New Functions of the GRUCON Processing Code Package, version 2020.

A some new functions of the GRUCON code package become available for user. Here is a brief description of some functional modules, developed or revised in the 2020 year.

1. The UXEXP Processing Module

An new module for preparing the probability tables (P) from average resonance parameters (U) in the unresolved resonance range, the UXEXP one, is developed and added to the GRUCON package. The calculation method is based on generation resonance sequencies, or ladders, from average resonance parameters and coresponding distribution lows. In general, it repeat function of the PURR module of NJOY processsing code, preparing probability tables from point-wise cross sections reconstructed from resonance ladders in the P standard data structure. Together with PXDXF module, the set of cross section moments, needed for slef-shielded factors can be prepared in the unresolved resonance range.

The Figures 1,2 show comparison of self-shielding factors prepared through different calculation chains.

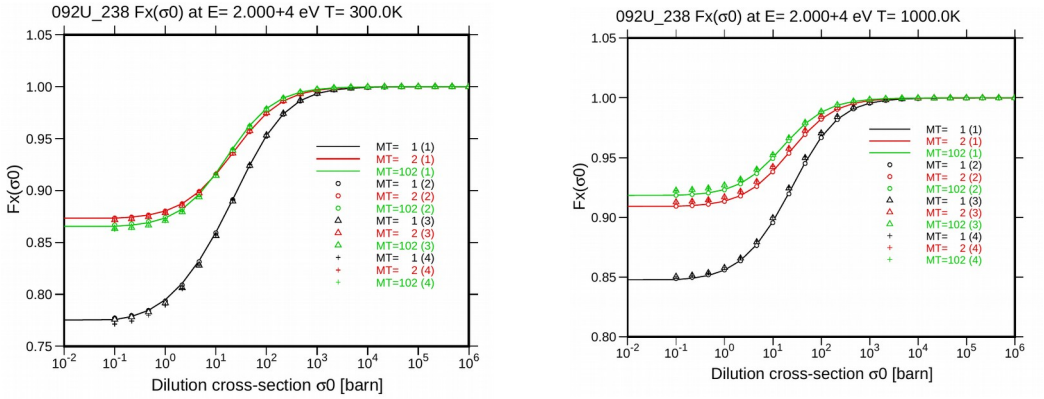

Fig 1 U-238 self-shielding factors for T=300K (left) and T=1000K (right) as a functions of dilution cross section, at energy point E=20.0 keV

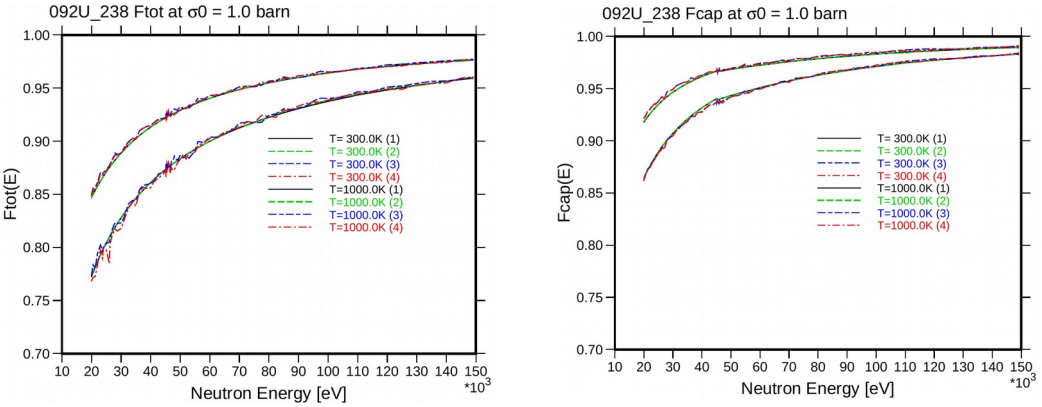

Fig 2 U-238 self-shielding factors for total (left) and radiative capture (right) cross sections at dilution σ0 = 1 barn, as functions of neutron energy.

Calculation chains for shielded cross sections computions int the unresolved resonance range:

(1) UXDXF/FXCXF (direct computing of the cross section moments)

(2) UXDXF/FXCXF/FXEXP/PXDXF (moments, prepared from subgroup parameters)

(3) UXEXP/PXDXF (moments, prepared from probability tables)

(4) PURR (moments, prepared by PURR module of NJOY)

2. The SXAEXFM, SXGXF, FXGXF, SXEXP Processing Module

The list of tabulated weight functions, used in the **SXAEXFM, SXGXF, FXGXF, SXEXP** modules, is increased to include eight typical neutron spectra:

10 epri-cell light water reactor,
11 thermal+1/e+fission+fusion,
12 similar to 11, temperature dependent,
13 thermal+1/e+fast reactor +fusion,
14 claw,
15 claw, temperature dependent,
16 vitamin-e,
17 vitamin-e, temperature dependent.

The functions of SXAEXFM module are extended to prepare, in addition to group transition and particle production matrices in neutron reactions, the cross section moments needed for preparing of self-shilding factors. Resonance structure data, needed for group averaging cross sections in the unresolved resonance range, allowed now two types of representations: by cross-section moments (F), and, optionally, by subgroup parameters/ probability (P), to simplify calculation chain.

An option of preparing weight function by solving slow-down equiation is included to the SXAEXFM module, allowing to take into account self-shielding effect not only for narrow resonances, but for intemediate and broad resonances, also.

3. The BNAB Output Module

The list of the BNAB tables, prepared by corresponing output module, is completed by other types of group and multigroup neutron data, not included to the previos versions of the package. Now it allows output file with tables:

1/301 - the main neutron group /multigroup cross section sets,
2/502 - inelastic group/multigroup transition probability matrices,
3/303 - anlular momenta of elastic group/multigroup transition matrices,
4/304 - group/multigroup resonance self-shielding factors and doppler increments,
15/315 - group/multigroup delayed neutron spectra,
18/518 - total and prompt fission group/multigroup spectra,
19/519 - delayed neutron group/multigroup parameters,
701 - detailed cross sections.

4. The CCCC Output Module

A new module for group data ontput in the CCCC-IV extended format CCCC-KIT (see Appendix), developed in Karlsruhe Institute of Technology for savety applications and used by C4P processing system [1,2]. The extended ISOTXS file differs from the ISOTXS-IV standard in following:

(a) the atomic weight AMASS is presented in units C12;

(b) the position of self-scatter position is permitted to take the values < 1, to remove zero values in scatter matrices;

(c) the temperature dependent thermal upscatter data for higher temperatures are represented as a matrix with reaction type number = 100+LORD*NTEM, where

LORD - number of Legendre moments,

NTEM - number of temperatures;

self-scatter positions of the 1-st group, free from use in this case, contains the temperature value;

(d) instead of (n,n'),(n,2n) cross sections, sum of reactions, including the reactions with charge particle emission with the same number of secondary neutrons, is used:

(n,n')+(n,pn)+(n,dn)...

(n,2n)+(n,p2n)+(n,d2n)...

(e) instead of inelastic scatter matrix, sum of reactions is used:

(n,n') + other (n,CP+n) reactions , where CP - charge particle (p,d,t,He3,alpha)

(f) Instead of emission based n,2n matrix, sum of matrices is used:

1/2*[2(n,2n) + 3(n,3n)+ k(n,CP+kn) reactions], k>1.

The matrix is normalized on (n,2n) cross section, so that emission rate is defined as

macroscopic scatter (j to g) times multiplication factor 2 times the flux in group j

The extended BRKOXS file allows increasing number of reaction-types NREACT, to include self-shielding factors for the most valuable inter-group transitions and its angular moments.

References

1. Rineiski, A., Sinitsa,V., Mashek, W., C4P, A Multi-Group Nuclear CCCC Data Processing System for Reactor Safety and Scenario Studies, Proc. Jahrestagung Kerntechnik 2005 (Annual Meeting on Nuclear Technology 2005), Berlin, Germany

2. Rineiski, A., Gabrielly,F., Sinitsa,V., Mashek, W.,C4P cross section library for savety analyses with SIMMER and related studies, *International Conference on Mathematics and Computational Methods Applied to Nuclear Science and Engineering (M&C 2011)* Rio de Janeiro, RJ, Brazil, May 8-12, 2011, on CD-ROM, Latin American Section (LAS) / American Nuclear Society (ANS) ISBN 978-85-63688-00-2

APPENDIX. Extended format for ISOTXS and BRKOXS files with neutron microscopic group cross sections and matrices

```
C*********************************************************************
C                                                                     -
CF         ISOTXS-KIT                                                 -
CE         MICROSCOPIC GROUP NEUTRON CROSS SECTIONS                   -
C                                                                     -
CN                     THIS FILE PROVIDES A MULTI AND BROAD GROUP      -
CN                     LIBRARY, ORDERED BY ISOTOPE                    -
CN                     FORMATS GIVEN ARE FOR FILE EXCHANGE PURPOSES    -
CN                     ONLY.                                          -
C                                                                     -
C*********************************************************************


C---------------------------------------------------------------------
CS         FILE STRUCTURE                                             -
CS                                                                    -
CS            RECORD TYPE                          PRESENT IF         -
CS            ================================     ==============     -
CS            FILE IDENTIFICATION                  ALWAYS             -
CS            FILE CONTROL                         ALWAYS             -
CS            FILE DATA                            ALWAYS             -
CS            FILE-WIDE CHI DATA                   ICHIST.GT.1        -
CS                                                                    -
CS   ************(REPEAT FOR ALL ISOTOPES)                           -
CS   *        ISOTOPE CONTROL AND GROUP                              -
CS   *                        INDEPENDENT DATA    ALWAYS             -
CS   *        PRINCIPAL CROSS SECTIONS            ALWAYS             -
CS   *        ISOTOPE CHI DATA                    ICHI.GT.1          -
CS   *                                                               -
CS   *  ********(REPEAT TO NSCMAX SCATTERING BLOKS)                   -
CS   *  *  *****(REPEAT FROM 1 TO NSBLOK)                            -
CS   *  *  *  SCATTERING SUB-BLOCK                LORD(N).GT.0       -
CS   ************                                                    -
C                                                                     -
C---------------------------------------------------------------------

C---------------------------------------------------------------------
CR         FILE IDENTIFICATION                                        -
C                                                                     -
CL     HNAME,(HUSE(I),I=1,2,IVERS                                     -
C                                                                     -
CW     1+3*MULT=NUMBER OF WORDS                                       -
C                                                                     -
CB     FORMAT(11H 0V ISOTXS ,A6,1H*,2A6,1H*,I6)                       -
```

```
C                                                                       -
CD     HNAME        HOLLERITH FILE NAME - ISOTXS - (A6)                 -
CD     HUSE(I)      HOLLERISH USER IDENTIFICATION (A6)                  -
CD     IVERS        FILE VERSION NUMBER                                 -
CD     MULT         DOUBLE PRECISIONPARAMETER                           -
CD                      1- A6 WORD IS SINGLE WORD                        -
CD                      2- A6 WORD IS DOUBLE PRECISION WORD              -
C                                                                       -
C-----------------------------------------------------------------------

C-----------------------------------------------------------------------
CR         FILE CONTROL   (1D RECORD)                                   -
C                                                                       -
CL     NGROUP,NSO,MAXUP,MAXDN,MAXORD,ICHIST,MSCMAX,NSBLOK               -
C                                                                       -
CW     8=NUMBER OF WORDS                                                -
C                                                                       -
CB     FORMAT(4H 1D ,8I6)                                               -
C                                                                       -
CD     NGROUP       NUMBER OF ENERGY GROUPS IN FILE                     -
CD     NISO         NUMBER OF ISOTOPES IN FILE                          -
CD     MAXUP        MAXIMUM NUMBER OF UPSCATTER GROUPS                  -
CD     MAXDN        MAXIMUM NUMBER OF DOWNSCATTER GROUPS                -
CD     MAXORD       MAXIMUM SCATTERING ORDER (MAXIMUM VALUE OF          -
CD                     LEGENDRE EXPANSION INDEX USED IN FILE).           -
CD     ICHIST       FILE-WIDE FISSION SPECTRUM FLAG                     -
CD                     ICHIST.EQ.0,      NO FILE-WIDE SPECTRUM          -
CD                     ICHIST.EQ.1,      FILE-WIDE CHI VECTOR           -
CD                     ICHIST.GT.1,      FILE WIDE CHI MATRIX           -
CD     NSCMAX       MAXIMUM NUMBER OF BLOCKS OF SCATTERING DATA         -
CD     NSBLOK       SUBBLOCKING CONTROL FOR SCATTER METRICES, THE       -
CD                     SCATTERING DATA ARE SUBBLOCKED INTO NSBLOK       -
CD                     RECORDS(SUBBLOCKS) PER SCATTERING BLOCK.         -
C                                                                       -
C-----------------------------------------------------------------------

C-----------------------------------------------------------------------
CR         FILE DATA      (2D RECORD)                                   -
C                                                                       -
CL     (HSETID(I),I=1,12),(HISONM(I),I=1,NISO),                         -
CL    1(CHI(J),J=1,NGROUP),(VEL(J),J=1,NGROUP),                         -
CL    2(EMAX(J),J=1,NGROUP),EMIN,(LOCA(I),I=1,NISO)                     -
C                                                                       -
CW     (NISO+12)*MULT+1+NISO                                            -
CW     +NGROUP*(2+ICHIST*(2/(ICHIST+1)))=NUMBER OF WORDS                -
C                                                                       -
CB     FORMAT(4H 2D ,1H*,11A6,1H*/                                      -
CB    11H*,A6,1H*,9(1XA6)/(10(1X,A6)))   HSETID,HISONM                  -
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```
CB     FORMAT( 6E12.5)                   CHI (PRESENT IF ICHIST.EQ.1)  -
CB     FORMAT( 6E12.5)                   VEL,EMAX,EMIN                 -
CB     FORMAT(12I6)                      LOCA                          -
C                                                                      -
CD     HSETID(I)    HOLLERITH IDENTIFICATION OF FILE (A6)             -
CD     HISONM(I)    HOLLERITH ISOTOPE LABEL FOR ISOTOPE I (A6)        -
CD     CHI(J)       FILE-WIDE FISSION SPECTRUM(PRESENT IF ICHIST.EQ.1) -
CD     VEL(J)       MEAN NEUTRON VELOCITY IN GROUP J (CM/SEC)         -
CD     EMAX(J)      MAXIMUM ENERGY BOUND OF GROUP J (EV)              -
CD     EMIN         MAXIMUM ENERGY BOUND OF SET (EV)                  -
CD     LOCA(I)      NUMBER OF RECORDS TO BE SKIPPED TO READ DATA FOR  -
CD                     ISOTOPE I. LOCA(1)=0                           -
C                                                                      -
C----------------------------------------------------------------------

C----------------------------------------------------------------------
CR         FILE-WIDE CHI DATA   (3D RECORD)                           -
C                                                                      -
CC         PRESENT IF ICHIST.GT.1                                     -
C                                                                      -
CL     ((CHI(K,J),K=1,ICHIST),J=1,NGROUP),(ISSPEC(I),I=1,NGROUP)      -
C                                                                      -
CW     NGROUP*(ICHIST+1)=NUMBER OF WORDS                              -
C                                                                      -
CB     FORMAT(4H 3D ,5E12.5/(6E12.5)) CHI                             -
CB     FORMAT(12I6)                   ISSPEC                          -
C                                                                      -
CD     CHI(K,J)     FRACTION OF NEUTRONS EMITTED INTO GROUP J AS A    -
CD                     RESULT OF FISSION IN ANY GROUP,USING SPECTRUM K -
CD                                                                     -
CD     ISSPEC(I)    ISSPEC(I)=K IMPLIES THAT SPECTRUM K IS USED       -
CD                     TO CALCULATE EMISSION SPECTRUM FROM FISSION    -
CD                     IN GROUP I                                     -
C                                                                      -
C----------------------------------------------------------------------

C----------------------------------------------------------------------
CR         ISOTOPE CONTROL AND GROUP INDEPENDENT DATA   (4D RECORD)   -
C                                                                      -
CL     HABSID,HIDENT,HMAT,AMASS,EFISS,ECAPT,TEMP,SIGPOT,ADENS,KBR,ICHI,-
CL    1IFIS,IALF,INP,IN2N,IND,INT,LTOT,LTRN,ISTRPD,                   -
CL    2(IDSCT(N),N=1,NSCMAX),(LORD(N),N=1,NSCMAX),                    -
CL    3(JBAND(J,N),J=1,NGROUP),N=1,NSCMAX),                           -
CL    4(IJJ(J,N),J=1,NGROUP),N=1,NSCMAX)                              -
C                                                                      -
CW     3*MULT=17+NSCMAX*(2*NGROUP+2)=NUMBER OF WORDS                  -
C                                                                      -
CB     FORMAT(4H 4D ,3(1X,A6)/ 6E12.5/                                -
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CB    1(12I6))                                                          -
C                                                                       -
CD     HABSID       HOLLERITH ABSOLUTE ISOTOPE LABEL - SAME FOR ALL    -
CD                          VERSIONS OF THE SAME ISOTOPE IN FILE (A6)  -
CD     HIDENT       IDENTIFIER OF LIBRARY FROM WHICH BASIC DATA CAME   -
CD                           (E.G. ENDF/B) (A6)                        -
CD     HMATT        ISOTOPE IDENTIFICATION (E,G, ENDF/B MAT NO.) (A6)  -
CD     AMASS        ATOMIC WEIGHT (C12)                                -
CD     EFISS        TOTAL THERMAL ENERGY YIELD/FISSION (EV*SEC/FISS)   -
CD     ECAPT        TOTAL THERMAL ENERGY YIELD/CAPTURE (EV*SEC/CAPT)   -
CD     TEMP         ISOTOPE TEMPERATURE (DEGREES KELVIN)               -
CD     SIGPOT       AVERAGE EFFECTIVE POTENTIAL SCATTERING             -
CD                           IN RESONANCE RANGE (BARNS/ATOM)           -
CD     ADENS        DENCITY OF ISOTOPE IN MIXTURE IN WHICH ISOTOPE     -
CD                            CROSS SECTIONS WERE GENERATED (A/BARN-CM)-
CD     KBR          ISOTOPE CLASSIFICATION                             -
CD                     0=UNDEFINED                                      -
CD                     1=FISSILE                                        -
CD                     2=FERTILE                                        -
CD                     3=OTHER ACTINIDE                                 -
CD                     4=FISSION PRODUCT                                -
CD                     5=STRUCTURE                                      -
CD                     6=COOLANT                                        -
CD                     7=CONTROL                                        -
CD     ICHI         ISOTOPE FISSION SPECTRUM FLAG                      -
CD                     ICHI.EQ.0,      USE FILE-WIDE CHI                -
CD                     ICHI.EQ.1,      USE CHI VECTOR                   -
CD                     ICHI.GT.1,      USE CHI MATRIX                   -
CD     IFIS         (N,F) CROSS SECTION FLAG                           -
CD                     IFIS=0,  NO FISSION DATA IN PRINCIPAL CROSS      -
CD                                    SECTION RECORD                   -
CD                         =1,  FISSION DATA PRESENT IN PRINCIPAL       -
CD                                    CROSS SECTION RECORD             -
CD     IALF         (N,ALPHA) CROSS SECTION FLAG                       -
CD                     SAME OPTION AS IFIS                              -
CD     INP          (N,P) CROSS SECTION FLAG                           -
CD                     SAME OPTION AS IFIS                              -
CD     IN2N         (N,2N) CROSS SECTION FLAG                          -
CD                     SAME OPTION AS IFIS                              -
CD     IND          (N,D) CROSS SECTION FLAG                           -
CD                     SAME OPTION AS IFIS                              -
CD     INT          (N,T) CROSS SECTION FLAG                           -
CD                     SAME OPTION AS IFIS                              -
CD     LTOT         NUMBER OF MOMENTS OF TOTAL CROSS SECTION PROVIDED  -
CD                     IN PRINCIPAL CROSS SECTION RECORD                -
CD     LTRN         NUMBER OF MOMENTS OF TRANSPORT CROSS SECTION       -
CD                     PROVIDED IN PRINCIPAL CROSS SECTION RECORD       -
CD     ISTRPD       NUMBER OF COORDINATE DIRECTIONS FOR WHICH          -
```

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CD                    COORDINATE DEPENDENT TRANSPORT CROSS SECTIONS   -
CD                    ARE GIVEN. IF ISTRPD=0, NO COORDINATE DEPENDENT -
CD                    TRANSPORT CROSS SECTONS ARE GIVEN.              -
CD     IDSCT(N)     SCATTERING MATRIX TYPE IDENTIFICATION FOR         -
CD                    SCATTERING BLOCK N. SIGNIFICANT ONLY IF         -
CD                    LORD(N).GT.0                                    -
CD                    IDSCT(N)=000, TOTAL SCATTERING, (SUM OF         -
CD                         ELASTIC,INELASTIC, AND N,2N SCATTERING     -
CD                         MATRIX TERMS).                             -
CD                             =100, ELASTIC SCATTERING               -
CD                             =200, INELASTIC SCATTERING             -
CD                             =300, (N2N) SCATTERING                 -
CD                             =100+NN, THERMAL TEMPERATURE DEPENDENT -
CD                                      SCATERING, NN=LORD(N)*NTEM,   -
CD                                      NTEM - NUMBER OF TEMPERATURES -
CD     LORD(N)      NUMBER OF SCATTERING ORDERS IN BLOCK N. IF         -
CD                    LORD(N)=0, THIS BLOCK IS NOT PRESENT FOR THIS   -
CD                    ISOTOPE. IF NN IS THE VALUE TAKEN FROM          -
CD                    IDSCT(N), THEN THE MATRICES IN THIS BLOCK       -
CD                    HAVE LEGENDRE EXPANSION INDICES OF NN,NN+1,     -
CD                    NN+2,...,NN+LORD(N)-1                           -
CD     JBAND(J,N)   NUMBER OF GROUPS THET SCATTER INTO GROUP J,        -
CD                    INCLUDING SELF-SCATTER, IN SCATTERING BLOCK N.  -
CD                    IF JBAND(J,N)=0, NO SCATTER DATA IS PRESENT IN  -
CD                    BLOCK N                                         -
CD     IJJ(J,N)     POSITION OF IN-GROUP SCATTERING CROSS SCTIONS IN   -
CD                    SCATTERING DATA FOR GROUP J, SCATTERING BLOCK   -
CD                    N, COUNTED FROM THE FIRST WORD OF GROUP J DATA. -
CD                    IF JBAND(J,N).NE.0 THEN IJJ(J,N) MUST SATISFY   -
CD                    THE RELATION  IJJ(J,N).LE.JBAND(J,N)            -
CD                    IF JBAND(J,N).LE.0 THEN IJJ(J,N) IS CONDITINAL  -
CD                    POSITION OF IN-GROUP SCATTERING                 -
CD                  NOTE- FOR N,2N SCATTER, MATRIX CONTAINS SUM       -
CD                    1/2*[2(N,2N)+3(N,3N)+K(N,CP+KN),K>1..]          -
CD                    NORMALIZED ON (N,2N) REACTION RATE, I.E.        -
CD                    EMISSION RATE IS MACROSCOPIC SCAT(J TO G)       -
CD                    TIMES MULTIPLICATION FACTOR 2                   -
CD                    TIMES FLUX                                      -
C                                                                     -
C---------------------------------------------------------------------

C---------------------------------------------------------------------
CR         PRINCIPAL CROSS SECTIONS  (5D RECORD)                      -
C                                                                     -
CL     ((STRPL(J,L),J=1,NGROUP),L=1,LTRN),                            -
CL    1((STOTPL(J,L),J=1,NGROUP),L=1,LTOT),(SNGAM(J),J=1,NGROUP)      -
CL    2(SFIS(J),J=1,NGROUP),SNUTOT(J),J=1,NGROUP),                    -
CL    3(CHISO(J),J=1,NGROUP),(SNALF(J),J=1,NGROUP),                   -
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CL    4(SNP(J),J=1,NGROUP),(SN2N(J),J=1,NGROUP),                        -
CL    5(SND(J),J=1,NGROUP),(SNT(J),J=1,NGROUP),                         -
CL    6(STRPD(J,I),J=1,NGROUP),I=1,ISTRPD)                              -
C                                                                       -
CW     (1+LTRN+LTOT+LALF+INP+IN2N+IND+INT+ISTRPD+2*IFIS+                -
CW     ICHI*(2/(ICHI+1))*NGROUP=NUMBER OF WORDS                         -
C                                                                       -
CB     FORMAT(4H 5D ,  5E12.5/(6E12.5)) LENGTH OF LIST AS ABOVE         -
C                                                                       -
CD     STRPL(J,L)   PL WEIGHTED TRANSPORT CROSS SECTION                 -
CD                     THE FIRST ELEMENT OF ARRAY STRPL IS THE          -
CD                     CURRENT (P1) WEIGHTED TRANSPORT CROSS SECTION.   -
CD                     THE LEGENDRE EXPANSION COEFFICIENT FACTOR (2L+1)-
CD                     IS NOT INCLUDED IN STRPL(J,L).                   -
CD     STOTPL(J,L)  PL WEIGHTED TOTAL CROSS SECTION                     -
CD                     THE FIRST ELEMENT OF ARRAY STOTPL IS THE         -
CD                     FLUX (P0) WEIGHTED TOTAL CROSS SECTION           -
CD                     THE LEGENDRE EXPANSION COEFFICIENT FACTOR (2L+1)-
CD                     IS NOT INCLUDED IN STOTPL(J,L).                  -
CD     SNGAM(J)     (N,GAMMA)                                           -
CD     SFIS(J)      (N,F)        (PRESENT IF IFIS.GT.0)                 -
CD     SNUTOT(J)    TOTAL NEUTRON YIELD/FISSION (PRESENT IF IFIS.GT.0) -
CD     CHISO(J)     ISOTOPE CHI  (PRESENT IF ICHI.EQ.1)                 -
CD     SNALF(J)     (N,ALFA)     (PRESENT IF IALF.GT.0)                 -
CD     SNP(J)       (N,P)        (PRESENT IF INP.GT.0)                  -
CD     SN2N(J)      (N,2N)+SUM(N,CP+2N) , WHERE CP - OTHER PARTICLES,   -
CD                               I.E. P,D,T,HE3,ALPHA HE3               -
CD                               (PRESENT IF IN2N.GT.0)                 -
CD     SND(J)       (N,D)        (PRESENT IF IND.GT.0)                  -
CD     SNT(J)       (N,T)        (PRESENT IF INT.GT.0)                  -
CD     STRPD(J)     COORDINATE DIRECTION I TRANSPORT CROSS SECTION      -
CD                               (PRESENT IF ISTRPD.GT.0)               -
C                                                                       -
C-----------------------------------------------------------------------

C-----------------------------------------------------------------------
CR         ISOTOPE CHI DATA   (6D RECORD)                               -
C                                                                       -
CC         PRESENT IF ICHI.GT.1                                         -
C                                                                       -
C      ((CHIISO(K,J),K=1,ICHI),J=1,NGROUP),(ISOPEC(I),I=1,NGROUP)       -
C                                                                       -
CW     NGROUP*(ICHI+1)=NUMBER OF WORDS                                  -
C                                                                       -
CB     FORMAT(4H 6D , 5E12.5/(6E12.5)) CHIISO                           -
CB     FORMAT(12I6)                    ISOPEC                           -
C                                                                       -
CD     CHIISO(K,J)  FRACTION OF NEUTRONS EMITTED INTO GROUP J AS A      -
```

```
CD                    RESULT OF FISSION IN ANY GROUP,USING SPECTRUM K -
CD     ISOPEC(I)    ISOPEC(I)=K IMPLIES THAT SPECTRUM K IS USED       -
CD                    TO CALCULATE EMISSION SPECTRUM FROM FISSION     -
CD                    IN GROUP I                                      -
C                                                                     -
C---------------------------------------------------------------------

C---------------------------------------------------------------------
CR         SCATTERING SUB-BLOCK (7D RECORD)                           -
C                                                                     -
CC         PRESENT IF LORD(N).GT.0                                    -
C                                                                     -
CL     ((SCAT(K,L),K=1,KMAX),L=1,LORDN)                               -
C                                                                     -
CC     KMAX=SUM OVER J OF JBAND(J,N) WITHIN THE J-GROUP RANGE OF THIS  -
CC        SUB-BLOCK. IF M IS THE INDEX OF THE SUB-BLOCK, THE J-GROUP   -
CC        RANGE CONTAINED WITHIN THIS SUB-BLOCK IS                     -
CC        JL=(M-1)*((NGROUP-1)/NSBLOK+1)+1) TO JU=MIN(NGROUP,JUP),     -
CC        WHERE JUP=M*((NGROUP-1)/NSBLOK+1).                           -
C                                                                     -
CC     LORDN=LORD(N)                                                  -
CC     N IS THE INDEX FOR THE LOOP OVER NSCMAX (SEE FILE STRUCTURE)    -
C                                                                     -
CW     KMAX*LORDN=NUMBER OF WORDS                                     -
C                                                                     -
CB     FORMAT(4H 7D , 5E12.5/(6E12.5))                                -
C                                                                     -
CD     SCAT(K,L)    SCATTERING MATRIX OF SCATTERING ORDER L, FOR       -
CD                     REACTION TYPE IDENTIFIED BY IDSCT(N) FOR THIS   -
CD                     BLOCK, JBAND(J,N) VALUES FOR SCATTERING INTO    -
CD                     GROUP J ARE STORED AT LOCATIONS K=SUM FROM 1    -
CD                     TO (J-1) OF JBAND(J,N) PLUS 1 TO K-1+JBAND(J,N).-
CD                     THE SUM IS ZERO WHEN J=1. J-TO-J SCATTER IS     -
CD                     THE IJJ(J,N)-TH ENTRY ( OR CONVENTIONAL ENTRY,  -
CD                     IF IJJ(J,N).LE.0 ). VALUES ARE STORED IN THE    -
CD                     THE ORDER                                       -
CD                     (J+JUP),(J+JUP-1),...,(J+1),J,(J-1),(J-JDN),    -
CD                     WHERE JUP=MAX(0,IJJ(J,N)-1) AND                 -
CD                           JDN=JBAND(J,N)-JUP-1                      -
C                                                                     -
C---------------------------------------------------------------------
```

```
C*0*************************************************************************
C                                                                        -
CF         BRKOXS-KIT                                                   -
CE         BONDARENKO SELF-SHIELDING TABLES                              -
C                                                                        -
CN                     THIS FILE PROVIDES DATA NECESSARY FOR             -
CN                     BONDARENKO TREATMENT IN ADDITION TO               -
CN                     THOSE DATA IN FILE ISOTXS                         -
CN                     FORMATS GIVEN ARE FOR FILE EXCHANGE PURPOSES      -
CN                     ONLY.                                             -
C                                                                        -
C*************************************************************************


C------------------------------------------------------------------------
CS         FILE STRUCTURE                                                -
CS                                                                       -
CS            RECORD TYPE                          PRESENT IF           -
CS            ================================     ==============       -
CS            FILE IDENTIFICATION                  ALWAYS               -
CS            FILE CONTROL                         ALWAYS               -
CS            FILE DATA                            ALWAYS               -
CS                                                                       -
CS   ************(REPEAT FROM 1 TO NISOSH)                              -
CS   *        SELF-SHIELDIG FACTORS                ALWAYS               -
CS   *                                                                  -
CS   *        CROSS SECTIONS                       ALWAYS               -
CS   ************                                                       -
C                                                                        -
C------------------------------------------------------------------------

C------------------------------------------------------------------------
CR         FILE IDENTIFICATION                                           -
C                                                                        -
CL     HNAME,(HUSE(I),I=1,2,IVERS                                        -
C                                                                        -
CW     1+3*MULT=NUMBER OF WORDS                                          -
C                                                                        -
CB     FORMAT(11H 0V BRKOXS ,A6,1H*,2A6,1H*,I6)                          -
C                                                                        -
CD     HNAME        HOLLERITH FILE NAME - ISOTXS - (A6)                  -
CD     HUSE(I)      HOLLERISH USER IDENTIFICATION (A6)                   -
CD     IVERS        FILE VERSION NUMBER                                  -
CD     MULT         DOUBLE PRECISIONPARAMETER                            -
CD                      1- A6 WORD IS SINGLE WORD                       -
CD                      2- A6 WORD IS DOUBLE PRECISION WORD             -
C                                                                        -
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C-----------------------------------------------------------------------

C-----------------------------------------------------------------------
CR         FILE CONTROL   (1D RECORD)                                  -
C                                                                      -
CL     NGROUP,NISOSH,NSIGPT,NTEMPT,NREACT,IBLK                         -
C                                                                      -
CW     6=NUMBER OF WORDS                                               -
C                                                                      -
CB     FORMAT(4H 1D ,6I6)                                              -
C                                                                      -
CD     NGROUP       NUMBER OF ENERGY GROUPS IN SET                     -
CD     NISOSH       NUMBER OF ISOTOPES WITH SELF-SHIELDING FACTORS     -
CD     NSIGPT       TOTAL NUMBER OF VALUES OF VARIABLE X (SEE FILE DATA-
CD                  RECORD) WHICH ARE GIVEN. NSIGPT IS EQUAL TO        -
CD                  THE SUM FROM 1 TO NISOSH OF NTABP(I)               -
CD     NREACT       NUMBER OF REACTION TYPES FOR WHICH SELF-SHIELDING  -
CD                  FACTORS ARE GIVEN                                  -
CD     IBLK         BLOCKING OPTION FLAG FOR SELF-SHIELDING FACTORS.   -
CD                     IBLK=0, FACTORS NOT BLOCKED BY REACTION TYPE.   -
CD                     IBLK=1, FACTORS ARE BLOCKED BY REACTION TYPE.   -
C                                                                      -
C-----------------------------------------------------------------------

C-----------------------------------------------------------------------
CR         FILE DATA      (2D RECORD)                                  -
C                                                                      -
CL     (HISONM(I),I=1,12),(XK(),K=1,NSIGPT),(TB(K),K=1,NTEMPT),        -
CL    1(EMAX(J),J=1,NGROUP),EMIN,(JBFL(I),I=1,NISOSH),                 -
CL    2(JBFH(I),I=1,NISOSH),NTABP(I),I=1,NISOSH),(NTABT(I),I=1,NISOSH) -
C                                                                      -
CW     (4+MULT)*NISOSH+NSIGPT+NTEMPT+NGROUP+1=NUMBER OF WORDS          -
C                                                                      -
CB     FORMAT(4H 2D ,9(1X,A6)/                                         -
CB    1(10(1X,A6)))                      HISONM                        -
CB     FORMAT( 6E12.5)                   X,IB,EMAX,EMIN                -
CB     FORMAT(12I6)                      JBFL,JBFH,NTABP,NTABT         -
C                                                                      -
CD     HISONM(I)    HOLLERITH ISOTOPE LABEL FOR ISOTOPE I (A6). THESE  -
CD                     LABELS MUST BE A SUBSET OF THOSE IN FILE ISOTXS -
CD                     OR GRUPXS, IN THE CORRESPONDING ARRAY           -
CD     X(K)         ARRAY OF LN10(SIGP0) VALUES FOR ALL ISOTOPES       -
CD                     WHERE SIGP0 IS THE TOTAL CROSS SECTION OF THE   -
CD                     OTHER ISOTOPES IN THE MIXTURE IN BARNS PER ATOM -
CD                     OF THIS ISOTOPE. FOR ISOTOPE I, THE NTABP(I)    -
CD                     VALUES OF X FOR WHICH SELF-SHIELDING FACTORS    -
CD                     ARE GIVEN ARE STORED STARTING AT LOCATION       -
CD                     L=1+SUM FROM 1 TO I-1 OF NTABP(K).              -
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CD     TB(K)        ARRAY OF TEMPERATURES (DEGREES C) FOR ALL ISOTOPES.-
CD                     FOR ISOTOPE I, THE NTABT(I) VALUES OF TB  FOR   -
CD                     WHICH SELF-SHIELDING FACTORS ARE GIVEN ARE      -
CD                     STORED AT LOCATION L=1+SUM FROM 1 TO I-1 OF     -
CD                     NTABT(K)                                        -
CD     EMAX(J)      MAXIMUM ENERGY BOUND OF GROUP J (EV)              -
CD     EMIN         MAXIMUM ENERGY BOUND OF SET (EV)                  -
CD     JBFL(I)      LOWEST NUMBERED OR HIGHEST ENERGY GROUP FOR WHICH  -
CD                     SELF-SHIELDING FACTORS ARE GIVEN                -
CD     JBFH(I)      HIGHEST NUMBERED OR LOWEST ENERGY GROUP FOR WHICH  -
CD                     SELF-SHIELDING FACTORS ARE GIVEN                -
CD     NTABP(I)     NUMBER OF SIGP0 VALUES FOR WHICH SELF-SHIELDING    -
CD                  FACTORS ARE GIVEN FOR ISOTOPE I.                  -
CD     NTABT(I)     NUMBER OF TEMPERATURE VALUES FOR WHICH SELF-       -
CD                  SHIELDING FACTORS ARE GIVEN FOR ISOTOPE I.        -
C                                                                      -
C----------------------------------------------------------------------

C----------------------------------------------------------------------
CR         SELF-SHIELDING FACTORS   (3D RECORD)                       -
C                                                                      -
CL     ((FFACT(N,K,J,M),N=1,NBINT),K=1,NBTEM),J=JBFLI,JBFHI),M=ML,MU)  -
C                                                                      -
CC     NBINT=NTABP(I)                                                  -
CC     NBTEM=NTABT(I)                                                  -
CC     JBFLI=JBFL(I)                                                   -
CC     JBFHI=JBFH(I)                                                   -
CC     FOR ML,MU SEE STRUCTURE BELOW                                   -
C                                                                      -
CW     NBINT*NBTEM*(JBFHI-JBFLI+1)*(MU-ML+1) = NUMBER OF WORDS         -
C                                                                      -
CB     FORMAT(4H 3D ,5E12.5/(6E12.5))                                  -
C                                                                      -
CC     DO L=1,NBLOK                                                    -
CC     READ(N) *LIST AS ABOVE*                                         -
CC     END DO                                                          -
C                                                                      -
CC          IF IBLK=0, NBLOK=1, ML=1, MU=NREACT                        -
CC          IF IBLK=1, NBLOK=NREACT, ML=MU=L, WHERE L IS THE BLOCK     -
CC             INDEX.                                                  -
C                                                                      -
CD     FFACT(N,K,J,M)  SELF-SHIELDING FACTOR EVALUATED AT X(N) AND     -
CD                        TB(K) FOR ENERGY GROUP J. THE M INDEX IS     -
CD                        A DUMMY INDEX TO DENOTE THE REACTION-TYPE.   -
CD                        THE FIRST FIVE REACTION TYPES ARE, IN        -
CD                        ORDER, TOTAL, CAPTURE, FISSION, TRANSPORT,   -
CD                        AND ELASTIC.                                 -
C                                                                      -
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CN          NOTE THAT IF IBLK=1, EACH REACTION-TYPE WILL CONSTITUTE    -
CN             A SEPARATE DATA BLOCK.                                  -
C                                                                      -
C----------------------------------------------------------------------

C----------------------------------------------------------------------
CR         CROSS SECTIONS   (4D RECORD)                                -
C                                                                      -
CL     (XSPO(J),J=1,NGROUP),(XSIN(J),J=1,NGROUP),(XSE(J),J=1,NGROUP),  -
CL    1(XSMU(J),J=1,NGROUP),(XSED(J),J=1,NGROUP),(XSXI(J),J=1,NGROUP)  -
C                                                                      -
CW     6*NGROUP=NUMBER OF WORDS                                        -
C                                                                      -
CB     FORMAT(4H 4D ,  5E12.5/(6E12.5))                                -
C                                                                      -
CD     XSPO(J)      POTENTIAL SCATTERING CROSS SECTION (BARNS)         -
CD     XSIN(J)      SUM OF (N,N')+(N,PN)+(N,DN)...(BARNS)              -
CD     XSE(J)       ELASTIC CROSS SECTION (BARNS)                      -
CD     XSMU(J)      AVERAGE COSINE OF ELASTIC SCATTERING ANGLE         -
CD     XSED(J)      ELASTIC DOWN SCATTERING TO ADJACENT GROUP          -
CD     XSXI(J)      AVERAGE ELASTIC SCATTERING LETHARGY INCREMENT      -
C                                                                      -
C----------------------------------------------------------------------
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