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====================================================================== Groupie
                                                                       Groupie
     PROGRAM GROUPIE                                                   Groupie
     VERSION 76-1 (NOVEMBER 1976)                                      Groupie
     VERSION 79-1 (OCTOBER 1979) CDC-7600 AND CRAY-1 VERSION.          Groupie
     VERSION 80-1 (MAY 1980) IBM, CDC AND CRAY VERSION                 Groupie
     VERSION 81-1 (JANUARY 1981) EXTENSION TO 3000 GROUPS              Groupie
     VERSION 81-2 (MARCH 1981) IMPROVED SPEED                          Groupie
     VERSION 81-3 (AUGUST 1981) BUILT-IN 1/E WEIGHTING SPECTRUM        Groupie
     VERSION 82-1 (JANUARY 1982) IMPROVED COMPUTER COMPATIBILITY       Groupie
     VERSION 83-1 (JANUARY 1983)*MAJOR RE-DESIGN.                      Groupie
                                *ELIMINATED COMPUTER DEPENDENT CODING. Groupie
                                *NEW, MORE COMPATIBLE I/O UNIT NUMBERS.Groupie
                                *NEW MULTI-BAND LIBRARY BINARY FORMAT. Groupie
     VERSION 83-2 (OCTOBER 1983) ADDED OPTION TO ALLOW SIGMA-0 TO BE   Groupie
                                 DEFINED EITHER AS MULTIPLES OF        Groupie
                                 UNSHIELDED TOTAL CROSS SECTION IN EACHGroupie
                                 GROUP, OR POWERS OF 10 IN ALL GROUPS. Groupie
     VERSION 84-1 (APRIL 1984)   ADDED MORE BUILT IN MULTIGROUP ENERGY Groupie
                                 STRUCTURES.                           Groupie
     VERSION 85-1 (APRIL 1985)  *UPDATED FOR ENDF/B-VI FORMATS.        Groupie
                                *SPECIAL I/O ROUTINES TO GUARANTEE     Groupie
                                 ACCURACY OF ENERGY.                   Groupie
                                *DOUBLE PRECISION TREATMENT OF ENERGY  Groupie
                                 (REQUIRED FOR NARROW RESONANCES).     Groupie
                                *MINIMUM TOTAL CROSS SECTION TREATMENT Groupie
     VERSION 85-2 (AUGUST 1985) *FORTRAN-77/H VERSION                  Groupie
     VERSION 86-1 (JANUARY 1986)*ENDF/B-VI FORMAT                      Groupie
     VERSION 86-2 (JUNE 1986)   *BUILT-IN MAXWELLIAN, 1/E AND FISSION  Groupie
                                 WEIGHTING SPECTRUM.                   Groupie
     VERSION 88-1 (JULY 1988)   *OPTION...INTERNALLY DEFINE ALL I/O    Groupie
                                 FILE NAMES (SEE, SUBROUTINES FILIO1   Groupie
                                 FILIO2 FOR DETAILS).                  Groupie
                                *IMPROVED BASED ON USER COMMENTS.      Groupie
     VERSION 89-1 (JANUARY 1989)*PSYCHOANALYZED BY PROGRAM FREUD TO    Groupie
                                 INSURE PROGRAM WILL NOT DO ANYTHING   Groupie
                                 CRAZY.                                Groupie
                                *UPDATED TO USE NEW PROGRAM CONVERT    Groupie
                                 KEYWORDS.                             Groupie
                                *ADDED LIVERMORE CIVIC COMPILER        Groupie
                                 CONVENTIONS.                          Groupie
     VERSION 91-1 (JUNE 1991)   *INCREASED PAGE SIZE FROM 1002 TO 5010 Groupie
                                 POINTS                                Groupie
                                *UPDATED BASED ON USER COMMENTS        Groupie
                                *ADDED FORTRAN SAVE OPTION             Groupie
                                *COMPLETELY CONSISTENT ROUTINE TO READ Groupie
                                 FLOATING POINT NUMBERS.               Groupie
     VERSION 92-1 (JANUARY 1992)*ADDED RESONANCE INTEGRAL CALCULATION - Groupie
                                 UNSHIELDED AND/OR SHIELDED - FOR      Groupie
                                 DETAILS SEE BELOW                     Groupie
                                *INCREASED NUMBER OF ENERGY POINTS     Groupie
                                 IN BUILT-IN SPECTRA - TO IMPROVE      Groupie
                                 ACCURACY.                             Groupie
                                *ALLOW SELECTION OF ZA/MF/MT OR        Groupie
                                 MAT/MF/MT RANGES - ALL DATA NOT       Groupie
                                 SELECTED IS SKIPPED ON INPUT AND      Groupie
                                 NOT WRITTEN AS OUTPUT.                Groupie
                                *COMPLETELY CONSISTENT I/O ROUTINES -  Groupie
                                 TO MINIMIZE COMPUTER DEPENDENCE.      Groupie
                                *NOTE, CHANGES IN INPUT PARAMETER      Groupie
                                 FORMAT - FOR ZA/MF/MT OR MAT/MF/MT    Groupie
                                 RANGES.                               Groupie
     VERSION 92-2 (JUNE 1992)   *MULTIBAND PARAMETERS OUTOUT AS        Groupie
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                            CHARACTER (RATHER THAN BINARY) FILE.   Groupie
VERSION 93-1 (APRIL 1993)  *INCREASED PAGE SIZE FROM 5010 TO       Groupie
                            30000 POINTS                           Groupie
                           *ELIMINATED COMPUTER DEPENDENCE.        Groupie
VERSION 94-1 (JANUARY 1994)*VARIABLE ENDF/B DATA FILENAMES        Groupie
                            TO ALLOW ACCESS TO FILE STRUCTURES     Groupie
                            (WARNING - INPUT PARAMETER FORMAT      Groupie
                            HAS BEEN CHANGED)                      Groupie
                           *CLOSE ALL FILES BEFORE TERMINATING     Groupie
                            (SEE, SUBROUTINE ENDIT)                Groupie
VERSION 95-1 (JANUARY 1994)*CORRECTED MAXWELLIAN WEIGHTING         Groupie
                           *CHANGING WEIGHTING SPECTRUM FROM       Groupie
                            0.1 TO 0.001 % UNCERTAINTY             Groupie
VERSION 96-1 (JANUARY 1996) *COMPLETE RE-WRITE                     Groupie
                            *IMPROVED COMPUTER INDEPENDENCE        Groupie
                            *ALL DOUBLE PRECISION                  Groupie
                            *ON SCREEN OUTPUT                      Groupie
                            *UNIFORM TREATMENT OF ENDF/B I/O       Groupie
                            *IMPROVED OUTPUT PRECISION             Groupie
                            *DEFINED SCRATCH FILE NAMES            Groupie
                            *UP TO 1000 GROUP MULTI-BAND           Groupie
                             CALCULATION (PREVIOUSLY 175)          Groupie
                            *MAXIMUM NUMBER OF GROUPS REDUCED      Groupie
                             FROM 3,000 TO 1,000                   Groupie
                            *UP TO 1000 MATERIALS                  Groupie
                             (PREVIOUSLY 100)                      Groupie
                            *CORRECTED USE OF MAXWELLIAN +         Groupie
                             1/E + FISSION SPECTRUM                Groupie
                            *ONLY 2 BAND VERSION DISTRIBUTED       Groupie
                             (CONTACT AUTHOR FOR DETAILS)          Groupie
                            *DEFINED SCRATCH FILE NAMES            Groupie
VERSION 99-1 (MARCH 1999)   *CORRECTED CHARACTER TO FLOATING       Groupie
                             POINT READ FOR MORE DIGITS            Groupie
                            *UPDATED TEST FOR ENDF/B FORMAT        Groupie
                             VERSION BASED ON RECENT FORMAT CHANGE Groupie
                            *GENERAL IMPROVEMENTS BASED ON         Groupie
                             USER FEEDBACK                         Groupie
VERSION 99-2 (JUNE 1999)    *ASSUME ENDF/B-VI, NOT V, IF MISSING   Groupie
                             MF=1, MT-451.                         Groupie
VERS. 2000-1 (FEBRUARY 2000)*ADDED MF=10, ACTIVATION CROSS SECTION Groupie
                             PROCESSING.                           Groupie
                            *GENERAL IMPROVEMENTS BASED ON         Groupie
                             USER FEEDBACK                         Groupie
VERS. 2002-1 (FEBRUARY 2002)*ADDED TART 700 GROUP STRUCTURE        Groupie
                            *ADDED VARIABLE SIGMA0 INPUT OPTION    Groupie
             (MAY 2002)     *OPTIONAL INPUT PARAMETERS             Groupie
             (NOV. 2002)    *ADDED SAND-II EXTENDED DOWN TO        Groupie
                             1.0E-5 EV.                            Groupie
             (JUNE 2003)    *CORRECTED SAND-II 620 AND 640 GROUP   Groupie
                             ENERGY BOUNDARIES DEFINITIONS.        Groupie
VERS. 2004-1 (SEPT. 2004)  *INCREASED PAGE SIZE FROM 30000 TO      Groupie
                            120000 POINTS                          Groupie
                           *ADDED "OTHER" AS ADDITIONAL REACTION   Groupie
                            TO IMPROVE MULTI-BAND FITTING          Groupie
                           *ADDED ITERATION FOR "BEST" PARTIAL     Groupie
                            PARAMETERS.                            Groupie
                           *DO NOT SKIP LOW TOTAL ENERGY RANGES    Groupie
                            WHEN DEFINING AVERAGE CROSS SECTIONS - Groupie
                            THIS MAKES OUTPUT COMPATIBLE WITH      Groupie
                            ANY STANDARD AVERAGING PROCEDURE       Groupie
VERS. 2005-1 (JAN. 2005)   *ADDED OPTION TO CHANGE TEMPERATURE OF  Groupie
                            BUILT-IN STANDARD SPECTRUM.            Groupie
VERS. 2007-1 (JAN. 2007)   *CHECKED AGAINST ALL ENDF/B-VII.    OF  Groupie
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*INCREASED PAGE SIZE FROM 120,000 TO 600,000 POINTS

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AUTHORS MESSAGE

THE REPORT DESCRIBED ABOVE IS THE LATEST PUBLISHED DOCUMENTATION FOR THIS PROGRAM. HOWEVER, THE COMMENTS BELOW SHOULD BE CONSIDERED THE LATEST DOCUMENTATION INCLUDING ALL RECENT IMPROVEMENTS. PLEASE READ ALL OF THESE COMMENTS BEFORE IMPLEMENTATION, PARTICULARLY THE COMMENTS CONCERNING MACHINE DEPENDENT CODING.

AT THE PRESENT TIME WE ARE ATTEMPTING TO DEVELOP A SET OF COMPUTER INDEPENDENT PROGRAMS THAT CAN EASILY BE IMPLEMENTED ON ANY ONE OF A WIDE VARIETY OF COMPUTERS. IN ORDER TO ASSIST IN THIS PROJECT IT WOULD BE APPECIATED IF YOU WOULD NOTIFY THE AUTHOR OF ANY COMPILER DIAGNOSTICS, OPERATING PROBLEMS OR SUGGESTIONS ON HOW TO IMPROVE THIS PROGRAM. HOPEFULLY, IN THIS WAY FUTURE VERSIONS OF THIS PROGRAM WILL BE COMPLETELY COMPATIBLE FOR USE ON YOUR COMPUTER.

PURPOSE

THIS PROGRAM IS DESIGNED TO CALCULATE ANY COMBINATION OF THE FOLLOWING QUANTITIES FROM LINEARLY INTERPOLABLE TABULATED CROSS SECTIONS IN THE ENDF/B FORMAT

(1) UNSHIELDED GROUP AVERAGED CROSS SECTIONS
(2) BONDARENKO SELF-SHIELDED GROUP AVERAGED CROSS SECTIONS
(3) MULTI-BAND PARAMETERS

IN THE FOLLOWING FOR SIMPLICITY THE ENDF/B TERMINOLOGY--ENDF/B TAPE--WILL BE USED. IN FACT THE ACTUAL MEDIUM MAY BE TAPE, CARDS, DISK OR ANY OTHER MEDIUM.

ENDF/B FORMAT

THIS PROGRAM ONLY USES THE ENDF/B BCD OR CARD IMAGE FORMAT (AS OPPOSED TO THE BINARY FORMAT) AND CAN HANDLE DATA IN ANY VERSION OF THE ENDF/B FORMAT (I.E., ENDF/B-I, II,III, IV OR V FORMAT).

IT IS ASSUMED THAT THE DATA IS CORRECTLY CODED IN THE ENDF/B FORMAT AND NO ERROR CHECKING IS PERFORMED. IN PARTICULAR IT IS

ASSUMED THAT THE MAT, MF AND MT ON EACH CARD IS CORRECT. SEQUENCE NUMBERS (COLUMNS 76-80) ARE IGNORED ON INPUT, BUT WILL BE CORRECTLY OUTPUT ON ALL CARDS. THE FORMAT OF SECTION MF=1, MT=451 AND ALL SECTIONS OF MF= 3 MUST BE CORRECT. THE PROGRAM COPIES ALL OTHER SECTION OF DATA AS HOLLERITH AND AS SUCH IS INSENSITIVE TO THE CORRECTNESS OR INCORRECTNESS OF ALL OTHER SECTIONS.

ALL FILE 3 CROSS SECTIONS THAT ARE USED BY THIS PROGRAM MUST BE LINEARLY INTERPOLABLE IN ENERGY AND CROSS SECTION (ENDF/B INTERPOLATION LAW 2). FILE 3 BACKGROUND CROSS SECTIONS MAY BE MADE LINEARLY INTERPOLABLE USING PROGRAM LINEAR (UCRL-50400, VOL. 17, PART A). THE RESONANCE CONTRIBUTION MAY BE ADDED TO THE BACKGROUND CROSS SECTIONS USING PROGRAM RECENT (UCRL-50400, VOL. 17, PART B). IF THIS PROGRAM FINDS THAT THE FILE 3 CROSS SECTIONS ARE NOT LINEARLY INTERPOLABLE THIS PROGRAM WILL TERMINATE EXECUTION.

CONTENTS OF OUTPUT

IF ENDF/B FORMATTED OUTPUT IS REQUESTED ENTIRE EVALUATIONS ARE OUTPUT, NOT JUST THE MULTI-GROUPED FILE 3 CROSS SECTIONS, E.G. ANGULAR AND ENERGY DISTRIBUTIONS ARE ALSO INCLUDED.

DOCUMENTATION

THE FACT THAT THIS PROGRAM HAS OPERATED ON THE DATA IS DOCUMENTED BY THE ADDITION OF THREE COMMENT CARDS AT THE END OF EACH HOLLERITH SECTION TO DESCRIBE THE GROUP STRUCTURE AND WEIGHTING SPECTRUM, E.G.

********** PROGRAM GROUPIE (2007-1) **********

UNSHIELDED GROUP AVERAGES USING 69 GROUPS (WIMS)
MAXWELLIAN, 1/E AND FISSION WEIGHTING SPECTRUM

THE ORDER OF ALL SIMILAR COMMENTS (FROM LINEAR, RECENT AND SIGMA1) REPRESENTS A COMPLETE HISTORY OF ALL OPERATIONS PERFORMED ON THE DATA.

THESE COMMENT CARDS ARE ONLY ADDED TO EXISTING HOLLERITH SECTIONS, I.E., THIS PROGRAM WILL NOT CREATE A HOLLERITH SECTION. THE FORMAT OF THE HOLLERITH SECTION IN ENDF/B-V DIFFERS FROM THE THAT OF EARLIER VERSIONS OF ENDF/B. BY READING AN EXISTING MF=1, MT=451 IT IS POSSIBLE FOR THIS PROGRAM TO DETERMINE WHICH VERSION OF THE ENDF/B FORMAT THE DATA IS IN. WITHOUT HAVING A SECTION OF MF=1, MT=451 PRESENT IT IS IMPOSSIBLE FOR THIS PROGRAM TO DETERMINE WHICH VERSION OF THE ENDF/B FORMAT THE DATA IS IN, AND AS SUCH IT IS IMPOSSIBLE FOR THE PROGRAM TO DETERMINE WHAT FORMAT SHOULD BE USED TO CREATE A HOLLERITH SECTION.

REACTION INDEX

THIS PROGRAM DOES NOT USE THE REACTION INDEX WHICH IS GIVEN IN SECTION MF=1, MT=451 OF EACH EVALUATION.

THIS PROGRAM DOES NOT UPDATE THE REACTION INDEX IN MF=1, MT=451. THIS CONVENTION HAS BEEN ADOPTED BECAUSE MOST USERS DO NOT REQUIRE A CORRECT REACTION INDEX FOR THEIR APPLICATIONS AND IT WAS NOT CONSIDERED WORTHWHILE TO INCLUDE THE OVERHEAD OF CONSTRUCTING A CORRECT REACTION INDEX IN THIS PROGRAM. HOWEVER, IF YOU REQUIRE A REACTION INDEX FOR YOUR APPLICATIONS, AFTER RUNNING THIS PROGRAM YOU MAY USE PROGRAM DICTIN TO CREATE A CORRECT REACTION INDEX.

SECTION SIZE

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------------                                                        Groupie
SINCE THIS PROGRAM USES A LOGICAL PAGING SYSTEM THERE IS NO LIMIT   Groupie
TO THE NUMBER OF POINTS IN ANY SECTION, E.G., THE TOTAL CROSS       Groupie
SECTION MAY BE REPRESENTED BY 200,000 DATA POINTS.                  Groupie
                                                                    Groupie
SELECTION OF DATA                                                   Groupie
-----------------                                                   Groupie
THE PROGRAM SELECTS MATERIALS TO BE PROCESSED BASED EITHER ON       Groupie
MAT (ENDF/B MAT NO.) OR ZA. THE PROGRAM ALLOWS UP TO 100 MAT OR     Groupie
ZA RANGES TO BE SPECIFIED. THE PROGRAM WILL ASSUME THAT THE         Groupie
ENDF/B TAPE IS IN EITHER MAT OR ZA ORDER, WHICHEVER CRITERIA IS     Groupie
USED TO SELECT MATERIALS, AND WILL TERMINATE WHEN A MAT OR ZA       Groupie
IS FOUND THAT IS ABOVE THE RANGE OF ALL REQUESTS.                   Groupie
                                                                    Groupie
ENERGY ORDER AND UNITS                                              Groupie
----------------------                                              Groupie
ALL ENERGIES (FOR CROSS SECTIONS, WEIGHTING SPECTRUM OR GROUP       Groupie
BOUNDARIES) MUST BE IN UNITS OF EV AND MUST BE IN ASCENDING         Groupie
NUMERICAL ORDER.                                                    Groupie
                                                                    Groupie
ENERGY GRID                                                         Groupie
-----------                                                         Groupie
ALTHOUGH ALL REACTIONS MUST TO LINEARLY INTERPOLABLE, THEY DO NOT   Groupie
ALL HAVE TO USE THE SAME ENERGY GRID. EACH REACTION CAN BE GIVEN    Groupie
BY AN INDEPENDENT ENERGY GRID. THIS PROGRAM WILL PROCEED FROM       Groupie
THE LOWEST TO HIGHEST ENERGY SELECTING EACH ENERGY INTERVAL OVER    Groupie
WHICH ALL DATA, FOR ANY GIVEN CALCULATION, ARE ALL LINEARLY         Groupie
INTERPOLABLE.                                                       Groupie
                                                                    Groupie
GROUP STRUCTURE                                                     Groupie
---------------                                                     Groupie
THIS PROGRAM IS DESIGNED TO USE AN ARBITRARY ENERGY GROUP           Groupie
STRUCTURE WHERE THE ENERGIES ARE IN EV AND ARE IN INCREASING        Groupie
ENERGY ORDER. THE MAXIMUM NUMBER OF GROUPS IS 1000.                 Groupie
                                                                    Groupie
THE USER MAY INPUT AN ARBITRARY GROUP STRUCTURE OR THE USER MAY     Groupie
USE USE ONE OF THE SEVEN BUILT-IN GROUP STRUCTURES.                 Groupie
(0) 175 GROUP (TART STRUCTURE)                                      Groupie
(1)  50 GROUP (ORNL STRUCTURE)                                      Groupie
(2) 126 GROUP (ORNL STRUCTURE)                                      Groupie
(3) 171 GROUP (ORNL STRUCTURE)                                      Groupie
(4) 620 GROUP (SAND-II STRUCTURE, UP TO 18 MEV)                     Groupie
(5) 640 GROUP (SAND-II STRUCTURE, UP TO 20 MEV)                     Groupie
(6)  69 GROUP (WIMS STRUCTURE)                                      Groupie
(7)  68 GROUP (GAM-I STRUCTURE)                                     Groupie
(8)  99 GROUP (GAM-II STRUCTURE)                                    Groupie
(9)  54 GROUP (MUFT STRUCTURE)                                      Groupie
(10)  28 GROUP (ABBN STRUCTURE)                                     Groupie
(11) 650 GROUP (TART STRUCTURE)                                     Groupie
(12) 700 GROUP (TART STRUCTURE)                                     Groupie
(13) 665 GROUP (SAND-II STRUCTURE, 1.0e-5 eV, UP TO 18 MEV)         Groupie
(14) 685 GROUP (SAND-II STRUCTURE, 1.0e-5 eV, UP TO 20 MEV)         Groupie
                                                                    Groupie
GROUP AVERAGES                                                      Groupie
--------------                                                      Groupie
THIS PROGRAM DEFINES GROUP AVERAGED CROSS SECTIONS AS...            Groupie
                                                                    Groupie
          (INTEGRAL E1 TO E2) (SIGMA(E)*S(E)*WT(E)*DE)              Groupie
AVERAGE = ----------------------------------------                  Groupie
          (INTEGRAL E1 TO E2) (S(E)*WT(E)*DE)                       Groupie
WHERE...                                                            Groupie
                                                                    Groupie
AVERAGE  = GROUP AVERAGED CROSS SECTION                             Groupie
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E1, E2   = ENERGY LIMITS OF THE GROUP                                  Groupie
SIGMA(E) = ENERGY DEPENDENT CROSS SECTION FOR ANY GIVEN REACTION       Groupie
S(E)     = ENERGY DEPENDENT WEIGHTING SPECTRUM                         Groupie
WT(E)    = ENERGY DEPENDENT SELF-SHIELDING FACTOR.                     Groupie
                                                                       Groupie
ENERGY DEPENDENT WEIGHTING SPECTRUM                                    Groupie
----------------------------------                                     Groupie
THE ENERGY DEPENDENT WEIGHTING SPECTRUM IS GIVEN BY AN ARBITRARY       Groupie
TABULATED LINERLY INTERPOLABLE FUNCTION WHICH CAN BE DESCRIBED         Groupie
BY AN ARBITRARY NUMBER OF POINTS. THIS ALLOWS THE USER TO              Groupie
SPECIFY ANY DESIRED WEIGHTING SPECTRUM TO ANY GIVEN DEGREE OF          Groupie
ACCURACY. REMEMBER THAT THE PROGRAM WILL ASSUME THAT THE SPECTRUM      Groupie
IS LINEARLY INTERPOLABLE BETWEEN TABULATED POINTS. THEREFORE THE       Groupie
USER SHOULD USE ENOUGH POINTS TO INSURE AN ADEQUATE REPRESENTATION     Groupie
OF THE SPECTRUM BETWEEN TABULATED DATA POINTS.                         Groupie
                                                                       Groupie
THE PRESENT VERSION OF THE CODE HAS THREE BULIT-IN WEIGHTING           Groupie
SPECTRA,                                                               Groupie
                                                                       Groupie
(1) CONSTANT                                                           Groupie
(2) 1/E                                                                Groupie
(3) MAXWELLIAN = E*EXP(-E/KT)/KT               (0.0 TO 4*KT)           Groupie
    1/E        = C1/E                          (4*KT TO 67 KEV)        Groupie
    FISSION    = C2*EXP(-E/WA)*SINH(SQRT(E*WB)) (ABOVE 67 KEV)         Groupie
                                                                       Groupie
    KT     = 0.253 EV (293 KELVIN)                                     Groupie
    WA     = 9.65E+5                                                   Groupie
    WB     = 2.29E-6                                                   Groupie
    C1, C2 = DEFINED TO MAKE SPECTRUM CONTINUOUS                       Groupie
                                                                       Groupie
    FISSION SPECTRUM CONSTANTS FROM                                    Groupie
    A.F.HENRY, NUCLEAR REACTOR ANALYSIS, P. 11, MIT PRESS (1975)       Groupie
                                                                       Groupie
UNSHIELDED GROUP AVERAGES                                              Groupie
-------------------------                                              Groupie
FOR UNSHIELDED AVERAGES THE SELF-SHIELDING FACTOR (WT(E)) IS SET       Groupie
TO UNITY. THIS PROGRAM ALLOWS UP TO 1000 GROUPS.                       Groupie
                                                                       Groupie
SELF-SHIELDED GROUP AVERAGES                                           Groupie
----------------------------                                           Groupie
IF SELF-SHIELDED AVERAGES AND/OR MULTI-BAND PARAMETERS ARE             Groupie
CALCULATED THIS PROGRAM ALLOWS UP TO 1000 GROUPS. SELF-SHIELDED        Groupie
AVERAGES AND/OR MULTI-BAND PARAMETERS ARE CALCULATED FOR THE           Groupie
TOTAL, ELASTIC, CAPTURE AND FISSION.                                   Groupie
                                                                       Groupie
FOR THE TOTAL, ELASTIC, CAPTURE AND FISSION THE PROGRAM USES A         Groupie
WEIGHTING FUNCTION THAT IS A PRODUCT OF THE ENERGY DEPENDENT           Groupie
WEIGHTING SPECTRUM TIMES A BONDERENKO TYPE SELF-SHIELDING FACTOR.      Groupie
                                                                       Groupie
WT(E) = S(E)/(TOTAL(E)+SIGMA0)**N                                      Groupie
                                                                       Groupie
WHERE...                                                               Groupie
                                                                       Groupie
S(E)     - ENERGY DEPENDENT WEIGHTING SPECTRUM (DEFINED BY             Groupie
           TABULATED VALUES AND LINEAR INTERPOLATION BETWEEN           Groupie
           TABULATED VALUES).                                          Groupie
TOTAL(E) - ENERGY DEPENDENT TOTAL CROSS SECTION FOR ONE MATERIAL       Groupie
           (DEFINED BY TABULATED VALUES AND LINEAR INTERPOLATION       Groupie
           BETWEEN TABULATED VALUES).                                  Groupie
SIGMA0   - CROSS SECTION TO REPRESENT THE EFFECT OF ALL OTHER          Groupie
           MATERIALS AND LEAKAGE (DEFINED WITHIN EACH GROUP TO BE      Groupie
           A MULTIPLE OF THE UNSHIELDED TOTAL CROSS SECTION WITHIN     Groupie
           THAT GROUP OR POWERS OF 10 - INPUT OPTION).                 Groupie
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N - A POSITIVE INTEGER (0, 1, 2 OR 3).

THE PROGRAM WILL USE ONE ENERGY DEPENDENT WEIGHTING SPECTRUM S(E) AND 25 DIFFERENT BONDERENKO TYPE SELF-SHIELDING FACTORS (25 SIGMA0 AND N COMBINATIONS) TO DEFINE 25 DIFFERENT AVERAGE CROSS SECTIONS, FOR EACH REACTION, WITHIN EACH GROUP.

THE 25 WEIGHTING FUNCTIONS USED ARE....

(1) - UNSHIELDED CROSS SECTIONS (N=0)

(2-22)- PARTIALLY SHIELDED CROSS SECTIONS (N=1 ,VARIOUS SIGMA0)
THE VALUES OF SIGMA0 USED WILL BE EITHER,
(A) THE VALUES OF SIGMA0 THAT ARE USED VARY FROM 1024 TIMES THE UNSHIELDED TOTAL CROSS SECTIONS IN STEPS OF 1/2 DOWN TO 1/1024 TIMES THE UNSHIELDED TOTAL CROSS SECTION (A RANGE OF OVER 1 MILLION, CENTERED ON THE UNSHIELDED TOTAL CROSS SECTION WITHIN EACH GROUP).
(B) THE SAME CONSTANT VALUES OF SIGMA0 IN EACH GROUP. THE VALUES OF SIGMA0 USED INCLUDE 40000, 20000, 10000, 7000, 4000, 2000, 1000, 700, 400, 200, 100, 70, 40, 20, 10, 7, 4, 2, 1, 0.7, 0.4 (A RANGE OF 100,000 SPANNING MORE THAN THE RANGE OF SIGMA0 VALUES THAT MAY BE ENCOUNTERED IN ACTUAL APPLICATIONS)

(23) - TOTALLY SHIELDED FLUX WEIGHTED CROSS SECTION
(N=1, SIGMA0=0)

(24) - TOTALLY SHIELDED CURRENT WEIGHTED CROSS SECTION
(N=2, SIGMA0=0)

(25) - TOTALLY SHIELDED COSINE SQUARED WEIGHTED CROSS SECTION
(N=3, SIGMA0=0)

FOR ALL OTHER REACTIONS (EXCEPT TOTAL, ELASTIC, CAPTURE AND FISSION) THE PROGRAM WILL USE THE ENERGY DEPENDENT WEIGHTING SPECTRUM S(E) TO DEFINE THE UNSHIELDED (BONDERENKO N=0) AVERAGED CROSS SECTION WITHIN EACH GROUP.

CALCULATION OF RESONANCE INTEGRALS

IN A PURE ELASTIC ISOTROPICALLY SCATTERING MATERIAL WITH A CONSTANT CROSS SECTION THE SPECTRUM WILL BE 1/E AND THERE WILL BE NO SELF-SHIELDING.

IN THIS CASE IF THE CROSS SECTION VARIES WITH ENERGY THE SPECTRUM WILL STILL BE 1/E AND THE SELF-SHIELDING FACTOR WILL BE EXACTLY 1/SIG-TOT(E) - WHERE SIG-TOT(E) = SIG-EL(E), SINCE THERE IS ONLY SCATTERING.

IF WE HAVE AN INFINITELY DILUTE AMOUNT OF A MATERIAL UNIFORMLY MIXED WITH A PURE ELASTIC ISOTROPICALLY SCATTERING MATERIAL WITH A CONSTANT CROSS SECTION THE STANDARD DEFINITION OF THE RESONANCE INTEGRAL CAN BE USED TO DEFINE REACTION RATES FOR EACH REACTION.

THE RESONANCE INTEGRAL IS DEFINED AS,

RI = (INTEGRAL E1 TO E2) (SIGMA(E)*S(E)*WT(E)*DE)

WHERE NORMALLY,
S(E) = 1/E
WT(E) = 1 - NO SELF-SHIELDING

FROM THE ABOVE DEFINITION OF GROUP AVERAGED CROSS SECTIONS THE RESONANCE INTEGRAL IS,

RI = AVERAGE * (INTEGRAL E1 TO E2) (S(E)*WT(E)*DE)

FOR A 1/E SPECTRUM AND NO SELF-SHIELDING THIS REDUCES TO, Groupie

RI = AVERAGE* LOG(E2/E1) Groupie

IN ANY OTHER SITUATION, INCLUDING ABSORPTION AND/OR ENERGY Groupie
DEPENDENT CROSS SECTIONS, THE SPECTRUM WILL NOT BE 1/E - Groupie
ABSORPTION WILL TEND TO DECREASE THE SPECTRUM PROGRESSIVELY Groupie
MORE AT LOWER ENERGIES - ENERGY DEPENDENCE OF THE CROSS SECTION Groupie
WILL LEAD TO SELF-SHIELDING. Groupie

HERE WE WILL NOT ATTEMPT TO PERFORM A DETAILED SPECTRUM Groupie
CALCULATION TO ACCOUNT FOR ABSORPTION. Groupie

HOWEVER, WE WILL EXTEND THE DEFINITION OF THE RESONANCE INTEGRAL Groupie
TO ACCOUNT FOR SELF-SHIELDING EFFECTS BY ALLOWING FOR INCLUSION Groupie
OF SELF-SHIELDING EFFECTS IN THE DEFINITION OF GROUP AVERAGES Groupie
AND THEN DEFINING THE RESONANCE INTEGRAL AS, Groupie

RI = AVERAGE* LOG(E2/E1) Groupie

IN ORDER TO CALCULATE RESONANCE INTEGRALS YOU MUST FOLLOW THESE Groupie
STEPS, Groupie

1) SELECT A 1/E SPECTRUM - ON FIRST LINE OF INPUT PARAMETERS. Groupie
2) SELECT THE ENERGY BOUNDARIES - NORMALLY ONLY 1 GROUP FROM Groupie
   0.5 EV UP TO 20 MEV - HOWEVER, YOU ARE FREE TO SELECT ANY Groupie
   ENERGY RANGE THAT YOU WISH - YOU MAY EVEN SELECT MORE THAN Groupie
   1 GROUP MERELY BY SPECIFYING MORE THAN 1 GROUP AS INPUT - Groupie
   THIS CAN BE USED TO DEFINE THE CONTRIBUTIONS TO THE RESONANCE Groupie
   INTEGRAL FROM INDIVIDUAL ENERGY RANGES. Groupie
3) SELECT THIS OPTION FOR THE UNSHIELDED AND/OR SHIELDED OUTPUT Groupie
   LISTING - ON THE SECOND LINE OF INPUT PARAMETERS. Groupie

WHEN THIS OPTION IS USED THE PROGRAM WILL CALCULATE GROUP AVERAGED Groupie
CROSS SECTIONS - AS DEFINED ABOVE - PRIOR TO OUTPUT THE RESULTS Groupie

WILL MERELY BE MULTIPLIED BY THE WIDTH OF THE GROUP ASSUMING YOU Groupie
HAVE SELECTED A 1/E SPECTRUM - THERE IS NO CHECK ON THIS - THE Groupie
PROGRAM MERELY MULTIPLIES THE GROUP AVERAGED CROSS SECTIONS BY, Groupie

LOG(E2/E1) - WHERE E2 AND E1 ARE THE GROUP ENERGY BOUNDARIES. Groupie

WARNING - IT IS UP TO YOU TO INSURE THAT YOU FOLLOW EXACTLY THE Groupie
          STEPS OUTLINED ABOVE IF YOU WISH TO OBTAIN MEANINGFUL Groupie
          RESULTS. Groupie

NOTE - OUTPUT IN THE ENDF/B FORMAT IS ALWAYS GROUP AVERAGED CROSS Groupie
       SECTIONS, REGARDLESS OF WHETHER YOU ASK FOR AVERAGED CROSS Groupie
       SECTIONS OR RESONANCE INTEGRALS - THIS IS BECAUSE DATA IN Groupie
       THE ENDF/B FORMAT IS EXPLICITLY DEFINED TO BE CROSS Groupie
       SECTIONS. Groupie

       RESONANCE INTEGRAL OUTPUT CAN ONLY BE OBTAINED IN THE Groupie
       LISTING FORMATS. Groupie

MINIMUM TOTAL CROSS SECTION TREATMENT Groupie
---------- Groupie
SINCE THE BONDARENKO SELF-SHIELDING DEPENDS ON 1/TOTAL CROSS Groupie
SECTION, THE ALGORITHM WILL BECOME NUMERICALLY UNSTABLE IF THE Groupie
TOTAL CROSS SECTION IS NEGATIVE (AS OCCURS IN MANY ENDF/B Groupie
EVALUATIONS). IF THE TOTAL IS LESS THAN SOME MINIMUM ALLOWABLE Groupie
VALUE (DEFINE BY OKMIN, PRESENTLY 1 MILLI-BARN) AN ERROR MESSAGE Groupie
WILL BE PRINTED AND FOR THE SELF-SHIELDING CALCULATION ALL ENERGY Groupie

INTERVALS IN WHICH THE TOTAL IS LESS THAN THE MINIMUM WILL BE IGNORED.

NOTE, FOR THE UNSHIELDED CALCULATIONS ALL CROSS SECTIONS WILL BE CONSIDERED WHETHER THEY ARE POSITIVE OR NEGATIVE. THEREFORE IF THE TOTAL CROSS SECTION IS NEGATIVE OR LESS THAN THE MINIMUM VALUE THERE MAY BE AN INCONSISTENCY BETWEEN THE UNSHIELDED AND THE SELF-SHIELDED CROSS SECTIONS. IF THE TOTAL CROSS SECTION IS NEGATIVE AND SELF-SHIELDED CROSS SECTIONS ARE CALCULATED THE PROGRAM WILL PRINT AN ERROR MESSAGE INDICATING THAT THE SELF-SHIELDED RESULTS ARE UNRELIABLE AND SHOULD NOT BE USED. THEREFORE IN THIS CASE THE PROGRAM WILL NOT ATTEMPT TO MODIFY THE UNSHIELDED RESULTS TO ELIMINATE THE EFFECT OF NEGATIVE CROSS SECTIONS, SINCE THE UNSHIELDED RESULTS ARE THE ONLY ONES WHICH TRULY REFLECT THE ACTUAL INPUT.

RESOLVED RESONANCE REGION

IN THE RESOLVED RESONANCE REGION (ACTUALLY EVERYWHERE BUT IN THE UNRESOLVED RESONANCE REGION) THE CROSS SECTIONS OUTPUT BY LINEAR-RECENT-SIGMA1 WILL BE ACTUAL ENERGY DEPENDENT CROSS SECTIONS AND THE CALCULATIONS BY THIS PROGRAM WILL YIELD ACTUAL SHIELDED AND UNSHIELDED CROSS SECTIONS.

UNRESOLVED RESONANCE REGION

IN THE UNRESOLVED RESONANCE REGION PROGRAM RECENT USES THE UNRESOLVED RESONANCE PARAMETERS TO CALCULATE INFINITELY DILUTE AVERAGE CROSS SECTIONS. THIS PROGRAM WILL MERELY READ THIS INFINITELY DILUTE DATA AS IF IT WERE ENERGY DEPENDENT DATA AND GROUP AVERAGE IT. AS SUCH THIS PROGRAM WILL PRODUCE THE CORRECT UNSHIELDED CROSS SECTION IN THE UNRESOLVED RESONANCE REGION, BUT IT WILL NOT PRODUCE THE CORRECT SELF-SHIELDING EFFECTS.

ACCURACY OF RESULTS

ALL INTEGRALS ARE PERFORMED ANALYTICALLY. THEREFORE NO ERROR IS INTRODUCED DUE TO THE USE OF TRAPAZOIDAL OR OTHER INTEGRATION SCHEME. THE TOTAL ERROR THAT CAN BE ASSIGNED TO THE RESULTING AVERAGES IS JUST THAT DUE TO THE ERROR IN THE CROSS SECTIONS AND ENERGY DEPENDENT WEIGHTING SPECTRUM. GENERALLY SINCE THE THE ENERGY DEPENDENT WEIGHTING SPECTRUM APPEARS IN BOTH THE NUMERATOR AND THE DENOMINATOR THE AVERAGES RAPIDLY BECOME INSENSITIVE TO THE WEIGHTING SPECTRUM AS MORE GROUPS ARE USED. SINCE THE WEIGHTING SPECTRUM IS LOADED IN THE PAGING SYSTEM THE USER CAN DESCRIBE THE SPECTRUM TO ANY REQUIRED ACCURACY USING ANY NUMBER OF ENERGY VS. SPECTRUM PAIRS.

MULTI-BAND PARAMETERS

MULTI-BAND PARAMETERS ARE CALCULATED FOR THE TOTAL, ELASTIC, CAPTURE AND FISSION REACTIONS. WITH THE NUMBER OF GROUPS THAT ARE NORMALLY USED (SEE BUILT IN GROUP STRUCTURES) ALL OTHER REACTIONS RESULT IN A NEGLIGABLE AMOUNT OF SELF-SHIELDING. AS SUCH THEIR EQUIVALENT BAND CROSS SECTION WILL MERELY BE THEIR UNSHIELDED VALUE WITHIN EACH BAND.

FOR ANY GIVEN EVALUATION, WITHIN ANY GIVEN GROUP THIS PROGRAM WILL GENERATE THE MINIMUM NUMBER OF BANDS REQUIRED WITHIN THAT GROUP. AS OUTPUT TO THE COMPUTER READABLE DISK FILE THE BAND PARAMETERS FOR EACH EVALUATION WILL BE FORMATTED TO HAVE THE SAME NUMBER OF BANDS IN ALL GROUPS (WITH ZERO WEIGHT FOR SOME BANDS WITHIN ANY GROUP). THE USER MAY DECIDE TO HAVE OUTPUT

EITHER WITH THE MINIMUM NUMBER OF BANDS REQUIRED FOR EACH EVALUATION (E.G. 2 BANDS FOR HYDROGEN AND 4 BANDS FOR U-233) OR THE SAME NUMBER OF BANDS FOR ALL EVALUATIONS (E.G. 4 BANDS FOR BOTH HYDROGEN AND U-233). Groupie

FOR 2 OR FEWER BANDS THE PROGRAM USES AN ANALYTIC EXPRESSION TO DEFINE ALL MULTI-BAND PARAMETERS. FOR MORE THAN 2 BANDS THE PROGRAM PERFORMS A NON-LINEAR FIT TO SELECT THE MULTI-BAND PARAMETERS THAT MINIMIZE THE MAXIMUM FRACTIONAL ERROR AT ANY POINT ALONG THE ENTIRE SELF-SHIELDING CURVE. THE NUMBER OF BANDS REQUIRED WITHIN ANY GIVEN GROUP IS DEFINED BY INSURING THAT THE MULTI-BAND PARAMETERS CAN BE USED TO ACCURATELY DEFINE SELF-SHIELDED CROSS SECTIONS ALONG THE ENTIRE SELF-SHIELDING CURVE FROM SIGMA0 = 0 TO INFINITY. THE USER MAY DEFINE THE ACCURACY REQUIRED. Groupie

ENDF/B FORMATTED UNSHIELDED AVERAGES Groupie

UNSHIELDED MULTI-GROUP AVERAGED CROSS SECTIONS FOR ALL REACTIONS MAY BE OBTAINED IN THE ENDF/B FORTRAN IN EITHER HISTOGRAM (INTERPOLATION LAW 1) OR LINEARLY INTERPOLABLE (INTERPOLATION LAW 2) FORM. SEE INPUT BELOW FOR DETAILS. Groupie

MIXTURES OF MATERIALS AND RESONANCE OVERLAP Groupie

THE SELF-SHIELDED CROSS SECTIONS FOR THE INDIVIDUAL CONSTITUENTS OF ANY MIXTURE CAN BE CALCULATED BY THIS PROGRAM BY REALIZING THAT THIS PROGRAM ESSENTIALLY ONLY USES THE TOTAL CROSS SECTION AS A WEIGHTING FUNCTION TO ACCOUNT FOR SELF-SHIELDING EFFECTS. FOR A MIXTURE IT IS THEREFORE ONLY NECESSARY TO USE THE TOTAL CROSS SECTION FOR THE MIXTURE IN PLACE OF THE ACTUAL TOTAL CROSS SECTION FOR EACH CONSTITUENT AND TO RUN THIS PROGRAM. THIS CAN BE DONE BY FIRST RUNNING PROGRAM MIXER TO CALCULATE THE ENERGY DEPENDENT TOTAL CROSS SECTION FOR ANY COMPOSITE MIXTURE. NEXT, SUBSTITUTE THIS COMPOSITE TOTAL CROSS SECTION FOR THE ACTUAL TOTAL CROSS SECTION OF EACH CONSTITUENT (IN EACH ENDF/B FORMATTED EVALUATION). FINALLY, RUN THIS PROGRAM TO CALCULATE THE SELF-SHIELDED CROSS SECTION FOR EACH CONSTITUENT, PROPERLY ACCOUNTING FOR RESONANCE OVERLAP BETWEEN THE RESONANCES OF ALL OF THE CONSTITUENTS OF THE MIXTURE. DURING THE SAME RUN THESE SELF-SHIELDED CROSS SECTIONS CAN IN TURN BE USED TO CALCULATE FULLY CORRELATED MULT-BAND Groupie

MULTI-BAND PARAMETER OUTPUT FORMAT Groupie

FOR VERSIONS 92-2 AND LATER VERSIONS THE MULTI-BAND PARAMETERS ARE OUTPUT IN A SIMPLE CHARACTER FORMAT, THAT CAN BE TRANSFERRED AND USED ON VIRTUALLY ANY COMPUTER. Groupie

THE BINARY FORMAT USED IN EARLIER VERSIONS OF THIS CODE IS NO LONGER USED. Groupie

CONTACT THE AUTHOR IF YOU WOULD LIKE TO RECEIVE A SIMPLE PROGRAM TO READ THE CHARACTER FORMATTED MULTI-BAND PARAMETER FILE AND CREATE A BINARY, RANDOM ACCESS FILE FOR USE ON VIRTUALLY ANY COMPUTER. Groupie

THE FORMAT OF THE CHARACTER FILE IS, Groupie

RECORD	COLUMNS	FORMAT	DESCRIPTION	
1	1-72	18A4	LIBRARY DESCRIPTION (AS READ)	Groupie
2	1-11	I11	MATERIAL ZA	Groupie
	12-22	I11	NUMBER GROUPS	Groupie
	23-33	I11	NUMBER OF BANDS	Groupie

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          34-44     D11.4   TEMPERATURE (KELVIN)                    Groupie
          45-55    1X,10A1  HOLLERITH DESCRIPTION OF ZA              Groupie
   3       1-11     D11.4   ENERGY (EV) - GROUP BOUNDARY.           Groupie
          12-22     D11.4   TOTAL      (FIRST BAND)                 Groupie
          23-33     D11.4   ELASTIC                                 Groupie
          34-44     D11.4   CAPTURE                                 Groupie
          35-55     D11.4   FISSION                                 Groupie
   4       1-11     -----   BLANK                                   Groupie
          12-22     D11.4   TOTAL      (SECOND BAND)                Groupie
          23-33     D11.4   ELASTIC                                 Groupie
          34-44     D11.4   CAPTURE                                 Groupie
          35-55     D11.4   FISSION                                 Groupie
                                                                    Groupie
LINES 3 AND 4 ARE REPEATED FOR EACH GROUP. THE LAST LINE FOR EACH   Groupie
MATERIAL (ZA) IS,                                                   Groupie
                                                                    Groupie
   N       1-11     D11.4   ENERGY (EV) - UPPER ENERGY LIMIT OF     Groupie
                                          LAST GROUP.               Groupie
                                                                    Groupie
FOR EXAMPLE, A 175 GROUP, 2 BAND FILE, FOR EACH MATERIAL WILL       Groupie
CONTAIN 352 LINES = 1 HEADER LINE, 175 * 2 LINES OF PARAMETERS,     Groupie
                    AND 1 FINAL LINE WITH THE UPPER ENERGY LIMIT    Groupie
                    OF THE LAST GROUP.                              Groupie
                                                                    Groupie
INPUT FILES                                                         Groupie
-----------                                                         Groupie
UNIT  DESCRIPTION                                                   Groupie
----  -----------                                                   Groupie
  2   INPUT DATA (BCD - 80 CHARACTERS/RECORD)                       Groupie
 10   ORIGINAL ENDF/B DATA (BCD - 80 CHARACTERS/RECORD)             Groupie
                                                                    Groupie
OUTPUT FILES                                                        Groupie
------------                                                        Groupie
UNIT  DESCRIPTION                                                   Groupie
----  -----------                                                   Groupie
 31   MULTI-BAND PARAMETERS CHARACTER FILE - OPTIONAL               Groupie
      (BCD - 80 CHARACTERS/RECORD)                                  Groupie
 32   SELF-SHIELDED CROSS SECTION LISTING - OPTIONAL                Groupie
      (BCD - 120 CHARACTERS/RECORD)                                 Groupie
 33   MULTI-BAND PARAMETER LISTING - OPTIONAL                       Groupie
      (BCD - 120 CHARACTERS/RECORD)                                 Groupie
 34   UNSHIELDED CROSS SECTION LISTING - OPTION                     Groupie
      (BCD - 120 CHARACTERS/RECORD)                                 Groupie
  3   OUTPUT REPORT (BCD - 80 CHARACTERS/RECORD)                    Groupie
 11   MULTI-GROUP ENDF/B DATA - OPTIONAL                            Groupie
      (BCD - 80 CHARACTERS/RECORD)                                  Groupie
                                                                    Groupie
SCRATCH FILES                                                       Groupie
-------------                                                       Groupie
UNIT  FILENAME  DESCRIPTION                                         Groupie
----  --------  -----------                                         Groupie
  8   ENERGY DEPENDENT WEIGHTING SPECTRUM                           Groupie
      (BINARY - 40080 WORDS/BLOCK)                                  Groupie
  9   TOTAL CROSS SECTION                                           Groupie
      (BINARY - 40080 WORDS/BLOCK)                                  Groupie
 12   ELASTIC CROSS SECTION - ONLY FOR SELF-SHIELDING CALCULATION   Groupie
      (BINARY - 40080 WORDS/BLOCK)                                  Groupie
 13   CAPTURE CROSS SECTION - ONLY FOR SELF-SHIELDING CALCULATION   Groupie
      (BINARY - 40080 WORDS/BLOCK)                                  Groupie
 14   FISSION CROSS SECTION - ONLY FOR SELF-SHIELDING CALCULATION   Groupie
      (BINARY - 40080 WORDS/BLOCK)                                  Groupie
                                                                    Groupie
OPTIONAL STANDARD FILE NAMES (SEE SUBROUTINES FILIO1 AND FILIO2)    Groupie
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------------------------------------------------------------------   Groupie
UNIT  FILE NAME                                                      Groupie
----  ----------                                                     Groupie
  2   GROUPIE.INP                                                    Groupie
  3   GROUPIE.LST                                                    Groupie
  8   (SCRATCH)                                                      Groupie
  9   (SCRATCH)                                                      Groupie
 10   ENDFB.IN                                                       Groupie
 11   ENDFB.OUT                                                      Groupie
 12   (SCRATCH)                                                      Groupie
 13   (SCRATCH)                                                      Groupie
 14   (SCRATCH)                                                      Groupie
 31   MULTBAND.TAB                                                   Groupie
 32   SHIELD.LST                                                     Groupie
 33   MULTBAND.LST                                                   Groupie
 34   UNSHIELD.LST                                                   Groupie
                                                                     Groupie
 I/O UNITS USED                                                      Groupie
 --------------                                                      Groupie
 UNITS 2, 3 8, 9 AND 10 WILL ALWAYS BE USED.                         Groupie
 UNITS 31 THROUGH 34 AND 11 ARE OPTIONALLY USED DEPENDING ON THE     Groupie
 OUTPUT REQUESTED.                                                   Groupie
 UNITS 12, 13 AND 14 WILL ONLY BE USED IF SELF-SHIELDED OR           Groupie
 MULTIBAND OUTPUT IS REQUESTED.                                      Groupie
                                                                     Groupie
INPUT CARDS                                                          Groupie
-----------                                                          Groupie
CARD  COLS.  FORMAT  DESCRIPTION                                     Groupie
----  -----  ------  -----------                                     Groupie
  1    1-11    I11   SELECTION CRITERIA (0=MAT, 1=ZA)               Groupie
  1   12-22    I11   NUMBER OF GROUPS.                               Groupie
                     =.GT.0 - ARBITRARY GROUP BOUNDARIES ARE READ    Groupie
                              FROM INPUT FILE (N GROUPS REQUIRE      Groupie
                              N+1 GROUP BOUNDARIES). CURRENT         Groupie
                              PROGRAM MAXIMUM IS 1000 GROUPS.        Groupie
                              BUILT-IN OPTIONS INCLUDE....           Groupie
                     =  0   - TART    175 GROUPS                     Groupie
                     = -1   - ORNL     50 GROUPS                     Groupie
                     = -2   - ORNL    126 GROUPS                     Groupie
                     = -3   - ORNL    171 GROUPS                     Groupie

                     = -4   - SAND-II 620 (665) GROUPS TO 18 MEV     Groupie
                     = -5   - SAND-II 640 (685) GROUPS TO 20 MEV     Groupie
                     = -6   - WIMS     69 GROUPS                     Groupie
                     = -7   - GAM-I    68 GROUPS                     Groupie
                     = -8   - GAM-II   99 GROUPS                     Groupie
                     = -9   - MUFT     54 GROUPS                     Groupie
                     =-10   - ABBN     28 GROUPS                     Groupie
                     =-11   - TART    650 GROUPS                     Groupie
                     =-12   - TART    700 GROUPS                     Groupie
                     =-13   - SAND-II 665 GROUPS TO 18 MEV           Groupie
                     =-14   - SAND-II 685 GROUPS TO 20 MEV           Groupie
  1   23-33    I11   MULTI-BAND SELECTOR                             Groupie
                     =  0 - NO MULTI-BAND CALCULATIONS               Groupie
                     =  1 - 2 BAND. CONSERVE AV(TOT), AV(1/TOT)      Groupie
                            AND AV(1/TOT**2)                         Groupie
                     =  2 - 2 BAND. CONSERVE AV(TOT), AV(1/TOT)      Groupie
                            AND AV(1/(TOT+SIGMA0)) WHERE             Groupie
                            SIGMA0 = AV(TOT) IN EACH GROUP           Groupie
                     = 3-5- MULTI-BAND FIT. CONSERVE AV(TOT) AND     Groupie
                            MINIMIZE FRACTIONAL ERROR FOR ENTIRE     Groupie
                            SELF-SHIELDING CURVE (SIGMA0 = 0 TO      Groupie
                            INFINITY)                                Groupie
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                        IF THE SELECTOR IS POSITIVE (1 TO 5) THE      Groupie
                        MINIMUM NUMBER OF BANDS WILL BE OUTPUT FOR    Groupie
                        EACH ISOTOPE INDEPENDENTLY. IF THE SELECTOR   Groupie
                        IS NEGATIVE (-1 TO -5) THE SAME NUMBER OF     Groupie
                        BANDS (ABS(SELECTOR)) WILL BE OUTPUT FOR      Groupie
                        ALL ISOTOPES.                                 Groupie
      1   34-44    I11  NUMBER OF POINTS USED TO DESCRIBE ENERGY      Groupie
                        DEPENDENT WEIGHTING SPECTRUM S(E).            Groupie
                        = -2    - MAXWELLIAN - UP TO 0.1 EV           Groupie
                                  1/E        - 0.1 EV TO 67 KEV       Groupie
                                  FISSION    - ABOVE 67 KEV           Groupie
05/01/20----------------ADDED OPTION TO ALLOW TEMPERATURE OF THE      Groupie
                        MAXWELLIAN TO BE CHANGED - SEE INPUT LINE 4,  Groupie
                        COLUMNS 55 - 66.                              Groupie
                        = -1    - 1/E                                 Groupie
                        = 0 OR 1- ENERGY INDEPENDENT (SO CALLED FLAT  Groupie
                                  WEIGHTING SPECTRUM).                Groupie
                        = .GT.1 - READ THIS MANY POINTS FROM INPUT    Groupie
                                  TO DESCRIBE WEIGHTING SPECTRUM.     Groupie
                                  NO LIMIT TO THE NUMBER OF POINTS    Groupie
                                  USED TO DESCRIBE WEIGHTING.         Groupie
      1   45-55   D11.4  MULTI-BAND CONVERGENCE CRITERIA.              Groupie
                        ONLY USED FOR 3 OR MORE BANDS. THE NUMBER OF  Groupie
                        BANDS IN EACH GROUPS IS SELECTED TO INSURE    Groupie
                        THAT THE ENTIRE SELF-SHIELDING CURVE CAN BE   Groupie
                        REPRODUCED TO WITHIN THIS FRACTIONAL ERROR.    Groupie
                        = .LT. 0.0001 - USE STANDARD 0.001            Groupie
                                        (0.1 PER-CENT)                Groupie
                        = .GE. 0.0001 - USE AS CONVERGENCE CRITERIA   Groupie
      1   56-66    I11  SIGMA-0 DEFINITION SELECTOR.                  Groupie
                        < 0 - 21 VALUES OF SIGMA0 ARE READ INPUT AND  Groupie
                              INTERPRETED AS FIXED VALUES = SAME AS   Groupie
                              = 1 DESCRIPTION BELOW                   Groupie
                              INPUT VALUES MUST ALL BE,               Groupie
                              1) GREATER THAN 0                       Groupie
                              2) IN DESCENDING VALUE ORDER            Groupie
                        = 0 - SIGMA-0 WILL BE DEFINED AS A MULTIPLE   Groupie
                              OF THE UNSHIELDED TOTAL CROSS SECTION   Groupie
                              IN EACH GROUP (VALUES OF 1/1024 TO      Groupie
                              1024 IN STEPS OF A FACTOR OF 2 WILL     Groupie
                              BE USED AS THE MULTIPLIER).             Groupie
                        = 1 - SIGMA-0 WILL BE DEFINED AS THE SAME     Groupie
                              NUMBER OF BARNS IN EACH GROUP (VALUES   Groupie
                              40000 TO 0.4 BARNS WILL BE USED. WITHIN Groupie
                              EACH DECADE VALUES OF 10, 7, 4, 2, 1    Groupie
                              BARNS WILL BE USED).                    Groupie
    2-4    1-66 6D11.4  IF SIGMA-0 DEFINITION SELECTOR < 0, THE NEXT  Groupie
                        4 LINES OF INPUT ARE THE 22 VALUES OF SIGMA0, Groupie
                        6 PER LINE.                                   Groupie
      2    1-60    A60  ENDF/B INPUT DATA FILENAME                    Groupie
                        (STANDARD OPTION = ENDFB.IN)                  Groupie
      3    1-60    A60  ENDF/B OUTPUT DATA FILENAME                   Groupie
                        (STANDARD OPTION = ENDFB.OUT)                 Groupie
                                                                      Groupie
    THE FOURTH INPUT CARD IS USED TO SELECT ALL DESIRED OUTPUT MODES.  Groupie
    EACH OUTPUT DEVICE MAY BE TURNED OFF (0) OR ON (1). THEREFORE      Groupie
    THEREFORE EACH OF THE FOLLOWING INPUT PARAMETERS MAY BE EITHER     Groupie
    ZERO TO INDICATE NO OUTPUT OR NON-ZERO TO INDICATE OUTPUT.         Groupie
                                                                      Groupie
      4     1-11    I11  SELF-SHIELDED CROSS SECTION LISTING          Groupie
                        = 1 - CROSS SECTIONS                          Groupie
                        = 2 - RESONANCE INTEGRALS                     Groupie
      4    12-22    I11  MULTI-BAND PARAMETER LISTING                 Groupie
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       4    23-33   I11   MULTI-BAND PARAMETERS COMPUTER READABLE       Groupie
       4    34-44   I11   UNSHIELDED CROSS SECTIONS IN ENDF/B FORMAT    Groupie
                          = 1 - HISTOGRAM FORMAT (INTERPOLATION LAW 1)  Groupie
                          = 2 - LINEAR-LINEAR (INTERPOLATION LAW 2)     Groupie
       4    45-55   I11   UNSHIELDED CROSS SECTIONS LISTING             Groupie
                          = 1 - CROSS SECTIONS                          Groupie
                          = 2 - RESONANCE INTEGRALS                     Groupie
05/01/20 - ADDED THE BELOW OPTION                                       Groupie
       4    56-66   D11.4 IF THE STANDARD BUILT-IN SPECTRA IS USED,     Groupie
                          INPUT LINE 1, COLUMNS 34-44 = 2, THIS FIELD   Groupie
                          CAN BE USED TO OPTIONALLY CHANGE TEMPERATURE  Groupie
                          OF THE MAXWELLIAN.                            Groupie
                          INPUT IS IN EV (0.0253 EV = ROOM TEMPERATURE) Groupie
                          = 0 - USE DEFAULT 0.0253 EV, ROOM TEMPERATURE Groupie
                          > 0 - USE THIS AS THE TEMPERATURE             Groupie
                          RESTRICTION - TEMPERATURE CANNOT EXCEED       Groupie
                          1000 EV.                                      Groupie
                                                                        Groupie
       5     1-80   18A4  LIBRARY IDENTIFICATION. ANY TEXT THAT THE     Groupie
                          USER WISHES TO IDENTIFY THE MULTI-BAND        Groupie
                          PARAMETERS. THIS LIBRARY IDENTIFICATION IS    Groupie
                          WRITTEN INTO THE COMPUTER READABLE MULTI-BAND Groupie
                          DATA FILE.                                    Groupie
                                                                        Groupie
     6-N    1- 6    I6    LOWER MAT OR ZA LIMIT                         Groupie
            7- 8    I2    LOWER MF LIMIT                                Groupie
            9-11    I3    LOWER MT LIMIT                                Groupie
           12-17    I11   UPPER MAT OR ZA LIMIT                         Groupie
           18-19    I2    UPPER MF LIMIT                                Groupie
           20-22    I3    UPPER MT LIMIT                                Groupie
                          UP TO 100 RANGES MAY BE SPECIFIED, ONE RANGE  Groupie
                          PER LINE. THE LIST OF RANGES IS TERMINATED    Groupie
                          BY A BLANK CARD. IF THE UPPER MAT OR ZA       Groupie
                          LIMIT IS LESS THAN THE LOWER LIMIT THE UPPER  Groupie
                          IS SET EQUAL TO THE LOWER LIMIT. IF THE UPPER Groupie
                          MF OR MT LIMIT IS ZERO IT WILL BE SET EQUAL   Groupie
                          TO ITS MAXIMUM VALUE, 99 OR 999, RESPECTIVELY Groupie
                          IF THE FIRST REQUEST LINE IS BLANK IT WILL    Groupie
                          TERMINATE THE LIST OF REQUESTS AND CAUSE ALL  Groupie
                          DATA TO BE RETRIEVED (SEE EXAMPLE INPUT).     Groupie
                                                                        Groupie
     VARY   1-66  6D11.4 ENERGY GROUP BOUNDARIES. ONLY REQUIRED IF     Groupie
                          THE NUMBER OF GROUPS INDICATED ON THE FIRST   Groupie
                          INPUT CARD IS POSITIVE. ALL ENERGIES MUST     Groupie
                          BE IN ASCENDING ENERGY IN EV. THE PRESENT     Groupie
                          LIMITS ARE 1 TO 1000 GROUPS. FOR N GROUPS     Groupie
                          N+1 BOUNDARIES WILL BE READ FROM THE          Groupie
                          INPUT FILE, E.G. IF THE FIRST INPUT CARD      Groupie
                          INDICATES 20 GROUPS, 21 ENERGY BOUNDARIES     Groupie
                          WILL BE READ FROM THE INPUT FILE.             Groupie
                                                                        Groupie
     VARY   1-66  6D11.4 ENERGY DEPENDENT WEIGHTING SPECTRUM. ONLY     Groupie
                          REQUIRED IF THE NUMBER OF POINTS INDICATED    Groupie
                          ON FIRST CARD IS MORE THAN ONE. DATA IS       Groupie
                          GIVEN IN (ENERGY, WEIGHT) PAIRS, UP TO 3      Groupie
                          PAIRS PER CARD, USING ANY NUMBER OF CARDS     Groupie
                          REQUIRED. ENERGIES MUST BE IN ASCENDING       Groupie
                          ORDER IN EV. THE SPECTRUM VALUES MUST BE      Groupie
                          NON-NEGATIVE. THE ENERGY RANGE OF SPECTRUM    Groupie
                          MUST AT LEAST SPAN THE ENERGY RANGE OF THE    Groupie
                          ENERGY GROUPS. SINCE SPECTRUM IS STORED IN    Groupie
                          PAGING SYSTEM THERE IS NO LIMIT TO NUMBER     Groupie
                          OF POINTS THAT CAN BE USED TO DESCRIBE THE    Groupie
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                        WEIGHTING SPECTRUM.                                Groupie
                                                                           Groupie
    EXAMPLE INPUT NO. 1                                                    Groupie
    -------------------                                                    Groupie
    REQUEST DATA BY MAT AND PROCESS ALL DATA (ALL MAT BETWEEN 1 AND        Groupie
    9999). USE THE TART 175 GROUP STRUCTURE, GENERATE 2 BAND               Groupie
    PARAMETERS (THE FOR ALL ISOTOPES) TO 0.1 PER-CENT ACCURACY             Groupie
    IN THE SELF-SHIELDING CURVE. OUTPUT ALL  LISTING, COMPUTER             Groupie
    READABLE AND ENDF/B FORMAT GROUP AVERAGES.                             Groupie
                                                                           Groupie
    EXPLICITLY SPECIFY THE STANDARD FILENAMES.                             Groupie
                                                                           Groupie
    THE FOLLOWING 7 INPUT LINES ARE REQUIRED.                              Groupie
                                                                           Groupie
         0          0         -2          0 1.00000-03          0        Groupie
 ENDFB.IN                                                                  Groupie
 ENDFB.OUT                                                                 Groupie
         1          1          1          1          1                    Groupie
 TART 175 GROUP, 2 BAND LIBRARY TO 0.1 PER-CENT ACCURACY                   Groupie
    1 1  1  9999 0  0                                                      Groupie
                      (BLANK CARD TERMINATES REQUEST LIST)                 Groupie
                                                                           Groupie
    EXAMPLE INPUT NO. 2                                                    Groupie
    -------------------                                                    Groupie
    THE SAME EXAMPLE 1, AS ABOVE, ONLY THE ENDF/B DATA WILL BE READ        Groupie
    FROM \ENDFB6\SIGMA1\K300\ZA092238 (U-238 AT 300 KELVIN) AND            Groupie
    WRITTEN TO \ENDFB6\GROUPIE\K300\ZA092238                               Groupie
                                                                           Groupie
    THE FOLLOWING 7 INPUT LINES ARE REQUIRED.                              Groupie
                                                                           Groupie
         0          0         -2          0 1.00000-03          0        Groupie
 \ENDFB6\SIGMA1\K300\ZA092238                                              Groupie
 \ENDFB6\GROUPIE\K300\ZA092238                                             Groupie
         1          1          1          1          1                    Groupie
 TART 175 GROUP, 2 BAND LIBRARY TO 0.1 PER-CENT ACCURACY                   Groupie
    1 1  1  9999 0  0                                                      Groupie
                      (BLANK CARD TERMINATES REQUEST LIST)                 Groupie
                                                                           Groupie
    EXAMPLE INPUT NO. 3                                                    Groupie
    -------------------                                                    Groupie
    PROCESS ALL DATA. USE 1/V WEIGHTING IN ORDER TO CALCULATE              Groupie
    UNSHIELDED ONE GROUP CROSS SECTIONS OVER THE ENERGY RANGE 0.5 EV       Groupie
    TO 1 MEV (NOTE THAT THE RESULTS ARE SIMPLY PROPORTIONAL TO THE         Groupie
    RESONANCE INTEGRAL FOR EACH REACTION). OUTPUT UNSHIELDED LISTING.      Groupie
                                                                           Groupie
    LEAVE THE DEFINITION OF THE FILENAMES BLANK - THE PROGRAM WILL         Groupie
    THEN USE STANDARD FILENAMES.                                           Groupie
                                                                           Groupie
    THE FOLLOWING 7 INPUT CARDS ARE REQUIRED.                              Groupie
                                                                           Groupie
         0          0          1         -1                    0         Groupie
                      (USE STANDARD FILENAME = ENDFB.IN)                   Groupie
                      (USE STANDARD FILENAME = ENDFB.OUT)                  Groupie
         0          0          0          0          1                    Groupie
 RESONANCE INTEGRAL CALCULATION (FROM 0.5 EV TO 1 MEV)                     Groupie
                      (RETRIEVE ALL DATA, TERMINATE REQUEST LIST)          Groupie
 5.00000-01 1.00000+06                                                     Groupie
                                                                           Groupie
========================================================================== Groupie
```