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================================================================   GROUPIE
                                                                   GROUPIE
     PROGRAM GROUPIE                                               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
                                 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
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                          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
                          1.0D-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.        GROUPIE
                         *INCREASED PAGE SIZE FROM 120,000 TO      GROUPIE
                          600,000 POINTS                           GROUPIE
VERS. 2008-1 (JAN. 2008)   *72 CHARACTER FILE NAMES.               GROUPIE
                         *GENERAL UPDATES                          GROUPIE
VERS. 2010-1 (Apr. 2010)   *INCREASED WEIGHTING SPECTRUM TO 30,000 GROUPIE
                          FROM 3,000 ENERGY POINTS.                GROUPIE
                         *ADDED OUTPUT TO PLOT/COMPARE SHIELDED    GROUPIE
                          AND UNSHIELDED CROSS SECTIONS.           GROUPIE
VERS. 2011-1 (June 2011)   *Corrected TART 700 groups to extend up GROUPIE
                          to 1 GeV (1,000 MeV) - previously it     GROUPIE
                          was ERRONEOUSLY cutoff at 20 MeV.        GROUPIE
VERS. 2011-2 (Nov. 2011)   *Corrected TART 616 groups lowest       GROUPIE
                          energy from 1.0D-4 eV to 1.0D-5 eV.      GROUPIE
                         *Added TART 666 to 200 MeV (for TENDL).   GROUPIE
                         *Optional high energy cross section       GROUPIE
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                          extension above tabulated energy rangeGROUPIE
                          (either = 0 = standard, or constant)  GROUPIE
                          WARNING - ENDF/B standard convention  GROUPIE
                          is that the cross section = 0 where itGROUPIE
                          is not explicitly defined - extension GROUPIE
                          = 0 is standard, constant is NOT, so  GROUPIE
                          constant extension is NOT RECOMMENDED.GROUPIE
VERS. 2012-1 (Aug. 2012)  *Added CODENAME                       GROUPIE
                         *32 and 64 bit Compatible              GROUPIE
                         *Added ERROR stop.                     GROUPIE
VERS. 2013-1 (Nov. 2013)  *Extended OUT9.                       GROUPIE
                         *Uses OUTG, not OUT10 for energies.    GROUPIE
VERS. 2015-1 (Jan. 2015)  *Corrected SPECTM - handle ALL includedGROUPIE
                          group structures, i.e., even those    GROUPIE
                          that start above thremal range by     GROUPIE
                          ALWAYS constructing weigthing spectrumGROUPIE
                          to be AT LEAST 1.0D-5 eV to 20 MeV.   GROUPIE
                         *Extended OUTG                         GROUPIE
                         *Replaced ALL 3 way IF Statements.     GROUPIE
                         *Generalized TART Group Strructures.   GROUPIE
                         *Generalized SAND-II Group Structures. GROUPIE
                         *Extended SAND-II to 60, 150, 200 MeV. GROUPIE
VERS. 2015-2 (Mar. 2015)  *Deleted 1P from formats reading input GROUPIE
                          parameters, causing incorrect scaling GROUPIE
                         *Changed ALL data to "D" instead of    GROUPIE
                          "E" to insure it is REAL*8 and avoid  GROUPIE
                          Truncation ERRORS.                    GROUPIE
VERS. 2015-3 (July 2015)  *Insure no 10 digit output - not      GROUPIE
                          needed for multi-group and this makes GROUPIE
                          listings simpler.                     GROUPIE
                         *Corrected High Energy Extension =     GROUPIE
                          Can effect highest energy group.      GROUPIE
VERS. 2016-1 (July 2016)  *Added UKAEA 1102 Group Structure.    GROUPIE
                         *Increased storage to accommodate      GROUPIE
                          much larger group structures =        GROUPIE
                          up to 20,000 Groups.                  GROUPIE
                         *Added output listing of the complete  GROUPIE
                          input parameters for URRFIT, includingGROUPIE
                          the NJOY parameters LSSF and ICOMP.   GROUPIE
                         *Changed multiple IF statements to     GROUPIE
                          accommodate compiler optimizer        GROUPIE
                         *Cosmetic changes based on FREUD       GROUPIE
                          psychoanalysis.                       GROUPIE
                         *Updated multi-band treatment to       GROUPIE
                          explcitly handle small shielding      GROUPIE
                          limit - without this update the small GROUPIE
                          limit becomes numerically unstable.   GROUPIE
VERS. 2017-1 (May  2017)  *Increased max. points to 3,000,000.  GROUPIE
                         *METHODB was incorrecctly named        GROUPIE
                          METHOD  in one routine = corrected.   GROUPIE
                         *Default multi-band is method #2 =     GROUPIE
                          conserve <x>, <1/(x+<x>>, <1/x>.      GROUPIE
                         *Definition of built-in group structureGROUPIE
                          using SUBROUTINE GROPE is identical   GROUPIE
                          for GROUPIE and VIRGIN.               GROUPIE
                         *All floating input parameters changed GROUPIE
                          to character input + IN9 conversion.  GROUPIE
                         *Output report identfies MF now that   GROUPIE
                          this code does more than just MF=3.   GROUPIE
                         *Added NRO = energy dependent scatter  GROUPIE
                          radius to copying FILE2 parameters    GROUPIE
                          to define unresolved energy range.    GROUPIE
                         *Corrected energy dependent scatter    GROUPIE
                          for all resonance types (see, above   GROUPIE
                          comments) = for multi-band output     GROUPIE
VERS. 2018-1 (Jan. 2018)  *Added on-line output for ALL ENDERROR GROUPIE
VERS. 2019-1 (June 2019)  *Major re-write to re-order output to  GROUPIE
                          include Unresolved Resonance Region   GROUPIE
                          self-shielding.                       GROUPIE
                         *Added Unresolved self-shielding by    GROUPIE
                          Extrapolating cross section moments   GROUPIE
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                          from Resolved (supersedes URRDO and   GROUPIE
                          URRFIT codes).                        GROUPIE
                         *Added entire self-shielding array to  GROUPIE
                          memory - previously only one group    GROUPIE
                          results were in memory - saving ALL   GROUPIE
                          greatly simplifies the logic.         GROUPIE
                         *Additional Interpolation Law Tests    GROUPIE
                         *Check maximum Tabulated Energy of MTs GROUPIE
                          to insure they ALL end at the same    GROUPIE
                          energy.                               GROUPIE
                         *Multi-band = 1 no longer allowed.     GROUPIE
                          The only allowed values are,          GROUPIE
                          0 = no multi-band calculations, or,   GROUPIE
                          2 = Conserve 1/[total + <total>]      GROUPIE
                         *Unresolved Resonance Region           GROUPIE
                          Self-Shielding Requires all of these, GROUPIE
                          1) Unresolved data with ENDF input    GROUPIE
                          2) 616 TART Groups (input -11)        GROUPIE
                          3) Define Sigma0 standard (input = 0) GROUPIE
                         *Unresolved Resonance Region           GROUPIE
                          Self-Shielding Always Outputs,        GROUPIE
                          1) LSSF   = 0 = Output cross sections GROUPIE
                          2) INTUNR = 2 = Interpolation law     GROUPIE
                         *Added ZAzzzaaa to filenames.          GROUPIE
VERS. 2020-1 (Aug. 2020)  *Major re-write to update for new URR  GROUPIE
                          self-shielding, MF/MT=2/152 and 2/153.GROUPIE
                         *Corrected BOTH ends of unresolved     GROUPIE
                          for MF/MT=2/152 and 2/153 output.     GROUPIE
                         *Unresolved extrapolation ONLY to      GROUPIE
                          groups completely inside the URR +    GROUPIE
                          per ends for MF/MT=2/152 & 153 output.GROUPIE
                         *Small shielding < 0.1 % = accuracy    GROUPIE
                          of reconstructed data.                GROUPIE
                         *Forced no self-shielding at upper end GROUPIE
                          of unresolved = match high energy     GROUPIE
                          tabulated.                            GROUPIE
                         *Corrected PLOTTAB output if no URR    GROUPIE
                          fit - it was outputting EMPTY tables  GROUPIE
                          for original and fit moments, which   GROUPIE
                          in this case did not exist.           GROUPIE
                         *Only 2 band, Method#2 [sigt + <sigt>] GROUPIE
                          alloed for multi-band calculation.    GROUPIE
                         *WARNING - if input Requested MF range GROUPIE
                          prevents unresolved region calculationGROUPIE
                         *Added Target Isomer Flag              GROUPIE
                         *Correct MULTBAND.LST output format.   GROUPIE
VERS. 2021-1 (Jan. 2021)  *Updated for FORTRAN 2018              GROUPIE
                                                                GROUPIE
2020-1 Acknowledgment                                           GROUPIE
=====================                                           GROUPIE
I Thank Jean-Christophe Sublet (NDS, IAEA, Vienna, Austria) for GROUPIE
reporting the ERROR in GROUPIE (2019-1) that led to the update in GROUPIE
GROUPIE (2020-1) to correctly define the PLOTTAB output, whether GROUPIE
or not Unresolved Resonance Region (URR) fit was performed.     GROUPIE
                                                                GROUPIE
2015-2 Acknowledgment                                           GROUPIE
=====================                                           GROUPIE
I thank Chuck Whitmer (TerraPower,WA) and Andrej Trkov (NDS,IAEA) GROUPIE
for reporting the errors that led to the 2015-2 Improvements in GROUPIE
this code.                                                      GROUPIE
                                                                GROUPIE
I thank Jean-Christophe Sublet (UKAEA) for contributing MAC     GROUPIE
executables and Bojan Zefran (IJS, Slovenia) for contributing   GROUPIE
LINUX (32 or 63 bit) executables. And most of all I must thank  GROUPIE
Andrej Trkov (NDS, IAEA) for overseeing the entire PREPRO project GROUPIE
at IAEA, Vienna. This was a truly International team who worked GROUPIE
together to produce PREPRO 2015-2.                              GROUPIE
                                                                GROUPIE
OWNED, MAINTAINED AND DISTRIBUTED BY                            GROUPIE
-----------------------------------                             GROUPIE
THE NUCLEAR DATA SECTION                                        GROUPIE
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INTERNATIONAL ATOMIC ENERGY AGENCY
P.O. BOX 100
A-1400, VIENNA, AUSTRIA
EUROPE

ORIGINALLY WRITTEN BY
Dermott E. Cullen

PRESENT CONTACT INFORMATION
Dermott E. Cullen
1466 Hudson Way
Livermore, CA 94550
U.S.A.
Telephone 925-443-1911
E. Mail   RedCullen1@Comcast.net
Website   RedCullen1.net/HOMEPAGE.NEW

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).

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IF THIS PROGRAM FINDS THAT THE FILE 3 CROSS SECTIONS ARE NOT      GROUPIE
LINEARLY INTERPOLABLE THIS PROGRAM WILL TERMINATE EXECUTION.      GROUPIE
                                                                  GROUPIE
CONTENTS OF OUTPUT                                                GROUPIE
------------------                                                GROUPIE
IF ENDF/B FORMATTED OUTPUT IS REQUESTED ENTIRE EVALUATIONS ARE    GROUPIE
OUTPUT, NOT JUST THE MULTI-GROUPED FILE 3 CROSS SECTIONS, E.G.    GROUPIE
ANGULAR AND ENERGY DISTRIBUTIONS ARE ALSO INCLUDED.               GROUPIE
                                                                  GROUPIE
DOCUMENTATION                                                     GROUPIE
-------------                                                     GROUPIE
THE FACT THAT THIS PROGRAM HAS OPERATED ON THE DATA IS DOCUMENTED GROUPIE
BY THE ADDITION OF THREE COMMENT CARDS AT THE END OF EACH         GROUPIE
HOLLERITH SECTION TO DESCRIBE THE GROUP STRUCTURE AND WEIGHTING   GROUPIE
SPECTRUM, E.G.                                                    GROUPIE
                                                                  GROUPIE
********************** PROGRAM GROUPIE (2021-1) ***************   GROUPIE
UNSHIELDED GROUP AVERAGES USING   69 GROUPS (WIMS)                GROUPIE
MAXWELLIAN, 1/E, FISSION TO CONSTANT WEIGHTING SPECTRUM           GROUPIE
                                                                  GROUPIE
THE ORDER OF ALL SIMILAR COMMENTS (FROM LINEAR, RECENT AND SIGMA1)GROUPIE
REPRESENTS A COMPLETE HISTORY OF ALL OPERATIONS PERFORMED ON      GROUPIE
THE DATA.                                                         GROUPIE
                                                                  GROUPIE
THESE COMMENT CARDS ARE ONLY ADDED TO EXISTING HOLLERITH SECTIONS,GROUPIE
I.E., THIS PROGRAM WILL NOT CREATE A HOLLERITH SECTION. THE FORMATGROUPIE
OF THE HOLLERITH SECTION IN ENDF/B-V DIFFERS FROM THE THAT OF     GROUPIE
EARLIER VERSIONS OF ENDF/B. BY READING AN EXISTING MF=1, MT=451   GROUPIE
IT IS POSSIBLE FOR THIS PROGRAM TO DETERMINE WHICH VERSION OF     GROUPIE
THE ENDF/B FORMAT THE DATA IS IN. WITHOUT HAVING A SECTION OF     GROUPIE
MF=1, MT=451 PRESENT IT IS IMPOSSIBLE FOR THIS PROGRAM TO         GROUPIE
DETERMINE WHICH VERSION OF THE ENDF/B FORMAT THE DATA IS IN, AND  GROUPIE
AS SUCH IT IS IMPOSSIBLE FOR THE PROGRAM TO DETERMINE WHAT FORMAT GROUPIE
SHOULD BE USED TO CREATE A HOLLERITH SECTION.                     GROUPIE
                                                                  GROUPIE
REACTION INDEX                                                    GROUPIE
--------------                                                    GROUPIE
THIS PROGRAM DOES NOT USE THE REACTION INDEX WHICH IS GIVEN IN    GROUPIE
SECTION MF=1, MT=451 OF EACH EVALUATION.                          GROUPIE
                                                                  GROUPIE
THIS PROGRAM DOES NOT UPDATE THE REACTION INDEX IN MF=1, MT=451.  GROUPIE
THIS CONVENTION HAS BEEN ADOPTED BECAUSE MOST USERS DO NOT        GROUPIE
REQUIRE A CORRECT REACTION INDEX FOR THEIR APPLICATIONS AND IT WASGROUPIE
NOT CONSIDERED WORTHWHILE TO INCLUDE THE OVERHEAD OF CONSTRUCTING GROUPIE
A CORRECT REACTION INDEX IN THIS PROGRAM. HOWEVER, IF YOU REQUIRE GROUPIE
A REACTION INDEX FOR YOUR APPLICATIONS, AFTER RUNNING THIS PROGRAMGROUPIE
YOU MAY USE PROGRAM DICTIN TO CREATE A CORRECT REACTION INDEX.    GROUPIE
                                                                  GROUPIE
SECTION SIZE                                                      GROUPIE
------------                                                      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
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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 20,000.             GROUPIE
                                                                  GROUPIE
THE USER MAY INPUT AN ARBITRARY GROUP STRUCTURE OR THE USER MAY   GROUPIE
USE USE ONE OF THE 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) 616 GROUP (TART STRUCTURE TO 20 MeV)                         GROUPIE
(12) 700 GROUP (TART STRUCTURE TO 1 GEV)                          GROUPIE
(13) 665 GROUP (SAND-II STRUCTURE, 1.0D-5 eV, UP TO 18 MEV)       GROUPIE
(14) 685 GROUP (SAND-II STRUCTURE, 1.0D-5 eV, UP TO 20 MEV)       GROUPIE
(15) 666 GROUP (TART STRUCTURE TO 200 MeV)                        GROUPIE
(16) 725 GROUP (SAND-II STRUCTURE, 1.0D-5 eV, UP TO  60 MEV)      GROUPIE
(17) 755 GROUP (SAND-II STRUCTURE, 1.0D-5 eV, UP TO 150 MEV)      GROUPIE
(18) 765 GROUP (SAND-II STRUCTURE, 1.0D-5 eV, UP TO 200 MEV)      GROUPIE
(19)1102 GROUP (UKAEA   STRUCTURE, 1.0D-5 eV, UP TO   1 GeV)      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
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 REPRESENTATIONGROUPIE
OF THE SPECTRUM BETWEEN TABULATED DATA POINTS.                    GROUPIE
                                                                  GROUPIE
THE PRESENT VERSION OF THE CODE HAS THREE BUILT-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)) (67 KeV, 10 MeV)  GROUPIE
    CONSTANT   = Equal to Fission at 10 MeV     (above 10 MeV)    GROUPIE
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                                                                    GROUPIE
    KT     = 0.253 EV (293 KELVIN)                                  GROUPIE
    WA     = 9.65D+5                                                GROUPIE
    WB     = 2.29D-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 20,000 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 20,000 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 WITHINGROUPIE
            THAT GROUP OR POWERS OF 10 - INPUT OPTION).             GROUPIE
N         - A POSITIVE INTEGER (0, 1, 2 OR 3).                      GROUPIE
                                                                    GROUPIE
THE PROGRAM WILL USE ONE ENERGY DEPENDENT WEIGHTING SPECTRUM S(E)   GROUPIE
AND 25 DIFFERENT BONDERENKO TYPE SELF-SHIELDING FACTORS (25 SIGMA0GROUPIE
AND N COMBINATIONS) TO DEFINE 25 DIFFERENT AVERAGE CROSS SECTIONS,GROUPIE
FOR EACH REACTION, WITHIN EACH GROUP.                               GROUPIE
                                                                    GROUPIE
THE 25 WEIGHTING FUNCTIONS USED ARE....                             GROUPIE
(1)    - UNSHIELDED CROSS SECTIONS (N=0)                            GROUPIE
(2-22)- PARTIALLY SHIELDED CROSS SECTIONS (N=1 ,VARIOUS SIGMA0)     GROUPIE
         THE VALUES OF SIGMA0 USED WILL BE EITHER,                  GROUPIE
         (A) THE VALUES OF SIGMA0 THAT ARE USED VARY FROM 1024      GROUPIE
         TIMES THE UNSHIELDED TOTAL CROSS SECTIONS IN STEPS OF 1/2  GROUPIE
         DOWN TO 1/1024 TIMES THE UNSHIELDED TOTAL CROSS SECTION    GROUPIE
         (A RANGE OF OVER 1 MILLION, CENTERED ON THE UNSHIELDED     GROUPIE
         TOTAL CROSS SECTION WITHIN EACH GROUP).                    GROUPIE
         (B) THE SAME CONSTANT VALUES OF SIGMA0 IN EACH GROUP. THE  GROUPIE
         VALUES OF SIGMA0 USED INCLUDE 40000, 20000, 10000, 7000,   GROUPIE
         4000, 2000, 1000, 700, 400, 200, 100, 70, 40, 20, 10, 7,   GROUPIE
         4, 2, 1, 0.7, 0.4 (A RANGE OF 100,000 SPANNING MORE THAN   GROUPIE
         THE RANGE OF SIGMA0 VALUES THAT MAY BE ENCOUNTERED IN      GROUPIE
         ACTUAL APPLICATIONS)                                       GROUPIE
(23)   - TOTALLY SHIELDED FLUX WEIGHTED CROSS SECTION               GROUPIE
         (N=1, SIGMA0=0)                                            GROUPIE
(24)   - TOTALLY SHIELDED CURRENT WEIGHTED CROSS SECTION            GROUPIE
         (N=2, SIGMA0=0)                                            GROUPIE
(25)   - TOTALLY SHIELDED COSINE SQUARED WEIGHTED CROSS SECTION     GROUPIE
         (N=3, SIGMA0=0)                                            GROUPIE
                                                                    GROUPIE
FOR ALL OTHER REACTIONS (EXCEPT TOTAL, ELASTIC, CAPTURE AND         GROUPIE
FISSION) THE PROGRAM WILL USE THE ENERGY DEPENDENT WEIGHTING        GROUPIE
SPECTRUM S(E) TO DEFINE THE UNSHIELDED (BONDERENKO N=0)             GROUPIE
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AVERAGED CROSS SECTION WITHIN EACH GROUP.                                GROUPIE
                                                                         GROUPIE
CALCULATION OF RESONANCE INTEGRALS                                       GROUPIE
---------------------------------                                        GROUPIE
IN A PURE ELASTIC ISOTROPICALLY SCATTERING MATERIAL WITH A               GROUPIE
CONSTANT CROSS SECTION THE SPECTRUM WILL BE 1/E AND THERE WILL           GROUPIE
BE NO SELF-SHIELDING.                                                    GROUPIE
                                                                         GROUPIE
IN THIS CASE IF THE CROSS SECTION VARIES WITH ENERGY THE                 GROUPIE
SPECTRUM WILL STILL BE 1/E AND THE SELF-SHIELDING FACTOR WILL            GROUPIE
BE EXACTLY 1/SIG-TOT(E) - WHERE SIG-TOT(E) = SIG-EL(E), SINCE            GROUPIE
THERE IS ONLY SCATTERING.                                                GROUPIE
                                                                         GROUPIE
IF WE HAVE AN INFINITELY DILUTE AMOUNT OF A MATERIAL UNIFORMLY           GROUPIE
MIXED WITH A PURE ELASTIC ISOTROPICALLY SCATTERING MATERIAL WITH         GROUPIE
A CONSTANT CROSS SECTION THE STANDARD DEFINITION OF THE RESONANCE        GROUPIE
INTEGRAL CAN BE USED TO DEFINE REACTION RATES FOR EACH REACTION.         GROUPIE
                                                                         GROUPIE
THE RESONANCE INTEGRAL IS DEFINED AS,                                    GROUPIE
                                                                         GROUPIE
RI      = (INTEGRAL E1 TO E2) (SIGMA(E)*S(E)*WT(E)*DE)                   GROUPIE
                                                                         GROUPIE
WHERE NORMALLY,                                                          GROUPIE
S(E)    = 1/E                                                            GROUPIE
WT(E)   = 1    - NO SELF-SHIELDING                                       GROUPIE
                                                                         GROUPIE
FROM THE ABOVE DEFINITION OF GROUP AVERAGED CROSS SECTIONS THE           GROUPIE
RESONANCE INTEGRAL IS,                                                   GROUPIE
                                                                         GROUPIE
RI      = AVERAGE * (INTEGRAL E1 TO E2) (S(E)*WT(E)*DE)                  GROUPIE
                                                                         GROUPIE
FOR A 1/E SPECTRUM AND NO SELF-SHIELDING THIS REDUCES TO,                GROUPIE
                                                                         GROUPIE
RI      = AVERAGE* LOG(E2/E1)                                            GROUPIE
                                                                         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
                                                                         GROUPIE
HERE WE WILL NOT ATTEMPT TO PERFORM A DETAILED SPECTRUM                   GROUPIE
CALCULATION TO ACCOUNT FOR ABSORPTION.                                   GROUPIE
                                                                         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
                                                                         GROUPIE
RI      = AVERAGE* LOG(E2/E1)                                            GROUPIE
                                                                         GROUPIE
IN ORDER TO CALCULATE RESONANCE INTEGRALS YOU MUST FOLLOW THESE          GROUPIE
STEPS,                                                                   GROUPIE
                                                                         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
                                                                         GROUPIE
WHEN THIS OPTION IS USED THE PROGRAM WILL CALCULATE GROUP AVERAGEDGROUPIE
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
                                                                         GROUPIE
LOG(E2/E1) - WHERE E2 AND E1 ARE THE GROUP ENERGY BOUNDARIES.            GROUPIE
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                                                                      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
                                                                      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
                                                                      GROUPIE
       RESONANCE INTEGRAL OUTPUT CAN ONLY BE OBTAINED IN THE          GROUPIE
       LISTING FORMATS.                                               GROUPIE
                                                                      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         GROUPIE
IGNORED.                                                              GROUPIE
                                                                      GROUPIE
NOTE, FOR THE UNSHIELDED CALCULATIONS ALL CROSS SECTIONS WILL BE      GROUPIE
CONSIDERED WHETHER THEY ARE POSITIVE OR NEGATIVE. THEREFORE IF        GROUPIE
THE TOTAL CROSS SECTION IS NEGATIVE OR LESS THAN THE MINIMUM          GROUPIE
VALUE THERE MAY BE AN INCONSISTENCY BETWEEN THE UNSHIELDED AND        GROUPIE
THE SELF-SHIELDED CROSS SECTIONS. IF THE TOTAL CROSS SECTION IS       GROUPIE
NEGATIVE AND SELF-SHIELDED CROSS SECTIONS ARE CALCULATED THE          GROUPIE
PROGRAM WILL PRINT AN ERROR MESSAGE INDICATING THAT THE SELF-         GROUPIE
SHIELDED RESULTS ARE UNRELIABLE AND SHOULD NOT BE USED. THEREFORE     GROUPIE
IN THIS CASE THE PROGRAM WILL NOT ATTEMPT TO MODIFY THE UNSHIELDEDGROUPIE
RESULTS TO ELIMINATE THE EFFECT OF NEGATIVE CROSS SECTIONS, SINCE     GROUPIE
THE UNSHIELDED RESULTS ARE THE ONLY ONES WHICH TRULY REFLECT THE      GROUPIE
ACTUAL INPUT.                                                         GROUPIE
                                                                      GROUPIE
RESOLVED RESONANCE REGION                                             GROUPIE
-------------------------                                             GROUPIE
IN THE RESOLVED RESONANCE REGION (ACTUALLY EVERYWHERE BUT IN THE      GROUPIE
UNRESOLVED RESONANCE REGION) THE CROSS SECTIONS OUTPUT BY LINEAR-     GROUPIE
RECENT-SIGMA1 WILL BE ACTUAL ENERGY DEPENDENT CROSS SECTIONS AND      GROUPIE
THE CALCULATIONS BY THIS PROGRAM WILL YIELD ACTUAL SHIELDED AND       GROUPIE
UNSHIELDED CROSS SECTIONS.                                            GROUPIE
                                                                      GROUPIE
UNRESOLVED RESONANCE REGION                                           GROUPIE
---------------------------                                           GROUPIE
IN THE UNRESOLVED RESONANCE REGION PROGRAM RECENT USES THE            GROUPIE
UNRESOLVED RESONANCE PARAMETERS TO CALCULATE INFINITELY DILUTE        GROUPIE
AVERAGE CROSS SECTIONS. THIS PROGRAM WILL MERELY READ THIS            GROUPIE
INFINITELY DILUTE DATA AS IF IT WERE ENERGY DEPENDENT DATA AND        GROUPIE
GROUP AVERAGE IT. AS SUCH THIS PROGRAM WILL PRODUCE THE CORRECT       GROUPIE
UNSHIELDED CROSS SECTION IN THE UNRESOLVED RESONANCE REGION, BUT      GROUPIE
IT WILL NOT PRODUCE THE CORRECT SELF-SHIELDING EFFECTS.               GROUPIE
                                                                      GROUPIE
ACCURACY OF RESULTS                                                   GROUPIE
-------------------                                                   GROUPIE
ALL INTEGRALS ARE PERFORMED ANALYTICALLY. THEREFORE NO ERROR IS       GROUPIE
INTRODUCED DUE TO THE USE OF TRAPAZOIDAL OR OTHER INTEGRATION         GROUPIE
SCHEME. THE TOTAL ERROR THAT CAN BE ASSIGNED TO THE RESULTING         GROUPIE
AVERAGES IS JUST THAT DUE TO THE ERROR IN THE CROSS SECTIONS          GROUPIE
AND ENERGY DEPENDENT WEIGHTING SPECTRUM. GENERALLY SINCE THE          GROUPIE
THE ENERGY DEPENDENT WEIGHTING SPECTRUM APPEARS IN BOTH THE           GROUPIE
NUMERATOR AND THE DENOMINATOR THE AVERAGES RAPIDLY BECOME             GROUPIE
INSENSITIVE TO THE WEIGHTING SPECTRUM AS MORE GROUPS ARE USED.        GROUPIE
SINCE THE WEIGHTING SPECTRUM IS LOADED IN THE PAGING SYSTEM THE       GROUPIE
USER CAN DESCRIBE THE SPECTRUM TO ANY REQUIRED ACCURACY USING         GROUPIE
ANY NUMBER OF ENERGY VS. SPECTRUM PAIRS.                              GROUPIE
                                                                      GROUPIE
MULTI-BAND PARAMETERS                                                 GROUPIE
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MULTI-BAND PARAMETERS ARE CALCULATED FOR THE TOTAL, ELASTIC,         GROUPIE
CAPTURE AND FISSION REACTIONS. WITH THE NUMBER OF GROUPS THAT        GROUPIE
ARE NORMALLY USED (SEE BUILT IN GROUP STRUCTURES) ALL OTHER          GROUPIE
REACTIONS RESULT IN A NEGLIGABLE AMOUNT OF SELF-SHIELDING. AS        GROUPIE
SUCH THEIR EQUIVALENT BAND CROSS SECTION WILL MERELY BE THEIR        GROUPIE
UNSHIELDED VALUE WITHIN EACH BAND.                                   GROUPIE
                                                                     GROUPIE
FOR ANY GIVEN EVALUATION, WITHIN ANY GIVEN GROUP THIS PROGRAM        GROUPIE
WILL GENERATE THE MINIMUM NUMBER OF BANDS REQUIRED WITHIN THAT       GROUPIE
GROUP. AS OUTPUT TO THE COMPUTER READABLE DISK FILE THE BAND         GROUPIE
PARAMETERS FOR EACH EVALUATION WILL BE FORMATTED TO HAVE THE         GROUPIE
SAME NUMBER OF BANDS IN ALL GROUPS (WITH ZERO WEIGHT FOR SOME        GROUPIE
BANDS WITHIN ANY GROUP). THE USER MAY DECIDE TO HAVE OUTPUT          GROUPIE
EITHER WITH THE MINIMUM NUMBER OF BANDS REQUIRED FOR EACH            GROUPIE
EVALUATION (E.G. 2 BANDS FOR HYDROGEN AND 4 BANDS FOR U-233) OR      GROUPIE
THE SAME NUMBER OF BANDS FOR ALL EVALUATIONS (E.G. 4 BANDS FOR       GROUPIE
BOTH HYDROGEN AND U-233).                                            GROUPIE
                                                                     GROUPIE
FOR 2 OR FEWER BANDS THE PROGRAM USES AN ANALYTIC EXPRESSION         GROUPIE
TO DEFINE ALL MULTI-BAND PARAMETERS. FOR MORE THAN 2 BANDS THE       GROUPIE
PROGRAM PERFORMS A NON-LINEAR FIT TO SELECT THE MULTI-BAND           GROUPIE
PARAMETERS THAT MINIMIZE THE MAXIMUM FRACTIONAL ERROR AT ANY         GROUPIE
POINT ALONG THE ENTIRE SELF-SHIELDING CURVE. THE NUMBER OF BANDS     GROUPIE
REQUIRED WITHIN ANY GIVEN GROUP IS DEFINED BY INSURING THAT THE      GROUPIE
MULTI-BAND PARAMETERS CAN BE USED TO ACCURATELY DEFINE SELF-         GROUPIE
SHIELDED CROSS SECTIONS ALONG THE ENTIRE SELF-SHIELDING CURVE        GROUPIE
FROM SIGMA0 = 0 TO INFINITY. THE USER MAY DEFINE THE ACCURACY        GROUPIE
REQUIRED.                                                            GROUPIE
                                                                     GROUPIE
ENDF/B FORMATTED UNSHIELDED AVERAGES                                 GROUPIE
-----------------------------------                                  GROUPIE
UNSHIELDED MULTI-GROUP AVERAGED CROSS SECTIONS FOR ALL REACTIONS     GROUPIE
MAY BE OBTAINED IN THE ENDF/B FORTRAN IN EITHER HISTOGRAM            GROUPIE
(INTERPOLATION LAW 1) OR LINEARLY INTERPOLABLE (INTERPOLATION        GROUPIE
LAW 2) FORM. SEE INPUT BELOW FOR DETAILS.                            GROUPIE
                                                                     GROUPIE
MIXTURES OF MATERIALS AND RESONANCE OVERLAP                          GROUPIE
-------------------------------------------                          GROUPIE
THE SELF-SHIELDED CROSS SECTIONS FOR THE INDIVIDUAL CONSTITUENTS     GROUPIE
OF ANY MIXTURE CAN BE CALCULATED BY THIS PROGRAM BY REALIZING THATGROUPIE
THIS PROGRAM ESSENTIALLY ONLY USES THE TOTAL CROSS SECTION AS A      GROUPIE
WEIGHTING FUNCTION TO ACCOUNT FOR SELF-SHIELDING EFFECTS. FOR A      GROUPIE
MIXTURE IT IS THEREFORE ONLY NECESSARY TO USE THE TOTAL CROSS        GROUPIE
SECTION FOR THE MIXTURE IN PLACE OF THE ACTUAL TOTAL CROSS SECTIONGROUPIE
FOR EACH CONSTITUENT AND TO RUN THIS PROGRAM. THIS CAN BE DONE BY GROUPIE
FIRST RUNNING PROGRAM MIXER TO CALCULATE THE ENERGY DEPENDENT        GROUPIE
TOTAL CROSS SECTION FOR ANY COMPOSITE MIXTURE. NEXT, SUBSTITUTE      GROUPIE
THIS COMPOSITE TOTAL CROSS SECTION FOR THE ACTUAL TOTAL CROSS        GROUPIE
SECTION OF EACH CONSTITUENT (IN EACH ENDF/B FORMATTED EVALUATION).GROUPIE
FINALLY, RUN THIS PROGRAM TO CALCULATE THE SELF-SHIELDED CROSS       GROUPIE
SECTION FOR EACH CONSTITUENT, PROPERLY ACCOUNTING FOR RESONANCE      GROUPIE
OVERLAP BETWEEN THE RESONANCES OF ALL OF THE CONSTITUENTS OF THE     GROUPIE
MIXTURE. DURING THE SAME RUN THESE SELF-SHIELDED CROSS SECTIONS      GROUPIE
CAN IN TURN BE USED TO CALCULATE FULLY CORRELATED MULT-BAND          GROUPIE
                                                                     GROUPIE
MULTI-BAND PARAMETER OUTPUT FORMAT                                   GROUPIE
---------------------------------                                    GROUPIE
FOR VERSIONS 92-2 AND LATER VERSIONS THE MULTI-BAND PARAMETERS       GROUPIE
ARE OUTPUT IN A SIMPLE CHARACTER FORMAT, THAT CAN BE TRANSFERRED     GROUPIE
AND USED ON VIRTUALLY ANY COMPUTER.                                  GROUPIE
                                                                     GROUPIE
THE BINARY FORMAT USED IN EARLIER VERSIONS OF THIS CODE IS NO        GROUPIE
LONGER USED.                                                         GROUPIE
                                                                     GROUPIE
CONTACT THE AUTHOR IF YOU WOULD LIKE TO RECEIVE A SIMPLE PROGRAM     GROUPIE
TO READ THE CHARACTER FORMATTED MULTI-BAND PARAMETER FILE AND        GROUPIE
CREATE A BINARY, RANDOM ACCESS FILE FOR USE ON VIRTUALLY ANY         GROUPIE
COMPUTER.                                                            GROUPIE
                                                                     GROUPIE
THE FORMAT OF THE CHARACTER FILE IS,                                 GROUPIE
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                                                                    GROUPIE
RECORD   COLUMNS   FORMAT   DESCRIPTION                             GROUPIE
   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
          34-44     E11.4   TEMPERATURE (KELVIN)                    GROUPIE
          45-57    1X,12A1  HOLLERITH DESCRIPTION OF ZA             GROUPIE
   3       1-11     E11.4   ENERGY (EV) - GROUP BOUNDARY.           GROUPIE
          12-22     E11.4   TOTAL      (FIRST BAND)                 GROUPIE
          23-33     E11.4   ELASTIC                                 GROUPIE
          34-44     E11.4   CAPTURE                                 GROUPIE
          35-55     E11.4   FISSION                                 GROUPIE
   4       1-11     -----   BLANK                                   GROUPIE
          12-22     E11.4   TOTAL      (SECOND BAND)                GROUPIE
          23-33     E11.4   ELASTIC                                 GROUPIE
          34-44     E11.4   CAPTURE                                 GROUPIE
          35-55     E11.4   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     E11.4   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
  3   OUTPUT REPORT (BCD - 80 CHARACTERS/RECORD)                    GROUPIE
 11   MULTI-GROUP ENDF/B DATA - OPTIONAL                            GROUPIE
      (BCD - 80 CHARACTERS/RECORD)                                  GROUPIE
 16   PLOTTAB FORMATTED SELF-SHIELDING RESULTS                      GROUPIE
      (BCD - 80 CHARACTERS/RECORD)                                  GROUPIE
 31   MULTI-BAND PARAMETERS CHARACTER FILE - OPTIONAL               GROUPIE
      (BCD - 80 CHARACTERS/RECORD)                                  GROUPIE
 32   UNRESOLVED FSELF-SHIELDED PSEUDO ENDF FORMAT - OPTIONAL       GROUPIE
      (BCD - 120 CHARACTERS/RECORD)                                 GROUPIE
 33   SELF-SHIELDED CROSS SECTION LISTING - OPTIONAL                GROUPIE
      (BCD - 120 CHARACTERS/RECORD)                                 GROUPIE
 34   MULTI-BAND PARAMETER LISTING - OPTIONAL                       GROUPIE
      (BCD - 120 CHARACTERS/RECORD)                                 GROUPIE
 35   UNSHIELDED CROSS SECTION LISTING - OPTION                     GROUPIE
      (BCD - 120 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
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                                                                      GROUPIE
     OPTIONAL STANDARD FILE NAMES (SEE SUBROUTINES FILIO1 AND FILIO2) GROUPIE
     ------------------------------------------------------------     GROUPIE
     UNIT  FILE NAME                                                  GROUPIE
     ----  ----------                                                 GROUPIE
       2   GROUPIE.INP                                                GROUPIE
       3   GROUPIE.LST                                                GROUPIE
----------------------                                                GROUPIE
       8   (SCRATCH)                                                  GROUPIE
       9   (SCRATCH)                                                  GROUPIE
      10   ENDFB.IN                                                   GROUPIE
      11   ENDFB.OUT                                                  GROUPIE
      12   (SCRATCH)                                                  GROUPIE
      13   (SCRATCH)                                                  GROUPIE
      14   (SCRATCH)                                                  GROUPIE
-----2019/6/23 - New Filenames (added ZAzzzaaa at Beginning)----------GROUPIE
----------(OLD)-------------(NEW)-------------------------------------GROUPIE
      16   PLOTTAB.CUR      ZAzzzaaa.PLOT.CUR                         GROUPIE
      31   MULTBAND.TAB     ZAzzzaaa.MULTBAND.TAB                     GROUPIE
      32                    ZAzzzaaa.URR.ENDF                         GROUPIE
      33   SHIELD.LST       ZAzzzaaa.SHIELD.LST                       GROUPIE
      34   MULTBAND.LST     ZAzzzaaa.MULTBAND.LST                     GROUPIE
      35   UNSHIELD.LST     ZAzzzaaa.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 35, 11 AND 16 ARE OPTIONALLY USED DEPENDING    GROUPIE
      ON THE 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
--------------------------2019/6/23 -11 (TART 616 groups) required for GROUPIE
                          Unresolved Resonance Region Self-Shielding  GROUPIE
                          calculation.                                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 20,000 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
    Current TART Standard =-11   - TART    616 GROUPS TO 20 MEV       GROUPIE
    (-11 is required for  =-12   - TART    700 GROUPS TO 1 GEV        GROUPIE
     unresolved resonance =-13   - SAND-II 665 GROUPS TO 18 MEV       GROUPIE
     region self-shielding=-14   - SAND-II 685 GROUPS TO 20 MEV       GROUPIE
     calculations)        =-15   - TART    666 GROUPS TO 200 MEV      GROUPIE
                          =-16   - SAND-II 725 GROUPS TO 60 MEV       GROUPIE
                          =-17   - SAND-II 755 GROUPS TO 150 MEV      GROUPIE
                          =-18   - SAND-II 765 GROUPS TO 200 MEV      GROUPIE
                          =-19   - UKAEA  1102 GROUPS TO   1 GeV      GROUPIE
       1   23-33    I11   MULTI-BAND SELECTOR                        GROUPIE
--------------------------2019/6/23 - ONLY 0 or 2 allowed = the = 1   GROUPIE
                          option has proven to give very poor results, GROUPIE
                          and therefore is no longer allowed.         GROUPIE
                          =  0 - NO MULTI-BAND CALCULATIONS           GROUPIE
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      No longer allowed   =  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
      No longer allowed   = 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
                          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
                          = 0 or 1 - Flat (Constant)                  GROUPIE
                          = -1     - 1/E at ALL energies              GROUPIE
                          = -2     - MAXWELLIAN - UP TO 0.1 eV        GROUPIE
                                     1/E        - 0.1 eV TO 67 KeV    GROUPIE
                                     FISSION    - 67 KeV to 10 MeV    GROUPIE
                                     CONSTANT   - Above 10 MeV        GROUPIE
                          = > 1    - Read input table                 GROUPIE
 2005/01/20---------------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   E11.4  MULTI-BAND CONVERGENCE CRITERIA.             GROUPIE
--------------------------2019/6/23 - No longer used now that code    GROUPIE
                          is restricted to no more than 2 bands.      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
--------------------------2019/6/23 - For multi-band calculations     GROUPIE
                          only 0 is alllowed = mulriples of unshielded GROUPIE
                          total in each group = This is required for  GROUPIE
                          the BEST self-shielding results.            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. WITHINGROUPIE
                                EACH DECADE VALUES OF 10, 7, 4, 2, 1  GROUPIE
                                BARNS WILL BE USED).                  GROUPIE
       1   67-70    I4    High energy extension = definition of cross GROUPIE
                          section above highest tabulated energy.     GROUPIE
--------------------------2019/6/23 - Ignored - will always use ENDF  GROUPIE
                          Standard Definition = 0.                    GROUPIE
                          = 0 = cross section = 0 (standard ENDF/B)   GROUPIE
                          = 1 = cross section = constant (equal to    GROUPIE
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                              value at highest tabulated energy).    GROUPIE
     2-4    1-66 6E11.4   SIGMA-0 Definition                         GROUPIE
--------------------------2019/6/23 - Only the GROUPIE standard = 0  GROUPIE
                           in allowed for Unresolved Resonance Region GROUPIE
                           Self-Shielding calculation                 GROUPIE
                           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    1-72    A72   ENDF/B INPUT DATA FILENAME                 GROUPIE
                           (STANDARD OPTION = ENDFB.IN)               GROUPIE
       3    1-72    A72   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
       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   E11.4 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 TEMPERATUREGROUPIE
                           > 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-BANDGROUPIE
                           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 UPPERGROUPIE
                           MF OR MT LIMIT IS ZERO IT WILL BE SET EQUAL GROUPIE
                           TO ITS MAXIMUM VALUE, 99 OR 999, RESPECTIVELYGROUPIE
                           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  6E11.4 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 20,000 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
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                        WILL BE READ FROM THE INPUT FILE.            GROUPIE
                                                                     GROUPIE
     VARY   1-66  6E11.4 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
                        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/E 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
```

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                                                                      GROUPIE
    EXAMPLE INPUT NO. 4                                               GROUPIE
    ------------------                                                GROUPIE
    THIS EXAMPLE USES A USER DEFINED GROUP STRUCTURE AND WEIGHTING    GROUPIE
    FUNCTION - THESE ARE NOT REALISTIC IN TERMS OF ACTUAL ENERGIES    GROUPIE
    AND WEIGHTS - THEY ARE ONLY INTENDED TO ILLUSTRATE THE ORDER OF   GROUPIE
    THE INPUT PARAMETERS.                                             GROUPIE
                                                                      GROUPIE
         0         11          0          6                    0     GROUPIE
RECENT.OUT                                                            GROUPIE
GROUPIE.OUT                                                           GROUPIE
         1          1          1          1          1                GROUPIE
Example with users defined groupus and spectrum weighting             GROUPIE
    1 1  1  999999999                                                 GROUPIE
                      (blabk line terminates request list)            GROUPIE
1.00000-05 1.00000-04 1.00000-03 1.00000-02 1.00000-01 1.00000+00 grouGROUPIE
1.00000+01 1.00000+02 1.00000+03 1.00000+04 1.00000+05 1.00000+06 grouGROUPIE
1.00000-05 1.0        1.00000-02 0.1        1.00000+00 0.01       weigGROUPIE
1.00000+02 0.001      1.00000+04 0.0001     1.00000+06 0.000001   weigGROUPIE
                                                                      GROUPIE
======================================================================GROUPIE
```