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A VERSION OF THE MORSE MULTIGROUP TRANSPORT CODE FOR FUSION REACTORS BLANKETS AND SHIELDS STUDIES

Magdi M. Ragheb and Charles W. Maynard

August 30, 1975

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Magdi M. Ragheb and Charles W. Maynard

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#### ABSTRACT

A guide for the use of a new version of the Morse Monte Carlo Multigroup neutron and gamma ray transport code with combinatorial geometry is presented. This version is in current use for neutronics studies of blankets and shields for fusion power reactors designs. A benchmark problem treating a cell calculation for a fusion reactor blanket and shield design , is presented. The modifications introduced to the different routines, the deck organization for the CDC-7600 computer system, a sample problem input and output, and a set of recommendations are given.

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### 1. Introduction

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This work is a documentation for a new version of the MORSE Monte Carlo code (1) used by the Fusion Technology group at the Department of Nuclear Engineering, the University of Wisconsin, (2, 3) and at the Department of Applied Science, Brookhaven National Laboratory <sup>(4)</sup>. The version distributed by the Radiation Shielding Information Center (RSIC) is set up for the solution of a sample problem for a point source in an infinite air medium with spherical geometry. After some modifications, the code has been successfully used for general geometries for blanket and shield neutronics studies for fusion power reactor designs. The present work concerns the use of the CDC-7600. A benchmark problem relating to a unit cell computation is used as an illustration for the necessary modifications and the corresponding input and output data for the code.

A discussion of future possible modifications to the code regarding a better implementation on the CDC-7500 and the analysis of geometrical shapes not presently implemented is given.

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#### 2. The MORSE Monte Carlo code with Combinational Geometry

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The MORSE (Multigroup Oak Ridge Stochastic Experiment) code <sup>(1)</sup> is being used in applications for which it was not originally written, and this entails much revision and continuous development of the code. It has the ability to treat the transport of either neutrons or gamma rays or a coupled neutron and secondary gamma ray problem. There are options of the code for the IBM-360, UNIVAC-1108, and CDC-6600, which are distributed by RSIC. The version described in this report has been used on a CDC-7600.

The combinational geometry option of the MORSE code has been recognized to be of great use. It depends on describing general three dimensional configurations by considering unions and intersections of simple bodies such as spheres, parallelepipeds, cylinders; etc.

A preparation of a problem for solution by the code requires: setting up a model, describing it by the combinational geometry technique, checking the geometry input with the PICTURE routine, preparing cross-sections data for input to the MORSEC module, preparing analysis data for input to the SAMBO module, and random-walk data. User routines may be required to be written for each problem.

-2-

Either the forward or adjoint mode can be used, and time dependence is provided for shielding and criticality problems, Multigroup cross-sections are accepted in either ANISN or DTF-IV formats, and anisotropic scattering is treated for each group to group transfer by a generalized Gaussian guadrature technique.

# 3. <u>Modifications introduced to MORSE routines in the</u> present version

The following corrections and modifications were introduced to the latest updated version of MORSE <sup>(1)</sup>:CCC-203B and distributed by RSIC on July, 1975. Both permanent and problem-dependent modifications are presented:

#### 3.1 Program MORSER

The statements:

COMMON	NC ()	MAIN1-6
NLFT =		MAIN1-29

Should be modified according to the needed size for the blank common area. For moderate size problems, the blank common area fits into the short core memory (SCM) of the CDC-7600, but for larger size problems, since the CDC-7600 lacks the facility of virtual memory, a larger blank common area could be fitted into the large core memory (LCM).

However, this would require modifying the corresponding routines. In addition, overlays could be used to reduce the required field length.

The statement:

COMMON/FISBNK/MFISTP (6) MAIN1-13

is modified to:

COMMON/FISBNK/MFISTP (6) MAIN1-13,

an apparently punching error.

3.2 ENDRUN Routine

The statement:

DATA MMED/20\*1/ ENDRU-27

is in the MORSE code for the sample problem of a point fission source in air. For problems with more than one medium, MMED should contain the media numbers corresponding to the different regions.

Preceding the first call to NSIGTA, a statement of the form: IF(NREG.EQ. --....) GO TO 86 is added to exclude regions containing media without stored crosssections. Following Statement #85 these two statements are added:

> GO TO 90 86 WTS(L) = 0.0

> > -4-

Similarly, preceding the second call to NSIGTA, we add:

د در این از میکنون از در ۱۹۵۰ می وده برده برده میشود. این در وارد بر در وارد میشود میکنون برده این از میتورد و در میکنون برده این و در ا

IF (NREG.EQ. -- .....) GO TO 101 and the statement 100 is followed by:

GO TO 105

101 WTS(L) = 0.0

3.3 GENI Routine

When the MA-array is needed for checking the geometry specifications, its listing can be obtained by deleting the statement:

IF (IDBG.EQ.O) RETURN GENI-148

3.4 GETMUS Routine

The present coding does not allow the possibility of using  $P_1$ -anisotropy. This can be corrected by inserting the statement:

IF (NMOM.EQ.1) GO TO 55

just after the computation of:

A(1,1) = -MOMENT(1) GETMU-30

3.5 GTMED Routine

1

Replacing the Statement:

MDXSEC = ]. GTMED-3

by: MDXSEC = MDGEOM GTMED-3

sets the cross-section medium to be the same as the geometry medium.

#### 3.6 INSCOR Routine

The routine is modified from its original use for spherical geometry to treat a general geometry. The following comment is inserted:

C THAT VERSION FOR THE GENERAL GEOMETRY READS THE REGION

C DETECTORS VOLUMES AND COMPUTES THEIR RECIPROCALS

C NDC IS LAST BOUNDARY CROSSING DETECTOR

C VV (I), I=1, ND ARE REGION DETECTOR VOLUMES

The vector VV(I) is dimensioned:

DIMENSION VV(21)

and the VV(I) are read, after NDC is read, by the statements:

READ (I1, 102) (VV(I), I = 1, ND)

102 FORMAT (8E10.4)

The statements from 5 to 12 are deleted, and replaced by:

5 BC(LF) = 1./VV(ID-1)

3.7 NSIGTA Routine

Inserting the statement:

IF (MED. EQ. 1000. OR.MED.EQ.0) GO TO 11 after the call to GTMED, results in excluding the computation of TSIG and PNAB when treating internal and external void regions.

-6-

Also, the following statements are inserted after statement 55:

GO TO 12 11 TSIG = 0.0PNAB = 0.0

and the three statements following the EQUIVALENCE:

IF (PNAB + 1.0) 3,1,3 NSIGT-18 1 MED = JMED NSIGT-19 GO TO 5 NSIGT-20

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are deleted. The RETURN statement is changed to: 12 RETURN NSIGT-45

#### 3.8 SOURCE Routine

This routine samples from an input frequency distribution function for the angular distribution of the source, and determines the direction cosines U,V,W. It also determines the coordinates of the source X,Y,Z when needed to follow a specified distribution. The routine has thus to be modified for each problem. As listed below, the routine uses the rejection method to sample for the source coordinates and the angular distribution. More efficient sampling can be achieved by construction of cumulative distributions. The following routine was used to sample from a discrete angular distribution of

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the neutron wall loading for a typical tokamak with a circular cross-section in the neutronics calculations of a modular blanket unit cell. Details of the problem will be included in a future publication.

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SUBACUTINE SOURCE(IG+U+V+W+X+Y+Z+WATE+MED+AG+ISOUR+ITSTR+NGPQT3+
                  1 DDF. ISBIAS. NHTG)
  С
  č
              IF ITSTROO. MUST PHUVIDE IG, X, Y, Z, U, V, W, WATE AND AG IF DESINED TO BE
                   UIFFERENT FROM CAND VALUES (WHICH ARE THE VALUES INPUT TO SOURCE)
F [ISTN#1, 10 IS THE GRP ND, CAUSING FISSION, MUST PROVIDE NEW IG
THIS VERSION OF SOURCE SELECTS INITIAL GROUP FROM THE INPUT SPEC
  C
  С
               1F
  c
                     DIMENSION FOF (50)
  С
                     COMMON /USER/ DUM(9),10,11,100#(12)
Common wTS(1)
                   DATA JCALL/1/
DATA PYE/3,14159/
                     IF (ICALL) 10.10.5
                IF (LULL) INTERVENTION IT ALL \alpha of the second se
    5
  1000
  C
             READING OF SOURCE DISTRIBUTION FUNCTION DATA
LOWER LIMITEAA UPPER LIMITEBU
 C
                                                                                                                                                         N.OF SUBDIVISIONS=NN
 c
NEAU(11.1002) AA
1002 FORMAT(2E14.8.15)
C
                   HEAD (11.1002)
                                                                 AL. BB.NN
 ĉ
                      READ UNNORMALIZED F.D.F.
                   HEAD(11+1003)(FDF(1)+1=1+NN)
   UPYE=2.0.F E
                   ANNENN
                   HNGEHH-AA
                   DELTA=RNG/ANN
 с
с
                     FIND MAX OF FOF (FMAX)
ċ
                                                I=1.NN
3 GO TO 1202
                  DO 1201
                   1F (1.E0.1)
                   11=1
                   IF (FDF (1) .GT.FDF (11) FHAX=FDF (1)
   GO TO 1201
1202 FMAA=FDF(1)
   1201 CONTINUE
C
CHECSING COUNDINATES OF SUUNCE PARTICLES
          10 Z=40.0
      103 X=RANF (0)+36.9504
                  Y=RANF(0)+32.0
IF(X.GT.18.4752) GD TO 101
                  GO TU 102
      101 XDU#=64.0-1.732+X
                  IF (Y.GT. XOUM) 80 TO 103
CHCOSING ANGULAR PARAMETERS FOR SOURCE PARTICLE
2
      102 HINHNGOFLINNF(0)
                  RZEFHAK FLTHNF (0)
```

c	
ċ	DETERMINE INTERVAL NUMBER FOR COS THETA
c	
	1=(61/DELTA)+.99
	1F(R2.LE.FUF(1)) GD 70 1203
	50 7C 102
1203	w=AA+R1
	xUuM=ACCS (w)
	xoup=sin (xuum)
	R2=DPYE•FLTRNF(0)
	U=xDu++CU5 (R2)
	V=x0UM+\$1N(R2)
	1F(150UR))5,15,60
C 10	) IF (150UR) 15,15,60
15	WATE=00F
	IF (ISBIAS) 20+20+25
20	NWT = 24NMTG
	GO TO 30
25	NRT = 3+NHTG
30	R = FLTRNF(R)
	DU 35 I=1.NGPOT3
	IF (R - #75(1+N#T)) 40,40+35
35	CONTINUE
40	1G=1
	1F (158145) 60.60.45
45	1F (I-1) 60.50.55
50	WATE # WATEBUTS(20NMTG+1)/WTS(30NMTG+1)
	60 TO 60
55	WATE # BATEO (#TS (20NMTG+11+#TS (20NMTG+1-1))/(#TS (30NMTG+1)-#TS (30
	1MTG+1-1);
60	RETURN
	END

#### 4. The PICTURE Routine

This routine is used as an aid in preparing correct input for the combinational geometry package. PICTURE <sup>(1)</sup> displays two-dimensional cuts through the specified threedimensional geometry. Media, regions, or zones may be displayed according to debugging needs. PICTURE uses two related subroutines: PRINT and MESH. Other subroutines from the MORSE package are also called as shown in the hierarchy of subroutines in Figure 1. Figures 2 and 3 show a two-dimensional cut through the geometry of the blanket unit cell for the benchmark problem treated in that report.

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Figure 1 . Hiearchy of subroutines in the PICTURE program

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Figure 2. Output of PICTURE for a vertical cut through the blanket and shield unit cell.

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JJJ	າງງ	JJ'	JJ	JJ	JJ	JJ	JJ	ມ.	JJ.	JJ	JJ	υ,	'n.	ມ	IJ,	JJ,	JJ,	JJ	JJ	JJ	JJ	JJ	JJ	IJJ	IJJ	JJ	JJ,	JJ'	'n,	JJ,	JJJ	ມ	JJJ	JJr	JJJ'	JJ
JJ.	JJJ	JJ,	JJ	JJ	JJ	JJ	JJ	IJ,	JJ	JJ	JJ	JJ.	JJ.	'n,	JJ,	JJ,	JJ	JJ	JJ	JJ	JJ	JJ	JJ	IJJ	IJJ	JJ	JJ	JJ,	JJ,	JJ.	JJ	IJ,	JJJ	JJ'	າງງ	JJ
JJ	้าาา	JJ'	JJ	JJ	JJ	JJ	JJ	IJ,	JJ	JJ	JJ	J.J.	IJ,	'n,	17	'n.	JJ.	JJ	JJ	JJ	JJ	JJ	IJJ	IJJ	JJ	JJ	JJ	JJ'	'n,	JJ.	JJJ	ມ	າງງ	JJ.	າງງ	JJ
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JJJ	າງງ	JJ'	JJ	JJ,	JJ	JJ	JJ	IJ,	JJ.	JJ	JJ	ມ.	JJ,	'n,	'n,	JJ'	JJ.	JJ	JJ	JJ	JJ	JJ	JJ	IJJ	JJ	JJ	J	JJ'	'n.	JJ,	JJJ	IJ,	JJJ	JJ	JJJ'	JJ
JJJ	JJJ	JJ'	JJ	JJ,	JJ	JJ	JJ	JJ,	JJ.	JJ	JJ	JJ.	'n,	'n,	'n,	'n.	JJ,	JJ	JJ	JJ	JJ	JJ	JJ	IJJ	JJ	JJ	JJ,	JJ,	JJ,	JJ,	JJJ	IJ,	JJJ	JJJ	177,	JJ
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JJJ	JJJ	JJ'	JJ	JJ,	JJ	JJ	JJ	IJ.	JJ,	JJ	JJ	J.	JJ,	'n,	JJ,	JJ,	JJ.	JJ.	JJ	JJ	JJ	JJ	JJ	JJ	JJ	JJ	JJ,	JJ,	JJ.	IJ,	JJJ	IJJ	JJJ	JJJ	IJJ,	JJ

Figure 3 . Output of PICTURE for a horizontal cut through the blanket and shield unit cell .

#### 5. Deck Organization for the CDC-7600

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For this Benchmark problem, the blank common area is considered as fitting into short core memory (SCM). A file MRS is attached containing the source routines, and changes to different routines are introduced by use of UPDATE <sup>(5)</sup>. A program library MORSELIB containing the object decks, of routines which were not updated, is then attached to the run. The UPDATE correction cards follow, and then the input data to MORSE. The CDC-7600 control cards, and the UPDATE correction cards are listed below, according to the modifications explained in section 4 for the benchmark problem.

MAGUI.CH70.T100.P666. ACCOUNT (LAZARETH . 128) MAP (ON) ATTACH, OLDPL, MRS, ID=LAZARETH. UPDATE. FTN(I,A) ATTACH ( LIB, MURSELIB, ID=LAZARETH) FILE MORSELIB (CATALOGUED) LIBRARY (LIB) L00. .ID,CORRECT #U:MAINI.6 C COWMON NC (22000) COMMON NC (33000) #0.MAIN1.13 COMMON/F158NK/MF1STP(6) Ć COMMON/FISBNK/PFISTP(6) \*U,MAIN1.29 C NLFT=22000 NLFT= 33000 .U.ENDRU.27 DATA MMED/20+1/ DATA MMED/1000.1.2.3.4.4.4.4.3.7.1.1.5.5.6.6.1.1000.8.0/ \*1.ENDRU.104 60 TO 86 IF (NREG.EG. 1.OH.NREG.GE.18) \*I.ENDHU.111 GU TO 90 86 #TS(L)=0.0 41.ENDHU.117 GO TO 101 IF (NREG. EQ. 1. OF .NHEG. GE. 18) +1. ENDRU. 124 GO TO 105 101 #75(L)=0.0 -13-

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```
+D.GENI.148
       IF (IDBG.EG.U) HETURN
 С
 +1.GETHU.30
        IF (NMOM.EC.1) GO TO 55
 +U.GTMEU.3
С
        MDXSEC=1
        MDXSEC=MDGEUM
                                  .
+1,1NSC0,2
С
            THAT VERSION FOR THE GENERAL GEOMETRY HEADS THE REGION
           DETECTORS VOLUMES AND COMPUTES THEIR RECIPHUCALS
С
                          IS LAST BOUNDARY CRUSSING DETECTOR
C
            NDC
                                       ARE REGION DETECTOR VOLUMES
           VV(I),I=1,ND
C
#1.1NSC0.13
        DIMENSION VV(21)
*1.INSC0.15
        READ(11+102) (VV(I)+I=1+ND)
   102 FORMAT(UE10.4)
+U, INSCO.21, INSCO.29
     5 8C(LF)=]./VV(1D-1)
                               NINE CAHDS WERE DELETED HERE
С
+D,NS1GT.18,NS1GT.20
C
        IF (PNA8+1.)3+1+3
     1 MED=JMED
£
C
       GO TO 5
#1.NSIGT.21
        IF (MED.E4,1000.CH.MED.E0.0) GO TO 11
#1,NSIGT,44
        GO TO 12
    11 TSIG=0.0
       PNAH=0.0
+U.NSIGT.45
      HETURN
С
   12 HETURN
40,HELC0,3
      SPHERICAL GEOMETRY
С
c
                                GENERAL GEOMETRY
+D.RELCO.16.RELCO.29
                          FIFTEEN CARUS WERE DELETED HEHL
С
       CALL NSIGTA (160, NMED, TSIG, PNAB)
      CON=WTBC/7516
       ID=NREG+1
+1NSEHT+SOURC.8
      DIMENSION FUF (50)
.INSERT, SOURC.12
      DATA PYE/3.14159/
.INSERT.SOURC.17
C
C
    REAUING OF SOURCE DISTRIBUTION FUNCTION DATA
                                                    N.OF SUBDIVISIONS=NN
C
C
            LUWER LIMITEAA
                                UPPER LIMIT=88
      READ(11+1002)
                      AA.88.NN
 1002 FORMAT (2E14.8.15)
C
Č,
       NEAD UNICHMALIZED F.D.F.
c
       3EAD(11+1003)(FDF(1)+1=1+NN)
 1003 FORMAT (10F5.3)
                        AA.HB.NN
      WHITE (10.1004)
UNITE(0,100) == 00000

1004 FORMAT(2x,12HLDRER LIMIT=,114,0,5X,12HUPPEH LIMIT=,E14,0,5X,24H NU

_NBER OF SUBDIVISIONS=,15,//.2X,3HFUF//)

wHITE(10,1005) IFUF(1),1=1.NN)

1005 FORMAT(2x,3E14,0/)

UPYE=2,U=PYE

There
      INNINN
      HNG=HR-AA
      UELTARHNG/XNN
c
       FIND MAX OF FUF (FMAX)
č
      DU 1201
                [#].Nh
      16 (1.64.1) 60 70 1202
      11=1-1
      1F (FOF (1) .GT.FOF (11)) FMAX#FUF (1)
GU TO 1201
1202 PMAXEFUF (1)
 1201 CONTINUE
```

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CHOUSING COCHUINATES OF SUUNCE PANTICLES
    10 2=40.0
  103 X=RANF (0)+36.9504
       Y=RANF (0)+32.0
  TEMANY (0)=32-0

IF (X.GT.1P.4752) GO TG 101

GO TO 102

IO1 XUUM=64.0-1.7324X

IF (Y.GT.XDUM) GO TG 103
CHOUSING ANGULAR PARAMEYERS FOR SOURCE PARTICLE
C
  102 RISHNGOFLTANF (0)
       H2=FMAX+FLTHNF (0)
C
C
        DETERMINE INTERVAL NUMBER FOR COS THETA
c
       1= (R]/DELTA)+.99
       1F (H2,LE,FUF (1)) GO TO 1203
GU TO 102
 1203 ##AA+R1
       XDUH=ACOS (*)
       ADUMESIN (ADUM)
       R2=DPYE=FLTHNF (C)
       U=KOUN+CUS (R2)
       V=XUUH+SIN(H2)
+UELETE, SOURC.18
       1F(ISOUH)15,15,60
C 10 [F([SOUR) 15+15+00
```

#### 6. Input data for the benchmark calculation

Table I shows the listing of the input cards. The MORSE data comprise a problem of 5 batches each of 150 histories. Six groups of neutrons are used. Both splitting and Russian roulette are allowed. The geometry data comprise 25 bodies defining 20 regions in the unit cell. Seven cross-section media are used, the albedo medium is numbered 8 and the internal and external void regions are designated by 1000 and 0 respectively. The regions volumes are shown as unity.

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Table I. Input data for the benchmark problem

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.1492	, 26+08 .	1350E+0	1.12	21E+08	11	05E+	08	.100	0E+0	B .9	048E+0	7		
000064	722612	6731716							•	•				
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-1	1	0 0	)	1 0	+100	00E+	02	.1000	0E-0	1.10	1000E+0	0.00	0006+	0 <b>0</b>
-1	0	· n ·	<b>`</b>											
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	18	.4752	35.0		-70.	0	9	0.0	~ ^	32.	0	-70	•0	
	0.	4763	0.0		250.	a	2	36,95	04	0.0	)	250	•0	
	10	• • <i>1 3 2</i> 62.	2673.	-	3784	-		1851.		123	.u. 14 .	587	eu 6-	
RPP	2	-40.0	2010	+72.0		-40	.0		•72.	0	-110.	0	•250	.0
HPP	3	-50.0		+82.0	)	-50	.0		+82.	0	-120.	0	+260	.0
HCC	4	0.0		0.0		48,	5		0.	0	0.	0	105	•2
000	•	32.0	)				-		•	~	•	•		•
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	_	24.25	•							•	•			•
HCC	8	0.0		0.0		151.	0		0.	0	0.	0	15	• 0
KPP	9	-2.5		30-0		-2-	5		30.	0	137.	0	138	- 0
RPP	10	-5.0		35.0		-5.	0		35.	ō	117.	õ	138	.0
84 <b>6</b>	ii	=10.0		37.5		-10.	0		37.	5	97.	Ó	138	.0
HPP	12	-2.5		30.0		-2.	5		30.	0	67.	0	68	• 0
RPP	13	-5.0		35.0		-5.0			35.0	-	67.0	•	77.	5
800	14	- 7.5		37.5		- 1.	5		3(*)	5	10	0	360	.0
NPP	15	-20.0		45.0		-20.	0		45.	5 0	1904	n	250	-0
SPH	17	0.0		0.0		100.	Ö		50.	õ	1000	•	200	••
SPH	18	0.0		0.0		100.	0	4	17.2	5				
SPH	19	4.0		0.0		104.	0		50.	0				
SPH ·	20	0.0		0.0		104.	0	4	57.2	5				•
HFP UDD	21	-16.0		40.U		-16	5		4U43 63.(	ji E	67	~	130	••
SPH	23	0.0		0.0		100	ŏ		50.	0	0101		130	
RPP	24	-15.0		52.5		-15.	0		52,	5	67,	)	130	0
hpp	25	-15.0		52.5		-15.	0		52.	5	67.	)	130,	0
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Table I. (Continued)

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1.0000E+0	01.00	00E+0	01.00	00E+0	01.00	005+0	01.00	00E+0	01.0000E+0	0	
LI 7	(N.T)	REA	CTION	RATE					-		
3.2924E-0	13.59	182-0	13.87	63E-0	14.08	0-350	14.16	32E-01	14.2086E-0	1	
LI 6 (1	NoT)	REA	CTION	RATE						-	
2.5580E-02	22.83	50E-0	23.22	90E-0	23.59	00E-02	24.01	20E-02	24.5290E-0	2	
NIOBIUM	{N+	ALPHA	RE	ACTIO	N RAT	Ē	•		• - • - •		
9-2200E-0	38.03	- 00F=0	36.38	008-0	34.91	068-0	33.62	00E=0	32.5800E.0	3	
1		, <b>.</b> .			•••••	••••				-	
1.0	1.0		1.0		1.0		1.0		1.0	1.0	1.0
1.0	1.0		1.0		1.0		1.0		1.0	1.0	1.0
1.0	1.0		1.0		1.0		1.0		1.0		
0.0		1-0			40						
0.0 0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0			
2.0 3.0	4.0	6.0	7.0	9.0	11.0	12.0	14.0	16.0			
17.0 18.0	19.0	21.0	22.0	23.0	24.0	24.0	26.0	26.0			
28.0 28.0	29.0	27.0	25.0	23.0	22.0	22.0	20.0	20.0			

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Table II . Sample output for the benchmark problem

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BAL MINAC . HEX.CELL MURSE UN-BNL NITS= NGUITE NGPOTNE NSTRT= 130 NMUST= 250 5 1 6 NCOLTP= NMGP= NHTG= IADJM= NGPUTG# 6 0 6 0 0 MAXIMUM EXECUTION TIME = 5 MINUTES MEUIA= MEUALB= 7 A IS81AS= ISCURE NGPFS= O NHESPE G. 1 1 EBOTG=0. \*TSTRT=1.0000E+00 E80TN=2.5000E-03 TCUT=0. VELTH=2.2000E+05 ZSTRT= 0. YSTRT= 0. AGSTRT= 0. XSTHT= 0. UINP= 0. VINP= 0. WINP= 0. GROUP PARAMETERS. GROLP NUMBERS GREATER THAN 6 CORRESPOND TO SECONDARY PARTICLES GHOUP UPPER EDGE VELOCITY (EV) (CM/SEC) 1.4920E+07 5.21348+09 1 2 1.3500E+07 4.9586E+09 З 1.2210E+07 4.7164E+09 4 1.1050E+07 4.4868E+09 5 1.00000 +07 4.2681E+09 6 9-0480E+05 2.20008+05 INITIAL RANDOM NUMBER = 20001057152522261031 MAXGP= 6 NKILL= 1 NULEAK= 0 IEBIAS= 0 MXREG= 20 NSPLT= 1 NPAST= 0 HEIGHT STANDARDS FUR SPLITTING AND RUSSIAN ROULETTE AND PATHLENGTH STRETCHING PARAMETERS NGP1 NDG NGP2 NRG1 NDRG NRG2 WTHIH1 WTLOW1 WTAVE1 XNU 1.0000E+01 1.0000E+02 1.0000E+01 0. Û 1 0 0 1 0 NSOUR= 0 MFISTP= 0 NURME# 0 NKCALC= 0

-91-9-

Table II. (Continued)

IVCPT = 3

IDBG = 0

•

	_			BODY (	DATA			
AHR	1	0.	0.	7000000E+02	+3695040E+02	0.	7000000F+02	
		•1847520E+02	•3500000€+05	700000E+02	0.	.3200000E.02	= 7000000C+02	-
		0.	0.	.2500000£+03	.3695040E+02	0.	-2500000000000	
		.184752GE+02	•35000C0E+05	.2500000E+03	0.	-3200000E+02	-2500000000000	
		•1562000E+04	.2673000E+04	.3784000E+04	+4851006E+04	-1234000E+04	-59760006+04	
			0.	.100000	0E+01 0.	0.	*3676000E+04	
			866025	5E+00499999	3E+00 0.	.319999	9F+07	
			0.	100000	0E+01 0.	.320000	0E+02	
			.100000	DE+01 0.	0.	+J20000	05405	
			0.	G e	-100000	V. 15+01 700000	05+00	
			0	0.	- 100000			
			184752	0E+02 .600000			UC+U3	
КРР	2	4000000E+02	.7200000E+02	400000F+02	7200005.02	- 1100/005.00		
RPP	3	5000000E+02	-8200000E+02	=-5000000E+02	82000000000000	**1100000E+03	•2500000E+03	35
RCC	- 4	0.	0.	-#850000E+02		1200000E+03	+260000E+03	43
	_	•3200000E+02	•••		V.	U.	+1065000E+03	51
RCC	5	0.	0.	.4750000E+02	0.	0.	+1100000F+03	60
-		•5452000F+05						
RUL	0	0.	0.	.6500000E+02	0.	0.	.2500060E+02	69
		•2675000E+02			•	•		· · ·
RUU	1	0.	<b>0</b> .	.8500000E+02	0.	0.	+6000000F+02	7 8
		•2425000E+02						
ACC	6	0.	0.	1510000E+03	0.	0.	-1500000E-02	87
400		•7500000E+01				••	112000005-05	
RPP	. 9	-,2500000E+01	.3000000E+02	2500000E+01	.300000E+02	.1370000E+03	-1380000E+03	94
KPP	10	500000E+01	.3500000E+02	-,5000000E+01	-3500000E+02	-1170000E+03	-1380000000000	104
RPP	11	100000E+02	.375000UE+02	100000E+02	.3750000E+02	-9700000E+02	1380000E+03	112
MPP	12	<b>-</b> ₂2500000E+01	.300000E+02	2500000E+01	.3000000E+02	-6700000E+02	+6800000E+03	120
RPP	13	+.500000E+01	.3500000E+02	5000000E+01	-3500000E+02	-6700000E+02	.77500005+02	120
HPP	14	7500000E+01	.3750000E+02	+.7500000E+01	-3750000E+02	-6700000E+02	-870000000000	120
RPP	15	5000000E+01	.3750000E+02	5000000E+01	-3750000E+02	-1900000E+03	. 35000002.02	130
HPP	16	2000000E+02	.4500000E+02	2000000E+02	-4500000E+02	-1020000E+03	250000000000	1 5 3
SPH	17	0.	e .	-1000000E+03	-5000000F+02		+2500000E+03	100
SPH	18	0.	0.	+1000000E+03	4725000E+02	=0,	-0-	100
SPH	19	0 🖕	0.	-1040000E+03	-5000000E+02	=0.	-0	100
SPH	20	0.	0.	.1040000E+03	-4725000E+02	-0.	-0	100
RPP	21	1250000E+02	+4000000E+02	-+1250000E+02	-4000000E+02	-00	13800005.03	104
RPP	25	1500000E+02	.5250000E+02	-1500000E+02	-52500005+02	47000000C+UZ	•1360000E303	170
SPH	23	0.	0.	+1000000E+03	-5000000E+02	-0100002+02	-0 •1300000c+03	200
RPP	24	1500000E+02	.5250000E+02	**1200000E*03	-52500000000000	-V.		208
RPP	25	15000005+02	.5250000L+02	-1500000E+02	5250000C+U2	•0700000E+CZ	·1300008E+03	210
END	26	-0.	=0.	=0.	-0	+0700002+02	.1300000±+03	224
NUMBER	0F	8001ES 25		~ •	-0.		-U.	232
LLNGTH	0F	FPD-ARRAY 237						

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and a management of the Monte of the second s

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 20 20	5000 5000 5000 5000 5000 5000 5000 500	# R 1109		-} 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	77 82677 790989055545120		6855411055006006754000		26 21 20 21 20 21 20 21 20 21 20 20 20 20 20 20 20 20 20 20 20 20 20		$ \begin{array}{c} 1 \\ - 0 \\ - 21 \\ - 0 \\$	н		FUT	204 -0 -0 -0 -0 -0 -0 -0 -0 -0 -0 -0 -0 -0	<b>Α</b> <u></u> <u></u>	TA -16 -00 -00 -00 -00 -00 -00 -00 -00 -00 -0		240000000000000000000000000000000000000	~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~	$\begin{array}{c} 1 \\ 3 \\ 4 \\ 5 \\ 6 \\ 7 \\ 8 \\ 9 \\ 1 \\ 1 \\ 1 \\ 1 \\ 1 \\ 1 \\ 1 \\ 1 \\ 1$					
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1	S	3	4	s	6	7	•	8	9	10	11	1	12	13	14	15	16	17	1	9	19	20				
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1000	3	2	3	4	4	4		4	з	7	1		1	5	5	6	6	1	100	5	8	O				
	51X	GRO	UPS	CHUS	5-5E	CTIC	NS	FUR	CO	DE	MU	RSE	E													
NUMBER NUMBER NUMBER NUMBER LOC OF NUMBER NUMBER NUMBER NUMBER NUMBER NUMBER NUMBER NUMBER NUMBER	OF OF OF OF OF OF OF OF OF OF SECT	PRI PRI SEC PRI TH MED INN COE ANG EFF ITC	MARY MARY ONDA UNDA (1TO GRO (1TO GRO (1TO C ING C ING C IS S S S S S S S S S S S S S S S S S	GROU DOWI RY GI C GRU L) UP (S NMED) LEMED ILEMED ILEMED ILENTA (NSC' TAT) RCM I S REA	UPS NSCAPONS UPS SIG NTS (ES (N F) UPS UF(	(NGF TTEF S (N CATT (IN GG) (NEL (NMI COEF E) E)	(15) (15) (15) (15) (15) (15) (15) (15)	(NUS 5 (N 566)	5) 1056					COEF	F101	LENT	1									
GP ABS	XSE	C	NU	FISS		101	L			FRO	M GF	1001	P TI	-ANS	FEH	PRU	HAUI	L17	IES							
2 1. 3 1. 4 1. 5 1. 6 1.	3926 3926 3176 1996 0506 8656	-03 -03 -03 -03 -04	0 0 0			1 • 1 1 • 1 1 • 1 1 • 1 1 • 1 1 • 1	0451 0511 0411 0328 7658	E - 02 E - 02 E - 02 E - 02 E - 02		3.5 3.3 3.2 3.3 1.7	98E- 69E- 96E- 96E- 66E-	03 03 03 03 03	1.( 9.9 9.9 5.9	003E 017E 925E 95GE 017E	-03 -04 -04 -03	2.2 2.3 2.3 4.9	79E-( 21E-( 93E-( 22E-(	04 04 04 03	2.51	2E - 4E - 7E -	04	1.23	5E=0 4E=0	4 3 3,9	985E	-03
GHOUP 1 7 2 7 3 7 4 7 5 7 6 1	898 970 944 867 795 349	1GT E=04 E=04 E=04 E=04 E=04 E=03	6 6 6 6 6 6 6 6 6 7 6 1 6 1 6 1 6 1 6 1	5IG57 866E- 919E- 950E- 961E- 961E- 334E-	RUS 04 04 04 04 04 03	5 5E PNUP 0.00 0.00 0.00 0.00 0.00 0.00	CTI 00 00 00 00 00	UNS PNAI .80 .80 .81 .81 .81 .81 .81 .81 .81 .91	F0F 693 641 748 549 549 595	ME GAM 0.0 0.0 0.0 0.0 0.0	UIA GEN 000 000 000 000 000 000	NU 0. 0. 0. 0.	1 000 000 000 000 000	S ( 0 0 0 0 0	UCWN: - 38: - 39: - 36: - 36: - 36:	5CA1 48 29 62 77 14 00	TER 111 111 100 100 .63	PRO 04 10 79 81 86	8481 .0 .0 .9	LJ 25 26 342	T¥ 1 3 0 2	.027 .029 .499	6	•013 •441	6 6	•438

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Table II. (Continued) ANALYSIS DATA NUE 21. NNER 0. NER 0. NTR 0. NAR 0. NHESPR 4. NEXH 22. NEXHUR 0 RESP( 4) RESP( 2) RESP( J1 68005 HESP( 1) 9.2200E-03 3-29246-01 2.5580E-02 1.00001+00 1 2.8350E-02 8.0300E=03 3.5914E-01 1.00006+00 2 3.2290E-02 6.3800E-03 1.00006+00 3.9763E-01 3 3.59008-02 4.9100E-03 4.0802E=01 1.00000E+00 3.6200E-03 4.1632E-01 4.0120E-02 1.00006+00 5 2.5800£-03 4.20866-01 4.5290E-02 1-00006+00 6 TIME REQUIRED FOR INPUT WAS YOU ARE USING THE DEFAULT VERSION OF STRUN WHICH DOES NOTHING. \*\*\*START BATCH 1 WANDUM#20001057152522201031 SOUNCE DATA YOU ARE USING THE DEFAULT VERSION OF SOUNCE WHICH SETS WATE TO DDF AND PROVIDES AN ENERGY IG. LOWER LIMIT=0. UPPER LIMIT# .10000000E+01 NUMBER OF SUBDIVISIONS\* 40 FOF 0. 0. 0. đ., 0. .1000000E+01 0. 0. 0. 0. .2000000E+01 .3000000E+01 .4000000E+01 .6000000E+01 .7000000E+01 •23000000E+02 .240000000E .240000000E. 20400000E.02 .2600000E.02 .28000000E+02 .28000000E+02 .29000000E+02 .27000000E+02 .25000000E+02 SWATE IAVE. AGEAVE UAVE VAVE WAVE XAVE YAVE ZAVE 1.5008+02 1.00 .0476 .0327 .6624 1.406E+01 1.469E+01 4.000E+01 ٥. YOU ARE USING DEFAULT VERSION OF ALBOO WHICH PERFURMS SPECULAR REFLECTION NUMBER OF COLLISIONS OF TYPE ACOLL SOURCE SPLIT(0) FISHN GAMGEN REALCOLL ALBEDO HDRYX ESCAPE E-CUT TIMEKILL & & KILL & & SURV GAMLOST 150 ٨ n 0 19 150 0 1887 3013 0 0 n n TIME REQUIRED FOR THE PRECEDING BATCH WAS 2 \*\*\*START BATCH 2 HANDOM=20005016326400052701 SUUNCE DATA SWATE IAVE AGEAVE UAVE VAVE WAVE XAVE YAVE ZAVE 1.500E+02 1.00 -.0685 -.0522 .7018 1.418E+01 1.385E+01 4.000E+01 0. NUMBER OF COLLISIONS OF TYPE NCOLL SOURCE SPLIT(D) FISHN GAMGEN REALCOLL ALBEDO BORYX ESCAPE E-CUT TIMEXILL R R KILL R R SURV GAMLOST 150 n. 0 0 26 1792 2965 150 • 0 0 n TIME REQUIRED FOR THE PRECEDING BATCH WAS 2

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The cross-section data consists of a six-group set with a  $P_3$ -anisotropy in ANISN-format card images. Only the cross-sections for two elements are displayed. The mixing table consists of 11 mixing operations using 4 elements to define 7 cross-section media. The points detectors locations are input as unities since they are not used. The region detector volumes are input and the number of the last boundary crossing detector are also set to unity. The analysis input data consist of three characteristic response functions used in blanket and shield studies. The input to the subroutines INSCOR, RELCOL and SOURCE complete the data.

#### 7 . Sample Output

Table II shows major parts of the output obtained for the cell benchmark problem. However, part of the input data is only used, and do not represent a real problem situation. The reader is referred to another publication (4) for realistic data input.

#### 8 . Recommendations and Conclusions

No complete documentation has been published before as a guidance on how to implement the MORSE code to the solution of practical problems. We have tried in this work to document that aspect in relation to Monte-Carlo

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calculations of blankets and shields for fusion blanket studies using the CDC-7600 computer system. The version has been used for cell calculations at Brookhaven National Laboratory.

والمحافظ والمحافظ المرابع والمراجع والمتكرمين المطلقة والمرامية الإرابي والمعاقبة والمستخلفا والمستعا

Due to the lack of the virtual memory facility on the CDC-7600, the code as set here requires the use of the SCM (Short Core Memory): for that case a group collapsing procedure by ANISN code is necessary to get a few-group cross-section set. If a fine group structure is needed, the LCM (large core memory) should be used with the subsequent modifications to the coding of the different routines.

Major code modifications for wider versatility in the future should include the implementation in the combinational geometry package of geometrical shapes not presently implementated, especially the circular and ellipsoidal toroids, the general ellipsoid shape, the right elliptical cylinder (for non-circular Tokomaks), and the wedge shape.

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