**==================================================================== 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**

 **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 CHANGEGROUPIE**

 **\*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 SECTIONGROUPIE**

 **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 30,000GROUPIE**

 **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 upGROUPIE**

 **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**

 **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**

 **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**

 **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**

 **GROUPIE**

 **PRESENT CONTACT INFORMATION GROUPIE**

 **--------------------------- GROUPIE**

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 **GROUPIE**

 **AUTHORS MESSAGE GROUPIE**

 **--------------- GROUPIE**

 **THE REPORT DESCRIBED ABOVE IS THE LATEST PUBLISHED DOCUMENTATION GROUPIE**

 **FOR THIS PROGRAM. HOWEVER, THE COMMENTS BELOW SHOULD BE CONSIDEREDGROUPIE**

 **THE LATEST DOCUMENTATION INCLUDING ALL RECENT IMPROVEMENTS. PLEASEGROUPIE**

 **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 COMPUTERGROUPIE**

 **INDEPENDENT PROGRAMS THAT CAN EASILY BE IMPLEMENTED ON ANY ONE GROUPIE**

 **OF A WIDE VARIETY OF COMPUTERS. IN ORDER TO ASSIST IN THIS PROJECTGROUPIE**

 **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 MADEGROUPIE**

 **LINEARLY INTERPOLABLE USING PROGRAM LINEAR (UCRL-50400, VOL. 17, GROUPIE**

 **PART A). THE RESONANCE CONTRIBUTION MAY BE ADDED TO THE BACKGROUNDGROUPIE**

 **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**

 **\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\* 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**

 **----------- 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 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**

 **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**

 **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**

 **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**

 **--------------------- 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**

 **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**

 **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**

 **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**

 **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**

 **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**

 **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**

 **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**