======================================================================= Virgin

 Virgin

 PROGRAM VIRGIN Virgin

 VERSION 76-1 (NOVEMBER 1976) Virgin

 VERSION 84-1 (JUNE 1984) \*DOUBLE PRECISION ENERGY Virgin

 VERSION 86-1 (JANUARY 1986)\*FORTRAN-77/H VERSION Virgin

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

 FILE NAMES (SEE, SUBROUTINE FILEIO Virgin

 FOR DETAILS). Virgin

 \*IMPROVED BASED ON USER COMMENTS. Virgin

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

 INSURE PROGRAM WILL NOT DO ANYTHING Virgin

 CRAZY. Virgin

 \*UPDATED TO USE NEW PROGRAM CONVERT Virgin

 KEYWORDS. Virgin

 \*ADDED LIVERMORE CIVIC COMPILER Virgin

 CONVENTIONS. Virgin

 VERSION 92-1 (JANUARY 1992)\*COMPLETE RE-WRITE Virgin

 \*OUTPUT IN PLOTTAB FORMAT Virgin

 \*UP TO 2000 THICKNESSES Virgin

 \*INCREASED INCORE PAGE SIZE TO 6000 Virgin

 CROSS SECTION POINTS Virgin

 \*ADDED PHOTON CALCULATIONS Virgin

 \*ADDED BLACKBODY SPECTRUM Virgin

 \*ADDED MULTIPLE LAYERS Virgin

 \*ADDED SPATIALLY DEPENDENT DENSITY Virgin

 \*ADDED FORTRAN SAVE OPTION Virgin

 \*COMPLETELY CONSISTENT I/O ROUTINES - Virgin

 TO MINIMIZE COMPUTER DEPENDENCE. Virgin

 VERSION 92-2 (MAY 1992) \*CORRECTED TO HANDLE MULTIGROUP CROSS Virgin

 SECTIONS AS INPUT IN ENDF/B FORMAT. Virgin

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

 \*IMPROVED COMPUTER INDEPENDENCE Virgin

 \*ALL DOUBLE PRECISION Virgin

 \*ON SCREEN OUTPUT Virgin

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

 \*IMPROVED OUTPUT PRECISION Virgin

 \*DEFINED SCRATCH FILE NAMES Virgin

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

 POINT READ FOR MORE DIGITS Virgin

 \*UPDATED TEST FOR ENDF/B FORMAT Virgin

 VERSION BASED ON RECENT FORMAT CHANGE Virgin

 \*GENERAL IMPROVEMENTS BASED ON Virgin

 USER FEEDBACK Virgin

 VERS. 2000-1 (FEBRUARY 2000)\*GENERAL IMPROVEMENTS BASED ON Virgin

 USER FEEDBACK Virgin

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

 VERS. 2004-1 (MARCH 2004) \*ADDED INCLUDE FOR COMMON Virgin

 \*UP TO 2000 THICKNESSES Virgin

 \*INCREASED INCORE PAGE SIZE TO 60,000 Virgin

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

 \*INCREASED INCORE PAGE SIZE TO Virgin

 240,000 FROM 60,000. Virgin

 VERS. 2007-2 (DEC. 2007) \*72 CHARACTER FILE NAME. Virgin

 VERS. 2010-1 (Apr. 2010) \*General update based on user feedback Virgin

 \*INCREASED INCORE PAGE SIZE TO Virgin

 600,000 FROM 240,000. Virgin

 VERS. 2012-1 (Aug. 2012) \*Added CODENAME Virgin

 \*32 and 64 bit Compatible Virgin

 \*Added ERROR stop Virgin

 VERS. 2015-1 (Jan. 2015) \*Extended OUT9. Virgin

 \*Replaced ALL 3 way IF Statements. Virgin

 \*Generalized TART Group Structures. Virgin

 \*Generalized SAND-II Group Structures. Virgin

 \*Extended SAND-II to 60, 150, 200 MeV. Virgin

 Virgin

 OWNED, MAINTAINED AND DISTRIBUTED BY Virgin

 ------------------------------------ Virgin

 THE NUCLEAR DATA SECTION Virgin

 INTERNATIONAL ATOMIC ENERGY AGENCY Virgin

 P.O. BOX 100 Virgin

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 ORIGINALLY WRITTEN BY Virgin

 ------------------------------------ Virgin

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 Virgin

 PURPOSE Virgin

 ------- Virgin

 THIS PROGRAM IS DESIGNED TO CALCULATE UNCOLLIDED (I.E. VIRGIN) Virgin

 FLUX AND REACTIONS DUE TO TRANSMISSION OF A MONODIRECTIONAL Virgin

 BEAM OF NEUTRONS THROUGH ANY THICKNESS OF MATERIAL. IN ORDER Virgin

 TO SIMULATE AN EXPERIMENTAL MEASUREMENT THE RESULTS ARE GIVEN Virgin

 AS INTEGRALS OVER ENERGY TALLY GROUPS (AS OPPOSED TO POINTWISE Virgin

 IN ENERGY). BY TAKING THE RATIO OF REACTIONS TO FLUX IN EACH Virgin

 GROUP AN EQUIVALENT SPATIALLY DEPENDENT GROUP AVERAGED CROSS Virgin

 SECTION IS CALCULATED BY THE PROGRAM. Virgin

 Virgin

 EVALUATED DATA Virgin

 -------------- Virgin

 THE EVALUATED DATA MUST BE IN THE ENDF/B FORMAT. HOWEVER IT Virgin

 MUST BE LINEAR-LINEAR INTERPOLABLE IN ENERGY-CROSS SECTION Virgin

 BETWEEN TABULATED POINTS. SINCE ONLY CROSS SECTIONS (FILE 3 OR 23) Virgin

 ARE USED, THIS PROGRAM WILL WORK ON ANY VERSION OF ENDF/B Virgin

 (I.E. ENDF/B-I, II, III, IV, V OR VI). Virgin

 Virgin

 RELATED COMPUTER CODES Virgin

 ---------------------- Virgin

 IN ORDER TO CONVERT ENDF/B DATA TO THE FORM REQUIRED BY THIS CODE Virgin

 THE FOLLOWING COMPUTER CODES MAY BE USED, Virgin

 Virgin

 LINEAR - CONVERT FROM GENERAL ENDF/B INTERPOLATION TO LINEAR- Virgin

 LINEAR INTERPOLATION. Virgin

 RECENT - ADD THE RESONANCE CONTRIBUTION TO TABULATED BACKGROUND Virgin

 CROSS SECTIONS TO OBTAIN LINEAR-LINEAR INTERPOLABLE Virgin

 RESULTS. Virgin

 SIGMA1 - DOPPLER BROADEN CROSS SECTION TO OBTAIN LINEAR-LINEAR Virgin

 INTERPOLABLE RESULTS. Virgin

 MIXER - MIX INDIVIDUAL MATERIALS TOGETHER TO DEFINE COMPOSITE Virgin

 MIXTURES, E.G., COMBINE MATERIALS TO DEFINE STAINLESS Virgin

 STELL. Virgin

 Virgin

 IN ORDER TO PLOT THE OUTPUT RESULTS OF THIS CODE USE PROGRAM Virgin

 PLOTTAB. Virgin

 Virgin

 COPIES OF ANY OR ALL OF THESE CODES MAY BE OBTAINED FROM D.E. Virgin

 CULLEN AT THE ABOVE ADDRESS. Virgin

 Virgin

 OUTPUT FORMAT Virgin

 ------------- Virgin

 FOR ALL VERSIONS OF THIS PROGRAM PRIOR TO VERSION 92-1 OUTPUT WAS Virgin

 IN TABULAR FORM. Virgin

 Virgin

 FOR VERSION 92-1 AND LATER VERSIONS OF THIS CODE ALL OUTPUT IS IN Virgin

 THE PROGRAM PLOTTAB FORMAT TO ALLOW RESULTS TO BE EASILY PLOTTED. Virgin

 FOR A COPY OF PROGRAM PLOTTAB CONTACT D.E. CULLEN AT THE ABOVE Virgin

 ADDRESS. Virgin

 Virgin

 TALLY GROUPS Virgin

 ------------ Virgin

 THE TALLY GROUP STRUCTURE MAY BE ANY SET OF MONONTONICALLY Virgin

 INCREASING ENERGY BOUNDARIES. THERE MAY BE UP TO 2000 TALLY Virgin

 GROUPS. BY USING THE INPUT PARAMETERS THE USER MAY SPECIFY ANY Virgin

 ARBITRARY TALLY GROUP STRUCTURE OR SELECT ONE OF THE FOLLOWING Virgin

 BUILT-IN GROUP STRUCTURES. Virgin

 Virgin

 (0) TART 175 GROUPS Virgin

 (1) ORNL 50 GROUPS Virgin

 (2) ORNL 126 GROUPS Virgin

 (3) ORNL 171 GROUPS Virgin

 (4) SAND-II 620 GROUPS - 1.0e-4 eV UP TO 18 MEV Virgin

 (5) SAND-II 640 GROUPS - 1.0e-4 eV UP TO 20 MEV Virgin

 (6) WIMS 69 GROUPS Virgin

 (7) GAM-I 68 GROUPS Virgin

 (8) GAM-II 99 GROUPS Virgin

 (9) MUFT 54 GROUPS Virgin

 (10) ABBN 28 GROUPS Virgin

 (11) TART 616 GROUPS TO 20 MeV Virgin

 (12) TART 700 GROUPS To 1 GeV Virgin

 (13) SAND-II 665 GROUPS - 1.0e-5 eV UP TO 18 MEV Virgin

 (14) SAND-II 685 GROUPS - 1.0e-5 eV UP TO 20 MEV Virgin

 (15) TART 666 GROUPS TO 200 MeV Virgin

 (16) SAND-II 725 GROUPS - 1.0e-5 eV UP TO 60 MEV Virgin

 (17) SAND-II 755 GROUPS - 1.0e-5 eV UP TO 150 MEV Virgin

 (18) SAND-II 765 GROUPS - 1.0e-5 eV UP TO 200 MEV Virgin

 Virgin

 INCIDENT SPECTRUM Virgin

 ----------------- Virgin

 THE INCIDENT SPECTRUM MAY BE ANY TABULATED FUNCTION THAT IS Virgin

 GIVEN BY A SET OF POINTS THAT IS MONOTONICALLY INCREASING IN Virgin

 ENERGY AND LINEAR-LINEAR INTERPOLABLE IN ENERGY-SPECTRUM Virgin

 BETWEEN TABULATED POINTS. THERE IS NO LIMIT TO THE NUMBER OF Virgin

 POINTS USED TO DESCRIBE THE SPECTRUM. THERE ARE FIVE BUILT-IN Virgin

 OPTIONS FOR THE SPECTRUM. Virgin

 Virgin

 (1) CONSTANT...ENERGY INDEPENDENT (INPUT 0) Virgin

 (2) 1/E (INPUT 1) Virgin

 (3) BLACKBODY - PHOTON SPECTRUM Virgin

 (4) BLACKBODY - ENERGY SPECTRUM (E TIMES THE PHOTON SPECTRUM) Virgin

 (5) TRANSMITTED SPECTRUM FROM PREVIOUS CASE Virgin

 Virgin

 NORMALIZATION OF SPECTRUM Virgin

 ------------------------- Virgin

 ANY INCIDENT SPECTRUM, EITHER READ AS INPUT OR ONE OF THE Virgin

 BUILT-IN SPECTRA, WILL BE NORMALIZED TO UNITY WHEN INTEGRATED Virgin

 OVER THEIR ENTIRE ENERGY RANGE. Virgin

 Virgin

 TRANSMITTED SPECTRA WILL NOT BE RE-NORMALIZED, SINCE IT ALREADY Virgin

 INCLUDES THE NORMALIZATION OF THE INCIDENT SPECTRUM. Virgin

 Virgin

 NOTE, INCIDENT SPECTRA IS NORMALIZED TO UNITY OVER THEIR ENTIRE Virgin

 ENERGY RANGE - NOT OVER THE ENERGY RANGE OF THE GROUPS. IF THE Virgin

 ENERGY RANGE OF THE GROUPS IS LESS THAN THAT OF THE SPECTRUM Virgin

 ONLY THAT PORTION OF THE SPECTRUM WILL BE USED AND THIS WILL Virgin

 NOT BE RE-NORMALIZED TO UNITY. Virgin

 Virgin

 COMPOSITION OF A LAYER Virgin

 ---------------------- Virgin

 YOU MAY RUN PROBLEMS INVOLVING Virgin

 1) A LAYER OF UNIFORM DENSITY - DENSITY FOR ATTENUATION IS THAT Virgin

 OF THE TOTAL. DENSITY FOR REACTIONS IS THAT OF THE REACTION. Virgin

 2) A LAYER OF UNIFORM DENSITY - DENSITY IS THE SUM OF THE TOTAL Virgin

 AND REACTION DENSITIES - THE SUM OF THE CROSS SECTIONS IS Virgin

 USED FOR ATTENUATION AND REACTIONS. Virgin

 3) A LAYER OF VARYING DENSITY BASED ON A UNIFORM TOTAL DENSITY Virgin

 PLUS A VARIATION BETWEEN 0 AND A MAXIMUM BASED ON THE Virgin

 REACTION DENSITY - 0 AT 0 THICKNESS AND MAXIMUM AT MAXIMUM Virgin

 THICKNESS. IN THIS CASE THE AVERAGE REACTION DENSITY IS EQUAL Virgin

 TO THE INPUT REACTION DENSITY. THE VARIATION IN REACTION Virgin

 DENSITY CAN BE LINEAR, SQUARE OR CUBIC. Virgin

 4) A LAYER OF VARYING DENSITY BASED ON A TOTAL DENSITY WHICH Virgin

 VARYING FROM MAXIMUM AT 0 THICKNESS TO 0 AT MAXIMUM THICKNESS Virgin

 PLUS A REACTION DENSITY WHICH VARIES FROM 0 AT 0 THICKNESS Virgin

 TO MAXIMUM AT MAXIMUM THICKNESS. IN THIS CASE THE AVERAGE Virgin

 DENSITY OF THE TOTAL AND REACTION WILL BOTH BE EQUAL TO THE Virgin

 INPUT TOTAL AND REACTION DENSITIES. THE VARIATION IN TOTAL Virgin

 AND REACTION DENSITY CAN BE LINEAR, SQUARE OR CUBIC. Virgin

 Virgin

 IN THE FIRST CASE THE TWO REQUESTED CROSS SECTIONS ARE CONSIDERED Virgin

 TO BE INDEPENDENT - THE TOTAL CROSS SECTION IS USED TO CALCULATE Virgin

 ATTENUATION AND THE REACTION CROSS SECTION IS USED TO CALCULATE Virgin

 REACTIONS, E.G., TRANSMISSION THROUGH NATURAL URANIUM (THE TOTAL Virgin

 CROSS SECTION SHOULD BE THAT OF NATURAL URANIUM) AND REACTIONS Virgin

 IN A U-235 DETECTOR (THE REACTION CROSS SECTION SHOULD BE THAT OF Virgin

 U-235). Virgin

 Virgin

 IN THE OTHER THREE CASES THE TWO REQUESTED CROSS SECTIONS ARE Virgin

 TREATED AS TWO CONSTITUENTS OF A MIXTURE OF TWO MATERIALS AND Virgin

 THE TWO CROSS SECTIONS ARE USED BOTH TO DEFINE A TOTAL CROSS Virgin

 SECTION FOR ATTENUATION AND A REACTION CROSS SECTION TO DEFINE Virgin

 REACTIONS. IN THESE CASES THE MIXTURE WILL VARY CONTINUOUSLY, Virgin

 E.G., IN CASE 4) HALF WAY THROUGH THE LAYER THE COMPOSITION WILL Virgin

 BE 1/2 THE MATERIAL DEFINED BY THE TOTAL AND 1/2 THE MATERIAL Virgin

 BASED ON THE REACTION. IN THESE CASES RATHER THAN THINKING OF Virgin

 THE TWO CROSS SECTIONS AS A TOTAL AND REACTION CROSS SECTION, Virgin

 IT IS BETTER TO THINK OF THEM AS THE TOTAL CROSS SECTIONS FOR Virgin

 MATERIALS A AND B AND THE CALCULATED REACTIONS WILL BE BASED Virgin

 ON THESE TWO TOTAL CROSS SECTIONS. Virgin

 Virgin

 MULTIPLE LAYERS Virgin

 --------------- Virgin

 THIS CODE MAY BE USED TO RUN EITHER A NUMBER OF INDEPENDENT Virgin

 PROBLEMS, EACH INVOLVING TRANSMISSION THROUGH A SINGLE LAYER OF Virgin

 MATERIAL, OR TRANSMISSION THROUGH A NUMBER OF LAYERS ONE AFTER Virgin

 THE OTHER. Virgin

 Virgin

 IN THE CASE OF MULTIPLE LAYERS, ONE LAYER AFTER ANOTHER, THE Virgin

 TRANSMITTED ENERGY DEPENDENT SPECTRUM IS USED AS THE INCIDENT Virgin

 SPECTRUM FOR THE NEXT LAYER. THERE IS NO LIMIT TO THE NUMBER Virgin

 OF LAYERS WHICH MAY BE USED - EACH LAYER IS TREATED AS A Virgin

 COMPLETELY INDEPENDENT PROBLEM WITH A DEFINED INCIDENT SOURCE, Virgin

 AND AS SUCH THE CYCLE OF TRANSMISSION THROUGH EACH LAYER AND Virgin

 USING THE TRANSMITTED SPECTRUM AS THE INCIDENT SPECTRUM FOR THE Virgin

 NEXT LAYER MAY BE REPEATED ANY NUMBER OF TIMES. Virgin

 Virgin

 REMEMBER - THE INCIDENT SPECTRUM IS ASSUMED TO BE LINEARLY Virgin

 INTERPOLABLE IN ENERGY AND SPECTRUM BETWEEN THE ENERGIES AT Virgin

 WHICH IT IS TABULATED. THE TRANSMITTED SPECTRUM WILL BE TABULATED Virgin

 AT THE UNION OF ALL ENERGIES OF THE INCIDENT SPECTRUM AND CROSS Virgin

 SECTIONS (TOTAL AND REACTION). IN ORDER TO INSURE THE ACCURACY Virgin

 OF THE RESULT WHEN PERFORMING MULTIPLE LAYER CALCULATION BE SURE Virgin

 TO SPECIFY THE INCIDENT SPECTRUM ON THE FIRST LAYER TO SUFFICIENT Virgin

 DETAIL (ENOUGH ENERGY POINTS CLOSELY SPACED TOGETHER) IN ORDER TO Virgin

 ALLOW THE TRANSMITTED SPECTRUM TO BE ACCURATELY REPRESENTED BY Virgin

 LINEAR INTERPOLATION BETWEEN SUCCESSIVE ENERGY POINTS - THERE IS Virgin

 NO LIMIT TO THE NUMBER OF POINTS ALLOWED IN THE INCIDENT SPECTRUM, Virgin

 SO IF YOU ARE IN DOUBT, SIMPLY USE MORE ENERGY POINTS TO SPECIFY Virgin

 THE INCIDENT SPECTRUM. Virgin

 Virgin

 RESULT OUTPUT UNITS Virgin

 ------------------- Virgin

 FLUX = EXACTLY AS CALCULATED Virgin

 REACTIONS = 1/CM OR 1/GRAM Virgin

 AVERAGE = 1/CM - MACROSCOPIC UNITS Virgin

 CROSS Virgin

 SECTION Virgin

 Virgin

 THICKNESS AND DENSITY Virgin

 --------------------- Virgin

 THE UNCOLLIDED CALCULATION ONLY DEPENDS ON THE PRODUCT OF Virgin

 THICKNESS AND DENSITY (I.E. GRAMS PER CM SQUARED). THIS FACT Virgin

 MAY BE USED TO SIMPLIFY INPUT BY ALLOWING THE THICKNESS AND Virgin

 DENSITY TO BE GIVEN EITHER AS CM AND GRAMS/CC RESPECTIVELY Virgin

 OR ELSE TO GIVE THICKNESS IN GRAMS/(CM\*CM) AND INPUT A Virgin

 DENSITY OF 1.0 - OR IN ANY OTHER CONVENIENT UNITS AS LONG AS Virgin

 THE PRODUCT OF THICKNESS AND DENSITY IS IN THE CORRECT GRAMS Virgin

 PER CENTIMETER SQUARED. Virgin

 Virgin

 GRAMS/(CM\*CM) ARE RELATED TO ATOMS/BARN THROUGH THE RELATIONSHIP Virgin

 Virgin

 GRAMS/(CM\*CM)=(ATOMS/BARN)\*(GRAMS/MOLE)\*(MOLE/ATOM) Virgin

 Virgin

 OR... Virgin

 Virgin

 GRAMS/(CM\*CM)=(ATOMS/BARN)\*(ATOMIC WEIGHT)/0.602 Virgin

 Virgin

 CROSS SECTIONS AT A SPACE POINT AND OPTICAL THICKNESS Virgin

 ----------------------------------------------------- Virgin

 THIS PROGRAM ALLOWS LAYERS OF EITHER UNIFORM DENSITY OR Virgin

 CONTINUOUSLY VARYING DENSITY. THE DENSITY CAN BE ONE OF THE Virgin

 FOLLOWING FORMS, Virgin

 1) C = UNIFORM DENSITY Virgin

 2) C\*2\*(X/T) = LINEAR VARIATION FROM 0 TO C Virgin

 3) C\*(2-2\*(X/T)) = LINEAR VARIATION FROM C TO 0 Virgin

 4) C\*3\*(X/T)\*\*2 = SQUARE VARIATION FROM 0 TO C Virgin

 5) C\*(3-3\*(X/T)\*\*2)/2 = SQUARE VARIATION FROM C TO 0 Virgin

 6) C\*4\*(X/T)\*\*3 = CUBIC VARIATION FROM 0 TO C Virgin

 7) C\*(4-4\*(X/T)\*\*3)/3 = CUBIC VARIATION FROM C TO 0 Virgin

 Virgin

 IN ORDER TO CALCULATE REACTIONS AT A POINT THE MICROSCOPIC Virgin

 REACTION CROSS SECTION NEED MERELY BE SCALED BY THESE DENSITIES. Virgin

 Virgin

 IN ORDER TO CALCULATE TRANSMISSION WE MUST DEFINE THE OPTICAL Virgin

 PATH LENGTH WHICH MAY BE DEFINED BY INTEGRATING EACH OF THE Virgin

 ABOVE DENSITY FORMS TO FIND, Virgin

 1) C\*X Virgin

 2) C\*X\*(X/T) Virgin

 3) C\*X\*(2-(X/T)) Virgin

 4) C\*X\*(X/T)\*\*2 Virgin

 5) C\*X\*(3-(X/T)\*\*2)/2 Virgin

 6) C\*X\*(X/T)\*\*3 Virgin

 7) C\*X\*(4-(X/T)\*\*3))/3 Virgin

 Virgin

 IN ORDER TO CALCULATE TRANSMISSION TO A POINT THE MICROSCOPIC Virgin

 TOTAL CROSS SECTION NEED MERELY BE SCALED BY THESE DENSITIES Virgin

 TO DEFINE THE OPTICAL PATH LENGTH. Virgin

 Virgin

 THE VARIATION OF THE DENSITY THROUGH THE LAYER MAY BE DEFINED Virgin

 BY SETTING X = 0 OR X = T TO FIND, Virgin

 X = 0 X = T Virgin

 ----- ----- Virgin

 1) C C Virgin

 2) 0 2\*C Virgin

 3) 2\*C 0 Virgin

 4) 0 3\*C Virgin

 5) 3\*C/2 0 Virgin

 6) 0 4\*C Virgin

 7) 4\*C/3 0 Virgin

 Virgin

 THE OPTICAL PATH THROUGH A LAYER OF THICKNESS T MAY BE DEFINED Virgin

 FROM THE ABOVE EXPRESSIONS BY SETTING X=T TO FIND THAT IN ALL Virgin

 CASES THE ANSWER WILL BY C\*T. THE CONSTANTS IN THE ABOVE Virgin

 EXPRESSIONS HAVE BEEN INTRODUCED IN ORDER TO FORCE THIS RESULT. Virgin

 WITH THESE FACTORS THE OPTICAL PATH LENGTH THROUGH THE LAYER Virgin

 WILL EXACTLY CORRESPOND TO AN AVERAGE DENSITY CORRESPONDING TO Virgin

 THAT INPUT FOR THE TOTAL AND/OR REACTION, I.E., C CORRESPONDS Virgin

 TO THE INPUT DENSITY. Virgin

 Virgin

 NOTE - FOR THE SAME OPTICAL PATH LENGTHS THROUGH THE LAYER THE Virgin

 TRANSMISSION WILL BE EXACTLY THE SAME. HOWEVER, VARYING THE Virgin

 DENSITY WILL ALLOW YOU TO MODIFY THE REACTION RATES AT SPECIFIC Virgin

 DEPTHS INTO THE LAYER. Virgin

 Virgin

 COMPUTATION OF INTEGRALS Virgin

 ------------------------ Virgin

 STARTING FROM TOTAL CROSS SECTIONS, REACTION CROSS SECTIONS AND Virgin

 A SOURCE SPECTRUM ALL OF WHICH ARE GIVEN IN TABULAR FORM WITH Virgin

 LINEAR INTERPOLATION BETWEEN TABULATED POINTS ALL REQUIRED Virgin

 INTEGRALS CAN BE DEFINED BY ANALYTICAL EXPRESSIONS INVOLVING Virgin

 NOTHING MORE COMPLICATED THAN EXPONENTIALS. THE INTEGRALS THAT Virgin

 MUST BE EVALUATED ARE OF THE FORM... Virgin

 Virgin

 FLUX Virgin

 ---- Virgin

 (INTEGRAL EK TO EK+1) (S(E)\* EXP(-XCT(E)\*Z)\*DE) Virgin

 Virgin

 REACTIONS Virgin

 --------- Virgin

 (INTEGRAL EK TO EK+1) (S(E)\*XCR(E)\*EXP(-XCT(E)\*Z)\*DE) Virgin

 Virgin

 WHERE.. Virgin

 EK TO EK+1 = LONGEST ENERGY INTERVAL OVER WHICH S(E), XCT(E) AND Virgin

 XCR(E) ARE ALL LINEARLY INTERPOLABLE. Virgin

 S(E) = ENERGY DEPENDENT WEIGHTING SPECTRUM Virgin

 XCR(E) = REACTION CROSS SECTION Virgin

 XCT(E) = OPTICAL PATH LENGTH (BASED ON TOTAL CROSS SECTION) Virgin

 Z = MATERIAL THICKNESS Virgin

 Virgin

 S(E), XCR(E) AND XCT(E) ARE ALL ASSUMED TO BE GIVEN IN TABULAR Virgin

 FORM WITH LINEAR INTERPOLATION USED BETWEEN TABULATED POINTS. Virgin

 IN OTHER WORDS BETWEEN TABULATED POINTS EACH OF THESE THREE IS Virgin

 DEFINED BY A FUNCTION OF THE FORM... Virgin

 Virgin

 F(E)=((E - EK)\*FK+1 + (EK+1 - E)\*FK)/(EK+1 - EK) Virgin

 Virgin

 EACH OF THESE THREE CAN BE CONVERTED TO NORMAL FORM BY THE Virgin

 CHANGE OF VARIABLES.... Virgin

 Virgin

 X=(E - 0.5\*(EK+1 + EK))/(EK+1 - EK) Virgin

 Virgin

 IN WHICH CASE X WILL VARY FROM -1 (AT EK) TO +1 (AT EK+1) AND Virgin

 EACH FUNCTION REDUCES TO THE NORMAL FORM... Virgin

 Virgin

 F(X)=0.5\*(FK\*(1 - X) + FK+1\*(1 + X)) Virgin

 =0.5\*(FK+1 + FK) + 0.5\*(FK+1 - FK)\*X Virgin

 Virgin

 BY DEFINING THE AVERAGE VALUE AND 1/2 THE CHANGE ACROSS THE Virgin

 INTERVAL. Virgin

 Virgin

 AVF=0.5\*(FK+1 + FK) Virgin

 DF= 0.5\*(FK+1 - FK) Virgin

 DE= 0.5\*(EK+1 - EK) Virgin

 Virgin

 EACH OF THE THREE FUNCTIONS REDUCES TO THE SIMPLE FORM... Virgin

 Virgin

 F(X)=AVF+DF\*X Virgin

 Virgin

 AND THE TWO REQUIRED INTEGRALS REDUCE TO... Virgin

 Virgin

 FLUX Virgin

 ---- Virgin

 DE\*EXP(-AVXCT\*Z) \* (INTEGRAL -1 TO +1) Virgin

 ((AVS+DS\*X)\*EXP(-DXCT\*Z\*X)\*DX) Virgin

 Virgin

 REACTION Virgin

 -------- Virgin

 DE\*EXP(-AVXCT\*Z) \* (INTEGRAL -1 TO +1) Virgin

 ((AVS\*AVXCR+(AVS\*DXCR+AVXCR\*DS)\*X+DS\*DXCR\*X\*X)\*EXP(-DXCT\*Z\*X)\*DX) Virgin

 Virgin

 WHERE Virgin

 Virgin

 AVXCT = AVERAGE VALUE OF THE TOTAL CROSS SECTION Virgin

 AVXCR = AVERAGE VALUE OF THE REACTION CROSS SECTION Virgin

 AVS = AVERAGE VALUE OF THE SOURCE Virgin

 DXCT = 1/2 THE CHANGE IN THE TOTAL CROSS SECTION Virgin

 DXCR = 1/2 THE CHANGE IN THE REACTION CROSS SECTION Virgin

 DS = 1/2 THE CHANGE IN THE SOURCE Virgin

 DE = 1/2 THE CHANGE IN THE ENERGY Virgin

 Virgin

 NOTE THAT IN THIS FORM THE ENERGY ONLY APPEARS IN FRONT OF THE Virgin

 INTEGRALS AND THE INTEGRALS ARE EXPRESSED ONLY IN TERMS OF THE Virgin

 TABULATED VALUES OF S(E), XCT(E) AND XCR(E). IN PARTICULAR NO Virgin

 DERIVATIVES ARE USED, SO THAT THERE ARE NO NUMERICAL INSTABILITY Virgin

 PROBLEMS IN THE VACINITY OF DISCONTINUITIES IN S(E), XCT(E) OR Virgin

 XCR(E). INDEED, SINCE (EK+1 - EK) APPEARS IN FRONT OF THE INTEGRAL Virgin

 POINTS OF DISCONTINUITY AUTOMATICALLY MAKE ZERO CONTRIBUTION TO Virgin

 THE INTEGRALS. Virgin

 Virgin

 THE REQUIRED INTEGRALS CAN BE EXPRESSED IN TERMS OF THE THREE Virgin

 INTEGRALS IN NORMAL FORM.... Virgin

 Virgin

 F(A,N) = (INTEGRAL -1 TO 1) (X\*\*N\*EXP(-A\*X)\*DX), N=0,1 AND 2. Virgin

 Virgin

 THESE THREE INTEGRALS CAN BE EVALUATED TO FIND... Virgin

 Virgin

 N=0 Virgin

 --- Virgin

 F(A,0) = (EXP(A)-EXP(-A))/A Virgin

 Virgin

 N=1 Virgin

 --- Virgin

 F(A,1) = ((1-A)\*EXP(A)-(1+A)\*EXP(-A))/(A\*A) Virgin

 Virgin

 N=2 Virgin

 --- Virgin

 F(A,2) = ((2-2\*A+A\*A)\*EXP(A)-(2+2\*A+A\*A)\*EXP(-A))/(A\*A\*A) Virgin

 Virgin

 HOWEVER THESE EXPRESSIONS ARE NUMERICALLY UNSTABLE FOR SMALL Virgin

 VALUES OF A. THEREFORE FOR SMALL A THE EXPONENTIAL IN THE Virgin

 INTEGRALS ARE EXPANDED IN A POWER SERIES... Virgin

 Virgin

 EXP(-AX)=1.0-(AX)+(AX)\*\*2/2-(AX)\*\*3/6+(AX)\*\*4/24-........ Virgin

 =(SUM K=0 TO INFINITY) (-AX)\*\*K/(K FACTORIAL) Virgin

 Virgin

 AND THE INTEGRAL REDUCES TO THE FORM.... Virgin

 Virgin

 (SUM K=0 TO INFINITY) ((-A)\*\*K/(K FACTORIAL)) \* Virgin

 (INTEGRAL -1 TO 1) (X\*\*(N+K))\*DX Virgin

 Virgin

 WHICH CAN BE ANALYTICALLY EVAULATED TO FIND.... Virgin

 (K(N) = K FACTORIAL) Virgin

 Virgin

 N=0 Virgin

 --- Virgin

 F(A,0) = 2\*(1+(A\*\*2)/K(3)+(A\*\*4)/K(5)+(A\*\*6)/K(7)+.... Virgin

 Virgin

 N=1 Virgin

 --- Virgin

 F(A,1) = -2\*A\*(2/K(3)+4\*(A\*\*2)/K(5)+6\*(A\*\*4)/K(7)+8\*(A\*\*6)/K(9)+.. Virgin

 Virgin

 N=2 Virgin

 --- Virgin

 F(A,2) = 2\*(2/K(3)+3\*4\*(A\*\*2)/K(5)+5\*6\*(A\*\*4)/K(7)+ Virgin

 7\*8\*(A\*\*6)/K(9)+.... Virgin

 Virgin

 THESE EXPANSIONS ARE USED WHEN THE ABSOLUTE VALUE OF A IS LESS Virgin

 THAN 0.1. BY TRUNCATING THE ABOVE SERIES BEFORE A\*\*8 THE ERROR Virgin

 RELATIVE TO THE LEADING TERM OF THE SERIES WILL BE 10\*\*(-10), Virgin

 YIELDING 10 DIGIT ACCURACY. Virgin

 Virgin

 AFTER EVALUATING THE ABOVE FUNCTIONS, EITHER DIRECTLY OR BY USING Virgin

 THE EXPANSION THE TWO REQUIRED INTEGRALS CAN BE WRITTEN AS... Virgin

 Virgin

 FLUX Virgin

 ---- Virgin

 DE\*EXP(-AVXCT\*Z)\*(AVS\*F(A,0) + DS\*F(A,1)) Virgin

 Virgin

 REACTIONS Virgin

 --------- Virgin

 DE\*EXP(-AVXCT\*Z)\* Virgin

 (AVS\*AVXCR\*F(A,0) + (AVS\*DXCR+AVXCR\*DS)\*F(A,1) + DS\*DXCR\*F(A,2)) Virgin

 Virgin

 INPUT FILES Virgin

 ----------- Virgin

 FILENAME UNIT DESCRIPTION Virgin

 -------- ---- ----------- Virgin

 INPUT 2 INPUT LINES Virgin

 ENDFIN 10 EVALUATED DATA IN ENDF/B FORMAT Virgin

 Virgin

 OUTPUT FILES Virgin

 ------------ Virgin

 FILENAME UNIT DESCRIPTION Virgin

 -------- ---- ----------- Virgin

 OUTPUT 3 OUTPUT LISTING Virgin

 Virgin

 SCRATCH FILES Virgin

 ------------- Virgin

 FILENAME UNIT DESCRIPTION Virgin

 -------- ---- ----------- Virgin

 SCR1 12 REACTION, FLUX AND CROSS SECTION RESULTS (BCD) Virgin

 (SORTED AT END OF RUN AND OUTPUT SEPARATELY) Virgin

 SCR2 13 TALLY GROUP ENERGY BOUNDARIES (BINARY) Virgin

 SCR3 14 SOURCE SPECTRUM (BINARY) Virgin

 SCR4 15 TOTAL CROSS SECTION (BINARY) Virgin

 SCR5 16 REACTION CROSS SECTION (BINARY) Virgin

 Virgin

 OPTIONAL STANDARD FILE NAMES (SEE SUBROUTINE FILIO1 AND FILEIO2) Virgin

 ---------------------------------------------------------------- Virgin

 UNIT FILE NAME FORMAT Virgin

 ---- ---------- ------ Virgin

 2 VIRGIN.INP BCD Virgin

 3 VIRGIN.LST BCD Virgin

 10 ENDFB.IN BCD Virgin

 11-15 (SCRATCH) BINARY Virgin

 16 PLOTTAB.CUR PLOTTAB OUTPUT FORMAT DATA Virgin

 Virgin

 INPUT LINES Virgin

 ----------- Virgin

 ANY NUMBER OF CASES MAY BE RUN ONE AFTER THE OTHER. AFTER THE Virgin

 FIRST CASE HAS BEEN RUN THE FOLLOWING CASES MAY USE THE SAME Virgin

 THICKNESSES, GROUP STRUCTURE AND SPECTRUM AS THE PRECEDING CASE. Virgin

 IN ADDITION THE TRANSMITTED SPECTRUM FROM ONE CASE MAY BE USED Virgin

 AS THE INCIDENT SPECTRUM IN THE NEXT CASE, TO ALLOW MULTIPLE Virgin

 LAYERS OF DIFFERENT MATERIALS. Virgin

 Virgin

 LINE COLS. FORMAT DESCRIPTION Virgin

 ---- ----- ------ ---------- Virgin

 1 1-60 ENDF/B INPUT DATA FILENAME Virgin

 (STANDARD OPTION = ENDFB.IN) Virgin

 Virgin

 LEAVE THE DEFINITION OF THE FILENAMES BLANK - THE PROGRAM WILL Virgin

 THEN USE STANDARD FILENAMES. Virgin

 Virgin

 2-3 1-72 18A4 TWO LINE TITLE DESCRIBING PROBLEM Virgin

 4 1- 6 I6 ZA (1000\*Z+A) OF TARGET FOR TOTAL Virgin

 7-11 I5 MT OF TOTAL Virgin

 12-22 E11.4 DENSITY FOR TOTAL Virgin

 23-28 I6 ZA (1000\*Z+A) OF TARGET FOR REACTION Virgin

 29-33 I5 MT OF REACTION Virgin

 = 0 - NO REACTION CALCULATION (ONLY FLUX). Virgin

 = GREATER THAN 0 - CALCULATE REACTIONS. Virgin

 34-44 E11.4 DENSITY FOR REACTION Virgin

 45-50 I6 NUMBER OF TARGET THICKNESSES Virgin

 = GREATER THAN 0 = READ FROM INPUT Virgin

 (1 TO 2000 ALLOWED) Virgin

 = 0 = SAME AS LAST CASE Virgin

 51-55 I5 NUMBER OF TALLY GROUPS Virgin

 (REMEMBER NUMBER OF GROUP BOUNDARIES Virgin

 IS ONE MORE THAN THE NUMBER OF GROUPS) Virgin

 UP TO 2000 GROUPS ARE ALLOWED Virgin

 BUILT-IN GROUP STRUCTURES. Virgin

 = GREATER THAN 0 = READ FROM INPUT Virgin

 = 0 TART 175 GROUPS Virgin

 = -1 ORNL 50 GROUPS Virgin

 = -2 ORNL 126 GROUPS Virgin

 = -3 ORNL 171 GROUPS Virgin

 = -4 SAND-II 620 GROUPS..1.0e-4 eV TO 18 MEV Virgin

 = -5 SAND-II 640 GROUPS..1.0e-4 eV TO 20 MEV Virgin

 = -6 WIMS 69 GROUPS Virgin

 = -7 GAM-I 68 GROUPS Virgin

 = -8 GAM-II 99 GROUPS Virgin

 = -9 MUFT 54 GROUPS Virgin

 =-10 ABBN 28 GROUPS Virgin

 =-11 TART 616 GROUPS TO 20 MeV Virgin

 =-12 TART 700 GROUPS TO 1 GeV Virgin

 =-13 SAND-II 665 GROUPS..1.0e-5 eV TO 18 MEV Virgin

 =-14 SAND-II 685 GROUPS..1.0e-5 eV TO 20 MEV Virgin

 =-15 TART 666 GROUPS TO 200 MeV Virgin

 =-16 SAND-II 725 GROUPS..1.0e-5 eV TO 60 MEV Virgin

 =-17 SAND-II 755 GROUPS..1.0e-5 eV TO 150 MEV Virgin

 =-18 SAND-II 765 GROUPS..1.0e-5 eV TO 200 MEV Virgin

 56-60 I5 NUMBER OF POINTS IN SOURCE SPECTRUM Virgin

 (MUST BE AT LEAST TWO POINTS) Virgin

 = GREATER THAN 1 = READ FROM INPUT Virgin

 = 0 = SAME AS LAST CASE Virgin

 = -1 = CONSTANT (ENERGY INDEPENDENT) Virgin

 = -2 = 1/E Virgin

 = -3 = BLACKBODY - PHOTON SPECTRUM Virgin

 = -4 = BLACKBODY - ENERGY SPECTRUM Virgin

 = -5 = TRANSMITTED SPECTRUM FROM LAST CASE Virgin

 NOTE, ALL SPECTRA, EXCEPT THE TRANSMITTED Virgin

 SPECTRUM FROM THE LAST CASE, WILL BE Virgin

 NORMALIZED SUCH THAT ITS INTEGRAL OVER Virgin

 ENERGY WILL BE UNITY. Virgin

 61-64 1X,3I1 SPATIALLY DEPENDENT OUTOUT Virgin

 = 0 = NO Virgin

 = 1 = YES Virgin

 FOR THE 3 QUANTITIES Virgin

 COLUMN 67 FLUX Virgin

 68 REACTIONS Virgin

 69 AVERAGE CROSS SECTION Virgin

 65-65 I1 ENERGY DEPENDENT OUTOUT Virgin

 = 0 = NONE Virgin

 = 1 = INCIDENT SPECTRUM Virgin

 = 2 = TRANSMITTED SPECTRUM Virgin

 = 3 = INCIDENT REACTIONS Virgin

 = 4 = TRANSMIITED REACTIONS Virgin

 = 5 = TOTAL CROSS SECTION Virgin

 = 6 = REACTION CROSS SECTION Virgin

 5 1-11 E11.4 BLACKBODY TEMPERATURE IN eV Virgin

 12-22 E11.4 FLUX NORMALIZATION Virgin

 23-33 E11.4 REACTION NORMALIZATION Virgin

 CALCULATIONS WILL BE BASED ON THE SPECTRUM Virgin

 AND CROSS SECTIONS AS READ. AT OUTPUT THE Virgin

 RESULTS WILL BE MULTIPLIED BY THESE Virgin

 NORMALIZATION FACTORS. Virgin

 34-44 I11 DENSITY PROFILE Virgin

 = 0 - UNIFORM - BASED ON TOTAL DENSITY Virgin

 = 1 - UNIFORM - TOTAL + REACTION DENSITY Virgin

 = 2 - TOTAL + LINEAR REACTION Virgin

 = 3 - LINEAR (TOTAL + REACTION) Virgin

 = 4 - TOTAL + SQUARE REACTION Virgin

 = 5 - SQUARE (TOTAL + REACTION) Virgin

 = 6 - TOTAL + CUBIC REACTION Virgin

 = 7 - CUBIC (TOTAL + REACTION) Virgin

 6-N 1-66 6E11.4 TARGET THICKNESSES IN CM Virgin

 IF SAME AS LAST CASE THIS SECTION IS NOT Virgin

 INCLUDED IN THE INPUT. Virgin

 VARY 1-66 6E11.4 TALLY GROUP ENERGY BOUNDARIES Virgin

 (NUMBER OF BOUNDARIES IS ONE MORE THAN Virgin

 THE NUMBER OF TALLY GROUPS) Virgin

 IF THE STANDARD OPTION (-14 TO 0) IS Virgin

 SELECTED THIS SECTION IS NOT INCLUDED Virgin

 IN THE INPUT Virgin

 VARY 1-66 6E11.4 SOURCE SPECTRUM IN ENERGY (eV)-SOURCE PAIRS Virgin

 (MUST BE AT LEAST TWO POINTS) Virgin

 IF STANDARD OPTION (-5 TO 0) IS SELECTED THIS Virgin

 SECTION IS NOT INCLUDED IN THE INPUT Virgin

 Virgin

 ANY NUMBER OF CASES MAY BE RUN ONE AFTER ANOTHER. Virgin

 Virgin

 EXAMPLE INPUT NO. 1 Virgin

 ------------------- Virgin

 CALCULATE THE UNCOLLIDED FLUX AND CAPTURE (MT=102) THROUGH Virgin

 30 CM OF IRON (DENSITY 7.87 G/CC). TALLY THE RESULTS USING Virgin

 THE TART 175 GROUP STRUCTURE. THE SOURCE WILL BE CONSTANT Virgin

 FROM 1 KEV TO 20 MEV. USE THE STANDARD ENDF/B INPUT DATA Virgin

 FILENAME. Virgin

 Virgin

 ENDFB.IN Virgin

 IRON 0 TO 30 CM THICK. Virgin

 CONSTANT SOURCE FROM 1 KEV TO 20 MEV. Virgin

 26000 1 7.87000+ 0 26000 102 7.87000+ 0 2 0 2 1100 Virgin

 0.00000+ 0 1.00000+ 0 1.00000+ 0 0 0.00000+00 Virgin

 0.00000+00 3.00000+01 Virgin

 1.0000E+03 1.0000E+00 2.0000E+07 1.0000E+00 Virgin

 Virgin

 EXAMPLE INPUT NO. 2 Virgin

 ------------------- Virgin

 CALCULATE THE UNCOLLIDED PHOTON FLUX THROUGH A MIXTURE OF SILICON Virgin

 AND IRON FOR 100 MEV PHOTONS INCIDENT. THE TRANSMISSION WILL BE Virgin

 CALCULATED FOR 21 THICKNESSES VARYING BETWEEN 0 AND 1 CM. THERE Virgin

 WILL BE ONLY 1 TALLY GROUP SPANNING A VERY NARROW ENERGY RANGE Virgin

 NEAR 100 MEV, AND THE SOURCE SPECTRUM WILL BE CONSTANT OVER THE Virgin

 SAME ENERGY RANGE. USE THE STANDARD ENDF/B INPUT DATA FILENAME Virgin

 BY LEAVING THE FIRST INPUT LINE BLANK. Virgin

 Virgin

 (THIS IS A BLANK LINE TO USE THE STANDARD INPUT FILENAME) Virgin

 100 MEV PHOTONS Virgin

 SILICON + 5 % IRON Virgin

 14000 521 2.30000+ 0 26000 521 1.15000- 1 21 1 2 1000 Virgin

 0.00000+ 0 1.00000+ 0 1.00000+ 0 1 0.00000+00 Virgin

 0.00000+00 5.00000-01 1.00000+00 1.50000+00 2.00000+00 2.50000+00 Virgin

 3.00000+00 3.50000+00 4.00000+00 4.50000+00 5.00000+00 5.50000+00 Virgin

 6.00000+00 6.50000+00 7.00000+00 7.50000+00 8.00000+00 8.50000+00 Virgin

 9.00000+00 9.50000+00 1.00000+01 Virgin

 9.99000+ 7 1.00100+ 8 Virgin

 9.99000+ 7 1.00000+ 4 1.00100+ 8 1.00000+ 4 Virgin

 Virgin

 ======================================================================= Virgin