405+00	2193841+00	4890046-01	1304839-01	3779355-02	1148296-02	6583093-04	4156539-05	1918299-07	
100.00000	3403405+00	2193841+00	4890046-01	1304839-01	3779355-02	1148296-02	6583093-04	4156539-05	1918299-07	
B (MFP)	20.00000	50.00000	100.00000	.10000	.25000	.50000	.75000	1.00000	2.00000	4.00000
A/L	1.00000	1.00000	1.00000	2.50000	2.50000	2.50000	2.50000	2.50000	2.50000	2.50000
R/L										
.01000	5152001-13	4818422-26	9286485-48	5170516-05	4450305-05	3465898-05	2699218-05	2102152-05	7733378-06	
.05000	1278142-11	1182994-24	2241018-46	1292436-03	1112398-03	8663204-04	6746724-04	5254259-04	1932794-04	
.07500	2847341-11	2600425-24	4820335-46	2907415-03	2502374-03	1948769-03	1517626-03	1181880-03	4347178-04	
.10000	4992393-11	4476829-24	8060782-46	5167330-03	4447367-03	3463356-03	2697040-03	2100302-03	7724308-04	
.25000	2665503-10	1982598-23	2771055-45	3219078-02	2769019-02	2156217-02	1678474-02	1306593-02	4197843-03	
.50000	6735554-10	3487480-23	3645100-45	1272918-01	1094406-01	8507618-02	6613586-02	5141240-02	1077619-02	
.75000	8870874-10	3757164-23	3683069-45	2811055-01	2413597-01	1872075-01	1452068-01	1126294-01	4077151-02	
1.00000	9593203-10	3781773-23	3683551-45	4872927-01	4176325-01	3229519-01	2497448-01	1931336-01	6968778-02	
2.50000	9834114-10	3783110-23	3683553-45	2387602+00	2009544+00	1508465+00	1132963+00	8514056-01	2730169-01	
5.00000	9834117-10	3783110-23	3683553-45	5807090+00	4695099+00	3307667+00	2341606+00	1665466+00	4447437-01	
7.50000	9834117-10	3783110-23	3683553-45	8390863+00	6522296+00	4337530+00	2924856+00	1997339+00	4810720-01	
10.00000	9834117-10	3783110-23	3683553-45	1027223+01	7707620+00	4889630+00	3183923+00	2119764+00	4875871-01	
25.00000	9834117-10	3783110-23	3683553-45	1533854+01	1000984+01	5565808+00	3400399+00	2193522+00	4890045-01	
50.00000	9834117-10	3783110-23	3683553-45	1744354+01	1040997+01	5597401+00	3403400+00	2193841+00	4890046-01	
100.00000	9834117-10	3783110-23	3683553-45	1813982+01	1044248+01	5597738+00	3403405+00	2193841+00	4890046-01	
B (MFP)	3.00000	4.00000	5.00000	7.50000	10.00000	15.00000	20.00000	50.00000	100.00000	
A/L	2.50000	2.50000	2.50000	2.50000	2.50000	2.50000	2.50000	2.50000	2.50000	
R/L										
.01000	2844927-06	1046592-06	3850202-07	3160392-08	2594341-09	1748230-11	1177901-13	1102019-26	2125141-48	
.05000	7109786-05	2615363-05	9620710-06	7895641-07	6480316-08	4365288-10	2940145-12	2744876-25	5274478-47	
.07500	1598961-04	5881298-05	2163256-05	1774956-06	1456452-07	9806444-10	6601863-12	6146349-25	1175644-46	
.10000	2840755-04	1044751-04	3842301-05	3151595-06	2585225-07	1739532-09	1170325-11	1085372-24	2062806-46	
.25000	1761758-03	6469237-04	2375527-04	1940985-05	1586052-06	1059036-08	7070691-11	6267392-24	1107392-48	
.50000	6857105-03	2504340-03	9146468-04	7373749-05	5945791-06	3867147-08	2516207-10	1929306-23	2770725-45	
.75000	1475993-02	5344020-03	1935039-03	1527385-04	1206433-05	7539843-08	4723251-10	2992917-23	3004354-45	
1.00000	2472176-02	8848929-03	3168362-03	2433702-04	1872979-05	1115219-07	6686711-10	3528301-23	3662021-45	
2.50000	8828989-02	2878175-02	9453993-03	6024741-04	3984418-05	1898556-07	9807869-10	3783105-23	3683553-45	
5.00000	1258388-01	3725019-02	1141498-02	6578591-04	4156188-05	1918296-07	9834117-10	3783110-23	3683553-45	
7.50000	1300683-01	3776875-02	1148135-02	6583072-04	4156538-05	1918299-07	9834117-10	3783110-23	3683553-45	
10.00000	1304475-01	3779246-02	1148292-02	6583093-04	4156539-05	1918299-07	9834117-10	3783110-23	3683553-45	
25.00000	1304839-01	3779355-02	1148296-02	6583093-04	4156539-05	1918299-07	9834117-10	3783110-23	3683553-45	
50.00000	1304839-01	3779355-02	1148296-02	6583093-04	4156539-05	1918299-07	9834117-10	3783110-23	3683553-45	
100.00000	1304839-01	3779355-02	1148296-02	6583093-04	4156539-05	1918299-07	9834117-10	3783110-23	3683553-45	

TABLE 6 (Continued)

TABLE OF THE FUNCTION C(R/L, B, A/L)										
B (MFP)	.10000	.25000	.50000	.75000	1.00000	2.00000	3.00000	4.00000	5.00000	
A/L	5.00000	5.00000	5.00000	5.00000	5.00000	5.00000	5.00000	5.00000	5.00000	5.00000
R/L										
.01000	1508074-05	1298012-05	1010892-05	7872765-06	6131317-06	2255588-06	8297791-07	3052600-07	1122992-07	
.05000	3770224-04	3244882-04	2527103-04	1968082-04	1532736-04	5638513-05	2074238-05	7630573-06	2807083-06	
.07500	8482086-04	7300552-04	5685608-04	4427863-04	3448384-04	1268532-04	4666421-05	1716608-05	6314773-06	
.10000	1507810-03	1297768-03	1010682-03	7870959-04	6129783-04	2254836-04	8294331-05	3051072-05	1122337-05	
.25000	9415069-03	8102991-03	6309784-03	4913375-03	3826038-03	1406784-03	5172516-04	1901871-04	6992944-05	
.50000	3753609-02	3229746-02	2514006-02	1956867-02	1523210-02	5591860-03	2052404-03	7536075-04	2768580-04	
.75000	8399579-02	7224485-02	5619808-02	4371537-02	3400553-02	1245143-02	4559132-03	1669384-03	6112701-04	
1.00000	1481992-01	1273970-01	9901037-02	7694887-02	5980333-02	2181908-02	7960517-03	2904475-03	1059749-03	
2.50000	8512285-01	7272786-01	5595084-01	4304745-01	3312083-01	1161357-01	4075823-02	1431619-02	5032788-03	
5.00000	2691363+00	2259099+00	1688338+00	1262610+00	9448661-01	2982746-01	9512534-02	3063415-02	9956712-03	
7.50000	4618636+00	3794065+00	2739257+00	1982624+00	1438546+00	4081551-01	1198537-01	3625801-02	1124848-02	
10.00000	6314379+00	5073149+00	3539393+00	2483740+00	1752698+00	4571918-01	1276321-01	3751085-02	1145323-02	
25.00000	1219445+01	8763983+00	5282844+00	3331994+00	2176159+00	4889066-01	1304832-01	3779354-02	1148296-02	
50.00000	1569289+01	1011012+01	5578235+00	3401969+00	2193724+00	4890046-01	1304839-01	3779355-02	1148296-02	
100.00000	1759920+01	1042283+01	5507615+00	3403404+00	2193841+00	4890046-01	1304839-01	3779355-02	1148296-02	
B (MFP)	7.50000	10.00000	15.00000	20.00000	50.00000	100.00000	.10000	.25000	.50000	
A/L	5.00000	5.00000	5.00000	5.00000	5.00000	5.00000	7.50000	7.50000	10.00000	
R/L										
.01000	9217997-09	7567020-10	5099187-12	3435706-14	3214577-27	6199670-49	7096823-06	6108297-06	4757146-06	
.05000	2304057-07	1891296-08	1274359-10	8585443-13	8027998-26	1546725-47	1774171-04	1527042-04	1189258-04	
.07500	5182831-07	4254072-08	2846023-10	1930606-12	1803829-25	3470808-47	3991781-04	3435749-04	2675749-04	
.10000	9210696-07	7559452-08	5091961-10	3429407-12	3200674-25	6147224-47	7096243-04	6107760-04	4756682-04	
.25000	5732579-06	4699689-07	3158678-09	2122672-11	1955195-24	3674371-46	4433226-03	3815574-03	2971389-03	
.50000	2259091-05	1844837-06	1230299-08	8203966-11	7219009-24	1260718-45	1770546-02	1523699-02	1186365-02	
.75000	4959449-05	4024254-06	2649926-08	1745083-10	1429178-23	2241005-45	3973490-02	3418883-02	2661155-02	
1.00000	8522832-05	6855853-06	4437957-08	2874244-10	2147820-23	2979034-45	7038704-02	6054711-02	4710788-02	
2.50000	3701378-04	2736238-05	1517407-07	8572771-10	3755791-23	3683297-45	4220319-01	3619501-01	2802131-01	
5.00000	6218757-04	4059816-05	1910222-07	9826444-10	3783110-23	3683553-45	1482866+00	1259701+00	959987-01	
7.50000	6558513-04	4153628-05	1918229-07	9834107-10	3783110-23	3683553-45	2809142+00	2355312+00	1757029+00	
10.00000	6581845-04	4156478-05	1918298-07	9834117-10	3783110-23	3683553-45	4147165+00	3426414+00	2496283+00	
25.00000	6583093-04	4156539-05	1918299-07	9834117-10	3783110-23	3683553-45	983606+00	7449357+00	4783839+00	
50.00000	6583093-04	4156539-05	1918299-07	9834117-10	3783110-23	3683553-45	1397551+01	9556541+00	5491285+00	
100.00000	6583093-04	4156539-05	1918299-07	9834117-10	3783110-23	3683553-45	1677377+01	1033225+01	5595021+00	
B (MFP)	.75000	1.00000	2.00000	3.00000	4.00000	5.00000	7.50000	10.00000	15.00000	
A/L	7.50000	7.50000	7.50000	7.50000	7.50000	7.50000	7.50000	7.50000	7.50000	
R/L										
.01000	3704835-06	2885330-06	1041455-06	3904852-07	1436521-07	5284686-08	4337900-09	3560970-10	2399636-12	
.05000	9261846-05	7213119-05	2653537-05	9761667-06	3591099-06	1321084-06	1084377-07	8901414-09	5998124-11	
.07500	2083845-04	1622892-04	5970164-05	2196240-05	8079376-06	2972183-06	2439564-07	2002522-08	1349298-10	
.10000	3704437-04	2884992-04	1061289-04	3904090-05	1436185-05	5283242-06	4336292-07	3559303-08	2399044-10	
.25000	2313957-03	1802001-03	6627574-04	2437534-04	8965023-05	3297249-05	2704862-06	2219051-07	1493517-09	
.50000	9237071-03	7192070-03	2643222-03	9714246-04	3570178-04	1312110-04	1074396-05	8798100-07	5899778-09	
.75000	2071349-02	1612277-02	5918184-03	2172360-03	7974101-04	2927063-04	2389481-05	1950785-06	1300246-08	
1.00000	3665148-02	2851624-02	1044965-02	3829172-03	1403193-03	5141995-04	4179944-05	3398239-06	2246198-08	
2.50000	2169396-01	1679539-01	6034794-02	2168780-02	7795730-03	2802740-03	2174032-04	1688513-05	1022082-07	
5.00000	7317464-01	5578442-01	1887487-01	6403807-02	2178464-02	7430368-03	5105012-04	3561460-05	1805909-07	
7.50000	1311646+00	9798774-01	3073734-01	9749128-02	3124967-02	1011695-02	6274279-04	4079095-05	1912571-07	
10.00000	1822031+00	1332392+00	3878444-01	1159568-01	3550819-02	1110383-02	6534604-04	4149612-05	7918130-07	
25.00000	3140506+00	2101914+00	4870694-01	1304322-01	3779200-02	1148291-02	6583093-04	4156539-05	1918299-07	
50.00000	3387742+00	2191313+00	4890021-01	1304839-01	3779355-02	1148296-02	6583093-04	4156539-05	1918299-07	
100.00000	3403321+00	2193838+00	4800046-01	1304839-01	3779355-02	1148296-02	6583093-04	4156539-05	1918299-07	

TABLE 6 (Continued)

TABLE OF THE FUNCTION C(R/L, B, Δ/L)										
B (MFP)	20.00000	50.00000	100.00000	.10000	.25000	.50000	.75000	1.00000	2.00000	
A/L	7.50000	7.50000	7.50000	10.00000	10.00000	10.00000	10.00000	10.00000	10.00000	10.00000
R/L										
.01000	1616819-14	1512777-27	2917625-49	4112935-06	3540037-06	2756983-06	2147121-06	1672180-06	6151618-07	
.05000	4041205-13	3780083-26	7287028-48	1028222-04	8849984-05	6892365-05	5367722-05	4180383-05	1537871-05	
.07500	9090248-13	8499742-26	1637524-47	2313464-04	1991214-04	1550754-04	1207714-04	9405660-05	3460111-05	
.10000	1615431-12	1509711-25	2926042-47	4112739-04	3539857-04	2756828-04	2146988-04	1672067-04	6151063-05	
.25000	1005062-11	9334960-25	1778529-46	2569816-03	2211815-03	1722502-03	1341426-03	1044667-03	3842575-04	
.50000	3955737-11	3594798-24	6688499-46	1027005-02	8838767-03	6882657-03	5359409-03	4173319-03	1534409-03	
.75000	8665705-11	7601144-24	1320798-45	13207318-02	1985547-02	1545850-02	1203514-02	9369980-03	3442630-03	
1.00000	1484730-10	1241834-23	2007375-45	4093368-02	3521996-02	2741373-02	2133755-02	1660826-02	6096017-03	
2.50000	6215953-10	3448318-23	3652515-45	2496522-01	2144278-01	1664139-01	1291521-01	1002338-01	3636688-02	
5.00000	9597079-10	3782633-23	3683553-45	9214000-01	7867804-01	6047090-01	4648129-01	3572938-01	1248235-01	
7.50000	9829340-10	3783110-23	3683553-45	1847200+01	1563823+00	1185076+00	8983244-01	6811302-01	2257477-01	
10.00000	9834070-10	3783110-23	3683553-45	2871664+00	2406254+00	1793240+00	1337384+00	9981731-01	3120444-01	
25.00000	9834117-10	3783110-23	3683553-45	8040760+00	6293404+00	4224836+00	2869383+00	1970043+00	4794810-01	
50.00000	9834117-10	3783110-23	3683553-45	1246677+01	8899292+00	5325086+00	3345203+00	2180296+00	488471-01	
100.00000	9834117-10	3783110-23	3683553-45	1587274+01	1015570+01	5582887+00	3402447+00	2193773+00	4890046-01	
B (MFP)	3.00000	4.00000	5.00000	7.50000	10.00000	15.00000	20.00000	50.00000	100.00000	
A/L	10.00000	10.00000	10.00000	10.00000	10.00000	10.00000	10.00000	10.00000	10.00000	
R/L										
.01000	2263041-07	8325303-08	3062718-08	2514013-09	2063748-10	1390702-12	9370233-15	8767308-28	1690925-49	
.05000	5657447-06	2081257-06	7656505-07	6284708-08	5159031-09	3476431-11	2342276-13	2191204-26	4224584-48	
.07500	1272880-05	4682629-06	1722628-06	1413964-07	1160683-08	7821023-11	5269296-13	4928382-26	9499245-48	
.10000	2262786-05	8324175-06	3062235-06	2513475-07	2063189-08	1390168-10	9365582-13	8757027-26	1687039-47	
.25000	1413395-04	5198876-05	1912295-05	1569137-06	1287644-07	8670897-10	5838103-12	5439237-25	1041643-46	
.50000	5641526-04	2074231-04	7626360-05	6251157-06	5124279-07	3443304-09	2313447-11	2128185-24	3991032-46	
.75000	1264845-03	4647183-04	1707427-04	1397065-05	1143200-06	7654761-09	5124946-11	4617253-24	8370489-46	
1.00000	2237498-03	8212699-04	3014460-04	2460449-05	2008417-06	1338251-08	8916300-11	7807113-24	1352808-48	
2.50000	1319452-02	4787721-03	1737356-03	1378548-04	1094368-05	6904629-08	4363151-10	2873245-23	3463392-48	
5.00000	4365196-02	1528005-02	5353864-03	3907041-04	2868001-05	1571535-07	8795456-10	3768869-23	3683473-45	
7.50000	7514491-02	2512013-02	8432281-03	5601542-04	3807127-05	1866946-07	9749685-10	3783072-23	3683553-45	
10.00000	9868430-02	3155448-02	1019485-02	6300023-04	4087610-05	1913509-07	9830380-10	3783110-23	3683553-45	
25.00000	1299773-01	3776377-02	1148110-02	6583073-04	4156538-05	1918299-07	9834117-10	3783110-23	3683553-45	
50.00000	1304836-01	3779354-02	1148296-02	6583093-04	4156539-05	1918299-07	9834117-10	3783110-23	3683553-45	
100.00000	1304839-01	3779355-02	1148296-02	6583093-04	4156539-05	1918299-07	9834117-10	3783110-23	3683553-45	
B (MFP)	.10000	.25000	.50000	.75000	1.00000	2.00000	3.00000	4.00000	5.00000	
A/L	25.00000	25.00000	25.00000	25.00000	25.00000	25.00000	25.00000	25.00000	25.00000	
R/L										
.01000	6960370-07	5990832-07	4665662-07	3633603-07	2829444-07	1041042-07	3829762-08	1408901-08	5183079-09	
.05000	1740085-05	1497706-05	1166414-05	9083957-06	7074595-06	2602600-06	9574369-07	3522228-07	1295759-07	
.07500	3915180-05	3369828-05	2624424-05	2043883-05	1591778-05	5855822-06	2154220-06	7924955-07	2915433-07	
.10000	6960297-05	5990783-05	4665622-05	3633554-05	2829813-05	1041028-05	3829692-06	1408867-06	5182932-07	
.25000	4350001-04	3744069-04	2915867-04	2270845-04	1768526-04	6505899-05	2393316-05	8804350-06	3238874-06	
.50000	1739737-03	1497385-03	1166136-03	9081578-04	7072573-04	2601609-04	9569811-05	3520216-05	1294896-05	
.75000	3913420-03	3368204-03	2623018-03	2042680-03	1590755-03	5850808-04	2151914-04	7914776-05	2911065-05	
1.00000	6954734-03	5985654-03	4661183-03	3629752-03	2826583-03	1039444-03	3822409-04	1405652-04	5169139-05	
2.50000	4328392-02	3724144-02	2898626-02	2256083-02	1755986-02	6444501-03	2365112-03	8680026-04	3185596-04	
5.00000	1705824-01	1466127-01	1139111-01	8850370-02	6876352-02	2505917-02	9132074-03	3328107-03	1212932-03	
7.50000	3747010-01	3214927-01	2490661-01	1929597-01	1494924-01	5386235-02	1940917-02	6995194-03	2521432-03	
10.00000	6450339-01	5521471-01	4261027-01	3288480-01	2537936-01	9006583-02	3197771-02	1135869-02	4036808-03	
25.00000	2990883+00	2503125+00	1841785+00	1385880+00	1032489+00	3206459-01	1008407-01	3209528-02	1033047-02	
50.00000	6779823+00	5412242+00	3739515+00	2601871+00	1822440+00	4656903-01	1286720-01	3763858-02	1146899-02	
100.00000	1128405+01	8291798+00	5124330+00	3278592+00	2158113+00	4886642-01	1304798-01	3779349-02	1148296-02	

TABLE 6 (Continued)

TABLE OF THE FUNCTION C(R/L,B,A/L)										
B (MFP)	7.50000	10.00000	15.00000	20.00000	50.00000	100.00000	.10000	.25000	.50000	
A/L	25.00000	25.00000	25.00000	25.00000	25.00000	25.00000	50.00000	50.00000	50.00000	
R/L										
.01000	4254474-10	3492503-11	2353498-13	1585738-15	1483713-28	2861621-50	1774185-07	1527102-07	1189308-07	
.05000	1063614-08	8731165-10	5883666-12	3964266-14	3709105-27	7153378-49	4435522-06	3817687-06	2973218-06	
.07500	2393104-08	1964484-09	1323798-11	8919361-14	8344963-27	1609313-48	9979895-06	8589789-06	6089737-06	
.10000	4254339-08	3492345-09	2353351-11	1585606-13	1483419-26	2860509-48	1774204-05	1527073-05	1189285-05	
.25000	2658451-07	2182187-08	1470339-10	9905630-13	9261636-26	1784140-47	1108865-04	9544091-05	7432935-05	
.50000	1062652-06	8721195-08	5874147-10	3955969-12	3690795-25	7084339-47	4435291-04	3817478-04	2973037-04	
.75000	2388239-06	1959442-07	1318986-09	8877438-12	8252670-25	1574651-46	9978762-04	8588734-04	6088821-04	
1.00000	4238983-06	3476434-07	2338175-09	1572390-11	1454424-24	2752219-46	1773842-03	1526739-03	1188996-03	
2.50000	2599330-05	2121130-06	1412487-08	9405190-11	8205969-24	1414031-45	1107455-02	9531085-03	7421679-03	
5.00000	9727254-05	7802921-06	5023476-08	3236235-10	2350171-23	3144989-45	4412837-02	3796775-02	2955123-02	
7.50000	1968257-04	1537946-05	9414755-08	5784304-10	3346081-23	3632247-45	9866026-02	8484802-02	6588923-02	
10.00000	3044902-04	2303453-05	1329005-07	7750533-10	3696394-23	3681464-45	1738617-01	1494272-01	1188928-01	
25.00000	6342765-04	4101083-05	1914854-07	9831729-10	3783110-23	3683553-45	9861464-01	8415963-01	6462419-01	
50.00000	6582703-04	4156526-05	1918299-07	9834117-10	3783110-23	3683553-45	3032657+00	2536985+00	1885644+00	
100.00000	6583093-04	4156539-05	1918299-07	9834117-10	3783110-23	3683553-45	6842262+00	5457116+00	3765398+00	
B (MFP)	.75000	1.00000	2.00000	3.00000	4.00000	5.00000	7.50000	10.00000	15.00000	
A/L	50.00000	50.00000	50.00000	50.00000	50.00000	50.00000	50.00000	50.00000	50.00000	
R/L										
.01000	9261997-08	7213385-08	2653630-08	9762192-09	3591306-09	1321209-09	1084456-10	8902477-12	5999118-14	
.05000	2315524-06	1803334-06	6634106-07	2440536-07	8978276-08	3302934-08	2711191-09	2225612-10	1499777-12	
.07500	5209924-06	4057494-06	1492670-06	5491194-07	2020107-07	7431581-08	6100161-09	5007605-10	3374460-12	
.10000	9262072-06	7213312-06	2653631-06	9762102-07	3591290-07	1321166-07	1084469-08	8902363-10	5999030-12	
.25000	5788713-05	4508250-05	1658485-05	6101156-06	2244487-06	8256990-07	6777599-08	5563633-09	3746066-11	
.50000	2315368-04	1803200-04	6633454-05	2440238-05	8976959-06	3302371-06	2710566-07	2224962-08	1499157-10	
.75000	5209140-04	4056828-04	1492344-04	5489694-05	2019445-05	7428741-06	6096999-07	5004325-08	3371348-10	
1.00000	9259601-04	7211211-04	2652601-04	9757364-05	3589200-05	1320269-05	1083469-06	8892002-08	5989138-10	
2.50000	5779074-03	4500060-03	1654471-03	6082696-04	2236341-04	8222041-05	6738703-06	5523346-07	3710666-09	
5.00000	2300030-02	1790171-02	6569659-03	2410934-03	8847790-04	3247018-04	2699147-05	2161537-06	1439071-08	
7.50000	5132192-02	3991491-02	1460409-02	5343260-03	1955020-03	7153187-04	5792735-05	4691654-06	3078019-08	
10.00000	9019456-02	7007410-02	2553223-02	9302809-03	3389732-03	1235175-03	9901340-05	7939182-06	5105946-08	
25.00000	4962829-01	3811380-01	1326824-01	4624230-02	1613383-02	5635295-03	4082587-04	2977508-05	1614155-07	
50.00000	1402690+00	1044334+00	3235650-01	1015602-01	3227266-02	1037419-04	6355951-04	4105058-05	1915216-07	
100.00000	2616799+00	1831050+00	4666434-01	1287775-01	3765028-02	1147028-02	6582755-04	4156529-05	1918299-07	
B (MFP)	20.00000	50.00000	100.00000	.10000	.25000	.50000	.75000	1.00000	2.00000	
A/L	50.00000	50.00000	50.00000	100.00000	100.00000	100.00000	100.00000	100.00000	100.00000	
R/L										
.01000	4042091-16	3782040-29	7294389-51	4480434-08	3856915-08	3002785-08	2339040-08	1821335-08	6701104-09	
.05000	1010516-14	9454939-28	1823545-49	1119862-06	9638599-07	7506661-07	5846142-07	4552959-07	1674948-07	
.07500	2273644-14	2127326-27	4172845-49	2519678-06	2168711-06	1688996-06	1315380-06	1024418-06	3768627-07	
.10000	4041995-14	3781828-27	7293627-49	4479452-06	3855492-06	3002659-06	2338454-06	1821192-06	6699786-07	
.25000	2525961-13	2363010-26	4556124-48	2799638-05	2409671-05	1876653-05	1461525-05	1138237-05	4187341-06	
.50000	1009976-12	9443010-26	1819037-47	1119844-04	9638586-05	7506527-05	5846027-05	4552885-05	1674906-05	
.75000	2270914-12	2121297-25	4080079-47	2519609-04	2168644-04	1688936-04	1315328-04	1024375-04	3768421-05	
1.00000	4033373-12	3762803-25	7221890-47	4479202-04	3855273-04	3002471-04	2338291-04	1821053-04	6699126-05	
2.50000	2492550-11	2290037-24	4285616-46	2798738-03	2408841-03	1875935-03	1460910-03	1137714-03	4184779-04	
5.00000	9580056-11	8347656-24	1435531-45	1118406-02	9625322-03	7495048-03	5836196-03	4544533-03	1670812-03	
7.50000	2019657-10	1620415-23	2446780-45	2512343-02	2161944-02	1683138-02	1310363-02	1020157-02	3747756-03	
10.00000	3287364-10	2377189-23	3165095-45	4456306-02	3834161-02	2984204-02	2322650-02	1807766-02	6634073-03	
25.00000	8961457-10	3772725-23	3683522-45	2712326-01	2329222-01	1807139-01	1402092-01	1087832-01	3442265-02	
50.00000	9832059-10	3783110-23	3683553-45	9948626-01	8489690-01	6518198-01	5005031-01	3843309-01	1337286-01	
100.00000	9834117-10	3783110-23	3683553-45	3053947+00	2554223+00	1897770+00	1411219+00	1050334+00	3250337+00	

TABLE 6 (Continued)

TABLE OF THE FUNCTION C(R/L, B, A/L)											
B (MFP)	= 3.00000	4.00000	5.00000	7.50000	10.00000	15.00000	20.00000	50.00000	100.00000	100.00000	100.00000
A/L	= 100.00000	100.00000	100.00000	100.00000	100.00000	100.00000	100.00000	100.00000	100.00000	100.00000	100.00000
R/L											
.01000	2464966-09	9067592-10	3335414-10	2737773-11	2247881-12	1514729-14	1020617-16	9549302-30	1841766-51		
.05000	6161726-08	2266783-08	8339072-09	6845114-10	5619110-11	3786572-13	2551304-15	2387150-28	4004065-50		
.07500	1386392-07	5100277-08	1876292-08	1540144-09	1264301-10	8519778-13	5740430-15	5371080-28	1035909-49		
.10000	2464699-07	9067173-08	3335636-08	2738033-09	2247648-10	1514626-12	1020521-14	9548555-28	1841600-49		
.25000	1540426-06	5666930-07	2084752-07	1711250-08	1404756-09	9466198-12	6378067-14	5967436-27	1150846-48		
.50000	6161562-06	2266709-06	8338739-07	6844701-08	5618714-09	3786181-11	2550967-13	2386399-26	4001206-48		
.75000	1386298-05	5099859-06	1876115-06	1539944-07	1264093-08	8517787-11	5738698-13	5367238-26	1034455-47		
1.00000	2464396-05	9065827-06	3335062-06	2737397-07	2246985-08	1513994-10	1019970-12	9536386-26	1837002-47		
2.50000	1539247-04	5661727-05	2082519-05	1708763-06	1402179-07	9441589-10	6356021-12	5920164-25	1133055-46		
5.00000	6142736-04	2258402-04	8323099-05	6805036-06	5577632-07	3747026-09	2516897-11	2311996-24	425453-46		
7.50000	1376799-03	5057963-04	1858149-04	1519976-05	1243437-06	8321416-09	5568267-11	5000654-24	9019050-46		
10.00000	2434514-03	8934115-04	3278621-04	2674773-05	2182318-06	1452735-08	9669901-11	8420251-24	146496-45		
25.00000	1428685-02	5178167-03	1876915-03	1485157-04	1175811-05	7379855-08	4640460-10	2982840-23	3513797-45		
50.00000	4658504-02	1624612-02	5672090-03	4105194-04	2991398-05	1619398-07	8981251-10	3773299-23	3883526-45		
100.00000	1019198-01	3236070-02	1039574-02	6362342-04	4106952-05	1915383-07	9832206-10	3783110-23	3883553-45		

7. The Function $G(\mu_s h, \mu_s R)$

The function $G(\mu_s h, \mu_s R)$ is useful in finding the flux at points on the axis of a cylindrical self-absorbing source.

8. The Function $L_0(\phi_0, b)$

The function $L_0(\phi_0, b)$ is useful in the cylindrical source approximation of Ono and Tsuru. It has been pointed out by D. Foderaro that to a good approximation, $L_0(\phi_0, b) = \bar{G}(\phi_0, b)$.

TABLE 7
THE FUNCTION $G(\mu_s h, \mu_s R)$

$\mu_s R$ (mfp) = $\mu_s h$ (mfp)	.01	.05	.10	.20	.30	.40	.50	.60	.70	.80	.90	1.00	1.25	1.50
.01000	.01126	.02571	.03212	.03811	.04127	.04331	.04473	.04579	.04659	.04722	.04773	.04813	.04886	.04933
.02500	.01365	.04233	.05776	.07259	.08048	.08555	.08911	.09175	.09376	.09534	.09660	.09762	.09944	.10060
.05000	.01458	.05521	.08277	.11145	.12705	.13713	.14423	.14948	.15350	.15665	.15917	.16120	.16485	.16717
.07500	.01488	.06091	.09750	.13843	.16140	.17637	.18694	.19478	.20079	.20551	.20928	.21233	.21779	.22126
.10000	.01504	.06618	.10696	.15835	.18821	.20790	.22188	.23227	.24025	.24651	.25152	.25558	.26284	.26747
.20000	.01525	.06974	.12393	.20237	.25425	.29046	.31490	.33687	.35235	.36459	.37442	.38240	.39676	.40593
.30000	.01532	.07083	.12989	.22154	.28749	.33602	.37762	.40084	.42300	.44269	.45499	.46666	.48776	.50132
.40000	.01535	.07156	.13270	.23143	.30618	.36343	.40787	.44284	.47071	.49219	.51150	.52654	.55393	.57164
.50000	.01536	.07196	.13426	.23713	.31753	.38088	.43120	.47153	.50412	.53269	.55252	.57057	.60370	.62530
.60000	.01537	.07220	.13520	.24069	.32483	.39248	.44719	.49169	.52812	.55811	.58295	.60363	.64191	.66710
.70000	.01538	.07236	.13581	.24304	.32975	.40047	.45844	.50619	.54569	.57850	.60589	.62885	.67169	.70013
.80000	.01538	.07246	.13623	.24465	.33318	.40613	.46656	.51682	.55876	.59389	.62341	.64830	.69513	.72651
.90000	.01539	.07254	.13653	.24579	.33564	.41024	.47254	.52474	.56864	.60664	.63893	.66346	.71374	.74775
1.00000	.01539	.07259	.13674	.24663	.33744	.41329	.47701	.53174	.57618	.61472	.64747	.67537	.72863	.76496
1.25000	.01539	.07267	.13707	.24791	.34024	.41806	.48410	.54037	.58847	.62669	.66507	.69550	.75445	.79540
1.50000	.01539	.07271	.13724	.24858	.34171	.42060	.48792	.54564	.59529	.63412	.67513	.70717	.76991	.81412
1.75000	.01540	.07274	.13733	.24895	.34254	.42204	.49009	.54866	.59925	.63906	.68109	.71416	.77940	.82588
2.00000	.01540	.07275	.13739	.24917	.34302	.42288	.49138	.55047	.60162	.64605	.68473	.71846	.78536	.83340
2.50000	.01540	.07277	.13744	.24938	.34350	.42372	.49267	.55228	.60402	.64910	.68846	.72291	.79164	.84149
3.00000	.01540	.07277	.13746	.24947	.34369	.42406	.49320	.55302	.60502	.65036	.69002	.72478	.79435	.84506
3.50000	.01540	.07277	.13747	.24951	.34378	.42421	.49342	.55334	.60545	.65092	.69072	.72562	.79558	.84670
4.00000	.01540	.07277	.13747	.24953	.34382	.42428	.49353	.55349	.60565	.65118	.69104	.72601	.79616	.84748
10.00000	.01540	.07277	.13748	.24954	.34385	.42434	.49363	.55363	.60584	.65142	.69134	.72638	.79671	.84824
20.00000	.01540	.07277	.13748	.24954	.34385	.42434	.49363	.55363	.60584	.65142	.69134	.72638	.79671	.84824
$\mu_s R$ (mfp) = $\mu_s h$ (mfp)	1.75	2.00	2.50	3.00	3.50	4.00	4.50	5.00	6.00	7.50	10.00	12.50	15.00	20.00
.01000	.04964	.04985	.05012	.05028	.05038	.05042	.05043	.05040	.05024	.04982	.04882	.04767	.04652	.04438
.02500	.10137	.10198	.10248	.10277	.10292	.10300	.10305	.10310	.10318	.10330	.10341	.10328	.10285	.10132
.05000	.16869	.16972	.17092	.17151	.17181	.17197	.17206	.17210	.17213	.17214	.17220	.17235	.17254	.17273
.07500	.22355	.22509	.22689	.22778	.22823	.22847	.22860	.22867	.22872	.22873	.22871	.22872	.22879	.22909
.10000	.27051	.27257	.27496	.27615	.27676	.27707	.27724	.27733	.27741	.27744	.27742	.27739	.27738	.27747
.20000	.41198	.41676	.42083	.42320	.42441	.42504	.42538	.42556	.42572	.42577	.42578	.42577	.42575	.42569
.30000	.51029	.51676	.52347	.52699	.52880	.52975	.53026	.53054	.53077	.53085	.53086	.53085	.53083	.53080
.40000	.58342	.59142	.60080	.60547	.60787	.60913	.60980	.61017	.61048	.61059	.61061	.61060	.61058	.61054
.50000	.63974	.64958	.66116	.66694	.66992	.67149	.67233	.67278	.67317	.67331	.67333	.67332	.67331	.67327
.60000	.68404	.69543	.70932	.71618	.71972	.72159	.72259	.72313	.72359	.72376	.72379	.72378	.72377	.72373
.70000	.71939	.73242	.74832	.75422	.76031	.76247	.76363	.76426	.76480	.76499	.76503	.76502	.76500	.76496
.80000	.74790	.76246	.78026	.78916	.79377	.79622	.79753	.79825	.79886	.79908	.79912	.79911	.79910	.79906
.90000	.77107	.78725	.80664	.81648	.82160	.82432	.82579	.82659	.82727	.82753	.82757	.82756	.82755	.82751
1.00000	.79003	.80751	.82856	.83931	.84492	.84790	.84951	.85039	.85115	.85143	.85148	.85147	.85145	.85141
1.25000	.82409	.84474	.86903	.88179	.88852	.89213	.89408	.89515	.89607	.89642	.89648	.89648	.89646	.89642
1.50000	.84549	.86746	.89548	.90995	.91765	.92180	.92406	.92531	.92639	.92679	.92687	.92686	.92685	.92681
1.75000	.85918	.88316	.91307	.92893	.93746	.94209	.94462	.94603	.94725	.94771	.94780	.94780	.94778	.94774
2.00000	.86809	.89374	.92492	.94190	.95111	.95615	.95893	.96047	.96182	.96233	.96244	.96243	.96241	.96238
2.50000	.87785	.90449	.93850	.95707	.96729	.97295	.97611	.97788	.97944	.98005	.98017	.98017	.98015	.98011
3.00000	.88225	.90946	.94497	.96448	.97534	.98142	.98485	.98678	.98851	.98918	.98932	.98932	.98931	.98927
3.50000	.88431	.91211	.94812	.96817	.97943	.98578	.98937	.99143	.99328	.99401	.99416	.99416	.99415	.99411
4.00000	.88529	.91370	.94969	.97005	.98154	.98806	.99177	.99390	.99583	.99660	.99677	.99677	.99675	.99671
10.00000	.88627	.91451	.95133	.97207	.98388	.99065	.99455	.99681	.99889	.99976	.99996	.99996	.99995	.99991
20.00000	.88627	.91451	.95133	.97207	.98388	.99065	.99455	.99681	.99890	.99976	.99996	.99996	.99995	.99991

TABLE 8
THE FUNCTION $L_0(\phi_0, b)$

ϕ (deg)	b (mfp) =	.01	.05	.10	.20	.40	.60	.80	1.00	1.25	1.50	1.75	2.00	2.50	3.00
	ϕ (rad)														
1.0	.01745	1.00000	1.00000	.99999	.99999	.99997	.99996	.99995	.99994	.99993	.99991	.99990	.99988	.99986	.99983
2.5	.04363	1.00000	.99998	.99995	.99991	.99984	.99976	.99969	.99962	.99953	.99945	.99936	.99928	.99911	.99895
5.0	.08727	.99998	.99991	.99982	.99965	.99934	.99895	.99876	.99848	.99813	.99779	.99745	.99712	.99646	.99580
7.5	.13090	.99996	.99979	.99959	.99922	.99852	.99785	.99720	.99657	.99579	.99503	.99427	.99352	.99204	.99058
10.0	.17453	.99992	.99962	.99927	.99861	.99736	.99617	.99502	.99390	.99252	.99116	.98983	.98850	.98589	.98331
12.5	.21817	.99988	.99941	.99886	.99782	.99586	.99400	.99221	.99046	.98881	.98720	.98412	.98206	.97802	.97403
15.0	.26180	.99982	.99915	.99835	.99684	.99402	.99134	.98876	.98624	.98316	.98014	.97716	.97423	.96847	.96281
20.0	.34907	.99968	.99846	.99703	.99432	.98927	.98451	.97992	.97547	.97004	.96474	.95955	.95445	.94450	.93482
25.0	.43633	.99949	.99755	.99528	.99100	.98305	.97558	.96844	.96153	.95316	.94503	.93712	.92939	.91443	.90005
30.0	.52360	.99925	.99640	.99307	.98681	.97525	.96447	.95421	.94436	.93251	.92109	.91005	.89935	.87885	.85942
35.0	.61087	.99895	.99498	.99033	.98166	.96574	.95102	.93713	.92390	.90811	.89305	.87862	.86475	.83853	.81410
40.0	.69813	.99858	.99324	.98701	.97542	.95435	.93508	.91708	.90009	.88004	.86112	.84319	.82615	.79441	.76542
45.0	.78540	.99813	.99112	.98298	.96794	.94088	.91645	.89391	.87289	.84839	.82559	.80427	.78425	.74764	.71493
50.0	.87266	.99758	.98856	.97813	.95901	.92506	.89401	.86751	.84232	.81341	.78693	.76253	.73997	.69453	.66429
60.0	1.04720	.99607	.98158	.96511	.93553	.88498	.84208	.80468	.77158	.73507	.70595	.67445	.64895	.60524	.56907
70.0	1.22173	.99363	.97058	.94510	.90108	.83049	.77487	.72932	.69111	.65106	.61746	.58878	.56393	.52281	.48992
80.0	1.39626	.98888	.95051	.91072	.84743	.75778	.69521	.64797	.61046	.57268	.54189	.51606	.49393	.45761	.42873
90.0	1.57080	.96454	.89281	.83771	.76513	.67638	.61874	.57621	.54271	.50907	.48168	.45872	.43905	.40677	.38110
	b (mfp) =	3.50	4.00	5.00	6.00	8.00	10.00	12.00	15.00	20.00	25.00	35.00	50.00	60.00	75.00
	ϕ (rad)														
1.0	.01745	.99981	.99978	.99973	.99968	.99957	.99947	.99937	.99922	.99896	.99871	.99820	.99744	.99694	.99618
2.5	.04363	.99879	.99862	.99830	.99798	.99734	.99670	.99607	.99512	.99355	.99198	.98985	.98420	.98113	.97654
5.0	.08727	.99515	.99451	.99322	.99195	.98942	.98691	.98442	.98071	.97459	.96855	.95667	.93936	.92814	.91177
7.5	.13090	.98913	.98769	.98483	.98201	.97642	.97092	.96548	.95744	.94432	.93155	.90696	.87232	.85061	.81996
10.0	.17453	.98076	.97823	.97324	.96831	.95865	.94919	.93992	.92635	.90456	.88374	.84477	.79230	.76084	.71822
12.5	.21817	.97010	.96622	.95859	.95109	.93649	.92235	.90864	.88880	.85757	.82844	.77575	.70853	.67023	.62070
15.0	.26180	.95726	.95178	.94107	.92662	.91046	.89117	.87269	.84635	.80584	.76009	.70518	.62835	.58687	.53562
20.0	.34907	.92539	.91618	.89836	.88127	.84906	.81918	.79141	.75325	.69767	.65240	.57492	.49432	.45481	.40922
25.0	.43633	.88619	.87779	.84729	.82334	.77951	.74041	.70535	.65917	.59590	.54563	.47139	.39902	.36551	.32791
30.0	.52360	.84095	.82334	.79044	.76031	.70708	.66161	.62245	.57310	.50936	.46159	.39487	.33286	.30470	.27328
35.0	.61087	.79123	.76978	.73061	.69573	.63645	.58812	.54810	.49967	.44002	.39704	.33870	.28533	.26117	.23424
40.0	.69813	.73880	.71427	.67058	.63287	.57124	.52317	.48473	.43961	.38569	.34761	.29638	.24966	.22852	.20496
45.0	.78540	.68553	.65897	.61288	.57432	.51357	.46792	.43230	.39127	.34293	.30900	.26345	.22192	.20313	.18219
50.0	.87266	.63332	.60590	.55952	.52180	.46412	.42187	.38936	.35222	.30865	.27810	.23710	.19973	.18282	.16397
60.0	1.04720	.53859	.51251	.47004	.43674	.38727	.35170	.32451	.29352	.25721	.23175	.19759	.16644	.15235	.13664
70.0	1.22173	.46281	.43992	.40309	.37441	.33195	.30146	.27815	.25159	.22046	.19865	.16936	.14266	.13059	.11712
80.0	1.39626	.40497	.38494	.35270	.32761	.29046	.26378	.24338	.22014	.19290	.17482	.14819	.12483	.11426	.10248
90.0	1.57080	.35998	.34217	.31351	.29121	.25818	.23447	.21634	.19568	.17147	.15450	.13172	.11096	.10157	.09109

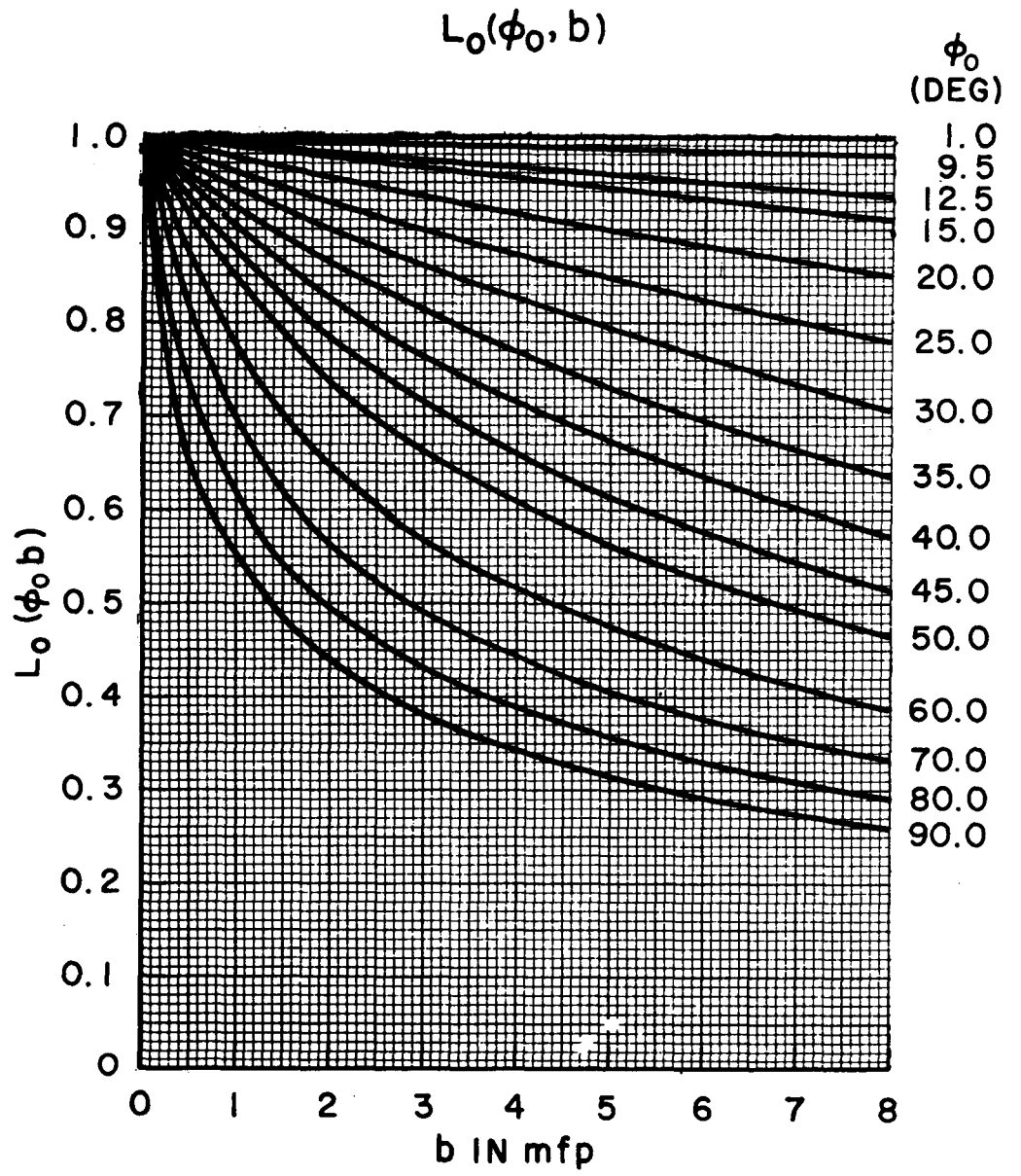


FIGURE 38

$L_0(\phi_0, b)$

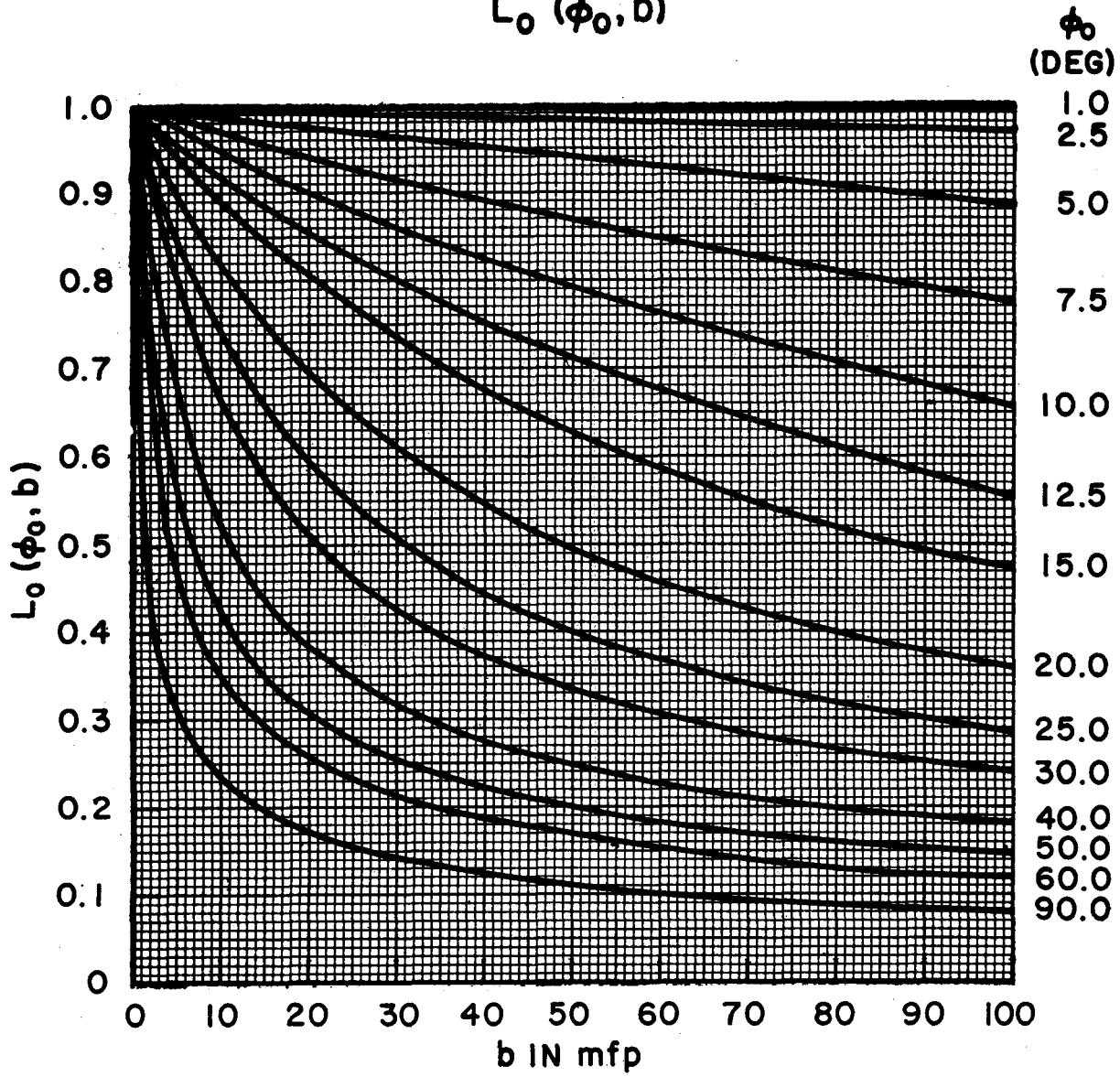


FIGURE 39

$G(\mu_s h, \mu_s R)$

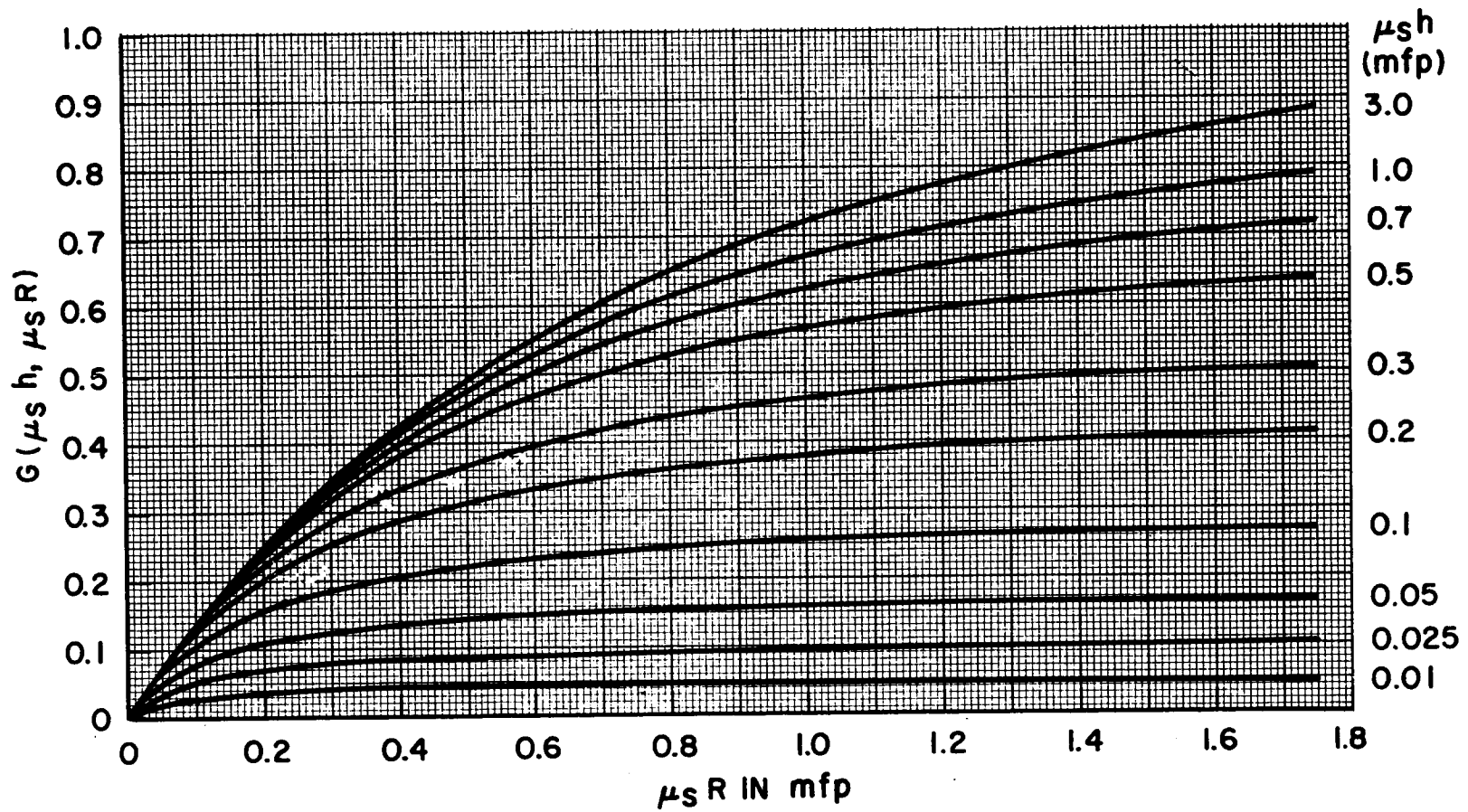


FIGURE 40

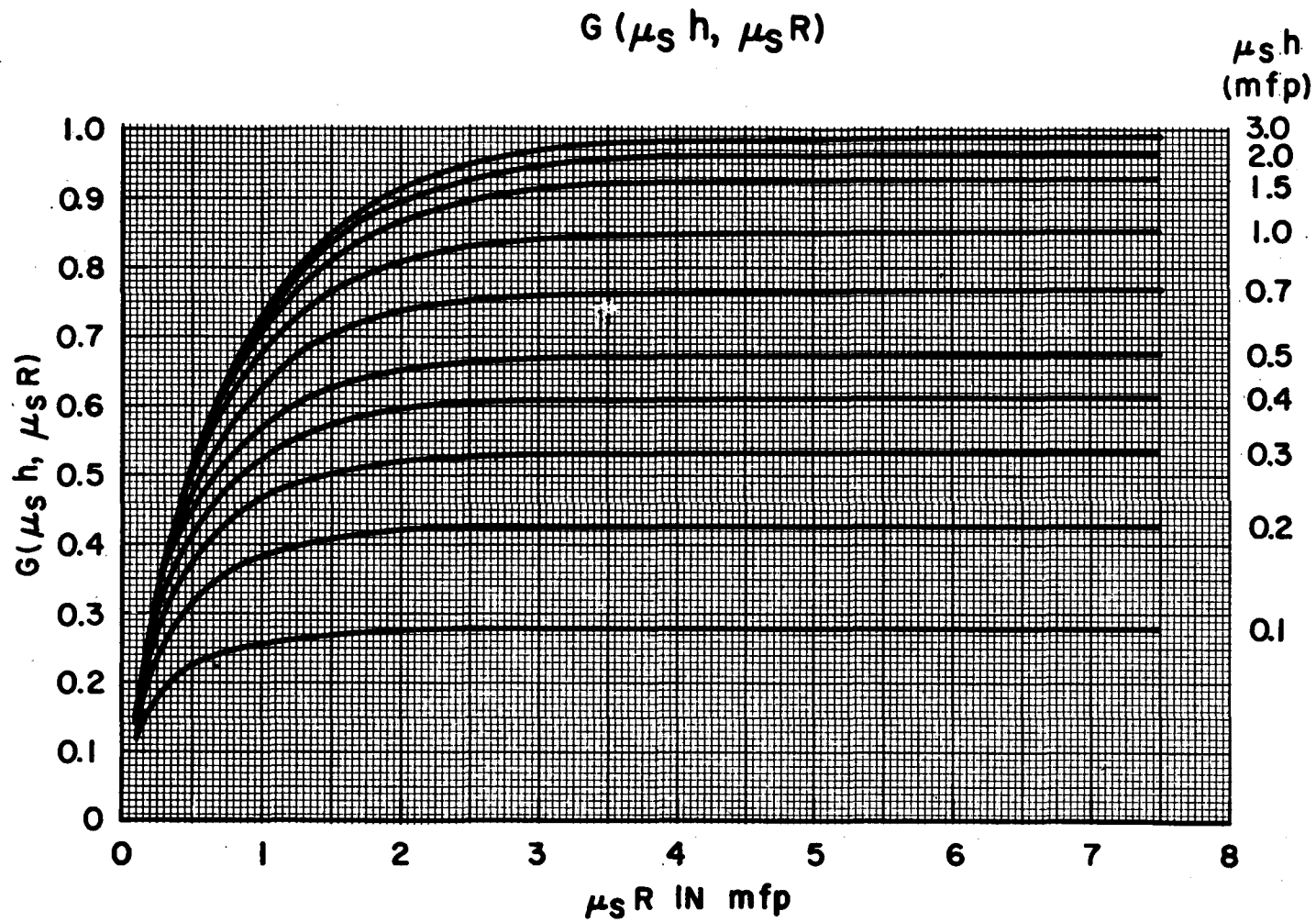


FIGURE 41

9. The Compact Function $\bar{G}(\theta_0, b)$

The function $G(\theta, b)$ is used in the cylindrical source approximation of Ono and Tsuru. Here we give the compact form $\bar{G}(\theta, b)$ because of its ease of interpolation. $G(\theta, b)$ is related to the compact form $\bar{G}(\theta, b)$ by

$$G(\theta_0, b) = \theta_0 e^{-b} \bar{G}(\theta_0, b) \quad (133)$$

where θ_0 is given in radians.

10. The Compact Function $\bar{F}(\theta_0, b)$

The function $F(\theta, b)$ is used in finding the flux from a line source. Here we give the compact form $\bar{F}(\theta_0, b)$ because of its ease of interpolation. $F(\theta_0, b)$ is related to $\bar{F}(\theta_0, b)$ by

$$F(\theta_0, b) = \theta_0 e^{-b} \bar{F}(\theta_0, b) \quad (134)$$

where θ_0 is given in radians.

It has been pointed out by A. Foderaro that, to a good approximation,

$$\bar{G}(\theta_0, b) = \bar{F}(\theta_0, b + 0.7)$$

TABLE 9
THE COMPACT FUNCTION $\bar{G}(\theta, b)$

b (mfp) =		.01	.05	.10	.20	.40	.60	.80	1.00	1.25	1.50	1.75	2.00	2.50	3.00
θ (deg)	θ (rad)														
1.0	.01745	.99995	.99995	.99994	.99994	.99993	.99992	.99991	.99990	.99989	.99987	.99986	.99985	.99982	.99980
2.5	.04363	.99968	.99967	.99965	.99962	.99956	.99949	.99943	.99937	.99929	.99921	.99913	.99905	.99889	.99873
5.0	.08727	.99872	.99867	.99860	.99848	.99822	.99797	.99772	.99746	.99715	.99683	.99652	.99620	.99557	.99494
7.5	.13090	.99712	.99700	.99686	.99658	.99601	.99544	.99487	.99430	.99359	.99288	.99218	.99147	.99006	.98865
10.0	.17453	.99488	.99468	.99442	.99392	.99291	.99190	.99089	.98988	.98863	.98738	.98613	.98489	.98240	.97993
12.5	.21817	.99201	.99169	.99130	.99051	.98893	.98736	.98579	.98423	.98228	.98034	.97841	.97648	.97265	.96885
15.0	.26180	.98850	.98805	.98748	.98634	.98408	.98183	.97958	.97735	.97457	.97181	.96905	.96632	.96089	.95551
20.0	.34907	.97961	.97881	.97780	.97579	.97180	.96784	.96391	.96001	.95517	.95038	.94563	.94093	.93166	.92255
25.0	.43633	.96826	.96700	.96544	.96232	.95615	.95005	.94402	.93807	.93072	.92249	.91636	.90933	.89559	.88224
30.0	.52360	.95448	.95268	.95044	.94600	.93722	.92860	.92013	.91180	.90100	.89162	.88185	.87206	.85378	.83604
35.0	.61087	.93835	.93501	.93289	.92690	.91514	.90367	.89248	.88156	.86828	.85640	.84289	.83076	.80754	.78564
40.0	.69813	.91993	.91678	.91287	.90514	.89007	.87549	.86140	.84776	.83133	.81555	.80039	.78582	.75834	.73289
45.0	.78540	.89932	.89576	.89046	.88082	.86218	.84434	.82727	.81091	.79143	.77294	.75539	.73871	.70775	.67966
50.0	.87266	.87660	.87176	.86578	.85409	.83169	.81054	.79054	.77162	.74937	.72855	.70905	.69075	.65739	.62778
60.0	1.04720	.82527	.81845	.81011	.79401	.76402	.73666	.71163	.68867	.66253	.63888	.61739	.59779	.56335	.53407
70.0	1.22173	.76685	.75784	.74698	.72650	.68993	.65825	.63056	.60613	.57933	.55591	.53523	.51680	.48524	.45906
80.0	1.39626	.70239	.69112	.67793	.65409	.61438	.58230	.55554	.53267	.50817	.48712	.46872	.45242	.42466	.40170
90.0	1.57080	.63312	.62055	.60685	.58353	.54672	.51778	.49387	.47350	.45171	.43599	.41664	.40215	.37747	.35707

b (mfp) =		3.50	4.00	5.00	6.00	8.00	10.00	12.00	15.00	20.00	25.00	35.00	50.00	60.00	75.00
θ (deg)	θ (rad)														
1.0	.01745	.99977	.99975	.99970	.99964	.99954	.99944	.99934	.99919	.99893	.99868	.99818	.99742	.99691	.99615
2.5	.04363	.99857	.99842	.99810	.99778	.99715	.99652	.99589	.99494	.99337	.99181	.98969	.98404	.98097	.97639
5.0	.08727	.99431	.99368	.99242	.99117	.98867	.98619	.98371	.98002	.97343	.96790	.95605	.93877	.92756	.91122
7.5	.13090	.98725	.98585	.98306	.98029	.97478	.96934	.96394	.95596	.94291	.93219	.90570	.87116	.84951	.81895
10.0	.17453	.97747	.97502	.97016	.96534	.95583	.94649	.93732	.92387	.90225	.88156	.84281	.79060	.75928	.71685
12.5	.21817	.96508	.96133	.95391	.94660	.93228	.91836	.90483	.88523	.85431	.82544	.77317	.70643	.66839	.61916
15.0	.26180	.95019	.94493	.93456	.92440	.90470	.88578	.86761	.84167	.80169	.76537	.70214	.62603	.58492	.53407
20.0	.34907	.91362	.90484	.88777	.87131	.84012	.81107	.78198	.74667	.69222	.64581	.57155	.49205	.45301	.40789
25.0	.43633	.86928	.85668	.83255	.80975	.76778	.73013	.69625	.65151	.58998	.54093	.46825	.39708	.36401	.32683
30.0	.52360	.81903	.80272	.77203	.74373	.69337	.65009	.61262	.56521	.50364	.45726	.39213	.33122	.30344	.27238
35.0	.61087	.76497	.74543	.70947	.67718	.62182	.57630	.53836	.49216	.43482	.39222	.33633	.28392	.26009	.23347
40.0	.69813	.70928	.68734	.64788	.61348	.55663	.51178	.47558	.43275	.38107	.34424	.29431	.24843	.22758	.20428
45.0	.78540	.65410	.63078	.58982	.55511	.49965	.45734	.42395	.38510	.33881	.30401	.26161	.22083	.20230	.18158
50.0	.87266	.60138	.57770	.53707	.50349	.45120	.41220	.38179	.34665	.30493	.27541	.23544	.19874	.18207	.16343
60.0	1.04720	.50885	.48687	.45031	.42098	.37638	.34361	.31819	.28888	.25411	.22950	.19620	.16562	.15172	.13619
70.0	1.22173	.43686	.41771	.38610	.36088	.32261	.29452	.27274	.24761	.21781	.19472	.16817	.14196	.13005	.11673
80.0	1.39626	.38226	.36550	.33784	.31577	.28229	.25770	.23864	.21666	.19058	.17213	.14715	.12421	.11379	.10214
90.0	1.57080	.33979	.32488	.30030	.28068	.25092	.22907	.21213	.19259	.16941	.15100	.13080	.11041	.10115	.09079

TABLE 10

THE COMPACT FUNCTION $\bar{F}(a_0, b)$

θ (deg)	b (mfp) = θ (rad)	.01	.05	.10	.20	.40	.60	.80	1.00	1.25	1.50	1.75	2.00	2.50	3.00
		1.0	.01745	1.00000	1.00000	.99999	.99999	.99998	.99997	.99996	.99995	.99994	.99992	.99991	.99990
2.5	.04363	1.00000	.99998	.99997	.99994	.99987	.99981	.99975	.99968	.99960	.99952	.99944	.99937	.99921	.99905
5.0	.08727	.99999	.99994	.99987	.99975	.99949	.99924	.99898	.99873	.99841	.99810	.99778	.99746	.99683	.99620
7.5	.13090	.99997	.99986	.99971	.99943	.99885	.99828	.99771	.99714	.99643	.99571	.99500	.99429	.99288	.99146
10.0	.17453	.99995	.99974	.99949	.99898	.99796	.99694	.99592	.99491	.99364	.99238	.99112	.98986	.98736	.98486
12.5	.21817	.99992	.99960	.99920	.99840	.99680	.99520	.99361	.99203	.99045	.98889	.98613	.98417	.98029	.97643
15.0	.26180	.99988	.99942	.99884	.99768	.99537	.99367	.99207	.99048	.98850	.98566	.98284	.98003	.97724	.97169
20.0	.34907	.99979	.99895	.99791	.99583	.99168	.98757	.98349	.97944	.97443	.96946	.96453	.95965	.95003	.94059
25.0	.43633	.99967	.99874	.99668	.99337	.98683	.98036	.97398	.96766	.95988	.95222	.94466	.93722	.92267	.90855
30.0	.52360	.99951	.99755	.99511	.99027	.98071	.97133	.96211	.95306	.94196	.93111	.92050	.91012	.89002	.87078
35.0	.61087	.99931	.99658	.99317	.98443	.97321	.96032	.94775	.93549	.92080	.90416	.88216	.87858	.85263	.82819
40.0	.69813	.99907	.99538	.99080	.98176	.96416	.94715	.93072	.91484	.89573	.87741	.85983	.84296	.81121	.78189
45.0	.78540	.99878	.99393	.98792	.97613	.95334	.93159	.91080	.89094	.86733	.84498	.82382	.80376	.76667	.73320
50.0	.87266	.99842	.99215	.98443	.96933	.94049	.91335	.88778	.86367	.83543	.80912	.78458	.76146	.72015	.68362
60.0	1.04720	.99743	.98729	.97492	.95113	.90713	.86739	.83140	.79870	.76188	.72096	.69940	.67274	.62665	.58826
70.0	1.22173	.99582	.97948	.95991	.92343	.85967	.80661	.76036	.72113	.67927	.64373	.61317	.58657	.54241	.50707
80.0	1.39626	.99263	.96443	.93267	.87723	.79145	.72795	.67867	.63897	.59864	.56560	.53781	.51396	.47484	.44376
90.0	1.57080	.97326	.91345	.86443	.79598	.70774	.64831	.60365	.56810	.53216	.50276	.47805	.45886	.42208	.39445
θ (deg)	b (mfp) = θ (rad)	3.50	4.00	5.00	6.00	8.00	10.00	12.00	15.00	20.00	25.00	35.00	50.00	60.00	75.00
		1.0	.01745	.99982	.99980	.99975	.99970	.99959	.99949	.99939	.99924	.99899	.99873	.99823	.99747
2.5	.04363	.99889	.99873	.99841	.99810	.99747	.99683	.99620	.99526	.99369	.99212	.98900	.98435	.98127	.97669
5.0	.08727	.99557	.99494	.99368	.99242	.98992	.98743	.98495	.98125	.97514	.96610	.95722	.93990	.92867	.91229
7.5	.13090	.99005	.98845	.98584	.98306	.97752	.97205	.96663	.95860	.94549	.93270	.90808	.87338	.85163	.82091
10.0	.17453	.98238	.97991	.97508	.97014	.96054	.95112	.94187	.92830	.90648	.88561	.84652	.79387	.76229	.71951
12.5	.21817	.97260	.96880	.96127	.95386	.93934	.92522	.91150	.89163	.86029	.83102	.77886	.71047	.67196	.62217
15.0	.26180	.96078	.95540	.94482	.93446	.91435	.89505	.87651	.85006	.80930	.77230	.70791	.63049	.58871	.53710
20.0	.34907	.93132	.92273	.90453	.88747	.85516	.82509	.79706	.75849	.70225	.65439	.57796	.49642	.45650	.41048
25.0	.43633	.89483	.88151	.85600	.83192	.78763	.74797	.71233	.66534	.60091	.54973	.47425	.40084	.36692	.32894
30.0	.52360	.85234	.83448	.80149	.77092	.71667	.67018	.63008	.57951	.51423	.46538	.39736	.33439	.30588	.27414
35.0	.61087	.80515	.78342	.74350	.70779	.64683	.59700	.55573	.50581	.44446	.40441	.34085	.28664	.26219	.23498
40.0	.69813	.75477	.72945	.68466	.64565	.58172	.53181	.49193	.44523	.38965	.35058	.29826	.25081	.22941	.20560
45.0	.78540	.70289	.67537	.62741	.58715	.52365	.47599	.43890	.39634	.34646	.31164	.26572	.22294	.20392	.18276
50.0	.87266	.65131	.62259	.57385	.53416	.47351	.42927	.39536	.35679	.31183	.28048	.23861	.20065	.18353	.16448
60.0	1.04720	.55581	.52842	.48282	.44747	.39522	.35789	.32951	.29733	.25986	.23373	.19884	.16721	.15294	.13707
70.0	1.22173	.47796	.45344	.41411	.38363	.33877	.30677	.28244	.25486	.22273	.20034	.17044	.14332	.13109	.11749
80.0	1.39626	.41824	.39677	.36235	.33568	.29642	.26842	.24713	.22300	.19489	.17530	.14913	.12540	.11471	.10280
90.0	1.57080	.37177	.35248	.32209	.29838	.26348	.23860	.21967	.19822	.17324	.15582	.13256	.11147	.10196	.09138

$$\bar{F}(\theta_0, b) = (e^b / \theta_0) F(\theta_0, b)$$

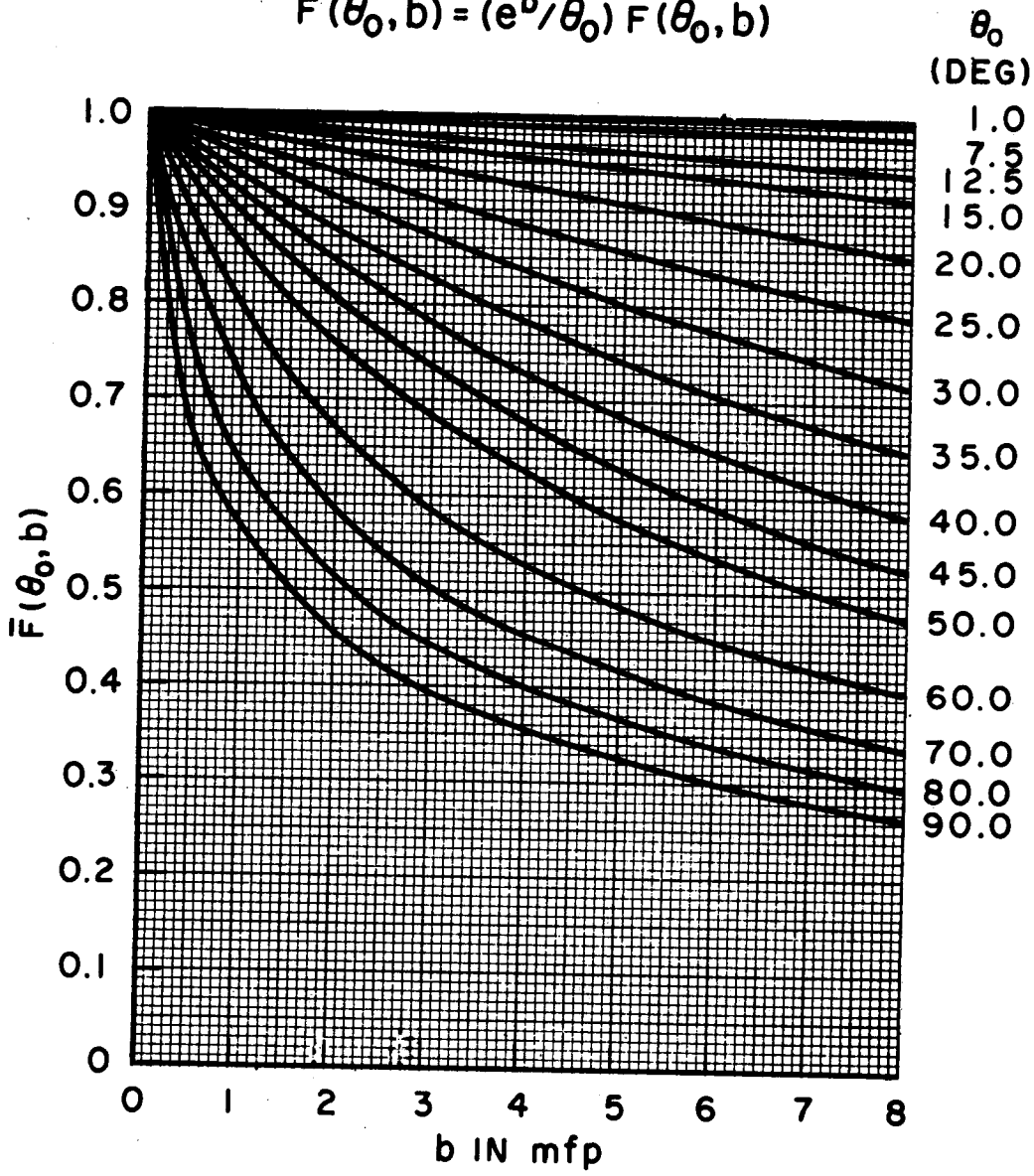


FIGURE 42

$$\bar{F}(\theta_0, b) = (e^b / \theta_0) F(\theta_0, b)$$

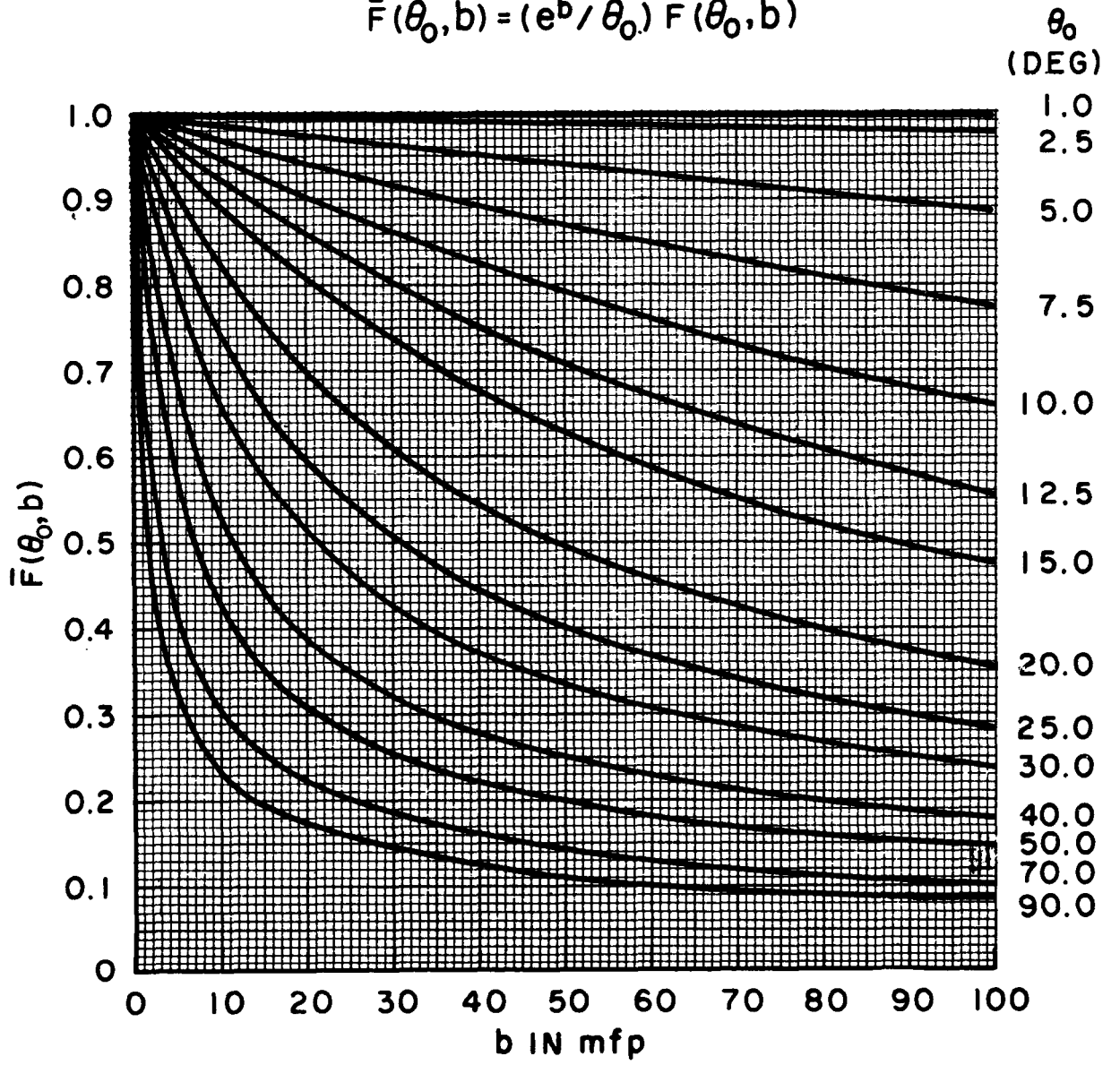


FIGURE 43

$$\bar{G}(\theta_0, b) = (e^b / \theta_0) G(\theta_0, b)$$

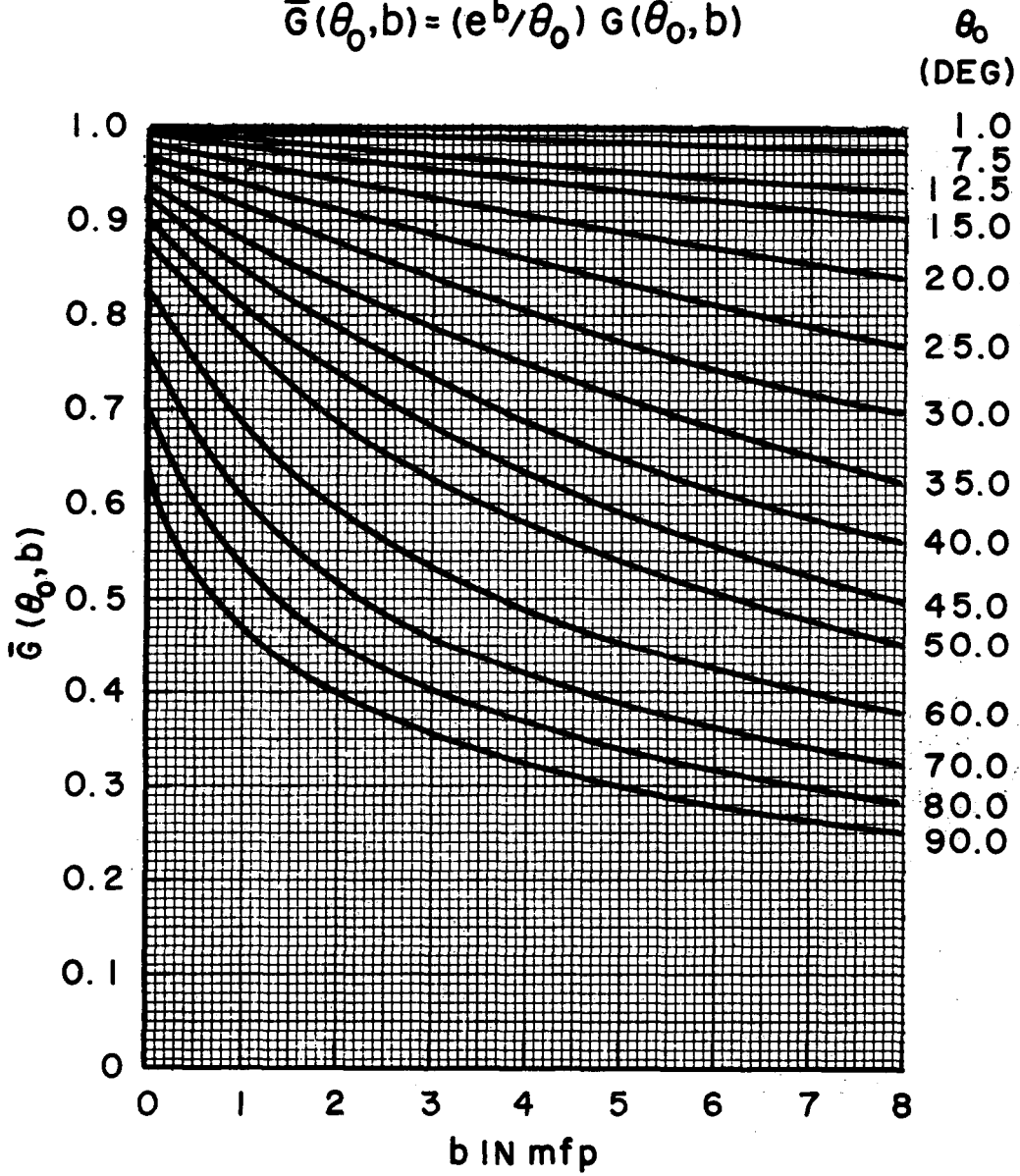


FIGURE 44

$$\bar{G}(\theta_0, b) = (e^b / \theta_0) G(\theta_0, b)$$

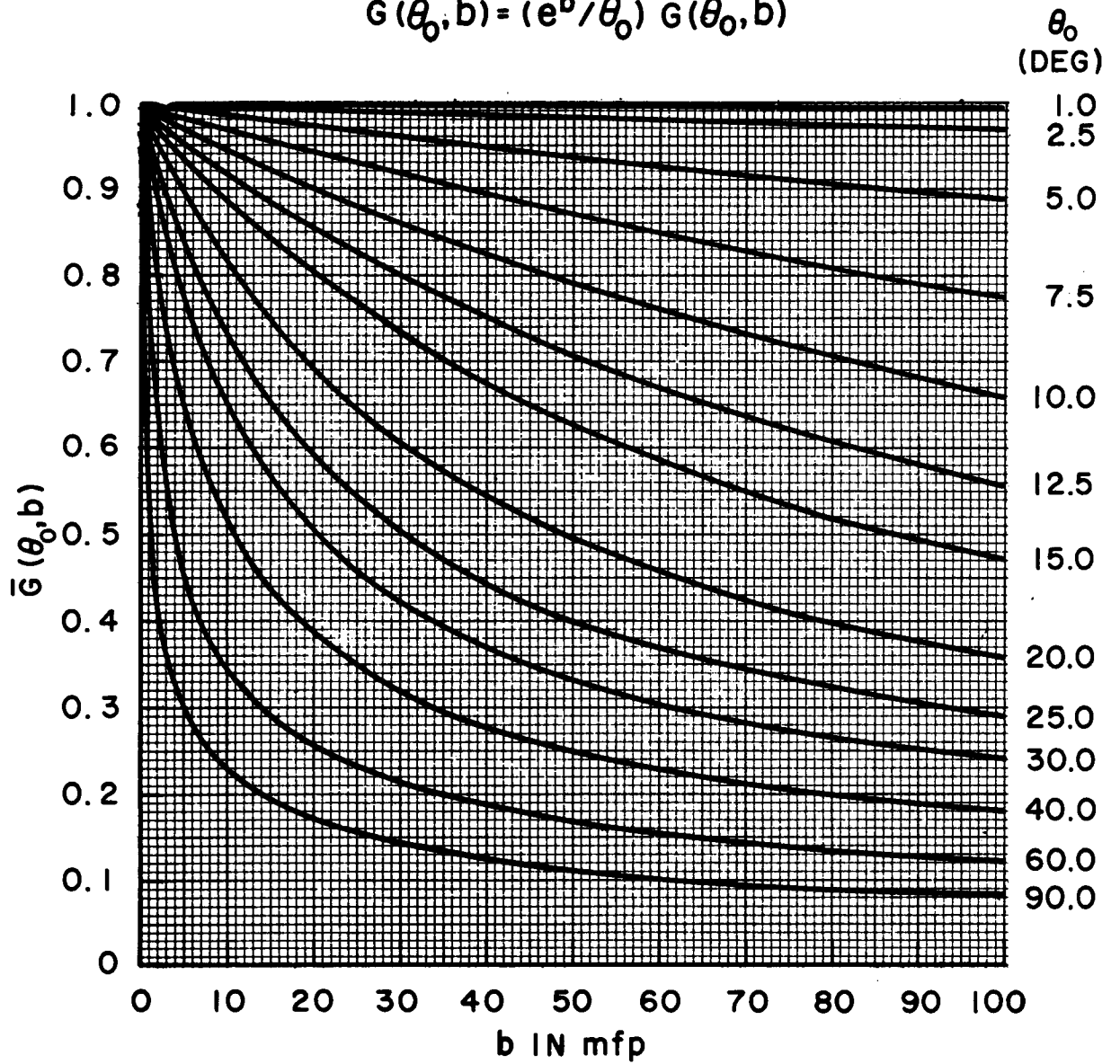


FIGURE 45

11. The Function $S(a/R, \mu_s R)$

The function $S(a/R, \mu_s R)$ is useful in finding the flux external to an unshielded spherical source.

TABLE 11
THE FUNCTION $S(a/R, \mu, R)$

TABLE OF THE FUNCTION $S(a/R, \mu, R)$		THE FUNCTION $S(a/R, \mu, R)$								
MUS*R (MFP)	A/R	.10000	.25000	.50000	.75000	1.00000	1.50000	2.00000	3.00000	5.00000
.01000		7710308+00	6584556+00	5133769+00	4072940+00	3286043+00	2241113+00	1614179+00	9497298-01	4474141-01
.05000		6184512+00	5220027+00	3984914+00	3092384+00	2438867+00	1588788+00	1094743+00	5956183-01	2508675-01
.07500		5621515+00	4726829+00	3586689+00	2765995+00	2167607+00	1394319+00	9493188-01	5061085-01	2076104-01
.10000		5172474+00	4338451+00	3277853+00	2516621+00	1963315+00	1251707+00	8451290-01	4443070-01	1790948-01
.25000		3520201+00	2938047+00	2191341+00	1660301+00	1278076+00	7937698-01	5230969-01	2643389-01	1017052-01
.50000		2240038+00	1856317+00	1373735+00	1032553+00	7885077-01	4821656-01	3132802-01	1548071-01	5813157-02
.75000		1575594+00	1303052+00	9609744-01	7197696-01	5477237-01	3326646-01	2148235-01	1051495-01	3909622-02
1.00000		1174115+00	9715777-01	7151410-01	5345983-01	4060228-01	2456788-01	1581167-01	7699239-02	2847623-02
2.50000		3654355-01	3012483-01	2209441-01	1645664-01	1245355-01	7483289-02	4786280-02	2308560-02	8458068-03
5.00000		1225682-01	1009803-01	7398786-02	5505292-02	4161937-02	2496074-02	1593732-02	7667011-03	2801886-03
7.50000		6085040-02	5012552-02	3671763-02	2731400-02	2064390-02	1237501-02	7898009-03	3797060-03	1386753-03
10.00000		3628181-02	2988541-02	2188932-02	1628170-02	1230447-02	7374532-03	4705796-03	2261788-03	8258398-04
25.00000		6482885-03	5339594-03	3910475-03	2908337-03	2197638-03	1316825-03	8401131-04	4036663-04	1473454-04
50.00000		1684428-03	1387355-03	1016016-03	7556267-04	5709662-04	3421103-04	2182538-04	1048637-04	3827525-05
100.00000		4294555-04	3537137-04	2500376-04	1926492-04	1455688-04	8722075-05	5564315-05	2673433-05	9757913-06
MUS*R (MFP)	A/R	7.50000	10.00000	15.00000	20.00000					
.01000		2330207-01	1425698-01	6857679-02	3963317-02					
.05000		1199584-01	6951180-02	3122244-02	1717141-02					
.07500		9755490-02	5596355-02	2481333-02	1349010-02					
.10000		8323553-02	4745418-02	2086538-02	1125149-02					
.25000		4601208-02	2584170-02	1110721-02	5838245-03					
.50000		2594497-02	1447605-02	6139529-03	3172237-03					
.75000		1737614-02	9658751-03	4071780-03	2086801-03					
1.00000		1262322-02	7005501-03	2943173-03	1501319-03					
2.50000		3732227-03	2065207-03	8619742-04	4357021-04					
5.00000		1234860-03	6827523-04	2844332-04	1433943-04					
7.50000		6109927-04	3377494-04	1406396-04	7085519-05					
10.00000		3638156-04	2010970-04	8372162-05	4216843-05					
25.00000		6490229-05	3587093-05	1493058-05	7517759-06					
50.00000		1685900-05	9317678-06	3878163-06	1952610-06					
100.00000		4290015-06	2375430-06	9886815-07	4977829-07					

12. The Function $S(b, a/R, \mu_s R)$

This function is useful in finding the flux from a spherical source with a slab shield.

TABLE 12

TABLE OF THE FUNCTION S(B, A/R, MUS * R)		THE FUNCTION S(b, a/R, μ, R)								
A/R	=	.01000	.05000	.07500	.10000	.25000	.50000	.75000	1.00000	2.50000
MUS * R (MFP)	=	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000
B (MFP)										
.10000		7500128-01	6608160-01	6166473-01	5781995-01	4172908-01	2739556-01	1955768-01	1471974-01	4644294-02
.25000		5906073-01	5330514-01	5015871-01	4732492-01	3483791-01	2316447-01	1663295-01	1255928-01	3987056-02
.50000		4053057-01	3757729-01	3575917-01	3403832-01	2581961-01	1752069-01	1269960-01	9640665-02	3091786-02
.75000		2835330-01	2673498-01	2566172-01	2460356-01	1916489-01	1325794-01	9698281-02	7401029-02	2397563-02
1.00000		2010566-01	1917085-01	1852365-01	1786460-01	1424625-01	1003678-01	7407686-02	5682244-02	1859235-02
2.00000		5520071-02	5373503-02	5269471-02	5156895-02	4409814-02	3310936-02	2526117-02	1976305-02	6723969-03
3.00000		1634161-02	1603315-02	1582048-02	1559013-02	1392014-02	1099481-02	8639817-03	6884221-03	2432053-03
4.00000		5047863-03	4973215-03	4922796-03	4868883-03	4468082-03	3673893-03	2963417-03	2401641-03	8797837-04
5.00000		1603339-03	1583762-03	1570692-03	1556870-03	1454616-03	1234769-03	1019232-03	8390716-04	3182982-04
7.50000		9843008-05	9758762-05	9703248-05	9645339-05	9233772-05	8271867-05	7151315-05	6091372-05	2507379-05
10.00000		6465731-06	6422980-06	6394971-06	6365912-06	6165306-06	5697238-06	5092482-06	4459344-06	1976723-06
15.00000		3118937-08	3104721-08	3095456-08	3085891-08	3021549-08	2879356-08	2682126-08	2444949-08	1231401-08
20.00000		1638116-10	1632411-10	1628703-10	1624883-10	1599457-10	1545483-10	1471517-10	1376443-10	7694104-11
50.00000		6612810-24	6603245-24	6597058-24	6590709-24	6549139-24	6465838-24	6362936-24	6236294-24	4849893-24
100.00000		6553633-46	6548827-46	6545723-46	6542542-46	6521819-46	6480876-46	6431531-46	6373177-46	5756529-46

A/R	=	5.00000	7.50000	10.00000	25.00000	50.00000	100.00000	.01000	.05000	.07500
MUS * R (MFP)	=	.10000	.10000	.10000	.10000	.10000	.10000	.25000	.25000	.25000
B (MFP)										
.10000		1564374-02	7774774-03	4637628-03	8290793-04	2154347-04	5492760-05	1699025+00	1494399+00	1393564+00
.25000		1345317-02	6688978-03	3990638-03	7135631-04	1854242-04	4727649-05	1333947+00	1203254+00	1131828+00
.50000		1046242-02	5205709-03	3106607-03	5556818-04	1444057-04	3681878-05	9118423-01	8458920-01	8050242-01
.75000		8136542-03	4051352-03	2418412-03	4327330-04	1124611-04	2867435-05	6359473-01	6003669-01	5764867-01
1.00000		6327731-03	3152973-03	1882671-03	3369876-04	8758309-05	2233150-05	4498549-01	4295882-01	4153354-01
2.00000		2314645-03	1156651-03	6914342-04	1239337-04	3221751-05	8215136-06	1227009-01	1196479-01	1174417-01
3.00000		8466945-04	4243123-04	2539381-04	4557898-05	1185124-05	3022120-06	3617984-02	3555167-02	3511277-02
4.00000		3097242-04	1556576-04	9326214-05	1676255-05	4359487-06	1111754-06	1114513-02	1099526-02	1089307-02
5.00000		1132999-04	5710271-05	3425180-05	6164758-06	1603641-06	4089832-07	3532795-03	3493888-03	3467720-03
7.50000		9170469-06	4654563-06	2799824-06	5056547-07	1316092-07	3356972-08	2161472-04	2144999-04	2134092-04
10.00000		7423196-07	3794113-07	2288661-07	4147561-08	1080104-08	2755434-09	1416853-05	1408577-05	1403134-05
15.00000		4865205-09	2521159-09	1529299-09	2790426-10	7274854-11	1856412-11	6817924-08	6790320-08	6772549-08
20.00000		3189768-11	1675431-11	1021918-11	1877365-12	4899851-13	1250717-13	3575491-10	3564648-10	3557587-10
50.00000		2551191-24	1445575-24	9103931-25	1741111-25	4574411-26	1169677-26	1438961-23	1437169-23	1436009-23
100.00000		3884713-46	2451228-46	1621557-46	3308685-47	8768701-48	2253778-48	1424394-45	1423496-45	1422920-45

A/R	=	.10000	.25000	.50000	.75000	1.00000	2.50000	5.00000	7.50000	10.00000
MUS * R (MFP)	=	.25000	.25000	.25000	.25000	.25000	.25000	.25000	.25000	.25000
B (MFP)										
.10000		1305980+00	9408281-01	6168941-01	4401441-01	3311566-01	1044185-01	3516576-02	1747623-02	1042433-02
.25000		1067554+00	7849285-01	5214319-01	3742371-01	2825056-01	8963758-02	3024111-02	1503545-02	8970002-03
.50000		7662874-01	5810997-01	3941584-01	2656288-01	2167961-01	6950467-02	2351767-02	1170122-02	6982860-03
.75000		5528545-01	4308893-01	2980874-01	2180432-01	1663870-01	5389411-02	1828905-02	9106385-03	5435934-03
1.00000		4007356-01	3199580-01	2255349-01	1664821-01	1277118-01	4178999-02	1422291-02	7086975-03	4231702-03
2.00000		1150269-01	9866803-02	7423591-02	5668937-02	4437171-02	1510885-02	5202133-03	2599689-03	1554099-03
3.00000		3463201-02	3104513-02	2460121-02	1936153-02	1544043-02	5463202-03	1902745-03	9536377-04	5707463-04
4.00000		1078280-02	9937398-03	8204692-03	6631921-03	5381169-03	1975693-03	6959622-04	3498218-04	2096080-04
5.00000		3439853-03	3227613-03	2792644-03	2278012-03	1878208-03	7145749-04	2545640-04	1283252-04	7697917-05
7.50000		2122666-04	2039777-04	1836927-04	1593561-04	1360358-04	5624868-05	2059926-05	1045877-05	6282002-06
10.00000		1397471+05	1357810-05	1261246-05	1131788-05	9937574-06	4431209-06	1667032-06	8524305-07	5142896-07
15.00000		6754163-08	6629423-08	6345549-08	5935289-08	5428142-08	2756515-08	1092048-08	5662953-09	3436018-09
20.00000		3550302-10	3501509-10	3395843-10	3245754-10	3046466-10	1719990-10	7156315-11	3762390-11	2295705-11
50.00000		1434818-23	1426999-23	1411227-23	1391537-23	1366925-23	1076580-23	5707672-24	3241573-24	2043402-24
100.00000		1422327-45	1418458-45	1410790-45	1401504-45	1390457-45	1268062-45	8654569-46	5484099-46	3634516-46

TABLE 12 (Continued)

TABLE OF THE FUNCTION		S(B,A/R,MUS*R)								
A/R	MUS*R (MFP)	.25000	.50000	1.00000	.01000	.05000	.07500	.10000	.25000	.50000
B (MFP)		.25000	.25000	.25000	.50000	.50000	.50000	.50000	.50000	.50000
.10000	1863540-03	4842359-04	1234615-04	2913392+00	2555505+00	2380502+00	2229017+00	1601227+00	1047880+00	
.25000	1603891-03	4167807-04	1062640-04	2276548+00	2051678+00	1928817+00	1818406+00	1334493+00	8852342-01	
.50000	1249016-03	3245827-04	8275804-05	1546513+00	1436074+00	1366873+00	1301123+00	9862666-01	6685520-01	
.75000	9726606-04	2527803-04	6445170-05	1073426+00	1015364+00	9758892-01	9359803-01	7300794-01	5051465-01	
1.00000	7574511-04	1968616-04	5019478-05	7564046-01	7241069-01	7007652-01	6766145-01	5412801-01	3818584-01	
2.00000	2785657-04	7241559-05	1846526-05	2042207-01	1996818-01	1962929-01	1925079-01	1659424-01	1252622-01	
3.00000	1024474-04	2663810-05	6792851-06	5984985-02	5895232-02	5830976-02	5759121-02	5195004-02	4137847-02	
4.00000	3767680-05	9798832-06	2498900-06	1835969-02	1815086-02	1800596-02	1784699-02	1655781-02	1375904-02	
5.00000	1385629-05	3604504-06	9192753-07	5801798-03	5748532-03	5712227-03	5673072-03	5358393-03	4603398-03	
7.50000	1136528-06	2958171-07	7545490-08	3531740-04	3509817-04	3495177-04	3479726-04	3363284-04	3053680-04	
10.00000	9322086-08	2427734-08	6193403-09	2307837-05	2297010-05	2289845-05	2282348-05	2228467-05	2086608-05	
15.00000	6271617-10	1635147-10	4172661-11	1106379-07	1102892-07	1100604-07	1098228-07	1081864-07	1042555-07	
20.00000	4219358-12	1101317-12	2811233-13	5790187-10	5776445-10	5758181-10	5695302-10	5654123-10	5554123-10	
50.00000	3912517-25	1028128-25	2629053-26	2319956-23	2317740-23	2316303-23	2314826-23	2305090-23	2285232-23	
100.00000	7433145-47	1975182-47	5065671-48	2292562-45	2291465-45	2290755-45	2290028-45	2285271-45	2275792-45	
A/R	MUS*R (MFP)	.75000	1.00000	2.50000	5.00000	7.50000	10.00000	25.00000	50.00000	100.00000
B (MFP)		.50000	.50000	.50000	.50000	.50000	.50000	.50000	.50000	.50000
.10000	7469709-01	5617191-01	1769449-01	5957442-02	2960448-02	1765817-02	3156618-03	8202342-04	2091278-04	
.25000	6348938-01	4790747-01	1518867-01	5123038-02	2546955-02	1519453-02	2716799-03	7059735-04	1799974-04	
.50000	4842841-01	3674902-01	1177586-01	3983890-02	1982110-02	1182832-02	2115679-03	5498015-04	1401814-04	
.75000	3694764-01	2819245-01	9129951-02	3098043-02	1542532-02	9207869-03	1647564-03	4281772-04	1091728-04	
1.00000	2819421-01	2163039-01	7078614-02	2409173-02	1200441-02	7167952-03	1283024-03	3334579-04	8502344-05	
2.00000	9578745-02	7502920-02	2558017-02	8810372-03	4403200-03	2632323-03	4718504-04	1226623-04	3127773-05	
3.00000	3264356-02	2606702-02	9245201-03	3222008-03	1615093-03	9666826-04	1735297-04	4512129-05	1150619-05	
4.00000	1115798-02	9070563-03	3341849-03	1178325-03	5924177-04	3550006-04	6381805-05	1659784-05	4232804-06	
5.00000	3824975-03	3161150-03	1208133-03	4309332-04	2173002-04	1303692-04	2347001-05	6105509-06	1557129-06	
7.50000	2663341-04	2281376-04	9499124-05	3485771-05	1770708-05	1095471-05	1925030-06	5010689-07	1278103-07	
10.00000	1883855-05	1661063-05	7474904-06	2819853-06	1442923-06	8707864-07	1578926-07	4112188-08	1049077-08	
15.00000	9813525-08	1902655-08	4639735-08	1845852-08	9582169-09	5016500-09	1062211-09	2769645-10	7067892-11	
20.00000	5339898-10	5038590-10	2888968-10	1208704-10	6363882-11	3885306-11	7145953-12	1865414-12	4761815-13	
50.00000	2259977-23	2227509-23	1788723-23	9598766-24	5470848-24	3453701-24	6624688-25	1741337-25	4453158-26	
100.00000	2264220-45	2250312-45	2082120-46	1446025-45	9222968-46	6129650-46	1258080-46	3345010-47	880136-48	
A/R	MUS*R (MFP)	.01000	.05000	.07500	.10000	.25000	.50000	.75000	1.00000	2.50000
B (MFP)		.75000	.75000	.75000	.75000	.75000	.75000	.75000	.75000	.75000
.10000	3792619+00	3318193+00	3087869+00	2889127+00	2070026+00	1352292+00	9631829-01	7239747-01	2278559-01	
.25000	2950424+00	2656879+00	2496510+00	2382563+00	1723553+00	1141827+00	8184025-01	6173179-01	1955755-01	
.50000	1992699+00	1852235+00	1763227+00	1678455+00	1211829+00	8616279-01	6239296-01	4733559-01	1516145-01	
.75000	1377009+00	1305016+00	1254654+00	1204189+00	9400519-01	6505029-01	4757660-01	3630047-01	1175360-01	
1.00000	9669182-01	9278156-01	8987407-01	8683541-01	6959409-01	4913451-01	3628606-01	2784081-01	9111813-02	
2.00000	2586632-01	2535530-01	2495969-01	2450815-01	2122244-01	1606813-01	1230271-01	9642951-02	3291372-02	
3.00000	7539501-02	7442647-02	7371375-02	7289809-02	6613653-02	5292565-02	4184413-02	3345401-02	1189072-02	
4.00000	2304378-02	2282436-02	2266911-02	2249555-02	2099794-02	1755146-02	1427581-02	1162477-02	4296329-03	
5.00000	7262585-03	7207652-03	7169661-03	7128094-03	6773139-03	5857654-03	4884914-03	4045802-03	1552550-03	
7.50000	4401740-04	4379796-04	4365006-04	4349270-04	4225399-04	3894837-04	3387202-04	2910411-04	1219466-04	
10.00000	2868721-05	2858077-05	2850984-05	2843521-05	2788291-05	2629514-05	2387065-05	2112759-05	9586362-06	
15.00000	1371015-07	1367658-07	1365445-07	1363139-07	1346994-07	1305751-07	1236081-07	1141404-07	5938653-08	
20.00000	7162525-10	7149453-10	7140884-10	7131996-10	7071121-10	6928840-10	6696180-10	6348242-10	3690753-10	
50.00000	2859385-23	2857328-23	2855993-23	2854619-23	2845526-23	2826759-23	2802420-23	2770131-23	2262973-23	
100.00000	2821722-45	2820714-45	2820061-45	2819391-45	2815005-45	2806216-45	2795397-45	2782254-45	2606577-45	

TABLE 12 (Continued)

TABLE OF THE FUNCTION S(B,A/R,MUS*R)									
A/R	= 5.00000	7.50000	10.00000	25.00000	50.00000	100.00000	.01000	.05000	.07500
MUS*R (MFP)	= .75000	.75000	.75000	.75000	.75000	.75000	1.00000	1.00000	1.00000
B (MFP)									
.10000	7669619-02	3811047-02	2273118-02	4063359-03	1055842-03	2691983-04	4437830+00	3873446+00	3601268+00
.25000	6595268-02	3278715-02	1955964-02	3497198-03	9087604-04	2317004-04	3438124+00	3093892+00	2905812+00
.50000	5128582-02	2551542-02	1522623-02	2723402-03	7077286-04	1804475-04	2309710+00	2149011+00	2046037+00
.75000	3988067-02	1985646-02	1185288-02	2120818-03	5511681-04	1405319-04	1589635+00	1509282+00	1451873+00
1.00000	3101188-02	1545258-02	9226891-03	1651563-03	4292412-04	1094458-04	1112672+00	1070055+00	1037427+00
2.00000	1133951-02	5667599-03	3388301-03	6073815-04	1578959-04	4026200-05	2952244-01	2900588-01	2858978-01
3.00000	4146359-03	2078733-03	1244254-03	2233716-04	5808182-05	1481125-05	8564593-02	8471011-02	8399990-02
4.00000	1516162-03	7624296-04	4569164-04	8214753-05	2136533-05	5448638-06	2609456-02	2588847-02	2573945-02
5.00000	5544098-04	2796420-04	1677896-04	3021072-05	7859212-06	2004399-06	8205418-03	8154833-03	8119281-03
7.50000	4483027-05	2278324-05	1371159-05	2477864-06	6449893-07	1645224-07	4954995-04	4935412-04	4922083-04
10.00000	3625360-06	1856258-06	1120506-06	2032329-07	5293294-08	1350411-08	3222193-05	3212872-05	3206616-05
15.00000	2371526-08	1232289-08	7483019-09	1367185-09	3565111-10	9098030-11	1536044-07	1533168-07	1531263-07
20.00000	1551888-10	8181355-11	4997504-11	9197315-12	2241155-12	6129555-13	8013234-10	8002172-10	7994896-10
50.00000	1227649-23	7019361-24	4437051-24	8524375-25	2201317-25	5732160-26	3189702-23	3188905-23	3186903-23
100.00000	1838647-45	1179609-45	7859611-46	1618303-46	4305042-47	1104419-47	3144260-45	3143436-45	3142903-45
A/R	= .10000	.25000	.50000	.75000	1.00000	2.50000	5.00000	7.50000	10.00000
MUS*R (MFP)	= 1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
B (MFP)									
.10000	3367096+00	2406801+00	1569819+00	1117305+00	8394743-01	2640006-01	8884287-02	4414374-02	2632918-02
.25000	2737173+00	2002244+00	1324908+00	9490868-01	7156576-01	2265868-01	7639647-02	3797734-02	2265551-02
.50000	1947734+00	1475422+00	9990471-01	7232183-01	5485786-01	1756387-01	5940525-02	2955405-02	1763605-02
.75000	1393996+00	1089064+00	7537039-01	5512183-01	4205510-01	1361475-01	4619306-02	2299904-02	1372869-02
1.00000	1002985+00	8052065-01	5688894-01	4202118-01	3224367-01	1055365-01	3591939-02	1789791-02	1088702-02
2.00000	2810389-01	2443755-01	1855291-01	1422130-01	1115335-01	3810770-02	1313234-02	6564085-03	3924350-03
3.00000	8316598-02	7584890-02	6095298-02	4828494-02	3864473-02	1376203-02	4801333-03	2407396-03	1441051-03
4.00000	2556925-02	2399776-02	2016521-02	1644550-02	1341180-02	4970631-03	1755447-03	8829224-04	5291653-04
5.00000	8079747-03	7718400-03	6715097-03	5618276-03	4662110-03	1795561-03	6418303-04	3238165-04	1943140-04
7.50000	4907774-04	4789381-04	4409468-04	3881285-04	3344158-04	1409061-04	5188348-05	2637832-05	1587772-05
10.00000	3199992-05	3149333-05	2988676-05	2726360-05	2421222-05	1106690-05	4194478-06	2148844-06	1297403-06
15.00000	1529270-07	1515068-07	1476155-07	1404356-07	1302030-07	6843894-08	2742171-08	1426099-08	8662853-09
20.00000	7987326-10	7934850-10	7806551-10	7578316-10	7214387-10	4246208-10	1793369-10	9465270-11	5784423-11
50.00000	3185766-23	3178213-23	3162438-23	3141546-23	3112832-23	2581179-23	1413818-23	8106688-24	5130295-24
100.00000	3142355-45	3138759-45	3131514-45	3122518-45	3111470-45	2945806-45	2106553-45	1358519-45	9071960-46
A/R	= 25.00000	50.00000	100.00000	.01000	.05000	.07500	.10000	.25000	.50000
MUS*R (MFP)	= 1.00000	1.00000	1.00000	1.50000	1.50000	1.50000	1.50000	1.50000	1.50000
B (MFP)									
.10000	4706403-03	1222928-03	3117984-04	5280260+00	4589408+00	4260129+00	3978258+00	2832286+00	1842465+00
.25000	4050640-03	1052571-03	2683665-04	4061090+00	3650354+00	3425786+00	3224793+00	2352832+00	1553868+00
.50000	3154384-03	8197255-04	2090029-04	2702949+00	2519643+00	2399604+00	2284505+00	1729727+00	1170267+00
.75000	2456436-03	6383893-04	1627707-04	1847452+00	1759962+00	1694786+00	1628324+00	1273898+00	8818154-01
1.00000	1912918-03	4971676-04	1267653-04	1286208+00	1241901+00	1205906+00	1167179+00	9398138-01	6647990-01
2.00000	7034935-04	1828822-04	4663334-05	3367101-01	3321164-01	3280706-01	3231137-01	2829690-01	2158219-01
3.00000	2587163-04	6727290-05	1715508-05	9695203-02	9619791-02	9558233-02	9481579-02	8723259-02	7060416-02
4.00000	9514535-05	2474622-05	6310863-06	2939564-02	2923954-02	2912071-02	2897787-02	2744462-02	2326611-02
5.00000	3499060-05	9102852-06	2321587-06	9211558-03	9174849-03	9148066-03	9117101-03	8785514-03	7719568-03
7.50000	2869861-06	7470492-07	1905571-07	5532300-04	5519019-04	5509778-04	5499650-04	5404986-04	5029651-04
10.00000	2353804-07	6130853-08	1564104-08	3586091-05	3580019-05	3575880-05	3571435-05	3534630-05	3388134-05
15.00000	1583397-09	4129185-10	1059371-10	1703328-07	1701539-07	1700343-07	1699081-07	1689717-07	1659262-07
20.00000	1065148-11	2781044-12	7099484-13	8868120-10	8861420-10	8856980-10	8852332-10	8819245-10	8729096-10
50.00000	9870486-25	2595789-25	6639122-26	3515878-23	3514903-23	3514268-23	3513612-23	3509211-23	3499782-23
100.00000	1873217-46	4985487-47	1279137-47	3460700-45	3460236-45	3459935-45	3459625-45	3457586-45	3453429-45

TABLE 12 (Continued)

TABLE OF THE FUNCTION S(B,A/R,MUS*R)										
A/R	.75000	1.00000	2.50000	5.00000	7.50000	10.00000	25.00000	50.00000	100.00000	
MUS*R (MFP)	1.50000	1.50000	1.50000	1.50000	1.50000	1.50000	1.50000	1.50000	1.50000	1.50000
B (MFP)										
.10000	1309775+00	9834147-01	3088696-01	1039048-01	5162293-02	3078898-02	5503364-03	1430003-03	3645937-04	
.25000	1112055+00	8380889-01	2650724-01	8934558-02	4441111-02	2649281-02	4736550-03	1230799-03	3138077-04	
.50000	8467409-01	6420722-01	2054391-01	6947087-02	3455997-02	2062287-02	3688518-03	9585264-04	2443923-04	
.75000	6448644-01	4919548-01	1592229-01	5401730-02	2689399-02	1605353-02	2872378-03	7464848-04	1903319-04	
1.00000	4912239-01	3769762-01	1234048-01	4200136-02	2092846-02	1249660-02	2236822-03	5813502-04	1482298-04	
2.00000	1657470-01	1301188-01	4453234-02	1535287-02	7674784-03	4588568-03	8226036-04	2138481-04	5452947-05	
3.00000	5611287-02	4498970-02	1607238-02	5612059-03	2814470-03	1684858-03	3025170-04	7866342-05	2005982-05	
4.00000	1905869-02	1558195-02	5801577-03	2051453-03	1032117-03	6186569-04	1112523-04	2893612-05	7379432-06	
5.00000	6493775-03	5405729-03	2094464-03	7499069-04	3784970-04	2271627-04	4091365-05	1064407-05	2714681-06	
7.50000	4458871-04	3859340-04	1641176-04	6058993-05	3082504-05	1855912-05	3355570-06	8735275-07	2228221-07	
10.00000	3115453-05	2782153-05	1287106-05	4895922-06	2510468-06	1516287-06	2752102-07	7168781-08	1828933-08	
15.00000	1591162-07	1484923-07	7936908-08	3197603-08	1665278-08	1012138-08	1851234-09	4828174-10	1232188-10	
20.00000	8533524-10	8177886-10	4910833-10	2089186-10	1104736-10	6756351-11	1245256-11	3251775-12	8301491-13	
50.00000	3486706-23	3467116-23	2943506-23	1637801-23	9434529-24	5981941-24	1153589-24	3034915-25	7763024-26	
100.00000	3448176-45	3441572-45	3310146-45	2419760-45	1573792-45	1054813-45	2188139-46	5828085-47	1495624-47	
A/R	.01000	.05000	.07500	.10000	.25000	.50000	.75000	1.00000	2.50000	
MUS*R (MFP)	2.00000	2.00000	2.00000	2.00000	2.00000	2.00000	2.00000	2.00000	2.00000	
B (MFP)										
.10000	5772898+00	5000153+00	4635421+00	4324492+00	3069088+00	1992449+00	1415094+00	1061943+00	3332103-01	
.25000	4413248+00	3963637+00	3717541+00	3497581+00	2546727+00	1679414+00	1201046+00	9047849-01	2859417-01	
.50000	2915215+00	2722216+00	2593244+00	2469086+00	1868912+00	1263646+00	9139600-01	6928802-01	2215878-01	
.75000	1981650+00	1893293+00	1824805+00	1754247+00	1374018+00	9513080-01	6956497-01	5306640-01	1717189-01	
1.00000	1373923+00	1331065+00	1294161+00	1253763+00	1011982+00	7165442-01	5296018-01	4064710-01	1330743-01	
2.00000	3561098-01	3523209-01	3486316-01	3438853-01	3028551-01	2318186-01	1782915-01	1400721-01	4799964-02	
3.00000	1020014-01	1014436-01	1009460-01	1002831-01	9288814-02	7559412-02	6022840-02	4835470-02	1731586-02	
4.00000	3082507-02	3071734-02	3062995-02	3051800-02	2910092-02	2483671-02	2041394-02	1672171-02	6247590-03	
5.00000	9637619-03	9613461-03	9595018-03	9572610-03	9283575-03	8218320-03	6941736-03	5792500-03	2254463-03	
7.50000	5768163-04	5760051-04	5754260-04	5747754-04	5676545-04	5323831-04	4744883-04	4120946-04	1764578-04	
10.00000	3731632-05	3728084-05	3725621-05	3722934-05	3698258-05	3302352-05	3302297-05	2961204-05	1382569-05	
15.00000	1768635-07	1767641-07	1766969-07	1766253-07	1760682-07	1738059-07	1676189-07	1571777-07	8506186-08	
20.00000	9197441-10	9193821-10	9191403-10	9188854-10	9170157-10	9111508-10	8950371-10	8618172-10	5252300-10	
50.00000	3638245-23	3637747-23	3637421-23	3637084-23	3634801-23	3629776-23	3622421-23	3610061-23	3115724-23	
100.00000	3578281-45	3578048-45	3577897-45	3577742-45	3576713-45	3574592-45	3571861-45	3568338-45	3467177-45	
A/R	5.00000	7.50000	10.00000	25.00000	50.00000	100.00000	.01000	.05000	.07500	
MUS*R (MFP)	2.00000	2.00000	2.00000	2.00000	2.00000	2.00000	3.00000	3.00000	3.00000	
B (MFP)										
.10000	1120626-01	5567219-02	3320315-02	5934691-03	1542072-03	3931662-04	6275667+00	5407645+00	5003933+00	
.25000	9635813-02	4789415-02	2858992-02	5107772-03	1327256-03	3384002-04	4754741+00	4266197+00	3998017+00	
.50000	7492068-02	3726973-02	2223953-02	3977594-03	1033645-03	2635448-04	3106868+00	2909556+00	2773030+00	
.75000	5825262-02	2900214-02	1731179-02	3097486-03	8049854-04	2052477-04	2096082+00	2011649+00	1941509+00	
1.00000	4529285-02	2256857-02	1347942-02	2412116-03	6269092-04	1598462-04	1445318+00	1407250+00	1370847+00	
2.00000	1655353-03	8275623-03	4947945-03	8870621-04	2306064-04	5880278-05	3700629-01	3675887-01	3645908-01	
3.00000	6050040-03	3034583-03	1816736-03	3262194-04	8482774-05	2163184-05	1053784-01	1050933-01	1047740-01	
4.00000	2211223-03	1112754-03	6670514-04	1199680-04	3120359-05	7957727-06	3173596-02	3168908-02	3164388-02	
5.00000	8081902-04	4080381-04	2449218-04	4411857-05	1147813-05	2927417-06	9899900-03	9890485-03	9882363-03	
7.50000	6527474-05	3222476-05	2000784-05	3618354-06	9419713-07	2402833-07	5905657-04	5902992-04	5900964-04	
10.00000	5272522-06	2705410-06	1634468-06	2967568-07	7730440-08	1972253-08	3813832-05	3812778-05	3812014-05	
15.00000	3441038-08	1793933-08	1090787-08	1996092-09	5206398-10	1328742-10	1804251-07	1803987-07	1803804-07	
20.00000	2246603-10	1189651-10	7270769-11	1342644-11	3506473-12	8951971-13	9373684-10	9372783-10	9372169-10	
50.00000	1753843-23	1013790-23	6437020-24	1243517-24	3272428-25	8371181-26	3701409-23	3701299-23	3701227-23	
100.00000	2575052-45	1685345-45	1132669-45	2357797-46	6283553-47	1612750-47	3638214-45	3638165-45	3638133-45	

TABLE 12 (Continued)

TABLE OF THE FUNCTION $S(B, A/R, \text{MUS}^*R)$

A/R	.10000	.25000	.50000	.75000	1.00000	2.50000	5.00000	7.50000	10.00000
MUS*R (MFP)	3.00000	3.00000	3.00000	3.00000	3.00000	3.00000	3.00000	3.00000	3.00000
B (MFP)									
.10000	4661850+00	3294185+00	2132781+00	1512933+00	1134603+00	3555638-01	1195386-01	5938111-02	3541395-02
.25000	3758754+00	2729470+00	1796370+00	1283490+00	9663780-01	3050970-01	1027835-01	5108417-02	3047197-02
.50000	2640743+00	1998225+00	1350006+00	9759473-01	7396490-01	2363968-01	7991273-02	3975115-02	2371979-02
.75000	1868047+00	1465708+00	1015108+00	7422658-01	5661800-01	1831679-01	6213107-02	3093238-02	1846380-02
1.00000	1329852+00	1077128+00	7637022-01	5646655-01	4334444-01	1419258-01	4830612-02	2407005-02	1437248-02
2.00000	3603702-01	3198035-01	2459697-01	1895391-01	1490553-01	5116214-02	1765142-02	8825362-03	5276834-03
3.00000	1042805-01	9744777-02	7987780-02	6384883-02	5135153-02	1844592-02	6450063-03	3235861-03	1937385-03
4.00000	3157567-02	3036867-02	2614513-02	2158345-02	1712318-02	6651448-03	2356976-03	1186448-03	7113102-04
5.00000	9871022-03	9647244-03	8621650-03	7320900-03	6127764-03	2398811-03	8612974-04	4350201-04	2611576-04
7.50000	5898526-04	5857008-04	5545413-04	4975974-04	4340080-04	1874887-04	6953096-05	3541345-05	2133116-05
10.00000	3811146-05	3800259-05	3699143-05	3446072-05	3106130-05	1466735-05	5613660-06	2882952-06	1742328-06
15.00000	1803605-07	1801840-07	1788525-07	1736214-07	1637526-07	9000933-08	3660244-08	1910765-08	1162444-08
20.00000	9371512-10	9366328-10	9341297-10	9224492-10	8931461-10	5543447-10	2387506-10	1266539-10	7755837-11
50.00000	3701151-23	3700631-23	3699412-23	3697353-23	3692369-23	3246552-23	1853973-23	1076362-23	6846647-24
100.00000	3638100-45	3637879-45	3637411-45	3636785-45	3635928-45	3568693-45	2700876-45	1781632-45	1201526-45
A/R	25.00000	50.00000	100.00000	.01000	.05000	.07500	.10000	.25000	.50000
MUS*R (MFP)	3.00000	3.00000	3.00000	5.00000	5.00000	5.00000	5.00000	5.00000	5.00000
B (MFP)									
.10000	6329584-03	1644670-03	4193239-04	6630330+00	5680558+00	5246322+00	4880813+00	3434393+00	2218006+00
.25000	5447634-03	1415561-03	3609142-04	4973139+00	4459565+00	4175972+00	3923363+00	2841749+00	1886918+00
.50000	4242245-03	1102415-03	2810786-04	3212932+00	3020222+00	2880326+00	2743653+00	2075852+00	1401504+00
.75000	3303571-03	8585418-04	2189029-04	2152177+00	2076297+00	2006966+00	1932872+00	1519456+00	1052714+00
1.00000	2572595-03	6686176-04	1704808-04	1476943+00	1445798+00	1411264+00	1371009+00	1114400+00	7911732-01
2.00000	9460690-04	2459480-04	6271490-05	3747463-01	3734905-01	3712288-01	3676300-01	3285660-01	2538210-01
3.00000	3479159-04	9047087-05	2307098-05	1063379-01	1092522-01	1060822-01	1057423-01	9956797-02	8213586-02
4.00000	1279457-04	3327931-05	8487140-06	3196746-02	3195812-02	3194247-02	3190763-02	3089819-02	3079901-02
5.00000	4705190-05	1224164-05	3122171-06	9961474-03	9960065-03	9958205-03	9954180-03	9784019-03	8812407-03
7.50000	3858832-06	1004624-06	2582683-07	5934188-04	5933930-04	5933689-04	5933315-04	5910863-04	5636292-04
10.00000	3164716-07	8244555-08	2103455-08	3829739-05	3829660-05	3829594-05	3829510-05	3825940-05	3744964-05
15.00000	2128594-09	5552578-10	1417130-10	1810647-07	1810632-07	1810621-07	1810608-07	1810406-07	1802509-07
20.00000	1431697-11	3739575-12	9547427-13	9404131-10	9404087-10	9404056-10	9404021-10	9403671-10	9394660-10
50.00000	1325599-24	3489699-25	8927827-26	3711576-23	3711572-23	3711569-23	3711566-23	3711546-23	3711489-23
100.00000	2512181-46	6699875-47	1719933-47	3647638-45	3647636-45	3647635-45	3647634-45	3647626-45	3647609-45
A/R	.75000	1.00000	2.50000	5.00000	7.50000	10.00000	25.00000	50.00000	100.00000
MUS*R (MFP)	5.00000	5.00000	5.00000	5.00000	5.00000	5.00000	5.00000	5.00000	5.00000
B (MFP)									
.10000	1571693+00	1177971+00	3687533-01	1239357-01	6156082-02	3671281-02	6561499-03	1704921-03	4346848-04
.25000	1332792+00	1003031+00	3163901-01	1065617-01	8295867-02	3158935-02	5647227-03	1467418-03	3741359-04
.50000	1012752+00	7673414-01	2451157-01	8284677-02	4120896-02	2458928-02	4397665-03	1142800-03	2913751-04
.75000	7697440-01	5871037-01	1898993-01	6440959-02	3206612-02	1914629-02	3424594-03	8899923-04	2289218-04
1.00000	5851836-01	4492549-01	1471228-01	5007557-02	2495176-02	1489996-02	2666834-03	6931103-04	1767258-04
2.00000	1959265-01	1542131-01	5300871-02	1829498-02	9147905-03	5469870-03	9807169-04	2549570-04	6501223-05
3.00000	6584193-02	5303594-02	1910209-02	6684130-03	3353851-03	2008161-03	3606545-04	9378457-05	2391609-05
4.00000	2220691-02	1827391-02	6884630-03	2442108-03	1229610-03	7372601-04	1326292-04	3449816-05	8798025-06
5.00000	7516433-03	6308044-03	2481684-03	8922613-04	4508095-04	2706721-04	4877382-05	1268997-05	3236835-06
7.50000	5084635-04	4451230-04	1937311-04	7200137-05	3669141-05	2210564-05	3999965-06	1041410-06	2666549-07
10.00000	3508117-05	3175257-05	1513781-05	5810767-06	2986390-06	1805372-06	3280392-07	8546397-08	2180497-08
15.00000	1757710-07	1665071-07	9268586-08	3785743-08	1978531-08	1204217-08	2206303-09	5755800-10	1469031-10
20.00000	9306904-10	9046297-10	5696070-10	2467429-10	1310937-10	8032639-11	1483901-11	3876398-12	9897061-13
50.00000	3711297-23	3709548-23	3302119-23	1907538-23	1111515-23	7081638-24	1373582-24	3617138-25	9254613-26
100.00000	3647584-45	3647543-45	3598415-45	2761324-45	1833175-45	1239854-45	2602011-46	6943775-47	1782838-47

TABLE 12 (Continued)

TABLE OF THE FUNCTION \$ (B,A/R,MUS*R)									
A/R	.01000	.05000	.07500	.10000	.25000	.50000	.75000	1.00000	2.50000
MUS*R (MFP)	7.50000	7.50000	7.50000	7.50000	7.50000	7.50000	7.50000	7.50000	7.50000
B (MFP)									
.10000	6769054+00	5780723+00	5333468+00	4958388+00	3481991+00	2246246+00	1590965+00	1192117+00	3730125-01
.25000	5047987+00	4526859+00	4237491+00	3979900+00	2879363+00	1890148+00	1348901+00	1014955+00	3200343-01
.50000	3242269+00	3055273+00	2914939+00	2777126+00	2101270+00	1418283+00	1024699+00	7763099-01	2479258-01
.75000	2164916+00	2094817+00	2026579+00	1962772+00	1536643+00	1064834+00	7786054-01	5938496-01	1920663-01
1.00000	1482965+00	1455736+00	1422463+00	1382892+00	1126029+00	7999294-01	5917564-01	4543290-01	1487938-01
2.00000	3752709-01	3744674-01	3725281-01	3692198-01	3310205-01	2562093-01	1979170-01	1558377-01	5359959-02
3.00000	1064132-01	1063797-01	1062596-01	1059769-01	1000927-01	8278877-02	6644518-02	5355630-02	1931103-02
4.00000	3198152-02	3197948-02	3197138-02	3194650-02	3101210-02	2697795-02	2238988-02	1844064-02	6958515-03
5.00000	9964566-03	9964377-03	9963756-03	9961474-03	9809205-03	8861579-03	7571978-03	6361485-03	2507811-03
7.50000	5935243-04	5935226-04	5935200-04	5935119-04	5917279-04	5656036-04	5112958-04	4482370-04	1956743-04
10.00000	3830232-05	3830229-05	3830225-05	3830218-05	3827916-05	3753094-05	3522660-05	3193453-05	1528235-05
15.00000	1810812-07	1810811-07	1810811-07	1810811-07	1810760-07	1804049-07	1761649-07	1671346-07	9388593-08
20.00000	9404849-10	9404848-10	9404848-10	9404847-10	9404825-10	9398234-10	9318105-10	9068307-10	5740386-10
50.00000	3711782-23	3711782-23	3711782-23	3711782-23	3711781-23	3711780-23	3711721-23	3710401-23	3315140-23
100.00000	3647820-45	3647820-45	3647820-45	3647820-45	3647820-45	3647820-45	3647819-45	3647818-45	3602463-45
A/R	5.00000	7.50000	10.00000	25.00000	50.00000	100.00000	.01000	.05000	.07500
MUS*R (MFP)	7.50000	7.50000	7.50000	7.50000	7.50000	7.50000	10.00000	10.00000	10.00000
B (MFP)									
.10000	1253518-01	6226230-02	3713071-02	6636092-03	1724299-03	4396251-04	6823766+00	5818503+00	5365911+00
.25000	1077781-01	5356187-02	3194883-02	5711423-03	1484097-03	3783874-04	5074499+00	4551393+00	4259862+00
.50000	8379108-02	4167798-02	2486898-02	4447652-03	1155788-03	2946866-04	3250870+00	3067293+00	2927011+00
.75000	6514264-02	3243081-02	1935802-02	3463517-03	9001073-04	2295008-04	2168004+00	2100753+00	2033116+00
1.00000	5064463-02	2523533-02	1506829-02	2697143-03	7899875-04	1787343-04	1484181+00	1458693+00	1426019+00
2.00000	1850163-02	9251559-03	5531924-03	9918592-04	2578543-04	6575108-05	3753291-01	3746702-01	3728523-01
3.00000	6759174-03	3391740-03	2030903-03	3647508-04	9485926-05	2418788-05	1064185-01	1063969-01	1062921-01
4.00000	2469360-03	1243460-03	7455947-04	1341351-04	3489014-05	8888008-06	3198223-02	3198134-02	3197504-02
5.00000	9021578-04	4558722-04	2737266-04	4932744-05	1283414-05	3273315-06	9964683-03	9964634-03	9964234-03
7.50000	7278786-05	3710039-05	2235400-05	4048332-06	1053239-06	2686737-07	5935266-04	5935268-04	5935258-04
10.00000	5873272-06	3619429-06	1825565-06	3317868-07	8643456-08	2205274-08	3830240-05	3830240-05	3830240-05
15.00000	3825222-08	2000093-08	1217568-08	2231268-09	5821140-10	1485722-10	1810814-07	1810814-07	1810814-07
20.00000	2492366-10	1325018-10	8120900-11	1500666-11	3920385-12	1000950-12	9404856-10	9404856-10	9404856-10
50.00000	1923399-23	1122392-23	7154743-24	1388954-24	3658083-25	9359685-26	3711783-23	3711783-23	3711783-23
100.00000	2777490-45	1848448-45	1251618-45	2630673-46	7022056-47	1803058-47	3647821-45	3647821-45	3647821-45
A/R	.10000	.25000	.50000	.75000	1.00000	2.50000	5.00000	7.50000	10.00000
MUS*R (MFP)	10.00000	10.00000	10.00000	10.00000	10.00000	10.00000	10.00000	10.00000	10.00000
B (MFP)									
.10000	4987015+00	3499155+00	2256313+00	1597805+00	1197126+00	3745146-01	1258507-01	6250938-02	3727789-02
.25000	4000396+00	2892836+00	1898405+00	1354608+00	1019172+00	3213191-01	1082067-01	5377432-02	3207543-02
.50000	2788887+00	2110272+00	1424218+00	1028920+00	7794757-01	2489161-01	8412369-02	4184316-02	2496747-02
.75000	1959533+00	1542659+00	1069100+00	7817270-01	5962262-01	1928296-01	6540079-02	3255923-02	1943465-02
1.00000	1386786+00	1130050+00	8029958-01	5940650-01	4561132-01	1493821-01	5084499-02	2533518-02	1512791-02
2.00000	3696586-01	3318250-01	2570283-01	1986077-01	1564044-01	5380719-02	1857434-02	9288046-03	5537771-03
3.00000	1060286-01	1002543-01	8300763-02	6665189-02	5373631-02	1938429-02	6785564-03	3405073-03	2038908-03
4.00000	3195299-02	3104474-02	2703647-02	2245175-02	1849783-02	6984369-03	2478938-03	1248333-03	7485279-04
5.00000	9962386-03	9815824-03	8877242-03	7590503-03	6379653-03	2516935-03	9056335-04	4576526-04	2748014-04
7.50000	5935214-04	5918553-04	5661861-04	5122054-04	4492712-04	1963493-04	7306363-05	3724411-05	2244135-05
10.00000	3830238-05	3828178-05	3755274-05	3527134-05	3199344-05	1533229-05	5895153-06	3031030-06	1832664-06
15.00000	1810814-07	1810777-07	1804358-07	1762738-07	1673262-07	9375933-08	3838998-08	2007652-08	1222256-08
20.00000	9404856-10	9404848-10	9398709-10	9320782-10	9074558-10	5755356-10	2501039-10	1329935-10	8181870-11
50.00000	3711783-23	3711783-23	3711783-23	3711733-23	3710489-23	3319189-23	1928800-23	1126163-23	7180458-24
100.00000	3647821-45	3647821-45	3647821-45	3647821-45	3647821-45	3603469-45	2782784-45	1853652-45	1255683-45

TABLE 12 (Continued)

TABLE OF THE FUNCTION S(B,A/R,MUS*R)

A/R MUS*R (MFP) B (MFP)	.25.00000	50.00000	100.00000	.01000	.05000	.07500	.10000	.25000	.50000
.10000	6662359-03	1731123-03	4413647-04	6866018+00	5846761+00	5389977+00	5008139+00	3511664+00	2263611+00
.25000	5734028-03	1489970-03	3798847-04	5093136+00	4569329+00	4276212+00	4015358+00	2902620+00	1904383+00
.50000	4465254-03	1160362-03	2958527-04	3255951+00	3075725+00	2935604+00	2797313+00	2116769+00	1428504+00
.75000	3477223-03	9036691-04	2304089-04	2169517+00	2104733+00	2037640+00	1964282+00	1546974+00	1072173+00
1.00000	2707815-03	7037613-04	1794416-04	1484675+00	1490580+00	1428401+00	1389465+00	1132916+00	8051993-01
2.00000	9957826-04	2588746-04	6601125-05	3753415-01	3747709-01	3730405-01	3699322-01	3323832-01	2576108-01
3.00000	3661931-04	9522552-05	2428359-05	1064192-01	1064029-01	1063075-01	1060571-01	1003632-01	8316166-02
4.00000	1346653-04	3502816-05	8932315-06	3198229-02	3198178-02	3197639-02	3195602-02	3106601-02	2707721-02
5.00000	4952236-05	1288491-05	3286266-06	9964690-03	9964673-03	9964361-03	9962690-03	9819995-03	8888018-03
7.50000	4061304-06	1057405-06	2697367-07	5935267-04	5935267-04	5935264-04	5935231-04	5919264-04	5665743-04
10.00000	3330655-07	8677630-08	2213999-08	3830240-05	3830240-05	3830240-05	3830240-05	3828302-05	3756675-05
15.00000	2240054-09	5844146-10	1491599-10	1810814-07	1810814-07	1810814-07	1810814-07	1810781-07	1804541-07
20.00000	1506565-11	3935872-12	1004909-12	9404856-10	9404856-10	9404856-10	9404856-10	9404850-10	9398952-10
50.00000	1394358-24	3672495-25	9396679-26	3711783-23	3711783-23	3711783-23	3711783-23	3711783-23	3711783-23
100.00000	2640733-46	7049598-47	1810177-47	3647821-45	3647821-45	3647821-45	3647821-45	3647821-45	3647821-45
A/R MUS*R (MFP) B (MFP)	.75000	1.00000	2.50000	5.00000	7.50000	10.00000	25.00000	50.00000	100.00000
.10000	1602754+00	1200747+00	3755987-21	1262106-01	6268761-02	3738405-02	6681305-03	1736044-03	4426195-04
.25000	1358734+00	1022219+00	3222463-01	1089158-01	5392756-02	3216675-02	5750334-03	1494206-03	3809647-04
.50000	1031967+00	7817609-01	2496308-01	8436361-02	4196231-02	2503852-02	4477951-03	1163661-03	2966938-04
.75000	7839774-01	5979400-01	1933801-01	6558700-02	3265187-02	1948993-02	3487110-03	9062381-04	2310639-04
1.00000	5957271-01	4573986-01	1498063-01	5098951-02	2540720-02	1817091-02	2715513-03	7057620-04	1799517-04
2.00000	1991022-01	1568112-01	5395676-02	1862677-02	9314359-03	5569527-03	9986125-04	2596104-04	6619891-05
3.00000	6679900-02	5386503-02	1943702-02	6804586-03	3414687-03	2044681-03	3672334-04	9549618-05	2435262-05
4.00000	2249552-02	1853856-02	7002960-03	2488839-03	1251845-03	7586430-04	1350477-04	3512771-05	8988609-06
5.00000	7603528-03	6392543-03	2523490-03	9081375-04	4869360-04	2758763-04	4966294-05	1292152-05	3295608-06
7.50000	5128347-04	4499978-04	1988331-04	7326218-05	3734768-05	2280431-05	4072823-06	1060409-06	2705034-07
10.00000	3530175-05	3203437-05	1836800-05	5910894-06	3039387-06	1837780-06	3340094-07	8702279-08	2220291-08
15.00000	1763449-07	1674562-07	9395388-08	3848893-08	2013094-08	1225634-08	2246391-09	5860738-10	1495838-10
20.00000	9322451-10	9878698-10	5785958-10	2507259-10	1333478-10	8174172-11	1510819-11	3947041-12	1007764-12
50.00000	3711737-23	3710533-23	3321964-23	1932640-23	1128863-23	7198930-24	1398253-24	3682888-25	9423362-26
100.00000	3647821-45	3647821-45	3604112-45	2786486-46	1857352-46	1288589-46	2647978-46	7069456-47	1815311-47
A/R MUS*R (MFP) B (MFP)	.01000	.05000	.07500	.10000	.25000	.50000	.75000	1.00000	2.50000
.10000	6881704+00	5857021+00	5398666+00	5015741+00	3516130+00	2266207+00	1604512+00	1202032+00	3759628-01
.25000	5099475+00	4875732+00	4282054+00	4020704+00	2906106+00	1906507+00	1360199+00	1023300+00	3225747-01
.50000	3257409+00	3078646+00	2938620+00	2800286+00	2119076+00	1430025+00	1033048+00	7825711-01	2498836-01
.75000	2169872+00	2106068+00	2039197+00	1965935+00	1548500+00	1073263+00	7847751-01	5985474-01	1935751-01
1.00000	1484768+00	1461191+00	1429206+00	1390385+00	1133926+00	8059792-01	5963157-01	4578536-01	1499565-01
2.00000	3753424+01	3747982-01	3730982-01	3760206-01	3325768-01	2578158-01	1992768-01	1569549-01	5400969-02
3.00000	1064192-01	1064042-01	1063117-01	1060058-01	1004003-01	8321554-02	6685076-02	5391042-02	1945567-02
4.00000	3198129-02	3198184-02	3197670-02	3195685-02	3107313-02	2709137-02	2251087-02	1855289-02	7009533-03
5.00000	9964690-03	9964676-03	9964384-03	9962771-03	9821362-03	8891741-03	7608080-03	6397069-03	2525806-03
7.50000	5935267-04	5935267-04	5935266-04	5935233-04	5919485-04	5667062-04	5130527-04	4502511-04	1970038-04
10.00000	3830240-05	3830240-05	3830240-05	3830240-05	3828337-05	3757143-05	3531219-05	3204858-05	1538058-05
15.00000	1810814-07	1810814-07	1810814-07	1810814-07	1810782-07	1804600-07	1763689-07	1675089-07	9482227-08
20.00000	9404856-10	9404856-10	9404856-10	9404856-10	9404851-10	9399026-10	9323001-10	9080097-10	5769672-10
50.00000	3711783-23	3711783-23	3711783-23	3711783-23	3711783-23	3711783-23	3711737-23	3710547-23	3322921-23
100.00000	3647821-45	3647821-45	3647821-45	3647821-45	3647821-45	3647821-45	3647821-45	3647821-45	3604327-46

TABLE OF THE FUNCTION S(B,A/R,MUS*R)

TABLE 12 (Continued)

A/R	5.00000	7.50000	10.00000	25.00000	50.00000	100.00000
MUS*R (MFP)	20.00000	20.00000	20.00000	20.00000	20.00000	20.00000
B (MFP)						
.10000	1263381-01	6275071-02	3742163-02	6688012-03	1737787-03	4430636-04
.25000	1086253-01	5398182-02	3219908-02	5756106-03	1495705-03	3813470-04
.50000	8444855-02	4200449-02	2506367-02	4482445-03	1164829-03	2969915-04
.75000	6565292-02	3268466-02	1950949-02	3490609-03	9071476-04	2312958-04
1.00000	5104067-02	2543269-02	1518614-02	2718238-03	7064703-04	1801323-04
2.00000	1864533-02	9323674-03	5575105-03	9996142-04	2598709-04	6626533-05
3.00000	6811318-03	3418090-03	2046724-03	3676018-04	9559199-05	2437706-05
4.00000	2488281-03	1253089-03	7513916-04	1351831-04	3516295-05	8967599-06
5.00000	9090234-04	4593903-04	2758506-04	4971271-05	1293448-05	3298914-06
7.50000	7333237-05	3738432-05	2252660-05	4076900-06	1061472-06	2707748-07
10.00000	5916458-06	3042344-06	1839591-06	3343434-07	8711004-08	2222519-08
15.00000	3852388-08	2015018-08	1226829-08	2248634-09	5866612-10	1497338-10
20.00000	2509455-10	1334731-10	8182060-11	1512325-11	3990995-12	1008775-12
50.00000	1933988-23	1129815-23	7205454-24	1399632-24	3686567-25	9432808-26
100.00000	2787775-45	1858651-45	1259614-45	2650541-46	7076484-47	1817128-47

13. M_c - The Factor which Equalizes the Areas of the Bases of the Cylinder and the Annular Sector
14. M_s - The Factor which Equalizes the Volumes of the Sphere and the Conical Sector of a Spherical Shell

These tables are useful in conjunction with Tables 1, 2, 8, and 9 in doing calculations using the cylindrical source approximation (Section B.13) and the spherical source approximation (Section B.20).

TABLE 13

MC--THE FACTOR WHICH EQUALIZES THE AREAS OF THE BASES OF THE CYLINDER AND THE ANNULAR SECTOR

A/R	0.	.1	.2	.3	.4	.5	.6	.7	.8	.9
0.	141421+01	156227+01	159696+01	161562+01	162699+01	163428+01	163904+01	164213+01	164407+01	164520+01
1.0	164575+01	164587+01	164567+01	164524+01	164464+01	164391+01	164309+01	164219+01	164125+01	164028+01
2.0	163929+01	163828+01	163728+01	163627+01	163528+01	163429+01	163332+01	163236+01	163142+01	163049+01
3.0	162959+01	162870+01	162783+01	162698+01	162615+01	162534+01	162455+01	162378+01	162302+01	162229+01
4.0	162157+01	162087+01	162018+01	161951+01	161886+01	161822+01	161760+01	161699+01	161640+01	161582+01

A/R	0.	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0
0.	141421+01	164575+01	163929+01	162959+01	162157+01	161525+01	161025+01	160622+01	160291+01	160016+01
10.0	159784+01	159585+01	159413+01	159263+01	159131+01	159014+01	158909+01	158815+01	158731+01	158654+01
20.0	158584+01	158520+01	158461+01	158407+01	158356+01	158310+01	158267+01	158226+01	158189+01	158153+01
30.0	158120+01	158089+01	158060+01	158032+01	158006+01	157981+01	157958+01	157936+01	157914+01	157894+01
40.0	157875+01	157857+01	157839+01	157822+01	157806+01	157791+01	157776+01	157762+01	157749+01	157736+01

TABLE 14

MS--THE FACTOR WHICH EQUALIZES THE VOLUMES OF THE SPHERE AND THE CONICAL SECTOR OF A SPHERICAL SHELL

A/R	0.	.1	.2	.3	.4	.5	.6	.7	.8	.9
0.	125992+01	140798+01	144851+01	147228+01	148777+01	149826+01	150541+01	151023+01	151334+01	151518+01
1.0	151607+01	151621+01	151578+01	151491+01	151370+01	151222+01	151054+01	150870+01	150674+01	150470+01
2.0	150259+01	150045+01	149827+01	149609+01	149390+01	149172+01	148956+01	148741+01	148529+01	148319+01
3.0	148113+01	147910+01	147710+01	147514+01	147321+01	147133+01	146947+01	146766+01	146588+01	146414+01
4.0	146243+01	146076+01	145913+01	145753+01	145596+01	145443+01	145293+01	145146+01	145002+01	144861+01

A/R	0.	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0
0.	125992+01	151607+01	150259+01	148113+01	146243+01	144724+01	143495+01	142491+01	141660+01	140962+01
10.0	140370+01	139861+01	139420+01	139033+01	138692+01	138390+01	138119+01	137875+01	137655+01	137454+01
20.0	137272+01	137105+01	136951+01	136809+01	136677+01	136556+01	136442+01	136336+01	136237+01	136145+01
30.0	136058+01	135976+01	135899+01	135826+01	135757+01	135691+01	135629+01	135570+01	135514+01	135461+01
40.0	135410+01	135362+01	135315+01	135271+01	135229+01	135188+01	135149+01	135111+01	135075+01	135041+01

15. Relation of ϕ_0 and θ_0 to the Geometry of the Cylinder

This table is useful in quickly determining the angles ϕ_0 and θ_0 which appear in Section B.13, which gives approximate formulas for the flux from a shielded, self-absorbing cylindrical source.

The angle ϕ_0 also appears in the flux formulas for a spherical source given in Equations (85), (98), and (99).

TABLE 15
RELATION OF ϕ_0 AND θ_0 TO THE GEOMETRY OF THE CYLINDER

A/L OR A/R	R/(A+R)	PHI0		THETA0	
		ARCSIN (R/(A+R)) DEG	RAD	ARCTAN (A/L) DEG	RAD
.001	.999 00	87.43872	1.5260936	.05730	100000-02
.002	.998 00	86.37931	1.5076034	.11459	200000-02
.005	.995 02	84.28232	1.4710040	.28648	499996-02
.007	.993 05	83.24036	1.4528183	.40106	699989-02
.010	.990 10	81.93070	1.4299605	.57294	999967-02
.025	.975 61	77.31962	1.3494819	1.43210	249948-01
.050	.952 38	72.24721	1.2609517	2.86241	499584-01
.075	.930 23	68.47110	1.1950461	4.28915	748598-01
.100	.909 09	65.38002	1.1410967	5.71059	996687-01
.150	.869 57	60.40815	1.0543212	8.53077	148890+00
.200	.833 33	56.44269	.9851108	11.30993	197396+00
.250	.800 00	53.13010	.9272952	14.03624	244979+00
.300	.769 23	50.28486	.8776364	16.69924	291457+00
.350	.740 74	47.79455	.8341723	19.29005	336675+00
.400	.714 29	45.58469	.7956030	21.80141	380506+00
.450	.689 66	43.60282	.7610128	24.22775	422854+00
.500	.666 67	41.81031	.7297277	26.56505	463648+00
.550	.645 15	40.17777	.7012344	28.81079	502843+00
.600	.625 00	38.68219	.6751315	30.96376	540420+00
.650	.606 06	37.30520	.6510986	33.02387	576375+00
.700	.588 24	36.03188	.6288749	34.99202	610726+00
.750	.571 43	34.84990	.6082456	36.86990	643501+00
.800	.555 55	33.74899	.5890310	38.65981	674741+00
.850	.540 54	32.72044	.5710795	40.36454	704494+00
.900	.526 32	31.75686	.5542618	41.98721	732815+00
.950	.512 82	30.85189	.5384670	43.53120	759763+00
1.000	.500 00	30.00000	.5235988	45.00000	785398+00
1.150	.465 12	27.71775	.4837660	48.99091	855053+00
1.200	.454 55	27.03569	.4718618	50.19443	876058+00
1.250	.444 44	26.38780	.4605540	51.34019	896055+00
1.300	.434 78	25.77146	.4497969	52.43141	915101+00
1.350	.425 53	25.18434	.4395496	53.47114	933248+00
1.400	.416 67	24.62432	.4297754	54.46232	950547+00
1.450	.408 15	24.08951	.4204412	55.40771	967047+00
1.500	.400 00	23.57818	.4115168	56.30993	982794+00
1.550	.392 16	23.08877	.4029751	57.17146	997830+00
1.600	.384 62	22.61986	.3947911	57.99462	101220+01
1.650	.377 36	22.17016	.3869422	58.78160	102593+01
1.700	.370 37	21.73846	.3794077	59.53446	103907+01
1.750	.363 54	21.32369	.3721685	60.25512	105165+01
1.800	.357 14	20.92483	.3652072	60.94540	106370+01
1.850	.350 88	20.54098	.3585077	61.60698	107524+01
1.900	.344 83	20.17127	.3520551	62.24146	108632+01
1.950	.338 98	19.81493	.3458357	62.85032	109694+01
2.000	.333 33	19.47122	.3398369	63.43495	110715+01
2.100	.322 58	18.81906	.3284546	64.53665	112638+01
2.200	.312 50	18.20996	.3178237	65.55605	114417+01
2.300	.303 03	17.63970	.3078709	66.50143	116067+01
2.400	.294 12	17.10464	.2985322	67.38014	117601+01
2.500	.285 71	16.60155	.2897517	68.19859	119029+01

TABLE 15 (Continued)

A/L OR A/R	R/(A+R)	PHI O		THETA O	
		ARCSIN (R/(A+R))		ARCTAN (A/L)	
		DEG	RAD	DEG	RAD
2.600	.27778	15.12762	.2814801	68.96249	120362+01
2.700	.27027	15.68035	.2736737	69.67686	121609+01
2.800	.26316	15.25752	.2662940	70.34618	122777+01
2.900	.25641	14.85717	.2593065	70.97439	123874+01
3.000	.25000	14.47751	.2526803	71.56505	124905+01
3.100	.24390	14.11698	.2463878	72.12130	125875+01
3.250	.23529	13.60896	.2375212	72.89727	127230+01
3.500	.22222	12.83959	.2240931	74.05460	129250+01
3.750	.21053	12.15320	.2121133	75.06858	131019+01
4.000	.20000	11.53696	.2013579	75.96376	132582+01
4.250	.19048	10.98058	.1916472	76.75948	133971+01
4.500	.18182	10.47568	.1828351	77.47119	135213+01
4.750	.17391	10.01541	.1748019	78.11134	136330+01
5.000	.16667	9.59407	.1674481	78.69007	137340+01
5.250	.16000	9.20690	.1606907	79.21570	138257+01
5.500	.15385	8.84988	.1544596	79.69515	139094+01
5.750	.14815	8.51962	.1486955	80.13419	139861+01
6.000	.14286	8.21321	.1433476	80.53768	140565+01
6.500	.13333	7.66226	.1337316	81.25384	141815+01
7.000	.12500	7.18076	.1253278	81.86990	142890+01
7.500	.11765	6.75633	.1179202	82.40536	143824+01
8.000	.11111	6.37937	.1113410	82.87498	144644+01
8.500	.10525	6.04233	.1054585	83.29016	145369+01
9.000	.10000	5.73917	.1001674	83.65981	146014+01
10.000	.09091	5.21591	.0910348	84.28941	147113+01
11.000	.08333	4.78019	.0834301	84.80557	148014+01
12.000	.07692	4.41173	.0769991	85.23636	148766+01
13.000	.07143	4.09604	.0714894	85.60129	149402+01
14.000	.06667	3.82255	.0667161	85.91438	149949+01
15.000	.06250	3.58332	.0625408	86.18593	150423+01
16.000	.05882	3.37229	.0588575	86.42367	150838+01
17.000	.05555	3.18474	.0555842	86.63354	151204+01
18.000	.05263	3.01696	.0526559	86.82017	151530+01
19.000	.05000	2.86598	.0500209	86.98721	151821+01
20.000	.04762	2.72940	.0476371	87.13759	152084+01
25.000	.03846	2.20423	.0384710	87.70939	153082+01
30.000	.03226	1.84857	.0322637	88.09085	153748+01
35.000	.02778	1.59175	.0277814	88.36342	154223+01
40.000	.02439	1.39760	.0243927	88.56790	154580+01
45.000	.02174	1.24566	.0217408	88.72697	154858+01
50.000	.01961	1.12352	.0196091	88.85424	155080+01
55.000	.01786	1.02319	.0178581	88.95837	155262+01
60.000	.01639	.93932	.0163942	89.04516	155413+01
65.000	.01515	.86815	.0151521	89.11860	155541+01
70.000	.01408	.80701	.0140850	89.18154	155651+01
75.000	.01316	.75391	.0131583	89.23610	155746+01
80.000	.01235	.70737	.0123460	89.28384	155830+01
90.000	.01039	.62964	.0109892	89.36341	155969+01
100.000	.00990	.56729	.0099012	89.42706	156080+01

16. Conditions for Accurate Results from the Cylindrical Source Approximation

TABLE 16

**Conditions for Accurate Results from
the Cylindrical Source Approximation**

$$.9 \leq \left| \frac{\phi_{15}}{\phi_{\text{corr}}} \right| \leq 1.1$$

if $\mu_s = 0.1$, $R \geq 10.$, and

$$1. \leq \left| \frac{\phi_{15}}{\phi_{\text{corr}}} \right| \leq 1.1$$

if $\mu_s = 0.5$, $R \geq 10.$, and

<u>$l/a \geq$</u>	<u>$a/R \geq$</u>	<u>$b \geq$</u>		<u>$l/a \geq$</u>	<u>$a/R \geq$</u>	<u>$b \geq$</u>
1.	5.	0.		0.1	5.	0.
2.5	2.	0.		0.8	2.	0.
4.25	1.	0.		1.4	1.	0.
4.25	0.5	1.		2.25	0.5	0.
0.5	0.5	10.		3.75	0.2	0.
0.75	2.	10.		1.6	0.5	1.
0.9	1.	10.		2.7	0.2	1.
1.25	0.5	10.		0.25	2.	10.
2.0	0.2	10.		0.5	1.	10.
				0.7	0.5	10.
				1.0	0.2	10.

$\frac{\phi_{15}}{\phi_{\text{corr}}}$ is the ratio of the uncollided flux calculated by the approximate cylindrical flux formula to the uncollided flux calculated by the exact cylindrical flux formula (see Reference (7) or Reference (25)) for the same geometrical configuration and shields.

17. Estimating the Effect of a Cylindrical Shield

The cylindrical source approximation of Section B.13 assumes a slab shield of thickness t and attenuation μ intervening between the source and an external lateral detector point. If a cylindrical shield of the same optical thickness is substituted for the slab shield, the uncollided flux will be decreased. The two nomograms given in Section F, Figures 47 and 48, give approximate values of this reduction factor $f = \frac{\phi_{\text{cyl shield}}^{\text{uncollided}}}{\phi_{\text{slab shield}}^{\text{uncollided}}}$.

In order to approximate the effect on gamma-ray build-up of the replacement of a slab shield with a cylindrical shield of the same thickness, the change in uncollided flux must be translated into the corresponding change in the optical distance. This change in the optical distance may then be added to the apparent optical distance through the slab shield and new values of the buildup factors found. That is, the apparent buildup factor is (for a given gamma energy)

$$B(\bar{b}_{\text{slab}}) = \frac{\phi_{\text{slab shield}}^{\text{total}}}{\phi_{\text{slab shield}}^{\text{uncollided}}} \text{ while the change in the apparent}$$

optical distance is
$$\Delta \bar{b} = \ln \frac{\phi_{\text{slab shield}}^{\text{uncollided}}}{\phi_{\text{cyl shield}}^{\text{uncollided}}} = \ln \frac{1}{f}$$

where f is the reduction factor defined above.

The apparent optical distance \bar{b}_{slab} may be found by interpolating a table of buildup factors to find the optical distance corresponding to $B(\bar{b}_{\text{slab}})$. Then

$$\phi_{\text{cyl shield}}^{\text{total}} = \phi_{\text{slab shield}}^{\text{uncollided}} \cdot f \cdot B(\bar{b}_{\text{slab}} + \Delta \bar{b})$$

D. Information About Shielding Functions

1. Exponential Integral Functions (References (1), (2), (3), (6), (7), (25), (26), (27))

Definition:

$$E_n(b) = b^{n-1} \int_b^{\infty} \frac{e^{-t}}{t^n} dt, \quad n = 1, 2, 3, \dots \quad (135)$$

If we set $t = by$, we get an equivalent definition

$$E_n(b) = \int_1^{\infty} \frac{e^{-by}}{y^n} dy, \quad n = 0, 1, 2, \dots \quad (136)$$

$E_n(b)$ is related to the incomplete gamma function

$$\Gamma(a, b) = \int_b^{\infty} e^{-t} t^{a-1} dt$$

by the expression

$$E_n(b) = b^{n-1} \int_b^{\infty} \frac{e^{-t} dt}{t^n} = b^{n-1} \Gamma(1-n, b) .$$

Integrating (135) by parts gives the recursion relation

$$E_{n+1}(b) = \frac{1}{n} [e^{-b} - b E_n(b)], \quad n > 1, \quad (137)$$

while differentiating (136) with respect to b gives

$$\frac{dE_{n+1}}{db} = -E_n(b) \quad (138)$$

Thus,

$$E_n(b+\delta) = E_n(b) - \delta E_{n-1}(b) + \frac{\delta^2}{2!} E_{n-2}(b) - \frac{\delta^3}{3!} E_{n-3}(b) + \dots \quad (139)$$

Also, we have specifically, from equations (135) through (138)

$$E_0(b) = \frac{e^{-b}}{b} \quad (140)$$

$$E_1(b) = \int_b^{\infty} \frac{e^{-t} dt}{t} \quad (141)$$

$$E_2(b) = b \int_b^{\infty} \frac{e^{-t} dt}{t^2} \quad (142)$$

$$E_3(b) = b^2 \int_b^{\infty} \frac{e^{-t} dt}{t^3} \quad (143)$$

$$\int_{a_1}^{a_2} E_1(y) dy = \int_1^{\infty} \int_{a_1}^{a_2} \frac{e^{-yt} dy dt}{t} = E_2(a_1) - E_2(a_2) \quad (144)$$

and

$$\int_{a_1}^{a_2} E_2(y) dy = E_3(a_1) - E_3(a_2) \quad (145)$$

$$E_1(0) \rightarrow \infty \quad (146)$$

$$E_1(\infty) = 0 \quad (147)$$

$$E_2(0) = 1 \quad (148)$$

$$E_2(\infty) = 0 \quad (149)$$

Use of the substitution $\rho = b \sec \theta$ enables us to show that

$$\int_0^{\theta_0} \tan \theta e^{-b \sec \theta} d\theta = E_1(b) - E_1(b \sec \theta_0) \quad (150)$$

$$\int_0^{\theta_0} \sin \theta e^{-b \sec \theta} d\theta = E_2(b) - \cos \theta_0 E_2(b \sec \theta_0), \quad (151)$$

and

$$\int_0^{\theta_0} \sin \theta \cos \theta e^{-b \sec \theta} d\theta = E_3(b) - \cos^2 \theta_0 E_3(b \sec \theta_0) \quad (152)$$

(150) through (152) may be generalized to give

$$E_n(b) = \int_0^{\frac{\pi}{2}} \sin \theta (\cos \theta)^{n-2} e^{-b \sec \theta} d\theta \text{ for } n = 0, 1, 2, \dots \quad (153)$$

Some useful approximations for $E_n(b)$ are:

For $b > 10$

$$E_n(b) = \frac{e^{-b}}{b} \left[1 - \frac{n}{b} + \frac{n(n+1)}{b^2} - \frac{n(n+1)(n+2)}{b^3} + \dots \right], \quad (154)$$

and for small values of b

$$E_1(b) = \sum_{n=1}^{\infty} (-1)^{n-1} \frac{b^n}{n \cdot n!} - r - \ln |b| \quad (155)$$

where $r = 0.577216\dots$ is the Euler-Mascheroni Constant.

For any value of b , the following inequality brackets the value of

$E_n(b)$:

$$\frac{e^{-b}}{b+n-1} > E_n(b) > \frac{e^{-b}}{b+n}, \quad n \geq 1. \quad (156)$$

Finally, for $b < 0$

$$E_1(b) = -E_1(-b) \quad (157)$$

where

$$E_1(b) = \int_{-\infty}^b \frac{e^t}{t} dt \quad (-\infty < b < \infty) \quad (158)$$

and

$$E_1(b) = \frac{e^b}{b} \left(1 + \frac{1}{b} + \frac{2!}{b^2} + \frac{3!}{b^3} + \dots \right) \text{ for } b \geq 10. \quad (159)$$

2. Sievert's Integral of the First Kind (References (1), (2), (3), (6), (7), and (25))

$$F(\theta_0, b) = \int_0^{\theta_0} e^{-b \sec \theta} d\theta, \quad b \geq 0 \quad (160)$$

$$0 \leq \theta_0 \leq \frac{\pi}{2}.$$

For $\theta_0 < 5^\circ$,

$$F(\theta_0, b) \doteq \theta_0 e^{-b} \quad (161)$$

and for a small angle δ ,

$$F(\theta_0 + \delta, b) \doteq F(\theta_0, b) + \delta e^{-b \sec \theta_0}. \quad (162)$$

The substitution $\rho = b \sec \theta$ gives

$$F(\theta_0, b) = b \int_b^{b \sec \theta_0} \frac{e^{-\rho} d\rho}{\rho \sqrt{\rho^2 - b^2}}. \quad (163)$$

Note that

$$F(\theta_0, 0) = \theta_0. \quad (164)$$

3. The G-Function Defined by Ono and Tsuru (References (5), (7), and (25))

$$G(\theta_0, b) = \int_0^{\theta_0} \cos \theta e^{-b \sec \theta} d\theta \quad (165)$$

which becomes, using $\rho = b \sec \theta$,

$$G(\theta_0, b) = b^2 \int_b^{b \sec \theta_0} \frac{e^{-\rho} d\rho}{\rho^2 \sqrt{\rho^2 - b^2}} \quad (166)$$

$$G(\theta_0, 0) = \int_0^{\theta_0} \cos \theta d\theta = \sin \theta_0. \quad (167)$$

The corresponding function for an infinitely high cylinder is defined by Ono and Tsuru as

$$H(b) = G\left(\frac{\pi}{2}, b\right) = \int_0^{\frac{\pi}{2}} \cos \theta e^{-b \sec \theta} d\theta . \quad (168)$$

$G(\theta_0, \mu a)/2\mu_s$ represents unit collided flux at the center of the base of an infinitely thick annular source of inner radius a , where the macroscopic self-attenuation coefficient of the source material is μ_s and the macroscopic attenuation coefficient of the shielding material filling the interior of the annulus is μ . The top surface of the annular source is conical, being defined by a line passing through the center at the angle θ_0 , and the height of the inner surface of the annular source is $l = a \tan \theta_0$. (See Figure 9 and Section B.13.)

4. The L_0 Function Defined by Ono and Tsuru (References (5), (7), (25))

$$L_0(\phi_0, b) = \frac{\int_0^{\phi_0} G\left(\frac{\pi}{2}, b \sec \phi\right) d\phi}{\phi_0 G\left(\frac{\pi}{2}, b\right)} \quad (169)$$

where $G\left(\frac{\pi}{2}, b\right)$ and $G\left(\frac{\pi}{2}, b \sec \phi\right)$ are as defined by (168). $L_0(\phi_0, b)$ gives an approximation to the ratio between the attenuation of a slab shield of optical thickness b and the attenuation of an annular shield (also of optical thickness b) which is curved around the dose point as a center. Both the slab and annular shields are assumed to be of infinite height, while subtending the angle ϕ_0 . (See Section B.13.) As noted in Reference (7), the value of $L_0(\phi_0, b)$ is only weakly dependent on the assumption that the slab and annular shields are infinitely high, and so this function is valid for shields of any height. Also, to a good approximation,

$$L_0(\phi_0, b) = \frac{e^{-b}}{\phi_0} G(\phi_0, b)$$

5. The G-Function Defined by Rockwell (References (1), (2), (25))

$$G(\mu_s h, \mu_s R) = \int_0^{\mu_s R} \int_0^{\tan^{-1} \frac{\mu_s h}{\mu_s X}} e^{-\mu_s X \sec \theta} d\theta d(\mu_s X) \quad (170)$$

$$G(\mu_s h, \mu_s R) = \int_0^{\mu_s R} F\left(\tan^{-1} \frac{\mu_s h}{\mu_s X}, \mu_s X\right) d(\mu_s X) \quad (171)$$

where the function $F\left(\tan^{-1} \frac{\mu_s h}{\mu_s X}, \mu_s X\right)$ is defined by (160).

$G(\mu_s h, \mu_s R)/2\mu_s$ represents unit uncollided flux at the center of the base of a cylindrical source of height h and radius R . μ_s is the macroscopic self-attenuation coefficient of the source. (See Figure 8.)

6. Relations Between Functions (Reference (25))

In terms of a cylinder of radius R , height h , and macroscopic self-attenuation coefficient μ_s , finding the flux at the center of the base in different ways gives the following relation between several of these functions:

$$G(\mu_s h, \mu_s R) = 1 - G\left(\tan^{-1} \frac{h}{R}, \mu_s R\right) - E_2(\mu_s h) + \frac{h}{\sqrt{R^2 + h^2}} E_2\left(\mu_s \sqrt{R^2 + h^2}\right) \quad (172)$$

where $G(\mu_s h, \mu_s R)$ is given by (171) and $G\left(\tan^{-1} \frac{h}{R}, \mu_s R\right)$ is given by (165).

To derive (172) the relation

$$\int_{\tan^{-1} \frac{h}{R}}^{\frac{\pi}{2}} \cos \theta e^{-\mu_s h \csc \theta} d\theta = \int_0^{\tan^{-1} \frac{R}{h}} \sin \psi e^{-\mu_s h \sec \psi} d\psi$$

$$= E_2(\mu_s h) - \frac{h}{\sqrt{R^2 + h^2}} E_2\left(\mu_s \sqrt{R^2 + h^2}\right) \quad (173)$$

is needed. Here $\psi = \frac{\pi}{2} - \theta$.

The left-hand side of (172) may also be expressed as

$$G(\mu_s h, \mu_s R) = 1 - E_2(\mu_s h) - \int_0^{\mu_s h} E_1(\sqrt{h^2 + (\mu_s R)^2}) dy, \quad (174)$$

where $y = \mu_s r$.

Equating the right-hand sides of (172) and (174) gives another useful relationship:

$$\int_0^{\mu_s h} E_1(\sqrt{y^2 + (\mu_s R)^2}) dy = G\left(\tan^{-1} \frac{h}{R}, \mu_s R\right) - \frac{h}{\sqrt{R^2 + h^2}} E_2\left(\mu_s \sqrt{R^2 + h^2}\right) \quad (175)$$

Finally, if we consider a cylinder of infinite height, (172) reduces to

$$G(\infty, \mu_s R) + G\left(\frac{\pi}{2}, \mu_s R\right) = 1.0. \quad (176)$$

This simple relationship furnishes us with the justification for assigning the letter G to represent both of these functions.

E. Total Flux Formulas Using Taylor Exponential Build-Up Factor Coefficients

The total flux formulas given here correspond to various flux formulas given in Section B of this report; inclusion of the appropriate γ -ray dose conversion factors in these formulas allows total dose rates or total energy absorption rates to be calculated.

A γ -ray buildup factor $B_f(b, Z, E)$ may be represented by Taylor coefficients $A(Z, E)$, $\alpha_1(Z, E)$, and $\alpha_2(Z, E)$. Here Z is an (equivalent) atomic number, E is an energy level, and b is an optical distance. Then

$$B_f(b, Z, E) = Ae^{-\alpha_1 b} + (1-A)e^{-\alpha_2 b} \quad (177)$$

which may be conveniently included in the integral of the point kernel over an extended source (See Eq. 7, 8, and 9).

The actual formulas obtained when this buildup factor representation is used to obtain total flux formulas for the various options of Section B are displayed below. The definitions of the various symbols and the nomenclature may be found by checking the corresponding formulas and figures in Section B.

As a preliminary, we define

$$U_1 = \frac{A}{1 + \alpha_1}, \quad U_2 = \frac{1 - A}{1 + \alpha_2} \quad (178)$$

$$U_3 = U_1 + U_2 = \frac{A}{1 + \alpha_1} + \frac{1 - A}{1 + \alpha_2}.$$

The notation and definitions used here are the same as in Section B, except that φ_{P_1} , φ_{P_2} , etc. refer to total flux.

1. Uniform Disk Source, with Shield

$$\varphi_{P_1} = \frac{S}{2} \left\{ A[E_1(B_1) - E_1(B_1 \sec \theta)] + (1-A) [E_1(B_2) - E_1(B_2 \sec \theta)] \right\} \quad (179)$$

where

$$B_1 = (1 + \alpha_1)b$$

$$B_2 = (1 + \alpha_2)b$$

Let $M_1 = \bar{\mu}(1 + \alpha_1)$ and $M_2 = \bar{\mu}(1 + \alpha_2)$.

$$\phi_{P_2} = \frac{S}{4\pi} \left\{ A \cdot D(M_1 R, M_1 a, M_1 h) - (1+A) \cdot D(M_2 R, M_2 a, M_2 h) \right\} \quad (180)$$

2. Infinite Slab Source of Infinite Depth, Self-Absorbing, No Shield

$$\phi_{P_1} = \phi_{P_2} = U_3 \frac{S_v}{2\mu_s} \quad (181)$$

$$\begin{aligned} \phi_{P_3} = \frac{S_v}{2\mu_s} \left\{ 2U_3 - U_1 E_2[\mu_s a'(1+\alpha_1)] \right. \\ \left. - U_2 E_2[\mu_s a'(1+\alpha_2)] \right\} \quad (182) \end{aligned}$$

3. Infinite Slab Source of Infinite Depth, Self Absorbing, with Shield

$$\phi_{P_1} = \frac{S_v}{2\mu_s} \left\{ U_1 E_2[b(1+\alpha_1)] + U_2 E_2[b(1+\alpha_2)] \right\} \quad (183)$$

4. Infinite Slab Source, Self-Absorbing, No Shield

$$\phi_{P_1} = \phi_{P_2} = \frac{S_v}{2\mu_s} \left\{ U_3 - U_1 E_2[\mu_s \ell(1+\alpha_1)] - U_2 E_2[\mu_s \ell(1+\alpha_2)] \right\} \quad (184)$$

$$\begin{aligned} \phi_{P_3} = \frac{S_v}{2\mu_s} \left\{ 2U_3 - U_1 \left[E_2[\mu_s a'(1+\alpha_1)] + E_2[\mu_s (\ell - a')(1+\alpha_1)] \right] \right. \\ \left. - U_2 \left[E_2[\mu_s a'(1+\alpha_2)] + E_2[\mu_s (\ell - a')(1+\alpha_2)] \right] \right\} \quad (185) \end{aligned}$$

5. Infinite Slab Source, No Self-Absorption, with Shield

$$\phi_{P_1} = \frac{S_v}{2} \ell \left\{ A E_1[b(1+\alpha_1)] + (1-A) E_1[b(1+\alpha_2)] \right\} \quad (186)$$

6. Infinite Slab Source, Self Absorbing, with Shield

$$\begin{aligned} \phi_{P_1} = \frac{S_v}{2\mu_s} \left\{ U_1 \left[E_2[b(1+\alpha_1)] - E_2[(b+\mu_s \ell)(1+\alpha_1)] \right] \right. \\ \left. + U_2 \left[E_2[b(1+\alpha_2)] - E_2[(b+\mu_s \ell)(1+\alpha_2)] \right] \right\} \quad (187) \end{aligned}$$

7. Cylindrical Source, Self-Absorbing, No Shield, Axial Detector Point

$$\varphi_{P_1} = \frac{S_v}{2\mu_s} \left\{ U_3 - U_1 \left[E_2[\mu_s \ell(1+\alpha_1)] + Z[\mu_s \ell(1+\alpha_1), a/\ell, R/\ell] \right] \right. \\ \left. - U_2 \left[E_2[\mu_s \ell(1+\alpha_2)] + Z[\mu_s \ell(1+\alpha_2), a/\ell, R/\ell] \right] \right\} \quad (188)$$

$$\varphi_{P_2} = \frac{S_v}{2\mu_s} \left\{ U_3 - U_1 \left[E_2[\mu_s \ell(1+\alpha_1)] + Z[\mu_s \ell(1+\alpha_1), R/\ell] \right] \right. \\ \left. - U_2 \left[E_2[\mu_s \ell(1+\alpha_2)] + Z[\mu_s \ell(1+\alpha_2), R/\ell] \right] \right\} \quad (189)$$

8. Cylindrical Source, Non-Absorbing, with Shield, Axial Detector Point

$$\varphi_{P_1} = \frac{S_v}{2} [A \cdot C(\ell, b(1+\alpha_1), a, R) \\ + (1-A) \cdot C(\ell, b(1+\alpha_2), a, R)] \quad (190)$$

9. Cylindrical Source, Self-Absorbing, with Shield, Axial Point

$$\varphi_{P_1} = \frac{S_v}{2\mu_s} \left\{ U_1 Z(b'(1+\alpha_1), b(1+\alpha_1), a/\ell, R/\ell) \right. \\ \left. + U_2 Z(b'(1+\alpha_2), b(1+\alpha_2), a/\ell, R/\ell) \right\} \quad (191)$$

10. Cylindrical Source, Self-Absorbing, Detector Point on Axis

$$\varphi_{P_1} = \frac{S_v}{2\mu_s} \left\{ U_1 \left[G[\mu_s h(1+\alpha_1), b(1+\alpha_1)] + G[\mu_s (\ell-h)(1+\alpha_1), b(1+\alpha_1)] \right] \right. \\ \left. + U_2 \left[G[\mu_s h(1+\alpha_2), b(1+\alpha_2)] + G[\mu_s (\ell-h)(1+\alpha_2), b(1+\alpha_2)] \right] \right\} \quad (192)$$

$$\varphi_{P_2} = \frac{S_v}{2\mu_s} \left\{ U_1 \cdot G[\mu_s \ell(1+\alpha_1), b(1+\alpha_2)] \right. \\ \left. + U_2 \cdot G[\mu_s \ell(1+\alpha_2), b(1+\alpha_2)] \right\} \quad (193)$$

11. Cylindrical Source Approximation, Self-Absorbing, with Shield, Lateral Detector Point

$$\text{Define } \lambda(\theta, \alpha) = L_0(\phi_0, b(1+\alpha))\{G(\theta, b(1+\alpha)) - G(\theta, b'(1+\alpha))\} \quad (194)$$

$$\begin{aligned} \varphi_P &= \frac{S_v \phi_0}{2\pi\mu_s} \left\{ U_1 \lambda(\theta_1, \alpha_1) + U_2 \lambda(\theta_1, \alpha_2) \right\} \\ \varphi_{P_3} &= \frac{S_v \phi_0}{2\pi\mu_s} \left\{ U_1 [\lambda(\theta_2, \alpha_1) + \lambda(\theta_3, \alpha_1)] \right. \\ &\quad \left. + U_2 [\lambda(\theta_2, \alpha_2) + \lambda(\theta_3, \alpha_2)] \right\} \end{aligned} \quad (195)$$

$$\begin{aligned} \varphi_{P_5} &= \frac{S_v \phi_0}{2\pi\mu_s} \left\{ U_1 [\lambda(\theta_5, \alpha_1) - \lambda(\theta_4, \alpha_1)] \right. \\ &\quad \left. + U_2 [\lambda(\theta_5, \alpha_2) - \lambda(\theta_4, \alpha_2)] \right\} \end{aligned} \quad (196)$$

12. Truncated Cone Source, Self-Absorbing with Shield, Apex Point

$$\text{Define } \eta(b, b') = E_2(b) - E_2(b') + \cos \theta_0 E_2(b' \sec \theta_0) - \cos \theta_0 E_2(b \sec \theta_0) \quad (197)$$

$$\varphi_{P_1} = \frac{S_v}{2\mu_s} \left[U_1 \eta[b(1+\alpha_1), b'(1+\alpha_1)] + U_2 \eta[b(1+\alpha_2), b'(1+\alpha_2)] \right] \quad (198)$$

13. Truncated Cone Source, Self-Absorbing, No Shield, Apex Point

$$\begin{aligned} \varphi_{P_1} &= \frac{S_v}{2\mu_s} \left\{ (1 - \cos \theta_0) U_3 + U_1 \left[\cos \theta_0 E_2[\mu_s \ell(1+\alpha_1) \sec \theta_0] - E_2[\mu_s \ell(1+\alpha_1)] \right] \right. \\ &\quad \left. + U_2 \left[\cos \theta_0 E_2[\mu_s \ell(1+\alpha_2) \sec \theta_0] - E_2[\mu_s \ell(1+\alpha_2)] \right] \right\} \end{aligned} \quad (199)$$

14. Spherical Source, Self-Absorbing, No Shield

$$\begin{aligned} \varphi_{P_1} &= \frac{S_v}{2\mu_s} \left[U_3 (1 - \cos \phi_0) - U_1 S[a/R, \mu_s (1+\alpha_1) R] \right. \\ &\quad \left. + U_2 S[a/R, \mu_s (1+\alpha_2) R] \right] \end{aligned} \quad (200)$$

$$\varphi_{P_2} = \frac{S_v}{2\mu_s} \left[U_3 - \left(\frac{U_1}{1+\alpha_1} \right) \left(\frac{1}{2\mu_s R} \right) \left(1 - e^{-2\mu_s R(1+\alpha_1)} \right) - \left(\frac{U_2}{1+\alpha_2} \right) \left(\frac{1}{2\mu_s R} \right) \left(1 - e^{-2\mu_s R(1+\alpha_2)} \right) \right] \quad (201)$$

$$\varphi_{P_4} = \frac{S_v}{\mu_s} \left[U_3 - U_1 e^{-\mu_s R(1+\alpha_1)} - U_2 e^{-\mu_s R(1+\alpha_2)} \right] \quad (202)$$

Define

$$K(\alpha) = \left\{ 1 - \frac{e^{-b_4(1+\alpha)}}{2} - \frac{e^{-b_5(1+\alpha)}}{2} - \frac{1}{4\mu_s A'(1+\alpha)} \left[e^{-b_4(1+\alpha)} [1 + b_4(1+\alpha)] - e^{-b_5(1+\alpha)} [1 + b_5(1+\alpha)] \right] + \frac{b_4 b_5 (1+\alpha)}{4\mu_s A'} \{ E_1[b_4(1+\alpha)] - E_1[b_5(1+\alpha)] \} \right\} \quad (203)$$

Then

$$\varphi_{P_3} = \frac{S_v}{\mu_s} [U_1 K(\alpha_1) + U_2 K(\alpha_2)] \quad (204)$$

15. Spherical Source, Self-Absorbing with Shield

$$\varphi_{P_1} = \frac{S_v}{2\mu_s} \left\{ U_1 S[(1+\alpha_1)b, a/R, \mu_s(1+\alpha_1)R] + U_2 S[(1+\alpha_2)b, a/R, \mu_s(1+\alpha_2)R] \right\} \quad (205)$$

16. Line Source with Shield

Define

$$\ddagger(\theta, \mu t) = \frac{S_L}{4\pi a} [A F(\theta, (1+\alpha_1)\mu t) + (1-A) F(\theta, (1+\alpha_2)\mu t)] \quad (206)$$

Then

$$\varphi_{P_1} = \Phi(\theta_1, \mu t)$$

$$\varphi_{P_3} = \Phi(\theta_2, \mu t) + \Phi(\theta_3, \mu t)$$

$$\varphi_{P_5} = \Phi(\theta_5, \mu t) - \Phi(\theta_4, \mu t)$$

All buildup is in the shield in this case.

Other total flux formulas may be easily found by the application of Equations (7), (8), and (9) to specific flux formulas.

F. Library Data

A limited amount of data useful in shielding calculations is given here. This data includes gamma-ray dose build-up factors and Taylor exponential coefficients for water, iron, and lead; gamma-ray dose rate conversion factor data, neutron removal cross section, and multiplier data for some selected shielding materials; macroscopic gamma-ray total attenuation and energy absorption data for common shielding materials; and information relative to activation gamma, capture gamma, and fission gamma sources. Nomograms for estimating the effect of a cylindrical versus a slab shield, taken directly from Reference (28), are also given.

The neutron removal cross section data come from Reference (10). The gamma-ray dose conversion factors come from References (10) and (29). The gamma-ray build-up factor data come from References (11) and (29). The gamma-ray cross section data is taken from References (2) and (29) and from the work of W. D. Brown*. The information on activation gamma, capture gamma, and fission gamma sources was obtained from References (10), (30), (31), (32), and (33).

* Much of this information was obtained from Mr. W. D. Brown, Aerospace Group, Boeing Aircraft Company.

1. Taylor Exponential Coefficients for Gamma-Ray Build-Up Factors for Water, Iron and Lead

TABLE 17
GAMMA-RAY DOSE BUILD-UP FACTORS FOR WATER

Energy (Mev)	b(mfp)								A	ALPHA1	ALPHA2	Type *	Error Magnitudes Greater than 5% Paired with Corresponding b values (% Error, b(mfp))
	0.	1.00	2.00	4.00	7.00	10.00	15.00	20.00					
.25	1.00	3.09	7.14	23.00	72.90	166.00	456.00	982.00	1.335	0.6924	0.0835	C	
.50	1.00	2.46	4.91	12.90	32.80	63.10	141.00	252.00	0.983	0.4805	0.0052	C	
.60	1.00	2.39	4.67	11.86	29.48	55.90	122.88	218.04	0.995	0.4095	0.0042	C	
.70	1.00	2.33	4.43	10.81	26.16	48.70	104.76	184.08	1.001	0.3386	0.0036	C	
.80	1.00	2.26	4.19	9.77	22.84	41.50	86.64	150.12	1.004	0.2845	0.0021	C	
.90	1.00	2.20	3.95	8.72	19.52	34.30	68.52	116.16	1.002	0.2215	0.0010	C	
1.00	1.00	2.13	3.71	7.68	16.20	27.10	50.40	82.20	1.048	0.1575	0.00	C	
1.25	1.00	2.05	3.47	6.98	14.26	23.42	42.67	68.57	1.007	0.1241	0.0	C	
1.50	1.00	1.98	3.24	6.28	12.33	19.75	34.95	54.95	0.966	0.0907	0.0	C	
1.75	1.00	1.90	3.00	5.58	10.39	16.07	27.22	41.32	0.926	0.0574	0.0	C	
2.00	1.00	1.83	2.77	4.88	8.46	12.40	19.50	27.70	13.369	-0.0521	0.0166	T	
2.20	1.00	1.80	2.70	4.69	8.01	11.65	18.16	25.56	12.917	-0.0488	0.0197	T	
2.50	1.00	1.76	2.59	4.39	7.34	10.51	16.15	22.35	12.239	-0.0438	0.0243	T	
2.75	1.00	1.72	2.51	4.15	6.79	9.57	14.47	19.67	11.675	-0.0397	0.0282	T	
3.00	1.00	1.69	2.42	3.91	6.23	8.63	12.80	17.00	11.110	-0.0355	0.0321	T	
3.50	1.00	1.63	2.30	3.63	5.68	7.78	11.38	14.95	11.137	-0.0305	0.0312	T	None
4.00	1.00	1.58	2.17	3.34	5.13	6.94	9.97	12.90	11.163	-0.0254	0.0303	T	
4.50	1.00	1.55	2.10	3.19	4.84	6.50	9.25	11.89	10.469	-0.0236	0.0331	T	
5.00	1.00	1.52	2.04	3.05	4.56	6.06	8.53	10.87	9.774	-0.0218	0.0359	T	
5.50	1.00	1.49	1.97	2.91	4.28	5.62	7.81	9.86	9.079	-0.0200	0.0388	T	
6.00	1.00	1.46	1.91	2.76	3.99	5.18	7.09	8.85	8.385	-0.0182	0.0416	T	
6.30	1.00	1.45	1.88	2.71	3.89	5.04	6.88	8.56	7.822	-0.0194	0.0460	T	
6.50	1.00	1.44	1.87	2.67	3.83	4.95	6.73	8.37	7.447	-0.0202	0.0490	T	
7.00	1.00	1.42	1.82	2.58	3.66	4.71	6.37	7.90	6.510	-0.0223	0.0563	T	
7.50	1.00	1.40	1.78	2.49	3.50	4.48	6.02	7.42	5.572	-0.0243	0.0636	T	
7.65	1.00	1.39	1.77	2.46	3.45	4.41	5.91	7.28	5.291	-0.0249	0.0658	T	
8.00	1.00	1.38	1.74	2.40	3.34	4.25	5.66	6.95	4.635	-0.0263	0.0710	T	
8.50	1.00	1.37	1.71	2.35	3.25	4.12	5.47	6.71	4.362	-0.0272	0.0750	T	
9.00	1.00	1.35	1.69	2.29	3.16	3.98	5.28	6.46	4.090	-0.0281	0.0791	T	
9.50	1.00	1.34	1.66	2.24	3.06	3.85	5.09	6.22	3.817	-0.0290	0.0831	T	
10.00	1.00	1.33	1.63	2.19	2.97	3.72	4.90	5.98	3.545	-0.0299	0.0872	T	

* T signifies Taylor exponential fit coefficients: Build-up factor = $A \cdot \exp(-\alpha_1 \cdot b) + (1-A) \cdot \exp(-\alpha_2 \cdot b)$.
 C signifies cubic polynomial fit coefficients: Build-up factor = $1.0 + A \cdot b + \alpha_1 \cdot b^2 + \alpha_2 \cdot b^3$.

TABLE 18
 DETAILED EVALUATION OF TAYLOR EXPONENTIAL COEFFICIENT
 REPRESENTATION OF DOSE BUILD-UP FACTORS FOR WATER

DOSE BUILD-UP FACTORS

Energy (Mev)	b(mfp)												Coefficients				
	1.0	%	2.0	%	4.0	%	7.0	%	10.0	%	15.0	%	20.0	%	A	Alpha 1	Alpha 2
0.50	2.46		4.91		12.90		32.80		63.10		141.00		252.00				
1.00	2.13		3.71		7.68		16.20		27.10		50.40		82.20				
2.00	1.83		2.77		4.88		8.46		12.40		19.50		27.70				
3.00	1.69		2.42		3.91		6.23		8.68		12.80		17.00				
4.00	1.58		2.17		3.34		5.13		6.94		9.97		12.90				
6.00	1.46		1.91		2.76		3.99		5.18		7.09		8.85				
8.00	1.38		1.74		2.40		3.34		4.25		5.66		6.95				
10.00	1.33		1.63		2.19		2.97		3.72		4.90		5.98				

CALCULATED DOSE BUILD-UP FACTORS (WITH PERCENTAGE ERRORS) FOR MINIMUM ERRORS AT MIDDLE OF b-RANGE

0.50	3.31	34.5	6.12	24.67	13.60	5.5	31.17	-5.0	60.02	-4.8	150.82	7.0	339.86	34.86	98.81319	-0.11604	-0.09594
1.00	2.43	13.9	4.03	8.6	7.84	2.1	15.39	-5.0	25.74	-5.0	51.67	2.5	93.59	13.9	34.17618	-0.08059	-0.04255
2.00	1.92	4.9	2.87	3.7	4.90	0.3	8.25	-2.5	12.04	-2.9	19.59	0.4	29.06	4.9	13.36870	-0.05214	0.01662
3.00	1.72	1.8	2.45	1.0	3.91	0.0	6.17	-1.0	8.51	-1.4	12.67	-1.0	17.27	1.6	11.11000	-0.03550	0.03206
4.00	1.59	0.7	2.18	0.4	3.35	0.4	5.11	-0.3	6.89	-0.8	9.89	-0.8	13.01	0.9	11.16300	-0.02543	0.03025
6.00	1.46	-0.3	1.90	-0.5	2.77	0.2	4.01	0.4	5.19	0.2	7.06	-0.4	8.86	0.1	8.38500	-0.01820	0.04164
8.00	1.37	-0.5	1.73	-0.5	2.41	0.5	3.36	0.6	4.24	-0.2	5.63	-0.6	6.97	0.3	4.63500	-0.02633	0.07097
10.00	1.32	-0.7	1.63	-0.3	2.20	0.4	2.99	0.6	3.72	-0.1	4.86	-0.7	6.00	0.4	3.54500	-0.02991	0.08717

CALCULATED DOSE BUILD-UP FACTORS (WITH PERCENTAGE ERRORS) FOR MINIMUM ERRORS AT ENDS OF b-RANGE

0.50	2.73	11.2	4.85	-1.2	10.50	-19.0	23.60	-28.0	45.14	-28.4	112.80	-20.0	253.60	0.6	73.20000	-0.11604	-0.09594
0.50	2.55	3.8	4.44	-9.5	9.50	-26.7	21.20	-35.4	40.38	-36.0	100.70	-28.6	225.90	-10.4	65.00000	-0.11604	-0.09594
1.00	2.26	6.0	3.67	-1.0	7.00	-8.5	13.70	-15.6	22.80	-16.0	45.60	-9.5	82.4	0.3	30.00000	-0.08059	-0.04255

TABLE 19

GAMMA-RAY ENERGY ABSORPTION BUILD-UP FACTORS FOR WATER

Energy (Mev)	b(mfp)								A	ALPHA1	ALPHA2	Type *	Error Magnitudes Greater than 5% Paired with Corresponding b values (% Error, b(mfp))
	0.	1.00	2.00	4.00	7.00	10.00	15.00	20.00					
.25	1.00	3.03	6.88	21.80	68.10	154.00	421.00	906.00	1.323	0.6448	0.0759	C	
.50	1.00	2.44	4.81	12.50	31.30	59.60	130.00	232.00	1.025	0.4392	0.0047	C	
.60	1.00	2.37	4.57	11.52	28.14	52.80	113.34	200.06	.998	0.4009	0.0028	C	
.70	1.00	2.29	4.32	10.54	24.98	46.00	96.68	168.12	1.008	0.3332	0.0021	C	
.80	1.00	2.22	4.08	9.55	21.82	39.20	80.02	136.18	1.012	0.2656	0.0016	C	
.90	1.00	2.14	3.83	8.57	18.66	32.40	63.36	104.24	1.012	0.1980	0.0008	C	
1.00	1.00	2.07	3.59	7.59	15.50	25.60	46.70	72.30	1.035	0.1334	0.0	C	
1.25	1.00	2.01	3.40	6.94	13.79	22.42	40.02	61.37	0.972	0.1093	0.0	C	
1.50	1.00	1.96	3.20	6.29	12.08	19.25	33.35	50.45	0.938	0.0801	0.0	C	
1.75	1.00	1.91	3.01	5.64	10.38	16.07	26.67	39.52	0.928	0.0538	0.0	C	
2.00	1.00	1.85	2.82	4.99	8.67	12.90	20.00	28.60	22.082	-0.0421	.0006	T	
2.20	1.00	1.83	2.76	4.81	8.25	12.14	18.68	26.46	20.931	-0.0392	.0036	T	
2.50	1.00	1.80	2.67	4.54	7.62	11.01	16.70	23.25	19.204	-0.0347	.0101	T	
2.75	1.00	1.77	2.59	4.32	7.09	10.06	15.05	20.57	17.765	-0.0310	.0154	T	
3.00	1.00	1.74	2.52	4.10	6.57	9.12	13.40	17.90	16.326	-0.0273	.0208	T	
3.50	1.00	1.66	2.35	3.73	5.88	8.06	11.75	15.45	13.828	-0.0263	.0255	T	None
4.00	1.00	1.59	2.18	3.37	5.18	7.01	10.10	13.00	11.330	-0.0253	.0303	T	
4.50	1.00	1.56	2.11	3.22	4.88	6.55	9.34	11.96	10.067	-0.0255	.0368	T	
5.00	1.00	1.52	2.03	3.06	4.58	6.09	8.58	10.91	8.805	-0.0257	.0434	T	
5.50	1.00	1.49	1.96	2.91	4.28	5.64	7.83	9.87	7.543	-0.0259	.0500	T	
6.00	1.00	1.46	1.89	2.76	3.98	5.18	7.07	8.83	6.280	-0.0261	.0566	T	
6.30	1.00	1.45	1.87	2.71	3.89	5.04	6.86	8.56	5.985	-0.0266	.0599	T	
6.50	1.00	1.44	1.85	2.67	3.83	4.95	6.73	8.37	5.788	-0.0269	.0620	T	
7.00	1.00	1.42	1.81	2.59	3.67	4.73	6.38	7.91	5.297	-0.0276	.0675	T	
7.50	1.00	1.40	1.78	2.50	3.52	4.50	6.04	7.46	4.805	-0.0284	.0729	T	
7.65	1.00	1.39	1.77	2.48	3.47	4.44	5.94	7.32	4.658	-0.0286	.0746	T	
8.00	1.00	1.38	1.74	2.42	3.36	4.28	5.70	7.00	4.314	-0.0291	.0784	T	
8.50	1.00	1.36	1.70	2.35	3.24	4.11	5.46	6.69	4.138	-0.0288	.0788	T	
9.00	1.00	1.34	1.67	2.27	3.12	3.94	5.21	6.38	3.962	-0.0285	.0791	T	
9.50	1.00	1.33	1.63	2.20	3.00	3.77	4.97	6.07	3.786	-0.0282	.0795	T	
10.00	1.00	1.31	1.60	2.13	2.88	3.60	4.73	5.76	3.610	-0.0279	.0799	T	

* T signifies Taylor exponential fit coefficients: Build-up factor = $A \cdot \exp(-\alpha_1 b) + (1-A) \cdot \exp(-\alpha_2 b)$.
 C signifies cubic polynomial fit coefficients: Build-up factor = $1.0 + A \cdot b + \alpha_1 \cdot b^2 + \alpha_2 \cdot b^3$.

TABLE 20
GAMMA-RAY DOSE BUILD-UP FACTORS FOR IRON

Energy (Mev)	b(mfp)								A	ALPHA1	ALPHA2	Type*	Error Magnitudes Greater than 5% Paired with Corresponding b values (% Error, b(mfp))
	0.	1.00	2.00	4.00	7.00	10.00	15.00	20.00					
.25	1.00	2.06	3.22	6.40	12.85	21.73	42.17	69.22	48.63800	-.07220	-.05130	T	(6.1,2), (-5.1,10), (6.1,20)
.50	1.00	1.98	3.09	5.98	11.70	19.20	35.40	55.60	40.43700	-.06410	-.03940	T	(5.7,1), (6.8,2), (6.2,20)
.60	1.00	1.96	3.05	5.86	11.40	18.60	33.98	53.02	38.04000	-.06300	-.03680	T	(6.6,1), (7.6,2), (7.2,20)
.70	1.00	1.94	3.01	5.74	11.10	18.00	32.56	50.44	35.64300	-.06180	-.03410	T	(7.1,1), (7.9,2), (7.6,20)
.80	1.00	1.91	2.97	5.63	10.80	17.40	31.14	47.86	33.24600	-.06070	-.03140	T	(7.2,1), (7.7,2), (7.6,20)
.90	1.00	1.89	2.93	5.51	10.50	16.80	29.72	45.28	30.84800	-.05960	-.02880	T	(6.9,1), (7.0,2), (7.1,20)
1.00	1.00	1.87	2.89	5.39	10.20	16.20	28.30	42.70	28.45100	-.05840	-.02610	T	(6.2,1), (5.7,2), (6.0,20)
1.25	1.00	1.84	2.77	5.07	9.46	14.87	25.62	38.30	25.80500	-.05540	-.02100	T	(5.5,1), (6.7,2), (5.5,20)
1.50	1.00	1.81	2.66	4.76	8.72	13.55	22.95	33.90	23.16000	-.05230	-.01580	T	(6.9,2)
1.75	1.00	1.79	2.54	4.44	7.99	12.22	20.27	29.50	20.51400	-.04920	-.01060	T	
2.00	1.00	1.76	2.43	4.13	7.25	10.90	17.60	25.10	17.97400	-.04630	-.00570	T	
2.20	1.00	1.72	2.37	4.01	6.97	10.42	16.78	23.90	17.02300	-.04590	-.00470	T	
2.50	1.00	1.65	2.29	3.82	6.55	9.70	15.55	22.10	15.59600	-.04530	-.00330	T	
2.75	1.00	1.60	2.22	3.66	6.20	9.11	14.52	20.60	14.40700	-.04480	-.00210	T	
3.00	1.00	1.55	2.15	3.51	5.85	8.51	13.50	19.10	13.21800	-.04430	-.00090	T	
3.50	1.00	1.50	2.05	3.27	5.38	7.81	12.35	17.55	11.42100	-.04560	.00040	T	
4.00	1.00	1.45	1.94	3.03	4.91	7.11	11.20	16.00	9.62400	-.04700	.00180	T	
4.50	1.00	1.42	1.88	2.92	4.72	6.84	10.87	15.67	8.68500	-.05060	.00080	T	
5.00	1.00	1.40	1.83	2.80	4.52	6.56	10.54	15.35	8.13225	-.05149	-.00006	T	
5.50	1.00	1.37	1.77	2.69	4.33	6.29	10.22	15.02	6.80600	-.05790	-.00100	T	
6.00	1.00	1.34	1.72	2.58	4.14	6.02	9.89	14.70	5.86700	-.06150	-.00190	T	
6.30	1.00	1.33	1.70	2.53	4.04	5.88	9.68	14.44	5.47300	-.06350	.00160	T	
6.50	1.00	1.32	1.68	2.49	3.98	5.78	9.54	14.27	4.95045	-.06490	.00546	T	
7.00	1.00	1.30	1.64	2.41	3.81	5.54	9.19	13.85	4.32725	-.06820	.01018	T	
7.50	1.00	1.29	1.60	2.32	3.65	5.31	8.85	13.42	3.89900	-.07160	.00930	T	
7.65	1.00	1.28	1.59	2.29	3.60	5.24	8.74	13.30	3.33180	-.07623	.01978	T	
8.00	1.00	1.27	1.56	2.23	3.49	5.07	8.50	13.00	3.24300	-.07500	.02120	T	
8.50	1.00	1.25	1.52	2.16	3.36	4.89	8.26	12.85	2.58210	-.08505	.03087	T	
9.00	1.00	1.23	1.49	2.09	3.24	4.71	8.02	12.70	2.37025	-.08700	.02622	T	
9.50	1.00	1.22	1.45	2.02	3.11	4.53	7.78	12.55	2.12100	-.09300	.03300	T	
10.00	1.00	1.20	1.42	1.95	2.99	4.35	7.54	12.40	1.74700	-.09900	.06630	T	

* T signifies Taylor exponential fit coefficients: Build-up factor = $A \cdot \exp(-\alpha_1 \cdot b) + (1-A) \cdot \exp(-\alpha_2 \cdot b)$.

TABLE 21

Gamma-Ray Energy Absorption Build-Up Factors for Iron

Energy (Mev)	b(mfp)								A	ALPHA1	ALPHA2	Type*	Error Magnitudes Greater than 5% Paired with Corresponding b values (% Error, b(mfp))
	0.	1.00	2.00	4.00	7.00	10.00	15.00	20.00					
.25	1.00	3.47	6.21	13.27	28.42	49.57	98.82	166.71	66.013	-0.0813	-0.0447	T	(5.7,2), (5.8,20)
.50	1.00	2.80	4.84	9.97	20.40	34.20	64.30	101.00	44.303	-0.0720	-0.0302	T	(6.5,1), (6.8,2), (-5.1,10), (6.8,20)
.60	1.00	2.68	4.59	9.38	19.04	31.74	59.20	92.50	41.429	-0.0703	-0.0284	T	(6.6,1), (6.7,2), (-5.4,10), (5.8,20)
.70	1.00	2.56	4.34	8.78	17.68	29.28	54.10	84.00	38.555	-0.0687	-0.0266	T	(6.8,1), (6.7,2), (-5.7,10), (5.2,20)
.80	1.00	2.43	4.08	8.19	16.32	26.82	49.00	75.50	35.682	-0.0670	-0.0248	T	(6.9,1), (6.6,2), (-5.7,10), (5.1,20)
.90	1.00	2.31	3.83	7.59	14.96	24.36	43.90	67.00	32.808	-0.0653	-0.0230	T	(7.1,1), (6.5,2), (-5.5,10), (5.7,20)
1.00	1.00	2.19	3.58	7.00	13.60	21.90	38.80	58.50	29.934	-0.0637	-0.0212	T	(7.2,1), (6.5,2), (7.2,20)
1.25	1.00	2.09	3.34	6.38	12.18	19.40	33.92	50.72	28.247	-0.0582	-0.0174	T	(6.1,1), (5.4,2), (-6.4,10)
1.50	1.00	1.98	3.11	5.76	10.75	16.90	29.05	42.95	26.559	-0.0527	-0.0136	T	(5.3,1), (-6.7,10), (-5.9,15)
1.75	1.00	1.88	2.88	5.15	9.33	14.40	24.17	35.17	24.872	-0.0473	-0.0098	T	(5.2,10)
2.00	1.00	1.78	2.64	4.53	7.90	11.90	19.30	27.40	23.252	-0.0420	-0.0061	T	(5.5,2), (6.2,20)
2.20	1.00	1.74	2.55	4.35	7.53	11.28	18.24	25.88	21.281	-0.0425	-0.0047	T	
2.50	1.00	1.68	2.42	4.07	6.97	10.36	16.65	23.60	18.325	-0.0431	-0.0026	T	(5.6,2), (6.7,20)
2.75	1.00	1.63	2.32	3.84	6.51	9.59	15.32	21.70	15.861	-0.0437	-0.0008	T	(5.5,20)
3.00	1.00	1.58	2.21	3.61	6.05	8.82	14.00	19.80	13.398	-0.0442	0.0009	T	
3.50	1.00	1.52	2.08	3.32	5.47	7.96	12.55	18.25	11.330	-0.0469	0.0006	T	
4.00	1.00	1.45	1.95	3.03	4.90	7.10	11.10	16.70	9.261	-0.0495	0.0003	T	
4.50	1.00	1.41	1.87	2.87	4.61	6.66	10.49	15.70	8.209	-0.0522	0.0005	T	
5.00	1.00	1.38	1.79	2.70	4.31	6.22	9.88	14.70	7.157	-0.0550	0.0008	T	
5.50	1.00	1.34	1.71	2.54	4.02	5.79	9.28	13.70	6.104	-0.0577	0.0011	T	
6.00	1.00	1.30	1.63	2.38	3.73	5.35	8.67	12.70	5.052	-0.0604	0.0014	T	
6.30	1.00	1.29	1.60	2.32	3.62	5.18	8.40	12.35	4.875	-0.0611	-0.0007	T	
6.50	1.00	1.28	1.59	2.28	3.54	5.07	8.22	12.12	4.758	-0.0616	-0.0021	T	
7.00	1.00	1.25	1.54	2.18	3.36	4.79	7.78	11.55	4.464	-0.0627	-0.0055	T	
7.50	1.00	1.23	1.49	2.09	3.17	4.51	7.33	10.97	4.169	-0.0639	-0.0089	T	
7.65	1.00	1.23	1.48	2.06	3.12	4.43	7.20	10.80	4.081	-0.0642	-0.0100	T	
8.00	1.00	1.21	1.45	1.99	2.99	4.23	6.89	10.40	3.875	-0.0650	-0.0124	T	
8.50	1.00	1.20	1.42	1.94	2.89	4.09	6.71	10.27	3.682	-0.0677	-0.0177	T	
9.00	1.00	1.18	1.40	1.88	2.80	3.96	6.53	10.14	3.488	-0.0703	-0.0230	T	
9.50	1.00	1.17	1.38	1.83	2.70	3.82	6.35	10.02	3.295	-0.0730	-0.0283	T	
10.00	1.00	1.16	1.35	1.78	2.61	3.69	6.17	9.89	3.101	-0.0756	-0.0336	T	

*T signifies Taylor exponential fit coefficients: Build-up factor = $A \cdot \exp(-\alpha_1 \cdot b) + (1-A) \cdot \exp(-\alpha_2 \cdot b)$.

TABLE 22
GAMMA-RAY DOSE BUILD-UP FACTORS FOR LEAD

Energy (Mev)	b(mfp)								A	ALPHA1	ALPHA2	Type*	Error Magnitudes Greater than 5% Paired with Corresponding b values (% Error, b(mfp))
	0.	1.00	2.00	4.00	7.00	10.00	15.00	20.00					
.25	1.00	1.17	1.29	1.40	1.49	1.53	1.57	1.72	1.34200	-.01080	.64100	T	
.50	1.00	1.24	1.42	1.69	2.00	2.27	2.65	3.10	1.67700	-.03080	.30900	T	
.60	1.00	1.27	1.47	1.80	2.20	2.56	3.08	3.65	1.93800	-.03170	.27400	T	
.70	1.00	1.29	1.53	1.92	2.41	2.86	3.51	4.20	2.09000	-.03575	.21510	T	
.80	1.00	1.32	1.58	2.03	2.61	3.15	3.95	4.76	2.46100	-.03340	.15300	T	
.90	1.00	1.34	1.64	2.15	2.82	3.45	4.38	5.31	2.72300	-.03420	.16900	T	
1.00	1.00	1.37	1.69	2.26	3.02	3.74	4.81	5.86	2.98400	-.03500	.13400	T	
1.25	1.00	1.37	1.71	2.32	3.18	4.01	5.32	6.65	3.05150	-.04025	.12210	T	
1.50	1.00	1.38	1.72	2.38	3.34	4.29	5.84	7.43	4.00425	-.03490	.07480	T	
1.75	1.00	1.38	1.74	2.45	3.50	4.56	6.35	8.21	4.83000	-.03315	.05525	T	
2.00	1.00	1.39	1.76	2.51	3.66	4.84	6.87	9.00	5.42100	-.03480	.04300	T	
2.20	1.00	1.38	1.74	2.49	3.68	4.93	7.18	9.66	5.45300	-.03870	.03600	T	None
2.50	1.00	1.37	1.72	2.47	3.70	5.07	7.65	10.65	5.50000	-.04450	.02500	T	
2.75	1.00	1.35	1.70	2.45	3.73	5.19	8.05	11.47	5.54000	-.04940	.01500	T	
3.00	1.00	1.34	1.68	2.43	3.75	5.30	8.44	12.30	5.58000	-.05420	.00600	T	
3.50	1.00	1.30	1.62	2.34	3.68	5.37	9.12	14.30	4.73900	-.06940	-.00800	T	
4.00	1.00	1.27	1.56	2.25	3.61	5.44	9.80	16.30	3.89700	-.08470	-.02300	T	
4.50	1.00	1.25	1.52	2.18	3.54	5.50	10.80	20.40	2.36500	-.11360	-.03200	T	
5.00	1.00	1.23	1.48	2.11	3.47	5.56	11.80	24.50	1.47800	-.14140	-.01300	T	
5.50	1.00	1.20	1.44	2.04	3.41	5.63	12.80	28.60	1.35100	-.15510	-.07500	T	
6.00	1.00	1.18	1.40	1.97	3.34	5.69	13.80	32.70	.92600	-.17860	-.04600	T	
6.30	1.00	1.17	1.38	1.94	3.27	5.60	13.84	34.48	.84200	-.18730	-.04700	T	
6.50	1.00	1.17	1.37	1.91	3.23	5.53	13.87	35.67	.74670	-.19320	-.04410	T	
7.00	1.00	1.16	1.35	1.85	3.11	5.38	13.95	38.65	.58230	-.20780	-.04845	T	
7.50	1.00	1.15	1.32	1.80	3.00	5.22	14.02	41.62	.45720	-.22230	-.05130	T	
7.65	1.00	1.15	1.32	1.78	2.97	5.18	14.05	42.52	.34950	-.23803	-.07700	T	
8.00	1.00	1.14	1.30	1.74	2.89	5.07	14.10	44.60	.36800	-.23690	-.05600	T	
8.50	1.00	1.13	1.28	1.70	2.80	4.89	13.70	43.25	.35400	-.23770	-.04900	T	
9.00	1.00	1.13	1.26	1.66	2.70	4.70	13.30	41.90	.34000	-.23860	-.04200	T	
9.50	1.00	1.12	1.25	1.62	2.61	4.52	12.90	40.55	.32500	-.23940	-.03500	T	
10.00	1.00	1.11	1.23	1.58	2.52	4.34	12.50	39.20	.31100	-.24020	-.02700	T	

* T signifies Taylor exponential fit coefficients: Build-up factor = $A \cdot \exp(-\alpha_1 \cdot b) + (1-A) \cdot \exp(-\alpha_2 \cdot b)$.

TABLE 23

GAMMA-RAY ENERGY ABSORPTION BUILD-UP FACTORS FOR LEAD

Energy (Mev)	b(mfp)								A	ALPHA1	ALPHA2	Type*	Error Magnitudes Greater than 5% Paired with Corresponding b values (% Error, b(mfp))
	0.	1.00	2.00	4.00	7.00	10.00	15.00	20.00					
.25	1.00	1.38	1.51	1.59	1.55	1.51	1.55	1.60	1.644	0.0024	0.906	T	
.50	1.00	1.51	1.80	2.19	2.61	3.01	3.52	4.30	2.030	-0.0374	0.5064	T	
.60	1.00	1.56	1.91	2.43	3.04	3.61	4.37	5.38	2.462	-0.0384	0.4424	T	(7.4,2), (7.9,4)
.70	1.00	1.61	2.03	2.67	3.46	4.21	5.22	6.46	2.750	-0.0415	0.2838	T	
.80	1.00	1.66	2.14	2.91	3.89	4.81	6.08	7.54	3.161	-0.0425	0.2358	T	
.90	1.00	1.71	2.26	3.15	4.31	5.41	6.93	8.62	3.760	-0.0415	0.2504	T	(7.0,2), (8.8,4), (5.5,7)
1.00	1.00	1.76	2.37	3.39	4.74	6.01	7.78	9.70	4.192	-0.0426	0.1864	T	
1.25	1.00	1.71	2.30	3.33	4.73	6.09	8.10	10.27	4.775	-0.0413	0.1536	T	(7.9,4), (7.6,7), (5.2,10)
1.50	1.00	1.67	2.23	3.27	4.72	6.16	8.41	10.85	4.555	-0.0440	0.1267	T	
1.75	1.00	1.62	2.17	3.20	4.71	6.24	8.73	11.42	4.456	-0.0437	0.1143	T	
2.00	1.00	1.58	2.10	3.14	4.70	6.32	9.05	12.00	6.502	-0.0375	0.0563	T	
2.20	1.00	1.54	2.03	3.01	4.53	6.14	8.97	12.12	6.640	-0.0396	0.0451	T	
2.50	1.00	1.47	1.91	2.82	4.27	5.88	8.85	12.30	6.848	-0.0427	0.0282	T	
2.75	1.00	1.42	1.82	2.66	4.06	5.65	8.75	12.45	7.021	-0.0454	0.0141	T	
3.00	1.00	1.37	1.73	2.50	3.85	5.43	8.65	12.60	7.194	-0.0480	0.0	T	
3.50	1.00	1.30	1.61	2.29	3.55	5.11	8.55	13.25	4.132	-0.0694	0.0	T	
4.00	1.00	1.24	1.49	2.09	3.25	4.79	8.46	13.90	2.529	-0.0909	0.0	T	
4.50	1.00	1.21	1.44	1.99	3.09	4.64	8.71	15.80	1.672	-0.1152	0.0058	T	
5.00	1.00	1.19	1.39	1.89	2.94	4.49	8.96	17.70	1.237	-0.1348	0.0267	T	
5.50	1.00	1.16	1.34	1.80	2.78	4.35	9.21	19.60	1.029	-0.1472	0.0172	T	
6.00	1.00	1.14	1.29	1.70	2.63	4.20	9.46	21.50	0.772	-0.1660	0.0382	T	
6.30	1.00	1.13	1.28	1.67	2.57	4.09	9.33	21.72	0.713	-0.1716	0.0325	T	
6.50	1.00	1.13	1.27	1.65	2.52	4.02	9.24	21.87	0.674	-0.1754	0.0287	T	
7.00	1.00	1.12	1.25	1.60	2.42	3.85	9.03	22.25	0.576	-0.1847	0.0191	T	(5.5,15), (5.5,20)
7.50	1.00	1.11	1.23	1.55	2.31	3.67	8.81	22.62	0.479	-0.1941	0.0096	T	
7.65	1.00	1.11	1.22	1.53	2.28	3.62	8.75	22.74	0.449	-0.1969	0.0067	T	
8.00	1.00	1.10	1.21	1.50	2.21	3.50	8.60	23.00	0.381	-0.2035	0.	T	
8.50	1.00	1.09	1.20	1.47	2.14	3.35	8.24	22.35	0.329	-0.2113	-0.0079	T	
9.00	1.00	1.09	1.18	1.44	2.06	3.21	7.88	21.70	0.276	-0.2192	-0.0158	T	(5.6,15), (6.6,20)
9.50	1.00	1.08	1.17	1.41	1.99	3.06	7.51	21.05	0.224	-0.2271	-0.0236	T	(5.6,20)
10.00	1.00	1.08	1.16	1.38	1.92	2.92	7.15	20.40	0.171	-0.2350	-0.0315	T	

*T signifies Taylor exponential fit coefficients: Build-up factor = $A \cdot \exp(-\alpha_1 \cdot b) + (1-A) \cdot \exp(-\alpha_2 \cdot b)$.

2. Gamma-Ray Dose Rate Conversion Factors

TABLE 24

GAMMA-RAY DOSE-RATE CONVERSION FACTORS

These factors convert flux in gamma/cm²-sec into dose rate in millirem/hr.

ENERGY (MEV)	GAMMA-RAY DOSE CONVERSION FACTORS
.100	.000160
.200	.000371
.300	.000596
.400	.000815
.500	.001022
.600	.001222
.700	.001410
.800	.001593
1.000	.001923
1.250	.002294
1.500	.002652
1.750	.002971
2.000	.003272
2.200	.003500
2.500	.003840
2.750	.004103
3.000	.004359
3.500	.004854
4.000	.005332
4.500	.005814
5.000	.006265
5.500	.006732
6.000	.007176
6.500	.007612
7.000	.008050
7.500	.008482
8.000	.008912
8.500	.009350
9.000	.009801
10.000	.010710

3. Neutron Removal Cross Section Kernels

Data for three neutron point kernels are given in Table 25. These three kernels give fast neutron dose rate, thermal neutron flux in low temperature water ($60^{\circ}\text{F} \leq T \leq 180^{\circ}\text{F}$), and thermal neutron flux in high temperature water ($450^{\circ}\text{F} \leq T \leq 650^{\circ}\text{F}$), respectively. More information on the fast neutron dose rate kernel is given below.

For these kernels, the point kernel equation is analogous to Equation (1) but has N terms, and the macroscopic total gamma attenuation coefficients μ_i are replaced by macroscopic neutron removal coefficients Σ_{r_i} :

$$D(\vec{r}) = \frac{S(\vec{r}') \sum_{i=1}^N A_i e^{-\Sigma_{r_i} t}}{4\pi |\vec{r} - \vec{r}'|^2} \quad (207)$$

The multipliers A_i are empirical numbers found by fitting a linear combination of single exponentials to the experimental fast neutron dose rate distribution in pure water, the experimental thermal neutron flux in water at 68°F , and the theoretical neutron flux in water at about 555°F . For the fast neutron dose rate kernel, the multipliers A_i contain dose conversion factors implicitly.

$N=3$ for the fast neutron dose rate kernel and the kernel for thermal neutron flux in high temperature water. $N=2$ for the thermal neutron flux in low temperature water kernel.

These data are also discussed in Reference (34), which gives a bibliography of the sources of these data. Reference (10) gives much the same discussion and bibliography. See also Reference (9).

Microscopic removal cross section data σ_i is given in Table 25; the units are barns/atom for elements and cm^2/gm for mixtures. To find the corresponding macroscopic removal coefficients these data must be multiplied by number density (atoms/barn-cm) for elements or by physical density (gm/cm^3) for mixtures. That is

$$\Sigma_{r_i} = \sigma_{r_i} \times \text{Number Density for elements and}$$

$$\Sigma_{r_i} = \sigma_{r_i} \times \text{Physical Density for mixtures.}$$

Number density information is given in Table 26.

The use of these kernels is valid only in problems with uniform shields, and, in general, at least fifteen centimeters of hydrogenous material must lie between the last non-hydrogenous shielding material and the detector points.

The most useful of these kernels is the fast neutron dose rate kernel, which may be used to find the biological dose rate (mrem/hr) in all water medium due to neutrons with energies greater than 1 ev. Neutrons with energies greater than about 0.3 MeV contribute over 90% of this dose rate. In practical applications, the effect of the non-hydrogenous materials such as the iron and/or lead within a hydrogenous shield is taken into account by the use of removal cross sections. These cross sections are empirical parameters describing the apparent exponential attenuation observed for the non-hydrogenous material in a water shield.

Most removal cross sections have been derived from measurements in the Lid Tank Shielding Facility at Oak Ridge National Laboratory. These values were derived from thermal neutron measurements made behind samples followed by a thickness of water (usually no less than 100 cm). This thickness is chosen large enough so that the neutron spectra at the point of measurement can be assumed to be essentially the same with or without the sample, and therefore the thermal neutron flux can be taken as a measure of the fast neutron dose rate. Strictly speaking, the resulting removal cross sections should be limited in applicability to situations comparable to those from which they were derived, i.e., 100 cm of water following the material. It is observed, however, that the thermal neutron flux curve becomes parallel to the all water curve at about 30 cm beyond the iron (Reference (1), p. 76) implying that neutron spectral equilibrium has been regained. Therefore, in actual practice, the removal cross sections could be used when at least 30 cm of hydrogenous material follows the non-hydrogenous material. The spectrum of the higher energy neutrons, which dictate the fast neutron dose rate, probably approaches the equilibrium water shape even more rapidly, i.e., in less than 30 cm.

A distance of 15 cm of hydrogenous material following non-hydrogenous material has therefore been used as a minimum for which full credit for removal cross sections can be taken in fast neutron dose rate calculations.

The variation of the fast neutron dose rate removal cross sections for iron and lead as the thickness of the hydrogenous material changes is shown in Figure 46, which is taken from Reference (9). Reference (9) also gives an equation and associated empirical constants which give a good fit of the curves of Figure 9. This equation and the constants are given in the footnote to Table 25.

TABLE 25

MICROSCOPIC NEUTRON REMOVAL CROSS SECTIONS AND MULTIPLIERS
(From Reference (10))

Material Name	Fast Neutron Dose Rate Kernel* Microscopic Removal Coefficients			Thermal Neutron Flux in Low Temp. Water Kernel Microscopic Removal Coefficients		Thermal Neutron Flux in High Temperature Water Kernel Microscopic Removal Coefficients		
	σ_{r_1}	σ_{r_2}	σ_{r_3}	σ_{r_1}	σ_{r_2}	σ_{r_1}	σ_{r_2}	σ_{r_3}
Hydrogen	.9720	1.9000	3.7420	1.8360	.9290	1.1770	2.3600	3.6850
Carbon (Graphite)	.8100	.8100	.8100	.8100	.8100	.8100	.8100	.8100
Standard Water	2.9340	4.7900	8.4730	4.6620	2.8470	3.3440	5.7100	8.3590
Oxygen	.9900	.9900	.9900	.9900	.9900	.9900	.9900	.9900
Ordinary Concrete	.0397	.0397	.0397	.0397	.0397	.0397	.0397	.0397
Aluminum	1.3100	1.3100	1.3100	1.3100	1.3100	1.3100	1.3100	1.3100
Chromium	1.8300	1.8300	1.8300	1.8300	1.8300	1.8300	1.8300	1.8300
Iron	1.9800	1.9800	1.9800	1.9800	1.9800	1.9800	1.9800	1.9800
Nickel	1.8900	1.8900	1.8900	1.8900	1.8900	1.8900	1.8900	1.8900
Zirconium	2.3200	2.3200	2.3200	2.3200	2.3200	2.3200	2.3200	2.3200
Tin (White)	2.5800	2.5800	2.5800	2.5800	2.5800	2.5800	2.5800	2.5800
Tungsten	3.1300	3.1300	3.1300	3.1300	3.1300	3.1300	3.1300	3.1300
Lead	3.5300	3.5300	3.5300	3.5300	3.5300	3.5300	3.5300	3.5300
Uranium	3.6000	3.6000	3.6000	3.6000	3.6000	3.6000	3.6000	3.6000
	A_1	A_2	A_3	A_1	A_2	A_1	A_2	A_3
Multipliers	.0316	.2210	-.1275	17.2000	.3570	2.8300	59.5000	-117.0000

* For this kernel, if less than 15 cm of hydrogenous material lies between the detector point and the last non-hydrogenous shields, the removal coefficients for that material intervening between the source and the detector point and lying closest to the detector point may be decremented to allow for the changed neutron spectrum. The decremented value is given by

$$\sigma_i(t) = \sigma_{r_i} (1 - be^{-ct})$$

where t is the actual distance through the hydrogenous material, given in cm, and b and c are equal to 0.6968 and 0.125 respectively for iron and to 0.7830 and 0.0931 respectively for lead. Plots of $\rho\sigma_{r_i}(t)$ for iron and lead are given in Figure 46. See Reference (9).

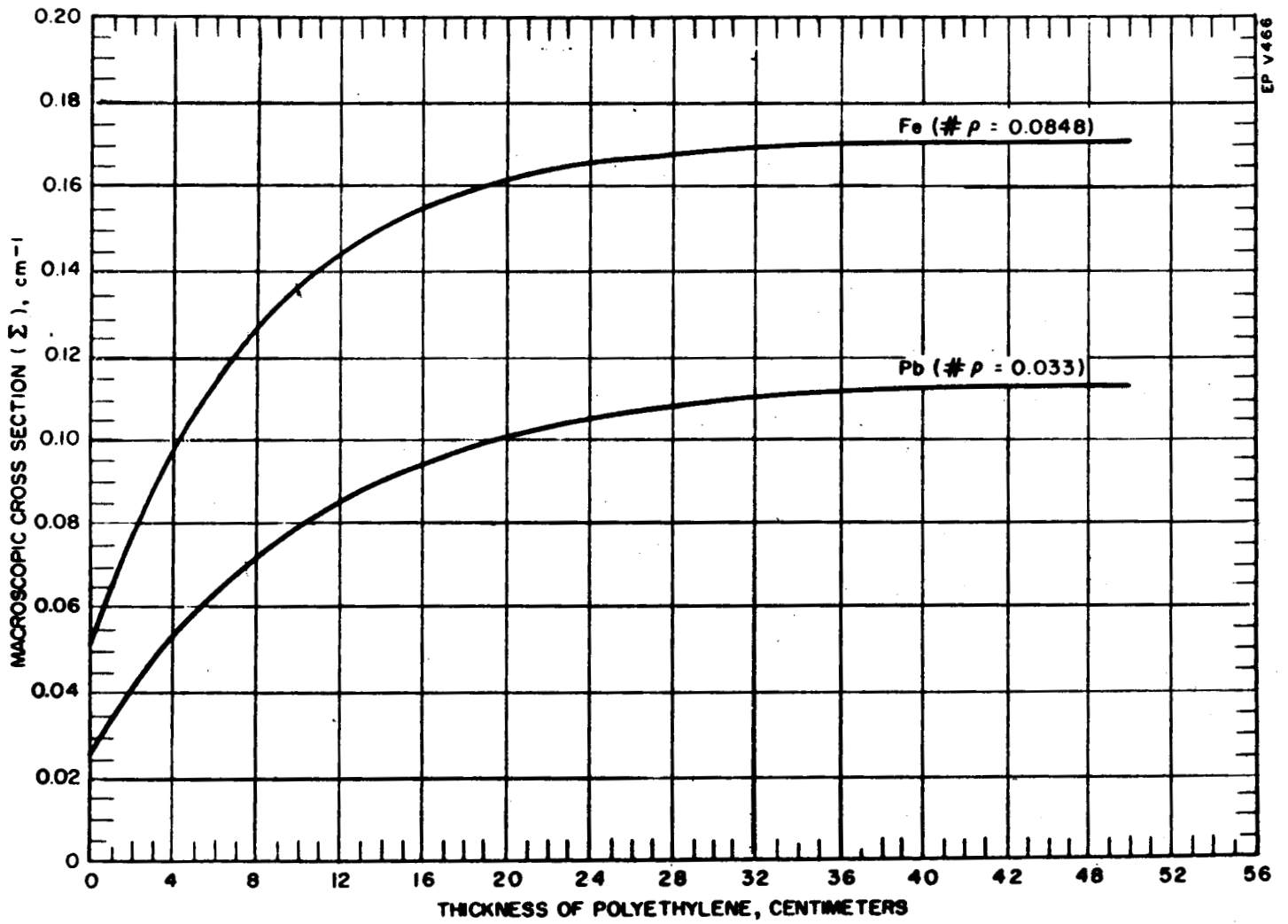


FIGURE 46

EFFECTIVE MACROSCOPIC FAST NEUTRON DOSE RATE REMOVAL CROSS SECTION AS A FUNCTION OF THICKNESS OF HYDROGENEOUS MATERIAL (POLYETHYLENE) INTERVENING BETWEEN IRON OR LEAD SHIELD AND THE DETECTOR POINT

5. Gamma-Ray Cross Section Data for Some Common Shielding Materials
(Based on the following number densities.)

TABLE 26

Nominal Number Densities of Common Shielding Materials

<u>Name</u>	<u>Nominal Number Density</u>
Standard Water	.333700-01 molecules/barn-cm
Water, 158°F, 14.7 psia	.326900-01 molecules/barn-cm
Iron	.849200-01 atoms/barn-cm
Zirconium	.431200-01 atoms/barn-cm
Lead	.329900-01 atoms/barn-cm
Uranium	.479500-01 atoms/barn-cm
Hydrogen	.537100-04 atoms/barn-cm
Carbon (Graphite)	.112800+00 atoms/barn-cm
Oxygen	.537900-04 atoms/barn-cm
Ordinary Concrete *	.233900+01 gm/cm ²
Aluminum	.602500-01 atoms/barn-cm
Chromium	.831700-01 atoms/barn-cm
Nickel	.913200-01 atoms/barn-cm
Tin	.371000-01 atoms/barn-cm
Tungsten	.632300-01 atoms/barn-cm

* Concrete number density varies greatly according to the exact mix. This number density assumes the following composition:

<u>Element</u>	<u>Partial Number Density in gm/cm²</u>
H	0.013
O	1.165
Na	0.040
Mg	0.006
Al	0.107
Si	0.737
S	0.003

TABLE 27
 GAMMA-RAY NOMINAL MACROSCOPIC ATTENUATION COEFFICIENTS*
 Units are cm⁻¹

Energies Mev	Standard Water	Water 158°F 14.7 psia	Iron	Zirconium	Lead	Uranium
100000+00	1674173+00	1640958+00	2694512+01	5941936+01	6376967+02	1085108+03
200000+00	1360495+00	1333503+00	1094619+01	1361730+01	1099557+02	2331329+02
300000+00	1182967+00	1159497+00	8429159+00	8093624+00	4367876+01	9172835+01
400000+00	1055827+00	1034880+00	7255565+00	6390384+00	2507900+01	5173805+01
500000+00	9643930-01	9452598-01	6530348+00	5480552+00	1747810+01	3506104+01
600000+00	8913127-01	8736293-01	5994503+00	4911368+00	1361827+01	2653553+01
700000+00	8319141-01	8154092-01	5572450+00	4506040+00	1121990+01	2138570+01
800000+00	7821928-01	7666743-01	5231072+00	4206356+00	9715555+00	1824977+01
100000+01	7037753-01	6898107-01	4695227+00	3744972+00	7818630+00	1428910+01
125000+01	6296919-01	6171990-01	4193350+00	3330158+00	6462741+00	1153197+01
150000+01	5736303-01	5622497-01	3828194+00	3043410+00	5776549+00	1019417+01
175000+01	5282471-01	5177668-01	3553902+00	2837296+00	5337782+00	9335865+00
200000+01	4918738-01	4821152-01	3347546+00	2691119+00	5106852+00	8909110+00
225000+01	4612846-01	4521329-01	3180396+00	2576923+00	4930905+00	8590242+00
275000+01	4134543-01	4052515-01	2932288+00	2420757+00	4743962+00	8285760+00
300000+01	3951008-01	3872621-01	2843971+00	2370738+00	4710972+00	8242605+00
350000+01	3637330-01	3565167-01	2704702+00	2296140+00	4674683+00	8189860+00
400000+01	3393729-01	3326399-01	2607893+00	2253451+00	4697776+00	8223425+00
450000+01	3192842-01	3129497-01	2534862+00	2228010+00	4747261+00	8295350+00
500000+01	3025992-01	2965957-01	2481362+00	2214212+00	4813241+00	8396045+00
550000+01	2882834-01	2825640-01	2440601+00	2204294+00	4875922+00	8506330+00
600000+01	2761034-01	2706256-01	2410879+00	2201276+00	4948500+00	8621410+00
650000+01	2656586-01	2603880-01	2388800+00	2203863+00	5027676+00	8746080+00
700000+01	2567154-01	2516223-01	2373514+00	2212056+00	5113450+00	8870750+00
750000+01	2489068-01	2439686-01	2362474+00	2224561+00	5205822+00	8990625+00
800000+01	2420326-01	2372308-01	2355681+00	2240084+00	5298194+00	9115295+00
850000+01	2359593-01	2312779-01	2351435+00	2256901+00	5393865+00	9239965+00
900000+01	2305533-01	2259792-01	2349736+00	2272855+00	5482938+00	9369430+00
950000+01	2259816-01	2214982-01	2352709+00	2282773+00	5555516+00	9508485+00
100000+02	2214099-01	2170172-01	2355681+00	2292690+00	5628094+00	9647540+00

*The nominal number densities of Table 26 were used to obtain these macroscopic cross sections. The corresponding microscopic cross sections may be found by dividing by the appropriate number density.

TABLE 28
**GAMMA-RAY NOMINAL MACROSCOPIC *
 ENERGY ABSORPTION COEFFICIENTS**

(The entries in this table may be used to convert gamma flux, which has units of $\frac{1}{\text{cm}^2 \cdot \text{sec}}$, to energy absorption rate in watts/cm³.)

Energies Mev	Standard Water	Water 150°F 14.7 psia	Iron	Zirconium	Lead
100000+00	4087825-15	4006724-15	2814249-13	8348032-13	1001576-11
200000+00	9480417-15	9292329-15	1256816-13	2605310-13	3246876-12
300000+00	1531016-14	1500641-14	1295030-13	1773526-13	1767274-12
400000+00	2093300-14	2051770-14	1554885-13	1677799-13	1228878-12
500000+00	2636897-14	2584582-14	1861446-13	1752397-13	9817824-13
600000+00	3149461-14	3086976-14	2173103-13	1914097-13	8640081-13
700000+00	3637330-14	3565167-14	2478815-13	2103394-13	7930796-13
800000+00	4101173-14	4019807-14	2776035-13	2313819-13	7637185-13
100000+01	4965456-14	4866943-14	3331412-13	2727771-13	7399657-13
125000+01	5933186-14	5815473-14	3977653-13	3220633-13	7541514-13
150000+01	6807480-14	6672422-14	4600116-13	3718238-13	8263995-13
175000+01	7635056-14	7483579-14	5235318-13	4251632-13	9167921-13
200000+01	8415914-14	8248945-14	5880710-13	4820816-13	1039845-12
225000+01	9146717-14	8965249-14	6525536-13	5414435-13	1168891-12
275000+01	1051822-13	1030955-13	7841513-13	6679288-13	1464756-12
300000+01	1116894-13	1094735-13	8517476-13	7356272-13	1630696-12
350000+01	1244034-13	1219352-13	9910164-13	8761984-13	1978080-12
400000+01	1366168-13	1339063-13	1135380-12	1025825-12	2356146-12
450000+01	1483964-13	1454523-13	1284840-12	1183213-12	2757964-12
500000+01	1598757-13	1567038-13	1438545-12	1346206-12	3181556-12
550000+01	1711547-13	1677591-13	1595647-12	1511787-12	3622302-12
600000+01	1822336-13	1786181-13	1756995-12	1682542-12	4080863-12
650000+01	1931789-13	1893463-13	1922589-12	1858903-12	4555919-12
700000+01	2039241-13	1998783-13	2094127-12	2042163-12	5050769-12
750000+01	2145024-13	2102467-13	2271610-12	2232322-12	5565413-12
800000+01	2249472-13	2204843-13	2453339-12	2428518-12	6093253-12
850000+01	2353586-13	2306892-13	2639314-12	2629026-12	6637588-12
900000+01	2458368-13	2409595-13	2827836-12	2832122-12	7191820-12
950000+01	2569323-13	2518349-13	3016783-12	3029396-12	7749351-12
100000+02	2680278-13	2627103-13	3205730-12	3226670-12	8306882-12

* The nominal number densities of Table 26 were used to obtain these macroscopic energy absorption coefficients. The corresponding microscopic energy absorption coefficients may be found by dividing by the appropriate number density.

6. Nomograms for Estimating the Effects of Slab Shields Versus Cylindrical Shields

These nomograms come directly from the work of J. W. Langhaar reported in Reference (28).

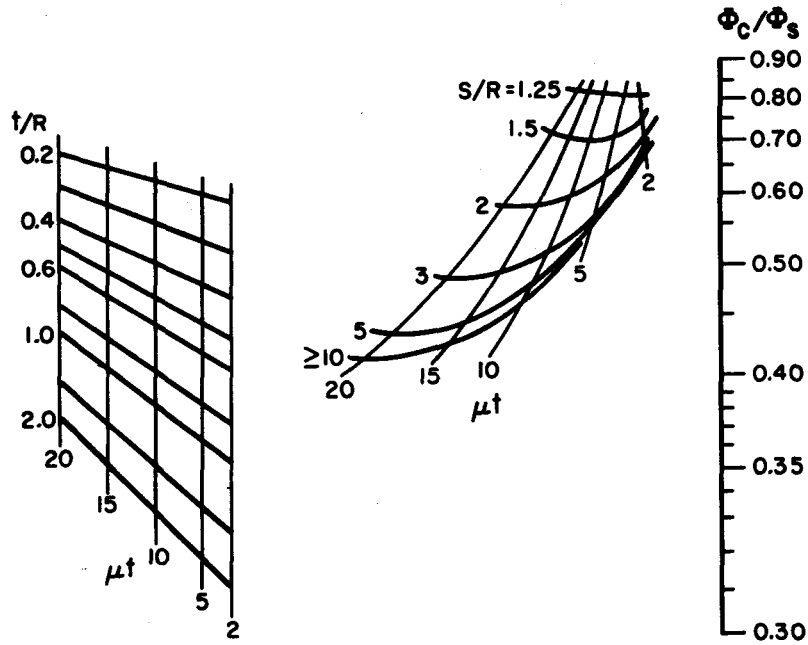


FIGURE 47. CYLINDRICAL VS FLAT SLAB SHIELD FOR $l/R \geq 2$ AND $\mu_s R \geq 4$ (FOR $\mu_s R < 4$, MULTIPLY THIS FACTOR BY FACTOR FROM FIGURE 47.)

Φ_c/Φ_s is ratio of uncollided flux for cylindrical shield to that for flat slab shield of thickness t and attenuation μ .

The cylindrical source is homogeneous and has radius R and length l . $S = a+R$ is distance from axis. For a cylindrical shield, negligible gap between source and shield is assumed. See Figures 9 and 10.

Key: From point in $(\mu t, t/R)$ grid, project straight line through point in $(\mu t, s/R)$ grid to Φ_c/Φ_s scale.

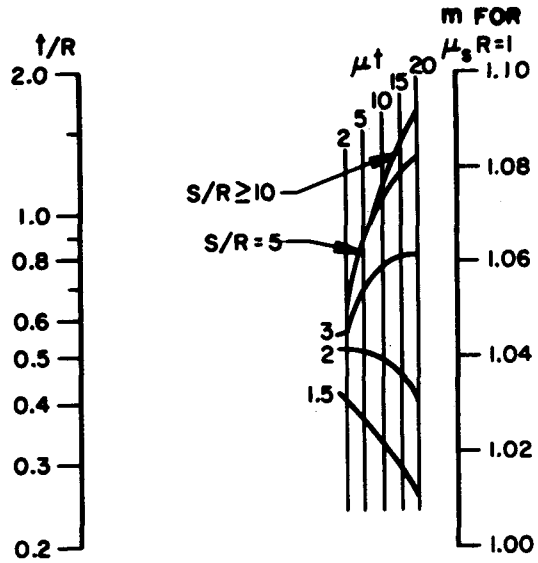


FIGURE 48. CYLINDRICAL VS FLAT SLAB SHIELD:
ADDITIONAL FACTOR FOR $\mu_s R < 4$

When $\mu_s R < 4$, value of ϕ_c / ϕ_s from Figure 46 should be multiplied by m , which for $\mu_s R = 1$ is given by Figure 47.

For $\mu_s R = 2$, m is about midway between unity and value for $\mu_s R = 1$.

Key: From t/R scale, project straight line through proper point in $(\mu t, s/R)$ grid to scale for m .

7. Activation, Capture and Fission Gamma Sources

The nominal number densities given in Tables 29 and 30 must almost always be replaced by partial number densities reflecting the actual abundance of the nuclides of interest when the source data from these tables is used in practical problems. Section A.3 discusses the use and units of these types of source data. The data given in Table 31 assume that the source strength will be given in fissions/cm³-sec. The data of Tables 29 and 30 assume that the source strength will be given in terms of thermal neutron flux.

TABLE 29
ACTIVATION GAMMA SOURCES

NAME	ACTIVATION CROSS SECTION.	HALF-LIFE HOURS	NOMINAL NUCLIDE NUMBER DENSITY	ENERGY MEV.	YIELD GAMMAS/DECAY
MN55 (N,GAM) MN56	13,3000	2576000*01	8157000-01	.8470 1,8110 2,1100	99000000+00 29000000+00 15000000+00
CO59 (N,GAM) CO60	37,2000	4597757*05	9096000-01	1,1730 1,3320	10000000+01 10000000+01
FE58 (N,GAM) FE59	1,2000	1094400*04	2800000-03	1,0950 1,2920	56000000+00 44000000+00
NA23 (N,GAM) NA24	,5340	1496000+02	2544000-01	1,3690 2,7540	10000000+01 10000000+01
ZR94 (N,GAM) ZR-NB95	,0750	1572000*04	7500000-02	,7240 ,7560 ,7650	49000000+00 49000000+00 10000000+01
HF174(N,GAM) HF175	390,0000	1680000+04	8000000-04	,3430	85000000+00
HF180(N,GAM) HF181	12,6000	1020000*04	1580000-01	,3460 ,4820	13000000+00 81000000+00
FE54 (N,P) MN54	1,0000	7536000+04	4940000-02	,8350	10000000+01
TA181(N,GAM) TA182	21,0000	2762400*04	5525000-01	1,1200 1,2200	34000000+00 10000000+01
NI58 (N,P) CO58	1,0000	1711200*04	6199000-01	,5100 ,8100 ,8650 1,6700	30000000+00 99000000+00 14000000+01 60000000+02

TABLE 30
CAPTURE GAMMA SOURCES

NAME		ABSORPTION CROSS SECTION,	DENSITY GM/CC	NOMINAL NUCLIDE NUMBER DENSITY	ENERGY MEV.	YIELD GAMMAS/CAPTURE
HYDROGEN	CAPTURE	.3300	8988000=03	5371000-04	2.2000	10000000+01
IRON	CAPTURE	2.5300	7874000+01	8492000-01	1.0000	18500000+01
					7.0000	86000000+00
ZIRCONIUM	CAPTURE	.1800	6530000+01	4312000-01	1.0000	70000000+00
					5.0000	14200000+01
URANIUM	CAPTURE	7.6800	1895000+02	4795000-01	.7000	36300000+01
					2.5000	12000000+01
WATER	CAPTURE	.6602	9980000+00	3337000-01	2.2000	10000000+01
STAINLESS STEEL CAPT		.0332	7900000+01	7900000+01	1.0000	16900000+01
					7.0000	93000000+00
INCONEL	CAPTURE	.0462	8510000+01	8510000+01	.5000	20000000+01
					5.5000	15100000+01
HAFNIUM	CAPTURE	105.0000	1329000+02	4485000-01	1.0000	75000000+00
					3.0000	23660000+01

TABLE 31
FISSION GAMMA SOURCES

NAME	ENERGY MEV.	YIELD GAMMAS/FISSION
N16		
GAMMAS		
	2.7400	10000000-01
	6.1300	69000000+00
	7.1200	50000000+01
PROMPT+DELAYED FISSION		
	.8000	72200000+01
	2.0000	22600000+01
	4.0000	10200000+01

G. Sample Problems

These sample problems are given to illustrate the use of the function tables.

1. Infinite Slab Source with a Slab Shield

See Figure 5 and Equation (56).

$$\begin{aligned} \text{For this problem, } \mu_s \ell &= 0.1 \\ b &= 1.0 \\ \mu_s &= 0.01 \\ S_v &= 1.0 \\ b' &= b + \mu_s \ell \end{aligned}$$

$$\Phi_{un}(P) = \frac{S_v}{2\mu_s} \left[E_2(b) - E_2(b + \mu_s \ell) \right]$$

Using the compact exponential integral function from Table 1 and the exponential function from Table 2.

$$\begin{aligned} \Phi_{un}(P) &= \frac{S_v}{2\mu_s} \left[\frac{e^{-b}}{b} \bar{E}_2(b) - \frac{e^{-b'}}{b'} \bar{E}(b') \right] \\ &= 50 \left[\frac{e^{-1}}{1} \bar{E}_2(1) - \frac{e^{-1.1}}{1.1} \bar{E}_2(1.1) \right] \\ &= 50 \left[.1481 - .1279 \right] = 1.010 \end{aligned}$$

Gamma-ray buildup factors may be included in this calculation by using the appropriate Taylor coefficients from Section F and equations from Section E.3.

2. Cylindrical Source with Slab Shield and Lateral Detector Point

See Figures 9 and 10 and Equation (68).

$$\begin{aligned} \text{For this problem, } a &= 95 \\ R &= 10 \\ b = \mu t &= 0.1 \times 10 = 1.0 \\ \ell &= 47.5 \\ \mu_s &= 0.2 \\ S_v &= 1.0 \end{aligned}$$

$$\frac{a}{R} = 9.5$$

$$\frac{l}{a} = .5$$

Using the functions from Tables 2, 8, 9, 13, 15, and 16

$$\phi_0 = \sin^{-1} \frac{R}{a+R} = \sin^{-1} \frac{10}{105} = \sin^{-1}(0.0951) = 5.44^\circ = .095 \text{ radian}$$

$$\theta_0 = \tan^{-1} \frac{l}{a} = \tan^{-1} \frac{47.5}{95} = \tan^{-1}(0.5) = 26.56^\circ = .4636 \text{ radian}$$

$$m_c = \sqrt{\left(\frac{a}{R}\right)^2 + \frac{\pi}{\phi_0}} - \frac{a}{R} = 1.6$$

$$b' = b + \mu_s m_c R = 1 + .2 \times 1.6 \times 10 = 4.2$$

$$\begin{aligned} \Phi_{un}(P) &= \frac{S_v \phi_0 \theta_0}{2\pi\mu_s} L_0(\phi_0, b) \left\{ e^{-b G(\theta_0, b)} - e^{-b' G(\theta_0, b)} \right\} \\ &= \frac{1. \times .4636 \times .095}{6.28 \times .2} L_0(5.44, 1) \left[e^{-1 G(26.56, 1)} - e^{-4.2 G(26.5, 4.2)} \right] \\ &= 0.0351(.99)(.36788 \times .940 - .015 \times .85) \\ &= 0.01157 \end{aligned}$$

From Figures 47 and 48, it is apparent that for this problem, in which the slab shield is thin and the source radius small, the effect of changing the slab shield to a cylindrical shield would be negligible.

Gamma-ray buildup factors may be included in this calculation by using the appropriate Taylor coefficients from Section F and equations from Section E.10.

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J. Appendix - A. Foderaro's Approximations of Cylindrical Sources

Reference (35) is an excellent brief reference which gives shielding formulas and data for the use of students. Material from this Reference which is of interest here gives approximations of the flux from a cylindrical source at lateral and axial detector points respectively.

Equation (68) for the flux from a cylindrical source at a lateral point, given in Section B.13 of this report, may be simplified a little, based on Professor Foderaro's observations that

$$L_0(\phi_0, b) \approx \bar{G}(\phi_0, b)$$

where

$$\bar{G}(\phi_0, b) \approx \bar{F}(\phi_0, b + 0.7)$$

(See Sections C.8, C.9, and C.10 of this report.)

Then Equation (68) may be written

$$\phi_{P_1} = \frac{S \phi_0 \theta_1}{2\pi r_s} \bar{G}(\phi_0, b) [e^{-b \bar{G}(\theta_1, b)} - e^{-b' \bar{G}(\theta_1, b')}]$$

and may be used even if only a Sievert Integral Table is available.

The approximate formula for the flux from a cylindrical source at an axial detector point given in Section B.20.a has also been improved by Professor Foderaro. (See Figures 7 and 17 and Equation (81)).

The flux is given by a modified truncated cone formula, as follows,

$$\phi_{P_1} = \frac{S v}{2\pi r_s} [E_2(b) - E_2(b') + \cos \xi E_2(b' \sec \xi) - \cos \xi E_2(b \sec \xi)]$$

where the effective angle ξ is found as a function of the geometry and attenuation of the problem. See Figure 17.

If $\mu_S R > 4$, $\xi = 0$.

(Results are overestimated no more than 20%.)

If $\mu_S R \leq 4$ and $l/R > 1$, $\xi = \frac{\theta_1 + \theta_2}{2}$

(Results are correct within $\pm 10\%$.)

If $\mu_S R \leq 4$ and $l/R > 1$, use the table below to find E; then $\xi = ER$.

(Results are correct within $\pm 10\%$.)

Ratio E for Finding $\xi = ER$					
a/R	b	μ_{S^R}			
		0.4	1	2	4
0.5	0.4	0.66	0.73	0.82	0.92
	1	0.64	0.71	0.80	0.90
	2	0.62	0.69	0.78	0.88
	4	0.58	0.64	0.73	0.85
	8	0.54	0.59	0.67	0.79
	10	0.53	0.57	0.65	0.76
1	0.4	0.69	0.75	0.82	0.93
	1	0.69	0.75	0.82	0.90
	2	0.68	0.74	0.81	0.89
	4	0.66	0.72	0.80	0.88
	8	0.64	0.69	0.77	0.87
	10	0.63	0.69	0.76	0.86
2	0.4	0.76	0.81	0.87	0.94
	1	0.76	0.80	0.86	0.93
	2	0.76	0.80	0.86	0.92
	4	0.76	0.80	0.86	0.92
	8	0.75	0.79	0.85	0.91
	10	0.75	0.79	0.85	0.91
4	0.4	0.84	0.87	0.94	0.98
	1	0.84	0.87	0.91	0.98
	2	0.84	0.87	0.91	0.96
	4	0.84	0.87	0.91	0.95
	8	0.84	0.87	0.91	0.95
	10	0.84	0.87	0.91	0.95
8	0.4	0.91	0.93	0.95	0.98
	1	0.91	0.93	0.95	0.98
	2	0.91	0.93	0.95	0.98
	4	0.91	0.93	0.95	0.98
	8	0.91	0.93	0.95	0.98
	10	0.91	0.93	0.95	0.97