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STATEMENT OF PROBLEM

Develop a method of calculating void sleeve reactivity worths.

ABSTRACT: A problem of increasing concern in reactor neutronic analysis is the criticality calculation of a reactor containing a void gap. This report presents the development of a method of calculating annular void sleeve reactivity worths in SNAP reactors. A code was developed to compute a geometrical escape probability and absorption cross section (DB^2) for the void region. This DB^2 is derived from S_n transport theory and characterizes axial leakage from the void in reactivity calculations with the DTK S_n transport code. Calculations of void sleeve reactivity worths by this method for the water immersed S8ER core compare very well with measurements.

FORM 701-C REV. 10-62

A Method of Calculating Annular Void Reactivity Effects in Cylindrical Reactors

Contents

1. INTRODUCTION

One of the areas of much difficulty and increasing concern to reactor neutronic analysts is the treatment of void regions where neutron streaming occurs. In heterogeneous lattices, methods have been developed through the use of collision probabilities in integral transport theory. Benoist[(1)] uses integral transport theory to obtain radial and transverse diffusion coefficients in terms of "directed collision probabilities", considering the lattice as a whole. Leslie's method[(2)] of weighting diffusion coefficients is restricted to a single lattice cell and considers a "tilted source" in the moderator regions. These techniques represent analytical closed-form solutions to the problem of calculating L^2, but do not apply to our problem in that we are considering small reactors (i.e., B^2 is large), with a homogeneous mixture of fuel and moderator. The method presented in this report is based on purely geometrical considerations of a cylindrical annular void and is extended to the calculation of reactivity effects by characterizing the transverse leakage from the void by a macroscopic absorption cross section in an S_n transport theory criticality code. Although D and B^2 are undefined in a void, the product DB^2 may be used as an absorption cross section because the one-dimensional transport theory does not distinguish between a neutron lost by absorption and a neutron lost by transverse leakage. At the present time this method is divided into two parts: (1) the geometrical probability that a neutron leaving the core is travelling in the right direction to escape out the ends of an annular void between the core and reflector, and (2) the calculation of an effective absorption cross section (i.e., DB^2) to be used in a one-dimensional S_n transport theory criticality calculation. A comparison is made between void reactivity worth calculations and measurements from water immersion experiments of the S8ER core with surrounding void sleeves.

2. CALCULATION OF ESCAPE PROBABILITIES

a. Escape Probability Model

Considering a single neutron at any point along the radial surface of a cylindrical core surrounded by an annular void gap, we are primarily concerned with whether or not the neutron will escape from the gap in the transverse direction, i.e., the escape probability of a distribution of neutrons on the core boundary. We are not concerned with neutrons after they reach the reflector; what happens there is treated by the S_n transport theory. There is another escape probability of interest, however, namely that for a neutron on the inner radial surface of the reflector. Again, those neutrons, having left the reflector, which do not escape out the ends of the gap are treated by the S_n transport theory within the core. The problem is to define an escape probability which would account for transverse leakage from the gap for neutrons on both boundaries of the void. The present model assumes the escape probability for a neutron on the core boundary and the reflector boundary to be the same. Both core neutron and reflector neutron escape probabilities are derived and were calculated, but only the core neutron escape probability is used in the derivation of DB^2 for reactivity calculations. Several factors that affect this assumption are: the greater importance of reflector neutrons, the lower density of reflector neutrons, and the larger escape probability for reflector neutrons. The assumption, in effect, is saying that these factors nullify one another. Neutron "importance" considerations have been neglected to the extent that a spatial fission neutron density distribution is used to weight the escape probability along the length of the core, rather than an "importance" distribution (e.g., the product of flux times adjoint flux).

b. Derivation of Equations

The escape probability of a neutron on the boundary of a void gap is simply defined as the probability of the neutron travelling in the direction of the open ends of the gap. The number of neutrons travelling in directions $d\omega$ about ω is simply: $N(\varphi, \theta)\, d\omega$, where $N(\varphi, \theta)$ is the number of neutrons in solid angle $d\omega = \sin\varphi \, d\theta \, d\varphi$.

The differential probability of neutrons leaving the surface in angles $d\omega$ about ω is then

$$dP = \frac{N(\phi,\theta)\,d\omega}{\int_0^{2\pi} N(\phi,\theta)\,d\omega} \tag{1a}$$

Considering one quadrant of the sphere in Figure 1, with origin of the neutron at a distance z_0 from the top of the core, ϕ is defined as the angle between the z-axis and the flight path of the neutron, and θ is defined as the angle (in the x-y plane) between the x-axis and the flight path of the neutron. The escape geometry is symmetrical about $\theta = 0$ (the x-axis) such that only the quadrant defined by $\phi = 0$ to π radians, and $\theta = 0$ to $\pi/2$ radians need be considered. Looking at the upper octant of this quadrant in detail we see a line of natural division in the lattitude ϕ_1. This is the projection on the sphere of the point on the rim of the reflector nearest to the core neutron (origin of the flight path). The lattitude ϕ_2 defines the most distant point on the rim of the reflector. From $\phi = 0$ to ϕ_1, ϕ is constant for any angle θ, therefore the probability of escape through this region is simply the integral of the differential probability:

$$P_1 = \frac{\int_0^{\phi_1}\int_0^{\pi/2} \sin\phi \cdot N(\phi,\theta)\,d\theta\,d\phi}{\int_0^{\pi}\int_0^{\pi/2} \sin\phi \cdot N(\phi,\theta)\,d\theta\,d\phi} \tag{1b}$$

To simplify the writing of escape probabilities henceforth, let us define the total number of neutrons emerging from the surface by symbol A,

$$A \equiv \int_0^{\pi}\int_0^{\pi/2} \sin\phi \cdot N(\phi,\theta)\,d\theta\,d\phi \tag{1c}$$

Between ϕ_1, and ϕ_2, due to the different location of the origin of the void boundary radii and the origin of the neutron flight path (see Figures 1 and 2) there arises an area with one boundary on which θ

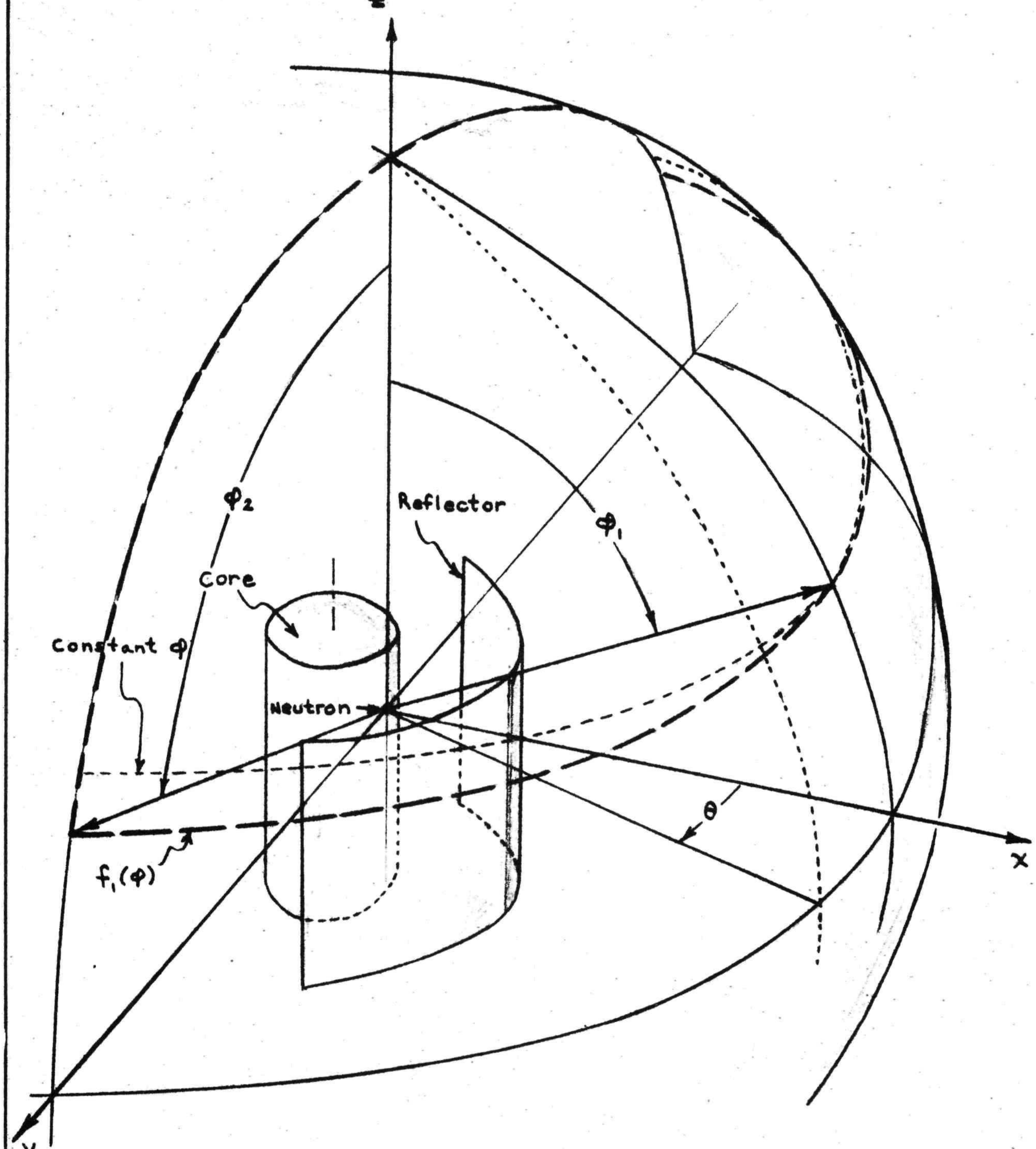

FIGURE 1. Illustration of the Probability of a Neutron Emitted from the Core Escaping from an Annular Void Gap.

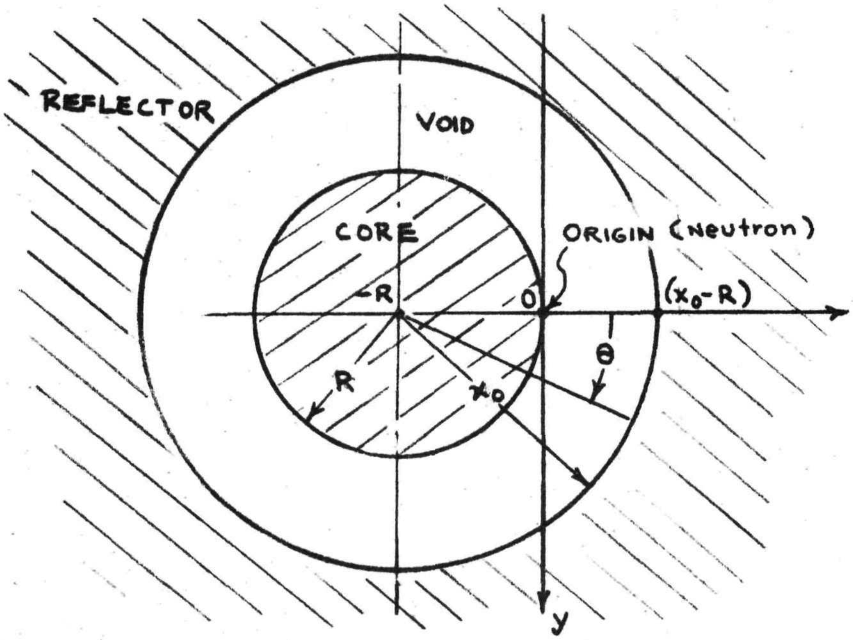

FIGURE 2. Top View of Void Gap.

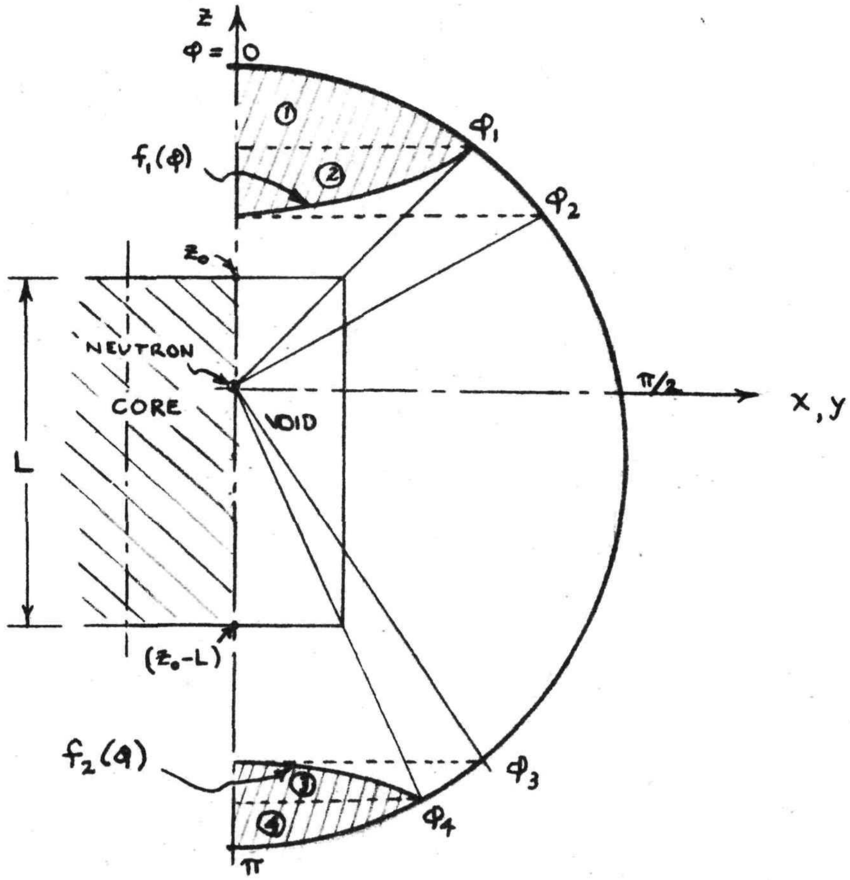

FIGURE 3. Side View of the Limits of Integration over φ .

varies with ϕ. To derive this relationship, $\theta = f_1(\phi)$, we begin by considering a cylindrical core of radius R within a reflector of radius x_0 (see Figure 2). With the distance from the origin of the neutron flight path to the top of the core given by z_0, and a core length of L, the equations of the cylinder of radius x_0 with origin at -R are

$$(x+R)^2 + y^2 = x_0^2 \tag{2a}$$

$$z = z_0 \tag{2b}$$

Transforming to spherical coordinates (ρ, θ, ϕ) by

$$\left.\begin{aligned} x &= \rho \cos\theta \sin\phi \\ y &= \rho \sin\theta \sin\phi \\ z &= \rho \cos\phi \end{aligned}\right\} \tag{2c}$$

equation (2a) becomes

$$\rho^2 \cos^2\theta \sin^2\phi + 2R\rho\cos\theta\sin\phi + \rho^2\sin^2\theta\sin^2\phi = x_0^2 - R^2 \tag{2d}$$

and equation (2b) becomes

$$\rho = \frac{z_0}{\cos\phi} \tag{2e}$$

Putting (2e) into (2d), and solving for θ,

$$\theta = f_1(\phi) = \cos^{-1}\left[\left(\frac{x_0^2 - R^2}{2Rz_0}\right)\cot\phi - \frac{z_0}{2R}\tan\phi\right] \tag{3a}$$

The second probability in the upper octant is therefore

$$P_2 = \frac{1}{A}\int_{\phi_1}^{\phi_2}\int_{f_1(\phi)}^{\pi/2} \sin\phi \; N(\phi,\theta)\, d\theta\, d\phi \tag{4}$$

Correspondingly, in the lower octant we have

$$P_3 = \frac{1}{A} \int_{\phi_3}^{\phi_4} \int_{f_2(\phi)}^{\pi/2} \sin\phi \cdot N(\phi,\theta)\, d\theta\, d\phi \tag{5}$$

and

$$P_4 = \frac{1}{A} \int_{\phi_4}^{\pi} \int_{0}^{\pi/2} \sin\phi \cdot N(\phi,\theta)\, d\theta\, d\phi \tag{6}$$

where, in the lower octant, $f_2(\phi)$ is obtained by simply replacing z_0 in the equation (3a) with $(z_0 - L)$,

$$f_2(\phi) = \cos^{-1}\left[\left(\frac{x_0^2 - R^2}{2R(z_0-L)}\right)\cot\phi - \frac{(z_0-L)}{2R}\tan\phi\right] \tag{3b}$$

In the present model the angular distribution $N(\phi,\theta)$ is assumed separable in angles ϕ and θ, and only the ϕ angular dependence is accounted for,

$$N(\phi,\theta) = a \cdot N'(\phi) \tag{7}$$

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where "a" is a constant. (The θ angular dependence remains to be investigated.) Then the total escape probability for a neutron leaving the core at a given point z_0, is

$$P_c(z_0) = \frac{1}{2}\int_0^{\phi_1} \sin\phi \cdot N(\phi)\cdot d\phi$$

$$+ \frac{1}{\pi}\int_{\phi_1}^{\phi_2} \sin\phi \cdot \left\{ \frac{\pi}{2} - \cos^{-1}\left[\left(\frac{x_0^2 - R^2}{2R z_0}\right)\cot\phi - \frac{z_0}{2R}\tan\phi\right]\right\}\cdot N(\phi)\, d\phi \qquad (8)$$

$$+ \frac{1}{\pi}\int_{\phi_3}^{\phi_4} \sin\phi \cdot \left\{ \frac{\pi}{2} - \cos^{-1}\left[\left(\frac{x_0^2 - R^2}{2R(z_0 - L)}\right)\cot\phi - \frac{(z_0 - L)}{2R}\tan\phi\right]\right\}\cdot N(\phi)\, d\phi$$

$$+ \frac{1}{2}\int_{\phi_4}^{\pi} \sin\phi \cdot N(\phi)\cdot d\phi$$

Where the normalized angular distribution, N (ϕ), is defined by

$$N(\phi) \equiv \frac{a \cdot N'(\phi)}{A} \qquad (9a)$$

and the limits of integration are (see Figure 3)

$$\left.\begin{aligned} \phi_1 &= \tan^{-1}\left(\frac{x_0 - R}{z_0}\right) \\ \phi_2 &= \tan^{-1}\left(\frac{\sqrt{x_0^2 - R^2}}{z_0}\right) \\ \phi_3 &= \tan^{-1}\left(\frac{\sqrt{x_0^2 - R^2}}{z_0 - L}\right) \\ \phi_4 &= \tan^{-1}\left(\frac{x_0 - R}{z_0 - L}\right) \end{aligned}\right\} \qquad (9b)$$

For a neutron leaving the reflector at a given point z_0, the escape probability, $P_R(z_0)$, is the sum of six probabilities. Figure 4 shows the three areas of consideration in the upper octant (there are correspondingly three more in the lower octant). The sum of probabilities for a neutron leaving the reflector can be written

$$\begin{aligned} P_R(z_0) = \frac{1}{A}\Bigg[& \int_0^{\phi_1}\int_0^{\theta_0} \sin\phi \cdot N(\phi,\theta)\, d\theta\, d\phi \\ & + \int_{\phi_1}^{\phi_2}\int_{f_3(\phi)}^{\theta_0} \sin\phi \cdot N(\phi,\theta)\, d\theta\, d\phi \\ & + \int_0^{\phi_5}\int_{\theta_0}^{f_4(\phi)} \sin\phi \cdot N(\phi,\theta)\, d\theta\, d\phi \\ & + \int_{\phi_6}^{\pi}\int_{\theta_0}^{f_5(\phi)} \sin\phi \cdot N(\phi,\theta)\, d\theta\, d\phi \\ & + \int_{\phi_3}^{\phi_4}\int_{f_6(\phi)}^{\theta_0} \sin\phi \cdot N(\phi,\theta)\, d\theta\, d\phi \\ & + \int_{\phi_4}^{\pi}\int_0^{\theta_0} \sin\phi \cdot N(\phi,\theta)\, d\theta\, d\phi \Bigg] \end{aligned} \qquad (10)$$

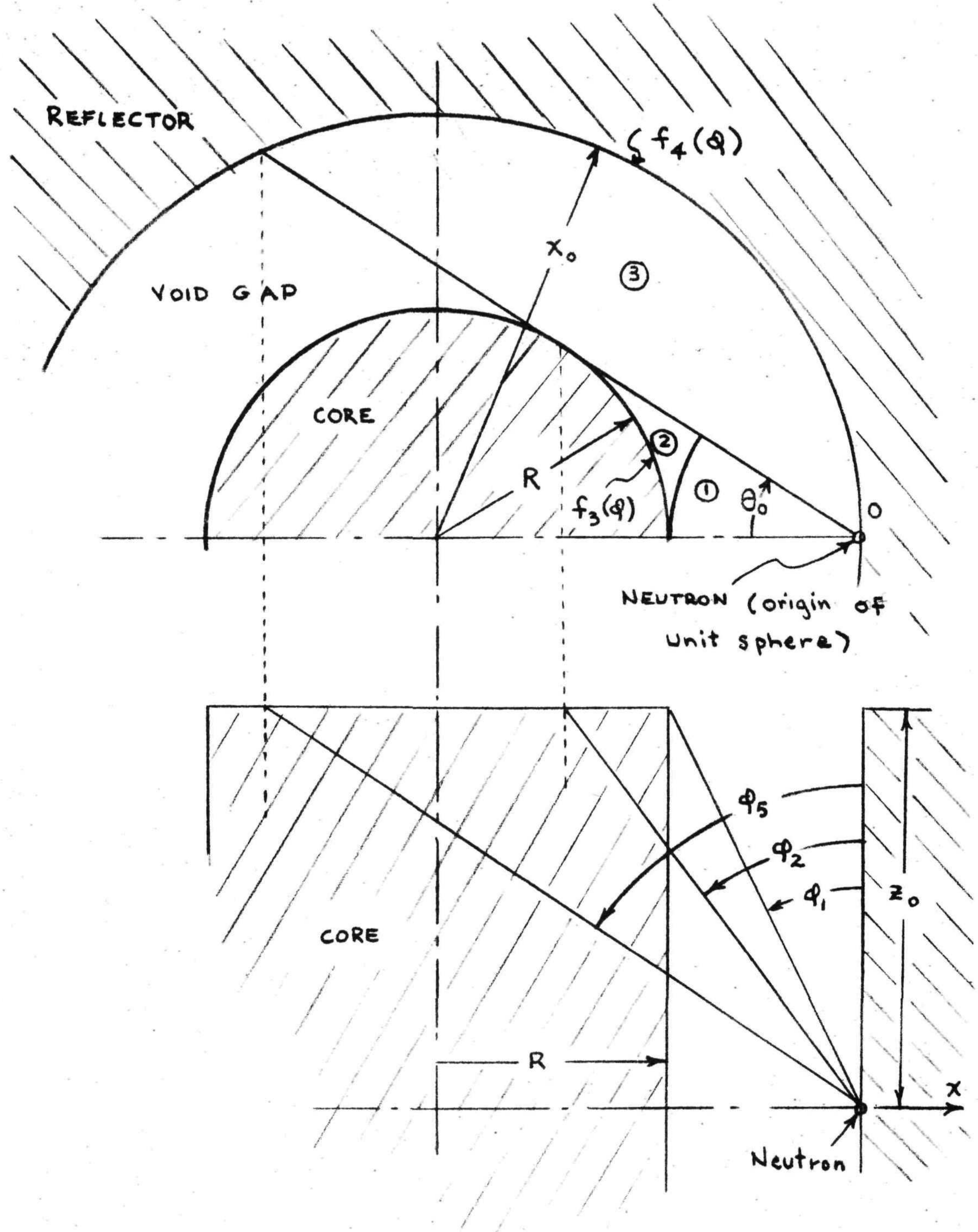

FIGURE 4. Illustration of the Three Areas of Consideration in Determining the Probability of a Neutron Leaving the Reflector and Escaping from the Annular Void Gap.

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where

$$\left.\begin{aligned} \theta_0 &= \tan^{-1}\left(\frac{R}{\sqrt{x_0^2 - R^2}}\right) \\ \phi_5 &= \tan^{-1}\left(\frac{2\sqrt{x_0^2 - R^2}}{z_0}\right) \\ \phi_6 &= \tan^{-1}\left(\frac{2\sqrt{x_0^2 - R^2}}{z_0 - L}\right) \end{aligned}\right\} \qquad (11)$$

and $\phi_1, \phi_2, \phi_3, \phi_4$ are given by equations (9b). To derive the functions $f_3(\phi)$ and $f_6(\phi)$, we write down the equations of a cylindrical core of radius R with origin at x_0 (the location of the origin of the neutron flight path in the void)

$$(x - x_0)^2 + y^2 = R^2 \qquad (12a)$$

$$z = z_0 \qquad (12b)$$

and transform to spherical coordinates by equations (2c), solving for θ,

$$\theta = f_3(\phi) = \cos^{-1}\left[\frac{x_0^2 - R^2 + z_0^2 \tan^2\phi}{2 z_0 x_0 \tan\phi}\right] \qquad (13)$$

and

$$f_6(\phi) = \cos^{-1}\left[\frac{x_0^2 - R^2 + (z_0 - L)^2 \tan^2\phi}{2 (z_0 - L) x_0 \tan\phi}\right] \qquad (14)$$

The functions $f_4(\phi)$ and $f_5(\phi)$ are derived from the equations of a cylindrical reflector of radius x_0 with origin at x_0,

$$(x - x_0)^2 + y^2 = x_0^2 \qquad (15a)$$

$$z = z_0 \qquad (15b)$$

Transforming to spherical coordinates by equations (2c), and again solving for θ,

$$\theta = f_4(\phi) = \cos^{-1}\left[\frac{z_0 \tan\phi}{2x_0}\right] \qquad (16)$$

and

$$f_5(\phi) = \cos^{-1}\left[\frac{(z_0 - L)\tan\phi}{2x_0}\right] \qquad (17)$$

Again, accounting for the ϕ angular dependence only, by equation (7), the total escape probability for a neutron leaving the reflector at point z_0 is

$$P_R(z_0) = \frac{\theta_0}{\pi}\int_0^{\phi_1} \sin\phi \cdot N(\phi)\cdot d\phi + \frac{1}{\pi}\int_{\phi_1}^{\phi_2} \sin\phi \cdot \left\{\theta_0 - \cos^{-1}\left[\frac{x_0^2 - R^2 + z_0^2\tan^2\phi}{2z_0 x_0 \tan\phi}\right]\right\}\cdot N(\phi)\cdot d\phi + \frac{1}{\pi}\int_0^{\phi_5} \sin\phi \cdot \left\{\cos^{-1}\left[\frac{z_0\tan\phi}{2x_0}\right] - \theta_0\right\}\cdot N(\phi)\, d\phi$$
$$+ \frac{1}{\pi}\int_{\phi_6}^{\pi} \sin\phi \cdot \left\{\cos^{-1}\left[\frac{(z_0 - L)}{2x_0}\tan\phi\right] - \theta_0\right\}\cdot N(\phi)\cdot d\phi + \frac{1}{\pi}\int_{\phi_3}^{\phi_4} \sin\phi \cdot \left\{\theta_0 - \cos^{-1}\left[\frac{x_0^2 - R^2 + (z_0 - L)^2\tan^2\phi}{2(z_0 - L)x_0\tan\phi}\right]\right\}\cdot N(\phi)\, d\phi + \frac{\theta_0}{\pi}\int_{\phi_4}^{\pi} \sin\phi \cdot N(\phi)\cdot d\phi \qquad (18)$$

where the angular distribution normalization, the limits of integration, and θ_0 are given by equations (9a), (9b), and (11).

The average escape probability over the entire core length z_0 = 0 to L, for a gap thickness (x_0 -R), is given by

$$\overline{P_c} = \frac{\int_0^L P_c(z_0) \cdot F(z_0)\, dz_0}{\int_0^L F(z_0)\, dz_0} \tag{19a}$$

where Pc(z_0) and F(z_0) are the escape probability and fission neutron density along the length of the core.

c. Angular Distribution

The angular distribution function, N(ϕ), is obtained from a high order S_n transport calculation* of the reactor configuration under consideration. The angular fluxes are summed over all energy groups for each discrete value of ϕ and normalized by equation (9a). It was found necessary to use at least 12th order in the S_n approximation to obtain a suitable angular distribution, S_{12} yielding 6 discrete ϕ angles in the forward direction between 0 and $\pi/2$ radians. The energy dependence of the angular distribution was found to be quite weak at the boundaries of the void gap, on the basis of S_4 calculations with 16 energy groups from 10 Mev to .0092 ev. Although energy dependence has been neglected in the present model, it would be simple, in principle, to calculate energy-dependent escape probabilities. The angular distribution at the void boundaries also depends on the gap thickness, but in the present model a single representative distribution is used for all gaps.

.d. Solution of Equations

Equation (8) has been programmed in FORTRAN II language for the IBM 7094 computer. The integrations are performed by the 5th order Legendre-Gauss quadrature method.[3] The first term in equation (8), for example, is computed as:

$$\frac{1}{2}\int_0^{\phi_1} \sin\phi \cdot N(\phi)\cdot d\phi = \frac{1}{2}\left\{\frac{\phi_1 - 0}{2}\sum_{K=1}^{5} \sin(\phi_K)\, N(\phi_K)\, w_K\right\},$$

* More detail is found in Section 3.

where $$\vartheta_K = \left(\frac{\vartheta_1 + 0}{2}\right) + \left(\frac{\vartheta_1 - 0}{2}\right) \cdot \xi_K$$

ξ_K are the zeros of Legendre polynomials, and w_K are the weights (Christoffel numbers). The angular weighting factor, $N(\vartheta_K)$, used in any particular numerical integration by the code is obtained from a linear interpolation in $\sin\vartheta_K$ of normalized angular fluxes. The end points of the distribution are linear (in $\sin\vartheta_K$) extrapolations of the normalized angular fluxes. The intergrals in equation (19a) are simply programmed as summations,

$$\bar{P}_C = \frac{\int_0^L P_c(z_0) F(z_0)\, dz_0}{\int_0^L F(z_0)\, dz_0} \approx \frac{\sum_{i=1}^{m} P_{ci} F_i}{\sum_{i=1}^{m} F_i} \qquad (19b)$$

where m is the number of equal interval mesh points. Equations (8) and (19b) are a part of the computer program designated FOSDICK; the details of the entire program appear in the Appendix.

e. Isotropic Escape Probabilities

A special case of the escape probability as already derived arises if the angular distribution of neutrons on the boundary of the void is isotropic, i.e., all directions of travel are equally probable. In this case the probability of a neutron escaping from the gap is the area projected onto the surface of a unit (area) sphere of the space between the core and reflector as seen by a neutron on the surface of the core or reflector. The equations (8) and (18) are simply modified by taking $N(\vartheta) = 1$. Although an isotropic distribution of neutrons at the void boundary is unrealistic, the isotropic escape probability was calculated for the sake of comparison. Figure 5 shows the effect

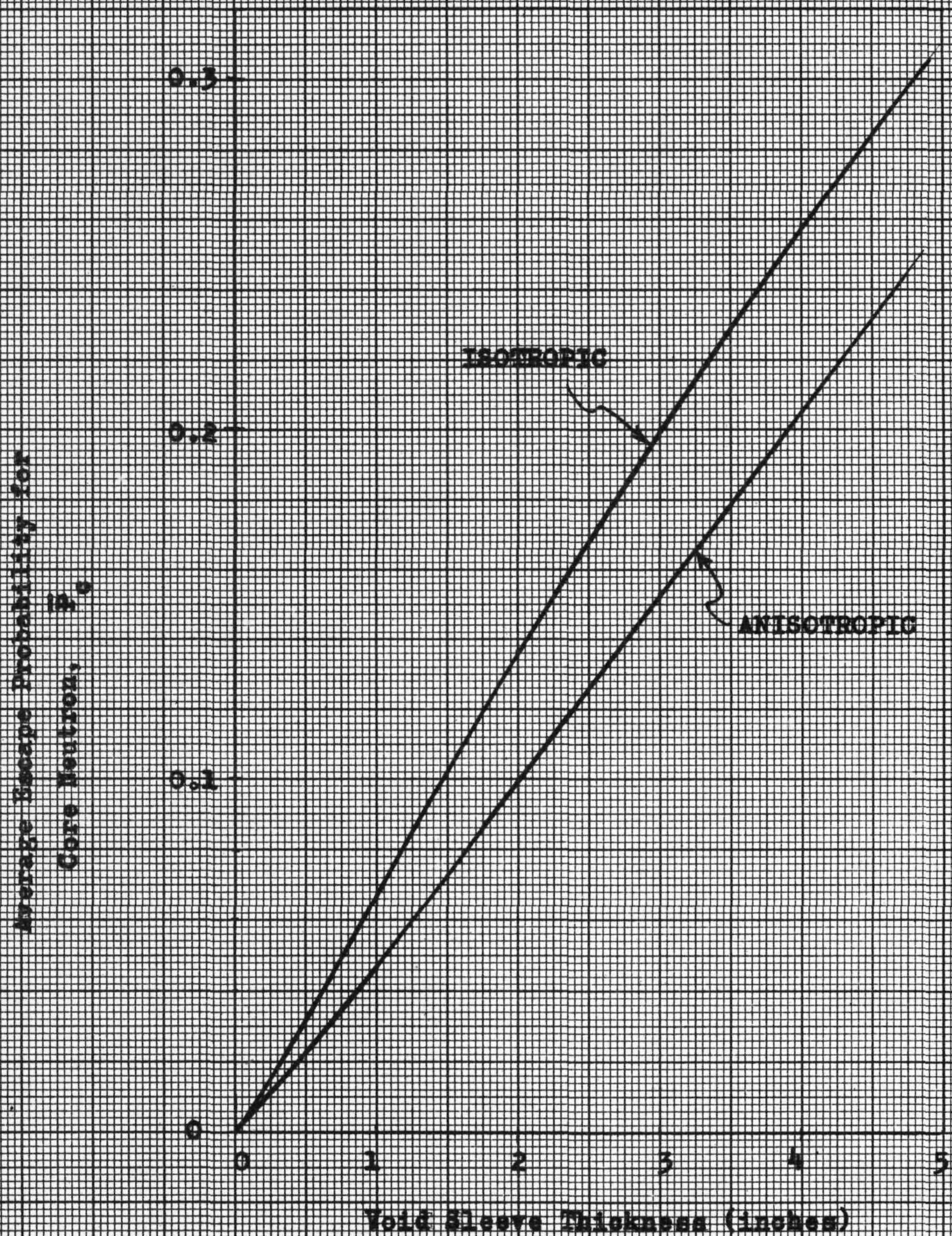

FIGURE 5. Comparison of Anisotropic and Isotropic Escape Probability for S8ER Model.

of angular distribution in the S8ER void-sleeve model, where an S_{12} calculated angular distribution for the 3-inch void thickness was used for all cases. The anisotropic curve is significantly lower than the isotropic curve showing the effect of the strong peaking of angular neutron flux at a core/void boundary in the forward direction.

[Equation (18) was programmed for $N(\ell) = 1$, and showed the escape probability for a neutron on the reflector surface to be significantly greater than that for neutrons on the core surface. The present model does not consider P_R, however. It remains to obtain an "effective" escape probability for both core and reflector neutrons.]

3. CALCULATION OF DB^2

a. Sn Transport Theory Model

The one-dimensional DTK S_n transport code[4] is used to calculate angular fluxes at the void boundaries. The discrete directions are determined by the order of the S_n approximation and the geometry, S_{12} having 21 discrete directions per spherical octant in cylindrical geometry. The S_4 approximation has 3 discrete directions per spherical octant in cylindrical geometry. This means there are 6 values of ϕ from 0 to $\pi/2$ radians in S_{12}, and only 2 in S_4. To account for transverse leakage from the void gap a macroscopic absorption cross section (or DB^2) is assigned to it. TheDTK code is limited in that it does not use angular-dependent absorption cross sections, therefore an average DB^2 is calculated to represent the total leakage in all directions from the gap. An energy-dependent DB^2 could be calculated but, as previously mentioned, the angular distribution at the core/void interface is not strongly energy-dependent.

b. Derivation and Solution of DB^2 Equation

The escape probability for neutrons at the void boundary of surface area A_i is defined as the total number of neutrons per second escaping from the gap divided by the total number of neutrons per second entering the gap at A_i,

$$\overline{P}_{c_i} \equiv \frac{J_i^+ A_i - J_{i+1}^+ A_{i+1}}{J_i^+ A_i} \qquad (22)$$

where "$i+1$" denotes the reflector boundary of the void gap. J_i^+ is the neutron flow in the forward directions at the core boundary of the void gap, and is given in the discrete S_n approximation by

$$J_i^+ \equiv \sum_{m;\mu_m>0} w_m \mu_m N_{m,i} \qquad (23)$$

where ω_m is the solid angle through which the neutrons travel in the m^{th} direction, μ_m is the m^{th} direction cosine, and $N_{m,i}$ is the angular neutron flux in direction m at the core boundary of the void gap. Considering only the escape probability in direction m we write

$$\overline{P}_{cm,i} = \frac{\mu_m N_{m,i} A_i - \mu_m N_{m,i+1} A_{i+1}}{\mu_m N_{m,i} A_i} \tag{24}$$

This requires an expression for $N_{m,i+1}$ in terms of $N_{m,i}$ and σ_i, consequently we turn to the one-dimensional, steady-state, Boltzmann neutron transport conservation equation. The "diamond"-central difference representation of this equation, as formulated by Lee[5], may be written

$$\frac{\mu_m}{V_i}\cdot\left(A_{i+1} N_{m,i+1} - A_i N_{m,i}\right) + \frac{1}{2V_i}\left(A_{i+1} - A_i\right)\cdot\Big[(\gamma+\beta)_{m+1} N_{m+1} - (\gamma-\beta)_{m+1} N_m\Big] + \sigma_i N'_{m,i} = S_{m,i} \tag{25a}$$

where "i" is a spatial index, "m" is an angular index, and the surface and volume elements in cylindrical geometry are given by

$$A_i = 2\pi r_i \quad ; \quad V_i = \pi\left(r_{i+1} + r_i\right)\cdot\left(r_{i+1} - r_i\right) \tag{25b}$$

σ_i is the macroscopic cross section, $S_{m,i}$ is the source, γ and β are angular coefficients determined by the integration and differentiation properties implicit in the finite-difference form of the transport conservation equations, and $N'_{m,i}$ is given by the "diamond" difference scheme as

$$2 N'_{m,i} = N_{m,i} + N_{m,i+1} \tag{25c}$$

The DB^2 (i.e., σ_i) is defined such that the conservation condition for radial transport is correct when transverse leakage from the void is included; the angular transport being calculated by the code independent of σ_i. In a void gap the source $S_{m,i}$ is identically zero,

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then equation (25a) may be written

$$\frac{\mu_m}{V_i}\left(A_{i+1}N_{m,i+1} - A_i N_{m,i}\right) + \sigma_i N'_{m,i} = 0 \qquad (26)$$

To get the desired expression for $N_{m,i+1}$, we insert equation (25c) into the conservation equation (26), and obtain

$$N_{m,i+1} = N_{m,i} \cdot \left(\frac{2\mu_m A_i - \sigma_i V_i}{2\mu_m A_{i+1} + \sigma_i V_i}\right) \qquad (27)$$

Putting equation (27) back into equation (24), multiplying the angular fluxes by their respective solid angles, and summing over all forward angles yields the total escape probability

$$\overline{P}_{ci} = \frac{\sum_{m;\mu_m>0} w_m \mu_m N_{m,i}\left[A_i - A_{i+1}\left(\frac{2\mu_m A_i - \sigma_i V_i}{2\mu_m A_{i+1} + \sigma_i V_i}\right)\right]}{\sum_{m;\mu_m>0} w_m \mu_m N_{m,i} A_i} \qquad (28)$$

or, by definition (23), equation (28) may be shortened to

$$\overline{P}_{ci} = 1 - \frac{A_{i+1}}{J_i^+ A_i} \sum_{m;\mu_m>0} J^+_{m,i}\left(\frac{2\mu_m A_i - \sigma_i V_i}{2\mu_m A_{i+1} + \sigma_i V_i}\right) \qquad (29)$$

where

$$J^+_{m,i} = w_m \mu_m N_{m,i} \quad ; \quad \mu_m > 0$$

Equation (29) is the DB^2 equation; it is solved for σ_i by the second-order Newton iteration method (or "Newton-Raphson algorithm")[6] which consists in drawing successive tangents to the $F(\sigma_i)$ curve. $F(\sigma_i)$ is defined by simply rearranging equation (29),

$$F(\sigma_i) \equiv Q_i - R_i \cdot \sum_{m;\mu_m>0} J^+_{m,i}\left(\frac{2\mu_m A_i - \sigma_i V_i}{2\mu_m A_{i+1} + \sigma_i V_i}\right) \qquad (30)$$

where $$Q_i \equiv (1 - \overline{P}_{ci})$$

$$R_i \equiv \frac{A_{i+1}}{J_i^+ A_i}$$

Then its first derivative is

$$F'(\sigma_i) = \frac{\partial F(\sigma_i)}{\partial \sigma_i} = 2 R_i V_i (A_{i+1} + A_i) \cdot \sum_{m;\mu_m>0} \frac{J^+_{m,i} \mu_m}{(2\mu_m A_{i+1} + \sigma_i V_i)^2} \quad (31)$$

Consider the i^{th} gap whose transverse leakage probability is characterized by σ_i, so we may henceforth drop the subscript "i". The iteration scheme begins with an initial guess for σ (eg. $\sigma_0 = 0$). The first calculated value of σ is then

$$\sigma_1 = \sigma_0 - \frac{F(\sigma_0)}{F'(\sigma_0)} \quad (32a)$$

or, more generally, after j iterations,

$$\sigma_{j+1} = \sigma_j - \frac{F(\sigma_j)}{F'(\sigma_j)} \quad (32b)$$

Convergence is satisfied when

$$\frac{\sigma_{j+1} - \sigma_j}{\sigma_{j+1}} = \frac{-F(\sigma_j)}{\sigma_{j+1} F'(\sigma_j)} \leq \epsilon \quad (33)$$

where ϵ is some specified convergence criterion. The value of σ obtained in this calculation is precisely the macroscopic absorption cross section for the void region. (In the DTK code this quantity must be entered as both an absorption and a transport cross section.) An estimate of the absorption cross section (DB^2) should be made for the high order S_n calculation of angular distribution. A good first guess based on the isotropic escape probability, $\overline{P}_{c\,iso}$, (calculated with FOSDICK by inputing $N(\phi) = 1$) can be derived from the DB^2 equation (29).

Assuming isotropic flux at the void boundary, $J_i^+ = \frac{\phi_i}{4}$, and $2\mu_m A_{i+1} > \sigma_i V_i$, one obtains from equation (29)

$$DB^2 = C \cdot \frac{R}{X^2 - R^2} \cdot \overline{P}_{c\,iso} \qquad (34)$$

where R and X are radii (in cm.) of the core and reflector, respectively; and C is a constant approximately correcting for assumptions applied to equation (29). If the angular distribution is slightly less forward-peaked than a sine distribution, C varies from .6 to .7 for gaps of 10 to 100 mils, and .9 to 1.3 for gaps of 1 to 4 inches surrounding a typical SNAP core.

4. COMPARISON OF REACTIVITY CALCULATIONS WITH MEASUREMENTS

Reactivity calculations have been made utilizing the DTK S_n transport code[4], with 16-group zirconium-hydride spectrum weighted cross section library, for the SNAP 8 Experimental Reactor (S8ER) in a water environment. The calculational model is presented in Addendum I of this report.[7] For the S8ER water flooded and reflected core the reactivity effect of void sleeves of 1, 3, and 4 inches were calculated and a comparison with measurements from critical assemblies[8] is presented in Table I, and plotted in Figure 6.

Table I

S8ER Void Sleeve Worth Calculations and Measurements

Void Gap Width (inches)	S_4 Calculations $\Delta K_{eff}/.008$ (\$)	Measured Reactivity Worth (\$)
1	-4.02	-3.90±.36
3	-8.44	-8.14±.54
4	-9.75	-9.44±.61

A modification of the reported measurements was made to account for the reactivity effect of the water on the ends of the void gap, since the calculations assumed open ends. This modification was estimated on the basis of results from another critical experiment.[9]

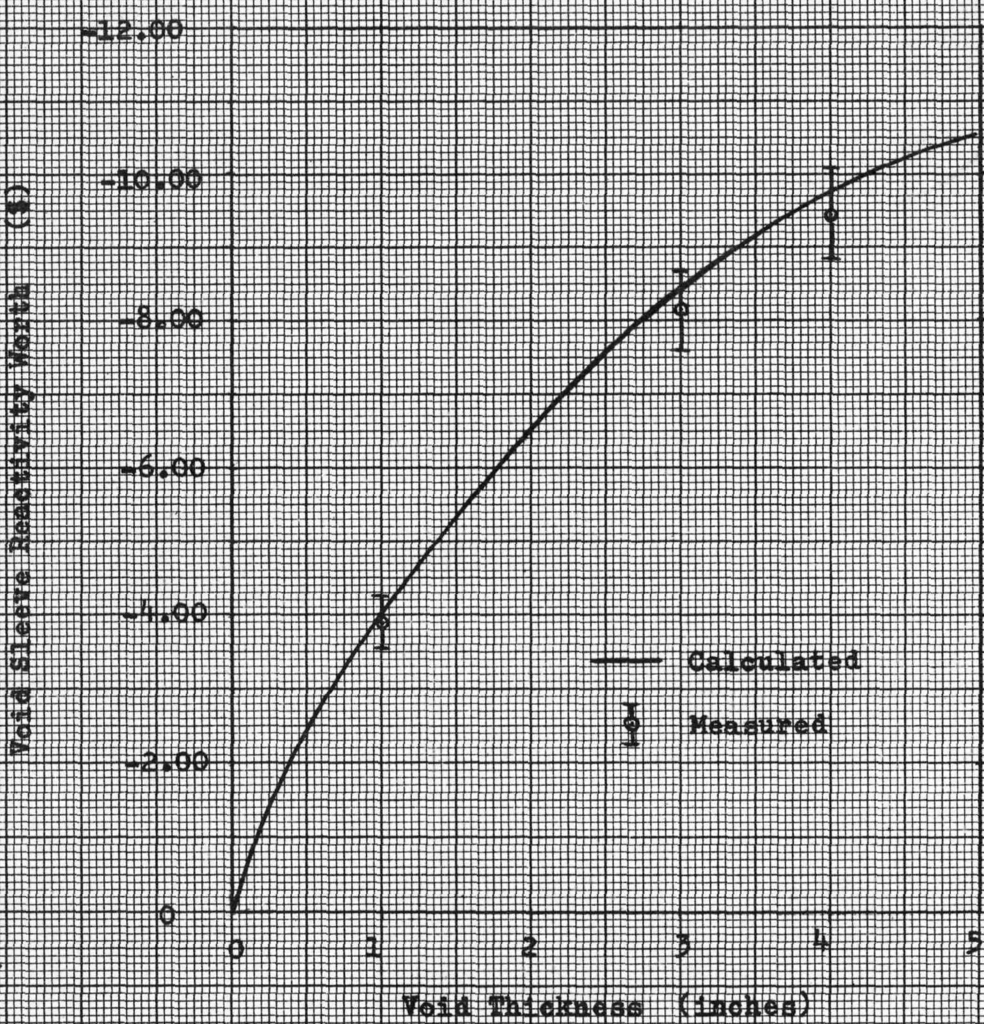

FIGURE 6. SSER Void Sleeve Worth Calculations and Measurements.

5. CONCLUSIONS AND FURTHER WORK

a. A method has been developed to calculate escape probabilities for neutrons entering an annular void, accounting for anistropic angular distributions and axial spatial distributions of neutrons on the surface of a cylindrical core. The escape probability is used to calculate a DB^2 which simulates axial leakage from the void in reactivity calculations with the DTK S_n transport code. The FOSDICK code has been written to perform the escape probability and DB^2 calculations. The present method of calculating DB^2 assumes the same escape probability for reflector neutrons as for core neutrons. An attempt to redefine the escape probability for the void in terms of both P_c and P_R should be made.

b. In the calculation of angular distribution only the φ angular dependence was considered. The inclusion of the θ angular dependence would not cause serious difficulty, and it may be a necessary factor in considering small gaps.

c. The FOSDICK code in its present form could be quite easily modified to read in angular fluxes and S_n constants directly from the output tape of a DTK calculation.

d. A comparison of reactivity calculations, using the FOSDICK code for DB^2 and the DTK code for reactivity, with measurements of void sleeve reactivity worths in SCA-4B water immersion experiments (S8ER core) shows very close agreement.

REFERENCES

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APPENDIX - The FOSDICK Code

This Appendix is a presentation of the FORTRAN II program, designated FOSDICK, written to compute escape probabilities and DB^2 to be used in the DTK/DTF II S_n Transport codes for reactivity worth calculations of cylindrical annular voids.

a. Description

The present form of the FOSDICK code consists of a main program of input-output and the following four subroutines:

(1) ANGLE - takes data from DTK/DTF II output (which was read into the main program from any S_n transport calculation up through the S_{16} approximation) and sets up an angular distribution of neutron flux as a function of sine of the angle (φ) measured from the z-axis. This subroutine is no more than a manipulation of the input angular fluxes (which have been summed over all energy groups at the core/void boundary), the S_n direction cosines, and the S_n point weights. The angular fluxes are (solid angle) weighted over each discrete (average) φ angle. The sine of φ is taken directly from the direction cosine. The end points of the distribution ($\varphi = 0, \pi$) are obtained from linear extrapolation in sin φ. The peak of the distribution ($\varphi = \pi/2$) is computed to be one-half the value between a linear extrapolation in sinφ and a flat peak determined by a straight line connecting the angular fluxes at the nearest points on each side of $\pi/2$. This subroutine also prints the (unnormalized) angular distribution in the output.

(2) NORM - normalizes the angular distribution (obtained from ANGLE) for direct use in the escape probability numerical integration scheme, and prints the normalization factor in the output.

(3) GPESC - computes the geometrical global probability of escape for each axial position specified, and averages it over an axial fission density distribution which was read into the main program. The

escape probability is computed as four separate escape probability integrals, an anisotropic weighting factor being obtained by linear interpolation (in sin φ) between the discrete values in the normalized angular distribution. The average escape probability is computed for each gap thickness specified, and each of the four integrals as well as their sum are printed out by axial position and gap thickness.

(4) DBSQ - computes DB^2 for the void gap using the average escape probability from GPESC and the angular fluxes, S_n direction cosines, and S_n point weights from DTK/DTF II output which were read into the main program. The angular fluxes used here should be of the same order as the reactivity calculation, usually S_4. The DB^2 is calculated by S_n theory, the transcendental equation being solved by the second-order Newton iteration method. DB^2 is computed and printed out for each gap thickness specified.

b. Code Equations

The bulk of the code equations are found in the subroutines GPESC and DBSQ, the derivation of the major equations being presented in detail in the body of this report. The following is a presentation of all the equations used in the code leading to the computation of escape probabilities and DB^2.

The gap thicknesses considered in a given calculation are determined by

$$\left.\begin{aligned} x_i &= \left(\frac{x_{max} - x_{min}}{N}\right)\cdot i + x_{min} \\ t_i &= x_i - R \end{aligned}\right\} \qquad (34)$$

where i = index denoting radial position,

x_i = radius of reflector medium for the i^{th} gap,

x_{max} = radius of reflector medium for largest gap considered,

x_{min} = radius of reflector medium for smallest gap considered, or usually, the core radius,

N = number of gaps considered,

t_i = gap thickness of i^{th} gap,

R = core radius.

The axial positions along half the length of the core are determined by

$$z_j = \left(\frac{L}{2}\right) \cdot \frac{j}{M} \tag{35}$$

where L = core length,

z_j = j^{th} axial position,

M = number of axial positions considered,

j = index denoting axial position.

The four escape probabilities for a neutron on the surface of the core are given in equation (8). The limits of integration are given by equations (9b). The integrals in equation (8) are evaluated by the 5th order Legendre-Gauss quadrature method as:

$$\left.\begin{aligned} P_{1ij} &= \frac{\theta_{1ij}}{4} \sum_{K=1}^{5} \sin\theta_K \cdot N_1(\theta_K) \cdot w_K \\ &\text{where } \theta_K = \frac{\theta_{1ij}}{2} \cdot (1 + u_K) \end{aligned}\right\} \tag{36a}$$

u_K, w_K are the Legendre zeros and Christoffel weights, respectively.

$$\left.\begin{aligned} P_{2ij} &= \frac{(\theta_{2ij} - \theta_{1ij})}{2\pi} \sum_{K=1}^{5} \sin\theta_K \cdot N_2(\theta_K) \cdot \left[\frac{\pi}{2} - f_{1ij}(\theta_K)\right] \cdot w_K \\ &\text{where } \theta_K = \left(\frac{\theta_{2ij} + \theta_{1ij}}{2}\right) + \left(\frac{\theta_{2ij} - \theta_{1ij}}{2}\right) \cdot u_K \end{aligned}\right\} \tag{36b}$$

$$\left.\begin{aligned} P_{3ij} &= \frac{(\theta_{4ij} - \theta_{3ij})}{2\pi} \sum_{K=1}^{5} \sin\theta_K \cdot N_3(\theta_K) \cdot \left[\frac{\pi}{2} - f_{2ij}(\theta_K)\right] \cdot w_K \\ &\text{where } \theta_K = \left(\frac{\theta_{4ij} + \theta_{3ij}}{2}\right) + \left(\frac{\theta_{4ij} - \theta_{3ij}}{2}\right) \cdot u_K \end{aligned}\right\} \tag{36c}$$

$$\left.\begin{aligned} P_{4ij} &= \frac{(\pi - \theta_{4ij})}{4} \sum_{K=1}^{5} \sin\theta_K \cdot N_4(\theta_K) \cdot w_K \\ &\text{where } \theta_K = \left(\frac{\pi + \theta_{4ij}}{2}\right) + \left(\frac{\pi - \theta_{4ij}}{2}\right) \cdot u_K \end{aligned}\right\} \tag{36d}$$

and

$$f_{1ij}(\phi_K) = \cos^{-1}\left[\left(\frac{x_i^2 - R^2}{2R z_j}\right)\cot\phi_K - \frac{z_j}{2R}\tan\phi_K\right] \tag{36e}$$

$$f_{2ij}(\phi_K) = \cos^{-1}\left[\left(\frac{x_i^2 - R^2}{2R(z_j - L)}\right)\cot\phi_K - \frac{(z_j - L)}{2R}\tan\phi_K\right]$$

The anistropic weighting factors $N_1(\phi_K)$, etc., are determined from the discrete angular distribution, Φ_ℓ (as a function of $\sin\phi_\ell$), by a linear interpolation scheme. For example,

$$N_1(\phi_K) = \Phi_\ell - \left(\frac{\sin\phi_\ell - \sin\phi_K}{\sin\phi_\ell - \sin\phi_{\ell-1}}\right)\cdot\left(\Phi_\ell - \Phi_{\ell-1}\right) \tag{37}$$

where Φ_ℓ is the normalized angular flux at angle ϕ_ℓ in the computed angular distribution; $\Phi_{\ell-1}$ is at the previous (smaller) angle, $\phi_{\ell-1}$; $N_1(\phi_K)$ is the normalized angular flux at angle ϕ_K, as determined by the quadrature integration. The angular distribution normalization factor (in NORM) is computed as

$$\text{"Normalization factor"} = \frac{\pi}{4}\sum_{K=1}^{5}\sin\phi_K \cdot N_m(\phi_K)\cdot w_K \tag{38}$$

where $\phi_K = \frac{\pi}{2}(1 + u_K)$, and $N_m(\phi_K)$ is obtained by equation (37). The average escape probability is then computed by

$$\overline{P}_{ci} = \frac{\sum_{j=1}^{m} P_{cij}\cdot\phi_j}{\sum_{j=1}^{m}\phi_j} \tag{39}$$

where $P_{cij} = P_{1ij} + P_{2ij} + P_{3ij} + P_{4ij}$

ϕ_j = axial fission neutron density as a function of z_j (alternately, an "importance" distribution).

The DB^2 equation and its solution by the Newton iteration method give rise to three summations, appearing in equations (25), (30), and (31).

Considering a given gap thickness t_i, (therefore dropping the subscript "i") the sums are computed for the j^{th} iteration as:

$$S_1 = \sum_{m=1}^{M} w_m \mu_m N_m \tag{40}$$

$$S_{2j} = \sum_{m=1}^{M} w_m \mu_m N_m \cdot \left(\frac{2\mu_m A_1 - \sigma_j V_1}{2\mu_m A_2 + \sigma_j V_1} \right) \tag{41}$$

$$S_{3j} = \sum_{m=1}^{M} \frac{w_m N_m \mu_m^2}{(2\mu_m A_2 + \sigma_j V_1)^2} \tag{42}$$

where N_m = angular neutron flux
w_m = S_n solid-angle weight for flux in the m^{th} direction
μ_m = S_n m^{th} direction cosine
$M = \frac{n(n+2)}{8}$, (n = order of S_n)
A_1 = inner surface area of annular void (cm^2)
A_2 = outer surface area of annular void (cm^2)
V_1 = volume of annular void (cm^3)
σ_j = DB^2 for the j^{th} iteration (cm^{-1})

Then the iteration scheme is comprised of the equations (30) through (33) written for the code as:

$$\left.\begin{aligned} Q &= 1 - \overline{P_c} \\ R &= A_2 / (A_1 \cdot S_1) \\ F_j &= Q - R \cdot S_{2j} \\ F'_j &= 2 R V_1 \cdot (A_1 + A_2) \cdot S_{3j} \end{aligned}\right\} \tag{43}$$

After j iterations DB^2 is computed as

$$\sigma_{j+1} = \sigma_j - \frac{F_j}{F'_j} \tag{44}$$

and the convergence is

$$\epsilon = - \frac{F_j}{\sigma_{j+1} F'_j} \tag{45}.$$

c. Program Listing

The FOSDICK code is presented in the following listing. For further information and program deck see R. H. Norman or W. R. Castle.

7911-99 (001) 001 020 25 R H NØRMAN- 1054001 A72 727-753 00-00-00 ******************

LISTING (COMPILATION)

BEGIN CØMPILATIØN 29 8 TAPES 00-00-00 08/17/24

```
C     FØSDICK - CØDE FØR CALCULATIØN ØF TRANSVERSE LEAKAGE PRØBABILITIES00000010
C      FRØM ANNULAR VØIDS IN CYLINDRICAL REACTØRS                       00000020
C     MAIN PRØGRAM . . . .                                              00000030
      DIMENSIØN X(20),Z(100),P1(20,100),P2(20,100),P3(20,100),PRØB(20,1000000100
     10),U(5),W(5),T(20),P4(20,100),PHI(100),AVG(20),PMS(20),AFX(20),AFX00000200
     25(20),PHX(40),PM7(40),WØ(40),PHY(40),SIG(20),CØN(20),AFLUX(3),S4M700000201
     3(3),S4WØ(3)                                                       00000202
   51 READ INPUT TAPE 5,1,M,(PHI(J),J=1,M)                              00000400
    1 FØRMAT(I12/(6E12.8))                                              00000600
   52 READ INPUT TAPE 5,57,NSN,MM,MAX,EPS,(PHX(MI),MI=1,MM),(PM7(MI),MI=00000610
     11,MM),(WØ(MI),MI=1,MM)                                            00000611
   57 FØRMAT(3I12,E12.8/(6E12.8))                                       00000620
   50 READ INPUT TAPE 5,55,R,XMAX,XMIN,CØRL,N                           00000700
   55 FØRMAT(4F12.8,I12)                                                00000710
  100 READ INPUT TAPE 5,101,(AFLUX(I),I=1,3),(S4M7(I),I=1,3),(S4WØ(I),I=00000750
     11,3)                                                              00000751
  101 FØRMAT(6E12.8)                                                    00000760
      WRITE ØUTPUT TAPE 6,6,R,XMAX,XMIN,CØRL,N,M                        00000800
    6 FØRMAT(1H0 2X,        16HTHE FØSDICK CØDE///2X,22H* * * INPUT DATA 00000900
     1* * *//2X,19HCYLINDER RADIUS, R=F8 5//2X,31HRADIUS ØF MEDIUM (MAX 00000901
     2), X-MAX=F8.5//2X,31HRADIUS ØF MEDIUM (MIN ), X-MIN=F8 5//2X,19HCY00000902
     3LINDER LENGTH, L=F8.5//2X,25HNUMBER ØF X INTERVALS, N=I2//2X,26HNU00000903
     4MBER ØF AXIAL PØINTS, M=I3)                                       00000904
      WRITE ØUTPUT TAPE 6,59,NSN                                        00001600
   59 FØRMAT(//2X,14HØRDER ØF SN = I2)                                  00001610
      WRITE ØUTPUT TAPE 6,58,EPS,MAX,(PHX(MI),PM7(MI),WØ(MI),MI=1,MM)   00001700
   58 FØRMAT(///2X,24HCØNVERGENCE CRITERIØN = F9 6,4X,22HMAX  NØ  ITERAT00001800
     1IØNS = I3//4X,12HANGULAR FLUX5X,17HDIRECTIØN CØSINES5X,13HPØINT WE00001801
     2IGHTS/(4X,E12.6,8X,F9.6,F20 6))                                   00001802
      WRITE ØUTPUT TAPE 6,102,(AFLUX(I),S4M7(I),S4WØ(I),I=1,3)          00001850
  102 FØRMAT(//2X,31HS-4 FLUXES FØR DBSQ CALCULATIØN/4X,12HANGULAR FLUX500001860
     1X,17HDIRECTIØN CØSINES5X,13HPØINT WEIGHTS/(4X,E12 6,8X,F9.6,F20.6)00001861
     2)                                                                 00001862
       U(1)=-.9061798                                                   00001900
       U(2)=-.5384693                                                   00001901
       U(3)=0.0                                                         00001902
       U(4)=.5384693                                                    00001903
       U(5)=.9061798                                                    00001904
       W(1)=.236927                                                     00001905
```

```
      W(2)=.478629                                                      00001906
      W(3)=.568889                                                      00001907
      W(4)=.478629                                                      00001908
      W(5)=.236927                                                      00001909
      CALL ANGLE (PM7,PHX,WØ,PMS,AFX,NSN,L)                             00002000
      CALL NØRM (U,W,PMS,AFX,L,AFX5,AFX4)                               00003010
      CALL GPESC (R,XMAX,XMIN,CØRL,N,M,U,W,PHI,L,PMS,AFX5,X,T,AVG,Z,P1,P00004220
     12,P3,PRØB,P4,AFX4)                                                00004221
      CALL DBSQ (R,MM,N,X,AVG,EPS,MAX,SIGMA,CØNV,SIG,CØN,AFLUX,S4M7,S4WØ00009420
     1)                                                                 00009430
      DØ 308 I=1,N                                                      00012650
      WRITE ØUTPUT TAPE 6,7,T(I),AVG(I),CØN(I),SIG(I)                   00012700
    7 FØRMAT(//2X,6HFØR T=F7.4,6X,44HAVERAGE ESCAPE PRØBABILITY, PC-ANIS00012800
     1ØTRØPIC =E12.5//22X,14HCØNVERGENCE = F9.7,6X,15HSIGMA (DBSQ) = F9.00012801
     27//)                                                              00012802
      WRITE ØUTPUT TAPE 6,9                                             00013000
    9 FØRMAT(1H ,8X,1HZ,13X,2HP1,15X,2HP2,15X,2HP3,15X,2HP4,15X,2HPC)   00013100
      DØ 308 J=1,M                                                      00013300
      WRITE ØUTPUT TAPE 6,10,Z(J),P1(I,J),P2(I,J),P3(I,J),P4(I,J),PRØB(I00013400
     1,J)                                                               00013401
   10 FØRMAT(F13.5,5E17.5)                                              00013600
  308 CØNTINUE                                                          00013700
      IF DIVIDE CHECK 44,45                                             00013800
   44 CALL DUMP                                                         00013900
   45 GØ TØ 50                                                          00014000
      END(1,0,0,0,0,0,1,0,0,1,0,0,0,0,0)
```

STØRAGE NØT USED BY PRØGRAM

DEC	ØCT	DEC	ØCT
11014	25406	32561	77461

STØRAGE LØCATIØNS FØR VARIABLES APPEARING IN DIMENSIØN AND EQUIVALENCE STATEMENTS

	DEC	ØCT		DEC	ØCT		DEC	ØCT		DEC	ØCT
AFLUX	10483	24363	AFX5	10703	24717	AFX	10723	24743	AVG	10763	25013
CØN	10503	24407	P1	10474	24352	P2	8474	20432	P3	6474	14512
P4	2474	04652	PHI	10863	25157	PHX	10683	24673	PHY	10563	24503
PM7	10643	24623	PMS	10743	24767	PRØB	4474	10572	S4M7	10480	24360
S4WØ	10477	24355	SIG	10523	24433	T	10883	25203	U	10893	25215
WØ	10603	24553	W	10888	25210	X	11013	25405	Z	10993	25361

STØRAGE LØCATIØNS FØR VARIABLES NØT APPEARING IN CØMMØN, DIMENSIØN, ØR EQUIVALENCE STATEMENTS

	DEC	ØCT		DEC	ØCT		DEC	ØCT		DEC	ØCT
AFX4	474	00732	CØNV	473	00731	CØRL	472	00730	EPS	471	00727
L	470	00726	MAX	469	00725	MM	468	00724	M	467	00723
N	466	00722	NSN	465	00721	R	464	00720	SIGMA	463	00717
XMAX	462	00716	XMIN	461	00715						

SYMBØLS AND LØCATIØNS FØR SØURCE PRØGRAM FØRMAT STATEMENTS

	EFN	LØC		EFN	LØC		EFN	LØC		EFN	LØC
8)1	1	00712	8)6	6	00677	8)7	7	00531	8)9	9	00503
8)A	10	00471	8)1N	55	00703	8)1P	57	00707	8)1Q	58	00612
8)1R	59	00617	8)35	101	00701	8)36	102	00557			

LØCATIØNS FØR ØTHER SYMBØLS NØT APPEARING IN SØURCE PRØGRAM

	DEC	ØCT		DEC	ØCT		DEC	ØCT		DEC	ØCT
2)	295	00447	3)	299	00453	4)	32767	77777	6)	305	00461
C)G2	459	00713	C)100	460	00714	D)20K	241	00361	D)30K	240	00360

LØCATIØNS ØF NAMES IN TRANSFER VECTØR

	DEC	ØCT		DEC	ØCT		DEC	ØCT		DEC	ØCT
ANGLE	5	00005	DBSQ	8	00010	DUMP	9	00011	GPESC	7	00007
NØRM	6	00006	(FIL)	4	00004	(FPT)	0	00000	(RTN)	2	00002
(STH)	3	00003	(TSH)	1	00001						

ENTRY PØINTS TØ SUBRØUTINES NØT ØUTPUT FRØM LIBRARY

ANGLE	DBSQ	DUMP	GPESC	NØRM	(FIL)	(FPT)	(RTN)
(STH)	(TSH)						

EXTERNAL FØRMULA NUMBERS WITH CØRRESPØNDING INTERNAL FØRMULA NUMBERS AND ØCTAL LØCATIØNS

EFN	IFN	LØC	EFN	IFN	LØC	EFN	IFN	LØC	EFN	IFN	LØC
51	14	00017	52	20	00034	50	32	00075	100	34	00113
308	81	00431	44	83	00443	45	84	00446			

BEGIN COMPILATION 29 8 TAPES 01-42-42 08/15/64

```
      SUBROUTINE ANGLE (PM7,PHX,WO,PMS,AFX,NSN,L)                       00002001
      DIMENSION PM7(40),PHX(40),WO(40),PMS(20),AFX(20),SUM1(10),SUM2(10)00002002
     1,AFXO(20),PMU(20)                                                 00002003
  200 MM=(NSN*(NSN+2))/8                                                00002010
  201 L=NSN+3                                                           00002012
  202 LM=(L+1)/2                                                        00002014
  203 LLM=LM-1                                                          00002016
  204 PMU(1)=1.0000                                                     00002018
  205 PMU(LM)=0.0                                                       00002020
  206 PMU(L)=-1.0000                                                    00002022
      DO 208 LA=2,LLM                                                   00002024
  207 MI=MM+2-LA                                                        00002026
  208 PMU(LA)=PM7(MI)                                                   00002028
  209 LE=(L-3)/2                                                        00002030
      DO 210 LA=1,LE                                                    00002032
  100 LAL=LA+(L+3)/2-1                                                  00002033
  101 MAM=MM-LE+LA                                                      00002034
  210 PMU(LAL)=-PM7(MAM)                                                00002035
      DO 212 N=1,10                                                     00002036
      SUM1(N)=0.0                                                       00002037
  212 SUM2(N)=0.0                                                       00002038
  213 NS=NSN/2                                                          00002040
  214 J=1                                                               00002042
  215 K=0                                                               00002044
      DO 222 N=1,NS                                                     00002046
  216 J=J+N-1                                                           00002048
  217 K=K+N                                                             00002050
      DO 219 MI=J,K                                                     00002052
  218 SUM1(N)=SUM1(N)+PHX(MI)*WO(MI)                                    00002054
  219 SUM2(N)=SUM2(N)+WO(MI)                                            00002056
  220 AFXO(N)=SUM1(N)/SUM2(N)                                           00002058
  221 AFX(N+1)=AFXO(N)                                                  00002060
  102 M=L-N                                                             00002061
  222 AFX(M)=AFX(N+1)                                                   00002062
  223 XPX=(QATANF(SQRTF(1.-(PM7(MM))**2),PM7(MM)))/(QATANF(SQRTF(1.-(PM700002064
     1(MM-1))**2),PM7(MM-1))-QATANF(SQRTF(1.-(PM7(MM))**2),PM7(MM)))    00002066
  224 AFX(1)=AFX(2)-XPX*(AFX(3)-AFX(2))                                 00002068
  225 AFX(L)=AFX(1)                                                     00002070
  103 MA1=MM-NS+1                                                       00002071
```

```
 104 MA2=MM-NS+2                                                       00002072
 226 ACM1=QATANF(SQRTF(1.-(PM7(MA1))**2),PM7(MA1))                     00002073
 227 ACM2=QATANF(SQRTF(1.-(PM7(MA2))**2),PM7(MA2))                     00002074
 228 AFXLO=AFX(LLM)                                                    00002076
 229 AFXHI=AFX(LLM)+(AFX(LLM)-AFX(LLM-1))*(1.5707963-ACM1)/(ACM1-ACM2) 00002078
 230 GAMMA=0.5                                                         00002080
 231 AFX(LM)=AFXLO+GAMMA*(AFXHI-AFXLO)                                 00002082
     DO 233 LA=1,L                                                     00002083
 233 PMS(LA)=SINF(QATANF(SQRTF(1.-(PMU(LA))**2),PMU(LA)))              00002084
     WRITE OUTPUT TAPE 6,232,(PMS(LA),AFX(LA),LA=1,L)                  00002086
 232 FORMAT(///2X,18H* * * OUTPUT * * *//2X,21HANGULAR DISTRIBUTION,5X,00002087
    14HSINE9X,4HFLUX//(25X,F8.5,4X,E13.6))                             00002088
     RETURN                                                            00002090
     END(1,0,0,0,0,0,1,0,0,1,0,0,0,0,0)
```

STORAGE NOT USED BY PROGRAM

DEC	OCT	DEC	OCT
509	00775	32561	77461

STORAGE LOCATIONS FOR VARIABLES APPEARING IN DIMENSION AND EQUIVALENCE STATEMENTS

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
AFXO	488	00750	PMU	468	00724	SUM1	508	00774	SUM2	498	00762

STORAGE LOCATIONS FOR VARIABLES NOT APPEARING IN COMMON, DIMENSION, OR EQUIVALENCE STATEMENTS

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
ACM1	448	00700	ACM2	447	00677	AFXHI	446	00676	AFXLO	445	00675
GAMMA	444	00674	J	443	00673	K	442	00672	LAL	441	00671
LA	440	00670	LE	439	00667	LLM	438	00666	LM	437	00665
MA1	436	00664	MA2	435	00663	MAM	434	00662	MI	433	00661
MM	432	00660	M	431	00657	N	430	00656	NS	429	00655
XPX	428	00654									

SYMBOLS AND LOCATIONS FOR SOURCE PROGRAM FORMAT STATEMENTS

	EFN	LOC		EFN	LOC		EFN	LOC		EFN	LOC
8)78	232	00633									

LOCATIONS FOR OTHER SYMBOLS NOT APPEARING IN SOURCE PROGRAM

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
1)	415	00637	2)	379	00573	3)	385	00601	6)	389	00605
9)	412	00634	C)G1	418	00642	C)G2	419	00643	C)G4	420	00644
C)G5	421	00645	C)G6	422	00646	C)G7	423	00647	C)G8	424	00650
C)G9	425	00651	C)GA	426	00652	C)GC	427	00653	D)107	196	00304

LOCATIONS OF NAMES IN TRANSFER VECTOR

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
QATAN	1	00001	SIN	2	00002	SQRT	0	00000	(FIL)	4	00004
(STH)	3	00003									

ENTRY POINTS TO SUBROUTINES NOT OUTPUT FROM LIBRARY

CATAN SIN SQRT (FIL) (STH)

EXTERNAL FORMULA NUMBERS WITH CORRESPONDING INTERNAL FORMULA NUMBERS AND OCTAL LOCATIONS

EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC
200	5	00123	201	6	00140	202	7	00145	203	8	00156
204	9	00163	205	10	00165	206	11	00167	207	13	00176
208	14	00204	209	15	00211	100	17	00225	101	18	00242
210	19	00250	212	22	00260	213	23	00264	214	24	00272
215	25	00274	216	27	00305	217	28	00311	218	30	00317
219	31	00323	220	32	00330	221	33	00333	102	34	00335
222	35	00341	223	36	00347	224	37	00403	225	38	00413
103	39	00416	104	40	00424	226	41	00431	227	42	00451
228	43	00472	229	44	00474	230	45	00510	231	46	00512
233	48	00525									

BEGIN COMPILATION 29 8 TAPES 01-43-02 08/15/64

```
      SUBROUTINE NORM (U,W,PMS,AFX,L,AFX5,AFX4)                          00003011
      DIMENSION U(5),W(5),PMS(20),AFX(20),AFX5(20)                       00003012
      AFX4=0.0                                                           00003098
   56 DO 40 K=1,5                                                        00003100
   46 A11=(3.1415926/2.)*(1.+U(K))                                       00003200
      DO 49 LA=1,L                                                       00003300
   48 IF(PMS(LA)-SINF(A11))49,54,54                                      00003400
   49 CONTINUE                                                           00003500
   54 A12 = (PMS(LA)-SINF(A11))/(PMS(LA)-PMS(LA-1))                      00003600
   55 AFX6 = AFX(LA)-A12*(AFX(LA)-AFX(LA-1))                             00003700
   40 AFX4 = (3.14159265/4.)*SINF(A11)*AFX6*W(K) + AFX4                  00004000
      DO 42 LA=1,L                                                       00004100
   42 AFX5(LA) = AFX(LA)/AFX4                                            00004200
      WRITE OUTPUT TAPE 6,43,AFX4                                        00004205
   43 FORMAT(//2X,44HANGULAR DISTRIBUTION NORMALIZATION FACTOR = E12.6)  00004206
      RETURN                                                             00004210
      END(1,0,0,0,0,0,1,0,0,1,0,0,0,0,0)
```

STORAGE NOT USED BY PROGRAM

DEC	OCT	DEC	OCT
173	00255	32561	77461

STORAGE LOCATIONS FOR VARIABLES NOT APPEARING IN COMMON, DIMENSION, OR EQUIVALENCE STATEMENTS

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
A11	172	00254	A12	171	00253	AFX6	170	00252	LA	169	00251

SYMBOLS AND LOCATIONS FOR SOURCE PROGRAM FORMAT STATEMENTS

	EFN	LOC		EFN	LOC		EFN	LOC		EFN	LOC
8)1B	43	00242									

LOCATIONS FOR OTHER SYMBOLS NOT APPEARING IN SOURCE PROGRAM

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
1)	165	00245	2)	139	00213	3)	141	00215	6)	147	00223
9)	163	00243	C)G0	167	00247	C)G1	168	00250	D)407	81	00121
E)3	70	00106	E)6	80	00120						

LOCATIONS OF NAMES IN TRANSFER VECTOR

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
SIN	0	00000	(FIL)	2	00002	(STH)	1	00001			

ENTRY POINTS TO SUBROUTINES NOT OUTPUT FROM LIBRARY

SIN (FIL) (STH)

EXTERNAL FORMULA NUMBERS WITH CORRESPONDING INTERNAL FORMULA NUMBERS AND OCTAL LOCATIONS

EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC
56	6	00060	46	7	00061	48	9	00073	49	10	00115
54	11	00122	55	12	00137	40	13	00147	42	15	00174

BEGIN COMPILATION 29 8 TAPES 01-43-19 08/15/64

```
      SUBROUTINE GPESC (R,XMAX,XMIN,CORL,N,M,U,W,PHI,L,PMS,AFX5,X,T,AVG,00004230
     1Z,P1,P2,P3,PROB,P4,AFX4)                                          00004231
      DIMENSION U(5),W(5),PHI(100),PMS(20),AFX5(20),X(20),T(20),AVG(20),00004233
     1Z(100),P1(20,100),P2(20,100),P3(20,100),PROB(20,100),P4(20,100)   00004234
   67 AN=FLOATF(N)                                                      00004250
      DO 2 I=1,N                                                        00004300
   68 AI=FLOATF(I)                                                      00004350
   69 X(I)=((XMAX-XMIN)/AN)*AI+XMIN                                     00004400
    2 T(I)=X(I)-R                                                       00004500
      DEN=0.0                                                           00004600
   70 AM=FLOATF(M)                                                      00004650
      DO 3 J=1,M                                                        00004700
   71 AJ=FLOATF(J)                                                      00004750
      DEN=PHI(J)+DEN                                                    00004800
    3 Z(J)=(CORL/2.)*AJ/AM                                              00004900
      DO 60 I=1,20                                                      00004908
      DO 60 J=1,100                                                     00004909
      P1(I,J)=0.0                                                       00004910
      P2(I,J)=0.0                                                       00004911
      P3(I,J)=0.0                                                       00004912
   60 P4(I,J)=0.0                                                       00004915
      UNM=0.0                                                           00004950
      DO 53 I=1,N                                                       00005000
      DO 51 J=1,M                                                       00005100
   11 A1=QATANF((X(I)-R),Z(J))                                          00005200
   12 A2=QATANF(SQRTF(X(I)**2-R**2),Z(J))                               00005300
   13 A3=QATANF(SQRTF(X(I)**2-R**2),(Z(J)-CORL))                        00005400
   14 A4=QATANF((X(I)-R),(Z(J)-CORL))                                   00005500
      A7=3.14159265                                                     00005600
      DO 90 K=1,5                                                       00005700
   23 A6=(A1/2.)*(1.+U(K))                                              00005800
      DO 36 LA=1,L                                                      00005810
   25 IF(PMS(LA)-SINF(A6))36,26,26                                      00005820
   36 CONTINUE                                                          00005830
   26 A8 = (PMS(LA)-SINF(A6))/(PMS(LA)-PMS(LA-1))                       00005840
   27 AFX1 = AFX5(LA)-A8*(AFX5(LA)-AFX5(LA-1))                          00005900
   15 P1(I,J)=(A1/4.)*SINF(A6)*AFX1*W(K)+P1(I,J)                        00006000
   17 A5=((A2+A1)/2.)+((A2-A1)/2.)*U(K)                                 00006600
      DO 37 LA=1,L                                                      00006610
```

```
 29 IF(PMS(LA)-SINF(A5))37,30,30                                         00006620
 37 CONTINUE                                                             00006630
 30 A9 = (PMS(LA)-SINF(A5))/(PMS(LA)-PMS(LA-1))                          00006640
 31 AFX2 = AFX5(LA)-A9*(AFX5(LA)-AFX5(LA-1))                             00007100
 18 C1=((1.-(X(I)/R)**2)*CØSF(A5)/SINF(A5)+((Z(J)/R)**2)*SINF(A5)/CØSF00007400
   1(A5))/(2.*Z(J)/(-R))                                                 00007500
 21 P2(I,J)=((A2-A1)/6.2831853)*SINF(A5)*AFX2*(1.5707963-(CATANF(SQRTF00007600
   1(1.-C1**2),C1)))*W(K)+P2(I,J)                                        00007601
 19 B5=((A4+A3)/2.)+((A4-A3)/2.)*U(K)                                    00007800
    DØ 38 LA=1,L                                                         00007810
 33 IF(PMS(LA)-SINF(B5))38,34,34                                         00007820
 38 CØNTINUE                                                             00007830
 34 A10 = (PMS(LA)-SINF(B5))/(PMS(LA)-PMS(LA-1))                         00007840
 35 AFX3 = AFX5(LA)-A10*(AFX5(LA)-AFX5(LA-1))                            00008300
 20 D1=((1.-(X(I)/R)**2)*CØSF(B5)/SINF(B5)+(((Z(J)-CØRL)/R)**2)*SINF(B00008600
   15)/CØSF(B5))/(2.*(CØRL-Z(J))/R)                                      00008700
  4 P3(I,J) = ((A4-A3)/6.2831853)*SINF(B5)*AFX3*(1.5707963-CATANF(SQRT00008800
   1F(1.-D1**2),D1))*W(K) + P3(I,J)                                      00008801
 88 B4 = ((A7+A4)/2.) + ((A7-A4)/2.)*U(K)                                00008900
    DØ 39 LA=1,L                                                         00008910
 40 IF(PMS(LA)-SINF(B4))39,41,41                                         00008920
 39 CØNTINUE                                                             00008930
 41 A13 = (PMS(LA)-SINF(B4))/(PMS(LA)-PMS(LA-1))                         00008940
 89 AFX6 = AFX5(LA)-A13*(AFX5(LA)-AFX5(LA-1))                            00008950
 90 P4(I,J) = ((A7-A4)/4.)*SINF(B4)*AFX6*W(K)+P4(I,J)                    00008960
  5 PRØB(I,J) = P1(I,J) + P2(I,J) + P3(I,J) + P4(I,J)                    00009000
    IF(PRØB(I,J))55,51,50                                                00009010
 55 PRØB(I,J)=0.0                                                        00009020
    GØ TØ 51                                                             00009030
 50 IF(PRØB(I,J)-1.0)51,51,56                                            00009040
 56 WRITE ØUTPUT TAPE 6,80,PRØB(I,J)                                     00009050
 80 FØRMAT(//3X,28HERRØR, ESCAPE PRØBABILITY = F9.6//)                   00009060
 51 UNM=PHI(J)*PRØB(I,J)+UNM                                             00009200
 52 AVG(I)=UNM/DEN                                                       00009300
 53 UNM=0.0                                                              00009400
    RETURN                                                               00009410
    END(1,0,0,0,0,0,1,0,0,1,0,0,0,0,0)
```

STORAGE NOT USED BY PROGRAM

DEC	OCT	DEC	OCT
871	01547	32561	77461

STORAGE LOCATIONS FOR VARIABLES NOT APPEARING IN COMMON, DIMENSION, OR EQUIVALENCE STATEMENTS

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
A10	870	01546	A13	869	01545	A1	868	01544	A2	867	01543
A3	866	01542	A4	865	01541	A5	864	01540	A6	863	01537
A7	862	01536	A8	861	01535	A9	860	01534	AFX1	859	01533
AFX2	858	01532	AFX3	857	01531	AFX6	856	01530	AI	855	01527
AJ	854	01526	AM	853	01525	AN	852	01524	B4	851	01523
B5	850	01522	C1	849	01521	D1	848	01520	DEN	847	01517
I	846	01516	J	845	01515	LA	844	01514	UNM	843	01513

SYMBOLS AND LOCATIONS FOR SOURCE PROGRAM FORMAT STATEMENTS

	EFN	LOC		EFN	LOC		EFN	LOC		EFN	LOC
8)2G	80	01475									

LOCATIONS FOR OTHER SYMBOLS NOT APPEARING IN SOURCE PROGRAM

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
1)	832	01500	2)	805	01445	3)	809	01451	6)	816	01460
9)	830	01476	C)G0	838	01506	C)G1	839	01507	C)G2	840	01510
C)G3	841	01511	C)100	842	01512	D)20B	331	00513	D)218	779	01413
D)40A	266	00412	D)40H	364	00554	D)40N	438	00666	D)40P	564	01064
D)40T	576	01100	D)413	711	01307	D)50P	563	01063	D)50T	575	01077
D)60A	265	00411	E)D	353	00541	E)G	363	00553	E)M	437	00665
E)S	574	01076	E)V	700	01274	E)12	710	01306	E)14	752	01360

LOCATIONS OF NAMES IN TRANSFER VECTOR

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
COS	3	00003	QATAN	0	00000	SIN	2	00002	SQRT	1	00001
(FIL)	5	00005	(STH)	4	00004						

ENTRY POINTS TO SUBROUTINES NOT OUTPUT FROM LIBRARY

COS CATAN SIN SQRT (FIL) (STH)

EXTERNAL FORMULA NUMBERS WITH CORRESPONDING INTERNAL FORMULA NUMBERS AND OCTAL LOCATIONS

EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC
67	5	00263	68	7	00275	69	8	00302	2	9	00310
70	11	00320	71	13	00332	3	15	00342	60	21	00362
11	25	00413	12	26	00424	13	27	00446	14	28	00473
23	31	00514	25	33	00526	36	34	00550	26	35	00555
27	36	00572	15	37	00602	17	38	00622	29	40	00641
37	41	00662	30	42	00667	31	43	00704	18	44	00714
21	45	00764	19	46	01031	33	48	01050	38	49	01073
34	50	01101	35	51	01116	20	52	01126	4	53	01175
88	54	01243	40	56	01261	39	57	01303	41	58	01310
89	59	01325	90	60	01335	5	61	01361	55	63	01371
50	65	01374	56	66	01401	51	68	01414	52	69	01426
53	70	01432									

BEGIN COMPILATION 29   8 TAPES   01-43-45   08/15/64

```
      SUBROUTINE CBSC (R,MM,N,X,AVG,EPS,MAX,SIGMA,CONV,SIG,CON,AFLUX,S4M00009421
     17,S4W0)                                                           00009422
      DIMENSION X(20),AVG(20),SIG(20),CON(20),AFLUX(3),S4M7(3),S4W0(3)  00009425
  100 R1=2.540005*R                                                     00009500
      DO 8 J=1,N                                                        00010000
      SIGMA=0.0                                                         00010054
      NITT=0                                                            00010056
  105 R2 = 2.540005*X(J)                                                00010100
  102 T = X(J)-R                                                        00010150
  101 A1 = 6.2831853*R1                                                 00010200
  103 A2 = 6.2831853*R2                                                 00010210
  104 V1 = 3.14159265*(R2+R1)*(R2-R1)                                   00010220
  107 C = 1.-AVG(J)                                                     00010230
  106 NITT=NITT+1                                                       00010600
      SUM1 = 0.0                                                        00010700
      SUM2 = 0.0                                                        00010710
      SUM3 = 0.0                                                        00010750
      DO 113 I=1,3                                                      00010800
  113 SUM1 = S4W0(I)*S4M7(I)*AFLUX(I)+SUM1                              00010900
      DO 127 I=1,3                                                      00011200
  127 SUM2 = S4W0(I)*S4M7(I)*AFLUX(I)*((2.*S4M7(I)*A1-SIGMA*V1)/(2.*S4M700011300
     1(I)*A2+SIGMA*V1))+SUM2                                            00011301
      DO 114 I=1,3                                                      00011400
  114 SUM3 = S4W0(I)*AFLUX(I)*(S4M7(I)**2)/(2.*S4M7(I)*A2+SIGMA*V1)**2+S00011410
     1UM3                                                               00011411
  128 RR = A2/(A1*SUM1)                                                 00011500
  115 F = C-RR*SUM2                                                     00011550
  116 FPRIME = 2.*RR*V1*(A1+A2)*SUM3                                    00011600
  117 SIGMA = SIGMA-F/FPRIME                                            00011700
  118 CONV = -F/(FPRIME*SIGMA)                                          00011800
  119 IF(ABSF(CONV)-EPS)120,120,122                                     00011900
  122 IF(NITT-MAX)106,106,123                                           00012000
  123 WRITE OUTPUT TAPE 6,124,T,CONV,SIGMA                              00012100
  124 FORMAT(///2X,3HT =F8.4,6X,53HMAXIMUM NUMBER OF ITERATIONS EXCEEDED00012400
     1, CONVERGENCE = F9.7/2X,8HSIGMA = F9.7)                           00012401
  120 SIG(J) = SIGMA                                                    00012500
  121 CON(J) = CONV                                                     00012600
    8 CONTINUE                                                          00012610
      RETURN                                                            00012620
      END(1,0,0,0,0,0,1,0,0,1,0,0,0,0,0)
```

STORAGE NOT USED BY PROGRAM

DEC	OCT	DEC	OCT
296	00450	32561	77461

STORAGE LOCATIONS FOR VARIABLES NOT APPEARING IN COMMON, DIMENSION, OR EQUIVALENCE STATEMENTS

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
A1	295	00447	A2	294	00446	FPRIME	293	00445	F	292	00444
NITT	291	00443	Q	290	00442	R1	289	00441	R2	288	00440
RR	287	00437	SUM1	286	00436	SUM2	285	00435	SUM3	284	00434
T	283	00433	V1	282	00432						

SYMBOLS AND LOCATIONS FOR SOURCE PROGRAM FORMAT STATEMENTS

	EFN	LOC		EFN	LOC		EFN	LOC		EFN	LOC
8)3S	124	00423									

LOCATIONS FOR OTHER SYMBOLS NOT APPEARING IN SOURCE PROGRAM

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
1)	277	00425	2)	243	00363	3)	247	00367	6)	253	00375
9)	276	00424	C)GC	281	00431	E)2	103	00147			

LOCATIONS OF NAMES IN TRANSFER VECTOR

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
(FIL)	1	00001	(STH)	0	00000						

ENTRY POINTS TO SUBROUTINES NOT OUTPUT FROM LIBRARY

(FIL) (STH)

EXTERNAL FORMULA NUMBERS WITH CORRESPONDING INTERNAL FORMULA NUMBERS AND OCTAL LOCATIONS

EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC
100	5	00102	105	9	00114	102	10	00117	101	11	00122
103	12	00125	104	13	00130	107	14	00143	106	15	00150
113	20	00162	127	22	00173	114	24	00224	128	25	00253

115	26 00261	116	27 00266	117	28 00302	118	29 00310
119	30 00320	122	31 00326	123	32 00333	120	34 00351
121	35 00353	8	36 00355				

d. Sample Problem

INPUT - The following sample input data is for the calculation of escape probabilities and DB^2 for 1 to 4 inch void sleeves between the S8ER core and surrounding water, and for 20 to 100 mil gaps between the SNAP 10A core and reflector. The angular fluxes for the angular distribution were calculated by the DTK S_{12} approximation for the S8ER water flooded core surrounded by 3-inch void sleeve and 6-inch water reflector. The angular fluxes for the DB^2 calculation were calculated in the S8ER model by the DTK S_4 approximation for a 3-inch sleeve, and in the SNAP 10A model by the DTF II S_4 approximation for a 50 mil gap. The axial fission density distribution was calculated by the DTK S_4 approximation for a SNAP 10A-type reactor.[(10)] FOSDICK is presently set up to run multiple cases where the axial fission density distribution (not printed out) and the angular flux data for the escape probability calculation is common to all cases. Only the geometry of the void gap and the angular flux data for the DB^2 calculation need be respecified in successive cases. All data are entered in E12.8 format except the integer data which is placed to the extreme right of the data field.

FORTRAN FIXED 10 DIGIT DECIMAL DATA

DECK NO. ______ PROGRAMMER ______ DATE ______ PAGE 1 of 8 JOB NO. ______

	NUMBER	IDENTIFICATION	DESCRIPTION DO NOT KEY PUNCH
1	* DATA		
13			
25			
37			
49		73 … 80	
61		1	
1	6.0		Number of axial points, M ≤ 100
13			
25			
37			
49		73 … 80	
61		2	
1	.8216		Axial fission density distribution (equal intervals over
13	.9795		half core) arbitrarily normalized. Enter M values starting
25	1.1072		from end of core to center.
37	1.2224		Format (6E12.8)
49	1.3300	73 … 80	
61	1.4326	3	
1	1.5315		
13	1.6278		
25	1.7220		
37	1.8143		
49	1.9050	73 … 80	
61	1.9942	4	

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FORTRAN FIXED 10 DIGIT DECIMAL DATA

DECK NO. ______ PROGRAMMER ______ DATE ______ PAGE 2 of 8 JOB NO. ______

	NUMBER	IDENTIFICATION	DESCRIPTION DO NOT KEY PUNCH
1	2.0820		
13	2.1685		
25	2.2535		
37	2.3371		
49	2.4193	73 80	
61	2.5001	5	
1	2.5795		
13	2.6574		
25	2.7339		
37	2.8088		
49	2.8821	73 80	
61	2.9540	6	
1	3.0242		
13	3.0928		
25	3.1598		
37	3.2251		
49	3.2887	73 80	
61	3.3506	7	
1	3.4108		
13	3.4692		
25	3.5259		
37	3.5807		
49	3.6337	73 80	
61	3.6849	8	

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FORTRAN FIXED 10 DIGIT DECIMAL DATA

DECK NO. ______ PROGRAMMER ______ DATE ______ PAGE 3 of 8 JOB NO. ______

	NUMBER	IDENTIFICATION	DESCRIPTION DO NOT KEY PUNCH
1	3.7342		
13	3.7816		
25	3.8271		
37	3.8706		
49	3.9122	73 80	
61	3.9519	9	
1	3.9896		
13	4.0252		
25	4.0589		
37	4.0905		
49	4.1201	73 80	
61	4.1476	10	
1	4.1730		
13	4.1964		
25	4.2176		
37	4.2368		
49	4.2538	73 80	
61	4.2687	11	
1	4.2815		
13	4.2922		
25	4.3007		
37	4.3070		
49	4.3113	73 80	
61	4.3133	12	

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FORTRAN FIXED 10 DIGIT DECIMAL DATA

DECK NO. ______ PROGRAMMER ______ DATE ______ PAGE 4 of 8 JOB NO. ______

	NUMBER	IDENTIFICATION	DESCRIPTION DO NOT KEY PUNCH
1	12		Order of S_n, NSN ≤ 16
13	21		Number of Angular Fluxes, MM = NSN(NSN+2)/8
25	25		Maximum No. of iterations in DBSQ, MAX
37	.00001		Convergence criterion on DBSQ, EPS; Format (E12.8)
49		73 80	
61		13	
1	507138 -02		Angular Fluxes from DTK/DTF II calculation.
13	369669 -02		These values are group-summed, forward-angle fluxes at
25	120629 -01		the core/void boundary.
37	427138 -02		Enter MM values corresponding to appropriate direction
49	506889 -02	73 80	cosines.
61	174542 -01	14	Format (6E12.8)
1	465507 -02		
13	378207 -02		
25	852100 -02		
37	208133 -01		
49	489001 -02	73 80	
61	379989 -02	15	
1	497708 -02		
13	118748 -01		
25	229607 -01		
37	524073 -02		
49	426609 -02	73 80	
61	446853 -02	16	

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FORTRAN FIXED 10 DIGIT DECIMAL DATA

DECK NO. ______ PROGRAMMER ______ DATE ______ PAGE 5 of 8 JOB NO. ______

	NUMBER	IDENTIFICATION	DESCRIPTION DO NOT KEY PUNCH
1	815255 -02		
13	175878 -01		
25	251422 -01		
37	.17408		S_n Direction Cosines, forward directions from
49	.17408	73 … 80	DTK/DTF II data. Enter MM values (in this order only).
61	.46057	17	
1	.17408		
13	.46057		
25	.62765		
37	.17408		
49	.46057	73 … 80	
61	.62765	18	
1	.75879		
13	.17408		
25	.46057		
37	.62765		
49	.75879	73 … 80	
61	.87039	19	
1	.17408		
13	.46057		
25	.62765		
37	.75879		
49	.87039	73 … 80	
61	.96922	20	

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FORTRAN FIXED 10 DIGIT DECIMAL DATA

DECK NO. ________ PROGRAMMER ________ DATE ________ PAGE 6 of 8 JOB NO. ________

Col.	NUMBER	IDENTIFICATION	DESCRIPTION DO NOT KEY PUNCH
1	.03188		S_n Point Weights from DTK/DTF II data.
13	.02845		Enter MM values corresponding to direction cosines.
25	.02845		
37	.02269		
49	.01737		
61	.02269	21	
1	.02269		
13	.01514		
25	.01514		
37	.02269		
49	.02845		
61	.01737	22	
1	.01514		
13	.01737		
25	.02845		
37	.03188		
49	.02845		
61	.02269	23	
1	.02269		
13	.02845		
25	.03188		
37			
49			
61		24	

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FORTRAN FIXED 10 DIGIT DECIMAL DATA

DECK NO. ______ PROGRAMMER ______ DATE ______ PAGE 7 of 8 JOB NO. ______

	NUMBER	IDENTIFICATION	DESCRIPTION DO NOT KEY PUNCH
1	4.71417		Core radius, R (inches)
13	8.71417		Maximum reflector radius, XMAX (inches)
25	4.71417		Minimum reflector radius, XMIN (inches)
37	14.00		Core length, L (inches)
49	4	73 80	Number of gaps, N ≤ 20 (each using same axial and
61		25	angular distributions input)
1	.02185115		
13	.01689931		S_4 Angular Fluxes, (3 values)
25	.03006210		
37	.33333333		
49	.33333333	73 80	S_4 Direction Cosines, (3 values)
61	.88191710	26	
1	.16666667		
13	.16666667		S_4 Point Weights (3 values)
25	.16666667		
37			
49		73 80	
61		27	
1	4.5		R Second Case
13	4.6		XMAX
25	4.5		XMIN
37	12.25		L
49	5	73 80	N
61		28	

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FORTRAN FIXED 10 DIGIT DECIMAL DATA

DECK NO. ______ PROGRAMMER ______ DATE ______ PAGE 8 of 8 JOB NO. ______

	NUMBER	IDENTIFICATION	DESCRIPTION DO NOT KEY PUNCH
1	.03501323		S_4 Angular Fluxes
13	.03091040		
25	.04203140		
37	.33333333		S_4 Direction Cosines
49	.33333333	73 80	
61	.88191710	29	
1	.16666667		S_4 Point Weights
13	.16666667		
25	.16666667		
37			
49		73 80	
61		30	
1			
13			
25			
37			
49		73 80	
61			
1			
13			
25			
37			
49		73 80	
61			

114-C-17

OUTPUT - The following sample output should be quite self-explanatory. When running multiple cases, each new case begins with "THE FOSDICK CODE"; all input data, whether common between cases or not, is printed out for each case. All spatial dimensions are in inches, and SIGMA (DBSQ) has units of cm^{-1}. The execution time for this problem was 32 seconds on the IBM 7094 computer.

```
*      DATA                                                                              00000010
  BEGIN LOADING      25                        01-44-03        08/15/64

  NAME   LOAD    ENTRY        NAME   LOAD    ENTRY        NAME   LOAD    ENTRY        NAME   LOAD    ENTRY

  000000 00200 00212          ANGLE  25606 25617          NORM   26603 26612          GPESC  27060 27072
  DBSQ   30627 30635

SUBROUTINES LOADED FROM LIBRARY.

  (FPT)  31277 31306          .FPTRP*31277*31306          DUMP   31501 31527          PDUMP *31501*31517
  XDUMP  31501 31511          (KEYS) 31501 31507          DDUMP *31501*31523          (KIKL) 31501 32116
  EXIT   32503 32511          (TES)  32550 32554          (CDIN) 32550 32567          (LOUT) 32550 32572
  (CDXC)*32550*32571          (TAPU) 32550 32561          (CTES) 32550 32555          (TCRT)*32550*32557
  (IDCD)*32550*32562          (WDCT) 32550 32566          (CTJB)*32550*32570          (WFT)  32550 32576
  (FTC)  32550 32643          (NUSE)*32550*32573          (DATE)*32550*32560          (TIME)*32550*32556
  (JOBN)*32550*32563          (BOXN)*32550*32564          (USEC)*32550*32565          (BADA1 32550 32574
  (FIBBX 32550 32575          SIN    32646 32666          SINE  *32646*32666          SIN1  *32646*32666
  SIND  *32646*32653          COS    32646 32660          COSINE*32646*32660          COS1  *32646*32660
  COSD  *32646*32656          ECSIN *32646*33054          EPSIN  33061 33061          SQRT   33074 33101
  ECSQRT*33074*33177          EPSQRT 33203 33203          ATN1  *33205*33311          ATAN  *33205*33311
  ARCTAN*33205*33311          ATAND *33205*33212          QATAN  33205 33220          QATAND*33205*33222
  ECQTAN*33205*33442          EPQTAN 33446 33446          ESCORT 33455 33471          ESCSWT*33455*34011
  PAKUP) 33455 33673          ERRGO *33455*34014          (ESOUT 34023 34025          (ESCFI 34023 34026
  (SESC) 34027 34027          (ESCO) 34030 34030          TRAPEX 34031 34032          (IOS)  34033 34037
  (RDS)  34033 34145          (WRS)  34033 34146          (BSR)  34033 34147          (WEF)  34033 34150
  (REW)  34033 34151          (ETT)  34033 34156          (RCH)  34033 34160          (TEF)  34033 34161
  (TCO)  34033 34162          (TRC)  34033 34163          (RUN)  34033 34152          (BTT) *34033*34157
  (STC) *34033*34164          (LCH) *34033*34165          (BSF) *34033*34153          (SCH) *34033*34154
  (SDL) *34033*34155          (UBCD)*34033*34166          (IOU)  34243 34246          (TSH)  34267 34275
  (STH)  34317 34334          (CNTV)*34317*34370          (CNTL)*34317*34376          (WER)  34457 34472
  (WTC)  34457 34522          (RER)  34600 34612          (RDC)  34600 34647          (ICH)  34745 34753
  (FIL)  34745 36641          (RTN)  34745 36652          PRINT) 37026 37026          (SCRTV 37313 37314
  (YTOP)*37313*37316          (YREG)*37313*37317          (CTAPE 37313 37315

LOWEST COMMON LOC. ( 77461)8 HIGHEST PROGRAM LOC.( 37317)8     STORAGE NOT USED BY PROGRAM. ( 40141)8
  BEGIN EXECUTION    25                        01-44-12
```

THE FOSDICK CODE

* * * INPUT DATA * * *

CYLINDER RADIUS, R= 4.71417

RADIUS OF MEDIUM (MAX.), X-MAX= 8.71417

RADIUS OF MEDIUM (MIN.), X-MIN= 4.71417

CYLINDER LENGTH, L=14.00000

NUMBER OF X INTERVALS, N= 4

NUMBER OF AXIAL POINTS, M= 60

ORDER OF SN = 12

CONVERGENCE CRITERION = 0.000010 MAX. NO. ITERATIONS = 25

ANGULAR FLUX	DIRECTION COSINES	POINT WEIGHTS
0.507138E-02	0.174080	0.031880
0.369669E-02	0.174080	0.028450
0.120629E-01	0.460570	0.028450
0.427138E-02	0.174080	0.022690
0.506889E-02	0.460570	0.017370
0.174542E-01	0.627650	0.022690
0.465507E-02	0.174080	0.022690
0.378207E-02	0.460570	0.015140
0.852100E-02	0.627650	0.015140
0.208133E-01	0.758790	0.022690
0.489001E-02	0.174080	0.028450
0.379989E-02	0.460570	0.017370
0.497708E-02	0.627650	0.015140
0.118748E-01	0.758790	0.017370
0.229607E-01	0.870390	0.028450
0.524073E-02	0.174080	0.031880
0.426609E-02	0.460570	0.028450
0.446853E-02	0.627650	0.022690

0.815255E-02	0.758790	0.022690
C.175878E-C1	0.870390	0.028450
0.251422E-01	0.969220	0.031880

S-4 FLUXES FOR DBSQ CALCULATION

ANGULAR FLUX	DIRECTION COSINES	POINT WEIGHTS
0.218511E-01	0.333333	C.166667
0.168993E-01	0.333333	C.166667
C.300621E-C1	0.881917	C.166667

* * * OUTPUT * * *

ANGULAR DISTRIBUTION,	SINE	FLUX
	-C.	0.244553E-02
	C.24620	C.507138E-02
	C.49236	C.787979E-02
	C.65134	C.925896E-02
	C.77850	C.100997E-01
	C.88762	C.106759E-01
	C.98473	C.113028E-01
	1.00000	C.114835E-01
	C.98473	C.113028E-01
	C.88762	C.106759E-01
	C.77850	C.100997E-01
	C.65134	C.925896E-02
	C.49236	C.787979E-02
	C.24620	C.507138E-02
	C.	C.244553E-02

ANGULAR DISTRIBUTION NORMALIZATION FACTOR = 0.100049E-01

FOR T= 1.0000 AVERAGE ESCAPE PROBABILITY, PC-ANISOTROPIC = C.46621E-01

CONVERGENCE = 0.0000002 SIGMA (DBSQ) = C.0107013

Z	P1	P2	P3	P4	PC
C.11667	0.42880E-00	0.18084E-01	0.85452E-03	0.38179E-03	0.44812E-00
0.23333	0.36584E-00	0.34464E-01	C.87121E-03	C.38883E-03	0.40156E-00

0.35000	0.30850E-00	0.48145E-01	0.88838E-03	0.39607E-03	0.35793E-00
0.46667	0.25814E-00	0.58536E-01	0.90604E-03	0.40350E-03	0.31799E-00
0.58333	0.21514E-00	0.65621E-01	0.92422E-03	0.41115E-03	0.28209E-00
0.70000	0.17882E-00	0.69834E-01	0.94294E-03	0.41901E-03	0.25002E-00
0.81667	0.14853E-00	0.71672E-01	0.96221E-03	0.42710E-03	0.22160E-00
0.93333	0.12366E-00	0.71634E-01	0.98205E-03	0.43543E-03	0.19671E-00
1.05000	0.10358E-00	0.70228E-01	0.10025E-02	0.44399E-03	0.17526E-00
1.16667	0.87214E-01	0.67860E-01	0.10236E-02	0.45281E-03	0.15655E-00
1.28333	0.73857E-01	0.64891E-01	0.10453E-02	0.46190E-03	0.14026E-00
1.40000	0.62782E-01	0.61574E-01	0.10677E-02	0.47125E-03	0.12590E-00
1.51667	0.53757E-01	0.58092E-01	0.10908E-02	0.48089E-03	0.11342E-00
1.63333	0.46356E-01	0.54515E-01	0.11146E-02	0.49083E-03	0.10248E-00
1.75000	0.40175E-01	0.51042E-01	0.11392E-02	0.50108E-03	0.92857E-01
1.86667	0.35021E-01	0.47723E-01	0.11646E-02	0.51165E-03	0.84420E-01
1.98333	0.30726E-01	0.44523E-01	0.11908E-02	0.52255E-03	0.76963E-01
2.10000	0.27113E-01	0.41508E-01	0.12179E-02	0.53380E-03	0.70373E-01
2.21667	0.24054E-01	0.38675E-01	0.12458E-02	0.54541E-03	0.64521E-01
2.33333	0.21448E-01	0.36031E-01	0.12747E-02	0.55741E-03	0.59312E-01
2.45000	0.19215E-01	0.33574E-01	0.13046E-02	0.56980E-03	0.54664E-01
2.56667	0.17291E-01	0.31263E-01	0.13355E-02	0.58260E-03	0.50472E-01
2.68333	0.15624E-01	0.29138E-01	0.13675E-02	0.59584E-03	0.46725E-01
2.80000	0.14172E-01	0.27184E-01	0.14006E-02	0.60952E-03	0.43367E-01
2.91667	0.12903E-01	0.25388E-01	0.14349E-02	0.62368E-03	0.40350E-01
3.03333	0.11789E-01	0.23733E-01	0.14703E-02	0.63833E-03	0.37631E-01
3.15000	0.10810E-01	0.22204E-01	0.15071E-02	0.65350E-03	0.35175E-01
3.26667	0.99414E-02	0.20798E-01	0.15452E-02	0.66921E-03	0.32954E-01
3.38333	0.91685E-02	0.19504E-01	0.15847E-02	0.68548E-03	0.30942E-01
3.50000	0.84783E-02	0.18305E-01	0.16257E-02	0.70235E-03	0.29112E-01
3.61667	0.78597E-02	0.17184E-01	0.16683E-02	0.71984E-03	0.27432E-01
3.73333	0.73035E-02	0.16149E-01	0.17125E-02	0.73799E-03	0.25903E-01
3.85000	0.68035E-02	0.15194E-01	0.17584E-02	0.75682E-03	0.24513E-01
3.96667	0.63514E-02	0.14311E-01	0.18061E-02	0.77638E-03	0.23245E-01
4.08333	0.59411E-02	0.13495E-01	0.18557E-02	0.79669E-03	0.22088E-01
4.20000	0.55679E-02	0.12738E-01	0.19072E-02	0.81779E-03	0.21031E-01
4.31667	0.52275E-02	0.12038E-01	0.19608E-02	0.83974E-03	0.20066E-01
4.43333	0.49163E-02	0.11389E-01	0.20166E-02	0.86257E-03	0.19184E-01
4.55000	0.46312E-02	0.10786E-01	0.20747E-02	0.88633E-03	0.18378E-01
4.66667	0.43693E-02	0.10224E-01	0.21352E-02	0.91107E-03	0.17640E-01
4.78333	0.41284E-02	0.96969E-02	0.21982E-02	0.93685E-03	0.16960E-01
4.90000	0.39062E-02	0.92055E-02	0.22639E-02	0.96372E-03	0.16339E-01
5.01667	0.37010E-02	0.87471E-02	0.23325E-02	0.99174E-03	0.15772E-01
5.13333	0.35110E-02	0.83189E-02	0.24040E-02	0.10210E-02	0.15255E-01
5.25000	0.33349E-02	0.79186E-02	0.24787E-02	0.10515E-02	0.14784E-01
5.36667	0.31714E-02	0.75440E-02	0.25568E-02	0.10834E-02	0.14356E-01

5.48333	0.30192E-02	0.71932E-02	0.26384E-02	0.11168E-02	0.13968E-01
5.60000	0.28775E-02	0.68638E-02	0.27237E-02	0.11517E-02	0.13617E-01
5.71667	0.27452E-02	0.65547E-02	0.28130E-02	0.11882E-02	0.13301E-01
5.83333	0.26217E-02	0.62648E-02	0.29065E-02	0.12265E-02	0.13019E-01
5.95000	0.25061E-02	0.59930E-02	0.30049E-02	0.12666E-02	0.12771E-01
6.06667	0.23978E-02	0.57372E-02	0.31080E-02	0.13087E-02	0.12552E-01
6.18333	0.22962E-02	0.54962E-02	0.32162E-02	0.13528E-02	0.12361E-01
6.30000	0.22008E-02	0.52689E-02	0.33298E-02	0.13993E-02	0.12199E-01
6.41667	0.21111E-02	0.50544E-02	0.34491E-02	0.14480E-02	0.12063E-01
6.53333	0.20266E-02	0.48519E-02	0.35745E-02	0.14994E-02	0.11952E-01
6.65000	0.19470E-02	0.46604E-02	0.37063E-02	0.15534E-02	0.11867E-01
6.76667	0.18719E-02	0.44793E-02	0.38451E-02	0.16104E-02	0.11807E-01
6.88333	0.18010E-02	0.43078E-02	0.39913E-02	0.16705E-02	0.11770E-01
7.00000	0.17339E-02	0.41453E-02	0.41453E-02	0.17339E-02	0.11758E-01

FOR T= 2.0000 AVERAGE ESCAPE PROBABILITY, PC-ANISOTROPIC = 0.99786E-01

CONVERGENCE = 0.0000001 SIGMA (DBSQ) = 0.0114974

Z	P1	P2	P3	P4	PC
0.11667	0.46188E-00	0.76847E-02	0.24610E-02	0.17670E-02	0.47379E-00
0.23333	0.42880E-00	0.15159E-01	0.25096E-02	0.18010E-02	0.44827E-00
0.35000	0.39680E-00	0.22228E-01	0.25596E-02	0.18359E-02	0.42342E-00
0.46667	0.36584E-00	0.28779E-01	0.26109E-02	0.18719E-02	0.39910E-00
0.58333	0.33634E-00	0.34729E-01	0.26638E-02	0.19089E-02	0.37564E-00
0.70000	0.30850E-00	0.39983E-01	0.27182E-02	0.19470E-02	0.35315E-00
0.81667	0.28246E-00	0.44494E-01	0.27742E-02	0.19862E-02	0.33171E-00
0.93333	0.25814E-00	0.48247E-01	0.28320E-02	0.20266E-02	0.31125E-00
1.05000	0.23569E-00	0.51258E-01	0.28915E-02	0.20682E-02	0.29191E-00
1.16667	0.21514E-00	0.53590E-01	0.29529E-02	0.21111E-02	0.27379E-00
1.28333	0.19615E-00	0.55302E-01	0.30161E-02	0.21552E-02	0.25662E-00
1.40000	0.17882E-00	0.56452E-01	0.30812E-02	0.22008E-02	0.24055E-00
1.51667	0.16309E-00	0.57090E-01	0.31482E-02	0.22477E-02	0.22558E-00
1.63333	0.14853E-00	0.57308E-01	0.32174E-02	0.22962E-02	0.21136E-00
1.75000	0.13544E-00	0.57121E-01	0.32887E-02	0.23462E-02	0.19819E-00
1.86667	0.12366E-00	0.56606E-01	0.33623E-02	0.23978E-02	0.18603E-00
1.98333	0.11309E-00	0.55811E-01	0.34381E-02	0.24511E-02	0.17479E-00
2.10000	0.10358E-00	0.54790E-01	0.35164E-02	0.25061E-02	0.16439E-00
2.21667	0.94997E-01	0.53605E-01	0.35972E-02	0.25629E-02	0.15476E-00
2.33333	0.87214E-01	0.52297E-01	0.36807E-02	0.26217E-02	0.14581E-00
2.45000	0.80214E-01	0.50886E-01	0.37668E-02	0.26824E-02	0.13755E-00
2.56667	0.73857E-01	0.49355E-01	0.38558E-02	0.27452E-02	0.12981E-00
2.68333	0.68032E-01	0.47791E-01	0.39478E-02	0.28102E-02	0.12258E-00

2.80000	0.62782E-01	0.46211E-01	0.40428E-02	0.28775E-02	0.11591E-00
2.91667	0.58043E-01	0.44603E-01	0.41410E-02	0.29471E-02	0.10973E-00
3.03333	0.53757E-01	0.42991E-01	0.42427E-02	0.30192E-02	0.10401E-00
3.15000	0.49877E-01	0.41405E-01	0.43478E-02	0.30939E-02	0.98723E-01
3.26667	0.46356E-01	0.39848E-01	0.44565E-02	0.31714E-02	0.93832E-01
3.38333	0.43135E-01	0.38332E-01	0.45691E-02	0.32516E-02	0.89287E-01
3.50000	0.40175E-01	0.36861E-01	0.46856E-02	0.33349E-02	0.85056E-01
3.61667	0.37478E-01	0.35439E-01	0.48063E-02	0.34213E-02	0.81144E-01
3.73333	0.35021E-01	0.34042E-01	0.49313E-02	0.35110E-02	0.77505E-01
3.85000	0.32779E-01	0.32669E-01	0.50615E-02	0.36042E-02	0.74114E-01
3.96667	0.30726E-01	0.31352E-01	0.51965E-02	0.37010E-02	0.70976E-01
4.08333	0.28843E-01	0.30091E-01	0.53365E-02	0.38016E-02	0.68072E-01
4.20000	0.27113E-01	0.28883E-01	0.54817E-02	0.39062E-02	0.65385E-01
4.31667	0.25521E-01	0.27729E-01	0.56324E-02	0.40151E-02	0.62898E-01
4.43333	0.24054E-01	0.26627E-01	0.57889E-02	0.41284E-02	0.60598E-01
4.55000	0.22700E-01	0.25549E-01	0.59513E-02	0.42464E-02	0.58447E-01
4.66667	0.21448E-01	0.24517E-01	0.61201E-02	0.43693E-02	0.56455E-01
4.78333	0.20289E-01	0.23529E-01	0.62954E-02	0.44975E-02	0.54612E-01
4.90000	0.19215E-01	0.22588E-01	0.64777E-02	0.46312E-02	0.52912E-01
5.01667	0.18218E-01	0.21692E-01	0.66673E-02	0.47707E-02	0.51348E-01
5.13333	0.17291E-01	0.20838E-01	0.68644E-02	0.49163E-02	0.49910E-01
5.25000	0.16428E-01	0.20026E-01	0.70696E-02	0.50685E-02	0.48592E-01
5.36667	0.15624E-01	0.19252E-01	0.72831E-02	0.52275E-02	0.47386E-01
5.48333	0.14873E-01	0.18514E-01	0.75055E-02	0.53938E-02	0.46287E-01
5.60000	0.14172E-01	0.17811E-01	0.77372E-02	0.55679E-02	0.45289E-01
5.71667	0.13517E-01	0.17142E-01	0.79789E-02	0.57501E-02	0.44388E-01
5.83333	0.12903E-01	0.16494E-01	0.82313E-02	0.59411E-02	0.43569E-01
5.95000	0.12327E-01	0.15875E-01	0.84944E-02	0.61413E-02	0.42838E-01
6.06667	0.11789E-01	0.15285E-01	0.87688E-02	0.63514E-02	0.42194E-01
6.18333	0.11285E-01	0.14722E-01	0.90552E-02	0.65719E-02	0.41634E-01
6.30000	0.10810E-01	0.14186E-01	0.93542E-02	0.68035E-02	0.41154E-01
6.41667	0.10363E-01	0.13675E-01	0.96665E-02	0.70471E-02	0.40751E-01
6.53333	0.99414E-02	0.13187E-01	0.99928E-02	0.73035E-02	0.40425E-01
6.65000	0.95439E-02	0.12722E-01	0.10334E-01	0.75743E-02	0.40174E-01
6.76667	0.91685E-02	0.12278E-01	0.10691E-01	0.78597E-02	0.39997E-01
6.88333	0.88138E-02	0.11854E-01	0.11062E-01	0.81606E-02	0.39891E-01
7.00000	0.84783E-02	0.11449E-01	0.11449E-01	0.84783E-02	0.39855E-01

FOR T= 3.0000 AVERAGE ESCAPE PROBABILITY, PC-ANISOTROPIC = 0.15318E-00

CONVERGENCE = 0.0000001 SIGMA (DBSQ) = 0.0116863

Z	P1	P2	P3	P4	PC

0.11667	0.47302E-00	0.44624E-02	0.45043E-02	0.44542E-02	0.48644E-00
0.23333	0.45077E-00	0.88671E-02	0.45919E-02	0.45414E-02	0.46877E-00
0.35000	0.42880E-00	0.13159E-01	0.46819E-02	0.46312E-02	0.45127E-00
0.46667	0.40740E-00	0.17285E-01	0.47743E-02	0.47235E-02	0.43419E-00
0.58333	0.38633E-00	0.21205E-01	0.48692E-02	0.48185E-02	0.41722E-00
0.70000	0.36584E-00	0.24913E-01	0.49668E-02	0.49163E-02	0.40063E-00
0.81667	0.34599E-00	0.28380E-01	0.50670E-02	0.50170E-02	0.38446E-00
0.93333	0.32686E-00	0.31575E-01	0.51701E-02	0.51207E-02	0.36873E-00
1.05000	0.30850E-00	0.34480E-01	0.52760E-02	0.52275E-02	0.35348E-00
1.16667	0.29093E-00	0.37085E-01	0.53849E-02	0.53375E-02	0.33874E-00
1.28333	0.27419E-00	0.39386E-01	0.54969E-02	0.54510E-02	0.32452E-00
1.40000	0.25814E-00	0.41384E-01	0.56122E-02	0.55679E-02	0.31071E-00
1.51667	0.24296E-00	0.43086E-01	0.57307E-02	0.56884E-02	0.29747E-00
1.63333	0.22863E-00	0.44508E-01	0.58526E-02	0.58128E-02	0.28480E-00
1.75000	0.21514E-00	0.45672E-01	0.59785E-02	0.59411E-02	0.27273E-00
1.86667	0.20231E-00	0.46598E-01	0.61081E-02	0.60735E-02	0.26109E-00
1.98333	0.19018E-00	0.47296E-01	0.62416E-02	0.62102E-02	0.24993E-00
2.10000	0.17882E-00	0.47778E-01	0.63790E-02	0.63514E-02	0.23933E-00
2.21667	0.16819E-00	0.48072E-01	0.65206E-02	0.64972E-02	0.22928E-00
2.33333	0.15807E-00	0.48192E-01	0.66664E-02	0.66478E-02	0.21958E-00
2.45000	0.14853E-00	0.48153E-01	0.68167E-02	0.68035E-02	0.21031E-00
2.56667	0.13965E-00	0.47957E-01	0.69715E-02	0.69645E-02	0.20154E-00
2.68333	0.13137E-00	0.47631E-01	0.71312E-02	0.71310E-02	0.19326E-00
2.80000	0.12366E-00	0.47198E-01	0.72957E-02	0.73035E-02	0.18546E-00
2.91667	0.11649E-00	0.46646E-01	0.74655E-02	0.74825E-02	0.17808E-00
3.03333	0.10980E-00	0.46011E-01	0.76405E-02	0.76678E-02	0.17112E-00
3.15000	0.10358E-00	0.45310E-01	0.78211E-02	0.78597E-02	0.16457E-00
3.26667	0.97781E-01	0.44552E-01	0.80074E-02	0.80585E-02	0.15840E-00
3.38333	0.92310E-01	0.43749E-01	0.81996E-02	0.82646E-02	0.15252E-00
3.50000	0.87214E-01	0.42897E-01	0.83981E-02	0.84783E-02	0.14699E-00
3.61667	0.82466E-01	0.42013E-01	0.86028E-02	0.86999E-02	0.14178E-00
3.73333	0.78039E-01	0.41085E-01	0.88142E-02	0.89299E-02	0.13687E-00
3.85000	0.73857E-01	0.40145E-01	0.90325E-02	0.91685E-02	0.13220E-00
3.96667	0.69907E-01	0.39198E-01	0.92580E-02	0.94164E-02	0.12778E-00
4.08333	0.66222E-01	0.38250E-01	0.94909E-02	0.96738E-02	0.12364E-00
4.20000	0.62782E-01	0.37283E-01	0.97317E-02	0.99414E-02	0.11974E-00
4.31667	0.59569E-01	0.36310E-01	0.99805E-02	0.10220E-01	0.11608E-00
4.43333	0.56566E-01	0.35348E-01	0.10238E-01	0.10509E-01	0.11266E-00
4.55000	0.53757E-01	0.34400E-01	0.10504E-01	0.10810E-01	0.10947E-00
4.66667	0.51128E-01	0.33468E-01	0.10778E-01	0.11123E-01	0.10650E-00
4.78333	0.48665E-01	0.32553E-01	0.11060E-01	0.11449E-01	0.10373E-00
4.90000	0.46356E-01	0.31656E-01	0.11352E-01	0.11789E-01	0.10115E-00
5.01667	0.44185E-01	0.30780E-01	0.11653E-01	0.12144E-01	0.98762E-01
5.13333	0.42117E-01	0.29910E-01	0.11966E-01	0.12515E-01	0.96508E-01

5.25000	0.40175E-01	0.29061E-01	0.12289E-01	0.12903E-01	0.94427E-01
5.36667	0.38349E-01	0.28233E-01	0.12624E-01	0.13308E-01	0.92514E-01
5.48333	0.36633E-01	0.27429E-01	0.12970E-01	0.13730E-01	0.90762E-01
5.60000	0.35021E-01	0.26634E-01	0.13328E-01	0.14172E-01	0.89156E-01
5.71667	0.33504E-01	0.25861E-01	0.13700E-01	0.14634E-01	0.87699E-01
5.83333	0.32075E-01	0.25110E-01	0.14084E-01	0.15118E-01	0.86387E-01
5.95000	0.30726E-01	0.24383E-01	0.14482E-01	0.15624E-01	0.85216E-01
6.06667	0.29453E-01	0.23679E-01	0.14895E-01	0.16154E-01	0.84181E-01
6.18333	0.28250E-01	0.22995E-01	0.15322E-01	0.16709E-01	0.83276E-01
6.30000	0.27113E-01	0.22331E-01	0.15756E-01	0.17291E-01	0.82491E-01
6.41667	0.26037E-01	0.21682E-01	0.16206E-01	0.17901E-01	0.81827E-01
6.53333	0.25019E-01	0.21045E-01	0.16671E-01	0.18542E-01	0.81277E-01
6.65000	0.24054E-01	0.20429E-01	0.17153E-01	0.19215E-01	0.80852E-01
6.76667	0.23140E-01	0.19835E-01	0.17653E-01	0.19922E-01	0.80549E-01
6.88333	0.22272E-01	0.19261E-01	0.18170E-01	0.20666E-01	0.80368E-01
7.00000	0.21448E-01	0.18706E-01	0.18706E-01	0.21448E-01	0.80308E-01

FOR T= 4.0000 AVERAGE ESCAPE PROBABILITY, PC-ANISOTROPIC = 0.20473E-00

CONVERGENCE = 0.0000001 SIGMA (DBSQ) = 0.0115432

Z	P1	P2	P3	P4	PC
0.11667	0.47860E-00	0.29723E-02	0.67769E-02	0.86437E-02	0.49699E-00
0.23333	0.46188E-00	0.59221E-02	0.69033E-02	0.88138E-02	0.48351E-00
0.35000	0.44523E-00	0.88273E-02	0.70329E-02	0.89887E-02	0.47008E-00
0.46667	0.42880E-00	0.11667E-01	0.71657E-02	0.91685E-02	0.45680E-00
0.58333	0.41272E-00	0.14421E-01	0.73019E-02	0.93535E-02	0.44379E-00
0.70000	0.39680E-00	0.17070E-01	0.74415E-02	0.95439E-02	0.43086E-00
0.81667	0.38115E-00	0.19613E-01	0.75847E-02	0.97398E-02	0.41809E-00
0.93333	0.36584E-00	0.22044E-01	0.77316E-02	0.99414E-02	0.40555E-00
1.05000	0.35089E-00	0.24351E-01	0.78822E-02	0.10149E-01	0.39327E-00
1.16667	0.33634E-00	0.26521E-01	0.80368E-02	0.10363E-01	0.38126E-00
1.28333	0.32220E-00	0.28545E-01	0.81954E-02	0.10583E-01	0.36952E-00
1.40000	0.30850E-00	0.30418E-01	0.83581E-02	0.10810E-01	0.35809E-00
1.51667	0.29525E-00	0.32136E-01	0.85250E-02	0.11044E-01	0.34695E-00
1.63333	0.28246E-00	0.33699E-01	0.86962E-02	0.11285E-01	0.33614E-00
1.75000	0.27012E-00	0.35105E-01	0.88720E-02	0.11533E-01	0.32563E-00
1.86667	0.25814E-00	0.36358E-01	0.90525E-02	0.11789E-01	0.31534E-00
1.98333	0.24668E-00	0.37460E-01	0.92379E-02	0.12054E-01	0.30543E-00
2.10000	0.23569E-00	0.38416E-01	0.94281E-02	0.12327E-01	0.29586E-00
2.21667	0.22518E-00	0.39240E-01	0.96236E-02	0.12610E-01	0.28665E-00
2.33333	0.21514E-00	0.39932E-01	0.98243E-02	0.12903E-01	0.27779E-00
2.45000	0.20547E-00	0.40510E-01	0.10030E-01	0.13205E-01	0.26922E-00

2.56667	0.19615E-00	0.40969E-01	0.10242E-01	0.13517E-01	0.26088E-00
2.68333	0.18727E-00	0.41316E-01	0.10458E-01	0.13839E-01	0.25288E-00
2.80000	0.17882E-00	0.41562E-01	0.10679E-01	0.14172E-01	0.24523E-00
2.91667	0.17078E-00	0.41715E-01	0.10907E-01	0.14517E-01	0.23792E-00
3.03333	0.16309E-00	0.41778E-01	0.11141E-01	0.14873E-01	0.23089E-00
3.15000	0.15562E-00	0.41758E-01	0.11382E-01	0.15242E-01	0.22400E-00
3.26667	0.14853E-00	0.41662E-01	0.11629E-01	0.15624E-01	0.21745E-00
3.38333	0.14181E-00	0.41491E-01	0.11883E-01	0.16019E-01	0.21120E-00
3.50000	0.13544E-00	0.41252E-01	0.12144E-01	0.16428E-01	0.20526E-00
3.61667	0.12939E-00	0.40956E-01	0.12413E-01	0.16852E-01	0.19961E-00
3.73333	0.12366E-00	0.40602E-01	0.12689E-01	0.17291E-01	0.19424E-00
3.85000	0.11823E-00	0.40194E-01	0.12973E-01	0.17746E-01	0.18915E-00
3.96667	0.11309E-00	0.39747E-01	0.13264E-01	0.18218E-01	0.18432E-00
4.08333	0.10821E-00	0.39266E-01	0.13564E-01	0.18707E-01	0.17974E-00
4.20000	0.10358E-00	0.38756E-01	0.13873E-01	0.19215E-01	0.17543E-00
4.31667	0.99197E-01	0.38220E-01	0.14184E-01	0.19742E-01	0.17134E-00
4.43333	0.94997E-01	0.37653E-01	0.14504E-01	0.20289E-01	0.16744E-00
4.55000	0.91002E-01	0.37068E-01	0.14832E-01	0.20858E-01	0.16376E-00
4.66667	0.87214E-01	0.36469E-01	0.15170E-01	0.21448E-01	0.16030E-00
4.78333	0.83622E-01	0.35859E-01	0.15518E-01	0.22062E-01	0.15706E-00
4.90000	0.80214E-01	0.35225E-01	0.15875E-01	0.22700E-01	0.15401E-00
5.01667	0.76979E-01	0.34585E-01	0.16242E-01	0.23364E-01	0.15117E-00
5.13333	0.73857E-01	0.33942E-01	0.16619E-01	0.24054E-01	0.14847E-00
5.25000	0.70869E-01	0.33294E-01	0.17007E-01	0.24773E-01	0.14594E-00
5.36667	0.68032E-01	0.32648E-01	0.17405E-01	0.25521E-01	0.14361E-00
5.48333	0.65340E-01	0.31984E-01	0.17815E-01	0.26301E-01	0.14144E-00
5.60000	0.62782E-01	0.31325E-01	0.18236E-01	0.27113E-01	0.13946E-00
5.71667	0.60352E-01	0.30673E-01	0.18669E-01	0.27960E-01	0.13765E-00
5.83333	0.58043E-01	0.30027E-01	0.19104E-01	0.28843E-01	0.13602E-00
5.95000	0.55847E-01	0.29389E-01	0.19548E-01	0.29765E-01	0.13455E-00
6.06667	0.53757E-01	0.28760E-01	0.20003E-01	0.30726E-01	0.13325E-00
6.18333	0.51769E-01	0.28140E-01	0.20471E-01	0.31730E-01	0.13211E-00
6.30000	0.49877E-01	0.27530E-01	0.20950E-01	0.32779E-01	0.13114E-00
6.41667	0.48074E-01	0.26925E-01	0.21442E-01	0.33875E-01	0.13032E-00
6.53333	0.46356E-01	0.26325E-01	0.21946E-01	0.35021E-01	0.12965E-00
6.65000	0.44718E-01	0.25738E-01	0.22459E-01	0.36220E-01	0.12914E-00
6.76667	0.43135E-01	0.25162E-01	0.22979E-01	0.37478E-01	0.12875E-00
6.88333	0.41620E-01	0.24598E-01	0.23507E-01	0.38795E-01	0.12852E-00
7.00000	0.40175E-01	0.24046E-01	0.24046E-01	0.40175E-01	0.12844E-00

THE FOSDICK CODE

* * * INPUT DATA * * *

CYLINDER RADIUS, R= 4.50000

RADIUS OF MEDIUM (MAX.), X-MAX= 4.60000

RADIUS OF MEDIUM (MIN.), X-MIN= 4.50000

CYLINDER LENGTH, L=12.25000

NUMBER OF X INTERVALS, N= 5

NUMBER OF AXIAL POINTS, M= 60

ORDER OF SN = 12

CONVERGENCE CRITERION = 0.000010   MAX. NO. ITERATIONS = 25

ANGULAR FLUX	DIRECTION COSINES	POINT WEIGHTS
0.507138E-02	0.174080	0.031880
0.369669E-02	0.174080	0.028450
0.120629E-01	0.460570	0.028450
0.427138E-02	0.174080	0.022690
0.506889E-02	0.460570	0.017370
0.174542E-01	0.627650	0.022690
0.465507E-02	0.174080	0.022690
0.378207E-02	0.460570	0.015140
0.852100E-02	0.627650	0.015140
0.208133E-01	0.758790	0.022690
0.489001E-02	0.174080	0.028450
0.379989E-02	0.460570	0.017370
0.497708E-02	0.627650	0.015140
0.118748E-01	0.758790	0.017370
0.229607E-01	0.870390	0.028450
0.524073E-02	0.174080	0.031880
0.426609E-02	0.460570	0.028450
0.446853E-02	0.627650	0.022690
0.815255E-02	0.758790	0.022690
0.175878E-01	0.870390	0.028450
0.251422E-01	0.969220	0.031880

S-4 FLUXES FOR DBSQ CALCULATION

ANGULAR FLUX	DIRECTION COSINES	POINT WEIGHTS
0.350132E-01	0.333333	0.166667
0.309104E-01	0.333333	0.166667
0.420314E-01	0.881917	0.166667

* * * OUTPUT * * *

ANGULAR DISTRIBUTION,	SINE	FLUX
	-0.	0.244553E-02
	0.24620	0.507138E-02
	0.49236	0.787979E-02
	0.65134	0.925896E-02
	0.77850	0.100997E-01
	0.88762	0.106759E-01
	0.98473	0.113028E-01
	1.00000	0.114835E-01
	0.98473	0.113028E-01
	0.88762	0.106759E-01
	0.77850	0.100997E-01
	0.65134	0.925896E-02
	0.49236	0.787979E-02
	0.24620	0.507138E-02
	0.	0.244553E-02

ANGULAR DISTRIBUTION NORMALIZATION FACTOR = 0.100049E-01

T = 0.0200 MAXIMUM NUMBER OF ITERATIONS EXCEEDED, CONVERGENCE = 0.0000153
SIGMA = 0.0052440

FOR T= 0.0200 AVERAGE ESCAPE PROBABILITY, PC-ANISOTROPIC = 0.48695E-03

CONVERGENCE = 0.0000153 SIGMA (DBSQ) = 0.0052440

Z	P1	P2	P3	P4	PC
0.10208	0.35571E-02	0.37278E-01	0.29807E-05	0.16644E-06	0.40839E-01
0.20417	0.74732E-03	0.15204E-01	0.30329E-05	0.16928E-06	0.15955E-01

0.30625	0.30902E-03	0.79167E-02	0.30865E-05	0.17219E-06	0.82290E-02
0.40833	0.16715E-03	0.46321E-02	0.31414E-05	0.17518E-06	0.48025E-02
0.51042	0.10438E-03	0.29536E-02	0.31979E-05	0.17824E-06	0.30613E-02
0.61250	0.71280E-04	0.20030E-02	0.32559E-05	0.18139E-06	0.20777E-02
0.71458	0.51732E-04	0.14262E-02	0.33155E-05	0.18462E-06	0.14814E-02
0.81667	0.39241E-04	0.10567E-02	0.33768E-05	0.18795E-06	0.10995E-02
0.91875	0.30779E-04	0.80992E-03	0.34398E-05	0.19135E-06	0.84433E-03
1.02083	0.24784E-04	0.63768E-03	0.35045E-05	0.19486E-06	0.66616E-03
1.12292	0.20384E-04	0.51337E-03	0.35711E-05	0.19846E-06	0.53752E-03
1.22500	0.17058E-04	0.42112E-03	0.36396E-05	0.20216E-06	0.44202E-03
1.32708	0.14485E-04	0.35109E-03	0.37101E-05	0.20597E-06	0.36949E-03
1.42917	0.12452E-04	0.29683E-03	0.37826E-05	0.20988E-06	0.31328E-03
1.53125	0.10819E-04	0.25397E-03	0.38573E-05	0.21391E-06	0.26886E-03
1.63333	0.94875E-05	0.21957E-03	0.39343E-05	0.21805E-06	0.23321E-03
1.73542	0.83873E-05	0.19158E-03	0.40135E-05	0.22232E-06	0.20420E-03
1.83750	0.74678E-05	0.16853E-03	0.40952E-05	0.22672E-06	0.18031E-03
1.93958	0.66917E-05	0.14932E-03	0.41794E-05	0.23124E-06	0.16043E-03
2.04167	0.60305E-05	0.13317E-03	0.42662E-05	0.23590E-06	0.14371E-03
2.14375	0.54627E-05	0.11947E-03	0.43557E-05	0.24071E-06	0.12953E-03
2.24583	0.49714E-05	0.10775E-03	0.44481E-05	0.24565E-06	0.11741E-03
2.34792	0.45435E-05	0.97648E-04	0.45434E-05	0.25076E-06	0.10699E-03
2.45000	0.41686E-05	0.88886E-04	0.46419E-05	0.25603E-06	0.97953E-04
2.55208	0.38382E-05	0.81238E-04	0.47435E-05	0.26147E-06	0.90082E-04
2.65417	0.35456E-05	0.74526E-04	0.48486E-05	0.26708E-06	0.83187E-04
2.75625	0.32853E-05	0.68603E-04	0.49572E-05	0.27287E-06	0.77119E-04
2.85833	0.30525E-05	0.63353E-04	0.50694E-05	0.27885E-06	0.71753E-04
2.96042	0.28437E-05	0.58677E-04	0.51855E-05	0.28502E-06	0.66991E-04
3.06250	0.26556E-05	0.54495E-04	0.53056E-05	0.29142E-06	0.62748E-04
3.16458	0.24855E-05	0.50741E-04	0.54300E-05	0.29802E-06	0.58955E-04
3.26667	0.23313E-05	0.47359E-04	0.55587E-05	0.30486E-06	0.55554E-04
3.36875	0.21910E-05	0.44301E-04	0.56921E-05	0.31193E-06	0.52496E-04
3.47083	0.20630E-05	0.41528E-04	0.58303E-05	0.31924E-06	0.49741E-04
3.57292	0.19459E-05	0.39006E-04	0.59737E-05	0.32683E-06	0.47252E-04
3.67500	0.18384E-05	0.36705E-04	0.61223E-05	0.33468E-06	0.45000E-04
3.77708	0.17397E-05	0.34600E-04	0.62766E-05	0.34283E-06	0.42959E-04
3.87917	0.16487E-05	0.32670E-04	0.64368E-05	0.35127E-06	0.41107E-04
3.98125	0.15646E-05	0.30896E-04	0.66031E-05	0.36003E-06	0.39424E-04
4.08333	0.14868E-05	0.29262E-04	0.67760E-05	0.36911E-06	0.37894E-04
4.18542	0.14147E-05	0.27754E-04	0.69558E-05	0.37855E-06	0.36503E-04
4.28750	0.13477E-05	0.26359E-04	0.71428E-05	0.38835E-06	0.35237E-04
4.38958	0.12853E-05	0.25065E-04	0.73374E-05	0.39855E-06	0.34087E-04
4.49167	0.12272E-05	0.23864E-04	0.75400E-05	0.40914E-06	0.33041E-04
4.59375	0.11730E-05	0.22747E-04	0.77512E-05	0.42017E-06	0.32092E-04
4.69583	0.11222E-05	0.21707E-04	0.79713E-05	0.43164E-06	0.31232E-04

4.79792	0.10747E-05	0.20735E-04	0.82009E-05	0.44360E-06	0.30455E-04
4.90000	0.10301E-05	0.19828E-04	0.84406E-05	0.45605E-06	0.29754E-04
5.00208	0.98826E-06	0.18978E-04	0.86909E-05	0.46904E-06	0.29126E-04
5.10417	0.94891E-06	0.18181E-04	0.89525E-05	0.48258E-06	0.28565E-04
5.20625	0.91186E-06	0.17434E-04	0.92260E-05	0.49674E-06	0.28069E-04
5.30833	0.87694E-06	0.16731E-04	0.95123E-05	0.51152E-06	0.27632E-04
5.41042	0.84398E-06	0.16070E-04	0.98120E-05	0.52696E-06	0.27253E-04
5.51250	0.81286E-06	0.15447E-04	0.10126E-04	0.54312E-06	0.26930E-04
5.61458	0.78342E-06	0.14860E-04	0.10455E-04	0.56003E-06	0.26659E-04
5.71667	0.75555E-06	0.14305E-04	0.10801E-04	0.57776E-06	0.26440E-04
5.81875	0.72914E-06	0.13781E-04	0.11164E-04	0.59632E-06	0.26271E-04
5.92083	0.70410E-06	0.13285E-04	0.11546E-04	0.61580E-06	0.26151E-04
6.02292	0.68032E-06	0.12815E-04	0.11947E-04	0.63625E-06	0.26079E-04
6.12500	0.65773E-06	0.12370E-04	0.12370E-04	0.65773E-06	0.26055E-04

FOR T= 0.0400 AVERAGE ESCAPE PROBABILITY, PC-ANISOTROPIC = 0.12177E-02

CONVERGENCE = 0. SIGMA (DBSQ) = 0.0065598

Z	P1	P2	P3	P4	PC
0.10208	0.17516E-01	0.69689E-01	0.84490E-05	0.66889E-06	0.87214E-01
0.20417	0.35571E-02	0.33706E-01	0.85986E-05	0.68034E-06	0.37272E-01
0.30625	0.14173E-02	0.19304E-01	0.87522E-05	0.69207E-06	0.20731E-01
0.40833	0.74732E-03	0.12202E-01	0.89099E-05	0.70412E-06	0.12959E-01
0.51042	0.45846E-03	0.81922E-02	0.90719E-05	0.71647E-06	0.86604E-02
0.61250	0.30902E-03	0.57591E-02	0.92384E-05	0.72916E-06	0.60781E-02
0.71458	0.22207E-03	0.42125E-02	0.94095E-05	0.74219E-06	0.44447E-02
0.81667	0.16715E-03	0.31791E-02	0.95854E-05	0.75557E-06	0.33566E-02
0.91875	0.13030E-03	0.24599E-02	0.97662E-05	0.76930E-06	0.26007E-02
1.02083	0.10438E-03	0.19477E-02	0.99522E-05	0.78344E-06	0.20629E-02
1.12292	0.85484E-04	0.15725E-02	0.10144E-04	0.79795E-06	0.16689E-02
1.22500	0.71280E-04	0.12916E-02	0.10340E-04	0.81286E-06	0.13740E-02
1.32708	0.60339E-04	0.10774E-02	0.10543E-04	0.82821E-06	0.11491E-02
1.42917	0.51732E-04	0.91037E-03	0.10752E-04	0.84400E-06	0.97370E-03
1.53125	0.44842E-04	0.77798E-03	0.10967E-04	0.86025E-06	0.83465E-03
1.63333	0.39241E-04	0.67153E-03	0.11188E-04	0.87694E-06	0.72283E-03
1.73542	0.34626E-04	0.58483E-03	0.11416E-04	0.89416E-06	0.63177E-03
1.83750	0.30779E-04	0.51340E-03	0.11652E-04	0.91187E-06	0.55674E-03
1.93958	0.27539E-04	0.45408E-03	0.11894E-04	0.93012E-06	0.49444E-03
2.04167	0.24784E-04	0.40421E-03	0.12144E-04	0.94892E-06	0.44209E-03
2.14375	0.22423E-04	0.36192E-03	0.12403E-04	0.96830E-06	0.39771E-03
2.24583	0.20384E-04	0.32578E-03	0.12669E-04	0.98826E-06	0.35982E-03
2.34792	0.18610E-04	0.29468E-03	0.12944E-04	0.10089E-05	0.32725E-03

2.45000	0.17058E-04	0.26774E-03	0.13228E-04	0.10301E-05	0.29906E-03
2.55208	0.15693E-04	0.24426E-03	0.13522E-04	0.10521E-05	0.27453E-03
2.65417	0.14485E-04	0.22368E-03	0.13825E-04	0.10747E-05	0.25306E-03
2.75625	0.13411E-04	0.20555E-03	0.14139E-04	0.10981E-05	0.23419E-03
2.85833	0.12452E-04	0.18949E-03	0.14463E-04	0.11222E-05	0.21753E-03
2.96042	0.11593E-04	0.17522E-03	0.14799E-04	0.11472E-05	0.20276E-03
3.06250	0.10819E-04	0.16247E-03	0.15147E-04	0.11730E-05	0.18961E-03
3.16458	0.10121E-04	0.15105E-03	0.15507E-04	0.11996E-05	0.17787E-03
3.26667	0.94875E-05	0.14077E-03	0.15879E-04	0.12272E-05	0.16736E-03
3.36875	0.89120E-05	0.13149E-03	0.16266E-04	0.12558E-05	0.15792E-03
3.47083	0.83873E-05	0.12309E-03	0.16666E-04	0.12854E-05	0.14943E-03
3.57292	0.79075E-05	0.11545E-03	0.17082E-04	0.13160E-05	0.14176E-03
3.67500	0.74678E-05	0.10850E-03	0.17513E-04	0.13477E-05	0.13483E-03
3.77708	0.70638E-05	0.10215E-03	0.17961E-04	0.13806E-05	0.12856E-03
3.87917	0.66917E-05	0.96336E-04	0.18426E-04	0.14147E-05	0.12287E-03
3.98125	0.63482E-05	0.90998E-04	0.18909E-04	0.14501E-05	0.11771E-03
4.08333	0.60305E-05	0.86087E-04	0.19412E-04	0.14868E-05	0.11302E-03
4.18542	0.57361E-05	0.81559E-04	0.19935E-04	0.15250E-05	0.10875E-03
4.28750	0.54627E-05	0.77376E-04	0.20479E-04	0.15646E-05	0.10488E-03
4.38958	0.52084E-05	0.73503E-04	0.21045E-04	0.16058E-05	0.10136E-03
4.49167	0.49714E-05	0.69911E-04	0.21636E-04	0.16487E-05	0.98167E-04
4.59375	0.47502E-05	0.66574E-04	0.22251E-04	0.16933E-05	0.95269E-04
4.69583	0.45435E-05	0.63468E-04	0.22893E-04	0.17397E-05	0.92644E-04
4.79792	0.43500E-05	0.60573E-04	0.23563E-04	0.17881E-05	0.90274E-04
4.90000	0.41686E-05	0.57870E-04	0.24262E-04	0.18385E-05	0.88139E-04
5.00208	0.39983E-05	0.55342E-04	0.24993E-04	0.18911E-05	0.86225E-04
5.10417	0.38382E-05	0.52976E-04	0.25758E-04	0.19459E-05	0.84518E-04
5.20625	0.36876E-05	0.50756E-04	0.26558E-04	0.20032E-05	0.83005E-04
5.30833	0.35456E-05	0.48673E-04	0.27396E-04	0.20630E-05	0.81677E-04
5.41042	0.34117E-05	0.46714E-04	0.28273E-04	0.21256E-05	0.80525E-04
5.51250	0.32853E-05	0.44870E-04	0.29194E-04	0.21910E-05	0.79540E-04
5.61458	0.31657E-05	0.43133E-04	0.30160E-04	0.22595E-05	0.78718E-04
5.71667	0.30525E-05	0.41494E-04	0.31174E-04	0.23313E-05	0.78051E-04
5.81875	0.29454E-05	0.39946E-04	0.32240E-04	0.24066E-05	0.77538E-04
5.92083	0.28437E-05	0.38482E-04	0.33361E-04	0.24856E-05	0.77173E-04
6.02292	0.27472E-05	0.37098E-04	0.34542E-04	0.25685E-05	0.76955E-04
6.12500	0.26556E-05	0.35786E-04	0.35786E-04	0.26556E-05	0.76882E-04

FOR T= 0.0600 AVERAGE ESCAPE PROBABILITY, PC-ANISOTROPIC = 0.20584E-02

CONVERGENCE = 0.0000072 SIGMA (DBSQ) = 0.0073959

Z P1 P2 P3 P4 PC

0.10208	0.42622E-01	0.89637E-01	0.15554E-04	0.15121E-05	0.13228E-00
0.20417	0.90481E-02	0.50729E-01	0.15831E-04	0.15380E-05	0.59794E-01
0.30625	0.35571E-02	0.30988E-01	0.16117E-04	0.15646E-05	0.34563E-01
0.40833	0.18478E-02	0.20446E-01	0.16410E-04	0.15919E-05	0.22312E-01
0.51042	0.11196E-02	0.14251E-01	0.16710E-04	0.16199E-05	0.15389E-01
0.61250	0.74732E-03	0.10316E-01	0.17020E-04	0.16487E-05	0.11082E-01
0.71458	0.53285E-03	0.76835E-02	0.17338E-04	0.16782E-05	0.82354E-02
0.81667	0.39852E-03	0.58883E-02	0.17664E-04	0.17086E-05	0.63062E-02
0.91875	0.30902E-03	0.46183E-02	0.18001E-04	0.17397E-05	0.49470E-02
1.02083	0.24648E-03	0.36909E-02	0.18346E-04	0.17717E-05	0.39575E-02
1.12292	0.20110E-03	0.29982E-02	0.18702E-04	0.18046E-05	0.32198E-02
1.22500	0.16715E-03	0.24732E-02	0.19069E-04	0.18385E-05	0.26612E-02
1.32708	0.14110E-03	0.20673E-02	0.19446E-04	0.18733E-05	0.22297E-02
1.42917	0.12068E-03	0.17489E-02	0.19834E-04	0.19091E-05	0.18913E-02
1.53125	0.10438E-03	0.14956E-02	0.20234E-04	0.19459E-05	0.16222E-02
1.63333	0.91171E-04	0.12919E-02	0.20646E-04	0.19838E-05	0.14057E-02
1.73542	0.80312E-04	0.11254E-02	0.21071E-04	0.20228E-05	0.12288E-02
1.83750	0.71280E-04	0.98793E-03	0.21510E-04	0.20630E-05	0.10828E-02
1.93958	0.63688E-04	0.87326E-03	0.21962E-04	0.21044E-05	0.96101E-03
2.04167	0.57246E-04	0.77675E-03	0.22428E-04	0.21471E-05	0.85858E-03
2.14375	0.51732E-04	0.69488E-03	0.22909E-04	0.21910E-05	0.77171E-03
2.24583	0.46978E-04	0.62489E-03	0.23406E-04	0.22363E-05	0.69751E-03
2.34792	0.42849E-04	0.56478E-03	0.23919E-04	0.22831E-05	0.63383E-03
2.45000	0.39241E-04	0.51272E-03	0.24449E-04	0.23313E-05	0.57874E-03
2.55208	0.36069E-04	0.46735E-03	0.24997E-04	0.23811E-05	0.53079E-03
2.65417	0.33267E-04	0.42758E-03	0.25563E-04	0.24325E-05	0.48885E-03
2.75625	0.30779E-04	0.39257E-03	0.26149E-04	0.24856E-05	0.45198E-03
2.85833	0.28560E-04	0.36159E-03	0.26755E-04	0.25404E-05	0.41944E-03
2.96042	0.26572E-04	0.33405E-03	0.27382E-04	0.25970E-05	0.39060E-03
3.06250	0.24784E-04	0.30948E-03	0.28032E-04	0.26556E-05	0.36495E-03
3.16458	0.23171E-04	0.28747E-03	0.28705E-04	0.27162E-05	0.34206E-03
3.26667	0.21711E-04	0.26768E-03	0.29402E-04	0.27789E-05	0.32157E-03
3.36875	0.20384E-04	0.24982E-03	0.30125E-04	0.28437E-05	0.30318E-03
3.47083	0.19175E-04	0.23367E-03	0.30874E-04	0.29109E-05	0.28663E-03
3.57292	0.18070E-04	0.21900E-03	0.31652E-04	0.29805E-05	0.27170E-03
3.67500	0.17058E-04	0.20565E-03	0.32460E-04	0.30526E-05	0.25822E-03
3.77708	0.16129E-04	0.19346E-03	0.33298E-04	0.31273E-05	0.24601E-03
3.87917	0.15274E-04	0.18231E-03	0.34170E-04	0.32049E-05	0.23495E-03
3.98125	0.14485E-04	0.17208E-03	0.35075E-04	0.32853E-05	0.22492E-03
4.08333	0.13755E-04	0.16267E-03	0.36017E-04	0.33688E-05	0.21581E-03
4.18542	0.13079E-04	0.15401E-03	0.36998E-04	0.34555E-05	0.20754E-03
4.28750	0.12452E-04	0.14601E-03	0.38019E-04	0.35457E-05	0.20002E-03
4.38958	0.11869E-04	0.13860E-03	0.39082E-04	0.36394E-05	0.19320E-03
4.49167	0.11326E-04	0.13175E-03	0.40190E-04	0.37368E-05	0.18700E-03

4.59375	0.10819E-04	0.12538E-03	0.41346E-04	0.38383E-05	0.18138E-03
4.69583	0.10346E-04	0.11945E-03	0.42552E-04	0.39439E-05	0.17629E-03
4.79792	0.99027E-05	0.11393E-03	0.43811E-04	0.40539E-05	0.17170E-03
4.90000	0.94875E-05	0.10879E-03	0.45127E-04	0.41687E-05	0.16757E-03
5.00208	0.90978E-05	0.10397E-03	0.46503E-04	0.42883E-05	0.16386E-03
5.10417	0.87317E-05	0.99471E-04	0.47941E-04	0.44131E-05	0.16056E-03
5.20625	0.83873E-05	0.95252E-04	0.49448E-04	0.45436E-05	0.15763E-03
5.30833	0.80628E-05	0.91293E-04	0.51026E-04	0.46798E-05	0.15506E-03
5.41042	0.77568E-05	0.87573E-04	0.52680E-04	0.48223E-05	0.15283E-03
5.51250	0.74678E-05	0.84074E-04	0.54415E-04	0.49714E-05	0.15093E-03
5.61458	0.71948E-05	0.80778E-04	0.56236E-04	0.51276E-05	0.14934E-03
5.71667	0.69364E-05	0.77671E-04	0.58151E-04	0.52911E-05	0.14805E-03
5.81875	0.66917E-05	0.74738E-04	0.60163E-04	0.54627E-05	0.14706E-03
5.92083	0.64597E-05	0.71967E-04	0.62281E-04	0.56427E-05	0.14635E-03
6.02292	0.62396E-05	0.69346E-04	0.64512E-04	0.58318E-05	0.14593E-03
6.12500	0.60305E-05	0.66864E-04	0.66864E-04	0.60305E-05	0.14579E-03

FØR T= 0.0800 AVERAGE ESCAPE PRØBABILITY, PC-ANISØTRØPIC = 0.29626E-02

CØNVERGENCE = 0. SIGMA (DBSQ) = 0.0079879

Z	P1	P2	P3	P4	PC
0.10208	0.74629E-01	0.98459E-01	0.23993E-04	0.27009E-05	0.17311E-00
0.20417	0.17516E-01	0.64953E-01	0.24425E-04	0.27473E-05	0.82496E-01
0.30625	0.68934E-02	0.42161E-01	0.24868E-04	0.27949E-05	0.49082E-01
0.40833	0.35571E-02	0.28799E-01	0.25323E-04	0.28437E-05	0.32384E-01
0.51042	0.21385E-02	0.20578E-01	0.25790E-04	0.28939E-05	0.22746E-01
0.61250	0.14173E-02	0.15238E-01	0.26271E-04	0.29454E-05	0.16685E-01
0.71458	0.10044E-02	0.11579E-01	0.26765E-04	0.29983E-05	0.12613E-01
0.81667	0.74732E-03	0.89761E-02	0.27273E-04	0.30526E-05	0.97537E-02
0.91875	0.57695E-03	0.71065E-02	0.27796E-04	0.31084E-05	0.77144E-02
1.02083	0.45846E-03	0.57298E-02	0.28334E-04	0.31657E-05	0.62198E-02
1.12292	0.37284E-03	0.46929E-02	0.28888E-04	0.32247E-05	0.50978E-02
1.22500	0.30902E-03	0.38894E-02	0.29458E-04	0.32853E-05	0.42311E-02
1.32708	0.26022E-03	0.32635E-02	0.30044E-04	0.33476E-05	0.35571E-02
1.42917	0.22207E-03	0.27688E-02	0.30649E-04	0.34118E-05	0.30249E-02
1.53125	0.19171E-03	0.23721E-02	0.31272E-04	0.34777E-05	0.25986E-02
1.63333	0.16715E-03	0.20505E-02	0.31914E-04	0.35457E-05	0.22531E-02
1.73542	0.14701E-03	0.17869E-02	0.32575E-04	0.36156E-05	0.19702E-02
1.83750	0.13030E-03	0.15695E-02	0.33258E-04	0.36876E-05	0.17367E-02
1.93958	0.11627E-03	0.13879E-02	0.33962E-04	0.37618E-05	0.15419E-02
2.04167	0.10438E-03	0.12348E-02	0.34688E-04	0.38383E-05	0.13777E-02
2.14375	0.94229E-04	0.11046E-02	0.35438E-04	0.39171E-05	0.12382E-02

2.24583	0.85484E-04	0.99327E-03	0.36213E-04	0.39983E-05	0.11190E-02
2.34792	0.77900E-04	0.89733E-03	0.37013E-04	0.40822E-05	0.10163E-02
2.45000	0.71280E-04	0.81416E-03	0.37840E-04	0.41687E-05	0.92745E-03
2.55208	0.65469E-04	0.74165E-03	0.38694E-04	0.42579E-05	0.85008E-03
2.65417	0.60339E-04	0.67816E-03	0.39578E-04	0.43500E-05	0.78243E-03
2.75625	0.55788E-04	0.62234E-03	0.40492E-04	0.44452E-05	0.72306E-03
2.85833	0.51732E-04	0.57294E-03	0.41438E-04	0.45436E-05	0.67065E-03
2.96042	0.48103E-04	0.52903E-03	0.42417E-04	0.46452E-05	0.62420E-03
3.06250	0.44842E-04	0.48985E-03	0.43431E-04	0.47503E-05	0.58287E-03
3.16458	0.41902E-04	0.45476E-03	0.44482E-04	0.48590E-05	0.54600E-03
3.26667	0.39241E-04	0.42322E-03	0.45571E-04	0.49714E-05	0.51300E-03
3.36875	0.36825E-04	0.39477E-03	0.46701E-04	0.50879E-05	0.48339E-03
3.47083	0.34626E-04	0.36904E-03	0.47873E-04	0.52084E-05	0.45675E-03
3.57292	0.32618E-04	0.34569E-03	0.49089E-04	0.53333E-05	0.43273E-03
3.67500	0.30779E-04	0.32444E-03	0.50352E-04	0.54627E-05	0.41103E-03
3.77708	0.29092E-04	0.30505E-03	0.51663E-04	0.55969E-05	0.39140E-03
3.87917	0.27539E-04	0.28731E-03	0.53027E-04	0.57361E-05	0.37361E-03
3.98125	0.26107E-04	0.27105E-03	0.54444E-04	0.58806E-05	0.35748E-03
4.08333	0.24784E-04	0.25610E-03	0.55919E-04	0.60305E-05	0.34284E-03
4.18542	0.23560E-04	0.24234E-03	0.57454E-04	0.61863E-05	0.32954E-03
4.28750	0.22423E-04	0.22964E-03	0.59053E-04	0.63482E-05	0.31746E-03
4.38958	0.21367E-04	0.21789E-03	0.60719E-04	0.65166E-05	0.30649E-03
4.49167	0.20384E-04	0.20701E-03	0.62456E-04	0.66917E-05	0.29654E-03
4.59375	0.19467E-04	0.19691E-03	0.64268E-04	0.68740E-05	0.28752E-03
4.69583	0.18610E-04	0.18752E-03	0.66160E-04	0.70638E-05	0.27935E-03
4.79792	0.17809E-04	0.17878E-03	0.68135E-04	0.72617E-05	0.27198E-03
4.90000	0.17058E-04	0.17062E-03	0.70200E-04	0.74679E-05	0.26535E-03
5.00208	0.16354E-04	0.16300E-03	0.72358E-04	0.76830E-05	0.25940E-03
5.10417	0.15693E-04	0.15588E-03	0.74618E-04	0.79076E-05	0.25410E-03
5.20625	0.15071E-04	0.14921E-03	0.76983E-04	0.81421E-05	0.24940E-03
5.30833	0.14485E-04	0.14295E-03	0.79462E-04	0.83873E-05	0.24528E-03
5.41042	0.13932E-04	0.13707E-03	0.82062E-04	0.86437E-05	0.24170E-03
5.51250	0.13411E-04	0.13154E-03	0.84790E-04	0.89120E-05	0.23865E-03
5.61458	0.12918E-04	0.12633E-03	0.87655E-04	0.91930E-05	0.23610E-03
5.71667	0.12452E-04	0.12143E-03	0.90666E-04	0.94875E-05	0.23404E-03
5.81875	0.12011E-04	0.11680E-03	0.93833E-04	0.97964E-05	0.23244E-03
5.92083	0.11593E-04	0.11243E-03	0.97168E-04	0.10121E-04	0.23131E-03
6.02292	0.11196E-04	0.10830E-03	0.10068E-03	0.10461E-04	0.23064E-03
6.12500	0.10819E-04	0.10439E-03	0.10439E-03	0.10819E-04	0.23041E-03

FOR T= 0.1000 AVERAGE ESCAPE PROBABILITY, PC-ANISOTROPIC = 0.39065E-02

CONVERGENCE = 0.0000038 SIGMA (DBSQ) = 0.0084309

Z	P1	P2	P3	P4	PC
0.10208	0.10821E-00	0.99921E-01	0.33595E-04	0.42398E-05	0.20817E-00
0.20417	0.28843E-01	0.76307E-01	0.34202E-04	0.43128E-05	0.10519E-00
0.30625	0.11533E-01	0.52330E-01	0.34826E-04	0.43878E-05	0.63902E-01
0.40833	0.59411E-02	0.36962E-01	0.35467E-04	0.44646E-05	0.42943E-01
0.51042	0.35571E-02	0.26973E-01	0.36126E-04	0.45436E-05	0.30571E-01
0.61250	0.23462E-02	0.20301E-01	0.36804E-04	0.46246E-05	0.22688E-01
0.71458	0.16551E-02	0.15673E-01	0.37500E-04	0.47078E-05	0.17370E-01
0.81667	0.12265E-02	0.12322E-01	0.38217E-04	0.47933E-05	0.13592E-01
0.91875	0.94346E-03	0.98381E-02	0.38954E-04	0.48811E-05	0.10825E-01
1.02083	0.74732E-03	0.79833E-02	0.39712E-04	0.49714E-05	0.87753E-02
1.12292	0.60605E-03	0.65758E-02	0.40493E-04	0.50642E-05	0.72274E-02
1.22500	0.50108E-03	0.54856E-02	0.41296E-04	0.51597E-05	0.60332E-02
1.32708	0.42101E-03	0.46235E-02	0.42124E-04	0.52578E-05	0.50919E-02
1.42917	0.35860E-03	0.39343E-02	0.42977E-04	0.53588E-05	0.43412E-02
1.53125	0.30902E-03	0.33791E-02	0.43856E-04	0.54627E-05	0.37375E-02
1.63333	0.26901E-03	0.29267E-02	0.44762E-04	0.55696E-05	0.32461E-02
1.73542	0.23626E-03	0.25541E-02	0.45696E-04	0.56798E-05	0.28417E-02
1.83750	0.20912E-03	0.22446E-02	0.46659E-04	0.57933E-05	0.25062E-02
1.93958	0.18638E-03	0.19852E-02	0.47654E-04	0.59101E-05	0.22252E-02
2.04167	0.16715E-03	0.17667E-02	0.48680E-04	0.60305E-05	0.19886E-02
2.14375	0.15074E-03	0.15811E-02	0.49739E-04	0.61547E-05	0.17877E-02
2.24583	0.13662E-03	0.14220E-02	0.50833E-04	0.62827E-05	0.16157E-02
2.34792	0.12440E-03	0.12848E-02	0.51964E-04	0.64148E-05	0.14675E-02
2.45000	0.11373E-03	0.11657E-02	0.53132E-04	0.65510E-05	0.13391E-02
2.55208	0.10438E-03	0.10618E-02	0.54340E-04	0.66917E-05	0.12272E-02
2.65417	0.96138E-04	0.97069E-03	0.55589E-04	0.68370E-05	0.11293E-02
2.75625	0.88830E-04	0.89041E-03	0.56882E-04	0.69870E-05	0.10431E-02
2.85833	0.82323E-04	0.81936E-03	0.58219E-04	0.71420E-05	0.96704E-03
2.96042	0.76505E-04	0.75622E-03	0.59605E-04	0.73022E-05	0.89963E-03
3.06250	0.71280E-04	0.70001E-03	0.61040E-04	0.74679E-05	0.83979E-03
3.16458	0.66573E-04	0.64965E-03	0.62527E-04	0.76392E-05	0.78638E-03
3.26667	0.62316E-04	0.60437E-03	0.64068E-04	0.78166E-05	0.73858E-03
3.36875	0.58454E-04	0.56355E-03	0.65667E-04	0.80002E-05	0.69567E-03
3.47083	0.54939E-04	0.52661E-03	0.67326E-04	0.81903E-05	0.65706E-03
3.57292	0.51732E-04	0.49309E-03	0.69048E-04	0.83873E-05	0.62226E-03
3.67500	0.48798E-04	0.46261E-03	0.70837E-04	0.85915E-05	0.59083E-03
3.77708	0.46106E-04	0.43479E-03	0.72696E-04	0.88032E-05	0.56240E-03
3.87917	0.43630E-04	0.40936E-03	0.74628E-04	0.90228E-05	0.53664E-03
3.98125	0.41348E-04	0.38604E-03	0.76637E-04	0.92508E-05	0.51328E-03
4.08333	0.39241E-04	0.36462E-03	0.78728E-04	0.94875E-05	0.49208E-03
4.18542	0.37290E-04	0.34489E-03	0.80905E-04	0.97335E-05	0.47282E-03
4.28750	0.35481E-04	0.32669E-03	0.83173E-04	0.99891E-05	0.45534E-03

4.38958	0.33801E-04	0.30987E-03	0.85536E-04	0.10255E-04	0.43946E-03
4.49167	0.32237E-04	0.29429E-03	0.88001E-04	0.10531E-04	0.42506E-03
4.59375	0.30779E-04	0.27983E-03	0.90573E-04	0.10819E-04	0.41200E-03
4.69583	0.29418E-04	0.26639E-03	0.93258E-04	0.11119E-04	0.40019E-03
4.79792	0.28145E-04	0.25388E-03	0.96063E-04	0.11432E-04	0.38952E-03
4.90000	0.26953E-04	0.24222E-03	0.98995E-04	0.11757E-04	0.37992E-03
5.00208	0.25834E-04	0.23133E-03	0.10206E-03	0.12097E-04	0.37132E-03
5.10417	0.24784E-04	0.22114E-03	0.10527E-03	0.12452E-04	0.36365E-03
5.20625	0.23797E-04	0.21160E-03	0.10864E-03	0.12823E-04	0.35686E-03
5.30833	0.22868E-04	0.20266E-03	0.11216E-03	0.13211E-04	0.35090E-03
5.41042	0.21991E-04	0.19426E-03	0.11586E-03	0.13616E-04	0.34573E-03
5.51250	0.21165E-04	0.18637E-03	0.11974E-03	0.14040E-04	0.34131E-03
5.61458	0.20384E-04	0.17894E-03	0.12381E-03	0.14485E-04	0.33763E-03
5.71667	0.19645E-04	0.17195E-03	0.12810E-03	0.14951E-04	0.33464E-03
5.81875	0.18946E-04	0.16534E-03	0.13261E-03	0.15439E-04	0.33234E-03
5.92083	0.18283E-04	0.15911E-03	0.13736E-03	0.15952E-04	0.33070E-03
6.02292	0.17655E-04	0.15322E-03	0.14236E-03	0.16492E-04	0.32973E-03
6.12500	0.17058E-04	0.14764E-03	0.14764E-03	0.17058E-04	0.32940E-03

END OF FILE A2 ,JOB COMPLETED.

R H NCRMAN- 0147CC17911-99 L55 4 TAPES 01-44-44 08/15/64
**PRINTING= 1209 LINES **PUNCHING= 114 CARDS **CRT= 0-35MM 0-9INCH