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

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August 30, 1975

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UPTON, NEW YORK 11973

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

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* Research sponsored by the U. S. Energy Research & Development Administration.

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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

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 [4]. 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-7600 and the analysis of geometrical shapes not presently implemented is given.

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

The MORSE (Multigroup Oak Ridge Stochastic Experiment) code [1] 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.

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 quadrature technique.

## 3. Modifications introduced to MORSE routines in the present version

The following corrections and modifications were introduced to the latest updated version of MORSE [1]: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/F1SBNK/MF1STP (6)                    MAIN1-13
```

is modified to:

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

an apparently punching error.

3.2 <u>ENDRUN Routine</u>

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 cross-sections. Following Statement #85 these two statements are added:

```
      GO TO   90
86    WTS(L) = 0.0
```

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

```
        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.0) 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

Replacing the Statement:

```
        MDXSEC = 1                                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.

Also, the following statements are inserted after statement 55:

```
      GO TO 12
   11 TSIG = 0.0
      PNAB = 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
```

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 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.

```
      SUBROUTINE SOURCE(IG,U,V,W,X,Y,Z,WATE,MED,AG,ISOUR,ITSTR,NGPQT3,
     1 DDF,ISBIAS,NMTG)
C
C    IF ITSTR=0, MUST PROVIDE IG,X,Y,Z,U,V,W,WATE AND AG IF DESIRED TO BE
C      DIFFERENT FROM CARD VALUES (WHICH ARE THE VALUES INPUT TO SOURCE)
C    IF ITSTR=1, IG IS THE GRP NO. CAUSING FISSION, MUST PROVIDE NEW IG
C      THIS VERSION OF  SOURCE  SELECTS INITIAL GROUP FROM THE INPUT SPEC
      DIMENSION  FDF(50)
C
      COMMON /USER/ DUM(9),IO,I1,IDUM(12)
      COMMON WTS(1)
      DATA ICALL/1/
      DATA  PYE/3.14159/
      IF (ICALL) 10,10,5
 5    ICALL = 0
      WRITE (IO,1000)
1000  FORMAT(94H YOU ARE USING THE DEFAULT VERSION OF SOURCE WHICH SETS
     1WATE TO DDF AND PROVIDES AN ENERGY IG. )
C
C    READING OF SOURCE DISTRIBUTION FUNCTION DATA
C            LOWER LIMIT=AA    UPPER LIMIT=BB       N.OF SUBDIVISIONS=NN
C
      READ(I1,1002)  AA,BB,NN
 1002 FORMAT(2E14.8,I5)
C
C       READ UNNORMALIZED F.D.F.
C
      READ(I1,1003)(FDF(I),I=1,NN)
 1003 FORMAT(10F5.3)
      WRITE(IO,1004)   AA,BB,NN
 1004 FORMAT(2X,12HLOWER LIMIT=,E14.8,5X,12HUPPER LIMIT=,E14.8,5X,24H NU
     .MBER OF SUBDIVISIONS=,I5,//,2X,3HFDF//)
      WRITE(IO,1005)  (FDF(I),I=1,NN)
 1005 FORMAT(2X,5E14.8/)
      DPYE=2.0*PYE
      XNN=NN
      RNG=BB-AA
      DELTA=RNG/XNN
C
C       FIND MAX OF FDF  (FMAX)
C
      DO 1201   I=1,NN
      IF(I.EQ.1)   GO TO 1202
      II=I-1
      IF(FDF(I).GT.FDF(II))  FMAX=FDF(I)
      GO TO 1201
 1202 FMAX=FDF(I)
 1201 CONTINUE
C
CHOOSING COORDINATES OF SOURCE PARTICLES
C
   10 Z=40.0
  103 X=RANF(0)*36.9504
      Y=RANF(0)*32.0
      IF(X.GT.18.4752)  GO TO 101
      GO TO 102
  101 XDUM=64.0-1.732*X
      IF(Y.GT.XDUM)  GO TO 103
C
CHOOSING ANGULAR PARAMETERS FOR SOURCE PARTICLE
C
  102 R1=RNG*FLTRNF(0)
      R2=FMAX*FLTRNF(0)
```

```
C
C       DETERMINE INTERVAL NUMBER FOR COS  THETA
C
      I=(R1/DELTA)+.99
      IF(R2.LE.FUF(I))  GO TO 1203
      GO TO 102
 1203 W=AA*R1
      XDUM=ACOS(W)
      XDUM=SIN(XDUM)
      R2=DPYE*FLTRNF(0)
      U=XDUM*COS(R2)
      V=XDUM*SIN(R2)
      IF(ISOUR)15,15,60
C  10 IF(ISOUR) 15,15,60
 15   WATE=DDF
      IF (ISBIAS) 20,20,25
 20   NWT = 2*NMTG
      GO TO 30
 25   NWT = 3*NMTG
 30   R = FLTRNF(R)
      DO 35 I=1,NGPOT3
      IF (R - WTS(I+NWT)) 40,40,35
 35   CONTINUE
 40   IG=I
      IF (ISBIAS) 60,60,45
 45   IF (I-1) 60,50,55
 50   WATE = WATE*WTS(2*NMTG+1)/WTS(3*NMTG+1)
      GO TO 60
 55   WATE = WATE*(WTS(2*NMTG+I)-WTS(2*NMTG+I-1))/(WTS(3*NMTG+I)-WTS(3*N
     1MTG+I-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 [1] displays two-dimensional cuts through the specified three-dimensional 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.

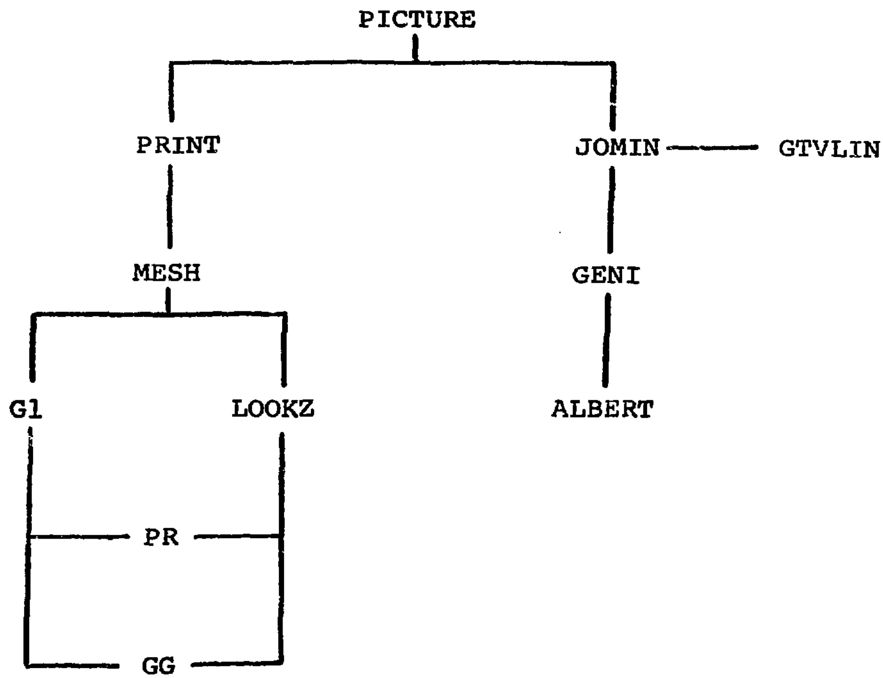


Figure 1 . Hiearchy of subroutines in the PICTURE program

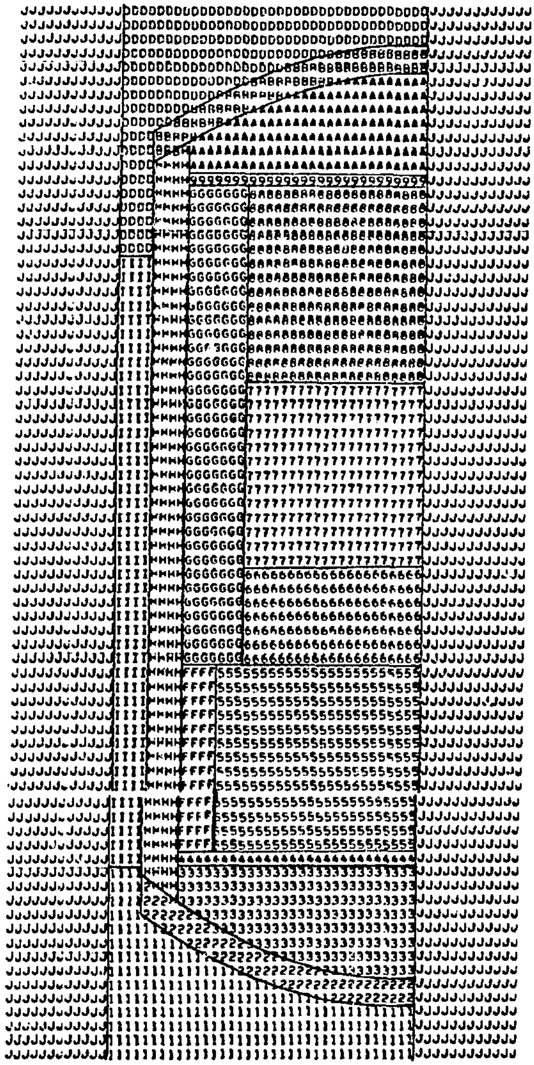

Figure 2. Output of PICTURE for a vertical cut through the blanket and shield unit cell.

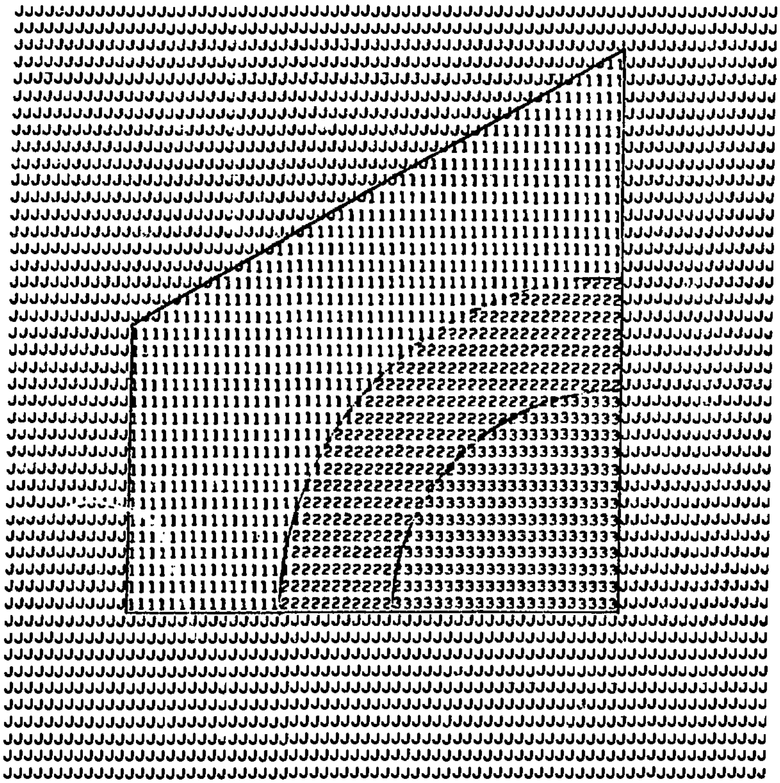

Figure 3 . Output of PICTURE for a horizontal cut through the blanket and shield unit cell .

## 5. Deck Organization for the CDC-7600

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 [5]. 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,CP70,T100,P666.
ACCOUNT(LAZARETH,128)
MAP(ON)
ATTACH,OLDPL,MRS,ID=LAZARETH.
UPDATE.
FTN(I,A)
ATTACH(  LIB,MORSELIB,ID=LAZARETH)     FILE MORSELIB(CATALOGUED)
LIBRARY(LIB)
LGO.
7
*ID,CORRECT
*D,MAIN1.6
C     COMMON NC(22000)
      COMMON  NC(33000)
*D,MAIN1.13
C     COMMON/FISBNK/MFISTP(6)
      COMMON/FISBNK/MFISTP(6)
*D,MAIN1.29
C     NLFT=22000
      NLFT= 33000
*D,ENDRU.27
C     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/
*I,ENDRU.104
      IF(NREG.EQ. 1.OR.NREG.GE.18)                      GO TO 86
*I,ENDRU.111
      GO TO 90
   86 WTS(L)=0.0
*I,ENDRU.117
      IF(NREG.EQ. 1.OR.NREG.GE.18)                            GO TO 101
*I,ENDRU.124
      GO TO 105
  101 WTS(L)=0.0
```

```
*D,GENI,148
C       IF(IDBG.EQ.0)  RETURN
*I,GETMU,30
        IF(NMOM.EQ.1)  GO TO 55
*D,GTMED,3
C       MDXSEC=1
        MDXSEC=MDGEUM
*I,INSCO,2
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
*I,INSCO,13
        DIMENSION VV(21)
*I,INSCO,15
        READ(I1,102) (VV(I),I=1,ND)
  102 FORMAT(8E10.4)
*D,INSCO,21,INSCO,29
    5 BC(LF)=1./VV(ID-1)
C                              NINE CARDS WERE DELETED HERE
*D,NSIGT,18,NSIGT,20
C       IF(PNAB+1.)3,1,3
C     1 MED=JMED
C       GO TO 5
*I,NSIGT,21
        IF(MED.EQ.1000.OR.MED.EQ.0)  GO TO 11
*I,NSIGT,44
        GO TO 12
   11 TSIG=0.0
        PNAB=0.0
*D,NSIGT,45
C       RETURN
   12 RETURN
*D,RELCO,3
C       SPHERICAL GEOMETRY
C                                 GENERAL GEOMETRY
*D,RELCO,16,RELCO,29
C                          FIFTEEN CARDS WERE DELETED HERE
        CALL NSIGTA(IGO,NMED,TSIG,PNAB)
        CON=WTBC/TSIG
        ID=NREG+1
*INSERT,SOURC,8
        DIMENSION  FDF(50)
*INSERT,SOURC,12
        DATA  PYE/3.14159/
*INSERT,SOURC,17
C
C    READING OF SOURCE DISTRIBUTION FUNCTION DATA
C            LOWER LIMIT=AA    UPPER LIMIT=BB      N.OF SUBDIVISIONS=NN
C
        READ(I1,1002)  AA,BB,NN
 1002 FORMAT(2E14.8,I5)
C
C        READ UNNORMALIZED F.D.F.
C
        READ(I1,1003)(FDF(I),I=1,NN)
 1003 FORMAT(10F5.3)
        WRITE(IO,1004)   AA,BB,NN
 1004 FORMAT(2X,12HLOWER LIMIT=,E14.8,5X,12HUPPER LIMIT=,E14.8,5X,24H NU
     .MBER OF SUBDIVISIONS=,I5,//,2X,3HFDF//)
        WRITE(IO,1005)  (FDF(I),I=1,NN)
 1005 FORMAT(2X,5E14.8/)
        DPYE=2.0*PYE
        XNN=NN
        RNG=BB-AA
        DELTA=RNG/XNN
C
C        FIND MAX OF FDF  (FMAX)
C
        DO 1201   I=1,NN
        IF(I.EQ.1)   GO TO 1202
        II=I-1
        IF(FDF(I).GT.FDF(II))  FMAX=FDF(I)
        GO TO 1201
 1202 FMAX=FDF(I)
 1201 CONTINUE
```

```
C
CHOOSING COORDINATES OF SOURCE PARTICLES
C
   10 Z=40.0
  103 X=RANF(0)*36.9504
      Y=RANF(0)*32.0
      IF(X.GT.18.4752)  GO TO 101
      GO TO 102
  101 XDUM=64.0-1.732*X
      IF(Y.GT.XDUM)  GO TO 103
C
CHOOSING ANGULAR PARAMETERS FOR SOURCE PARTICLE
C
  102 R1=RNG*FLTRNF(0)
      R2=FMAX*FLTRNF(0)
C
C      DETERMINE INTERVAL NUMBER FOR COS  THETA
C
      I=(R1/DELTA)+.95
      IF(R2.LE.FUF(I))  GO TO 1203
      GO TO 102
 1203 W=AA+R1
      XDUM=ACOS(W)
      XDUM=SIN(XDUM)
      R2=DPYE*FLTRNF(0)
      U=XDUM*COS(R2)
      V=XDUM*SIN(R2)
*DELETE,SOURC.18
      IF(ISOUR)15,15,60
C  10 IF(ISOUR) 15,15,60
```

## 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.

Table I. Input data for the benchmark problem

```
MORSE UW-BNL          BNL  MINAC  ,  HEX.CELL      MAGDI RAGHEB
 150  250    5    1    6    0    6    6    0    0    5    7    8
   1    1    0    0.10000E+01.00250E+00.00000E+00.00000E+00.22000E+06
  0.0      0.0     +.0000E+00+.0000E+00+.0000E+00+.0000E+00+.0000E+00
.1492E+08 .1350E+08 .1221E+08 .1105E+08 .1000E+08 .9048E+07
00006472261267317161
   1    1    0    0    0   20   006
   0    1    0    0    1    0.10000E+02.10000E-01.10000E+00.00000E+00
  -1
   0    0  ' 0    0
   3    0      MORSE-LW-BNL      BNL MINAC    MAGDI RAGHEB
  ARB      10.0       0.0         -70.0       36.9504   0.0        -70.0
            18.4752   32.0        -70.0       0.0       32.0       -70.0
            0.0       0.0         250.0       36.9504   0.0        250.0
            18.4752   32.0        250.        0.0       32.0       250.0
            1562.     2673.       3784.       4851.     1234.      5876.
  RPP   2     -40.0       +72.0       -40.0       +72.0     -110.0     +250.0
  RPP   3     -50.0       +82.0       -50.0       +82.0     -120.0     +260.0
  RCC   4       0.0         0.0        48.5         0.0        0.0      106.5
               32.0
  RCC   5       0.0         0.0        47.5         0.0        0.0      110.0
              29.25
  RCC   6       0.0         0.0        65.0         0.0        0.0       25.0
              26.75
  RCC   7       0.0         0.0        85.0         0.0        0.0       60.0
              24.25
  RCC   8       0.0         0.0       151.0         0.0        0.0       15.0
                7.5
  RPP   9      -2.5        30.0        -2.5        30.0      137.0      138.0
  RPP  10      -5.0        35.0        -5.0        35.0      117.0      138.0
  RPP  11     -10.0        37.5       -10.0        37.5       97.0      138.0
  RPP  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
  RPP  14     - 7.5        37.5       - 7.5        37.5       67.0       87.0
  RPP  15      -5.0        37.5        -5.0        37.5      190.0      250.0
  RPP  16     -20.0        45.0       -20.0        45.0      102.0      250.0
  SPH  17       0.0         0.0       100.0        50.0
  SPH  18       0.0         0.0       100.0       47.25
  SPH  19       0.0         0.0       104.0        50.0
  SPH  20       0.0         0.0       104.0       47.25
  RPP  21     -12.5        40.0       -12.5        40.0       87.0      138.0
  RPP  22     -15.0        52.5       -15.0        52.5       67.0      130.0
  SPH  23       0.0         0.0       100.0        50.0
  RPP  24     -15.0        52.5       -15.0        52.5       67.0      130.0
  RPP  25     -15.0        52.5       -15.0        52.5       67.0      130.0
  END
    1   200R    1    -17    -16    -220R    1    23    -4   -16   -24
    2   20      1     17    -18    -16     +4
    3   20      1     18      5    -22    -16
    4   20      1     12      5
    5   20      1      6     14    -12    -21
    6   20      1      7     21    -11    -14
    7   20      1      7     11    -10
    8   20      1      7     10     -9
    9   20      1      9      5
   10   20      1     20      5     16    -21    -8
   11   20      1     19    -20     16     -8     4
   12   20      1      9
   13   200R    1    -19     16    -15    -80R    1    19    16   -22
               -4
   14   20      1     15
   15   20      1      5     -6     14    -12
   16   20      1      5     -7     21    -14    -9
   17   200R    1      4     -5    180R    20     1     4    -5
   18   20      1     25     -4
   19   20      2     -1
   20   20      3     -2
  END
```

Table I. (Continued)

```
    1     2     3     4     5     6     7     8     9    10    11    12    13    14
   15    16    17    18    19    20
 1000     1     2     3     4     4     4     4     3     7     1     1     5     5
    6     6     1  1000     8     0
.10000E+01.10000E+01.10000E+01.10000E+01.10000E+01.10000E+01.10000E+01
.10000E+01.10000E+01.10000E+01.10000E+01.10000E+01.10000E+01.10000E+01
.10000E+01.10000E+01.10000E+01.10000E+01.10000E+01  1.0
     SIX GROUPS CROSS-SECTIONS FOR CODE    MORSE
    6     6     0     0     6     9     4     7     4    11     4     2     0
    1     0     0     0     0     0     0     0     0     0     0
    35612- 6           0.     39757- 4     19269- 4 5R         0.                      1
    36969- 6           0.     40973- 4     20443- 4     50001- 6 4R          0.         2
    33017- 6           0.     41905- 4     21305- 4     54621- 6     47287- 8           3
 3R         0.                                                                         4
    28400- 6           0.     42581- 4     21903- 4     61129- 6     85392- 8           5
    97701- 8 2R        0.                                                              6
    23298- 6           0.     42921- 4     22412- 4     69712- 6     14651- 7           7
    16870- 7     18496- 7           0.                                                 8
    18724- 6           0.     42831- 4     21885- 4     80200- 6     25381- 7           9
    27737- 7     30667- 7     32350- 7                                                10
 3R         0.   52215- 4 5R        0.                                                 1
 3R         0.   55307- 4     31950- 6 4R         0.                                   2
 3R         0.   57268- 4     40674- 6 4R         0.                                   3
 3R         0.   58244- 4     48593- 6 4R         0.                                   4
 3R         0.   57978- 4     54069- 6 4R         0.                                   5
 3R         0.   56190- 4     55854- 6 4R         0.                                   6
 3R         0.   52215- 4 5R        0.                                                 1
 3R         0.   55307- 4     31950- 6 4R         0.                                   2
 3R         0.   57268- 4     40674- 6 4R         0.                                   3
 3R         0.   58244- 4     48593- 6 4R         0.                                   4
 3R         0.   57978- 4     54069- 6 4R         0.                                   5
 3R         0.   56190- 4     55854- 6 4R         0.                                   6
 3R         0.   52215- 4 5R        0.                                                 1
 3R         0.   55307- 4     31950- 6 4R         0.                                   2
 3R         0.   57268- 4     40674- 6 4R         0.                                   3
 3R         0.   58244- 4     48593- 6 4R         0.                                   4
 3R         0.   57978- 4     54069- 6 4R         0.                                   5
 3R         0.   56190- 4     55854- 6 4R         0.                                   6
    32994- 6           0.     14146- 4     48894- 5 5R         0.                      1
    36838- 6           0.     14976- 4     49780- 5     31814- 5 4R          0.         2
    41948- 6           0.     15834- 4     50347- 5     33803- 5     72915- 6           3
 3R         0.                                                                         4
    46633- 6           0.     16622- 4     50550- 5     35031- 5     82515- 6           5
    51034- 6 2R        0.                                                              6
    52027- 6           0.     17369- 4     50708- 5     36747- 5     94082- 6           7
    55596- 6     48249- 6           0.                                                 8
    58462- 6           0.     18034- 4     50656- 5     38115- 5     10429- 5           9
    60973- 6     53065- 6     42685- 6                                                10
 3R         0.   13595- 4 5R        0.                                                 1
 3R         0.   13830- 4     72922- 5 4R         0.                                   2
 3R         0.   13973- 4     77841- 5     55463- 6 3R         0.                      3
 3R         0.   14021- 4     82453- 5     65683- 6     58[illegible]- 7 2R      0.    4
 3R         0.   14048- 4     86682- 5     77598- 6     65746- 7     69208- 7           5
            0.                                                                         6
 3R         0.   14030- 4     89653- 5     90374- 6     74941- 7     81161- 7           7
    13055- 6                                                                           8
 3R         0.   52215- 4 5R        0.                                                 1
 3R         0.   55307- 4     31950- 6 4R         0.                                   2
 3R         0.   57268- 4     40674- 6 4R         0.                                   3
 3R         0.   58244- 4     48593- 6 4R         0.                                   4
 3R         0.   57978- 4     54069- 6 4R         0.                                   5
 3R         0.   56190- 4     55854- 6 4R         0.                                   6
 3R         0.   52215- 4 5R        0.                                                 1
 3R         0.   55307- 4     31950- 6 4R         0.                                   2
 3R         0.   57268- 4     40674- 6 4R         0.                                   3
 3R         0.   58244- 4     48593- 6 4R         0.                                   4
 3R         0.   57978- 4     54069- 6 4R         0.                                   5
 3R         0.   56190- 4     55854- 6 4R         0.                                   6
    1   -1+.7556E-01
    2   +2+.3334E-03
    2   -3+.4038E-01
    3   -4+.8040E-01
    4   +2+.3334E-03
    4    3+.4038E-01
    4   -4+.8040E-01
    5    1+.5556E-03
    5   -4+.3334E-03
    6   -3+.4038E-01
    7   -3+.4000E-01
```

Table I. (Continued)

```
      ANALYSIS DATA
   21     0     0     0     0     4    22     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
     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       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
     *TRITIUM BREEDING IN MINAC*
  NEUTRONS/(CM2*SEC)
1.0000E+001.0000E+001.0000E+001.0000E+001.0000E+001.0000E+00
  LI  7   (N,T)    REACTION RATE
3.2924E-013.5918E-013.8763E-014.0802E-014.1632E-014.2086E-01
  LI 6   (N,T)    REACTION RATE
2.5580E-022.8350E-023.2290E-023.5900E-024.0120E-024.5290E-02
  NIOBIUM   (N,ALPHA)   REACTION RATE

9.2200E-038.0300E-036.3800E-034.9100E-033.6200E-032.5800E-03
    1
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
```

## Table II . Sample output for the benchmark problem

```
MORSE UW-BNL        BNL  MINAC  ,  HEX.CELL

NSTRT=  130      NMOST=  250      NITS=    5        NQUIT=    1       NGPQTN=    6
NGPQTG=    0     NMGP=     6      NMTG=     6       NCOLTP=    0      IADJM=     0
      MAXIMUM EXECUTION TIME =     5 MINUTES        MEDIA=    7       MEDALB=    8

ISOUR=    1   NGPFS=    1   ISBIAS=     0   NRESP=     0
  WTSTRT=1.0000E+00   EBOTN=2.5000E-03   EBOTG=0.            TCUT=0.            VELTH=2.2000E+05

XSTRT= 0.                YSTRT= 0.                ZSTRT= 0.                AGSTRT= 0.
UINP= 0.                VINP= 0.                 WINP= 0.

GROUP PARAMETERS, GROUP NUMBERS GREATER THAN    6 CORRESPOND TO SECONDARY PARTICLES

   GROUP      UPPER EDGE          VELOCITY
                 (EV)             (CM/SEC)
     1      1.4920E+07       5.2134E+09
     2      1.3500E+07       4.9586E+09
     3      1.2210E+07       4.7164E+09
     4      1.1050E+07       4.4868E+09
     5      1.0000E+07       4.2681E+09
     6      9.0480E+06       2.2000E+05

INITIAL RANDOM NUMBER = 200010571525222610311

NSPLT= 1     NKILL= 1     NPAST= 0     NOLEAK= 0     IEBIAS= 0     MXREG= 20     MAXGP=  6

WEIGHT STANDARDS FOR SPLITTING AND RUSSIAN ROULETTE AND PATHLENGTH STRETCHING PARAMETERS

 NGP1  NDG NGP2  NRG1 NDRG NRG2     WTHIH1      WTLOW1      WTAVE1        XNU
   0    1    0     0    1    0   1.0000E+01  1.0000E-02  1.0000E-01  0.

NSOUR= 0     MFISTP=  0     NKCALC= 0     NORMF= 0
```

Table II. (Continued)

IVCPT = 3        IDBG = 0

BODY DATA

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| ARB | 1 | 0. | 0. | -.7000000E+02 | .3695040E+02 | 0. | -.7000000E+02 | 3 |
| | | .1847520E+02 | .3200000E+02 | -.7000000E+02 | 0. | .3200000E+02 | -.7000000E+02 | |
| | | 0. | 0. | .2500000E+03 | .3695040E+02 | 0. | .2500000E+03 | |
| | | .1847520E+02 | .3200000E+02 | .2500000E+03 | 0. | .3200000E+02 | .2500000E+03 | |
| | | .1562000E+04 | .2673000E+04 | .3784000E+04 | .4851000E+04 | .1234000E+04 | .5876000E+04 | |
| | | | 0. | .1000000E+01 | 0. | 0. | | |
| | | | -.8660255E+00 | -.4999998E+00 | 0. | .3199999E+02 | | |
| | | | 0. | -.1000000E+01 | 0. | .3200000E+02 | | |
| | | | .1000000E+01 | 0. | 0. | 0. | | |
| | | | 0. | 0. | .1000000E+01 | .7000000E+02 | | |
| | | | 0. | 0. | -.1000000E+01 | .2500000E+03 | | |
| | | | .1847520E+02 | .6000000E+01 | | | | |
| RPP | 2 | -.4000000E+02 | .7200000E+02 | -.4000000E+02 | .7200000E+02 | -.1100000E+03 | .2500000E+03 | 35 |
| RPP | 3 | -.5000000E+02 | .8200000E+02 | -.5000000E+02 | .8200000E+02 | -.1200000E+03 | .2600000E+03 | 43 |
| RCC | 4 | 0. | 0. | .4850000E+02 | 0. | 0. | .1065000E+03 | 51 |
| | | .3200000E+02 | | | | | | |
| RCC | 5 | 0. | 0. | .4750000E+02 | 0. | 0. | .1100000E+03 | 60 |
| | | .2925000E+02 | | | | | | |
| RCC | 6 | 0. | 0. | .6500000E+02 | 0. | 0. | .2500000E+02 | 69 |
| | | .2675000E+02 | | | | | | |
| RCC | 7 | 0. | 0. | .8500000E+02 | 0. | 0. | .6000000E+02 | 78 |
| | | .2425000E+02 | | | | | | |
| RCC | 8 | 0. | 0. | .1510000E+03 | 0. | 0. | .1500000E+02 | 87 |
| | | .7500000E+01 | | | | | | |
| RPP | 9 | -.2500000E+01 | .3000000E+02 | -.2500000E+01 | .3000000E+02 | .1370000E+03 | .1380000E+03 | 96 |
| RPP | 10 | -.5000000E+01 | .3500000E+02 | -.5000000E+01 | .3500000E+02 | .1170000E+03 | .1380000E+03 | 104 |
| RPP | 11 | -.1000000E+02 | .3750000E+02 | -.1000000E+02 | .3750000E+02 | .9700000E+02 | .1380000E+03 | 112 |
| RPP | 12 | -.2500000E+01 | .3000000E+02 | -.2500000E+01 | .3000000E+02 | .6700000E+02 | .6800000E+02 | 120 |
| RPP | 13 | -.5000000E+01 | .3500000E+02 | -.5000000E+01 | .3500000E+02 | .6700000E+02 | .7750000E+02 | 128 |
| RPP | 14 | -.7500000E+01 | .3750000E+02 | -.7500000E+01 | .3750000E+02 | .6700000E+02 | .8700000E+02 | 136 |
| RPP | 15 | -.5000000E+01 | .3750000E+02 | -.5000000E+01 | .3750000E+02 | .1900000E+03 | .2500000E+03 | 144 |
| RPP | 16 | -.2000000E+02 | .4500000E+02 | -.2000000E+02 | .4500000E+02 | .1020000E+03 | .2500000E+03 | 152 |
| SPH | 17 | 0. | 0. | .1000000E+03 | .5000000E+02 | -0. | -0. | 160 |
| SPH | 18 | 0. | 0. | .1000000E+03 | .4725000E+02 | -0. | -0. | 168 |
| SPH | 19 | 0. | 0. | .1040000E+03 | .5000000E+02 | -0. | -0. | 176 |
| SPH | 20 | 0. | 0. | .1040000E+03 | .4725000E+02 | -0. | -0. | 184 |
| RPP | 21 | -.1250000E+02 | .4000000E+02 | -.1250000E+02 | .4000000E+02 | .8700000E+02 | .1380000E+03 | 192 |
| RPP | 22 | -.1500000E+02 | .5250000E+02 | -.1500000E+02 | .5250000E+02 | .6700000E+02 | .1300000E+03 | 200 |
| SPH | 23 | 0. | 0. | .1000000E+03 | .5000000E+02 | -0. | -0. | 208 |
| RPP | 24 | -.1500000E+02 | .5250000E+02 | -.1500000E+02 | .5250000E+02 | .6700000E+02 | .1300000E+03 | 216 |
| RPP | 25 | -.1500000E+02 | .5250000E+02 | -.1500000E+02 | .5250000E+02 | .6700000E+02 | .1300000E+03 | 224 |
| END | 26 | -0. | -0. | -0. | -0. | -0. | -0. | 232 |

NUMBER OF BODIES 25

LENGTH OF FPD-ARRAY 237

Table II. (Continued)

INPUT ZONE DATA

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 200R | 1 | -17 | -16 | -22OR | 1 | 23 | -4 | -16 | -24 | Z | 1 |
| 2 | 20 | 1 | 17 | -18 | -16 | 4 | -0 | -0 | -0 | -0 | Z | 3 |
| 3 | 20 | 1 | 18 | 5 | -22 | -16 | -0 | -0 | -0 | -0 | Z | 4 |
| 4 | 20 | 1 | 12 | 5 | -0 | -0 | -0 | -0 | -0 | -0 | Z | 5 |
| 5 | 20 | 1 | 6 | 14 | -12 | -21 | -0 | -0 | -0 | -0 | Z | 6 |
| 6 | 20 | 1 | 7 | 21 | -11 | -14 | -0 | -0 | -0 | -0 | Z | 7 |
| 7 | 20 | 1 | 7 | 11 | -10 | -0 | -0 | -0 | -0 | -0 | Z | 8 |
| 8 | 20 | 1 | 7 | 10 | -9 | -0 | -0 | -0 | -0 | -0 | Z | 9 |
| 9 | 20 | 1 | 9 | 5 | -0 | -0 | -0 | -0 | -0 | -0 | Z | 10 |
| 10 | 20 | 1 | 20 | 5 | 16 | -21 | -8 | -0 | -0 | -0 | Z | 11 |
| 11 | 20 | 1 | 19 | -20 | 16 | -8 | 4 | -0 | -0 | -0 | Z | 12 |
| 12 | 20 | 1 | 8 | -0 | -0 | -0 | -0 | -0 | -0 | -0 | Z | 13 |
| 13 | 200R | 1 | -19 | 16 | -15 | -80R | 1 | 19 | 16 | -22 | Z | 14 |
| | -0 | -4 | -0 | -0 | -0 | -0 | -0 | -0 | -0 | -0 | Z | 16 |
| 14 | 20 | 1 | 15 | -0 | -0 | -0 | -0 | -0 | -0 | -0 | Z | 16 |
| 15 | 20 | 1 | 5 | -6 | 14 | -12 | -0 | -0 | -0 | -0 | Z | 17 |
| 16 | 20 | 1 | 5 | -7 | 21 | -14 | -9 | -0 | -0 | -0 | Z | 18 |
| 17 | 200R | 1 | 4 | -5 | 180R | 20 | 1 | 4 | -5 | -0 | Z | 19 |
| 18 | 20 | 1 | 25 | -4 | -0 | -0 | -0 | -0 | -0 | -0 | Z | 21 |
| 19 | 20 | 2 | -1 | -0 | -0 | -0 | -0 | -0 | -0 | -0 | Z | 22 |
| 20 | 20 | 3 | -2 | -0 | -0 | -0 | -0 | -0 | -0 | -0 | Z | 23 |
| END | -0 | -0 | -0 | -0 | -0 | -0 | -0 | -0 | -0 | -0 | Z | 24 |

NUMBER OF INPUT ZONES 20
NUMBER OF CODE ZONES 23
LENGTH OF INTEGER ARRAY 1379

MORSE REGION IN INPUT ZONE(I) ARRAY MRIZ(I),I=1,20)

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20

MORSE MEDIA IN INPUT ZONE(I) ARRAY MMIZ(I),I=1,20)

1000 1 2 3 4 4 4 4 3 7 1 1 5 5 6 6 11000 8 0

SIX GROUPS CROSS-SECTIONS FOR CODE MORSE

| | |
|---|---|
| NUMBER OF PRIMARY GROUPS (NGP) | 6 |
| NUMBER OF PRIMARY DOWNSCATTERS (NDS) | 6 |
| NUMBER OF SECONDARY GROUPS (NGG) | 0 |
| NUMBER OF SECONDARY DOWNSCATTERS (NDSG) | 0 |
| NUMBER OF PRIM+SEC GROUPS (INGP) | 6 |
| TABLE LENGTH (ITBL) | 9 |
| LOC OF WITHIN GROUP (SIG GG) (ISGG) | 4 |
| NUMBER OF MEDIA (NMED) | 7 |
| NUMBER OF INPUT ELEMENTS (NELEM) | 4 |
| NUMBER OF MIXING ENTRIES (NMIX) | 11 |
| NUMBER OF COEFFICIENTS (NCOEF) | 4 |
| NUMBER OF ANGLES (NSCT) | 2 |
| RESTORE COEFF (ISTAT) | 0 |
| ADJOINT SWITCH (FROM MORSE) | 0 |

CROSS SECTIONS AS READ FOR ELEMENT 1 COEFFICIENT 1

| GP | ABS XSEC | NU*FISS | TOTAL | FROM GROUP TRANSFER PROBABILITIES | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 1.366E-03 | 0. | 1.045E-02 | 3.496E-03 | | | | | |
| 2 | 1.392E-03 | 0. | 1.055E-02 | 3.598E-03 | 1.003E-03 | | | | |
| 3 | 1.317E-03 | 0. | 1.051E-02 | 3.369E-03 | 1.017E-03 | 2.279E-04 | | | |
| 4 | 1.199E-03 | 0. | 1.041E-02 | 3.296E-03 | 9.925E-04 | 2.321E-04 | 2.512E-04 | | |
| 5 | 1.050E-03 | 0. | 1.032E-02 | 3.349E-03 | 9.956E-04 | 2.393E-04 | 2.664E-04 | 1.235E-04 | |
| 6 | 1.865E-04 | 0. | 1.785E-02 | 1.766E-02 | 5.917E-03 | 4.922E-03 | 6.597E-03 | 4.044E-03 | 3.985E-03 |

CROSS SECTIONS FOR MEDIA 1

| GROUP | SIGT | SIGST | PNUP | PNABS | GAMGEN | NU*FIS | DOWNSCATTER PROBABILITY | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 7.898E-04 | 6.866E-04 | 0.0000 | .8693 | 0.0000 | 0.0000 | .3848 | .1104 | .0251 | .0276 | .0136 | .4385 |
| 2 | 7.970E-04 | 6.919E-04 | 0.0000 | .8681 | 0.0000 | 0.0000 | .3929 | .1110 | .0253 | .0291 | .4416 | |
| 3 | 7.944E-04 | 6.950E-04 | 0.0000 | .8748 | 0.0000 | 0.0000 | .3662 | .1079 | .0260 | .4998 | | |
| 4 | 7.867E-04 | 6.961E-04 | 0.0000 | .8649 | 0.0000 | 0.0000 | .3577 | .1081 | .5342 | | | |
| 5 | 7.795E-04 | 7.002E-04 | 0.0000 | .8982 | 0.0000 | 0.0000 | .3614 | .6386 | | | | |
| 6 | 1.349E-03 | 1.334E-03 | 0.0000 | .9895 | 0.0000 | 0.0000 | 1.0000 | | | | | |

ANALYSIS DATA

# Table II. (Continued)

ND= 21, NNE= 0, NE= 0, NT= 0, NA= 0, NHESP= 4, NEX= 22, NEXND= 0

| GROUP | RESP( 1) | RESP( 2) | RESP( 3) | RESP( 4) |
|---|---|---|---|---|
| 1 | 1.0000E+00 | 3.2924E-01 | 2.5580E-02 | 9.2200E-03 |
| 2 | 1.0000E+00 | 3.5918E-01 | 2.8350E-02 | 8.0300E-03 |
| 3 | 1.0000E+00 | 3.8763E-01 | 3.2290E-02 | 6.3800E-03 |
| 4 | 1.0000E+00 | 4.0802E-01 | 3.5900E-02 | 4.9100E-03 |
| 5 | 1.0000E+00 | 4.1632E-01 | 4.0120E-02 | 3.6200E-03 |
| 6 | 1.0000E+00 | 4.2086E-01 | 4.5290E-02 | 2.5800E-03 |

TIME REQUIRED FOR INPUT WAS 1
YOU ARE USING THE DEFAULT VERSION OF STRUN WHICH DOES NOTHING.

***START BATCH 1 RANDOM=200010571525222O1031

SOURCE DATA
YOU ARE USING THE DEFAULT VERSION OF SOURCE WHICH SETS WATE TO ODF AND PROVIDES AN ENERGY IG.
LOWER LIMIT=0. UPPER LIMIT= .10000000E+01 NUMBER OF SUBDIVISIONS= 40

FDF

| | | | | |
|---|---|---|---|---|
| 0. | 0. | 0. | 0. | 0. |
| 0. | 0. | 0. | 0. | .10000000E+01 |
| .20000000E+01 | .30000000E+01 | .40000000E+01 | .60000000E+01 | .70000000E+01 |
| .90000000E+01 | .11000000E+02 | .12000000E+02 | .14000000E+02 | .16000000E+02 |
| .17000000E+02 | .18000000E+02 | .19000000E+02 | .21000000E+02 | .22000000E+02 |
| .23000000E+02 | .24000000E+02 | .24000000E+02 | .26000000E+02 | .26000000E+02 |
| .28000000E+02 | .28000000E+02 | .29000000E+02 | .27000000E+02 | .25000000E+02 |
| .23000000E+02 | .22000000E+02 | .22000000E+02 | .20000000E+02 | .20000000E+02 |

| SWATE | IAVE | UAVE | VAVE | WAVE | XAVE | YAVE | ZAVE | AGEAVE |
|---|---|---|---|---|---|---|---|---|
| 1.500E+02 | 1.00 | .0476 | .0327 | .6624 | 1.406E+01 | 1.469E+01 | 4.000E+01 | 0. |

YOU ARE USING DEFAULT VERSION OF ALBDO WHICH PERFORMS SPECULAR REFLECTION

NUMBER OF COLLISIONS OF TYPE NCOLL

| SOURCE | SPLIT(D) | FISHN | GAMGEN | REALCOLL | ALBEDO | BDRYX | ESCAPE | E-CUT | TIMEKILL | R R KILL | R R SURV | GAMLOST |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 150 | 0 | 0 | 0 | 19 | 1887 | 3013 | 150 | 0 | 0 | 0 | 0 | 0 |

TIME REQUIRED FOR THE PRECEDING BATCH WAS 2

***START BATCH 2 RANDOM=200050163264000527O1

SOURCE DATA

| SWATE | IAVE | UAVE | VAVE | WAVE | XAVE | YAVE | ZAVE | AGEAVE |
|---|---|---|---|---|---|---|---|---|
| 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 | BDRYX | ESCAPE | E-CUT | TIMEKILL | R R KILL | R R SURV | GAMLOST |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 150 | 0 | 0 | 0 | 26 | 1792 | 2965 | 150 | 0 | 0 | 0 | 0 | 0 |

TIME REQUIRED FOR THE PRECEDING BATCH WAS 2

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 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.

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.

## REFERENCES


1. M. B. Emmett, "The MORSE Monte Carlo radiation transport code System", ORNL-4972, UC-32 Mathematics and computers, February 1975.

2. M. M. H. Ragheb, C.W. Maynard,"Three-Dimensional Neutronics for a Fusion Reactor Non-Mobile Gas-cooled Solid blanket" UWFD-92, The University of Wisconsin, February 1975.

3. L.A. El Guebaly, C.W. Maynard, "Monte Carlo Calculations for a Fusion Reactor Blanket and Shield", FDM 79 The University of Wisconsin, January 1974.

4. M.Ragheb,et al.,"Monte carlo neutronics analysis of a modular fusion reactor blanket "(To be published)

5. Control Data Cyber 170, CYBER 70, 6000, 7600 Series Computer Systems UPDATE Reference Manual, Publication No. 60342500; Revision E, (1974).

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