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The Code PERTUBAT for Processing Neutron Diffusion Theory Neutronics Results for Perturbation Analyses

D. R. Vondy
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THE CODE PERTUBAT FOR PROCESSING NEUTRON DIFFUSION THEORY NEUTRONICS RESULTS FOR PERTURBATION ANALYSES

D. R. Vondy and T. B. Fowler

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ABSTRACT

This report documents a code which is used for perturbation analyses. The PERTUBAT code is a module in the local computation system which contains the VENTURE neutronics code for applying multi-group diffusion theory. First order effects are calculated for changes in macroscopic cross sections. These may be due to changes in nuclide densities and microscopic cross sections. A fractional change may be made in macroscopic cross sections or the effects of temperature changes may be accounted for directly given the temperature distributions and associated cross section data. Regular, adjoint flux integrals are made available for other use. These integrals and the perturbations may be obtained for selected conditions with multiple sets of the reference data files available in the run of the modular code system. Thus the regular flux may be generated for a reference state, the adjoint flux for a specific perturbed state, and the individual components to the net reactivity change may be obtained for the change between the two states in this computation system. Nuclide importance data may be obtained.

COMPUTER CODE ABSTRACT

1. Program Identification: Perturbation Code Module: PERTUBAT.
2. Function: This code performs first order perturbation calculations. Provision has been made to calculate perturbations due to changes in microscopic cross sections and nuclide densities. Perturbations due to a linear dependence of macroscopic cross sections on temperature may be obtained given temperature distributions and associated cross section data. Nuclide importance data may be calculated.
3. Method of Solution: Numerical integration.
4. Related Material: Standard interface data files adopted in the DOE Reactor Physics code coordination effort are used. User input data must be processed externally. Other modules using consistent formulations and interface data file specifications will couple directly with this one.
5. Restrictions: Variable dimensioning is used throughout. Three data handling modes are programmed, the choice of which depends upon the amount of core storage available. (This is not a stand-alone code; it must be implemented in a modular environment.)
6. Computer: This code has been run on IBM model 360 computers.
7. Running Time: Required time depends upon the problem to be solved and the mode of data handling. Since the calculations performed are non-iterative, the required CPU time is small compared with that required to solve neutronics problems.
8. Programming Languages: Most of the programming is in FORTRAN language. Known limitations of manufacturer's current compilers are not exceeded. Special routines programmed in IBM assembler language are used for certain functions, e.g., memory allocation.
9. Operating System: The basic OS-360 IBM operating system has been used under HASP and ASP with a FORTRAN IV, H level compiler version 21.8.

10. Machine Requirements: A 50,000 short word or larger memory is required in addition to auxiliary disk storage. Typically 30 logical I/O units are used.

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I. INTRODUCTION

The PERTUBAT code was developed for calculating perturbation effects. There is considerable need in nuclear reactor analysis for such capability. The code is a companion of the VENTURE diffusion theory neutronics code[1]. These codes are used with others in a local modular code system driven by a control module[2]. Primary interfacing of basic data and flux values is done in defined standard interface data files[3]. These codes use only data from these files without access of input data from the user input data stream. Input data processors are in use locally for generating the interface data files[4].

This code satisfies the basic objectives of the inter-installation code coordination activity of the Physics Branch, formerly DRRD of ERDA. Although new files have been required, the specifications for most of the files which have been implemented were those developed cooperatively. Reasonable steps have been taken to solve a wide range in type of problems with effective data transfer schemes and reasonable and variable computer memory requirements. Conversion of the code to other computer types and use in similar modular systems with compatible data file management should not be difficult. The programming techniques known to cause difficulty in conversion have been avoided.

The code is in routine use locally on a production basis, available at ORNL and to other installations via remote terminal. A reasonable amount of testing has been done, especially comparison of results with those produced by other codes or other methods.

This code contains extended capability over that available in the past. We are anxious to get feedback from application.

The effort of implementing and testing this code required eight man months. The use of part of the VENTURE program considerably reduced the amount of work under what would have been required otherwise. However, the effort devoted to this project was more than originally intended due to the incorporation of increased flexibility and capability which were found to be desirable as the work progressed.

II. APPLICATION INFORMATION

This section presents information about the code which is of special interest to the user. Included is a sample problem which demonstrates application.

A. Program Description

This code calculates first order perturbation effects. The effect on the multiplication factor may be determined due to changes in nuclide densities, microscopic cross sections, or both. Provision has also been made to account for changes in nuclide referencing (correspondence between densities and cross sections). Perturbations due to a linear dependence of cross sections on temperature may be determined given temperature distributions and associated cross sections. Nuclide importance data may be obtained.

This code is a member of the local modular nuclear reactor computation system and does not read input data. Information is supplied via standard interface data files, and results are printed and written on interface data files.

B. Program Considerations

Figure 1 lists the contents of the record PERINS of the standard interface data file CONTRL (see section 204 of reference 2). This figure shows the instructions to PERTUBAT, lists the program options and explains the use of the interface files required. For many of the options, the required versions of the interface data files would have to be available, created previously in that computer run, or in previous runs and saved.

This record of the file CONTRL may be created with the input processor[3], or alternatively with the special processor DUTLIN[4].

Figure 2 documents the contents of the zone temperature file ZNTEMP. Requirements for the temperature data depend on the options in the PERINS control record discussed above.

FIGURE 1. CONTENTS OF THE PEPINS RECORD OF INTERFACE FILE CONTRL.

```
C-----------------------------------------------------------------------
CR          PERTURBATION MODULE INSTRUCTIONS
C
CL     PERINS, (XX(I),I=1,100), (IX(I),I=1,100)
C
CW     101*MULT + 100
C
CD     PERINS        PERTURBATION MODULE DATA IDENTIFIER (6HPERINS)
CD
CC     NOTE- UNDEFINED DATA ARE RESERVED FOR FUTURE USE.
CC     NOTE- THE VALUE OF ZERO IS A DEFAULT MEANING THAT THE OPTION TO
CC           PERFORM THE TASK IS NOT EXERCISED.
CC     NOTE- THE INTERFACE FILES -GRUPXS- -GEODST- -NDXSRF- -ZNATDN-
CC           -RTFLUX- AND -ATFLUX- ARE NEEDED.
C
C
CD     XX( 1) - REFERENCE TEMPERATURE T1, DEGREES C (SEE IX(7) BELOW).
C
CD     XX( 2) - CHANGED TEMPERATURE T2, DEGREES C.
CD     XX( 3) - TEMPERATURE CORRELATING PARAMETER 'ALFA'
C
CD     XX( 4)
CD     XX( 5)
CD     XX( 6)
CD     XX( 7)
CD     XX( 8)
CD     XX( 9)
CD     XX(10)
CD     XX(11)
CD     XX(12)
C
CD     XX(13) - CONSTANT BUCKLING, OVERRIDES DATA ON GEODST.
C
CD     XX(14)
CD     XX(15)
CD     XX(16)
CD     XX(17)
CD     XX(18)
CD     XX(19)
CD     XX(20)
CD     XX(21)
CD     XX(22)
CD     XX(23)
CD     XX(24)
C
CD     XX(25) - FRACTION CHANGE IN MACRO. CROSS SECTIONS FOR IX(2)=1.
C
```

```
CC     THE FOLLOWING TABLE SHOWS THE INTERFACE FILES REQUIRED FOR
CC     OPTIONS IX(1) AND IX(2), AND THE FILE VERSIONS USED TO OBTAIN THE
CC     PERTURBATION (DELTA MACRO = SIGB-SIGA). ADDITIONAL FILES ARE
CC     ALSO REQUIRED.
C
CC            IX(1)-|   -1    |    0    |    1    |    2    |    3    |
CC        IX(2)     |         |         |         |         |         |
CC                  -----+---------+---------+---------+---------+---------|
CC                       |         |N1,N2,S1,|         |         |         |
CC          0            | EXCLUDED|S2,X     |N1,N2,S,X|N,S1,S2,X|  N,S,X  |
CC                       |         |         |         |         |         |
CC                  -----+---------+---------+---------+---------+---------|
CC                  SIGA |  N,S,X  | N1,S1,X | N1,S,X  | N,S1,X  |  N,S,X  |
CC          1            |         |         |         |         |         |
CC                       |         |  N2,S2  |   N2    |   S2    |         |
CC                  -----+---------+---------+---------+---------+---------|
CC                  SIGA | N1,S,X  | N1,S1,X | N1,S,X  | N1,S1,X | N1,S,X  |
CC          2            |         |         |         |         |         |
CC                  SIGB | N2,S,X  | N2,S2,X | N2,S,X  | N2,S2,X | N2,S,X  |
CC                  -----+---------+---------+---------+---------+---------|
CC                  SIGA | N,S1,X  | N1,S1,X | N1,S1,X | N,S1,X  | N,S1,X  |
CC          3            |         |         |         |         |         |
CC                  SIGB | N,S2,X  | N2,S2,X | N2,S2,X | N,S2,X  | N,S2,X  |
CC                  -----+---------+---------+---------+---------+---------|
CC                  SIGA | N1,S1,X | N1,S1,X | N1,S1,X | N1,S1,X | N1,S1,X |
CC          4            |         |         |         |         |         |
CC                  SIGB | N2,S2,X | N2,S2,X | N2,S2,X | N2,S2,X | N2,S2,X |
CC                  -----+---------+---------+---------+---------+---------|
CC                  SIGA | N,S,X1  |N1,S1,X1 | N1,S,X1 | N,S1,X1 | N,S,X1  |
CC          5            |         |         |         |         |         |
CC                  SIGB | N,S,X2  |N2,S2,X2 | N2,S,X2 | N,S2,X2 | N,S,X2  |
CC                  -----+---------+---------+---------+---------+---------|
CC                  SIGA | N1,S,X1 |N1,S1,X1 | N1,S,X1 |N1,S1,X1 | N1,S,X1 |
CC          6            |         |         |         |         |         |
CC                  SIGB | N2,S,X2 |N2,S2,X2 | N2,S,X2 |N2,S2,X2 | N2,S,X2 |
CC                  -----+---------+---------+---------+---------+---------|
CC                  SIGA |N1,S1,X1 |N1,S1,X1 |N1,S1,X1 |N1,S1,X1 |N1,S1,X1 |
CC          7            |         |         |         |         |         |
CC                  SIGB |N2,S2,X2 |N2,S2,X2 |N2,S2,X2 |N2,S2,X2 |N2,S2,X2 |
CC                  ---------------------------------------------------------
C
CC     WHERE -- N1 = NEXT-TO-LATEST VERSION (UNPERTURBED) ZNATDN FILE.
CC              N2 =          LATEST VERSION (  PERTURBED) ZNATDN FILE.
CC              S1 = NEXT-TO-LATEST VERSION (UNPERTURBED) GRUPXS FILE.
CC              S2 =          LATEST VERSION (  PERTURBED) GRUPXS FILE.
CC              X1 = NEXT-TO-LATEST VERSION (UNPERTURBED) NDXSRF FILE.
CC              X2 =          LATEST VERSION (  PERTURBED) NDXSRF FILE.
CC              N, S, X = LATEST (MAY BE ONLY ONE) VERSION OF ZNATDN,
CC              GRUPXS, AND NDXSRF FILES.
C
CC     IF FILES DO NOT EXIST FOR IX(1) OPTIONS 0, 1, OR 2, IX(1) IS
CC     DEFAULTED TO 3 AND THE ATTEMPT IS MADE TO PROCEED USING A SINGLE
CC     EXISTING FILE AS NEXT-TO-LATEST VERSION UNLESS IX(6) GT 0.
```

(CONT)

```
CC      NOTE --  DIFFERENT GRUPXS FILES MUST HAVE THE SAME GROUP STRUCTURE.
CC               THE FILES GEODST, RTFLUX, AND ATFLUX MUST HAVE THE SAME
CC               NUMBER OF GROUPS AND THE SAME MESH.
CC               THE FILES GEODST AND NDXSRF MUST HAVE THE SAME NUMBER
CC               OF ZONES.
CC               THE FILES GRUPXS AND NDXSRF MUST HAVE THE SAME TOTAL
CC               NUMBER OF NUCLIDES.
CC               THE FILES ZNATDN AND NDXSRF MUST HAVE THE SAME MAXIMUM
CC               NUMBER OF NUCLIDES IN ANY SET, AND THE SAME NUMBER OF
CC               ZONES PLUS SUB-ZONES.
C
C
C
CD      IX( 1) - OPTIONS FOR CALCULATING BASIC INTEGRALS.
CD              -1 - NO CALCULATION (PERTUB ALREADY EXISTS).
CD               0 - CALCULATE INTEGRALS USING FILES N1, S1.
CD               1 - CALCULATE INTEGRALS USING FILES N1, S2 (USUALLY NOT
CD                   DONE).
CD               2 - CALCULATE INTEGRALS USING FILES N2, S1 (USUALLY NOT
CD                   DONE).
CD               3 - CALCULATE INTEGRALS USING FILES N2, S2 (OR N, S).
C
CD      IX( 2) - OPTIONS FOR CALCULATING (DELTA K)/K = (PERTURBATION
CD               INTEGRALS)*(SIGB-SIGA).
CD               0 - ONLY CALCULATE BASIC INTEGRALS.
CD               1 - CHANGE MACROSCOPIC CROSS SECTIONS BY MULTIPLYING
CD                   THEM BY XX(25).
CD               2 - CHANGE ONLY DENSITIES.
CD               3 - CHANGE ONLY CROSS SECTIONS.
CD               4 - CHANGE BOTH DENSITIES AND CROSS SECTIONS.
CD               5 - CHANGE ONLY REFERENCING.
CD               6 - CHANGE DENSITIES AND REFERENCING.
CD               7 - CHANGE DENSITIES, CROSS SECTIONS, AND REFERENCING.
C
CD      IX( 3) - PERTUBATION CALCULATION OPTIONS FOR IX(1) GE 0.
CD              -1 - DO NOT CALCULATE TRANSPORT INTEGRALS.
CD               0 - CALCULATE ALL INTEGRALS.
CD               1 - ALSO CALCULATE RESULTS FOR 100 PERCENT CHANGE IN
CD                   MACROSCOPIC CROSS SECTIONS AND UNCERTAINTY
CD                   (SENSITIVITY) RESULTS.
CD               6 - SAME AS 0 BUT NO EDITS ARE PRINTED.
C
CD      IX( 4) - EDIT OPTIONS FOR IMPORTANCE MAPPING FOR IX(1) GE 0.
CD               1 - ABSORPTION CROSS SECTION SPACE POINT IMPORTANCE MAP.
CD               2 - ALSO PRODUCTION AND PRODUCTION-ABSORPTION SPACE
CD                   POINT IMPORTANCE MAPS.
CD               3 - ALSO 1/V SPACE POINT IMPORTANCE MAP.
C
CD      IX( 5) - OPTION TO WRITE INTERFACE FILE PERTUB FOR IX(1) GE 0.
CD               0 - REPLACE OLD FILE, IF NONE EXISTS SET UP NEW ONE.
CD               1 - WRITE NEW FILE.
```

(CONT)

```
CD     IX( 6) - OPTION TO DEFAULT FILES FOR IX(1) = 0, 1, OR 2.
CD              0 - DEFAULT IX(1) TO 3 IF FILES FOR IX(1) = 0, 1, OR 2
CD                  DO NOT EXIST.
CD              1 - STOP CALCULATION IF FILES DO NOT EXIST.
C
CD     IX( 7) - OPTIONS TO CONSIDER A CORRELATION OF MACROSCOPIC
CD              CROSS SECTIONS ON ZONE TEMPERATURE IF GT 0, REQUIRES
CD              ZONE TEMPERATURE DATA IN INTERFACE FILE(S).
CD              0 - NO TEMPERATURE DEPENDENCE, SEE DISCUSSION ABOUT
CD                  OPTIONS ABOVE.
CD              1 - SIGA = SIGAT1, AND
CD                  SIGB = SIGBT1+F1*(SIGBT2-SIGBT1).
CD              2 - SIGA = SIGAT1+F1*(SIGAT2-SIGAT1), AND
CD                  SIGB = SIGBT1+F1*(SIGBT2-SIGBT1).
CD              3 - SIGA = SIGAT1+F1*(SIGAT2-SIGAT1), AND
CD                  SIGB = SIGBT1+F2*(SIGBT2-SIGBT1).
C
CC     WHERE -- SIGA = STATE A MACROS.
CC              SIGB = STATE B MACROS.
CC              SIGAT1 = MACROS CALCULATED USING FILE N1 (OR N) AND
CC                       FILE S1 (REFERENCE TEMPERATURE) OR X1.
CC              SIGAT2 = MACROS CALCULATED USING FILE N1 (OR N) AND
CC                       FILE S2 (CHANGED TEMPERATURE) OR X2.
CC              SIGBT1 = MACROS CALCULATED USING FILE N2 (OR N) AND
CC                       FILE S1 (REFERENCE TEMPERATURE) OR X1.
CC              SIGBT2 = MACROS CALCULATED USING FILE N2 (OR N) AND
CC                       FILE S2 (CHANGED TEMPERATURE) OR X2.
CC              A1 = (Z1-T1)/(T2-T1).
CC              A2 = (Z2-T1)/(T2-T1).
CC              T1 = REFERENCE TEMPERATURE (XX(1) ABOVE).
CC              T2 = CHANGED TEMPERATURE (XX(2) ABOVE).
CC              Z1 = ZONE DEPENDENT REFERENCE TEMPERATURES
CC                   (FROM FILE ZNTEMP).
CC              Z2 = ZONE DEPENDENT CHANGED TEMPERATURES
CC                   (FROM FILE ZNTEMP).
CC              IF ALFA= 0, F1=A1,
CC                 OTHERWISE F1=TAN-1(ALFA*A1)/TAN-1(ALFA)
CC              IF ALFA= 0, F2=A2,
CC                 OTHERWISE F2=TAN-1(ALFA*A2)/TAN-1(ALFA)
C
CC     NOTE --  FOR IX(7) = 0, ALL IX(1) AND IX(2) OPTIONS APPLY.
CC              FOR IX(7) GT 0, IX(1) OPTIONS -1, 0, OR 3 APPLY, AND
CC              IX(2) OPTIONS 3, 4, 5, 6, AND 7 APPLY.
C
CD     IX( 8) - OPTION TO CALCULATE IMPORTANCE BY NUCLIDE NAME IN EACH
CD              ZONE. POSITIVE VALUES SPECIFY IMPORTANCE BY ABSOLUTE
CD              NUCLIDE NAMES, NEGATIVE VALUES SPECIFY IMPORTANCE BY
CD              UNIQUE NUCLIDE NAMES.
CD              0 - NO.
CD              1 - CALCULATE (DELTA K)/(K*DELTA N) FOR NUCLIDES HAVING
CD              CLASSIFICATION 1, 2, AND 3 (ACTINIDES). DEFAULT TO ALL
CD              NUCLIDES IF NO 1, 2, OR 3 CLASSIFICATION.
CD              2 - ALSO CALCULATE (N*DELTA K)/(K*DELTA N).
CD              3 - SAME AS 1 BUT FOR ALL NUCLIDES.
CD              4 - SAME AS 2 BUT FOR ALL NUCLIDES.
```

(CONT)

```
CC     NOTE --  THE ZNATDN, GRUPXS, AND NDXSRF FILES USED FOR THIS
CC              OPTION WILL BE THE ONES LAST USED AS REQURIED BY OPTIONS
CC              IX(1), IX(2), AND IX(7).
C
CD     IX( 9)
C
CD     IX(10) - OPTION TO USE LOCAL I/O ROUTINES IF GT 0.
C
CD     IX(11) - OPTION TO PREVENT FILES FROM DEFAULTING TO CORE IF GT 0.
C
CD     IX(12)
C
CD     IX(13) - 0 OR 1 = NORMAL RTFLUX. 2 = FIXED SOURCE RTFLUX.
C
CD     IX(14) - 0 OR 1 = NORMAL ATFLUX. 2 = FIXED SOURCE ATFLUX.
CD     IX(15) - EDIT MACROSCOPIC CROSS SECTIONS IF GT 0.
C
CD     IX(16) - EDIT MACROSCOPIC SCATTERING CROSS SECTIONS IF GT 0.
C
CD     IX(17)
C
CD     IX(18) - FISSION SOURCE DISTRIBUTION FUNCTION OPTION.
CD              0 - SET VALUES TO BE USED (SAME IN EACH ZONE).
CD              1 - REGION DEPENDENT VALUES TO BE USED.
C
CD     IX(19) - FISSION SOURCE DISTRIBUTION NORMALIZATION OPTION.
CD              0 - LEAVE UNNORMALIZED.
CD              1 - NORMALIZE EACH SET TO SUM TO UNITY.
C
CD     IX(20) - OPTION TO FORCE DATA HANDLING MODE.
CD              1 - 1-ROW STORED MODE.
CD              2 - SPACE STORED MODE.
CD              3 - PLANE STORED MODE.
C
CD     IX(21) - ORDER IN THE CROSS SECTION FILE OF THE DIRECTION
CD              DEPENDENT TRANSPORT CROSS SECTION TO BE USED FOR THE
CD              FIRST COORDINATE DIRECTION (USUALLY 0).
C
CD     IX(22) - DITTO, SECOND COORDINATE DIRECTION.
C
CD     IX(23) - DITTO, THIRD COORDINATE DIRECTION.
C
CD     IX(24) - FORCE DATA TRANSFER IN INITIALIZATION (FOR TESTING ONLY).
C
CD     IX(25) - DEBUG OUTPUT OPTION.
CD              0 - NO DEBUG EDIT.
CD              1 - EDIT NUCLIDE IMPORTANCE (SEE IX(8)) BY REACTION
CD                  TYPE (SIGA, NUSIGF, SIGTR, DB**2, SIGR, AND SIGS)
CD                  AND FOR EACH ZONE CLASS. ALSO EDIT CONTENTS OF I/O
CD                  ISIGMA.
CD              2 - PLUS EDIT CONTENTS OF I/O ISIGS AND OTHER SIGMAS.
CD              3 - PLUS EDIT CONTENTS OF I/O 23 AND/OR 40.
C
C-----------------------------------------------------------------------
```

FIGURE 2. CONTENTS OF THE INTERFACE FILE ZNTEMP.

```
C*********************************************************************
CN          DATE 1-1-76
C
CF          ZNTEMP
C
CE          ZONE TEMPERATURE DATA
C
C*********************************************************************

C---------------------------------------------------------------------
CR         FILE IDENTIFICATION
C
CL    HNAME,(HUSE(I),I=1,2),IVERS
C
CW          3*MULT + 1
C
CD    HNAME          FILE NAME (A6) 'ZNTEMP'
CD    HUSE           USER IDENTIFICATION (A6)
CD    IVERS          FILE VERSION NUMBER
C
CN    MULT           1 FOR LONG WORD, 2 FOR SHORT WORD MACHINES
C
C---------------------------------------------------------------------

C---------------------------------------------------------------------
CR          FILE REFERENCE INFORMATION
C
CL    NRZ,NZT,(NA(I),I=1,18)
C
CW          20
C
CD    NRZ            NUMBER OF REACTOR ZONES
CD    NZT            NUMBER OF TEMPERATURES FOR EACH ZONE  .LE. 5
CD    NA             RESERVED
C
CN        OFTEN A SINGLE TEMPERATURE WILL BE CARRIED WHICH SERVES AS A
CN        REFERENCE, AS TO EXPRESS THE EFFECTIVE TEMPERATURE OF THE ZONE
CN        WHICH MAY BE USED SIMPLY FOR SUCH PURPOSE AS CROSS SECTION
CN        CORRELATION.  EVEN IF TWO TEMPERATURES ARE CARRIED TO INCLUDE
CN        THE COOLANT TEMPERATURE, THE FIRST IS INTENDED TO ADMIT SUCH
CN        SIMPLE APPLICATION  (LINEAR INTERPOLATION OF CROSS SECTIONS
CN        IS ADMITTED WHICH MAY BE DONE AT THE MACROSCOPIC LEVEL USING
CN        TWO MICROSCOPIC CROSS SECTION SETS).
C
C
C---------------------------------------------------------------------

C---------------------------------------------------------------------
CR          ZONE TEMPERATURES
C
```

(CONT)

```
CL     ((ZTEMP(I,M),I=1,NZT),M=1,NRZ)
C
CW           NZT*NRZ
C
CD     ZTEMP          TEMPERATURE OF REFERENCE I IN ZONE M (DEGREES C)
CD                          I      REFERENCE
CD                          -      ---------
CD                          1      ACTINIDES (FUEL) --- REFERENCE
CD                          2      COOLANT
CD                          3      MODERATOR
CD                          4      STRUCTURAL
CD                          5      SPECIAL
C
C-----------------------------------------------------------------------
```

C. System Control Requirements

The job control instructions required to execute PERTUBAT are the same as those shown in section 8 of reference 2 and will not be repeated here. The user-supplied job control instructions are discussed under Sample Problem below.

Figure 3 shows the space requirements for the scratch I/O logical units. Generally the space for these units is specified by supplying override parameters in the job control instructions in the same way as described in section 8 of reference 2. The values of the override parameters shown are sufficient for a wide range of problems; however, it is not simple to define space requirements for all possible options. Therefore, values for these parameters may have to be determined and supplied, or override I/O control cards used to specify space for individual units.

D. Sample Problem

This sample problem is a large core LMFBR benchmark problem which is described in reference 5. Figure 4 shows the user-supplied job control instructions. The problem is set up as a two step job; the first step produces the standard interface data files required by PERTUBAT, and the second step uses these files for the perturbation calculations. This illustrates the use of files by PERTUBAT that have previously been created and saved.

Referring to Figure 4, the control module instructions present the module access sequence 1 6 2 7 99 2 7 . Number 1 is the input processor which is to be used to write the records PROINS, DVRINS, and XCPINS of the interface file CONTRL, and the nuclide ordered cross section file ISOTXS.

Module number 6, the cross section processor, is then used. From instructions in the XCPINS record of CONTRL, the ISOTXS file is processed and the group ordered cross section file GRUPXS is written. Note that the control module was instructed to identify the logical unit number of only one interface file (CONTRL) as unit 10. All of the other files to be created in step 1 will have logical unit numbers starting with 11 and

FIGURE 3. SPACE REQUIREMENTS FOR THE SCRATCH DATA FILES.

```
C     DEFINE C=COLUMNS, R=ROWS, P=PLANES, G=GROUPS, Z=ZONES,
C            N=MAX NUCLIDES IN ANY ZONE, AND W=MAX SCATTERING BAND WIDTH
C
C     UNIT NUMBER      NUMBER OF RECORDS      RECORD LENGTH
C     -----------      -----------------      -------------
C     21,41,42,54              G                    W*Z
C                   PLUS       1                    2*G
C                   PLUS       2                    G*Z
C                   PLUS       G                     Z
C
C       24,27,28             P*G                    C*R
C
C          29                G*Z                    N*W
C
C          40                P*G                 8*C*R+C+R
C
C       45,47,52             G                      N*Z
C
C          46     LARGEST   4*Z+3                   N*Z
C                   OR        5                    G*Z
C
C          48                G                      W*Z
```

FIGURE 4. JOB CONTROL INSTRUCTIONS FOR SAMPLE PROBLEM.

```
//USERID   JOB (CHARG),'USER ADDRESS  - NAME',
// MSGLEVEL=(1,1)
//*CLASS   CPU95=03M,REGION=0500K,IO=015,LINES=05,CARDS=00
//STEP1 EXEC BCLDVENT,
// N2=20,N3=10,N4=10,N5=10,N6=10,N7=10,N8=10,N9=10,N10=10,N11=10,
// N12=10,N13=10,N14=10,N15=10,N16=20,
// GOSIZE=500K
//GO.FT11F001 DD DSN=&&ISOTXS,DISP=(NEW,PASS)
//GO.FT12F001 DD DSN=&&GRUPXS,DISP=(NEW,PASS)
//GO.FT13F001 DD DSN=&&GEODST,DISP=(NEW,PASS)
//GO.FT14F001 DD DSN=&&NDXSRF,DISP=(NEW,PASS)
//GO.FT15F001 DD DSN=&&ZNATDNV1,DISP=(NEW,PASS)
//GO.FT16F001 DD DSN=&&RTFLUX,DISP=(NEW,PASS)
//GO.FT17F001 DD DSN=&&ZNATDNV2,DISP=(NEW,PASS)
//GO.FT18F001 DD DSN=&&ATFLUX,DISP=(NEW,PASS)
//GO.SYSIN DD *
=CONTROL1
 2-D LARGE LMFBR REACTOR MODEL BENCHMARK PROBLEM - PERTURBATION EXAMPLE.
 46000                                                          1
  1  6  2  7 99  2  7  0
END
  INPUT DATA TO INPUT PROCESSOR
0V CONTBL
1D PROINS
*2-D LARGE LMFBR REACTOR MODEL BENCHMARK PROBLEM - PERTURBATION EXAMPLE*
*                                  ORNL, 1977, VENTURE                 *
* DV   * * DV    * .0 74R 0 100R
1D DVRINS  0. 100R 46000 0  99R
1D XCPINS  0. 100R  0 0 0 1 0 0 1 2 0 14R 0 0 0 76R /
1D *       *   0. 100R 0 100R
0V ISOTXS   ***CROSS SECTIONS***
 1D      4     30     0     4     1     1     1     4
 2D * LARGE CORE X-SECTIONS                                          *
*      *
    6HMAT 10    6HMAT 11    6HMAT 12    6HMAT 13    6HMAT 14    6HMAT 15
    6HMAT 16    6HMAT 28    6HMAT 40    6HMAT 44    6HMAT 50    6HMAT 56
    6HMAT 60    6HMAT 88    6HMAT112    6HMAT135    6HMAT138    6HMAT139
    6HMAT140    6HMAT141    6HMAT142    6HMAT176    6HMAT224    6HMAT238
    6HMAT239    6HMAT240    6HMAT242    6HMAT335    6HMAT338    6HMAT352
 7.59691E-01  2.37146E-01  3.12704E-03  3.56784E-05
 1.87602E+09  5.56731E+08  1.58760E+08  4.29811E+07  1.64900E+07
 8.20800E+05  4.08700E+04  2.03500E+03  1.00000E-05
     0     6    12    18    24    30    36    42    48    54    60    66
    72    78    84    90    96   102   108   114   120   126   132   138
   144   150   156   162   168   174
 4D 6HCR      6HENDFB3  6H  2400
 5.19000E+01  0.          0.          7.54100E+02  0.
 2.98000E-03
     5     0     0     0     0     0     0     0     0     1     0     0
     1     1     2     3     2     1     1     1     1
 5D  2.33235E+00  3.54714E+00  7.75291E+00  5.44459E+00  4.50048E-03
```

(CONT)

```
6.33641E-03  4.11306E-02  1.05545E-01
7D  1.88266E+00
7D  3.46467E+00  4.44267E-01
7D  7.67668E+00  7.61311E-02  9.15585E-04
7D  5.33905E+00  3.50977E-02
4D 6HFE      6HENDFB3  6H  2600
5.58000E+01  0.           0.           7.54100E+02  0.
6.26000E-03
    5     0     0     0     0     1     0     0     0     1     0     0
    1     1     2     3     2     1     1     1     1
5D  2.24952E+00  3.15837E+00  7.30377E+00  8.94202E+00  7.50050E-03
6.25554E-03  1.36236E-02  9.30693E-02  1.03797E-04  0.
0.           0.
7D  1.86991E+00
7D  3.10804E+00  3.68014E-01
7D  7.25592E+00  4.40735E-02  4.20349E-03
7D  8.84895E+00  3.42184E-02
4D 6HNI      6HENDFB3  6H  2800
5.87000E+01  0.           0.           7.54100E+02  0.
5.26000E-03
    5     0     0     0     0     0     0     0     0     1     0     0
    1     1     2     3     2     1     1     1     1
5D  2.54869E+00  4.75729E+00  1.90691E+01  1.68520E+01  8.64997E-02
1.22271E-02  4.95660E-02  2.60255E-02
7D  2.10394E+00
7D  4.68772E+00  3.57451E-01
7D  1.89484E+01  5.73395E-02  7.94368E-04
7D  1.68260E+01  7.11062E-02
4D 6HMO      6HENDFB3  6H  4200
9.54000E+01  0.           0.           7.54100E+02  0.
2.60000E-04
    5     0     0     0     0     1     0     0     0     1     0     0
    1     1     2     3     2     1     1     1     1
5D  3.54254E+00  6.90495E+00  8.38855E+00  1.18955E+01  1.81308E-02
5.91863E-02  3.04344E-01  1.33673E+00  2.77422E-03  0.
0.           0.
7D  2.65566E+00
7D  6.79867E+00  8.68723E-01
7D  8.05587E+00  4.70868E-02  2.80074E-03
7D  1.05588E+01  2.83314E-02
4D 6HNA      6HENDFB3  6H  1100
2.29000E+01  0.           0.           7.33000E+02  0.
8.08000E-03
    6     0     0     0     0     1     0     0     0     1     0     0
    1     1     2     3     2     1     1     1     1
5D  1.88299E+00  3.79083E+00  5.69793E+00  5.06238E+00  2.54849E-03
9.15280E-04  4.73260E-03  1.23878E-02  2.87633E-06  0.
0.           0.
7D  1.46673E+00
7D  3.68117E+00  4.13709E-01
7D  5.43819E+00  1.08752E-01  4.49804E-07
7D  5.05000E+00  2.55000E-01
4D 6HFE      6HENDFB3  6H  9999
1.00000E+02  0.           0.           7.54100E+02  0.
```

(CONT)

```
2.40000E-04
    4     0     0     0     0     0     0     0     0     1     0     0
    1     1     2     3     2     1     1     1     1
5D  7.61564E+00  1.18709E+01  1.63518E+01  2.32574E+01  5.17349E-02
2.25078E-01  8.72613E-01  3.62165E+00
7D  5.69712E+00
7D  1.15739E+01  1.85852E+00
7D  1.54380E+01  7.18814E-02  8.26870E-03
7D  1.96357E+01  4.11351E-02
4D 6HO        6HENDFB3  6H    80
0.            1.60000E+01  0.            0.            7.54100E+02
0.
    0     0     0     0     0     0     0     0     0     1     0     0
    1     1     2     3     2     1     1     1     1
5D  1.84106E+00  3.37143E+00  3.55431E+00  3.54834E+00  7.60674E-03
7.03775E-08  2.46771E-07  9.11535E-07
7D  1.25201E+00
7D  3.24373E+00  5.81445E-01
7D  3.50740E+00  1.27702E-01  0.
7D  3.54834E+00  4.69054E-02
4D 6HNA       6HENDFB3  6H  1100
2.29000E+01  0.            0.            7.33000E+02  0.
2.40000E-04
    6     0     0     0     0     1     0     0     0     1     0     0
    1     1     2     3     2     1     1     1     1
5D  1.88126E+00  3.78723E+00  5.61962E+00  5.15836E+00  2.58715E-03
8.99325E-04  4.59006E-03  1.26002E-02  2.91533E-06  0.
0.           0.
7D  1.48151E+00
7D  3.68432E+00  3.97157E-01
7D  5.37318E+00  1.02011E-01  4.56092E-07
7D  5.14576E+00  2.41849E-01
4D 6HB-10     6HENDFB3  6H   510
1.00000E+01  0.            0.            7.33000E+02  0.
7.64000E-03
    7     0     0     0     0     0     0     0     0     1     0     0
    1     1     2     3     2     1     1     1     1
5D  1.77863E+00  4.33870E+00  6.61554E+00  1.98988E+01  3.91142E-01
1.48332E+00  4.80291E+00  1.80004E+01
7D  9.49931E-01
7D  2.72928E+00  4.37556E-01
7D  1.79179E+00  1.26102E-01  1.91998E-06
7D  1.89836E+00  2.08453E-02
4D 6HFE       6HENDFB3  6H 2600
5.58000E+01  0.            0.            7.54100E+02  0.
4.04000E-03
    5     0     0     0     0     1     0     0     0     1     0     0
    1     1     2     3     2     1     1     1     1
5D  2.26052E+00  3.38777E+00  7.85045E+00  9.35125E+00  7.36585E-03
6.45551E-03  1.38873E-02  9.58798E-02  1.00434E-04  0.
0.           0.
7D  1.83629E+00
7D  3.32210E+00  4.13103E-01
7D  7.79560E+00  5.92151E-02  3.86137E-03
```

(CONT)

```
7D   9.25537E+00  4.09641E-02
4D 6HB-11     6HENDFB3  6H    511
1.10000E+01  0.            0.            7.33000E+02  0.
1.14700E-02
    7     0     0     0     0     0     0     0     0     1     0     0
    1     1     2     3     2     1     1     1     1
5D   1.73615E+00  3.42551E+00  4.78647E+00  4.72473E+00  5.57323E-05
3.05045E-06  1.13341E-04  2.38576E-05
7D   1.23197E+00
7D   3.20508E+00  5.04120E-01
7D   4.74088E+00  2.20429E-01  3.36695E-07
7D   4.72471E+00  4.54811E-02
4D 6HNA       6HENDFB3  6H   1100
2.29000E+01  0.            0.            7.33000E+02  0.
6.07000E-03
    6     0     0     0     0     1     0     0     0     1     0     0
    1     1     2     3     2     1     1     1     1
5D   1.86462E+00  3.85874E+00  6.54646E+00  4.61370E+00  2.50659E-03
1.02756E-03  5.91149E-03  1.15346E-02  2.78311E-06  0.
0.           0.
7D   1.33353E+00
7D   3.71173E+00  5.28590E-01
7D   6.22384E+00  1.45983E-01  4.36968E-07
7D   4.60216E+00  3.16701E-01
4D 6HFP       6HENDFB3  6H    600
1.20000E+01  0.            0.            7.33040E+02  0.
4.78000E-03
    7     0     0     0     0     0     0     0     0     1     0     0
    1     1     2     3     2     1     1     1     1
5D   1.74016E+00  3.52596E+00  4.39388E+00  4.47585E+00  8.43481E-04
0.           1.72470E-07  1.62503E-05
7D   1.28945E+00
7D   3.33175E+00  4.49861E-01
7D   4.35264E+00  1.94213E-01  2.57901E-08
7D   4.47583E+00  4.12408E-02
4D 6HFE       6HENDFB3  6H   2600
5.58000E+01  0.            0.            7.59100E+02  0.
3.53700E-02
    5     0     0     0     0     1     0     0     0     1     0     0
    1     1     2     3     2     1     1     1     1
5D   2.22851E+00  2.84999E+00  5.92953E+00  9.86922E+00  5.61198E-03
6.33207E-03  1.17788E-02  6.22297E-02  6.66970E-05  0.
0.           0.
7D   1.52382E+00
7D   2.77493E+00  6.95159E-01
7D   5.83354E+00  6.87290E-02  3.98328E-03
7D   9.80699E+00  8.42155E-02
4D 6HNA       6HENDFB3  6H   1100
2.29000E+01  0.            0.            7.33000E+02  0.
1.45300E-02
    6     0     0     0     0     1     0     0     0     1     0     0
    1     1     2     3     2     1     1     1     1
5D   1.89180E+00  3.71570E+00  4.83263E+00  5.49786E+00  2.38604E-03
8.45860E-04  3.31712E-03  1.33330E-02  2.75148E-06  0.
```

(CONT)

```
0.            0.
7D   1.46410E+00
7D   3.61371E+00  4.25317E-01
7D   4.68210E+00  1.01135E-01  4.28348E-07
7D   5.48453E+00  1.47209E-01
4D 6HU-235   6HENDFB3  6H  9235
2.35000E+02  0.           0.           1.29240E+03  0.
1.90000E-05
    1     0     1     0     0     1     0     0     0     1     0     0
    1     1     2     3     3     1     1     1     1
5D  4.68474E+00  8.29209E+00  1.44278E+01  2.47463E+01  5.83333E-02
3.51060E-01  1.04574E+00  4.07153E+00  1.24073E+00  1.46579E+00
2.89339E+00  9.07953E+00  2.68931E+00  2.44889E+00  2.42468E+00
2.42311E+00  1.08886E-02  0.           0.           0.
7D   2.66045E+00
7D   6.42257E+00  7.31972E-01
7D   1.04759E+01  5.26434E-02  4.14506E-03
7D   1.15952E+01  1.28007E-02  3.23548E-05
4D 6HU-238   6HENDFB3  6H  9238
2.38000E+02  0.           0.           1.29240E+03  0.
7.69000E-03
    2     0     1     0     0     1     0     0     0     1     0     0
    1     1     2     3     3     1     1     1     1
5D  4.72115E+00  8.54519E+00  1.33366E+01  1.25213E+01  6.39481E-02
1.79014E-01  6.16305E-01  1.41179E+00  3.70183E-01  3.48353E-04
4.84479E-05  3.93085E-04  2.77311E+00  2.41872E+00  2.32700E+00
2.32700E+00  1.87891E-02  0.           0.           0.
7D   2.58302E+00
7D   8.30431E+00  1.71294E+00
7D   1.27041E+01  6.14318E-02  9.84888E-03
7D   1.11091E+01  1.61135E-02  8.48086E-05
4D 6HPU-239  6HENDFB3  6H  9439
2.39000E+02  0.           0.           1.29240E+03  0.
7.60000E-04
    1     0     1     0     0     1     0     0     0     1     0     0
    1     1     2     3     3     1     1     1     1
5D  4.69324E+00  8.19171E+00  1.39951E+01  2.30947E+01  1.16223E-02
2.04450E-01  1.05720E+00  4.91931E+00  1.89780E+00  1.59197E+00
1.96675E+00  5.74588E+00  3.18890E+00  2.91595E+00  2.88218E+00
2.88012E+00  2.32297E-03  0.           0.           0.
7D   1.99618E+00
7D   6.34695E+00  7.84199E-01
7D   1.09426E+01  4.83271E-02  5.76564E-03
7D   1.24295E+01  2.85658E-02  1.81555E-05
4D 6HPU-240  6HENDFB3  6H  9440
2.40000E+02  0.           0.           1.29240E+03  0.
2.90000E-04
    2     0     1     0     0     1     0     0     0     1     0     0
    1     1     2     3     3     1     1     1     1
5D  4.75812E+00  8.03104E+00  1.38680E+01  2.21745E+01  6.04094E-02
2.23054E-01  7.36510E-01  3.41123E+00  1.50403E+00  2.51700E-01
1.00587E-01  2.05348E-01  3.11872E+00  2.94155E+00  2.89171E+00
2.89012E+00  6.33798E-03  0.           0.           0.
7D   2.49341E+00
```

(CONT)

```
7D  7.45956E+00  7.03193E-01
7D  1.30158E+01  9.63796E-02  3.42027E-03
7D  1.85580E+01  1.50681E-02  3.51853E-04
4D 6HPU-241  6HENDFB3  6H  9441
2.41000E+02  0.            0.            1.29240E+03  0.
1.40000E-04
    1     0     1     0     0     1     0     0     0     1     0     0
    1     1     2     3     3     1     1     1     1
5D  4.65262E+00  8.69088E+00  1.47979E+01  2.63804E+01  8.71624E-02
2.71861E-01  7.77532E-01  2.95514E+00  1.64303E+00  1.92557E+00
3.36957E+00  1.11019E+01  3.25761E+00  2.97067E+00  2.93821E+00
2.93614E+00  1.75066E-02  0.            0.            0.
7D  2.14922E+00
7D  6.40867E+00  7.83679E-01
7D  1.06377E+01  8.46050E-02  7.03386E-03
7D  1.23233E+01  1.30478E-02  1.79024E-04
4D 6HPU-242  6HENDFB3  6H  9442
2.42000E+02  0.            0.            1.29240E+03  0.
8.00000E-05
    0     0     1     0     0     1     0     0     0     1     0     0
    1     1     2     3     3     1     1     1     1
5D  4.43459E+00  7.85891E+00  1.61521E+01  3.33309E+01  3.86613E-02
1.57409E-01  6.30532E-01  3.48330E+00  1.46922E+00  1.60931E-01
3.75722E-02  0.            3.15128E+00  2.89001E+00  2.81119E+00
0.           7.01546E-03  0.            0.            0.
7D  2.32603E+00
7D  7.46940E+00  6.02978E-01
7D  1.54570E+01  7.11672E-02  4.71878E-03
7D  2.98476E+01  2.69626E-02  2.82795E-06
4D 6HFE      6HENDFB3  6H  2600
5.58000E+01  0.            0.            7.54100E+02  0.
6.26000E-03
    5     0     0     0     0     1     0     0     0     1     0     0
    1     1     2     3     3     1     1     1     1
5D  2.25038E+00  3.16307E+00  7.39224E+00  8.74893E+00  7.13862E-03
6.22619E-03  1.36146E-02  9.10613E-02  9.92917E-05  0.
0.           0.
7D  1.86546E+00
7D  3.11507E+00  3.74033E-01
7D  7.35902E+00  4.17796E-02  3.84292E-03
7D  8.65787E+00  1.96008E-02  0.
4D 6HNA      6HENDFB3  6H  1100
2.29000E+01  0.            0.            7.33000E+02  1.83200E-02
6.26000E-03
    6     0     0     0     0     1     0     0     0     1     0     0
    1     1     2     3     3     1     1     1     1
5D  1.91211E+00  3.66470E+00  4.87979E+00  4.53246E+00  2.34797E-03
8.00667E-04  3.64182E-03  1.17056E-02  2.67263E-06  0.
0.           0.
7D  1.46651E+00
7D  3.55405E+00  4.43247E-01
7D  4.64146E+00  1.09849E-01  4.16718E-07
7D  4.52075E+00  2.34691E-01  0.
4D 6HU-238   6HENDFB3  6H  9238
```

(CONT)

```
2.38000E+02  0.           0.           1.29240E+03  0.
7.23000E-03
    2     0     1     0     0     1     0     0     0     1     0     0
    1     1     2     3     3     1     1     1     1
5D  4.71790E+00  8.47037E+00  1.33625E+01  1.26739E+01  6.37775E-02
1.76722E-01  6.14084E-01  1.43077E+00  3.70720E-01  3.59312E-04
4.90293E-05  3.81712E-04  2.77541E+00  2.41907E+00  2.32700E+00
2.32700E+00  1.90889E-02  0.           0.           0.
7D  2.58424E+00
7D  8.23485E+00  1.70837E+00
7D  1.27330E+01  5.83547E-02  9.89101E-03
7D  1.12427E+01  1.53333E-02  7.97368E-05
4D 6HPU-239  6HENDFB3  6H  9439
2.39000E+02  0.           0.           1.29240E+03  0.
1.01000E-02
    1     0     1     0     0     1     0     0     0     1     0     0
    1     1     2     3     3     1     1     1     1
5D  4.69169E+00  8.11945E+00  1.39570E+01  2.24568E+01  1.15952E-02
2.01419E-01  1.04271E+00  4.73989E+00  1.89707E+00  1.59081E+00
1.95960E+00  5.52732E+00  3.19035E+00  2.91682E+00  2.88221E+00
2.88013E+00  2.36028E-03  0.           0.           2.98023E-07
7D  1.99608E+00
7D  6.28148E+00  7.83536E-01
7D  1.09272E+01  4.57164E-02  5.76496E-03
7D  1.21896E+01  2.75043E-02  1.72659E-05
4D 6HPU-240  6HENDFB3  6H  9440
2.40000E+02  0.           0.           1.29240E+03  0.
4.10000E-04
    2     0     1     0     0     1     0     0     0     1     0     0
    1     1     2     3     3     1     1     1     1
5D  4.75598E+00  7.95748E+00  1.38110E+01  2.15603E+01  6.02559E-02
2.20485E-01  7.29371E-01  3.26456E+00  1.50417E+00  2.57590E-01
1.00331E-01  2.04446E-01  3.11971E+00  2.94206E+00  2.89173E+00
2.89013E+00  6.43841E-03  0.           0.           0.
7D  2.49128E+00
7D  7.38749E+00  7.03257E-01
7D  1.29671E+01  9.15838E-02  3.45118E-03
7D  1.80913E+01  1.41961E-02  3.30811E-04
4D 6HPU-242  6HENDFB3  6H  9442
2.42000E+02  0.           0.           1.29240E+03  0.
1.12000E-04
    0     0     1     0     0     1     0     0     0     1     0     0
    1     1     2     3     3     1     1     1     1
5D  4.43405E+00  7.78332E+00  1.60967E+01  3.30550E+01  3.85623E-02
1.55429E-01  6.24791E-01  3.39261E+00  1.47067E+00  1.65483E-01
3.79382E-02  0.           3.15289E+00  2.89051E+00  2.81120E+00
0.           7.12688E-03  0.           0.           0.
7D  2.32653E+00
7D  7.39477E+00  6.00700E-01
7D  1.54085E+01  6.76346E-02  4.71148E-03
7D  2.96624E+01  2.54621E-02  2.65883E-06
4D 6HU-235   6HENDFB3  6H  9235
2.35000E+02  0.           0.           1.29240E+03  0.
4.20000E-05
```

(CONT)

```
     1     0     1     0     0     1     0     0     0     1     0     0
     1     1     2     3     3     1     1     1     1
 5D  4.68293E+00  8.63408E+00  1.46030E+01  2.79653E+01  5.75815E-02
 3.80684E-01  1.07410E+00  5.12103E+00  1.24297E+00  1.50987E+00
 2.97315E+00  1.11918E+01  2.68902E+00  2.44610E+00  2.42457E+00
 2.42308E+00  1.07322E-02  0.           0.           0.
 7D  2.65663E+00
 7D  6.67934E+00  7.32276E-01
 7D  1.05406E+01  6.41510E-02  4.20327E-03
 7D  1.16524E+01  1.51799E-02  4.20589E-05
 4D 6HU-238    6HENDFB3  6H  9238
 2.38000E+02  0.           0.           1.29240E+03  0.
 1.40100E-02
     2     0     1     0     0     1     0     0     0     1     0     0
     1     1     2     3     3     1     1     1     1
 5D  4.71980E+00  8.85015E+00  1.30441E+01  1.13609E+01  6.28789E-02
 1.90045E-01  6.14909E-01  1.22303E+00  3.78375E-01  3.09868E-04
 4.63034E-05  3.82381E-04  2.76659E+00  2.41733E+00  2.32700E+00
 2.32700E+00  1.85889E-02  0.           0.           0.
 7D  2.54269E+00
 7D  8.58263E+00  1.74491E+00
 7D  1.24115E+01  7.70606E-02  9.52718E-03
 7D  1.01375E+01  1.76742E-02  1.10245E-04
 4D 6HFE       6HENDFB3  6H  2600
 5.58000E+01  0.           0.           7.54100E+02  0.
 6.26000E-03
     5     0     0     0     0     1     0     0     0     1     0     0
     1     1     2     3     3     1     1     1     1
 5D  2.24227E+00  3.07496E+00  6.49763E+00  9.08309E+00  7.11246E-03
 6.23925E-03  1.32693E-02  7.89989E-02  9.64467E-05  0.
 0.           0.
 7D  1.85187E+00
 7D  3.02225E+00  3.79213E-01
 7D  6.44904E+00  4.64676E-02  4.16895E-03
 7D  9.00409E+00  3.53218E-02  0.
STOP
END
DVENTR    ***REGULAR FLUX PROBLEM***
001
                                        3.085    +6     1.0       1.282     -3
                              -.1
  4.44     -4
  1  0      0  0                    60
  1  1      1  1                 2  1         1  1  0                 0
003
  9  1  2  1  2                    1  1
  5
004
  2 8.019395 14 56.13576  8 32.07758 10 40.09698 16 64.15516
  1 8.019395  7 56.13576  4 32.07758  5 40.09698  8 64.15516
005
  1  1  2  2  4
  1  1  2  2  4
  2  2  2  3  5
```

(CONT)

```
  2   2   3   4   5
  4   4   5   5   5
006
   2
  16  16   8   8   1   1
   1
  17  22   1   1   1   1  17  23   2   3   1   1  17  22   4   4   1   1
  17  21   5   5   1   1  17  17   6   6   1   1   1  10   9  10   1   1
   1   9  11  11   1   1   3   5  12  12   1   1  11  11   9   9   1   1
  24  24   2   2   1   1
   3
  35  43   1   1   1   1  34  42   2   2   1   1  33  41   3   3   1   1
  32  40   4   4   1   1  31  39   5   5   1   1   3  38   6   6   1   1
  29  37   7   7   1   1  28  36   8   8   1   1   1  16  18  18   1   1
   1  13  19  19   1   1   1   9  20  20   1   1   1   5  21  21   1   1
   1   1  22  22   1   1  24  24   9   9   1   1  23  24  10  10   1   1
  22  24  11  11   1   1  18  24  12  12   1   1  35  35   9   9   1   1
  16  27  14  14   1   1  12  16  15  15   1   1   8  16  16  16   1   1
   4  16  17  17   1   1  25  28  13  13   1   1  17  17  18  18   1   1

   4
  17  25  19  19   1   1  17  21  20  20   1   1  17  17  21  21   1   1
  34  39  11  11   1   1  30  38  12  12   1   1  18  29  18  18   1   1
  36  41   9   9   1   1  35  40  10  10   1   1  35  37  13  13   1   1
  35  36  14  14   1   1  24  35  15  15   1   1  23  34  16  16   1   1
  22  33  17  17   1   1
   5
  50  50   1   1   1   1  49  50   2   2   1   1  48  50   3   3   1   1
  47  50   4   4   1   1  46  50   5   5   1   1  45  50   6   6   1   1
  44  50   7   7   1   1  43  50   8   8   1   1  42  50   9   9   1   1
  41  50  10  10   1   1  40  50  11  11   1   1  39  50  12  12   1   1
  38  50  13  13   1   1  37  50  14  14   1   1  36  50  15  15   1   1
  35  50  16  16   1   1  34  50  17  17   1   1  30  50  18  18   1   1
  26  50  19  19   1   1  22  50  20  20   1   1  18  50  21  21   1   1
  14  50  22  22   1   1  10  50  23  23   1   1   6  50  24  24   1   1
   2  50  25  25   1   1
   6
   1   1   1   1   1   1
   7
   1   2   6   6   1   1   1   1   7   7   1   1  11  13   1   1   1   1

   8
  23  25   1   1   1   1   1   2  12  12   1   1   1   1  13  13   1   1
  14  16   7   7   1   1  13  15   8   8   1   1
   9
  14  16   7   7   1   1  13  15   8   8   1   1
0
012
0
  1   1   1   1   1.0
  2   2   1   1   1.0
  3   3   1   2   1.0
  4   4   1   3   1.0
  5   5   1   3   1.0
```

(CONT)

```
  6   8   2   4   1.0
  9   9   2   4   1.0

013
 24
 24
MAT 10MAT 11MAT 12MAT 13MAT 14MAT 15MAT 16MAT 28MAT 56MAT 44MAT 88MAT135
MAT138MAT139MAT140MAT141MAT142MAT176MAT238MAT239MAT240MAT242MAT335MAT338
 10
MAT 10MAT 12MAT 13MAT 40MAT 50MAT 60MAT112MAT176MAT224MAT352
020
  1   1
MAT139 7.6       -4MAT140  2.9      -4MAT141  1.4      -4MAT142  8.       -5
MAT138 7.69      -3MAT135  1.9      -5MAT 10  2.98     -3MAT 11  6.26     -3
MAT 12 5.26      -3MAT 13  2.6      -4MAT 14  8.08     -3MAT 16  1.804    -2
MAT 15  2.4      -4
  2   2
MAT239 10.1      -4MAT240  4.1      -4MAT141  1.9      -4MAT242  1.12     -4
MAT238  7.23     -3MAT135  1.8      -5MAT 10  2.98     -3MAT 11  6.26     -3
MAT 12  5.26     -3MAT 13  2.6      -4MAT 28  8.08     -3MAT 16  1.804    -2
MAT 15  2.4      -4
  3   3
MAT338  1.401    -2MAT335   4.2     -5MAT 10  1.73     -3MAT 44  4.04     -3
MAT 12  3.84     -3MAT 13   1.9     -4MAT 56  6.07     -3MAT 16  2.802    -2

  4   4
MAT 10 1.516     -2MAT 88 3.537     -2MAT 12 3.368     -2MAT 13 1.47      -3

  5   5
MAT 10 1.516     -7MAT 88 3.537     -7MAT 12 3.368     -7MAT 13 1.47      -8

  6   8
MAT 10  2.98     -3MAT352   6.26    -3MAT 12  5.26     -3MAT 13  2.6      -4
MAT224  1.832    -2
  9   9
MAT 10  2.98     -3MAT176   6.26    -3MAT 12  5.26     -3MAT 13  2.6      -4
MAT112  1.453    -2MAT 40   7.64    -3MAT 50  1.147    -2MAT 60 4.78      -3

0
END
DENMAN    ***PERTURBED NUCLIDE DENSITIES***
018
  1   0   1         1
020
  9   9
MAT 10  2.98     -3MAT176            MAT 12  5.26     -3MAT 13  2.6      -4
MAT112             MAT 40            MAT 50             MAT 60
MAT224  1.832    -2MAT352  6.26     -3

END
DUTLIN    ***CHANGE NEUTRONICS INSTRUCTIONS TO DO ADJOINT ONLY PROBLEM***
DTNINS         0 13  0  6
```

(CONT)

```
 0.0
 0.0
 0.000444
  0   0   0   0   3   1

END
/*
//STEP2 EXEC BCLDVENT,
// NB1=1,NB2=1,B1=3520,B2=7200,N1=40,N2=040,N3=01,N4=01,N5=40,N6=10,
// N7=40,N8=40,N9=40,N10=40,N11=40,
// N12=40,N13=40,N14=40,N15=40,N16=40,NX=10,NS=50,
// GOSIZE=500K
//GO.FT11F001 DD DSN=&&ISOTXS,DISP=(OLD,DELETE)
//GO.FT12F001 DD DSN=&&GRUPXS,DISP=(OLD,DELETE)
//GO.FT13F001 DD DSN=&&GEODST,DISP=(OLD,DELETE)
//GO.FT14F001 DD DSN=&&NDXSRF,DISP=(OLD,DELETE)
//GO.FT15F001 DD DSN=&&ZNATDNV1,DISP=(OLD,DELETE)
//GO.FT16F001 DD DSN=&&RTFLUX,DISP=(OLD,DELETE)
//GO.FT17F001 DD DSN=&&ZNATDNV2,DISP=(OLD,DELETE)
//GO.FT18F001 DD DSN=&&ATFLUX,DISP=(OLD,DELETE)
//GO.SYSIN DD *
=CONTROL1
 2-D LARGE LMFBR REACTOR MODEL BENCHMARK PROBLEM - PERTURBATION EXAMPLE.
 46000                                    1                    1
  2 15  0
  ISOTXS  GRUPXS  GEODST  NDXSRF  ZNATDN  RTFLUX  ZNATDN  ATFLUX

END
DUTLIN   ***PERTURBATION INSTRUCTIONS***
PERINS        0 13  0 16
 0.0
 0.0
 0.000444
  2   2   1   3   1   0   0   4   0   0   0   0   0   0   1   1

END
/*
//
```

will be incremented by 1 as they are written. The logical unit control cards (DD cards) shown override those in the catalogued job control instructions and are needed to "pass" the data sets created in step 1 to step 2.

The special processor DVENTR is then used to create the files GEODST, NDXSRF, and ZNATDN. Then the VENTURE neutronics code module number 7 creates the regular flux file RTFLUX. The density manipulation module number 99 is accessed to create a perturbed nuclide density file ZNATDN version 2. The ZNATDN version 1 file specifies a condition of control rod insertion as the reference state, while the version 2 file is the perturbed condition of control rod removed.

The special processor DUTLIN is used to change the neutronics instruction record DTNINS of the CONTRL file so that only the adjoint problem will be solved. The VENTURE module is then used to create the adjoint flux file ATFLUX using the perturbed nuclide density file.

In step 2, the special input processor DUTLIN is accessed to create the record PERINS (the instructions to PERTUBAT) of the file CONTRL and then PERTUBAT (module number 15) is accessed. Note that the list of interface data file names designated as files that already exist (control module instructions) includes the file ISOTXS. PERTUBAT does not use this file; however, it is included here so that the files will be on the same logical unit numbers as used in step 1. Only the necessary files need be included in the list, and in any order. The user must be careful, however, to relate the right logical unit numbers given on the unit (DD) cards to the proper file numbers as specified in the list of names in the control module input, and order is important. If this job had been run in a single step, no list would be required and no unit control (DD) cards would be needed.

The instructions to PERTUBAT specify that the regular adjoint flux integrals are to be calculated using the perturbed density file ZNATDN version 2 to create the perturbation file PERTUB.

Figure 5 shows selected edits from the run.

FIGURE 5. SELECTED OUTPUT OF THE SAMPLE PROBLEM.

```
BOLD VENTURE VERS-2 RUN AT K-25 ON 360/195. CONTROL MOD=CONTROL1, DATE=01-24-78, TIME=18.28.27, JOBNAME=TBF1

INITILIZATION, REFERENCE - REMAINING I/O=  14.94, CPU MIN=   2.99

RUN TITLE AND CONTROL MODULE DATA
 2-D LARGE LMFBR REACTOR MODEL BENCHMARK PROBLEM - PERTURBATION EXAMPLE.
 46000     0     0     0     0     0     0     0     0  0  0  1  0  0  0
  1  6  2  7 99  2  7

MODULES TO BE ACCESSED IN ORDER
     1     6     2     7    99     2     7

                         INITIAL I/O FILE MANAGEMENT TABLES
                     FILE NAME SUPPLIED BY
                 ------------------------------
FILE NUMBER       SEEK   USER-EXIST   USER-STACK      VERSION       WRITTEN
    10           CONTRL                                  1             1

READ DATA AND ACCESS MODULE  1     - REMAINING I/O=  14.87, CPU MIN=   2.99

READ INPUT DATA ONLY (LOOK-AHEAD) - REMAINING I/O=  13.24, CPU MIN=   2.81

ACCESS MODULES  6  0  0  0  0      - REMAINING I/O=  13.09, CPU MIN=   2.80

ACCESS PROCESSOR 'DVENTR'          - REMAINING I/O=  10.53, CPU MIN=   2.75

ACCESS MODULES  7  0  0  0  0      - REMAINING I/O=  10.23, CPU MIN=   2.72
     ITERATIONS, CONVERGENCE, SEARCH, PEAK PRODUCTION,    K -    22   5.95839D-06   0.0          1.28409E-04    0.9995911
     PRIMITIVE CONVERSION RATIO, ALSO FOR CRITICAL SYSTEM, FUEL CONSUMPTION(ATOMS/WATT-SEC) -   1.14354   1.14233   8.59720E-05

READ DATA AND ACCESS MODULE 99     - REMAINING I/O=   8.81, CPU MIN=   2.24

READ DATA FOR A SPECIAL PROCESSOR - REMAINING I/O=   8.68, CPU MIN=   2.23

ACCESS PROCESSOR 'DUTLIN'          - REMAINING I/O=   8.64, CPU MIN=   2.22

ACCESS MODULES  7  0  0  0  0      - REMAINING I/O=   8.53, CPU MIN=   2.20
     ADJOINT - ITERATIONS, CONVERGENCE, K -    20  -2.01454D-05    1.0226584

                         FINAL I/O FILE MANAGEMENT TABLES
                     FILE NAME SUPPLIED BY
                 ------------------------------
FILE NUMBER       SEEK   USER-EXIST   USER-STACK      VERSION       WRITTEN
    10           CONTRL                                  1             1
    11           ISOTXS                                  1             1
    12           GRUPXS                                  1             1
    13           GEODST                                  1             1
    14           NDXSRF                                  1             1
    15           ZNATDN                                  1             1
    16           RTFLUX                                  1             1
    17           ZNATDN                                  2             1
    18           ATFLUX                                  1             1

WRAP-UP NOW COMPLETE. -- DRIVER TO SEEK NEW CASE - REMAINING I/O=   7.27, CPU MIN=   1.77 - TIME=18.45.44
```

(CON'T)

```
BOLD VENTURE VERS-2 RUN AT K-25 ON 360/195. CONTROL MOD=CONTROL1. DATE=01-24-78. TIME=18.47.08. JOBNAME=TBF1

INITILIZATION. REFERENCE - REMAINING I/O=   7.20. CPU MIN=   1.76

RUN TITLE AND CONTROL MODULE DATA
 2-D LARGE LMFBR REACTOR MODEL BENCHMARK PROBLEM - PERTURBATION EXAMPLE.
 46000     0     0     0     0     0     1     0     0  0  0  1  0  0  0
  2 15
ISOTXS  GRUPXS  GEODST  NDXSRF  ZNATDN  RTFLUX  ZNATDN  ATFLUX


MODULES TO BE ACCESSED IN ORDER
     2    15

                         INITIAL I/O FILE MANAGEMENT TABLES
                    FILE NAME SUPPLIED BY
                 -------------------------------
FILE NUMBER       SEEK   USER-EXIST   USER-STACK       VERSION       WRITTEN
    10           CONTRL                                   1             1
    11                     ISOTXS                         1             1
    12                     GRUPXS                         1             1
    13                     GEODST                         1             1
    14                     NDXSRF                         1             1
    15                     ZNATDN                         1             1
    16                     RTFLUX                         1             1
    17                     ZNATDN                         2             1
    18                     ATFLUX                         1             1

READ DATA FOR A SPECIAL PROCESSOR - REMAINING I/O=   7.06. CPU MIN=   1.75

ACCESS PROCESSOR 'DUTLIN'         - REMAINING I/O=   7.02. CPU MIN=   1.74

ACCESS MODULES 15  0  0  0  0     - REMAINING I/O=   6.91. CPU MIN=   1.72
     FWD ADJ K 1.025557 1.022658. LIFETIME  3.63601E-07. B.D. NORM.  3.71660E 04. SUM (N DELTA K)/(K DELTA N)  1.99840D-01

                         FINAL I/O FILE MANAGEMENT TABLES
                    FILE NAME SUPPLIED BY
                 -------------------------------
FILE NUMBER       SEEK   USER-EXIST   USER-STACK       VERSION       WRITTEN
    10           CONTRL                                   1             1
    11                     ISOTXS                         1             1
    12                     GRUPXS                         1             1
    13                     GEODST                         1             1
    14                     NDXSRF                         1             1
    15                     ZNATDN                         1             1
    16                     RTFLUX                         1             1
    17                     ZNATDN                         2             1
    18                     ATFLUX                         1             1
    19           PERTUB                                   1             1

WRAP-UP NOW COMPLETE. -- DRIVER TO SEEK NEW CASE - REMAINING I/O=   4.15. CPU MIN=   1.26 - TIME=18.54.12
```

(CON'T)

```
CONVERSION OF INTERFACE FILE ISOTXS TO INTERFACE FILE GRUPXS

THE SCATTERING BLOCKING WILL BE     1

ONLY SCATTERING ORDERS UP TO P   1 WILL BE SAVED

ONLY TOTAL SCATTERING DATA WILL BE SAVED

THE DIRECT ACCESS STORAGE WILL BE SETUP FOR 1 SCATTERING TYPES

CORE REQUIRED   760
CORE SUPPLIED 46000

DIRECT ACCESS FILE 27  REQUIRES   150 RECORDS        26 WORDS IN LENGTH

DIRECT ACCESS FILE 24  REQUIRES   240 RECORDS         8 WORDS IN LENGTH


CONVERSION COMPLETE

INTERFACE FILE GRUPXS HAS BEEN WRITTEN ON UNIT   12


CASE TITLE - 2-D LARGE LMFBR REACTOR MODEL BENCHMARK PROBLEM - PERTURBATION EXAMPLE
                                                    ORNL, 1977, VENTURE

MPARM     46000        0        0        0        0        0        0        0        0        0        0        0


INPUT SECTION  1
RXX      0.0            0.0            0.0            3.085000E 06  1.000000E 00  1.282000E-03
RXX      0.0            0.0           -9.999996E-02  0.0            9.999994E-07  4.999999E-05
RXX      4.439999E-04   0.0            0.0            0.0            0.0            0.0
IXC       1   0   0   0   0   0   0   0   0   0   0  60   0   0   0   0   0   0   0   0   0   0   0   0
IXF       1   1   0   1   1   0   0   0   0   0   2   1   0   0   1   1   0   0   0   0   0   0   0   0
IXCN      0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
IXFN      0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
IXUN      0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
RXXN     0.0            0.0            0.0            0.0            0.0            0.0
RXXN     0.0            0.0            0.0            0.0            0.0            0.0

DTNINS RECORD ADDED TO FILE CONTRL


INPUT SECTION  3

   9   1   2   1   2   0   0   0   0   0   1   1   0   0   0   0   0   0
GEOMETRY NO.  9   2-D TRIAGONAL
TRIAGONAL OPTION  1   PARALLELOGRAM - 60 DEGREE
BSQ     0.0
INRB      1
BNDC    0.0            4.692000E-01  0.0            4.692000E-01  9.999999E 29  9.999999E 29
BNDI    4.692000E-01
NZHBB    5


INPUT SECTION  4

MEMORY REQUIRED     1298
```

(CON'T)

```
MSHJ/XSHJ        2  8.019395D 00    14  5.613577D 01     8  3.207758D 01    10  4.009698D 01    16  6.415516D 01
MSHI/XSHI        1  8.019395D 00     7  5.613577D 01     4  3.207758D 01     5  4.009698D 01     8  6.415516D 01
MSHKB/XSHKB      1  1.000000D 00
XMESH    0.0          8.019395D 00  6.415516D 01  9.623274D 01  1.363297D 02  2.004849D 02
YMESH    0.0          8.019395D 00  6.415516D 01  9.623274D 01  1.363297D 02  2.004849D 02
ZMESH    0.0          1.000000D 00

GEOMETRY NO.   9
J/XX      1   0.0       2   4.0097    3   8.0194    4  12.0291    5  16.0388    6  20.0485    7  24.0582    8  28.0679
J/XX      9  32.0776   10  36.0873   11  40.0970   12  44.1067   13  48.1164   14  52.1261   15  56.1358   16  60.1455
J/XX     17  64.1552   18  68.1649   19  72.1746   20  76.1843   21  80.1939   22  84.2036   23  88.2133   24  92.2230
J/XX     25  96.2327   26 100.2424   27 104.2521   28 108.2618   29 112.2715   30 116.2812   31 120.2909   32 124.3006
J/XX     33 128.3103   34 132.3200   35 136.3297   36 140.3394   37 144.3491   38 148.3588   39 152.3685   40 156.3782
J/XX     41 160.3879   42 164.3976   43 168.4073   44 172.4170   45 176.4267   46 180.4364   47 184.4461   48 188.4558
J/XX     49 192.4655   50 196.4752   51 200.4849
I/YY      1   0.0       2   8.0194    3  16.0388    4  24.0582    5  32.0776    6  40.0970    7  48.1164    8  56.1358
I/YY      9  64.1552   10  72.1746   11  80.1939   12  88.2133   13  96.2327   14 104.2521   15 112.2715   16 120.2909
I/YY     17 128.3103   18 136.3297   19 144.3491   20 152.3685   21 160.3879   22 168.4073   23 176.4267   24 184.4461
I/YY     25 192.4655   26 200.4849
KB/ZZ     1   0.0       2   1.0000
J/X       1   2.0048    2   6.0145    3  10.0242    4  14.0339    5  18.0436    6  22.0533    7  26.0630    8  30.0727
J/X       9  34.0824   10  38.0921   11  42.1018   12  46.1115   13  50.1212   14  54.1309   15  58.1406   16  62.1503
J/X      17  66.1600   18  70.1697   19  74.1794   20  78.1891   21  82.1988   22  86.2085   23  90.2182   24  94.2279
J/X      25  98.2376   26 102.2473   27 106.2570   28 110.2667   29 114.2764   30 118.2861   31 122.2958   32 126.3055
J/X      33 130.3152   34 134.3249   35 138.3346   36 142.3443   37 146.3540   38 150.3637   39 154.3734   40 158.3831
J/X      41 162.3927   42 166.4024   43 170.4121   44 174.4218   45 178.4315   46 182.4412   47 186.4509   48 190.4606
J/X      49 194.4703   50 198.4800
I/Y       1   4.0097    2  12.0291    3  20.0485    4  28.0679    5  36.0873    6  44.1067    7  52.1261    8  60.1455
I/Y       9  68.1649   10  76.1843   11  84.2036   12  92.2230   13 100.2424   14 108.2618   15 116.2812   16 124.3006
I/Y      17 132.3200   18 140.3394   19 148.3588   20 156.3782   21 164.3976   22 172.4170   23 180.4364   24 188.4558
I/Y      25 196.4752
KB/Z      1   0.5000

MEMORY REQUIRED    2623

INPUT SECTION  5

ZONE INPUT BY REGION

  LAYER NUMBER   1
   1   1   2   2   4
   1   1   2   2   4
   2   2   2   3   5
   2   2   3   4   5
   4   4   5   5   5

INPUT SECTION  6

    25 REGIONS MAY BE INCREASED TO 14458 REGIONS

MEMORY REQUIRED   45997

   2
  16  16   8   8   1   1   0   0   0   0   0   0   0   0   0   0   0   0

   1
  17  22   1   1   1   1  17  23   2   3   1   1  17  22   4   4   1   1
  17  21   5   5   1   1  17  17   6   6   1   1   1  10   9  10   1   1
   1   9  11  11   1   1   3   5  12  12   1   1  11  11   9   9   1   1
  24  24   2   2   1   1   0   0   0   0   0   0   0   0   0   0   0   0
```

(CON'T)

3

35	43	1	1	1	1	34	42	2	2	1	1	33	41	3	3	1	1
32	40	4	4	1	1	31	39	5	5	1	1	30	38	6	6	1	1
29	37	7	7	1	1	28	36	8	8	1	1	1	16	18	18	1	1
1	13	19	19	1	1	1	9	20	20	1	1	1	5	21	21	1	1
1	1	22	22	1	1	24	24	9	9	1	1	23	24	10	10	1	1
22	24	11	11	1	1	18	24	12	12	1	1	35	35	9	9	1	1
16	27	14	14	1	1	12	16	15	15	1	1	8	16	16	16	1	1
4	16	17	17	1	1	25	28	13	13	1	1	17	17	18	18	1	1
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

4

17	25	19	19	1	1	17	21	20	20	1	1	17	17	21	21	1	1
34	39	11	11	1	1	30	38	12	12	1	1	18	29	18	18	1	1
36	41	9	9	1	1	35	40	10	10	1	1	35	37	13	13	1	1
35	36	14	14	1	1	24	35	15	15	1	1	23	34	16	16	1	1
22	33	17	17	1	1	0	0	0	0	0	0	0	0	0	0	0	0

5

50	50	1	1	1	1	49	50	2	2	1	1	48	50	3	3	1	1
47	50	4	4	1	1	46	50	5	5	1	1	45	50	6	6	1	1
44	50	7	7	1	1	43	50	8	8	1	1	42	50	9	9	1	1
41	50	10	10	1	1	40	50	11	11	1	1	39	50	12	12	1	1
38	50	13	13	1	1	37	50	14	14	1	1	36	50	15	15	1	1
35	50	16	16	1	1	34	50	17	17	1	1	30	50	18	18	1	1
26	50	19	19	1	1	22	50	20	20	1	1	18	50	21	21	1	1
14	50	22	22	1	1	10	50	23	23	1	1	6	50	24	24	1	1
2	50	25	25	1	1	0	0	0	0	0	0	0	0	0	0	0	0

6

1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0

7

1	2	6	6	1	1	1	1	7	7	1	1	11	13	1	1	1	1
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

8

23	25	1	1	1	1	1	2	12	12	1	1	1	1	13	13	1	1
14	16	7	7	1	1	13	15	8	8	1	1	0	0	0	0	0	0

9

14	16	7	7	1	1	13	15	8	8	1	1	0	0	0	0	0	0

0

THERE ARE NOW 30 REGIONS

ZONE NUMBER AT EACH MESH INTERVAL

SPECIFICATION FOR PLANE NUMBER 1

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
1	6	1	1	1	1	1	1	1	1	1	7	7	7	1	1	1	1	1	1	1	1	1	8	8	8	2	2	2	2	2	2	2	2	2	3	3	3	3	3	3
2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	3	3	3	3	3	3	3
3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3
4	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3
5	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	4
6	7	7	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	4	4
7	7	1	1	1	1	1	1	1	1	1	1	1	1	9	9	9	2	2	2	2	2	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	4	4	4
8	1	1	1	1	1	1	1	1	1	1	1	1	9	9	9	2	2	2	2	2	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	4	4	4	4
9	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	4	4	4	4	4
10	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	4	4	4	4	4	4

(CON'T)

11	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	4	4	4	4	4	4	5
12	8	8	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	4	4	4	4	4	4	4	4	4	5	5
13	8	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	4	4	4	4	4	4	4	4	4	5	5	5
14	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	4	4	4	4	4	4	4	4	4	5	5	5	5
15	2	2	2	2	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	4	4	4	4	4	4	4	4	4	4	4	4	5	5	5	5	5
16	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	4	4	4	4	4	4	4	4	4	4	4	4	5	5	5	5	5	5
17	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	4	4	4	4	4	4	4	4	4	4	4	4	5	5	5	5	5	5	5
18	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	4	4	4	4	4	4	4	4	4	4	4	5	5	5	5	5	5	5	5	5	5	5	5
19	3	3	3	3	3	3	3	3	3	3	3	3	3	4	4	4	4	4	4	4	4	4	4	4	4	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
20	3	3	3	3	3	3	3	3	3	4	4	4	4	4	4	4	4	4	4	4	4	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
21	3	3	3	3	3	4	4	4	4	4	4	4	4	4	4	4	4	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
22	3	4	4	4	4	4	4	4	4	4	4	4	4	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
23	4	4	4	4	4	4	4	4	4	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
24	4	4	4	4	4	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
25	4	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5

ZONE NUMBER AT EACH MESH INTERVAL

	41	42	43	44	45	46	47	48	49	50
1	3	3	3	4	4	4	4	4	4	5
2	3	3	4	4	4	4	4	4	5	5
3	3	4	4	4	4	4	4	5	5	5
4	4	4	4	4	4	4	5	5	5	5
5	4	4	4	4	4	5	5	5	5	5
6	4	4	4	4	5	5	5	5	5	5
7	4	4	4	5	5	5	5	5	5	5
8	4	4	5	5	5	5	5	5	5	5
9	4	5	5	5	5	5	5	5	5	5
10	5	5	5	5	5	5	5	5	5	5
11	5	5	5	5	5	5	5	5	5	5
12	5	5	5	5	5	5	5	5	5	5
13	5	5	5	5	5	5	5	5	5	5
14	5	5	5	5	5	5	5	5	5	5
15	5	5	5	5	5	5	5	5	5	5
16	5	5	5	5	5	5	5	5	5	5
17	5	5	5	5	5	5	5	5	5	5
18	5	5	5	5	5	5	5	5	5	5
19	5	5	5	5	5	5	5	5	5	5
20	5	5	5	5	5	5	5	5	5	5
21	5	5	5	5	5	5	5	5	5	5
22	5	5	5	5	5	5	5	5	5	5
23	5	5	5	5	5	5	5	5	5	5
24	5	5	5	5	5	5	5	5	5	5
25	5	5	5	5	5	5	5	5	5	5

```
INPUT SECTION 12
NSZ   0
   1   1   1   1   1.000000E 00
   2   2   1   1   1.000000E 00
   3   3   1   2   1.000000E 00
   4   4   1   3   1.000000E 00
   5   5   1   3   1.000000E 00
   6   8   2   4   1.000000E 00
   9   9   2   4   1.000000E 00
   0   0   0   0   0.0

REGION VOL SUM   3.480792D 04  ZONE VOL SUM   3.480792D 04

MEMORY REQUIRED    2828

INTERFACE FILE GEODST HAS BEEN WRITTEN ON UNIT  13
```

(CON'T)

```
INPUT SECTION 13
NNS  24

MEMORY REQUIRED    3808

TITLE FROM CROSS SECTION FILE / LARGE CORE X-SECTIONS

NDXS(1)  24 FOR SET  1
MAT 10  MAT 11  MAT 12  MAT 13  MAT 14  MAT 15  MAT 16  MAT 28  MAT 56  MAT 44  MAT 88  MAT135
MAT138  MAT139  MAT140  MAT141  MAT142  MAT176  MAT238  MAT239  MAT240  MAT242  MAT335  MAT338

NDXS(1)  10 FOR SET  2
MAT 10  MAT 12  MAT 13  MAT 40  MAT 50  MAT 60  MAT112  MAT176  MAT224  MAT352


INPUT SECTION 20
NOPD   0 NCYS   0 TIMES  0.0

   1   1
MAT139     7.600000E-04  MAT140     2.899999E-04  MAT141     1.400000E-04  MAT142     8.000000E-05
MAT138     7.689998E-03  MAT135     1.900000E-05  MAT 10     2.980000E-03  MAT 11     6.259996E-03
MAT 12     5.259998E-03  MAT 13     2.599999E-04  MAT 14     8.079998E-03  MAT 16     1.804000E-02
MAT 15     2.400000E-04             0.0                      0.0                      0.0

   2   2
MAT239     1.010000E-03  MAT240     4.099999E-04  MAT141     1.900000E-04  MAT242     1.120000E-04
MAT238     7.229999E-03  MAT135     1.799999E-05  MAT 10     2.980000E-03  MAT 11     6.259996E-03
MAT 12     5.259998E-03  MAT 13     2.599999E-04  MAT 28     8.079998E-03  MAT 16     1.804000E-02
MAT 15     2.400000E-04             0.0                      0.0                      0.0

   3   3
MAT338     1.401000E-02  MAT335     4.200000E-05  MAT 10     1.730000E-03  MAT 44     4.039999E-03
MAT 12     3.840000E-03  MAT 13     1.900000E-04  MAT 56     6.069999E-03  MAT 16     2.802000E-02
           0.0                      0.0                      0.0                      0.0

   4   4
MAT 10     1.516000E-02  MAT 88     3.537000E-02  MAT 12     3.368000E-02  MAT 13     1.470000E-03
           0.0                      0.0                      0.0                      0.0

   5   5
MAT 10     1.516000E-07  MAT 88     3.537000E-07  MAT 12     3.368000E-07  MAT 13     1.470000E-08
           0.0                      0.0                      0.0                      0.0

   6   8
MAT 10     2.980000E-03  MAT352     6.259996E-03  MAT 12     5.259998E-03  MAT 13     2.599999E-04
MAT224     1.832000E-02             0.0                      0.0                      0.0

   9   9
MAT 10     2.980000E-03  MAT176     6.259996E-03  MAT 12     5.259998E-03  MAT 13     2.599999E-04
MAT112     1.453000E-02  MAT 40     7.639997E-03  MAT 50     1.147000E-02  MAT 60     4.779998E-03
           0.0                      0.0                      0.0                      0.0

   0   0

INTERFACE FILE NDXSRF HAS BEEN WRITTEN ON UNIT  14

INTERFACE FILE ZNATDN HAS BEEN WRITTEN ON UNIT  15
```

(CON'T)

```
RUN TITLE - 2-D LARGE LMFBR REACTOR MODEL BENCHMARK PROBLEM - PERTURBATION EXAMPLE
                                                ORNL, 1977, VENTURE

                        VENTURE NEUTRONICS CODE BLOCK - VERSION 2 ---   JULY 1, 1977.
                        -------------------------------------------------------------

REFERENCE REAL TIME FROM ZNATDN INTERFACE FILE =  0.0          DAYS

SOLUTION BY FINITE-DIFFERENCE DIFFUSION THEORY
EIGENVALUE PROBLEM
GEOMETRY NO.  9   2-D TRIAGONAL
TRIAGONAL OPTION  1   PARALLELOGRAM - 60 DEGREE
NUMBER OF ENERGY GROUPS                                  4
NUMBER OF UPSCATTER GROUPS (MAX)                         0
NUMBER OF DOWNSCATTER GROUPS (MAX)                       4
NUMBER OF INTERVALS IN DIMENSION 1 (COLUMNS)            50
NUMBER OF INTERVALS IN DIMENSION 2 (ROWS)               25
NUMBER OF INTERVALS IN DIMENSION 3 (PLANES)              1
NUMBER OF ZONES                                          9
NUMBER OF REGIONS                                       30
NUMBER OF BLACK ABSORBER ZONES                           1
BOUNDARY INDICATORS-   LEFT  1  RIGHT  2
                        TOP  1 BOTTOM  2


                                   MEMORY REQUIREMENTS FOR DATA STORAGE

                                          TOTAL                  A         B         C         D
                                      MINIMUM   MAXIMUM
STORAGE AVAILABLE                       46000
MACRO CALCULATION                        1491
EQUATION CONSTANTS CALCULATION
          CORE CONTAINED OR SPACE STORED  7250      7250
          PLANE STORED                    9750      9750
          ROW STORED                      2174      2174
          MULTI-LEVEL PLANE STORED       10974     10974
INITIAL FLUX
          CORE CONTAINED OR SPACE STORED  4251      4251
          OTHER MODES                     4251      4251
ITERATIVE PROCESS
          CORE CONTAINED                 45175                37802      1899       398      5076
          SPACE STORED                   17121                15076      1899       146         0
        1 PLANES STORED                  22121                20076      1899       146         0
        1 PLANE STORED                   22121                20076      1899       146         0
       20 ROWS STORED                    13385                11340      1899       146         0
        1 ROW STORED                      2045                    0      1899       146         0
        1 MULTI-LEVEL PLANES STORED      28345                 7500      1899       146     18800
PERTURBATION CALCULATION                  7680

DATA WILL BE STORED FOR ALL GROUPS, ALL SPACE

MEMORY LOCATIONS RESERVED FOR DATA STORAGE---   46000
MAX MEMORY LOCATIONS REQUIRED FOR THIS PROB--   45175
MEMORY LOCATIONS NOT USED-------------------      825

     SPECIAL SCRATCH DATASET REQUIREMENTS
     MAXIMUM PHYSICAL RECORD IS      7200 WORDS

RITE CONTAINER ARRAYS, CONTROL       36 DATA     779
DIRECT ACCESS FILE 24  REQUIRES      4 RECORDS     2500 WORDS IN LENGTH
DIRECT ACCESS FILE 27  REQUIRES      4 RECORDS     2500 WORDS IN LENGTH
```

(CON'T)

```
A FLUX - EIGENVALUE PROBLEM FOLLOWS
      4 INNERS MIN.  4 INNERS MAX - CHEBYCHEV  BETA ON INNERS
    SIGMA-1 ORDERING
PROCEDURE=0,1,2,3,4-NORMAL,CHEBYSHEV,SEMEX,DEMEX,SEMEXF.   ICVR=0,1-YES,NO INNERS CONVR.   OCVR=0,1-YES,NO OUTERS CONVR.
ITER  PROC  ICVR  OCVR   FLUX CHANGE    MU-BAR  OTHER-MU  SEM-IND   ACCELERATION PARAMETERS   SOURCE       K-USED     K-CALC
   1     0     0     0   3.99974D 00   0.0       0.0      1.00000      0.0         0.0       6.45540E 14  1.0000000  0.9320176
   2     0     0     0   2.95886D 01  22.19196   0.0      1.00000      1.00000     0.0       6.07809E 14  1.0000000  0.9819946
   3     0     0     1   4.55827D 00   0.09356   0.0      1.00000      0.10321     0.0       5.95687E 14  1.0000000  0.9917081
NEW OVERRELAXATION COEFFICIENTS CALCULATED
  1.25899  1.40869  1.25727  1.18569
   4     0     0     0   9.53078D-01   0.11040   0.0      1.00000      0.10505     0.00175   5.90637E 14  1.0000000  0.9949963
   5     0     0     0  -5.66974D-01   0.16394   0.0      1.00000      0.74973    -0.05744   5.87747E 14  1.0000000  0.9964604
   6     1     0     0  -2.17713D-01   0.0       0.0      1.00000      0.63315     0.0       5.85704E 14  1.0000000  0.9977118
   7     1     0     0  -1.17311D-01   0.0       0.0      1.00000      1.39178     0.46452   5.83103E 14  0.9977745  0.9955589
   8     1     0     0   6.66803D-02   0.57036   0.53506  1.00000      1.12721     0.30252   5.82039E 14  0.9959542
   9     1     0     0   3.02599D-02   0.49815   0.46894  1.00000      1.05834     0.26035   5.85144E 14  0.9986038
  10     1     0     0   1.55733D-02   0.57468   0.56606  1.00000      1.04113     0.24981   5.86740E 14  0.9999634
  11     1     0     0   7.13244D-03   0.52938   0.45037  1.00000      1.03688     0.24721   5.86500E 14  0.9996491
  12     1     0     0  -5.64560D-03   0.52032   0.79436  1.00000      1.03583     0.24656   5.86242E 14  0.9994298
  13     1     0     0  -2.49737D-03   0.52975   0.44483  1.00000      1.03557     0.24641   5.86278E 14  0.9994772
  14     1     0     0   7.14404D-04   0.49275   0.33612  1.00000      1.03551     0.24637   5.86372E 14  0.9995577
  15     1     0     0  -5.12713D-04   0.54541   0.72903  1.00000      1.03549     0.24636   5.86415E 14  0.9996306
  16     1     0     0  -2.61162D-04   0.50249   0.57198  1.00000      1.03549     0.24635   5.86375E 14  0.9995954
  17     1     0     0   1.69050D-04   0.49517   0.21193  1.00000      1.03549     0.24635   5.86357E 14  0.9995645
  18     1     1     0   7.14450D-05   0.55927   0.42266  1.00000      1.03548     0.24635   5.86380E 14  0.9995844
  19     1     0     0  -4.93877D-05   0.50353   0.69129  1.00000      1.03548     0.24635   5.86392E 14  0.9995947
  20     0     0     0  -2.42590D-05   0.0       0.0      1.00000      2.69592    -1.05949   5.86391E 14  0.9995925  0.9995910
  21     1     0     0  -6.92487D-06   0.0       0.0      1.00000      0.63315     0.0       5.86390E 14  0.9995910
  22     1     0     0   5.95839D-06   0.0       0.0      1.00000      1.03548     0.24635   5.86390E 14  0.9995911

ESTIMATED ABSOLUTE POINT FLUX RELATIVE ERROR  4.18519D-05

FINAL CALCULATED KEFFECTIVE   0.9995911
MULTIPLICATION RELIABILITY ESTIMATORS
BY THE SUM OF THE SQUARES OF THE RESIDUES--------------------------   0.9995913
UPPER AND LOWER BOUNDS ESTIMATES BY MAX REL FLUX CHANGE------------   0.9995971   0.9995852
UPPER AND LOWER BOUNDS ESTIMATES OVER ALL SIGNIFICANT POINTS-------   0.9996286   0.9995046

NEUTRON BALANCE KEFFECTIVE   0.9995912

NUMBER OF INNER ITERATIONS, OUTER ITERATION ERROR EIGENVALUE, AND OVERRELAXATION COEFFICIENTS     4  8.75374D-01
  1.25898  1.40840  1.25726  1.18569

CPU AND CLOCK MINUTES REQUIRED FOR THIS EIGENVALUE PROBLEM APE  0.302   2.022
DOPC FILE CLOSING DATA - UNIT, ARRAYS      27       6       1
DOPC FILE CLOSING DATA - UNIT, ARRAYS      28       6       1

    LEAKAGE  0.0          TOTAL LOSSES  1.00041E 00  TOTAL PRODUCTIONS  1.00000E 00  REACTOR POWER(WATTS)  0.0

PRIMITIVE FISSILE CONVERSION RATIO IS  1.14354D 00, ESTIMATE FOR CRITICAL SYSTEM IS  1.14233D 00
FISSILE DESTRUCTION PER UNIT ENERGY (ATOMS/WATT-SEC) IS  8.59720D-05

GROUP NEUTRON BALANCE FOR EACH ZONE

ZONE GROUP ABSORPTIONS  B**2 LOSSES    1/V LOSS   OUT-SCATTER  IN-SCATTER  P1 IN-SCATTER   SOURCE     POWER(WATTS)  AVERAGE FLUX
   1    1   5.62848E-02  1.05535E-02  0.0         3.12743E-01  0.0          0.0          3.85961E-01  0.0           1.82038E-03
   1    2   1.65303E-01  3.11476E-02  0.0         2.19159E-01  3.11662E-01  0.0          1.20482E-01  0.0           9.56158E-03
   1    3   1.48614E-01  6.16300E-03  0.0         6.37910E-02  2.20202E-01  0.0          1.58869E-03  0.0           3.37495E-03
   1    4   6.63595E-02  9.83823E-04  0.0         0.0          6.38290E-02  0.0          1.81264E-05  0.0           5.32505E-04
SUM         4.36562E-01  4.88479E-02  0.0         5.95694E-01  5.95694E-01  0.0          5.08049E-01  0.0

   2    1   5.22272E-02  8.92463E-03  0.0         2.59496E-01  0.0          0.0          3.62470E-01  0.0           1.53824E-03
```

(CON'T)

2	2	1.40373E-01	2.30631E-02	0.0	1.58794E-01	2.58597E-01	0.0	1.13149E-01	0.0	7.05113E-03
2	3	1.10075E-01	4.20605E-03	0.0	4.22348E-02	1.59666E-01	0.0	1.49200E-03	0.0	2.30191E-03
2	4	4.28711E-02	5.60467E-04	0.0	0.0	4.22618E-02	0.0	1.70232E-05	0.0	3.07883E-04
SUM		3.45546E-01	3.67543E-02	0.0	4.60525E-01	4.60525E-01	0.0	4.77128E-01	0.0	
3	1	5.11165E-03	7.52609E-04	0.0	3.73932E-02	0.0	0.0	1.15705E-02	0.0	1.19287E-04
3	2	2.44968E-02	4.52027E-03	0.0	5.28881E-02	3.72731E-02	0.0	3.61185E-03	0.0	1.32013E-03
3	3	3.87044E-02	1.40714E-03	0.0	1.67899E-02	5.29948E-02	0.0	4.76264E-05	0.0	6.45851E-04
3	4	1.65154E-02	3.23141E-04	0.0	0.0	1.68032E-02	0.0	5.43400E-07	0.0	1.34679E-04
SUM		8.48283E-02	7.00316E-03	0.0	1.07071E-01	1.07071E-01	0.0	1.52305E-02	0.0	
4	1	1.83176E-05	4.12772E-06	0.0	2.56567E-04	0.0	0.0	0.0	0.0	1.00757E-06
4	2	3.59423E-04	1.99916E-04	0.0	2.45172E-03	2.55504E-04	0.0	0.0	0.0	7.72675E-05
4	3	1.06098E-03	5.06602E-05	0.0	1.99877E-03	2.45278E-03	0.0	0.0	0.0	5.91607E-05
4	4	1.51111E-03	3.31158E-05	0.0	0.0	1.99877E-03	0.0	0.0	0.0	4.00446E-05
SUM		2.94984E-03	2.87819E-04	0.0	4.70706E-03	4.70706E-03	0.0	0.0	0.0	
5	1	5.51849E-06	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	2	8.55459E-04	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	3	2.61802E-04	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	4	2.28713E-04	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SUM		1.35149E-03	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
6	1	2.69835E-05	1.01509E-04	0.0	6.73425E-04	0.0	0.0	0.0	0.0	1.73256E-03
6	2	4.30464E-05	3.37935E-04	0.0	8.03788E-04	6.71798E-04	0.0	0.0	0.0	1.01490E-02
6	3	6.62524E-05	6.26478E-05	0.0	5.41817E-04	8.05416E-04	0.0	0.0	0.0	3.88620E-03
6	4	4.43311E-05	1.75545E-05	0.0	0.0	5.41817E-04	0.0	0.0	0.0	1.05570E-03
SUM		1.80613E-04	5.19646E-04	0.0	2.01903E-03	2.01903E-03	0.0	0.0	0.0	
7	1	1.55476E-04	5.84886E-04	0.0	3.88021E-03	0.0	0.0	0.0	0.0	1.66380E-03
7	2	2.48075E-04	1.94751E-03	0.0	4.63220E-03	3.87083E-03	0.0	0.0	0.0	9.74804E-03
7	3	3.81591E-04	3.60830E-04	0.0	3.12069E-03	4.64158E-03	0.0	0.0	0.0	3.73054E-03
7	4	2.55118E-04	1.01023E-04	0.0	0.0	3.12069E-03	0.0	0.0	0.0	1.01256E-03
SUM		1.04026E-03	2.99425E-03	0.0	1.16331E-02	1.16331E-02	0.0	0.0	0.0	
8	1	1.56122E-04	5.87316E-04	0.0	3.89633E-03	0.0	0.0	0.0	0.0	1.67071E-03
8	2	2.32629E-04	1.82625E-03	0.0	4.34378E-03	3.88691E-03	0.0	0.0	0.0	9.14109E-03
8	3	3.44661E-04	3.25909E-04	0.0	2.81867E-03	4.35320E-03	0.0	0.0	0.0	3.36949E-03
8	4	2.22469E-04	8.80948E-05	0.0	0.0	2.81867E-03	0.0	0.0	0.0	8.82977E-04
SUM		9.55882E-04	2.82757E-03	0.0	1.10588E-02	1.10588E-02	0.0	0.0	0.0	
9	1	7.74627E-04	3.09041E-04	0.0	5.08358E-03	0.0	0.0	0.0	0.0	1.30814E-03
9	2	1.24523E-02	8.00616E-04	0.0	7.25703E-03	5.07665E-03	0.0	0.0	0.0	6.49053E-03
9	3	1.09455E-02	1.17874E-04	0.0	1.06418E-03	7.26396E-03	0.0	0.0	0.0	1.75668E-03
9	4	2.35356E-03	5.32597E-06	0.0	0.0	1.06418E-03	0.0	0.0	0.0	1.01276E-04
SUM		2.65260E-02	1.23286E-03	0.0	1.34048E-02	1.34048E-02	0.0	0.0	0.0	

OVERALL NEUTRON BALANCE

GROUP	ABSORPTIONS	B**2 LOSSES	1/V LOSS	OUT-SCATTER	IN-SCATTER	P1 IN-SCATTER	SOURCE	POWER(WATTS)
1	1.14761E-01	2.18176E-02	0.0	6.23423E-01	0.0	0.0	7.60001E-01	0.0
2	3.44364E-01	6.38432E-02	0.0	4.50330E-01	6.21294E-01	0.0	2.37243E-01	0.0
3	3.10454E-01	1.26941E-02	0.0	1.32360E-01	4.52380E-01	0.0	3.12832E-03	0.0
4	1.30361E-01	2.11254E-03	0.0	0.0	1.32438E-01	0.0	3.56930E-05	0.0
SUM	8.99941E-01	1.00467E-01	0.0	1.20611E 00	1.20611E 00	0.0	1.00041E 00	0.0

ZONE VOLUMES FOLLOW. TOTAL VOLUME 3.48079E 04
5.01250E 03 5.01250E 03 6.51615E 03 5.68083E 03 1.20568E 04 2.78473E 01 1.67084E 02 1.67084E 02 1.67084E 02

POINT REGULAR FLUX INTERFACE FILE RTFLUX (VERSION 1) HAS BEEN WRITTEN ON UNIT NUMBER 16

NOTE--ZERO POWER PER UNIT FLUX - TRAVERSES AND MAP ARE CALCULATED USING NU*SIGF

GROUP FLUX VALUES AT PLANE 1 ROW 2 COLUMN 26 = POINT AT FIRST GROUP MAXIMUM

(CON'T)

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RUN TITLE - 2-D LARGE LMFBR REACTOR MODEL BENCHMARK PROBLEM - PERTURBATION EXAMPLE
                                                ORNL, 1977, VENTURE

                        VENTURE NEUTRONICS CODE BLOCK - VERSION 2 ---   JULY 1, 1977.
                        -------------------------------------------------------------


REFERENCE REAL TIME FROM ZNATDN INTERFACE FILE =  0.0          DAYS

SOLUTION BY FINITE-DIFFERENCE DIFFUSION THEORY
REGULAR ADJOINT PROBLEM
GEOMETRY NO.  9   2-D TRIAGONAL
TRIAGONAL OPTION  1   PARALLELOGRAM - 60 DEGREE
NUMBER OF ENERGY GROUPS                                  4
NUMBER OF UPSCATTER GROUPS (MAX)                         0
NUMBER OF DOWNSCATTER GROUPS (MAX)                       4
NUMBER OF INTERVALS IN DIMENSION 1 (COLUMNS)            50
NUMBER OF INTERVALS IN DIMENSION 2 (ROWS)               25
NUMBER OF INTERVALS IN DIMENSION 3 (PLANES)              1
NUMBER OF ZONES                                          9
NUMBER OF REGIONS                                       30
NUMBER OF BLACK ABSORBER ZONES                           1
BOUNDARY INDICATORS-   LEFT  1  RIGHT  2
                        TOP  1 BOTTOM  2


                                   MEMORY REQUIREMENTS FOR DATA STORAGE

                                          TOTAL                  A         B         C         D
                                       MINIMUM   MAXIMUM
STORAGE AVAILABLE                        46000
MACRO CALCULATION                         1491
EQUATION CONSTANTS CALCULATION
          CORE CONTAINED OR SPACE STORED   7250      7250
          PLANE STORED                     9750      9750
          ROW STORED                       2174      2174
          MULTI-LEVEL PLANE STORED        10974     10974
INITIAL FLUX
          CORE CONTAINED OR SPACE STORED   4251      4251
          OTHER MODES                      4251      4251
ITERATIVE PROCESS
          CORE CONTAINED                  45175                37802      1899       398      5076
          SPACE STORED                    17121                15076      1899       146         0
        1 PLANES STORED                   22121                20076      1899       146         0
        1 PLANE STORED                    22121                20076      1899       146         0
       20 ROWS STORED                     13385                11340      1899       146         0
        1 ROW STORED                       2045                    0      1899       146         0
        1 MULTI-LEVEL PLANES STORED       28345                 7500      1899       146     18800
PERTURBATION CALCULATION                   7680

DATA WILL BE STORED FOR ALL GROUPS, ALL SPACE

MEMORY LOCATIONS RESERVED FOR DATA STORAGE---   46000
MAX MEMORY LOCATIONS REQUIRED FOR THIS PROB--   45175
MEMORY LOCATIONS NOT USED-------------------      825

     SPECIAL SCRATCH DATASET REQUIREMENTS
     MAXIMUM PHYSICAL RECORD IS     7200 WORDS

RITE CONTAINER ARRAYS, CONTROL      36 DATA     779
DIRECT ACCESS FILE 24  REQUIRES     4 RECORDS     2500 WORDS IN LENGTH
DIRECT ACCESS FILE 27  REQUIRES     4 RECORDS     2500 WORDS IN LENGTH
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(CON'T)

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ADJOINT PROBLEM FOLLOWS
K WILL BE CALCULATED FROM SOURCE RATIO
      4 INNERS MIN.  4 INNERS MAX - CHEBYCHEV  BETA ON INNERS
    SIGMA-1 ORDERING
PROCEDURE=0,1,2,3,4-NORMAL,CHEBYSHEV,SEMEX,DEMEX,SEMEXF.   ICVR=0,1-YES,NO INNERS CONVR.   OCVR=0,1-YES,NO OUTERS CONVR.
ITER  PROC  ICVR  OCVR   FLUX CHANGE     MU-BAR  OTHER-MU  SEM-IND   ACCELERATION PARAMETERS   SOURCE        K-USED     K-CALC
   1    0     0     0    2.85272D 02    0.0     0.0       1.00000      0.0          0.0       5.29598E 14  1.0000000
   2    0     0     0    1.18297D 01    0.06152 0.0       1.00000      1.00000      0.0       5.15738E 14  1.0000000
   3    0     0     0    3.71679D 00    0.15868 0.0       1.00000      0.18860      0.0       5.12627E 14  1.0000000
NEW OVERRELAXATION COEFFICIENTS CALCULATED
  1.18716  1.25569  1.41641  1.26155
   4    0     0     0   -5.24312D-01    0.09044 0.0       1.00000      0.05719      0.00725   5.18595E 14  1.0057870
   5    0     0     0   -2.20039D-01    0.33914 0.0       1.00000     -0.15747      0.04407   5.24076E 14  1.0164163
   6    1     0     0   -1.28714D-01    0.0     0.0       1.00000      0.63315      0.0       5.25541E 14  1.0164163
   7    1     0     0   -7.91913D-02    0.0     0.0       1.00000      1.39178      0.46452   5.28688E 14  1.0225032
   8    1     0     0    3.28420D-02    0.53245 0.51899   1.00000      1.12721      0.30252   5.29071E 14  1.0232427
   9    1     0     0    2.42306D-02    0.43629 0.49493   1.00000      1.05834      0.26035   5.28411E 14  1.0226049
  10    1     1     0    1.31889D-02    0.37879 0.55090   1.00000      1.04113      0.24981   5.28381E 14  1.0225468
  11    1     0     0    1.08320D-02    0.36581 0.76012   1.00000      1.03688      0.24721   5.28437E 14  1.0226010
  12    1     1     0   -9.28116D-03    0.51099 0.86146   1.00000      1.03583      0.24656   5.28470E 14  1.0226329
  13    1     0     0    2.82351D-03    0.46360 0.46722   1.00000      1.03557      0.24641   5.28484E 14  1.0226584
  14    1     0     0    6.37387D-04    0.32623 0.22414   1.00000      1.03551      0.24637   5.28485E 14  1.0226617
  15    1     0     0   -3.06344D-04    1.17954 0.47682   1.00000      1.03549      0.24636   5.28488E 14  1.0226645
  16    1     0     1    6.94017D-04    0.70114 2.26514   1.00000      1.03549      0.24635   5.28487E 14  1.0226634
  17    0     0     0   -2.59510D-04    0.0     0.0       1.00000      1.59788     -1.46891   5.28485E 14  1.0226614
  18    1     0     0    4.08366D-05    0.0     0.0       1.00000      0.49957      0.0       5.28484E 14  1.0226614
  19    1     0     0   -2.88123D-05    0.0     0.0       1.00000      0.70372      0.13614   5.28483E 14  1.0226584
  20    1     0     0   -2.01454D-05    0.76275 0.82789   1.00000      0.70372      0.13614   5.28483E 14  1.0226589

ESTIMATED ABSOLUTE POINT FLUX RELATIVE ERROR  6.60493D-05

FINAL CALCULATED KEFFECTIVE   1.0226584
MULTIPLICATION RELIABILITY ESTIMATORS
BY THE SUM OF THE SQUARES OF THE RESIDUES--------------------------   1.0226588
UPPER AND LOWER BOUNDS ESTIMATES BY MAX REL FLUX CHANGE------------   1.0226790   1.0226378
UPPER AND LOWER BOUNDS ESTIMATES OVER ALL SIGNIFICANT POINTS-------   1.0227396   1.0226173

NUMBER OF INNER ITERATIONS, OUTER ITERATION ERROR EIGENVALUE, AND OVERRELAXATION COEFFICIENTS     4  7.66280D-01
  1.18716  1.25568  1.41607  1.26154

CPU AND CLOCK MINUTES REQUIRED FOR THIS EIGENVALUE PROBLEM ARE  0.277   1.474

ADJOINT FLUX ENERGY SPECTRUM BY GROUP, 1 TO MAX, (SUMMED OVER SPACE)
  9.36541D-06  7.60708D-06  5.73366D-06  6.02295D-06

ADJOINT FLUX SPACE FUNCTION BY ZONE (SUMMED OVER ENERGY)
  9.61334D-05  7.89509D-05  1.07712D-05  5.07402D-07  0.0          8.86253D-05  9.03699D-05  9.36322D-05  9.64174D-05

POINT ADJOINT FLUX INTERFACE FILE ATFLUX (VERSION  1) HAS BEEN WRITTEN ON UNIT NUMBER  18

TOTAL CPU TIME IS  0.423 MINUTES AND TOTAL CLOCK TIME IS   4.078 MINUTES


*** UTILITY INPUT *** ADD OR REPLACE RECORDS IN CONTRL FILE
RECORD NAME *PERINS*  NO. HOLLERITH   0  NO. REAL  13  NO. INTEGER(I6)   0  NO. INTEGER(I3)  16  PRINT OPT.   0
RECORD NAME *      *  NO. HOLLERITH   0  NO. REAL   0  NO. INTEGER(I6)   0  NO. INTEGER(I3)   0  PRINT OPT.   0

THE FOLLOWING RECORDS ARE ON CONTRL
*PERINS*
*PROINS*
*DVRINS*
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(CON'T)

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*      *

RUN TITLE -  2-D LARGE LMFBR REACTOR MODEL BENCHMARK PROBLEM - PERTURBATION EXAMPLE.


                        PERTURBATION CODE BLOCK MODULE - VERSION 1---  APRIL 1, 1978.
                        -------------------------------------------------------------


      +-------------------------------------------------------------------------------------------------------------+
      | CALCULATED DERIVATIVES (DELTA K)/(K DELTA X) AND THE CHANGES FOR PERTURBATIONS (DELTA K)K ARE REACTIVITY EFFECTS |
      | ESTIMATED BY APPLICATION OF FIRST ORDER PERTURBATION THEORY, NORMALLY PRECISE ONLY IN THE LIMIT OF NO CHANGE. IT |
      | IS ASSUMED THAT APPLICABLE, CONSISTENT REGULAR AND ADJOINT FLUX DISTRIBUTIONS, GEOMETRIC DESCRIPTION, CROSS      |
      | SECTIONS, AND NUCLIDE CONCENTRATIONS AND ASSOCIATIONS ARE SUPPLIED FOR A PROBLEM. OTHERWISE THE RESULTS MAY NOT  |
      | HAVE A SENSIBLE INTERPRETATION, OR PERHAPS HAVE A SPECIAL INTERPRETATION WHICH INVALIDATES THE LABELS.          |
      +-------------------------------------------------------------------------------------------------------------+


REFERENCE REAL TIME FROM ZNATDN INTERFACE FILE =  0.0          DAYS
GEOMETRY NO.  9   2-D TRIAGONAL
TRIAGONAL OPTION  1   PARALLELOGRAM - 60 DEGREE
NUMBER OF ENERGY GROUPS                                  4
NUMBER OF UPSCATTER GROUPS (MAX)                         0
NUMBER OF DOWNSCATTER GROUPS (MAX)                       4
NUMBER OF INTERVALS IN DIMENSION 1 (COLUMNS)            50
NUMBER OF INTERVALS IN DIMENSION 2 (ROWS)               25
NUMBER OF INTERVALS IN DIMENSION 3 (PLANES)              1
NUMBER OF ZONES                                          9
NUMBER OF REGIONS                                       30
NUMBER OF BLACK ABSORBER ZONES                           1
BOUNDARY INDICATORS-   LEFT  1  RIGHT  2
                        TOP  1 BOTTOM  2


                                        MEMORY REQUIREMENTS FOR DATA STORAGE

                                          MINIMUM   MAXIMUM
STORAGE AVAILABLE                          46000
MACRO CALCULATION                           2341
EQUATION CONSTANTS CALCULATION
          CORE CONTAINED OR SPACE STORED    7250      7250
          PLANE STORED                      9750      9750
          ROW STORED                        2174      2174
PERTURBATION CALCULATION                    3214     16358

DATA WILL BE STORED FOR 1 GROUP, ALL SPACE

MEMORY LOCATIONS RESERVED FOR DATA STORAGE---   46000
MAX MEMORY LOCATIONS REQUIRED FOR THIS PROB--   16358
MEMORY LOCATIONS NOT USED-------------------    29642

     SPECIAL SCRATCH DATASET REQUIREMENTS
     MAXIMUM PHYSICAL RECORD IS     7200 WORDS

RITE CONTAINER ARRAYS, CONTROL      36 DATA   29596
FILE 27 DEFAULTS TO CORE - NO.RECS, REC.LNTH, TOT.LNTH, START LOC, CORE LEFT.      4   2500  10000      1  19596
FILE 28 DEFAULTS TO CORE - NO.RECS, REC.LNTH, TOT.LNTH, START LOC, CORE LEFT.      4   2500  10000  10001   9596
DIRECT ACCESS FILE 29  REQUIRES     4 RECORDS      864 WORDS IN LENGTH
DIRECT ACCESS FILE 40  REQUIRES     4 RECORDS     5075 WORDS IN LENGTH

DD PARAMETERS FOLLOW FOR  B1 = 3520  AND  B2 =  32000
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(CON'T)

INTEGRAL NEUTRON BALANCE (REACTION RATE) INFORMATION FOR FLUX, ADJOINT WEIGHTING CONDITIONS.

	PRODUCTION	ABSORPTION	BLACK ABS.	LEAKAGE	KEFFECTIVE
FORWARD FLUX	9.99984D-01	9.73713D-01	1.35149D-03	0.0	1.0255572
ADJOINT FLUX	9.97159D-01	9.74619D-01	4.45264D-04	0.0	1.0226591
FROM RTFLUX					0.9995911
FROM ATFLUX					1.0226583

REGULAR, ADJOINT FLUX INTERGRALS---(DELTA K)/(K*DELTA S WHERE S REPERSENTS MACRO. CROSS SECTIONS. BIG DADDY = 3.716598D 04

ZONE	GRP	SIGA,SIGR,DB**2	B**2	NU*SIGF	DIFF. COEF.
1	1	-1.052280E 01	-2.741127E 01	1.005752E 01	-1.289221E-04
	2	-4.514105E 01	-6.607382E 01	5.281593E 01	-1.159259E-04
	3	-1.211738E 01	-9.942542E 00	1.863690E 01	1.045619E-04
	4	-2.017764E 00	-1.675046E 00	2.936513E 00	1.601875E-04
2	1	-7.386776E 00	-1.925677E 01	7.088217E 00	-3.855938E-03
	2	-2.800417E 01	-4.115710E 01	3.229808E 01	-1.194577E-02
	3	-7.363670E 00	-6.045647E 00	1.048575E 01	-2.951106E-03
	4	-1.049801E 00	-8.586851E-01	1.396468E 00	-2.287464E-04
3	1	-2.696391E-01	-5.880128E-01	2.528491E-01	-2.534058E-03
	2	-1.804935E 00	-2.136171E 00	2.304880E 00	-9.809751E-03
	3	-4.196814E-01	-3.160460E-01	1.033466E 00	-2.106989E-03
	4	-6.539005E-02	-5.422866E-02	1.943391E-01	-1.677102E-04
4	1	-1.205494E-04	-1.957973E-04	1.117674E-04	-2.505889E-06
	2	-5.396303E-03	-5.535442E-03	7.035520E-03	-4.537152E-05
	3	-8.053489E-04	-2.734151E-04	5.401857E-03	-1.024065E-05
	4	-3.001045E-04	-9.839414E-05	3.235048E-03	-6.335933E-07
5	1	0.0	0.0	0.0	0.0
	2	0.0	0.0	0.0	0.0
	3	0.0	0.0	0.0	0.0
	4	0.0	0.0	0.0	0.0
6	1	-5.138217E-02	-2.434806E-01	4.920413E-02	-1.564799E-06
	2	-2.481995E-01	-6.684124E-01	2.882288E-01	-1.018891E-06
	3	-7.189912E-02	-9.374273E-02	1.103671E-01	4.341941E-07
	4	-2.017567E-02	-2.713383E-02	2.998152E-02	3.081618E-06
7	1	-3.018703E-01	-1.430448E 00	2.890778E-01	-8.992771E-06
	2	-1.458526E 00	-3.927877E 00	1.693676E 00	-5.125549E-06
	3	-4.223042E-01	-5.506041E-01	6.481630E-01	2.850073E-06
	4	-1.183892E-01	-1.592191E-01	1.759278E-01	1.815264E-05
8	1	-3.069636E-01	-1.454582E 00	2.947730E-01	-7.996852E-06
	2	-1.403195E 00	-3.778872E 00	1.612854E 00	-4.848718E-06
	3	-4.050838E-01	-5.281520E-01	5.945198E-01	7.309604E-06
	4	-1.094362E-01	-1.471784E-01	1.557954E-01	1.948993E-05
9	1	-2.456682E-01	-1.164127E 00	2.360830E-01	-1.426100E-05
	2	-1.021757E 00	-2.751639E 00	1.171358E 00	-3.688732E-05
	3	-2.189212E-01	-2.854314E-01	3.170308E-01	-1.441009E-05
	4	-1.303729E-02	-1.753357E-02	1.827746E-02	-1.066201E-05

VOLUME INTEGRALS FLUX*ADJOINT FLUX -1.22586E 02 CHI*ADJOINT FLUX, NU-SIGF*FLUX 1.00000D 00

GRP. TO GRP. DELTA-K/(K*DELTA-SIGS) FOR ALL ZONES 1,2,3,.... - (THE IN-GROUP TERMS MAKE NO CONTRIBUTION.)

1	1	1.052280E 01	7.386776E 00	2.696391E-01	1.205494E-04	0.0	5.138217E-02	3.018703E-01	3.069636E-01
		2.456682E-01							
2	1	5.526016E 01	3.366098E 01	2.465294E 00	7.568382E-03	0.0	3.009874E-01	1.768626E 00	1.679572E 00
		1.218936E 00							
3	1	1.949969E 01	1.092890E 01	1.106840E 00	5.810916E-03	0.0	1.152526E-01	6.768462E-01	6.191162E-01
		3.299106E-01							

(CON'T)

4	1	3.072453E 00	1.455574E 00	2.084283E-01	3.473085E-03	0.0	3.130868E-02	1.837131E-01	1.622413E-01
		1.902046E-02							
1	2	8.596532E 00	6.147532E 00	2.004980E-01	8.470190E-05	0.0	4.237066E-02	2.489421E-01	2.564645E-01
		2.059430E-01							
2	2	4.514105E 01	2.800417E 01	1.804935E 00	5.396303E-03	0.0	2.481995E-01	1.458526E 00	1.403195E 00
		1.021757E 00							
3	2	1.592771E 01	9.089682E 00	8.048323E-01	4.143495E-03	0.0	9.503931E-02	5.581719E-01	5.172287E-01
		2.765322E-01							
4	2	2.509668E 00	1.210273E 00	1.504448E-01	2.503858E-03	0.0	2.581768E-02	1.515020E-01	1.355396E-01
		1.594127E-02							
1	3	6.542923E 00	4.989145E 00	1.127666E-01	1.735403E-05	0.0	3.205425E-02	1.883457E-01	2.009097E-01
		1.631060E-01							
2	3	3.434946E 01	2.270387E 01	9.638993E-01	1.048971E-03	0.0	1.877678E-01	1.103498E 00	1.099046E 00
		8.090119E-01							
3	3	1.211738E 01	7.363670E 00	4.196814E-01	8.053489E-04	0.0	7.189912E-02	4.223042E-01	4.050838E-01
		2.189212E-01							
4	3	1.908712E 00	9.795284E-01	7.640660E-02	4.680711E-04	0.0	1.953159E-02	1.146240E-01	1.061472E-01
		1.261503E-02							
1	4	6.917071E 00	5.347963E 00	1.004694E-01	1.135128E-05	0.0	3.311129E-02	1.945326E-01	2.071533E-01
		1.686076E-01							
2	4	3.631487E 01	2.433510E 01	8.409829E-01	6.786713E-04	0.0	1.939598E-01	1.139746E 00	1.133142E 00
		8.362328E-01							
3	4	1.281137E 01	7.892772E 00	3.627380E-01	5.210878E-04	0.0	7.427007E-02	4.361762E-01	4.176410E-01
		2.262770E-01							
4	4	2.017764E 00	1.049801E 00	6.539005E-02	3.001045E-04	0.0	2.017567E-02	1.183892E-01	1.094362E-01
		1.303729E-02							

PROMPT-NEUTRON LIFETIME IS 3.63601D-07 SEC.

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NORMALIZATION OF IMPORTANCE MAPS IS TO UNIT FISSION SOURCE IMPORTANCE FOR THE ACTUAL PROBLEM.     *
MULTIPLY BY THE FRACTION OF THE CORE TREATED IF THE VALUES ARE TO BE MADE RELATIVE TO THE         *
TOTAL, BUT TAKE CARE TO UNDERSTAND THAT THIS IS APPROPRIATE IN A SPECIFIC SITUATION.              *
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(CON'T)

MACRO. ABSORP. CROSS SECTION IMPORTANCE MAP (SIGA/K)(DELTA K/DELTA SIGA).

	1	2	3	4	5	6	7	8	9	10	11
1	5.063D-06	8.079D-05	8.025D-05	8.029D-05	8.035D-05	8.031D-05	8.005D-05	7.969D-05	7.934D-05	7.954D-05	4.968D-06
2	8.025D-05	8.029D-05	8.035D-05	8.041D-05	8.035D-05	8.012D-05	7.976D-05	7.942D-05	7.907D-05	7.882D-05	7.908D-05
3	8.035D-05	8.031D-05	8.035D-05	8.012D-05	8.006D-05	7.974D-05	7.949D-05	7.921D-05	7.886D-05	7.860D-05	7.825D-05
4	8.005D-05	7.969D-05	7.976D-05	7.942D-05	7.949D-05	7.921D-05	7.916D-05	7.888D-05	7.862D-05	7.816D-05	7.774D-05
5	7.934D-05	7.954D-05	7.908D-05	7.882D-05	7.886D-05	7.860D-05	7.862D-05	7.816D-05	7.782D-05	7.680D-05	7.611D-05
6	4.968D-06	4.956D-06	7.908D-05	7.827D-05	7.825D-05	7.792D-05	7.774D-05	7.687D-05	7.611D-05	7.429D-05	7.287D-05
7	4.944D-06	7.862D-05	7.801D-05	7.767D-05	7.759D-05	7.701D-05	7.641D-05	7.500D-05	7.348D-05	7.073D-05	6.772D-05
8	7.779D-05	7.750D-05	7.745D-05	7.710D-05	7.675D-05	7.583D-05	7.473D-05	7.297D-05	7.053D-05	6.741D-05	6.222D-05
9	7.732D-05	7.700D-05	7.686D-05	7.624D-05	7.568D-05	7.465D-05	7.326D-05	7.175D-05	6.894D-05	6.714D-05	6.228D-05
10	7.663D-05	7.612D-05	7.593D-05	7.530D-05	7.470D-05	7.393D-05	7.261D-05	7.178D-05	6.959D-05	6.929D-05	7.514D-05
11	7.582D-05	7.600D-05	7.524D-05	7.487D-05	7.422D-05	7.377D-05	7.269D-05	7.210D-05	7.045D-05	7.761D-05	7.525D-05
12	4.772D-06	4.774D-06	7.558D-05	7.479D-05	7.416D-05	8.248D-05	8.128D-05	7.797D-05	7.598D-05	6.986D-05	6.704D-05
13	4.790D-06	8.483D-05	8.385D-05	8.119D-05	8.052D-05	7.544D-05	7.407D-05	6.652D-05	6.437D-05	5.498D-05	5.216D-05
14	8.188D-05	7.726D-05	7.694D-05	7.022D-05	6.941D-05	6.066D-05	5.923D-05	4.915D-05	4.719D-05	3.675D-05	3.444D-05
15	7.093D-05	6.275D-05	6.238D-05	5.270D-05	5.189D-05	4.143D-05	4.024D-05	2.993D-05	2.852D-05	1.921D-05	1.785D-05
16	5.347D-05	4.327D-05	4.293D-05	3.253D-05	3.192D-05	2.208D-05	2.137D-05	9.875D-06	9.325D-06	4.788D-06	4.387D-06
17	3.312D-05	2.324D-05	2.303D-05	1.084D-05	1.060D-05	5.593D-06	5.386D-06	2.735D-06	2.570D-06	1.262D-06	1.145D-06
18	1.106D-05	5.918D-06	5.855D-06	3.036D-06	2.963D-06	1.498D-06	1.436D-06	7.108D-07	6.641D-07	3.229D-07	2.914D-07
19	3.105D-06	1.595D-06	1.576D-06	7.971D-07	7.760D-07	3.884D-07	3.709D-07	1.851D-07	1.722D-07	8.705D-08	7.824D-08
20	8.173D-07	4.160D-07	4.106D-07	2.095D-07	2.035D-07	1.057D-07	1.005D-07	5.488D-08	5.115D-08	8.821D-09	7.862D-09
21	2.153D-07	1.138D-07	1.122D-07	6.264D-08	6.084D-08	1.076D-08	1.017D-08	4.730D-09	4.390D-09	1.905D-09	1.710D-09
22	6.456D-08	1.162D-08	1.143D-08	5.422D-09	5.252D-09	2.337D-09	2.214D-09	8.947D-10	8.277D-10	2.724D-10	2.451D-10
23	5.594D-09	2.535D-09	2.494D-09	1.029D-09	9.944D-10	3.350D-10	3.172D-10	5.784D-11	5.334D-11	0.0	0.0
24	1.062D-09	3.641D-10	3.582D-10	6.657D-11	6.424D-11	0.0	0.0	0.0	0.0	0.0	0.0
25	6.874D-11	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

	12	13	14	15	16	17	18	19	20	21	22
1	4.956D-06	4.944D-06	7.862D-05	7.779D-05	7.750D-05	7.732D-05	7.700D-05	7.663D-05	7.612D-05	7.582D-05	7.600D-05
2	7.827D-05	7.801D-05	7.767D-05	7.745D-05	7.710D-05	7.686D-05	7.624D-05	7.593D-05	7.530D-05	7.524D-05	7.487D-05
3	7.792D-05	7.759D-05	7.701D-05	7.675D-05	7.583D-05	7.568D-05	7.465D-05	7.470D-05	7.393D-05	7.422D-05	7.377D-05
4	7.687D-05	7.641D-05	7.500D-05	7.473D-05	7.297D-05	7.326D-05	7.175D-05	7.261D-05	7.178D-05	7.269D-05	7.210D-05
5	7.429D-05	7.348D-05	7.073D-05	7.053D-05	6.741D-05	6.894D-05	6.714D-05	6.959D-05	6.929D-05	7.045D-05	7.761D-05
6	6.960D-05	6.772D-05	6.231D-05	6.222D-05	5.622D-05	6.228D-05	7.017D-05	7.514D-05	7.486D-05	7.525D-05	7.066D-05
7	6.231D-05	5.629D-05	2.675D-06	2.676D-06	2.677D-06	6.282D-05	6.766D-05	7.144D-05	6.909D-05	6.732D-05	6.003D-05
8	5.622D-05	2.676D-06	2.677D-06	2.659D-06	6.079D-05	6.593D-05	6.654D-05	6.599D-05	6.003D-05	5.603D-05	4.658D-05
9	7.017D-05	6.282D-05	6.766D-05	6.593D-05	6.654D-05	6.508D-05	5.980D-05	5.617D-05	4.715D-05	4.196D-05	3.164D-05
10	7.486D-05	7.144D-05	6.909D-05	6.599D-05	6.003D-05	5.617D-05	4.715D-05	4.232D-05	3.211D-05	2.700D-05	1.757D-05
11	7.066D-05	6.732D-05	6.003D-05	5.603D-05	4.658D-05	4.196D-05	3.164D-05	2.700D-05	1.757D-05	1.398D-05	5.608D-06
12	5.857D-05	5.498D-05	4.503D-05	4.085D-05	3.051D-05	2.597D-05	1.256D-05	9.792D-06	4.922D-06	3.618D-06	1.676D-06
13	4.187D-05	3.854D-05	2.844D-05	2.479D-05	1.587D-05	9.259D-06	4.631D-06	3.292D-06	1.555D-06	1.093D-06	4.991D-07
14	2.469D-05	2.223D-05	1.407D-05	1.183D-05	4.651D-06	3.182D-06	1.459D-06	1.018D-06	4.634D-07	3.233D-07	1.473D-07
15	7.922D-06	6.954D-06	3.348D-06	2.715D-06	1.228D-06	9.033D-07	4.061D-07	2.914D-07	1.321D-07	9.445D-08	4.459D-08
16	2.136D-06	1.855D-06	8.631D-07	6.997D-07	3.169D-07	2.417D-07	1.097D-07	8.134D-08	3.791D-08	2.827D-08	1.417D-08
17	5.451D-07	4.711D-07	2.193D-07	1.794D-07	8.335D-08	6.522D-08	3.121D-08	2.374D-08	1.205D-08	9.352D-09	1.462D-09
18	1.404D-07	1.214D-07	5.924D-08	4.887D-08	2.496D-08	2.017D-08	3.284D-09	2.491D-09	1.076D-09	8.137D-10	3.239D-10
19	4.133D-08	3.615D-08	6.036D-09	4.950D-09	2.181D-09	1.766D-09	7.263D-10	5.641D-10	2.110D-10	1.587D-10	4.824D-11
20	3.558D-09	3.102D-09	1.307D-09	1.093D-09	4.189D-10	3.397D-10	1.060D-10	8.314D-11	1.411D-11	1.061D-11	0.0
21	6.733D-10	5.864D-10	1.878D-10	1.581D-10	2.745D-11	2.223D-11	0.0	0.0	0.0	0.0	0.0
22	4.362D-11	3.789D-11	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
23	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
24	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

	23	24	25	26	27	28	29	30	31	32	33
1	4.772D-06	4.774D-06	4.790D-06	8.483D-05	8.188D-05	7.726D-05	7.093D-05	6.275D-05	5.347D-05	4.327D-05	3.312D-05
2	7.558D-05	7.479D-05	8.385D-05	8.119D-05	7.694D-05	7.022D-05	6.238D-05	5.270D-05	4.293D-05	3.253D-05	2.303D-05
3	7.416D-05	8.248D-05	8.052D-05	7.544D-05	6.941D-05	6.066D-05	5.188D-05	4.143D-05	3.192D-05	2.208D-05	1.060D-05
4	8.128D-05	7.797D-05	7.407D-05	6.652D-05	5.923D-05	4.915D-05	4.024D-05	2.993D-05	2.137D-05	9.875D-06	5.386D-06
5	7.598D-05	6.986D-05	6.437D-05	5.498D-05	4.719D-05	3.674D-05	2.852D-05	1.921D-05	9.325D-06	4.788D-06	2.570D-06
6	6.704D-05	5.857D-05	5.216D-05	4.187D-05	3.444D-05	2.469D-05	1.785D-05	7.922D-06	4.387D-06	2.136D-06	1.145D-06
7	5.498D-05	4.503D-05	3.854D-05	2.844D-05	2.223D-05	1.407D-05	6.954D-06	3.348D-06	1.855D-06	8.631D-07	4.711D-07
8	4.085D-05	3.051D-05	2.479D-05	1.587D-05	1.183D-05	4.651D-06	2.715D-06	1.228D-06	6.997D-07	3.169D-07	1.794D-07

(CON'T)

9	2.597D-05	1.256D-05	9.259D-06	4.631D-06	3.182D-06	1.459D-06	9.033D-07	4.061D-07	2.417D-07	1.097D-07	6.522D-08
10	9.792D-06	4.922D-06	3.292D-06	1.555D-06	1.018D-06	4.634D-07	2.914D-07	1.321D-07	8.134D-08	3.791D-08	2.374D-08
11	3.618D-06	1.576D-06	1.093D-06	4.991D-07	3.233D-07	1.473D-07	9.445D-08	4.459D-08	2.827D-08	1.417D-08	9.352D-09
12	1.133D-06	5.149D-07	3.407D-07	1.551D-07	1.023D-07	4.836D-08	3.362D-08	5.577D-09	3.495D-09	1.572D-09	9.885D-10
13	3.407D-07	1.551D-07	1.046D-07	4.883D-08	3.345D-08	1.692D-08	3.846D-09	1.730D-09	1.082D-09	4.625D-10	2.785D-10
14	1.023D-07	4.836D-08	3.345D-08	1.692D-08	1.213D-08	1.921D-09	1.197D-09	5.072D-10	3.123D-10	1.281D-10	7.442D-11
15	3.362D-08	5.577D-09	3.846D-09	1.730D-09	1.197D-09	5.072D-10	3.273D-10	1.349D-10	8.335D-11	3.217D-11	1.758D-11
16	3.495D-09	1.572D-09	1.082D-09	4.625D-10	3.123D-10	1.281D-10	8.335D-11	3.217D-11	1.965D-11	6.426D-12	3.057D-12
17	9.885D-10	4.098D-10	2.785D-10	1.106D-10	7.442D-11	2.698D-11	1.758D-11	5.112D-12	3.057D-12	4.511D-13	1.762D-13
18	2.289D-10	8.369D-11	5.788D-11	1.742D-11	1.184D-11	1.981D-12	1.286D-12	0.0	0.0	0.0	0.0
19	3.490D-11	5.851D-12	4.087D-12	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
21	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
23	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
24	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

	34	35	36	37	38	39	40	41	42	43	44
1	2.324D-05	1.106D-05	5.918D-06	3.105D-06	1.595D-06	8.172D-07	4.160D-07	2.153D-07	1.138D-07	6.456D-08	1.162D-08
2	1.084D-05	5.855D-06	3.036D-06	1.576D-06	7.971D-07	4.106D-07	2.095D-07	1.122D-07	6.264D-08	1.143D-08	5.422D-09
3	5.593D-06	2.963D-06	1.498D-06	7.760D-07	3.884D-07	2.035D-07	1.057D-07	6.084D-08	1.076D-08	5.252D-09	2.337D-09
4	2.735D-06	1.436D-06	7.108D-07	3.708D-07	1.851D-07	1.005D-07	5.488D-08	1.017D-08	4.730D-09	2.214D-09	8.946D-10
5	1.262D-06	6.641D-07	3.229D-07	1.722D-07	8.705D-08	5.115D-08	8.821D-09	4.390D-09	1.905D-09	8.277D-10	2.724D-10
6	5.451D-07	2.914D-07	1.404D-07	7.824D-08	4.133D-08	7.862D-09	3.558D-09	1.710D-09	6.733D-10	2.451D-10	4.362D-11
7	2.193D-07	1.214D-07	5.924D-08	3.615D-08	6.036D-09	3.102D-09	1.307D-09	5.864D-10	1.878D-10	3.789D-11	0.0
8	8.335D-08	4.887D-08	2.496D-08	4.950D-09	2.181D-09	1.093D-09	4.189D-10	1.581D-10	2.745D-11	0.0	0.0
9	3.121D-08	2.017D-08	3.284D-09	1.766D-09	7.263D-10	3.397D-10	1.060D-10	2.223D-11	0.0	0.0	0.0
10	1.205D-08	2.491D-09	1.076D-09	5.641D-10	2.110D-10	8.314D-11	1.411D-11	0.0	0.0	0.0	0.0
11	1.462D-09	8.137D-10	3.239D-10	1.587D-10	4.824D-11	1.061D-11	0.0	0.0	0.0	0.0	0.0
12	4.098D-10	2.289D-10	8.369D-11	3.490D-11	5.851D-12	0.0	0.0	0.0	0.0	0.0	0.0
13	1.106D-10	5.788D-11	1.742D-11	4.087D-12	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14	2.698D-11	1.184D-11	1.981D-12	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15	5.112D-12	1.286D-12	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16	4.511D-13	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
17	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
18	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
19	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
21	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
23	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
24	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

	45	46	47	48	49	50
1	5.594D-09	2.535D-09	1.062D-09	3.641D-10	6.874D-11	0.0
2	2.494D-09	1.029D-09	3.582D-10	6.657D-11	0.0	0.0
3	9.944D-10	3.350D-10	6.424D-11	0.0	0.0	0.0
4	3.172D-10	5.784D-11	0.0	0.0	0.0	0.0
5	5.334D-11	0.0	0.0	0.0	0.0	0.0
6	0.0	0.0	0.0	0.0	0.0	0.0
7	0.0	0.0	0.0	0.0	0.0	0.0
8	0.0	0.0	0.0	0.0	0.0	0.0
9	0.0	0.0	0.0	0.0	0.0	0.0
10	0.0	0.0	0.0	0.0	0.0	0.0
11	0.0	0.0	0.0	0.0	0.0	0.0
12	0.0	0.0	0.0	0.0	0.0	0.0
13	0.0	0.0	0.0	0.0	0.0	0.0
14	0.0	0.0	0.0	0.0	0.0	0.0
15	0.0	0.0	0.0	0.0	0.0	0.0
16	0.0	0.0	0.0	0.0	0.0	0.0
17	0.0	0.0	0.0	0.0	0.0	0.0
18	0.0	0.0	0.0	0.0	0.0	0.0
19	0.0	0.0	0.0	0.0	0.0	0.0
20	0.0	0.0	0.0	0.0	0.0	0.0
21	0.0	0.0	0.0	0.0	0.0	0.0
22	0.0	0.0	0.0	0.0	0.0	0.0

(CON'T)

MACRO. NU*FISS. CROSS SECTION IMPORTANCE MAP (NUSIGF/K)(DELTA K/DELTA NUSIGF).

	1	2	3	4	5	6	7	8	9	10	11
1	0.0	1.174D-04	1.181D-04	1.190D-04	1.194D-04	1.195D-04	1.190D-04	1.182D-04	1.168D-04	1.156D-04	0.0
2	1.181D-04	1.190D-04	1.194D-04	1.197D-04	1.196D-04	1.192D-04	1.185D-04	1.178D-04	1.164D-04	1.160D-04	1.149D-04
3	1.194D-04	1.195D-04	1.196D-04	1.192D-04	1.192D-04	1.186D-04	1.182D-04	1.178D-04	1.169D-04	1.168D-04	1.160D-04
4	1.190D-04	1.182D-04	1.185D-04	1.178D-04	1.182D-04	1.178D-04	1.178D-04	1.175D-04	1.171D-04	1.165D-04	1.158D-04
5	1.168D-04	1.156D-04	1.164D-04	1.160D-04	1.169D-04	1.168D-04	1.171D-04	1.165D-04	1.160D-04	1.146D-04	1.135D-04
6	0.0	0.0	1.149D-04	1.152D-04	1.160D-04	1.159D-04	1.158D-04	1.146D-04	1.135D-04	1.108D-04	1.087D-04
7	0.0	1.142D-04	1.148D-04	1.152D-04	1.154D-04	1.147D-04	1.139D-04	1.119D-04	1.096D-04	1.055D-04	1.011D-04
8	1.145D-04	1.149D-04	1.151D-04	1.148D-04	1.144D-04	1.130D-04	1.114D-04	1.088D-04	1.052D-04	1.005D-04	9.293D-05
9	1.149D-04	1.146D-04	1.144D-04	1.135D-04	1.127D-04	1.112D-04	1.092D-04	1.069D-04	1.027D-04	9.991D-05	9.274D-05
10	1.139D-04	1.128D-04	1.127D-04	1.115D-04	1.110D-04	1.098D-04	1.080D-04	1.066D-04	1.034D-04	1.026D-04	1.259D-04
11	1.114D-04	1.101D-04	1.105D-04	1.098D-04	1.097D-04	1.091D-04	1.077D-04	1.066D-04	1.042D-04	1.295D-04	1.255D-04
12	0.0	0.0	1.091D-04	1.091D-04	1.091D-04	1.374D-04	1.356D-04	1.299D-04	1.266D-04	1.163D-04	1.116D-04
13	0.0	1.378D-04	1.381D-04	1.345D-04	1.338D-04	1.254D-04	1.232D-04	1.107D-04	1.071D-04	9.159D-05	8.690D-05
14	1.345D-04	1.278D-04	1.275D-04	1.167D-04	1.154D-04	1.010D-04	9.864D-05	8.201D-05	7.874D-05	6.158D-05	5.774D-05
15	1.177D-04	1.044D-04	1.038D-04	8.790D-05	8.656D-05	6.942D-05	6.743D-05	5.066D-05	4.826D-05	3.338D-05	3.103D-05
16	8.916D-05	7.250D-05	7.193D-05	5.506D-05	5.402D-05	3.837D-05	3.714D-05	4.234D-06	3.992D-06	1.812D-06	1.657D-06
17	5.605D-05	4.038D-05	4.002D-05	4.644D-06	4.539D-06	2.117D-06	2.038D-06	9.425D-07	8.849D-07	4.053D-07	3.672D-07
18	4.735D-06	2.239D-06	2.215D-06	1.046D-06	1.020D-06	4.813D-07	4.612D-07	2.171D-07	2.028D-07	9.528D-08	8.592D-08
19	1.069D-06	5.123D-07	5.061D-07	2.435D-07	2.370D-07	1.146D-07	1.094D-07	5.335D-08	4.963D-08	2.462D-08	2.214D-08
20	2.497D-07	1.228D-07	1.212D-07	6.039D-08	5.865D-08	2.989D-08	2.843D-08	1.507D-08	1.405D-08	0.0	0.0
21	6.207D-08	3.219D-08	3.172D-08	1.720D-08	1.670D-08	0.0	0.0	0.0	0.0	0.0	0.0
22	1.772D-08	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
23	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
24	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

	12	13	14	15	16	17	18	19	20	21	22
1	0.0	0.0	1.142D-04	1.145D-04	1.149D-04	1.149D-04	1.146D-04	1.139D-04	1.128D-04	1.114D-04	1.101D-04
2	1.152D-04	1.148D-04	1.152D-04	1.151D-04	1.148D-04	1.144D-04	1.135D-04	1.127D-04	1.115D-04	1.105D-04	1.098D-04
3	1.159D-04	1.154D-04	1.147D-04	1.144D-04	1.130D-04	1.127D-04	1.112D-04	1.110D-04	1.098D-04	1.097D-04	1.091D-04
4	1.146D-04	1.139D-04	1.119D-04	1.114D-04	1.088D-04	1.092D-04	1.069D-04	1.080D-04	1.066D-04	1.077D-04	1.066D-04
5	1.108D-04	1.096D-04	1.055D-04	1.052D-04	1.005D-04	1.027D-04	9.991D-05	1.034D-04	1.026D-04	1.042D-04	1.295D-04
6	1.039D-04	1.011D-04	9.311D-05	9.293D-05	8.424D-05	9.274D-05	1.180D-04	1.259D-04	1.250D-04	1.255D-04	1.177D-04
7	9.311D-05	8.443D-05	0.0	0.0	0.0	1.062D-04	1.134D-04	1.193D-04	1.151D-04	1.121D-04	9.996D-05
8	8.424D-05	0.0	0.0	0.0	1.027D-04	1.105D-04	1.111D-04	1.100D-04	9.999D-05	9.333D-05	7.774D-05
9	1.180D-04	1.062D-04	1.134D-04	1.105D-04	1.111D-04	1.085D-04	9.961D-05	9.357D-05	7.867D-05	7.016D-05	5.335D-05
10	1.250D-04	1.193D-04	1.151D-04	1.100D-04	9.999D-05	9.357D-05	7.867D-05	7.070D-05	5.398D-05	4.571D-05	3.067D-05
11	1.177D-04	1.121D-04	9.996D-05	9.333D-05	7.774D-05	7.016D-05	5.335D-05	4.571D-05	3.067D-05	2.477D-05	2.265D-06
12	9.752D-05	9.157D-05	7.514D-05	6.830D-05	5.145D-05	4.444D-05	5.579D-06	4.193D-06	1.856D-06	1.323D-06	5.570D-07
13	6.992D-05	6.442D-05	4.786D-05	4.202D-05	2.773D-05	3.962D-06	1.747D-06	1.169D-06	5.092D-07	3.469D-07	1.508D-07
14	4.183D-05	3.775D-05	2.464D-05	2.100D-05	1.882D-06	1.165D-06	4.856D-07	3.235D-07	1.401D-07	9.578D-08	4.264D-08
15	3.387D-06	2.946D-06	1.249D-06	9.916D-07	4.078D-07	2.887D-07	1.231D-07	8.648D-08	3.829D-08	2.713D-08	1.266D-08
16	7.340D-07	6.332D-07	2.746D-07	2.200D-07	9.514D-08	7.158D-08	3.178D-08	2.340D-08	1.083D-08	8.034D-09	3.972D-09
17	1.662D-07	1.432D-07	6.447D-08	5.253D-08	2.396D-08	1.870D-08	8.869D-09	6.758D-09	3.386D-09	2.624D-09	0.0
18	4.046D-08	3.497D-08	1.678D-08	1.386D-08	6.924D-09	5.610D-09	0.0	0.0	0.0	0.0	0.0
19	1.137D-08	9.958D-09	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
21	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
23	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
24	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

	23	24	25	26	27	28	29	30	31	32	33
1	0.0	0.0	0.0	1.378D-04	1.345D-04	1.278D-04	1.177D-04	1.044D-04	8.916D-05	7.249D-05	5.605D-05
2	1.091D-04	1.091D-04	1.381D-04	1.345D-04	1.275D-04	1.167D-04	1.038D-04	8.790D-05	7.193D-05	5.506D-05	4.002D-05
3	1.091D-04	1.374D-04	1.338D-04	1.254D-04	1.154D-04	1.010D-04	8.656D-05	6.942D-05	5.402D-05	3.837D-05	4.539D-06
4	1.356D-04	1.299D-04	1.232D-04	1.107D-04	9.864D-05	8.201D-05	6.743D-05	5.066D-05	3.713D-05	4.234D-06	2.038D-06
5	1.266D-04	1.163D-04	1.071D-04	9.159D-05	7.874D-05	6.158D-05	4.826D-05	3.338D-05	3.992D-06	1.812D-06	8.849D-07
6	1.116D-04	9.752D-05	8.690D-05	6.992D-05	5.774D-05	4.183D-05	3.103D-05	3.387D-06	1.657D-06	7.340D-07	3.672D-07
7	9.157D-05	7.514D-05	6.442D-05	4.786D-05	3.775D-05	2.464D-05	2.946D-06	1.249D-06	6.332D-07	2.746D-07	1.431D-07
8	6.830D-05	5.145D-05	4.202D-05	2.773D-05	2.100D-05	1.882D-06	9.916D-07	4.078D-07	2.200D-07	9.514D-08	5.253D-08

(CON'T)

9	4.444D-05	5.579D-06	3.962D-06	1.747D-06	1.165D-06	4.856D-07	2.887D-07	1.231D-07	7.158D-08	3.178D-08	1.870D-08
10	4.193D-06	1.856D-06	1.169D-06	5.092D-07	3.235D-07	1.401D-07	8.648D-08	3.829D-08	2.340D-08	1.083D-08	6.758D-09
11	1.323D-06	5.570D-07	3.469D-07	1.508D-07	9.578D-08	4.264D-08	2.713D-08	1.266D-08	8.034D-09	3.972D-09	2.624D-09
12	3.618D-07	1.560D-07	1.010D-07	4.491D-08	2.937D-08	1.373D-08	9.390D-09	0.0	0.0	0.0	0.0
13	1.010D-07	4.491D-08	3.006D-08	1.391D-08	9.488D-09	4.728D-09	0.0	0.0	0.0	0.0	0.0
14	2.937D-08	1.373D-08	9.488D-09	4.728D-09	3.386D-09	0.0	0.0	0.0	0.0	0.0	0.0
15	9.390D-09	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
17	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
18	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
19	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
21	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
23	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
24	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

	34	35	36	37	38	39	40	41	42	43	44
1	4.038D-05	4.735D-06	2.239D-06	1.069D-06	5.123D-07	2.497D-07	1.228D-07	6.207D-08	3.219D-08	1.772D-08	0.0
2	4.644D-06	2.215D-06	1.046D-06	5.061D-07	2.435D-07	1.212D-07	6.039D-08	3.172D-08	1.720D-08	0.0	0.0
3	2.117D-06	1.020D-06	4.813D-07	2.370D-07	1.146D-07	5.865D-08	2.989D-08	1.670D-08	0.0	0.0	0.0
4	9.425D-07	4.612D-07	2.171D-07	1.094D-07	5.335D-08	2.843D-08	1.507D-08	0.0	0.0	0.0	0.0
5	4.053D-07	2.028D-07	9.528D-08	4.963D-08	2.462D-08	1.405D-08	0.0	0.0	0.0	0.0	0.0
6	1.662D-07	8.592D-08	4.046D-08	2.214D-08	1.137D-08	0.0	0.0	0.0	0.0	0.0	0.0
7	6.447D-08	3.497D-08	1.678D-08	9.958D-09	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8	2.396D-08	1.386D-08	6.924D-09	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9	8.369D-09	5.610D-09	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	3.386D-09	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
13	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
17	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
18	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
19	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
21	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
23	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
24	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

	45	46	47	48	49	50
1	0.0	0.0	0.0	0.0	0.0	0.0
2	0.0	0.0	0.0	0.0	0.0	0.0
3	0.0	0.0	0.0	0.0	0.0	0.0
4	0.0	0.0	0.0	0.0	0.0	0.0
5	0.0	0.0	0.0	0.0	0.0	0.0
6	0.0	0.0	0.0	0.0	0.0	0.0
7	0.0	0.0	0.0	0.0	0.0	0.0
8	0.0	0.0	0.0	0.0	0.0	0.0
9	0.0	0.0	0.0	0.0	0.0	0.0
10	0.0	0.0	0.0	0.0	0.0	0.0
11	0.0	0.0	0.0	0.0	0.0	0.0
12	0.0	0.0	0.0	0.0	0.0	0.0
13	0.0	0.0	0.0	0.0	0.0	0.0
14	0.0	0.0	0.0	0.0	0.0	0.0
15	0.0	0.0	0.0	0.0	0.0	0.0
16	0.0	0.0	0.0	0.0	0.0	0.0
17	0.0	0.0	0.0	0.0	0.0	0.0
18	0.0	0.0	0.0	0.0	0.0	0.0
19	0.0	0.0	0.0	0.0	0.0	0.0
20	0.0	0.0	0.0	0.0	0.0	0.0
21	0.0	0.0	0.0	0.0	0.0	0.0
22	0.0	0.0	0.0	0.0	0.0	0.0

(CON'T)

NUSIGF-SIGA IMPORTANCE MAP.

	1	2	3	4	5	6	7	8	9	10	11
1	-5.063D-06	3.663D-05	3.786D-05	3.875D-05	3.909D-05	3.918D-05	3.895D-05	3.847D-05	3.746D-05	3.610D-05	-4.968D-06
2	3.786D-05	3.875D-05	3.900D-05	3.926D-05	3.926D-05	3.912D-05	3.873D-05	3.834D-05	3.733D-05	3.720D-05	3.586D-05
3	3.909D-05	3.918D-05	3.926D-05	3.912D-05	3.913D-05	3.891D-05	3.868D-05	3.855D-05	3.807D-05	3.819D-05	3.779D-05
4	3.895D-05	3.847D-05	3.873D-05	3.834D-05	3.868D-05	3.855D-05	3.864D-05	3.858D-05	3.844D-05	3.832D-05	3.809D-05
5	3.746D-05	3.610D-05	3.733D-05	3.720D-05	3.807D-05	3.819D-05	3.844D-05	3.832D-05	3.820D-05	3.775D-05	3.742D-05
6	-4.968D-06	-4.956D-06	3.586D-05	3.694D-05	3.779D-05	3.798D-05	3.809D-05	3.775D-05	3.742D-05	3.654D-05	3.586D-05
7	-4.944D-06	3.563D-05	3.681D-05	3.750D-05	3.782D-05	3.773D-05	3.752D-05	3.686D-05	3.614D-05	3.480D-05	3.335D-05
8	3.669D-05	3.739D-05	3.761D-05	3.768D-05	3.761D-05	3.720D-05	3.671D-05	3.584D-05	3.467D-05	3.313D-05	3.071D-05
9	3.760D-05	3.756D-05	3.757D-05	3.723D-05	3.706D-05	3.651D-05	3.590D-05	3.511D-05	3.376D-05	3.277D-05	3.046D-05
10	3.724D-05	3.666D-05	3.681D-05	3.624D-05	3.630D-05	3.585D-05	3.538D-05	3.487D-05	3.379D-05	3.334D-05	5.072D-05
11	3.561D-05	3.411D-05	3.526D-05	3.495D-05	3.552D-05	3.533D-05	3.506D-05	3.453D-05	3.374D-05	5.192D-05	5.020D-05
12	-4.772D-06	-4.774D-06	3.352D-05	3.433D-05	3.494D-05	5.493D-05	5.437D-05	5.189D-05	5.059D-05	4.643D-05	4.455D-05
13	-4.790D-06	5.301D-05	5.429D-05	5.326D-05	5.326D-05	4.998D-05	4.917D-05	4.419D-05	4.278D-05	3.661D-05	3.475D-05
14	5.259D-05	5.051D-05	5.059D-05	4.644D-05	4.601D-05	4.034D-05	3.941D-05	3.286D-05	3.156D-05	2.484D-05	2.330D-05
15	4.674D-05	4.161D-05	4.141D-05	3.520D-05	3.467D-05	2.799D-05	2.719D-05	2.072D-05	1.974D-05	1.417D-05	1.319D-05
16	3.569D-05	2.922D-05	2.899D-05	2.252D-05	2.210D-05	1.628D-05	1.576D-05	-5.641D-06	-5.333D-06	-2.976D-06	-2.730D-06
17	2.293D-05	1.715D-05	1.699D-05	-6.196D-06	-6.060D-06	-3.476D-06	-3.347D-06	-1.793D-06	-1.685D-06	-8.569D-07	-7.782D-07
18	-6.322D-06	-3.679D-06	-3.640D-06	-1.990D-06	-1.943D-06	-1.017D-06	-9.749D-07	-4.936D-07	-4.613D-07	-2.276D-07	-2.055D-07
19	-2.036D-06	-1.083D-06	-1.070D-06	-5.536D-07	-5.390D-07	-2.738D-07	-2.614D-07	-1.317D-07	-1.225D-07	-6.243D-08	-5.610D-08
20	-5.676D-07	-2.933D-07	-2.894D-07	-1.491D-07	-1.448D-07	-7.583D-08	-7.211D-08	-3.981D-08	-3.711D-08	-8.821D-09	-7.862D-09
21	-1.532D-07	-8.165D-08	-8.047D-08	-4.544D-08	-4.414D-08	-1.076D-08	-1.017D-08	-4.730D-09	-4.390D-09	-1.905D-09	-1.710D-09
22	-4.684D-08	-1.162D-08	-1.143D-08	-5.422D-09	-5.252D-09	-2.337D-09	-2.214D-09	-8.947D-10	-8.277D-10	-2.724D-10	-2.451D-10
23	-5.594D-09	-2.535D-09	-2.494D-09	-1.029D-09	-9.944D-10	-3.350D-10	-3.172D-10	-5.784D-11	-5.334D-11	0.0	0.0
24	-1.062D-09	-3.641D-10	-3.582D-10	-6.657D-11	-6.424D-11	0.0	0.0	0.0	0.0	0.0	0.0
25	-6.874D-11	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

	12	13	14	15	16	17	18	19	20	21	22
1	-4.956D-06	-4.944D-06	3.563D-05	3.669D-05	3.739D-05	3.760D-05	3.756D-05	3.724D-05	3.666D-05	3.561D-05	3.411D-05
2	3.694D-05	3.681D-05	3.750D-05	3.761D-05	3.768D-05	3.757D-05	3.723D-05	3.681D-05	3.624D-05	3.526D-05	3.495D-05
3	3.798D-05	3.782D-05	3.773D-05	3.761D-05	3.720D-05	3.706D-05	3.651D-05	3.630D-05	3.585D-05	3.552D-05	3.533D-05
4	3.775D-05	3.752D-05	3.686D-05	3.671D-05	3.584D-05	3.590D-05	3.511D-05	3.538D-05	3.487D-05	3.506D-05	3.453D-05
5	3.654D-05	3.614D-05	3.480D-05	3.467D-05	3.313D-05	3.376D-05	3.277D-05	3.379D-05	3.334D-05	3.374D-05	5.192D-05
6	3.426D-05	3.335D-05	3.080D-05	3.071D-05	2.801D-05	3.046D-05	4.783D-05	5.072D-05	5.011D-05	5.020D-05	4.700D-05
7	3.080D-05	2.814D-05	-2.675D-06	-2.676D-06	-2.677D-06	4.338D-05	4.579D-05	4.784D-05	4.604D-05	4.478D-05	3.993D-05
8	2.801D-05	-2.676D-06	-2.677D-06	-2.659D-06	4.194D-05	4.459D-05	4.452D-05	4.397D-05	3.996D-05	3.731D-05	3.115D-05
9	4.783D-05	4.338D-05	4.579D-05	4.459D-05	4.452D-05	4.342D-05	3.982D-05	3.740D-05	3.152D-05	2.820D-05	2.171D-05
10	5.011D-05	4.784D-05	4.604D-05	4.397D-05	3.996D-05	3.740D-05	3.152D-05	2.838D-05	2.188D-05	1.872D-05	1.310D-05
11	4.700D-05	4.478D-05	3.993D-05	3.731D-05	3.115D-05	2.820D-05	2.171D-05	1.872D-05	1.310D-05	1.079D-05	-3.342D-06
12	3.895D-05	3.659D-05	3.011D-05	2.746D-05	2.094D-05	1.847D-05	-6.979D-06	-5.600D-06	-3.066D-06	-2.295D-06	-1.119D-06
13	2.805D-05	2.589D-05	1.942D-05	1.722D-05	1.186D-05	-5.297D-06	-2.884D-06	-2.124D-06	-1.046D-06	-7.456D-07	-3.483D-07
14	1.714D-05	1.551D-05	1.057D-05	9.173D-06	-2.769D-06	-2.017D-06	-9.736D-07	-6.947D-07	-3.233D-07	-2.276D-07	-1.047D-07
15	-4.535D-06	-4.008D-06	-2.099D-06	-1.723D-06	-8.206D-07	-6.146D-07	-2.829D-07	-2.049D-07	-9.379D-08	-6.733D-08	-3.192D-08
16	-1.402D-05	-1.222D-06	-5.885D-07	-4.798D-07	-2.218D-07	-1.701D-07	-7.794D-08	-5.794D-08	-2.708D-08	-2.024D-08	-1.020D-08
17	-3.789D-07	-3.279D-07	-1.548D-07	-1.269D-07	-5.939D-08	-4.652D-08	-2.234D-08	-1.698D-08	-8.664D-09	-6.729D-09	-1.462D-09
18	-9.992D-08	-8.643D-08	-4.246D-08	-3.501D-08	-1.804D-08	-1.456D-08	-3.284D-09	-2.491D-09	-1.076D-09	-8.137D-10	-3.239D-10
19	-2.995D-08	-2.619D-08	-6.036D-09	-4.950D-09	-2.181D-09	-1.766D-09	-7.263D-10	-5.641D-10	-2.110D-10	-1.587D-10	-4.824D-11
20	-3.558D-09	-3.102D-09	-1.307D-09	-1.093D-09	-4.189D-10	-3.397D-10	-1.060D-10	-8.314D-11	-1.411D-11	-1.061D-11	0.0
21	-6.733D-10	-5.864D-10	-1.878D-10	-1.581D-10	-2.745D-11	-2.223D-11	0.0	0.0	0.0	0.0	0.0
22	-4.362D-11	-3.789D-11	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
23	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
24	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

	23	24	25	26	27	28	29	30	31	32	33
1	-4.772D-06	-4.774D-06	-4.790D-06	5.301D-05	5.259D-05	5.051D-05	4.674D-05	4.161D-05	3.569D-05	2.922D-05	2.293D-05
2	3.352D-05	3.433D-05	5.429D-05	5.326D-05	5.059D-05	4.644D-05	4.141D-05	3.520D-05	2.899D-05	2.252D-05	1.699D-05
3	3.494D-05	5.493D-05	5.326D-05	4.998D-05	4.601D-05	4.034D-05	3.467D-05	2.799D-05	2.210D-05	1.628D-05	-6.060D-06
4	5.437D-05	5.189D-05	4.917D-05	4.419D-05	3.941D-05	3.286D-05	2.719D-05	2.072D-05	1.576D-05	-5.641D-06	-3.347D-06
5	5.059D-05	4.643D-05	4.278D-05	3.661D-05	3.156D-05	2.484D-05	1.974D-05	1.417D-05	-5.333D-06	-2.976D-06	-1.685D-06
6	4.455D-05	3.895D-05	3.475D-05	2.805D-05	2.330D-05	1.714D-05	1.319D-05	-4.535D-06	-2.730D-06	-1.402D-06	-7.782D-07
7	3.659D-05	3.011D-05	2.589D-05	1.942D-05	1.551D-05	1.057D-05	-4.008D-06	-2.099D-06	-1.222D-06	-5.885D-07	-3.279D-07
8	2.746D-05	2.094D-05	1.722D-05	1.186D-05	9.172D-06	-2.769D-06	-1.723D-06	-8.206D-07	-4.798D-07	-2.218D-07	-1.269D-07

(CON'T)

9	1.847D-05	-6.979D-06	-5.297D-06	-2.884D-06	-2.017D-06	-9.736D-07	-6.146D-07	-2.829D-07	-1.701D-07	-7.794D-08	-4.652D-08
10	-5.600D-06	-3.066D-06	-2.124D-06	-1.046D-06	-6.947D-07	-3.233D-07	-2.049D-07	-9.379D-08	-5.794D-08	-2.708D-08	-1.698D-08
11	-2.295D-06	-1.119D-06	-7.456D-07	-3.483D-07	-2.276D-07	-1.047D-07	-6.733D-08	-3.192D-08	-2.024D-08	-1.020D-08	-6.729D-09
12	-7.707D-07	-3.589D-07	-2.397D-07	-1.102D-07	-7.297D-08	-3.464D-08	-2.423D-08	-5.577D-09	-3.495D-09	-1.572D-09	-9.885D-10
13	-2.397D-07	-1.102D-07	-7.458D-08	-3.492D-08	-2.396D-08	-1.219D-08	-3.846D-09	-1.730D-09	-1.082D-09	-4.625D-10	-2.785D-10
14	-7.297D-08	-3.464D-08	-2.396D-08	-1.219D-08	-8.742D-09	-1.921D-09	-1.197D-09	-5.072D-10	-3.123D-10	-1.281D-10	-7.442D-11
15	-2.423D-08	-5.577D-09	-3.846D-09	-1.730D-09	-1.197D-09	-5.072D-10	-3.273D-10	-1.349D-10	-8.335D-11	-3.217D-11	-1.758D-11
16	-3.495D-09	-1.572D-09	-1.082D-09	-4.625D-10	-3.123D-10	-1.281D-10	-8.335D-11	-3.217D-11	-1.965D-11	-6.426D-12	-3.057D-12
17	-9.885D-10	-4.098D-10	-2.785D-10	-1.106D-10	-7.442D-11	-2.698D-11	-1.758D-11	-5.112D-12	-3.057D-12	-4.511D-13	-1.762D-13
18	-2.289D-10	-8.369D-11	-5.788D-11	-1.742D-11	-1.184D-11	-1.981D-12	-1.286D-12	0.0	0.0	0.0	0.0
19	-3.490D-11	-5.851D-12	-4.087D-12	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
21	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
23	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
24	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

	34	35	36	37	38	39	40	41	42	43	44
1	1.715D-05	-6.322D-06	-3.679D-06	-2.036D-06	-1.083D-06	-5.676D-07	-2.933D-07	-1.532D-07	-8.165D-08	-4.684D-08	-1.162D-08
2	-6.195D-06	-3.640D-06	-1.990D-06	-1.070D-06	-5.536D-07	-2.894D-07	-1.491D-07	-8.047D-08	-4.544D-08	-1.143D-08	-5.422D-09
3	-3.476D-06	-1.943D-06	-1.017D-06	-5.390D-07	-2.738D-07	-1.448D-07	-7.583D-08	-4.414D-08	-1.076D-06	-5.252D-09	-2.337D-09
4	-1.793D-06	-9.749D-07	-4.936D-07	-2.614D-07	-1.317D-07	-7.211D-08	-3.981D-08	-1.017D-08	-4.730D-09	-2.214D-09	-8.946D-10
5	-8.569D-07	-4.613D-07	-2.276D-07	-1.225D-07	-6.243D-08	-3.711D-08	-8.821D-09	-4.390D-09	-1.905D-09	-8.277D-10	-2.724D-10
6	-3.789D-07	-2.055D-07	-9.992D-08	-5.610D-08	-2.995D-08	-7.862D-09	-3.558D-09	-1.710D-09	-6.733D-10	-2.451D-10	-4.362D-11
7	-1.548D-07	-8.643D-08	-4.246D-08	-2.619D-08	-6.036D-09	-3.102D-09	-1.307D-09	-5.864D-10	-1.878D-10	-3.789D-11	0.0
8	-5.939D-08	-3.501D-08	-1.804D-08	-4.950D-09	-2.181D-09	-1.093D-09	-4.189D-10	-1.581D-10	-2.745D-11	0.0	0.0
9	-2.234D-08	-1.456D-08	-3.284D-09	-1.766D-09	-7.263D-10	-3.397D-10	-1.060D-10	-2.223D-11	0.0	0.0	0.0
10	-8.664D-09	-2.491D-09	-1.076D-09	-5.641D-10	-2.110D-10	-8.314D-11	-1.411D-11	0.0	0.0	0.0	0.0
11	-1.462D-09	-8.137D-10	-3.239D-10	-1.587D-10	-4.824D-11	-1.061D-11	0.0	0.0	0.0	0.0	0.0
12	-4.098D-10	-2.289D-10	-8.369D-11	-3.490D-11	-5.851D-12	0.0	0.0	0.0	0.0	0.0	0.0
13	-1.106D-10	-5.788D-11	-1.742D-11	-4.087D-12	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14	-2.698D-11	-1.184D-11	-1.981D-12	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15	-5.112D-12	-1.286D-12	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16	-4.511D-13	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
17	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
18	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
19	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
21	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
23	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
24	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

	45	46	47	48	49	50
1	-5.594D-09	-2.535D-09	-1.062D-09	-3.641D-10	-6.874D-11	0.0
2	-2.494D-09	-1.029D-09	-3.582D-10	-6.657D-11	0.0	0.0
3	-9.944D-10	-3.350D-10	-6.424D-11	0.0	0.0	0.0
4	-3.172D-10	-5.784D-11	0.0	0.0	0.0	0.0
5	-5.334D-11	0.0	0.0	0.0	0.0	0.0
6	0.0	0.0	0.0	0.0	0.0	0.0
7	0.0	0.0	0.0	0.0	0.0	0.0
8	0.0	0.0	0.0	0.0	0.0	0.0
9	0.0	0.0	0.0	0.0	0.0	0.0
10	0.0	0.0	0.0	0.0	0.0	0.0
11	0.0	0.0	0.0	0.0	0.0	0.0
12	0.0	0.0	0.0	0.0	0.0	0.0
13	0.0	0.0	0.0	0.0	0.0	0.0
14	0.0	0.0	0.0	0.0	0.0	0.0
15	0.0	0.0	0.0	0.0	0.0	0.0
16	0.0	0.0	0.0	0.0	0.0	0.0
17	0.0	0.0	0.0	0.0	0.0	0.0
18	0.0	0.0	0.0	0.0	0.0	0.0
19	0.0	0.0	0.0	0.0	0.0	0.0
20	0.0	0.0	0.0	0.0	0.0	0.0
21	0.0	0.0	0.0	0.0	0.0	0.0
22	0.0	0.0	0.0	0.0	0.0	0.0

(CON'T)

1/V (NEUTRON IMPORTANCE) MAP (1/V/K)(DELTA K/DELTA 1/V).

	1	2	3	4	5	6	7	8	9	10	11
1	5.011D-11	4.679D-11	4.550D-11	4.496D-11	4.478D-11	4.469D-11	4.461D-11	4.461D-11	4.496D-11	4.605D-11	4.915D-11
2	4.550D-11	4.496D-11	4.484D-11	4.473D-11	4.467D-11	4.456D-11	4.450D-11	4.446D-11	4.481D-11	4.467D-11	4.579D-11
3	4.478D-11	4.469D-11	4.467D-11	4.456D-11	4.451D-11	4.437D-11	4.430D-11	4.414D-11	4.414D-11	4.384D-11	4.379D-11
4	4.461D-11	4.461D-11	4.450D-11	4.446D-11	4.430D-11	4.414D-11	4.404D-11	4.383D-11	4.370D-11	4.336D-11	4.314D-11
5	4.496D-11	4.605D-11	4.481D-11	4.467D-11	4.414D-11	4.384D-11	4.370D-11	4.336D-11	4.314D-11	4.253D-11	4.213D-11
6	4.915D-11	4.905D-11	4.579D-11	4.436D-11	4.379D-11	4.337D-11	4.314D-11	4.259D-11	4.213D-11	4.108D-11	4.025D-11
7	4.894D-11	4.554D-11	4.422D-11	4.346D-11	4.319D-11	4.273D-11	4.233D-11	4.150D-11	4.061D-11	3.901D-11	3.724D-11
8	4.410D-11	4.338D-11	4.319D-11	4.283D-11	4.256D-11	4.200D-11	4.134D-11	4.031D-11	3.888D-11	3.701D-11	3.389D-11
9	4.307D-11	4.280D-11	4.267D-11	4.231D-11	4.193D-11	4.133D-11	4.047D-11	3.955D-11	3.787D-11	3.668D-11	3.365D-11
10	4.264D-11	4.250D-11	4.225D-11	4.198D-11	4.143D-11	4.093D-11	4.004D-11	3.942D-11	3.804D-11	3.762D-11	3.606D-11
11	4.279D-11	4.372D-11	4.240D-11	4.210D-11	4.121D-11	4.066D-11	3.987D-11	3.924D-11	3.820D-11	3.723D-11	3.594D-11
12	4.669D-11	4.655D-11	4.327D-11	4.169D-11	4.080D-11	3.995D-11	3.922D-11	3.736D-11	3.633D-11	3.331D-11	3.193D-11
13	4.648D-11	4.289D-11	4.141D-11	3.934D-11	3.879D-11	3.611D-11	3.540D-11	3.172D-11	3.068D-11	2.621D-11	2.486D-11
14	4.024D-11	3.733D-11	3.703D-11	3.360D-11	3.317D-11	2.895D-11	2.825D-11	2.348D-11	2.254D-11	1.763D-11	1.653D-11
15	3.403D-11	3.001D-11	2.981D-11	2.520D-11	2.480D-11	1.988D-11	1.931D-11	1.447D-11	1.379D-11	9.416D-12	8.748D-12
16	2.558D-11	2.077D-11	2.061D-11	1.573D-11	1.544D-11	1.082D-11	1.047D-11	6.075D-12	5.740D-12	3.024D-12	2.773D-12
17	1.602D-11	1.139D-11	1.128D-11	6.669D-12	6.522D-12	3.532D-12	3.401D-12	1.758D-12	1.652D-12	8.221D-13	7.465D-13
18	6.804D-12	3.737D-12	3.698D-12	1.951D-12	1.904D-12	9.754D-13	9.350D-13	4.676D-13	4.370D-13	2.146D-13	1.937D-13
19	1.996D-12	1.038D-12	1.026D-12	5.243D-13	5.105D-13	2.580D-13	2.463D-13	1.243D-13	1.157D-13	5.947D-14	5.346D-14
20	5.376D-13	2.763D-13	2.727D-13	1.407D-13	1.366D-13	7.220D-14	6.866D-14	3.861D-14	3.602D-14	2.029D-14	1.809D-14
21	1.446D-13	7.774D-14	7.661D-14	4.407D-14	4.281D-14	2.474D-14	2.339D-14	1.118D-14	1.038D-14	4.553D-15	4.088D-15
22	4.542D-14	2.671D-14	2.627D-14	1.281D-14	1.241D-14	5.583D-15	5.290D-15	2.140D-15	1.980D-15	6.474D-16	5.824D-16
23	1.322D-14	6.055D-15	5.958D-15	2.460D-15	2.379D-15	7.959D-16	7.538D-16	1.336D-16	1.232D-16	0.0	0.0
24	2.540D-15	8.651D-16	8.510D-16	1.537D-16	1.483D-16	0.0	0.0	0.0	0.0	0.0	0.0
25	1.587D-16	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

	12	13	14	15	16	17	18	19	20	21	22
1	4.905D-11	4.894D-11	4.554D-11	4.410D-11	4.338D-11	4.307D-11	4.280D-11	4.264D-11	4.250D-11	4.279D-11	4.372D-11
2	4.436D-11	4.422D-11	4.346D-11	4.319D-11	4.283D-11	4.267D-11	4.231D-11	4.225D-11	4.198D-11	4.240D-11	4.210D-11
3	4.337D-11	4.318D-11	4.273D-11	4.256D-11	4.200D-11	4.193D-11	4.133D-11	4.143D-11	4.093D-11	4.121D-11	4.066D-11
4	4.259D-11	4.233D-11	4.150D-11	4.134D-11	4.031D-11	4.047D-11	3.955D-11	4.004D-11	3.942D-11	3.987D-11	3.924D-11
5	4.109D-11	4.061D-11	3.901D-11	3.888D-11	3.701D-11	3.787D-11	3.668D-11	3.804D-11	3.762D-11	3.820D-11	3.723D-11
6	3.835D-11	3.724D-11	3.398D-11	3.389D-11	3.009D-11	3.365D-11	3.350D-11	3.606D-11	3.573D-11	3.594D-11	3.366D-11
7	3.398D-11	3.027D-11	2.209D-11	2.200D-11	2.173D-11	2.942D-11	3.194D-11	3.393D-11	3.282D-11	3.202D-11	2.856D-11
8	3.009D-11	2.200D-11	2.173D-11	2.146D-11	2.827D-11	3.105D-11	3.150D-11	3.132D-11	2.853D-11	2.667D-11	2.223D-11
9	3.360D-11	2.942D-11	3.194D-11	3.105D-11	3.150D-11	3.085D-11	2.841D-11	2.672D-11	2.249D-11	2.007D-11	1.525D-11
10	3.573D-11	3.393D-11	3.282D-11	3.132D-11	2.853D-11	2.672D-11	2.249D-11	2.023D-11	1.546D-11	1.307D-11	8.650D-12
11	3.366D-11	3.202D-11	2.856D-11	2.667D-11	2.223D-11	2.007D-11	1.525D-11	1.307D-11	8.650D-12	6.922D-12	3.506D-12
12	2.789D-11	2.618D-11	2.150D-11	1.954D-11	1.471D-11	1.261D-11	7.643D-12	6.023D-12	3.110D-12	2.302D-12	1.085D-12
13	2.001D-11	1.844D-11	1.370D-11	1.201D-11	7.813D-12	5.697D-12	2.927D-12	2.104D-12	1.009D-12	7.128D-13	3.290D-13
14	1.195D-11	1.079D-11	6.932D-12	5.859D-12	2.909D-12	2.026D-12	9.452D-13	6.643D-13	3.055D-13	2.141D-13	9.845D-14
15	4.880D-12	4.297D-12	2.125D-12	1.731D-12	7.970D-13	5.895D-13	2.679D-13	1.931D-13	8.831D-14	6.349D-14	3.043D-14
16	1.375D-12	1.196D-12	5.639D-13	4.583D-13	2.097D-13	1.604D-13	7.353D-14	5.471D-14	2.584D-14	1.945D-14	1.005D-14
17	3.590D-13	3.106D-13	1.460D-13	1.197D-13	5.622D-14	4.409D-14	2.147D-14	1.639D-14	8.585D-15	6.745D-15	3.452D-15
18	9.438D-14	8.168D-14	4.054D-14	3.347D-14	1.761D-14	1.427D-14	7.608D-15	5.786D-15	2.562D-15	1.947D-15	7.787D-16
19	2.909D-14	2.549D-14	1.391D-14	1.141D-14	5.167D-15	4.191D-15	1.740D-15	1.353D-15	5.055D-16	3.804D-16	1.145D-16
20	8.412D-15	7.343D-15	3.127D-15	2.615D-15	1.003D-15	8.135D-16	2.519D-16	1.976D-16	3.263D-17	2.448D-17	0.0
21	1.611D-15	1.403D-15	4.463D-16	3.759D-16	6.346D-17	5.131D-17	0.0	0.0	0.0	0.0	0.0
22	1.008D-16	8.746D-17	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
23	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
24	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

	23	24	25	26	27	28	29	30	31	32	33
1	4.669D-11	4.655D-11	4.648D-11	4.289D-11	4.024D-11	3.732D-11	3.403D-11	3.001D-11	2.558D-11	2.077D-11	1.602D-11
2	4.327D-11	4.169D-11	4.141D-11	3.934D-11	3.703D-11	3.360D-11	2.981D-11	2.520D-11	2.061D-11	1.573D-11	1.128D-11
3	4.080D-11	3.995D-11	3.879D-11	3.611D-11	3.317D-11	2.895D-11	2.480D-11	1.988D-11	1.543D-11	1.082D-11	6.522D-12
4	3.922D-11	3.736D-11	3.540D-11	3.172D-11	2.825D-11	2.348D-11	1.931D-11	1.447D-11	1.047D-11	6.075D-12	3.401D-12
5	3.633D-11	3.331D-11	3.068D-11	2.621D-11	2.254D-11	1.763D-11	1.379D-11	9.416D-12	5.740D-12	3.024D-12	1.652D-12
6	3.193D-11	2.789D-11	2.486D-11	2.001D-11	1.653D-11	1.195D-11	8.748D-12	4.880D-12	2.773D-12	1.375D-12	7.465D-13
7	2.618D-11	2.150D-11	1.844D-11	1.370D-11	1.079D-11	6.932D-12	4.297D-12	2.125D-12	1.196D-12	5.639D-13	3.106D-13
8	1.954D-11	1.471D-11	1.201D-11	7.813D-12	5.859D-12	2.909D-12	1.731D-12	7.970D-13	4.583D-13	2.097D-13	1.197D-13

(CON'T)

9	1.261D-11	7.643D-12	5.697D-12	2.927D-12	2.026D-12	9.452D-13	5.895D-13	2.679D-13	1.604D-13	7.352D-14	4.409D-14
10	6.023D-12	3.110D-12	2.104D-12	1.009D-12	6.643D-13	3.055D-13	1.931D-13	8.831D-14	5.471D-14	2.584D-14	1.639D-14
11	2.302D-12	1.085D-12	7.128D-13	3.290D-13	2.141D-13	9.845D-14	6.349D-14	3.043D-14	1.945D-14	1.005D-14	6.745D-15
12	7.384D-13	3.393D-13	2.256D-13	1.036D-13	6.876D-14	3.299D-14	2.336D-14	1.270D-14	8.052D-15	3.725D-15	2.362D-15
13	2.256D-13	1.036D-13	7.024D-14	3.320D-14	2.299D-14	1.199D-14	8.861D-15	4.100D-15	2.584D-15	1.110D-15	6.685D-16
14	6.876D-14	3.299D-14	2.299D-14	1.199D-14	8.725D-15	4.528D-15	2.858D-15	1.219D-15	7.499D-16	3.060D-16	1.771D-16
15	2.336D-14	1.270D-14	8.861D-15	4.100D-15	2.858D-15	1.219D-15	7.867D-16	3.225D-16	1.985D-16	7.597D-17	4.129D-17
16	8.052D-15	3.725D-15	2.584D-15	1.110D-15	7.499D-16	3.060D-16	1.985D-16	7.597D-17	4.619D-17	1.496D-17	7.071D-18
17	2.362D-15	9.848D-16	6.685D-16	2.641D-16	1.771D-16	6.365D-17	4.129D-17	1.187D-17	7.071D-18	1.023D-18	3.956D-19
18	5.499D-16	1.998D-16	1.377D-16	4.095D-17	2.773D-17	4.531D-18	2.928D-18	0.0	0.0	0.0	0.0
19	8.263D-17	1.349D-17	9.377D-18	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
21	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
23	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
24	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

	34	35	36	37	38	39	40	41	42	43	44
1	1.139D-11	6.804D-12	3.737D-12	1.996D-12	1.038D-12	5.376D-13	2.763D-13	1.446D-13	7.774D-14	4.542D-14	2.671D-14
2	6.669D-12	3.698D-12	1.951D-12	1.026D-12	5.243D-13	2.727D-13	1.407D-13	7.661D-14	4.407D-14	2.627D-14	1.281D-14
3	3.532D-12	1.904D-12	9.754D-13	5.105D-13	2.580D-13	1.366D-13	7.220D-14	4.281D-14	2.474D-14	1.241D-14	5.583D-15
4	1.758D-12	9.350D-13	4.676D-13	2.463D-13	1.243D-13	6.866D-14	3.861D-14	2.339D-14	1.118D-14	5.290D-15	2.140D-15
5	8.221D-13	4.370D-13	2.146D-13	1.157D-13	5.947D-14	3.602D-14	2.029D-14	1.038D-14	4.553D-15	1.980D-15	6.474D-16
6	3.590D-13	1.937D-13	9.438D-14	5.346D-14	2.909D-14	1.809D-14	8.412D-15	4.088D-15	1.611D-15	5.824D-16	1.008D-16
7	1.460D-13	8.168D-14	4.054D-14	2.549D-14	1.391D-14	7.343D-15	3.127D-15	1.403D-15	4.463D-16	8.746D-17	0.0
8	5.622D-14	3.347D-14	1.761D-14	1.141D-14	5.167D-15	2.615D-15	1.003D-15	3.759D-16	6.345D-17	0.0	0.0
9	2.147D-14	1.427D-14	7.608D-15	4.191D-15	1.740D-15	8.135D-16	2.519D-16	5.131D-17	0.0	0.0	0.0
10	8.585D-15	5.786D-15	2.562D-15	1.353D-15	5.055D-16	1.976D-16	3.263D-17	0.0	0.0	0.0	0.0
11	3.452D-15	1.947D-15	7.787D-16	3.804D-16	1.145D-16	2.448D-17	0.0	0.0	0.0	0.0	0.0
12	9.848D-16	5.499D-16	1.998D-16	8.263D-17	1.349D-17	0.0	0.0	0.0	0.0	0.0	0.0
13	2.641D-16	1.377D-16	4.095D-17	9.377D-18	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14	6.365D-17	2.773D-17	4.531D-18	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15	1.187D-17	2.928D-18	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16	1.023D-18	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
17	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
18	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
19	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
21	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
23	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
24	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

	45	46	47	48	49	50
1	1.322D-14	6.055D-15	2.540D-15	8.651D-16	1.587D-16	0.0
2	5.958D-15	2.460D-15	8.510D-16	1.537D-16	0.0	0.0
3	2.379D-15	7.959D-16	1.483D-16	0.0	0.0	0.0
4	7.538D-16	1.336D-16	0.0	0.0	0.0	0.0
5	1.232D-16	0.0	0.0	0.0	0.0	0.0
6	0.0	0.0	0.0	0.0	0.0	0.0
7	0.0	0.0	0.0	0.0	0.0	0.0
8	0.0	0.0	0.0	0.0	0.0	0.0
9	0.0	0.0	0.0	0.0	0.0	0.0
10	0.0	0.0	0.0	0.0	0.0	0.0
11	0.0	0.0	0.0	0.0	0.0	0.0
12	0.0	0.0	0.0	0.0	0.0	0.0
13	0.0	0.0	0.0	0.0	0.0	0.0
14	0.0	0.0	0.0	0.0	0.0	0.0
15	0.0	0.0	0.0	0.0	0.0	0.0
16	0.0	0.0	0.0	0.0	0.0	0.0
17	0.0	0.0	0.0	0.0	0.0	0.0
18	0.0	0.0	0.0	0.0	0.0	0.0
19	0.0	0.0	0.0	0.0	0.0	0.0
20	0.0	0.0	0.0	0.0	0.0	0.0
21	0.0	0.0	0.0	0.0	0.0	0.0
22	0.0	0.0	0.0	0.0	0.0	0.0

(CON'T)

23	0.0	0.0	0.0	0.0	0.0	0.0
24	0.0	0.0	0.0	0.0	0.0	0.0
25	0.0	0.0	0.0	0.0	0.0	0.0

THE FOLLOWING ARE CHANGES DUE TO 100 PERCENT CHANGE IN MACROSCOPIC CROSS SECTIONS.
(DIVIDE BY 100 TO GET THE EFFECT OF A 1 PERCENT CHANGE).

FOR INSCATTER

GRP.	TO GRP.	FOR ALL ZONES							
1	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		0.0							
2	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		0.0							
3	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		0.0							
4	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		0.0							
1	2	2.936237E-01	2.061796E-01	9.614423E-03	3.780991E-06	0.0	5.899738E-04	3.466299E-03	3.571042E-03
		2.867575E-03							
2	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		0.0							
3	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		0.0							
4	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		0.0							
1	3	7.752674E-04	5.818598E-04	1.741355E-05	3.221614E-09	0.0	1.081517E-06	6.354825E-06	6.778738E-06
		5.503231E-06							
2	3	1.570437E-01	1.019875E-01	5.924784E-03	5.859024E-06	0.0	5.340185E-04	3.138388E-03	3.125727E-03
		2.300858E-03							
3	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		0.0							
4	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		0.0							
1	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		0.0							
2	4	2.883100E-05	1.860326E-05	1.300408E-06	0.0	0.0	0.0	0.0	0.0
		0.0							
3	4	4.830965E-02	2.889058E-02	1.447164E-03	3.099056E-06	0.0	3.718417E-04	2.183767E-03	2.090968E-03
		1.132882E-03							
4	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		0.0							

SUM OF ALL INSCATTER IS 8.798502D-01

ZONE	GRP	REMOVAL
1	1	-3.606643E-01
	2	-2.064180E-01
	3	-4.569271E-02
	4	0.0
2	1	-2.486036E-01
	2	-1.258182E-01
	3	-2.695387E-02
	4	0.0
3	1	-1.297157E-02
	2	-1.109716E-02
	3	-1.674344E-03
	4	0.0
4	1	-5.403561E-06
	2	-3.014103E-05
	3	-4.789636E-06
	4	0.0
5	1	0.0

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	2	0.0
	3	0.0
	4	0.0
6	1	-7.171850E-04
	2	-7.058885E-04
	3	-3.599711E-04
	4	0.0
7	1	-4.213460E-03
	2	-4.148100E-03
	3	-2.114315E-03
	4	0.0
8	1	-4.284550E-03
	2	-3.990740E-03
	3	-2.028099E-03
	4	0.0
9	1	-3.429003E-03
	2	-2.905915E-03
	3	-1.096054E-03
	4	0.0

SUM IS -1.069927D 00

ZONE	GRP	ABSORPTIONS	SCATTERING	FISSION SOURCE	TRANSPORT	OVERALL
1	1	-6.490916D-02	-6.626540D-02	1.512355D-01	1.679171D-04	2.022881D-02
	2	-1.556932D-01	-4.934549D-02	2.458806D-01	8.484149D-05	4.092678D-02
	3	-1.064505D-01	2.616938D-03	1.103509D-01	-4.289752D-05	6.474449D-03
	4	-5.016448D-02	0.0	5.208723D-02	-6.648977D-05	1.856255D-03
2	1	-5.003492D-02	-4.184222D-02	1.210104D-01	5.026072D-03	3.415930D-02
	2	-1.112224D-01	-2.381206D-02	2.005234D-01	8.778211D-03	7.426715D-02
	3	-7.024914D-02	1.936715D-03	8.224541D-02	1.211444D-03	1.514443D-02
	4	-2.916295D-02	0.0	3.200237D-02	9.355160D-05	2.932968D-03
3	1	-1.773214D-03	-3.339730D-03	3.743718D-03	2.763060D-03	1.393833D-03
	2	-5.140003D-03	-5.171075D-03	3.817168D-04	5.805004D-03	-4.124357D-03
	3	-3.859726D-03	-2.271791D-04	3.144536D-04	7.933462D-04	-2.979105D-03
	4	-1.230577D-03	0.0	2.237712D-04	6.954189D-05	-9.372634D-04
4	1	-3.857878D-07	-1.619348D-06	0.0	2.035044D-06	2.990771D-08
	2	-4.418692D-06	-2.428200D-05	0.0	2.327068D-05	-5.430006D-06
	3	-2.542423D-06	-1.690580D-06	0.0	1.738345D-05	-2.494658D-06
	4	-1.993488D-06	0.0	0.0	1.038669D-07	-1.889621D-06
5	1	0.0	0.0	0.0	0.0	0.0
	2	0.0	0.0	0.0	0.0	0.0
	3	0.0	0.0	0.0	0.0	0.0
	4	0.0	0.0	0.0	0.0	0.0
6	1	-2.873687D-05	-1.261297D-04	0.0	3.707491D-06	-1.511591D-04
	2	-3.780352D-05	-1.718700D-04	0.0	1.371958D-06	-2.083016D-04
	3	-4.401656D-05	1.187064D-05	0.0	-2.830531D-07	-3.242898D-05
	4	-3.042381D-05	0.0	0.0	-2.072200D-06	-3.249601D-05
7	1	-1.688292D-04	-7.408059D-04	0.0	2.130664D-05	-8.883285D-04
	2	-2.221495D-04	-1.009712D-03	0.0	6.901666D-06	-1.224960D-03
	3	-2.585340D-04	6.945198D-05	0.0	-1.857975D-06	-1.909400D-04
	4	-1.785245D-04	0.0	0.0	-1.220654D-05	-1.907311D-04
8	1	-1.716777D-04	-7.067290D-04	0.0	1.894700D-05	-8.594597D-04
	2	-2.137222D-04	-8.650129D-04	0.0	6.528907D-06	-1.072206D-03
	3	-2.479916D-04	6.286893D-05	0.0	-4.765165D-06	-1.898879D-04
	4	-1.650237D-04	0.0	0.0	-1.310580D-05	-1.781295D-04
9	1	-1.373967D-04	-5.559251D-04	0.0	3.378869D-05	-6.595331D-04
	2	-1.556249D-04	-6.050563D-04	0.0	4.966959D-05	-7.110117D-04
	3	-1.340233D-04	3.682775D-05	0.0	9.394000D-06	-8.780153D-05
	4	-1.965952D-05	0.0	0.0	7.169554D-06	-1.248997D-05

BY ZONE					
1	-3.772173D-01	-1.129940D-01	5.555542D-01	1.433713D-04	6.948630D-02
2	-2.605695D-01	-6.371756D-02	4.357816D-01	1.510928D-02	1.265038D-01

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3	-1.200352D-02	-8.737985D-03	4.663659D-03	9.430953D-03	-6.646892D-03
4	-9.340391D-06	-2.759192D-05	0.0	2.714794D-05	-9.784378D-06
5	0.0	0.0	0.0	0.0	0.0
6	-1.409808D-04	-2.861291D-04	0.0	2.724197D-06	-4.243856D-04
7	-8.280372D-04	-1.681066D-03	0.0	1.414378D-05	-2.494959D-03
8	-7.984152D-04	-1.508873D-03	0.0	7.604948D-06	-2.299683D-03
9	-4.467044D-04	-1.124154D-03	0.0	1.000218D-04	-1.470836D-03
BY GROUP					
1	-1.172243D-01	-1.135786D-01	2.759895D-01	8.036834D-03	5.322349D-02
2	-2.726893D-01	-8.100456D-02	4.467858D-01	1.475580D-02	1.078477D-01
3	-1.812465D-01	4.505803D-03	1.929108D-01	1.966119D-03	1.813622D-02
4	-8.095363D-02	0.0	8.431336D-02	7.649260D-05	3.436224D-03
TOTALS					
	-6.521138D-01	-1.900773D-01	9.999994D-01	2.483524D-02	1.826436D-01

THE FOLLOWING ARE UNCERTAINTY ASSOCIATED WITH A 100 PERCENT UNCERTAINTY IN THE DATA (UNCORRELATED), BUT NET SCATTERING IN THE ABOVE TABLE TREATED AS AN ENTITY.

	ABSORPTIONS	SCATTERING	FISSION SOURCE	TRANSPORT	OVERALL
BY ZONE					
1	2.056739D-01	8.266152D-02	3.134004D-01	2.040963D-04	6.019399D-01
2	1.437336D-01	4.818232D-02	2.502831D-01	1.018797D-02	4.523869D-01
3	6.780540D-03	6.159986D-03	3.782867D-03	6.478179D-03	2.320157D-02
4	5.487401D-06	2.439458D-05	0.0	2.342431D-05	5.330629D-05
5	0.0	0.0	0.0	0.0	0.0
6	7.154005D-05	2.135156D-04	0.0	4.472348D-06	2.895280D-04
7	4.201958D-04	1.254246D-03	0.0	2.557455D-05	1.700017D-03
8	4.048247D-04	1.118779D-03	0.0	2.441483D-05	1.548018D-03
9	2.478824D-04	8.224974D-04	0.0	6.122412D-05	1.131604D-03
BY GROUP					
1	8.197508D-02	7.844998D-02	1.937258D-01	5.738124D-03	3.598890D-01
2	1.914088D-01	5.505357D-02	3.172807D-01	1.052451D-02	5.742676D-01
3	1.275997D-01	3.265137D-03	1.376289D-01	1.448776D-03	2.699426D-01
4	5.803901D-02	0.0	6.113330D-02	1.355925D-04	1.193079D-01
TOTALS					
	2.510129D-01	9.589554D-02	4.010932D-01	1.207513D-02	4.829337D-01

PERTURBATION INTERFACE FILE PERTUB HAS BEEN WRITTEN ON NEW UNIT NUMBER 19

I/O UNIT NUMBERS FOR NEXT-TO-LATEST AND LATEST VERSIONS OF ZNATDN, GRUPXS, NDXSRF ARE 15 17 0 12 0 14

CROSS SECTION CALC. PASS= 1-0, I/O UNIT NUMBPES FOR ZNATDN, GRUPXS, AND NDXSRF ARE 15 12 14

TITLE FROM CROSS SECTION FILE / LARGE CORE X-SECTIONS /

PRINCIPAL MACROSCOPIC CROSS SECTIONS

GROUP 1

ZONE	D	SIGA	SIGNF	SIGWF	SIGAS	SIGNFS
1	2.604939E 00	6.168436E-03	1.503706E-02	0.0	0.0	0.0
2	2.606928E 00	6.773584E-03	1.707205E-02	0.0	0.0	0.0
3	2.180740E 00	6.576255E-03	1.480614E-02	0.0	0.0	0.0

(CON'T)

THE FOLLOWING ARE (DELTA K)/K DUE TO THE PERTURBATION.

FOR INSCATTER GRP.	TO GRP.	FOR ALL ZONES							
1	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		0.0							
2	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		0.0							
3	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		0.0							
4	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		0.0							
1	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		-1.915816E-03							
2	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		0.0							
3	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		0.0							
4	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		0.0							
1	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		3.300761E-07							
2	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		-3.112896E-03							
3	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		0.0							
4	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		0.0							
1	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		0.0							
2	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		0.0							
3	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		3.124743E-04							
4	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		0.0							

SUM OF ALL INSCATTER IS -4.715908D-03

ZONE	GRP	REMOVAL
1	1	0.0
	2	0.0
	3	0.0
	4	0.0
2	1	0.0
	2	0.0
	3	0.0
	4	0.0
3	1	0.0
	2	0.0
	3	0.0
	4	0.0
4	1	0.0
	2	0.0
	3	0.0
	4	0.0
5	1	0.0
	2	0.0
	3	0.0
	4	0.0
6	1	0.0
	2	0.0

(CON'T)

SCATTERING	FISSION SOURCE	TRANSPORT	OVERALL
0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0
3.693798D-04	0.0	-1.916789D-04	9.109718D-04
8.185925D-04	0.0	-5.054092D-04	1.188981D-02
1.015794D-05	0.0	-4.456739D-05	7.995428D-03
0.0	0.0	-1.046253D-05	1.783179D-03
0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0

(CON'T)

8	0.0	0.0	0.0	0.0	0.0
9	2.213359D-02	1.198141D-03	0.0	-7.521247D-04	2.257960D-02
BY GROUP					
1	7.332778D-04	3.693844D-04	0.0	-1.916813D-04	9.109808D-04
2	1.157673D-02	8.185985D-04	0.0	-5.054132D-04	1.188992D-02
3	8.029915D-03	1.015794D-05	0.0	-4.456764D-05	7.995506D-03
4	1.793659D-03	0.0	0.0	-1.046255D-05	1.783196D-03
TOTALS					
	2.213359D-02	1.198141D-03	0.0	-7.521247D-04	2.257960D-02

THE TOTAL BUCKLING CONTRIBUTION (INCLUDED IN THE TRANSPORT) IS -6.79421E-04

THE FOLLOWING ARE STATISTICAL WEIGHTING OF INDEPENDENT CONTRIBUTIONS (SQRT SUM-SQUARES) WITH THE NET CONTRIBUTION FROM SCATTERING TREATED AS AN ENTITY -- AN UNCERTAINTY ANALYSIS, NOT THE PERTURBATION WHICH IS GIVEN ABOVE.

	ABSORPTIONS	SCATTERING	FISSION SOURCE	TRANSPORT	OVERALL
BY ZONE					
1	0.0	0.0	0.0	0.0	0.0
2	0.0	0.0	0.0	0.0	0.0
3	0.0	0.0	0.0	0.0	0.0
4	0.0	0.0	0.0	0.0	0.0
5	0.0	0.0	0.0	0.0	0.0
6	0.0	0.0	0.0	0.0	0.0
7	0.0	0.0	0.0	0.0	0.0
8	0.0	0.0	0.0	0.0	0.0
9	1.422165D-02	8.981378D-04	0.0	5.424757D-04	1.566226D-02
BY GROUP					
1	7.332777D-04	3.693844D-04	0.0	1.916813D-04	1.294343D-03
2	1.157673D-02	8.185985D-04	0.0	5.054131D-04	1.290075D-02
3	8.029915D-03	1.015793D-05	0.0	4.456764D-05	8.084641D-03
4	1.793659D-03	0.0	0.0	1.046255D-05	1.804121D-03
TOTALS					
	1.422165D-02	8.981378D-04	0.0	5.424757D-04	1.426030D-02

UNIT NUMBERS FOR FILES ZNATDN,GRUPXS, AND NDXSRF FOR OPTION IX(8) ARE 17 12 14

TITLE FROM CROSS SECTION FILE / LARGE CORE X-SECTIONS

==========MEMORY REQUIRED FOR CROSS SECTION CALCULATION FOR NUCLIDE BASIS IS 2247

USER JOB NAME AND DATE ON FILE PERTUB ARE TBFX 01-13-81

MEMORY USED FOR DELTA K/DELTA N IS 2189

(N DELTA K)/(K DELTA N) FOR UNIQUE NUCLIDE NAMES FOR EACH ZONE

ZONE 1

MAT 10 -5.73031E-03	MAT 11 -7.32462E-03	MAT 12 -1.20038E-02	MAT 13 -2.61114E-03	MAT 14 -9.69890E-03	MAT 15 -7.30885E-03
MAT 16 -3.40156E-02	MAT135 4.71947E-03	MAT138 -1.12832E-01	MAT139 2.28475E-01	MAT140 1.08641E-02	MAT141 6.15555E-02
MAT142 2.20440E-03					

TOTAL FOR ZONE IS 1.16293E-01

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ZONE   2
MAT 10 -1.66066E-03   MAT 11 -1.12004E-03   MAT 12 -3.67750E-03   MAT 13 -1.30128E-03   MAT 15 -3.92976E-03   MAT 16 -1.04394E-02
MAT 28 -3.74366E-04   MAT135  2.55036E-03   MAT141  4.81440E-02   MAT238 -5.03267E-02   MAT239  1.79805E-01   MAT240  1.13786E-02
MAT242  2.45652E-03
TOTAL FOR ZONE IS  1.71505E-01

ZONE   3
MAT 10  2.51249E-04   MAT 12  9.40259E-04   MAT 13  9.83214E-06   MAT 16  2.32618E-03   MAT 56  5.27783E-04   MAT 44  6.62814E-04
MAT335  6.75243E-04   MAT338 -1.23530E-03
TOTAL FOR ZONE IS  4.15806E-03

ZONE   4
MAT 10  2.35542E-06   MAT 12  1.47015E-05   MAT 13 -9.56510E-08   MAT 88  3.11249E-06
TOTAL FOR ZONE IS  2.00737E-05

ZONE   5
MAT 10  0.0           MAT 12  0.0           MAT 13  0.0           MAT 88  0.0
TOTAL FOR ZONE IS  0.0

ZONE   6
MAT 10 -4.75879E-06   MAT 12  6.28956E-06   MAT 13 -1.31912E-05   MAT224  3.74201E-05   MAT352  1.11238E-05
TOTAL FOR ZONE IS  3.68834E-05

ZONE   7
MAT 10 -2.81985E-05   MAT 12  3.61904E-05   MAT 13 -7.74908E-05   MAT224  2.18068E-04   MAT352  6.48534E-05
TOTAL FOR ZONE IS  2.13423E-04

ZONE   8
MAT 10 -1.46687E-05   MAT 12  4.14711E-05   MAT 13 -7.21369E-05   MAT224  2.96995E-04   MAT352  7.97657E-05
TOTAL FOR ZONE IS  3.31426E-04

ZONE   9
MAT 10  3.13299E-05   MAT 12  7.06636E-05   MAT 13 -2.18103E-05   MAT224  3.03874E-04   MAT352  1.18254E-04
TOTAL FOR ZONE IS  5.02311E-04

TOTAL OVERALL IS  2.93060E-01


(N DELTA K)/(K DELTA N) FOR UNIQUE   NUCLIDE NAMES SUMMED OVER ZONES
MAT 10 -7.15365E-03   MAT 11 -8.44466E-03   MAT 12 -1.45717E-02   MAT 13 -4.08731E-03   MAT 14 -9.69890E-03   MAT 15 -1.12386E-02
MAT 16 -4.21289E-02   MAT135  7.26983E-03   MAT138 -1.12832E-01   MAT139  2.28475E-01   MAT140  1.08641E-02   MAT141  1.09699E-01
MAT142  2.20440E-03   MAT 28 -3.74366E-04   MAT238 -5.03267E-02   MAT239  1.79805E-01   MAT240  1.13786E-02   MAT242  2.45652E-03
MAT 56  5.27783E-04   MAT 44  6.62814E-04   MAT335  6.75243E-04   MAT338 -1.23530E-03   MAT 88  3.11249E-06   MAT224  8.56357E-04
MAT352  2.73997E-04

TOTAL OVERALL IS  2.93060E-01


(DELTA K)/(K DELTA N) FOR UNIQUE   NUCLIDE NAMES FOR EACH ZONE

ZONE   1
MAT 10 -1.92292E 00   MAT 11 -1.17007E 00   MAT 12 -2.28209E 00   MAT 13 -1.00428E 01   MAT 14 -1.20036E 00   MAT 15 -3.04535E 01
MAT 16 -1.88557E 00   MAT 28 -1.10458E 00   MAT 56 -1.78245E 00   MAT 44 -1.39355E 00   MAT 88 -1.98536E 00   MAT135  2.48393E 02
MAT138 -1.46726E 01   MAT139  3.00625E 02   MAT140  3.74625E 01   MAT141  4.39682E 02   MAT142  2.75550E 01   MAT176 -1.15503E 00
MAT238 -1.45249E 01   MAT239  2.99572E 02   MAT240  3.86609E 01   MAT242  2.84928E 01   MAT335  2.61449E 02   MAT338 -1.48430E 01
TOTAL FOR ZONE IS  1.58147E 03

ZONE   2
MAT 10 -5.57268E-01   MAT 11 -1.78920E-01   MAT 12 -6.99145E-01   MAT 13 -5.00493E 00   MAT 14 -9.49306E-02   MAT 15 -1.63740E 01
MAT 16 -5.78682E-01   MAT 28 -4.63324E-02   MAT 56 -3.94507E-01   MAT 44 -2.74898E-01   MAT 88 -6.98315E-01   MAT135  1.41687E 02
MAT138 -7.04779E 00   MAT139  1.78480E 02   MAT140  2.70579E 01   MAT141  2.53389E 02   MAT142  2.13843E 01   MAT176 -1.73741E-01
MAT238 -6.96081E 00   MAT239  1.78025E 02   MAT240  2.77526E 01   MAT242  2.19332E 01   MAT335  1.48058E 02   MAT338 -7.13906E 00
TOTAL FOR ZONE IS  9.51543E 02
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ZCNE   3
MAT 10  1.45231E-01   MAT 11  1.67921E-01   MAT 12  2.44859E-01   MAT 13  5.17481E-02   MAT 14  1.24889E-01   MAT 15 -3.24949E-01
MAT 16  8.30187E-02   MAT 28  1.32023E-01   MAT 56  8.69495E-02   MAT 44  1.64063E-01   MAT 88  1.05372E-01   MAT135  1.50209E 01
MAT138 -8.07003E-02   MAT139  1.60907E 01   MAT140  1.91363E 00   MAT141  2.45220E 01   MAT142  1.35545E 00   MAT176  1.71116E-01
MAT238 -7.66092E-02   MAT239  1.59842E 01   MAT240  1.96014E 00   MAT242  1.39149E 00   MAT335  1.60772E 01   MAT338 -8.81727E-02
TOTAL FOR ZONE IS  9.52224E 01

ZCNE   4
MAT 10  1.55371E-04   MAT 11  2.62285E-04   MAT 12  4.36505E-04   MAT 13 -6.50687E-05   MAT 14  5.90123E-05   MAT 15 -1.39224E-03
MAT 16 -3.06938E-05   MAT 28  9.19424E-05   MAT 56 -1.12932E-04   MAT 44  2.27759E-04   MAT 88  8.79979E-05   MAT135  1.18766E-01
MAT138 -7.12288E-04   MAT139  1.03075E-01   MAT140  5.62847E-03   MAT141  1.81222E-01   MAT142  1.88116E-03   MAT176  2.78048E-04
MAT238 -7.00952E-04   MAT239  1.01074E-01   MAT240  5.78113E-03   MAT242  2.00234E-03   MAT335  1.35665E-01   MAT338 -7.38235E-04
TOTAL FOR ZONE IS  6.52942E-01

ZCNE   5
MAT 10  0.0           MAT 11  0.0           MAT 12  0.0           MAT 13  0.0           MAT 14  0.0           MAT 15  0.0
MAT 16  0.0           MAT 28  0.0           MAT 56  0.0           MAT 44  0.0           MAT 88  0.0           MAT135  0.0
MAT138  0.0           MAT139  0.0           MAT140  0.0           MAT141  0.0           MAT142  0.0           MAT176  0.0
MAT238  0.0           MAT239  0.0           MAT240  0.0           MAT242  0.0           MAT335  0.0           MAT338  0.0
TOTAL FOR ZONE IS  0.0

ZONE   6
MAT 10 -1.59691E-03   MAT 12  1.19573E-03   MAT 13 -5.07356E-02   MAT 40 -1.09308E 00   MAT 50 -5.70838E-03   MAT 60 -3.49803E-03
MAT112  2.61395E-03   MAT176  2.16935E-03   MAT224  2.04258E-03   MAT352  1.77697E-03
TOTAL FOR ZONE IS -1.14482E 00

ZONE   7
MAT 10 -9.46257E-03   MAT 12  6.88030E-03   MAT 13 -2.98042E-01   MAT 40 -6.41960E 00   MAT 50 -3.36178E-02   MAT 60 -2.06334E-02
MAT112  1.52636E-02   MAT176  1.26652E-02   MAT224  1.19033E-02   MAT352  1.03600E-02
TOTAL FOR ZONE IS -6.72428E 00

ZONE   8
MAT 10 -4.92238E-03   MAT 12  7.88425E-03   MAT 13 -2.77450E-01   MAT 40 -6.09164E 00   MAT 50 -2.33716E-02   MAT 60 -1.18757E-02
MAT112  1.91570E-02   MAT176  1.48351E-02   MAT224  1.62115E-02   MAT352  1.27421E-02
TOTAL FOR ZONE IS -6.33842E 00

ZONE   9
MAT 10  1.05134E-02   MAT 12  1.34341E-02   MAT 13 -8.38856E-02   MAT 40 -2.87527E 00   MAT 50 -1.24972E-02   MAT 60 -4.10135E-03
MAT112  1.89389E-02   MAT176  2.12670E-02   MAT224  1.65870E-02   MAT352  1.88905E-02
TOTAL FOR ZONE IS -2.87612E 00

TOTAL OVERALL IS  2.61181E 03


(DELTA K)/(K DELTA N) FOR UNIQUE   NUCLIDE NAMES SUMMED OVER ZONES
MAT 10 -2.34027E 00   MAT 11 -1.18080E 00   MAT 12 -2.70654E 00   MAT 13 -1.57062E 01   MAT 14 -1.17034E 00   MAT 15 -4.71538E 01
MAT 16 -2.38126E 00   MAT 28 -1.01880E 00   MAT 56 -2.09012E 00   MAT 44 -1.50415E 00   MAT 88 -2.57822E 00   MAT135  4.05219E 02
MAT138 -2.18017E 01   MAT139  4.95298E 02   MAT140  6.64396E 01   MAT141  7.17774E 02   MAT142  5.02966E 01   MAT176 -1.10644E 00
MAT238 -2.15630E 01   MAT239  4.93682E 02   MAT240  6.83794E 01   MAT242  5.18194E 01   MAT335  4.25719E 02   MAT338 -2.20710E 01
MAT 40 -1.64796E 01   MAT 50 -7.51950E-02   MAT 60 -4.01084E-02   MAT112  5.59734E-02   MAT224  4.67444E-02   MAT352  4.37696E-02

TOTAL OVERALL IS  2.61180E 03


(N DELTA K)/(K DELTA N) FOR UNIQUE   NUCLIDE NAMES FOR ABSORPTION (SIGA) ONLY FOR EACH GROUP

GROUP   1
MAT 10 -2.54449E-04   MAT 11 -8.29272E-04   MAT 12 -8.65070E-03   MAT 13 -7.59140E-05   MAT 14 -2.16435E-04   MAT 15 -2.22372E-04
MAT 16 -2.51512E-03   MAT 28 -1.54243E-04   MAT 56 -4.09810E-06   MAT 44 -7.91472E-06   MAT 88 -2.36448E-08   MAT135 -4.28825E-04
MAT138 -3.36091E-02   MAT139 -1.52515E-02   MAT140 -4.75464E-03   MAT141 -4.92685E-03   MAT142 -1.26344E-03   MAT176  0.0
MAT238 -2.21859E-02   MAT239 -1.42225E-02   MAT240 -4.71857E-03   MAT242 -1.24274E-03   MAT335 -1.46073E-05   MAT338 -1.59672E-03
MAT 40  0.0           MAT 50  0.0           MAT 60  0.0           MAT112  0.0           MAT224 -3.89217E-05   MAT352 -3.97863E-05
TOTAL FOR GROUP IS -1.17224E-01
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GROUP   2
MAT 10 -1.47948E-03   MAT 11 -2.86433E-03   MAT 12 -5.05697E-03   MAT 13 -1.20993E-03   MAT 14 -3.33834E-04   MAT 15 -3.95120E-03
MAT 16 -9.64249E-08   MAT 28 -2.03497E-04   MAT 56 -1.12582E-05   MAT 44 -4.70742E-05   MAT 88 -1.20861E-06   MAT135 -2.47410E-03
MAT138 -6.22619E-02   MAT139 -6.16292E-02   MAT140 -6.21485E-03   MAT141 -2.55793E-02   MAT142 -1.14960E-03   MAT176  0.0
MAT238 -3.58543E-02   MAT239 -5.06927E-02   MAT240 -5.48922E-03   MAT242 -1.00655E-03   MAT335 -1.43321E-04   MAT338 -4.81364E-03
MAT 40  0.0           MAT 50  0.0           MAT 60  0.0           MAT112  0.0           MAT224 -6.06038E-05   MAT352 -1.61372E-04
TOTAL FOR GROUP IS -2.72689E-01

GROUP   3
MAT 10 -2.55519E-03   MAT 11 -1.66141E-03   MAT 12 -5.45177E-03   MAT 13 -1.65463E-03   MAT 14 -4.63353E-04   MAT 15 -4.07984E-03
MAT 16 -8.96263E-08   MAT 28 -2.73106E-04   MAT 56 -1.50597E-05   MAT 44 -2.35467E-05   MAT 88 -3.35530E-07   MAT135 -1.42902E-03
MAT138 -5.74324E-02   MAT139 -2.78477E-02   MAT140 -2.94154E-03   MAT141 -1.28375E-02   MAT142 -6.47643E-04   MAT176  0.0
MAT238 -3.26966E-02   MAT239 -2.23295E-02   MAT240 -2.50500E-03   MAT242 -5.46584E-04   MAT335 -7.13411E-05   MAT338 -3.61586E-03
MAT 40  0.0           MAT 50  0.0           MAT 60  0.0           MAT112  0.0           MAT224 -7.46039E-05   MAT352 -9.28837E-05
TOTAL FOR GROUP IS -1.81246E-01

GROUP   4
MAT 10 -1.05934E-03   MAT 11 -1.78720E-03   MAT 12 -4.62461E-04   MAT 13 -1.17404E-03   MAT 14 -2.01961E-04   MAT 15 -2.66630E-03
MAT 16 -5.21132E-08   MAT 28 -1.06882E-04   MAT 56 -4.57840E-06   MAT 44 -2.53297E-05   MAT 88 -6.60568E-07   MAT135 -7.52682E-04
MAT138 -2.19119E-02   MAT139 -1.63548E-02   MAT140 -2.11621E-03   MAT141 -6.77476E-03   MAT142 -5.62268E-04   MAT176  0.0
MAT238 -1.08627E-02   MAT239 -1.08865E-02   MAT240 -1.49315E-03   MAT242 -3.98903E-04   MAT335 -4.48024E-05   MAT338 -1.12081E-03
MAT 40  0.0           MAT 50  0.0           MAT 60  0.0           MAT112  0.0           MAT224 -5.59779E-05   MAT352 -1.29090E-04
TOTAL FOR GROUP IS -8.09531E-02

TOTAL OVERALL IS -6.52113E-01


(N DELTA K)/(K DELTA N) FOR UNIQUE   NUCLIDE NAMES FOR PRODUCTION (NUSIGF) ONLY FOR EACH GROUP

GROUP   1
MAT 10  0.0           MAT 11  0.0           MAT 12  0.0           MAT 13  0.0           MAT 14  0.0           MAT 15  0.0
MAT 16  0.0           MAT 28  0.0           MAT 56  0.0           MAT 44  0.0           MAT 88  0.0           MAT135  1.06334E-03
MAT138  7.93950E-02   MAT139  4.62582E-02   MAT140  1.36809E-02   MAT141  1.47447E-02   MAT142  3.72518E-03   MAT176  0.0
MAT238  5.27298E-02   MAT239  4.33299E-02   MAT240  1.36377E-02   MAT242  3.68118E-03   MAT335  3.54957E-05   MAT338  3.70832E-03
MAT 40  0.0           MAT 50  0.0           MAT 60  0.0           MAT112  0.0           MAT224  0.0           MAT352  0.0
TOTAL FOR GROUP IS  2.75989E-01

GROUP   2
MAT 10  0.0           MAT 11  0.0           MAT 12  0.0           MAT 13  0.0           MAT 14  0.0           MAT 15  0.0
MAT 16  0.0           MAT 28  0.0           MAT 56  0.0           MAT 44  0.0           MAT 88  0.0           MAT135  5.68895E-03
MAT138  3.42207E-04   MAT139  1.86332E-01   MAT140  1.13401E-02   MAT141  7.73997E-02   MAT142  1.96511E-03   MAT176  0.0
MAT238  2.02975E-04   MAT239  1.51368E-01   MAT240  1.00357E-02   MAT242  1.73034E-03   MAT335  3.57538E-04   MAT338  2.41885E-05
MAT 40  0.0           MAT 50  0.0           MAT 60  0.0           MAT112  0.0           MAT224  0.0           MAT352  0.0
TOTAL FOR GROUP IS  4.46786E-01

GROUP   3
MAT 10  0.0           MAT 11  0.0           MAT 12  0.0           MAT 13  0.0           MAT 14  0.0           MAT 15  0.0
MAT 16  0.0           MAT 28  0.0           MAT 56  0.0           MAT 44  0.0           MAT 88  0.0           MAT135  3.80833E-03
MAT138  1.61571E-05   MAT139  8.02879E-02   MAT140  1.57203E-03   MAT141  4.55567E-02   MAT142  1.57476E-04   MAT176  0.0
MAT238  8.64963E-06   MAT239  5.98166E-02   MAT240  1.24734E-03   MAT242  1.25255E-04   MAT335  3.12901E-04   MAT338  1.56011E-06
MAT 40  0.0           MAT 50  0.0           MAT 60  0.0           MAT112  0.0           MAT224  0.0           MAT352  0.0
TOTAL FOR GROUP IS  1.92911E-01

GROUP   4
MAT 10  0.0           MAT 11  0.0           MAT 12  0.0           MAT 13  0.0           MAT 14  0.0           MAT 15  0.0
MAT 16  0.0           MAT 28  0.0           MAT 56  0.0           MAT 44  0.0           MAT 88  0.0           MAT135  1.78051E-03
MAT138  2.06554E-05   MAT139  3.69322E-02   MAT140  5.05392E-04   MAT141  2.20497E-02   MAT142  0.0           MAT176  0.0
MAT238  8.96827E-06   MAT239  2.24537E-02   MAT240  3.38313E-04   MAT242  0.0           MAT335  2.21354E-04   MAT338  2.42271E-06
MAT 40  0.0           MAT 50  0.0           MAT 60  0.0           MAT112  0.0           MAT224  0.0           MAT352  0.0
TOTAL FOR GROUP IS  8.43130E-02

TOTAL OVERALL IS  9.99999E-01
```

III. PROBLEM DEFINITION

This section presents the perturbation and related equations. The equations and discussion are oriented toward the routine user, not the theorist. Some detail has been omitted since it would seem to cause confusion rather than convey useful information.

A. Discussion

The equations used to estimate the effect of small changes are discussed here. First order perturbation theory is applied which is precise only in the limit of zero change[a]. The adjoint flux is used which requires solution of this special problem. The fact that finite-difference equations must be dealt with rather than a continuum introduces complexity.

The following discussion contains an introduction cast in simple terms. This is intended to help the reader who desires to understand the subject from a practical standpoint. Then the actual equations used in the code are presented. A theoretical analysis has been presented[6].

Consider a neutron balance associated with the finite-difference volume about a mesh point for a one-energy-group, one-dimensional slab geometry problem. With usual terminology,

Source = Removal + Leakage, or

$$\frac{1}{k}\,\nu\Sigma_{f,i}V_i\phi_i = \Sigma_i V_i \phi_i + D_i A_i \left[\left(\frac{\phi_i-\phi_{i-1}}{\Delta_{i/2}}\right) + \left(\frac{\phi_i-\phi_{i+1}}{\Delta_{i+1/2}}\right)\right] , \tag{1}$$

where i refers to a location, ϕ the regular flux, V refers to volume, A to the leakage surface, and Δ to mesh spacing.

A change in the nuclear properties would change the flux distribution and also the multiplication factor. Let us neglect the change in flux and consider the partial derivative of terms of Eq. (1) with respect to

---

[a]Here it is assumed that the regular and adjoint fluxes are for the same reference state. They may be for different states, if desired. In the special situation where the regular flux for one state and the adjoint flux for the other state are used, the so-called "exact" perturbation is treated. This situation is usually considered only when a small change causes the direct Δk to lack significance, or to generate its components.

Σ_i. This operation gives

$$\nu \Sigma_{f,i} V_i \phi_i \frac{\partial(\frac{1}{k})}{\partial \Sigma_i} = V_i \phi_i .$$

Considering change in Σ_i only at certain points within some material m and summing equations gives

$$\frac{\partial(\frac{1}{k})}{\partial \Sigma_m} \sum_i \nu \Sigma_{f,i} V_i \phi_i = \sum_{i \varepsilon m} V_i \phi_i .$$

Since $\partial(\frac{1}{k}) = -\frac{1}{k^2} \partial k$,

$$\frac{1}{k} \frac{\partial k}{\partial \Sigma_m} = \frac{-\sum_{i \varepsilon m} V_i \phi_i}{\frac{1}{k} \sum_i \nu \Sigma_{f,i} V_i \phi_i} .$$

If we simply accept that Eq. (1) may be multiplied through by a weighting factor, namely the adjoint flux, ϕ_i^*, which will cause both $\phi_i \phi_i^*$ and the flux slope in the leakage terms to be invariant, increasing the accuracy, then the result becomes

$$\frac{1}{k} \frac{\partial k}{\partial \Sigma_m} = \frac{-\sum_{i \varepsilon m} V_i \phi_i \phi_i^*}{\frac{1}{k} \sum_i \nu \Sigma_{f,i} V_i \phi_i \phi_i^*} . \tag{2}$$

This expresses the change in the multiplication factor associated with a unit change in the cross section. Similarly for uniform spacing

$$\frac{1}{k} \frac{\partial k}{\partial D_m} = \frac{-\sum_{i \varepsilon m} \frac{2A_i}{\Delta_i} \left[(\phi_i - \phi_{i-1}) + (\phi_i - \phi_{i+1})\right] \phi_i^*}{\frac{1}{k} \sum_i \nu \Sigma_{f,i} V_i \phi_i \phi_i^*} . \tag{3}$$

Also,

$$\frac{1}{k}\frac{\partial k}{\partial(\nu\,\Sigma_{f,m})} = \frac{\sum\limits_{i\varepsilon m} V_i\,\phi_i\,\phi_i^*}{\sum\limits_{i} \nu\,\Sigma_{f,i}\,V_i\,\phi_i\,\phi_i^*}\,, \tag{4}$$

where the region of interest m must be for $\nu\,\Sigma_{f,i} \neq 0$. Complications associated with material interfaces have been avoided here, and the equations must be extended to consider more than one group and other dimensions, and to treat the trans-group scattering.

<u>The Perturbation Derivatives (Regular, Adjoint Flux Integrals)</u>

Within region m, the change in multiplication factor relative to change in a macroscopic property is calculated as

$$\frac{\partial k}{k\partial X_{m,n}} = \frac{\sum\limits_{i\varepsilon m} G_i(n)}{\frac{1}{k}\sum\limits_{i} V_i \sum\limits_{g} \chi(m,g)\,\phi_{i,g}^* \sum\limits_{n} \nu\,\Sigma_{f,n}\,\phi_{i,n}}\,, \tag{5}$$

where $X_{m,n}$ refers to a macroscopic property in region m, i refers to a space point in geometric space and g and n to energy groups. G_i is defined below. It is assumed in this discussion that $\sum\limits_{g} \chi(m,g) = 1$.

$$\underline{\mathbf{X} = \Sigma_a(n),\ \Sigma_r(n) = \sum_g \Sigma(n\to g),\ \text{or}\ D(n)B^2(n)} \tag{6}$$

$$G_i(n) = -V_i\ \phi_{i,n}\,\phi_{i,n}^*$$

$$\underline{\mathbf{X} = \Sigma(g\to n)} \tag{7}$$

$$G_i(n) = V_i\,\phi_{i,g}\,\phi_{i,n}^*$$

$\underline{\mathbf{X} = D(n)}$

$$G_i(n) = \sum_j A_j \begin{cases} \left[\dfrac{1}{\Delta_i + \Delta_j}\right] \phi^*_{i,n} \left[\phi_{i,n} - \phi_{j,n}\right], \text{ internal}, \\[2ex] \dfrac{1}{\Delta_i} \left[\dfrac{1}{1 + \dfrac{\Delta_j\ D_i(n)}{\Delta_i\ D_j(n)}}\right]^2 \left[\phi^*_{i,n} - \phi^*_{j,n}\right]\left[\phi_{i,n} - \phi_{j,n}\right], \text{ at} \\[2ex] \text{material interfaces, or} \\[2ex] \dfrac{1}{\Delta_i}\left[\dfrac{1}{1 + \dfrac{D_i(n)}{\Delta_i C_s(n)}}\right] \phi^*_{i,n}\ \phi_{i,n}, \text{ adjacent to} \\[2ex] \text{any black boundary.} \end{cases} \tag{8}$$

Here j refers to each of the nearest neighboring mesh points, A_j is the normal leakage area, and Δ_i is the distance from a point to the appropriate interface between mesh points. $C_s(n)$ is the internal or external black boundary constant. At reflecting boundaries there is zero contribution.

$\underline{\mathbf{X} = \nu\ \Sigma_f(n)}$ (9)

$$G_i(n) = \frac{V_i}{k}\ \phi_{i,n} \sum_g \chi(m,g)\ \phi^*_{i,g}\ .$$

Given regular and adjoint flux solutions, the derivatives of k with respect to each macroscopic (zone) cross section are calculated and edited, Eqs. (6) through (9) above. The basic zone integrals are written on an interface data file for further use.

We should note here that the integrals are made for the conditions selected by the user. For reliable results, there must be consistency regarding the geometric description, the nuclide densities, the cross

sections and their referencing, and the regular and adjoint flux data. These flux values do not have to be for the same situation--one may be for the perturbed state, or an approximation to it. The flexibility of this code is useful, but it also places a burden on the user to insure consistency.

Note that only P_0 scattering has been considered; the $\nabla \cdot J$ term and P_1 data are ignored even if treated in the neutronics code.

C. Macroscopic Information

To produce additional information at the macroscopic cross section level, the effects of proportional changes in the cross sections are calculated. Consider

$$\Delta k = \sum \frac{\partial k}{\partial \Sigma} (f\Sigma) = f \sum \frac{\partial k}{\partial \Sigma} (\Sigma) \tag{10}$$

where f represents a fractional change, set to unity for the calculations (100% change). The contributions to Δk are determined for neutron production, absorption, scattering and transport and the total for the common value of f unity. These results are edited by option to reflect energy, zone dependence, summed over zones to yield energy dependence, summed over energy to yield zone dependence, and totals are generated.

Additional information is produced to indicate the effect of uncertainties at the macroscopic cross section level. Consider that in an uncertainty sense,

$$\delta k = \left\{ \sum \left[\frac{\partial k}{\partial \Sigma} (f\Sigma) \right]^2 \right\}^{\frac{1}{2}} = f \left\{ \sum \left[\frac{\partial k}{\partial \Sigma} (\Sigma) \right]^2 \right\}^{\frac{1}{2}} , \tag{11}$$

and again f is set at unity. The results are obtained for individual contributions, summed over zones, energy, zones and energy, and individual components added. In this calculation, transfer from one group to all other groups is treated as an entity (loss and source), correlated rather than independent group to group scattering.

D. Prompt Neutron Lifetime

For the estimate of the prompt neutron lifetime, the weighting is of reciprocal neutron velocity,

$$\ell = \frac{\sum_n \sum_i \frac{V_i}{v(n)} \phi^*_{i,n} \phi_{i,n}}{\frac{1}{k} \sum_i V_i \sum_g \chi(m,g) \phi^*_{i,g} \sum_n \nu \Sigma_{f,n} \phi_{i,n}} , \tag{12}$$

accurate only for the near critical state for which the regular and adjoint flux values are supplied.

E. Importance Maps

Importance maps over space may be obtained. "Importance" is used here to mean the contribution to the multiplication factor per unit volume from some factor, for example

$$I_{\Sigma_a}(i) = \sum_n \frac{\Sigma_a(n)}{k} \frac{\partial k}{\partial \Sigma_a(n)} , \tag{13}$$

where i represents a mesh point location. Importance maps may be obtained for $\nu\Sigma_f$, Σ_a and $\nu\Sigma_f - \Sigma_a$.

F. Reactivity Coefficient

We note that a temperature or power coefficient of reactivity may be calculated directly from the partial derivatives discussed above using additional data,

$$\Delta k = \sum_\ell \left[\frac{\partial k}{\partial X_\ell}\right] \Delta X_\ell , \tag{14}$$

where X_ℓ refers to each contributing macroscopic property including cross sections and diffusion constants. To consider the general situation, discrete changes would have to be considered. Thus resonance calculations may be done at two temperatures representing some desired change, and the

generated microscopic data used in the form:

$$\frac{\Delta k}{k} = \sum_{\ell} \frac{\partial k}{k \partial X_{\ell}} \left[X_{\ell}(P_2) - X_{\ell}(P_1) \right] , \tag{15}$$

where $X_{\ell}(P_1)$ refers to a macroscopic cross section determined from initial nuclide densities and the originally specified microscopic cross sections; $X_{\ell}(P_2)$ refers to the altered value due to specified changes in nuclide densities and new microscopic data.

G. Nuclide Density Change and Importance

It is of interest to examine the equations for reactivity change associated with unit nuclide density change. These equations may often be simply applied over narrow ranges of the variables.

Once the effects from unit changes in macroscopic cross sections have been determined, the effects of nuclide density changes may be obtained. Adding contributions gives

$$\frac{\partial k}{\partial N_{b,m}} = \left[\sum_{j} \frac{\partial k}{\partial \Sigma_{j,m}} \frac{d\,\Sigma_{j,m}}{d\,N_{b,m}} \right] + \frac{\partial k}{\partial D_m} \frac{d\,D_m}{d\,N_{b,m}} + \frac{\partial k}{\partial (\nu\,\Sigma_{f,m})} \frac{d(\nu\,\Sigma_{f,m})}{dN_{b,m}} , \tag{16}$$

where $N_{b,m}$ is the density of a nuclide in region m and index j is over appropriate cross sections including group to group scattering. Since

$$\Sigma_{j,m} = \sum_{b} N_{b,m}\,\sigma_{j,b,m} , \quad \frac{d\,\Sigma_{j,m}}{d\,N_{b,m}} = \sigma_{j,b,m} ;$$

$$D_m = \frac{1}{\sum_{b} 3\,N_{b,m}\,\sigma_{tr,b,m}} , \quad \frac{d\,D_m}{d\,N_{b,m}} = -\,3D_m^2\,\sigma_{tr,b,m} ;$$

$$\nu\,\Sigma_{f,m} = \sum_{b} N_{b,m}\,\nu\,\sigma_{f,b,m}, \quad \frac{d\,(\nu\,\Sigma_{f,m})}{d\,N_{b,m}} = \nu\,\sigma_{f,b,m} ;$$

$$\frac{\partial k}{k\partial N_{b,m}} = \left[\sum_j \left(\frac{\partial k}{k\partial \Sigma_{j,m}}\right)\sigma_{j,b,m}\right] + \left(\frac{\partial k}{k\partial D_m}\right)\left(-3\, D_m^2\, \sigma_{tr,b,m}\right) \tag{17}$$

$$+ \left[\frac{\partial k}{k\partial(\nu\, \Sigma_{f,m})}\right] \nu\, \sigma_{f,b,m} \quad .$$

The estimate of the effect of an actual change, decreasing in accuracy as the amount of change increases, is then

$$\left.\frac{\Delta k}{k}\right|_{b,m} \simeq \Delta N_{b,m} \quad \frac{\partial k}{k\partial N_{b,m}} \quad . \tag{18}$$

Equations (17) and (18) may be applied to a single zone given the $\partial k/\partial \Sigma$ data by summing all of the contributions.

Importance data for individual nuclides may be obtained in edit, integrals over all reactions and groups by zone, and over zones by group. The calculations start with the group dependent data

$$\left.\frac{\partial k}{k\partial N_{b,m}}\right]_n = \sum_{j\varepsilon n}\left[\frac{\partial k}{k\partial \Sigma_{j,m,n}}\right] \sigma_{j,b,m,n} \quad , \tag{19}$$

where a symbolic form is used to indicate all reactions are considered and the group dependence retained (see Eq. (17) for details). For out-scattering, the contribution of the source at the scattered into group is included, leaving a net scattering contribution in the group where the removal occurs.

Edit may be obtained of the data

$$\frac{\partial k}{k\partial N_{b,m}} = \sum_n \left.\frac{\partial k}{k\partial N_{b,m}}\right]_n \quad , \tag{20}$$

and of the importance

$$I_{b,m} = N_{b,m} \frac{\partial k}{k\partial N_{b,m}} \quad , \tag{21}$$

and

$$I_b = \sum_m I_{b,m} \quad . \tag{22}$$

Also, the importance by energy group may be obtained,

$$I_{b,g} = \sum_{m} N_{b,m} \left[\frac{\partial k}{k \partial N_{b,m}} \right]_{n} \quad . \tag{23}$$

The above results are reported by absolute nuclide name, summed over zone and subzone contributions. Default is to unique nuclide name lacking absolute labels. The implemented option does not admit selecting only one or a few nuclides, but all nuclides, or only the actinides may be treated given nuclide classifications.

H. The Effect of Perturbation

After the perturbation integrals have been obtained, change in k relative to change in macroscopic cross section, effect of perturbation to a new state can be calculated. The equation applied in a symbolic form with m indexed over zones and groups is

$$\frac{\Delta k}{k} \simeq \sum_{m,j} \left[\Sigma_{j,m}(b) - \Sigma_{j,m}(a) \right] \frac{\partial k}{k \Sigma_{j,m}} \quad , \tag{24}$$

where the last term is the derivative, Eqs. (5) through (9), and the difference in macroscopic cross sections is used, those for the perturbed state (b) and the reference, unperturbed state (a).

The calculation of macroscopic cross sections is documented in reference 2. We note that there are both zone and subzone contributions. At each state, the macroscopic cross sections depend on

1) the zone and subzone nuclide densities
2) the microscopic cross sections, and
3) the nuclide, cross section referencing.

(In addition, zone fractions and subzone volumes are involved.)

In this code, the data is selected for the reference state, for the calculation of the perturbation integrals, and for the perturbed state. The perturbed state may involve any combination of the above three changes. Only nuclide concentrations may be changed, or only the microscopic cross

sections, or only the referencing (to change the cross section data within a single data file). All three may be changed. Perhaps the major challenge to the user in effecting consistency is the use of a change in the nuclide, cross section referencing; this should be done carefully or not at all. The use of two cross section files (which are ordered the same way) is recommended which avoids a change in the referencing.

A single perturbation may be made with one access of the code. Additional results may be obtained with multiple accesses; but usually some changes are required to the data in the interface files. However, if acceptable, the perturbation integrals may be saved (in an interface file) and reused, eliminating the bulk of the calculation for all but the first case.

Temperature distributions may be supplied. A linear interpolation is made between the two states. Consider that microscopic cross section data is given for two reference temperatures, T_1 and T_2. Then the macroscopic cross sections at the two temperatures in a zone are given by

$$\Sigma(1) = \sum_b N_b(1)\ \sigma_b(1) \quad , \tag{25}$$

$$\Sigma(2) = \sum_b N_b(2)\ \sigma_b(2) \quad .$$

At some other temperature, T_a, we assume that

$$\Sigma(a) = \Sigma(1) + \left[\frac{T_a - T_1}{T_2 - T_1}\right] \left[\Sigma(2) - \Sigma(1)\right] \quad . \tag{26}$$

This leads to the estimate of the change in macroscopic cross sections from reference state (a) to perturbed state (b) of

$$\Sigma(b) - \Sigma(a) = \left[\frac{T_b - T_a}{T_2 - T_1}\right] \left[\Sigma(2) - \Sigma(1)\right] \quad . \tag{27}$$

It is recognized that the change in cross section with change in temperature decreases as the temperature increases. An arctangent fit is allowed with the parameter α input,

$$\Sigma(a) = \Sigma(1) + \frac{\tan^{-1}\left[\dfrac{\alpha(T_a - T_1)}{T_2 - T_1}\right]}{\tan^{-1}(\alpha)} \left[\Sigma(2) - \Sigma(1)\right] \quad . \tag{28}$$

Thus changes in macroscopic cross sections are accounted for over the zones given the temperature distributions by zone. Note that the procedure involves application of Eq. (25) which also admits change in the nuclide densities. Thus the procedure is quite general, only limited by the linear approximation and the usual restraint on first order perturbation theory.

There may be limitations in practical application when there is a strong temperature dependence. A simple scheme is not available for accounting for the temperature variation in the neutronics problems when the flux solutions are obtained. Also, there is no provision for temperature variation within a zone over the various materials in the fine detail or cell sense. Still it should be possible to generate quite useful results, as of the power coefficient of reactivity.

I. Validation

Considerable effort went into the programming in this code to produce overall neutron balance estimates of the multiplication factor for the reference conditions and the regular and the adjoint flux values supplied. These values are edited along with the values in the flux files. This information is generated as a verification step in application. The user is urged to carefully consider this edit. Given a common reference condition of geometric description, nuclide densities, referencing, etc., the calculated multiplication factors should be the same as those obtained from the files. Given small changes of reference conditions, these numbers should reflect the small change. A large difference indicates an inconsistency and results will not likely be reliable.

A check may be made of a first order perturbation result by comparing it to the direct change obtained by solving a reference problem and a perturbed problem, $\Delta k=k_p-k_r$. Information is available from the sample problem described previously. For the reference problem (rod in), $k_r=0.999591$, and for the perturbed adjoint problem (rod out), $k_p=1.022658$. Using $\bar{k}=\frac{1}{2}(k_p+k_r)$, $\Delta k/\bar{k}=0.022813$ direct. This value compares favorably with the value of 0.022579 from the first order perturbation calculation. (Using first order perturbation theory and regular and adjoint flux values

for the reference state, the rod worth is estimated at only about half this amount.)

IV. PROGRAMMING INFORMATION

This section presents information of primary use to the individual implementing this code. Information is given about the subroutines, program overlay, and local adaptation.

A. Source Program

Most of the programming in this code is FORTRAN language. However, some service routines are in machine dependent IBM ASSEMBLER language. Figure 6 lists the names of the subroutines and their use. The source program consists of 90 routines totaling nearly 18,000 cards.

B. Program Implementation

This code is not a stand-alone code and must be implemented in a modular environment under compatible rules.

The data used in this code is variably dimensioned and therefore the core storage requirements are a function of the problem to be solved. On the IBM-360 model computers, the program plus system routines require approximately 36,000 words of core storage when the code is loaded with the recommended overlay structure shown in Figure 7. The core storage for data is supplied by the user at run time. Depending upon the amount of storage available for data, the code chooses one of three modes of data storage. Information about disk storage requirements is included in the printout of each run.

C. Conversion to Other Computers

On an IBM machine, much of the calculation is done in double precision and certain data carried as long words. On long-word machines, this data should be carried as regular length and the associated double precision operations changed to single precision. This change is essential to minimize storage requirements. Alphanumeric characters are carried in the guise of real numbers (Hollerith) as A(6) requiring long-word storage on an IBM machine.

FIGURE 6. SUBROUTINES AND THEIR USE.

```
C     UBIV = 02 - GETS CORE STORAGE, STARTS CALCULATION, FREES CORE.
C     UIFF = 03 - CONTROLS CALCULATION.
C     NBOD = 04 - DETERMINES IF A ZONE IS BLACK.
C     UENT = 05 - GETS CONTRCL INFORMATION FROM INTERFACES, SETS FLAGS.
C     UCNO = 06 - SETS UP SCRATCH LOGICAL I/O UNITS.
C     UORE = 07 - DETERMINES CORE STORAGE REQUIREMENTS.
C     UCBI = 08 - GETS SPECS FROM INTERFACE FILES.
C     UNAM = 09 - GEOMETRY CHECK.
C     UCBD = 10 - EDIT.
C     UORB = 11 - CHECKS BOUNDARY INDICATORS.
C     UDSP = 12 - EDITS DISK SPACE REQUIREMENTS.
C     UASU = 13 - CONTROLS OPENING RANDOM ACCESS FILES.
C     UPRT = 14 - DETERMINES CORE STORAGE REQUIREMENTS FOR PERT. CALC.
C     MCON = 15 - CONTROLS PERTUBATION MACRO CALCULATIONS.
C     NCON = 16 - CONTROLS PERT. CALC. ON MICROSCOPIC LEVEL.
C     UAC1 = 17 - CONTROLS MACROSCOPIC CROSS SECTION CALCULATION.
C     UAC2 = 18 - CALCULATES PRINCIPAL MACROSCOPIC CROSS SECTIONS.
C     UAC3 = 19 - CALCULATES SCATTERING MACROSCOPIC CROSS SECTIONS.
C     UAC5 = 20 - CORRECTS MACROS. FOR P1.
C     UAC6 = 21 - EDITS MACROSCOPIC CROSS SECTIONS.
C     UACA = 22 - MACRO. UTILITY ROUTINE.
C     UACB = 23 - ERROR CHECK ROUTINE.
C     UCAL = 24 - LOCATE SCATTERING RECORD IN GRUPXS DATA.
C     IONS = 25 - GET UNIT NUMBERS OF PROPER INTERFACE FILE VERSIONS.
C     UCN1 = 26 - CONTROL EQUATION CONSTANTS CALCULATION.
C     USH0 = 27 - COARSE MESH SETUP.
C     URCF = 28 - COARSE TO FINE MESH.
C     USH1 = 29 - GET FINE MESH DISTANCES.
C     UCN2 = 30 - SET UP DATA FROM GEODST FILE.
C     UON3 = 31 - CALCULATES DIFFUSION CONSTANTS AND TOTAL REMOVAL.
C     UKCT = 32 - DIFFUSION CONSTANT INDEXING.
C     UON4 = 33 - CALCULATES LEAKAGE CONSTANTS.
C     UCN5 = 34 - CALCULATES LEAKAGE CONSTANTS, TRIANGULAR GEOMETRY.
C     UON7 = 35 - CALCULATES LEAKAGE CONSTANTS, HEX GEOMETRY.
C     UCN9 = 36 - CALCULATES ZONE VOLUMES.
C     BNDY = 37 - CONSTANTS CALCULATION UTILITY ROUTINE.
C     USH3 = 38 - EDITS MESH SPACING.
C     WDFL = 39 - WRITES DELTA-SIGMA FILES.
C     WEFL = 40 - WRITES DELTA-SIGMA FILES.
C     URLX = 41 - CONTROLS WRITING MACRO FILE.
C     UCN6 = 42 - WRITES MACRO FILE.
C     UJNT = 43 - CONTROLS REORDER MACRO SCATTERING FOR MACRO PERT CALC.
C     SCAT = 44 - REORDERS MACRO SCATTERING.
C     OSIG = 45 - REORDERS OTHER MACRO CROSS SECTIONS.
C     UEV1 = 46 - REORDER UTILITY ROUTINE.
C     VAC1 = 47 - CONTROLS SIGMA CALC FOR PERT ON MICRO LEVEL.
C     GNEQ = 47.5 - GET MAX NUMBER OF ABSOLUTE NUCLIDES OVER ZONES.
C     VAC2 = 48 - SUM PRINCIPAL MACROS WITH SAME ABSOLUTE NAME.
C     VAC3 = 49 - SUM SCATTERING MACROS WITH SAME ABSOLUTE NAME.
C     VACA = 50 - UTILITY ROUTINE.
C     VACL = 51 - UTILITY ROUTINE.
```

(CONT)

```
C     DKOM = 52 - CONTROLS PERT CALCULATION ON MICROSCOPIC LEVEL.
C     WNEK = 52.5 - GET ZONE CLASSIFICATION.
C     DKDN = 53 - CALC PERTURBATIONS BY ZONE ADN REACTION TYPE.
C     TEMP = 54 - EDITS RESULTS BY REACTION TYPE.
C     TANS = 55 - EDITS RESULTS BY ZONE AND NUCLIDE.
C     TENS = 55.5 - EDITS RESULTS BY ZONE CLASS AND NUCLIDE.
C     UNEK = 56 - GETS UNIQUE ABSOLUTE NUCLIDE NAMES.
C     KANS = 57 - EDITS RESULTS BY GROUP AND NUCLIDE.
C     KENS = 57.5 - EDITS RESULTS BY GROUP AND NUCLIDE OVER ZONE CLASS.
C     PERO = 58 - EDITS MACRO PERTURBATION RESULTS.
C     RTUB = 59 - WRITES INTERFACE FILE PERTUB.
C     MRPT = 60 - CALC AND EDIT RESULTS FOR 100 PERCENT CHANGE (MACROS).
C     QCUT = 61 - EDITS IMPORTANCE MAPS.
C     BBB1 = 62 - UTILITY ROUTINE.
C     BEB2 = 63 - UTILITY ROUTINE.
C     PERT = 64 - CONTROLS MACRO PERTUREATION CALCULATIONS.
C     TUFY = 65 - CALCULATES RESULTS DUE TO CHANGES IN DIFFUSION COEF.
C     LIFE = 66 - CALCULATES RESULTS DUE TO CHANGES IN MACROS.
C     DAFA = 67 - PROCESS RTFLUX, ATFLUX TO WRITE RANDOM ACCESS FILES.
C     MAPS = 68 - CALCULATES POINT IMPORTANCE MAPS.
C     PMAP = 69 - UTILITY ROUTINE.
C     JERT = 70 - SAME AS PERT BUT FOR ONE ROW STORED MODE.
C     JUFY = 71 - SAME AS TUFY BUT FOR ONE ROW STORED MODE.
C     JIFE = 72 - SAME AS LIFE BUT FOR ONE ROW STORED MODE.
C     JAFA = 73 - SAME AS DAFA BUT FOR ONE ROW STORED MODE.
C     JAPS = 74 - SAME AS MAPS BUT FOR ONE ROW STORED MODE.
C     JMAP = 75 - SAME AS PMAP BUT FOR ONE ROW STORED MODE.
C     JGET = 76 - UTILITY ROUTINE.
C     INLK = 77 - CALCULATES IN-LEAKAGE FOR KEFFECTIVE.
C     KEFF = 78 - CALCULATES KEFFECTIVE FROM RTFLUX.
C     KEFA = 79 - CALCULATES KEFFECTIVE FROM ATFLUX.
C     DKOK = 80 - CONTROLS PERT CALCULATIONS DUE TO DELTA-MACROS.
C     DLK1 = 81 - CALCULATES AND EDITS RESULTS DUE TO DELTA-MACROS.
C     RITE = XX - I/O ROUTINE.
C     CRIT = XX - IN-CORE TRANSFER ROUTINE.
C     DCPC = XX - I/O CONTROLER.
C     SEEK = XX - SETS UP LOGICAL INTERFACE UNIT NUMBERS.
C     FERR = XX - ERROR STOPER.
C     SKER = XX - ERROR STOPER.
C     STOR = XX - UTILITY.
C     TIMER = XX - GETS TIME DATE, ETC.
C     FEASM = XX - LOCAL I/O METHOD CONTROLER.
C     KBLCK = XX - ASSEMBLY - I/O UTILITY.
C     DEFILE = XX - ASSEMBLY - OPENS RANDOM ACCESS FILES.
C     CLOSDA = XX - ASSEMBLY - CLOSES RANDOM ACCESS FILES.
C     ITTIME = XX - ASSEMBLY - GETS ELAPSED CLOCK TIME.
C     GETCOR = XX - ASSEMBLY - GETS MAIN STORAGE.
C     FRECOR = XX - ASSEMBLY - FREES MAIN STORAGE.
C     KWRITE = XX - ASSEMBLY - I/O UTILITY.
C     KIOERR = XX - ASSEMBLY - I/O UTILITY.
```

FIGURE 7. THE RECOMMENDED OVERLAY STRUCTURE.

```
OVERLAY LEVELD
INSERT UENT,UONO,UORE,UORI,UNAM,UORD,UORB,UDSP,UASU,UPRT
OVERLAY LEVELD
INSERT GETCOR,FRECOR
OVERLAY LEVELD
INSERT MCON,NCON
OVERLAY LEVELE
INSERT UAC1,UAC2,UAC3,UAC5,UAC6,UACA,UACB,UCAL,IONS
OVERLAY LEVELE
INSERT UON1,USH0,URCF,USH1,UON2,UON3,UKCT,UON4,UON5,UON7,UON9,BNDY
INSERT USH3,WDFL,WEFL
OVERLAY LEVELE
INSERT URLX,UCN6,UJNT,SCAT,OSIG,UEV1
OVERLAY LEVELE
INSERT VAC1,GNEQ,VAC2,VAC3,VACA,VCAL,DKOM,WNEK,DKDN,TEMP,TANS,TENS
INSERT UNEK,KANS,KENS
OVERLAY LEVELD
INSERT PERO,RTUB,MRPT,QOUT,BBB1,BBB2
OVERLAY LEVELE
INSERT PERT,TUFY,LIFE,DAFA,MAPS,PMAP
OVERLAY LEVELE
INSERT JERT,JUFY,JIFE,JAFA,JAPS,JMAP,JGET,INLK,KEFF,KEFA
OVERLAY LEVELD
INSERT DKOK,DLK1
```

As a convenience for conversion, a multiplier is carried through the routines, MULT or NDP or LX(39), which must be 2 for an IBM machine and 1 for long-word machines. This multiplier adjusts the lengths of words for short-word storage and manipulations avoiding extensive reprogramming upon conversion.

The following basic changes are required for use on a long-word machine:

1. Remove all REAL*8 statements.
2. Supply single precision library functions, e.g., SQRT and EXP instead of DSQRT and DEXP.
3. Change all references to "Double Precision," as in function definition statements.
4. Change LX(39) to 1 from 2.
5. Change the apostrophes which delimit alphanumeric strings in FORMAT and DATA statements.
6. Replace the subroutine TIMER to provide information from the local system,

   ICLOCK -- gives cpu time
   ITTIME -- gives clock time
   MODEL -- gives computer model
   IDAY -- gives alphanumeric: Month-Day-Year
   JSTIME -- gives cpu time remaining
   JOBNUM -- gives alphanumeric: Job number
   IOLEFT -- gives the number of I/O's remaining
   TIME -- gives alphanumeric: time of day
7. Satisfy the data access, transfer requirements including the dynamic opening of the files with parameters which are problem dependent and defaulting the files to be resident by replacing the data handling service routines.
8. Provide local capability to allocate memory at run time, or fix the allocations for container arrays and communication.
9. Provide the necessary overlay structure.

10. The assembly language routines can only be used on compatible IBM machines (otherwise use the Fortran source decks).
11. Correct any discrepancies missed by the IBM compiler (and please report this information back to us).

Local system routines would be needed to satisfy items 6, 7, and 8, unless those supplied are compatible.

The code is used locally as a module of a computation system. Effecting stand alone capability should not be hard using those modules needed including input data processing capability. It should be most attractive to implement an equivalent modular system, either one-to-one with that in use at ORNL, or adapt the modules into another system.

In converting this code, consideration should be given to data storage and transfer requirements. If large problems are to be solved, even a large extended core cannot contain a set of the flux values, so they should be carried on disc.

D. Limitations

Certain features of the standard interface data file specifications imply capability which is not available. Only the geometry options implemented in the VENTURE code are available. Quite generally, it has been assumed that the data is simply blocked in the files. No provision has been made to account for partially filled records, for example.

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