A MIXED ZONE GEOMETRY OPTION FOR THE
RAFFLE GENERAL PURPOSE MONTE CARLO CODE

R.S. Marsden
F.J. Wheeler
D.E. Wessol

Aerojet Nuclear Company

IDAHO NATIONAL ENGINEERING LABORATORY

Idaho Falls, Idaho — 83401

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ABSTRACT

A mixed zone geometry option for the RAFFLE general purpose Monte Carlo code is described, and instructions for preparation of the input data for this option are presented. This option simplifies preparation of the zone geometry input for problems having an array of fuel pins. This report supplements The RAFFLE General Purpose Monte Carlo Code, ANCR-1022, by W.E. Vesely, F.J. Wheeler, and R.S. Marsden.

SUMMARY

A new zone geometry option for the RAFFLE general purpose Monte Carlo code is presented. Preparation of the input data for this option is described with reference to a sample problem, and detailed instructions for inputting the data in the formats required by RAFFLE are given. This new zone geometry option, designated as the "mixed" zone geometry, substantially simplifies the preparation of the input data for problems having an array of fuel pins. At the time of this report, the majority of the RAFFLE problems were of this type. The mixed zone geometry option combines features of three previous zone geometries in a two-level zone search. Since its introduction, users have universally selected this option for problems having an array of fuel pins.

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A MIXED ZONE GEOMETRY OPTION FOR THE RAFFLE MONTE CARLO CODE

I. INTRODUCTION

This report supplements The RAFFLE General Purpose Monte Carlo Code, ANCR-1022, by W.E. Vesely, F.J. Wheeler, and R.S. Marsden. A new zone geometry option for RAFFLE is described, and instructions for preparing the input data are given. This new zone geometry, designated as the "mixed" zone geometry, is especially suitable for problems having an array of cylinders. It combines features of the rectangular, cylindrical R, Z, and cylindrical R, Θ , Z zone geometries described in Section III-7 of ANCR-1022. A RAFFLE problem requires input specifying two geometries. The first, the region geometry, describes the physical model and the enclosing vacuum regions (see Sections III-1 through III-5 of ANCR-1022). The second, the zone geometry, is used to provide an efficient method to determine the region in which an event occurs. Given the coordinates of an event, the program first finds the zone containing the event and then finds which region in the zone contains the event. Restrictions are placed on the zone geometry so that the program can make an efficient search for the zone containing the event. However, these restrictions make the zone geometry inadequate for describing the actual geometry of many problems. On the other hand, the rather arbitrary shape allowed for a region makes it difficult to locate the region containing an event. When there is only one region per zone, the program bypasses the time-consuming region search.

Other than the mixed zone geometry, only the rectangular zone geometry is suitable for problems having a number of nonconcentric cylindrical regions. For such problems, preparation of the input to describe the rectangular zone geometry becomes tedious, time consuming, and error prone. If the cylinders are subdivided into a number of regions to obtain, for example, detailed power distributions, it may even be difficult to limit the number of regions per zone to seven as required by the program. The mixed zone geometry alleviates this problem by providing a two-level zone search. The rectangular zone containing the event is first found. Then if the zone contains a cylindrical region, the event is located in a cylindrical zone or a sector of it lying within the rectangular zone. For problems with an array of cylinders, the mixed zone geometry permits a natural correspondence between the zones and the regions. Figure 1 shows the region geometry, a rectangular zone geometry, and a mixed zone geometry for a problem having two cylindrical fuel pins. Note that there is no unique zone geometry for a problem; often a choice must be made between ease of input preparation and efficiency of execution.

The mixed zone geometry was developed primarily to reduce the time to prepare the input for problems having an array of fuel pins. At the time of this report, RAFFLE was being used almost exclusively for this type of problem. To be useful, a reduction in time for input preparation must not be offset by an excessive increase in execution time. No actual determination of the effect of the mixed zone geometry on execution time has been made

because of the difficulty in preparing a rectangular zone geometry description for realistic problems having an array of fuel pins. However, it is believed that the factors increasing execution time are compensated by those decreasing it. The following discussion assumes problems suitable for use of mixed zone geometry. The zone search is more complicated with the mixed zone geometry, and thus the search time per zone is greater than with rectangular zone geometry. However, the number of zones to be searched with mixed zone geometry is usually much smaller. In addition, the mixed zone geometry usually reduces the number of regions per zone, thus reducing execution time. Indeed, for a wide class of problems, only one region per zone is needed so that no region search is required. Since its introduction, users have universally chosen the mixed zone option for problems with an array of fuel pins, thus indicating their satisfaction with the performance of this option.

Region Geometry

Rectangular Zone Geometry

Mixed Zone Geometry

ANC-A-4688

FIG. 1 A COMPARISON OF MIXED AND RECTANGULAR ZONE GEOMETRIES.

II. THE MIXED ZONE GEOMETRY OPTION

This section discusses the use of the mixed zone geometry option and describes the preparation of the input data with reference to the geometry of the sample problem depicted in Figure 2. Detailed instructions for inputting the data in the exact formats required by RAFFLE are presented in Section III. To establish a correspondence between Tables VI and VII of Section III, and the present section, the mnemonic names from these tables are printed in capital letters and referred to as data types, i.e., data type IZONGE.

$R_1 = 6.0$
 $R_2 = 7.0$
 $R_3 = 0.5$
 $R_4 = 1.0$
Height = 100
All Dimensions in cm
Not to Scale

FIG. 2 MODEL FOR SAMPLE PROBLEM.

1. THE PRIMARY ZONE DESCRIPTION

To determine the region containing an event, RAFFLE first finds the primary zone containing the event. A primary zone is a rectangular volume, and the primary zone description is almost identical to that for the rectangular zone geometry as described in Section III-7.3.1 of ANCR-1022. The discussion in the present report is a condensation of that in ANCR-1022. First the entire problem, including the enclosing vacuum regions, must be enclosed in a rectangular box as shown in Figure 3. However, there may be portions of the box that do not contain any region, as may be the case when the physical regions are bounded by a cylindrical vacuum region. As with the rectangular zone description, the origin and orientation of this box must agree with that chosen for the region geometry. The primary zone description is specified by X lines, Y lines, and Z lines. This terminology is historical and not precise since actual surfaces are used to specify the zone geometry. For example, the value entered for a Z line is the perpendicular distance from the plane $Z=0$. The values for the X, Y, and Z lines are given in centimeters.

Next, the box is divided into horizontal slabs by the assignment of Z lines. Typically, four Z lines are used to divide the box into three Z zones, as shown in Figure 4, with all of the physical regions lying in Z zone 2. A Z zone is all of the volume lying between two Z lines. The Z lines and the Z zones are both numbered from bottom to top. The first Z line, Z_1 , must have a value of 0.0; and there may be any number of Z lines and, hence, any number of Z zones.

Each Z zone is then divided into one or more X zones by X lines, as shown in Figure 5, with each X zone extending from front to back of the zone geometry volume. For each Z zone, the first X line must have a value of 0.0; and the X zones must completely fill the Z zone. The X lines are numbered from left to right starting with the bottom Z zone and continuing sequentially through the Z zones from bottom to top (see Figure 5).

Next, each X zone is divided into one or more primary zones by Y lines as shown in Figure 6. The spacing of the Y lines within each X zone is arbitrary, except that the first Y line of each X zone must have a value of 0.0; and all the final Y lines for the X zones must have the same value. That is, each X zone must be completely filled by primary zones. The Y lines are numbered from front to back starting with the first X zone in the first Z zone. The numbering continues from front to back through the X zones, from left to right through the first Z zone, and then in the same way through the remaining Z zones as shown in Figure 7. The primary zones are numbered by the same ordering scheme as the Y lines (see Figure 6) and also in the same way as the zones of a rectangular zone description (see Section III-7.3.3 of ANCR-1022).

ANC-A-4690

FIG. 3 THE ZONE GEOMETRY VOLUME.

ANC-A-4691

FIG. 4 THE Z ZONES.

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FIG. 5 THE X ZONES.

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ANC-A-4694

FIG. 6 THE PRIMARY ZONES.

FIG. 7 THE Y LINES.

2. THE SECONDARY ZONE DESCRIPTIONS

Each primary zone may optionally contain a secondary zone description. There are two types of secondary zone descriptions; the first is the R, Z cylindrical zone description; the second is the R, Θ , Z cylindrical zone description. For a given primary zone, the secondary zone description is almost identical to that described in Section III-7.3.4 or III-7.3.7 of ANCR-1022 for an R, Z or R, Θ , Z description, respectively. Each secondary zone description must have its axis parallel to the Z axis of the coordinate system and extends from bottom to top of the Z zone containing its primary zone. In Figure 8, primary zones 2, 3, 4, 5, 6, 7, 9, 10, 13, 14, 15, 16, and 17 each contain an R, Z secondary zone description; and primary zones 8 and 12 each contain an R, Θ , Z secondary zone description. The secondary zones in primary zones 2, 3, 4, 5, 6, 9, 10, 13, 14, 15, 16, and 17 have their centers outside of their respective primary zones and thus are not contained entirely within their respective primary zones. Since the primary zone containing the event is determined first, an event in a particular primary zone cannot lie in that portion of the secondary zone description lying outside of its primary zone. The secondary zone descriptions for primary zones 7 and 8 are centered in their respective primary zones while all other secondary zone descriptions are not. If the secondary zone description is not centered in its primary zone, then the X and Y coordinates (in centimeters) with respect to the origin of the zone geometry must be entered as input data; otherwise, the program calculates these coordinates.

An R, Z secondary zone description is specified in terms of R lines and consists of one or more R zones (cylindrical zones). For an R, Θ , Z description, each R zone is subdivided into four or more sectors by Θ lines. Each secondary zone description must have an R line with a value of 0.0 at its center. The other R lines for that secondary zone description are specified by the radial distance (in centimeters) from the 0.0 line. A Θ line is measured in degrees counterclockwise from the horizontal line at the right of its R zone. If an R, Θ , Z description is selected, then every R zone in the description must have at least four Θ lines specified, those at 90, 180, 270, and 360 degrees. Any other Θ lines, $0 < \Theta < 360$, may be entered in any R zone of an R, Θ , Z secondary zone description. A Θ line of 0.0 degrees is never allowed.

To prepare the input data for the mixed zone geometry, the secondary zones and the R and Θ lines must be numbered. The secondary zone numbers in a primary zone are numbered independently of the numbers in any other primary zone as shown in Figure 9. Thus the first secondary zone in a primary zone is always numbered 1. For an R, Z description, the secondary zones are numbered starting with 1 for the innermost R zone and proceeding sequentially to the outermost R zone in the primary zone. For an R, Θ , Z description, secondary zone 1 is the first one above the 360 degree Θ line in the innermost R zone. The numbering then proceeds sequentially counterclockwise through the inner R zone and continues in the same way through each R zone ending in the outermost R zone.

The numbering of the R lines is shown in Figure 10. R line 1 is that with value 0.0 in the lowest numbered primary zone having a secondary zone description. The numbers then proceed outward, increasing by one each time, to the outermost R line in this primary zone. The numbers then proceed in the same way through each primary zone, as ordered by the primary zone numbers, having a secondary zone description. If the last R line in a primary zone has the number N, then the first R line in the next primary zone having a secondary zone description has the number N+1.

The numbering of the Θ lines is shown in Figure 11. Θ line 1 is that with the smallest value in degrees in the innermost R zone of the lowest numbered primary zone having an R, Θ , Z secondary zone description. The numbers then proceed, increasing by one each time, counterclockwise through this R zone ending with the 360 degree Θ line. The numbers proceed in the same way through each R zone in this primary zone with the R zones ordered from inside to outside. If the last Θ line in an R zone is numbered N, then the first Θ line in the next R zone is numbered N+1. The numbering then continues in the same way through each primary zone having an R, Θ , Z zone description. If the last Θ line in a primary zone is numbered M, then the first Θ line in the next primary zone having an R, Θ , Z description is numbered M+1.

FIG. 8 ASSIGNMENT OF SECONDARY ZONES TO PRIMARY ZONES.

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FIG. 9 THE SECONDARY ZONE NUMBERS.

ANC-A-4697

FIG. 10 THE R LINE NUMBERS.

FIG. 11 THE 8 LINE NUMBERS.

3. THE ZONE SEARCH

The user prepares the input for the mixed zone geometry by specifying the data needed to describe the primary and secondary zones. The program deals with zones where a zone is an elementary portion of the zone geometry volume that is not further subdivided. A primary zone that does not contain secondary zones is both a zone and a primary zone. If a primary zone contains a secondary zone description, then that part of the primary zone outside of the secondary zones is a zone and each secondary zone is a zone. The zone numbers for the problem of Figure 2 are shown in Figure 12. The zone numbers are calculated by the program and listed in the edited output as shown in Table V. Some error messages that assist in debugging the input data contain the zone number; otherwise, the user need not be concerned with them.

After the coordinates of an event have been determined, a search is made to find the zone containing the event. In the following discussion, it is assumed that the event lies within the zone geometry volume; if not, an error count is updated and a decision made as whether to proceed with a new source neutron or to terminate the problem.

First the Z zone containing the event is found by successively comparing the Z coordinate of the event with the values of the Z lines starting from the bottom. The search stops when the Z coordinate of the event is less than or equal to that for the Z line. Since Z zone N lies between Z line N and Z line N+1, the event is in Z zone N. Next the X zone containing the event is found with the search starting with the X lines for the previously determined Z zone. During the edit of the input data, tables are set up containing the first X line in each Z zone and the first Y line in each X zone. The X coordinate is successively compared with the X lines until the X zone containing the event is determined. Then the primary zone containing the event is found by comparing the Y coordinate against the Y lines in the X zone.

A flag is now checked to determine if the primary zone contains a secondary zone description and, if so, whether it is an R, Z or an R, Θ , Z description. If the primary zone does not contain a secondary zone description, a check on the number of regions in the zone is made. If there is only one region, then the number of this region is used in processing the event as described in Section II-1 of ANCR-1022. Otherwise, a search is made to determine which one of the regions in the zone actually contains the event.

If the primary zone contains secondary zones, temporary X and Y coordinates with respect to the center of the secondary zones are calculated. Then the R zone containing the collision is found by the same type of successive comparisons used in the search for the primary zone. An R zone is that cylindrical volume lying between two adjacent R lines. If the event is not contained in some R zone, then it must be in the zone consisting of that part of the primary zone outside of the secondary zones. For an R, Z description, the zone search is completed when the R zone is found or the event is determined to be beyond the secondary zones. For an R, Θ , Z description, the previously determined R zone is searched counterclockwise to find the secondary zone containing the event. In either case, the region is then determined by a search of the regions in the zone, with this search bypassed if there is only one region in the zone.

FIG. 12 THE ZONE NUMBERS.

4. PREPARATION OF THE INPUT DATA

This section describes the preparation of the mixed zone geometry input so that it can readily be put into the exact formats required for input to RAFFLE as described in Tables VI and VII of Section III. In the present discussion, the mnemonic names as used in Section III are capitalized, for example IZONGE. The preparation of the input data is described with reference to the geometry of the problem shown in Figure 2. Table IV of Section II-5 lists the card images for the actual RAFFLE mixed zone geometry input for this problem. There are five steps in preparing the input data as follows:

- (1) Selection of the mixed zone geometry option
- (2) Specification of the number of primary zones
- (3) Specification of the primary zone description

- (4) Specification of the secondary zone descriptions
- (5) Assignment of regions to the primary and secondary zones.

The mixed zone geometry is selected by entering a value of 5 for IZONGE in the integer data of Table VI.

The number of primary zones is entered as data type NNZONE in the integer data of Table VI.

The primary zone description is specified by entering values in centimeters for the X, Y, and Z lines. To prepare these data, the X, Y, and Z lines must be numbered as illustrated in Figures 4, 5, and 7. The values of the X lines are entered as a group in progression from X line 1 to X line I, where I is the number of X lines, as data type XLINE in the floating point data of Table VII. The values of the Y and Z lines are entered as data types YLINE and ZLINE, respectively, in the same way as the data for the X lines. Table I lists the X, Y, and Z line numbers and values for the problem of Figure 2. A more detailed description of the input for the X, Y, and Z lines is given in Section III-7.3.2 of ANCR-1022.

The secondary zone descriptions are specified by entering values for the R lines in centimeters and for the Θ lines in degrees. Again these lines must be numbered (see Figures 10 and 11 and Table I). The values for the R lines are entered as a group in progression from R line 1 to R line L, where L is the total number of R lines, as data type RLINE of the floating point data. The values for the Θ lines are entered as data type Θ LINE in the same way. With the mixed zone geometry option, it is not necessary to enter values for the number of R or Θ lines. Even if it lies completely outside of its primary zone, a secondary zone must be described.

For each secondary zone description not centered in its primary zone, the X and Y coordinates of the secondary zone description axis must be specified in the input data. The values for these coordinates are in centimeters with respect to the common origin of the region and zone geometries. The X coordinates are entered as data type XSC and the Y coordinates as data type YSC in the floating point data of Table VII. Table II lists the coordinates of the noncentered secondary zone descriptions for the problem of Figure 2. If the secondary zone description is centered, then these coordinates are calculated by the program and need not be entered in the input data.

The assignment of regions to the primary and secondary zones and the types of secondary zone descriptions are specified by data types PZONE and SZONE in the integer data of Table VI of Section III. The types of secondary zone descriptions are shown in Figure 8 for the problem of Figure 2. The regions in the primary zones can be established from Figures 6, 9, and 13. The preparation of this input is described with reference to Table III, which is quite similar to the input data for PZONE and SZONE in Table IV. Each input card for data types PZONE and SZONE has a 3 in Index 1. For a primary zone not

containing a secondary zone description, only a PZONE card is required. The primary zone number is entered in Index 3, the number of regions in the primary zone in IWC, and the region numbers as integer data in I4 format starting in column 13. For a more detailed discussion that explains how to enter the data in I4 format, see Section III-1.

When the primary zone contains secondary zones, the input starts with a PZONE card identical to that described above, except that the type of secondary zone description is entered in Index 2. An R, Z description is Type 1; and an R, Θ , Z description is Type 2. The region numbers entered on this card are for the regions lying in that portion of the primary zone outside of the secondary zone description. It is acceptable, although unusual, for the secondary zone geometry to cover the entire primary zone. In such a case, enter 1 in IWC and 1 for the region number. This procedure prevents termination from an editing check, and the zone search procedure assures that any event in the primary zone will be placed in the proper secondary zone. Now one SZONE card is required for each secondary zone belonging to the primary zone, even if the secondary zone lies completely outside of the primary zone. The number of the primary zone is entered in Index 3, the number of the secondary zone in Index 4, and the number of regions in the zone in IWC. Then the region numbers for the regions in the zone are input as integer data in I4 format. In no case must the number of regions as indicated by IWC exceed seven. Some versions of RAFFLE allow only one region per zone. Unlike most of the RAFFLE data, the cards for data types PZONE and SZONE must be entered in a particular order. The PZONE cards must be entered in increasing magnitude of primary zone number. Each group of SZONE cards must follow immediately after their associated PZONE card and must be in order of the secondary zone numbers. That is, the PZONE and SZONE cards must be ordered in the way indicated by Table III.

TABLE I

THE ZONE LINES

<u>Line No.</u>	<u>X Line Value (cm)</u>	<u>Y Line Value (cm)</u>	<u>Z Line Value (cm)</u>	<u>R Line Value (cm)</u>	<u>Θ Line Value (degrees)</u>
1	0.0	0.0	0.0	0.0	90.0
2	16.0	16.0	1.0	6.0	180.0
3	0.0	0.0	100.0	7.0	270.0
4	4.0	4.0	101.0	0.0	360.0
5	7.0	8.0		6.0	90.0
6	12.0	12.0		7.0	180.0
7	16.0	16.0		0.0	270.0
8	0.0	0.0		6.0	360.0
9	16.0	4.0		7.0	45.0
10		8.0		0.0	90.0
11		12.0		6.0	135.0

TABLE I (contd.)

<u>Line No.</u>	<u>X Line Value (cm)</u>	<u>Y Line Value (cm)</u>	<u>Z Line Value (cm)</u>	<u>R Line Value (cm)</u>	<u>θ Line Value (degrees)</u>
12		16.0		7.0	180.0
13		0.0		0.0	225.0
14		4.0		6.0	270.0
15		8.0		7.0	315.0
16		12.0		0.0	360.0
17		16.0		0.5	
18		0.0		1.0	
19		4.0		0.0	
20		8.0		1.0	
21		12.0		0.0	
22		16.0		6.0	
23		0.0		7.0	
24		16.0		0.0	
25				6.0	
26				7.0	
27				0.0	
28				0.5	
29				1.0	
30				0.0	
31				6.0	
32				7.0	
33				0.0	
34				6.0	
35				7.0	
36				0.0	
37				6.0	
38				7.0	
39				0.0	
40				6.0	
41				7.0	
42				0.0	
43				6.0	
44				7.0	

TABLE II
COORDINATES OF THE AXES FOR THE
NONCENTERED SECONDARY ZONE DESCRIPTIONS

Primary Zone Number	X Coordinate XSC (cm)	Y Coordinate YSC (cm)
2	8.0	8.0
3	8.0	8.0
4	8.0	8.0
5	8.0	8.0
6	8.0	8.0
9	8.0	8.0
10	8.0	8.0
12	10.0	10.0
13	8.0	8.0
14	8.0	8.0
15	8.0	8.0
16	8.0	8.0
17	8.0	8.0

TABLE III
ASSIGNMENT OF REGIONS TO PRIMARY AND SECONDARY ZONES

Data Type	Secondary Zone Type	Primary Zone No.	Secondary Zone No.	Number of Regions	Region Number
Index 1 Cols. 2-3	Index 2 Cols. 4-5	Index 3 Cols. 6-8	Index 4 Cols. 9-10	IWC Cols. 11-12	Cols. 13-16
3		1		1	29
3	1	2		1	28
3		2	1	1	24
3		2	2	1	27
3	1	3		1	28
3		3	1	1	23
3		3	2	1	27
3	1	4		1	28
3		4	1	1	23
3		4	2	1	27
3	1	5		1	28

TABLE III (contd.)

Data Type	Secondary Zone Type	Primary Zone No.	Secondary Zone No.	Number of Regions	Region Number
Index 1 Cols. 2-3	Index 2 Cols. 4-5	Index 3 Cols. 6-8	Index 4 Cols. 9-10	IWC Cols. 11-12	Cols. 13-16
3		5	1	1	25
3		5	2	1	27
3	1	6		1	28
3		6	1	1	24
3		6	2	1	27
3	1	7		1	1
3		7	1	1	2
3		7	2	1	3
3	2	8		1	4
3		8	1	1	5
3		8	2	1	6
3		8	3	1	7
3		8	4	1	8
3	1	9		1	28
3		9	1	1	25
3		9	2	1	27
3	1	10		1	28
3		10	1	1	24
3		10	2	1	27
3		11		1	9
3	2	12		1	10
3		12	1	1	11
3		12	2	1	12
3		12	3	1	13
3		12	4	1	14
3		12	5	1	15
3		12	6	1	16
3		12	7	1	17
3		12	8	1	18
3		12	9	1	19
3		12	10	1	20
3		12	11	1	21
3		12	12	1	22
3	1	13		1	28
3		13	1	1	25
3		13	2	1	27
3	1	14		1	28
3		14	1	1	24
3		14	2	1	27
3	1	15		1	28
3		15	1	1	26
3		15	2	1	27
3	1	16		1	28
3		16	1	1	26
3		16	2	1	27

TABLE III (contd.)

Data Type	Secondary Zone Type	Primary Zone No.	Secondary Zone No.	Number of Regions	Region Number
Index 1 Cols. 2-3	Index 2 Cols. 4-5	Index 3 Cols. 6-8	Index 4 Cols. 9-10	IWC Cols. 11-12	Cols. 13-16
3	1	17		1	28
3		17	1	1	25
3		17	2	1	27
3		18		1	30

FIG. 13 THE REGION NUMBERS.

5. MIXED ZONE GEOMETRY INPUT FOR THE SAMPLE PROBLEM

This section presents the mixed zone geometry input for the sample problem of Figure 2. Table IV lists the actual card images and the corresponding mnemonic names for the RAFFLE input data pertinent to the mixed zone geometry option. Table V shows the mixed zone geometry input data as edited by RAFFLE.

TABLE IV

MIXED ZONE GEOMETRY INPUT FOR THE SAMPLE PROBLEM

<u>Card Images</u>					<u>Mnemonic Name</u>
		.			
		.			
		.			
	7	1	5		IZONGE
		.			
		.			
		.			
3	1	1	29		PZONE
3	1	2	1	28	PZONE
3	2	1	1	24	SZONE
3	2	2	1	27	
3	1	3	1	28	
3	3	1	1	23	
3	3	2	1	27	
3	1	4	1	28	
3	4	1	1	23	
3	4	2	1	27	
3	1	5	1	28	
3	5	1	1	25	
3	5	2	1	27	
3	1	6	1	28	
3	6	1	1	24	
3	6	2	1	27	
3	1	7	1	1	
3	7	1	1	2	
3	7	2	1	3	
3	2	8	1	4	
3	8	1	1	5	
3	8	2	1	6	
3	8	3	1	7	
3	8	4	1	8	
3	1	9	1	28	
3	9	1	1	25	
3	9	2	1	27	
3	1	10	1	28	
3	10	1	1	24	
3	10	2	1	27	
3	11	1	9		
3	2	12	1	10	

TABLE IV (contd.)

Card Images					Mnemonic Name
3	12	1	1	11	
3	12	2	1	12	
3	12	3	1	13	
3	12	4	1	14	
3	12	5	1	15	
3	12	6	1	16	
3	12	7	1	17	
3	12	8	1	18	
3	12	9	1	19	
3	12	10	1	20	
3	12	11	1	21	
3	12	12	1	22	
3	1	13	1	28	
3	13	1	1	25	
3	13	2	1	27	
3	1	14	1	28	
3	14	1	1	24	
3	14	2	1	27	
3	1	15	1	28	
3	15	1	1	26	
3	15	2	1	27	
3	1	16	1	28	
3	16	1	1	26	
3	16	2	1	27	
3	1	17	1	28	
3	17	1	1	25	
3	17	2	1	27	
3	18	1	1	30	
.					
.					
.					
10	1	3	0.0	6.0	7.0
10	4	3	0.0	6.0	7.0
10	7	3	0.0	6.0	7.0
10	10	3	0.0	6.0	7.0
10	13	3	0.0	6.0	7.0
10	16	3	0.0	0.5	1.0
10	19	2	0.0	1.0	
10	21	3	0.0	6.0	7.0
10	24	3	0.0	6.0	7.0
10	27	3	0.0	0.5	1.0
10	30	3	0.0	6.0	7.0
10	33	3	0.0	6.0	7.0
10	36	3	0.0	6.0	7.0
10	39	3	0.0	6.0	7.0
10	42	3	0.0	6.0	7.0
.					
.					
.					

RLINE

TABLE IV (contd.)

Card Images				Mnemonic Name		
11	1	4	90.0	180.0	270.0	360.0
11	5	4	90.0	180.0	270.0	360.0
11	9	4	45.0	90.0	135.0	180.0
11	13	4	225.0	270.0	315.0	360.0
	.					
	.					
	.					
12	2	1	8.0			
12	3	1	8.0			
12	4	1	8.0			
12	5	1	8.0			
12	6	1	8.0			
12	9	1	8.0			
12	10	1	8.0			
12	12	1	10.0			
12	13	1	8.0			
12	14	1	8.0			
12	15	1	8.0			
12	16	1	8.0			
12	17	1	8.0			
	.					
	.					
	.					
13	2	1	8.0			
13	3	1	8.0			
13	4	1	8.0			
13	5	1	8.0			
13	6	1	8.0			
13	9	1	8.0			
13	10	1	8.0			
13	12	1	10.0			
13	13	1	8.0			
13	14	1	8.0			
13	15	1	8.0			
13	16	1	8.0			
13	17	1	8.0			

9LINE

XSC

YSC

TABLE V

RAFFLE EDIT OF THE MIXED ZONE GEOMETRY INPUT FOR THE SAMPLE PROBLEM

MIXED ZONE GEOMETRY, IZONGE = 5
PRIMARY ZONE DESCRIPTION

NUMBER OF PRIMARY ZONES = 18
NUMBER OF Z LINES = 4

Z LINES
0.0 1.00000 100.00000 101.00000

INFORMATION FOR Z ZONE 1

XLINES
0.0 16.00000

Y LINES FOR X ZONE 1
0.0 16.00000

INFORMATION FOR Z ZONE 2

XLINES
0.0 4.00000 7.00000 12.00000 16.00000

Y LINES FOR X ZONE 1
0.0 4.00000 8.00000 12.00000 16.00000

Y LINES FOR X ZONE 2
0.0 4.00000 8.00000 12.00000 16.00000

Y LINES FOR X ZONE 3
0.0 4.00000 8.00000 12.00000 16.00000

Y LINES FOR X ZONE 4
0.0 4.00000 8.00000 12.00000 16.00000

INFORMATION FOR Z ZONE 3

XLINES
0.0

Y LINES FOR X ZONE 1
0.0

TABLE V (contd.)

DESCRIPTION OF SECONDARY ZONES					
PRIMARY ZONE 2 R-Z SECONDARY ZONES					CENTER OF SECONDARY ZONE GEOMETRY
BOUNDED BY X LINES		0.0	4.00000		
BOUNDED BY Y LINES		0.0	4.00000		
BOUNDED BY Z LINES		1.00000	100.00000		Y = 8.00000
RADIAL LINES					
0.0	6.00000	7.00000			
PRIMARY ZONE 3 R-Z SECONDARY ZONES					CENTER OF SECONDARY ZONE GEOMETRY
BOUNDED BY X LINES		0.0	4.00000		
BOUNDED BY Y LINES		4.00000	8.00000		
BOUNDED BY Z LINES		1.00000	100.00000		Y = 8.00000
RADIAL LINES					
0.0	6.00000	7.00000			
PRIMARY ZONE 4 R-Z SECONDARY ZONES					CENTER OF SECONDARY ZONE GEOMETRY
BOUNDED BY X LINES		0.0	4.00000		
BOUNDED BY Y LINES		8.00000	12.00000		
BOUNDED BY Z LINES		1.00000	100.00000		Y = 8.00000
RADIAL LINES					
0.0	6.00000	7.00000			
PRIMARY ZONE 5 R-Z SECONDARY ZONES					CENTER OF SECONDARY ZONE GEOMETRY
BOUNDED BY X LINES		0.0	4.00000		
BOUNDED BY Y LINES		12.00000	16.00000		
BOUNDED BY Z LINES		1.00000	100.00000		Y = 8.00000
RADIAL LINES					
0.0	6.00000	7.00000			
PRIMARY ZONE 6 R-Z SECONDARY ZONES					CENTER OF SECONDARY ZONE GEOMETRY
BOUNDED BY X LINES		4.00000	7.00000		
BOUNDED BY Y LINES		0.0	4.00000		
BOUNDED BY Z LINES		1.00000	100.00000		Y = 8.00000
RADIAL LINES					
0.0	6.00000	7.00000			
PRIMARY ZONE 7 R-Z SECONDARY ZONES					CENTER OF SECONDARY ZONE GEOMETRY
BOUNDED BY X LINES		4.00000	7.00000		
BOUNDED BY Y LINES		4.00000	8.00000		
BOUNDED BY Z LINES		1.00000	100.00000		Y = 6.00000
RADIAL LINES					
0.0	0.50000	1.00000			
PRIMARY ZONE 8 R-Z-Y SECONDARY ZONES					CENTER OF SECONDARY ZONE GEOMETRY
BOUNDED BY X LINES		4.00000	7.00000		
BOUNDED BY Y LINES		8.00000	12.00000		
BOUNDED BY Z LINES		1.00000	100.00000		Y = 10.00000
RADIAL ZONE 1 OUTER RADIUS 1.00000					
THETA LINES					
90.00000	180.00000	270.00000	360.00000		
PRIMARY ZONE 9 R-Z SECONDARY ZONES					CENTER OF SECONDARY ZONE GEOMETRY
BOUNDED BY X LINES		4.00000	7.00000		
BOUNDED BY Y LINES		12.00000	16.00000		

TABLE V (contd.)

BOUNDED BY Z LINES		1.00000	100.00000	Y = 8.00000	
RADIAL LINES					
0.0	6.00000	7.00000			
PRIMARY ZONE 10		R-Z SECONDARY ZONES			
BOUNDED BY X LINES		7.00000	12.00000	CENTER OF SECONDARY ZONE GEOMETRY	
BOUNDED BY Y LINES		0.0	4.00000	X = 8.00000	
BOUNDED BY Z LINES		1.00000	100.00000	Y = 8.00000	
RADIAL LINES					
0.0	6.00000	7.00000			
PRIMARY ZONE 12		R-Z-T SECONDARY ZONES			
BOUNDED BY X LINES		7.00000	12.00000	CENTER OF SECONDARY ZONE GEOMETRY	
BOUNDED BY Y LINES		8.00000	12.00000	X = 10.00000	
BOUNDED BY Z LINES		1.00000	100.00000	Y = 10.00000	
RADIAL ZONE 1		OUTER RADIUS			
THETA LINES		0.50000			
90.00000	180.00000	270.00000	360.00000		
RADIAL ZONE 2		OUTER RADIUS			
THETA LINES		1.00000			
45.00000	90.00000	135.00000	180.00000	225.00000	270.00000 315.00000 360.00000
PRIMARY ZONE 13		R-Z SECONDARY ZONES			
BOUNDED BY X LINES		7.00000	12.00000	CENTER OF SECONDARY ZONE GEOMETRY	
BOUNDED BY Y LINES		12.00000	16.00000	X = 8.00000	
BOUNDED BY Z LINES		1.00000	100.00000	Y = 8.00000	
RADIAL LINES					
0.0	6.00000	7.00000			
PRIMARY ZONE 14		R-Z SECONDARY ZONES			
BOUNDED BY X LINES		12.00000	16.00000	CENTER OF SECONDARY ZONE GEOMETRY	
BOUNDED BY Y LINES		0.0	4.00000	X = 8.00000	
BOUNDED BY Z LINES		1.00000	100.00000	Y = 8.00000	
RADIAL LINES					
0.0	6.00000	7.00000			
PRIMARY ZONE 15		R-Z SECONDARY ZONES			
BOUNDED BY X LINES		12.00000	16.00000	CENTER OF SECONDARY ZONE GEOMETRY	
BOUNDED BY Y LINES		4.00000	8.00000	X = 8.00000	
BOUNDED BY Z LINES		1.00000	100.00000	Y = 8.00000	
RADIAL LINES					
0.0	6.00000	7.00000			
PRIMARY ZONE 16		R-Z SECONDARY ZONES			
BOUNDED BY X LINES		12.00000	16.00000	CENTER OF SECONDARY ZONE GEOMETRY	
BOUNDED BY Y LINES		8.00000	12.00000	X = 8.00000	
BOUNDED BY Z LINES		1.00000	100.00000	Y = 8.00000	
RADIAL LINES					
0.0	6.00000	7.00000			
PRIMARY ZONE 17		R-Z SECONDARY ZONES			
BOUNDED BY X LINES		12.00000	16.00000	CENTER OF SECONDARY ZONE GEOMETRY	
BOUNDED BY Y LINES		12.00000	16.00000	X = 8.00000	
BOUNDED BY Z LINES		1.00000	100.00000	Y = 8.00000	
RADIAL LINES					
0.0	6.00000	7.00000			

TABLE V (contd.)

ZONE	PRIMARY ZONE	SECONDARY ZONE	NO. OF REGIONS	REGION NUMBERS
1	1	0	1	29
2	2	0	1	28
3	2	1	1	24
4	2	2	1	27
5	3	0	1	28
6	3	1	1	23
7	3	2	1	27
8	4	0	1	28
9	4	1	1	23
10	4	2	1	27
11	5	0	1	28
12	5	1	1	25
13	5	2	1	27
14	6	0	1	28
15	6	1	1	24
16	6	2	1	27
17	7	0	1	1
18	7	1	1	2
19	7	2	1	3
20	8	0	1	4
21	8	1	1	5
22	8	2	1	6
23	8	3	1	7
24	8	4	1	8
25	9	0	1	28
26	9	1	1	25
27	9	2	1	27
28	10	0	1	28
29	10	1	1	24
30	10	2	1	27
31	11	0	1	9
32	12	0	1	10
33	12	1	1	11
34	12	2	1	12
35	12	3	1	13
36	12	4	1	14
37	12	5	1	15
38	12	6	1	16
39	12	7	1	17
40	12	8	1	18
41	12	9	1	19
42	12	10	1	20
43	12	11	1	21
44	12	12	1	22
45	13	0	1	28
46	13	1	1	25
47	13	2	1	27
48	14	0	1	28
49	14	1	1	24
50	14	2	1	27
51	15	0	1	28
52	15	1	1	26
53	15	2	1	27
54	16	0	1	28

ZONE	PRIMARY ZONE	SECONDARY ZONE	NO. OF REGIONS	REGION NUMBERS
55	16	1	1	26
56	16	2	1	27
57	17	0	1	28
58	17	1	1	25
59	17	2	1	27
60	18	0	1	30

III. THE MIXED ZONE GEOMETRY INPUT DATA

This section, which supplements Section V of ANCR-1022, presents the detailed instructions for preparing the input data for the mixed zone geometry option.

1. THE INTEGER DATA

The FORTRAN format for an integer data card is:

The first 12 columns of an integer data card are devoted to the identification of the data on the cards as follows:

Column 1	IEND	Zero or blank means other integer data cards follow. 1 punched means this is the last integer data card.
Columns 2-3	INDEX 1	The value of these four indices identify the integer data punched on the card.
Columns 4-5	INDEX 2	
Columns 6-8	INDEX 3	
Columns 9-10	INDEX 4	
Columns 11-12	IWC	This word tells the number of integer words punched on the card (1 to 15). If IWC is zero or blank, a value of 15 is assumed.

The value of IWC specifies the number of successive words of data given on the card, excluding the data control information in card column 1 to 12.

Each integer data word must be right adjusted; that is, the number must end in the extreme right column of the 4 column field.

TABLE VI

MIXED ZONE GEOMETRY INTEGER DATA
(A supplement to Table V of ANCR-1022)

Index 1	Index 2	Index 3	Index 4		
Card Cols. 2-3	Card Cols. 4-5	Card Cols. 6-8	Card Cols. 9-10	Mnemonic Name of Data	Notes on Application of Data
Format 12	Format 12	Format 13	Format 12		
3	ITYPE	7 17 NPZ		IZONGE NNZONE PZONE(NPZ)	Zone Geometry Type, 5 - Mixed Number of primary zones List of regions in primary zone NPZ ITYPE blank - no secondary zone description 1 - R,Z secondary zone description 2 - R,θ,Z secondary zone description
3		NPZ	NSZ	SZONE(NPZ,NSZ)	If ITYPE equals 1 or 2, only regions in that part of the primary zone outside of the secondary zone are listed. List of regions in secondary zone NSZ of primary zone NPZ Notes for PZONE and SZONE cards: The SZONE cards, if any, for primary zone NPZ must immediately follow the corresponding PZONE card and must be in order of the secondary zone number. The groups of PZONE and associated SZONE cards, if any, must be ordered by primary zone number. A list of regions may not contain more than seven region numbers (for some versions of RAFFLE, only one region number). See Table III.

2. THE FLOATING POINT DATA

The FORTRAN format for a floating point data card is:

The first 12 columns of a floating point data card are devoted to the identification of the data on the card.

Column 1	IEND	Zero or blank means other floating point data cards follow. A 1 punched means this is the last floating point data card.
Columns 2-3	INDEX 1	The values of these four indices identify the floating point data punched on the card; hence, the card order is irrelevant.
Columns 4-5	INDEX 2	
Columns 6-8	INDEX 3	
Columns 9-10	INDEX 4	
Columns 11-12	IWC	This word tells the number of floating point words punched on the card (1 to 5). If IWC is zero or blank, a value of 5 is assumed.
Columns 13-72		1 to 5 floating point words of format E12.8 can be punched in these columns.

The value of IWC specifies the number of successive words of data given on the card, excluding the data control information in card column 1-12.

The floating point data cards can be in any order so long as the last card has a 1 punched in card column 1. The floating point data deck must follow the general integer data deck.

TABLE VII

MIXED ZONE GEOMETRY FLOATING POINT DATA

(A supplement to Table VI of ANCR-1022)

Index 1	Index 2	Index 3	Index 4	Mnemonic Name of Data	
Card Cols. 2-3	Card Cols. 4-5	Card Cols. 6-8	Card Cols. 9-10		
Format 12	Format 12	Format 13	Format 12	Notes on Application of Data	
	5	IX		XLINE(IX)	The zone X lines. The values start with 0.0 for the first Z zone, proceed to the largest for this Z zone, continue with 0.0 for the second Z zone, and end with the largest value for the last Z zone. At least two values, the first being 0.0, are required for each Z zone.
	6	IY		YLINE(IY)	The zone Y lines. The values start with 0.0 in the first X zone of the first Z zone. At least two values, the first being 0.0, are required for each X zone. The values proceed through the first X zone of the first Z zone to the last X zone of the last Z zone.
	7	IZ		ZLINE(IZ)	The zone Z lines increasing in value from 0.0, the first value, to the height of the top Z plane.
	10	IR		RLINE(IR)	The secondary zone R lines. At least two values, the first being 0.0, are required for each secondary zone description. The values start with 0.0 in the first, lowest numbered, primary zone having a secondary zone description and proceed in order of magnitude to the last value for that primary zone. They then continue through the next primary zone having a secondary zone description and proceed in the same way to the final value in the last primary zone having a secondary zone description.

TABLE VII (contd.)

Index 1	Index 2	Index 3	Index 4		
Card Cols. 2-3	Card Cols. 4-5	Card Cols. 6-8	Card Cols. 9-10		
Format 12	Format 12	Format 13	Format 12	Mnemonic Name of Data	Notes on Application of Data
	11	I θ		θ LINE (I θ)	The secondary zone θ lines. For each R zone the values 90.0, 180.0, 270.0, and 360.0 are required. Any other values, $0 < \theta < 360.0$, in degrees may be entered in any R zone. The value 0.0 is not allowed. In each primary zone having an R, θ ,Z, Type 2, secondary zone description, the values start with the inner R zone and proceed to the outer R zone. The values start in the first primary zone having an R, θ ,Z secondary zone description and proceed in order of the primary zone number through the primary zones having R, θ ,Z secondary zone description.
	12	NPZ		XSC (NPZ)	X coordinate, with respect to the origin, of the secondary zone description for primary zone NPZ
	13	NPZ		YSC (NPZ)	Y coordinate, with respect to the origin, of the secondary zone description for primary zone NPZ.
					Note: XSC and YSC are required only if primary zone NPZ contains a secondary zone description not centered in that primary zone.

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