X-822

OAK RIDGE NATIONAL LABORATORY
Operated By
UNION CARBIDE NUCLEAR COMPANY
UCC
POST OFFICE BOX P
OAK RIDGE, TENNESSEE

DATE: August 20, 1956

SUBJECT: Operating Manual for ORACLE Code No. 243: The Calculation of Gamma Heating in Reactors of Rectangular Geometry

TO: Distribution

FROM: T. B. Fowler and H. C. Claiborne

NOTICE

This document contains information of a preliminary nature and was prepared primarily for internal use at the Oak Ridge National Laboratory. It is subject to revision or correction and therefore does not represent a final report.

846-1

DISCLAIMER

SUMMARY

A method of calculating heat generation due to gamma ray absorption in structural members of reactors of rectangular geometry was coded for the ORACLE. The derivation of the basic equations used in the calculation was given in a previous memorandum.[1] Complete instructions as to preparation of input parameter tapes and performing the calculation on the ORACLE are given. The code tapes are in possession of the authors and are available upon request.

845 2

INTRODUCTION

The code is the "fixed point" type and is divided into six parts corresponding to the six faces or target planes of a rectanguloid (see Fig. 1). The number and location of core volume elements (or source points), the number and location of points on a target plane outside the core where the gamma heating is to be computed and the number of energy groups for which the calculation is to be performed must be specified by the input parameter tapes. The maximum number of core volume elements or source points is limited to 3150, i.e., 14 x 15 x 15 volume elements (see Fig. 1), and the maximum number of points on a target plane parallel to one of the six core faces is limited to 256, i.e., 16 x 16 rectangular elements. The number of energy groups that may be used is limited only by the time involved in doing the calculation.

The ORACLE requires approximately 4 minutes per 1000 core source points to compute the heat generation at one point outside the core for one energy group.

IN PUT PARAMETER TAPES

The input parameter paper tapes for a particular calculation comprise four separate tapes designated as tape A, tape B, tape C, and tape D. Tape A specifies scale factors, number of volume elements and number of points in the target plane at which the heat generation is to be calculated. Tape B gives the value of the thermal flux at each source point. Tape C gives the coordinates of all core and target plane points, and tape D consists of energy group constants.

Tape A:

The following is a list and description of tape A input parameters. All of these numbers are ten digit hex* numbers, i.e., hexidecimal numbers preceded by enough zeros to make ten digits. Each of the tape A numbers is typed to single space on paper tape with a double space following the last number.

1. B_o - number of blocks of magnetic tape (drive zero) used by the code. B_o is equal to n_{zc} (see below) when $n_{xc} n_{yc}$ (decimal) ≤ 128, and is equal to $2\, n_{zc}$ when $n_{xc} n_{yc} > 128$.

2. SF_b - a number such that $\frac{1}{2^{SF_b}} \left[1 + a_i + b_i + c_i \right] < 1$, $i = c, r$, where a_i, b_i, and c_i are the coefficients in the build-up factor equations.[1]

3. Zero - ten zero digits

4. n_{xc} - number of core divisions in the X direction (see Fig. 1)

5. n_{yc} - number of core divisions in the Y direction

6. n_{zc} - number of core divisions in the Z direction

7. n_{xt} - number of divisions in a target plane in the X direction (see Fig. 1)

8. n_{yt} - number of divisions in a target plane in the Y direction

9. n_{zt} - number of divisions in a target plane in the Z direction

10. $n_{xc}n_{yc}$ - product of items 4 and 5 above

11. SF_d - a number such that $\frac{s}{2^{SF_d}} < 1$, where s is the dimension of greatest magnitude of the reactor, i.e., the diagonal of the rectanguloid (see Fig. 1)

12. SF_ϕ - a number such that $\frac{\phi_{th}\ (max)}{2^{SF_\phi}} < 1$

Tape B:

Tape B consists of the values of the thermal flux at each of the core volume elements. Each of these numbers is a ten digit decimal floating point number of the form:

$$\overset{0}{F}.\ x\ x\ x\ x\ x\ x\ \overset{0}{F}\ y\ y$$

The first digit is 0 if the number is positive, or F if the number is negative; the next six digits are a decimal fraction; the eighth digit is 0 or F, representing the sign of the exponent of ten and the last two digits are the exponent of ten. All of the numbers on tape B are typed to single space including the last number.

The number of thermal flux values will depend upon the number of core volume elements taken, and the order in which they are listed is the same regardless of which target plane is being considered.

With reference to Fig. 1, the thermal flux values are listed as:

1. $\phi\ (x_1, y_1, z_1)$ - $\frac{\text{neuts}}{\text{cm}^2\text{-sec}}$

2. $\phi\ (x_2, y_1, z_1)$

3. $\phi\ (x_3, y_1, z_1)$

.
.
.
.
.

n_{xc}. $\phi(n_{xc}, y_1, z_1)$

$n_{xc} + 1$. $\phi(x_1, y_2, z_1)$

$n_{xc} + 2$. $\phi(x_2, y_2, z_1)$

$n_{xc} + 3$. $\phi(x_3, y_2, z_1)$

.
.
.
.
.

$n_{xc}n_{yc}$. $\phi(n_{xc}, n_{yc}, z_1)$

$n_{xc}n_{yc} + 1$. $\phi(x_1, y_1, z_2)$

$n_{xc}n_{yc} + 2$. $\phi(x_2, y_1, z_2)$

$n_{xc}n_{yc} + 3$. $\phi(x_3, y_1, z_2)$

.
.
.
.
.
.

$n_{xc}n_{yc}n_{zc}$. $\phi(n_{xc}, n_{yc}, n_{zc})$

Tape C:

Tape C comprises 106 numbers as listed below, each being a ten digit floating point number of the same form as tape B numbers. With reference to Fig. 1, the numbers on this tape give the x, y, z coordinates of the center of each core volume element, the x, y, z coordinates of the center of each target plane rectangular element, the coordinates of the six core faces, and the coordinates of three target planes.

1. x_{1c} - cm

2. x_{2c}

3. x_{3c}

.
.
.
.
.
.

14. x_{14c}

15. zero - ten zero digits

16. zero - ten zero digits

17. y_{1c}

18. y_{2c}

19. y_{3c}

.
.
.
.
.

31. y_{15c}

32. zero - ten zero digits

33. z_{1c}

34. z_{2c}

35. z_{3c}

.
.
.
.
.

47. z_{15c}

48. zero - ten zero digits

49. x_{1t}

50. x_{2t}

51. x_{3t}

.
.
.
.
.

64. x_{16t}

65. y_{1t}

66. y_{2t}

67. y_{3t}

.
.
.
.
.
.

80. y_{16t}

81. z_{1t}

82. z_{2t}

83. z_{3t}

.
.
.
.
.

96. z_{16t}

97. x_{cf}^{III} - distance from origin to core face III (see Fig. 1), cm.

98. x_{cf}^{IV}

99. y_{cf}^{V}

100. y_{cf}^{VI}

101. z_{cf}^{I}

102. z_{cf}^{II}

103. x_{tp}^{III} - distance from origin to target plane parallel to core face III

104. y_{tp}^{V}

105. z_{tp}^{I}

106. $\epsilon^{(1)}$

For all dimensions on tape C that do not exist, a ten zero digit number should be typed, i.e., if a particular reactor core is to have only 5 divisions in the X direction, then zeros would be typed for items 6 through 14, and if only target plane I (see Fig. 1) were being considered, items 81 through 96 would be zero.

It should be noted that figure 1 is drawn to show all of the six target planes that may be considered by the calculation; however, it is entirely possible to specify the geometry as shown in figures 2 and 3, the only restrictions being that the coordinate axis must be drawn in the same position and the thermal flux distribution listed as shown.

Tape D:

The following ten digit decimal floating point numbers comprise tape D. All are typed to single space on the tape.

1. $Q = \left[\frac{S/\phi \; KE}{4\pi}\right]^{(1)} \times f$, where f is a number such that $Q <$ the dimension of greatest magnitude of the reactor.

2. $1 =$ 0100000001

3. $a_c^{(1)}$

4. $b_c^{(1)}$

5. $c_c^{(1)}$

6. $a_r^{(1)}$ = zero for no reflector, i.e., $s_r^{(1)} = 0$

7. $b_r^{(1)}$ = zero for no reflector, i.e., $s_r^{(1)} = 0$

8. $c_r^{(1)}$ = zero for no reflector, i.e., $s_r^{(1)} = 0$

9. $\mu_r^{(1)}$

10. $\mu_r^{(1)}$ = zero for no reflector, i.e., $s_r^{(1)} = 0$

NOTES ON INPUT PARAMETER TAPES, CALCULATION, AND ANSWERS

It is assumed that for a given reactor, i.e., one particular flux distribution and geometry, the heat generation at the target plane points for several energy groups will be computed. Hence, the code is such that for a particular case only one tape A, one tape B, and one tape C are required for a series of D tapes corresponding to the various energy groups; i.e., the code uses this series of D tapes independently of the other input parameter tapes. The section on machine operating instructions explains the procedure for using the input tapes.

The code performs the calculation by computing the heat generation for point one on a target plane for one energy group considering, in order, each source point in the core. Then point two on the target plane is considered, etc., and the procedure repeated for each energy group in turn. The bulk of the calculation is concerned with the computation of $s_c^{(1)}$ and $s_r^{(1)}$.

The answers that are punched out are ten digit floating point numbers of the same form as the input numbers on tapes B, C, and D. The output answers are proportional (see below) to the true answers and will be punched on the output tape in the following order:

1. $A_{P_1G_1}$ - heat generation at point one (see Fig. 1) on target plane for first energy group.
2. $A_{P_2G_1}$ - heat generation at point two on target plane for first energy group.

•
•
•
•

P_n. $A_{P_n G_1}$ - heat generation at the n^{th} point on target plane for first energy group

$P_n + 1$. $A_{P_1 G_2}$ - heat generation at point one on target plane for second energy group

.
.
.
.
.

$P_n G_n$. $A_{P_n G_n}$ - heat generation at the n^{th} point on target plane for n^{th} energy group

To obtain the true heat generation at a particular point on the target plane for a particular target material, the following calculation must be done.

$$A_{P_i} = \frac{1}{f} \sum_{1}^{n} A_{P_i G_n} \times \left(\frac{\mu_n}{\rho_n}\right)_h^{(1)} \frac{\text{watts}}{\text{gm}} = \text{heat generation}$$

at point i for target material h.

MACHINE OPERATING INSTRUCTIONS

1. Single memory - B.P. up.
2. Load master code tape - 90:3C0
3. Load Code i - 90:100, i = I, II, III, IV, V, VI, corresponding to the particular target plane being considered.
4. Input tape A under reader - 43:0F9 - tape A is loaded and code stops on B.P. at 0DA-R.
5. Input tape B under reader - go through B.P. - tape B is loaded and stored on magnetic tape drive zero - code stops on B.P. at 0FA-R.
6. Input tape C under reader - go through B.P. - tape C is loaded and code stops on B.P. at 3D0-R.
7. Input tape D-1 under reader - go through B.P. - tape D-1 is loaded and calculation begins. Code stops on B.P. at 3D0-R after P_n words punch, where P_n is the number of target plane points at which the gamma heating is to be calculated.
8. Input tape D-2, etc., under reader - repeat step 7.

To rerun the calculation using a different tape C, at B.P. stop at 3D0-R put tape C under reader - 41:0FA and repeat steps 6, 7, and 8.

REFERENCES

1. Claiborne, H. C. and T. B. Fowler, The Calculation of Gamma Heating in Reactors of Rectanguloid Geometry, ORNL CF-56-7-97.

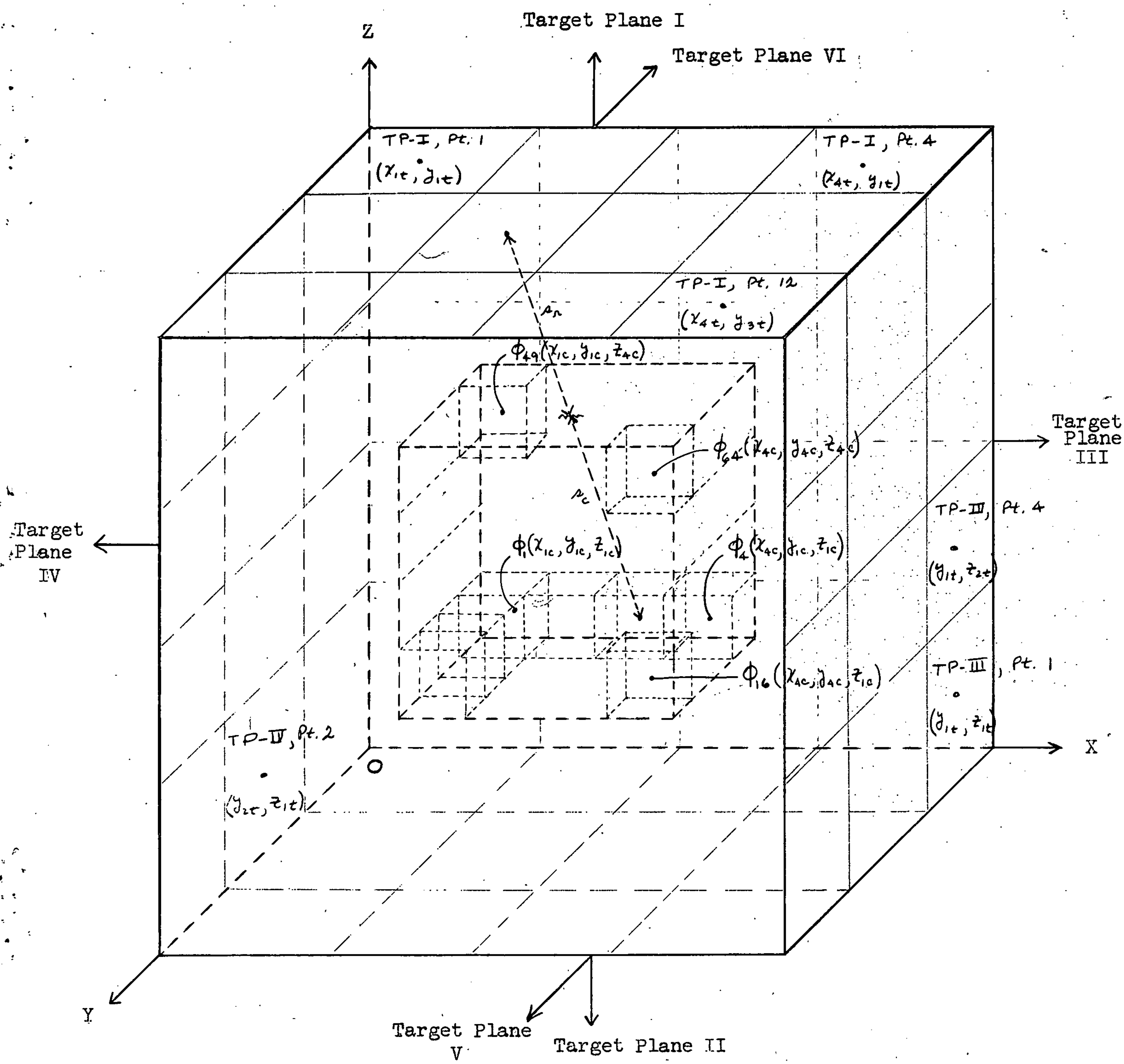
Target Plane I
Target Plane VI
Z
TP-I, Pt. 1
TP-I, Pt. 4
TP-I, Pt. 12
Target Plane III
Target Plane IV
TP-III, Pt. 4
TP-III, Pt. 1
TP-IV, Pt. 2
O
X
Y
Target Plane V
Target Plane II

Figure 1

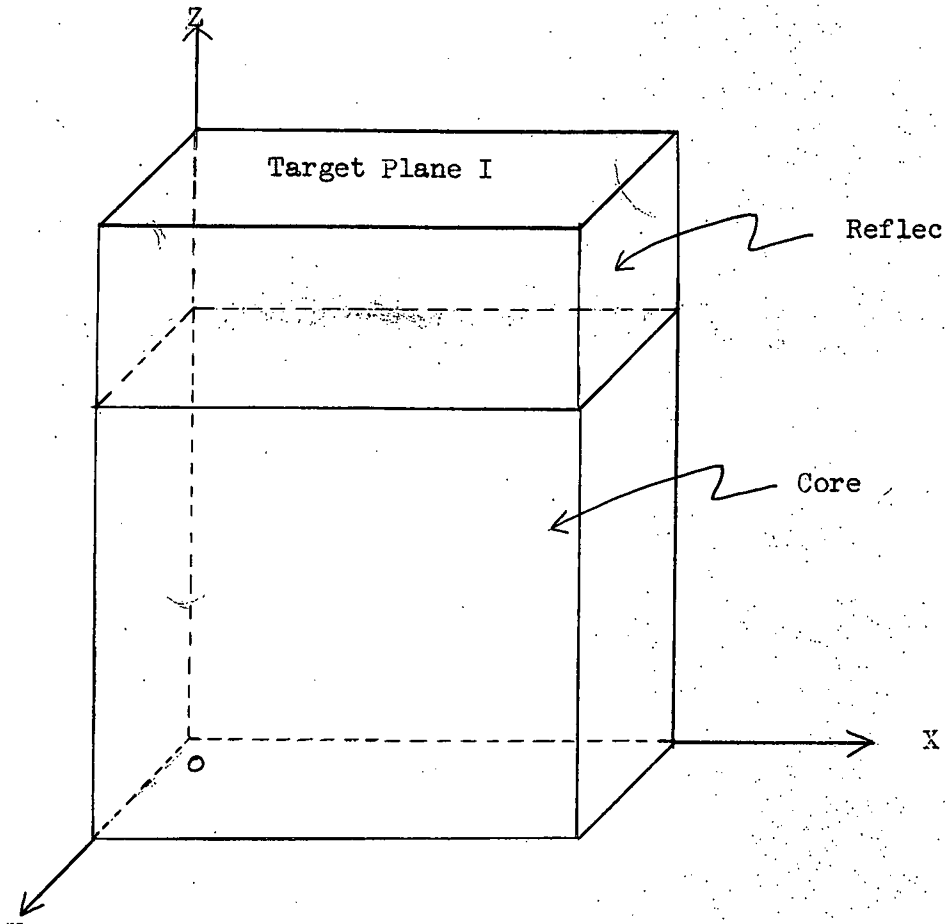

Figure 2

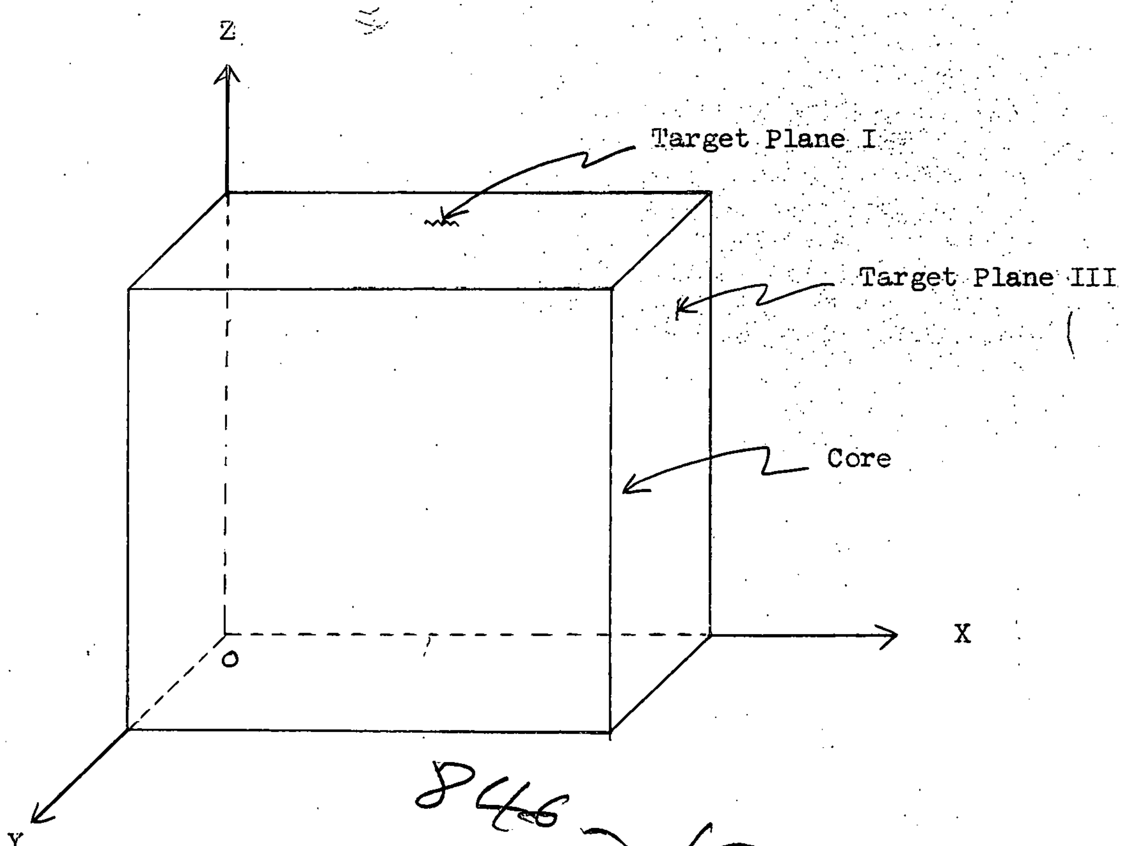

Figure 3

846 - 66