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DRC2: A Code with Specialized Applications for Coupling Localized Monte Carlo Adjoint Calculations with Fluences from Two-Dimensional R-Z Discrete Ordinates Air-Over-Ground Calculations

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ABSTRACT

The DRC2 code, which couples MASH or MASHX adjoint leakages with DORT 2-D discrete ordinates forward directional fluences, is described. The forward fluences are allowed to vary both axially and radially over the coupling surface, as opposed to the strictly axial variation allowed by the predecessor DRC code. Input instructions are presented along with descriptions and results from several sample problems. Results from the sample problems are used to compare DRC2 with DRC, DRC2 with DORT, and DRC2 with itself for the case of x-y dependence versus no x-y dependence of the forward fluence. The test problems demonstrate that for small systems DRC and DRC2 give essentially the same results. Some significant differences are noted for larger systems. Additionally, DRC2 results with no x-y dependence of the forward directional fluences are practically the same as those calculated by DRC.

1. INTRODUCTION

The DRC2 code has been written to couple DORT[1] forward fluences with adjoint leakages from a special version of the MORSE[2] Monte Carlo computer code called MASHX. DRC2 has specialized applications because of the limited use of MORSE features, limitations on input parameters, and the manner in which the detectors are used. The code is an extensive modification of the DRC[3] code, which has been used in the past for coupling. With DRC, the spatial dependence of the fluence was limited to axial variation. Linear interpolation was used to obtain the fluence at axial locations falling between the DORT fluence locations. However, since radial variation of the DORT fluences could be important for large vehicle systems or other large structures, the DRC2 code was developed to incorporate coupling with axially and radially varying DORT forward fluence fields. An option was included for specifying either linear or logarithmic interpolation or extrapolation of the fluences. In either case, linear is used when negatives are encountered.

An interim version of the MASH code[4] (called MASHX) was used to provide data for testing the code. The MASHX code adds the X and Y coordinates of each adjoint particle escape location to the list of collision file parameters output along with five undefined and unused parameters. Thus, the collision file records, which are 1020 words in length, each contain data for 60 collisions at 17 words per collision. The number of words per collision and the record length are input parameters for DRC2.

DRC2 is set up to use the MASHX file either with or without X-Y dependence or the MASH file with its fewer collision file parameters (8 vs 10 defined parameters). In addition, DRC2 can calculate results for several range/orientations in a single pass through the code. Titles written to unit 11 are constructed from the input range and orientation data and the first 56 characters of the case title. The format is the expected one for an unpublished text-formatting and transmission-factor-calculating code (TFX).

The inclusion of X-Y dependent fluence fields in the DRC2 calculation and the calculation of results for several ranges and orientations in one pass through the code results in considerably more data in core than was the case with the DRC code. Therefore, if the allocated memory is not large enough to store all data in core, the code will perform the calculation "ex-core" with group blocking (i.e. the calculation is performed for a portion of the groups at a time until all group calculations are finished), provided data for at least one group will fit in core. There is probably little CPU charge penalty when the calculation is performed ex-core. The largest charge differences should be for IO (ex-core larger) and memory (in-core larger). For example, for a 69-group calculation performed ex-core with three blocks (29 groups each for the first two blocks) and then in-core, charge ratios (in-core to ex-core) were 1.02, 4.49, 0.23, and 1.51 for CPU, IO, memory, and total charges, respectively. A significant charge improvement was achieved for the ex-core calculation by reading the sequentially-processed forward fluence file with direct access rather than sequential. With sequential access and rewinding, the respective charge ratios were 9.37, 13.9, 2.36, and 8.18. Since the in-core calculation is likely to give the smallest total charge, whenever possible, one should allocate enough core to store fluence data for all groups. For the case cited, about 1.9 million words were required to store all data in core.

2. FILES

DRC2 uses and creates several files. The files are assigned unit numbers 5, 6, 10, 11, 15, and 24. The respective default file names are ft05drc, ft06drc, ft10drc, ft11drc, ft15drc, and ft24msh. The names may be changed by specifying alternate names on the execute line as follows:

drc2 f5=a,f6=b,f10=c,f11=d,f15=e,f24=f

where the letters to the right of the equal signs represent the alternate names for the files. By unit numbers, the files are defined as follows:

Description of DRC2 Input and Output Files

Unit Number	File Description
5	input file for DRC2
6	printed output file for DRC2
10	special output text file
11	special output text file
15	VISTA[3] fluence file
24	MASHX or MASH collision file

The special output text files contain formatted summary data for generating tabular output. Scratch files may be created and used, but their names are formed by the code and cannot be named by the user.

The interim MASHX code may be executed similarly:

mashx f5=a,f6=b,f8=c,f24=d

where the file descriptions by unit numbers are given below:

Descriptions of MASHX Input and Output Files

Unit Number	File Description
5	input file for MASHX (default=ft05msh)
6	printed output file for MASHX (default=ft06msh)
8	cross-section library file (default=ft08msh)
24	output collision file (default=ft24msh)

Scratch files are created and named by the code.

3. CODE SYSTEM

Several codes are executed to produce the final DRC2 results. Files produced by one code may be used by one or more of the other codes executed in the calculational sequence. The production of the forward fluence file generally involves a calculational sequence executing the GIP[5], GRTUNCL[4], DORT[2], and VISTA[3] codes. The VISTA code creates the fluence file that is used by DRC2. The MASH[4] (or MASHX) code produces the collision file, and DRC2 couples the VISTA and MASH output files to produce the quantities of interest (fluence, dose, etc.). The sharing of files is outlined below, where "I" and "O" superscripts respectively indicate input and output for the codes. A code to the right uses data from a code to the left whenever the leftmost file on a line has a superscript "O" and a file to the right has a superscript "I." The underlined file names are default Cray file names that are used if alternative names are not assigned on the execute line. File names in quotes ("") are generic names for the ANISN- ("ansxs") and GIP-formatted ("gipxs") cross-section files. The other names refer to the code internal variable names for the files.

Sharing of Files by Codes

GIP	GRTUNCL	DORT	VISTA	MASH	DRC2
"ansxs"^{I}				<u>ft08msh</u>^{I}	
"gipxs"^{O*}	"gipxs"^{I}	"gipxs"^{I}			
	npso^{O}	ntdsi^{I}	nuncl^{I}		
		nflsv^{O}	nflsv^{I}		
		ntdir^{O}	naft^{I}		
			ndata^{O}		<u>ft15drc</u>^{I}
				<u>ft24msh</u>^{O}	<u>ft24msh</u>^{I}

*GRTUNCL reads cross sections from unit 4; therefore in a calculational sequence, GIP should write cross sections to unit 4 and DORT, like GRTUNCL, should read cross sections from unit 4.

4. PROGRAM LOCATION

The DRC2 and MASHX programs (source files and CTSS executable files) may be found in the cfs directory "/dos/vcs/slater" at LANL. Comments on field test experience are welcome.

5. DRC2 INPUT INSTRUCTIONS

The following input instructions are patterned after draft documentation written by M. B. Emmett for the DRC code. In the input instructions, the term "vehicle" is used to refer to the object(s) or structure(s) perturbing the air-over-ground radiation field. It is modeled in the localized MASH calculation. A "vehicle system" includes the object(s) and the air and ground modeled in the MASH calculation.

Input Card A: (20A4) Title for this problem.

Input Card B: Free-form FIDO format – Begin with '**' in columns 2 and 3.

a. xd – x-location (cm) of the detector in MORSE geometry

b. yd – y-location (cm) of the detector in MORSE geometry

c. zd – z-location (cm) of the detector in MORSE geometry

d. zbot – bottom of coupling surface relative to MORSE geometry (cm)

e. ztop – top of coupling surface relative to MORSE geometry (cm)

f. iprt – printout options
0 = print VISTA file control data and vehicle doses
1 = print VISTA file control data and free-field spectra
2 = print VISTA file control data, free-field spectra, vehicle doses and dose spectra, and protection factors
3 = print VISTA file control data, vehicle doses, and protection factors.
(Note: iprt must be 2 for unit 10 output)

g. watmx – maximum adjoint particle weight accepted

h. ndet – number of vehicle range/orientations

i. idif – 0/>0 = same/different group structures for MORSE and VISTA data

j. ksiz – k-words of storage to be allocated (0 uses the default size of 500k words or the value used in a previous case. One should use 0 in follow-on cases if the same core allocation is desired.)

k. ibufsz – MASH or MASHX collision file record length in words (1000 for MASH and 1020 for MASHX)

l. nparm – number of parameters written on collision file (8 for MASH and 17 for MASHX)

m. idxy – 0 = no x-y data on collision file
1 = x-y data on collision file but no x-y dependence in the coupling calculation

2 = x-y data on collision file and x-y dependence in the coupling calculation

n. iww – number of responses desired (less than or equal to 10. Note that a 0 implies 2 responses and iww must be > 0 for unit 11 to be written).

o. xq – x-location (cm) of the vehicle system rotation point relative to MORSE geometry

p. yq – y-location (cm) of the vehicle system rotation point relative to MORSE geometry

q. interp – 1/2 = linear/log flux interpolation

(Note: all the above parameters are read as real numbers and are converted to integers where required)

Input Card C: Ranges, MORSE-DORT Z offsets, and orientation arrays – Free-form FIDO format – Begin with '**' in columns 2 and 3.

Ranges (xo(i),i=1,ndet) (cm) – DORT radii to the vehicle system rotation point for each case

MORSE-DORT Z offsets (zo(i),i=1,ndet) – DORT ground-air interface z-location (cm) minus MORSE ground-air interface z-location (cm). For simplicity, the MORSE ground-air interface should be placed at z=0.0. Then one need only specify the locations of the DORT ground-air interface.

Orientation array (alpha(i),i=1,ndet) – orientation angles (degrees counterclockwise) of the vehicle system with respect to the positive portion of the DORT system x-axis.

Input Card D: (if idif > 0) nneut,ngam – Free-form FIDO format – Begin with '$$' in columns 2 and 3.

nneut – group number of lowest energy neutron group in VISTA

ngam – group number of lowest energy gamma-ray group in VISTA

Input Card E: (if idif > 0) VISTA energy group boundaries (nog+2 entries)* – Free-form FIDO – Begin with '**' in columns 2 and 3.

Enter neutron upper energy boundaries in descending order followed by gamma-ray upper energy boundaries in descending order followed by the lower energy boundaries of the 'nneut' neutron group and the 'ngam' gamma-ray group.

* nog is read from the VISTA file and is equal to the number of groups for which data is provided on the file.

Input Card F: (20A4) Alphanumeric Title Information

Input Card G: (20A4) Title or units for total responses for all detectors

Input Card H: Title or units for each total response

Input Card I: Response Function – Free-form FIDO format – Begin with '**' in columns 2 and 3.

(resp(i),i=1,nmtg) – enter values in order of decreasing energy

Repeat Cards H and I for each response function.

Input Card J: Title of units for energy dependent fluence

To run additional cases, respecify all cards. In these follow-on cases, set ksiz on Card B to zero to maintain the same core allocation.

6. TEST PROBLEMS

Several test problems were run to verify the correct operation of the code features. These include:

1. a problem designed to reproduce free-field fluences calculated by DORT,
2. a calculation of detector responses in a relatively small system called the "metric doghouse" (the reference DRC test case),
3. calculations of detector responses in two relatively large systems to examine the effects of including x-y dependence in the coupling calculation, and
4. a problem solvable by DORT involving the calculation of detector responses in a shielded, large-radius, annular, cylindrical tunnel in an air-over-ground radiation field.

For the latter calculation, the deterministic results from the DORT calculation can serve as a basis for checking the accuracy of the results from the coupled method.

6.1 TEST PROBLEM 1: FREE-FIELD FLUENCE CALCULATION

For this test problem, a 2-group DORT calculation is performed for a point source in air 300m above a purely absorbing medium. Then an adjoint MASHX calculation is performed for a 1 cm × 1 cm × 50.5 cm air box over a purely absorbing medium ("ground") with the detector located at the x-y center of the box 50 cm above "ground" [i.e. at the coordinate location (100.0,0.0,50.0)]. Coupling of the forward fluences with the adjoint leakages is performed with DRC2 and the results are compared with the free-field fluences also calculated by DRC2. Logarithmic interpolation of the VISTA fluences is used.

This problem is intended to demonstrate whether the coupled calculation reproduces the free-field fluences calculated by DORT. The DORT calculation file is shown in Fig. 1, the MASHX calculation file in Fig. 2, and the DRC2 calculation file in Fig. 3.

The DORT and DRC2 fluences are compared in Table 1 for 25,000 and 105,000 MASHX histories. For the two cases, the last six range/orientation combinations shown in Table 1 correspond to VISTA R-mesh locations and the detector is at a VISTA Z-mesh location. Hence, the free-field fluences should be calculated almost exactly at these range/orientations. The results show that the free-field fluences are reproduced within about 4%. Also, since the system is very small in its x and y dimensions, the inclusion of x-y fluence dependence in the coupling did not significantly influence the results. There is only the slightest variation due to the small distance of the escape surface from the detector point.

Listing For CRAY File "mshdos3 "

```
*select printlog=lmshdos3
*/ - - - - - dos input data file
*file name=imshdos3
=gip
"cross section data for grtuncl test problem
1$$  2 3 4 5 12   12 0 24 0 3   0 0 0 60   a18  4 9 8  e t   /output on 4
10$$ 2i13 16 2q4
11$$ 4r0 6i1 8
12** 4r0 4r1.0697-5 4r4.0242-5
  t
14**
/ oxygen
49547-6 0 1.635 79559-5 0   11307-5 0 1.6140 67344-5 18561-5
3z 2.0854 0   3z 1.7727 19093-5
3z 2.7465 0   3z 2.3445 -77476-6
3z 2.9080 0   3z 2.4849 -96091-6
/ nitrogen
17504-5 0 1.5593 74305-5 0   21900-5 0 1.5825 65669-5 18222-5
3z 1.9705 0   3z 1.7640 21830-5
3z 2.6333 0   3z 2.3925 -35378-6
3z 2.7991 0   3z 2.5433 -60930-6
/ absorbogen
.1 0 .1 0 0  q5
10z
10z
10z
  t
=grtuncl
" air/ground first collision source; isotropic source at z=300m; p3
1$$ 0 3 6 48 57   2 3 4 5 0  0 16 16 2 0   4 0 0 21 2
    0 0 0 40 6  e
2** 1.0 300+2 0.0  e
 t
2** 5i-243.84 5i-180 5i-60 5i0 5i600 5i2400 5i8000 14i2.4+4 1+5
4** 4i0 5i30.48 2i60.96 2i150 2i450 3i1040 5i3000 5i1.2+4 11i4.2+4 1+5
8$$  5r1 15r2 28r3 17q48  12r4 22r5 14r6 25q48 f6
9$$  3r-9 f-13  e
15** 1 f0
  t
=dort
"dort air/ground transport; p3
61$$  0 23 4 0 21   0 0 0 0 22   0  e
62$$  0 3 6 48 57   2 3 4 5 0   0 0 16 0 240   1 1 0 0 0
      1 15 0 3 0   2 0 0 0 0   0 0 0 0 0   1 0 0 0 2
      17 31 90 11 0   0 1 1 1 1   4 50 0 0 0   21 38 0 0 0
      0 -1 0 0 0   4 0 0 0   e
63**  0.0 0.0 1-4 1-2 0.0   1-3 1.0 2-1 1.5 1+1
      1.0 1.0 -1.0 3-1 1.2   1-1 1-4 0.0 3-1 -1.5
      1.0 6-1 0.0 1-40 0.0   0.0 2-1 9-1   e
 t
 t
81**      / wts mm240
   0 2r102900-8 0 2r307825-8 0 2r510200-8 0 2r708425-8 0
   2r901350-8 0 563869-8 316131-8 n2 0 641385-8 359590-8 n2 0
   714976-8 400849-8 n2 0 784547-8 439853-8 n2 0 857529-8
   480771-8 n2 0 642875-8 293289-8 479164-8 n3 0 681415-8
   310872-8 507890-8 n3 0 716550-8 326901-8 534077-8 n3 0
   745915-8 340298-8 555965-8 n3 0 775565-8 353825-8 578064-8
   n3 0 489468-8 386282-8 513536-8 364389-8 n4 0 500102-8
   394674-8 524693-8 372306-8 n4 0 508580-8 401365-8 533587-8
   378617-8 n4 0 515474-8 406806-8 540820-8 383750-8 n4 0
   517107-8 408094-8 542534-8 384965-8 n4 q120
82**      / mus mm240
   -641230-7 -421582-7 m1 -142963-6 -939923-7 m1 -229252-6
   -150724-6 m1 -315291-6 -207291-6 m1 -399349-6 -262555-6 m1
   -472796-6 -411087-6 -143488-6 m2 -537046-6 -466952-6
   -162988-6 m2 -598374-6 -520275-6 -181600-6 m2 -656401-6
   -570729-6 -199211-6 m2 -711034-6 -618231-6 -215791-6 m2
   -761567-6 -713133-6 -470428-6 -164201-6 m3 -807567-6
   -756207-6 -498843-6 -174119-6 m3 -849108-6 -795106-6
   -524503-6 -183075-6 m3 -885925-6 -829582-6 -547246-6
   -191013-6 m3 -917890-6 -859514-6 -566991-6 -197905-6 m3
   -944812-6 -922954-6 -765692-6 -505099-6 -176303-6 m4
   -966490-6 -944130-6 -783260-6 -516688-6 -180348-6 m4
   -982847-6 -960108-6 -796516-6 -525433-6 -183400-6 m4
   -993815-6 -970823-6 -805405-6 -531297-6 -185447-6 m4
   -999313-6 -976194-6 -809860-6 -534236-6 -186473-6 m4 q120
83**      / etas mm240
   3r-.997942 3r-.989728 3r-.973367 3r-.948995 3r-.916799
   5r-.881172 5r-.843553 5r-.801217 5r-.754412 5r-.703158
   7r-.648086 7r-.589776 7r-.528222 7r-.463828 7r-.396835
   9r-.327613 9r-.256704 9r-.184425 9r-.111045 9r-.037054 g120
```

Fig. 1. GIP-GRTUNCL-DORT-VISTA Input for Test Problem 1: Free-Field Fluence Calculation.

```
 t
2** 5i-243.84 5i-180 5i-60 5i0 5i600 5i2400 5i8000 14i2.4+4 1+5
4** 4i0 5i30.48 2i60.96 2i150 2i450 3i1040 5i3000 5i1.2+4 11i4.2+4 1+5
8$$  5r1 15r2 28r3 17q48  12r4 22r5 14r6 25q48 f6
9$$  3r-9 f-13   e
24**  4r1-10  1 f1-1
 t
end
=vista
"vista 2-group mash-drc output
 1$$  6 17 31 0 0   2 23 22 21 24   5 6 17 31 0   0 0 0  e
  t
 2**  300+2  0 e
 4$$ 4i 32 37  e
  t
=end
*/ - - - - - select output filename
*let output = 'omshdos3'
*/
*/ - - - - - select remote for routing output
*/
*interrupt on deadstart      to end,
           on checkpoint     to end,
           on timeup         to end,
           on jccerror       to end,
           on softwareerror to end,
           on hardwareerror to end
*/------------------------------------------------------------------
*/
*/ - - - - - find and rename driver dropfile
*dos: */lect ttyecho=e
*destroy $oc $od ft06
*porb  f6=$oc,f99=imshdos3
*let mes=rplcc(lastml,' ')
*switch \mes\ $driver dst.
*/
*/ - - - - - execute dos module up to halt instruction
*driver: $driver
*/
*/ - - - - - interpret module specification
*let mes=rplcc(lastml,' ')
*if mes .hasnot. '=' then goto p
*destroy $dosxeq
*let mes = trim( rplpat( mes, '=', '')
*let code = getsym(mes, 1)
*/
*/ - - - - - extract module from porb
*lib porb
extract \code\
end
*rename  \code\ $dosxeq
*/
*/ - - - - - execute module and save output
*$dosxeq
*/
*out: cat ft06 >> $od
*goto driver
*/
*/ - - - - - assemble combined output file
*p: select ttyecho=y
*if output.eq.0 then goto end
*psave: destroy  \output\
*coll $oc > xxid
*coll $od > xxod
*select printlog=lmshdos3
*cat lmshdos3 xxid xxod > \output\
*/------------------------------------------------------------------
*/
*end:
*goto
```

Fig. 1. (continued)

Listing For CRAY File "mshx07 "

```
*select printlog=lmshx07
*interrupt on softwareerror to end,
           on hardwareerror to end,
           on jccerror to end,
           on timeup to end
*file name=infile
x10
mshing0c
mshing0d
*file name=mshing0c
mash air-over-ground problem -- 25,000 histories -- small volume
 $$  1000 1100   25    1    2    0    2    2    0    1    5    2    0
 $$     0    2    1    0 **  1.0    6.3763+6   10000.  0.0          2.2e+5
 **      100.0        0.0       50.0        0.0        0.0        0.0        0.0
 **     1.          1.
 **     1.          1.
 **   1.9640e+7 1.0000e+7
    0000343277244615
 $$     1    1    0    0    0    1    2    0
 $$     0    0    0    0    0    0 **    1.0+01    5.0-02    5.0-01    0.
 $$    -1   9r0
 $$     0    0    0    0
    0    0              air-over-ground
   rpp          -500.0      500.0     -500.0      500.0     -500.0      500.0
   rpp            99.5      100.5       -0.5        0.5      -10.0       50.5
   rpp            99.5      100.5       -0.5        0.5        0.0       50.5
   end
   exv            +1       -2
   air            +3
   grn            +2       -3
   end
    1    1    1
    0    2    1
cross sections 2 n - 0 gps
 $$  2    2    0    0    2    5    4    2    3    3    4    2    1    3
 $$ 11z
 **
49547-6 0 1.635 79559-5 0   11307-5 0 1.6140 67344-5 18561-5
3z 2.0854 0   3z 1.7727 19093-5
3z 2.7465 0   3z 2.3445 -77476-6
3z 2.9080 0   3z 2.4849 -96091-6
17504-5 0 1.5593 74305-5 0   21900-5 0 1.5825 65669-5 18222-5
3z 1.9705 0   3z 1.7640 21830-5
3z 2.6333 0   3z 2.3925 -35378-6
3z 2.7991 0   3z 2.5433 -60930-6
.1 0 .1 0 0  .1 0 .1 0 0
10z
10z
10z
 $$ 1 -3 ** 1.0
 $$ 2  1 ** 1.0697-5
 $$ 2 -2 ** 4.0242-5
mash case air-over-ground 2 gp
 ** 1.0
 $$     2    2
*file name=mshing0d
mash air-over-ground problem -- 100,000 histories -- small volume
 $$  1000 1100  105    1    2    0    2    2    0    1    5    2    0
 $$     0    2    1    0 **  1.0    6.3763+6   10000.  0.0          2.2e+5
 **      100.0        0.0       50.0        0.0        0.0        0.0        0.0
 **     1.          1.
 **     1.          1.
 **   1.9640e+7 1.0000e+7
    0000343265244071
 $$     1    1    0    0    0    1    2    0
 $$     0    0    0    0    0    0 **    1.0+01    5.0-02    5.0-01    0.
 $$    -1   9r0
 $$     0    0    0    0
    0    0              air-over-ground
   rpp          -500.0      500.0     -500.0      500.0     -500.0      500.0
   rpp            99.5      100.5       -0.5        0.5      -10.0       50.5
   rpp            99.5      100.5       -0.5        0.5        0.0       50.5
   end
   exv            +1       -2
   air            +3
   grn            +2       -3
   end
    1    1    1
    0    2    1
cross sections 2 n - 0 gps
 $$  2    2    0    0    2    5    4    2    3    3    4    2    1    3
 $$ 11z
```

Fig. 2. MASHX Input for Test Problem 1: Free-Field Fluence Calculation.

```
 **
49547-6 0 1.635 79559-5 0   11307-5 0 1.6140 67344-5 18561-5
3z 2.0854 0   3z 1.7727 19093-5
3z 2.7465 0   3z 2.3445 -77476-6
3z 2.9080 0   3z 2.4849 -96091-6
17504-5 0 1.5593 74305-5 0   21900-5 0 1.5825 65669-5 18222-5
3z 1.9705 0   3z 1.7640 21830-5
3z 2.6333 0   3z 2.3925 -35378-6
3z 2.7991 0   3z 2.5433 -60930-6
.1 0 .1 0 0  .1 0 .1 0 0
10z
10z
10z
 $$ 1 -3 ** 1.0
 $$ 2  1 ** 1.0697-5
 $$ 2 -2 ** 4.0242-5
mash case air-over-ground 2 gp
 ** 1.0
 $$     2    2
*mass get wait=on waitime=60 lstfil mashx
*lstfil
*mashx f5=mshing0c,f6=ft6c,f24=mrstap12
*mashx f5=mshing0d,f6=ft6d,f24=mrstap13
*mass store wait=on waitime=60 mrstap12 mrstap13
*end:
*select printlog=lmshx07
*copy lmshx07 xmshxx
*fred xmshxx
nv
dop1,];*** page;bc,,1;1;dl.-1
dnp1,];*** page;bc,,1; ;
sv
end
*cconcat xmshxx filst ft6c ft6d -o omshx07
*mass store wait=on waitime=60 omshx07
*cdestroy xmshxx ft*  mashx lstfil mrstap* mshing* filst
*goto
```

Fig. 2. (continued)

Listing For CRAY File "drc2tlc "

```
*select printlog=ldrc2tlc
*interrupt on softwareerror to end,
           on hardwareerror to end,
           on jccerror to end,
           on timeup to end
*file name=ina
x10
indrc1
*file name=indrc1
drc2 for air-over-ground -- xd=100.0 -- iprt=2 -- xy dep.
 ** 100. 0. 50. -10. 50.5 2. 50. 12. 1. 50. 1020. 17. 2. 2. 100. 0. 2.
 ** 2r24556. 2r33000. 2r42500. 2r24500. 2r34500. 2r44416.7
 ** 12z
 ** 45. 270. 60. 210. 150. 330. 45. 270. 60. 210. 150. 330.
 $$ 2 0
 ** 1.964e7 1.0e7 6.3763+6 0
2 neutron - 0 gamma flat response input
 -- 1=neut  2=veh n-g 3=grd n-g 4=photons
mash 2n/0g group flat response
 ** 1.0000 1.0000
 dose rate (rd/h/(n/cm**2.s))
 ** 6.0e-9 5.0e-9
energy group totals
drc2 for air-over-ground -- xd=0.0 -- iprt=2 -- no xy dep.
 ** 0. 0. 50. -10. 50.5 2. 50. 12. 1. 0. 1020. 17. 1. 2. 2z 2.
 ** 2r24556. 2r33000. 2r42500. 2r24500. 2r34500. 2r44416.7
 ** 12z
 ** 45. 270. 60. 210. 150. 330. 45. 270. 60. 210. 150. 330.
 $$ 2 0
 ** 1.964e7 1.0e7 6.3763+6 0
2 neutron - 0 gamma flat response input
 -- 1=neut  2=veh n-g 3=grd n-g 4=photons
mash 2n/0g group flat response
 ** 1.0000 1.0000
 dose rate (rd/h/(n/cm**2.s))
 ** 6.0e-9 5.0e-9
energy group totals
*mass
get wait=on waitime=60 drc2 lstfil vstaflx2
get wait=on waitime=60 mrstap12 mrstap13
end
*destroy drcxxx drcyyy drcprlc
*drc2 f5=indrc1,f6=ft06a,f15=vstaflx2,f24=mrstap12,f10=q10a,f11=q11a
*drc2 f5=indrc1,f6=ft06b,f15=vstaflx2,f24=mrstap13,f10=q10b,f11=q11b
*end: cconcat ft06* -o drcyyy
*lstfil f5=ina,f6=oua
*cconcat oua drcyyy -o drczzz
*select printlog=ldrc2tlc
*copy ldrc2tlc drcxxx
*fred drcxxx
nv
dop1,];*** page;bc,,1;1;dl.-1
dnp1,];*** page;bc,,1; ;
sv
end
*cconcat drcxxx drczzz -o drcprlc
*cdestroy drczzz indr* ft06* drcxxx ina drcyyy oua
*cconcat q10* -o f10txt
*cconcat q11* -o f11txt
*mass store wait=on waitime=60 drcprlc f10txt:f10txlc f11txt:f11txlc
*cdestroy q10* q11* mrstap* vist* vst* lstfil drc2
*goto
```

Fig. 3. DRC2 Input for Test Problem 1: Free-Field Fluence Calculation.

Table 1. Comparison of DORT and DRC2 Calculated Fluences for Test Problem 1: Free-Field Fluence Calculation

		DORT Fluence/DRC2 Fluence	
Range (cm)	Orientation (degrees)	With No X-Y Dependence	With X-Y Dependence
	Case 1 (240 Directions; 25,000 Histories)		
24556	45	0.999(.030)*	0.999(.030)
24556	270	1.009(.027)	1.009(.027)
33000	60	1.008(.035)	1.008(.035)
33000	210	1.036(.029)	1.036(.029)
42500	150	0.994(.021)	0.994(.021)
42500	330	1.040(.018)	1.040(.018)
24500	45	0.999(.030)	0.999(.030)
24500	270	1.009(.027)	1.009(.027)
34500	60	1.004(.034)	1.004(.034)
34500	210	1.032(.029)	1.032(.029)
44417	150	0.960(.024)	0.960(.024)
44417	330	1.008(.020)	1.008(.020)
	Case 2 (240 Directions; 105,000 Histories)		
24556	45	1.001(.014)	1.001(.014)
24556	270	1.021(.013)	1.021(.013)
33000	60	1.003(.012)	1.003(.012)
33000	210	1.011(.013)	1.011(.013)
42500	150	1.037(.011)	1.037(.011)
42500	330	1.020(.010)	1.020(.010)
24500	45	1.000(.014)	1.000(.014)
24500	270	1.021(.013)	1.021(.013)
34500	60	0.998(.012)	0.998(.012)
34500	210	1.007(.013)	1.007(.013)
44417	150	1.010(.011)	1.010(.011)
44417	330	0.993(.011)	0.993(.011)

*Fractional standard deviations are shown in parentheses.

The agreement of the coupled results with the DORT free-field results did not improve with the increased number of histories. However, as noted in Table 1, the fractional standard deviations (fsd's) of the results were cut in half in most cases from the range 0.018-0.035 to the range 0.010-0.014. The DRC2 results generally fall within three fsd's about the DORT results.

There were only two scatterings in the air in the small box for the 25,000 history case and only one for the 105,000 history case. The scatterings were undersampled, but those few scatterings should not have contributed much to the fluence, since scatterings below the detector point must direct the neutron upward for it to contribute significantly (the upward-directed angular fluence in the air from 0 to 50 cm above the purely absorbing medium should be much smaller than the downward-directed angular fluence).

Some printed output pages from this test problem are shown in the Appendix.

6.2 TEST PROBLEM 2: METRIC DOGHOUSE

The second test case is a two-group calculation of detector responses within a 3 m × 1 m × 1 m building with 5-cm-thick side walls and a 10-cm-thick roof all composed of purely absorbing material and a 1 m-wide doorway along and at one end of the 3 m wall (X dimension). A drawing of the building is shown in Fig. 4. The detector is centered on the doorway and at the Y center of the room. This problem was calculated mainly to compare results with those obtained with DRC for this same test problem. The DORT calculation file is shown in Fig. 5, the MASHX calculation file* in Fig. 6, and the DRC2 calculation file in Fig. 7. The DORT calculation used a 30 direction quadrature set (S_6) and a P_3 cross-section Legendre expansion. For this problem, the coupling surface is at the outside of the building. Rigorous calculations using forward and adjoint coupling require that the coupling surface be located at such a distance from the object (building, vehicle, etc.) that there is no significant perturbation of the free-field fluence by the object. In practice, if the object is small, the coupling surface may be located very close to the object. The effect the metric doghouse, with its purely absorbing walls, has on the inward-directed free-field fluences at the house outer surface is not known. Certainly, fluences incident on surfaces hidden from direct view of the source will be perturbed. The contributions of those fluences to the calculated response may be small, however, because the fluences are basically forward peaked.

Protection factors calculated by DRC2 are compared in Table 2 for coupling with and without x-y dependent forward fluences and both without and with in-group biasing (INGB=0 or 1, respectively). It is noted that for this small system, x-y dependent coupling influenced the answers very little. A greater difference is shown

---

* This file also contains input for an air-over-ground free-field fluence calculation using a larger air box than that used in Test Problem 1. Results from this calculation were superseded by those reported in Test Problem 1 (Section 6.1).

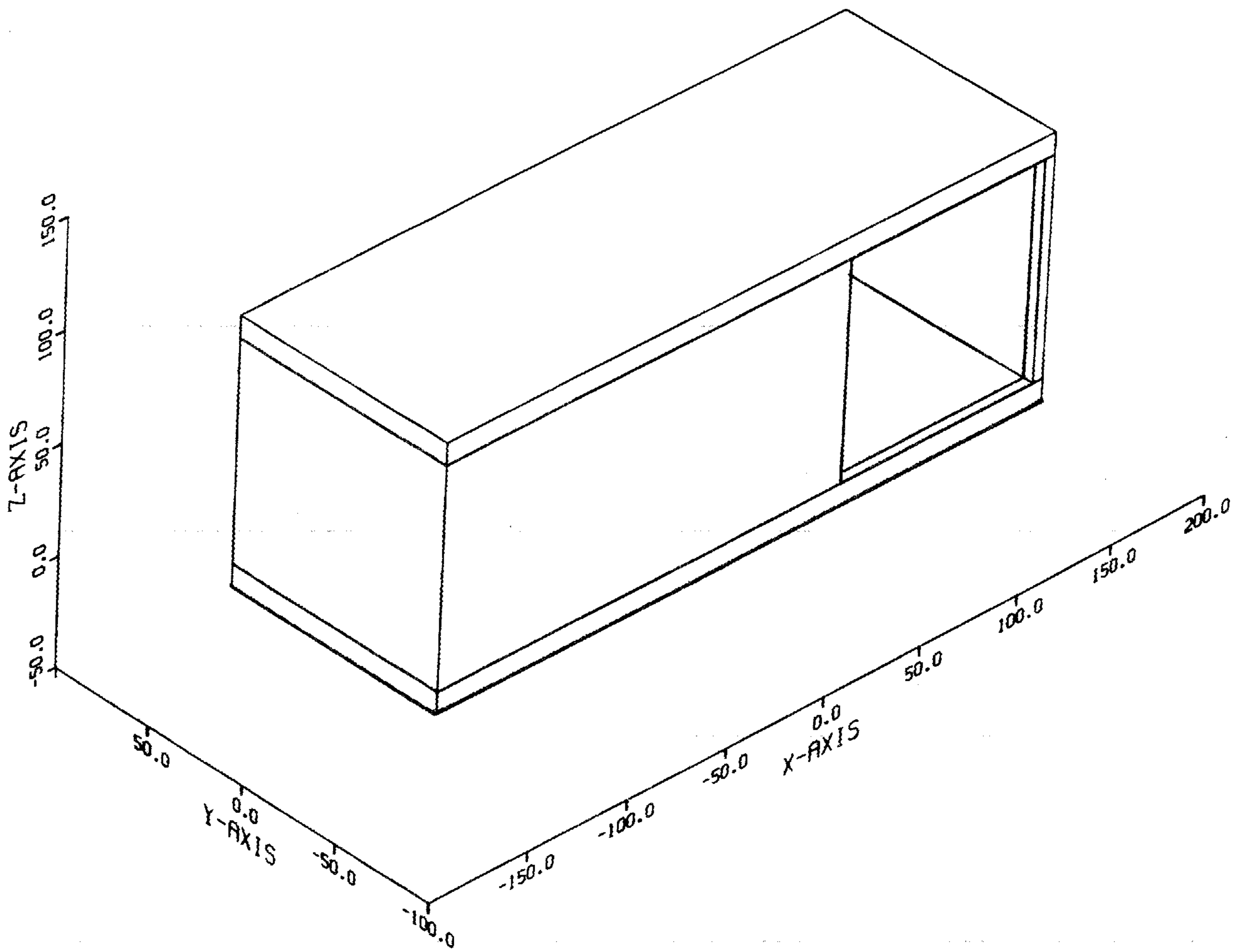


Fig. 4. Geometry for Test Problem 2: Metric Doghouse.

Listing For CRAY File "mshdos2 "

```
*select printlog=lmshdos2
*/ - - - - - dos input data file
*file name=imshdos2
=gip
"cross section data for grtuncl test problem
1$$  2 3 4 5 12   12 0 24 0 3   0 0 0 60   a18  4 9 8  e t   /output on 4
10$$ 2i13 16 2q4
11$$ 4r0 6i1 8
12** 4r0 4r1.0697-5 4r4.0242-5
  t
14**
/ oxygen
49547-6 0 1.635 79559-5 0   11307-5 0 1.6140 67344-5 18561-5
3z 2.0854 0   3z 1.7727 19093-5
3z 2.7465 0   3z 2.3445 -77476-6
3z 2.9080 0   3z 2.4849 -96091-6
/ nitrogen
17504-5 0 1.5593 74305-5 0   21900-5 0 1.5825 65669-5 18222-5
3z 1.9705 0   3z 1.7640 21830-5
3z 2.6333 0   3z 2.3925 -35378-6
3z 2.7991 0   3z 2.5433 -60930-6
/ absorbogen
.1 0 .1 0 0  q5
10z
10z
10z
  t
=grtuncl
" air/ground first collision source; isotropic source at z=300m; p3
1$$ 0 3 6 48 57   2 3 4 5 0   0 16 16 2 0   4 0 0 21 2
    0 0 0 40 6  e
2** 1.0 300+2 0.0  e
 t
2** 5i-243.84 5i-180 5i-60 5i0 5i600 5i2400 5i8000 14i2.4+4 1+5
4** 4i0 5i30.48 2i60.96 2i150 2i450 3i1040 5i3000 5i1.2+4 11i4.2+4 1+5
8$$  5r1 15r2 28r3 17q48  12r4 22r5 14r6 25q48 f6
9$$  3r-9 f-13  e
15** 1 f0
  t
=dort
"dort air/ground transport; p1
61$$  0 23 4 0 21   0 0 0 0 22   0  e
62$$  0 1 6 48 57   2 3 4 5 0   0 0 16 0 30   1 1 0 0 0
      1 15 0 3 0   2 0 0 0 0   0 0 0 0 0   1 0 0 0 2
      17 31 90 11 0   0 1 1 1 1   4 50 0 0 0   21 38 0 0 0
      0 -1 0 0 0   4 0 0 0   e
63**  0.0 0.0 1-4 1-2 0.0   1-3 1.0 2-1 1.5 1+1
      1.0 1.0 -1.0 3-1 1.2   1-1 1-4 0.0 3-1 -1.5
      1.0 6-1 0.0 1-40 0.0   0.0 2-1 9-1   e
 t
 t
/  s   6 full symmetric -- 30 directions -- dort
81*
 0 +    0+ 0 2r+41667- 6 0 +    0+ 0 0 +41667- 6 2r+41667- 6 0 +41667- 6
 0 +    0+ 0 0 +41667- 6 0 +41667- 6 2r+41667- 6 0 +41667- 6 0 +41667- 6
 0 +    0+ 0 2r+41667- 6 0 +    0+ 0 0 +41667- 6 2r+41667- 6 0 +41667- 6
 0 +    0+ 0 0 +41667- 6 0 +41667- 6 2r+41667- 6 0 +41667- 6 0 +41667- 6
82*
 0 -36515- 5 0 -25820- 5 0 +25820- 5 0 -73030- 5 0 -68313- 5 0 -25820- 5
 0 +25820- 5 0 +68313- 5 0 -96609- 5 0 -93095- 5 0 -68313- 5 0 -25820- 5
 0 +25820- 5 0 +68313- 5 0 +93095- 5 0 -36515- 5 0 -25820- 5 0 +25820- 5
 0 -73030- 5 0 -68313- 5 0 -25820- 5 0 +25820- 5 0 +68313- 5 0 -96609- 5
 0 -93095- 5 0 -68313- 5 0 -25820- 5 0 +25820- 5 0 +68313- 5 0 +93095- 5
83*
 3r-93095- 5 5r-68313- 5 7r-25820- 5 3r+93095- 5 5r+68313- 5 7r+25820- 5
 t
2** 5i-243.84 5i-180 5i-60 5i0 5i600 5i2400 5i8000 14i2.4+4 1+5
4** 4i0 5i30.48 2i60.96 2i150 2i450 3i1040 5i3000 5i1.2+4 11i4.2+4 1+5
8$$  5r1 15r2 28r3 17q48  12r4 22r5 14r6 25q48 f6
9$$  3r-9 f-13   e
24**  4r1-10  1 f1-1
 t
end
=vista
"vista 2-group mash-drc output
 1$$  6 17 31 3 0   2 23 22 21 24   5 6 17 31 0   0 0 0  e
  t
 2**  300+2  0 e
 4$$ 4i 32 37  e
  t
=end
*/ - - - - - select output filename
```

Fig. 5. GIP-GRTUNCL-DORT-VISTA Input for Test Problem 2: Metric Doghouse.

```
*let output = 'omshdos2'
*/
*/ - - - - - select remote for routing output
*/
*interrupt on deadstart     to end,
           on checkpoint    to end,
           on timeup        to end,
           on jccerror      to end,
           on softwareerror to end,
           on hardwareerror to end
*/------------------------------------------------------------------
*/
*/ - - - - - find and rename driver dropfile
*dos: */lect ttyecho=e
*destroy $oc $od ft06
*porb  f6=$oc,f99=imshdos2
*let mes=rplcc(lastm1,' ')
*switch \mes\ $driver dst.
*/
*/ - - - - - execute dos module up to halt instruction
*driver: $driver
*/
*/ - - - - - interpret module specification
*let mes=rplcc(lastm1,' ')
*if mes .hasnot. '=' then goto p
*destroy $dosxeq
*let mes = trim( rplpat( mes, '=', '')
*let code = getsym(mes, 1)
*/
*/ - - - - - extract module from porb
*lib porb
extract \code\
end
*rename  \code\ $dosxeq
*/
*/ - - - - - execute module and save output
*$dosxeq
*/
*out: cat ft06 >> $od
*goto driver
*/
*/ - - - - - assemble combined output file
*p: select ttyecho=y
*if output.eq.0 then goto end
*psave: destroy  \output\
*col1 $oc > xxid
*col1 $od > xxod
*select printlog=lmshdos2
*cat lmshdos2 xxid xxod > \output\
*/------------------------------------------------------------------
*/
*end:
*goto
```

Fig. 5. (continued)

Listing For CRAY File "mshx1 "

```
*select printlog=lmshx1
*file name=infile
x10
mshing0
mshing1
mshing0b
*file name=mshing0
mash metric doghouse problem
 $$  1000 1100   25    1    2    0    2    2    0    1    5    2    0
 $$      0    2    1    0 **  1.0    6.3763+6   10000.  0.0        2.2e+5
 **      100.0       0.0       50.0       0.0       0.0       0.0       0.0
 **    1.          1.
 **    1.          1.
 **   1.9640e+7 1.0000e+7
     0000343277244615
 $$     1     1     0     0     0     1    2    0
 $$     0     0     0     0     0     0 **     1.0+01     5.0-02     5.0-01     0.
 $$    -1   9r0
 $$     0     0     0     0
     0     0               metric doghouse
   rpp          -500.     500.     -500.      500.       -500.      500.
   rpp         -155.     155.       -55.      55.         0.       110.
   rpp          -150.    150.       -50.      50.         0.       100.
   rpp          50.      150.       -55.     -50.         0.        100.
   rpp         -155.     155.       -55.       55.        -10.       0.
   end
   shl          +2      -3      -4      -5
   ins          +3      -4      -5
   dor          +4      -3      -5
   flr          +5
   exv          +1      -2      -3      -4      -5
   end
     1     1     1     1     1
     1     2     2     1     0
cross sections 2 n - 0 gps
 $$  2     2     0     0     2     5     4     2     3     3     4     2     1     3
 $$ 11z
 **
49547-6 0 1.635 79559-5 0   11307-5 0 1.6140 67344-5 18561-5
3z 2.0854 0    3z 1.7727 19093-5
3z 2.7465 0    3z 2.3445 -77476-6
3z 2.9080 0    3z 2.4849 -96091-6
17504-5 0 1.5593 74305-5 0   21900-5 0 1.5825 65669-5 18222-5
3z 1.9705 0    3z 1.7640 21830-5
3z 2.6333 0    3z 2.3925 -35378-6
3z 2.7991 0    3z 2.5433 -60930-6
.1 0 .1 0 0  .1 0 .1 0 0
10z
10z
10z
 $$ 1 -3 ** 1.0
 $$ 2  1 ** 1.0697-5
 $$ 2 -2 ** 4.0242-5
mash case metric doghouse 2 gp
 ** 1.0
 $$      2    2
*file name=mshing1
mash metric doghouse problem
 $$  1000 1100   25    1    2    0    2    2    0    1    5    2    0
 $$      0    2    1    0 **  1.0    6.3763+6   10000.  0.0        2.2e+5
 **      100.0       0.0       50.0       0.0       0.0       0.0       0.0
 **    1.          1.
 **    1.          1.
 **   1.9640e+7 1.0000e+7
     0000343277244615
 $$     1     1     0     0     0     1    2    1
 $$     0     0     0     0     0     0 **     1.0+01     5.0-02     5.0-01     0.
 $$    -1   9r0
 $$     0     0     0     0
     0     0               metric doghouse
   rpp          -500.     500.     -500.      500.       -500.      500.
   rpp         -155.     155.       -55.      55.         0.       110.
   rpp          -150.    150.       -50.      50.         0.       100.
   rpp          50.      150.       -55.     -50.         0.        100.
   rpp         -155.     155.       -55.       55.        -10.       0.
   end
   shl          +2      -3      -4      -5
   ins          +3      -4      -5
   dor          +4      -3      -5
   flr          +5
   exv          +1      -2      -3      -4      -5
   end
```

Fig. 6. MASHX Input for Test Problem 2: Metric Doghouse.

```
         1    1    1    1    1
         1    2    2    1    0
cross sections 2 n - 0 gps
 $$  2    2    0    0    2    5    4    2    3    3    4    2    1    3
 $$ 11z
 **
49547-6 0 1.635 79559-5 0   11307-5 0 1.6140 67344-5 18561-5
3z 2.0854 0   3z 1.7727 19093-5
3z 2.7465 0   3z 2.3445 -77476-6
3z 2.9080 0   3z 2.4849 -96091-6
17504-5 0 1.5593 74305-5 0   21900-5 0 1.5825 65669-5 18222-5
3z 1.9705 0   3z 1.7640 21830-5
3z 2.6333 0   3z 2.3925 -35378-6
3z 2.7991 0   3z 2.5433 -60930-6
.1 0 .1 0 0  .1 0 .1 0 0
10z
10z
10z
 $$ 1 -3 ** 1.0
 $$ 2  1 ** 1.0697-5
 $$ 2 -2 ** 4.0242-5
mash case metric doghouse 2 gp
 ** 1.0
 $$     2    2
*file name=mshing0b
mash air-over-ground problem
 $$  1000 1100   25    1    2    0    2    2    0    1    5    2    0
 $$     0    2    1    0 **  1.0     6.3763+6   10000.  0.0          2.2e+5
 **      100.0        0.0        50.0        0.0        0.0        0.0        0.0
 **     1.           1.
 **     1.           1.
 **   1.9640e+7 1.0000e+7
       0000343277244615
 $$     1    1    0    0    0    1    2    0
 $$     0    0    0    0    0    0 **     1.0+01     5.0-02     5.0-01     0.
 $$     -1   9r0
 $$     0    0    0    0
       0    0             air-over-ground
   rpp          -500.0     500.0     -500.0      500.0     -500.0      500.0
   rpp          -150.0     150.0      -50.0       50.0      -10.0      100.0
   rpp          -150.0     150.0      -50.0       50.0        0.0      100.0
   end
   exv            +1     -2
   air            +3
   grn            +2     -3
   end
     1    1    1
     0    2    1
cross sections 2 n - 0 gps
 $$  2    2    0    0    2    5    4    2    3    3    4    2    1    3
 $$ 11z
 **
49547-6 0 1.635 79559-5 0   11307-5 0 1.6140 67344-5 18561-5
3z 2.0854 0   3z 1.7727 19093-5
3z 2.7465 0   3z 2.3445 -77476-6
3z 2.9080 0   3z 2.4849 -96091-6
17504-5 0 1.5593 74305-5 0   21900-5 0 1.5825 65669-5 18222-5
3z 1.9705 0   3z 1.7640 21830-5
3z 2.6333 0   3z 2.3925 -35378-6
3z 2.7991 0   3z 2.5433 -60930-6
.1 0 .1 0 0  .1 0 .1 0 0
10z
10z
10z
 $$ 1 -3 ** 1.0
 $$ 2  1 ** 1.0697-5
 $$ 2 -2 ** 4.0242-5
mash case air-over-ground 2 gp
 ** 1.0
 $$     2    2
*/ - - - - - select output filename
*let output = 'omshx1'
*/
*/ - - - - - select remote for routing output
*/
*interrupt on deadstart      to end,
           on checkpoint     to end,
           on timeup         to end,
           on jccerror       to end,
           on softwareerror  to end,
           on hardwareerror  to end
*/-------------------------------------------------------------------
*/
*cdestroy mrstap* $od
*lstfil
```

Fig. 6. (continued)

```
*destroy ft05msh
*copy mshing0 ft05msh
*mashx
*cat ft06msh >> $od
*switch ft24msh mrstap1
*switch ft34msh mrstap2
*destroy ft05msh
*copy mshing1 ft05msh
*mashx
*cat ft06msh >> $od
*switch ft24msh mrstap3
*switch ft34msh mrstap4
*destroy ft05msh
*copy mshing0b ft05msh
*mashx
*cat ft06msh >> $od
*switch ft24msh mrstap5
*switch ft34msh mrstap6
*if output.eq.0 then goto end
*psave: destroy  \output\
*col1 filst > xxfl
*col1 $od > xxod
*select printlog=lmshx1
*cat lmshx1 xxfl xxod > \output\
*destroy xxfl xxod mshing0 mshing0b mshing1 $od ft23msh
*destroy ft33msh filst infile ft05msh ft06msh
*/------------------------------------------------------------------
*/
*end:
*goto
```

Fig. 6. (continued)

Listing For CRAY File "drc2tlx "

```
*select printlog=ldrc2tlx
*interrupt on softwareerror to end,
           on hardwareerror to end,
           on jccerror to end,
           on timeup to end
*file name=ina
x10
indrc1
*file name=indrc1
drc2 for metric doghouse -- xd=0.0 -- iprt=2 -- no xy dep.
 ** 0. 0. 50. -10. 110. 2. 50. 6. 1. 50. 1020. 17. 1. 2. 2z 1.
 ** 2r24556. 2r33000. 2r42500.
 ** 6z
 ** 45. 270. 60. 210. 150. 330.
 $$ 2 0
 ** 1.964e7 1.0e7 6.3763+6 0
2 neutron - 0 gamma flat response input
 -- 1=neut  2=veh n-g 3=grd n-g 4=photons
mash 2n/0g group flat response
 ** 1.0000 1.0000
 dose rate (rd/h/(n/cm**2.s))
 ** 6.0e-9 5.0e-9
energy group totals
drc2 for metric doghouse -- xd=100.0 -- iprt=2 -- xy dep.
 ** 100. 0. 50. -10. 110. 2. 50. 6. 1. 0. 1020. 17. 2. 2. 2z 1.
 ** 2r24556. 2r33000. 2r42500.
 ** 6z
 ** 45. 270. 60. 210. 150. 330.
 $$ 2 0
 ** 1.964e7 1.0e7 6.3763+6 0
2 neutron - 0 gamma flat response input
 -- 1=neut  2=veh n-g 3=grd n-g 4=photons
mash 2n/0g group flat response
 ** 1.0000 1.0000
 dose rate (rd/h/(n/cm**2.s))
 ** 6.0e-9 5.0e-9
energy group totals
drc2 for metric doghouse -- xd=100.0 -- iprt=1 -- xy dep.
 ** 100. 0. 50. -10. 110. 1. 50. 6. 1. 0. 1020. 17. 2. 2. 2z 1.
 ** 2r24556. 2r33000. 2r42500.
 ** 6z
 ** 45. 270. 60. 210. 150. 330.
 $$ 2 0
 ** 1.964e7 1.0e7 6.3763+6 0
2 neutron - 0 gamma flat response input
 -- 1=neut  2=veh n-g 3=grd n-g 4=photons
mash 2n/0g group flat response
 ** 1.0000 1.0000
 dose rate (rd/h/(n/cm**2.s))
 ** 6.0e-9 5.0e-9
energy group totals
*mass
get wait=on waitime=60 drc2 lstfil vistaflx
get wait=on waitime=60 mrstap1 mrstap3
end
*destroy drcxxx drcyyy drcprlx
*drc2 f5=indrc1,f6=ft06a,f15=vistaflx,f24=mrstap1,f10=q10a,f11=q11a
*drc2 f5=indrc1,f6=ft06b,f15=vistaflx,f24=mrstap3,f10=q10b,f11=q11b
*end: cconcat ft06* -o drcyyy
*lstfil f5=ina,f6=oua
*cconcat oua drcyyy -o drczzz
*select printlog=ldrc2tlx
*copy ldrc2tlx drcxxx
*fred drcxxx
nv
dop1,1;*** page;bc,,1;1;dl.-1
dnp1,1;*** page;bc,,1; ;
sv
end
*cconcat drcxxx drczzz -o drcprlx
*cdestroy drczzz indr* ft06* drcxxx ina drcyyy oua
*cconcat q10* -o f10txt
*cconcat q11* -o f11txt
*mass store wait=on waitime=60 drcprlx f10txt:f10txtlx f11txt:f11txtlx
*cdestroy q10* q11* mrstap* vist* lstfil drc2
*goto
```

Fig. 7. DRC2 Input for Test Problem 2: Metric Doghouse.

Table 2. Comparison of DRC2 Calculated Protection Factors for Test Problem 2: Metric Doghouse

Range (cm)	Orientation (degrees)	DRC2 Protection Factors: With No X-Y Dependence	DRC2 Protection Factors: With X-Y Dependence	% Difference*
		Case 1 (INGB=0)		
24556	45	2.715	2.718	0.11
24556	270	1.912**	1.908	−0.21
33000	60	2.576	2.574	−0.08
33000	210	2.104	2.104	—
42500	150	2.261	2.258	−0.13
42500	330	2.373	2.368	−0.21
		Case 2 (INGB=1)		
24556	45	2.798	2.797	−0.04
24556	270	1.883***	1.880	−0.16
33000	60	2.643	2.642	−0.04
33000	210	2.062	2.060	−0.10
42500	150	2.302	2.298	−0.17
42500	330	2.375	2.371	−0.17

*$\left(\frac{\text{x−y dep}}{\text{no x−y dep}} - 1\right) \times 100$.

**DRC calculated a protection factor of 1.913.

***DRC calculated a protection factor of 1.884.

between results without in-group biasing and those with in-group biasing. Also note that DRC gave essentially the same result as the no X-Y dependence DRC2 at the one point indicated in Table 2, differing by only 0.05% for both INGB=0 and INGB=1. Fractional standard deviations ranged from 0.015 to 0.029.

6.3 TEST PROBLEM 3: LARGE (30M × 6M × 3M) STEEL-TOPPED CONCRETE BUILDING

The third test case is a 69-group (46 neutron and 23 gamma-ray) calculation of detector responses in a large (30 m long by 6 m wide by 3 m high) steel-topped concrete building. The side walls of the building are 20 cm thick and are composed of ordinary concrete. The floor is a 10-cm-thick slab of borated concrete and the roof is a 10-cm-thick steel slab. There are two doorways, two windows, an interior partial concrete wall, and an opening in the roof. Drawings of the building are shown in Figs. 8 and 9. Fig. 9, with the roof removed, shows the interior of the building. The detector position is near a window and the interior partial wall so that it may be shielded by the wall or exposed by the window or the roof opening, depending on the orientation. The system rotation point is at x=1500 cm and y=300 cm.

This problem is intended to test the effects on calculated responses of including x-y dependence in the coupling calculation. While the building may occupy only one DORT radial mesh interval or portions of two, the variation of the fluence across the expanse of the building could be significant.

The source for the calculation is a point source at zero radius and 300 m above the ground. It consists of prompt neutron and gamma-ray fission sources obtained by extrapolating and regrouping data from Ref. 6 and combining without regard to normalization except that all values were multiplied by 10^{15}. The tissue dose response function was obtained from the DABL69[7] response function set. A 240 direction quadrature set and the DABL69 cross section library with a P_5 Legendre expansion were used.

Table 3 is a comparison of neutron and gamma-ray tissue dose protection factors calculated with DRC2 using x-y dependent coupling with those calculated by DRC2 using no x-y dependent coupling. At close range (26.73 m) and an orientation (172.5 deg.) where the detector position is partially exposed due to the roof opening, the neutron and gamma-ray protection factors calculated with x-y dependent coupling show a greater than 10% difference from the result with no x-y dependent coupling. At distant ranges, the 180 deg. orientation gives the largest differences in the protection factors, probably because of the exposure provided by the roof opening. Although the neutron protection factors differ by less than 5%, the gamma-ray protection factors at two range/orientations differ by greater than 10%.

Even though differences in neutron protection factors were less than 5% at distant ranges, Table 4 shows that the calculated neutron doses can differ by greater amounts. The protection factors tend to differ less than the fluences or doses be-

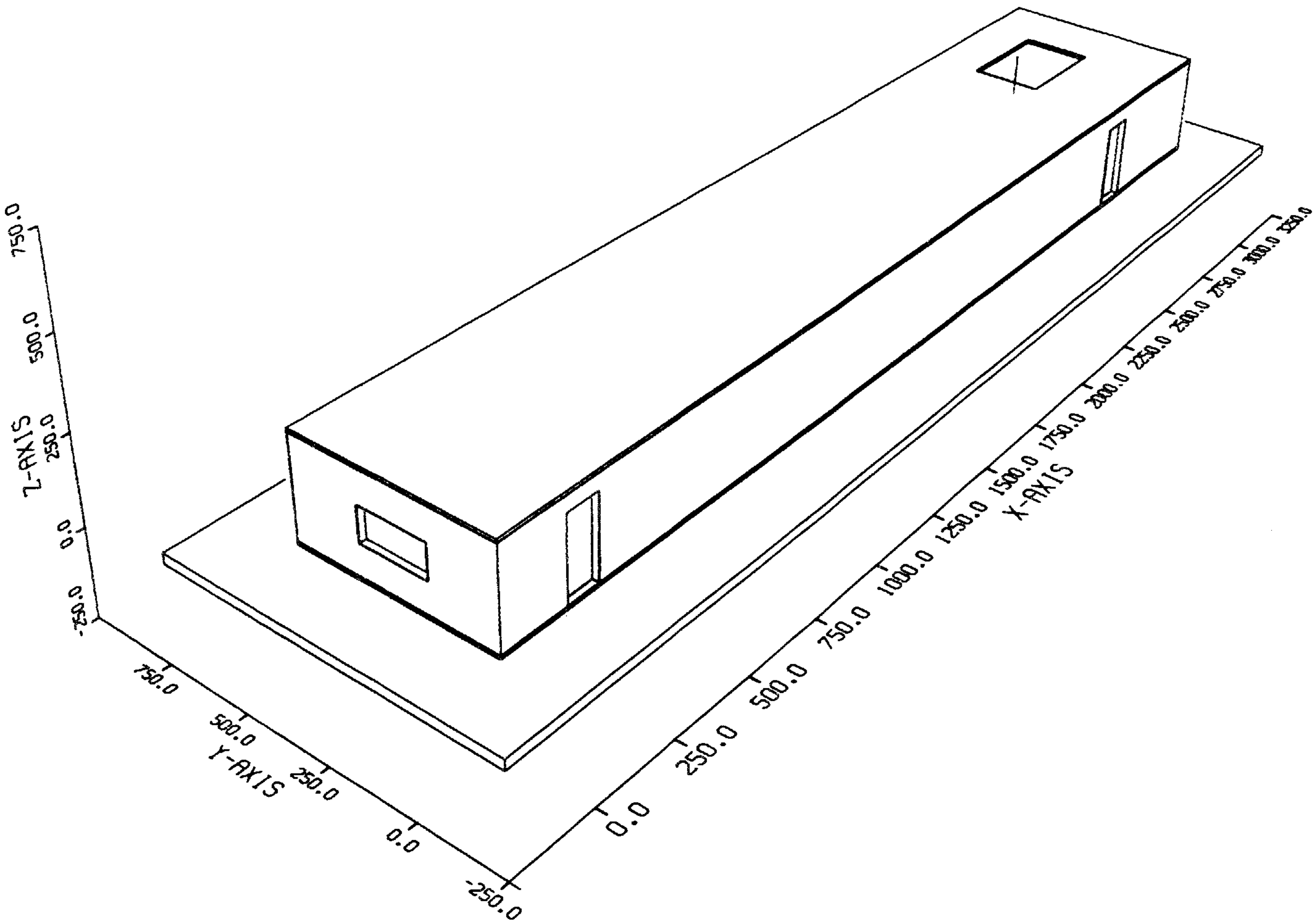


Fig. 8. Exterior View of the Geometry for Test Problem 3: Large, Steel-Topped Concrete Building.

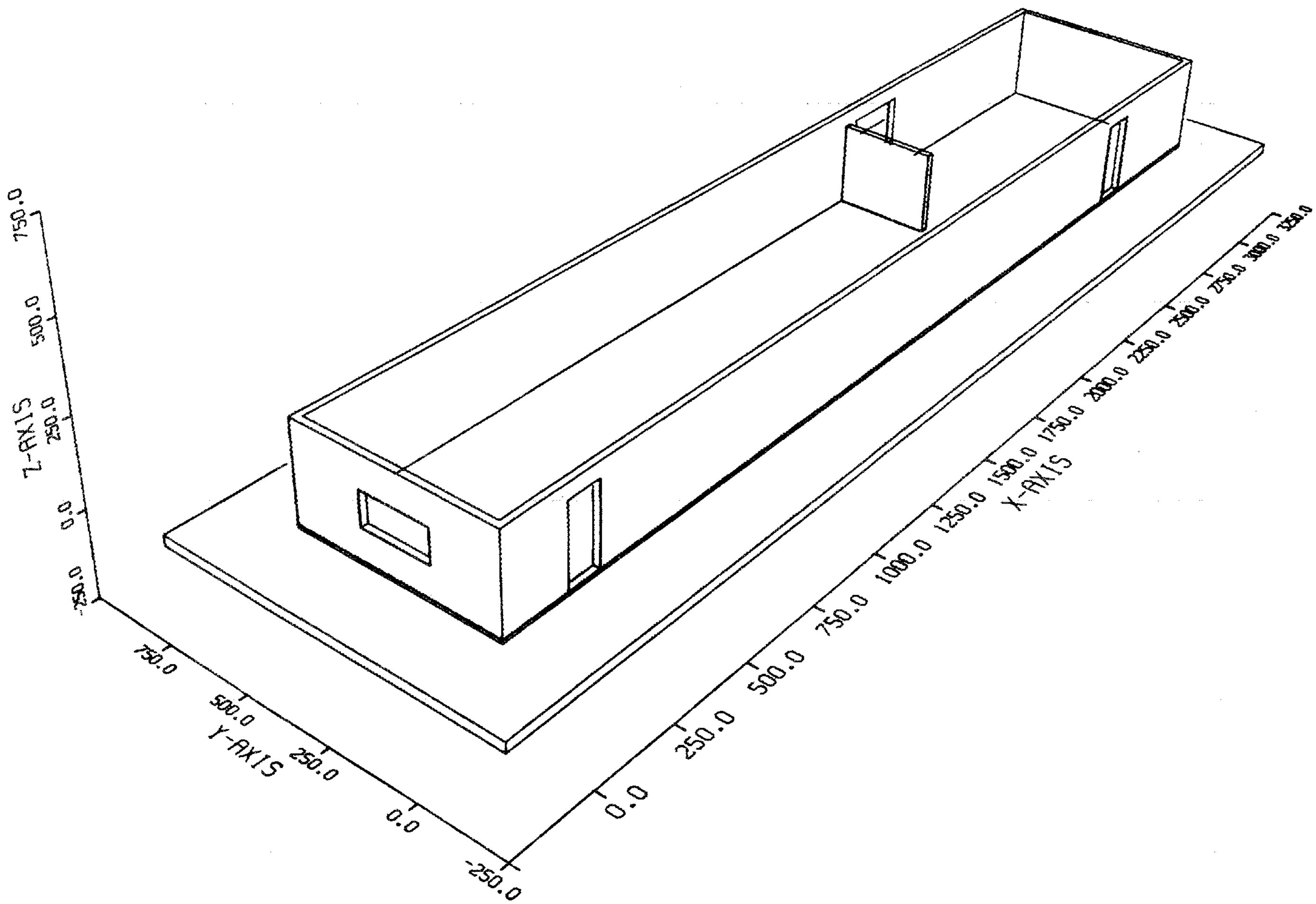


Fig. 9. Interior View of the Geometry for Test Problem 3: Large, Steel-Topped Concrete Building.

Table 3. Comparison of DRC2 Calculated Neutron and Gamma-Ray Tissue Dose Protection Factors for Test Problem 3: Large Steel-Topped Concrete Building

		Protection Factors (tissue dose)		
Range (m)	Orientation (degrees)	With No X-Y Dependence	With X-Y Dependence	% Difference*
		Neutron		
26.73	0	2.997	2.774	−7.44
26.73	172.5	2.700	2.986	10.6
150	0	4.077	4.131	1.32
150	90	2.769	2.792	0.83
150	180	3.194	3.127	−2.1
150	270	3.797	3.821	0.63
300	0	4.026	4.090	1.59
300	90	2.422	2.399	−0.95
300	180	3.088	2.939	−4.83
300	270	3.624	3.588	−0.99
		Gamma Ray		
26.73	0	39.41	39.88	1.19
26.73	172.5	21.33	26.48	24.1
150	0	36.53	37.46	2.55
150	90	12.60	13.39	6.27
150	180	16.27	18.30	12.5
150	270	25.79	25.90	0.43
300	0	33.33	34.07	2.22
300	90	6.630	6.742	1.69
300	180	13.45	12.04	−10.5
300	270	16.04	15.56	−2.99

*$\left(\frac{\text{x−y dep}}{\text{no x−y dep}} - 1\right) \times 100.$

Table 4. Comparison of DRC2 Calculated Neutron Tissue Dose for Test Problem 3: Large Steel-Topped Concrete Building

		Neutron Tissue Dose*		
Range (cm)	Orientation (degrees)	With No X-Y Dependence	With X-Y Dependence	% Difference**
26.73	0	4.035-2***	4.157-2	3.02
26.73	172.5	4.475-2	4.215-2	−5.81
150	0	5.297-3	4.822-3	8.97
150	90	8.123-3	8.081-3	−0.52
150	180	6.966-3	7.702-3	10.6
150	270	5.757-3	5.673-3	−1.46
300	0	8.580-4	7.918-4	−7.72
300	90	1.517-3	1.539-3	1.45
300	180	1.164-3	1.308-3	12.4
300	270	9.742-4	9.790-4	0.49

*The free-field doses are 1.323-1, 2.499-2, and 4.079-3 at 26.73m, 150m, and 300m, respectively. With the detector located about 550 cm from the vehicle system rotation point, the x-y dependent free-field dose varies from 7.6% below to 8.2% above the reference values, the largest variations being for 0- and 180-degree rotations.

**$\left(\frac{\text{x−y dep}}{\text{no x−y dep}} - 1\right) \times 100$.

***Read as 4.035×10^{-2}.

cause the division of the free-field quantities by the shielded quantities cancels errors in both quantities, particularly when there is not much spectral shift in the important energy regions. Fractional standard deviations of the cited results are in the range 0.027 to 0.059 with x-y dependent coupling and 0.027 to 0.049 without x-y dependent coupling.

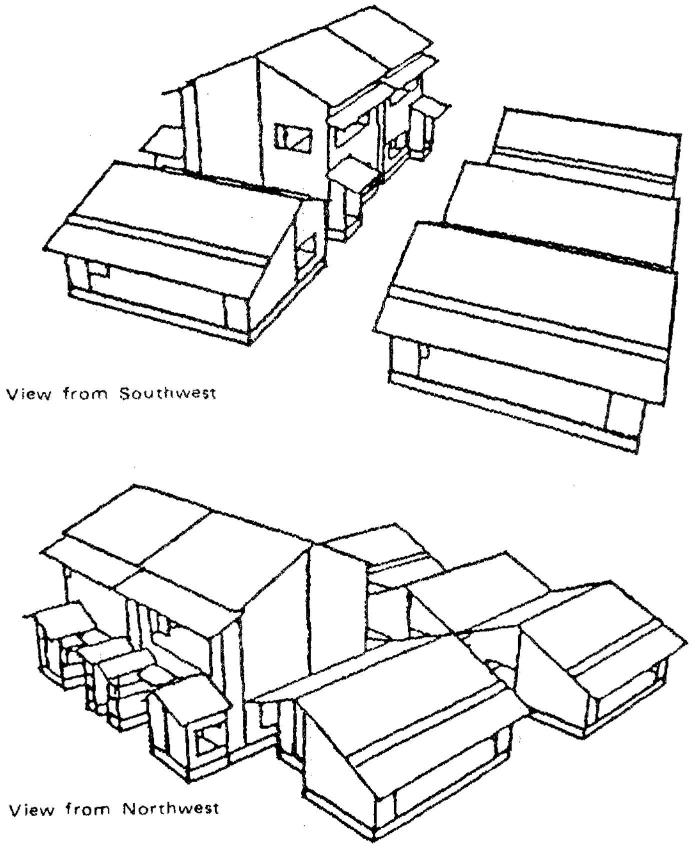
6.4 TEST PROBLEM 4: BREN SIX-HOUSE CLUSTER

The fourth test case involves the calculation of neutron and gamma-ray dose rates and protection factors at a detector location within a BREN six-house cluster. A picture of the cluster (from Ref. 8) is shown in Fig. 10. A plan view of the cluster is shown in Fig. 11. The detector locations identified on the figure have no meaning for this test problem. The box enclosing the local system geometry is about 25.4 m $\times$ 25.3 m $\times$ 10.2 m. Overall, this system is larger than that for test problem 3. However, because VISTA fluences were available for only four radial locations and these were 300 to 500 m apart, the entire system can fit within one interval between the VISTA fluence points (The fluences were obtained from a file created by W. A. Rhoades). The ranges were chosen at the VISTA fluence locations; hence for a given range, the calculated fluences incident on the system may involve up to three of the VISTA fluence radial points in the interpolation of the fluences. Logarithmic interpolation of the fluences was used.

For a rotation point at the center of the system, the surface points are removed from the VISTA fluence points by at most about 6% of the distance between adjacent points. Thus, the x-y dependent fluence values should be 94 to 100% of the VISTA fluence values when linear interpolation is used and one could expect little difference between results obtained with x-y dependent coupling and those obtained with no x-y dependent coupling. For the fluence differences over the given ranges, logarithmic interpolation should also show small differences between the x-y dependent and the no x-y dependent results.

Table 5 compares soft tissue kerma total protection factors calculated by DRC2 using x-y dependence in the coupling operation to those calculated by DRC2 without using x-y dependence in the coupling operation. All differences are essentially 3% or less. Table 6 compares DRC and DRC2 calculated soft tissue kerma total protection factors. Differences less than 3% are observed here also. Finally, Table 7 compares DRC and DRC2 calculated soft tissue kerma values. The differences are generally larger than those observed for the protection factors, but they fall within the 6% variation in the incident fluence over the surface of the system mentioned above. With no x-y dependent coupling, DRC2 gives the same results as DRC. Fractional standard deviations of total quantities ranged from about 0.01 to 0.06. The uncertainties associated with the dose due to capture gamma rays in the houses were generally greater than 30%.

A computation charge comparison between DRC and DRC2 was also made for this test problem. A separate DRC calculation was performed for each range, but



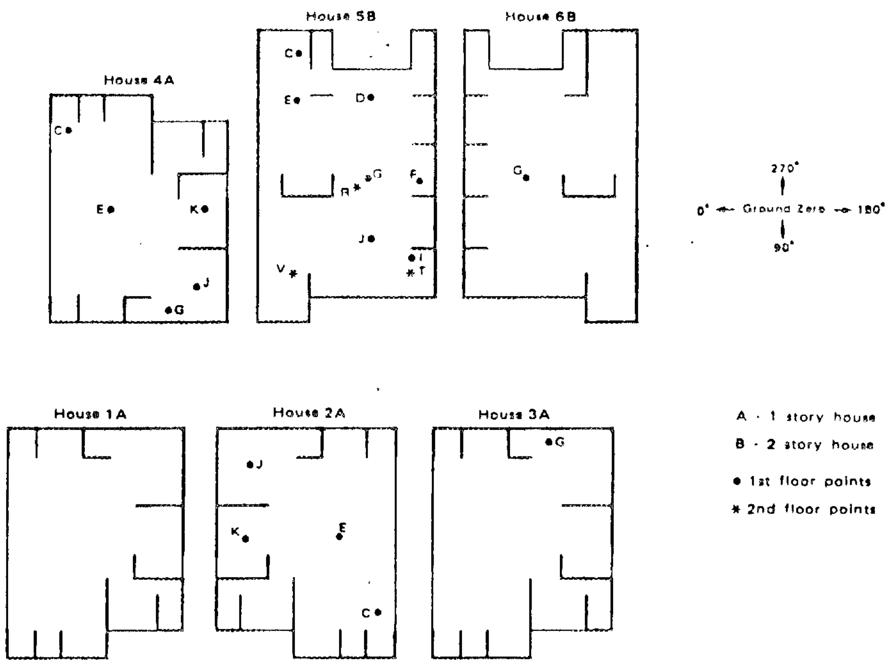
Combinatorial geometry of the six-house cluster model

Dimensions of Model Japanese Houses (cm)

House Type	Roof Peak	Length	Width	Second Story Floor Height	Partition Height
Single story house A	475	872	700	–	270
Two story house B	915	858[a]	675	400	315
Tenement (one unit)	860	700[a]	500	360	300

[a]Main portion of house

Fig. 10. Geometry for Test Problem 4: BREN Six-House Cluster.



Plan of the six-house cluster showing location of detectors

Fig. 11. Plan View of the Geometry for Test Problem 4: BREN Six-House Cluster.

Table 5. Comparison of DRC2 Calculated Soft Tissue Kerma Total Protection Factors for Test Problem 4: BREN Six-House Cluster

		Soft Tissue Kerma Total Protection Factor		
Range (m)	Orientation (degrees)	With No X-Y Dependence	With X-Y Dependence	% Difference*
700	0	1.509	1.481	−1.86
700	90	1.682	1.632	−2.97
700	180	3.378	3.349	−0.86
700	270	1.825	1.780	−2.47
1000	0	1.341	1.352	0.82
1000	90	1.836	1.817	−1.03
1000	180	4.514	4.472	−0.93
1000	270	2.244	2.191	−2.36
1500	0	1.098	1.095	−0.27
1500	90	1.846	1.826	−1.08
1500	180	5.824	5.682	−2.44
1500	270	3.009	2.922	−2.89
2000	0	0.945	0.939	−0.63
2000	90	1.824	1.804	−1.10
2000	180	6.596	6.393	−3.08
2000	270	3.654	3.597	−1.56

*$\left(\frac{\text{x−y dep}}{\text{no x−y dep}} - 1\right) \times 100.$

Table 6. Comparison of DRC and DRC2 Calculated Soft Tissue Kerma Protection Factors for Test Problem 4: BREN Six-House Cluster

Range (m)	Orientation (degrees)	Soft Tissue Kerma Total Protection Factor		% Difference*
		DRC	DRC2	
700	0	1.506	1.481	−1.66
700	90	1.680	1.632	−2.86
700	180	3.372	3.349	−0.68
700	270	1.822	1.780	−2.31
1000	0	1.339	1.352	0.97
1000	90	1.832	1.817	−0.82
1000	180	4.506	4.472	−0.75
1000	270	2.241	2.191	−2.23
1500	0	1.096	1.095	−0.09
1500	90	1.843	1.826	−0.92
1500	180	5.813	5.682	−2.25
1500	270	3.003	2.922	−2.70
2000	0	0.943	0.939	−0.42
2000	90	1.821	1.804	−0.93
2000	180	6.584	6.393	−2.90
2000	270	3.647	3.597	−1.37

*$(\frac{\mathrm{DRC2}}{\mathrm{DRC}} - 1) \times 100.$

Table 7. Comparison of DRC and DRC2 Calculated Soft Tissue Kerma for Test Problem 4: BREN Six-House Cluster

		Soft Tissue Kerma*		
Range (m)	(degrees)	DRC	DRC2 (X-Y dep)	% Difference**
700	0	9.23+2***	9.73+2	5.42
700	90	8.28+2	8.72+2	5.31
700	180	4.12+2	4.01+2	−2.67
700	270	7.63+2	7.65+2	0.26
1000	0	2.78+2	2.86+2	2.88
1000	90	2.03+2	2.10+2	3.45
1000	180	8.26+1	8.07+1	−2.30
1000	270	1.66+2	1.67+2	0.60
1500	0	4.44+1	4.59+1	3.38
1500	90	2.64+1	2.72+1	3.03
1500	180	8.36+0	8.32+0	−0.48
1500	270	1.62+1	1.64+1	1.23
2000	0	8.29+0	8.58+0	3.50
2000	90	4.29+0	4.42+0	3.03
2000	180	1.19+0	1.19+0	–
2000	270	2.14+0	2.14+0	–

*The DRC2-calculated free-field kerma values are 1393, 372.9, 48.7, and 7.831 at 700m, 1000m, 1500m, and 2000m, respectively. They differ slightly from the DRC values because of logarithmic versus linear interpolation in the Z direction. The x-y dependent values vary from about 2% below to 3.5% above the reference values.

**$(\frac{DRC2}{DRC} - 1) \times 100$.

***Read as 9.23×10^2.

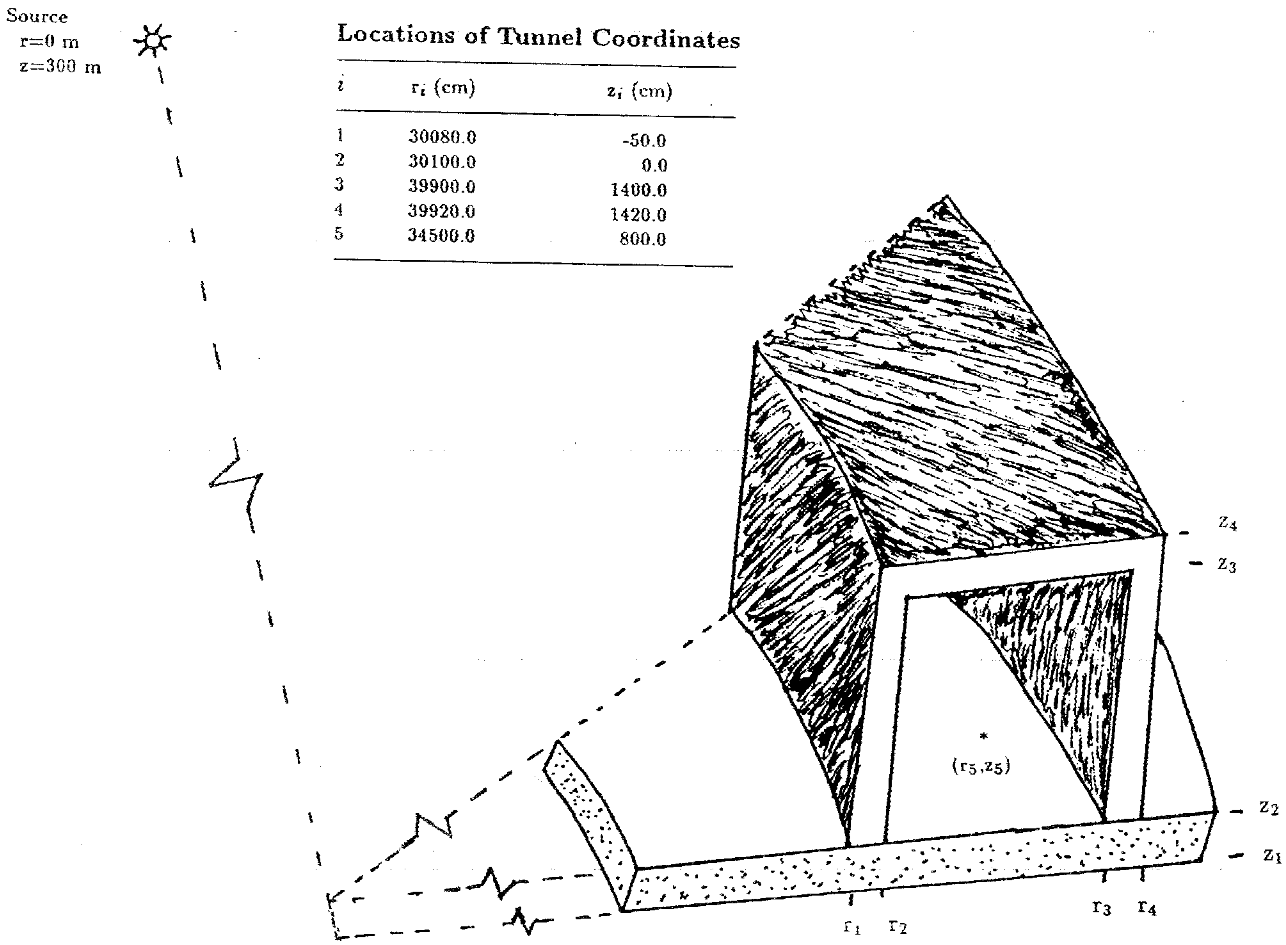
results for all four orientations were obtained from a single calculation. The DRC2 calculation was performed for all ranges and orientations in a single pass through the code. In addition, the core allocation was large enough that fluence data for all groups could be stored in core during coupling (430,000 words were allocated versus slightly more than 423,000 required). The DRC core allocation was fixed at 150,000 words. Both the DRC and DRC2 calculations were performed for two source conditions, and DRC2 performed the calculations with and without x-y dependence of the forward fluence during coupling. For these calculational conditions, the DRC to DRC2 charge ratios for the case of no x-y dependence in the DRC2 coupling were 1.90, 2.34, 0.65, and 1.79 for CPU, IO, memory, and total charges, respectively. The respective ratios for the case with x-y dependence in DRC2 were 1.91, 3.23, 0.76, and 1.88. IO and memory charges for a DRC2 calculation having no x-y dependence in the coupling with one of the sources appeared to be anomalous. The IO charge was 75% higher than that for the x-y dependent coupling case with the same source and 80% higher than that for both no x-y and x-y dependent coupling with the other source. Smaller differences were noted for the memory charges. The memory charge was 37% higher than that for the x-y dependent coupling case with the same source and 25% higher than that for both no x-y and x-y dependent coupling with the other source.

From the above time comparisons, it would appear that DRC2 has a distinct advantage in all categories except memory, for which DRC has a slight advantage. The larger memory charge for DRC2 may be attributed to the greater amount of storage allocated (280,000 more words than DRC). Also, it can be noted from the above data that the IO and memory charges can fluctuate significantly between similar calculations (compare the no x-y dependent versus the x-y dependent cases). While the CPU charges are about the same for the two DRC2 cases, IO charges differ by about 38% and memory charges differ by about 17%.

6.5 TEST PROBLEM 5: LARGE RADIUS, AIR-FILLED, ANNULAR, CYLINDRICAL CONCRETE TUNNEL

The fifth test case involves the calculation of neutron and gamma-ray fluences and doses within a large-radius, 9.8 m wide, air-filled, annular, cylindrical concrete tunnel. The concrete walls surrounding the tunnel are 20 cm thick, and the tunnel is centered at a radius of 3.45×10^4 cm. A sketch of the problem geometry is shown in Fig. 12. The geometry for the calculation is such that DORT should be able to calculate the desired quantities. Therefore, the DRC2-calculated results can be compared against reasonably well-known quantities and the accuracy of the DRC2 coupling process can be established.

Again, the DABL69 group structure that was used in test problem 3 is used here. The source and cross-section library are the same. An S_{12} quadrature (96 directions) was used initially rather than the 240-direction quadrature. However, the 240-direction quadrature is used in the final analysis, mainly to aid in the transport



Locations of Tunnel Coordinates

i	r_i (cm)	z_i (cm)
1	30080.0	-50.0
2	30100.0	0.0
3	39900.0	1400.0
4	39920.0	1420.0
5	34500.0	800.0

Fig. 12. Sketch of the Geometry for Test Problem 5: Large-Radius, Air-Filled, Annular, Cylindrical Concrete Tunnel.

down range of secondary gamma rays produced near the source. In addition, two air-layer thicknesses are used in the MASHX calculations (10.8 m and 50 m). A mean-free-path in the air mixture ranges from 19 to 171 m for neutrons and 4.3 to 460 m for gamma rays. The optical thickness of the thicker air layer is several mean-free-paths for several neutron and gamma-ray groups. Hopefully, this layer is thick enough that the presence of the concrete tunnel would not perturb the free-field fluence at the system boundaries.

The DRC2 results obtained by folding adjoint leakages and forward fluences are compared to the DORT-calculated results in Table 8. Fractional standard deviations of the results are also given. With the 10.8-m-thick air layer, both the x-y dependent and no x-y dependent DRC2 results are reasonably close to the DORT results. The results without x-y dependence are slightly lower. An analysis of the DRC2 results showed a significant contribution to the gamma-ray fluence and dose from the production of secondary gamma rays in the regions around the tunnel. As shown in the Table 8, all fractional standard deviations are less than 0.07 for the 10.8-m-thick air layer.

When one compares the results for the 50-m-thick air layer to those for the 10.8-m-thick air layer, one finds that overall agreement for the 50-m-thick air layer results improves for the x-y dependent coupling case. In particular, excellent agreement is achieved for the neutron and gamma-ray fluences, but the agreement for the doses worsens slightly. Perhaps, the better agreement for the fluences may be attributed to the adjoint source being a fluence response function. The results obtained with no x-y dependence in the coupling operation are lower than the DORT results by 14 to 25%. Fractional standard deviations range from 0.034 to 0.085. The good agreement between the DRC2 x-y dependent results and the DORT results give added confidence in the correctness of the DRC2 coupling procedure.

As mentioned above, (Section 6.2) the air layer around the object should be thick enough that the fluence at the boundary of the air layer is not perturbed by the presence of the object. Since the 50-m-thick air layer led to better overall agreement with DORT than did the 10.8-m-thick air layer, perturbations to fluences at system boundaries with those air layer thicknesses were examined. Table 9 shows the maximum percent differences between the above-ground perturbed and unperturbed neutron and gamma-ray total fluences as a function of leakage surface. The six surfaces shown represent the leakage surfaces used in the MASHX calculations (i.e. a top and inner and outer radial surfaces bounding either a 10.8-m-thick or a 50-m-thick air layer surrounding the concrete tunnel). One can see that there is much more perturbation for the 10.8-m-thick air layer surfaces. The outer radial surface shows greater differences because the tunnel partially shields some points on that surface.

Table 8. Comparison of DRC2 and DORT Calculated Fluences and Doses for Test Problem 5: Large-Radius, Air-Filled, Cylindrical Concrete Tunnel.

DORT Calculation		
Calculated Quantity	Perturbed	Unperturbed
Neutron Fluence	4.225+3[a]	7.263+4
Gamma-Ray Fluence	3.960+3	3.881+4
Neutron Dose	7.335-5	1.361-3
Gamma-Ray Dose	4.387-5	4.243-4
DRC2 with 10.8-m-Thick Air Layer		
Calculated Quantity	With No X-Y Dependence	With X-Y Dependence
Neutron Fluence	3.911+3[0.026](0.93)[b]	4.035+3[0.027](0.96)
Gamma-Ray Fluence	4.010+3[0.066](1.04)	4.209+3[0.067](1.06)
Neutron Dose	6.761-5[0.035](0.92)	6.975-5[0.034](0.95)
Gamma-Ray Dose	4.295-5[0.066](0.98)	4.408-5[0.066](1.00)
DRC2 with 50.0-m-Thick Air Layer		
Calculated Quantity	With No X-Y Dependence	With X-Y Dependence
Neutron Fluence	3.650+3[0.042](0.86)	4.228+3[0.044](1.00)
Gamma-Ray Fluence	3.342+3[0.062](0.84)	3.971+3[0.068](1.00)
Neutron Dose	5.490-5[0.034](0.75)	6.903-5[0.060](0.94)
Gamma-Ray Dose	3.730-5[0.078](0.85)	4.506-5[0.085](1.03)

[a]Read as 4.225×10^3.

[b]Fractional standard deviations are in brackets and ratios of DRC2 to DORT quantities are in parentheses.

Table 9.
Maximum Percent Differences Between the Above-Ground Perturbed and Unperturbed Neutron and Gamma-Ray Total Fluences as a Function of Leakage Surface for Test Problem 5: Large-Radius, Air-Filled, Cylindrical Concrete Tunnel.

	Maximum Percent Difference in Fluences*	
Leakage Surface	Neutron	Gamma-Ray
Inner Radial		
10.8-m Air Layer	10.5	3.3
50.0-m Air Layer	0.4	1.2
Outer Radial		
10.8-m Air Layer	39.0	47.6
50.0-m Air Layer	9.3	14.2
Top		
10.8-m Air Layer	8.8	15.2
50.0-m Air Layer	-1.4	6.7

$$* \left(\frac{\text{Unperturbed Fluence}}{\text{Perturbed Fluence}} - 1 \right) \times 100$$

For the top surface, the perturbation is significant for the 10.8-m-thick air layer but is much less for the 50-m-thick air layer. There is probably less perturbation of the inward-directed fluences than that shown in Table 9.

It should be noted that the results for the MASHX calculations were quite sensitive to the GWLO values input. In addition, the value of NMOST had to be increased for some changes in GWLO due to "imaxn" being exceeded. Therefore, to eliminate the requirement for having to input these values and to guard against inappropriate selections of the parameters, the calculations were performed as if they were neutron only and a modified version of the MASHX code (called MASHY) sorted the various collision or pseudo-collision events. This required an additional input card following the last MASHX input card (the air and ground media identifiers). The input is free form; hence, the data should be preceded by '$$' in columns 2 and 3. The two entries on the card are:

jptyp	a signal to indicate no effect if 0 or a coupled problem run as neutron-only if 1, and
jprigp	the number of neutron groups.

The code calculates the gamma-to-neutron transfer probabilities through the cross-section scattering matrix. MASHY uses the above parameters along with old and new group numbers to determine when a gamma-to-neutron transfer has occurred at real scattering events.

Finally, the change to a 240-direction quadrature and the inclusion of the thicker air layer in the MASHX calculation led to a very large data storage requirement in DRC2. Nearly six million words would be required to store all data in core (i.e. data for 69 groups, 200 nonzero weight directions, 10 i mesh, and 42 j mesh). The DRC2 calculation was performed with a core allocation of three million words. While a CPU charge of about two minutes was required for the four calculations (for two coupling surfaces with and without x-y dependence during coupling), large memory and IO charges resulted in a total charge of about 30 minutes. For the DRC2 calculation of the perturbed fluence by integration of the perturbed DORT-VISTA angular fluences, the total charge was only about three seconds.

7. CONCLUSIONS

The DRC2 code has been written and tested and appears to be performing the coupling operation correctly. Results have been compared with some from the DRC code and some simulated DRC results (obtained with DRC2 by coupling without x-y dependence). Those results indicated that there were some significant effects (greater than 10%) of including x-y dependence in the coupling operation, but small effects were observed in small systems and even one reasonably large system. In addition, the good agreement for a test case solvable directly with DORT gave added assurance of the correctness of the coupling procedure.

Although the code allows for calculations with very large fluence data requirements to be solved "ex-core," one may incur a large IO cost penalty when data has to be stored ex-core. It is therefore recommended that, whenever possible, enough core be allocated so that all fluence data can be stored in core.

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APPENDIX A

Partial Output Listing for Test Problem 1: Free-Field Fluence Calculation

```
14:08:59 000:00.009 506/06/91 lslcc cosmos 4.3 dna 605021 xxx *** +cosm5a0 *** drc2t1c slater c *** page 1

14:08:59 000:00.017        1 *select printlog=ldrc2t1c
14:08:59 000:00.050        2 *interrupt on softwareerror to end,
                           3            on hardwareerror to end,
                           4            on jccerror to end,
                           5            on timeup to end
14:08:59 000:00.059        6 *file name=ina
14:09:00 000:00.080          file ******* ina *******created with 2 line(s) *******
14:09:00 000:00.084        9 *file name=indrc1
14:09:00 000:00.116          file ******* indrc1 *******created with 28 line(s) *******
14:09:00 000:00.120       38 *mass
14:09:00 000:00.195   ----- ?
                          39 get wait=on waittime=60 drc2 lstfil vstaflx2
14:09:02 000:00.358   ----- 000 91/06/06 14:03:17.828  get drc2:/605021/drc2
14:09:02 000:00.427   ----- 001 (25573700b bits) 91/05/07 11:26:32.639
14:09:03 000:00.522   ----- 000 91/06/06 14:03:19.345  get lstfil:/605021/lstfil
14:09:03 000:00.591   ----- 001 (15362600b bits) 90/09/19 10:33:12.503
14:11:00 000:00.687   ----- 000 91/06/06 14:03:20.312  get vstaflx2:/605021/vstaflx2
14:11:00 000:00.756   ----- 001 (12577000b bits) 90/05/03 12:45:08.454
14:11:00 000:00.824   ----- ?
                          40 get wait=on waitime=60 mrstap12 mrstap13
14:12:48 000:00.988   ----- 000 91/06/06 14:05:17.236  get mrstap12:/605021/mrstap12
14:12:48 000:01.057   ----- 001 (15201060 0b bits) 90/10/03 12:08:59.674
14:14:38 000:01.153   ----- 000 91/06/06 14:07:05.136  get mrstap13:/605021/mrstap13
14:14:38 000:01.222   ----- 001 (6751632 00b bits) 90/10/03 12:09:06.027
14:14:38 000:01.290   ----- ?
                          41 end
14:14:38 000:01.411           all done
14:14:38 000:01.416       42 *destroy drcxxx drcyyy drcpr1c
14:14:38 000:01.474   ----- not found:
14:14:38 000:01.529   -----    drcxxx   drcyyy  drcpr1c
14:14:38 000:01.900           all done
14:14:38 000:01.905       43 *drc2 f5=indrc1,f6=ft06a,f15=vstaflx2,f24=mrstap12,f10=q10a,f11=q11a
14:16:12 000:45.951   ----- drc2      ctss time       43.967   seconds
14:16:12 000:46.063   ----- cpu=      38.989 i/o=      2.038 mem=      2.941
14:16:13 000:46.141           all done
14:16:13 000:46.146       44 *drc2 f5=indrc1,f6=ft06b,f15=vstaflx2,f24=mrstap13,f10=q10b,f11=q11b
14:21:52 003:39.427   ----- drc2      ctss time      173.202  seconds
14:21:52 003:39.539   ----- cpu=     160.594 i/o=      5.650 mem=      6.958
14:21:52 003:39.617           all done
14:21:53 003:39.621       45 *end: cconcat ft06* -o drcyyy
14:21:56 003:40.866           all done
14:21:56 003:40.871       46 *lstfil f5=ina,f6=oua
14:21:57 003:40.985   ----- lstfil    ctss time        .057      seconds
14:21:57 003:41.054   ----- cpu=         .026 i/o=       .030 mem=        .001
14:21:57 003:41.111           all done
14:21:57 003:41.116       47 *cconcat oua drcyyy -o drczzz
14:22:00 003:42.366           all done
14:22:00 003:42.371       48 *select printlog=ldrc2t1c
```

Listing For CRAY File "indrc1 "

```
drc2 for air-over-ground -- xd=100.0 -- iprt=2 -- xy dep.
 ** 100. 0. 50. -10. 50.5 2. 50. 12. 1. 50. 1020. 17. 2. 2. 100. 0. 2.
 ** 2r24556. 2r33000. 2r42500. 2r24500. 2r34500. 2r44416.7
 ** 12z
 ** 45. 270. 60. 210. 150. 330. 45. 270. 60. 210. 150. 330.
 $$ 2 0
 ** 1.964e7 1.0e7 6.3763+6 0
2 neutron - 0 gamma flat response input
 -- 1=neut  2=veh n-g 3=grd n-g 4=photons
mash 2n/0g group flat response
 ** 1.0000 1.0000
 dose rate (rd/h/(n/cm**2.s))
 ** 6.0e-9 5.0e-9
energy group totals
drc2 for air-over-ground -- xd=0.0 -- iprt=2 -- no xy dep.
 ** 0. 0. 50. -10. 50.5 2. 50. 12. 1. 0. 1020. 17. 1. 2. 2z 2.
 ** 2r24556. 2r33000. 2r42500. 2r24500. 2r34500. 2r44416.7
 ** 12z
 ** 45. 270. 60. 210. 150. 330. 45. 270. 60. 210. 150. 330.
 $$ 2 0
 ** 1.964e7 1.0e7 6.3763+6 0
2 neutron - 0 gamma flat response input
 -- 1=neut  2=veh n-g 3=grd n-g 4=photons
mash 2n/0g group flat response
 ** 1.0000 1.0000
 dose rate (rd/h/(n/cm**2.s))
 ** 6.0e-9 5.0e-9
energy group totals
```

```
*** dropfile= +drc2a  , length=      552448.  program loaded 05/07/91 06:55:25
```

This case began on June 6, 1991 at 14:14:39.

```
detector response code:      drc2 for air-over-ground -- xd=100.0 -- iprt=2 -- xy dep.

xd     = x-loc. (cm) of det. in MORSE geom                          1.00000e+02
yd     = y-loc. (cm) of det. in MORSE geom                          0.00000e+00
zd     = z-loc. (cm) of det. in MORSE geom                          5.00000e+01
zbot   = bottom of coupling surface (cm)                           -1.00000e+01
ztop   = top of coupling surface (cm)                               5.05000e+01
iprt   = 0  print vehicle doses only                                          2
         1  print VISTA data+free field spectra
         2  print VISTA data+ff spec+veh doses+spec+prot
         3  print VISTA data+veh doses+prot facs
wtmx   = maximum weight accepted                                    5.00000e+01
ndet   = no. of vehicle range/orientations                                   12
idif   = 0/>0 same/different group structure                                  1
ksiz   = k-words of storage to be allocated                                  50
ibufsz= MORSE collision file record length                                1020
nparm  = no. of parameters written on coll. file                             17
idxy   = 0  no x-y data                                                       2
         1  x-y data but no x-y dependence
         2  x-y data and x-y dependence
iww    = no. of responses desired (.le.10)                                    2
         note: 0 implies 2 responses
xq     = x-loc. (cm) of veh. sys. rot.point                         1.00000e+02
yq     = y-loc. (cm) of veh. sys. rot.point                         0.00000e+00
interp= 1/2 -- linear/log flux interpolation                                  2
```

vehicle range/orientation parameters

i	loc. of morse origin x	z	rotation angle
1	2.45560e+04	0.00000e+00	4.50000e+01
2	2.45560e+04	0.00000e+00	2.70000e+02
3	3.30000e+04	0.00000e+00	6.00000e+01
4	3.30000e+04	0.00000e+00	2.10000e+02
5	4.25000e+04	0.00000e+00	1.50000e+02
6	4.25000e+04	0.00000e+00	3.30000e+02
7	2.45000e+04	0.00000e+00	4.50000e+01
8	2.45000e+04	0.00000e+00	2.70000e+02
9	3.45000e+04	0.00000e+00	6.00000e+01
10	3.45000e+04	0.00000e+00	2.10000e+02
11	4.44167e+04	0.00000e+00	1.50000e+02
12	4.44167e+04	0.00000e+00	3.30000e+02

rotation matrix for range/orientation no. 1

7.07107e-01	-7.07107e-01	0.00000e+00
7.07107e-01	7.07107e-01	0.00000e+00
0.00000e+00	0.00000e+00	1.00000e+00

rotation matrix for range/orientation no. 2

-6.80385e-07	1.00000e+00	0.00000e+00
-1.00000e+00	-6.80385e-07	0.00000e+00
0.00000e+00	0.00000e+00	1.00000e+00

rotation matrix for range/orientation no. 3

5.00000e-01	-8.66025e-01	0.00000e+00
8.66025e-01	5.00000e-01	0.00000e+00
0.00000e+00	0.00000e+00	1.00000e+00

rotation matrix for range/orientation no. 4

-8.66026e-01	5.00000e-01	0.00000e+00
-5.00000e-01	-8.66026e-01	0.00000e+00
0.00000e+00	0.00000e+00	1.00000e+00

rotation matrix for range/orientation no. 5

-8.66025e-01	-5.00000e-01	0.00000e+00
5.00000e-01	-8.66025e-01	0.00000e+00
0.00000e+00	0.00000e+00	1.00000e+00

rotation matrix for range/orientation no. 6

8.66025e-01	5.00001e-01	0.00000e+00
-5.00001e-01	8.66025e-01	0.00000e+00
0.00000e+00	0.00000e+00	1.00000e+00

rotation matrix for range/orientation no. 7

7.07107e-01	-7.07107e-01	0.00000e+00
7.07107e-01	7.07107e-01	0.00000e+00
0.00000e+00	0.00000e+00	1.00000e+00

rotation matrix for range/orientation no. 8

-6.80385e-07	1.00000e+00	0.00000e+00
-1.00000e+00	-6.80385e-07	0.00000e+00
0.00000e+00	0.00000e+00	1.00000e+00

rotation matrix for range/orientation no. 9

```
 5.00000e-01         -8.66025e-01          0.00000e+00
 8.66025e-01          5.00000e-01          0.00000e+00
 0.00000e+00          0.00000e+00          1.00000e+00

rotation matrix for range/orientation no.   10

-8.66026e-01          5.00000e-01          0.00000e+00
-5.00000e-01         -8.66026e-01          0.00000e+00
 0.00000e+00          0.00000e+00          1.00000e+00

rotation matrix for range/orientation no.   11

-8.66025e-01         -5.00000e-01          0.00000e+00
 5.00000e-01         -8.66025e-01          0.00000e+00
 0.00000e+00          0.00000e+00          1.00000e+00

rotation matrix for range/orientation no.   12

 8.66025e-01          5.00001e-01          0.00000e+00
-5.00001e-01          8.66025e-01          0.00000e+00
 0.00000e+00          0.00000e+00          1.00000e+00
```

```
energy parameters for the vista group structure
       energy
grp.  boundary      delta-e
    1 1.96400e+07 9.64000e+06
    2 1.00000e+07 3.62370e+06
    3 6.37630e+06
    4 0.00000e+00

vehicle escape histories from: mash case air-over-ground 2 gp          ( 10/03/90 -- 12:04:24 )

fluence file from:             "vista 2-group mash-drc output

                               dot title ("dort air/ground transport; p3

nang    = no. of quadrature angles                       240
nradi   = no. of radial points                            48
naxii   = no. of axial points                             57
nog     = no. of energy groups                             2
nogp1   = no. of energy groups plus 1                      3
ndwn    = no. of angles down                             120
njflx   = no. of axial fluxes                             15
niflx   = no. of radial fluxes                             6
jstrt   = index of first j flux                           17
jlst    = index of last j flux                            31
```

quadrature weights and angles

	mu	eta	wgt
1	-6.41230e-02	-9.97942e-01	0.00000e+00
2	-4.21582e-02	-9.97942e-01	1.02900e-03
3	4.21582e-02	-9.97942e-01	1.02900e-03
4	-1.42963e-01	-9.89728e-01	0.00000e+00
5	-9.39923e-02	-9.89728e-01	3.07825e-03
6	9.39923e-02	-9.89728e-01	3.07825e-03
7	-2.29252e-01	-9.73367e-01	0.00000e+00
8	-1.50724e-01	-9.73367e-01	5.10200e-03
9	1.50724e-01	-9.73367e-01	5.10200e-03
10	-3.15291e-01	-9.48995e-01	0.00000e+00
11	-2.07291e-01	-9.48995e-01	7.08425e-03
12	2.07291e-01	-9.48995e-01	7.08425e-03
13	-3.99349e-01	-9.16799e-01	0.00000e+00
14	-2.62555e-01	-9.16799e-01	9.01350e-03
15	2.62555e-01	-9.16799e-01	9.01350e-03
16	-4.72796e-01	-8.81172e-01	0.00000e+00
17	-4.11087e-01	-8.81172e-01	5.63869e-03
18	-1.43488e-01	-8.81172e-01	3.16131e-03
19	1.43488e-01	-8.81172e-01	3.16131e-03
20	4.11087e-01	-8.81172e-01	5.63869e-03
21	-5.37046e-01	-8.43553e-01	0.00000e+00
22	-4.66952e-01	-8.43553e-01	6.41385e-03
23	-1.62988e-01	-8.43553e-01	3.59590e-03
24	1.62988e-01	-8.43553e-01	3.59590e-03
25	4.66952e-01	-8.43553e-01	6.41385e-03
26	-5.98374e-01	-8.01217e-01	0.00000e+00
27	-5.20275e-01	-8.01217e-01	7.14976e-03
28	-1.81600e-01	-8.01217e-01	4.00849e-03
29	1.81600e-01	-8.01217e-01	4.00849e-03
30	5.20275e-01	-8.01217e-01	7.14976e-03
31	-6.56401e-01	-7.54412e-01	0.00000e+00
32	-5.70729e-01	-7.54412e-01	7.84547e-03
33	-1.99211e-01	-7.54412e-01	4.39853e-03
34	1.99211e-01	-7.54412e-01	4.39853e-03
35	5.70729e-01	-7.54412e-01	7.84547e-03
36	-7.11034e-01	-7.03158e-01	0.00000e+00
37	-6.18231e-01	-7.03158e-01	8.57529e-03
38	-2.15791e-01	-7.03158e-01	4.80771e-03
39	2.15791e-01	-7.03158e-01	4.80771e-03
40	6.18231e-01	-7.03158e-01	8.57529e-03
41	-7.61567e-01	-6.48086e-01	0.00000e+00
42	-7.13133e-01	-6.48086e-01	6.42875e-03
43	-4.70428e-01	-6.48086e-01	2.93289e-03
44	-1.64201e-01	-6.48086e-01	4.79164e-03
45	1.64201e-01	-6.48086e-01	4.79164e-03
46	4.70428e-01	-6.48086e-01	2.93289e-03
47	7.13133e-01	-6.48086e-01	6.42875e-03
48	-8.07567e-01	-5.89776e-01	0.00000e+00
49	-7.56207e-01	-5.89776e-01	6.81415e-03
50	-4.98843e-01	-5.89776e-01	3.10872e-03
51	-1.74119e-01	-5.89776e-01	5.07890e-03
52	1.74119e-01	-5.89776e-01	5.07890e-03
53	4.98843e-01	-5.89776e-01	3.10872e-03
54	7.56207e-01	-5.89776e-01	6.81415e-03
55	-8.49108e-01	-5.28222e-01	0.00000e+00
56	-7.95106e-01	-5.28222e-01	7.16550e-03
57	-5.24503e-01	-5.28222e-01	3.26901e-03
58	-1.83075e-01	-5.28222e-01	5.34077e-03
59	1.83075e-01	-5.28222e-01	5.34077e-03
60	5.24503e-01	-5.28222e-01	3.26901e-03
61	7.95106e-01	-5.28222e-01	7.16550e-03
62	-8.85925e-01	-4.63828e-01	0.00000e+00
63	-8.29582e-01	-4.63828e-01	7.45915e-03
64	-5.47246e-01	-4.63828e-01	3.40298e-03
65	-1.91013e-01	-4.63828e-01	5.55965e-03
66	1.91013e-01	-4.63828e-01	5.55965e-03
67	5.47246e-01	-4.63828e-01	3.40298e-03
68	8.29582e-01	-4.63828e-01	7.45915e-03
69	-9.17890e-01	-3.96835e-01	0.00000e+00
70	-8.59514e-01	-3.96835e-01	7.75565e-03
71	-5.66991e-01	-3.96835e-01	3.53825e-03
72	-1.97905e-01	-3.96835e-01	5.78064e-03

```
73 1.97905e-01-3.96835e-01 5.78064e-03
74 5.66991e-01-3.96835e-01 3.53825e-03
75 8.59514e-01-3.96835e-01 7.75565e-03
76-9.44812e-01-3.27613e-01 0.00000e+00
77-9.22954e-01-3.27613e-01 4.89468e-03
78-7.65692e-01-3.27613e-01 3.86282e-03
79-5.05099e-01-3.27613e-01 5.13536e-03
80-1.76303e-01-3.27613e-01 3.64389e-03
81 1.76303e-01-3.27613e-01 3.64389e-03
82 5.05099e-01-3.27613e-01 5.13536e-03
83 7.65692e-01-3.27613e-01 3.86282e-03
84 9.22954e-01-3.27613e-01 4.89468e-03
85-9.66490e-01-2.56704e-01 0.00000e+00
86-9.44130e-01-2.56704e-01 5.00102e-03
87-7.83260e-01-2.56704e-01 3.94674e-03
88-5.16688e-01-2.56704e-01 5.24693e-03
89-1.80348e-01-2.56704e-01 3.72306e-03
90 1.80348e-01-2.56704e-01 3.72306e-03
91 5.16688e-01-2.56704e-01 5.24693e-03
92 7.83260e-01-2.56704e-01 3.94674e-03
93 9.44130e-01-2.56704e-01 5.00102e-03
94-9.82847e-01-1.84425e-01 0.00000e+00
95-9.60108e-01-1.84425e-01 5.08580e-03
96-7.96516e-01-1.84425e-01 4.01365e-03
97-5.25433e-01-1.84425e-01 5.33587e-03
98-1.83400e-01-1.84425e-01 3.78617e-03
99 1.83400e-01-1.84425e-01 3.78617e-03
100 5.25433e-01-1.84425e-01 5.33587e-03
101 7.96516e-01-1.84425e-01 4.01365e-03
102 9.60108e-01-1.84425e-01 5.08580e-03
103-9.93815e-01-1.11045e-01 0.00000e+00
104-9.70823e-01-1.11045e-01 5.15474e-03
105-8.05405e-01-1.11045e-01 4.06806e-03
106-5.31297e-01-1.11045e-01 5.40820e-03
107-1.85447e-01-1.11045e-01 3.83750e-03
108 1.85447e-01-1.11045e-01 3.83750e-03
109 5.31297e-01-1.11045e-01 5.40820e-03
110 8.05405e-01-1.11045e-01 4.06806e-03
111 9.70823e-01-1.11045e-01 5.15474e-03
112-9.99313e-01-3.70540e-02 0.00000e+00
113-9.76194e-01-3.70540e-02 5.17107e-03
114-8.09860e-01-3.70540e-02 4.08094e-03
115-5.34236e-01-3.70540e-02 5.42534e-03
116-1.86473e-01-3.70540e-02 3.84965e-03
117 1.86473e-01-3.70540e-02 3.84965e-03
118 5.34236e-01-3.70540e-02 5.42534e-03
119 8.09860e-01-3.70540e-02 4.08094e-03
120 9.76194e-01-3.70540e-02 5.17107e-03
121-6.41230e-02 9.97942e-01 0.00000e+00
122-4.21582e-02 9.97942e-01 1.02900e-03
123 4.21582e-02 9.97942e-01 1.02900e-03
124-1.42963e-01 9.89728e-01 0.00000e+00
125-9.39923e-02 9.89728e-01 3.07825e-03
126 9.39923e-02 9.89728e-01 3.07825e-03
127-2.29252e-01 9.73367e-01 0.00000e+00
128-1.50724e-01 9.73367e-01 5.10200e-03
129 1.50724e-01 9.73367e-01 5.10200e-03
130-3.15291e-01 9.48995e-01 0.00000e+00
131-2.07291e-01 9.48995e-01 7.08425e-03
132 2.07291e-01 9.48995e-01 7.08425e-03
133-3.99349e-01 9.16799e-01 0.00000e+00
134-2.62555e-01 9.16799e-01 9.01350e-03
135 2.62555e-01 9.16799e-01 9.01350e-03
136-4.72796e-01 8.81172e-01 0.00000e+00
137-4.11087e-01 8.81172e-01 5.63869e-03
138-1.43488e-01 8.81172e-01 3.16131e-03
139 1.43488e-01 8.81172e-01 3.16131e-03
140 4.11087e-01 8.81172e-01 5.63869e-03
141-5.37046e-01 8.43553e-01 0.00000e+00
142-4.66952e-01 8.43553e-01 6.41385e-03
143-1.62988e-01 8.43553e-01 3.59590e-03
144 1.62988e-01 8.43553e-01 3.59590e-03
145 4.66952e-01 8.43553e-01 6.41385e-03
146-5.98374e-01 8.01217e-01 0.00000e+00
147-5.20275e-01 8.01217e-01 7.14976e-03
```

148	-1.81600e-01	8.01217e-01	4.00849e-03
149	1.81600e-01	8.01217e-01	4.00849e-03
150	5.20275e-01	8.01217e-01	7.14976e-03
151	-6.56401e-01	7.54412e-01	0.00000e+00
152	-5.70729e-01	7.54412e-01	7.84547e-03
153	-1.99211e-01	7.54412e-01	4.39853e-03
154	1.99211e-01	7.54412e-01	4.39853e-03
155	5.70729e-01	7.54412e-01	7.84547e-03
156	-7.11034e-01	7.03158e-01	0.00000e+00
157	-6.18231e-01	7.03158e-01	8.57529e-03
158	-2.15791e-01	7.03158e-01	4.80771e-03
159	2.15791e-01	7.03158e-01	4.80771e-03
160	6.18231e-01	7.03158e-01	8.57529e-03
161	-7.61567e-01	6.48086e-01	0.00000e+00
162	-7.13133e-01	6.48086e-01	6.42875e-03
163	-4.70428e-01	6.48086e-01	2.93289e-03
164	-1.64201e-01	6.48086e-01	4.79164e-03
165	1.64201e-01	6.48086e-01	4.79164e-03
166	4.70428e-01	6.48086e-01	2.93289e-03
167	7.13133e-01	6.48086e-01	6.42875e-03
168	-8.07567e-01	5.89776e-01	0.00000e+00
169	-7.56207e-01	5.89776e-01	6.81415e-03
170	-4.98843e-01	5.89776e-01	3.10872e-03
171	-1.74119e-01	5.89776e-01	5.07890e-03
172	1.74119e-01	5.89776e-01	5.07890e-03
173	4.98843e-01	5.89776e-01	3.10872e-03
174	7.56207e-01	5.89776e-01	6.81415e-03
175	-8.49108e-01	5.28222e-01	0.00000e+00
176	-7.95106e-01	5.28222e-01	7.16550e-03
177	-5.24503e-01	5.28222e-01	3.26901e-03
178	-1.83075e-01	5.28222e-01	5.34077e-03
179	1.83075e-01	5.28222e-01	5.34077e-03
180	5.24503e-01	5.28222e-01	3.26901e-03
181	7.95106e-01	5.28222e-01	7.16550e-03
182	-8.85925e-01	4.63828e-01	0.00000e+00
183	-8.29582e-01	4.63828e-01	7.45915e-03
184	-5.47246e-01	4.63828e-01	3.40298e-03
185	-1.91013e-01	4.63828e-01	5.55965e-03
186	1.91013e-01	4.63828e-01	5.55965e-03
187	5.47246e-01	4.63828e-01	3.40298e-03
188	8.29582e-01	4.63828e-01	7.45915e-03
189	-9.17890e-01	3.96835e-01	0.00000e+00
190	-8.59514e-01	3.96835e-01	7.75565e-03
191	-5.66991e-01	3.96835e-01	3.53825e-03
192	-1.97905e-01	3.96835e-01	5.78064e-03
193	1.97905e-01	3.96835e-01	5.78064e-03
194	5.66991e-01	3.96835e-01	3.53825e-03
195	8.59514e-01	3.96835e-01	7.75565e-03
196	-9.44812e-01	3.27613e-01	0.00000e+00
197	-9.22954e-01	3.27613e-01	4.89468e-03
198	-7.65692e-01	3.27613e-01	3.86282e-03
199	-5.05099e-01	3.27613e-01	5.13536e-03
200	-1.76303e-01	3.27613e-01	3.64389e-03
201	1.76303e-01	3.27613e-01	3.64389e-03
202	5.05099e-01	3.27613e-01	5.13536e-03
203	7.65692e-01	3.27613e-01	3.86282e-03
204	9.22954e-01	3.27613e-01	4.89468e-03
205	-9.66490e-01	2.56704e-01	0.00000e+00
206	-9.44130e-01	2.56704e-01	5.00102e-03
207	-7.83260e-01	2.56704e-01	3.94674e-03
208	-5.16688e-01	2.56704e-01	5.24693e-03
209	-1.80348e-01	2.56704e-01	3.72306e-03
210	1.80348e-01	2.56704e-01	3.72306e-03
211	5.16688e-01	2.56704e-01	5.24693e-03
212	7.83260e-01	2.56704e-01	3.94674e-03
213	9.44130e-01	2.56704e-01	5.00102e-03
214	-9.82847e-01	1.84425e-01	0.00000e+00
215	-9.60108e-01	1.84425e-01	5.08580e-03
216	-7.96516e-01	1.84425e-01	4.01365e-03
217	-5.25433e-01	1.84425e-01	5.33587e-03
218	-1.83400e-01	1.84425e-01	3.78617e-03
219	1.83400e-01	1.84425e-01	3.78617e-03
220	5.25433e-01	1.84425e-01	5.33587e-03
221	7.96516e-01	1.84425e-01	4.01365e-03
222	9.60108e-01	1.84425e-01	5.08580e-03

```
223-9.93815e-01 1.11045e-01 0.00000e+00
224-9.70823e-01 1.11045e-01 5.15474e-03
225-8.05405e-01 1.11045e-01 4.06806e-03
226-5.31297e-01 1.11045e-01 5.40820e-03
227-1.85447e-01 1.11045e-01 3.83750e-03
228 1.85447e-01 1.11045e-01 3.83750e-03
229 5.31297e-01 1.11045e-01 5.40820e-03
230 8.05405e-01 1.11045e-01 4.06806e-03
231 9.70823e-01 1.11045e-01 5.15474e-03
232-9.99313e-01 3.70540e-02 0.00000e+00
233-9.76194e-01 3.70540e-02 5.17107e-03
234-8.09860e-01 3.70540e-02 4.08094e-03
235-5.34236e-01 3.70540e-02 5.42534e-03
236-1.86473e-01 3.70540e-02 3.84965e-03
237 1.86473e-01 3.70540e-02 3.84965e-03
238 5.34236e-01 3.70540e-02 5.42534e-03
239 8.09860e-01 3.70540e-02 4.08094e-03
240 9.76194e-01 3.70540e-02 5.17107e-03
```

index of each radial flux

```
i flux     index

     1        32
     2        33
     3        34
     4        35
     5        36
     6        37
```

radial and axial mesh points

```
    i       radius      height

    1 1.95000e+04-1.50000e+01
    2 2.45000e+04-5.00000e+00
    3 2.95000e+04 5.00000e+01
    4 3.45000e+04 1.50000e+02
    5 3.95000e+04 2.50000e+02
    6 4.44167e+04 3.50000e+02
    7             4.50000e+02
    8             5.50000e+02
    9             7.50000e+02
   10             1.05000e+03
   11             1.35000e+03
   12             1.65000e+03
   13             1.95000e+03
   14             2.25000e+03
   15             2.86667e+03
```

i	phi	nphi	ncmp	pol	znew	iang
1	-1.57080e+00	2	0	-9.95884e-01	-1.50000e+01	2
2	0.00000e+00	2	2	-9.83571e-01	-5.00000e+00	3
3	-1.57080e+00	2	4	-9.63163e-01	5.00000e+01	5
4	0.00000e+00	2	6	-9.34826e-01	1.50000e+02	6
5	-1.57080e+00	2	8	-8.98772e-01		8
6	0.00000e+00	4	10	-8.63572e-01		9
7	-1.57080e+00	4	14	-8.23533e-01		11
8	0.00000e+00	4	18	-7.78900e-01		12
9	-1.57080e+00	4	22	-7.29924e-01		14
10	0.00000e+00	4	26	-6.76392e-01		15
11	-2.13509e+00	6	30	-6.19779e-01		17
12	-1.57080e+00	6	36	-5.59772e-01		18
13	-1.00650e+00	6	42	-4.96671e-01		19
14	0.00000e+00	6	48	-4.30984e-01		20
15	-2.13509e+00	6	54	-3.62686e-01		22
16	-1.57080e+00	8	60	-2.92539e-01		23
17	-1.00650e+00	8	68	-2.20868e-01		24
18	0.00000e+00	8	76	-1.47982e-01		25
19	-2.13509e+00	8	84	-7.41080e-02		27
20	-1.57080e+00	8	92	0.00000e+00		28
21	-1.00650e+00	8	192	7.41080e-02		29
22	0.00000e+00	8	184	1.47982e-01		30
23	-2.13509e+00	8	176	2.20868e-01		32
24	-1.57080e+00	8	168	2.92539e-01		33
25	-1.00650e+00	8	160	3.62686e-01		34
26	0.00000e+00	6	154	4.30984e-01		35
27	-2.13509e+00	6	148	4.96671e-01		37
28	-1.57080e+00	6	142	5.59772e-01		38
29	-1.00650e+00	6	136	6.19779e-01		39
30	0.00000e+00	6	130	6.76392e-01		40
31	-2.42810e+00	4	126	7.29924e-01		42
32	-2.10259e+00	4	122	7.78900e-01		43
33	-1.57080e+00	4	118	8.23533e-01		44
34	-1.03900e+00	4	114	8.63572e-01		45
35	-7.13492e-01	4	110	8.98772e-01		46
36	0.00000e+00	2	108	9.34826e-01		47
37	-2.42810e+00	2	106	9.63163e-01		49
38	-2.10259e+00	2	104	9.83571e-01		50
39	-1.57080e+00	2	102	9.95884e-01		51
40	-1.03900e+00	2	100	1.00000e+00		52
41	-7.13492e-01					53
42	0.00000e+00					54
43	-2.42810e+00					56
44	-2.10259e+00					57
45	-1.57080e+00					58
46	-1.03900e+00					59
47	-7.13492e-01					60
48	0.00000e+00					61
49	-2.42810e+00					63
50	-2.10259e+00					64
51	-1.57080e+00					65
52	-1.03900e+00					66
53	-7.13492e-01					67
54	0.00000e+00					68
55	-2.42810e+00					70
56	-2.10259e+00					71
57	-1.57080e+00					72
58	-1.03900e+00					73
59	-7.13492e-01					74
60	0.00000e+00					75
61	-2.70317e+00					77
62	-2.35717e+00					78
63	-1.89719e+00					79
64	-1.57080e+00					80
65	-1.24441e+00					81
66	-7.84424e-01					82
67	-4.38425e-01					83
68	0.00000e+00					84
69	-2.70317e+00					86
70	-2.35717e+00					87
71	-1.89719e+00					88
72	-1.57080e+00					89
73	-1.24441e+00					90
74	-7.84424e-01					91

75-4.38425e-01	92
76 0.00000e+00	93
77-2.70317e+00	95
78-2.35717e+00	96
79-1.89719e+00	97
80-1.57080e+00	98
81-1.24441e+00	99
82-7.84424e-01	100
83-4.38425e-01	101
84 0.00000e+00	102
85-2.70317e+00	104
86-2.35717e+00	105
87-1.89719e+00	106
88-1.57080e+00	107
89-1.24441e+00	108
90-7.84424e-01	109
91-4.38425e-01	110
92 0.00000e+00	111
93-2.70317e+00	113
94-2.35717e+00	114
95-1.89719e+00	115
96-1.57080e+00	116
97-1.24441e+00	117
98-7.84424e-01	118
99-4.38425e-01	119
100 0.00000e+00	120
101-1.57080e+00	122
102 0.00000e+00	123
103-1.57080e+00	125
104 0.00000e+00	126
105-1.57080e+00	128
106 0.00000e+00	129
107-1.57080e+00	131
108 0.00000e+00	132
109-1.57080e+00	134
110 0.00000e+00	135
111-2.13509e+00	137
112-1.57080e+00	138
113-1.00650e+00	139
114 0.00000e+00	140
115-2.13509e+00	142
116-1.57080e+00	143
117-1.00650e+00	144
118 0.00000e+00	145
119-2.13509e+00	147
120-1.57080e+00	148
121-1.00650e+00	149
122 0.00000e+00	150
123-2.13509e+00	152
124-1.57080e+00	153
125-1.00650e+00	154
126 0.00000e+00	155
127-2.13509e+00	157
128-1.57080e+00	158
129-1.00650e+00	159
130 0.00000e+00	160
131-2.42810e+00	162
132-2.10259e+00	163
133-1.57080e+00	164
134-1.03900e+00	165
135-7.13492e-01	166
136 0.00000e+00	167
137-2.42810e+00	169
138-2.10259e+00	170
139-1.57080e+00	171
140-1.03900e+00	172
141-7.13492e-01	173
142 0.00000e+00	174
143-2.42810e+00	176
144-2.10259e+00	177
145-1.57080e+00	178
146-1.03900e+00	179
147-7.13492e-01	180
148 0.00000e+00	181
149-2.42810e+00	183

150-2.10259e+00	184
151-1.57080e+00	185
152-1.03900e+00	186
153-7.13492e-01	187
154 0.00000e+00	188
155-2.42810e+00	190
156-2.10259e+00	191
157-1.57080e+00	192
158-1.03900e+00	193
159-7.13492e-01	194
160 0.00000e+00	195
161-2.70317e+00	197
162-2.35717e+00	198
163-1.89719e+00	199
164-1.57080e+00	200
165-1.24441e+00	201
166-7.84424e-01	202
167-4.38425e-01	203
168 0.00000e+00	204
169-2.70317e+00	206
170-2.35717e+00	207
171-1.89719e+00	208
172-1.57080e+00	209
173-1.24441e+00	210
174-7.84424e-01	211
175-4.38425e-01	212
176 0.00000e+00	213
177-2.70317e+00	215
178-2.35717e+00	216
179-1.89719e+00	217
180-1.57080e+00	218
181-1.24441e+00	219
182-7.84424e-01	220
183-4.38425e-01	221
184 0.00000e+00	222
185-2.70317e+00	224
186-2.35717e+00	225
187-1.89719e+00	226
188-1.57080e+00	227
189-1.24441e+00	228
190-7.84424e-01	229
191-4.38425e-01	230
192 0.00000e+00	231
193-2.70317e+00	233
194-2.35717e+00	234
195-1.89719e+00	235
196-1.57080e+00	236
197-1.24441e+00	237
198-7.84424e-01	238
199-4.38425e-01	239
200 0.00000e+00	240

the morse case was run with ingb = 0

group structure and source spectrum

group	energy	unnormalized source spectrum	bias function
1	1.9640e+07	1.0000e+00	5.0000e-01
2	1.0000e+07	1.0000e+00	5.0000e-01

```
2 neutron - 0 gamma flat response input

nd= 84, nne=  2, ng=  2, nt=  0, na=  0, nresp=  2, nex=  0, nexnd=  1


 group        resp( 1)        resp( 2)
     1      1.0000e+00      6.0000e-09
     2      1.0000e+00      5.0000e-09

        number of primary energy bins     2
        total number of energy bins       2
           lower    lower
bin no.    limit    energy        delta
           group    limit           e

                  1.964e+07
   1          1   1.000e+07    9.640e+06
   2          2   6.376e+06    3.624e+06

      number of time bins   0

       number of angle bins   0
upper limits of cosine bins


 2192 cells used by analysis,   45258 cells remain unused.

first storage location used for fluxes is      4743
 last storage location used for fluxes is     14342
calculation performed in     1 blocks with     2 groups per block




morse leakage by batch and total

        1000        1000        1000        1000        1000        1000        1000        1000        1000        1000
        1000        1000        1000        1000        1000        1000        1000        1000        1000        1000
        1000        1000        1000        1000        1000       25000

The number of leakage data records in the file is     425




                             group structure and free field spectra for response no.     1
           xo=  2.4556e+04     zo=  0.0000e+00     case no.     1     orientation angle=      45.000 deg.

group          energy                          fluence                          free field dose

  1        1.9640e+07                        1.1180e-11                           1.1180e-11
  2        1.0000e+07                        3.1163e-12                           3.1163e-12

free field neutron flux =   1.4297e-11     free field photon flux =     0.0000e+00     free field total flux =     1.4297e-11

free field neutron dose =   1.4297e-11     free field photon dose =     0.0000e+00     free field total dose =     1.4297e-11
```

group structure and free field spectra for response no. 2

xo= 2.4556e+04 zo= 0.0000e+00 case no. 1 orientation angle= 45.000 deg.

group	energy	fluence	free field dose
1	1.9640e+07	1.1180e-11	6.7082e-20
2	1.0000e+07	3.1163e-12	1.5582e-20

free field neutron flux = 1.4297e-11 free field photon flux = 0.0000e+00 free field total flux = 1.4297e-11

free field neutron dose = 8.2664e-20 free field photon dose = 0.0000e+00 free field total dose = 8.2664e-20

mash 2n/0g group flat response

responses(detector) -- 1=neut 2=veh n-g 3=grd n-g 4=photons
for case no. 1 orientation angle= 45.000 deg.

detector	uncoll response	fsd uncoll	total response	fsd total
1	0.0000e+00	0.00000	1.4310e-11	0.02980
2	0.0000e+00	0.00000	0.0000e+00	0.00000
3	0.0000e+00	0.00000	0.0000e+00	0.00000
4	0.0000e+00	0.00000	0.0000e+00	0.00000
5	0.0000e+00	0.00000	0.0000e+00	0.00000
6	0.0000e+00	0.00000	0.0000e+00	0.00000
7	0.0000e+00	0.00000	1.4310e-11	0.02980

protection factor (neutrons) = 9.9908e-01
protection factor (photons) = 0.0000e+00
protection factor (total) = 9.9908e-01

reduction factor (neutrons) = 9.9908e-01
reduction factor (photons) = 0.0000e+00
reduction factor (total) = 9.9908e-01

dose rate (rd/h/(n/cm**2.s))

responses(detector) -- 1=neut 2=veh n-g 3=grd n-g 4=photons
for case no. 1 orientation angle= 45.000 deg.

detector	uncoll response	fsd uncoll	total response	fsd total
1	0.0000e+00	0.00000	8.2736e-20	0.03069
2	0.0000e+00	0.00000	0.0000e+00	0.00000
3	0.0000e+00	0.00000	0.0000e+00	0.00000
4	0.0000e+00	0.00000	0.0000e+00	0.00000
5	0.0000e+00	0.00000	0.0000e+00	0.00000
6	0.0000e+00	0.00000	0.0000e+00	0.00000
7	0.0000e+00	0.00000	8.2736e-20	0.03069

protection factor (neutrons) = 9.9913e-01
protection factor (photons) = 0.0000e+00
protection factor (total) = 9.9913e-01

reduction factor (neutrons) = 9.9913e-01
reduction factor (photons) = 0.0000e+00
reduction factor (total) = 9.9913e-01

fluence(energy,detector) energy group totals
for case no. 1 orientation angle= 45.000 deg.

energies	direct neutron	capture photons from vehicle	capture photon source from ground	direct photons	sum of all photons	photon source entering vehicle
1.964e+07						
	1.119e-11 0.037	0.000e+00 0.000	0.000e+00 0.000	0.000e+00 0.000	0.000e+00 0.000	0.000e+00 0.000
1.000e+07						
	3.123e-12 0.016	0.000e+00 0.000	0.000e+00 0.000	0.000e+00 0.000	0.000e+00 0.000	0.000e+00 0.000
6.376e+06						

normalized fluence spectra per unit lethargy
for case no. 1 orientation angle= 45.000 deg.

energies	neutrons	photons
1.964e+07		
	1.15818e+00 0.037	0.00000e+00 0.000
1.000e+07		
	4.84996e-01 0.016	0.00000e+00 0.000
6.376e+06		

dose spectra(energy,detector)
for response no. 2 for case no. 1 orientation angle= 45.000 deg.

energies	direct neutron	capture photons from vehicle	capture photon source from ground	direct photons	sum of all photons	photon source entering vehicle
1.964e+07						
	6.712e-20 0.037	0.000e+00 0.000	0.000e+00 0.000	0.000e+00 0.000	0.000e+00 0.000	0.000e+00 0.000
1.000e+07						
	1.562e-20 0.016	0.000e+00 0.000	0.000e+00 0.000	0.000e+00 0.000	0.000e+00 0.000	0.000e+00 0.000
6.376e+06						

normalized dose spectra per unit lethargy for response 2
for case no. 1 orientation angle= 45.000 deg.

energies	neutrons	photons
1.964e+07		
	1.20190e+00 0.037	0.00000e+00 0.000
1.000e+07		
	4.19419e-01 0.016	0.00000e+00 0.000
6.376e+06		

extra arrays of length nod= 7

25000 0 0 0 0 0 25000

group structure and free field spectra for response no. 1

xo= 2.4556e+04 zo= 0.0000e+00 case no. 2 orientation angle= 270.000 deg.

group	energy	fluence	free field dose
1	1.9640e+07	1.1180e-11	1.1180e-11
2	1.0000e+07	3.1163e-12	3.1163e-12

free field neutron flux = 1.4297e-11 free field photon flux = 0.0000e+00 free field total flux = 1.4297e-11

free field neutron dose = 1.4297e-11 free field photon dose = 0.0000e+00 free field total dose = 1.4297e-11

group structure and free field spectra for response no. 2

xo= 2.4556e+04 zo= 0.0000e+00 case no. 2 orientation angle= 270.000 deg.

group	energy	fluence	free field dose
1	1.9640e+07	1.1180e-11	6.7082e-20
2	1.0000e+07	3.1163e-12	1.5582e-20

free field neutron flux = 1.4297e-11 free field photon flux = 0.0000e+00 free field total flux = 1.4297e-11

free field neutron dose = 8.2664e-20 free field photon dose = 0.0000e+00 free field total dose = 8.2664e-20 mash 2n/0g group flat response

responses(detector) -- 1=neut 2=veh n-g 3=grd n-g 4=photons
for case no. 2 orientation angle= 270.000 deg.

detector	uncoll response	fsd uncoll	total response	fsd total
1	0.0000e+00	0.00000	1.4164e-11	0.02676
2	0.0000e+00	0.00000	0.0000e+00	0.00000
3	0.0000e+00	0.00000	0.0000e+00	0.00000
4	0.0000e+00	0.00000	0.0000e+00	0.00000
5	0.0000e+00	0.00000	0.0000e+00	0.00000
6	0.0000e+00	0.00000	0.0000e+00	0.00000
7	0.0000e+00	0.00000	1.4164e-11	0.02676

protection factor (neutrons) = 1.0094e+00
protection factor (photons) = 0.0000e+00
protection factor (total) = 1.0094e+00

reduction factor (neutrons) = 1.0094e+00
reduction factor (photons) = 0.0000e+00
reduction factor (total) = 1.0094e+00

dose rate (rd/h/(n/cm**2.s))

responses(detector) -- 1=neut 2=veh n-g 3=grd n-g 4=photons
for case no. 2 orientation angle= 270.000 deg.

detector	uncoll response	fsd uncoll	total response	fsd total
1	0.0000e+00	0.00000	8.1800e-20	0.02794
2	0.0000e+00	0.00000	0.0000e+00	0.00000
3	0.0000e+00	0.00000	0.0000e+00	0.00000
4	0.0000e+00	0.00000	0.0000e+00	0.00000
5	0.0000e+00	0.00000	0.0000e+00	0.00000
6	0.0000e+00	0.00000	0.0000e+00	0.00000
7	0.0000e+00	0.00000	8.1800e-20	0.02794

protection factor (neutrons) = 1.0106e+00
protection factor (photons) = 0.0000e+00
protection factor (total) = 1.0106e+00

reduction factor (neutrons) = 1.0106e+00
reduction factor (photons) = 0.0000e+00
reduction factor (total) = 1.0106e+00

fluence(energy,detector) energy group totals
for case no. 2 orientation angle= 270.000 deg.

energies	direct neutron	capture photons from vehicle	capture photon source from ground	direct photons	sum of all photons	photon source entering vehicle
1.964e+07						
	1.098e-11	0.000e+00	0.000e+00	0.000e+00	0.000e+00	0.000e+00
	0.036	0.000	0.000	0.000	0.000	0.000
1.000e+07						
	3.182e-12	0.000e+00	0.000e+00	0.000e+00	0.000e+00	0.000e+00
	0.016	0.000	0.000	0.000	0.000	0.000
6.376e+06						

normalized fluence spectra per unit lethargy
for case no. 2 orientation angle= 270.000 deg.

energies	neutrons	photons
1.964e+07		
	1.14870e+00	0.00000e+00
	0.036	0.000
1.000e+07		
	4.99218e-01	0.00000e+00
	0.016	0.000
6.376e+06		

dose spectra(energy,detector)
for response no. 2 for case no. 2 orientation angle= 270.000 deg.

energies	direct neutron	capture photons from vehicle	capture photon source from ground	direct photons	sum of all photons	photon source entering vehicle
1.964e+07						
	6.589e-20 0.036	0.000e+00 0.000	0.000e+00 0.000	0.000e+00 0.000	0.000e+00 0.000	0.000e+00 0.000
1.000e+07						
	1.591e-20 0.016	0.000e+00 0.000	0.000e+00 0.000	0.000e+00 0.000	0.000e+00 0.000	0.000e+00 0.000
6.376e+06						

normalized dose spectra per unit lethargy for response 2
for case no. 2 orientation angle= 270.000 deg.

energies	neutrons	photons
1.964e+07		
	1.19338e+00 0.036	0.00000e+00 0.000
1.000e+07		
	4.32197e-01 0.016	0.00000e+00 0.000
6.376e+06		

extra arrays of length nod= 7

25000	0	0	0	0	0	25000

group structure and free field spectra for response no. 1
xo= 3.3000e+04 zo= 0.0000e+00 case no. 3 orientation angle= 60.000 deg.

group	energy	fluence	free field dose
1	1.9640e+07	6.4969e-12	6.4969e-12
2	1.0000e+07	1.9697e-12	1.9697e-12

free field neutron flux = 8.4666e-12 free field photon flux = 0.0000e+00 free field total flux = 8.4666e-12

free field neutron dose = 8.4666e-12 free field photon dose = 0.0000e+00 free field total dose = 8.4666e-12

group structure and free field spectra for response no. 2
xo= 3.3000e+04 zo= 0.0000e+00 case no. 3 orientation angle= 60.000 deg.

group	energy	fluence	free field dose
1	1.9640e+07	6.4969e-12	3.8982e-20
2	1.0000e+07	1.9697e-12	9.8484e-21

free field neutron flux = 8.4666e-12 free field photon flux = 0.0000e+00 free field total flux = 8.4666e-12

free field neutron dose = 4.8830e-20 free field photon dose = 0.0000e+00 free field total dose = 4.8830e-20 mash 2n/0g group flat response

responses(detector) -- 1=neut 2=veh n-g 3=grd n-g 4=photons
for case no. 3 orientation angle= 60.000 deg.

detector	uncoll response	fsd uncoll	total response	fsd total
1	0.0000e+00	0.00000	8.4024e-12	0.03515
2	0.0000e+00	0.00000	0.0000e+00	0.00000
3	0.0000e+00	0.00000	0.0000e+00	0.00000
4	0.0000e+00	0.00000	0.0000e+00	0.00000
5	0.0000e+00	0.00000	0.0000e+00	0.00000
6	0.0000e+00	0.00000	0.0000e+00	0.00000
7	0.0000e+00	0.00000	8.4024e-12	0.03515

protection factor (neutrons) = 1.0076e+00
protection factor (photons) = 0.0000e+00
protection factor (total) = 1.0076e+00

reduction factor (neutrons) = 1.0076e+00
reduction factor (photons) = 0.0000e+00
reduction factor (total) = 1.0076e+00

dose rate (rd/h/(n/cm**2.s))

responses(detector) -- 1=neut 2=veh n-g 3=grd n-g 4=photons
for case no. 3 orientation angle= 60.000 deg.

detector	uncoll response	fsd uncoll	total response	fsd total
1	0.0000e+00	0.00000	4.8425e-20	0.03635
2	0.0000e+00	0.00000	0.0000e+00	0.00000
3	0.0000e+00	0.00000	0.0000e+00	0.00000
4	0.0000e+00	0.00000	0.0000e+00	0.00000
5	0.0000e+00	0.00000	0.0000e+00	0.00000
6	0.0000e+00	0.00000	0.0000e+00	0.00000
7	0.0000e+00	0.00000	4.8425e-20	0.03635

protection factor (neutrons) = 1.0084e+00
protection factor (photons) = 0.0000e+00
protection factor (total) = 1.0084e+00

reduction factor (neutrons) = 1.0084e+00
reduction factor (photons) = 0.0000e+00
reduction factor (total) = 1.0084e+00

fluence(energy,detector) energy group totals
for case no. 3 orientation angle= 60.000 deg.

energies	direct neutron	capture photons from vehicle	capture photon source from ground	direct photons	sum of all photons	photon source entering vehicle
1.964e+07						
	6.413e-12	0.000e+00	0.000e+00	0.000e+00	0.000e+00	0.000e+00
	0.044	0.000	0.000	0.000	0.000	0.000
1.000e+07						
	1.989e-12	0.000e+00	0.000e+00	0.000e+00	0.000e+00	0.000e+00
	0.016	0.000	0.000	0.000	0.000	0.000
6.376e+06						

normalized fluence spectra per unit lethargy
for case no. 3 orientation angle= 60.000 deg.

energies	neutrons	photons
1.964e+07		
	1.13083e+00 0.044	0.00000e+00 0.000
1.000e+07		
	5.26028e-01 0.016	0.00000e+00 0.000
6.376e+06		

dose spectra(energy,detector)
for response no. 2 for case no. 3 orientation angle= 60.000 deg.

energies	direct neutron	capture photons from vehicle	capture photon source from ground	direct photons	sum of all photons	photon source entering vehicle
1.964e+07						
	3.848e-20 0.044	0.000e+00 0.000	0.000e+00 0.000	0.000e+00 0.000	0.000e+00 0.000	0.000e+00 0.000
1.000e+07						
	9.945e-21 0.016	0.000e+00 0.000	0.000e+00 0.000	0.000e+00 0.000	0.000e+00 0.000	0.000e+00 0.000
6.376e+06						

normalized dose spectra per unit lethargy for response 2
for case no. 3 orientation angle= 60.000 deg.

energies	neutrons	photons
1.964e+07		
	1.17727e+00 0.044	0.00000e+00 0.000
1.000e+07		
	4.56361e-01 0.016	0.00000e+00 0.000
6.376e+06		

extra arrays of length nod= 7

25000	0	0	0	0	0	25000

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normalized dose spectra per unit lethargy for response 2
for case no. 12 orientation angle= 330.000 deg.

energies	neutrons	photons
1.964e+07		
	1.15327e+00 0.028	0.00000e+00 0.000
1.000e+07		
	4.92370e-01 0.019	0.00000e+00 0.000
6.376e+06		

extra arrays of length nod= 7

25000	0	0	0	0	0	25000

This case ended on June 6, 1991 at 14:15:17.

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