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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
                                 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
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                          *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
                                                                  Groupie
OWNED, MAINTAINED AND DISTRIBUTED BY                              Groupie
-----------------------------------                               Groupie
THE NUCLEAR DATA SECTION                                          Groupie
INTERNATIONAL ATOMIC ENERGY AGENCY                                Groupie
P.O. BOX 100                                                      Groupie
A-1400, VIENNA, AUSTRIA                                           Groupie
EUROPE                                                            Groupie
                                                                  Groupie
ORIGINALLY WRITTEN BY                                             Groupie
-----------------------------------                               Groupie
DERMOTT E. CULLEN                                                 Groupie
UNIVERSITY OF CALIFORNIA                                          Groupie
LAWRENCE LIVERMORE NATIONAL LABORATORY                            Groupie
L-159                                                             Groupie
P.O. BOX 808                                                      Groupie
LIVERMORE, CA 94550                                               Groupie
U.S.A.                                                            Groupie
TELEPHONE  925-423-7359                                           Groupie
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E. MAIL    CULLEN1@LLNL.GOV                                          Groupie
WEBSITE    HTTP://WWW.LLNL.GOV/CULLEN1                               Groupie
                                                                     Groupie
AUTHORS MESSAGE                                                      Groupie
--------------                                                       Groupie
THE REPORT DESCRIBED ABOVE IS THE LATEST PUBLISHED DOCUMENTATION     Groupie
FOR THIS PROGRAM. HOWEVER, THE COMMENTS BELOW SHOULD BE CONSIDERED   Groupie
THE LATEST DOCUMENTATION INCLUDING ALL RECENT IMPROVEMENTS. PLEASE   Groupie
READ ALL OF THESE COMMENTS BEFORE IMPLEMENTATION, PARTICULARLY       Groupie
THE COMMENTS CONCERNING MACHINE DEPENDENT CODING.                    Groupie
                                                                     Groupie
AT THE PRESENT TIME WE ARE ATTEMPTING TO DEVELOP A SET OF COMPUTER   Groupie
INDEPENDENT PROGRAMS THAT CAN EASILY BE IMPLEMENTED ON ANY ONE       Groupie
OF A WIDE VARIETY OF COMPUTERS. IN ORDER TO ASSIST IN THIS PROJECT   Groupie
IT WOULD BE APPECIATED IF YOU WOULD NOTIFY THE AUTHOR OF ANY         Groupie
COMPILER DIAGNOSTICS, OPERATING PROBLEMS OR SUGGESTIONS ON HOW TO    Groupie
IMPROVE THIS PROGRAM. HOPEFULLY, IN THIS WAY FUTURE VERSIONS OF      Groupie
THIS PROGRAM WILL BE COMPLETELY COMPATIBLE FOR USE ON YOUR           Groupie
COMPUTER.                                                            Groupie
                                                                     Groupie
PURPOSE                                                              Groupie
-------                                                              Groupie
THIS PROGRAM IS DESIGNED TO CALCULATE ANY COMBINATION OF             Groupie
THE FOLLOWING QUANTITIES FROM LINEARLY INTERPOLABLE TABULATED        Groupie
CROSS SECTIONS IN THE ENDF/B FORMAT                                  Groupie
                                                                     Groupie
(1) UNSHIELDED GROUP AVERAGED CROSS SECTIONS                         Groupie
(2) BONDARENKO SELF-SHIELDED GROUP AVERAGED CROSS SECTIONS           Groupie
(3) MULTI-BAND PARAMETERS                                            Groupie
                                                                     Groupie
IN THE FOLLOWING FOR SIMPLICITY THE ENDF/B TERMINOLOGY--ENDF/B       Groupie
TAPE--WILL BE USED. IN FACT THE ACTUAL MEDIUM MAY BE TAPE, CARDS,    Groupie
DISK OR ANY OTHER MEDIUM.                                            Groupie
                                                                     Groupie
ENDF/B FORMAT                                                        Groupie
-------------                                                        Groupie
THIS PROGRAM ONLY USES THE ENDF/B BCD OR CARD IMAGE FORMAT (AS       Groupie
OPPOSED TO THE BINARY FORMAT) AND CAN HANDLE DATA IN ANY VERSION     Groupie
OF THE ENDF/B FORMAT (I.E., ENDF/B-I, II,III, IV OR V FORMAT).       Groupie
                                                                     Groupie
IT IS ASSUMED THAT THE DATA IS CORRECTLY CODED IN THE ENDF/B         Groupie
FORMAT AND NO ERROR CHECKING IS PERFORMED. IN PARTICULAR IT IS       Groupie
ASSUMED THAT THE MAT, MF AND MT ON EACH CARD IS CORRECT. SEQUENCE    Groupie
NUMBERS (COLUMNS 76-80) ARE IGNORED ON INPUT, BUT WILL BE            Groupie
CORRECTLY OUTPUT ON ALL CARDS. THE FORMAT OF SECTION MF=1, MT=451    Groupie
AND ALL SECTIONS OF MF= 3 MUST BE CORRECT. THE PROGRAM COPIES ALL    Groupie
OTHER SECTION OF DATA AS HOLLERITH AND AS SUCH IS INSENSITIVE TO     Groupie
THE CORRECTNESS OR INCORRECTNESS OF ALL OTHER SECTIONS.               Groupie
                                                                     Groupie
ALL FILE 3 CROSS SECTIONS THAT ARE USED BY THIS PROGRAM MUST BE      Groupie
LINEARLY INTERPOLABLE IN ENERGY AND CROSS SECTION (ENDF/B            Groupie
INTERPOLATION LAW 2). FILE 3 BACKGROUND CROSS SECTIONS MAY BE MADE   Groupie
LINEARLY INTERPOLABLE USING PROGRAM LINEAR (UCRL-50400, VOL. 17,     Groupie
PART A). THE RESONANCE CONTRIBUTION MAY BE ADDED TO THE BACKGROUND   Groupie
CROSS SECTIONS USING PROGRAM RECENT (UCRL-50400, VOL. 17, PART B).   Groupie
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
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********************** PROGRAM GROUPIE (2004-1) ***************    Groupie
UNSHIELDED GROUP AVERAGES USING   69 GROUPS (WIMS)                 Groupie
MAXWELLIAN, 1/E AND FISSION 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 FORMAT Groupie
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 WAS Groupie
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 PROGRAM Groupie
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
-----------                                                        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
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 (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
 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
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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
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 SIGMA0 Groupie
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
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
```

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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 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
                                                                     Groupie
LOG(E2/E1) - WHERE E2 AND E1 ARE THE GROUP ENERGY BOUNDARIES.        Groupie
                                                                     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
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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 UNSHIELDED Groupie
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
---------------------                                              Groupie
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
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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 THAT Groupie
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 SECTION Groupie
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
                                                                   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     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
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   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
---------------------------------------------------------------   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
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                                                                    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
                     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
                     = -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
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                    = 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
  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
                                                                  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
                        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
```