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CANEL

TECHNICAL INFORMATION MEMORANDUM

MASTER

SUBJECT: MORTIMER - A Neutron Shielding Code For SNAP
Systems Utilizing the Two-Component Method

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The MORTIMER Code

I. Introduction

The MORTIMER Code, received from Atomic International⁽¹⁾, has been modified and checked out on the Control Data 1604A machine in use at CANEL. The code as received was designed for running on an IBM 7090 machine, but was converted to FORTRAN 63 for use here. Errors found in both the mechanics of the code and in the physics of the model used were corrected. A comparison of MORTIMER calculations with Monte Carlo calculations is given in TIM-882.

MORTIMER calculates the neutron flux at a dose point anywhere in a SNAP-50 geometry utilizing the two-component method of Motreff⁽²⁾, where the flux is composed of a collimated component, made up of essentially uncollided or very low-angle elastically scattered neutrons, and a diffuse component, made up of neutrons which have either undergone large-angle elastic scattering or have been inelastically scattered and reduced in energy. The collimated component is obtained with point kernel calculations using collimated removal cross sections. The diffuse component is obtained by first calculating a total current at a point on the shield surface using broad-beam, or total, removal cross sections, and then subtracting from this the collimated current at the same point. This diffuse current at the surface of the shield is assigned an angular distribution, and attenuated geometrically to give the flux at the dose point.

The code will also calculate the weight of the grid region, coolant region, and shield (See Fig. 1).

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MORTIMER GEOMETRY - $\frac{1}{2}$ MOCKUP

TM 880

$$\Delta H = \frac{H8 - H7}{LM}$$

$$\Delta R = \frac{R7}{LP}$$

$$\Delta \theta = \frac{2\pi}{LN}$$

$$\Delta R2 = \frac{R2}{LK}$$

$$\Delta \phi = \frac{2\pi}{LL2}$$

II. Geometry

The geometry of the system is shown in Fig. 1. The system is cylindrically symmetric about the Z - axis, and increasing Z is to the left. Both end surfaces of the shield are spherical, and the code computes their centers and radii from the input data.

The core-reflector system is divided into axial, radial, and azimuthal slices to produce source volume elements whose central coordinates are calculated as follows:

$$\begin{aligned} X_{ijk} &= \Delta r (j - 1/2) \cos \left[\frac{2\pi}{LN} (k - 1/2) \right] \\ Y_{ijk} &= \Delta r (j - 1/2) \sin \left[\frac{2\pi}{LN} (k - 1/2) \right] \\ Z_{ijk} &= \Delta h (i - 1/2) \end{aligned}$$

where:

$$i = 1, 2, \dots, LM; \quad j = 1, 2, \dots, LP; \quad k = 1, 2, \dots, LN$$

$$\Delta r = R/LP$$

$$\Delta h = H/LM$$

and LM, LP, and LN are the number of core axial, radial, and azimuthal slices respectively, $R = R_7$ = reflector radius, and $H = H_8 - H_7$ = core height.

It should be noted that for any particular system, care should be taken in mocking up the core and reflector radial boundaries. This is necessary because the code calculates a radial Δr based on the reflector radius. One also inputs the number of Δr 's in the core-reflector system. However, the number of Δr 's in the core times Δr in most cases will not equal the core radius. Because of this, it is possible for a volume element to span both core and reflector. The code treats such an element as either all core or all reflector, depending upon which region contains the center of that element.

To eliminate this discrepancy between mockup and the actual system, one should adjust the radius of the reflector in such a way that division by the code will leave the radius of the core exact. Compensation for this change may be made by changing the number density (and therefore the cross sections) of the reflector in such a way that the total number of reflector atoms is conserved.

In the diffuse flux calculation, the shield surface is broken up into sections by radial and azimuthal slices. The coordinates of the center points of these sections are calculated as follows:

$$X_{st} = (\Delta r_2)(s - 1/2) \cos \left[\frac{2\pi}{LL2} (t - 1/2) \right]$$

$$Y_{st} = (\Delta r_2)(s - 1/2) \sin \left[\frac{2\pi}{LL2} (t - 1/2) \right]$$

$$Z_{st} = \text{smallest positive root of} \\ X_{st}^2 + Y_{st}^2 + (Z_{st} - ZC2)^2 = (RAD2)^2$$

where $\Delta r_2 = R2/LK$

$s = 1, 2, \dots, LK$ (sphere radial divisions)

$t = 1, 2, \dots, LL2$ (sphere azimuthal divisions)

$ZC2 =$ coordinate of center point of exit sphere on Z axis

$RAD2 =$ radius of exit sphere

The area of such a section is calculated as

$$A_{st} = \frac{\pi (\Delta r_2)^2}{LL2} (2s - 1) \frac{1}{\cos \psi}$$

where $\psi =$ angle between plane tangent to sphere at (X_{st}, Y_{st}, Z_{st}) and the XY plane, and

$$\cos \psi = \left[1 - \frac{X_{st}^2 + Y_{st}^2}{(RAD2)^2} \right]^{1/2}$$

III. Theory

A. Flux Calculation

Core sources for each source element are computed as follows:

$$S_{ijk} = S_0 \cos \left[G(z_{ijk} - H7 - H/2) \right] J_0(\omega r) \frac{\pi (2j-1) (\Delta r)^2 \Delta z}{LN}$$

where S_0 = peak core source strength ($n/cm^3\text{-sec}$)
 G = axial core source strength constant (cm^{-1})

$$G = \frac{\cos^{-1} m_c}{H/2}$$

H = $H_8 - H_7$ = length of core

m_c = ratio of minimum to maximum power in core in axial direction

$J_0(\omega r)$ = zero order Bessel Function distribution in radial direction

ω = radial core source strength constant (cm^{-1})

$$\omega = 2.405/R$$

R = radial distance at which extrapolated J_0 function = 0

Similarly, the reflector source is:

$$S_{ijk} = A_0 \cos [G(z_{ijk} - H_7 - H/2)] e^{-B(r - R_8)} \frac{\pi(2j-1)(\Delta r)^2(\Delta z)}{LN}$$

where A_0 = peak reflector source strength ($n/cm^3\text{-sec}$)

B = radial reflector source strength constant (cm^{-1})

$$B = \frac{\ln m_r}{R_8 - R_7}$$

m_r = ratio of minimum to maximum source density in reflector (radial direction)

The collimated flux is calculated as an exponential attenuation kernel through all regions of the system (See Fig. 2):

$$D_c = \sum_{ijk} \frac{S_{ijk} e^{-\sum_n (l_n \Sigma_n)}}{4\pi L_{ijk}^2}$$

where S_{ijk} is as defined previously for either core or reflector

L_{ijk} is the straight line distance from source point to dose point

l_n is the distance traveled through the n th region of the system

Σ_n is the collimated cross section for that n th region

MORTIMER CALCULATIONS

The diffuse flux is calculated in the following manner: the shield exit surface is broken up into sections whose center points and areas are calculated as previously mentioned. The code picks the coordinates of the center point of the first of these sections and calculates the total current at that point using broad-beam cross sections. It then calculates the collimated current at that point and subtracts the two to obtain the diffuse flux at the shield exit point:

$$J_D = \text{DIFFUSE CURRENT} = \sum_{ijk} S_{ijk} \left(\frac{e^{-\sum_n (l_n \mu_n)} - e^{-\sum_n (l_n \Sigma_n)}}{4\pi \chi_{ijk}^2} \right) \cos \theta_{st}$$

The diffuse current is equal to an assigned angular distribution integrated over 2π steradians:

$$J_D = \int_0^{2\pi} A \cos^m \theta_{st} d\omega$$

where A = a constant

$\cos^m \theta_{st}$ = input cosine distribution, see below

$d\omega$ = element of solid angle, $= 2\pi \sin \theta_{st} d\theta_{st}$

Therefore:

$$J_D = \int_0^{\pi/2} A \cos^m \theta_{st} 2\pi \sin \theta_{st} d\theta_{st}$$

Integrating and solving for A:

$$A = J_D \left(\frac{m+1}{2\pi} \right)$$

and the current per solid angle is

$$J_D \left(\frac{m+1}{2\pi} \right) \cos^m \theta_{st}$$

The total diffuse flux at the dose point from all source points and all shield exit points is then:

$$D_D = T_0 \sum_{s,t} \sum_{ijk} A_{st} S_{ijk} \left(\frac{e^{-\sum_n (l_n \mu_n)} - e^{-\sum_n (l_n \Sigma_n)}}{4\pi \chi_{ijk,st}^2} \right) \left(\frac{m+1}{2\pi} \cos^m \theta_{st} \right) \cos \theta_{st}$$

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where T_0 = an input constant equal to the fraction of the diffuse flux which is to be added to the collimated flux to produce the total

$A_{st}, S_{ijk}, l_n, \Sigma_n$ have been previously defined

μ_n = broad beam cross section for the nth region of the system

$L_{ijk, st}$ = straight line distance from any source point to any shield exit point

d_{st} = distance from shield exit point to dose point

m = exponent for cosine distribution desired by user

θ_{st} = angle between the ray and the normal to the shield at the shield exit point, used in evaluating neutron current at that point

Various options are available in the code for choosing θ_{st} : if in the input KOSINE =1, the angle between the normal and the line from shield exit point to dose point is selected; if KOSINE =2, the angle between the ray and the line from the shield exit point to dose point is selected; if KOSINE =3, the code computes the cosines of both of the above angles and used the arithmetic average in the calculation.

If $\cos \theta_{st}$ is calculated to be a negative value, no diffuse flux is calculated for that source point. This could happen when the dose point is close to the exit shield surface.

The total flux is, of course,

$$D_T = D_c + D_D$$

A calculation similar to that performed by the FARSE code (TM-798) is obtained by using large collimated cross sections, i.e., when in each region of the system.

B. Weight Calculation

The code calculates, in pounds, the weights of the grid, coolant, and shield using the following relationships:

$$W_{GRID} = \frac{\rho_{GRID}}{454} \pi (R_6)^2 (H_7 - H_6)$$

$$W_{COOLANT} = \frac{\rho_{COOLANT}}{454} \pi (R_5)^2 (H_6 - H_5)$$

$$W_{SHIELD} = \frac{\rho_{SHIELD}}{454} \pi \left\{ \left[(RAD1^2 - ZC1^2)(H4 - H3) + ZC1(H4^2 - H3^2) - \frac{H4^3 - H3^3}{3} \right] + \right. \\ \left. + \left[(H3 - H2)(R3 + H3 \tan \phi)^2 + \frac{(H3^3 - H2^3) \tan^2 \phi}{3} - (H3^2 - H2^2) \tan \phi (R3 + H3 \tan \phi) \right] + \right. \\ \left. + \left[(RAD2^2 - ZC2^2)(H2 - H1) + ZC2(H2^2 - H1^2) - \frac{H2^3 - H1^3}{3} \right] \right\}$$

$$W_{TOT} = W_{GRID} + W_{COOLANT} + W_{SHIELD}$$

$$\tan \phi = \frac{R2 - R3}{H3 - H2}$$

IV. Output

Output consists of the following items:

- 1) A complete listing of the input data.
- 2) For each dose point, the direct (collimated) flux from core sources, reflector sources, and a total.
- 3) For each dose point, the diffused flux, as in (2).
- 4) For each dose point, the total of (2) and (3).
- 5) The weight in pounds of the grid, coolant, and shield, and the total of the three components.

Output from a sample case is included at the end of this report.

V. Input

Input information is put on cards of three types:

- 1) a title card
- 2) a "non-FORCED" card
- 3) FORCED format cards

The code has provisions in it for running successive cases. Cases may be run back to back by providing a complete set of input for the first case, then for each successive case providing a title card, a "non-FORCED" card, and a card (or cards) containing the changes to be made from the previous case and its address. The last card of each case must contain a one in column one. A blank card must follow the last case.

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Running time for one case may be approximated by assuming that 3000 points per minute can be run on the Control Data 1604A machine, including set up and print time. Consecutive cases may be estimated at about 4500 points per minute. The number of points equals the number of source points multiplied by the number of shield exit points multiplied by the number of dose points.

Description of Input

Card 1: Title Card

Any identifying information desired, the only limitation being that the title must start somewhere within the first eight columns.

Card 2: Non-FORC Card

All numbers are fixed-point and must be right - adjusted in fields of four.

<u>Columns</u>	<u>Symbol</u>	<u>Description</u>
1 - 4	IM	Number of core-reflector axial slices (10 max)
5 - 8	IP	Number of core-reflector radial slices (10 max)
9 - 12	IN	Number of core-reflector azimuthal slices (10 max)
13 - 16	ND	Number of dose points (50 max)
17 - 20	LK	Number of exit sphere radial divisions (40 max)
21 - 24	IL2	Number of exit sphere azimuthal divisions (16 max)
25 - 28	MM	Degree of cosine distribution desired ($\cos^m \Theta_{st}$)
29 - 32	IUNIT	= 0 if length dimensions are in cm = 1 if length dimensions are in inches
33 - 36	ISAME	not used, set = 0
37 - 40	IGRAPH	not used, set = 0
41 - 44	KOSINE	Choice of Θ_{st} in diffuse calculation = 1; angle between normal and line to dose point = 2; angle between ray and line to dose point = 3; average cosine of above angles

Cards 3 to Completion of Input Data:

Use FORC input format, i.e., exponent of S_0 and A_0 is right adjusted, all numbers are floating point and left adjusted. Address of the first piece of input on a card is entered in columns 5 and 6 of the card (fixed point). Columns 1, 13, 25, 37, 49, and 61 are left blank.

<u>Address</u>	<u>Symbol</u>	<u>Description</u>
1	SO	peak core source strength ($n/cm^3\text{-sec}$)
2	G	axial core source strength constant (cm^{-1})
3	OMEGA(ω)	radial core source strength constant (cm^{-1})
4	AO	peak reflector source strength ($n/cm^3\text{-sec}$)
5	B	radial reflector source strength constant (cm^{-1})
6	SIGMAC	core collimated cross section (cm^{-1})
7	SIGMAR	reflector collimated cross section (cm^{-1})
8	SIGMAG	grid collimated cross section (cm^{-1})
9	SGCOOL	coolant collimated cross section (cm^{-1})
10	SIGSEL	shield collimated cross section (cm^{-1})
11	R2	radial intersection of shield cone and exit sphere cap
12	R3	radial intersection of shield cone and entrance sphere cap
13	R5	radius of coolant
14	R6	radius of grid
15	R7	radius of reflector
16	R8	radius of core
17	H1	Z coordinate of exit sphere vertex
18	H2	Z coordinate of intersection corresponding to R2
19	H3	Z coordinate of intersection corresponding to R3
20	H4	Z coordinate of entrance sphere vertex
21	H5	Z coordinate of bottom of coolant
22	H6	Z coordinate of bottom of grid
23	H7	Z coordinate of bottom of core
24	H8	Z coordinate of top of core
25	RHO G	density of grid (g/cc)

<u>Address</u>	<u>Symbol</u>	<u>Description</u>
26	RHOC	density of coolant (g/cc)
27	RHOSHL	density of shield (g/cc)
28	ZMUC	core broad beam (total) cross section (cm^{-1})
29	ZMUR	reflector broad beam (total) cross section (cm^{-1})
30	ZMUG	grid broad beam (total) cross section (cm^{-1})
31	ZMCOOL	coolant broad beam (total) cross section (cm^{-1})
32	ZMUSH	shield broad beam (total) cross section (cm^{-1})
33	TO	fraction of diffuse flux desired
34	ZGRAPH	not used, set = 0.0
35 (new card.) etc.	COORD(I)	R and Z coordinates for each dose point, entered as R_{D1} , Z_{D1} , R_{D2} , Z_{D2} , etc. for up to 50 dose points

References

1. Green, W. B., NAA-SR-TDR-9327, "MORTIMER - A Modification of the RAETRAP Code Which Includes the Two Component Method of Shield Analysis", December 16, 1963.
2. Moteff, J. and Osgood, H. W., "Comparison of Neutron Dose and Spectrum Calculations With Experiment For Finite Shield Systems", pp 213-225 of "Neutron Dosimetry", Vol. II, International Atomic Energy Agency, Vienna, 1963.

UAC CODING FORM # 3

ENGINEER: _____ MAIL ADDRESS: _____ EXTENSION: _____

TITLE: MORTIMER - SAMPLE CASE ANALYST: _____ SHEET 1 OF 1

JOB NO.: _____ ACCT. NO.: _____ W.O. NO.: _____

2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80

MORTIMER - SAMPLE CASE 1											TITLE
4	8	8	2	8	8	4	0	0	0	1	NONFORD
1			1.186	+10	0.0135		0.05		0.0	0.0	FORD 1
6			0.1		0.1		0.1		0.0	0.5	FORD 2
11			90.00		85.00		25.00		20.32	20.32	FORD 3
16			12.70		101.60		101.70		177.70	177.80	FORD 4
21			220.98		233.68		241.30		304.80	1.0	FORD 5
26			0.0		1.0		0.1		0.07	0.07	FORD 6
31			0.0		0.14		1.0		0.0		FORD 7
1 35			0.0		0.0		20.0		0.0		FORD 8

MORTIMER CONSECUTIVE CASE 1											TITLE
4	8	8	2	8	8	6	0	0	0	1	NONFORD
1 26			0.0								FORD 6

MORTIMER CONSECUTIVE CASE 2											TITLE
4	8	8	2	8	8	6	0	0	0	1	NONFORD
1 14			22.86								FORD

MORIMER - SAMPLE CASE 1

SOURCE SPECIFICATION--

M = 4 AXIAL DIVS. P = 8 RADIAL DIVS. N = 8 ANGULAR DIVS. ND = 2 DOSE POINTS

CORE SOURCE = $1.186000E 10 * JO(5.000000E-02 * R) * COS(1.350000E-02 * (Z-H7-H/2))$

REFLECTOR SOURCE = $0 * COS(1.350000E-02 * (Z-H7-H/2)) * EXP(- 0 * (R-RC))$

DIFFUSE DOSE CALCULATION--

K = 8 RADIAL DIVS., L = 8 ANGULAR DIVISIONS TO = 1.000000

COS** 4 DISTRIBUTION, ANGLE WITH NORMAL

SHIELD SPECIFICATION (CM.)--

R2= 9.000000E 01	R3= 8.500000E 01	R5= 2.500000E 01	R6= 2.032000E 01
R7= 2.032000E 01	R8= 1.270000E 01	H1= 1.016000E 02	H2= 1.017000E 02
H3= 1.777000E 02	H4= 1.778000E 02	H5= 2.209800E 02	H6= 2.336800E 02
	H7= 2.413000E 02	H8= 3.048000E 02	

MATERIAL PROPERTIES--

	CORE	REFLECTOR	GRID	COOLANT	SHIELD
DENSITIES			1.000000E 00	0	1.000000E 00
COLLIMATED CROSS SECTION	1.000000E-01	1.000000E-01	1.000000E-01	0	5.000000E-01
BROAD BEAM CROSS SECTION	1.000000E-01	7.000000E-02	7.000000E-02	0	1.400000E-01

MORTIMER - SAMPLE CASE 1

DIRECT DOSE RATE PER POINT

R (CM.)	Z (CM.)	R (IN.)	Z (IN.)	FROM CORE	FROM REFL	TOTAL
0	0	0	0	7.930527E-10	0	7.930527E-10
20.00	0	7.88	0	6.986180E-10	0	6.986180E-10

MORTIMER - SAMPLE CASE 1

DIFFUSED DOSE RATE PER POINT

R (CM.)	Z (CM.)	R (IN.)	Z (IN.)	FROM CORE	FROM REFL	TOTAL
0	0	0	0	1.026814E 03	0	1.026814E 03
20.00	0	7.88	0	9.772231E 02	0	9.772231E 02

MORTIMER - SAMPLE CASE 1

TOTAL DOSE RATE PER POINT

R (CM.)	Z (CM.)	R (IN.)	Z (IN.)	FROM CORE	FROM REFL	TOTAL
0	0	0	0	1.026814E 03	0	1.026814E 03
20.00	0	7.88	0	9.772231E 02	0	9.772231E 02

MORTIMER - SAMPLE CASE 1

SHIELD WEIGHTS

(LB.)

GRID= 21.77
COOLANT= 0
SHIELD= 4032.86

TIM-880

MORTIMER CONSECUTIVE CASE 1

SOURCE SPECIFICATION--

M = 4 AXIAL DIVS. P = 8 RADIAL DIVS. N = 8 ANGULAR DIVS. ND = 2 DOSE POINTS

CORE SOURCE = $1.186000E 10 * J0(5.000000E-02 * R) * \cos(1.350000E-02 * (Z-H7-H/2))$

REFLECTOR SOURCE = $0 * \cos(1.350000E-02 * (Z-H7-H/2)) * \exp(- 0 * (R-RC))$

DIFFUSE DOSE CALCULATION--

K = 8 RADIAL DIVS., L = 8 ANGULAR DIVISIONS TO = 1.000000

COS** 6 DISTRIBUTION, ANGLE WITH NORMAL

SHIELD SPECIFICATION (CM.)--

R2= 9.000000E 01	R3= 8.500000E 01	R5= 2.500000E 01	R6= 2.032000E 01
R7= 2.032000E 01	R8= 1.270000E 01	H1= 1.016000E 02	H2= 1.017000E 02
H3= 1.777000E 02	H4= 1.778000E 02	H5= 2.209800E 02	H6= 2.336800E 02
	H7= 2.413000E 02	H8= 3.048000E 02	

MATERIAL PROPERTIES--

	CORE	REFLECTOR	GRID	COGLANT	SHIELD
DENSITIES			1.000000E 00	0	1.000000E 00
COLLIMATED CROSS SECTION	1.000000E-01	1.000000E-01	1.000000E-01	0	5.000000E-01
BROAD BEAM CROSS SECTION	1.000000E-01	7.000000E-02	7.000000E-02	0	1.400000E-01

MORTIMER CONSECUTIVE CASE 1

DIRECT DOSE RATE PER POINT

R (CM.)	Z (CM.)	R (IN.)	Z (IN.)	FROM CORE	FROM REFL	TOTAL
0	0	0	0	7.930527E-10	0	7.930527E-10
20.00	0	7.88	0	6.986180E-10	0	6.986180E-10

MORTIMER CONSECUTIVE CASE 1

DIFFUSED DOSE RATE PER POINT

R (CM.)	Z (CM.)	R (IN.)	Z (IN.)	FROM CORE	FROM REFL	TOTAL
0	0	0	0	1.235902E 03	0	1.235902E 03
20.00	0	7.88	0	1.165910E 03	0	1.165910E 03

MORTIMER CONSECUTIVE CASE 1

TOTAL DOSE RATE PER POINT

R (CM.)	Z (CM.)	R (IN.)	Z (IN.)	FROM CORE	FROM REFL	TOTAL
0	0	0	0	1.235902E 03	0	1.235902E 03
20.00	0	7.88	0	1.165910E 03	0	1.165910E 03

MORTIMER CONSECUTIVE CASE 1

SHIELD WEIGHTS

(LB.)

GRID=	21.77
COOLANT=	0
SHIELD=	4032.86
TOTAL=	4054.63

MURTIMER CONSECUTIVE CASE 2

SOURCE SPECIFICATION--

M = 4 AXIAL DIVS. P = 8 RADIAL DIVS. N = 8 ANGULAR DIVS. ND = 2 DOSE POINTS

CORE SOURCE = $1.186000E 10 * J0(5.000000E-02 * R) * COS(1.350000E-02 * (Z-H7-H/2))$

REFLECTOR SOURCE = $0 * COS(1.350000E-02 * (Z-H7-H/2)) * EXP(- 0 * (R-RC))$

DIFFUSE DOSE CALCULATION--

K = 8 RADIAL DIVS., L = 8 ANGULAR DIVISIONS TO = 1.000000

COS** 6 DISTRIBUTION, ANGLE WITH NORMAL

SHIELD SPECIFICATION (CM.)--

K2= 9.000000E 01	K3= 8.500000E 01	K5= 2.500000E 01	R6= 2.286000E 01
K7= 2.032000E 01	K8= 1.270000E 01	H1= 1.016000E 02	H2= 1.017000E 02
K3= 1.177000E 02	H4= 1.778000E 02	H5= 2.209800E 02	H6= 2.336800E 02
	H7= 2.413000E 02	H8= 3.048000E 02	

MATERIAL PROPERTIES--

	CORE	REFLECTOR	GRID	COOLANT	SHIELD
DENSITIES			1.000000E 00	0	1.000000E 00
COLLIMATED CROSS SECTION	1.000000E-01	1.000000E-01	1.000000E-01	0	5.000000E-01
BROAD BEAM CROSS SECTION	1.000000E-01	7.000000E-02	7.000000E-02	0	1.400000E-01

MORTIMER CONSECUTIVE CASE 2

DIRECT DOSE RATE PER POINT

R (CM.)	Z (CM.)	R (IN.)	Z (IN.)	FROM CORE	FROM REFL	TOTAL
0	0	0	0	7.930527E-10	0	7.930527E-10
20.00	0	7.88	0	6.986180E-10	0	6.986180E-10

MORTIMER CONSECUTIVE CASE 2

DIFFUSED DOSE RATE PER POINT

R (CM.)	Z (CM.)	R (IN.)	Z (IN.)	FROM CORE	FROM REFL	TOTAL
0	0	0	0	1.230043E 03	0	1.230043E 03
20.00	0	7.88	0	1.159751E 03	0	1.159751E 03

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TOTAL DOSE RATE PER POINT

R (CM.)	Z (CM.)	R (IN.)	Z (IN.)	FROM CORE	FROM REFL	TOTAL
0	0	0	0	1.230043E 03	0	1.230043E 03
20.00	0	7.88	0	1.159751E 03	0	1.159751E 03

MORTIMER CONSECUTIVE CASE 2

SHIELD WEIGHTS

(LB.)

GRID= 27.56
COOLANT= 0
SHIELD= 4032.86
TOTAL= 4060.42

7/17-88