**=======================================================================SIGMA1**

**SIGMA1**

**PROGRAM SIGMA1 SIGMA1**

**============== SIGMA1**

**VERSION 73-1 (MARCH 1973) SIGMA1**

**VERSION 76-1 (FEBRUARY 1976) SIGMA1**

**VERSION 76-2 (OCTOBER 1976) SIGMA1**

**VERSION 77-1 (JANUARY 1977) SIGMA1**

**VERSION 78-1 (JULY 1978) SIGMA1**

**VERSION 79-1 (JULY 1979) CDC-7600 AND CRAY-1 VERSION. SIGMA1**

**VERSION 80-1 (MAY 1980) IBM, CDC AND CRAY VERSION SIGMA1**

**VERSION 80-2 (DECEMBER 1980)IMPROVED BASED ON USER COMMENTS. SIGMA1**

**VERSION 81-1 (MARCH 1981) DOUBLE PRECISION IBM VERSION SIGMA1**

**VERSION 81-2 (AUGUST 1981) IMPROVED IBM SPEED AND STABILITY SIGMA1**

**VERSION 82-1 (JANUARY 1982) IMPROVED COMPUTER COMPATIBILITY SIGMA1**

**VERSION 83-1 (JANUARY 1983)\*MAJOR RE-DESIGN. SIGMA1**

**\*PAGE SIZE INCREASED - 1002 TO 2004. SIGMA1**

**\*ELIMINATED COMPUTER DEPENDENT CODING. SIGMA1**

**\*NEW, MORE COMPATIBLE I/O UNIT NUMBER. SIGMA1**

**\*ADDED STANDARD ALLOWABLE ERROR OPTION SIGMA1**

**(CURRENTLY 0.1 PER-CENT). SIGMA1**

**\*UNRESOLVED RESONANCE REGION COPIED. SIGMA1**

**\*1/V EXTENSION OF CROSS SECTIONS SIGMA1**

**OUTSIDE OF TABULATED ENERGY RANGE AND SIGMA1**

**INTO UNRESOLVED ENERGY RANGE. SIGMA1**

**VERSION 83-2 (OCTOBER 1983)\*IMPROVED BASED ON USER COMMENTS. SIGMA1**

**VERSION 84-1 (APRIL 1984) \*IMPROVED NUMERICAL STABILITY. SIGMA1**

**\*PARTIAL EVALUATION TREATMENT. SIGMA1**

**VERSION 85-1 (APRIL 1985) \*ITERATE TO CONVERGENCE (USING THE SAMESIGMA1**

**ENERGY GRID FOR HOT CROSS SECTION AS SIGMA1**

**COLD CROSS SECTIONS WAS FOUND TO BE SIGMA1**

**INACCURATE). SIGMA1**

**\*NEW FASTER HIGH ENERGY BROADENING. SIGMA1**

**\*UPDATED FOR ENDF/B-6 FORMATS. SIGMA1**

**\*SPECIAL I/O ROUTINES TO GUARANTEE SIGMA1**

**ACCURACY OF ENERGY. SIGMA1**

**\*DOUBLE PRECISION TREATMENT OF ENERGY SIGMA1**

**(REQUIRED FOR NARROW RESONANCES). SIGMA1**

**VERSION 85-2 (AUGUST 1985) \*FORTRAN-77/H VERSION SIGMA1**

**VERSION 86-1 (JANUARY 1986)\*ENERGY DEPENDENT SCATTERING RADIUS SIGMA1**

**VERSION 88-1 (JULY 1988) \*OPTION...INTERNALLY DEFINE ALL I/O SIGMA1**

**FILE NAMES (SEE, SUBROUTINE FILEIO SIGMA1**

**FOR DETAILS). SIGMA1**

**\*IMPROVED BASED ON USER COMMENTS. SIGMA1**

**VERSION 89-1 (JANUARY 1989)\*PSYCHOANALYZED BY PROGRAM FREUD TO SIGMA1**

**INSURE PROGRAM WILL NOT DO ANYTHING SIGMA1**

**CRAZY. SIGMA1**

**\*UPDATED TO USE NEW PROGRAM CONVERT SIGMA1**

**KEYWORDS. SIGMA1**

**\*ADDED LIVERMORE CIVIC COMPILER SIGMA1**

**CONVENTIONS. SIGMA1**

**VERSION 90-1 (JUNE 1990) \*UPDATED BASED ON USER COMMENTS SIGMA1**

**\*ADDED FORTRAN SAVE OPTION SIGMA1**

**\*NEW MORE CONSISTENT ENERGY OUTPUT SIGMA1**

**ROUTINES SIGMA1**

**VERSION 91-1 (JULY 1991) \*WARNING...INPUT PARAMETER FORMAT SIGMA1**

**HAS BEEN CHANGED - SEE BELOW FOR SIGMA1**

**DETAILS. SIGMA1**

**\*ADDED CHARGED PARTICLE PROJECTILES SIGMA1**

**\*OUTPUT ENERGY RANGE IS ALWAYS AT SIGMA1**

**LEAST AS LARGE AS INPUT ENERGY RANGE. SIGMA1**

**\*NO 1/V EXTENSION OF CROSS SECTIONS SIGMA1**

**FROM UNRESOLVED ENERGY RANGE. SIGMA1**

**VERSION 92-1 (JANUARY 1992)\*INSURE MINIMUM AND MAXIMUM CROSS SIGMA1**

**SECTIONS ARE ALWAYS KEPT (NOT THINNED)SIGMA1**

**\*MT=19 (FIRST CHANCE FISSION) TREATED SIGMA1**

**THE SAME AS FISSION. SIGMA1**

**\*VARIABLE MINIMUM CROSS SECTION OF SIGMA1**

**INTEREST - TO ALLOW SMALL CROSS SIGMA1**

**SECTIONS NEAR THRESHOLDS TO BE SIGMA1**

**TREATED PROPERLY. SIGMA1**

**\*ALL ENERGIES INTERNALLY ROUNDED PRIOR SIGMA1**

**TO CALCULATIONS. SIGMA1**

**\*COMPLETELY CONSISTENT I/O AND ROUNDINGSIGMA1**

**ROUTINES - TO MINIMIZE COMPUTER SIGMA1**

**DEPENDENCE. SIGMA1**

**VERSION 92-2 (JULY 1992) \*CORRECTED BUG ASSOCIATED WITH SIGMA1**

**THRESHOLD REACTIONS. SIGMA1**

**\*UNRESOLVED REGION COPIED WITHOUT SIGMA1**

**THINNING (IT SHOULD BE EXACTLY THE SIGMA1**

**SAME AT ALL TEMPERATURES). SIGMA1**

**\*NO THINNING OF REACTIONS (MT) THAT SIGMA1**

**WERE NOT BROADENED. SIGMA1**

**VERSION 93-1 (APRIL 1993) \*INCREASED PAGE SIZE FROM 2004 SIGMA1**

**TO 24000 ENERGY PONTS. SIGMA1**

**VERSION 94-1 (JANUARY 1994)\*VARIABLE ENDF/B DATA FILENAMES SIGMA1**

**TO ALLOW ACCESS TO FILE STRUCTURES SIGMA1**

**(WARNING - INPUT PARAMETER FORMAT SIGMA1**

**HAS BEEN CHANGED) SIGMA1**

**\*CLOSE ALL FILES BEFORE TERMINATING SIGMA1**

**(SEE, SUBROUTINE ENDIT) SIGMA1**

**VERSION 96-1 (JANUARY 1996) \*COMPLETE RE-WRITE SIGMA1**

**\*IMPROVED COMPUTER INDEPENDENCE SIGMA1**

**\*ALL DOUBLE PRECISION SIGMA1**

**\*ON SCREEN OUTPUT SIGMA1**

**\*UNIFORM TREATMENT OF ENDF/B I/O SIGMA1**

**\*IMPROVED OUTPUT PRECISION SIGMA1**

**\*DEFINED SCRATCH FILE NAMES SIGMA1**

**\*ALWAYS INCLUDE THERMAL VALUE SIGMA1**

**VERSION 97-1 (APRIL 1997) \*OPTIONALLY SET NEGATIVE CROSS SIGMA1**

**SECTIONS = 0 ON INPUT AND SIGMA1**

**OUTPUT. SIGMA1**

**\*INCREASED PAGE SIZE FROM 24000 SIGMA1**

**TO 60000 ENERGY POINTS. SIGMA1**

**VERSION 99-1 (MARCH 1999) \*CORRECTED CHARACTER TO FLOATING SIGMA1**

**POINT READ FOR MORE DIGITS SIGMA1**

**\*UPDATED TEST FOR ENDF/B FORMAT SIGMA1**

**VERSION BASED ON RECENT FORMAT CHANGESIGMA1**

**\*TREAT LOW ENERGY INITIAL CROSS SIGMA1**

**SECTIONS AS LOG-LOG INTERPOLABLE SIGMA1**

**\*CONSTANT (RATHER THAN 1/V) EXTENSION SIGMA1**

**TO HIGHER ENERGY. SIGMA1**

**\*UPDATED CONSTANTS BASED ON CSEWG SIGMA1**

**SUBCOMMITTEE RECOMMENDATIONS SIGMA1**

**\*GENERAL IMPROVEMENTS BASED ON SIGMA1**

**USER FEEDBACK SIGMA1**

**VERSION 99-2 (JUNE 1999) \*EXTENDED RANGE OF INTEGRALS FROM 4 SIGMA1**

**TO 5 UNITS ON EACH SIDE OF ENERGY SIGMA1**

**POINT TO ALLOW FOR LARGER VARIATION SIGMA1**

**IN THE LOCAL CROSS SECTION SIGMA1**

**\*ASSUME ENDF/B-6, NOT 5, IF MISSING SIGMA1**

**MF=1, MT-451. SIGMA1**

**VERSION 99-3 (OCTOBER 1999))\*IMPROVED ERFC FUNCTION DEFINITION. SIGMA1**

**I THANK BOB MACFARLANE (LANL) FOR SIGMA1**

**SUPPLYING A MORE ACCURATE ERFC SIGMA1**

**FUNCTION. SIGMA1**

**VERS. 2000-1 (FEBRUARY 2000)\*CORRECTED LOW ENERGY INTERPOLATION SIGMA1**

**FOR NON-POSITIVE CROSS SECTIONS SIGMA1**

**\*GENERAL IMPROVEMENTS BASED ON SIGMA1**

**USER FEEDBACK SIGMA1**

**VERS. 2002-1 (MAY 2002) \*OPTIONAL INPUT PARAMETERS SIGMA1**

**VERS. 2004-1 (JAN. 2004) \*OPTIONALLY IGNORE UNRESOLVED REGION SIGMA1**

**\*CORRECTED PROBLEM AT THE RESOLVED/ SIGMA1**

**UNRESOLVED ENERGY BOUNDARY. SIGMA1**

**\*CORRECTED HIGH ENERGY CONSTANT CROSS SIGMA1**

**SECTION EXTENSION. SIGMA1**

**\*TIGHTER CRITERIA FOR INITIAL ENERGY SIGMA1**

**POINT SPACING SIGMA1**

**\*TEMPERATURE DEPENDENT ENERGY POINT SIGMA1**

**SPACING. SIGMA1**

**\*ADDED NEW REICH-MOORE (LRF=7) TO SIGMA1**

**FILE2 TO ALLOW COPY TO FIND ANY SIGMA1**

**FOLLOWING UNRESOLVED PARAMETERS SIGMA1**

**VERS. 2005-1 (JUNE 2005) \*CORRECTED ERROR IN EHOT3 EQUIVALENCE SIGMA1**

**TO EHOT - THIS ONLY EFFECTS VERY BIG SIGMA1**

**OUTPUT FILES. SIGMA1**

**VERS. 2007-1 (JAN. 2007) \*CHECKED AGAINST ALL ENDF/B-6. SIGMA1**

**\*INCREASED PAGE SIZE FROM 60,000 SIGMA1**

**TO 360,000 ENERGY POINTS. SIGMA1**

**VERS. 2008-1 (APRIL 2008) \*1/2 INITIAL ENERGY POINT SPACING SIGMA1**

**\*72 CHARACTER FILE NAMES. SIGMA1**

**VERS. 2010-1 (Apr. 2010) \*ASSUME LOW ENERGY LOG-LOG VARIATION SIGMA1**

**UP TO 1/A (eV) FOR ALL BUT TOTAL AND SIGMA1**

**ELASTIC. SIGMA1**

**\*CHANGED DEFAULT UNCERTAINTY TO 0.01% SIGMA1**

**FROM 0.1% SIGMA1**

**\*ALLOW MULTIPLE, ADJACENT UNRESOLVED SIGMA1**

**RESONANCE REGIONS = COMBINE INTO ONE SIGMA1**

**LARGER ENERGY RANGE TO COPY. SIGMA1**

**\*DO NOT BROADEN SECTIONS THAT START SIGMA1**

**ABOVE 1 MILLION KT - PREVIOUSLY IT SIGMA1**

**WAS ASSUMED TOTAL, ELASTIC, CAPTURE SIGMA1**

**AND FISSION, AND LARGE SECTIONS (OVERSIGMA1**

**10,000 ENERGY POINTS) WOULD BROADEN. SIGMA1**

**VERS. 2012-1 (Aug. 2012) \*CHANGE COPY CRITERIA TO HANDLE NEW SIGMA1**

**(N,N') DATA = THRESHOLD MAY BE VERY SIGMA1**

**HIGH (OLD CRITERIA) BUT INCLUDES MANYSIGMA1**

**TABULATED ENERGY POINTS (NEW ADDED SIGMA1**

**CRITERIA). SIGMA1**

**\*ADDED STOP IF INCIDENT PARTICLE DATA SIGMA1**

**CANNOT BE DOPPLER BROADENED, E.G., SIGMA1**

**PHOTON INCIDENT. SIGMA1**

**\*Added CODENAME SIGMA1**

**\*32 and 64 bit Compatible SIGMA1**

**\*Added ERROR stop SIGMA1**

**VERS. 2013-1 (Nov. 2013) \*Added NO broadening above 10 MeV - SIGMA1**

**this is to handle newer evaluations SIGMA1**

**that extend to higher energies and SIGMA1**

**may do "strange" things to stop one SIGMA1**

**MT and then include it as part of SIGMA1**

**a sum at higher energies, e.g. this SIGMA1**

**change will copy ALL points above SIGMA1**

**10 MeV, thus avoiding problems near SIGMA1**

**transistion energies at 20. 30, etc. SIGMA1**

**MeV or higher energies. SIGMA1**

**VERS. 2015-1 (Jan. 2015) \*Replaced ALL 3 way IF Statements. SIGMA1**

**\*Replaced ALL LOGICAL by INTEGER. SIGMA1**

**\*Extended OUT9. SIGMA1**

**VERS. 2017-1 (May 2017) \*For MF=2 only use MT=151 = Defines SIGMA1**

**Unresolved Resonance Region (URR). SIGMA1**

**Ignore - NJOY created MT=152 and 153.SIGMA1**

**\*Increased page size to 1,2000,000. SIGMA1**

**\*All floating input parameters changedSIGMA1**

**to character input + IN9 conversion. SIGMA1**

**\*Added NRO = energy dependent scatter SIGMA1**

**radius to copying FILE2 parameters SIGMA1**

**to define unresolved energy range. SIGMA1**

**\*Corrected energy dependent scatteringSIGMA1**

**radius for all resonance types (see, SIGMA1**

**the above comments). SIGMA1**

**VERS. 2018-1 (Nov. 2018) \*Added on-line report for ALL ENDERRORSIGMA1**

**VERS. 2019-1 (June 2019) \*Terminate if MF=3 Point Count and SIGMA1**

**Interpolation Law do not agree. SIGMA1**

**\*Terminate if MF=3 Background SIGMA1**

**Interpolation is NOT Linear. SIGMA1**

**\*Terminate if MF/MT=1/451 Input SIGMA1**

**temperature exceeds requested SIGMA1**

**Temperature - otherwise the output SIGMA1**

**by this code to MF=3 would appear SIGMA1**

**to be at the WRONG temperature. SIGMA1**

**\*Additional Interpolation Law Tests SIGMA1**

**\*Check consistency of Maximum SIGMA1**

**Tabulated cross sections for ALL MT SIGMA1**

**processed - print WQARNING if NOT SIGMA1**

**the same for ALL MTs. SIGMA1**

**VERS. 2020-1 (Dec. 2020) \*Complete Re-write of convergence SIGMA1**

**\*Replaced INCORE9 by INCORE10. SIGMA1**

**\*Updated minimum/maximum convergence SIGMA1**

**procedure. SIGMA1**

**\*Added Target Isomer State SIGMA1**

**\*Check Atomic Weight > 0 SIGMA1**

**VERS. 2021-1 (Mar. 2021) \*Updated for FORTRAN 2018 SIGMA1**

**\*Minimum Cross Section is no longer SIGMA1**

**an input option - set to 1.0d-30. SIGMA1**

**VERS. 2023-1 (Feb. 2023) \*Decreased page size from 1,200,000 SIGMA1**

**to 120,000. SIGMA1**

**SIGMA1**

**OWNED, MAINTAINED AND DISTRIBUTED BY SIGMA1**

**------------------------------------ SIGMA1**

**THE NUCLEAR DATA SECTION SIGMA1**

**INTERNATIONAL ATOMIC ENERGY AGENCY SIGMA1**

**P.O. BOX 100 SIGMA1**

**A-1400, VIENNA, AUSTRIA SIGMA1**

**EUROPE SIGMA1**

**SIGMA1**

**ORIGINALLY WRITTEN BY SIGMA1**

**------------------------------------ SIGMA1**

**Dermott E. Cullen SIGMA1**

**SIGMA1**

**PRESENT CONTACT INFORMATION SIGMA1**

**--------------------------- SIGMA1**

**Dermott E. Cullen SIGMA1**

**1466 Hudson Way SIGMA1**

**Livermore, CA 94550 SIGMA1**

**U.S.A. SIGMA1**

**Telephone 925-443-1911 SIGMA1**

**E. Mail RedCullen1@Comcast.net SIGMA1**

**Website RedCullen1.nedt/HOMEPAGE.NEW SIGMA1**

**SIGMA1**

**Acknowledgement 2004 SIGMA1**

**-------------------- SIGMA1**

**Currently almost all improvements to this code are based upon SIGMA1**

**feedback from code users who report problems. This feedback SIGMA1**

**benefits ALL users of this code, and ALL users are encouraged SIGMA1**

**to report problems. SIGMA1**

**SIGMA1**

**Improvements on the 2004 version of this code based on user SIGMA1**

**feedback including, SIGMA1**

**1) Bret Beck - reported a problem at the resolved/unresolved SIGMA1**

**energy boundary. SIGMA1**

**2) S. Ganesan - reported a problem for small temperature changes. SIGMA1**

**SIGMA1**

**AUTHORS MESSAGE SIGMA1**

**--------------- SIGMA1**

**THE REPORT DESCRIBED ABOVE IS THE LATEST PUBLISHED DOCUMENTATION SIGMA1**

**FOR THIS PROGRAM. HOWEVER, THE COMMENTS BELOW SHOULD BE CONSIDEREDSIGMA1**

**THE LATEST DOCUMENTATION INCLUDING ALL RECENT IMPROVEMENTS. PLEASESIGMA1**

**READ ALL OF THESE COMMENTS BEFORE IMPLEMENTATION, PARTICULARLY SIGMA1**

**THE COMMENTS CONCERNING MACHINE DEPENDENT CODING. SIGMA1**

**SIGMA1**

**AT THE PRESENT TIME WE ARE ATTEMPTING TO DEVELOP A SET OF COMPUTERSIGMA1**

**INDEPENDENT PROGRAMS THAT CAN EASILY BE IMPLEMENTED ON ANY ONE SIGMA1**

**OF A WIDE VARIETY OF COMPUTERS. IN ORDER TO ASSIST IN THIS PROJECTSIGMA1**

**IT WOULD BE APPECIATED IF YOU WOULD NOTIFY THE AUTHOR OF ANY SIGMA1**

**COMPILER DIAGNOSTICS, OPERATING PROBLEMS OR SUGGESTIONS ON HOW TO SIGMA1**

**IMPROVE THIS PROGRAM. HOPEFULLY, IN THIS WAY FUTURE VERSIONS OF SIGMA1**

**THIS PROGRAM WILL BE COMPLETELY COMPATIBLE FOR USE ON YOUR SIGMA1**

**COMPUTER. SIGMA1**

**SIGMA1**

**PURPOSE SIGMA1**

**------- SIGMA1**

**THIS PROGRAM IS DESIGNED TO DOPPLER BROADEN NEUTRON INDUCED SIGMA1**

**CROSS SECTIONS. EACH SECTION OF CROSS SECTIONS (FILE 3) IS READ SIGMA1**

**FROM THE ENDF/B FORMAT. THE DATA IS DOPPLER BROADENED, THINNED SIGMA1**

**AND OUTPUT IN THE ENDF/B FORMAT. SIGMA1**

**SIGMA1**

**IN THE FOLLOWING DISCUSSION FOR SIMPLICITY THE ENDF/B TERMINOLOGY SIGMA1**

**---ENDF/B TAPE---WILL BE USED. IN FACT THE ACTUAL MEDIUM MAY BE SIGMA1**

**TAPE, CARDS, DISK OR ANY OTHER MEDIUM. SIGMA1**

**SIGMA1**

**ENDF/B FORMAT SIGMA1**

**------------- SIGMA1**

**THIS PROGRAM ONLY USES THE ENDF/B BCD OR CARD IMAGE FORMAT (AS SIGMA1**

**OPPOSED TO THE BINARY FORMAT) AND CAN HANDLE DATA IN ANY VERSION SIGMA1**

**OF THE ENDF/B FORMAT (I.E., ENDF/B-1, 2, 3, 4, 5, 6 FORMAT). SIGMA1**

**SIGMA1**

**IT IS ASSUMED THAT THE DATA IS CORRECTLY CODED IN THE ENDF/B SIGMA1**

**FORMAT AND NO ERROR CHECKING IS PERFORMED. IN PARTICULAR IT IS SIGMA1**

**ASSUMED THAT THE MAT, MF AND MT ON EACH CARD IS CORRECT. SEQUENCE SIGMA1**

**NUMBERS (COLUMNS 76-80) ARE IGNORED ON INPUT, BUT WILL BE SIGMA1**

**CORRECTLY OUTPUT ON ALL CARDS. THE FORMAT OF SECTION MF=1, MT=451 SIGMA1**

**AND ALL SECTIONS OF MF=3 MUST BE CORRECT. THE PROGRAM COPIES ALL SIGMA1**

**OTHER SECTION OF DATA AS HOLLERITH AND AS SUCH IS INSENSITIVE TO SIGMA1**

**THE CORRECTNESS OR INCORRECTNESS OF ALL OTHER SECTIONS. SIGMA1**

**SIGMA1**

**ALL CROSS SECTIONS THAT ARE USED BY THIS PROGRAM MUST BE TABULATEDSIGMA1**

**AND LINEARLY INTERPOLABLE IN ENERGY AND CROSS SECTION (ENDF/B SIGMA1**

**INTERPOLATION LAW 2). FILE 3 CROSS SECTIONS MAY BE MADE LINEARLY SIGMA1**

**INTERPOLABLE BY USING PROGRAM LINEAR (UCRL-50400, VOL.17, PART A).SIGMA1**

**FILE 2 RESONANCE PARAMETERS MAY BE USED TO RECONSTRUCT ENERGY SIGMA1**

**DEPENDENT CROSS SECTIONS AND ADD IN FILE 3 BACKGROUND CROSS SIGMA1**

**SECTIONS TO DEFINE LINEARLY INTERPOLABLE CROSS SECTIONS BY USING SIGMA1**

**PROGRAM RECENT (UCRL-50400, VOL. 17, PART C). IF THIS PROGRAM SIGMA1**

**FINDS THAT THE FILE 3 CROSS SECTIONS ARE NOT LINEARLY INTERPOLABLESIGMA1**

**THIS PROGRAM WILL TERMINATE EXECUTION. SIGMA1**

**SIGMA1**

**UNRESOLVED RESONANCE REGION SIGMA1**

**--------------------------- SIGMA1**

**IN THE UNRESOLVED RESONANCE REGION IT IS NOT POSSIBLE TO EXACTLY SIGMA1**

**DEFINE THE ENERGY DEPENDENCE OF THE CROSS SECTIONS. THE AVERAGE SIGMA1**

**WIDTHS AND SPACINGS GIVEN IN ENDF/B ARE ONLY ADEQUATE TO DEFINE SIGMA1**

**AVERAGE VALUES OF THE CROSS SECTIONS. THEREFORE ALL CROSS SECTIONSSIGMA1**

**IN THE ENDF/B FORMAT FOR THE UNRESOLVED REGION ARE REALLY AVERAGE SIGMA1**

**VALUES WHICH CANNOT BE DOPPLER BROADENED USING THE SIGMA1 METHOD SIGMA1**

**(WHICH REQUIRES TABULATED, LINEARLY INTERPOLABLE, ENERGY DEPENDENTSIGMA1**

**CROSS SECTIONS. SIGMA1**

**SIGMA1**

**THEREFORE, SIGMA1**

**(1) ALL TABULATED POINTS WITHIN THE UNRESOLVED RESONANCE REGION SIGMA1**

**WILL BE COPIED, WITHOUT MODIFICATION OR BROADENING. ADOPTION OF SIGMA1**

**THIS CONVENTION WILL ALLOW SUBSEQUENT PROGRAMS TO PROPERLY DEFINE SIGMA1**

**SELF-SHIELDED, DOPPLER BROADENED CROSS SECTIONS IN THE UNRESOLVED SIGMA1**

**RESONANCE REGION. SIGMA1**

**(2) CROSS SECTIONS WILL BE EXTENDED AS 1/V ABOVE THE UPPER ENERGY SIGMA1**

**LIMIT OF THE RESOLVED RESONANCE REGION AND BELOW THE LOWER ENERGY SIGMA1**

**LIMIT OF THE CONTINUUUM REGION (I.E. INTO THE UNRESOLVED SIGMA1**

**RESONANCE REGION). THIS CONVENTION WILL GUARANTEE A SMOOTH SIGMA1**

**BEHAVIOR CLOSE TO THE UNRESOLVED RESONANCE REGION BOUNDARIES. SIGMA1**

**SIGMA1**

**OUTPUT FORMAT SIGMA1**

**------------- SIGMA1**

**IN THIS VERSION OF SIGMA1 ALL FILE 3 ENERGIES WILL BE OUTPUT IN SIGMA1**

**F (INSTEAD OF E) FORMAT IN ORDER TO ALLOW ENERGIES TO BE WRITTEN SIGMA1**

**WITH UP TO 9 DIGITS OF ACCURACY. IN PREVIOUS VERSIONS THIS WAS AN SIGMA1**

**OUTPUT OPTION. HOWEVER USE OF THIS OPTION TO COMPARE THE RESULTS SIGMA1**

**OF ENERGIES WRITTEN IN THE NORMAL ENDF/B CONVENTION OF 6 DIGITS SIGMA1**

**TO THE 9 DIGIT OUTPUT FROM THIS PROGRAM DEMONSTRATED THAT FAILURE SIGMA1**

**TO USE THE 9 DIGIT OUTPUT CAN LEAD TO LARGE ERRORS IN THE DATA SIGMA1**

**JUST DUE TO TRANSLATION OF THE ENERGIES TO THE ENDF/B FORMAT. SIGMA1**

**SIGMA1**

**CONTENTS OF OUTPUT SIGMA1**

**------------------ SIGMA1**

**ENTIRE EVALUATIONS ARE OUTPUT, NOT JUST THE BROADENED FILE 3 SIGMA1**

**CROSS SECTIONS, E.G. ANGULAR AND ENERGY DISTRIBUTIONS ARE ALSO SIGMA1**

**INCLUDED. SIGMA1**

**SIGMA1**

**DOCUMENTATION SIGMA1**

**------------- SIGMA1**

**THE FACT THAT THIS PROGRAM HAS OPERATED ON THE DATA IS DOCUMENTED SIGMA1**

**BY THE ADDITION OF THREE COMMENTS CARDS AT THE END OF EACH SIGMA1**

**HOLLERITH SECTION IN THE FORM SIGMA1**

**SIGMA1**

**\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\* PROGRAM SIGMA1 (2023-1) \*\*\*\*\*\*\*\*\*\*\*\*\*\*\* SIGMA1**

**DATA DOPPLER BROADENED TO 300.0 KELVIN AND SIGMA1**

**DATA THINNED TO WITHIN AN ACCURACY OF 0.1 PER-CENT SIGMA1**

**SIGMA1**

**THE ORDER OF ALL SIMILAR COMMENTS (FROM LINEAR,RECENT AND GROUPY) SIGMA1**

**REPRESENTS A COMPLETE HISTORY OF ALL OPERATIONS PERFORMED ON SIGMA1**

**THE DATA. SIGMA1**

**SIGMA1**

**THESE COMMENT CARDS ARE ONLY ADDED TO EXISTING HOLLERITH SECTIONS,SIGMA1**

**I.E., THIS PROGRAM WILL NOT CREATE A HOLLERITH SECTION. THE FORMATSIGMA1**

**OF THE HOLLERITH SECTION IN ENDF/B-5 DIFFERS FROM THE THAT OF SIGMA1**

**EARLIER VERSIONS OF ENDF/B. BY READING AN EXISTING MF=1, MT=451 SIGMA1**

**IT IS POSSIBLE FOR THIS PROGRAM TO DETERMINE WHICH VERSION OF SIGMA1**

**THE ENDF/B FORMAT THE DATA IS IN. WITHOUT HAVING A SECTION OF SIGMA1**

**MF=1, MT=451 PRESENT IT IS IMPOSSIBLE FOR THIS PROGRAM TO SIGMA1**

**DETERMINE WHICH VERSION OF THE ENDF/B FORMAT THE DATA IS IN, AND SIGMA1**

**AS SUCH IT IS IMPOSSIBLE FOR THE PROGRAM TO DETERMINE WHAT FORMAT SIGMA1**

**SHOULD BE USED TO CREATE A HOLLERITH SECTION. SIGMA1**

**SIGMA1**

**REACTION INDEX SIGMA1**

**-------------- SIGMA1**

**THIS PROGRAM DOES NOT USE THE REACTION INDEX WHICH IS GIVEN IN SIGMA1**

**SECTION MF=1, MT=451 OF EACH EVALUATION. SIGMA1**

**SIGMA1**

**THIS PROGRAM DOES NOT UPDATE THE REACTION INDEX IN MF=1, MT=451. SIGMA1**

**THIS CONVENTION HAS BEEN ADOPTED BECAUSE MOST USERS DO NOT SIGMA1**

**REQUIRE A CORRECT REACTION INDEX FOR THEIR APPLICATIONS AND IT WASSIGMA1**

**NOT CONSIDERED WORTHWHILE TO INCLUDE THE OVERHEAD OF CONSTRUCTING SIGMA1**

**A CORRECT REACTION INDEX IN THIS PROGRAM. HOWEVER, IF YOU REQUIRE SIGMA1**

**A REACTION INDEX FOR YOUR APPLICATIONS, AFTER RUNNING THIS PROGRAMSIGMA1**

**YOU MAY USE PROGRAM DICTIN TO CREATE A CORRECT REACTION INDEX. SIGMA1**

**SIGMA1**

**SECTION SIZE SIGMA1**

**------------ SIGMA1**

**SINCE THIS PROGRAM USES A LOGICAL PAGING SYSTEM THERE IS NO LIMIT SIGMA1**

**TO THE NUMBER OF POINTS IN ANY SECTION, E.G., THE TOTAL CROSS SIGMA1**

**SECTION MAY BE REPRESENTED BY 200,000 DATA POINTS. SIGMA1**

**SIGMA1**

**SELECTION OF DATA SIGMA1**

**----------------- SIGMA1**

**THE PROGRAM SELECTS MATERIALS TO BE BROADENED BASED EITHER ON SIGMA1**

**MAT (ENDF/B MAT NO.) OR ZA. THE PROGRAM ALLOWS UP TO 100 MAT OR SIGMA1**

**ZA RANGES TO BE SPECIFIED. THE PROGRAM WILL ASSUME THAT THE SIGMA1**

**ENDF/B TAPE IS IN EITHER MAT OR ZA ORDER, WHICHEVER CRITERIA IS SIGMA1**

**USED TO SELECT MATERIALS, AND WILL TERMINATE WHEN A MAT OR ZA SIGMA1**

**IS FOUND THAT IS ABOVE THE RANGE OF ALL REQUESTS. SIGMA1**

**SIGMA1**

**ENERGY GRID OF BROADENED DATA SIGMA1**

**----------------------------- SIGMA1**

**THE ENERGY GRID FOR THE DOPPLER BROADENED CROSS SECTIONS IS SIGMA1**

**SELECTED TO INSURE THAT THE BROADENED DATA IS LINEAR-LINEAR SIGMA1**

**INTERPOLABLE. AS SUCH THE ENERGY GRID FOR THE BROADENED DATA SIGMA1**

**MAY NOT BE THE SAME AS THE ENERGY GRID FOR THE ORIGINAL SIGMA1**

**UNBROADENED DATA. GENERALLY AFTER BROADENING THERE WILL BE SIGMA1**

**FEWER DATA POINTS IN THE RESONANCE REGION, BUT AT LOW ENERGY SIGMA1**

**THERE MAY BE MORE POINTS, DUE TO THE 1/V LOW ENERGY EFFECT SIGMA1**

**CREATED BY DOPPLER BROADENING. SIGMA1**

**SIGMA1**

**EFFECTIVE TEMERATURE INCREASE SIGMA1**

**----------------------------- SIGMA1**

**IF THE ORIGINAL DATA IS NOT AT ZERO KELVIN THE PROGRAM WILL SIGMA1**

**BROADEN THE DATA BY THE EFFECTIVE TEMPERATURE DIFFENCE TO THE SIGMA1**

**FINAL TEMPERATURE. IF THE DATA IS ALREADY AT A TEMPERATURE THAT SIGMA1**

**IS HIGHER THAN THE FINAL TEMPERATURE DOPPLER BROADENING IS SIGMA1**

**NATURALLY NOT PERFORMED AND THE TEMPERATURE IN THE SECTION IS LEFTSIGMA1**

**AT ITS ORIGINAL VALUE. SIGMA1**

**SIGMA1**

**MULTIPLE FINAL TEMPERATURES SIGMA1**

**--------------------------- SIGMA1**

**THE PRESENT VERSION ONLY DOPPLER BROADENS TO ONE FINAL TEMPERATURESIGMA1**

**(IF THERE IS SUFFICIENT INTEREST EXPRESSED BY USERS FUTURE SIGMA1**

**VERSION MAY BROADEN TO MULTIPLE TEMPERATURES. PLEASE SIGMA1**

**CONTACT THE AUTHOR IF YOU ARE INTERESTED IN A MULTIPLE SIGMA1**

**TEMPERATURE OPTION). SIGMA1**

**SIGMA1**

**PROGRAM OPERATION SIGMA1**

**----------------- SIGMA1**

**EACH SECTION OF FILE 3 DATA IS CONSIDERED SEPERATELY. THE DATA SIGMA1**

**IS READ AND DOPPLER BROADENED A PAGE AT A TIME (ONE PAGE IS SIGMA1**

**60000 DATA POINTS). UP TO THREE PAGES OF DATA MAY BE IN THE CORE SIGMA1**

**AT ANY GIVEN TIME, THE PAGE BEING BROADENED, THE PAGE BELOW IT SIGMA1**

**IN ENERGY AND THE PAGE ABOVE IT IN ENERGY. AFTER A PAGE HAS BEEN SIGMA1**

**BROADENED IT IS THINNED, IF THE ENTIRE SECTION CONTAINS ONLY SIGMA1**

**ONE PAGE OR LESS, IT WILL STILL BE CORE RESIDENT AND WILL BE SIGMA1**

**WRITTEN DIRECTLY FROM CORE TO THE OUTPUT TAPE. IF THE BROADENED, SIGMA1**

**THINNED SECTION IS LARGER THAN A PAGE, AFTER A PAGE HAS BEEN SIGMA1**

**BROADENED AND THINNED IT IS WRITTEN TO A SCRATCH FILE. AFTER THE SIGMA1**

**ENTIRE SECTION HAS BEEN BROADENED AND THINNED THE DATA IS READ SIGMA1**

**FROM SCRATCH TO CORE, ONE PAGE AT A TIME, THE OUTPUT TO THE OUTPUTSIGMA1**

**TAPE. SIGMA1**

**SIGMA1**

**ALLOWABLE ERROR SIGMA1**

**--------------- SIGMA1**

**AFTER DOPPLER BROADENING THE CROSS SECTION IN THE RESONANCE REGIONSIGMA1**

**WILL GENERALLY BE MUCH SMOOTHER THAN THE UNBROADENED DATA AND CAN SIGMA1**

**BE REPRESENTED TO THE SAME ACCURACY BY A SMALLER NUMBER OF ENERGY SIGMA1**

**POINTS. THEREFORE AFTER DOPPLER BROADENING THE DATA CAN BE THINNEDSIGMA1**

**WITH ESSENTIALLY NO LOSE OF INFORMATION. SIGMA1**

**SIGMA1**

**THE ALLOWABLE ERROR MAY BE ENERGY INDEPENDENT (CONSTANT) OR ENERGYSIGMA1**

**DEPENDENT. THE ALLOWABLE ERROR IS DESCRIBED BY A TABULATED SIGMA1**

**FUNCTION OF UP TO 20 (ENERGY,ERROR) PAIRS AND LINEAR INTERPOLATIONSIGMA1**

**BETWEEN TABULATED POINTS. IF ONLY ONE TABULATED POINT IS GIVEN THESIGMA1**

**ERROR WILL BE CONSIDERED CONSTANT OVER THE ENTIRE ENERGY RANGE. SIGMA1**

**WITH THIS ENERGY DEPENDENT ERROR ONE MAY OPTIMIZE THE OUTPUT FOR SIGMA1**

**ANY GIVEN APPLICATION BY USING A SMALL ERROR IN THE ENERGY RANGE SIGMA1**

**OF INTEREST AND A LESS STRINGENT ERROR IN OTHER ENERGY RANGES. SIGMA1**

**SIGMA1**

**INPUT FILES SIGMA1**

**----------- SIGMA1**

**UNIT DESCRIPTION SIGMA1**

**---- ----------- SIGMA1**

**2 INPUT CARDS (BCD - 80 CHARACTERS/RECORD) SIGMA1**

**10 ORIGINAL ENDF/B DATA (BCD - 80 CHARACTERS/RECORD) SIGMA1**

**SIGMA1**

**OUTPUT FILES SIGMA1**

**------------ SIGMA1**

**UNIT DESCRIPTION SIGMA1**

**---- ----------- SIGMA1**

**3 OUTPUT REPORT (BCD - 120 CHARACTERS/RECORD) SIGMA1**

**11 FINAL ENDF/B DATA (BCD - 80 CHARACTERS/RECORD) SIGMA1**

**SIGMA1**

**SCRATCH FILES SIGMA1**

**------------- SIGMA1**

**UNIT DESCRIPTION SIGMA1**

**---- ----------- SIGMA1**

**12 SCRATCH FILE FOR BROADENED DATA SIGMA1**

**(BINARY - 180000 WORDS/RECORD - DOUBLE PRECISION/ SIGMA1**

**42000 WORDS/RECORD - SINLGE PRECISION) SIGMA1**

**SIGMA1**

**OPTIONAL STANDARD FILE NAMES (SEE SUBROUTINE FILEIO) SIGMA1**

**---------------------------------------------------- SIGMA1**

**UNIT FILE NAME SIGMA1**

**---- ---------- SIGMA1**

**2 SIGMA1.INP SIGMA1**

**3 SIGMA1.LST SIGMA1**

**10 ENDFB.IN SIGMA1**

**11 ENDFB.OUT SIGMA1**

**12 (SCRATCH) SIGMA1**

**SIGMA1**

**INPUT CARDS SIGMA1**

**----------- SIGMA1**

**CARD COLS. DESCRIPTION SIGMA1**

**---- ----- ----------- SIGMA1**

**1 1-11 SELECTION CRITERIA (0=MAT, 1=ZA) SIGMA1**

**12-22 MONITOR MODE SELECTOR SIGMA1**

**= 0 - NORMAL OPERATION SIGMA1**

**= 1 - MONITOR PROGRESS OF DOPPLER BROADENING OF DATA.SIGMA1**

**EACH TIME A PAGE OF DATA POINTS IS WRITTEN TO SIGMA1**

**THE SCRATCH FILE PRINT OUT THE TOTAL NUMBER OF SIGMA1**

**POINTS ON SCRATCH AND THE LOWER AND UPPER SIGMA1**

**ENERGY LIMITS OF THE PAGE (THIS OPTION MAY BE SIGMA1**

**USED IN ORDER TO MONITOR THE EXECUTION SPEED SIGMA1**

**OF LONG RUNNING JOBS). SIGMA1**

**23-33 KELVIN TEMPERATURE SIGMA1**

**34-44 MINIMUM CROSS SECTION OF INTEREST SIGMA1**

**(DEFAULT VALUE = 1.0E-10 BARNS). SIGMA1**

**45-55 NEGATIVE CROSS SECTION TREATMENT SIGMA1**

**= 0 - O.K. SIGMA1**

**= 1 - SET = 0 SIGMA1**

**56-66 UNRESOLVED RESONANCE REGION TREATMENT SIGMA1**

**= 0 - COPY (NO BROADENING) SIGMA1**

**= 1 - IGNORE (BROADEN) SIGMA1**

**2 1-72 ENDF/B INPUT DATA FILENAME SIGMA1**

**(STANDARD OPTION = ENDFB.IN) SIGMA1**

**3 1-72 ENDF/B OUTPUT DATA FILENAME SIGMA1**

**(STANDARD OPTION = ENDFB.OUT) SIGMA1**

**4-N 1-11 LOWER MAT OR ZA LIMIT SIGMA1**

**12-22 UPPER MAT OR ZA LIMIT SIGMA1**

**UP TO 100 MAT OR ZA RANGES MAY BE SPECIFIED, ONE SIGMA1**

**RANGE PER CARD. THE LIST OF RANGES IS TERMINATED BY SIGMA1**

**A BLANK CARD. IF THE UPPER LIMIT IS LESS THAN THE SIGMA1**

**LOWER LIMIT THE UPPER LIMIT WILL BE SET EQUAL TO THE SIGMA1**

**LOWER LIMIT. IF THE FIRST REQUEST CARD IS BLANK IT SIGMA1**

**WILL TERMINATE THE LIST OF REQUESTS AND CAUSE ALL SIGMA1**

**DATA TO BE RETRIEVED (SEE EXAMPLE INPUT). SIGMA1**

**VARY 1-11 ENERGY FOR ERROR LAW SIGMA1**

**12-22 ERROR FOR ERROR LAW SIGMA1**

**THE ACCEPTABLE LINEARIZING ERROR CAN BE GIVEN AS AN SIGMA1**

**ENERGY DEPENDENT FUNCTION SPECIFIED BY UP TO 20 SIGMA1**

**(ENERGY,ERROR) PAIRS AND LINEAR INTERPOLATION SIGMA1**

**TABULATE POINTS. ENERGIES MUST BE IN ASCENDING ORDER.SIGMA1**

**THE ERROR LAW IS TERMINATED BY A BLANK CARD. IF THE SIGMA1**

**FIRST ERROR LAW CARD IS BLANK IT WILL TERMINATE THE SIGMA1**

**ERROR LAW AND THE ERROR WILL BE TREATED AS ENERGY SIGMA1**

**INDEPENDENT, EQUAL TO ZERO, WHICH INDICATES THAT THE SIGMA1**

**BROADENED DATA SHOULD NOT BE THINNED. SIGMA1**

**SIGMA1**

**EXAMPLE INPUT NO. 1 SIGMA1**

**------------------- SIGMA1**

**BROADEN ALL URANIUM ISOTOPES AND THORIUM-232 TO 300 KELVIN. FROM SIGMA1**

**0 TO 100 EV THIN OUTPUT DATA TO 0.1 PER-CENT ACCURACY. FROM 100 EVSIGMA1**

**TO 1 KEV VARY THE ERROR BETWEEN 0.1 AND 1 PER-CENT. ABOVE 1 KEV SIGMA1**

**USE 1 PER-CENT ACCURACY. SIGMA1**

**SIGMA1**

**EXPLICITLY SPECIFY THE STANDARD FILENAMES. SIGMA1**

**SIGMA1**

**THE FOLLOWING 11 CARDS ARE REQUIRED SIGMA1**

**SIGMA1**

**1 0 3.00000+ 2 SIGMA1**

**ENDFB.IN SIGMA1**

**ENDFB.OUT SIGMA1**

**92000 92999 SIGMA1**

**90232 (UPPER LIMIT WILL AUTOMATICALLY BE DEFINED) SIGMA1**

**(BLANK CARD INDICATES END OF REQUEST LIST) SIGMA1**

**0.00000+ 0 1.00000-03 SIGMA1**

**1.00000+ 2 1.00000-03 SIGMA1**

**1.00000+ 3 1.00000-02 SIGMA1**

**1.00000+ 9 1.00000-02 SIGMA1**

**(BLANK CARD INDICATES END OF ERROR LAW) SIGMA1**

**SIGMA1**

**EXAMPLE INPUT NO. 2 SIGMA1**

**------------------- SIGMA1**

**BROADEN ALL DATA TO 300 KELVIN AND DO NOT THIN THE BROADEN DATA. SIGMA1**

**ALL OF THE STANDARD OPTION MAY BE INVOKED MERELY BY SPECIFYING SIGMA1**

**THE KELVIN TEMPERATURE ON THE FIRST CARD. ALL OTHER FIELDS MAY SIGMA1**

**BE LEFT BLANK. SIGMA1**

**SIGMA1**

**LEAVE THE DEFINITION OF THE FILENAMES BLANK - THE PROGRAM WILL SIGMA1**

**THEN USE STANDARD FILENAMES. SIGMA1**

**SIGMA1**

**THE FOLLOWING 5 CARDS ARE REQUIRED SIGMA1**

**SIGMA1**

**3.00000+ 2 SIGMA1**

**(USE STANDARD FILENAME = ENDFB.IN) SIGMA1**

**(USE STANDARD FILENAME = ENDFB.OUT) SIGMA1**

**(RETRIEVE ALL DATA, TERMINATE REQUEST LIST) SIGMA1**

**(0.0 ALLOWABLE ERROR, TERMINATE ERROR LAW) SIGMA1**

**SIGMA1**

**EXAMPLE INPUT NO. 3 SIGMA1**

**------------------- SIGMA1**

**THE SAME AS ABOVE, ONLY DEFINE THE MINIMUM CROSS SECTION OF SIGMA1**

**INTEREST TO BE 1.0E-30 BARNS (INSTEAD OF THE DEFAULT VALUE OF SIGMA1**

**1.0E-10). SIGMA1**

**SIGMA1**

**READ ENDF/B DATA FROM \ENDFB6\RECENT\ZA092238 AND WRITE ENDF/B SIGMA1**

**DATA TO \ENDFB\SIGMA1\ZA092238 SIGMA1**

**SIGMA1**

**THE FOLLOWING 5 CARDS ARE REQUIRED SIGMA1**

**SIGMA1**

**3.00000+ 2 1.00000-30 SIGMA1**

**\ENDFB6\RECENT\ZA092238 SIGMA1**

**\ENDFB6\SIGMA1\ZA092238 SIGMA1**

**(RETRIEVE ALL DATA, TERMINATE REQUEST LIST) SIGMA1**

**(0.0 ALLOWABLE ERROR, TERMINATE ERROR LAW) SIGMA1**

**SIGMA1**

**=======================================================================SIGMA1**