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Volume II

**WANL SOURCE TERM PROGRAM
STATUS REPORT
VOLUME II OF II**

(Title Unclassified)

MASTER

**Astronuclear Laboratory
Westinghouse Electric Corporation**

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796 II

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WANL-TME-796, Volume II

WANL SOURCE TERM PROGRAM
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VOLUME II OF II

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1.0 SUMMARY

This document describes a computer program that is capable of calculating the source strength of radioactive debris on the earth's surface resulting from the re-entry of reactor fragments following operation of a nuclear powered rocket vehicle. The factors that must be considered in evaluating the radiological hazards associated with the radioactive material are described in Volume I of this report.

The WANL Source Term Computer Program is written in FORTRAN II for the IBM 7094 computer. The program calculates 1) the resultant velocity and re-entry angles imparted to core fragments by an explosive destruct action, 2) the fragment's orbit lifetime and re-entry time to ground impact, 3) the mass loss of the fragment due to re-entry burnup, and 4) fission product inventory and gamma and beta energy source strength of the fragment at ground impact.

The program is suitable for use in parametric studies where the relative hazards of many particles of different size and different initial orbit parameters must be evaluated. Up to 200 cases may be run in one set of problems, with no limit on the number of stacked sets of problems. Average machine running time is approximately 5-6 seconds per case.

The present program is limited to the calculation of the fission product inventory of fragments of NERVA type fuel. Only normal reactor operations are considered and loss of fission products by diffusion is neglected.

2.0 INTRODUCTION

The radioactivity or source term associated with the operation and subsequent re-entry of nuclear powered rocket vehicles were defined in Volume I of this report. In order to evaluate the radiological hazards arising from the re-entry of radioactive components or debris resulting from such operations, it is necessary to consider all events of the flight operation. Such events include: (a) the buildup and decay of fission products during reactor operation, (b) loss of fission products from the fuel by diffusion, (c) post-operational history including effects of reactor destruct or passive re-entry of the intact reactor, (d) determination of orbital lifetime and re-entry trajectories of the engine or engine fragments, and (e) estimation of the radioactive source strength and biological hazards associated with the fragments at the time of ground impact.

The approach followed for the solution of the overall problem has been to develop a technique which is capable of analyzing the separate events or conditions contributing to the definition of the source term. Specifically, our objective has been to develop an IBM 7094 computer program for the determination of the radiological hazards on the ground resulting from re-entry of the reactor or reactor fragments of a nuclear powered rocket vehicle following normal and abnormal modes of operation of the nuclear rocket engine. The program shall accept as input: (1) reactor power and cooldown history and core temperature profiles, (2) size and velocity vectors of fragments resulting from a destruct action, excursion, or other events causing engine disassembly, and (3) the altitude and velocity vectors of the engine just prior to the destruct event. Output from the computer program shall include the time of impact and

radionuclide inventory of re-entering fragments, the size and radiation levels of these fragments, and the distance traveled by these fragment from the point of destruct.

WANL has developed such a program known as the WANL Source Term Computer Program. The program is comprised of a system of computer codes linked together in two or more chains. The program described in this report is comprised of six major programs and numerous subprograms coupled together in two links. Link 1 considers the destruct action, the orbital lifetime, the re-entry times, and the distances traveled by resulting core fragments. Link 2 calculates the fission product inventory and radiation levels of the core fragments utilizing the decay times (re-entry times) from Link 1. The program considers only the radioactivity originating from the fission products in the reactor fuel. As pointed out in Volume I, the fission product activity accounts for the large majority of the total source term activity upon re-entry. The present program calculates the fission product inventory for normal operations and neglects losses by diffusion. However, the code is written in a flexible manner, so that when separate computer programs become available to calculate core temperature profiles and loss of fission products by diffusion, they can readily be coupled to the existing system of codes.

This report contains a detailed description of the present status of the WANL Source Term Computer Program. Operation of the program and instructions for its use are presented. A sample problem showing application and results of the program is included.

3.0 PROGRAM DESCRIPTION

This chapter describes the structure of the WANL Source Term Computer Program, and a description of the operations performed in each of the two chain links. Operating procedures and instructions for input data are described in Chapter 4.

3.1 PROGRAM STRUCTURE

Evaluation of the re-entry hazards resulting from nuclear rocket flight operations can be classified into two main categories (1) that of determining the post-mission flight trajectories, the ground impact time and location of the vehicle or fragments, and (2) that of calculating the fission product activity and radiation source strength associated with these fragments. Calculation of items in the first category is accomplished in Chain Link 1 by means of a control program (MAIN - LINK 1) calling on subsidiary programs (subroutines) for the computation of re-entry trajectories, orbit lifetimes, etc. Calculation of the fission product inventory is accomplished in Chain Link 2 by a subroutine called by its control program (MAIN 2 - LINK 2). The names and purpose of each of the important programs and subprograms used in each link are summarized in Table 3-1. Description of the operation of each of these links is presented in paragraph 3.2.

Provision is included in Link 1 for iteration of calculations to accommodate up to 200 cases in order to determine the effects of varying particle size and destruct parameters. At completion of the Link 1 calculations, re-entry and ground impact time for each case are retained in the computer core storage for use in the Link 2 calculations.

During operation of the FPIP subroutine in Link 2, detailed data on the activity and radiation source strength for each nuclide in the library is stored on magnetic tape. Normal

TABLE 3-1

CHAIN LINKS AND PROGRAMS

Chain Link 1

<u>Program Name</u>	<u>Purpose</u>	<u>Comments</u>
Main - Link 1	Logical control of computation sequence in Link 1	
Subroutine VECTOR	Calculates resultant velocity and re-entry angle of particle following destruct action.	
Subroutine D4	Solves particle trajectory equations to calculate re-entry time for fragments to reach velocity of Mach 1; calculates re-entry burn-up.	See Appendix A
Subroutine F1	Calculates orbital lifetime of fragments whose space residence time exceeds 10 orbital revolutions.	See Appendix A

Chain Link 2

Main 2 - Link 2	Logical control of computation sequence in Link 2.	
Subroutine SORT	Calculates decay time for a range of fragment impact times for which the dose from the particle can be estimated within 10% accuracy.	See Appendix B
Subroutine FPIP	Calculates fission product inventory and radiation source strength for each fragment at time of ground impact.	See Appendix C
Subroutine SCRIB	Prints out from data stored on magnetic tape complete fission product activity for any selected case.	

print-out includes only the total microcuries and beta and gamma energies (in 5 and 4 energy groups, respectively) of each fragment. The detailed data is retrievable by use of Subroutine SCRIB. This subprogram reads and prints the data stored on the tape for any selected case.

Provision is included in Link 2 for the future coupling of the output of the FIPDIF program (Volume 1, Chapter 3.0, Paragraph 3.1.2.2). The final fission product inventory of the core for 273 isotopes as calculated by FIPDIF, can be outputted on magnetic tape or punched cards. Link 2 will accept either the card or tape input and then calculate activity of each core fragment based on the re-entry time as determined by Link 1 and based on the initial inventory as calculated by FIPDIF.

Following completion of the last case, control is returned to Link 1 for computation of the next set of problems. This feature allows stacking of problems. Each problem set may contain as many as 200 cases, with no limit on the number of stacked sets of problems. The detailed data for each set is retrievable by individual case number in any selected set by use of the SCRIB subroutine.

3.2 OPERATING DESCRIPTION

The Source Term Computer Program is designed to calculate the radioactivity level of core fragments at ground impact resulting from a high energy destruct action of the reactor. The program accepts as input, data from punched cards. A main control program for each chain link then reads the data cards and initiates and controls the sequence of computations in each link.

3.2.1 Link 1

The sequence of operations as controlled by the main program of Link 1 is given in Figure 3-1. Table 3-2 is a FORTRAN listing of the main program. The listings of the sub-programs called by the main program are given in Appendix E.

Input data required for Link 1 is as follows:

- (1) Altitude of vehicle prior to destruct.
- (2) Velocity of vehicle.
- (3) Velocity imparted to core fragment by destruct action.
- (4) Vertical angle, measured with reference to the local horizontal, imparted to the fragment by destruct action.
- (5) Azimuthal angle, measured with reference to the motion of the vehicles center of mass, imparted to the fragment by destruct action.
- (6) Re-entry angle of the vehicle prior to destruct, measured with respect to the local horizontal.
- (7) Diameter of the core fragment (assumed to be a spherical particle).
- (8) Initial temperature of the core fragment.
- (9) Time from last reactor shutdown to time of destruct.
- (10) Density of the core fragment.
- (11) Maximum computer time allowed for calculation of each case.

Items 8, 9, 10, and 11 are initialized by the program for the most common case, and do not require input values unless desired. These initial values and instructions for preparation of

FIGURE 3-1
MAIN PROGRAM FOR LINK 1

input data are given in Chapter 4.

Calculations of the resultant velocities, re-entry angles, and orbit parameters of the core fragments are made by Subroutine VECTOR. Provision is made for automatically by-passing the VECTOR routine if vector calculations are not required for following cases. This would be true if different cases had the same destruct parameters, but only particle diameter or time of destruct was changed. In the future, if a program becomes available which calculates destruct parameters, the Source Term Computer Program will be capable of accepting data from that program as input. This could be accomplished with minor programming changes, and with the addition of another chain link to supply destruct data to the existing Link 1.

Following the vector calculations, the main program computes the approximate orbit time of the particle based on the initial perigee and eccentricity of the particle orbit. Transfer is then made to either Subroutine D4 or F1 to calculate the re-entry or orbit lifetime of the particle. A detailed description of the D4 and F1 subprograms is presented in Appendix A. For fragments with an anticipated space lifetime greater than ten orbits, the F1 subprogram is used. This program has been found to yield accurate calculations of lifetime with maximum computer speed (< than five seconds for lifetimes up to two years in orbit). For those fragments with estimated lifetime of less than ten orbital revolutions, the D4 subprogram is used. This program calculates the re-entry time for the particle to reach a velocity of Mach 1. In addition, for those fragments that re-enter in less than one revolution, the distance traveled from the point of destruct to the point of impact is calculated. The D4 program also calculates burnup of the core material due to re-entry reheating, with resulting loss in mass and decrease

in particle size. For particles using the F1 program, burnup is calculated in the main program by one of three analytical functions derived from applications of the D4 program.

Following the re-entry or lifetime computations, the time interval between time at Mach 1 and ground impact (the "settling time") is calculated and added to the re-entry time. In the case of particles having long orbit lifetimes, this settling time is insignificant in comparison to the total time from destruct to ground impact. However, for very small particles (< 1000 microns) which re-enter rapidly, the settling time can be an appreciable portion of the total time to ground impact. The total time to ground impact is then calculated for each particle as the sum of: (time interval between last reactor shutdown and destruct time) + (re-entry time or orbit lifetime) + (settling time).

The program then checks to determine if additional cases (up to 200) are to be calculated in Link 1. If not, a summary of the re-entry and ground impact data are printed out. Control is then transferred to the main program of Link 2. The particle mass, diameter, input time, and problem set number are retained in computer core storage for use in the Link 2 calculations.

3.2.2 Link 2

The sequence of computer operation in Link 2 is controlled by the main program, MAIN 2 (Figure 3-2). The FORTRAN listing for this program is shown in Table 3-3.

Input data required for Link 2 is as follows:

- (1) Number of reactor operating and shutdown periods.
- (2) Time at start and shutdown of each operating period, and reactor power level during each period.
- (3) Reactor fuel core mass (UC_2 + graphite).

FIGURE 3-2

MAIN PROGRAM FOR LINK 2

- (4) Time values used in calculating approximate decay times to allow dose estimates to be within 10% accuracy.
- (5) Boundary limits defining gamma and beta energy groups desired.
- (6) Fission product library data including disintegration constant, fission product yield, nuclide beta and gamma energies, etc.
- (7) Choice of options desired for print out, use of SORT routine, and use of library tapes.

Following read-in of the data and initializing steps, Link 2 calculates the fission product inventory and the radiation level of core fragments at the time of ground impact. The program utilizes as a subroutine a modified version of the Fission Product Inventory Program (Subroutine FPIP, Appendix C) to calculate the microcuries and beta and gamma emission rates of individual nuclides or of group sums in any of five chosen energy groups. The FPIP subprogram normally uses a library of 273 fission product nuclides, but a lesser number can be used if desired.

Prior to calculation of the fission product inventory, an option is available (Subroutine SORT, Appendix B) to sort the impact times into groups. The grouping is made on the assumption that a 10% error is allowable in calculation of the dose delivered by the particle. For each grouping, the SORT routine computes a new decay time to be used for the calculation of the activity of each particle within that group. Thus, if the SORT routine is used, the FPIP subroutine will calculate an average fission product inventory for a group of particles, from which the dose can be calculated within 10% accuracy. This

provision reduces computer running time in that the fission product inventory need not be calculated for every particle under consideration. If the SORT option is not selected, the exact inventory will be calculated for each particle at ground impact time.

At the completion of calculating the activity for each particle, a summary of the results are printed for each case. If desired, complete data on each fission product nuclide for any specific case can be requested by use of Subroutine SCRIB. However, the more usual practice would be to save the data stored on magnetic tape for later retrieval of data by case number after the summary print out has been evaluated.

TABLE 3-2 (Cont'd)

VI(8) = 4000.	1MA	41
VI(9) = 0.	1MA	42
VI(10) = 137.	1MA	43
VI(11) = 15.	1MA	44
IVEC = 0	1MA	45
LAST = 0	1MA	46
CALL EPMDE(5)	1MA	47
C EPMDE(5) SUPPRESSES ERRCR PRINTOUT ON UNDERFLOW	1MA	48
CALL FAPTBL	1MA	49
C FAPTBL GENERATES AND STORES TABULAR DATA	1MA	50
READ INPUT TAPE NIN, 1000, TITLE	1MA	51
WRITE OUTPUT TAPE NCUT, 1002, TITLE	1MA	52
WRITE OUTPUT TAPE NOUT, 1010	1MA	53
100 READ INPUT TAPE NIN, 1001, (ISUB(J), TDATA(J), J = 1,6)	1MA	54
DO 110 J = 1,6	1MA	55
IF(ISUB(J))114,115,106	1MA	56
C ISUB = -1 LAST CASE	1MA	57
106 ITEMP = ISUB(J)	1MA	58
IF(ITEMP - 6) 107,107,108	1MA	59
107 IVEC = 1	1MA	60
108 VI(ITEMP) = TDATA(J)	1MA	61
110 CONTINUE	1MA	62
GO TO 100	1MA	63
114 LAST = 1	1MA	64
115 Y = VI(1)	1MA	65
VORIG = VI(2)	1MA	66
VDEST = VI(3)	1MA	67
ZETAR = VI(4) * R	1MA	68
EPSR = VI(5) * R	1MA	69
PHIR = VI(6) * R	1MA	70
DIA = VI(7)	1MA	71
TEMP = VI(8)	1MA	72
TIN = VI(9)	1MA	73
RHOB = VI(10)	1MA	74
TMAX = VI(11)	1MA	75
CONST = 3.0300854E-4 * RHOB	1MA	76
DIA T = DIA / 12.	1MA	77
IF(KASE) 122,120,122	1MA	78
120 WRITE OUTPUT TAPE NOUT, 1003, TEMP,RHOB,TIN	1MA	79
WRITE OUTPUT TAPE NCUT, 1004	1MA	80
122 KASE = KASE + 1	1MA	81

TABLE 3-2 (Cont'd)

C KASE = CASE COUNTER	1MA 82
WRITE OUTPUT TAPE NOUT, 1007, KASE, DIA, VORIG, VDEST, Y, VI(4),	1MA 83
1 VI(5), VI(6)	1MA 84
CALL RTIME(MON, IDAY, I HOUR, MIN, I SEC, 160TH)	1MA 85
SEC1 = I SEC + MIN * 60 + 3600 * I HOUR	1MA 86
IF(IVEC)125,126,125	1MA 87
125 CALL VECTOR(Y ,VORIG,VDEST,ZETAR,EPSR,PHIR,PSIR,V,PER,APD,ECC,PD)	1MA 88
C VECTOR CALCULATES V AND PSIR	1MA 89
C V = RESULTANT PARTICLE VELOCITY (FT./SEC.)	1MA 90
C PSIR = RESULTANT RE-ENTRY ANGLE (RADIAN)	1MA 91
C PER = PERIGEE (NEAREST POINT ABOVE EARTH)	1MA 92
C APD = APOGEE (HIGHEST POINT ABOVE EARTH)	1MA 93
C ECC = ECCENTRICITY	1MA 94
C PD = PERIOD (SEC)	1MA 95
IVEC = 0	1MA 96
126 VPN (KASE) = V	1MA 97
PSIPN(KASE) = PSIR* DEG	1MA 98
PERPN(KASE) = PER	1MA 99
ECCPN(KASE) = ECC	1MA 100
PDPN(KASE) = PD / 60.	1MA 101
APOPN(KASE) = APD	1MA 102
IF(PER)145,145,127	1MA 103
127 IF(PER-6.E5)128,128,129	1MA 104
128 IF(ECC - .02)145,145,129	1MA 105
129 TTEMP = CUT(ECC,PER)	1MA 106
C TORBIT = APPROX. ORBIT TIME	1MA 107
130 TORBIT = TTEMP * RHCB * DIAFT / 3.	1MA 108
TIMMIN = TORBIT / PD	1MA 109
IF(TIMMIN - 10.) 140,155,155	1MA 110
140 TIMMAX = TORBIT / 5310.	1MA 111
IF(TIMMAX - 10.) 145,155,155	1MA 112
145 CALL D4	1MA 113
C D4 CALCULATES TIME,DISTANCE, PARTICLE DIA AND MASS TO MACH-1	1MA 114
TAG(KASE) = 2FD4	1MA 115
C X = TOTAL DISTANCE COVERED BY PARTICLE (FEET)	1MA 116
X = F(1) * ERAD	1MA 117
IF(X - 1.313E8) 148,148,146	1MA 118
*6 IF1(KASE) = 1	1MA 119
GO TO 150	1MA 120
*3 IF1(KASE) = 0	1MA 121
XPNI(KASE) = X	1MA 122

TABLE 3-2 (Cont'd)

C DIA2 = PARTICLE DIAMETER AT MACH 1 (INCHES)	1MA 123
150 DIA2 = F(6) * 24.	1MA 124
GO TO 205	1MA 125
155 CALL F1	1MA 126
C F1 CALCULATES TIME IN ORBIT TO MACH-1 DISTANCE GREATER THAN 10 ORBITS	1MA 127
TAG(KASE) = 2HF1	1MA 128
IF1(KASE) = 1	1MA 129
C CALCULATE NEW PARTICLE SIZE DUE TO BURNUP ON RE-ENTRY	1MA 130
IF(DIA - .0625) 160,160,165	1MA 131
160 EMM = .57 * DIA **3 * CONST	1MA 132
GO TO 200	1MA 133
165 IF(DIA - .28) 170,170,180	1MA 134
170 EMM = (1. + .15667*LCGF(DIA)) * DIA **3 *CONST	1MA 135
GO TO 200	1MA 136
180 IF(DIA - 1.5) 185,190,190	1MA 137
185 EMM = (1. - .35927875 + .73952545*DIA - .64581095*DIA**2 +	1MA 138
1 .19414098*DIA**3) * DIA **3 * CONST	1MA 139
GO TO 200	1MA 140
190 EMM = (1.0 - .075/DIA) * DIA **3 * CONST	1MA 141
200 DIA2 = (EMM / CONST) ** .33333333	1MA 142
C CALCULATE SETTLING TIME AS FUNCTION OF PARTICLE SIZE AFTER BURNUP	1MA 143
C TSET = SETTLING TIME(SEC)	1MA 144
205 IF(DIA2 - .055) 210,210,220	1MA 145
210 TSET = (3.246226E-2 * DIA2) ** (-1.2672665)	1MA 146
GO TO 300	1MA 147
220 IF(DIA2 - .25) 230,230,240	1MA 148
230 TSET = 6.622049E3 - 9.570148E4 * DIA2 + 6.326960E5 * DIA2**2 -	1MA 149
1 1.8559E6 * DIA2**3 + 1.942195E6 * DIA2**4	1MA 150
GO TO 300	1MA 151
240 IF(DIA2 - .35) 250,250,260	1MA 152
250 TSET = (3.578074E-5 * DIA2) ** (-.5828405)	1MA 153
GO TO 300	1MA 154
260 TSET = (2.014098E-6 * DIA2) ** (-.4647186)	1MA 155
C TIN = TIME FROM LAST REACTOR SHUT DOWN TO TIME OF DEST. IN SEC.)	1MA 156
C TMACH1 = TIME FROM DESTRUCT TO TIME AT MACH-1 (SEC.)	1MA 157
C TIMIMP = TOTAL TIME AT IMPACT (MIN)	1MA 158
300 TIMIMP(KASE) = (TSET + TMACH1 + TIN)/60.	1MA 159
C DIAIMP = FINAL DIAMETER OF PARTICLE AT GROUND IMPACT(INCHES)	1MA 160
DIAIMP(KASE) = DIA2	1MA 161
C XMASS = FINAL MASS AT IMPACT	1MA 162
XMASS(KASE) = EMM * 453.5924	1MA 163

TABLE 3-2 (Cont'd)

C IHANG = 1(NO ERROR), 2(NON-CON), 3(HANG-UP), 4(TIME LIMIT)	1MA 164
IH = IHANG	1MA 165
GO TO (310,312,314,316),IH	1MA 166
310 HANG(KASE) = 1H	1MA 167
GO TO 325	1MA 168
312 HAN (KASE) = 6HNONCON	1MA 169
GO TO 325	1MA 170
314 HANG(KASE) = 6HHANGUP	1MA 171
GO TO 325	1MA 172
316 HANG(KASE) = 6HTM-LIM	1MA 173
325 CONTINUE	1MA 174
IF(SENSE SWITCH 1)350,330	1MA 175
330 IF(LAST) 350,100,350	1MA 176
350 WRITE OUTPUT TAPE NOUT, 1002, TITLE	1MA 177
WRITE OUTPUT TAPE NOUT, 1011	1MA 178
WRITE OUTPUT TAPE NOUT, 1005	1MA 179
WRITE OUTPUT TAPE NOUT, 1008 , (I, VPN(I), PSIPN(I), PERPN(I),	1MA 180
1 AOPN(I), ECCPN(I), POPN(I), I = 1,KASE)	1MA 181
WRITE OUTPUT TAPE NOUT, 1002, TITLE	1MA 182
WRITE OUTPUT TAPE NOUT, 1012	1MA 183
WRITE OUTPUT TAPE NOUT, 1006	1MA 184
DO 500 I = 1,KASE	1MA 185
C IF1 = 1 (DISTANCE GREATER THAN 1 ORBIT)	1MA 186
IF(IF1(I))420,410,420	1MA 187
410 WRITE OUTPUT TAPE NOUT, 1009, I, DIAIMP(I), XMASS(I), TIMIMP(I),	1MA 188
1 XPN(I), TAG(I), HANG(I)	1MA 189
GO TO 500	1MA 190
420 WRITE OUTPUT TAPE NOUT, 1013, I, DIAIMP(I), XMASS(I), TIMIMP(I),	1MA 191
1 TAG(I), HANG(I)	1MA 192
500 CONTINUE	1MA 193
IF(SENSE SWITCH 1)600,620	1MA 194
600 IF(LAST)605,605,620	1MA 195
605 READ INPUT TAPE NIN, 1001, (ISUB(J), TDATA(J), J = 1,6)	1MA 196
DO 610 J = 1,6	1MA 197
IF(ISUB(J))620,610,610	1MA 198
610 CON INUE	1MA 199
GO TO 605	1MA 200
TIME = CLOCKF(A,B)	1MA 201
PRINT 1026, TIME	1MA 202
WRITE OUTPUT TAPE NOUT, 1027, TIME	1MA 203
CALL CHAIN(2,N2)	1MA 204

TABLE 3-2 (Cont'd)

1000	FORMAT(12A6)				1MA	205
1001	FORMAT(6(I2,E10.4))				1MA	206
1002	FORMAT(1H1,20X12A6 ///)				1MA	207
1003	FORMAT(10X14HTEMPERATURE = F7.2, 42H DEGREES RANKINE			PARTICLE	1MA	208
	1E DENSITY = F7.2, 14H POUNDS/CU.FT. / 10X50H TIME FROM REACTOR SHUT				1MA	209
	2 DOWN TO TIME OF DESTRUCT = 1PE14.6, 8H SECONDS ///				1MA	210
1004	FORMAT(110H	NO.	PARTICLE	ORIGINAL	DESTRUCT	1MA 211
	1 ALTITUDE	VERTICAL	AZIMUTHAL	RE-ENTRY	/	1MA 212
	2 110H		DIAMETER	VELOCITY	VELOCITY	1MA 213
	3	ANGLE	ANGLE	ANGLE	/	1MA 214
	4 110H		(INCHES)	(FT/SEC)	(FT/SEC)	1MA 215
	5 (FEET)		(DEGREES)	(DEGREES)	(DEGREES)	1MA 216
1005	FORMAT(110H	NO.	RESULTANT	RESULTANT	PERIGEE	1MA 217
	1 APOGEE		ECCENTRICITY	PERIOD	/	1MA 218
	2 110H		VELOCITY	ANGLE	ALTITUDE	1MA 219
	3 ALTITUDE				/	1MA 220
	4 110H		(FT/SEC)	(DEGREES)	(FEET)	1MA 221
	5 (FEET)			(MINUTES)	///	1MA 222
1006	FORMAT(110H	NO.	PARTICLE	PARTICLE	IMPACT	1MA 223
	1 RANGE		RE-ENTRY	ERROR	/	1MA 224
	2 110H		DIAMETER	MASS	TIME	1MA 225
	3		MODE	TAG	/	1MA 226
	4 110H		(INCHES)	(GRAMS)	(MINUTES)	1MA 227
	5) (FEET)				///	1MA 228
1007	FORMAT(6XI3, OPF12.5, 1P3E16.6, OP3F12.4)					1MA 229
1008	FORMAT(6XI3, 1P6E16.6)					1MA 230
1009	FORMAT(6XI3, 1P4E16.6, 10XA2, 10XA6)					1MA 231
1010	FORMAT(46X18H*** INPUT LIST *** ///					1MA 232
1011	FORMAT(35X39H*** OUTPUT LIST AT TIME OF DESTRUCT *** ///					1MA 233
1012	FORMAT(36X37H*** OUTPUT LIST AT TIME OF IMPACT *** ///					1MA 234
1013	FORMAT(6XI3, 1P3E16.6, 17H GT.TN. 1 ORBIT, 9XA2, 10XA6)					1MA 235
1026	FORMAT(10X23H LINK 1 COMPLETE--TIME , -3PF6.3)					1MA 236
1027	FORMAT(//16X30H TIME AT COMPLETION OF LINK 1 , -3PF6.3)					1MA 237
	END					1MA 238

TABLE 3-3

FORTRAN LISTING - MAIN PROGRAM LINK 2

MAIN2 LINK 2 WANL SOURCE TERM PROGRAM	2MA	1
C COMMON TO LINK ONE AND LINK TWO	2MA	2
COMMON TIMIMP,XMASS,DIAIMP,KASE,TITLE,ISET2	2MA	3
DIMENSION TIMIMP(200),XMASS(200),DIAIMP(200),TITLE(12)	2MA	4
C COMMON TO LINK TWO	2MA	5
COMMON A, ACTIV,ACTO,ACTTOT,BETSUB,BTOTAL,BETA,BETTOT,D,DIS,EGAM,	2MA	6
1 EG1,EG2,EB1,EB2,EBETA,FGAM,FR,F1,F2,F3,GAMSUB,GTOTAL,GAMMA,ICASE	2MA	7
2,J1,J2,J3,LINK,LLAST,M,N,NTIME,NOP,NO,SYMBOL,TIME,YIELD,FBETA	2MA	8
3,TSTART,POWER,Y,D,ACTIN,ALFA,NB,NG,G,B,GECONV,BECONV,N5,N6,N11,N9	2MA	9
4,TD,DELT,LIBCHS,INPUT,MICRO,CORMAS,NOC,IWANT,ICASE2	2MA	10
5,TIME2,N12,IALL,JT	2MA	11
DIMENSION A(1448),ACTIV(200),ACTTOT(274),BETSUB(5,200),BTOTAL(200)	2MA	12
1,DIS(274),EGAM(25),EG1(5),EG2(4),EB1(6),EB2(5),EBETA(25),FGAM(25)	2MA	13
2,FR(1448),F1(274),F2(274),F3(274),GAMSUB(4,200),GTOTAL(200)	2MA	14
3,ICASE(200),J1(274),J2(274),J3(274),LINK(645),M(275),N(645)	2MA	15
4,SYMBOL(274),TIME(200),YIELD(274),FBETA(25),TSTART(10),POWER(10)	2MA	16
5,Y(645),D(1448),ACTIN(274),ALFA(1448),ACTO(645),G(5),B(5)	2MA	17
6,GECONV(274,5),BECONV(274,5),BETA(274,5),GAMMA(274,4),BETTOT(274)	2MA	18
7,GAMTOT(274),IWANT(200),ICASE2(200),TIME2(200)	2MA	19
C* LIBCHS = -1 EXISTING LIBRARIES ARE TO BE USED FROM TAPE 11	2MA	20
C* = 0 EXISTING LIBRARIES WITH FIXED GAMMA AND BETA ENERGY	2MA	21
C* GROUP BOUNDARIES ARE TO BE USED FROM TAPE 10.	2MA	22
C* = 1 NEW LIBRARIES ARE TO BE GENERATED FROM DATA CARDS	2MA	23
C* INPUT = OPTION TO PRINT OUT LIBRARIES 0=NO, 1=YES	2MA	24
C* ISORT = OPTION TO USE SORT SUBROUTINE 0=NO 1=YES	2MA	25
C* MICRO = -1 MICROCURIES ARE READ FROM TAPE 12	2MA	26
C* MICRO = 0 MICROCURIES WILL NOT BE READ IN	2MA	27
C* MICRO = +1 MICROCURIES ARE READ FROM DATA CARDS	2MA	28
C* ISET = CONTROL FOR STACKED PROBLEMS 0=LAST CASE 1=MORE CASES	2MA	29
C* TO FOLLOW	2MA	30
C* ISCRIB = OPTION TO PRINT COMPLETE DATA FROM TAPE N9 0=NO,1=YES	2MA	31
C* IFOL = CONTROL TO SEARCH MORE THAN 1 SET OF PROBLEMS ON TAPE N9	2MA	32
C* 1 = MORE SETS TO FOLLOW, 0= NO SETS TO FOLLOW	2MA	33
C* ISET3 = PROBLEM SET NUMBER AS STORED ON TAPE N9	2MA	34
C* IALL = OPTION TO PRINT OUT ALL DATA 0=NO 1=YES	2MA	35
C* NOC = NUMBER OF CASES YOU WISH PRINTED	2MA	36
C* IWANT = CASE NUMBERS OF THOSE YOU WISH PRINTED	2MA	37
2 = 2	2MA	38
5=5	2MA	39

TABLE 3-3 (Cont'd)

N6=6	2MA	40
N9=9	2MA	41
N11=11	2MA	42
N12=12	2MA	43
REWIND N2	2MA	44
IF(ISET2)9,8,9	2MA	45
8 REWIND N9	2MA	46
9 ISET2 = ISET2 + 1	2MA	47
C ISET2 = NUMBER OF EACH SET OF STACKED CASES	2MA	48
READ INPUT TAPE N5,1015,NOP,ISORT,ISCRIB,LIBCHS,INPUT,MICRO,ISET	2MA	49
WRITE TAPE N9, ISET2,ISET, TITLE	2MA	50
15 READ INPUT TAPE N5,1016,CORMAS,TD,DELT	2MA	51
C CORMAS=CORE MASS(GRAMS) TD,DELT DEFINITIONS GIVEN IN SUBROUTINE SORT	2MA	52
DO 20 I=1,NOP	2MA	53
READ INPUT TAPE N5,1016,TSTART(I),POWER(I),TIME2(I)	2MA	54
20 CONTINUE	2MA	55
NUMOP =NOP-1	2MA	56
IF (LIBCHS) 25,30,25	2MA	57
25 READ INPUT TAPE N5,1016,{G(I),I=1,4}	2MA	58
READ INPUT TAPE N5,1016,{B(I),I=1,5}	2MA	59
30 IF (MICRO) 35,45,40	2MA	60
35 REWIND N12	2MA	61
READ INPUT TAPE N5,1020,NO	2MA	62
NO=NO+1	2MA	63
READ TAPE N12,{ACTIN(I),I=2,NO}	2MA	64
REWIND N12	2MA	65
GO TO 45	2MA	66
40 READ INPUT TAPE N5,1020,NO	2MA	67
NO=NO+1	2MA	68
READ INPUT TAPE N5,1013,{ACTIN(I),I=2,NO}	2MA	69
45 CONTINUE	2MA	70
DO 50 I = 1,KASE	2MA	71
TIME(I) = TIMIMP(I)	2MA	72
C TIMIMP = GROUND IMPACT TIME (MINUTES)	2MA	73
50 ICASE(I) = I	2MA	74
IF (ISORT) 55,60,55	2MA	75
55 CALL SORT	2MA	76
C SORT CALCULATES DECAY TIME FOR RANGE OF PARTICLE IMPACT TIMES	2MA	77
60 CALL FPIP	2MA	78
C FPIP CALCULATES RADIOACTIVITY AND SOURCE STRENGTH FOR EACH PARTICLE	2MA	79
DO 65 I = 1,KASE	2MA	80

TABLE 3-3 (Cont'd)

	I1 = ICASE(I)	2MA	81
65	ICASE2(I1) = I	2MA	82
	WRITE OUTPUT TAPE N6,1000	2MA	83
	WRITE OUTPUT TAPE N6,1001,TITLE	2MA	84
	WRITE OUTPUT TAPE N6,1002	2MA	85
	DO 70 K=1,NOP	2MA	86
	WRITE OUTPUT TAPE N6,1003,TSTART(K),POWER(K)	2MA	87
70	CONTINUE	2MA	88
	WRITE OUTPUT TAPE N6,1004	2MA	89
	DO 75 K = 1,KASE	2MA	90
	I1 = ICASE2(K)	2MA	91
	I2 = I1 + NUMOP	2MA	92
	WRITE OUTPUT TAPE N6,1005,K,DIAIMP(K),XMASS(K),TIMIMP(K),	2MA	93
	1TIME(I1),ACTIV(I2)	2MA	94
75	CONTINUE	2MA	95
	WRITE OUTPUT TAPE N6,1006,TITLE	2MA	96
	WRITE OUTPUT TAPE N6,1007	2MA	97
	WRITE OUTPUT TAPE N6,1008,(EG1(L),EG2(L),L=1,3),EG1(4)	2MA	98
	DO 80 K=1,KASE	2MA	99
	I1 = ICASE2(K)	2MA	100
	I2 = I1 + NUMOP	2MA	101
	GENDIS = GTOTAL(I2)/(37000. * ACTIV(I2))	2MA	102
	WRITE OUTPUT TAPE N6,1009,K,TIME(I1),(GAMSUB(L,I2),L=1,4),	2MA	103
	1GTOTAL(I2),GENDIS	2MA	104
80	CONTINUE	2MA	105
	WRITE OUTPUT TAPE N6,1006,TITLE	2MA	106
	WRITE OUTPUT TAPE N6,1010	2MA	107
	WRITE OUTPUT TAPE N6,1011,(EB1(L),EB2(L),L=1,4),EB1(5)	2MA	108
	DO 85 K= 1,KASE	2MA	109
	I1 = ICASE2(K)	2MA	110
	I2 = I1 + NUMOP	2MA	111
	BENDIS = BTOTAL(I2)/(37000. * ACTIV(I2))	2MA	112
	WRITE OUTPUT TAPE N6,1012,K,TIME(I1),(BETSUB(L,I2),L=1,5),	2MA	113
	1BTOTAL(I2),BENDIS	2MA	114
85	CONTINUE	2MA	115
	WRITE OUTPUT TAPE N6,1014	2MA	116
C SC	B READS AND PRINTS COMPLETE DATA FROM TAPE N9	2MA	117
	IF(SENSE SWITCH 1)110,100	2MA	118
	WRITE OUTPUT TAPE N6, 1017,ISET2,(ICASE(I), I=1,KASE)	2MA	119
	IMEX= CLOCKF(A,P)	2MA	120
	WRITE OUTPUT TAPE N6 , 1019, TIMEX	2MA	121

TABLE 3-3 (Cont'd)

PRINT 1018, TIMEX	2MA 122
IF(ISET) 115,115,105	2MA 123
105 CALL CHAIN(1,N2)	2MA 124
110 WRITE OUTPUT TAPE N6, 1017,ISET2,(ICASE(I), I=1,KASE)	2MA 125
TIMEX= CLOCKF(A,B)	2MA 126
WRITE OUTPUT TAPE N6 , 1019, TIMEX	2MA 127
PRINT 1018, TIMEX	2MA 128
115 END FILE N9	2MA 129
REWIND N9	2MA 130
IF (ISCRIB)125,125,120	2MA 131
120 CALL SCRIB	2MA 132
125 CALL EXIT	2MA 133
1000 FORMAT (1H1,46H SUMMARY OF PARTICLE FISSION PRODUCT INVENTORY//)	2MA 134
1001 FORMAT (19X,12A6///)	2MA 135
1002 FORMAT (5X,21HREACTOR POWER HISTORY/1X,19HSTARTING TIME (MIN),6X,	2MA 136
1 20HPOWER (FISSIONS/MIN))	2MA 137
1003 FORMAT(4X1PE12.5, 14X1PE12.5)	2MA 138
1004 FORMAT (///,24X,59HPARTICLE SIZE AND FISSION PRODUCT ACTIVITY AT G2MA 139	
1ROUND IMPACT///2X,18HCASE NO. DIAMETER,6X,4HMASS,4X,35HACTUAL IMP2MA 140	
2ACT TIME DECAY TIME USED,5X,8HACTIVITY/12X,8H(INCHES),4X,7H(GRAMS2MA 141	
3),7X,9H(MINUTES),9X,9H(MINUTES),6X,14H(MICRO-CURIES)//)	2MA 142
1005 FORMAT (4X,I3,3X,F9.5,4X,1PE10.4,4X,1PE10.4,10X,1PE10.4,7X1PE10.4)2MA 143	
1006 FORMAT (1H1,18X,12A6///)	2MA 144
1007 FORMAT (24X,57HPARTICLE GAMMA SOURCE ENERGIES (MEV/SEC) AT GROUND 2MA 145	
1IMPACT///2X,20HCASE NO. DECAY TIME,18X,18HENERGY GROUPS(MEV),18X,2MA 146	
211HTOTAL GAMMA,3X,9H(MEV/DIS))	2MA 147
1008 FORMAT (13X,9H(MINUTES),3(2X,F6.2,1H-F4.2),4X,F6.2,2H--,4X,9H(MEV/2MA 148	
1SEC)///)	2MA 149
1009 FORMAT (4X,I3,5X,1PE10.4,5(3X,1PE10.4),5X,OPF5.3)	2MA 150
1010 FORMAT(24X,56HPARTICLE BETA SOURCE ENERGIES (MEV/SEC) AT GROUND 1M2MA 151	
1PACT//2X,20HCASE NO. DECAY TIME, 23X, 19HENERGY GROUPS (MEV), 25X2MA 152	
2, 21HTOTAL BETA (MEV/DIS))	2MA 153
1011 FORMAT (13X,9H(MINUTES),4(2X,F6.2,1H-F4.2),4X,F6.2,2H--,4X,9H(MEV/2MA 154	
1SEC)///)	2MA 155
1012 FORMAT (4X,I3,5X,1PE10.4,3X,1PE10.4,3X,1PE10.4,3X,1PE10.4,3X,	2MA 156
1 1PE10.4,3X,1PE10.4,3X,1PE10.4,3X,OPF5.3)	2MA 157
1013 FORMAT(5(4X,E10.4))	2MA 158
1014 FORMAT(//16X,67H* *COMPLETE DATA ON PARTICLES IS STORED ON TAPE 9 2MA 159	
1BY CASE NUMBER* *)	2MA 160
1015 FORMAT (12I6)	2MA 161
1016 FORMAT(6E12.4)	2MA 162

TABLE 3-3 (Cont'd)

1017	FORMAT(// 5X63H	THE ORDER IN WHICH THE CASE NUMBERS IS STORED ON	TA2MA 163
	1PE 9 FOR SET , I3 , 14H IS AS FOLLOWS, //(1H0, 8I12))		2MA 164
1018	FORMAT(10X23H	LINK 2 COMPLETE--TIME , -3PF6.3)	2MA 165
1019	FORMAT(//16X30H	TIME AT COMPLETION OF LINK 2 , -3PF6.3)	2MA 166
1020	FORMAT (I4)		2MA 167
	END		2MA 168

4.0 OPERATING PROCEDURE

This chapter provides instructions for use of the WANL Source Term Computer Program. Input required and input card formats are described. Information also is provided on the selection of operating options and an estimate of computer operating time required.

4.1 INPUT DESCRIPTION AND FORMATS

4.1.1 Link 1

The scheme used for the input data cards of Link 1 has been especially constructed to facilitate parametric studies. The first card of the data deck is a title card used to identify the set of problems. The subsequent decimal data cards are read on a FORTRAN format of 6(I2, E10.4). Each data item, entered in floating point in the ten column field is preceded by a fixed-point integer in the two column field. Columns 1-72 are thus used to enter as many as six data items on one card. The integer accompanying each datum is an index which identifies that datum as a particular input variable. The FORTRAN names of the variables and their identifying index numbers are listed in Table 4-1.

The indices of the input data are also the subscripts of these items in a dimensional array known as VI (named for Value Initial). As each datum is read from the input card, its accompanying index is also checked, and the datum is stored in the indicated cell of VI. Data cards are read in this manner, left to right, until a zero (or blank) index is encountered. This is a signal that the input for this case is completed, and the contents of the 11 cells of VI are stored in their proper cells to initialize the problem. This card reading procedure permits selective alteration of any or all of the input variables, although

TABLE 4-1

FORMAT AND NOMENCLATURE
LINK 1

Card No.	Column (s)	Format	Index No. (VI)	FORTRAN Name	Description
1	1-72	12A6		TITLE	Alphanumeric title card.
*	1-72	6(I2, E10.4)	1	Y	Initial altitude of vehicle (ft.)
			2	VORIG	Original velocity of vehicle before destruct (ft./sec).
			3	VDEST	Destruct velocity imparted to core fragment (ft./sec).
			4	ZETA	Vertical destruct angle (degrees)
			5	EPS	Azimuthal destruct angle (degrees)
			6	PHI	Initial re-entry angle before destruct (degrees)
			7	.DIA	Particle diameter (inches)
			8	TEMP	Temperature of particle at time of destruct (°R)
			9	TIN	Time from last reactor shutdown to time of destruct (seconds)
			10	RHOB	Density of the particle (lbs/ft ³)
			11	TMAX	Maximum computer running time allowed for D4 or F1 computation (seconds)
		I2	-1	ISUB	Indicator to signal last case.

* Use one or two cards for each case depending on the number of input variables used. Variables may be entered on data card in any order, provided index number and name are matched according to this table.

all of them are always used as initial values for the new case. Thus, any initial values which are not set from the input cards for the next case will be set from the data "left over" in the VI array from the previous case. This feature facilitates input for parametric studies, where only one or two variables vary from case to case, since only the variables being changed need to be entered on cards. If the number of data items entered on one card is exactly six, (column 61-72 used), the data card for that case must be followed by a blank card to provide a blank index field as a signal that all the data for that case have been read. For the last case in a set of problems, a -1 should be inserted in the index field to signal completion of Link 1 and allow Link 2 to be called. If this last-case index signal is omitted, the program will fail without calling Link 2 and the job will be terminated. Up to 200 cases may be included in one set.

Four input variables are initialized by the program and need not be read in by data cards unless so desired. These values were selected as those most likely to be used for most problems:

VI (8) TEMP = 4000°R

VI (9) TIN = 0 (corresponding to destruct immediately at shutdown)

VI (10) RHOB = 137 lbs/ft³ (density of fueled graphite)

VI (11) TMAX = 15 seconds

A value of 15 seconds for TMAX has been found to be adequate time for the computations in the D4 and F1 program. Only those fragments with orbit lifetimes greater than about 12 years have reached this 15-second time limit. If the time limit is reached, that

case is terminated, an error tag (TM—LIM) is printed on the output, and computation on the next case is automatically started.

4.1.2 Link 2

The card formats and variable names used to operate this link are listed in Table 4-2. Further description on the use of the options available in this link is given in paragraph 4.2.

4.1.3 Coupling of Link 1 and Link 2

Data cards for Link 2 are placed behind those of Link 1. If stacked sets of problems are submitted, place the additional data card sets in the same order (Link 1 - Link 2) behind the first set. * CHAIN (1,2) and * CHAIN (2,2) cards must immediately precede the object decks of Link 1 and Link 2, respectively.

4.2 LINK 2 OPTIONS

Several options are available for use in Link 2. A brief description of the use of each follows.

ISORT - This option is used to reduce computer running time when solving many problems. This option calculates a decay time for a range of particle impact times. This new decay time is then used in subroutine FPIP to calculate the fission particle inventory for those particles having similar re-entry times. A complete explanation of the theory and use of SORT is given in Appendix B.

ISCRIB - This option is used to print the detailed fission product inventory data (calculated by FPIP) for each of the 273 nuclides. Data, for each nuclide includes:

TABLE 4-2

FORMAT AND NOMENCLATURE
LINK 2

Card No.	Column (s)	Format	FORTRAN Name	Description
1	4-6	12I6	NOP	No. of operating and shutdown periods. For example, for a single operating period followed by a shutdown period, NOP =
	12		ISORT	Use SORT routine 0 = No, 1 = Yes.
	18		ISCRIB	Use SCRIB routine 0 = No, 1 = Yes.
	24		LIBCHS	<u>-1</u> use library from tape 11 <u>0</u> use library from tape 10 with constant boundaries defining gamma and beta energy ranges. <u>1</u> use new library and generate tapes 10 and 11.
	30		INPUT	Print-out libraries 0 = No, 1 = Yes
	36		MICRO	<u>-1</u> read microcuries tape 12 <u>1</u> read microcuries cards <u>0</u> don't read in microcuries
	42		ISSET	1 = more sets to follow; 0 = last set
If ISORT = 0 then TD and DELT = 0.0				
2	1-12	6E12.4	CORMAS	Core mass (grams)
	13-24		TD	Time interval between ground impact and initial exposure of critical organ to the particle (hrs.)
	25-36		DELT	Total exposure time of critical organ to the particle (hrs.)

TABLE 4-2

(CONTINUED)

Card No.	Column (s)	Format	FORTTRAN Name	Description
3	1-12	6E12.4	TSTART	Time at start of period (min.)
	13-24		POWER	Power level during period (fissions/min.)
	25-36		TIME2	Ending time of each period (min.). For the last shutdown period (re-entry period), insert TIME2 = 0.
NOTE: Use one input card 3 for each operating period (NOP). For one operating period followed by reactor destruct, NOP = 2. For reactor restarts use additional cards. Enter in order of increasing time.				
If LIBCHS = 0 omit cards 4,5,6				
4	1-48	6E12.4	G (I)	Upper bounds defining gamma energy groups in order of increasing energy. Maximum of 4 energy groups. Enter 20.0 for last boundary (Mev.)
5	1-60	6E12.4	B (I)	Upper bound defining beta energy groups in order of increasing energy. Maximum of 5 energy groups. Enter 20.0 for last boundary (Mev.).
6	2-4	I3	NO	Number of nuclides (273). This card to be included only when LIBCHS = <u>1</u> or MICRO = <u>1</u> .
Only include card 7 if MICRO = <u>1</u> .				
7	1-70	5(4X,E10.4)	ACTIN	Nuclide activity (μ c) from external program. In 4X, put nuclide identification number, in E10.4 put microcuries. Use as many cards as required, 5 nuclides per card.

TABLE 4-2

(CONTINUED)

Card No.	Column (s)	Format	FORTRAN Name	Description
Cards 8-9-10-11 needed only when LIBCHS = <u>1</u>				
8	3			Enter <u>1</u>
	6-11			Enter <u>BASIC</u>
	12-14			Enter <u>0.0</u>
	24-26			Enter <u>0.0</u>
	39			Enter <u>0</u>
	43			Enter <u>0</u>
	47			Enter <u>0</u>
	48-50			Enter <u>0.0</u>
	55-57			Enter <u>0.0</u>
	62-64			Enter <u>0.0</u>

Library decay input data: Enter NO cards, one card for each nuclide. Nuclides are numbered and inputted sequentially in order of decay, i.e., a parent always precedes a daughter in the same chain, beginning with number 2. Use the following format on each card.

9	2-4	13	1	Nuclide Identification Number
	6-11	A6	SYMBOL	Nuclide chemical symbol and mass number (e.g., CO-72)
	12-13	E12.4	DIS	Nuclide disintegration constant (Min. ⁻¹)
	24-35	E12.4	YIELD	Nuclide individual fission product yield fraction
	37-39	12	J1	Identification number of nuclide's first direct parent. Enter <u>1</u> if there are no parents

TABLE 4-2

(CONTINUED)

Card No.	Column (s)	Format	FORTRAN Name	Description
9	41-43	I3	J2	Identification of 2nd direct parent. Enter <u>1</u> if one or no direct parent.
	45-47	I3	J3	Identification of 3rd direct parent. Enter <u>1</u> for 2 or less direct parents.
	48-54	F7.3	F1	Branching ratio for decay from J1. Enter 1.0 if J1 = 1.
	55-61	F7.3	F2	Branching ratio for decay from J2. Enter 1.0 if J2 = 1.
	62-68	F7.3	F3	Branching ratio for decay from J3. Enter 1.0 if J3 = 1.
Gamma energy input data: Enter NO sets of data, a set for each nuclide in the same order as the decay input data, i.e., increasing identification number. Begin each set with a new card. Use the following format for each set.				
10	2-4	I3	I	Nuclide identification number
	6-7	I2	NG	No. of discrete gamma energies to be entered for nuclide (≤ 25).
	8-72	5 (F7.4 F6.4)	EGAM FGAM	Enter NG pairs of gamma energies and their fractions of occurrence per disintegration $NG > 5$. Use additional cards, but leave col. 1-7 blank. NG = 5 insert blank card before next set (Mev.).
Beta energy input data: Enter NO sets of data, a set for each nuclide, in the same order as the decay input data, i.e., increasing identification number. Begin each set with a new card. Use the following format on each card.				
11	2-4	I3	I	Nuclide Identification number.
	6-7	I2	NB	No. of discrete beta energies to be entered for nuclide (≤ 25).
	8-72	5 (F7.4, F6.4)	EBETA FBETA	Same as gamma energies.

TABLE 4-2

(CONTINUED)

Card No.	Column (s)	Format	FORTRAN Name	Description
Only include card (s) 12 if ISCRIB = 1. Start with a new card for each set of problems to be printed. Place in order of increasing set number.				
12	6	12 I6	IFOL	If another set follows = 1, otherwise = 0.
	12		ISET 3	Set number to be selected for tape 9 search.
	16-18		IALL	Option to print all data in the selected set 0 = no, 1 = yes.
	22-24		NOC	Number of cases you wish printed in the selected set.
	34-36		IWANT(J)	Case numbers of those you wish printed. Use additional cards as needed, entering case numbers in 12I6 field, 6 cases per card.
	46-48, etc.			

microcuries, gamma energies in each of 4 groups, beta energy in each of 5 groups, and total gamma and beta energies. The printout uses 12 pages for each case.

Printout of any (or all) cases in any or all sets can be accomplished by use of this option during execution of the program. However, when using the SORT option in order to minimize computer operating time, it is recommended to set ISCRIB = 0, with instructions given to the computer operator to save tape 9 (Channel Unit A5). After the summary data is analyzed, tape 9 can then be remounted and specific cases retrieved by the use of a separate main program (SCRIB-T9S). This program is the same as the subroutine SCRIB (see Appendix E FORTRAN listing), with the values of ISET 3, NOC, and WANT(J) read from separately prepared input data cards.

If the ISCRIB option is requested during execution of the program (and SORT routine is used), the order in which the cases are stored on tape 9 cannot be predicted. Thus, extra 7094 time is required to search the tapes to find the cases requested.

LIBCHS - This option is used to select whether the fission product library data is read from data cards or magnetic tape. With LIBCHS = 1, the library is read from cards, and the Subroutine FPIP program calculates each nuclide subchain and simultaneously writes the chain libraries on tapes 10 and 11. Once tapes 10 and 11 have been generated, library data cards need not be used.

Further description of the generation and use of tapes 10 and 11 is described in Appendix C. For the minimum computer running time, the tape 10 library should be used. With this tape, the gamma and beta energy ranges are fixed at those values selected when

generating the tape. If different boundary limits are desired, tape 11 is used, and data cards 4 and 5 must then be read in. When tape 11 is used, a new tape 10 is generated with the new boundaries.

INPUT - This option selects the printing out of the input library read from data cards or the library stored on tape 11. The option is useful when preparing a new library and it is desired to check the card data or tape 11 to insure no errors have been introduced. A listing of the 273 nuclide library used in this program is given in Appendix C.

MICRØ - This option was included for future coupling with the FIPDIF program. It allows reading in from tape or data cards of any arbitrary value of microcuries for 273 nuclides. These input activities can then be decayed for the varying times corresponding to the impact times calculated in Link 1. When using this option it is necessary to specify a reactor operating period and power level (input card 3). This is a dummy period and any values may be used, as they will not be used in the final calculation.

ISET - This is a program control option and must be used when stacking sets of problems. ISET must be set equal to 1 when more than one set of problems comprises the job. For only one set or the last set, ISET = 0.

4.3 ADDITIONAL OPERATING INSTRUCTIONS

The libraries used by subroutine FPIP are stored on the following tapes:

Regular Library (Tape 11) WANL Tape No. 6D5

"Speedy" Library (Tape 10) WANL Tape No. 4D12

When either of these library tapes are to be used, the following instructions must be used on

the 7094 request form:

For Regular Library:

- (1) Mount TAPE 6D5 on B5, 800 BPI
- (2) Mount blank tape on A5 and A6 and save, 800 BPI

For "Speedy" Library:

- (1) Mount TAPE 4D12 on A6, 800 BPI
- (2) Mount blank tape on A5 and save, 800 BPI

If new library tapes are to be generated from data cards, replace instruction (1) by "Mount Blank Tapes on B5 and A6, 800 BPI, and SAVE".

Computer operating time required for processing in each link is shown on the output for each set of problems. On the average, 10 to 12 cases per minute can be expected as the normal operating rate on the 7094 computer. This time refers to the total calculation time required to process a case through both links. This time estimate is based on the use of the "speedy" library tape (Tape 10), the SORT option, and with three sets of stacked problems of 20 cases each. A repeat of the same job without using the SORT routine required about nine seconds per case. Use of the SCRIB routine adds another 2-5 seconds per case. Time required to generate tapes 10 and 11 is about 30 seconds; time to read tapes 11 and 10 into core storage is about seven and one seconds, respectively.

The above information may be used to estimate computation time. Operating time used in each link is written on the 7094 on-line printer. On large jobs, if excessive running

time is consumed in Link 1, a forced exit from this link can be accomplished by depressing Sense Switch 1. This action terminates reading of further data in Link 1, writes output on the cases calculated to that time, and transfers control to Link 2.

5.0 PROGRAM APPLICATION

To illustrate application of the Source Term Program, a typical nuclear vehicle flight was selected. The vehicle is assumed to be a three stage vehicle consisting of two chemical stages and an orbit start nuclear stage. The vehicle is launched into a 100 nautical mile orbit by the chemical stages, and then the nuclear stage separates and coasts for one inertial revolution. The nuclear engine is then started, and the engine operated at a 1000 MW power level continuously until escape velocity is reached, or until prior failure or power cutoff.

For our illustration, two failure times were selected: (1) Nuclear power (1000 MW) is maintained for 1 minute with (a) immediate explosive destruct and with (b) delayed destruct until the vehicle reaches perigee of its new orbit following the engine failure; (2) Nuclear power (1000 MW) is maintained for 5 minutes with delayed destruct until the vehicle reaches (a) apogee and (b) perigee of its new orbit. The core is assumed to be destructed into many fragments. The fate of one fragment, a 1000 micron spherical fuel particle, is followed to ground impact. A number of cases are considered. The particle is assumed to receive velocity increments of 100, 500, or 1500 fps at four different angles imparted by the explosive destruct action. The activity of the particle at ground impact for each initial condition is then calculated by the program.

Data for the initial flight trajectory of the vehicle prior to destruct has been calculated by Lockheed*. This trajectory information was used to define the initial

* Lockheed Missiles and Space Company, "Nuclear Flight Executive Program, Nuclear Vehicle Flight Safety Study, Phase III Report", LMSC-A304973, January 31, 1964.

altitude, initial velocity, and initial re-entry angle of the vehicle after 1 and 5 minutes powered flight at 1000 MW power level.

5.1 SAMPLE PROBLEM INPUT

Analysis of the two mission failures described above can be handled as two problem sets (Set 1--1 minute power, Set 2--5 minutes power), with each set containing up to 200 cases. For the problem considered here, 24 cases are analyzed for Set 1 and 18 cases for Set 2.

Input data used in Link 1 for both sets is shown in Table 5-1. Data for Link 2 is listed in Table 5-2. Input for Link 2 was designed for use of the "Speedy" library tape, and therefore input data cards 4 to 6 and 8 to 11 are omitted. The values of TD and DELT are based on the model that the GI Tract is the critical organ for a 1000 μ (0.03937 inches) diameter particle (See Appendix B). Sample coding forms used for key punching input data cards for Set 1 are shown in Figure 5-1 and 5-2.

5.2 COMPUTER RESULTS

The printout of the results for the computer solution of the sample problem are presented in the following tables:

TABLE 5-3	One Minute Power Operation - Link 1
TABLE 5-4	One Minute Power Operation - Link 2
TABLE 5-5	Five Minute Power Operation - Link 1
TABLE 5-6	Five Minute Power Operation - Link 2
TABLE 5-7	Fission Product Nuclide Activity, Set 1, Case 8.

TABLE 5-1

SAMPLE PROBLEM INPUT DATA - LINK 1

Variable	<u>SET 1</u>		<u>SET 2</u>	
	Problem 1a	Problem 1b	Problem 5a	Problem 5b
Y	6.070806×10^5	1.678053×10^6	6.171845×10^5	8.973235×10^6
VORIG	2.59004×10^4	2.4671×10^4	2.7585×10^4	1.9869×10^4
VDEST	100,500,1500	100,500,1500	100,500,1500	100,500,1500
ZETA	+90°, -90°	+90°, -90°	+90°	+90°
EPS	0°, 180°	0°, 180°	0°, 180°	0°, 180°
PHI	-0.041°	0°	0°	0°
DIA	0.03937	0.03937	0.03937	0.03937
TIN	0	2.750×10^3	6.750×10^3	3.350×10^3

TABLE 5-2

SAMPLE PROBLEM INPUT DATA - LINK 2

<u>Card No.</u>	<u>Variable</u>	<u>Set 1</u>	<u>Set 2</u>
1	NOP	2	2
	ISORT	1	1
	ISCRIB	1	0
	LIBCHS	0	0
	INPUT	0	0
	MICRO	0	0
	ISSET	1	1
2	CORMAS	1.043×10^6	1.043×10^6
	TD	13	13
	DELT	18	18
3A	TSTART	0	0
	POWER	1.93×10^{21}	1.93×10^{21}
	TIME 2	1	5
3B	TSTART	1	5
	POWER	0	0
	TIME 2	0	0
12	IFOL	1	
	ISSET 3	1	
	IALL	0	
	NCC	1	
	IWANT	8	

The data of Table 5-7 was obtained by use of the ISCRIB option, utilizing Sub-routine SCRIB to print the complete data for case 8 of Set 1. Note from page 3 of Table 5-4 that case 8 is the tenth case stored on tape 9.

Westinghouse Electric Corporation

CODING FORM FOR IBM TYPE 7090 COMPUTER
FORTRAN - FAP

TITLE SAMPLE PROBLEM SET 1 - LINK 1															ANALYST W.S. Brown										PHONE					DATE					PROGRAM NO.					DECK NO.					L.S. NO.					SHEET																																												
FORTRAN															STAT. NO. #										FORTRAN STATEMENT															DECK NO.					SEQ. NO.																																																	
FAP															SYMBOL										OPERATION															ADDRESS, TAG										DECREMENT										REMARKS																																		
REF.															1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80																																																																															
															100 NM ORBIT START 1 MIN AT 1000 MW DESTRUCT AT PERIGEE AND APOGEE																																																																															
															1 607080.6										2 25900.4															3 100.										4 0.															5 0.															6 -0.041														
															7 0.03937										9 0.																																																																					
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FIGURE 5-1

CODING FORM FOR SAMPLE PROBLEM - LINK 1

[illegible]

FIGURE 5-2

CODING FORM FOR SAMPLE PROBLEM - LINK 2

TABLE 5-3

ONE MINUTE POWER OPERATION - LINK 1

100 M4 ORBIT START. 1 MIN AT 1000 MW DESTRUCT AT PERIGEE AND APOGEE

*** INPUT LIST ***

TEMPERATURE = 4000.00 DEGREES RANKINE PARTICLE DENSITY = 137.00 POUNDS/CU.FT.
 TIME FROM REACTOR SHUT DOWN TO TIME OF DESTRUCT = 0. SECONDS

NO.	PARTICLE DIAMETER (INCHES)	ORIGINAL VELOCITY (FT/SEC)	DESTRUCT VELOCITY (FT/SEC)	ALTITUDE (FEET)	VERTICAL ANGLE (DEGREES)	AZIMUTHAL ANGLE (DEGREES)	RE-ENTRY ANGLE (DEGREES)
1	0.03937	2.590040E 04	1.000000E 02	6.070806E 05	0.	0.	-0.0410
2	0.03937	2.590040E 04	1.000000E 02	6.070806E 05	0.	180.0000	-0.0410
3	0.03937	2.590040E 04	1.000000E 02	6.070806E 05	90.0000	0.	-0.0410
4	0.03937	2.590040E 04	1.000000E 02	6.070806E 05	-90.0000	0.	-0.0410
5	0.03937	2.590040E 04	5.000000E 02	6.070806E 05	0.	0.	-0.0410
6	0.03937	2.590040E 04	5.000000E 02	6.070806E 05	0.	180.0000	-0.0410
7	0.03937	2.590040E 04	5.000000E 02	6.070806E 05	90.0000	0.	-0.0410
8	0.03937	2.590040E 04	5.000000E 02	6.070806E 05	-90.0000	0.	-0.0410
9	0.03937	2.590040E 04	1.500000E 03	6.070806E 05	0.	0.	-0.0410
10	0.03937	2.590040E 04	1.500000E 03	6.070806E 05	0.	180.0000	-0.0410
11	0.03937	2.590040E 04	1.500000E 03	6.070806E 05	90.0000	0.	-0.0410
12	0.03937	2.590040E 04	1.500000E 03	6.070806E 05	-90.0000	0.	-0.0410
13	0.03937	2.467100E 04	1.000000E 02	1.678053E 06	0.	0.	0.
14	0.03937	2.467100E 04	1.000000E 02	1.678053E 06	0.	180.0000	0.
15	0.03937	2.467100E 04	1.000000E 02	1.678053E 06	90.0000	0.	0.
16	0.03937	2.467100E 04	1.000000E 02	1.678053E 06	-90.0000	0.	0.
17	0.03937	2.467100E 04	5.000000E 02	1.678053E 06	0.	0.	0.
18	0.03937	2.467100E 04	5.000000E 02	1.678053E 06	0.	180.0000	0.
19	0.03937	2.467100E 04	5.000000E 02	1.678053E 06	90.0000	0.	0.
20	0.03937	2.467100E 04	5.000000E 02	1.678053E 06	-90.0000	0.	0.
21	0.03937	2.467100E 04	1.500000E 03	1.678053E 06	0.	0.	0.
22	0.03937	2.467100E 04	1.500000E 03	1.678053E 06	0.	180.0000	0.
23	0.03937	2.467100E 04	1.500000E 03	1.678053E 06	90.0000	0.	0.
24	0.03937	2.467100E 04	1.500000E 03	1.678053E 06	-90.0000	0.	0.

Case Numbers 1-12 represent destruct at shutdown and at Perigee

Case Number 13-24 represent destruct at apogee - Time from reactor shutdown to time of destruct = 2750 seconds.

TABLE 5-3 (Cont'd)

100 NM ORBIT START. 1 MIN AT 1000 MW DESTRUCT AT PERIGEE AND APOGEE

*** OUTPUT LIST AT TIME OF DESTRUCT ***

NO.	RESULTANT VELOCITY (FT/SEC)	RESULTANT ANGLE (DEGREES)	PERIGEE ALTITUDE (FLEET)	APOGEE ALTITUDE (FLEET)	ECCENTRICITY	PERIOD (MINUTES)
1	2.600040E 04	-4.084231E-02	6.068967E 05	2.038702E 06	3.223639E-02	9.239346E Q1
2	2.580040E 04	-4.115801E-02	6.067082E 05	1.324651E 06	1.642606E-02	9.017350E 01
3	2.590052E 04	1.302153E-01	6.026105E 05	1.682816E 06	2.451578E-02	9.127144E 01
4	2.570066E 04	-2.622140E-01	5.976827E 05	1.688256E 06	2.475079E-02	9.127303E 01
5	2.640040E 04	-4.022340E-02	6.069880E 05	3.558112E 06	6.423683E-02	9.717376E 01
6	2.540040E 04	-4.180707E-02	-2.291550E 04	6.074792E 05	1.488157E-02	8.603789E 01
7	2.590437E 04	1.064357E 00	4.700657E 05	1.830894E 06	3.087378E-02	9.131971E 01
8	2.590558E 04	-1.146926E 00	4.509150E 05	1.852602E 06	3.179891E-02	9.132765E 01
9	2.740040E 04	-3.375550E-02	6.070400E 05	7.974300E 06	1.463838E-01	1.115336E 02
10	2.440040E 04	-4.352045E-02	-2.975343E 06	6.071405E 05	9.090752E-02	7.720060E 01
11	2.594273E 04	3.273671E 00	-1.837845E 05	2.620612E 06	6.342918E-02	9.174227E 01
12	2.594487E 04	-3.555397E 00	-2.101652E 05	2.654715E 06	6.478588E-02	9.176631E 01
13	2.477100E 04	0.	2.498720E 05	1.678068E 06	1.639927E-02	9.233775E 01
14	2.457100E 04	0.	2.693785E 05	1.678057E 06	3.221778E-02	9.022326E 01
15	2.467120E 04	2.322381E-01	5.396172E 05	1.685443E 06	2.464354E-02	9.127030E 01
16	2.467120E 04	-2.522381E-01	5.396172E 05	1.685443E 06	2.464354E-02	9.127030E 01
17	2.517100E 04	0.	1.678043E 06	2.394406E 06	1.562452E-02	9.687995E 01
18	2.417100E 04	0.	-1.015569E 06	1.678054E 06	3.347093E-02	8.627540E 01
19	2.467607E 04	1.161038E 00	4.599407E 05	1.841674E 06	3.134760E-02	9.132174E 01
20	2.467607E 04	-1.161038E 00	4.599407E 05	1.841674E 06	3.134760E-02	9.132174E 01
21	2.617100E 04	0.	1.678052E 06	6.577407E 06	9.792508E-02	1.104362E 02
22	2.317100E 04	0.	-3.842268E 06	1.678053E 06	1.393598E-01	7.780079E 01
23	2.471656E 04	3.473308E 00	-1.974242E 05	2.637486E 06	6.411463E-02	9.175234E 01
24	2.471656E 04	-3.479308E 00	-1.974242E 05	2.637486E 06	6.411463E-02	9.175234E 01

TABLE 5-3 (Cont'd)

100 NM ORBIT START. 1 MIN AT 1000 MW DESTRUCT AT PERIGEE AND APOGEE

*** OUTPUT LIST AT TIME OF IMPACT ***

NO.	PARTICLE DIAMETER (INCHES)	PARTICLE MASS (GRAMS)	IMPACT TIME (MINUTES)	RANGE (FEET)	RE-ENTRY MODE	ERROR TAG
1	3.105972E-02	5.642007E-04	4.105221E 02	GT.TN. 1 ORBIT	D4	
2	3.103557E-02	5.628801E-04	2.451059E 02	GT.TN. 1 ORBIT	D4	
3	3.116168E-02	5.697758E-04	3.042230E 02	GT.TN. 1 ORBIT	D4	
4	3.116314E-02	5.628555E-04	3.101206E 02	GT.TN. 1 ORBIT	D4	
5	3.264303E-02	6.543562E-04	1.033535E 03	GT.TN. 1 ORBIT	F1	
6	3.108736E-02	5.657028E-04	1.253927E 02	2.894208E 07	D4	
7	3.100544E-02	5.612480E-04	1.588403E 02	7.888813E 07	D4	
8	3.097310E-02	5.597645E-04	1.944283E 02	1.261545E 08	D4	
9	3.264303E-02	6.549562E-04	3.385619E 03	GT.TN. 1 ORBIT	F1	
10	3.119610E-02	5.711163E-04	1.138134E 02	1.215217E 07	D4	
11	3.097874E-02	5.597994E-04	1.104302E 02	6.404177E 06	D4	
12	3.097402E-02	5.595438E-04	1.706318E 02	8.760310E 07	D4	
13	3.264303E-02	6.549562E-04	1.456452E 03	GT.TN. 1 ORBIT	F1	
14	3.110037E-02	5.664204E-04	1.912795E 02	5.690350E 07	D4	
15	3.121665E-02	5.727900E-04	3.634575E 02	GT.TN. 1 ORBIT	D4	
16	3.112101E-02	5.675477E-04	3.685621E 02	GT.TN. 1 ORBIT	D4	
17	3.264303E-02	6.549562E-04	4.109395E 04	GT.TN. 1 ORBIT	F1	
18	3.107579E-02	5.650773E-04	1.748103E 02	3.265401E 07	D4	
19	3.108870E-02	5.657819E-04	2.005248E 02	7.171646E 07	D4	
20	3.113419E-02	5.632691E-04	2.210166E 02	9.972606E 07	D4	
21	3.264303E-02	6.549562E-04	4.567273E 05	GT.TN. 1 ORBIT	F1	
22	3.132504E-02	5.787835E-04	1.651129E 02	1.995889E 07	D4	
23	3.112411E-02	5.677174E-04	1.668562E 02	2.254726E 07	D4	
24	3.106305E-02	5.643623E-04	2.051645E 02	7.190863E 07	D4	

TIME AT COMPLETION OF LINK 1 9.851

TABLE 5-4
ONE MINUTE POWER OPERATION - LINK 2

SUMMARY OF PARTICLE FISSION PRODUCT INVENTORY

100 NM ORBIT START. 1 MIN AT 1000 MW DESTRUCT AT PERIGEE AND APOGEE

REACTOR POWER HISTORY
STARTING TIME (MIN) POWER (FISSIONS/MIN)
0. 1.93000E 21
1.00000E 00 0.

PARTICLE SIZE AND FISSION PRODUCT ACTIVITY AT GROUND IMPACT

CASE NO.	DIAMETER (INCHES)	MASS (GRAMS)	ACTUAL IMPACT TIME (MINUTES)	DECAY TIME USED (MINUTES)	ACTIVITY (MICRO-CURIES)
1	0.03106	5.6420E-04	4.1052E 02	4.9297E 02	3.1892E 02
2	0.03104	5.6289E-04	2.4511E 02	2.1685E 02	7.1357E 02
3	0.03116	5.6978E-04	3.0422E 02	2.1685E 02	7.2230E 02
4	0.03116	5.6986E-04	3.1012E 02	2.1685E 02	7.2241E 02
5	0.03264	6.5496E-04	1.0335E 03	1.0335E 03	1.7175E 02
6	0.03109	5.6571E-04	1.2539E 02	2.1685E 02	7.1715E 02
7	0.03101	5.6125E-04	1.5884E 02	2.1685E 02	7.1149E 02
8	0.03098	5.5976E-04	1.9443E 02	2.1685E 02	7.0961E 02
9	0.03264	6.5496E-04	3.3856E 03	3.3856E 03	4.2327E 01
10	0.03119	5.7112E-04	1.1381E 02	2.1685E 02	7.2400E 02
11	0.03098	5.5980E-04	1.1043E 02	2.1685E 02	7.0966E 02
12	0.03097	5.5954E-04	1.7063E 02	2.1685E 02	7.0933E 02
13	0.03264	6.5496E-04	1.4565E 03	1.4565E 03	1.1633E 02
14	0.03110	5.6642E-04	1.9128E 02	2.1685E 02	7.1805E 02
15	0.03122	5.7280E-04	3.6346E 02	4.9297E 02	3.2377E 02
16	0.03112	5.6755E-04	3.6856E 02	4.9297E 02	3.2081E 02
17	0.03264	6.5496E-04	4.1094E 04	4.1094E 04	2.6968E 00
18	0.03108	5.6508E-04	1.7481E 02	2.1685E 02	7.1635E 02
19	0.03109	5.6578E-04	2.0052E 02	2.1685E 02	7.1724E 02
20	0.03113	5.6827E-04	2.2102E 02	2.1685E 02	7.2039E 02
21	0.03264	6.5496E-04	4.5673E 05	4.5673E 05	1.0311E-01
22	0.03133	5.7878E-04	1.6511E 02	2.1685E 02	7.3372E 02
23	0.03112	5.6772E-04	1.6686E 02	2.1685E 02	7.1969E 02
24	0.03106	5.6438E-04	2.0516E 02	2.1685E 02	7.1547E 02

TABLE 5-4 (Cont'd)

100 NM ORBIT START. 1 MIN AT 1000 MW DESTRUCT AT PERIGEE AND APOGEE

PARTICLE GAMMA SOURCE ENERGIES (MEV/SEC) AT GROUND IMPACT

CASE NO.	DECAY TIME (MINUTES)	ENERGY GROUPS (MEV)				TOTAL GAMMA (MEV/SEC)	(MEV/DIS)
		0. -0.25	0.26-1.00	1.01-1.70	1.71--		
1	4.9297E 02	3.3922E 05	2.7190E 06	2.7667E 06	1.1835E 06	7.0085E 06	0.594
2	2.1685E 02	6.6758E 05	9.4200E 06	7.1779E 06	4.0582E 06	2.1324E 07	0.808
3	2.1685E 02	6.7576E 05	9.5353E 06	7.2658E 06	4.1079E 06	2.1585E 07	0.808
4	2.1685E 02	6.7585E 05	9.5367E 06	7.2668E 06	4.1085E 06	2.1588E 07	0.808
5	1.0335E 03	2.4719E 05	1.7127E 06	1.0651E 06	2.6001E 05	3.2850E 06	0.517
6	2.1685E 02	6.7093E 05	9.4673E 06	7.2139E 06	4.0786E 06	2.1431E 07	0.808
7	2.1685E 02	6.6564E 05	9.3926E 06	7.1570E 06	4.0464E 06	2.1262E 07	0.808
8	2.1685E 02	6.6388E 05	9.3678E 06	7.1381E 06	4.0357E 06	2.1206E 07	0.808
9	3.3856E 03	7.5590E 04	4.7530E 05	7.5876E 04	7.4571E 04	7.0133E 05	0.448
10	2.1685E 02	6.7735E 05	9.5578E 06	7.2829E 06	4.1176E 06	2.1636E 07	0.808
11	2.1685E 02	6.6392E 05	9.3684E 06	7.1386E 06	4.0360E 06	2.1207E 07	0.808
12	2.1685E 02	6.6362E 05	9.3641E 06	7.1353E 06	4.0341E 06	2.1197E 07	0.808
13	1.4565E 03	1.9316E 05	1.2665E 06	5.4771E 05	1.1070E 05	2.1180E 06	0.492
14	2.1685E 02	6.7173E 05	9.4792E 06	7.2230E 06	4.0837E 06	2.1458E 07	0.808
15	4.9297E 02	3.4433E 05	2.7605E 06	2.8089E 06	1.2015E 06	7.1153E 06	0.594
16	4.9297E 02	3.4123E 05	2.7352E 06	2.7832E 06	1.1905E 06	7.0501E 06	0.594
17	4.1024E 04	2.5812E 03	2.0398E 04	2.1475E 03	2.7823E 04	5.2950E 04	0.531
18	2.1685E 02	6.7019E 05	9.4567E 06	7.2059E 06	4.0740E 06	2.1407E 07	0.808
19	2.1685E 02	6.7102E 05	9.4685E 06	7.2148E 06	4.0791E 06	2.1433E 07	0.808
20	2.1685E 02	6.7397E 05	9.5101E 06	7.2466E 06	4.0971E 06	2.1528E 07	0.808
21	4.5673E 05	4.2374E 01	8.9602E 02	5.6650E 00	1.5363E 01	9.6002E 02	0.252
22	2.1685E 02	6.8644E 05	9.6861E 06	7.3806E 06	4.1729E 06	2.1926E 07	0.808
23	2.1635E 02	6.7331E 05	9.5009E 06	7.2395E 06	4.0931E 06	2.1507E 07	0.808
24	2.1685E 02	6.6936E 05	9.4451E 06	7.1970E 06	4.0690E 06	2.1380E 07	0.808

TABLE 5-4 (Cont'd)

1000 MW ORBIT START. 1 MIN AT 1000 MW DESTRUCT AT PERIGEE AND APOGEE

PARTICLE BETA SOURCE ENERGIES (MEV/SEC) AT GROUND IMPACT

CASE NO.	DECAY TIME (MINUTES)	ENERGY GROUPS (MEV)						TOTAL BETA (MEV/SEC)	(MEV/DIS
		0. -0.25	0.26-0.75	0.76-1.25	1.26-1.75	1.76--			
1	4.9207E 02	2.8407E 05	2.3073E 06	2.9315E 06	7.7362E 05	0.	6.2765E 06	0.532	
2	2.1685E 02	5.9619E 05	5.1830E 06	6.4734E 06	4.1461E 06	0.	1.6399E 07	0.621	
3	2.1685E 02	6.0343E 05	5.2465E 06	6.5526E 06	4.1969E 06	0.	1.6599E 07	0.621	
4	2.1685E 02	6.0357E 05	5.2472E 06	6.5535E 06	4.1975E 06	0.	1.6602E 07	0.621	
5	1.0335E 03	1.3101E 05	1.4467E 06	1.0714E 06	7.1951E 04	0.	2.7210E 06	0.428	
6	2.1635E 02	5.9913E 05	5.2090E 06	6.5058E 06	4.1669E 06	0.	1.6481E 07	0.621	
7	2.1685E 02	5.9445E 05	5.1680E 06	6.4545E 06	4.1341E 06	0.	1.6351E 07	0.621	
8	2.1685E 02	5.9288E 05	5.1543E 06	6.4375E 06	4.1231E 06	0.	1.6308E 07	0.621	
9	3.3856E 03	5.9812E 04	3.4327E 05	3.8754E 04	1.5833E 02	0.	4.4199E 05	0.282	
10	2.1685E 02	6.0470E 05	5.2588E 06	6.5680E 06	4.2068E 06	0.	1.6639E 07	0.621	
11	2.1685E 02	5.9292E 05	5.1546E 06	6.4379E 06	4.1234E 06	0.	1.6309E 07	0.621	
12	2.1685E 02	5.9265E 05	5.1523E 06	6.4349E 06	4.1215E 06	0.	1.6301E 07	0.621	
13	1.4565E 03	9.9439E 04	1.0213E 06	4.8058E 05	1.2992E 04	0.	1.6143E 06	0.375	
14	2.1635E 02	5.9993E 05	5.2156E 06	6.5140E 06	4.1722E 06	0.	1.6502E 07	0.621	
15	4.9297E 02	2.6812E 05	2.3425E 06	2.9762E 06	7.3541E 05	0.	6.3721E 06	0.532	
16	4.9297E 02	2.6566E 05	2.3210E 06	2.9489E 06	7.7821E 05	0.	6.3138E 06	0.532	
17	4.1094E 04	5.1063E 03	1.8827E 04	1.9127E 03	1.4987E-07	0.	2.5846E 04	0.259	
18	2.1685E 02	5.9851E 05	5.2032E 06	6.4986E 06	4.1623E 06	0.	1.6463E 07	0.621	
19	2.1685E 02	5.9925E 05	5.2097E 06	6.5067E 06	4.1675E 06	0.	1.6483E 07	0.621	
20	2.1685E 02	6.0187E 05	5.2326E 06	6.5353E 06	4.1858E 06	0.	1.6556E 07	0.621	
21	4.5673E 05	1.9991E 02	1.8068E 02	9.6372E 02	0.	0.	1.3443E 03	0.352	
22	2.1685E 02	6.1302E 05	5.3294E 06	6.6562E 06	4.2632E 06	0.	1.6862E 07	0.621	
23	2.1685E 02	6.0130E 05	5.2275E 06	6.5289E 06	4.1817E 06	0.	1.6540E 07	0.621	
24	2.1685E 02	5.9777E 05	5.1968E 06	6.4906E 06	4.1572E 06	0.	1.6442E 07	0.621	

* *COMPLETE DATA ON PARTICLES IS STORED ON TAPE 9 BY CASE NUMBER* *

THE ORDER IN WHICH THE CASE NUMBERS IS STORED ON TAPE 9 FOR SET 1 IS AS FOLLOWS

11	10	6	7	22	23	12	18
14	8	19	24	20	2	3	4
15	16	1	5	13	9	17	21

TIME AT COMPLETION OF LINK 2 9.866

TABLE 5-5

FIVE MINUTE POWER OPERATION - LINK 1

100 NM ORBIT START. 5 MIN AT 1000 MW DESTRUCT AT PERIGEE AND APOGEE

*** INPUT LIST ***

TEMPERATURE = 4000.00 DEGREES RANKINE PARTICLE DENSITY = 137.00 POUNDS/CU.FT.
 TIME FROM REACTOR SHUT DOWN TO TIME OF DESTRUCT = 6.750000E 03 SECONDS

NO.	PARTICLE DIAMETER (INCHES)	ORIGINAL VELOCITY (FT/SEC)	DESTRUCT VELOCITY (FT/SEC)	ALTITUDE (FEET)	VERTICAL ANGLE (DEGREES)	AZIMUTHAL ANGLE (DEGREES)	RE-ENTRY ANGLE (DEGREES)
1	0.03937	2.758500E 04	1.000000E 02	6.171845E 05	0.	0.	0.
2	0.03937	2.758500E 04	1.000000E 02	6.171845E 05	0.	180.0000	0.
3	0.03937	2.758500E 04	1.000000E 02	6.171845E 05	90.0000	0.	0.
4	0.03937	2.758500E 04	5.000000E 02	6.171845E 05	0.	0.	0.
5	0.03937	2.758500E 04	5.000000E 02	6.171845E 05	0.	180.0000	0.
6	0.03937	2.758500E 04	5.000000E 02	6.171845E 05	90.0000	0.	0.
7	0.03937	2.758500E 04	1.500000E 03	6.171845E 05	0.	0.	0.
8	0.03937	2.758500E 04	1.500000E 03	6.171845E 05	0.	180.0000	0.
9	0.03937	2.758500E 04	1.500000E 03	6.171845E 05	90.0000	0.	0.
10	0.03937	1.986900E 04	1.000000E 02	8.973235E 06	0.	0.	0.
11	0.03937	1.986900E 04	1.000000E 02	8.973235E 06	0.	180.0000	0.
12	0.03937	1.986900E 04	1.000000E 02	8.973235E 06	90.0000	0.	0.
13	0.03937	1.986900E 04	5.000000E 02	8.973235E 06	0.	0.	0.
14	0.03937	1.986900E 04	5.000000E 02	8.973235E 06	0.	180.0000	0.
15	0.03937	1.986900E 04	5.000000E 02	8.973235E 06	90.0000	0.	0.
16	0.03937	1.986900E 04	1.500000E 03	8.973235E 06	0.	0.	0.
17	0.03937	1.986900E 04	1.500000E 03	8.973235E 06	0.	180.0000	0.
18	0.03937	1.986900E 04	1.500000E 03	8.973235E 06	90.0000	0.	0.

Case Numbers 1-9 represent destruct at Perigee

Case Number 10-18 represent destruct at apogee - Time
 from reactor shutdown to time of destruct = 3350 seconds.

TABLE 5-5 (Cont'd)

100 NM ORBIT START. 5 MIN AT 1000 MW DESTRUCT AT PERIGEE AND APOGEE

*** OUTPUT LIST AT TIME OF DESTRUCT ***

NO.	RESULTANT VELOCITY (FT/SEC)	RESULTANT ANGLE (DEGREES)	PERIGEE ALTITUDE (FEET)	APOGEE ALTITUDE (FEET)	ECCENTRICITY	PERIOD (MINUTES)
1	2.768500E 04	0.	6.171822E 05	9.480973E 06	1.708704E-01	1.165932E 02
2	2.748500E 04	0.	6.171827E 05	8.447398E 06	1.540144E-01	1.131260E 02
3	2.758518E 04	2.077054E-01	6.161717E 05	8.959997E 06	1.624818E-01	1.148378E 02
4	2.808500E 04	0.	6.171827E 05	1.170448E 07	2.049483E-01	1.241693E 02
5	2.708500E 04	0.	6.171817E 05	6.519458E 06	1.206692E-01	1.067526E 02
6	2.758953E 04	1.038418E 00	6.920342E 05	9.000623E 06	1.637880E-01	1.149132E 02
7	2.908500E 04	0.	6.171835E 05	1.835036E 07	2.922837E-01	1.478489E 02
8	2.608500E 04	0.	6.171777E 05	2.383400E 06	3.944505E-02	9.350253E 01
9	2.762575E 04	3.112529E 00	6.998780E 05	9.386956E 06	1.742930E-01	1.155452E 02
10	1.996900E 04	0.	9.968467E 05	8.973235E 06	1.541442E-01	1.161617E 02
11	1.974900E 04	0.	7.518740E 05	8.973234E 06	1.710026E-01	1.136622E 02
12	1.986925E 04	2.583653E-01	6.197115E 05	8.975183E 06	1.626493E-01	1.149006E 02
13	2.036900E 04	0.	2.578281E 06	8.973235E 06	1.199180E-01	1.215272E 02
14	1.936900E 04	0.	-1.154566E 06	8.973235E 06	2.042106E-01	1.089932E 02
15	1.987529E 04	1.441534E 00	6.955925E 05	9.021808E 06	1.639545E-01	1.149761E 02
16	2.136900E 04	0.	7.155997E 06	8.973237E 06	3.138299E-02	1.375064E 02
17	1.836900E 04	0.	-4.245902E 06	8.973234E 06	2.942609E-01	9.896304E 01
18	1.992554E 04	4.317326E 00	4.035555E 05	9.402159E 06	1.744527E-01	1.156086E 02

TABLE 5-5 (Cont'd)

100 NM ORBIT START. 10 MIN AT 1000 MW DESTROY AT PERIGEE AND APOGEE

*** OUTPUT LIST AT TIME OF IMPACT ***

NO.	PARTICLE DIAMETER (INCHES)	PARTICLE MASS (GRAMS)	IMPACT TIME (MINUTES)	RANGE (FEET)	RECOVERY MODE	ERROR TAG
1	3.264303E-02	6.549562E-04	3.632937E 04	GT.TN. 1 ORBIT	F1	
2	3.264303E-02	6.549562E-04	3.323979E 04	GT.TN. 1 ORBIT	F1	
3	3.264303E-02	6.549562E-04	3.462729E 04	GT.TN. 1 ORBIT	F1	
4	3.264303E-02	6.549562E-04	4.318562E 04	GT.TN. 1 ORBIT	F1	
5	3.264303E-02	6.549562E-04	2.759395E 04	GT.TN. 1 ORBIT	F1	
6	3.264303E-02	6.549562E-04	3.217937E 04	GT.TN. 1 ORBIT	F1	
7	3.264303E-02	6.549562E-04	6.501895E 04	GT.TN. 1 ORBIT	F1	
8	3.264303E-02	6.549562E-04	1.610229E 04	GT.TN. 1 ORBIT	F1	
9	3.264303E-02	6.549562E-04	1.725020E 04	GT.TN. 1 ORBIT	F1	
10	3.264303E-02	6.549562E-04	2.675136E 05	GT.TN. 1 ORBIT	F1	
11	3.070868E-02	5.452861E-04	2.735994E 02	6.217729E 07	D4	
12	3.264303E-02	6.549562E-04	1.714070E 04	GT.TN. 1 ORBIT	F1	
13	3.264303E-02	6.549562E-04	1.015101E 07	GT.TN. 1 ORBIT	F1	Tr-LINK
14	3.141890E-02	5.840019E-04	2.603340E 02	4.950035E 07	D4	
15	3.264303E-02	6.549562E-04	1.580424E 04	GT.TN. 1 ORBIT	F1	
16	3.264303E-02	6.549562E-04	9.251013E 06	GT.TN. 1 ORBIT	F1	Tr-LINK
17	3.228126E-02	6.334211E-04	2.459811E 02	3.743973E 07	D4	
18	3.264303E-02	6.549562E-04	8.364660E 03	GT.TN. 1 ORBIT	F1	

TIME AT COMPLETION OF LINK 1 9.060

TABLE 5-6
FIVE MINUTE POWER OPERATION - LINK 2

SUMMARY OF PARTICLE FISSION PRODUCT INVENTORY

100 NM ORBIT START. 5 MIN AT 1000 MW DESTRUCT AT PERIGEE AND APOGEE

REACTOR POWER HISTORY	
STARTING TIME (MIN)	POWER (FISSIONS/MIN)
0.	1.93000E 21
5.00000E 00	-0.

PARTICLE SIZE AND FISSION PRODUCT ACTIVITY AT GROUND IMPACT

CASE NO.	DIAMETER (INCHES)	MASS (GRAMS)	ACTUAL IMPACT TIME (MINUTES)	DECAY TIME USED (MINUTES)	ACTIVITY (MICRO-CURIES)
1	0.03264	6.5496E-04	4.6877E 03	4.6877E 03	1.4510E 02
2	0.03264	6.5496E-04	4.0294E 03	4.1127E 03	1.6827E 02
3	0.03264	6.5496E-04	4.3315E 03	4.1127E 03	1.6827E 02
4	0.03264	6.5496E-04	6.1815E 03	6.1815E 03	1.0757E 02
5	0.03264	6.5496E-04	2.8315E 03	2.8315E 03	2.6249E 02
6	0.03264	6.5496E-04	3.6981E 03	4.1127E 03	1.6827E 02
7	0.03264	6.5496E-04	1.0824E 04	1.0824E 04	5.9383E 01
8	0.03115	5.6731E-04	6.6830E 02	6.6830E 02	1.1853E 03
9	0.03264	6.5496E-04	2.1062E 02	3.0577E 02	2.9256E 03
10	0.03264	6.5496E-04	4.3954E 04	4.3954E 04	1.2561E 01
11	0.03090	5.5540E-04	2.1755E 02	3.0577E 02	2.4809E 03
12	0.03264	6.5496E-04	4.3894E 03	4.1127E 03	1.6827E 02
13	0.03264	6.5496E-04	5.8510E 06	5.8510E 06	2.3962E-02
14	0.03117	5.7147E-04	2.0458E 02	3.0577E 02	2.5526E 03
15	0.03264	6.5496E-04	3.7644E 03	4.1127E 03	1.6827E 02
16	0.03264	6.5496E-04	8.0843E 06	8.0843E 06	2.0556E-02
17	0.03187	6.0977E-04	1.9184E 02	3.0577E 02	2.7238E 03
18	0.03264	6.5496E-04	2.8416E 02	3.0577E 02	2.9256E 03

TABLE 5-6 (Cont'd)

100 NM ORBIT START. 5 MIN AT 1000 NM DESTRUCT AT PERIGEE AND APOGEE

PARTICLE GAMMA SOURCE ENERGIES (MEV/SEC) AT GROUND IMPACT

CASE NO.	DECAY TIME (MINUTES)	ENERGY GROUPS(MEV)				TOTAL GAMMA (MEV/SEC)	(MEV/DIS)
		0. -0.25	0.26-1.00	1.01-1.70	1.71--		
1	4.6877E 03	2.6510E 05	1.5092E 06	2.0644E 05	4.0281E 05	2.3835E 06	0.444
2	4.1127E 03	3.0334E 05	1.8154E 06	2.5775E 05	3.9120E 05	2.7677E 06	0.445
3	4.1127E 03	3.0334E 05	1.8154E 06	2.5775E 05	3.9120E 05	2.7677E 06	0.445
4	6.1815E 03	2.0303E 05	1.0204E 06	1.3796E 05	4.2089E 05	1.7822E 06	0.448
5	2.3315E 03	4.6720E 05	3.0057E 06	5.7014E 05	3.5826E 05	4.4033E 06	0.453
6	4.1127E 03	3.0334E 05	1.8154E 06	2.5775E 05	3.9120E 05	2.7677E 06	0.445
7	1.0924E 04	1.0865E 05	4.7740E 05	6.6360E 04	4.9766E 05	1.0601E 06	0.482
8	6.6830E 02	1.3912E 06	1.0408E 07	9.2538E 06	3.2710E 06	2.4324E 07	0.555
9	3.0577E 02	2.3751E 06	3.0636E 07	2.7907E 07	1.4293E 07	7.5712E 07	0.699
10	4.3954E 04	1.1724E 04	9.7231E 04	9.5860E 03	1.2494E 05	2.4348E 05	0.524
11	3.0577E 02	2.4380E 06	2.5979E 07	2.3665E 07	1.2120E 07	6.4203E 07	0.699
12	4.1127E 03	3.0334E 05	1.8154E 06	2.5775E 05	3.9120E 05	2.7677E 06	0.445
13	5.8510E 06	4.8989E-02	1.3280E 02	5.7344E-03	8.9802E-03	1.3286E 02	0.150
14	3.0577E 02	2.5096E 06	2.6731E 07	2.4350E 07	1.2471E 07	6.6061E 07	0.699
15	4.1127E 03	3.0334E 05	1.8154E 06	2.5775E 05	3.9120E 05	2.7677E 06	0.445
16	8.0843E 06	9.5654E-03	1.2019E 02	2.3963E-04	1.3217E-04	1.2020E 02	0.158
17	3.0577E 02	2.6767E 06	2.8523E 07	2.5982E 07	1.3307E 07	7.0489E 07	0.699
18	3.0577E 02	2.8751E 06	3.0636E 07	2.7907E 07	1.4293E 07	7.5712E 07	0.699

TABLE 5-6 (Cont'd)

100 NM ORBIT START. 5 MIN AT 1000 MW DESTRUCT AT PERIGEE AND APOGEE

PARTICLE BETA SOURCE ENERGIES (MEV/SEC) AT GROUND IMPACT

CASE NO.	DECAY TIME (MINUTES)	ENERGY GROUPS (MEV)					TOTAL BETA (MEV/SEC)	(MEV/DIS)
		0.	-0.25	0.26-0.75	0.76-1.25	1.26-1.75	1.76--	
1	4.6877E 03	2.4256E 05	1.0775E 06	5.2662E 04	3.7328E 02	0.	1.3730E 06	0.256
2	4.1127E 03	2.6464E 05	1.2971E 06	9.0723E 04	5.1341E 02	0.	1.6530E 06	0.265
3	4.1127E 03	2.6464E 05	1.2971E 06	9.0723E 04	5.1341E 02	0.	1.6530E 06	0.265
4	6.1815E 03	1.9815E 05	7.4072E 05	1.8642E 04	1.5406E 02	0.	9.5768E 05	0.241
5	2.8315E 03	3.3252E 05	2.2094E 06	3.5913E 05	1.2841E 03	0.	2.9024E 06	0.299
6	4.1127E 03	2.6464E 05	1.2971E 06	9.0723E 04	5.1341E 02	0.	1.6530E 06	0.265
7	1.0824E 04	1.1999E 05	3.8246E 05	1.0416E 04	1.2760E 01	0.	5.1288E 05	0.233
8	6.6830E 02	9.1683E 05	9.1211E 06	1.0001E 07	1.5748E 06	0.	2.1614E 07	0.493
9	3.0577E 02	2.5630E 06	2.0452E 07	2.7108E 07	1.3289E 07	0.	6.3411E 07	0.586
10	4.3954E 04	2.3641E 04	8.6962E 04	9.5093E 03	1.5522E-07	0.	1.2011E 05	0.258
11	3.0577E 02	2.1734E 06	1.7343E 07	2.2987E 07	1.1269E 07	0.	5.3772E 07	0.586
12	4.1127E 03	2.6464E 05	1.2971E 06	9.0723E 04	5.1341E 02	0.	1.6530E 06	0.265
13	5.8510E 06	7.7782E 01	4.1036E 00	1.4836E 02	0.	0.	2.3025E 02	0.260
14	3.0577E 02	2.2363E 06	1.7845E 07	2.3652E 07	1.1595E 07	0.	5.5328E 07	0.586
15	4.1127E 03	2.6464E 05	1.2971E 06	9.0723E 04	5.1341E 02	0.	1.6530E 06	0.265
16	3.0843E 06	6.6924E 01	3.7164E 00	1.3294E 02	0.	0.	2.0358E 02	0.268
17	3.0577E 02	2.3862E 06	1.9041E 07	2.5238E 07	1.2372E 07	0.	5.9037E 07	0.586
18	3.0577E 02	2.5630E 06	2.0452E 07	2.7108E 07	1.3289E 07	0.	6.3411E 07	0.586

* *COMPLETE DATA ON PARTICLES IS STORED ON TAPE 9 BY CASE NUMBER* *

THE ORDER IN WHICH THE CASE NUMBERS IS STORED ON TAPE 9 FOR SET 1 IS AS FOLLOWS

17	14	9	11	18	8	5	6
15	2	3	12	1	4	7	10
13	16						

TIME AT COMPLETION OF LINK 2 15.370

TABLE 5-7

FISSION PRODUCT NUCLIDE ACTIVITY, SET 1, CASE 8

SET NO. = 1 100 NM ORBIT START. 1 MIN AT 1000 MW DESTRUCT AT PERIGEE AND APOGEE

ACTIVITY OF PARTICLE BY INDIVIDUAL FISSION PRODUCT NUCLIDE

CASE NO. 8 GROUND IMPACT TIME = 1.9443E 02 MIN. DECAY TIME USED = 2.1685E 02 MIN.

PARTICLE GAMMA SOURCE ENERGIES (MEV/SEC)

NUCLIDE NO.	CHEMICAL SYMBOL	ACTIVITY (MICRO-CURIES)	0. -0.25MEV	0.26-1.00MEV	1.01-1.70MEV	1.71-- MEV	TOTAL GAMMA ENERGY (MEV/SEC)
2	ZN-72	0.1413E-04	0.	0.	0.	0.	0.
3	GA-72	0.5565E-05	0.	0.1573E-00	0.1281E-00	0.2857E-00	0.5711E 00
4	ZN-73	0.3270E-33	0.	0.	0.	0.3025E-28	0.3025E-28
5	GA-73	0.7304E-03	0.	0.8941E 01	0.2810E-00	0.	0.9222E 01
6	GE 73M	0.7304E-03	0.1838E 01	0.	0.	0.	0.1838E 01
7	GA-74	0.5839E-09	0.	0.1444E-04	0.7545E-05	0.4534E-04	0.6733E-04
8	GE 75M	0.	0.	0.	0.	0.	0.
9	GE-75	0.7302E-02	0.8062E 00	0.8608E 01	0.	0.	0.9414E 01
10	GA-76	0.	0.	0.	0.	0.	0.
11	GE-77M	0.	0.	0.	0.	0.	0.
12	GE-77	0.1963E-01	0.9655E 02	0.4529E 03	0.1668E 03	0.8698E 02	0.8032E 03
13	AS-77	0.5437E-02	0.1386E 01	0.2846E 01	0.	0.	0.4232E 01
14	GE-78	0.1524E-00	0.	0.	0.	0.	0.
15	AS-78M	0.8003E-01	0.	0.1481E 04	0.	0.	0.1481E 04
16	AS-78	0.2071E-00	0.7355E 01	0.3569E 04	0.2179E 04	0.1031E 04	0.6786E 04
17	AS-79	0.1073E-05	0.	0.	0.4367E-01	0.	0.4367E-01
18	SE-79M	0.1890E-05	0.6712E-02	0.	0.	0.	0.6712E-02
19	SE-79	0.5699E-08	0.	0.	0.	0.	0.
20	AS-80	0.	0.	0.	0.	0.	0.
21	AS-81	0.	0.	0.	0.	0.	0.
22	SE-81M	0.4397E-01	0.1676E 03	0.	0.	0.	0.1676E 03
23	SE-81	0.7134E-01	0.	0.	0.	0.	0.
24	AS-82	0.	0.	0.	0.	0.	0.
25	SE-83M	0.	0.	0.	0.	0.	0.
26	SE-83	0.1728E-00	0.	0.2078E 04	0.3229E 04	0.	0.5307E 04
27	BR-83	0.7091E 01	0.2414E 04	0.	0.	0.	0.2414E 04
28	KR-83M	0.7102E 01	0.1314E 05	0.	0.	0.	0.1314E 05
29	SE-84	0.1657E-18	0.	0.5826E-14	0.	0.	0.5826E-14
30	BR-84	0.1009E 01	0.	0.1807E 05	0.6261E 04	0.3605E 05	0.6039E 05
31	AS-85	0.	0.	0.	0.	0.	0.
32	SE-85	0.	0.	0.	0.	0.	0.
33	BR-85	0.2690E-18	0.	0.	0.	0.	0.
34	KR-85M	0.9155E 01	0.4116E 05	0.1963E 05	0.	0.	0.6079E 05
35	KR-85	0.6465E-04	0.	0.1229E-01	0.	0.	0.1229E-01
36	SE-86	0.	0.	0.	0.	0.	0.

TABLE 5-7 (Cont'd)

37	BK-86	0.	0.	0.	0.	0.	0.
38	KK-90	0.	0.	0.	0.	0.	0.
39	RB-90	0.4608E-20	0.	0.	0.	0.5609E-15	0.5609E-15
40	SK-90	0.1187E-02	0.	0.	0.	0.	0.
41	Y-90	0.4474E-04	0.	0.	0.	0.	0.
42	BK-89	0.	0.	0.	0.	0.	0.
43	KK-89	0.8973E-17	0.	0.	0.	0.	0.
44	RB-89	0.6945E-01	0.	0.2555E 03	0.3899E 04	0.2049E 04	0.6204E 04
45	SR-89	0.2099E-00	0.	0.	0.	0.	0.
46	Y-89M	0.2099E-00	0.	0.7067E 04	0.	0.	0.7067E 04
47	BR-88	0.	0.	0.	0.	0.	0.
48	KK-88	0.2819E 02	0.8388E 05	0.2214E 06	0.2759E 06	0.1576E 07	0.2158E 07
49	RB-88	0.3145E 02	0.	0.1517E 06	0.2264E 05	0.5682E 06	0.7425E 06
50	SE-87	0.	0.	0.	0.	0.	0.
51	BK-87	0.	0.	0.	0.	0.	0.
52	KK-87	0.4347E 01	0.	0.7410E 05	0.	0.1008E 06	0.1749E 06
53	RB-87	0.8856E-13	0.	0.	0.	0.	0.
54	KK-91	0.	0.	0.	0.	0.	0.
55	RB-91M	0.1375E-01	0.	0.	0.	0.	0.
56	RB-91	0.	0.	0.	0.	0.	0.
57	SK-91	0.2532E 02	0.	0.3140E 06	0.3808E 06	0.	0.6948E 06
58	Y-91M	0.1532E 02	0.	0.3124E 06	0.	0.	0.3124E 06
59	Y-91	0.3973E-01	0.	0.	0.5327E 01	0.	0.5327E 01
60	KK-92	0.	0.	0.	0.	0.	0.
61	RB-92	0.	0.	0.	0.	0.	0.
62	SK-92	0.4706E 02	0.1402E 05	0.3141E 05	0.2147E 07	0.	0.2192E 07
63	Y-92	0.3764E 02	0.	0.	0.	0.3777E 06	0.3777E 06
64	SK-93	0.1698E-04	0.	0.	0.	0.1256E 01	0.1256E 01
65	Y-93	0.2674E 02	0.	0.4332E 05	0.1211E 05	0.3655E 05	0.9198E 05
66	ZR-93	0.8592E-08	0.2305E-05	0.	0.	0.	0.2305E-05
67	NB-93M	0.3226E-10	0.3462E-07	0.	0.	0.	0.3462E-07
68	SR-94	0.	0.	0.	0.	0.	0.
69	Y-94	0.5881E 00	0.	0.9339E 04	0.1229E 04	0.	0.1057E 05
70	SR-95	0.	0.	0.	0.	0.	0.
71	Y-95	0.6136E-03	0.	0.	0.	0.5335E 02	0.5335E 02
72	ZK-95	0.2159E-00	0.3754E 02	0.5773E 04	0.	0.	0.5811E 04
73	NB-95M	0.1107E-03	0.9625E 00	0.	0.	0.	0.9625E 00
74	NB-95	0.5873E-03	0.	0.1641E 02	0.	0.	0.1641E 02
75	Y-96	0.3014E-24	0.	0.	0.	0.	0.
76	SK-97	0.	0.	0.	0.	0.	0.
77	Y-97	0.	0.	0.	0.	0.	0.
78	ZK-97	0.1500E 02	0.	0.	0.1843E 05	0.	0.1843E 05
79	NB-97M	0.1442E 02	0.	0.4001E 06	0.	0.	0.4001E 06
80	NB-97	0.1713E 02	0.	0.4174E 06	0.6467E 04	0.	0.4239E 06
81	ZK-98	0.	0.	0.	0.	0.	0.
82	NB-98M	0.2844E-00	0.	0.1389E 05	0.5430E 04	0.7914E 03	0.2011E 05
83	NB-98	0.2243E 01	0.	0.	0.	0.1743E 06	0.1743E 06
84	ZK-99	0.	0.	0.	0.	0.	0.
85	NB-99	0.5671E-23	0.	0.	0.3357E-18	0.	0.3357E-18

TABLE 5-7 (Cont'd)

86	MO-99	0.4738E 01	0.	0.1909E 05	0.	0.	0.1909E 05
87	TC-99M	0.1412E 01	0.7417E 04	0.	0.	0.	0.7417E 04
88	TC-99	0.2019E 01	0.	0.	0.	0.	0.
89	NB-100	0.1018E-17	0.	0.	0.	0.1300E-12	0.1300E-12
90	NB-101	0.	0.	0.	0.	0.	0.
91	MO-101	0.3888E-01	0.7765E 02	0.6897E 03	0.1145E 04	0.4788E 03	0.2391E 04
92	TC-101	0.3368E-00	0.	0.3984E 04	0.	0.	0.3984E 04
93	MO-102	0.2288E-02	0.	0.	0.	0.	0.
94	TC102M	0.1880E-02	0.	0.	0.	0.1461E 03	0.1461E 03
95	TC-102	0.1152E-02	0.	0.	0.	0.8742E 02	0.8742E 02
96	TC-103	0.	0.	0.	0.	0.	0.
97	RU-103	0.1672E-00	0.	0.3066E 04	0.	0.	0.3066E 04
98	RH103M	0.1551E-00	0.2296E 03	0.	0.	0.	0.2296E 03
99	MO-104	0.1252E-22	0.	0.	0.	0.	0.
100	TC-104	0.8407E-01	0.	0.	0.	0.8087E 04	0.8087E 04
101	MO-105	0.2176E-29	0.	0.	0.	0.2214E-24	0.2214E-24
102	TC-105	0.2114E-04	0.	0.	0.1330E 01	0.	0.1330E 01
103	RU-105	0.6483E 01	0.	0.1643E 06	0.	0.	0.1643E 06
104	RH105M	0.1336E 01	0.6377E 04	0.	0.	0.	0.6377E 04
105	RH-105	0.5334E 00	0.	0.6296E 03	0.	0.	0.6296E 03
106	RU-106	0.2411E-02	0.	0.	0.	0.	0.
107	RH-106	0.2411E-02	0.	0.1544E 02	0.1399E 01	0.	0.1684E 02
108	TC-107	0.	0.	0.	0.	0.	0.
109	RU-107	0.1012E-11	0.1241E-08	0.2575E-08	0.1542E-08	0.	0.5358E-08
110	RH-107	0.3933E-01	0.	0.4763E 03	0.	0.	0.4763E 03
111	PD-107	0.1674E-09	0.	0.	0.	0.	0.
112	RU-108	0.3203E-13	0.5475E-10	0.	0.	0.	0.5475E-10
113	RH-108	0.3443E-13	0.	0.4101E-09	0.	0.	0.4101E-09
114	RH109M	0.	0.	0.	0.	0.	0.
115	RH-109	0.	0.	0.	0.	0.	0.
116	PD109M	0.1532E-12	0.1020E-08	0.	0.	0.	0.1020E-08
117	PD-109	0.9717E-01	0.	0.	0.	0.	0.
118	AG109M	0.9724E-01	0.3166E 03	0.	0.	0.	0.3166E 03
119	RH-110	0.	0.	0.	0.	0.	0.
120	PD111M	0.1291E-02	0.5523E 01	0.	0.2584E 02	0.	0.3136E 02
121	PD-111	0.4535E-02	0.	0.	0.	0.	0.
122	AG111M	0.5156E-02	0.1240E 02	0.	0.	0.	0.1240E 02
123	AG-111	0.5237E-02	0.5927E 00	0.4042E 01	0.	0.	0.4635E 01
124	PD-112	0.2279E-01	0.1518E 02	0.	0.	0.	0.1518E 02
125	AG-112	0.1328E-01	0.	0.4740E 02	0.8615E 02	0.4565E 02	0.1792E 03
126	PD-113	0.	0.	0.	0.	0.	0.
127	AG113M	0.	0.	0.	0.	0.	0.
128	AG-113	0.9222E-01	0.	0.	0.	0.	0.
129	PD-114	0.1004E-25	0.	0.	0.	0.	0.
130	AG-114	0.1040E-25	0.	0.	0.	0.8847E-21	0.8847E-21
131	PD-115	0.	0.	0.	0.	0.	0.
132	AG115M	0.	0.	0.	0.	0.	0.
133	AG-115	0.1330E-02	0.	0.	0.	0.	0.

TABLE 5-7 (Cont'd)

134	CD115M	0.5361E-04	0.	0.4551E-01	0.2579E-01	0.	0.7130E-01
135	CD-115	0.9721E-02	0.	0.6824E 02	0.	0.	0.6824E 02
136	IN115M	0.3738E-02	0.	0.4379E 02	0.	0.	0.4379E 02
137	IN-115	0.8318E-21	0.	0.	0.	0.	0.
138	AG-116	0.1561E-24	0.	0.7044E-20	0.	0.	0.7044E-20
139	AG-117	0.	0.	0.	0.	0.	0.
140	CD117M	0.4305E-01	0.	0.4460E 03	0.2023E 04	0.	0.2469E 04
141	CD-117	0.4769E-01	0.	0.7499E 03	0.	0.	0.7499E 03
142	IN117M	0.1083E-00	0.1484E 03	0.3802E 03	0.	0.	0.5286E 03
143	IN-117	0.2386E-01	0.1421E 03	0.4988E 03	0.	0.	0.6409E 03
144	SN117M	0.7356E-06	0.8709E-02	0.	0.	0.	0.8709E-02
145	CD-118	0.4526E-01	0.	0.	0.	0.	0.
146	IN-118	0.4534E-01	0.	0.	0.4093E 03	0.	0.4093E 03
147	CD119M	0.2325E-05	0.	0.	0.	0.3097E-01	0.3097E-01
148	CD-119	0.1186E-20	0.	0.	0.	0.8117E-16	0.8117E-16
149	IN119M	0.6008E-03	0.	0.1477E 01	0.	0.	0.1477E 01
150	IN-119	0.2813E-04	0.2248E-01	0.7680E 00	0.	0.	0.7905E 00
151	IN-120	0.	0.	0.	0.	0.	0.
152	CD-121	0.	0.	0.	0.	0.	0.
153	IN121M	0.6494E-20	0.	0.	0.	0.4445E-15	0.4445E-15
154	IN-121	0.	0.	0.	0.	0.	0.
155	SN121M	0.8646E-05	0.3199E-02	0.	0.	0.	0.3199E-02
156	SN-121	0.1280E-01	0.	0.	0.	0.	0.
157	IN-122	0.	0.	0.	0.	0.	0.
158	IN123M	0.	0.	0.	0.	0.	0.
159	IN-123	0.	0.	0.	0.	0.	0.
160	SN123M	0.1365E-04	0.	0.	0.1091E-01	0.	0.1091E-01
161	SN-123	0.3104E-01	0.1837E 03	0.	0.	0.	0.1837E 03
162	IN-124	0.	0.	0.	0.	0.	0.
163	SB24M1	0.	0.	0.	0.	0.	0.
164	SB24M2	0.1965E-05	0.	0.	0.	0.	0.
165	SB-124	0.6227E-06	0.	0.1688E-01	0.2247E-01	0.3990E-02	0.4334E-01
166	SN125M	0.6093E-06	0.	0.7371E-02	0.6677E-03	0.	0.8039E-02
167	SN-125	0.2403E-02	0.	0.1652E 01	0.3703E 01	0.2102E 01	0.7457E 01
168	SB-125	0.3554E-04	0.1833E-01	0.5465E 00	0.	0.	0.5648E 00
169	TE125M	0.1805E-07	0.9681E-04	0.	0.	0.	0.9681E-04
170	SN-126	0.8446E-09	0.	0.	0.	0.	0.
171	SB125M	0.1346E-03	0.4931E-00	0.	0.	0.	0.4931E-00
172	SB-126	0.7789E-03	0.	0.5116E 02	0.	0.	0.5116E 02
173	SN-127	0.8197E 00	0.	0.	0.4853E 05	0.	0.4853E 05
174	SB-127	0.5638E-01	0.7801E 02	0.9424E 03	0.	0.	0.1020E 04
175	TE127M	0.3634E-04	0.1191E-00	0.8941E-04	0.	0.	0.1191E-00
176	TE-127	0.1314E-01	0.2868E-01	0.1801E 01	0.	0.	0.1829E 01
177	SN-128	0.9611E 00	0.	0.	0.	0.	0.
178	SB128M	0.1138E 01	0.	0.	0.	0.	0.
179	SB-128	0.2797E-00	0.	0.	0.1501E 05	0.	0.1501E 05
180	SN-129	0.3335E 01	0.	0.	0.	0.2468E 06	0.2468E 06
181	SB-129	0.4843E 01	0.7894E 04	0.7158E 05	0.	0.	0.7947E 05
182	TE129M	0.6581E-02	0.2581E 02	0.	0.	0.	0.2581E 02
183	TE-129	0.2870E 01	0.2630E 04	0.9219E 04	0.1189E 04	0.	0.1304E 05

TABLE 5-7 (Cont'd)

184	I -129	0.3803E-10	0.5636E-07	0.	0.	0.	0.5636E-07
185	SN-130	0.8119E-27	0.	0.3004E-17	0.	0.	0.3004E-17
186	SB-130	0.6422E-06	0.	0.	0.	0.5941E-01	0.5941E-01
187	I -130	0.1971E-01	0.	0.1317E 04	0.2515E 03	0.	0.1569E 04
188	SN-131	0.6210E-16	0.	0.	0.	0.5744E-11	0.5744E-11
189	SB-131	0.5348E 00	0.	0.	0.3166E 05	0.	0.3166E 05
190	TC-131M	0.9979E 00	0.1270E 04	0.3912E 05	0.2197E 05	0.1678E 05	0.7914E 05
191	TE-131	0.3491E 01	0.1498E 05	0.2232E 05	0.1460E 05	0.	0.5240E 05
192	I -131	0.6487E 00	0.	0.9331E 04	0.	0.	0.9331E 04
193	XE131M	0.3174E-04	0.1926E-00	0.	0.	0.	0.1926E-00
194	SN-132	0.2480E-26	0.	0.	0.1377E-21	0.	0.1377E-21
195	SB-132	0.5271E-25	0.	0.	0.	0.5851E-20	0.5851E-20
196	TE-132	0.2820E 01	0.2974E 05	0.	0.	0.	0.2974E 05
197	I -132	0.3199E 01	0.3692E 03	0.2246E 06	0.2542E 05	0.	0.2504E 06
198	SB-133	0.2865E-12	0.	0.	0.	0.2120E-07	0.2120E-07
199	TE133M	0.1340E 02	0.	0.8610E 06	0.	0.	0.8610E 06
200	TE-133	0.1811E 01	0.	0.	0.	0.	0.
201	I -133	0.1496E 02	0.	0.3367E 06	0.2878E 05	0.	0.3655E 06
202	XE133M	0.1394E-01	0.1193E 03	0.	0.	0.	0.1193E 03
203	XC-133	0.2485E-00	0.7506E 03	0.	0.	0.	0.7506E 03
204	SB-134	0.	0.	0.	0.	0.	0.
205	TE-134	0.1347E 07	0.	0.	0.	0.	0.
206	I -134	0.5949E 02	0.9245E 04	0.4047E 07	0.3880E 06	0.1970E 06	0.5241E 07
207	SB-135	0.	0.	0.	0.	0.	0.
208	TE-135	0.	0.	0.	0.	0.	0.
209	I -135	0.3074E 02	0.	0.1242E 06	0.2340E 07	0.	0.2464E 07
210	XC135M	0.9601E 01	0.	0.1883E 06	0.	0.	0.1883E 06
211	XE-135	0.1280E 02	0.1149E 06	0.1029E 05	0.	0.	0.1252E 06
212	CS-135	0.1316E-08	0.	0.	0.	0.	0.
213	I 136	0.	0.	0.	0.	0.	0.
214	CS-136	0.6464E-01	0.6907E 02	0.2603E 04	0.2770E 04	0.	0.5442E 04
215	I -139	0.	0.	0.	0.	0.	0.
216	XE-139	0.	0.	0.	0.	0.	0.
217	CS-139	0.2747E-03	0.	0.2561E-00	0.2081E 01	0.	0.2337E 01
218	BA-139	0.4702E 02	0.8086E 05	0.	0.7464E 04	0.	0.8833E 05
219	I -138	0.	0.	0.	0.	0.	0.
220	XC-138	0.1134E-00	0.	0.1762E 04	0.	0.	0.1762E 04
221	CS-138	0.9322E 01	0.2755E 04	0.6817E 05	0.4462E 06	0.2246E 06	0.7417E 06
222	I -137	0.	0.	0.	0.	0.	0.
223	XE-137	0.7763E-13	0.	0.	0.	0.	0.
224	CS-137	0.1245E-02	0.	0.	0.	0.	0.
225	BA137M	0.1195E-02	0.	0.2928E 02	0.	0.	0.2928E 02
226	XE-140	0.	0.	0.	0.	0.	0.
227	CS-140	0.	0.	0.	0.	0.	0.
228	BA-140	0.1112E 01	0.1693E 04	0.7900E 04	0.	0.	0.9792E 04
229	LA-140	0.1139E-00	0.	0.	0.4709E 03	0.9830E 04	0.1030E 05
230	BA-141	0.2538E-00	0.	0.	0.1315E 05	0.	0.1315E 05
231	LA-141	0.5097E 02	0.	0.	0.167E 05	0.	0.5167E 05
232	CE-141	0.1933E-00	0.7258E 03	0.	0.	0.	0.7258E 03
233	CS-142	0.	0.	0.	0.	0.	0.

TABLE 5-7 (Cont'd)

234	BA-142	0.5254E-03	0.	0.	0.2236E 02	0.	0.2236E 02
235	LA-142	0.4343E 02	0.	0.7392E 06	0.	0.4242E 06	0.1163E 07
236	BA-143	0.	0.	0.	0.	0.	0.
237	LA-143	0.2480E-00	0.	0.	0.1514E 05	0.	0.1514E 05
238	CE-143	0.9205E 01	0.2038E 05	0.1216E 06	0.3372E 05	0.	0.1757E 06
239	PR-143	0.6342E-01	0.	0.	0.	0.	0.
240	LA-144	0.3182E-00	0.	0.	0.	0.3355E 05	0.3355E 05
241	CE-144	0.4414E-01	0.6582E 02	0.	0.	0.	0.6582E 02
242	PR-144	0.4406E-01	0.	0.1462E 02	0.7288E 01	0.2843E 02	0.5035E 02
243	CE-145	0.6667E-18	0.	0.2467E-13	0.	0.	0.2467E-13
244	PR-145	0.2380E 02	0.	0.	0.	0.	0.
245	CE-146	0.1355E-01	0.7615E 02	0.5176E 02	0.	0.	0.1279E 03
246	PR-146	0.1917E 01	0.	0.4433E 05	0.3487E 05	0.	0.7920E 05
247	CE-147	0.	0.	0.	0.	0.	0.
248	PR-147	0.2484E-02	0.	0.	0.	0.	0.
249	ND-147	0.4758E-00	0.1233E 04	0.2226E 04	0.	0.	0.3459E 04
250	PM-147	0.4807E-04	0.	0.	0.	0.	0.
251	PR-148	0.7827E-30	0.	0.	0.	0.7240E-25	0.7240E-25
252	ND-149	0.2191E 02	0.2030E 06	0.6055E 05	0.	0.	0.2636E 06
253	PM-149	0.1990E 01	0.	0.6316E 03	0.	0.	0.6316E 03
254	PR-150	0.	0.	0.	0.	0.	0.
255	PM-150	0.3682E 01	0.	0.1095E 06	0.1275E 06	0.	0.2370E 06
256	ND-151	0.9666E-03	0.	0.	0.	0.	0.
257	PM-151	0.7745E 00	0.	0.2049E 05	0.	0.	0.2049E 05
258	SM-151	0.2651E-05	0.2158E-04	0.	0.	0.	0.2158E-04
259	ND-152	0.4007E-19	0.	0.	0.	0.	0.
260	PM-152	0.3456E-08	0.	0.	0.	0.3580E-03	0.3580E-03
261	PM-153	0.3187E-05	0.	0.	0.	0.	0.
262	SM-153	0.1867E-00	0.7389E 03	0.3717E 03	0.	0.	0.1111E 04
263	PM-154	0.1417E-19	0.	0.	0.6552E-15	0.	0.6552E-15
264	SM-155	0.8190E-02	0.3481E 02	0.	0.	0.	0.3481E 02
265	EU-155	0.1177E-03	0.9470E-01	0.1287E 01	0.	0.	0.1381E 01
266	SM-156	0.5600E-01	0.	0.	0.	0.	0.
267	EU-156	0.5379E-03	0.	0.	0.	0.2388E 02	0.2388E 02
268	EU-157	0.2346E-01	0.1736E 03	0.5209E 03	0.	0.	0.6945E 03
269	EU-158	0.8646E-02	0.	0.	0.4159E 03	0.	0.4159E 03
270	GD-159	0.2727E-02	0.5703E 00	0.6940E 01	0.	0.	0.7510E 01
271	EU-160	0.	0.	0.	0.	0.	0.
272	TB-160	0.6144E-07	0.5725E-04	0.1655E-02	0.4292E-03	0.	0.2141E-02
273	GD-161	0.1334E-18	0.3943E-15	0.1584E-14	0.	0.	0.1978E-14
274	TB-161	0.9767E-06	0.	0.	0.	0.	0.
TOTALS		0.7096E 03	0.6639E 06	0.9368E 07	0.7138E 07	0.4036E 07	0.2121E 08

TABLE 5-7 (Cont'd)

PARTICLE BETA SOURCE ENERGIES (MEV/SEC)								
NUCLIDE NO.	CHEMICAL SYMBOL	ACTIVITY (MICRO-CURIES)	ENERGY GROUPS					BETA ENERGY (MEV/SEC)
			0. -0.25MEV	0.26-0.75MEV	0.76-1.25MEV	1.26-1.75MEV	1.76-- MEV	
2	ZN-72	0.1413E-04	0.4968E-01	0.1395E-01	0.	0.	0.	0.6362E-01
3	GA-72	0.5565E-05	0.1890E-01	0.3961E-01	0.1955E-01	0.	0.	0.7805E-01
4	ZN-73	0.3270E-33	0.	0.	0.1008E-28	0.	0.	0.1008E-28
5	GA-73	0.7304E-03	0.2522E-00	0.1902E 02	0.	0.	0.	0.1027E 02
6	GE-73M	0.7304E-03	0.	0.	0.	0.	0.	0.
7	GA-74	0.5839E-09	0.	0.1844E-05	0.1480E-04	0.9290E-06	0.	0.1758E-04
8	GE-75M	0.	0.	0.	0.	0.	0.	0.
9	GE-75	0.7302E-02	0.3926E-00	0.1034E 03	0.	0.	0.	0.1038E 03
10	GA-76	0.	0.	0.	0.	0.	0.	0.
11	GE-77M	0.	0.	0.	0.	0.	0.	0.
12	GE-77	0.1963E-01	0.2760E 01	0.3116E 03	0.7694E 02	0.	0.	0.3913E 03
13	AS-77	0.5437E-02	0.4442E 02	0.	0.	0.	0.	0.4442E 02
14	GE-78	0.1524E-00	0.	0.1692E 04	0.	0.	0.	0.1692E 04
15	AS-78M	0.8003E-01	0.	0.	0.	0.	0.	0.
16	AS-78	0.2071E-00	0.	0.1026E 04	0.2504E 04	0.5125E 04	0.	0.8655E 04
17	AS-79	0.1073E-05	0.	0.1456E-01	0.	0.	0.	0.1456E-01
18	SE-79M	0.1890E-05	0.	0.	0.	0.	0.	0.
19	SL-79	0.5679E-08	0.1125E-04	0.	0.	0.	0.	0.1125E-04
20	AS-80	0.	0.	0.	0.	0.	0.	0.
21	AS-81	0.	0.	0.	0.	0.	0.	0.
22	SE-81M	0.4397E-01	0.	0.	0.	0.	0.	0.
23	SL-81	0.7134E-01	0.	0.1214E 04	0.	0.	0.	0.1214E 04
24	AS-82	0.	0.	0.	0.	0.	0.	0.
25	SL-83M	0.	0.	0.	0.	0.	0.	0.
26	SE-83	0.1728E-00	0.	0.3197E 04	0.	0.	0.	0.3197E 04
27	BR-83	0.7091E 01	0.	0.8308E 05	0.	0.	0.	0.8308E 05
28	KR-83M	0.7102E 01	0.	0.	0.	0.	0.	0.
29	SE-84	0.1657E-18	0.	0.1942E-14	0.	0.	0.	0.1942E-14
30	BR-84	0.1009E 01	0.1807E 03	0.4824E 04	0.5227E 04	0.2531E 05	0.	0.3555E 05
31	AS-85	0.	0.	0.	0.	0.	0.	0.
32	SE-85	0.	0.	0.	0.	0.	0.	0.
33	BR-85	0.2690E-18	0.	0.	0.8295E-14	0.	0.	0.8295E-14
34	KR-85M	0.9155E 01	0.	0.7536E 05	0.	0.	0.	0.7536E 05
35	KR-85	0.6465E-04	0.5316E 00	0.	0.	0.	0.	0.5316E 00
36	SE-86	0.	0.	0.	0.	0.	0.	0.
37	BR-86	0.	0.	0.	0.	0.	0.	0.
38	KR-90	0.	0.	0.	0.	0.	0.	0.
39	RE-90	0.4608E-20	0.	0.	0.1870E-15	0.	0.	0.1870E-15
40	SR-90	0.1187E-02	0.7964E 01	0.	0.	0.	0.	0.7964E 01
41	Y-90	0.4474E-04	0.	0.	0.1252E 01	0.	0.	0.1252E 01
42	BR-89	0.	0.	0.	0.	0.	0.	0.
43	KR-89	0.973E-17	0.	0.7747E-13	0.	0.2805E-12	0.	0.3580E-12

TABLE 5-7 (Cont'd)

44	RL-89	0.6945E-01	0.1675E 03	0.7837E 03	0.1229E 03	0.2350E 03	0.	0.1309E 04
45	SR-89	0.2079E-00	0.	0.3787E 04	0.	0.	0.	0.3787E 04
46	Y-89M	0.2079E-00	0.	0.	0.	0.	0.	0.
47	BR-88	0.	0.	0.	0.	0.	0.	0.
48	KR-88	0.2819E 02	0.1265E 06	0.3129E 05	0.1877E 06	0.	0.	0.3455E 06
49	RB-88	0.3145E 02	0.	0.	0.1885E 06	0.1533E 07	0.	0.1721E 07
50	SE-87	0.	0.	0.	0.	0.	0.	0.
51	BR-87	0.	0.	0.	0.	0.	0.	0.
52	KR-87	0.4347E 01	0.	0.1675E 05	0.1769E 05	0.1324E 06	0.	0.1669E 06
53	RB-87	0.2856E-13	0.2932E-09	0.	0.	0.	0.	0.2982E-09
54	KR-91	0.	0.	0.	0.	0.	0.	0.
55	RB-91M	0.1375E-01	0.	0.	0.5088E 03	0.	0.	0.5088E 03
56	RB-91	0.	0.	0.	0.	0.	0.	0.
57	SR-91	0.2532E 02	0.1334E 05	0.2609E 06	0.2251E 06	0.	0.	0.4994E 05
58	Y-91M	0.1532E 02	0.	0.	0.	0.	0.	0.
59	Y-91	0.3973E-01	0.4851E-00	0.7546E 03	0.	0.	0.	0.7551E 03
60	KR-92	0.	0.	0.	0.	0.	0.	0.
61	KR-92	0.	0.	0.	0.	0.	0.	0.
62	SR-92	0.4706E 02	0.2847E 06	0.8706E 05	0.	0.	0.	0.3717E 06
63	Y-92	0.3764E 02	0.	0.7701E 05	0.1471E 07	0.	0.	0.1548E 07
64	SR-93	0.1698E-04	0.	0.4188E-00	0.	0.	0.	0.4188E-00
65	Y-93	0.2674E 02	0.4512E 04	0.2366E 05	0.8915E 06	0.	0.	0.2197E 06
66	ZR-93	0.3592E-08	0.5737E-05	0.	0.	0.	0.	0.5907E-05
67	NB-93M	0.3226E-10	0.	0.	0.	0.	0.	0.
68	SR-94	0.	0.	0.	0.	0.	0.	0.
69	Y-94	0.5881E 00	0.	0.	0.	0.1451E 05	0.	0.1451E 05
70	SR-95	0.	0.	0.	0.	0.	0.	0.
71	Y-95	0.6136E-03	0.	0.	0.1778E 02	0.	0.	0.1778E 02
72	ZR-95	0.2159E-00	0.7920E 03	0.5016E 02	0.	0.	0.	0.1051E 04
73	NB-95M	0.1107E-03	0.	0.	0.	0.	0.	0.
74	NB-95	0.5878E-03	0.1148E 01	0.6742E-01	0.	0.	0.	0.1216E 01
75	Y-96	0.3014E-24	0.	0.	0.	0.	0.	0.
76	SR-97	0.	0.	0.	0.	0.	0.	0.
77	Y-97	0.	0.	0.	0.	0.	0.	0.
78	ZR-97	0.1500E 02	0.6327E 04	0.3181E 06	0.	0.	0.	0.3264E 06
79	NB-97M	0.1442E 02	0.	0.	0.	0.	0.	0.
80	NB-97	0.1713E 02	0.	0.2670E 06	0.	0.	0.	0.2670E 06
81	ZR-98	0.	0.	0.	0.	0.	0.	0.
82	NB-98M	0.2844E-00	0.	0.	0.4459E 04	0.	0.	0.4459E 04
83	NB-98	0.2243E 01	0.	0.5310E 05	0.	0.	0.	0.5810E 05
84	ZR-99	0.	0.	0.	0.	0.	0.	0.
85	NB-99	0.5671E-23	0.	0.1117E-18	0.	0.	0.	0.1119E-18
86	MO-99	0.4738E 01	0.3631E 04	0.6160E 05	0.	0.	0.	0.6528E 05
87	TC-99M	0.1412E 01	0.	0.	0.	0.	0.	0.
88	TC-99	0.2019E 01	0.7272E 04	0.	0.	0.	0.	0.7272E 04
89	NB-100	0.1018E-17	0.	0.	0.4333E-13	0.	0.	0.4333E-13
90	NB-101	0.	0.	0.	0.	0.	0.	0.
91	MO-101	0.3888E-01	0.1362E 03	0.4120E 03	0.	0.	0.	0.5482E 03
92	TC-101	0.3364E-00	0.	0.5290E 04	0.	0.	0.	0.5290E 04

TABLE 5-7 (Cont'd)

93	MO-102	0.2288E-02	0.	0.3387E 02	0.	0.	0.	0.3387E 02
94	TC102M	0.1380E-02	0.	0.4637E 02	0.	0.	0.	0.4637E 02
95	TC-102	0.1152E-02	0.	0.2914E 02	0.	0.	0.	0.2914E 02
96	TC-103	0.	0.	0.	0.	0.	0.	0.
97	RU-103	0.1672E-00	0.4554E 03	0.	0.	0.	0.	0.4554E 03
98	RH103M	0.1551E-00	0.	0.	0.	0.	0.	0.
99	MO-104	0.1252E-22	0.	0.	0.	0.	0.	0.
100	TC-104	0.8407E-01	0.	0.	0.2488E 04	0.	0.	0.2488E 04
101	MO-105	0.2176E-29	0.	0.	0.7379E-25	0.	0.	0.7379E-25
102	TC-105	0.2114E-04	0.	0.4433E-00	0.	0.	0.	0.4433E-00
103	RU-105	0.6483E 01	0.1682E 04	0.9066E 05	0.	0.	0.	0.9234E 05
104	RH105M	0.1336E 01	0.	0.	0.	0.	0.	0.
105	RH-105	0.5334E 00	0.3510E 04	0.	0.	0.	0.	0.3510E 04
106	RU-106	0.2411E-02	0.1160E 01	0.	0.	0.	0.	0.1160E 01
107	RH-106	0.2411E-02	0.	0.1190E 01	0.9711E 02	0.	0.	0.9830E 02
108	TC-107	0.	0.	0.	0.	0.	0.	0.
109	RU-107	0.1012E-11	0.	0.	0.4491E-08	0.4369E-07	0.	0.4818E-07
110	RH-107	0.3933E-01	0.	0.5714E 03	0.	0.	0.	0.5714E 03
111	PD-107	0.1674E-09	0.7225E-07	0.	0.	0.	0.	0.7225E-07
112	RU-108	0.3203E-13	0.	0.5026E-09	0.	0.	0.	0.5026E-09
113	RH-108	0.3443E-13	0.	0.	0.3270E-09	0.1271E-08	0.	0.1598E-08
114	RH109M	0.	0.	0.	0.	0.	0.	0.
115	RH-109	0.	0.	0.	0.	0.	0.	0.
116	PD109M	0.1532E-12	0.	0.	0.	0.	0.	0.
117	PD-109	0.9717E-01	0.	0.1228E 04	0.	0.	0.	0.1228E 04
118	AG109M	0.9724E-01	0.	0.	0.	0.	0.	0.
119	RH-110	0.	0.	0.	0.	0.	0.	0.
120	PD111M	0.1291E-02	0.3108E 01	0.	0.	0.	0.	0.3108E 01
121	PD-111	0.4535E-02	0.	0.1191E 03	0.	0.	0.	0.1191E 03
122	AG111M	0.5156E-02	0.	0.	0.	0.	0.	0.
123	AG-111	0.5237E-02	0.2763E 01	0.6343E 02	0.	0.	0.	0.6619E 02
124	PD-112	0.2279E-01	0.7871E 02	0.	0.	0.	0.	0.7871E 02
125	AG-112	0.1328E-01	0.	0.5523E 02	0.1239E 03	0.3705E 03	0.	0.5497E 03
126	PD-113	0.	0.	0.	0.	0.	0.	0.
127	AG113M	0.	0.	0.	0.	0.	0.	0.
128	AG-113	0.9222E-01	0.	0.2275E 04	0.	0.	0.	0.2275E 04
129	PD-114	0.1004E-25	0.	0.1733E-21	0.	0.	0.	0.1733E-21
130	AG-114	0.1040E-25	0.	0.	0.2949E-21	0.	0.	0.2949E-21
131	PD-115	0.	0.	0.	0.	0.	0.	0.
132	AG115M	0.	0.	0.	0.	0.	0.	0.
133	AG-115	0.1330E-02	0.	0.	0.4727E 02	0.	0.	0.4727E 02
134	CD115M	0.5361E-04	0.1130E-01	0.1045E 01	0.	0.	0.	0.1057E 01
135	CD-115	0.9721E-02	0.2678E 02	0.8356E 02	0.	0.	0.	0.1103E 03
136	IN115M	0.3738E-02	0.	0.2130E 01	0.	0.	0.	0.2130E 01
137	IN-115	0.8318E-21	0.5129E-17	0.	0.	0.	0.	0.5129E-17
138	AG-116	0.1561E-24	0.	0.	0.	0.9623E-20	0.	0.9623E-20
139	AG-117	0.	0.	0.	0.	0.	0.	0.
140	CD117M	0.4305E-01	0.	0.5310E 03	0.	0.	0.	0.5310E 03

TABLE 5-7 (Cont'd)

141	CD-117	0.4769E-01	0.	0.	0.1353E 04	0.	0.	0.1353E 04
142	IN117M	0.1083E-00	0.	0.1802E 04	0.	0.	0.	0.1802E 04
143	IN-117	0.2386E-01	0.2178E 03	0.	0.	0.	0.	0.2178E 03
144	SN117M	0.7356E-06	0.	0.	0.	0.	0.	0.
145	CD-118	0.4526E-01	0.	0.4466E 03	0.	0.	0.	0.4466E 03
146	IN-118	0.4534E-01	0.	0.	0.3691E 03	0.2013E 04	0.	0.2382E 04
147	CD119M	0.2325E-05	0.	0.1032E-01	0.8022E-01	0.	0.	0.9062E-01
148	CD-119	0.1186E-20	0.	0.2706E-16	0.	0.	0.	0.2706E-16
149	IN119M	0.6009E-03	0.	0.8003E 00	0.1801E 02	0.	0.	0.1881E 02
150	IN-119	0.2813E-04	0.	0.5550E 00	0.	0.	0.	0.5550E 00
151	IN-120	0.	0.	0.	0.	0.	0.	0.
152	CD-121	0.	0.	0.	0.	0.	0.	0.
153	IN121M	0.6494E-20	0.	0.1482E-15	0.	0.	0.	0.1482E-15
154	IN-121	0.	0.	0.	0.	0.	0.	0.
155	SN121M	0.8646E-05	0.4478E-01	0.	0.	0.	0.	0.4478E-01
156	SN-121	0.1280E-01	0.6044E 02	0.	0.	0.	0.	0.6044E 02
157	IN-122	0.	0.	0.	0.	0.	0.	0.
158	IN123M	0.	0.	0.	0.	0.	0.	0.
159	IN-123	0.	0.	0.	0.	0.	0.	0.
160	SN123M	0.1365E-04	0.1145E-02	0.2343E-00	0.	0.	0.	0.2355E-00
161	SN-123	0.3104E-01	0.	0.4823E 03	0.	0.	0.	0.4823E 03
162	IN-124	0.	0.	0.	0.	0.	0.	0.
163	SB24M1	0.	0.	0.	0.	0.	0.	0.
164	SB24M2	0.1965E-05	0.	0.	0.7757E-01	0.	0.	0.7757E-01
165	SB-124	0.6227E-06	0.2630E-02	0.1074E-02	0.4086E-02	0.	0.	0.7810E-02
166	SN125M	0.6093E-06	0.1075E-03	0.1499E-01	0.	0.	0.	0.1510E-01
167	SN-125	0.2403E-02	0.4392E-00	0.5008E 00	0.6560E 02	0.	0.	0.6654E 02
168	SB-125	0.3554E-04	0.1212E-00	0.	0.	0.	0.	0.1212E-00
169	TE125M	0.1805E-07	0.	0.	0.	0.	0.	0.
170	SN-126	0.8446E-09	0.4167E-05	0.	0.	0.	0.	0.4167E-05
171	SB125M	0.1346E-03	0.	0.	0.6143E-01	0.	0.	0.6143E-01
172	SB-126	0.7789E-03	0.	0.1325E 02	0.	0.	0.	0.1825E 02
173	SN-127	0.8197E 00	0.	0.1618E 05	0.	0.	0.	0.1618E 05
174	SB-127	0.5633E-01	0.	0.7332E 03	0.	0.	0.	0.7332E 03
175	TE127M	0.3634E-04	0.4907E-02	0.	0.	0.	0.	0.4907E-02
176	TE-127	0.1314E-01	0.1119E 03	0.	0.	0.	0.	0.1119E 03
177	SN-128	0.9611E 00	0.	0.1541E 05	0.	0.	0.	0.1541E 05
178	SB128M	0.1138E 01	0.	0.1403E 05	0.	0.	0.	0.1403E 05
179	SB-128	0.2797E-00	0.	0.5003E 04	0.	0.	0.	0.5003E 04
180	SN-129	0.3335E 01	0.	0.8225E 05	0.	0.	0.	0.8225E 05
181	SB-129	0.4843E 01	0.	0.7012E 05	0.	0.	0.	0.7012E 05
182	TE129M	0.6581E-02	0.	0.	0.	0.	0.	0.
183	TE-129	0.2870E 01	0.8496E 03	0.4676E 05	0.	0.	0.	0.4761E 05
184	I -129	0.3308E-10	0.7045E-07	0.	0.	0.	0.	0.7045E-07
185	SN-130	0.8119E-22	0.	0.1001E-17	0.	0.	0.	0.1001E-17
186	SB-130	0.6422E-06	0.	0.	0.1980E-01	0.	0.	0.1980E-01
187	I -130	0.1971E-01	0.6854E 02	0.1314E 03	0.	0.	0.	0.1999E 03
188	SN-131	0.6210E-16	0.	0.	0.1915E-11	0.	0.	0.1915E-11
189	SB-131	0.5349E 00	0.	0.1055E 05	0.	0.	0.	0.1055E 05

TABLE 5-7 (Cont'd)

190	TE131M	0.9979E 00	0.4477E 04	0.	0.1149E 04	0.	0.	0.5626E 04
191	TE-131	0.3491E 01	0.	0.8125E 05	0.	0.	0.	0.8125E 05
192	I -131	0.6497E 00	0.4538E 04	0.4530E 02	0.	0.	0.	0.4584E 04
193	XE131M	0.3174E-04	0.	0.	0.	0.	0.	0.
194	SN-132	0.2480E-26	0.	0.4589E-22	0.	0.	0.	0.4589E-22
195	SB-132	0.5271E-25	0.	0.	0.1950E-20	0.	0.	0.1950E-20
196	TE-132	0.2820E 01	0.7633E 04	0.	0.	0.	0.	0.7653E 04
197	I -132	0.3179E 01	0.	0.5414E 05	0.	0.	0.	0.5414E 05
198	SE-133	0.2865E-12	0.	0.7067E-08	0.	0.	0.	0.7067E-08
199	TE133M	0.1340E 02	0.	0.1504E 06	0.6742E 05	0.	0.	0.2178E 06
200	TE-133	0.1811E 01	0.	0.	0.5362E 05	0.	0.	0.5362E 05
201	I -133	0.1476E 02	0.1079E 05	0.2183E 06	0.	0.	0.	0.2290E 06
202	XE133M	0.1384E-01	0.	0.	0.	0.	0.	0.
203	XL-133	0.2485E-00	0.1061E 04	0.	0.	0.	0.	0.1061E 04
204	SE-134	0.	0.	0.	0.	0.	0.	0.
205	TE-134	0.1347E 02	0.	0.2325E 06	0.	0.	0.	0.2325E 06
206	I -134	0.5947E 02	0.2385E 05	0.7959E 06	0.4421E 06	0.	0.	0.1262E 07
207	SB-135	0.	0.	0.	0.	0.	0.	0.
208	TE-135	0.	0.	0.	0.	0.	0.	0.
209	I -135	0.3074E 02	0.6237E 05	0.2543E 06	0.	0.	0.	0.3467E 06
210	XE135M	0.9601E 01	0.	0.	0.	0.	0.	0.
211	XL-135	0.1280E 02	0.2605E 04	0.1334E 06	0.	0.	0.	0.1420E 06
212	CS-135	0.1316E-08	0.3408E-05	0.	0.	0.	0.	0.3408E-05
213	I -136	0.	0.	0.	0.	0.	0.	0.
214	CS-136	0.6464E-01	0.2905E 03	0.	0.	0.	0.	0.2905E 03
215	I -139	0.	0.	0.	0.	0.	0.	0.
216	XE-139	0.	0.	0.	0.	0.	0.	0.
217	CS-139	0.2747E-03	0.	0.	0.1924E 01	0.1084E 02	0.	0.1276E 02
218	BA-139	0.4702E 02	0.	0.3524E 06	0.9770E 06	0.	0.	0.1329E 07
219	I -138	0.	0.	0.	0.	0.	0.	0.
220	XL-138	0.1134E-00	0.	0.	0.3356E 04	0.	0.	0.3356E 04
221	CS-138	0.9327E 01	0.	0.2615E 05	0.2843E 06	0.	0.	0.3105E 06
222	I -137	0.	0.	0.	0.	0.	0.	0.
223	XL-137	0.7763E-13	0.	0.	0.3351E-08	0.	0.	0.3351E-08
224	CS-137	0.1245E-02	0.7499E 01	0.9060E 00	0.	0.	0.	0.8405E 01
225	BA137M	0.1175E-02	0.	0.	0.	0.	0.	0.
226	XE-140	0.	0.	0.	0.	0.	0.	0.
227	CS-140	0.	0.	0.	0.	0.	0.	0.
228	BA-140	0.1112E 01	0.2537E 04	0.8846E 04	0.	0.	0.	0.1138E 05
229	LA-140	0.1139E-00	0.	0.1871E 04	0.	0.	0.	0.1871E 04
230	BA-141	0.2538E-00	0.	0.4382E 04	0.	0.	0.	0.4382E 04
231	LA-141	0.5097E 02	0.	0.1533E 05	0.1497E 07	0.	0.	0.1510E 07
232	CE-141	0.1933E-00	0.1140E 04	0.	0.	0.	0.	0.1140E 04
233	CS-142	0.	0.	0.	0.	0.	0.	0.
234	BA-142	0.5254E-03	0.	0.7452E 01	0.	0.	0.	0.7452E 01
235	LA-142	0.4343E 02	0.	0.	0.	0.2410E 07	0.	0.2410E 07
236	BA-143	0.	0.	0.	0.	0.	0.	0.
237	LA-143	0.2480E-00	0.	0.5046E 04	0.	0.	0.	0.5046E 04

TABLE 5-7 (Cont'd)

238	CE-143	0.7205E-01	0.1267E-05	0.1075E-06	0.	0.	0.	0.1201E-06
239	PR-143	0.6342E-01	0.	0.7297E-03	0.	0.	0.	0.7297E-03
240	LA-144	0.3132E-00	0.	0.	0.1118E-05	0.	0.	0.1118E-05
241	CE-144	0.4414E-01	0.1561E-03	0.	0.	0.	0.	0.1561E-03
242	PR-144	0.4406E-01	0.	0.4348E-01	0.1598E-04	0.	0.	0.1603E-04
243	CE-145	0.6667E-18	0.	0.8222E-14	0.	0.	0.	0.8222E-14
244	PR-145	0.2380E-02	0.	0.5284E-06	0.	0.	0.	0.5284E-06
245	CE-146	0.1355E-01	0.1170E-03	0.	0.	0.	0.	0.1170E-03
246	PR-146	0.1917E-01	0.	0.	0.7291E-05	0.	0.	0.7291E-05
247	CE-147	0.	0.	0.	0.	0.	0.	0.
248	PR-147	0.2434E-02	0.	0.	0.	0.	0.	0.
249	ND-147	0.4754E-00	0.4692E-03	0.3660E-04	0.	0.	0.	0.4129E-04
250	PM-147	0.4807E-04	0.1334E-00	0.	0.	0.	0.	0.1334E-00
251	PR-148	0.7827E-30	0.	0.	0.2413E-25	0.	0.	0.2413E-25
252	ND-149	0.2191E-02	0.	0.2919E-06	0.	0.	0.	0.2919E-06
253	PM-149	0.1990E-01	0.	0.2607E-05	0.	0.	0.	0.2607E-05
254	PR-150	0.	0.	0.	0.	0.	0.	0.
255	PA-150	0.3682E-01	0.	0.7265E-05	0.2725E-05	0.	0.	0.9990E-05
256	ND-151	0.9666E-03	0.2217E-00	0.1994E-02	0.	0.	0.	0.2016E-02
257	PM-151	0.7745E-00	0.	0.1051E-05	0.	0.	0.	0.1051E-05
258	SM-151	0.2651E-05	0.2445E-02	0.	0.	0.	0.	0.2445E-02
259	ND-152	0.4007E-19	0.	0.	0.	0.	0.	0.
260	PR-152	0.3456E-08	0.	0.9376E-04	0.	0.	0.	0.9376E-04
261	PM-153	0.3187E-05	0.	0.	0.	0.	0.	0.
262	SM-153	0.1867E-00	0.1203E-04	0.4069E-03	0.	0.	0.	0.1610E-04
263	PM-154	0.1417E-19	0.	0.2184E-15	0.	0.	0.	0.2184E-15
264	SM-155	0.3190E-02	0.	0.1656E-03	0.	0.	0.	0.1656E-03
265	EJ-155	0.1177E-03	0.2584E-00	0.	0.	0.	0.	0.2584E-00
266	SM-156	0.5600E-01	0.	0.6216E-03	0.	0.	0.	0.6216E-03
267	EU-156	0.5379E-03	0.1990E-01	0.	0.6369E-01	0.	0.	0.8359E-01
268	EU-157	0.2346E-01	0.	0.3400E-03	0.	0.	0.	0.3400E-03
269	EU-158	0.8646E-02	0.	0.1386E-03	0.	0.	0.	0.1386E-03
270	GD-159	0.2727E-02	0.4969E-01	0.2539E-02	0.	0.	0.	0.2936E-02
271	FU-160	0.	0.	0.	0.	0.	0.	0.
272	TB-160	0.6144E-07	0.2548E-03	0.1989E-03	0.	0.	0.	0.4537E-03
273	GD-161	0.1334E-18	0.	0.2617E-14	0.	0.	0.	0.2617E-14
274	TB-161	0.9767E-06	0.6060E-02	0.	0.	0.	0.	0.6060E-02
TOTALS		0.7096E-03	0.5929E-06	0.5154E-07	0.6437E-07	0.4123E-07	0.	0.1631E-08

APPENDIX A

RE-ENTRY (D4) AND LIFETIME (F1) PROGRAMS

A.1 Introduction

A number of computer programs have been developed at WANL which compute various quantities as functions of time during the atmospheric re-entry from orbit of a spherical particle of NERVA core material. Because these programs are all rather similar in form, they have been given the generic acronym NERO (NERVA Re-Entry from Orbit); specific codes are distinguished by a letter-and-number suffix (e.g., NERO D4 and NERO F1). The D4 program (also designated WEREC, for Westinghouse Electric Re-Entry Code) is used to solve the equations of motions defining the re-entry trajectory and to determine the aerodynamic heating and oxidation of the re-entering graphite. The F1 program is used for the computation of the orbit lifetime of a particle and is based on the decay of elliptical orbits over long periods of time. The D4 program could be used to calculate lifetime, but would require excessive computer running time. The trajectory equations and orbit lifetime equations which are solved by the two programs have been described in WANL-TME-635^(A1). The differential equations defining the temperature variation and mass loss of graphite particles during re-entry have been reported by Hargrove^(A2) and Bridges^(A3). The latter reference presents results on the use of the D4 program for calculations of re-entry of NERVA fuel particles.

The original D4 and F1 programs have been modified for use as subroutines in the present Source Term Computer Program. Special print options and other minor features were eliminated, but the basic operation of the programs remain the same. Both programs have general qualities

common to each other. The following paragraphs therefore, refer to both programs and will provide a brief description of how these subroutines operate in the Source Term Computer Program.

A.2 General Program Description

The D4 and F1 codes operate by numerical integration of ordinary differential equations. A large part of the input involves setting up the initial conditions for these equations, while the output is derived from their step-by-step simultaneous solution. The actual numerical operations are performed by a general differential equation routine known as AA ICE 3 (ICE - Integration with Controlled Error). The features of ICE are discussed in paragraph A.3 and are more fully explained in Appendix D. Flow diagrams showing the sequence of operations for the D4 and F1 subroutines are given in Figures A-1 and A-2, respectively. Fortran listings for these programs are given in Appendix E.

Six non-linear first order differential equations are solved simultaneously by D4^(A3). Four are differential equations of motion, the fifth defines heat input to and temperature variations of the particle, and the sixth gives the rate of ablation (mass loss) of the particle. In the F1 program, two differential equations are solved. These equations define the change in perigee and apogee with time while the particle is in orbit. The equations incorporate the assumption that the orbit semi-major axis and orbit eccentricity vary slowly^(A1). Thus, the equations are not valid during the final re-entry of the body and do not yield accurate lifetimes for short lived orbits (less than ten revolutions or lifetimes less than about 60,000 seconds).

These programs make numerous subsidiary computations that are not directly involved in the solution of the equations. Some of these involve deciding what equations are applicable under the conditions currently being experienced by the particle. For example, the D4 program calculates the Knudsen number and determines the flow regime -- free molecule, near-free molecule,

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FIGURE A-1
SUBROUTINE D4

FIGURE A-2
SUBROUTINE F1

or continuum -- partly on this basis. A separate subroutine (called VALUES) accomplishes this flow regime determination in the D4 code. The subsidiary calculations also include numerous "end of case" checks which are made at each point of the computation. These checks include low velocity (below Mach 1 for D4), perigee rate change greater than - 20 ft./sec. (F1), excessive computer running time, non-convergence, etc.

Both programs involve various quantities to be read out of tables at each point in the computation. For instance, the atmospheric density ρ_a , on which the drag is highly dependent, must be interpolated from a table of ρ_a versus altitude. In this case an exponential interpolation scheme is used. The various interpolations required are accomplished by a package of interpolating subroutines which fit the desired function type -- exponential, power function, linear, parabolic -- to the tabulated points. The tables themselves are introduced into the common storage region by the subroutine called FAPTBL, which is called in the initializing portion of the program.

A.3 Construction of Programs Using ICE

The structure of the D4 and F1 codes is largely dictated by the peculiar requirements of the ICE routine. The ICE routine takes the form of two FORTRAN subprograms: the first is the subroutine ICE, with ten arguments, which is called only once per case to initialize the problem; the second is the library function XICE, with one dummy argument, which is called many times and which actually handles the numerical integration.

A program using ICE is divided into several sections. The first section is devoted to initialization. The requirement of ICE is that all the independent variables have their initial values set up before ICE is called. There may also be other operations preliminary to the case, such as reading input and printing out the initial data defining the case, which are included in this section. After the initializing section comes a special sequence of FORTRAN statements

in which ICE and XICE are called. The remainder of the program is embodied in four sections called "BOXES" and designated by letter -- BØX A, BØX B, BØX C, and BØX D.

A.3.1 Calling Sequence

The calling sequence for use of ICE in the D4 code is:

	CALL ICE (DT, T, TP, E1, E2, N, F, FD, FN, ICER)
S ₂	ICEX = ICER
	GO TO (BØX A, BØX B, BØX C, BØX D) ICEX
S ₁	ICER = XICEF (O)
	GO TO S ₂

The definitions of the arguments are as follows:

- DT Maximum step size permitted in the calculations; must be set up in the initializing section.
- T Independent variable; its initial value is set up in the initializing section, while its subsequent value is controlled by XICE, being increased by increments no greater than DT. In D4 and F1, this variable is the time in seconds.
- TP Value of T at which the program will enter BØX C; to be initialized and incremented by the program.
- E1 Lower bound on relative error in one step of the computation; to be set up in the initializing section. If the estimated error is lower

than E1, XICE will double its T step size, unless this doubling would violate the upper bound (DT) imposed on the increment. In D4, E1 = 0.00001; in F1, E1 = 0.000001.

- E2 Upper bound on relative error in one step of the computation; to be set up in the initializing section. If the estimated error is higher than E2, XICE halves its increments in T. In D4, E2 = 0.0015; in F1, E2 = 0.00015.
- (N) The number of simultaneous first-order differential equations being solved; usually designated by the integer itself in the argument list. In D4, N = 6; in F1, N = 2. In discussions below, this quantity will be referred to as "N".
- F The name of the dependent variables being solved for; these are members of an array whose dimension is N. All the F's are given initial values, whereafter their values are determined by XICE as T increases. In the F1 program, this variable is designated "Q".
- FD The name of the first derivatives of the F's with respect to T; statements to calculate the FD's must be included in BØX A. The dimension of the FD array is also N, and the j^{th} FD is the derivative of the j^{th} F. In the F1 program, this variable is designated "QD".
- FN The name of an array which is used only by XICE. Its dimension is 5 x N; thus, in D4, we have FN(30). In F1, the dimension is QN(10).

ICER A control variable whose value is selected to be 1, 2, 3, or 4
by XICE; its value determines the program's entry into the
four "BØXES".

The transfer into the various boxes is effected by the "computed go to" statement, following statement number S_2 . The value of ICER, which controls this transfer, is fixed by XICE on the basis of various criteria such as error estimation, comparison between T and TP, and the requirements of the numerical procedure. In statement S_1 where XICE is called, the argument T or O has been provided. This is a dummy argument whose identity is immaterial. It is provided only because XICE has been written to be called as a FORTRAN library function, and such a calling statement must include at least one argument. Repetitive entry into XICE is accomplished by coding in the boxes. The final statement in each of BØXES A, B, and C is a transfer to statement number S_1 .

A.3.2 ICE Controlled Subroutines (BØXES)

The coding in the "BØXES" embodies the essence of the problem being solved.

BØX A, calculates the first derivatives (FD or QD) as functions of the current values of T and the values of F or Q. Thus, it is here that the ICE routine is supplied with the first order differential equations it is to solve. For example, in the D4 program, two of the equations (heat input rate and mass loss rate) are included in the subroutine BURNUP which is called in BØX A. Thus, ICE can calculate F(5), the particle's temperature, and F(6) size (radians). BURNUP selects the equations for FD(5) and FD(6) according to the flow regime, which has been selected by VALUES. BURNUP has been constructed specifically for graphite material; it is made a separate routine so that D4 may accommodate other materials by the use of a BURNUP with the appropriate equations. After evaluating the derivatives of each of the variables,

BØX A transfers control to XICE via statement number S_1 .

After a step in the computation has been completed, XICE sets ICER = 2, sending the program to BØX B. This section is used to make various checks on the progress of the calculation. The "end-of-case" checks mentioned earlier are coded here, as well as statements to modify the maximum time step, DT, to be used for subsequent calculations. Assuming that the end-of-case conditions have not been met, the next step of calculation is started by transfer back to statement number S_1 . One cannot know when or how often BØX B will be entered, since XICE chooses the size of the T-steps in accordance with its error criteria.

BØX C is entered by XICE whenever, after a step is completed, T is found to have become equal to or greater than TP. The use of BØX C is usually to provide print out at controlled intervals in the computation. It was used for this purpose in the original D4 and F1 programs. However, since only a final print out is desired for the present program, BØX C serves no real purpose. Whenever BØX C is entered, TP must be incremented to provide for the next entry. This is accomplished by addition of relatively large increment to TP (to reduce number of entry times to BØX C). Control is then returned to XICE via statement S_1 .

The control variable ICER is set to 4 only when XICE encounters difficulty in the numerical integration. This occasions entry into BØX D which is called the "non-convergence box." The criterion of XICE for this condition is the step size. If it finds that the upper-bound error criterion remains unsatisfied as the T step is reduced to an extremely small size, it sends control to BØX D. The D4 program contains coding which attempts to restart the calculation. After two tries, the case is terminated. In the case of the F1 program, entry into BØX D results in termination of the case, with the error tag "NON-CON" (non-convergence) indicated on the print out.

To optimize computer running time, relatively large time steps (DT) were used when programming the D4 and F1 subroutines. If the integration is valid over the maximum time step, the calculation proceeds, and the next derivative calculation is made by BOX A. If the error limits are exceeded the time step is reduced until a valid integration is obtained. However, in certain re-entry problems with the D4 program, the use of a large time step ($DT = 10$ seconds) has resulted in the error message OVERFLOW being printed out. This is illustrated in Table A-1, page A-11 for case number 17.

For this case, the initial orbit of the particle at time of destruct (page A-12) is very eccentric with a negative perigee (perigee is defined as (altitude above earth's surface) - (earth radius)). The re-entry time of this particle will be less than one earth revolution, and its velocity during re-entry will decrease at a rapid rate. Thus the derivative of the velocity (FD (4)) will be large, and when multiplied by a large time step, the apparent velocity for this time step will be very large. In this particular case, OVERFLOW occurred when the velocity was squared (core location 07114 corresponding to statement No. 150 in the D4 listing, Appendix E) within BOX A. The integration was not valid, and smaller time steps were automatically selected by ICE. The final answer is correct, though the error message is printed on the output. If desired, programming changes could be incorporated to suppress the print out of this error message.

TABLE A-1

ILLUSTRATION OF OVERFLOW OCCURRING IN ICE ROUTINE

100 NM ORBIT START. 10 MIN AT 1000 MW DESTRUCT AT PERIGEE AND APOGEE

*** INPUT LIST ***

TEMPERATURE = 4000.00 DEGREES RANKINE PARTICLE DENSITY = 137.00 POUNDS/CU.FT.
 TIME FROM REACTOR SHUT DOWN TO TIME OF DESTRUCT = 0. SECONDS

NO.	PARTICLE DIAMETER (INCHES)	ORIGINAL VELOCITY (FT/SEC)	DESTRUCT VELOCITY (FT/SEC)	ALTITUDE (FEET)	VERTICAL ANGLE (DEGREES)	AZIMUTHAL ANGLE (DEGREES)	Re-ENTRY ANGLE (DEGREES)
1	0.03937	2.977700E 04	1.000000E 02	7.301928E 05	0.	0.	0.
2	0.03937	2.977700E 04	1.000000E 02	7.301928E 05	0.	180.0000	0.
3	0.03937	2.977700E 04	1.000000E 02	7.301928E 05	90.0000	0.	0.
4	0.03937	2.977700E 04	5.000000E 02	7.301928E 05	0.	0.	0.
5	0.03937	2.977700E 04	5.000000E 02	7.301928E 05	0.	180.0000	0.
6	0.03937	2.977700E 04	5.000000E 02	7.301928E 05	90.0000	130.0000	0.
7	0.03937	2.977700E 04	1.500000E 03	7.301928E 05	0.	0.	0.
8	0.03937	2.977700E 04	1.500000E 03	7.301928E 05	0.	180.0000	0.
9	0.03937	2.977700E 04	1.500000E 03	7.301928E 05	90.0000	0.	0.
10	0.03937	1.393800E 04	1.000000E 02	2.522411E 07	0.	0.	0.
11	0.03937	1.393800E 04	1.000000E 02	2.522411E 07	0.	180.0000	0.
12	0.03937	1.393800E 04	1.000000E 02	2.522411E 07	90.0000	0.	0.
13	0.03937	1.393800E 04	5.000000E 02	2.522411E 07	0.	0.	0.
14	0.03937	1.393800E 04	5.000000E 02	2.522411E 07	0.	180.0000	0.
15	0.03937	1.393800E 04	5.000000E 02	2.522411E 07	90.0000	0.	0.
16	0.03937	1.393800E 04	1.500000E 03	2.522411E 07	0.	0.	0.
17	0.03937	1.393800E 04	1.500000E 03	2.522411E 07	0.	180.0000	0.

*** OVERFLOW ON +,-,OR * OPERATION AT CORE LOCATION 07114 . BLOCK REFERENCE CODE NOT SET .
 ACC 1.7014118E 38 3777777777777777 MQ 3.3427057E 37 375022272111 PQ 0

*** OVERFLOW ON +,-,OR * OPERATION AT CORE LOCATION 07120 . BLOCK REFERENCE CODE NOT SET .
 ACC 1.7014118E 38 3777777777777777 MQ 0.7111239E 30 345270000000 PQ 0

*** OVERFLOW ON A DIVIDE OPERATION AT CORE LOCATION 16115 . BLOCK REFERENCE CODE NOT SET .
 ACC 0.2583527E 30 345064131025 MQ 1.7014118E 38 3777777777777777 PQ 0

*** OVERFLOW ON +,-,OR * OPERATION AT CORE LOCATION 07143 . BLOCK REFERENCE CODE NOT SET .
 ACC 1.7014118E 38 3777777777777777 MQ 1.7014118E 38 3777777777777777 PQ 0

*** OVERFLOW ON +,-,OR * OPERATION AT CORE LOCATION 07150 . BLOCK REFERENCE CODE NOT SET .
 ACC -1.7014118E 38 7777777777777777 MQ -1.7014118E 38 7777777777777777 PQ 0
 18 0.03937 1.393800E 04 1.500000E 03 2.522411E 07 90.0000 0. 0.

TABLE A-1 (Cont'd)

100 NM ORBIT START. 10 MIN AT 1000 MW DESTROY AT PERIGEE AND APOGEE

*** OUTPUT LIST AT TIME OF DESTROY ***

NO.	RESULTANT VELOCITY (FT/SEC)	RESULTANT ANGLE (DEGREES)	PERIGEE ALTITUDE (FEET)	APOGEE ALTITUDE (FEET)	ECCENTRICITY	PERIOD (MIN)
1	2.987700E 04	0.	7.301917E 05	2.620993E 07	3.707065E-01	1.777581E 02
2	2.967700E 04	0.	7.301920E 05	2.426793E 07	3.524953E-01	1.702975E 02
3	2.977717E 04	1.924155E-01	7.297325E 05	2.522493E 07	3.616949E-01	1.733999E 02
4	3.027700E 04	0.	7.301922E 05	3.049599E 07	4.077973E-01	1.949579E 02
5	2.927700E 04	0.	7.301912E 05	2.073111E 07	3.162952E-01	1.569550E 02
6	2.978120E 04	9.619907E-01	7.187340E 05	2.527506E 07	3.523480E-01	1.741909E 02
7	3.127700E 04	0.	7.301927E 05	4.436003E 07	5.022935E-01	2.526951E 02
8	2.827700E 04	0.	7.301910E 05	1.349221E 07	2.276999E-01	1.307795E 02
9	2.981476E 04	2.383806E 00	6.283037E 05	2.569331E 07	3.599735E-01	1.753959E 02
10	1.403800E 04	0.	1.057462E 06	2.522411E 07	3.944931E-01	1.753005E 02
11	1.383800E 04	0.	1.816742E 05	2.522411E 07	3.727952E-01	1.719999E 02
12	1.393836E 04	4.110690E-01	6.294990E 05	2.522619E 07	3.636355E-01	1.755805E 02
13	1.443800E 04	0.	3.016108E 05	2.522411E 07	3.171029E-01	1.629299E 02
14	1.343800E 04	0.	-1.522953E 06	2.522411E 07	4.949933E-01	1.993911E 02
15	1.394697E 04	2.054499E 00	6.186222E 05	2.527594E 07	3.643727E-01	1.737107E 02
16	1.543800E 04	0.	8.635969E 06	2.522411E 07	2.193210E-01	2.052749E 02
17	1.243800E 04	0.	-5.239950E 06	2.522411E 07	4.932526E-01	1.994693E 02
18	1.401848E 04	6.142499E 00	5.295185E 05	2.569201E 07	3.700499E-01	1.749799E 02

TABLE A-1 (Cont'd)

100 NM ORBIT START. 5 MIN AT 1000 MW DESTRUCT AT PERIGEE AND APOGEE

*** OUTPUT LIST AT TIME OF IMPACT ***

NO.	PARTICLE DIAMETER (INCHES)	PARTICLE MASS (GRAMS)	IMPACT TIME (MINUTES)	RANGE (FEET)	RE-ENTRY MODE	ERROR TAG
1	3.264303E-02	6.549562E-04	4.687702E 03	GT.TN. 1 ORBIT	F1	
2	3.264303E-02	6.549562E-04	4.029369E 03	GT.TN. 1 ORBIT	F1	
3	3.264303E-02	6.549562E-04	4.331452E 03	GT.TN. 1 ORBIT	F1	
4	3.264303E-02	6.549562E-04	6.181452E 03	GT.TN. 1 ORBIT	F1	
5	3.264303E-02	6.549562E-04	2.831452E 03	GT.TN. 1 ORBIT	F1	
6	3.264303E-02	6.549562E-04	3.698119E 03	GT.TN. 1 ORBIT	F1	
7	3.264303E-02	6.549562E-04	1.082416E 04	GT.TN. 1 ORBIT	F1	
8	3.115318E-02	5.693095E-04	6.682775E 02	GT.TN. 1 ORBIT	D4	
9	3.264303E-02	6.549562E-04	2.106188E 02	GT.TN. 1 ORBIT	F1	
10	3.264303E-02	6.549562E-04	4.395395E 04	GT.TN. 1 ORBIT	F1	
11	3.089729E-02	5.553754E-04	2.175481E 02	6.255202E 07	D4	
12	3.264303E-02	6.549562E-04	4.389369E 03	GT.TN. 1 ORBIT	F1	
13	3.264303E-02	6.549562E-04	5.850987E 06	GT.TN. 1 ORBIT	F1	TM-LIM
14	3.119247E-02	5.714672E-04	2.045848E 02	4.663561E 07	D4	
15	3.264303E-02	6.549562E-04	3.764369E 03	GT.TN. 1 ORBIT	F1	
16	3.264303E-02	6.549562E-04	8.084320E 06	GT.TN. 1 ORBIT	F1	TM-LIM
17	3.187441E-02	6.097725E-04	1.918449E 02	3.378682E 07	D4	
18	3.264303E-02	6.549562E-04	2.841604E 02	GT.TN. 1 ORBIT	F1	

TIME AT COMPLETION OF LINK 1 15.358

REFERENCES

- A1. H. G. Hargrove, and D. A. Hoecker, "Flight Mechanics of NERVA Re-Entry and Orbital Lifetime Studies," WANL-TME-635, December 1963.
- A2. H. G. Hargrove, "Aerodynamic Heating and Oxidation of Graphite Particles in the Free Molecule Flow Regime," WANL-TNR-067, September 1962.
- A3. J. M. Bridges, H. G. Hargrove, and D. A. Hoecker, "Summary Report of the Theoretical, Analytical, and Experimental Studies Performed in the Investigation of the Re-Entry Burnup of NERVA Fuel," WANL-TNR-135, September 1963.

APPENDIX B
SUBROUTINE SORT

The WANL Source Term Computer Program is capable of evaluating the source strength of up to 200 re-entering particles each of which may have different ballistic parameters and different initial re-entry angles and velocities. Consequently, it may be expected that each particle will have different re-entry times. At first glance, it would appear that evaluation of the source strength of the 200 particles would involve the evaluation of the fission product inventory 200 times. However, a large number of particles will re-enter in approximately the same length of time and will have essentially the same relative fission product inventory upon earth impactation (e.g., the relative inventories of particles re-entering in 61, 62, and 63 minutes after shutdown will be identical for all practical purposes). Thus, if some criteria could be established for grouping these re-entry times, the number of computer runs required for performing an adequate source strength evaluation would be reduced considerably.

Since one of the important functions of the source term computer program is to provide input information for performing radiological dose evaluations, it would appear that one means of grouping re-entry times might be based on dose considerations. Thus, if it could be demonstrated that the dose delivered by a particle entering within time "t" was essentially identical with that delivered by a particle re-entering in time $t + \Delta t$, then one computer run of FPIP for both particles would suffice. A derivation designed to show the effect of variable re-entry time on the dose delivered by NERVA fuel particles is given in the following paragraphs.

The integrated dose delivered by a radioactive particle is given by the following equation:

$$D = \alpha \int_{t_i}^{t_f} A(t) dt \quad (B-1)$$

where:

- D = dose delivered, rads
- t_i = initial time of contact, hrs.
- t_f = final time of contact, hrs.
- A(t) = the radioactivity of the fragment as a function of time,
microcuries
- α = a constant, which is a function of the fission product
energy spectrum.

The activity of a particle, containing mixed fission products, as a function of time may be approximated by the Way-Wigner formula as:

$$A = \sigma t^{-1.2} \quad (B-2)$$

where:

- σ = a constant dependent on the total number of fissions
occurring during reactor operation
- t = time after reactor shutdown.

Equation (B-2) may be rewritten with an appropriate change in limits as follows:

$$D = \alpha \sigma \int_{t_i = \tau}^{t_f = \tau + \Delta t} t^{-1.2} dt \quad (B-3)$$

where:

- τ = time after reactor shutdown that the fragment comes
 into contact with the critical organ of interest, hrs.
 Δt = time of contact of particle with critical organ, hrs.

Integrating equation (B-3) yields the following:

$$D = \frac{\sigma \alpha}{0.2} \left[-\tau^{-0.2} + (\tau + \Delta t)^{-0.2} \right] \quad (B-4)$$

In order to determine the effect of error in τ on dose, equation (B-4) must be differentiated with respect to τ and yields:

$$\frac{dD}{d\tau} = -\sigma \alpha \left[(\tau + \Delta t)^{-1.2} - \tau^{-1.2} \right] \quad (B-5)$$

Equations (B-4) and (B-5) may be combined to determine the percentage error in dose resulting from an error in τ (called $d\tau$) with the result that:

$$\frac{dD}{D} = -0.2 \frac{(\tau + \Delta t)^{-1.2} - \tau^{-1.2}}{(\tau + \Delta t)^{-0.2} - \tau^{-0.2}} \quad (B-6)$$

The quantity $\mathcal{U}$ is actually a sum of two times: t_G , the time from reactor shutdown to earth impact of the particle, and t_D , the time interval between earth impact and the initial time at which the critical organ comes into contact with the particle. Thus, equation (B-6) may be written:

$$\frac{dD}{D} = -0.2 \frac{(t_G + t_D + \Delta t)^{-1.2} - (t_G + t_D)^{-1.2}}{(t_G + t_D + \Delta t)^{0.2} - (t_G + t_D)^{-0.2}} \quad (B-7)$$

For the purposes of evaluating errors, the quantity dD/D is to be considered the percentage error in dose produced by an uncertainty in time measurement, $d\mathcal{U}$.

As an example of using equation (B-7) consider the dose delivered to the lower large intestine. In this case, assuming ingestion immediately on earth impactation, t_G equals the ground impact time evaluated by the Link 1, t_D equals 13 hours, the time required for an ingested particle to come into contact with the lower large intestine following ingestion, and Δt equals 18 hours, the time the particle is in contact with the intestine⁽¹⁾. Using these values and equation (B-7), an error evaluation was performed in order to determine the errors in t_G measurements which will produce a ten percent error in dose measurements. This evaluation is shown in Figure B-1. It is apparent that at short re-entry times large errors in re-entry time produce relatively small errors in dose.

Therefore, in order to conserve computer time, a SORT function was built into the source term program. This function is based on equation (B-7), with the quantities Δt and t_D being arbitrary input to the program. (In the case of external γ -dose measurements, Δt would equal 96 hours and t_D would equal zero). This SORT function operates in Link 2 and serves to sort the ground impact times generated by Link 1. The function is illustrated in Figure B-2 by a flow diagram. The FORTRAN listings for subroutine SORT are given in Appendix E.

FIGURE B-1

PER CENT ERROR ALLOWED FOR SPACE RESIDENCE TIME MEASUREMENTS FOR THOSE PARTICLES $< 1000 \mu$ IN DIAMETER (A TEN PER CENT ERROR IN DOSE EVALUATION IS ASSUMED TO BE ALLOWABLE)

B-6

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REFERENCES

- B1. M. I. Goldman, A. W. DeAgazio, L. F. Garcia, and J. S. Lee, "Radiobiological Considerations in Re-Entry of Nuclear Reactor Fragments," Nuclear Utility Services, Inc., NUS-145, July 1963.

APPENDIX C

SUBROUTINE FPIP

Subroutine FPIP is the largest and most complex of the subprograms used in the WANL Source Term Computer Program. Its purpose is to calculate the fission product activity of the core fragments at the time of ground impact.

This subroutine is basically a modification of the WANL Fission Product Inventory Program (FPPI)*. The theory of the computations and the nomenclature used remains the same as in the original FPIP. The original report should be referred to for a complete discussion of the operation of the program.

A flow diagram of the FPIP subroutine is given in Figure C-1. The FORTRAN listing is included in Appendix E. The major modifications made in the original FPIP program and incorporated in the present Subroutine FPIP are summarized in the following paragraphs.

The original fission product library of 499 nuclides has been reduced to 273 nuclides for use in this program (Table C-1). Nuclides eliminated were generally first members of a given decay chain that have short half lives (less than 1 minute), and for which the gamma and beta energy spectra data were unknown. *There is no significant difference in results using the two libraries* (See Volume I, paragraph 3.1.1.2). The use of the reduced library resulted in additional computer core storage space. This additional storage space was utilized to eliminate the temporary storage of data on tape 12 and certain records on tape 11 that were necessary in the original program. The elimination of repetitive writing and reading

* Call, D. W., "Fission Product Inventory Program", WANL-TME-537, Westinghouse Astronuclear Laboratory, September 1963.

of these tapes has speeded up computation time. .

Subroutine FPIP calculates the activity of an individual core fragment rather than the activity of the entire core as does the original FPIP program. This is accomplished by means of the statement $RATIO = \text{particle mass}/\text{core mass}$. It assumes that upon destruct, the reactor fuel is uniformly dispersed amongst the fragments, and that all fragments have the same fuel loading. When using the SORT subroutine and more than one particle has the same decay time, the buildup and decay calculations are bypassed and the activity of the subsequent particles are calculated from the activity of the preceding case using a corrected RATIO factor.

Use of magnetic tape for library storage has also been modified from that in the original program. The input library is stored on tape 11 as originally, but a second tape, tape 10, is also generated when either generating or reading tape 11. Tape 10 stores additional data on the beta and gamma energy contributions of each nuclide in each energy group. Thus, when using this tape for read-in of the library, the requirement of calculating the beta and gamma energy groups (as is required if using tape 11) is eliminated, thereby diminishing computer running time. The sequence of operations when using tapes 10 and 11 is shown at points (A) and (B) in Figure C-1.

The print out of data has been changed in accordance with the needs of the Source Term Program. Ordinarily, only the summary data of total microcuries and of beta and gamma source strengths is printed. This method of output was selected since for most purposes in comparing relative hazards and dose rates for different flight missions, the

data given in the summary is adequate. If more detailed data is required, it is available for retrieval from tape 9 using Subroutine SCRIB or the program SCRIB - T9S. The use of SCRIB is discussed in paragraph 4.2 of the body of this report. A flow diagram of SCRIB is shown in Figure C-2.

FIGURE C-1
SUBROUTINE FPIP

FIGURE C-1 (Cont'd)

FIGURE C-2
SUBROUTINE SCRIB

TABLE C-1

273 NUCLIDE FISSION PRODUCT LIBRARY

TOTAL NUMBER OF NUCLIDES= 273

NUCLIDE NO.	CHEMICAL SYMBOL	DIS. CONST.(MIN-1)	FISSION YIELD	DIRECT PARENTS			BRANCHING RATIOS		
1	BASIC	-0.	0.	0	0	0	0.	0.	0.
2	ZN-72	0.2458E-03	0.130E-06	1	1	1	1.000	1.000	1.000
3	GA-72	0.8193E-03	1.000E-08	2	1	1	1.000	1.000	1.000
4	ZN-73	0.3466E-00	0.105E-05	1	1	1	1.000	1.000	1.000
5	GA-73	0.2407E-02	0.400E-07	4	1	1	1.000	1.000	1.000
6	GE-73M	0.7847E-02	0.	5	1	1	1.000	1.000	1.000
7	GA-74	0.8886E-01	0.344E-05	1	1	1	1.000	1.000	1.000
8	GE-75M	0.8487E-00	0.115E-04	1	1	1	1.000	1.000	1.000
9	GE-75	0.8453E-02	0.500E-07	8	1	1	1.000	1.000	1.000
10	GA-76	0.1386E-01	0.332E-04	1	1	1	1.000	1.000	1.000
11	GE-77M	0.7702E-00	0.484E-04	1	1	1	1.000	1.000	1.000
12	GE-77	0.1022E-02	0.339E-04	11	1	1	0.360	1.000	1.000
13	AS-77	0.2985E-03	0.110E-06	12	11	1	1.000	0.640	1.000
14	GE-78	0.5501E-02	0.196E-03	1	1	1	1.000	1.000	1.000
15	AS-78M	0.1155E-00	0.232E-05	14	1	1	0.500	1.000	1.000
16	AS-78	0.7617E-02	0.232E-05	15	14	1	1.000	0.500	1.000
17	AS-79	0.7702E-01	0.556E-03	1	1	1	1.000	1.000	1.000
18	SE-79M	0.1782E-00	0.	17	1	1	1.000	1.000	1.000
19	SE-79	0.2196E-10	0.	18	1	1	1.000	1.000	1.000
20	AS-80	0.1155E-01	0.938E-03	1	1	1	1.000	1.000	1.000
21	AS-81	0.8318E-00	0.136E-02	1	1	1	1.000	1.000	1.000
22	SE-81M	0.1216E-01	0.263E-04	21	1	1	0.060	1.000	1.000
23	SE-81	0.3767E-01	0.263E-04	22	21	1	1.000	0.940	1.000
24	AS-82	0.2310E-01	0.228E-02	1	1	1	1.000	1.000	1.000
25	SE-83M	0.6027E-00	0.243E-02	1	1	1	1.000	1.000	1.000
26	SE-83	0.2773E-01	0.299E-02	25	1	1	1.000	1.000	1.000
27	BR-83	0.4813E-02	0.713E-05	26	25	1	1.000	1.000	1.000
28	KR-83M	0.6080E-02	0.	27	1	1	1.000	1.000	1.000
29	SE-84	0.2310E-00	0.980E-02	1	1	1	1.000	1.000	1.000
30	BR-84	0.2166E-01	0.248E-03	29	1	1	1.000	1.000	1.000
31	AS-85	0.1040E-03	0.440E-02	1	1	1	1.000	1.000	1.000
32	SE-85	0.1066E-01	0.609E-02	31	1	1	1.000	1.000	1.000
33	BR-85	0.2310E-00	0.250E-02	32	1	1	1.000	1.000	1.000
34	KR-85M	0.2625E-02	0.555E-04	33	1	1	1.000	1.000	1.000

TABLE C-1 (Cont'd)

35	KR-85	0.1243E-06	0.555E-04	34	1	1	0.190	1.000	1.000
36	SE-86	0.2599E 01	0.125E-01	1	1	1	1.000	1.000	1.000
37	BR-86	0.6931E 00	0.643E-02	36	1	1	1.000	1.000	1.000
38	KR-90	0.1260E 01	0.442E-01	1	1	1	1.000	1.000	1.000
39	RB-90	0.2567E-00	0.986E-02	38	1	1	1.000	1.000	1.000
40	SR-90	0.4707E-07	0.	39	1	1	1.000	1.000	1.000
41	Y-90	0.1799E-03	0.	40	1	1	1.000	1.000	1.000
42	BR-89	0.9452E 01	0.258E-01	1	1	1	1.000	1.000	1.000
43	KR-89	0.2193E-00	0.207E-01	42	1	1	0.882	1.000	1.000
44	RB-89	0.4501E-01	0.386E-02	43	1	1	1.000	1.000	1.000
45	SR-89	0.9532E-05	0.	44	1	1	1.000	1.000	1.000
46	Y-89M	0.2599E 01	0.	45	1	1	1.000	1.000	1.000
47	BR-88	0.2520E 01	0.261E-01	1	1	1	1.000	1.000	1.000
48	KR-88	0.4011E-02	0.869E-02	47	42	1	0.930	0.118	1.000
49	RB-88	0.3851E-01	0.933E-03	48	1	1	1.000	1.000	1.000
50	SE-87	0.2446E 01	0.109E-01	1	1	1	1.000	1.000	1.000
51	BR-87	0.7631E 00	0.107E-01	50	1	1	1.000	1.000	1.000
52	KR-87	0.8886E-02	0.328E-02	51	47	1	0.097	0.070	1.000
53	RB-87	0.3065E-16	0.428E-04	52	1	1	1.000	1.000	1.000
54	KR-91	0.4159E 01	0.385E-01	1	1	1	1.000	1.000	1.000
55	RB-91M	0.4951E-01	0.860E-02	54	1	1	0.500	1.000	1.000
56	RB-91	0.4077E-00	0.860E-02	54	1	1	0.500	1.000	1.000
57	SR-91	0.1191E-02	0.258E-02	55	56	1	1.000	1.000	1.000
58	Y-91M	0.1359E-01	0.	57	1	1	0.600	1.000	1.000
59	Y-91	0.8299E-05	0.	58	57	1	1.000	0.400	1.000
60	KR-92	0.1386E 02	0.285E-01	1	1	1	1.000	1.000	1.000
61	RB-92	0.7847E 01	0.246E-01	60	1	1	1.000	1.000	1.000
62	SR-92	0.4279E-02	0.659E-02	61	1	1	1.000	1.000	1.000
63	Y-92	0.3301E-02	0.605E-04	62	1	1	1.000	1.000	1.000
64	SR-93	0.8664E-01	0.633E-01	1	1	1	1.000	1.000	1.000
65	Y-93	0.1122E-02	0.103E-02	64	1	1	1.000	1.000	1.000
66	ZR-93	0.1387E-11	0.	65	1	1	1.000	1.000	1.000
67	NB-93M	0.3562E-06	0.	66	1	1	0.250	1.000	1.000
68	SR-94	0.5332E 00	0.594E-01	1	1	1	1.000	1.000	1.000
69	Y-94	0.3466E-01	0.445E-02	68	1	1	1.000	1.000	1.000
70	SR-95	0.1040E 01	0.529E-01	1	1	1	1.000	1.000	1.000
71	Y-95	0.6931E-01	0.944E-02	70	1	1	1.000	1.000	1.000
72	ZR-95	0.7405E-05	0.189E-03	71	1	1	1.000	1.000	1.000
73	NB-95M	0.1284E-03	0.	72	1	1	0.020	1.000	1.000
74	NB-95	0.1375E-04	-0.	73	72	1	1.000	0.980	1.000
75	Y-96	0.3014E-00	0.603E-01	1	1	1	1.000	1.000	1.000
76	SR-97	0.2773E 02	0.613E-02	1	1	1	1.000	1.000	1.000
77	Y-97	0.8318E 01	0.246E-01	76	1	1	1.000	1.000	1.000
78	ZR-97	0.6795E-03	0.241E-01	77	1	1	1.000	1.000	1.000
79	NB-97M	0.6931E 00	0.298E-02	78	1	1	0.960	1.000	1.000
80	NB-97	0.9495E-02	0.298E-02	79	78	1	1.000	0.040	1.000
81	ZR-98	0.6931E 00	0.561E-01	1	1	1	1.000	1.000	1.000
82	NB-98M	0.1359E-01	0.860E-03	1	1	1	1.000	1.000	1.000

TABLE C-1 (Cont'd)

83	NB-98	0.2666E-01	0.860E-03	81	1	1	1.000	1.000	1.000
84	ZR-99	0.1260E 01	0.538E-01	1	1	1	1.000	1.000	1.000
85	NB-99	0.2888E-00	0.681E-02	84	1	1	1.000	1.000	1.000
86	MO-99	0.1737E-03	0.805E-04	85	1	1	1.000	1.000	1.000
87	TC-99M	0.1925E-02	0.	86	1	1	0.870	1.000	1.000
88	TC-99	0.6267E 00	0.	87	86	1	1.000	0.130	1.000
89	NB-100	0.2310E-00	0.602E-01	1	1	1	1.000	1.000	1.000
90	NB-101	0.6931E 00	0.425E-01	1	1	1	1.000	1.000	1.000
91	MO-101	0.4748E-01	0.760E-02	90	1	1	1.000	1.000	1.000
92	TC-101	0.4951E-01	0.157E-03	91	1	1	1.000	1.000	1.000
93	MO-102	0.6027E-01	0.398E-01	1	1	1	1.000	1.000	1.000
94	TC102M	0.1540E-00	0.705E-03	93	1	1	0.500	1.000	1.000
95	TC-102	0.8318E 01	0.705E-03	93	1	1	0.500	1.000	1.000
96	TC-103	0.5776E 00	0.298E-01	1	1	1	1.000	1.000	1.000
97	RU-103	0.1212E-04	0.	96	1	1	0.995	1.000	1.000
98	RH103M	0.1216E-01	0.	97	1	1	1.000	1.000	1.000
99	MO-104	0.2773E-00	0.145E-01	1	1	1	1.000	1.000	1.000
100	TC-104	0.3851E-01	0.340E-02	99	1	1	1.000	1.000	1.000
101	MO-105	0.3466E-00	0.698E-02	1	1	1	1.000	1.000	1.000
102	TC-105	0.7702E-01	0.198E-02	101	1	1	1.000	1.000	1.000
103	RU-105	0.2596E-02	0.776E-04	102	1	1	1.000	1.000	1.000
104	RH105M	0.7094E 01	0.	103	1	1	0.206	1.000	1.000
105	RH-105	0.3209E-03	0.	104	103	1	1.000	0.794	1.000
106	RU-106	0.1318E-05	0.392E-02	1	1	1	1.000	1.000	1.000
107	RH-106	0.1386E 01	0.	106	1	1	1.000	1.000	1.000
108	TC-107	0.6931E 00	0.183E-02	1	1	1	1.000	1.000	1.000
109	RU-107	0.1507E-00	0.806E-04	108	1	1	1.000	1.000	1.000
110	RH-107	0.3151E-01	0.	109	1	1	1.000	1.000	1.000
111	PD-107	0.1883E-12	0.	110	1	1	1.000	1.000	1.000
112	RU-108	0.1612E-00	0.700E-03	1	1	1	1.000	1.000	1.000
113	RH-108	0.2310E 01	0.	112	1	1	1.000	1.000	1.000
114	RH109M	0.8318E 00	0.150E-03	1	1	1	1.000	1.000	1.000
115	RH-109	0.1386E 01	0.150E-03	114	1	1	1.000	1.000	1.000
116	PD109M	0.1475E-00	0.	115	1	1	0.500	1.000	1.000
117	PD-109	0.8252E-03	0.	116	115	1	1.000	0.500	1.000
118	AG109M	0.1066E 01	0.	117	1	1	1.000	1.000	1.000
119	RH-110	0.1155E 02	0.178E-03	1	1	1	1.000	1.000	1.000
120	PD111M	0.2100E-02	0.208E-05	1	1	1	1.000	1.000	1.000
121	PD-111	0.3014E-01	0.179E-03	120	1	1	0.680	1.000	1.000
122	AG111M	0.5620E 00	0.	121	120	1	1.000	0.320	1.000
123	AG-111	0.6334E-04	0.	122	1	1	1.000	1.000	1.000
124	PD-112	0.5501E-03	0.100E-03	1	1	1	1.000	1.000	1.000
125	AG-112	0.3703E-02	0.	124	1	1	1.000	1.000	1.000
126	PD-113	0.4951E-00	0.160E-03	1	1	1	1.000	1.000	1.000
127	AG113M	0.5776E 00	0.	126	1	1	1.000	1.000	1.000
128	AG-113	0.2180E-02	0.	127	1	1	0.900	1.000	1.000
129	PD-114	0.2888E-00	0.135E-03	1	1	1	1.000	1.000	1.000
130	AG-114	0.8318E 01	0.186E-05	129	1	1	1.000	1.000	1.000

TABLE C-1 (Cont'd)

131	PD-115	0.9242E 00	0.103E-03	1	1	1	1.000	1.000	1.000
132	AG115M	0.2097E 01	0.353E-05	1	1	1	1.000	1.000	1.000
133	AG-115	0.3301E-01	0.353E-05	132	131	1	0.720	1.000	1.000
134	CD115M	0.1119E-04	0.	133	132	1	0.090	0.140	1.000
135	CD-115	0.2180E-03	0.	133	132	1	0.910	0.140	1.000
136	IN115M	0.2561E-02	0.	135	1	1	1.000	1.000	1.000
137	IN-115	0.2196E-20	0.	136	134	1	0.950	1.000	1.000
138	AG-116	0.2773E-00	0.180E-03	1	1	1	1.000	1.000	1.000
139	AG-117	0.6301E 00	0.106E-03	1	1	1	1.000	1.000	1.000
140	CD117M	0.3851E-02	0.194E-05	139	1	1	0.500	1.000	1.000
141	CD-117	0.1386E-01	0.194E-05	140	139	1	0.500	0.600	1.000
142	IN117M	0.5776E-02	0.	141	140	1	1.000	0.400	1.000
143	IN-117	0.1540E-01	0.	142	1	1	0.220	1.000	1.000
144	SN117M	0.3438E-04	0.	142	1	1	0.001	1.000	1.000
145	CD-118	0.1386E-01	0.142E-03	1	1	1	1.000	1.000	1.000
146	IN-118	0.8318E 01	0.	145	1	1	1.000	1.000	1.000
147	CD119M	0.6301E-01	0.701E-04	1	1	1	1.000	1.000	1.000
148	CD-119	0.2310E-00	0.701E-04	1	1	1	1.000	1.000	1.000
149	IN119M	0.3851E-01	0.750E-06	147	1	1	0.800	1.000	1.000
150	IN-119	0.3014E-00	0.750E-06	149	148	147	0.040	1.000	0.200
151	IN-120	0.8318E 00	0.141E-03	1	1	1	1.000	1.000	1.000
152	CD-121	0.1664E 01	0.120E-03	1	1	1	1.000	1.000	1.000
153	IN121M	0.2236E-00	0.101E-04	152	1	1	0.500	1.000	1.000
154	IN-121	0.1386E 01	0.101E-04	152	1	1	0.500	1.000	1.000
155	SN121M	0.2636E-06	0.170E-06	153	1	1	1.000	1.000	1.000
156	SN-121	0.4279E-03	0.170E-06	154	1	1	1.000	1.000	1.000
157	IN-122	0.9242E 00	0.144E-03	1	1	1	1.000	1.000	1.000
158	IN123M	0.1155E 01	0.731E-04	1	1	1	1.000	1.000	1.000
159	IN-123	0.4159E 01	0.731E-04	1	1	1	1.000	1.000	1.000
160	SN123M	0.3851E-05	0.760E-05	1	1	1	1.000	1.000	1.000
161	SN-123	0.1691E-01	0.760E-05	159	158	1	1.000	1.000	1.000
162	IN-124	0.2079E 01	0.142E-03	1	1	1	1.000	1.000	1.000
163	SB24M1	0.5332E 00	0.167E-06	1	1	1	1.000	1.000	1.000
164	SB24M2	0.3301E-01	0.167E-06	1	1	1	1.000	1.000	1.000
165	SB-124	0.8022E-05	0.167E-06	1	1	1	1.000	1.000	1.000
166	SN125M	0.7146E-01	0.102E-03	1	1	1	1.000	1.000	1.000
167	SN-125	0.5121E-04	0.102E-03	1	1	1	1.000	1.000	1.000
168	SB-125	0.6589E-06	0.128E-04	167	166	1	1.000	1.000	1.000
169	TE125M	0.8299E-05	0.	168	1	1	0.300	1.000	1.000
170	SN-126	0.6589E-11	0.275E-03	1	1	1	1.000	1.000	1.000
171	SB125M	0.3648E-01	0.220E-04	170	1	1	1.000	1.000	1.000
172	SB-126	0.3851E-04	0.220E-04	171	1	1	0.990	1.000	1.000
173	SN-127	0.5776E-02	0.107E-02	1	1	1	1.000	1.000	1.000
174	SB-127	0.1269E-03	0.207E-03	173	1	1	1.000	1.000	1.000
175	TE127M	0.4584E-05	0.130E-04	174	1	1	0.220	1.000	1.000
176	TE-127	0.1242E-02	0.130E-04	175	174	1	0.980	0.780	1.000
177	SN-128	0.1216E-01	0.238E-02	1	1	1	1.000	1.000	1.000
178	SB128M	0.6730E-01	0.585E-03	177	1	1	0.970	1.000	1.000

TABLE C-1 (Cont'd)

179	SB-128	0.1179E-02	0.585E-03	177	1	1	0.030	1.000	1.000
180	SN-129	0.6418E-02	0.449E-02	1	1	1	1.000	1.000	1.000
181	SB-129	0.2511E-02	0.291E-02	180	1	1	1.000	1.000	1.000
182	TE129M	0.1301E-04	0.310E-03	181	1	1	0.360	1.000	1.000
183	TE-129	0.9627E-02	0.310E-03	182	181	1	1.000	0.640	1.000
184	I -129	0.7752E-13	0.	183	1	1	1.000	1.000	1.000
185	SN-130	0.2666E-00	0.753E-02	1	1	1	1.000	1.000	1.000
186	SB-130	0.9763E-01	0.812E-02	185	1	1	1.000	1.000	1.000
187	I -130	0.9169E-03	0.562E-04	1	1	1	1.000	1.000	1.000
188	SN-131	0.2039E-00	0.115E-01	1	1	1	1.000	1.000	1.000
189	SB-131	0.3014E-01	0.131E-01	188	1	1	1.000	1.000	1.000
190	TE131M	0.3851E-03	0.230E-02	189	1	1	0.150	1.000	1.000
191	TE-131	0.2888E-01	0.230E-02	190	189	1	0.200	0.850	1.000
192	I -131	0.5979E-04	0.945E-04	191	190	1	1.000	0.800	1.000
193	XE131M	0.4011E-04	0.	192	1	1	0.008	1.000	1.000
194	SN-132	0.3151E-00	0.932E-02	1	1	1	1.000	1.000	1.000
195	SB-132	0.3301E-00	0.206E-01	194	1	1	1.000	1.000	1.000
196	TE-132	0.1481E-03	0.122E-01	195	1	1	1.000	1.000	1.000
197	I -132	0.5023E-02	0.167E-02	196	1	1	1.000	1.000	1.000
198	SB-133	0.1691E-00	0.333E-01	1	1	1	1.000	1.000	1.000
199	TE133M	0.1333E-01	0.131E-01	198	1	1	0.720	1.000	1.000
200	TE-133	0.3466E-00	0.131E-01	199	198	1	0.130	0.280	1.000
201	I -133	0.5554E-03	0.655E-02	200	199	1	1.000	0.870	1.000
202	XE133M	0.2093E-03	0.	201	1	1	0.024	1.000	1.000
203	XE-133	0.9134E-04	0.	202	201	1	1.000	0.976	1.000
204	SB-134	0.8664E-00	0.181E-01	1	1	1	1.000	1.000	1.000
205	TE-134	0.1575E-01	0.378E-01	204	1	1	1.000	1.000	1.000
206	I -134	0.1308E-01	0.217E-01	205	1	1	1.000	1.000	1.000
207	SB-135	0.6931E-01	0.437E-02	1	1	1	1.000	1.000	1.000
208	TE-135	0.4751E-00	0.225E-01	207	1	1	1.000	1.000	1.000
209	I -135	0.1729E-02	0.285E-01	208	1	1	1.000	1.000	1.000
210	XE135M	0.4443E-01	0.465E-02	209	1	1	0.300	1.000	1.000
211	XE-135	0.1256E-02	0.465E-02	210	209	1	1.000	0.700	1.000
212	CS-135	0.6589E-12	0.	211	1	1	1.000	1.000	1.000
213	I -136	0.4751E-00	0.392E-01	1	1	1	1.000	1.000	1.000
214	CS-136	0.3703E-04	0.377E-02	1	1	1	1.000	1.000	1.000
215	I -139	0.2079E-02	0.785E-02	1	1	1	1.000	1.000	1.000
216	XE-139	0.1014E-01	0.275E-01	215	1	1	0.960	1.000	1.000
217	CS-139	0.7296E-01	0.244E-01	216	1	1	1.000	1.000	1.000
218	BA-139	0.8155E-02	0.547E-02	217	1	1	1.000	1.000	1.000
219	I -138	0.6601E-01	0.146E-01	1	1	1	1.000	1.000	1.000
220	XE-138	0.4077E-01	0.275E-01	219	215	1	0.970	0.040	1.000
221	CS-138	0.2166E-01	0.140E-01	220	1	1	1.000	1.000	1.000
222	I -137	0.1704E-01	0.266E-01	1	1	1	1.000	1.000	1.000
223	XE-137	0.1777E-00	0.266E-01	222	219	1	0.960	0.030	1.000
224	CS-137	0.4393E-07	0.815E-02	223	1	1	1.000	1.000	1.000
225	BA137M	0.2666E-00	0.585E-04	224	1	1	0.960	1.000	1.000
226	XE-140	0.2599E-01	0.231E-01	1	1	1	1.000	1.000	1.000

TABLE C-1 (Cont'd)

227	CS-140	0.6301E-00	0.296E-01	226	1	1	1.000	1.000	1.000
228	BA-140	0.3761E-04	0.112E-01	227	1	1	1.000	1.000	1.000
229	LA-140	0.2874E-03	0.371E-03	228	1	1	1.000	1.000	1.000
230	BA-141	0.3851E-01	0.610E-01	1	1	1	1.000	1.000	1.000
231	LA-141	0.3040E-02	0.341E-02	230	1	1	1.000	1.000	1.000
232	CE-141	0.1459E-04	0.	231	1	1	1.000	1.000	1.000
233	CS-142	0.6931E-00	0.286E-01	1	1	1	1.000	1.000	1.000
234	BA-142	0.6931E-01	0.249E-01	233	1	1	1.000	1.000	1.000
235	LA-142	0.8252E-02	0.670E-02	234	1	1	1.000	1.000	1.000
236	BA-143	0.3199E-01	0.447E-01	1	1	1	1.000	1.000	1.000
237	LA-143	0.3851E-01	0.143E-01	236	1	1	1.000	1.000	1.000
238	CE-143	0.3501E-03	0.125E-02	237	1	1	1.000	1.000	1.000
239	PR-143	0.3488E-04	0.	238	1	1	1.000	1.000	1.000
240	LA-144	0.3648E-01	0.519E-01	1	1	1	1.000	1.000	1.000
241	CE-144	0.1698E-05	0.385E-02	240	1	1	1.000	1.000	1.000
242	PR-144	0.4007E-01	0.	241	1	1	1.000	1.000	1.000
243	CE-145	0.2310E-00	0.394E-01	1	1	1	1.000	1.000	1.000
244	PR-145	0.1958E-02	0.111E-03	243	1	1	1.000	1.000	1.000
245	CE-146	0.4987E-01	0.297E-01	1	1	1	1.000	1.000	1.000
246	PR-146	0.2841E-01	0.112E-02	245	1	1	1.000	1.000	1.000
247	CE-147	0.5776E-00	0.215E-01	1	1	1	1.000	1.000	1.000
248	PR-147	0.5776E-01	0.221E-02	247	1	1	1.000	1.000	1.000
249	ND-147	0.4336E-04	0.	248	1	1	1.000	1.000	1.000
250	PM-147	0.5069E-06	0.	249	1	1	1.000	1.000	1.000
251	PR-148	0.3555E-00	0.170E-01	1	1	1	1.000	1.000	1.000
252	ND-149	0.5776E-02	0.113E-01	251	1	1	1.000	1.000	1.000
253	PM-149	0.2180E-03	0.	252	1	1	1.000	1.000	1.000
254	PR-150	0.2773E-01	0.446E-02	1	1	1	1.000	1.000	1.000
255	PM-150	0.4279E-02	0.212E-03	254	1	1	1.000	1.000	1.000
256	ND-151	0.5332E-01	0.419E-02	1	1	1	1.000	1.000	1.000
257	PM-151	0.4068E-03	0.232E-03	256	1	1	1.000	1.000	1.000
258	SM-151	0.1647E-07	0.	257	1	1	1.000	1.000	1.000
259	ND-152	0.2310E-00	0.237E-02	1	1	1	1.000	1.000	1.000
260	PM-152	0.1155E-00	0.383E-03	259	1	1	1.000	1.000	1.000
261	PM-153	0.7702E-01	0.165E-02	1	1	1	1.000	1.000	1.000
262	SM-153	0.2458E-03	0.603E-04	261	1	1	1.000	1.000	1.000
263	PM-154	0.2301E-00	0.692E-03	1	1	1	1.000	1.000	1.000
264	SM-155	0.2888E-01	0.324E-03	1	1	1	1.000	1.000	1.000
265	EU-155	0.7752E-06	0.249E-05	264	1	1	1.000	1.000	1.000
266	SM-156	0.1155E-02	0.134E-03	1	1	1	1.000	1.000	1.000
267	EU-156	0.3126E-04	0.738E-05	266	1	1	1.000	1.000	1.000
268	EU-157	0.7702E-03	0.772E-04	1	1	1	1.000	1.000	1.000
269	EU-158	0.1155E-01	0.197E-04	1	1	1	1.000	1.000	1.000
270	GD-159	0.6418E-03	0.105E-04	1	1	1	1.000	1.000	1.000
271	EU-160	0.5941E-00	0.280E-05	1	1	1	1.000	1.000	1.000
272	TB-160	0.6594E-05	0.200E-07	1	1	1	1.000	1.000	1.000
273	GD-161	0.1873E-00	0.730E-06	1	1	1	1.000	1.000	1.000
274	TB-161	0.7079E-04	0.300E-07	272	1	1	1.000	1.000	1.000

TABLE C-1 (Cont'd)

GAMMA SPECTRA

NUCLIDE NO.	SYMBOL	(MEV)	FRACT.	(MEV)	FRACT.	(MEV)	FRACT.	(MEV)	FRACT.	(MEV)	FRACT.	(MEV)	FRACT.
2	ZN-72	0.	0.										
3	GA-72	0.601	0.072	0.630	0.045	0.786	0.030	0.812	0.026	0.835	0.690	0.894	0.080
		1.050	0.053	1.231	0.012	1.268	0.014	1.465	0.235	1.598	0.103	1.680	0.015
		1.860	0.053	2.201	0.290	2.490	0.090	2.508	0.170				
4	ZN-73	2.500	1.000										
5	GA-73	0.295	0.970	0.745	0.060	1.040	0.010						
6	GE-73M	0.014	1.000	0.054	1.000								
7	GA-74	0.490	0.075	0.596	0.760	0.600	0.037	0.870	0.095	1.000	0.074	1.100	0.060
		1.200	0.110	1.310	0.022	1.450	0.080	1.600	0.004	1.720	0.064	1.840	0.028
		1.760	0.055	2.200	0.009	2.350	0.588	2.550	0.025	2.720	0.040	2.950	0.031
		3.170	0.018	3.330	0.018	3.600	0.013						
8	GE-75M	0.139	1.000										
9	GE-75	0.066	0.003	0.199	0.014	0.265	0.110	0.427	0.003	0.477	0.003		
10	GA-76	0.	0.										
11	GE-77M	0.159	0.360	0.215	0.180								
12	GE-77	0.153	0.011	0.210	0.625	0.265	0.563	0.368	0.170	0.416	0.272	0.563	0.152
		0.632	0.113	0.709	0.101	0.800	0.014	0.920	0.064	1.080	0.078	1.190	0.014
		1.370	0.071	1.500	0.021	1.740	0.005	1.960	0.002	2.020	0.045	2.320	0.007
13	AS-77	0.246	0.028	0.524	0.027								
14	GE-78	0.	0.										
15	AS-78M	0.500	1.000										
16	AS-78	0.080	0.012	0.270	0.020	0.345	0.012	0.615	0.420	0.695	0.155	0.830	0.079
		0.990	0.025	1.100	0.029	1.210	0.042	1.310	0.108	1.490	0.021	1.700	0.017
		1.820	0.014	1.940	0.015	2.050	0.010	2.240	0.010	2.650	0.014		
17	AS-79	1.100	1.000										
18	SE-79M	0.096	1.000										
19	SE-79	0.	0.										
20	AS-80	3.250	1.000										
21	AS-81	1.900	1.000										
22	SE-81M	0.103	1.000										
23	SE-81	0.	0.										
24	AS-82	3.700	1.000										
25	SE-83M	0.350	0.100	0.650	0.100	1.010	0.050	2.020	0.050				
26	SE-83	0.650	0.500	1.010	0.500								
27	BR-83	0.046	0.200										
28	KR-83M	0.009	1.000	0.041	1.000								
29	SE-84	0.950	1.000										
30	BR-84	0.270	0.005	0.350	0.010	0.430	0.021	0.470	0.009	0.520	0.024	0.610	0.023
		0.740	0.029	0.810	0.003	0.880	0.417	1.010	0.038	1.210	0.032	1.470	0.017
		1.510	0.010	1.740	0.020	1.900	0.150	2.050	0.016	2.170	0.016	3.030	0.030
		3.280	0.024	3.930	0.104								
31	AS-85	4.000	1.000										
32	SE-85	2.500	1.000										
33	BR-85	0.	0.										

TABLE C-1 (Cont'd)

34	KR-85M	0.150	0.810	0.305	0.190						
35	KR-85	0.514	0.010								
36	SE-86	2.000	1.000								
37	BR-86	4.000	1.000								
38	KR-90	0.	0.								
39	KB-90	3.290	1.000								
40	SR-90	0.	0.								
41	Y-90	0.	0.								
42	BR-87	4.500	1.000								
43	KR-89	0.	0.								
44	RB-89	0.663	0.150	1.050	0.750	1.260	0.530	1.550	0.040	2.200	0.140
		2.750	0.030	3.520	0.020					2.590	0.130
45	SR-83	0.	0.								
46	Y-89M	0.910	1.000								
47	BR-38	4.350	1.000								
48	KR-88	0.028	0.070	0.166	0.070	0.191	0.350	0.360	0.050	0.845	0.230
		1.550	0.140	1.850	0.150	2.190	0.180	2.400	0.350	1.190	0.040
49	KB-89	0.899	0.145	1.390	0.014	2.110	0.010	2.680	0.025	2.760	0.145
50	SE-87	4.000	1.000								
51	BR-87	3.000	0.140	5.400	0.560						
52	KR-87	0.403	0.870	0.847	0.130	2.050	0.030	2.570	0.220		
53	KB-87	0.	0.								
54	KR-31	1.800	1.000								
55	RB-91M	0.	0.								
56	KB-31	0.	0.								
57	SR-31	0.645	0.140	0.748	0.230	0.930	0.030	1.025	0.300	1.413	0.070
58	Y-31M	0.551	1.000								
59	Y-91	1.208	0.003								
60	KR-32	3.000	1.000								
61	KB-32	3.250	1.000								
62	SR-32	0.230	0.035	0.440	0.041	1.370	0.900				
63	Y-92	1.840	0.030	2.400	0.090						
64	SR-93	2.000	1.000								
65	Y-33	0.267	0.066	0.490	0.	0.665	0.007	0.935	0.023	1.150	0.002
		1.900	0.016	2.410	0.	2.180	0.003			1.420	0.007
66	ZR-93	0.029	0.250								
67	NB-93M	0.029	1.000								
68	SR-94	1.700	1.000								
69	Y-94	0.560	0.060	0.920	0.430	1.130	0.050				
70	SR-95	2.250	1.000								
71	Y-35	2.350	1.000								
72	ZR-35	0.235	0.020	0.720	0.550	0.760	0.430				
73	NB-95M	0.235	1.000								
74	NB-95	0.762	0.090								
75	Y-36	0.	0.								
76	SR-37	3.500	1.000								
77	Y-97	2.750	1.000								
78	ZR-97	1.020	0.010	1.150	0.020						
79	NB-37M	0.750	1.000								

TABLE C-1 (Cont'd)

30	NB-97	0.665	0.990	1.070	0.010							
81	ZR-98	2.250	1.000									
82	NB-98M	0.720	0.750	0.780	1.000	1.160	0.300	1.680	0.100	1.880	0.040	
83	NB-98	2.100	1.000									
84	ZR-99	1.800	1.000									
85	NB-99	1.600	1.000									
86	MO-99	0.372	0.010	0.740	0.100	0.780	0.040					
87	TC-99M	0.002	0.986	0.140	0.986	0.142	0.014					
88	TC-99	0.	0.									
89	NB-100	3.450	1.000									
90	NB-101	1.250	1.000									
91	MO-101	0.080	0.030	0.191	0.270	0.300	0.070	0.400	0.020	0.510	0.160	0.590 0.210
		0.700	0.120	0.840	0.010	0.890	0.150	0.950	0.020	1.024	0.250	1.140 0.010
		1.180	0.110	1.280	0.030	1.380	0.090	1.460	0.010	1.560	0.110	1.660 0.030
		2.080	0.160									
92	TC-101	0.307	0.900	0.543	0.080							
93	MO-102	0.	0.									
94	TC102M	2.100	1.000									
95	TC-102	2.050	1.000									
96	TC-103	1.250	1.000									
97	RU-103	0.323	0.030	0.498	0.890	0.610	0.070					
98	RH103M	0.040	1.000									
99	MO-104	0.	0.									
100	TC-104	2.600	1.000									
101	MO-105	2.750	1.000									
102	TC-105	1.700	1.000									
103	RU-105	0.263	0.050	0.318	0.106	0.400	0.056	0.475	0.160	0.485	0.050	0.670 0.150
		0.726	0.480	0.874	0.043	0.966	0.030					
104	RH105M	0.129	1.000									
105	RH-105	0.319	0.100									
106	RU-106	0.	0.									
107	RH-106	0.513	0.205	0.612	0.010	0.624	0.092	1.045	0.015			
108	TC-107	3.000	1.000									
109	RU-107	0.195	0.170	0.860	0.080	1.030	0.040					
110	RH-107	0.305	0.840	0.390	0.130	0.680	0.030					
111	PD-107	0.	0.									
112	RU-108	0.165	0.280									
113	RH-108	0.433	0.430	0.617	0.220							
114	RH109M	0.110	1.000									
115	RH-109	1.400	1.000									
116	PD109M	0.180	1.000									
117	PD-109	0.	0.									
118	AG109M	0.088	1.000									
119	RH-110	0.	0.									
120	PD111M	0.170	0.680	1.690	0.320							
121	PD-111	0.	0.									
122	AG111M	0.065	1.000									
123	AG-111	0.095	0.001	0.247	0.012	0.342	0.061					

TABLE C-1 (Cont'd)

TABLE C-1 (Cont'd)

		0.652	0.007	0.668	0.016								
169	TE125M	0.035	1.000	0.110	1.000								
170	SN-126	0.	0.										
171	SB125M	0.100	0.390										
172	SB-126	0.415	1.000	0.665	1.000	0.695	1.000						
173	SN-127	1.600	1.000										
174	SB-127	0.000	0.040	0.250	0.140	0.310	0.060	0.460	0.540	0.770	0.240		
175	TE127M	0.059	0.015	0.089	0.985	0.665	0.000						
176	TE-127	0.059	0.001	0.360	0.001	0.418	0.008						
177	SN-128	0.	0.										
178	SB128M	0.	0.										
179	SB-128	1.450	1.000										
180	SN-129	2.000	1.000										
181	SB-129	0.534	0.270	0.165	0.267	0.308	0.267	0.788	0.267				
182	TE129M	0.106	1.000										
183	TE-129	0.027	0.800	0.211	0.015	0.475	0.160	0.720	0.015	1.120	0.010		
184	I -129	0.040	1.000										
185	SN-130	1.000	1.000										
186	SB-130	2.500	1.000										
187	I -130	0.410	0.240	0.530	1.000	0.660	1.000	0.740	0.700	1.150	0.300		
188	SN-131	2.500	1.000										
189	SB-131	1.600	1.000										
190	TE131M	0.080	0.040	0.100	0.080	0.200	0.080	0.240	0.030	0.335	0.160	0.780	0.800
		0.840	0.400	0.920	0.050	1.080	0.050	1.140	0.250	1.220	0.170	1.620	0.030
		1.920	0.020	2.000	0.040	2.240	0.150						
191	TE-131	0.145	0.300	0.454	0.200	0.600	0.050	0.920	0.050	0.985	0.010	1.130	0.100
192	I -131	0.284	0.055	0.364	0.810	0.638	0.091	0.724	0.028				
193	XE131M	0.164	1.000										
194	SN-132	1.500	1.000										
195	SB-132	3.000	1.000										
196	TE-132	0.052	1.000	0.233	1.000								
197	I -132	0.240	0.013	0.460	0.022	0.520	0.190	0.620	0.052	0.647	0.090	0.650	0.260
		0.673	0.390	0.720	0.065	0.775	0.820	0.950	0.190	1.140	0.045	1.400	0.083
		1.450	0.014	1.500	0.013								
198	SB-133	2.000	1.000										
199	TE133M	0.334	0.130	0.432	0.700	0.754	1.000	0.910	0.700				
200	TE-133	0.	0.										
201	I -133	0.530	1.000	0.870	0.070	1.300	0.040						
202	XF133M	0.233	1.000										
203	XC-133	0.079	0.078	0.081	1.000								
204	SB-134	4.300	1.000										
205	TE-134	0.	0.										
206	I -134	0.140	0.030	0.390	0.070	0.410	0.005	0.430	0.030	0.510	0.010	0.540	0.080
		0.610	0.180	0.630	0.070	0.750	0.010	0.770	0.060	0.848	0.950	0.860	0.045
		0.870	0.705	0.960	0.020	1.000	0.045	1.070	0.180	1.150	0.095	1.460	0.035
		1.430	0.010	1.620	0.050	1.790	0.050						
207	SB-135	3.500	1.000										

TABLE C-1 (Cont'd)

208	TE-135	3.000	1.000									
209	I -135	0.420	0.200	1.280	1.000	1.690	0.460					
210	XE-135M	0.530	1.000									
211	XE-135	0.250	0.970	0.360	0.010	0.604	0.030					
212	CS-135	0.	0.									
213	I -136	0.200	0.120	0.390	0.190	0.460	0.010	0.710	0.030	1.000	0.060	1.320 0.950
		1.550	0.040	1.720	0.020	1.910	0.050	2.250	0.070	2.400	0.130	2.630 0.110
		2.840	0.080	3.200	0.050							
214	CS-136	0.152	0.190	0.270	0.220	0.337	0.590	0.830	1.000	1.065	0.840	1.255 0.210
215	I -139	3.500	1.000									
216	XE-139	0.	0.									
217	CS-139	0.630	0.040	1.280	0.160							
218	BA-139	0.166	0.280	1.430	0.003							
219	I -138	3.900	1.000									
220	XE-138	0.420	1.000									
221	CS-138	0.139	0.020	0.193	0.008	0.229	0.016	0.411	0.030	0.463	0.230	0.550 0.080
		0.870	0.040	1.010	0.250	1.426	0.730	2.210	0.180	2.630	0.090	3.340 0.005
222	I -137	2.750	1.000									
223	XE-137	0.	0.									
224	CS-137	0.	0.									
225	BA-137M	0.662	1.000									
226	XE-140	2.000	1.000									
227	CS-140	3.000	1.000									
228	BA-140	0.030	1.000	0.160	0.100	0.300	0.100	0.540	0.300			
229	LA-140	1.576	0.070	2.080	0.100	2.410	0.450	2.650	0.260	2.920	0.120	
230	BA-141	1.400	1.000									
231	LA-141	1.370	0.020									
232	CE-141	0.145	0.700									
233	CS-142	4.300	1.000									
234	BA-142	1.150	1.000									
235	LA-142	0.640	0.550	0.900	0.120	2.400	0.110					
236	BA-143	1.750	1.000									
237	LA-143	1.650	1.000									
238	CE-143	0.057	1.050	0.294	0.430	0.351	0.080	0.565	0.110	0.668	0.100	0.722 0.090
		0.861	0.010	1.100	0.090							
239	PR-143	0.	0.									
240	LA-144	2.850	1.000									
241	CE-144	0.034	0.100	0.054	0.100	0.081	0.100	0.100	0.100	0.134	0.100	
242	PR-144	0.690	0.013	1.490	0.003	2.180	0.008					
243	CE-145	1.000	1.000									
244	PR-145	0.	0.									
245	CE-146	0.110	0.570	0.142	0.070	0.220	0.360	0.270	0.240	0.320	0.120	
246	PR-146	0.460	1.000	0.750	0.220	1.490	0.330					
247	CE-147	0.	0.									
248	PR-147	0.	0.									
249	ND-147	0.091	0.170	0.532	0.200	0.668	0.030					
250	PM-147	0.	0.									
251	PR-148	2.500	1.000									

TABLE C-1 (Cont'd)

252	ND-149	0.096 0.040	0.112 0.110	0.114 0.430	0.124 0.060	0.188 0.030	0.198 0.025
		0.210 0.410	0.226 0.030	0.266 0.100	0.240 0.310	0.424 0.050	0.538 0.050
253	PM-149	0.286 0.030					
254	PR-150	0. 0.					
255	PM-150	0.340 0.200	0.400 0.200	0.820 0.200	1.170 0.800		
256	ND-151	0. 0.					
257	PM-151	0.715 1.000					
258	SM-151	0.027 0.010					
259	ND-152	0. 0.					
260	PM-152	2.300 1.000					
261	PM-153	0. 0.					
262	SM-153	0.070 0.350	0.103 0.780	0.538 0.100			
263	PM-154	1.250 1.000					
264	SM-155	0.105 0.230	0.246 0.070				
265	EU-155	0.060 0.100	0.105 0.150	0.270 0.200	0.450 0.150	0.870 0.200	
266	SM-156	0. 0.					
267	EU-156	2.000 0.600					
268	EU-157	0.200 1.000	0.600 1.000				
269	EU-158	1.300 1.000					
270	GD-159	0.058 0.066	0.079 0.006	0.225 0.006	0.362 0.190		
271	CU-160	0. 0.					
272	TR-160	0.087 0.100	0.196 0.040	0.216 0.040	0.298 0.300	0.400 0.030	0.876 0.330
		0.904 0.350	1.180 0.160				
273	GD-161	0.057 0.719	0.078 0.085	0.102 0.236	0.106 0.012	0.134 0.013	0.165 0.004
		0.151 0.025	0.259 0.018	0.273 0.012	0.284 0.073	0.315 0.210	0.361 0.600
		0.432 0.002	0.531 0.016				
274	TR-161	0. 0.					

TABLE C-1 (Cont'd)

BETA SPECTRA

NUCLIDE NO.	SYMBOL	(MEV) FRACT.	(MEV) FRACT.	(MEV) FRACT.	(MEV) FRACT.	(MEV) FRACT.	(MEV) FRACT.
2	Zn-72	0.300 0.000	1.600 0.050				
3	Ga-72	0.660 0.170 3.166 0.050	0.680 0.240	0.959 0.350	1.508 0.070	1.940 0.070	2.529 0.050
4	Zn-73	2.500 1.000					
5	Ga-73	0.400 0.070	1.100 0.110	1.430 0.020			
6	Ge-73M	0. 0.					
7	As-74	1.100 0.110	1.840 0.040	2.000 0.030	2.270 0.100	2.650 0.690	4.300 0.030
8	Ge-75M	0. 0.					
9	Ge-75	0.550 0.004	0.720 0.003	0.920 0.114	0.980 0.014	1.190 0.665	
10	Ga-76	0. 0.					
11	Ge-77M	2.700 0.100	2.900 0.460				
12	Ge-77	0.300 0.030 2.270 0.140	0.760 0.150	1.200 0.110	1.300 0.040	1.560 0.240	2.120 0.290
13	As-77	0.160 0.028	0.435 0.028	0.604 0.944			
14	Ge-78	0.000 1.000					
15	As-78M	0. 0.					
16	As-78	1.420 0.022 4.270 0.470	1.490 0.021	1.600 0.140	1.860 0.062	2.960 0.097	3.650 0.190
17	As-79	1.100 1.000					
18	Se-79M	0. 0.					
19	Se-79	0.100 1.000					
20	As-80	3.250 1.000					
21	As-81	1.000 1.000					
22	Sr-81M	0. 0.					
23	Se-81	1.300 1.000					
24	As-82	3.700 1.000					
25	Sr-83M	1.500 0.100	3.400 0.000				
26	Sr-83	1.500 1.000					
27	Rb-83	0.010 0.200	0.960 0.600				
28	Kr-83M	0. 0.					
29	Se-84	0.000 1.000					
30	Rb-84	0.000 0.030 3.830 0.140	0.770 0.190 4.680 0.320	0.900 0.020	1.390 0.140	1.810 0.015	2.800 0.150
31	As-85	4.000 1.000					
32	Sr-85	2.500 1.000					
33	Rb-85	2.500 1.000					
34	Kr-85M	0.324 0.510					
35	Kr-85	0.100 0.010	0.672 0.990				
36	Sr-86	2.000 1.000					
37	Rb-86	4.000 1.000					
38	Kr-86	3.200 1.000					
39	Rb-86	3.200 1.000					
40	Sr-86	0.544 1.000					
41	Y-86	2.270 1.000					

TABLE C-1 (Cont'd)

42	BR-39	4.500	1.000								
43	KR-39	2.000	0.350	3.900	0.650						
44	RB-39	0.400	0.020	0.670	0.240	1.170	0.030	1.330	0.020	1.610	0.530
		3.720	0.070							2.870	0.050
45	SR-39	1.463	1.000								
46	Y-39M	0.	0.								
47	BR-38	4.850	1.000								
48	KR-38	0.520	0.700	0.900	0.100	2.700	0.200				
49	Y-38	2.500	0.140	3.400	0.040	5.200	0.760				
50	SF-37	4.000	1.000								
51	BR-37	2.600	0.700	8.000	0.300						
52	KR-37	1.250	0.250	3.300	0.100	3.800	0.650				
53	RB-37	0.273	1.000								
54	KR-31	1.800	1.000								
55	RB-91M	3.000	1.000								
56	RB-31	4.600	1.000								
57	SR-91	0.610	0.070	1.070	0.330	1.360	0.290	2.030	0.040	2.670	0.270
58	Y-91M	0.	0.								
59	Y-91	1.540	1.000	0.330	0.003						
60	KR-92	3.000	1.000								
61	RB-92	3.250	1.000								
62	SR-92	0.545	0.900	1.500	0.100						
63	Y-92	1.260	0.090	1.750	0.030	3.600	0.880				
64	SR-93	2.000	1.000								
65	Y-93	0.450	0.002	0.710	0.018	1.470	0.009	1.950	0.030	2.620	0.039
										2.890	0.900
66	ZR-93	0.034	0.250	0.063	0.750						
67	NB-93M	0.	0.								
68	SR-94	1.700	1.000								
69	Y-94	5.000	0.400								
70	SR-95	2.250	1.000								
71	Y-95	2.350	1.000								
72	ZR-95	0.360	0.430	0.396	0.550	0.885	0.020	1.130	0.004		
73	NB-95M	0.	0.								
74	NB-95	0.160	0.990	0.930	0.010						
75	Y-96	0.	0.								
76	SR-97	3.500	1.000								
77	Y-97	2.750	1.000								
78	ZR-97	0.450	0.100	1.910	0.900						
79	NB-97M	0.	0.								
80	NB-97	0.930	0.010	1.267	0.990						
81	ZR-98	2.250	1.000								
82	NB-98M	3.100	0.410								
83	NB-98	2.100	1.000								
84	ZR-99	1.800	1.000								
85	NB-99	1.600	1.000								
86	MO-99	0.450	0.140	0.870	0.010	1.230	0.850				
87	TC-99M	0.	0.								

TABLE C-1 (Cont'd)

88	TC-99	0.292	1.000									
89	NB-100	3.450	1.000									
90	NB-101	1.250	1.000									
91	MO-101	0.600	0.030	0.700	0.380	0.800	0.130	1.200	0.110	1.600	0.250	2.230 0.100
92	TC-101	1.070	0.080	1.320	0.900							
93	MO-102	1.200	1.000									
94	TC102M	2.000	1.000									
95	TC-102	2.050	1.000									
96	TC-103	1.250	1.000									
97	RU-103	0.100	0.070	0.212	0.890	0.390	0.010	0.710	0.030			
98	RH103M	0.	0.									
99	MO-104	0.	0.									
100	TC-104	2.400	1.000									
101	MO-105	2.750	1.000									
102	TC-105	1.700	1.000									
103	RU-105	0.526	0.040	0.915	0.080	1.080	0.300	1.145	0.480	1.870	0.100	
104	RH105M	0.	0.									
105	RH-105	0.250	0.100	0.565	0.900							
106	RU-106	0.039	1.000									
107	RH-106	2.000	0.020	2.400	0.110	3.000	0.080	2.540	0.780			
108	TC-107	3.000	1.000									
109	RU-107	3.000	0.120	3.800	0.090	4.000	0.790					
110	RH-107	0.900	0.030	1.100	0.130	1.200	0.840					
111	PD-107	0.035	1.000									
112	RU-108	1.150	0.280	1.320	0.720							
113	RH-108	3.500	0.220	4.100	0.170	4.500	0.510					
114	RH109M	0.	0.									
115	RH-109	1.400	1.000									
116	PD109M	0.	0.									
117	PD-109	1.025	1.000									
118	AG109M	0.	0.									
119	RH-110	0.	0.									
120	PD111M	0.610	0.320									
121	PD-111	2.130	1.000									
122	AG111M	0.	0.									
123	AG-111	0.690	0.062	0.790	0.011	1.050	0.927					
124	PD-112	0.230	1.000									
125	AG-112	1.220	0.026	1.340	0.036	1.500	0.018	1.610	0.020	1.780	0.044	2.010 0.053
		2.200	0.006	2.570	0.016	2.630	0.009	2.730	0.028	3.420	0.180	4.040 0.560
126	PD-113	1.650	1.000									
127	AG113M	2.000	0.100									
128	AG-113	2.000	1.000									
129	PD-114	1.400	1.000									
130	AG-114	2.300	1.000									
131	PD-115	2.250	1.000									
132	AG115M	2.900	0.280									
133	AG-115	2.700	0.020	2.900	0.910							
134	CD115M	2.335	0.010	0.687	0.029	1.630	0.970					

TABLE C-1 (Cont'd)

135	CD-115	0.500	0.244	0.630	0.126	0.850	0.009	1.110	0.621
136	IN115M	0.840	0.055						
137	IN-115	0.500	1.000						
138	AG-116	5.000	1.000						
139	AG-117	1.000	1.000						
140	CD117M	1.000	1.000						
141	CD-117	2.300	1.000						
142	IN117M	0.950	0.040	1.620	0.230	1.770	0.530		
143	IN-117	0.740	1.000						
144	SN117M	0.	0.						
145	CD-118	0.300	1.000						
146	IN-118	3.300	0.200	4.500	0.800				
147	CD119M	1.300	0.200	3.500	0.800				
148	CD-119	1.850	1.000						
149	IN119M	1.800	0.060	2.700	0.900				
150	IN-119	1.600	1.300						
151	IN-120	2.200	1.000						
152	CD-121	2.400	1.000						
153	IN121M	1.850	1.000						
154	IN-121	2.900	1.000						
155	SN121M	0.420	1.000						
156	SN-121	0.383	1.000						
157	IN-122	3.000	1.000						
158	IN123M	2.300	1.000						
159	IN-123	3.300	1.000						
160	SN123M	0.340	0.020	1.420	0.930				
161	SN-123	1.250	1.000						
162	IN-124	0.	0.						
163	SB24M1	2.500	1.000						
164	SB24M2	3.200	1.000						
165	SB-124	0.051	0.020	0.225	0.110	0.621	0.510	0.954	0.050
		2.313	0.230					1.016	0.015
166	SB-125	0.650	0.022	2.040	0.078				
167	SN-125	0.370	0.021	0.470	0.015	1.300	0.013	2.330	0.050
168	SB-125	0.000	0.019	0.105	0.007	0.118	0.060	0.124	0.307
		0.437	0.058	0.612	0.134			0.233	0.010
								0.295	0.404
169	TE125M	0.	0.						
170	SN-126	0.400	1.000						
171	SB125M	3.700	0.010						
172	SN-126	1.000	1.000						
173	SN-127	1.600	1.000						
174	SP-127	0.800	0.350	0.860	0.100	1.110	0.350	1.500	0.200
175	TE127M	0.730	0.015						
176	TE-127	0.270	0.010	0.695	0.100				
177	SN-128	1.300	1.000						
178	SB128M	1.000	1.000						
179	SB-128	1.450	1.000						
180	SN-129	2.000	1.000						

TABLE C-1 (Cont'd)

181	SB-129	1.370	0.200	1.000	0.300				
182	TE129M	0.	0.						
183	TE-129	0.300	0.010	0.700	0.030	0.990	0.100	1.453	0.000
184	I -129	0.150	1.000						
185	SN-130	1.000	1.000						
186	SB-130	2.500	1.000						
187	I -130	0.600	0.470	1.020	0.510				
188	SN-131	2.500	1.000						
189	SB-131	1.600	1.000						
190	TE131M	0.215	0.030	0.420	0.430	0.570	0.310	2.457	0.038
191	TE-131	1.150	0.100	1.360	0.050	1.680	0.250	2.140	0.000
192	I -131	0.250	0.028	0.330	0.091	0.666	0.875	0.810	0.007
193	XE131M	0.	0.						
194	SN-132	1.500	1.000						
195	SB-132	3.000	1.000						
196	TE-132	0.220	1.000						
197	I -132	0.800	0.210	1.040	0.150	1.220	0.120	1.400	0.120
								1.610	0.210
								2.140	0.180
198	SB-133	2.000	1.000						
199	TE133M	1.300	0.700	2.400	0.170				
200	TE-133	2.400	1.000						
201	I -133	0.650	0.030	1.300	0.110				
202	XE133M	0.	0.						
203	XC-133	0.268	0.010	0.347	0.990				
204	SB-134	4.300	1.000						
205	TE-134	1.400	1.000						
206	I -134	0.500	0.065	1.050	0.010	1.250	0.230	1.490	0.150
		2.210	0.120	2.410	0.250			1.680	0.075
								1.810	0.095
207	SB-135	3.500	1.000						
208	TE-135	3.000	1.000						
209	I -135	0.470	0.350	1.000	0.400	1.400	0.250		
210	XE135M	0.	0.						
211	XE-135	0.550	0.030	0.910	0.970				
212	CS-135	0.210	1.000						
213	I -136	2.730	0.060	4.160	0.050	4.370	0.240	5.600	0.150
								7.000	0.060
								3.500	0.440
214	CS-136	0.341	0.026	0.657	0.074				
215	I -139	3.500	1.000						
216	XE-139	4.600	1.000						
217	CS-139	2.700	0.160	3.400	0.040	4.000	0.800		
218	BA-139	2.170	0.280	2.340	0.720				
219	I -138	3.900	1.000						
220	XE-138	2.400	1.000						
221	CS-138	1.490	0.005	2.200	0.100	2.390	0.360	2.530	0.050
		3.400	0.210					2.620	0.160
								2.940	0.120
222	I -137	2.750	1.000						
223	XE-137	3.500	1.000						
224	CS-137	0.514	0.750	1.180	0.050				
225	BA137M	0.	0.						

TABLE C-1 (Cont'd)

226	XE-140	2.000	1.000								
227	CS-140	3.000	1.000								
228	BA-140	0.500	0.250	0.600	0.100	0.900	0.050	1.000	0.600		
229	LA-140	0.830	0.120	1.100	0.260	1.380	0.450	1.710	0.100	2.200	0.070
230	BA-141	1.400	1.000								
231	LA-141	1.060	0.020	2.430	0.980						
232	CE-141	0.435	0.700	0.580	0.300						
233	CS-142	4.300	1.000								
234	BA-142	1.150	1.000								
235	LA-142	4.500	1.000								
236	BA-143	1.750	1.000								
237	LA-143	1.650	1.000								
238	CE-143	0.220	0.060	0.520	0.120	0.720	0.050	1.090	0.400	1.380	0.370
239	PR-143	0.933	1.000								
240	LA-144	2.850	1.000								
241	CE-144	0.186	0.200	0.240	0.080	0.320	0.720				
242	PR-144	0.800	0.010	2.290	0.013	2.980	0.977				
243	CE-145	1.000	1.000								
244	PR-145	1.800	1.000								
245	CE-146	0.700	1.000								
246	PR-146	2.300	0.440	3.700	0.560						
247	CE-147	0.	0.								
248	PR-147	0.	0.								
249	ND-147	0.212	0.030	0.368	0.200	0.810	0.770				
250	PM-147	0.225	1.000								
251	PR-148	2.500	1.000								
252	ND-149	0.950	0.150	1.100	0.430	1.500	0.310				
253	PM-149	0.784	0.030	1.071	0.970						
254	PR-150	0.	0.								
255	PM-150	2.000	0.800	3.000	0.200						
256	ND-151	0.240	0.010	0.540	0.030	1.190	0.300	1.650	0.070	1.820	0.150
										2.060	0.450
257	PM-151	1.100	1.000								
258	SM-151	0.053	0.010	0.075	0.990						
259	ND-152	0.	0.								
260	PM-152	2.200	1.000								
261	PM-153	0.	0.								
262	SM-153	0.640	0.380	0.698	0.400	0.803	0.220				
263	PM-154	1.250	1.000								
264	SM-155	1.500	0.070	1.650	0.930						
265	EU-155	0.150	0.300	0.160	0.400	0.190	0.100	0.250	0.200		
266	SM-156	0.900	1.000								
267	EU-156	0.500	0.600	2.400	0.400						
268	EU-157	1.000	0.750	1.700	0.250						
269	EU-158	1.300	1.000								
270	GD-159	0.590	0.200	0.890	0.060	0.948	0.740				
271	EU-160	0.	0.								
272	FB-160	0.300	0.120	0.460	0.190	0.560	0.380	0.760	0.110	0.860	0.200
										1.710	0.004

APPENDIX D

DESCRIPTION OF SUBROUTINE AA ICE 3 - INTEGRATION WITH CONTROLLED ERROR

Purpose

This is a Fortran II Call function to provide the numerical solution of an Nth order system of linear and/or non-linear differential equations expressed as a system of N first order equations:

$$\dot{Y}_n = f_n(t, Y_1, Y_2, \dots, Y_N); Y_n(t_o) = Y_{n,o}; n = 1, 2, 3, \dots, N$$

where Y_n are the N dependent variables and t is the independent variable. The local error generated by the numerical process is controlled by adjusting the integration step size based on the relative error as estimated by extrapolation to zero grid size.

Restrictions

ICE is a general routine rather than a subroutine in that it contains all the logical control needed to solve a large class of problems. It is usual for all additional coding to be incorporated into the ICE routine during assembly. The programmer may exit at any time from the ICE controlled subroutines (BØXES A, B, C, D), perform a series of operations and re-enter ICE at the initialization point to continue the problem. However, if exit has been made from the derivative evaluation subroutine (BØX A), the independent variable t should be separately controlled, since t may have been stepped ahead in the computational flow from λ_r (Figure D-1).

Method

The basic method of the ICE routine can be summarized by the following steps:

- (1) Use the initial conditions for the N dependent variables as solutions at $t = 0$ and adopt the maximum step size permissible.
- (2) Perform the computation to obtain the single step solution for the new value of the independent variable, t .
- (3) Halve the integration step size.
- (4) Solve the problem again from the last convergent point using two applications of the reduced step size.
- (5) Compute an extrapolated solution making use of both solutions.
- (6) Compare the two step solution with the extrapolated solution.
- (7) If these two solutions are sufficiently close, the procedure is continued using the extrapolated solution as initial values at the updated time t .
- (8) If the two solutions are not sufficiently close then the reduced step size is again halved and the procedure restarted from step 4 using the conditions at the last convergent point.
- (9) If the two solutions agree too closely then the basic step is doubled and the procedure repeated beginning at step 1 using the extrapolated solution at the new value of the independent variable.

The above briefly describes the method, however additional details, including the complete flow chart of the method, are given in the following discussion.

The equations used for numerical integration are those usually designated "Modified-Euler" with a single iteration. The superscripts (1) and (2) refer to the first and second approximations respectively. The subscript $i+1$ refers to the solution at the new value of the independent variable, i referring to the old value. $h = t_{i+1} - t_i$ is the step size.

$$\dot{Y}_{n,i} = f_n(t_i; Y_{1,i}; Y_{2,i}; \dots; Y_{N,i}) \quad (D-1)$$

where t_o and N initial values for $Y_{n,o}$ must be given.

$$\bar{Y}_{n,i+1} = Y_{n,i} + \frac{h}{2} \dot{Y}_{n,i} \quad (D-2)$$

$$Y_{n,i+1} = Y_{n,i} + h \dot{Y}_{n,i} \quad (D-3)$$

Equation (2) is introduced in order to save both $Y_{n,i}$ and $\dot{Y}_{n,i}$ in the form required for the final approximation and is used in equation (4). A first approximation to the derivative at the new time point, t_{i+1} , is then computed by substituting the values from equation (3) into equation (1) obtaining:

$$\dot{Y}_{n,i+1}^{(1)} = f_n(t_{i+1}; Y_{1,i+1}^{(1)}; Y_{2,i+1}^{(1)}; \dots; Y_{N,i+1}^{(1)}) \quad (D-1)'$$

Final approximations for each of the N functions are computed as follows:

$$Y_{n,i+1}^{(2)} = \bar{Y}_{n,i+1} + \frac{h}{2} \dot{Y}_{n,i+1}^{(1)} \quad (D-4)$$

Again using (1), the values for the derivatives at t_{i+1} are obtained.

The procedure used to automatically control the error is as follows:

- (1) Integrate from t_i to t_{i+1} with $h = t_{i+1} - t_i$, to obtain a solution $Y_{n,i+1}^{(I)}$ and store the results. The superscript (I) denotes the results of a one-step integration, while a superscript (II) will denote the results of a two-step integration.
- (2) Integrate again from t_i to t_{i+1} , using 2 steps of $h/2$ each, to obtain results designated $Y_{n,i+1}^{(II)}$. At the same time store the intermediate results obtained at the midpoint $t_i + h/2$.
- (3) An error estimate for each of the N dependent variables using extrapolation to zero-step size is expressed as:

$$E_{n,i+1} = \frac{Y_{n,i+1}^{(II)} - Y_{n,i+1}^{(I)}}{3} \quad (D-5)$$

- (4) These values, $E_{n,i+1}$ are added to the II step results to obtain extrapolated solutions:

$$Y_{n,i+1} = Y_{n,i+1}^{(II)} + E_{n,i+1} \quad (D-6)$$

- (5) A relative error term is next defined and computed for each variable:

$$R_{n,i+1} = \left| \frac{E_{n,i+1}}{Y_{n,i+1}} \right| \quad (D-7)$$

- (6) The maximum relative error (R_n) max, is designated $N1$ and is tested against two bounds $E1$ and $E2$ to control the error. $E1$ is used to keep

the integration interval from remaining too small, and E2 is used to keep the interval from becoming too large. The program then halves the interval and repeats the step, continues at the same step or continues at twice the previous step.

References

AA ICE 3 SHARE distribution 411, N. Moraff, Westinghouse Air Arm (AA), October 20, 1959. The error control procedure as outlined above is essentially the same as that presented at the ACM Meeting, University of Houston, June 19, 1957 in the paper "Automatic Error Control in the Solution of Differential Equations" by W. B. Fritz and N. Moraff. A FORTRAN I version of ICE dated March 5, 1958 and a FORTRAN II version dated August 12, 1959 have also had limited distribution.

Usage

A. Calling Sequence

	Call ICE (P, T, TP, E1, E2, N, Y, $\dot{Y}$, 5N, J)
S_2	GØ TØ (BØXA, BØXB, BØXC, BØXD), J
S_1	J = XICEF (A)
	GØ TØ S_2

B. Definition of Arguments

- P - Maximum allowable step size
- T - Independent variable
- TP - Value of independent variable at which ICE will provide entry to BØXC
- E1 - Lower bound error for controlling step size
- E2 - Upper bound error for controlling step size
- N - Number of dependent variables expressed as a fixed point variable or constant
- Y - First dependent variable followed by the remaining N - 1 dependent variables (must be dimensioned)
- $\dot{Y}$ - Derivative of first dependent variable followed by the remaining N - 1 derivatives in the same order as the corresponding dependent variables (must be dimensioned)
- 5N - The first cell of 5N cells required by AA ICE for storage (must be dimensioned)
- J - A fixed point variable developed by AA ICE to exit to the proper section of the users main program
- A - Any variable
- BØXA - Statement number for derivative computations
- BØXB - Statement number for supplementary computations after valid integration step. Checks for end of case based on conditions of dependent variables should be done in BØXB
- BØXC - Statement number for print routine
- BØXD - Statement number for non-convergence

- C. Space Required: ICE to ICE +214 (215 cells) plus 3 COMMON.
- D. Error Return: Specified by the user in BOXD, non-convergence.
- E. The Derivative subroutine must be coded as follows:

BØXA	_____	Evaluate N derivatives

GØTØS ₁		

- F. The Print subroutine must be coded as follows:

BØXC	_____	Print

	TP = TP + P	
	GØTØS ₁	

If it is desired to accomplish the printing of results at every value of the independent variable for which valid results of the N dependent variables have been obtained, it is necessary that the programmer do the following:

- (1) Set $P = \pm 10^9$ The sign of p is dependent on the direction of integration.
- (2) Set $TP = \pm 10^9$ The sign of tp is dependent on the direction of integration.
- (3) Code BØXC BØXC GØ TØ S₁
- (4) Code print routine in BØXB.

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BØXB

Supplementary computations
as desired, which may include
printing at each valid point.
(See above)

Test for end of computation based on values of dependent and/or independent variables.

G Ø T Ø S,

H. It has been shown by experience that $E2 = 2^7 E1$ will in general give satisfactory results where E2 indicates the number of satisfactory significant binary digits desired. For example:

$$E1 = 2^{-21}$$

$$E2 = 2^{-14}$$

(1) Set $E1 = 0, E2 = 2$

(2) Set P = constant step size desired

(3) Code the desired print option in $B\emptyset XB$

(4) Code $B\emptyset XC$ $B\emptyset XB G\emptyset T\emptyset S_1$

J. Another option is available to the user. Since the error control is based on the assumption that a fixed number of significant digits are required in the integration, it is necessary to take certain precautions. When a solution for one of the variables approaches zero it may not be possible to achieve this accuracy within the limits of machine numbers ranging from 10^{-38} to 10^{+38} . ICE is, therefore, programmed to disregard the error control on an individual variable when this variable is equal to zero to at least six zeros to the right of the decimal point. The control number accomplishing this is stored in ICE +205 in the form 10^{-S+1} where S is equal to 4 in the standard program. Depending on the range of the variables in the problem, this fixed bound may be unreasonable and the user is instructed to replace the control number, 10^{-S+1} using a suitable value of S in the range from $S = -37$ to $S = +39$. For example, additional relative error for variables close to zero will be obtained by increasing S . In general, it should not be necessary for S to be modified. In the present program it is not possible to set individual controls for each dependent variable.

K. As may be noted on the flow chart, it is also possible to replace the simple modified-Euler integrating procedure with other single step procedures. In addition to programming a new procedure and incorporating it successfully into ICE, it should be noted that it is also necessary to modify the denominator of the error estimate in equation (5). This value is $2^k - 1$ where k is the order of the new integrating procedure.

FIGURE D-1
 FLOW CHART AAICE 3

FIGURE D-1 (Cont'd)

APPENDIX E
FORTRAN LISTINGS

This appendix includes listings of the subprograms used in the Source Term Computer Program. In addition, the listing of a non-subprogram, T9S - SCRIB, is given. This program is for use in retrieving data from tape 9 at a later date following execution of a given job. The listings of the main programs of Link 1 and Link 2 are given as Table 3-2 and 3-3 respectively in the body of the report.

Listings of three subroutines are not included here. These are:

1. ICE This is used as a library program at WANL. The program is available as standard SHARE distribution 411. Description of this function is given in Appendix D.
2. EPMDE (5) This program meaning Error Print Mode, is a subroutine developed at Westinghouse and is used to control print out of error messages. EPMDE (5) suppresses print out of the error message when UNDERFLOW occurs. If desired the program card calling this subroutine can be omitted, or the users of this program may substitute their own error printing subprograms.
3. RTIME - a subprogram developed by Westinghouse and stored on WANL's computer library tape. This function reads the clock time in hours, minutes, seconds, and fractions of seconds. It is used for checking computer running time in subroutines D4 and F1. Users of this program should substitute their own clock routine.

TABLE E-1

FORTRAN LISTING - SUBROUTINE VECTOR

VECTOR SUBROUTINE

SUBROUTINE VECTOR (ALT,ORIVEL,DSTVEL,ZETA,EPS,PHI,PSI,VR,PER,	VEC	2
1 APO,ECC,PD)	VEC	3
C	VEC	4
C**** SUBROUTINE VECTOR CALCULATES RESULTANT VELOCITY AND RESULTANT	VEC	5
C**** RE-ENTRY ANGLE (PSI) OF PARTICLE FOLLOWING DESTRUCT ACTION.	VEC	6
C	VEC	7
C ALT = ALTITUDE - FT	VEC	8
C ORIVEL= ORIGINAL VELOCITY FT/SEC	VEC	9
C DSTVEL= DESTRUCT VELOCITY FT/SEC	VEC	10
C ZETA = ANGLE ZETA -RADIANS	VEC	11
C EPS = ANGLE EPSILON -RADIANS	VEC	12
C PHI = ANGLE PHI -RADIANS	VEC	13
C PSI = ANGLE PSI -RADIANS	VEC	14
C VR = RESULTANT VELOCITY	VEC	15
C PER = PERIGEE	VEC	16
C ECC = ECCENTRICITY	VEC	17
C PD = PERIOD	VEC	18
ERAD = 2.0089-03AE7	VEC	19
GMU = 1.40775E16	VEC	20
RV = ALT - ERAD	VEC	21
SZETA = SIN(ZETA)	VEC	22
SPHI = SIN(PHI)	VEC	23
CZETA = COS(ZETA)	VEC	24
CPHI = COS(PHI)	VEC	25
CEP = COS(EPS)	VEC	26
TOP = DSTVEL * SZETA + ORIVEL * SPHI	VEC	27
BOT = ((DSTVEL*CZETA)**2 + 2. * ORIVEL * DSTVEL * CZETA* CPHI * 1CEPS + (ORIVEL * CPHI)**2)	VEC	28
XBT = SQRTF(BOT)	VEC	29
PSI = ARCTN(TOP,XBT)	VEC	30
VRS = DSTVEL **2 + ORIVEL **2 + 2. * ORIVEL * DSTVEL * (CZETA * 1CPHI*CEPS + SZETA* SPHI)	VEC	31
VR = SQRTF(VRS)	VEC	32
CPSI = COSF(PSI)	VEC	33
A = GMU * RV / (GMU * 2.0 - RV * VRS)	VEC	34
ECCS = 1.0 - ((VRS*(RV*CPSI)**2)/(A*GMU))	VEC	35
ECC = SQRTF(ECCS)	VEC	36
APD = A * (1.0 + ECC) - ERAD	VEC	37
	VEC	38
	VEC	39

TABLE E-1 (Cont'd)

PER = A * (1.0 - ECC) - ERAD

PD = (6.28352 * A) * SQRTF (A/GMU)

RETURN

END

VEC 40

VEC 41

VEC 42

VEC 43

TABLE E-2
FORTRAN LISTING - FUNCTION CUT

CUT FUNCTION

C	FUNCTION CUT(ECC,PER)	CUT	2
C****	FUNCTION CUT DETERMINES FROM EMPIRICAL EXPRESSIONS THE	CUT	3
C****	APPROXIMATE ORBIT LIFETIME IN ORDER TO PROVIDE DECISION WHICH	CUT	4
C****	RE-ENTRY SUBROUTINE (D4 OR F1) WILL BE USED.	CUT	5
C		CUT	6
	PERP = PER / 1.0E6	CUT	7
	IF(PERP - .6)10,10,45	CUT	8
10	EXX = EXPF(8.03 * PERP)	CUT	9
	IF(ECC - .035)15,15,20	CUT	10
15	CUT = 5.57E2 * EXX	CUT	11
	GO TO 50	CUT	12
20	IF(ECC - .075)25,25,30	CUT	13
25	CUT = 2.05E3 * EXX	CUT	14
	GO TO 50	CUT	15
30	IF(ECC - .150)35,35,40	CUT	16
35	CUT = 5.57E3 * EXX	CUT	17
	GO TO 50	CUT	18
40	CUT = 1.64E4 * EXX	CUT	19
	GO TO 50	CUT	20
45	TZ = 1.3E5 * PERP ** 6.9	CUT	21
	CAY = 9.3E7 + 1.47E7 * EXPF(PERP * 3.525) - PER * 325.	CUT	22
	CUT = TZ + CAY * ECC **1.46	CUT	23
50	RETURN	CUT	24
	END	CUT	25
		CUT	26

TABLE E-3
FORTRAN LISTING - SUBROUTINE D4

D4 SUBROUTINE

SUBROUTINE D4		D4	2
C		D4	3
C****	SUBROUTINE D4 SOLVES PARTICLE TRAJECTORY EQUATIONS TO CALCULATE	D4	4
C****	RE-ENTRY TIME FOR PARTICLE TO REACH VELOCITY OF MACH 1.	D4	5
C		D4	6
	COMMON TIMIMP,XMASS,DIAIMP,KASE,TITLE,ISET2	D4	7
	COMMON YTBL,DTBL,RTBL,CPTBL,HGHTBL,PATBL,WYETBL,GNUTBL,DELTBL	D4	8
	1,HTBL,VTBL,RNTBL,CTBL,DLTBL,XPATBL,Q,QD,QN,RHOS,A,FRAD,PI2,GMU,GEED4	D4	9
	2,Y,LINT,ECC,ECSQ,DMR,ASQ,PER,APQ,RHCB,TMACH1	D4	10
	3,ITE,MODE,IND,F,FD,FN,Y,V,VSQ,PSIR,DRAG,CD,RSQ,AD,AS,DIAFT,DIA	D4	11
	4,RHOA,RHOS,EMM,DMDT,EMDOX,TEMP,DELTA,GNU,EMCFPE,ENKNUD,GMACH,T	D4	12
	5,TIN,IHANG,SEC1,TMAX	D4	13
	DIMENSION TIMIMP(200),XMASS(200),DIAIMP(200),TITLE(12)	D4	14
	DIMENSION YTBL(37),DTBL(37),RTBL(14),CPTBL(14),HGHTBL(59)	D4	15
	1,PATBL(59),WYETBL(20),GNUTBL(20),DELTBL(20),HTBL(31),VTBL(31)	D4	16
	2,RNTBL(30),CTBL(30),DLTBL(37),XPATBL(37),Q(2),QD(2),QN(10),F(6)	D4	17
	3,FD(6),FN(30)	D4	18
C	F-VALUES ARE DEPENDENT VARIABLES	D4	19
C	FD=DERIVATIVE OF DEPENDENT VARIABLES	D4	20
C	DT = MAXIMUM ALLOWABLE TIME STEP	D4	21
C	T = INDEPENDENT VARIABLE	D4	22
C	F(1) = ANGULAR DISPLACEMENT(RADIANS)	D4	23
C	F(2) = TRANSVERSE VELOCITY(FT/SEC)	D4	24
C	F(3) = RADIUS FROM EARTH CENTER (FEET)	D4	25
C	F(4) = RADIAL VELOCITY(FT/SEC)	D4	26
C	F(5) = TEMPERATURE (DEG. R.)	D4	27
C	F(6) = BODY RADIUS(FEET)	D4	28
C	FD(1)= ANGULAR DISPLACEMENT CHANGE	D4	29
C	FD(2)= TRANSVERSE ACCEL. (RADIANS / SQ. SEC.)	D4	30
C	FD(3)= CHANGE IN RADIUS FROM EARTH CENTER	D4	31
C	FD(4)= RADIAL ACCEL. (FT/SQ. SEC.)	D4	32
C	FD(5)= TEMPERATURE CHANGE	D4	33
C	FD(6)= RADIUS CHANGE	D4	34
C	IHANG = 1(NO ERROR), 2(NON-CON), 3(HANG-UP), 4(TIME LIMIT)	D4	35
	IHANG = 1	D4	36
	EMDOX = 0.	D4	37
	DMDT = 0.	D4	38
	FD(5) = 0.	D4	39

TABLE E-3 (Cont'd)

```

FD(6) = 0.
TP = 1000.
DT = 25.
E1 = .00001
E2 = .0015
F(1) = 0.
ICON = 0
VTAN = V * COSF(PSIR)
F(3) = Y + ERAD
F(2) = VTAN / F(3)
F(4) = -V * SINF(PSIR)
F(5) = TEMP
F(6) = DIAFT / 2.
T = 0.
TSTEP = 0.
YOLD = -3.1415926
NONCON = -2
10 LINT = 30
CALL VALUES
C ** VALUES PROVIDES MODE, CD, ENKNUD, GMACH, ITE, CHI, GNU, DELTA
C ** GMACH IS APPROXIMATE MACH NUMBER
15 FACT=RHOB*4.1887902
C ** RHOB IS PROJECTILE DENSITY (LB/FT**3) 4.1887902 = (PI*4/3)
C ICE ROUTINE HAS CONTROL OF PROGRAM UNTIL SUBSONIC FLOW IS OBTAINED
20 CALL ICE (DT,T,TP,E1,E2,6,F,FD,FN,ICER)
25 ICER=ICER
30 GO TO (45,215,270,300),ICER
35 ICER=XICEF(0)
40 GO TO 25
C ** BOXA -- CALCULATE DERIVATIVES FD(6)
45 Y = F(3) -- ERAD
50 RSQ=F(6)**2
55 AD=RSQ*3.1415926
60 AS=AD*4.
C ** AD= FRONTAL AREA AS = SURFACE AREA (FTSQ)
C ** RHOS = SLUG/FT**3 ** RHOA= LB/FT**3 ATMOSPHERE DENSITY
C ** CHECK FOR FLOW EXTRAPOLATION
75 IF (Y-ERAD) .GT. 0.80
80 LINT = LINT + 1
85 IF (LINT) .GT. 10
90 GO TO 10
95 IF (LINT) .GT. 10
100 GO TO 10
105 IF (LINT) .GT. 10
110 GO TO 10
115 IF (LINT) .GT. 10
120 GO TO 10
125 IF (LINT) .GT. 10
130 GO TO 10
135 IF (LINT) .GT. 10
140 GO TO 10
145 IF (LINT) .GT. 10
150 GO TO 10
155 IF (LINT) .GT. 10
160 GO TO 10
165 IF (LINT) .GT. 10
170 GO TO 10
175 IF (LINT) .GT. 10
180 GO TO 10
185 IF (LINT) .GT. 10
190 GO TO 10
195 IF (LINT) .GT. 10
200 GO TO 10
205 IF (LINT) .GT. 10
210 GO TO 10
215 IF (LINT) .GT. 10
220 GO TO 10
225 IF (LINT) .GT. 10
230 GO TO 10
235 IF (LINT) .GT. 10
240 GO TO 10
245 IF (LINT) .GT. 10
250 GO TO 10
255 IF (LINT) .GT. 10
260 GO TO 10
265 IF (LINT) .GT. 10
270 GO TO 10
275 IF (LINT) .GT. 10
280 GO TO 10
285 IF (LINT) .GT. 10
290 GO TO 10
295 IF (LINT) .GT. 10
300 GO TO 10
305 IF (LINT) .GT. 10
310 GO TO 10
315 IF (LINT) .GT. 10
320 GO TO 10
325 IF (LINT) .GT. 10
330 GO TO 10
335 IF (LINT) .GT. 10
340 GO TO 10
345 IF (LINT) .GT. 10
350 GO TO 10
355 IF (LINT) .GT. 10
360 GO TO 10
365 IF (LINT) .GT. 10
370 GO TO 10
375 IF (LINT) .GT. 10
380 GO TO 10
385 IF (LINT) .GT. 10
390 GO TO 10
395 IF (LINT) .GT. 10
400 GO TO 10
405 IF (LINT) .GT. 10
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415 IF (LINT) .GT. 10
420 GO TO 10
425 IF (LINT) .GT. 10
430 GO TO 10
435 IF (LINT) .GT. 10
440 GO TO 10
445 IF (LINT) .GT. 10
450 GO TO 10
455 IF (LINT) .GT. 10
460 GO TO 10
465 IF (LINT) .GT. 10
470 GO TO 10
475 IF (LINT) .GT. 10
480 GO TO 10
485 IF (LINT) .GT. 10
490 GO TO 10
495 IF (LINT) .GT. 10
500 GO TO 10
505 IF (LINT) .GT. 10
510 GO TO 10
515 IF (LINT) .GT. 10
520 GO TO 10
525 IF (LINT) .GT. 10
530 GO TO 10
535 IF (LINT) .GT. 10
540 GO TO 10
545 IF (LINT) .GT. 10
550 GO TO 10
555 IF (LINT) .GT. 10
560 GO TO 10
565 IF (LINT) .GT. 10
570 GO TO 10
575 IF (LINT) .GT. 10
580 GO TO 10
585 IF (LINT) .GT. 10
590 GO TO 10
595 IF (LINT) .GT. 10
600 GO TO 10
605 IF (LINT) .GT. 10
610 GO TO 10
615 IF (LINT) .GT. 10
620 GO TO 10
625 IF (LINT) .GT. 10
630 GO TO 10
635 IF (LINT) .GT. 10
640 GO TO 10
645 IF (LINT) .GT. 10
650 GO TO 10
655 IF (LINT) .GT. 10
660 GO TO 10
665 IF (LINT) .GT. 10
670 GO TO 10
675 IF (LINT) .GT. 10
680 GO TO 10
685 IF (LINT) .GT. 10
690 GO TO 10
695 IF (LINT) .GT. 10
700 GO TO 10
705 IF (LINT) .GT. 10
710 GO TO 10
715 IF (LINT) .GT. 10
720 GO TO 10
725 IF (LINT) .GT. 10
730 GO TO 10
735 IF (LINT) .GT. 10
740 GO TO 10
745 IF (LINT) .GT. 10
750 GO TO 10
755 IF (LINT) .GT. 10
760 GO TO 10
765 IF (LINT) .GT. 10
770 GO TO 10
775 IF (LINT) .GT. 10
780 GO TO 10
785 IF (LINT) .GT. 10
790 GO TO 10
795 IF (LINT) .GT. 10
800 GO TO 10
805 IF (LINT) .GT. 10
810 GO TO 10
815 IF (LINT) .GT. 10
820 GO TO 10
825 IF (LINT) .GT. 10
830 GO TO 10
835 IF (LINT) .GT. 10
840 GO TO 10
845 IF (LINT) .GT. 10
850 GO TO 10
855 IF (LINT) .GT. 10
860 GO TO 10
865 IF (LINT) .GT. 10
870 GO TO 10
875 IF (LINT) .GT. 10
880 GO TO 10
885 IF (LINT) .GT. 10
890 GO TO 10
895 IF (LINT) .GT. 10
900 GO TO 10
905 IF (LINT) .GT. 10
910 GO TO 10
915 IF (LINT) .GT. 10
920 GO TO 10
925 IF (LINT) .GT. 10
930 GO TO 10
935 IF (LINT) .GT. 10
940 GO TO 10
945 IF (LINT) .GT. 10
950 GO TO 10
955 IF (LINT) .GT. 10
960 GO TO 10
965 IF (LINT) .GT. 10
970 GO TO 10
975 IF (LINT) .GT. 10
980 GO TO 10
985 IF (LINT) .GT. 10
990 GO TO 10
995 IF (LINT) .GT. 10
1000 GO TO 10

```

D4	40
D4	41
D4	42
D4	43
D4	44
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D4	46
D4	47
D4	48
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D4	77
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D4	79
D4	80

TABLE E-3 (Cont'd)

80 IF (Y-YTBL(37))95,85,85	D4	81
85 LINT = 37	D4	82
90 GO TO 140	D4	83
C ** GET YTBL(LINT) ABOVE Y	D4	84
95 IF (Y-YTBL(LINT)) 110,130,100	D4	85
100 LINT = LINT+1	D4	86
105 GO TO 95	D4	87
C ** GET YTBL(LINT-1) BELCW Y	D4	88
110 IF (Y-YTBL(LINT-1))115,125,140	D4	89
115 LINT = LINT-1	D4	90
120 GO TO 110	D4	91
125 LINT = LINT-1	D4	92
130 RHOS = DTBL(LINT)	D4	93
135 GO TO 145	D4	94
140 RHOS = DTBL(LINT-1) *EXP(XPATBL(LINT)*(YTBL(LINT-1)-Y))	D4	95
145 RHOA = RHOS*32.1741	D4	96
VTAN=F(3)*F(2)	D4	97
C ** VRD IS DOWNWARD VELOCITY COMPONENT VTAN IS TRANSVERSE COMPONENT	D4	98
150 VSQ=F(4)*F(4)+VTAN*VTAN	D4	99
155 V=SQRTF(VSQ)	D4	100
160 EMM=FACT*RSQ*F(6)	D4	101
C ** EMM IS MASS IN LB.	D4	102
165 DRAG=VSQ*CD*AC*RHOA*.5	D4	103
C ** DRAG IS DRAG FORCE IN POUNDS	D4	104
170 DA=DRAG/(EMM*V)	D4	105
C ** DA= DRAG ACCELERATION/VEL. VTAN/V=COSF(PSIR) VRD/V=SINF(PSIR)	D4	106
C G = ACCE. OF GRAVITY	D4	107
175 G = GMU / F(3)**2	D4	108
180 FD(2)=(-2.*F(2)*F(4) -DA*VTAN)/F(3)	D4	109
185 FD(4)= -G +F(2)*VTAN -DA*F(4)	D4	110
190 FD(1)=F(2)	D4	111
195 FD(3)=F(4)	D4	112
C ABOVE 400,000 FT. THERE IS NO BURNUP	D4	113
IF(Y - 400000.)200,200,35	D4	114
200 CALL BURNUP	D4	115
C BURNUP CALCULATES FD(5),FD(6), DMDT, EMDOX	D4	116
205 GO TO 35	D4	117
210 TMA H1 = T	D4	118
RETURN	D4	119
C ** BOXB -- CALCULATE NEW CONDITIONS	D4	120
215 CALL VALUES	D4	121

TABLE E-3 (Cont'd)

220 MDE=MODE	D4	122
225 IYT=ITE	D4	123
230 GO TO (235,260,260,210),MDE	D4	124
C ** MODE = 1 MEANS CONTINUUM FLOW REGIME	D4	125
C ** MODE = 2 MEANS NEAR-FREE-MOLECULE FLOW	D4	126
C ** MODE = 3 MEANS FREE-MOLECULE FLOW	D4	127
C ** MODE = 4 MEANS SUBSONIC FLOW REGIME	D4	128
235 GO TO (250,240), IYT	D4	129
240 DT = 10.	D4	130
245 GO TO 35	D4	131
250 DT = 20.	D4	132
255 GO TO 35	D4	133
260 GO TO (265,250),IYT	D4	134
265 DT = 100.	D4	135
GO TO 35	D4	136
C BOXC -- ADD 1000 SEC. TO TP AND CHECK FOR HANGUP	D4	137
270 TP = TP + 1000.	D4	138
CALL RTIME(MON,IDAY,IHOUR,MIN,ISEC,I60TH)	D4	139
SEC2 = ISEC +MIN * 60 + 3600 *IHOUR	D4	140
IF(SEC2 - SEC1 -TMAX) 275,275,271	D4	141
271 IHANG = 4	D4	142
GO TO 210	D4	143
275 IF(Y - YOLD) 280,290,280	D4	144
280 YOLD = Y	D4	145
285 GO TO 35	D4	146
290 IHANG = 3	D4	147
295 GO TO 210	D4	148
C ** BOXD -- NONCONVERGENCE WITH 2 TRIES TO PROCEED BEFORE CUTTING OFF	D4	149
300 IF (NONCON) 305,305,325	D4	150
305 TSTEP=T	D4	151
310 T = 0.	D4	152
315 TIN=TIN+TSTEP	D4	153
320 NONCON=NONCON+1	D4	154
GO TO 35	D4	155
325 IHANG = 2	D4	156
330 GO TO 210	D4	157
END	D4	158

TABLE E-4

FORTRAN LISTING - SUBROUTINE VALUES

VALUES SUBROUTINE

	SUBROUTINE VALUES	VAL	2
C		VAL	3
C****	SUBROUTINE VALUES DETERMINES FLOW REGIME PARTICLE IS IN DURING	VAL	4
C****	RE-ENTRY AND PROVIDES DRAG COEFFICIENT, ATMOSPHERIC MEAN FREE	VAL	5
C****	PATH, AND OTHER ATMOSPHERIC PARAMETERS.	VAL	6
C		VAL	7
	COMMON TIMIMP,XMASS,DIAIMP,KASE,TITLE,ISET2		
	COMMON YTBL,DTBL,RTBL,CPTBL,HGHTBL,PATBL,WYETBL,GNUTBL,DELTBL	VAL	9
	1,HTBL,VTBL,RNTBL,CTBL,DLTBL,XPATBL,Q,QD,QN,RHOS,A,ERAD,PI2,GMU,GEEVAL	VAL	10
	2,Y,LINT,ECC,ECSQ,DMR,ASQ,PER,APO,RHOB,TMACH1	VAL	11
	3,ITE,MODE,IND,F,FD,FN,Y,V,VSQ,PSIR,DRAG,CD,RSQ,AD,AS,DIAFT,DIA	VAL	12
	4,RHOA,RHOS,EMM,DMDT,EMDOX,TEMP,DELTA,GNU,EMEFPE,ENKNUD, GMACH,T	VAL	13
	5,TIN,IHANG,SECL,TMAX	VAL	14
	DIMENSION TIMIMP(200),XMASS(200),DIAIMP(200),TITLE(12)	VAL	15
	DIMENSION YTBL(37),DTBL(37),RTBL(14),CPTBL(14),HGHTBL(59)	VAL	16
	1,PATBL(59),WYETBL(20),GNUTBL(20),DELTBL(20),HTBL(31),VTBL(31)	VAL	17
	2,RNTBL(30),CTBL(30),DLTBL(37),XPATBL(37),Q(2),QD(2),QN(10),F(6)	VAL	18
	3,FD(6),FN(30)	VAL	19
	10 TEMP=F(5)	VAL	20
	15 EMEFPE= SXF (HGHTBL,PATBL,Y,59,IND,1,1)	VAL	21
	20 XTEMP=SQRTF(TEMP)/V	VAL	22
	25 ENKNUD = 95.*XTEMP*EMEFPE/F(6)	VAL	23
C **	EMEFPE= MEAN FREE PATH (FT) ENKNUD = KNUDSEN NO.	VAL	24
	30 CHI=.01475/XTEMP	VAL	25
C **	CHI IS DISCRIMINATOR FOR VALIDITY OF N-F-M EQUATIONS	VAL	26
	35 IF (V-1000.) 40,65,65	VAL	27
	40 VISC = SPF(HTBL,VTBL,Y,31,IND,1,1)	VAL	28
	45 REYNO = V*F(6)*2.*RHOS/VISC	VAL	29
	50 MODE=4	VAL	30
	55 CD=SGF(RNTBL,CTBL,REYNO,30,IND,1,1)	VAL	31
	60 GO TO 140	VAL	32
	65 IF (ENKNUD-10.) 70,70,105	VAL	33
	70 IF (ENKNUD-.33) 90,90,75	VAL	34
	75 IF (CHI-2.) 90,90,80	VAL	35
	80 MODE=2	VAL	36
	85 GO TO 110	VAL	37
	90 MODE=1	VAL	38
	95 CD=1.	VAL	39

TABLE E-4 (Cont'd)

100 GO TO 140	VAL 40
105 MODE=3	VAL 41
110 CD=2.	VAL 42
C ** MODE = 1 MEANS CONTINUUM FLOW REGIME	VAL 43
C ** MODE = 2 MEANS NEAR-FREE-MOLECULE FLOW	VAL 44
C ** MODE = 3 MEANS FREE-MOLECULE FLOW	VAL 45
C ** MODE = 4 MEANS SUBSONIC FLOW REGIME	VAL 46
115 CALL BPF(DELTA,GNU,Y,DELTBL,GNUTBL,WYETBL,20,INDP,1,1)	VAL 47
C ** BPF INTERPOLATES FITTING PARABOLA ARCS -- GETS GNU + DELTA	VAL 48
120 IF (INDP) 125,140,135	VAL 49
125 DELTA = .21	VAL 50
GNU = 0	VAL 51
130 GO TO 140	VAL 52
135 GNU = GNUTBL(20)	VAL 53
140 IF (Y-400000.) 145,145,155	VAL 54
145 ITE = 2	VAL 55
150 GO TO 160	VAL 56
155 ITE = 1	VAL 57
160 RETURN	VAL 58
END	VAL 59

TABLE E-5

FORTRAN LISTING - SUBROUTINE BURNUP

BURNUP SUBROUTINE

```

SUBROUTINE BURNUP
C
C**** SUBROUTINE BURNUP CALCULATES MASS LOSS OF PARTICLE DUE TO RE-
C**** ENTRY BURNUP.
C
COMMON TIMIMP,XMASS,DIAIMP,KASE,TITLE,ISET2
COMMON YTBL,DTBL,RTBL,CPTBL,HGHTBL,PATBL,WYETBL,GNUTBL,DELTBL
1,HTBL,VTBL,RNTBL,CTBL,DLTBL,XPATBL,Q,QD,QN,RHCS,A,ERAD,PI2,GMU,GEEBUN
2,Y,LINT,ECC,ECSQ,DMR,ASQ,PER,APC,RHCB,TMACH1
3,ITE,MODE,IND,F,FD,FN,Y,V,VSQ,PSIR,DRAG,CD,RSQ,AD,AS,DIAFT,DIA
4,RHOA,RHCS,EMM,DMCT,EMDOX,TEMP,DELTA,GNU,EMEFPE,ENKNUD,GMACH,T
5,TIN,IHANG,SEC1,TMAX
DIMENSION TIMIMP(200),XMASS(200),DIAIMP(200),TITLE(12)
DIMENSION YTBL(37),DTBL(37),RTBL(14),CPTBL(14),HGHTBL(59)
1,PATBL(59),WYETBL(20),GNUTBL(20),DELTBL(20),HTBL(31),VTBL(31)
2,RNTBL(30),CTBL(30),DLTBL(37),XPATBL(37),Q(2),QD(2),QN(10),F(6)
3,FD(6),FN(30)
10 ZEEF(R) = PROD*(.001166*VSQ-CORR-R*9.7+GNU*596320.+DELTA*185700.)
C ** ZEEF(TEMP)=F.M.+N.F.M. HEAT INPUT PER FRONTAL AREA (FT*LB/FTSQ*SECBUN
C ** ZEEF DOES NOT INCLUDE RADIATION TERMS
15 RATIO=RHOS/DTBL
20 TEMP=F(5)
25 CP = SPF(RTBL,CPTBL,TEMP,14,IND,1,1)
30 MDE=MODE
35 GO TO (95,40,50,175),MDE
C ** MODE = 1 MEANS CONTINUUM FLOW REGIME
C ** MODE = 2 MEANS NEAR-FREE-MOLECULE FLOW
C ** MODE = 3 MEANS FREE-MOLECULE FLOW
C ** MODE = 4 MEANS SUBSONIC FLOW REGIME
C ** NEAR-FREE-MOLECULE (CORRECTION TERM FOR FREE MOLECULE) **
40 CORR=(F(6)*VSQ/EMEFPE)*(.561E-5*V/SQRTF(TEMP)+4.56E-3)
45 GO TO 55
C ** FREE-MOLECULE ANALYSIS **
50 CORR = 0.
55 PROD =RATIO*V
60 FLUX=ZEEF(TEMP)
C ** FLUX IS NET HEAT INPUT PER FRONTAL AREA. INCL. LOSS BY RADIATION
65 GO TO (95,70,80),MDE

```

TABLE E-5 (Cont'd)

70 IF(FLUX) 75,80,80	BUN	40
75 CORR = 0.	BUN	41
GO TO 60	BUN	42
80 QNET = (FLUX + 74.72 - 1197. * (TEMP/1000.) ** 4) * AD / 778.16	BUN	43
C ** 74.62 IS SOLAR TERM THIRD TERM = RADIATION LOSS TERM	BUN	44
C ** QNET = NET HEAT INPUT (BTU/SEC)	BUN	45
C ** 778.16 = FT*LB/BTU	BUN	46
85 EMDOX = PROD * (DELTA + GNU) * .0151118	BUN	47
C ** .1899 / (4 * PI) = .0151118	BUN	48
90 GO TO 155	BUN	49
C ** CONTINUUM (SCALA) ANALYSIS **	BUN	50
95 XTEMP = TEMP / 1000.	BUN	51
100 QRAD = 0.384 * XTEMP ** 4 - .024005	BUN	52
C ** QRAD = RADIANT HEAT LOSS (BTU/SEC*FTSQ) .024005 IS SOLAR TERM	BUN	53
C ** ERAD * (S - B CONST) * 10. ** 12 = .8 * .48 = .384	BUN	54
105 A = - .32 - 8.776E-5 * Y	BUN	55
110 C = 1.828 - 4.156E-4 * TEMP + 4.097E-8 * TEMP ** 2	BUN	56
115 QST = (C / SQRT(F(6))) * 10. ** A * V ** 2.5645	BUN	57
C ** QST IS STAGNATION HEAT FLUX PER FRONTAL AREA (BTU/FTSQ*SEC)	BUN	58
120 IF (TEMP - 3000.) 125,125,135	BUN	59
125 D = .508 + TEMP * 1.4725E-4	BUN	60
130 GO TO 140	BUN	61
135 D = 1.17 - 1.045E-6 * Y - (7.41E-5 - 2.85E-10 * Y) * TEMP	BUN	62
140 E = -4.6759 - 9.16E-6 * Y	BUN	63
145 EMDOX = (.13 * D / SQRT(F(6))) * 10. ** E * V ** .875	BUN	64
C ** EMDOX IS MASS LOSS RATE (LB/(FTSQ*SEC))	BUN	65
150 QNET = AD * QST - AS - QRAD	BUN	66
C ** FINAL STATEMENTS FOR ALL ANALYSES **	BUN	67
155 FD(5) = QNET / (CP * EMT)	BUN	68
160 FD(6) = -EMDOX / RHOB	BUN	69
165 DMDT = EMDOX * AS	BUN	70
C ** DMDT IS MASS LOSS RATE (LB/SEC)	BUN	71
170 RETURN	BUN	72
175 QNET = (74.62 - 1197. * (TEMP / 1000.) ** 4) * AD / 778.16	BUN	73
180 EMDOX = 0.	BUN	74
185 GO TO 155	BUN	75
END	BUN	76

TABLE E-6

FORTRAN LISTING - SUBROUTINE SEARCH

SEARCH ROUTINE FOR INTERPOLATORS FUNCTION

```

      SUBROUTINE SEARCH (XTBL,XX,NN,IND,NATURE,IUABS,I2)
C
C**** SUBROUTINE SEARCH PROVIDES PROGRAM FOR SEARCHING, INTERPOLATION,
C**** AND EXTRAPOLATION OF VALUES IN INTERPOLATOR TABLES.
C
      DIMENSION XTBL(2),YTBL(2)
C ** IUABS=(0,1,2) MEANS MAKE UPPER EXTRAPOLATION (ERROR+EXIT,LINEAR,
C      PARABOLIC)
C ** SET UP ARGUMENT ALIASES      (ALSO HAVE INT=IND AND II=I2)
      10 N = NN
C ** N = NUMBER OF POINTS IN TABLE
      15 X = XX
C ** X = VALUE OF INDEPENDENT VARIABLE
      20 INT = 0
      25 NM1 = N-1
C ** CHECK FOR LOWER EXTRAPOLATION
      30 IF (X-XTBL) 35,40,50
      35 INT = -1
      40 II = 2
      45 GO TO 105
C ** CHECK FOR UPPER EXTRAPOLATION
      50 IF (XTBL(N)-X) 55,60,85
      55 INT = +1
      60 IF (IUABS-1) 65,65,75
C ** LINEAR CASE
      65 II = N
      70 GO TO 105
C ** PARABOLIC CASE
      75 II = NM1
      80 GO TO 105
C ** NO EXTRAPOLATION -- SEARCH TABLE
      85 DO 95 II = 2,NM1
      90 IF (X-XTBL(II)) 105,105,95
      95 CONTINUE
C ** DROP THROUGH DO LOOP MEANS X IS IN LAST INTERVAL
C ** II IS FIXED TO BE THE SECOND POINT OF TWO OR THREE BRACKETING X
      100 GO TO (65,75), NATURE
C ** NATURE = (1,2) MEANS WANT (LINEAR,PARABOLIC) INTERPOLATION

```

SEA 2
SEA 3
SEA 4
SEA 5
SEA 6
SEA 7
SEA 8
SEA 9
SEA 10
SEA 11
SEA 12
SEA 13
SEA 14
SEA 15
SEA 16
SEA 17
SEA 18
SEA 19
SEA 20
SEA 21
SEA 22
SEA 23
SEA 24
SEA 25
SEA 26
SEA 27
SEA 28
SEA 29
SEA 30
SEA 31
SEA 32
SEA 33
SEA 34
SEA 35
SEA 36
SEA 37
SEA 38
SEA 39

TABLE E-6 (Cont'd)

105 I2 = II	SEA	40
110 IND = INT	SEA	41
C ** IND = (-1,0,1) MEANS HAVE FOUND NEED FOR (LOWER,NO,UPPER) EXTRAPCLASEA	SEA	42
115 RETURN	SEA	43
END	SEA	44

TABLE E-7

FORTRAN LISTING - SUBROUTINE BPF

BPF BI-VALUE PARABOLIC INTERPOLATOR SUBROUTINE

```

SUBROUTINE BPF (DEPA,DEPB,XX,YATBL,YBTBL,XTBL,NN,IND,INDLE,INDUE) BPF 2
C                                                                    BPF 3
C**** SUBROUTINE BPF PROVIDES LINEAR OR PARABOLIC EXTRAPOLATION OF BPF 4
C**** TABLES TO CALCULATE ATOM FRACTION OF MOLECULAR AND ATOMIC OXYGEN BPF 5
C**** IN THE ATMOSPHERE. BPF 6
C                                                                    BPF 7
C      DIMENSION XTBL(2),YATBL(2),YBTBL(2) BPF 8
C ** SET UP ARGUMENT ALIASES (ALSO HAVE INT=IND) BPF 9
C      10 X = XX BPF 10
C ** X = VALUE OF INDEPENDENT VARIABLE BPF 11
C      15 N = NN BPF 12
C ** N = NUMBER OF POINTS IN TABLE BPF 13
C      20 IUAB = XABSF(INDUE) BPF 14
C ** IUAB = (0,1,2) MEANS MAKE UPPER EXTRAPOLATION (ERROR+EXIT,LINEAR,PABPF 15
C ** INDUE (+,-) MEANS (DON'T,DO) GET ERROR PRINTOUT ON UPPER EXTRAPOLAT BPF 16
C      25 ILAB = XABSF(INDLE) BPF 17
C ** ILAB=(0,1,2) MEANS MAKE UPPER EXTRAPOLATION (ERROR+EXIT,LINEAR, BPF 18
C      PARABOLIC) BPF 19
C ** INDLE (+,-) MEANS (DON'T,DO) GET ERROR PRINTOUT ON LOWER BPF 20
C      EXTRAPOLATION BPF 21
C      30 CALL SEARCH (XTBL,X,N,INT, 2,IUAB,II) BPF 22
C ** SEARCH FIXES INT, II BPF 23
C ** II IS FIXED TO BE THE SECOND POINT OF THREE BRACKETING X BPF 24
C      35 IF (INT) 40,100,85 BPF 25
C ** TREAT LOWER EXTRAPOLATION BPF 26
C      40 IF (INDLE) 45,45,100 BPF 27
C      45 CALL ERROR (2CH LOWER EXTRAPOLATION ) BPF 28
C      50 IF (ILAB-1) 55,65,75 BPF 29
C      55 WRITE OUTPUT TAPE 6, 1000 BPF 30
C      1000 FORMAT (47H 9TH OR 10TH ARGUMENT IS ZERO ** EXIT IS CALLED) BPF 31
C      60 CALL EXIT BPF 32
C      65 WRITE OUTPUT TAPE 6, 1001 BPF 33
C      1001 FORMAT (28H TABLE EXTRAPOLATED LINEARLY) BPF 34
C      70 GO TO 100 BPF 35
C      75 WRITE OUTPUT TAPE 6, 1002 BPF 36
C      1002 FORMAT (33H TABLE EXTRAPOLATED PARABOLICALLY) BPF 37
C      80 GO TO 100 BPF 38
C ** TREAT UPPER EXTRAPOLATION BPF 39

```

TABLE E-7 (Cont'd)

85 IF (INDUE) 90,90,100	BPF	40
90 CALL ERRCR (2CH UPPER EXTRAPOLATION)	BPF	41
95 IF (IUAB-1) 55,65,75	BPF	42
C ** GET FIRST TWO POINTS	BPF	43
100 X1 = XTBL(II-1)	BPF	44
105 X2 = XTBL(II)	BPF	45
110 XMX1 = X-X1	BPF	46
115 X12F = XMX1/(X2-X1)	BPF	47
120 YA1=YATBL(II-1)	BPF	48
125 YB1=YBTBL(II-1)	BPF	49
130 YA2=YATBL(II)	BPF	50
135 YB2=YBTBL(II)	BPF	51
140 IF (INT) 145,170,150	BPF	52
145 GO TO (155,170), ILAB	BPF	53
150 GO TO (155,170), IUAB	BPF	54
C ** LINEAR EXTRAPOLATION	BPF	55
155 DEPA = YA1 + (YA2-YA1)*X12F	BPF	56
160 DEPB = YB1 + (YB2-YB1)*X12F	BPF	57
165 GO TO 205	BPF	58
C ** THIRD POINT VALUES FOR PARABOLIC	BPF	59
170 X3 = XTBL(II+1)	BPF	60
175 X231F = (X2-X)/(X3-X1)	BPF	61
180 X132F = XMX1/(X3-X2)	BPF	62
185 YA3=YATBL(II+1)	BPF	63
190 YB3=YBTBL(II+1)	BPF	64
C ** PARABOLIC INTERPOLATION OR EXTRAPOLATION	BPF	65
195 DEPA = YA1+(1.+X231F)*(YA2-YA1)*X12F - (YA3-YA2)*X231F*X132F	BPF	66
200 DEPB = YB1+(1.+X231F)*(YB2-YB1)*X12F - (YB3-YB2)*X231F*X132F	BPF	67
205 IND = INT	BPF	68
C ** IND =(-1,0,1) MEANS HAVE HAD (LOWER,NO,UPPER) EXTRAPOLATION	BPF	69
210 RETURN	BPF	70
END	BPF	71

TABLE E-8

FORTRAN LISTING - FUNCTION SGF

SGF SINGLE LOGARITHMIC INTERPOLATOR

FUNCTION SGF (XTBL,YTBL,XX,NN,IND,INDLE,INDUE)	SGF	2
C	SGF	3
C**** FUNCTION SGF PROVIDES SINGLE LOGARITHMIC INTERPOLATION OF TABLES	SGF	4
C**** T CALCULATE DRAG COEFFICIENTS.	SGF	5
C	SGF	6
DIMENSION XTBL(2),YTBL(2)	SGF	7
C ** SET UP ARGUMENT ALIASES (ALSO HAVE INT=IND)	SGF	8
10 X = XX	SGF	9
C ** X = VALUE OF INDEPENDENT VARIABLE	SGF	10
15 N = NN	SGF	11
C ** N = NUMBER OF POINTS IN TABLE	SGF	12
C ** INDLE=(-1,0,1) MEANS LOWER EXTRAP TO BE (ERROR+LINEAR,ERROR+EXIT,LIN	SGF	13
C ** INDUE=(-1,0,1) MEANS UPPER EXTRAP TO BE (ERROR+LINEAR,ERROR+EXIT,LIN	SGF	14
20 CALL SEARCH (XTBL,X,N,INT,1,1,II)	SGF	15
C ** SEARCH FIXES INT, II	SGF	16
C ** II IS FIXED TO BE THE SECOND POINT OF TWO BRACKETING X	SGF	17
25 IF (INT) 30,80,65	SGF	18
C ** TREAT LOWER EXTRAPOLATION	SGF	19
30 IF (INDLE) 35,35,80	SGF	20
35 CALL ERROR (2CH LOWER EXTRAPOLATION)	SGF	21
40 IF (INDLE) 55,45,80	SGF	22
45 WRITE OUTPUT TAPE 6, 1000	SGF	23
1000 FORMAT (46H 6TH OR 7TH ARGUMENT IS ZERO ** EXIT IS CALLED)	SGF	24
50 CALL EXIT	SGF	25
55 WRITE OUTPUT TAPE 6, 1001	SGF	26
1001 FORMAT (39H TABLE EXTRAPOLATED WITH POWER FUNCTION)	SGF	27
60 GO TO 80	SGF	28
C ** TREAT UPPER EXTRAPOLATION	SGF	29
65 IF (INDUE) 70,70,80	SGF	30
70 CALL ERROR (2CH UPPER EXTRAPOLATION)	SGF	31
75 IF (INDUE) 55,45,80	SGF	32
C ** GET POINT VALUES	SGF	33
80 X1 = LOGF(XTBL(II-1))	SGF	34
85 X2 = LOGF(XTBL(II))	SGF	35
90 Y1 = LOGF(YTBL(II-1))	SGF	36
95 Y2 = LOGF(YTBL(II))	SGF	37
100 X = LOGF(X)	SGF	38
C ** LINEAR INTERPOLATION OR EXTRAPOLATION	SGF	39

TABLE E-8 (Cont'd)

```
105 SGF = EXPF(Y1+((Y2-Y1)*(X-X1)/(X2-X1)))
110 IND = INT
C ** IND = (-1,0,1) MEANS HAVE HAD (LOWER,NO,UPPER) EXTRAPOLATION
115 RETURN
    END
```

```
SGF 40
SGF 41
SGF 42
SGF 43
SGF 44
```

TABLE E-9

FORTRAN LISTING - FUNCTION SPF

SPF SINGLE PARABOLIC INTERPOLATOR FUNCTION

FUNCTION SPF (XTBL,YTBL,XX,NN,IND,INDLE,INDUE)	SPF 2
C	SPF 3
C**** FUNCTION SPF PROVIDES SINGLE PARABOLIC INTERPOLATION OF TABLES	SPF 4
C**** TO CALCULATE SPECIFIC HEAT AND VISCOSITY.	SPF 5
C	SPF 6
DIMENSION XTPL(2),YTBL(2)	SPF 7
C ** SET UP ARGUMENT ALIASES (ALSO HAVE INT=IND)	SPF 8
10 X = XX	SPF 9
C ** X = VALUE OF INDEPENDENT VARIABLE	SPF 10
15 N = NN	SPF 11
C ** N = NUMBER OF POINTS IN TABLE	SPF 12
20 IUAB = XABSF(INDUE)	SPF 13
C ** IUAB=(0,1,2) MEANS MAKE UPPER EXTRAPOLATION (ERROR+EXIT,LINEAR,	SPF 14
PARABOLIC)	SPF 15
C ** INDUE (+,-) MEANS (DON'T,DO) GET ERROR PRINTOUT ON LOWER	SPF 16
C EXTRAPOLATION	SPF 17
25 ILAB = XABSF(INDLE)	SPF 18
C ** ILAB=(0,1,2) MEANS MAKE UPPER EXTRAPOLATION (ERROR+EXIT,LINEAR,	SPF 19
C PARABOLIC)	SPF 20
C ** INDLE (+,-) MEANS (DON'T,DO) GET ERROR PRINTOUT ON LOWER	SPF 21
C EXTRAPOLATION	SPF 22
30 CALL SEARCH (XTBL,X,N,INT, 2,IUAB,II)	SPF 23
C ** SEARCH FIXES INT, II	SPF 24
C ** II IS FIXED TO BE THE SECOND POINT OF THREE BRACKETING X	SPF 25
35 IF (INT) 40,100,85	SPF 26
C ** TREAT LOWER EXTRAPOLATION	SPF 27
40 IF (INDLE) 45,45,100	SPF 28
45 CALL ERROR (2CH LOWER EXTRAPOLATION)	SPF 29
50 IF (ILAB-1) 55,65,75	SPF 30
55 WRITE OUTPUT TAPE 6, 1000	SPF 31
1000 FORMAT (46H 6TH OR 7TH ARGUMENT IS ZERO ** EXIT IS CALLED)	SPF 32
60 CALL EXIT	SPF 33
65 WRITE OUTPUT TAPE 6, 1001	SPF 34
1001 FORMAT (28H TABLE EXTRAPOLATED LINEARLY)	SPF 35
70 GO TO 100	SPF 36
75 WRITE OUTPUT TAPE 6, 1002	SPF 37
1002 FORMAT (33H TABLE EXTRAPOLATED PARABOLICALLY)	SPF 38
80 GO TO 100	SPF 39

TABLE E-9 (Cont'd)

C ** TREAT UPPER EXTRAPOLATION	SPF	40
85 IF (INDUE) 90,90,10C	SPF	41
90 CALL ERROR (2CH UPPER EXTRAPOLATION)	SPF	42
95 IF (IUAB-1) 55,65,75	SPF	43
C ** GET FIRST TWO POINTS	SPF	44
100 X1 = XTBL(II-1)	SPF	45
105 X2 = XTBL(II)	SPF	46
110 Y1 = YTBL(II-1)	SPF	47
115 Y2 = YTBL(II)	SPF	48
120 IF (INT) 125,145,13C	SPF	49
125 GO TO (135,145), ILAB	SPF	50
130 GO TO (135,145), IUAB	SPF	51
C ** LINEAR EXTRAPOLATION	SPF	52
135 SPF = Y1+((Y2-Y1)*(X-X1)/(X2-X1))	SPF	53
140 GO TO 155	SPF	54
C ** THIRD POINT VALUES FOR PARABOLIC	SPF	55
145 X3 = XTBL(II+1)	SPF	56
C ** PARABOLIC INTERPOLATION OR EXTRAPOLATION	SPF	57
150 SPF = Y1+(1.+((X2-X)/(X3-X1)))*(Y2-Y1)*(X-X1)/(X2-X1)	SPF	58
1 - ((X2-X)/(X3-X1))*(X-X1)*(Y3-Y2)/(X3-X2)	SPF	59
155 IND = INT	SPF	60
C ** IND =(-1,0,1) MEANS HAVE HAD (LOWER,NO,UPPER) EXTRAPOLATION	SPF	61
160 RETURN	SPF	62
END	SPF	63

TABLE E-10

FORTRAN LISTING - FUNCTION SXF

SXF SINGLE EXPONENTIAL INTERPOLATOR

FUNCTION SXF (XTBL,YTBL,XX,NN,IND,INDLE,INDUE)	SXF	2
C	SXF	3
C**** FUNCTION SXF PROVIDES SINGLE EXPONENTIAL INTERPOLATION OF TABLES	SXF	4
C**** TO CALCULATE MEAN FREE PATH.	SXF	5
C	SXF	6
DIMENSION XTBL(2),YTBL(2)	SXF	7
C ** SET UP ARGUMENT ALIASES (ALSO HAVE INT=IND)	SXF	8
10 X = XX	SXF	9
C ** X = VALUE OF INDEPENDENT VARIABLE	SXF	10
15 N = NN	SXF	11
C ** N = NUMBER OF POINTS IN TABLE	SXF	12
C ** INDLE=(-1,0,1)MEANS LOWER EXTRAP TO BE (ERROR+LINEAR,ERROR+EXIT,LINSXF	SXF	13
C ** INDUE=(-1,0,1)MEANS UPPER EXTRAP TO BE (ERROR+LINEAR,ERROR+EXIT,LINSXF	SXF	14
20 CALL SEARCH (XTBL,X,N,INT,1,1,II)	SXF	15
C ** SEARCH FIXES INT, II	SXF	16
C ** II IS FIXED TO BE THE SECOND POINT OF TWO BRACKETING X	SXF	17
25 IF (INT) 30,80,65	SXF	18
C ** TREAT LOWER EXTRAPOLATION	SXF	19
30 IF (INDLE) 35,35,80	SXF	20
35 CALL ERROR (20H LOWER EXTRAPOLATION)	SXF	21
40 IF (INDLE) 55,45,80	SXF	22
45 WRITE OUTPUT TAPE 6, 1000	SXF	23
1000 FORMAT (46H 6TH OR 7TH ARGUMENT IS ZERO ** EXIT IS CALLED)	SXF	24
50 CALL EXIT	SXF	25
55 WRITE OUTPUT TAPE 6, 1001	SXF	26
1001 FORMAT (33H TABLE EXTRAPOLATED EXPONENTIALLY)	SXF	27
60 GO TO 80	SXF	28
C ** TREAT UPPER EXTRAPOLATION	SXF	29
65 IF (INDUE) 70,70,80	SXF	30
70 CALL ERROR (20H UPPER EXTRAPOLATION)	SXF	31
75 IF (INDUE) 55,45,80	SXF	32
C ** GET POINT VALUES	SXF	33
80 X1 = XTBL(II-1)	SXF	34
85 X2 = XTBL(II)	SXF	35
90 Y1 = LOGF(YTBL(II-1))	SXF	36
95 Y2 = LOGF(YTBL(II))	SXF	37
C ** LINEAR INTERPOLATION OR EXTRAPOLATION	SXF	38
100 SXFTEM = (Y1+((Y2-Y1)*(X-X1)/(X2-X1)))	SXF	39A

TABLE E-10 (Cont'd)

```
      IF(SXFTEM -10.)102,102,103
102  SXF = EXPF(SXFTEM)
      GO TO 105
103  SXF = 20000.
105  IND = INT
C  ** IND =(-1,0,1) MEANS HAVE HAD (LOWER,NO,UPPER) EXTRAPOLATION
110  RETURN
      END
```

```
SXF  39B
SXF  39C
SXF  39D
SXF  39E
SXF  40
SXF  41
SXF  42
SXF  43
```

TABLE E-11

FORTRAN LISTING - SUBROUTINE F1

F1 SUBROUTINE

	SUBROUTINE F1	F1	2
C		F1	3
C****	SUBROUTINE F1 CALCULATES ORBITAL LIFETIME OF PARTICLES THAT HAVE	F1	4
C****	SPACE RESIDENCE TIMES GREATER THAN 10 ORBITS.	F1	5
C		F1	6
	COMMON TIMIMP,XMASS,DIAIMP,KASE,TITLE,ISET2	F1	7
	COMMON YTBL,DTBL,RTBL,CPTBL,HGHTBL,PATBL,WYETBL,GNUTBL,DELTBL	F1	8
	1,HTBL,VTBL,RNTBL,CTBL,DLTBL,XPATBL,Q,QD,QN,RHOS,A,ERAD,PI2,GMU,GEEF1	F1	9
	2,Y,LINT,ECC,ECSQ,DMR,ASQ,PER,APO,RHOB,TMACH1	F1	10
	3,ITE,MODE,IND,F,FD,FN,Y,V,VSQ,PSIR,DRAG,CD,RSQ,AD,AS,DIAFT,DIA	F1	11
	4,RHOA,RHOS,EMM,DMDT,EMDOX,TEMP,DELTA,GNU,EMEFPE,ENKNUD,GMACH,T	F1	12
	5,TIN,IHANG,SECL,TMAX	F1	13
	DIMENSION TIMIMP(200),XMASS(200),DIAIMP(200),TITLE(12)	F1	14
	DIMENSION YTBL(37),DTBL(37),RTBL(14),CPTBL(14),HGHTBL(59)	F1	15
	1,PATBL(59),WYETBL(20),GNUTBL(20),DELTBL(20),HTBL(31),VTBL(31)	F1	16
	2,RNTBL(30),CTBL(30),DLTBL(37),XPATBL(37),Q(2),QD(2),QN(10),F(6)	F1	17
	3,FD(6),FN(30)	F1	18
	ICON = 0	F1	19
C	Q = VALUES OF DEPENDENT VARIABLES	F1	20
C	Q(1) = PERIGEE + EARTH RADIUS (FEET)	F1	21
C	Q(2) = APOGEE + EARTH RADIUS (FEET)	F1	22
C	QD = DERIVATIVE OF DEPENDENT VARIABLE (FT/SEC)	F1	23
C	QD(1) = PERIGEE RATE CHANGE WITH RESPECT TO EARTH CENTER (FT/SEC)	F1	24
C	QD(2) = APOGEE RATE CHANGE WITH RESPECT TO EARTH CENTER (FT/SEC)	F1	25
C	DT = MAXIMUM ALLOWABLE TIME STEP (SECONDS)	F1	26
C	IHANG = 1(NO ERROR), 2(NON-CON), 3(HANG-UP), 4(TIME LIMIT)	F1	27
	IHANG = 1	F1	28
	PI = 3.141592654	F1	29
	PI2 = 6.283185308	F1	30
	GEE = 32.1741	F1	31
	CD = 2.	F1	32
	E1 = .000001	F1	33
	E2 = .00015	F1	34
C	YLAST= CUTOFF ALTITUDE ABOVE EARTH(FEET)	F1	35
	YLA T = 400000.	F1	36
C	QL = CUTOFF PERIGEE RATE(FT/SEC)	F1	37
	QL = 20.	F1	38
	LINT = 30	F1	39

TABLE E-11 (Cont'd)

RV = Y + ERAC	F1	40
C QLAST = CUTOFF ALTITUDE ABOVE EARTH CENTER (FEET)	F1	41
QLAST = YLAST + ERAC	F1	42
XTEMP = RHOB * 4.1887902	F1	43
C DMR = RECIPROCAL CF BALLISTIC PARAMETER = 1./((MASS/CD*AREA) (FTSQ/LB	F1	44
DMR = 3./((RHOB*DIAFT)	F1	45
C A = SEMI-MAJOR AXIS CF ORBIT (FEET)	F1	46
A = GMU * RV / (GMU * 2. - RV * V **2)	F1	47
ECSQ = ECC **2	F1	48
RSQ = DIAFT **2	F1	49
AD = PI * RSQ	F1	50
Q(1) = PER + ERAC	F1	51
Q(2) = APO + ERAC	F1	52
DT = 50000.	F1	53
APOLD = PI	F1	54
T = 0.0	F1	55
INIT = 0	F1	56
TP = 50000.	F1	57
10 CALL ICE(DT,T,TP,E1,E2,2,Q,QD,QN,ICER)	F1	58
15 ICER = ICER	F1	59
20 GO TO (35,50,95,125),ICER	F1	60
25 ICER = XICEF(T)	F1	61
30 GO TO 15	F1	62
35 CALL BOXA	F1	63
C BOX-A CALCULATES DERIVATIVES OF Q, ATMOS.DENSITY AND ATMOS LOG DECREM.	F1	64
40 GO TO 25	F1	65
C TMACH1= TIME AT CUTOFF AS DETERMINED BY QLAST OR QL	F1	66
45 TMACH1 = T	F1	67
RETURN	F1	68
C BOXB	F1	69
C ** BOX B-- CHECKS IF PARTICLE IS IN LAST ORBIT	F1	70
C CUTOFF AT 400000 FEET	F1	71
50 IF(Q(1) - QLAST) 45,65,65	F1	72
C CUTOFF AT PERIGEE RATE GREATER THAN -20.0 FT/SEC	F1	73
65 IF (QD+QL) 45,45,70	F1	74
70 IF(QD+5.) 75,80,80	F1	75
75 DT = 1000.	F1	76
GO TO 25	F1	77
80 IF(D + .1) 85,85,90	F1	78
85 DT = 50000.	F1	79
GO TO 25	F1	80

TABLE E-11 (Cont'd)

90	DT = 1000000.	F1	81
	GO TO 25	F1	82
C	BOXC	F1	83
C **	BOX C-- ASSIGNS NEW TIME STEP FOR DERIVATIVE CALCULATIONS AND	F1	84
C	CHECKS COMPUTER RUNNING TIME	F1	85
95	IF(DT - 50000.) 100,105,105	F1	86
100	TP = TP + 50000.	F1	87
	GO TO 110	F1	88
105	TP = TP + 1.00E 6	F1	89
110	IF (APOLD - Q(2)) 115,120,115	F1	90
115	APOLD = Q(2)	F1	91
	CALL RTIME(MON,IDAY,IHOUR,MIN,ISEC,I60TH)	F1	92
	SEC2 = ISEC +MIN * 60 + 3600 *IHOUR	F1	93
	IF(SEC2-SEC1-TMAX)25,25,116	F1	94
116	IHANG = 4	F1	95
	GO TO 45	F1	96
120	IHANG = 3	F1	97
	GO TO 45	F1	98
C	BOXD	F1	99
C **	BOX D-- CHECKS FOR NON-CONVERGENCE	F1	100
125	IHANG = 2	F1	101
	GO TO 45	F1	102
	END	F1	103

TABLE E-12
FORTTRAN LISTING - SUBROUTINE FAPTBL

*	FAP	TBL	1
	FAPTBL TABULAR DATA GENERATOR SUBROUTINE		
	ENTRY FAPTBL	TBL	3
*		TBL	4
*****	SUBROUTINE FAPTBL GENERATES AND STORES TABULAR DATA NEEDED IN	TBL	5
*****	RE-ENTRY(D4),LIFETIME(F1), AND BURNUP CALCULATIONS.	TBL	6
*		TBL	7
FAPTBL	SXA XR1,1	TBL	8
	SXA XR2,2	TBL	9
	SXD FAPTBL-2,4	TBL	10
*		TBL	11
	LXA =0,1 GENERATE + ENTER YTBL(37)	TBL	12
	CLA =0.	TBL	13
LOOP1	STO CATBL,1	TBL	14
	FAD =20000.	TBL	15
	TXI *+1,1,1	TBL	16
	TXL LOOP1,1,2	TBL	17
*		TBL	18
	CLA =120000.	TBL	19
LOOP2	STO CATBL,1	TBL	20
	FAD =20000.	TBL	21
	TXI *+1,1,1	TBL	22
	TXL LOOP2,1,5	TBL	23
*		TBL	24
	CLA =220000.	TBL	25
LOOP3	STO CATBL,1	TBL	26
	FAD =20000.	TBL	27
	TXI *+1,1,1	TBL	28
	TXL LOOP3,1,20	TBL	29
*		TBL	30
	CLA =530000.	TBL	31
	STO CATBL-21	TBL	32
	CLA =560000.	TBL	33
	STO CATBL-22	TBL	34
*		TBL	35
	AXT 23,1	TBL	36
	CLA =600000.	TBL	37
LOOP4	STO CATBL,1	TBL	38
	FAD =50000.	TBL	39

TABLE E-12 (Cont'd)

	TXI	*+1,1,1		TBL	40
	TXL	LOOP4,1,28		TBL	41
*				TBL	42
LOOP5	STO	CATBL,1		TBL	43
	FAD	=1C00C0.		TBL	44
	TXI	*+1,1,1		TBL	45
	TXL	LOOP5,1,31		TBL	46
*				TBL	47
LOOP6	STO	CATBL,1		TBL	48
	FAD	=2000C0.		TBL	49
	TXI	*+1,1,1		TBL	50
	TXL	LOOP6,1,36		TBL	51
*				TBL	52
	LXA	=0,2	ENTER DLTBL(37),DTBL(37)	TBL	53
LOOP7	CLA	FAT+37,1		TBL	54
	STO	CWTBL,2		TBL	55
	FDP	GEE		TBL	56
	STQ	CATBL-37,2		TBL	57
	XCA			TBL	58
	CALL	LOG		TBL	59
	STO	CWTBL-37,2		TBL	60
	TXI	*+1,2,1		TBL	61
	TIX	LOOP7,1,1		TBL	62
*			GENERATE + ENTER XPATBL(37)	TBL	63
	AXT	36,1		TBL	64
LOOP8	CLA	CATBL,1		TBL	65
	FSB	CATBL+1,1		TBL	66
	STO	XTEMP		TBL	67
	CLA	CWTBL-36,1		TBL	68
	FSB	CWTBL-37,1		TBL	69
	FDP	XTEMP		TBL	70
	STQ	CWTBL-37,1		TBL	71
	TIX	LOOP8,1,1		TBL	72
	STQ	CWTBL-37		TBL	73
*				TBL	74
	LXA	=0,1	GENERATE + ENTER RTBL(14)	TBL	75
	CLA	=460.		TBL	76
LUP1	STO	CMTBL,1		TBL	77
	FAD	=500.		TBL	78
	TXI	*+1,1,1		TBL	79
	TXL	LUP1,1,13		TBL	80

TABLE E-12 (Cont'd)

*				TBL	81
	LXA	=0,1	ENTER CPTBL(14)	TBL	82
	LXA	=0,2		TBL	83
LUP2	CLA	FBT,2		TBL	84
	STO	CBTBL,1		TBL	85
	TXI	*+1,1,1		TBL	86
	TXI	*+1,2,-1		TBL	87
	TXL	LUP2,1,13		TBL	88
*				TBL	89
	LXA	=0,1	GENERATE + ENTER HGHTBL(59)	TBL	90
	LXA	=0,2		TBL	91
	CLA	=140000.		TBL	92
LOUPE1	FAD	=10000.		TBL	93
	STO	CNTBL,1		TBL	94
	TXI	*+1,1,1		TBL	95
	TXL	LOUPE1,1,35		TBL	96
*				TBL	97
LOUPE2	FAD	=20000.		TBL	98
	STO	CNTBL,1		TBL	99
	TXI	*+1,1,1		TBL	100
	TXL	LOUPE2,1,40		TBL	101
*				TBL	102
LOUPE3	FAD	=50000.		TBL	103
	STO	CNTBL,1		TBL	104
	TXI	*+1,1,1		TBL	105
	TXL	LOUPE3,1,48		TBL	106
*				TBL	107
LOUPE4	FAD	=100000.		TBL	108
	STO	CNTBL,1		TBL	109
	TXI	*+1,1,1		TBL	110
	TXL	LOUPE4,1,58		TBL	111
*				TBL	112
LOUPE1	CLA	FMT,2	ENTER PATBL(59),WYETBL(20),GNUTBL(20),DELTBTBL	TBL	113
	STO	CNTBL,1		TBL	114
	TXI	*+1,1,1		TBL	115
	TXI	*+1,2,-1		TBL	116
	TXL	LOUPE1,1,177		TBL	117
*				TBL	118
	LXA	=31,2	GENERATE + ENTER HTBL(31)	TBL	119
	CLA	=300000.		TBL	120
LUUP1	STO	CLTBL+1,2		TBL	121

TABLE E-12 (Cont'd)

	FSB	=1000C.		TBL 122
	TIX	LUUP1,2,1		TBL 123
*				TBL 124
	LXA	=0,1	ENTER VTBL(31)	TBL 125
	LXA	=31,2		TBL 126
LUUP2	CLA	FVT+31,2		TBL 127
	STO	CVTBL,1		TBL 128
	TXI	*+1,1,1		TBL 129
	TIX	LUUP2,2,1		TBL 130
*				TBL 131
	LXA	=0,1	ENTER RNTBL(30),CTBL(30)	TBL 132
	LXA	=0,2		TBL 133
LP	CLA	FRT,1		TBL 134
	STO	CRTBL,2		TBL 135
	TXI	*+1,1,-1		TBL 136
	TXI	*+1,2,1		TBL 137
	TXI	LP,2,59		TBL 138
*		RETURN SEQUENCE		TBL 139
XR1	AXT	**,1		TBL 140
XR2	AXT	**,2		TBL 141
	LXD	FAPTBL-2,4		TBL 142
	TRA	1,4		TBL 143
*		TABLE OF RHDA -- DLTBL(37) -- CLTBL(1-37)	76264-76220	TBL 144
FAT	DEC	.076474,.040773,.018895,4.1506E-4,1.6994E-4,7.4713E-5		TBL 145
	DEC	8.0356E-6,3.5353E-6,1.409E-6,4.6610E-7,1.488E-7,4.774E-8		TBL 146
	DEC	1.654E-8,6.385E-9,2.579E-9,1.164E-9,5.751E-10,3.301E-10		TBL 147
	DEC	2.088E-10,1.415E-10,1.02E-10,6.822E-11,4.906E-11,3.35E-11		TBL 148
	DEC	2.177E-11,1.467E-11,1.009E-11,7.135E-12,5.121E-12		TBL 149
	DEC	3.724E-12,2.046E-12,1.179E-12,7.02E-13,2.724E-13,1.16E-13		TBL 150
	DEC	5.351E-14,2.596E-14		TBL 151
*		TABLE OF SP. HT.-- CPTBL(14)-- CHTBL(1-14)	77331-77312	TBL 152
FBT	DEC	.125,.32,.4,.44,.47,.48,.5,.5,.5,.51,.51,.54,.62,.72		TBL 153
*		TABLE OF FREE PATH--PATBL(59)--CNTBL(60-118)	77220-77124	TBL 154
FMT	DEC	1.4967E-4,2.2274E-4,3.2529E-4,4.6775E-4,6.7477E-4		TBL 155
	DEC	9.8140E-4,1.4165E-3,2.0710E-3,3.0882E-3,4.7073E-4		TBL 156
	DEC	7.353E-3,1.181E-2,2.036E-2,3.570E-2,6.257E-2,.1118		TBL 157
	DEC	.2001,.3480,.5933,1.000,1.629,2.571,4.114,6.301,9.273		TBL 158
	DEC	13.81,20.00,27.64,36.84,47.70,60.34,74.80,91.24,109.7		TBL 159
	DEC	130.3,151.3,198.7,250.3,309.5,373.2,447.0,675.9,986.1		TBL 160
	DEC	1408.,1956.,2676.,3611.,4811.,6325.,10550.,17040.		TBL 161
	DEC	26760.,40740.,60930.,89830.,130000.,185800.,263900.		TBL 162

TABLE E-12 (Cont'd)

E-30

	DEC	371100.		TBL	163
*		TABLE OF ALT --WYETBL(20)-- CNTBL(119-138)	77125-77100	TBL	164
	DEC	2.615E5,2.785E5,2.95E5,3.11E5,3.27E5,3.60E5,3.93E5,4.25E5		TBL	165
	DEC	4.580E5,5.240E5,5.90E5,6.53E5,7.20E5,7.85E5,8.20E5,9.80E5		TBL	166
	DEC	1.145E6,1.310E6,1.47E6,1.64E6		TBL	167
*		TABLE OF NU -- GNUTBL(20) -- CNTBL(139-158)	77101-77054	TBL	168
	DEC	.001,.004,.014,.058,.126,.152,.174,.174,.174,.174,.176		TBL	169
	DEC	.243,.288,.325,.342,.426,.560,.580,.632,.705		TBL	170
*		TABLE OF DELTA--DELTBL(20)--CNTBL(159-178)	77055-77030	TBL	171
	DEC	.220,.200,.180,.116,.080,.048,.039,.039,.028,.022,.016		TBL	172
	DEC	.011,.009,.007,.006,,,,,		TBL	173
*		TABLE CF VISCOSITY -- VTBL(31)-- CVTBL(1-31)	76537-76501	TBL	174
FVT	DEC	3.7372E-7,3.5342E-7,3.3244E-7,3.1069E-7,2.9691E-7		TBL	175
	DEC	2.9691E-7,2.9691E-7,2.9836E-7,3.0181E-7,3.0531E-7		TBL	176
	DEC	3.0865E-7,3.1476E-7,3.2408E-7,3.3325E-7,3.4226E-7		TBL	177
	DEC	3.5112E-7,3.5581E-7,3.5581E-7,3.5084E-7,3.4453E-7		TBL	178
	DEC	3.3816E-7,3.2657E-7,3.1342E-7,2.9993E-7,2.8616E-7		TBL	179
	DEC	2.7205E-7,2.5763E-7,2.5402E-7,2.5402E-7,2.5402E-7		TBL	180
	DEC	2.5931E-7		TBL	181
*		TABLE OF N(RE) -- RNTBL(30) -- CRTBL(1-30)	76500-76443	TBL	182
FRT	DEC	.1,.3,1.		TBL	183
	DEC	2.,4.,6.,10.,20.,40.,60.,100.,200.,400.,600.,1000.,2000.		TBL	184
	DEC	4000.,6000.,10000.,20000.,40000.,60000.,100000.,150000.		TBL	185
	DEC	200000.,250000.,260000.,300000.,1000000.,2000000.		TBL	186
*		TABLE OF CD -- CTBL(30) -- CRTBL(31-60)	76442-76405	TBL	187
	DEC	240.,80.,25.,15.,8.4,6.1,4.1,2.8,1.8,1.5,1.1,.81,.64,.56		TBL	188
	DEC	.51,.44,.41,.41,.42,.44,.50,.51,.51,.50,.43,.35,.17,.20		TBL	189
	DEC	.22,.22		TBL	190
*				TBL	191
XTEMP	PZE			TBL	192
GEE	DE	32.1741		TBL	193
*				TBL	194
	COMMON	614		TBL	195
CATBL	COMMON	74	YTBL(37),DTBL(37)	TBL	196
CMTBL	COMMON	14	RTBL(14)	TBL	197
CBTBL	COMMON	14	CPTBL(14)	TBL	198
CNTBL	COMMON	118	HGHTBL(59),PATBL(59)	TBL	199
COTBL	COMMON	60	WYETBL(20),GNUTBL(20),DELTBL(20)	TBL	200
CLTBL	COMMON	31	HTBL(31)	TBL	201
CVTBL	COMMON	31	VTBL(31)	TBL	202
CRTBL	COMMON	60	RNTBL(30),CTBL(30)	TBL	203

TABLE E-12 (Cont'd)

CWTBL COMMON 74
END

DELTBL(37),XPATBL(37)

TBL 204
TBL 205

TABLE E-13
FORTRAN LISTING - SUBROUTINE BOX A

*	FAP		BXA	1
	BOX-A SUBROUTINE FOR F1			
	ENTRY BCXA		BXA	3
*			BXA	4
*****	SUBROUTINE BOXA DETERMINES CHANGE IN ATMOSPHERE DENSITY WITH		BXA	5
*****	CHANGE IN ALTITUDE AND CALCULATES CHANGE IN PERIGEE AND APOGEE		BXA	6
*****	WITH TIME IN ORDER TO DEFINE ORBIT DECAY AND ORBITAL LIFETIME.		BXA	7
*			BXA	8
BOXA	SXD *-2,4		BXA	9
	SXA XR2,2		BXA	10
*		EXPAT SETS ATDEC + RFOA FROM Y	BXA	11
	STZ INDAT		BXA	12
	CL Q1		BXA	13
	FSB ERAD		BXA	14
	STO Y		BXA	15
*		CHECK FOR LOWER EXTRAPOLATION	BXA	16
N102	FSB YTBL		BXA	17
	TZE N106		BXA	18
	TP1 N110		BXA	19
*			BXA	20
N104	CLS ONE		BXA	21
	STO INDAT		BXA	22
*			BXA	23
N106	LXD TWO,2		BXA	24
	TRA N250		BXA	25
*		CHECK FOR UPPER EXTRAPOLATION	BXA	26
N110	CLA Y		BXA	27
	FSB YTBL-36		BXA	28
	TZE N114		BXA	29
	TMI N120		BXA	30
*			BXA	31
N112	CLA ONE		BXA	32
	STO INDAT		BXA	33
*			BXA	34
N114	LXD TRTSVA,2		BXA	35
	TRA N250		BXA	36
*		FIND UPPER SIDE OF BRACKET YTBL(LINT)	BXA	37
N120	LXD LINT,2		BXA	38
	CLA Y		BXA	39
	FSB YTBL+1,2		BXA	40

TABLE E-13 (Cont'd)

	TZE	N250		BXA	41
	TMI	N125		BXA	42
*			FIND LOWER SIDE OF BRACKET YTBL(LINT-1)	BXA	43
N122	TXI	N120+1,2,1		BXA	44
*				BXA	45
N125	CLA	Y		BXA	46
	FSB	YTBL+2,2		BXA	47
	TZE	N126		BXA	48
	TPL	N250		BXA	49
*				BXA	50
N126	TXI	N125,2,-1		BXA	51
*				BXA	52
N250	CLA	XPATBL+1,2	XPATBL(LINT)	BXA	53
	STO	ATDEC	LOG. DECREMENT OF DENSITY VS. ALTITUDE	BXA	54
*				BXA	55
N264	CLA	YTBL+2,2	YTBL(LINT-1)	BXA	56
	FSB	Y		BXA	57
	XCA			BXA	58
	FMP	ATDEC		BXA	59
	STO	XTEMP		BXA	60
	FSB	=88.		BXA	61
	TMI	*+3		BXA	62
	CLA	=0377777777777		BXA	63
	TRA	*+5		BXA	64
	CLA	XTEMP		BXA	65
	TS	\$EXP,4		BXA	66
	TXI	*+2,0,264		BXA	67
	PZE	BOXA-2,0,264		BXA	68
	XCA			BXA	69
	FMP	DLTBL+2,2	DLTBL(LINT-1)	BXA	70
	STO	RHOA		BXA	71
*			SAVE VALUE OF XR2 (LINT)	BXA	72
N270	SXD	LINT,2	LINT IS STARTPOINT FOR SEARCH NEXTIME	BXA	73
XR2	AXT	** ,2		BXA	74
*			QDCAL SETS QD(1) + QD(2) ACCORDING TO STERN	BXA	75
	CLA	Q1	PERIGEE RADIUS, Q(1)	BXA	76
	FAD	Q2	APOGEE RADIUS, Q(2)	BXA	77
	STO	QSUM		BXA	78
	XCA			BXA	79
	FMP	=.5		BXA	80
	STO	A	SEMI-MAJOR AXIS	BXA	81

TABLE E-13 (Cont'd)

	XCA			BXA 82
	FM	A		BXA 83
	STO	ASQ		BXA 84
	CLA	Q2		BXA 85
	FSB	Q1		BXA 86
	FDP	QSUM		BXA 87
	STQ	ECC	ECCENTRICITY	BXA 88
	FMP	ECC		BXA 89
	STO	ECSQ		BXA 90
*				BXA 91
	XCA			BXA 92
	FMP	=.5		BXA 93
	STO	ESQH		BXA 94
	LDQ	ATDEC		BXA 95
	FMP	A		BXA 96
	XCA			BXA 97
	FMP	ECC		BXA 98
	STO	C		BXA 99
	SSP			BXA 100
	LDQ	CUTOFF		BXA 101
	TLQ	HIC		BXA 102
*			PATH FOR LOW C	BXA 103
S214	CALL	BESMOD,C,ZERO	BMO = BESMOD(C,0)	BXA 104
	STO	BMO		BXA 105
*				BXA 106
S215	CALL	BESMOD,C,ONE	BM1 = BESMOD(C,1)	BXA 107
	STO	BM1		BXA 108
*				BXA 109
S216	CLS	C	COEFF = -EXP(-C)*DMR*RHOA*SQRTF(GMU*A)	BXA 110
	STO	XTEMP		BXA 111
	FSB	=88.		BXA 112
	TMI	++3		BXA 113
	CLA	=037777777777		BXA 114
	TRA	++5		BXA 115
	CLA	XTEMP		BXA 116
	TSX	\$EXP,4		BXA 117
	TXI	++2,0,216		BXA 118
	PZE	BOXA-2,0,216		BXA 119
	XCA			BXA 120
	FMP	RHOA	ENTRY POINT RETURNING FROM HIGH-C PATH	BXA 121
	XCA			BXA 122

TABLE E-13 (Cont'd)

FMP	DMR	BXA 123
STO	XTEMP	BXA 124
LDQ	GMU	BXA 125
FMP	A	BXA 126
TPL	*+3	BXA 127
CLA	ZERO	BXA 128
TRA	*+4	BXA 129
TSX	\$SQRT,4	BXA 130
TXI	*+2,0,216	BXA 131
PZE	BOXA-2,0,216	BXA 132
XCA		BXA 133
FMP	XTEMP	BXA 134
CHS		BXA 135
STO	COEFF	BXA 136
*		BXA 137
CLA	=1.	BXA 138
FAD	ECC	BXA 139
STO	CO1	BXA 140
CLA	=1.	BXA 141
FSB	ECC	BXA 142
STO	CO2	BXA 143
CLA	=1.	BXA 144
FDP	C	BXA 145
STQ	XTEMP	BXA 146
XCA		BXA 147
FAD	=1.	BXA 148
STO	CO3	BXA 149
CL /	=1.	BXA 150
FSB	XTEMP	BXA 151
STO	CO4	BXA 152
CLA	XTEMP	BXA 153
FDP	C	BXA 154
FMP	=2.	BXA 155
STO	XTEMP	BXA 156
FAD	CO3	BXA 157
STO	CO5	BXA 158
CLA	XTEMP	BXA 159
FAD	CO4	BXA 160
STO	CO6	BXA 161
*		BXA 162
*		BXA 163

TABLE E-13 (Cont'd)

S240	LDQ	C03	GET PERIGEE RATE	BXA 164
	FMP	ECC		BXA 165
	STO	XTEMP		BXA 166
	LDQ	C05		BXA 167
	FMP	ESQH		BXA 168
	FAD	=1.		BXA 169
	FSB	XTEMP		BXA 170
	XCA			BXA 171
	FMP	BM1		BXA 172
	STO	XTEMP		BXA 173
	LDQ	ESQH		BXA 174
	FMP	C03		BXA 175
	FAD	C02		BXA 176
	XCA			BXA 177
	FMP	BMO		BXA 178
	FSB	XTEMP		BXA 179
	XCA			BXA 180
	FMP	COEFF		BXA 181
	XCA			BXA 182
	FMP	C02		BXA 183
	STO	QD1		BXA 184
* S241	LDQ	C06	GET APOGEE RATE	BXA 185
	FMP	ESQH		BXA 186
	STO	XTEMP		BXA 187
	LDQ	ECC		BXA 188
	FMP	C04		BXA 189
	FAD	XTEMP		BXA 190
	FAD	=1.		BXA 191
	XCA			BXA 192
	FMP	BM1		BXA 193
	STO	XTEMP		BXA 194
	LDQ	C04		BXA 195
	FMP	ESQH		BXA 196
	FAD	C01		BXA 197
	XCA			BXA 198
	FMP	BMO		BXA 199
	FAD	XTEMP		BXA 200
	XCA			BXA 201
	FMP	COEFF		BXA 202
	XCA			BXA 203
				BXA 204

TABLE E-13 (Cont'd)

	FMP	CO1		BXA 205
	STO	QD2		BXA 206
*			RETURN SEQUENCE	BXA 207
S250	LXD	BOXA-2,4		BXA 208
	TRA	1,4		BXA 209
*				BXA 210
HIC	STO	CABS	THIS PATH FOR C GREATER THAN CUTOFF --	BXA 211
	XCA		EXP(-C) IN STERNE'S EQUATION IS CANCELLED	BXA 212
	FMP	PI2	BY EXP(C) IN ASYMPTOTIC SERIES FOR BESMOD	BXA 213
	TPL	*+3		BXA 214
	CLA	ZERO		BXA 215
	TRA	*+4		BXA 216
	CALL	SQRT		BXA 217
	STO	XTEMP		BXA 218
	CALL	ASER,CABS,ZERO	BM0 = EXP(-C)*BESMOD(C,0)	BXA 219
	FDP	XTEMP		BXA 220
	STQ	BM0		BXA 221
	CALL	ASER,CABS,ONE	BM1 = EXP(-C)*BESMOD(C,1)	BXA 222
	LDQ	C		BXA 223
	LLS	0		BXA 224
	FDP	XTEMP		BXA 225
	STQ	BM1		BXA 226
	LDQ	DMR	COEFF = -DMR*RHOA*SQRTF(GMU*A)	BXA 227
	TRA	S216+7		BXA 228
*				BXA 229
XTEMP	PZE			BXA 230
Y1	PZE			BXA 231
CABS	PZE			BXA 232
CUTOFF	DEC	15.		BXA 233
ZERO	OCT	0000000000000		BXA 234
ONE	OCT	000001000000		BXA 235
TWO	OCT	000002000000		BXA 236
TRTSVN	OCT	000045000000		BXA 237
	BSS	3		BXA 238
INDAT	BSS	1		BXA 239
	BSS	4		BXA 240
ATDEC	BSS	1		BXA 241
	BSS	5		BXA 242
RHOA	BSS	1		BXA 243
QSUM	BSS	1		BXA 244
	BSS	14		BXA 245

TABLE E-13 (Cont'd)

ESQH	BSS	1	BXA	246
C	BSS	1	BXA	247
BM0	BSS	1	BXA	248
	BSS	30	BXA	249
BM1	BSS	1	BXA	250
COEFF	BSS	1	BXA	251
CO1	BSS	1	BXA	252
CO2	BSS	1	BXA	253
CO3	BSS	1	BXA	254
CO4	BSS	1	BXA	255
CO5	BSS	1	BXA	256
	BSS	3	BXA	257
CO6	BSS	1	BXA	258
*			BXA	259
	COMMON	614	BXA	260
YTBL	COMMON	37	BXA	261
	COMMON	365	BXA	262
DLTBL	COMMON	37	BXA	263
XPATBL	COMMON	37	BXA	264
Q1	COMMON	1	BXA	265
Q2	COMMON	1	BXA	266
QD1	COMMON	1	BXA	267
QD2	COMMON	1	BXA	268
QN	COMMON	10	BXA	269
RHOS	COMMON	1	BXA	270
A	COMMON	1	BXA	271
ERAD	COMMON	1	BXA	272
PI2	COMMON	1	BXA	273
GMU	COMMON	1	BXA	274
GEE	COMMON	1	BXA	275
Y	COMMON	1	BXA	276
LINT	COMMON	1	BXA	277
ECC	COMMON	1	BXA	278
ECSQ	COMMON	1	BXA	279
DMR	COMMON	1	BXA	280
ASQ	COMMON	1	BXA	281
PER	COMMON	1	BXA	282
APO	COMMON	1	BXA	283
RHOB	COMMON	1	BXA	284
TMACH1	COMMON	1	BXA	285
	END		BXA	286

TABLE E-14

FORTRAN LISTING - SUBROUTINE BESMOD

*	FAP	BES	1
	BESMOD MODIFIED BESSEL FUNCTION SUBROUTINE		
	ENTRY BESMOD	BES	3
*		BES	4
*****	SUBROUTINE BESMOD SOLVES ANY-ORDER MODIFIED BESSEL FUNCTION	BES	5
*****	(FIRST KIND) USED IN ORBITAL LIFETIME COMPUTATIONS.	BES	6
*		BES	7
BESMOD	SXD *-2,4	BES	8
	SXA XR2,2	BES	9
N100	CLA* 1,4	BES	10
	STO X	BES	11
N1002	CLA* 2,4	BES	12
	SSP	BES	13
	STO N	BES	14
N1005	XCA	BES	15
	CLM	BES	16
	LL 0	BES	17
	DVP TWO	BES	18
	LRS 18	BES	19
	ORA CHR	BES	20
	FAD CHR	BES	21
	STO XN	BES	22
N1006	TZE N1007	BES	23
	TPL N101	BES	24
N1007	CLA =1.	BES	25
	STO SYNE	BES	26
	CLA X	BES	27
	TRA N102+1	BES	28
N101	CLA =1.	BES	29
	LDQ X	BES	30
	LLS 0	BES	31
	STO SYNE	BES	32
N102	XCA	BES	33
	SSP	BES	34
	STO X	BES	35
	TZE N150	BES	36
N104	FSB CUTOFF	BES	37
	TPL N200	BES	38
N106	CLA X	BES	39

TABLE E-14 (Cont'd)

	FDP	=2.	BES	40
	STQ	HX	BES	41
N107	CL /	=1.	BES	42
	STO	GMULT	BES	43
	STO	SUM	BES	44
	STO	TERM	BES	45
N1075	CLA	N	BES	46
	TZE	N113	BES	47
N108	STD	EA2	BES	48
	AXT	1,2	BES	49
LOOP1	PXA	0,2	BES	50
	ORA	CHR	BES	51
	FAD	CHR	BES	52
	STO	XI	BES	53
N110	CLA	HX	BES	54
	FDP	XI	BES	55
	FMP	GMULT	BES	56
	STO	GMULT	BES	57
	TXI	*+1,2,1	BES	58
EA2	TXI	LOOP1,2,0	BES	59
	CLA	N	BES	60
N113	LR	18	BES	61
	ORA	CHR	BES	62
	FAD	CHR	BES	63
	STO	XN	BES	64
N116	AXT	1,2	BES	65
N118	PXA	0,2	BES	66
LOOP2	ORA	CHR	BES	67
	FAD	CHR	BES	68
	STO	XI	BES	69
N120	CLA	XN	BES	70
	FAD	XI	BES	71
	STO	XTEMP	BES	72
	LDQ	TERM	BES	73
	FMP	HX	BES	74
	FDP	XTEMP	BES	75
	FMP	HX	BES	76
	FDP	XI	BES	77
	XCA		BES	78
	STO	TERM	BES	79
N121	FAD	SUM	BES	80

TABLE E-14 (Cont'd)

	STO	SUM	BES	81
N122	CLA	TERM	BES	82
	FSB	=.000CC01	BES	83
	TMI	N130	BES	84
N123	CLA	TERM	BES	85
	FDP	SUM	BES	86
	XCA		BES	87
	FSB	=.000CC01	BES	88
	TMI	N130	BES	89
N125	TXI	*+1,2,1	BES	90
	TXL	N118,2,30	BES	91
N130	LDQ	GMULT	BES	92
	FMP	SUM	BES	93
	LDQ	SYNE	BES	94
	LLS	0	BES	95
XR2	AXT	0,2	BES	96
	LXD	BESMCC-2,4	BES	97
	TRA	3,4	BES	98
N150	CLA	N	BES	99
	TZE	N151	BES	100
N155	PXD	0,0	BES	101
	TRA	XR2	BES	102
N151	CLA	=1.	BES	103
	TRA	XR2	BES	104
N200	LDQ	X	BES	105
	FMP	PI2	BES	106
	CALL	SQRT	BES	107
	STO	XTEMP	BES	108
	CLA	X	BES	109
	CALL	EXP	BES	110
	FDP	XTEMP	BES	111
	CLA	SYNE	BES	112
	LRS	0	BES	113
	STQ	XTEMP	BES	114
	CALL	ASER,X,N	BES	115
	XCA		BES	116
	FMP	XTEMP	BES	117
	TRA	XR2	BES	118
X	PZE		BES	119
XN	PZE		BES	120
SYNE	PZE		BES	121

TABLE E-14 (Cont'd)

N	PZE	
XI	PZE	
XTEMP	PZE	
SUM	PZE	
GMULT	PZE	
PI2	DEC	6.283185307
TERM	PZE	
CHR	OCT	233000000000
HX		
CUTOFF	DEC	15.
TWO	OCT	000002000000
	END	

BES	122
BES	123
BES	124
BES	125
BES	126
BES	127
BES	128
BES	129
BES	130
BES	131
BES	132
BES	133

TABLE E-15
FORTRAN LISTING - FUNCTION ASER

ASER ASYMTOTIC SERIES FUNCTION

C	FUNCTION ASER(ARG,NN)	ASE	2
		ASE	3
C****	FUNCTION ASER EVALUATES ASYMPTOTIC SERIES FOR MODIFIED BESSEL	ASE	4
C****	FUNCTION.	ASE	5
C		ASE	6
10	X = ARG	ASE	7
15	N = NN	ASE	8
20	M = 4*N*N	ASE	9
25	X8 = 8.*X	ASE	10
30	TERM = 1.	ASE	11
35	SUM = 1.	ASE	12
40	DO 70 I=1,25	ASE	13
45	DENOM = M-(I+I-1)**2	ASE	14
50	EYE = I	ASE	15
55	TERM = -TERM*DENOM/X8/EYE	ASE	16
60	SUM = SUM + TERM	ASE	17
65	IF (ABSF(TERM)-.0000001)75,70,70	ASE	18
70	CONTINUE	ASE	19
75	ASER = SUM	ASE	20
80	RETURN	ASE	21
	END	ASE	22

TABLE E-16

FORTRAN LISTING - SUBROUTINE SORT

SORT SUBROUTINE	SOR	1
SUBROUTINE SORT	SOR	2
C	SOR	3
C**** SUBROUTINE SORT SORTS GROUND IMPACT TIMES INTO ASCENDING ORDER.	SOR	4
C**** IT THEN CALCULATES A NEW DECAY TIME FOR A RANGE OF IMPACT TIMES	SOR	5
C**** SO THAT THE DOSE RATES FROM FISSION PRODUCTS WILL BE WITHIN 10	SOR	6
C**** PERCENT OF DOSE RATE HAD THE ACTUAL IMPACT TIME BEEN USED.	SOR	7
C	SOR	8
C COMMON TO LINK ONE AND LINK TWO	SOR	9
COMMON TIMIMP,XMASS,DIAIMP,KASE,TITLE,ISET2	SOR	10
DIMENSION TIMIMP(200),XMASS(200),DIAIMP(200),TITLE(12)	SOR	11
C COMMON TO LINK TWO	SOR	12
COMMON A, ACTIV,ACTO,ACTTOT,BETSUB,BTOTAL,BETA,BETTOT,D,DIS,EGAM,	SOR	13
1 EG1,EG2,EB1,EB2,EBETA,FGAM,FR,F1,F2,F3,GAMSUB,GTOTAL,GAMMA,ICASE	SOR	14
2,J1,J2,J3,LINK,LLAST,M,N,NTIME,NOP,NO,SYMBOL,TIME,YIELD,FBETA	SOR	15
3,TSTART,POWER,Y,D,ACTIN,ALFA,NB,NG,G,B,GECONV,BECONV,N5,N6,N11,N9	SOR	16
4,TD,DELT,LIBCHS,INPUT,MICRO,CORMAS,NOC,IWANT,ICASE2	SOR	17
5,TIME2,N12,IALL,JT	SOR	18
DIMENSION A(1448),ACTIV(200),ACTTOT(274),BETSUB(5,200),BTOTAL(200)	SOR	19
1,DIS(274),EGAM(25),EG1(5),EG2(4),EB1(6),EB2(5),EBETA(25),FGAM(25)	SOR	20
2,FR(1448),F1(274),F2(274),F3(274),GAMSUB(4,200),GTOTAL(200)	SOR	21
3,ICASE(200),J1(274),J2(274),J3(274),LINK(645),M(275),N(645)	SOR	22
4,SYMBOL(274),TIME(200),YIELD(274),FBETA(25),TSTART(10),POWER(10)	SOR	23
5,Y(645),D(1448),ACTIN(274),ALFA(1448),ACTO(645),G(5),B(5)	SOR	24
6,GECONV(274,5),BECONV(274,5),BETA(274,5),GAMMA(274,4),BETTOT(274)	SOR	25
7,GAMTOT(274),IWANT(200),ICASE2(200),TIME2(200)	SOR	26
C DTA = TOLERANCE ON IMPACT TIME FOR DOSE DELIVERED BY PARTICLE TO BE	SOR	27
C WITHIN 10 PERCENT OF ACTUAL DOSE	SOR	28
C TD =TIME INTERVAL BETWEEN GROUND IMPACT AND INITIAL EXPOSURE (HRS.)	SOR	29
C DELT = TIME INTERVAL OF EXPOSURE TO THE RADIOACTIVE PARTICLE (HOURS)	SOR	30
DELT = DELT * 60.	SOR	31
TD = TD * 60.	SOR	32
JASE = KASE-1	SOR	33
DO 12 I=1,JASE	SOR	34
IP1 =I+1	SOR	35
DO 12 J=IP1,KASE	SOR	36
IF(TIME(I)-TIME(J)) 12,12,13	SOR	37
13 TEMP = TIME(I)	SOR	38
TIME(I)=TIME(J)	SOR	39

TABLE E-16 (Cont'd)

TIME(J)=TEMP	SOR 40
ITEMP =ICASE(I)	SOR 41
ICASE(I) = ICASE(J)	SOR 42
ICASE(J)=ITEMP	SOR 43
12 CONTINUE	SOR 44
ICON = 0	SOR 45
DO 200 I = 1,KASE	SOR 46
IF(ICON)100,10,100	SOR 47
10 T1 = TIME(I)	SOR 48
DTA = DTAU(T1, TD, DELT)	SOR 50
TIMMID = DTA + T1	SOR 51
C CALCULATE LOWER LIMIT	SOR 52
20 DTA = DTAU(TIMMID, TD, DELT)	SOR 53
TIMLOW = TIMMID - DTA	SOR 54
C COMPARE LOWER LIMIT TO STARTING TIME	SOR 55
IF(TIMLOW - T1)75,75,50	SOR 56
C T1 IS LARGER THAN LOWER LIMIT	SOR 57
50 TIMMID = .95*TIMMID	SOR 58
GO TO 20	SOR 59
C CALCULATE MAXIMUM LIMIT	SOR 60
75 TIMMAX = TIMMID + DTA	SOR 61
100 IF(TIME(I) - TIMMAX)110,110,120	SOR 62
110 TEMP = TIME(I)	SOR 63
TIME(I) = TIMMID	SOR 64
ICON= ICON + 1	SOR 65
GO TO 200	SOR 66
120 IF(ICON - 1)140,130,140	SOR 67
130 TIME(I-1) = TEMP	SOR 68
140 ICON = 0	SOR 69
GO TO 10	SOR 70
200 CONTINUE	SOR 71
IF(ICON - 1) 220,210,220	SOR 72
210 TIME(KASE) = TEMP	SOR 73
220 RETURN	SOR 74
END	SOR 75

TABLE E-17

FORTRAN LISTING - FUNCTION DTAU

DTAU FUNCTION

C	FUNCTION DTAU(TG,TD,DELT)	DTA	1
		DTA	2
C****	FUNCTION DTAU CALCULATES IMPACT TIME TOLERANCE FOR DOSE FROM	DTA	3
C****	PARTICLE TO BE WITHIN 10 PERCENT OF ACTUAL DOSE.	DTA	4
C		DTA	5
	DTAU=.5*(((TG+TD+DELT)**(-.2))-(TG+TD)**(-.2))/	DTA	6
1	((TG+TD+DELT)**(-1.2))-(TG+TD)**(-1.2)))	DTA	7
	RETURN	DTA	8
	END	DTA	9

TABLE E-18

FORTRAN LISTING - SUBROUTINE FPIP

FPIP SUBROUTINE	FPI	1
SUBROUTINE FPIP	FPI	2
C	FPI	3
C**** SUBROUTINE FPIP CALCULATES RADIOACTIVITY AND BETA AND GAMMA	FPI	4
C**** SOURCE STRENGTHS FOR EACH PARTICLE AT TIME OF GROUND IMPACT.	FPI	5
C	FPI	6
C COMMON TO LINK ONE AND LINK TWO	FPI	7
COMMON TIMIMP,XMASS,DIAIMP,KASE,TITLE,ISET2	FPI	8
DIMENSION TIMIMP(200),XMASS(200),DIAIMP(200),TITLE(12)	FPI	9
C COMMON TO LINK TWO	FPI	10
COMMON A, ACTIV,ACTO,ACTTOT,BETSUB,BTOTAL,BETA,BETTOT,D,DIS,EGAM,	FPI	11
1 EG1,EG2,EB1,EB2,EBETA,FGAM,FR,F1,F2,F3,GAMSUB,GTOTAL,GAMMA,ICASE	FPI	12
2,J1,J2,J3,LINK,LLAST,M,N,NTIME,NOP,NO,SYMBOL,TIME,YIELD,FBETA	FPI	13
3,TSTART,POWER,Y,D,ACTIN,ALFA,NB,NG,G,B,GECONV,BECONV,N5,N6,N11,N9	FPI	14
4,TD,DELT,LIBCHS,INPUT,MICRO,CORMAS,NOC,IWANT,ICASE2	FPI	15
5,TIME2,N12,IALL,JT	FPI	16
DIMENSION A(1448),ACTIV(200),ACTTOT(274),BETSUB(5,200),BTOTAL(200)	FPI	17
1,DIS(274),EGAM(25),EG1(5),EG2(4),EB1(6),EB2(5),EBETA(25),FGAM(25)	FPI	18
2,FR(1448),F1(274),F2(274),F3(274),GAMSUB(4,200),GTOTAL(200)	FPI	19
3,ICASE(200),J1(274),J2(274),J3(274),LINK(645),M(275),N(645)	FPI	20
4,SYMBOL(274),TIME(200),YIELD(274),FBETA(25),TSTART(10),POWER(10)	FPI	21
5,Y(645),D(1448),ACTIN(274),ALFA(1448),ACTO(645),G(5),B(5)	FPI	22
6,GECONV(274,5),BECONV(274,5),BETA(274,5),GAMMA(274,4),BETTOT(274)	FPI	23
7,GAMTOT(274),IWANT(200),ICASE2(200),TIME2(200)	FPI	24
C DIMENSION FOR SUBROUTINE FPIP	FPI	25
DIMENSION ACT(645),RATIOS(200)	FPI	26
N10 =10	FPI	27
REWIND N10	FPI	28
REWIND N11	FPI	29
10 CALL EPMDE(5)		
IF(LIBCHS)100,196,15	FPI	31
C LIBCHS = -1 USE TAPEN11, = 0 USE TAPE N10, = +1 GENERATE N10 AND N11	FPI	32
15 CALL CHAINS	FPI	33
C CHAINS CALCULATES SUBCHAINS FOR FORMATION OF EACH NUCLIDE	FPI	34
WRITE TAPEN11,NO,(SYMBOL(I),DIS(I),YIELD(I),J1(I),J2(I),J3(I),	FPI	35
1F1(I),F2(I),F3(I),I=1,NO)	FPI	36
WRITE TAPEN11,LLAST,JT,(M(I),I=2,NO),(N(L),LINK(L),Y(L),L=1,LLAST)	FPI	37
1,(FR(J),D(J),A(J),J=1,JT)	FPI	38
C NUM = NUMBER OF NUCLIDES	FPI	39

TABLE E-18 (Cont'd)

IF (INPUT)30,30,20	FPI	40
20 NUM=NO-1	FPI	41
WRITE OUTPUT TAPEN6,1002,TITLE	FPI	42
WRITE OUTPUT TAPEN6,1003,NUM	FPI	44
WRITE OUTPUT TAPEN6,1004	FPI	45
DO 25 I=1,NO	FPI	46
WRITE OUTPUT TAPEN6,1005,I,SYMBOL(I),DIS(I),YIELD(I),J1(I),J2(I),	FPI	47
1 J3(I),F1(I),F2(I),F3(I)	FPI	48
25 CONTINUE	FPI	49
WRITE OUTPUT TAPEN6,1006	FPI	50
WRITE OUTPUT TAPEN6,1007	FPI	51
C READ IN GAMMA ENERGY SPECTRA	FPI	52
30 DO 55 I=2,NO	FPI	53
READ INPUT TAPE N5,1001,NG,(EGAM(J),FGAM(J),J=1,NG)	FPI	54
WRITE TAPEN11,NG,(EGAM(K),FGAM(K),K=1,NG)	FPI	55
DO 35 K=1,4	FPI	56
35 GECONV(I,K)=0.	FPI	57
DO 45 J=1,NG	FPI	58
K=0	FPI	59
40 K=K+1	FPI	60
IF(EGAM(J)-G(K))45,45,40	FPI	61
45 GECONV(I,K)=GECONV(I,K)+EGAM(J)*FGAM(J)	FPI	62
IF (INPUT)55,55,50	FPI	63
50 WRITE OUTPUT TAPEN6,1008,I,SYMBOL(I),(EGAM(K),FGAM(K),K=1,NG)	FPI	64
55 CONTINUE	FPI	65
IF (INPUT) 65,65,60	FPI	66
60 WRITE OUTPUT TAPEN6,1009	FPI	67
WRITE OUTPUT TAPEN6,1007	FPI	68
C READ IN BETA ENERGY SPECTRA	FPI	69
65 DO 95 I = 2,NO	FPI	70
70 READ INPUT TAPE N5,1001,NB,(EBETA(J),FBETA(J),J=1,NB)	FPI	71
WRITE TAPEN11,NB,(EBETA(K),FBETA(K),K=1,NB)	FPI	72
IF (INPUT)72,72,71	FPI	73
1 WRITE OUTPUT TAPEN6,1008,I,SYMBOL(I),(EBETA(K),FBETA(K),K=1,NB)	FPI	74
2 DO 75 K=1,5	FPI	75
5 BECONV(I,K)=0.	FPI	76
DO 85 J=1,NB	FPI	77
EBETA(J)=EBETA(J)/3.	FPI	78
K=0	FPI	79
K=K+1	FPI	80
IF(EBETA(J)-B(K))85,85,80	FPI	81

TABLE E-18 (Cont'd)

85	BECONV(I,K)=BECONV(I,K)+EBETA(J)*FBETA(J)	FPI	82
95	CONTINUE	FPI	83
C	LIBRARY IS COMPLETELY GENERATED AT THIS POINT	FPI	84
	END FILE N11	FPI	85
	REWIND N11	FPI	86
	GO TO 185	FPI	87
C	READ LIBRARY FROM TAPE 11	FPI	88
100	READ TAPEN11,NO,(SYMBOL(I),DIS(I),YIELD(I),J1(I),J2(I),J3(I),F1(I),F2(I),F3(I),I=1,NO)	FPI	89
	READ TAPEN11,LLAST,JT,(M(I),I=2,NO),(N(L),LINK(L),Y(L),L=1,LLAST),I(FR(J),D(J),A(J),J=1,JT)	FPI	91
	IF (INPUT)115,115,105	FPI	92
105	WRITE OUTPUT TAPEN6,1002,TITLE	FPI	94
	NUM = NO - 1	FPI	95A
	WRITE OUTPUT TAPEN6,1003,NUM	FPI	95B
	WRITE OUTPUT TAPEN6,1004	FPI	96
	DO 110 I=1,NO	FPI	97
	WRITE OUTPUT TAPEN6,1005,I,SYMBOL(I),DIS(I),YIELD(I),J1(I),J2(I),J3(I),F1(I),F2(I),F3(I)	FPI	98
110	CONTINUE	FPI	99
	WRITE OUTPUT TAPEN6,1006	FPI	100
	WRITE OUTPUT TAPEN6,1007	FPI	101
115	DO 145 I=2,NO	FPI	102
	DO 120 K=1,4	FPI	103
120	GECONV(I,K)=0.	FPI	104
125	READ TAPEN11,NG,(EGAM(K),FGAM(K),K=1,NG)	FPI	105
	DO 135 J=1,NG	FPI	106
	K=0	FPI	107
130	K=K+1	FPI	108
	IF(EGAM(J)-G(K))135,135,130	FPI	109
135	GECONV(I,K)=GECONV(I,K)+EGAM(J)*FGAM(J)	FPI	110
	IF (INPUT)145,145,140	FPI	111
140	WRITE OUTPUT TAPEN6,1008,I,SYMBOL(I),(EGAM(K),FGAM(K),K=1,NG)	FPI	112
145	CONTINUE	FPI	113
	IF (INPUT)155,155,150	FPI	114
150	WRITE OUTPUT TAPE 6,1009	FPI	115
	WRITE OUTPUT TAPE 6,1007	FPI	116
155	DO 180 I=2,NO	FPI	117
	DO 160 K=1,5	FPI	118
160	BECONV(I,K)=0.	FPI	119
	READ TAPEN11,NB,(EBETA(K),FBETA(K),K=1,NB)	FPI	120
		FPI	121
		FPI	122

TABLE E-18 (Cont'd)

IF (INPUT)162,162,161	FPI 123
161 WRITE OUTPUT TAPEN6,1008,I,SYMBOL(I),(EBETA(K),FBETA(K),K=1,NB)	FPI 124
162 DO 170 J=1,NB	FPI 125
EBETA(J)=EBETA(J)/3.	FPI 126
K=0	FPI 127
165 K=K+1	FPI 128
IF(EBETA(J)-B(K))170,170,165	FPI 129
170 BECONV(I,K)=BECONV(I,K)+EBETA(J)*FBETA(J)	FPI 130
180 CONTINUE	FPI 131A
REWIND N11	FPI 131B
C LIBRARY IS COMPLETELY READ INTO CORE FROM TAPE N11 AT THIS POINT	FPI 132
C CALCULATE LOWER AND UPPER BOUNDS OF GAMMA ENERGY GROUPS	FPI 133
185 EG1(1)=0.	FPI 134
DO 190 K=1,4	FPI 135
EG2(K)=G(K)	FPI 136
190 EG1(K+1)=EG2(K)+0.01	FPI 137
C CALCULATE LOWER AND UPPER BOUNDS OF BETA ENERGY GROUPS	FPI 138
EB1(1)=0.	FPI 139
DO 192 K=1,5	FPI 140
EB2(K)=B(K)	FPI 141
192 EB1(K+1)=EB2(K)+0.01	FPI 142
193 WRITE TAPEN10,NO,(SYMBOL(I),DIS(I),YIELD(I),J1(I),J2(I),J3(I),	FPI 143
1F1(I),F2(I),F3(I),I=1,NO)	FPI 144
WRITE TAPEN10,LLAST, JT, (M(I),I=2,NO),(N(L),LINK(L),Y(L),L=1,LLAST)	FPI 145
1,(FR(J),D(J),A(J),J=1,JT)	FPI 146
WRITE TAPE N10,((GECONV(I,L), L=1,4),(BECONV(I,M), M=1,5), I=2,NO)	FPI 147
195 WRITE TAPE N10, (EG1(L),EG2(L),L=1,3),EG1(4),(EB1(L),EB2(L),L=1,4)	FPI 148
1,EB1(5)	FPI 149
END FILE N10	FPI 150
REWIND N10	FPI 151
GO TO 199	FPI 152
96 READ TAPEN10,NO,(SYMBOL(I),DIS(I),YIELD(I),J1(I),J2(I),J3(I),	FPI 153
1F1(I),F2(I),F3(I),I=1,NO)	FPI 154
READ TAPEN10,LLAST, JT, (M(I),I=2,NO),(N(L),LINK(L),Y(L),L=1,LLAST)	FPI 155
1,(FR(J),D(J),A(J),J=1,JT)	FPI 156
READ TAPE N10,((GECONV(I,L), L=1,4),(BECONV(I,M), M=1,5), I=2,NO)	FPI 157
READ TAPE N10, (EG1(L),EG2(L),L=1,3),EG1(4),(EB1(L),EB2(L),L=1,4)	FPI 158
1,EB1(5)	FPI 159
REWIND N10	FPI 160
9 INPUT (NO.OF CASES, ENERGY LIMITS AND SYMBOLS)	FPI 161
WRITE TAPEN9,KASE,(EG1(L),EG2(L),L=1,3),EG1(4),(EB1(L),EB2(L),	FPI 162

TABLE E-18 (Cont'd)

1	L=1,4),EB1(5),NO,(SYMBOL(I),I=2,NO)	FPI 163
	DO 200 L=1,LLAST	FPI 164
200	ACTO(L)=0.	FPI 165
	TLAST = TSTART(NOP)	FPI 166
	NUMOP = NOP - 1	FPI 167
	NTIME = NUMOP + KASE	FPI 168
	I = 0	FPI 169
	DO 210 K = NOP,NTIME	FPI 170
	I = I+1	FPI 171
	TIME2(K) = TIME(I) + TLAST	FPI 172
210	CONTINUE	FPI 173
	NT2 = 0	FPI 174
	DO 380 NN = 1,NOP	FPI 175
	NT1 = NT2+1	FPI 176
	IF(NN-NUMOP)211,211,212	FPI 177
211	NT2 = NT2 + 1	FPI 178
	GO TO 214	FPI 179
212	NT2 = NT2 + KASE	FPI 180
214	TO = TSTART(NN)	FPI 181
	GAM = POWER(NN)	FPI 182
	CALL ALFAS(GAM)	FPI 183
	DO 380 K = NT1, NT2	FPI 184
	IF(NN - NUMOP)220,220,215	FPI 185
215	IF(TIME2(K-1)- TIME2(K))225,345,225	FPI 186
C IOP = 1	DO NOT WRITE DATA ON TAPE 9	FPI 187
220	IOP = 1	FPI 188
	T = TIME2(K)	FPI 189
	RATIO = 1.0	FPI 190
	GO TO 230	FPI 191
225	T = TIME2(K)	FPI 192
	K5 = K - NUMOP	FPI 193
	K1 = ICASE(K5)	FPI 194
	RATIOS(K) = XMASS(K1) / CORMAS	FPI 195
	RATIO = RATIOS(K)	FPI 196
	IOP = 0	FPI 197
230	JL = 0	FPI 198
	DO 260 L=1,LLAST	FPI 199
	JF=JL+1	FPI 200
	JL=JL+N(L)	FPI 201
	X=D(JL)*(T-TO)	FPI 202
	IF(X-0.5)235,240,240	FPI 203

TABLE E-18 (Cont'd)

```

235 TERM=X*(1.-(X/2.)*(1.-(X/3.)*(1.-(X/4.)*(1.-(X/5.)*(1.-(X/6.)*(1.-FPI 204
    1(X/7.)*(1.-(X/8.)*(1.-(X/9.)*(1.-(X/10.)))))))))) FPI 205
    GO TO 245 FPI 206
240 TERM=1.-EXP(-X) FPI 207
245 ACT(L)=ACTO(L)*EXP(-X) FPI 208
    DO 260 J=JF,JL FPI 209
    X=(D(JL)-D(J))*(T-TO) FPI 210
    ACT(L)=ACT(L)+A(J)*ALFA(J)*TERM FPI 211
    IF(ABS(X)-0.5)250,255,255 FPI 212
250 TERM=X*(1.-(X/2.)*(1.-(X/3.)*(1.-(X/4.)*(1.-(X/5.)*(1.-(X/6.)*(1.-FPI 213
    1(X/7.)*(1.-(X/8.)*(1.-(X/9.)*(1.-(X/10.)))))))))) FPI 214
    TERM=TERM*EXP(-D(J)*(T-TO)) FPI 215
    GO TO 260 FPI 216
255 TERM=EXP(-D(J)*(T-TO))-EXP(-D(JL)*(T-TO)) FPI 217
260 CONTINUE FPI 218
    IF(K-NT2)290,265,265 FPI 219
265 IF(MICRO)270,280,270 FPI 220
270 DO 275 I=2,NO FPI 221
    L=M(I)+1 FPI 222
275 ACTO(L)=ACTIN(I) FPI 223
    GO TO 290 FPI 224
280 DO 285 L=1,LLAST FPI 225
285 ACTO(L)=ACT(L) FPI 226
290 L2=0 FPI 227
    ACTIV(K)=0. FPI 228
    DO 300 I=2,NO FPI 229
    ACTTOT(I)=0. FPI 230
    L1=L2+1 FPI 231
    L2=M(I+1) FPI 232
    DO 295 L=L1,L2 FPI 233
35 ACTTOT(I)=ACTTOT(I)+ACT(L) FPI 234
6 IF(MICRO)297,299,297 FPI 235
7 ACTTOT(I)=ACTTOT(I)*RATIO FPI 236
8 GO TO 300 FPI 237
    ACTTOT(I)=(ACTTOT(I)/2220000.)*RATIO FPI 238
    ACTIV(K)=ACTIV(K)+ACTTOT(I) FPI 239
    DO 305 L=1,4 FPI 240
    GAMSUB(L,K)=0. FPI 241
    DO 315 I=2,NO FPI 242
    GAM(I,I)=0. FPI 243
    DO 310 L=1,4 FPI 244

```

TABLE E-18 (Cont'd)

GAMMA(I,L) = ACTTOT(I) * GECONV(I,L) * 37000.	FPI 245
GAMSUB(L,K) = GAMSUB(L,K) + GAMMA(I,L)	FPI 246
310 GAMTOT(I) = GAMTOT(I) + GAMMA(I,L)	FPI 247
315 CONTINUE	FPI 248
GTOTAL(K)=0.	FPI 249
DO 320 L=1,4	FPI 250
320 GTOTAL(K)=GTOTAL(K)+GAMSUB(L,K)	FPI 251
DO 325 L=1,5	FPI 252
325 BETSUB(L,K)=0.	FPI 253
DO 335 I=2,NO	FPI 254
BETTOT(I) = 0.	FPI 255
DO 330 L=1,5	FPI 256
BETA(I,L) = ACTTOT(I) * BECONV(I,L) * 37000.	FPI 257
BETSUB(L,K)=BETSUB(L,K)+BETA(I,L)	FPI 258
330 BETTOT(I) = BETTOT(I) + BETA(I,L)	FPI 259
335 CONTINUE	FPI 260
BTOTAL(K)=0.	FPI 261
DO 340 L=1,5	FPI 262
340 BTOTAL(K)=BTOTAL(K)+BETSUB(L,K)	FPI 263
IF(IOP)380,375,380	FPI 264
345 K5 = K - NUMOP	FPI 265
K1 = ICASE(K5)	FPI 266
RATIOS(K) = XMASS(K1) / CORMAS	FPI 267
RATIO = RATIOS(K) / RATIOS(K-1)	FPI 268
DO 360 I = 2,NO	FPI 269
ACTTOT(I) = ACTTOT(I) * RATIO	FPI 270
GAMTOT(I) = GAMTOT(I) * RATIO	FPI 271
BETTOT(I) = BETTOT(I) * RATIO	FPI 272
DO 350 L = 1,4	FPI 273
350 GAMMA(I,L) = GAMMA(I,L) * RATIO	FPI 274
DO 355 L = 1,5	FPI 275
355 BETA(I,L) = BETA(I,L) * RATIO	FPI 276
360 CONTINUE	FPI 277
DO 365 L = 1,4	FPI 278
365 GAMSUB(L,K) = GAMSUB(L,K-1) * RATIO	FPI 279
DO 370 L = 1,5	FPI 280
370 BETSUB(L,K) = BETSUB(L,K-1) * RATIO	FPI 281
ACTIV(K) = ACTIV(K-1) * RATIO	FPI 282
GTOTAL(K) = GTOTAL(K-1) * RATIO	FPI 283
BTOTAL(K) = BTOTAL(K-1) * RATIO	FPI 284
C TAPE 9 OUTPUT FOR EACH CASE	FPI 285

TABLE E-18 (Cont'd)

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375 WRITE TAPEN9, K1,      TIMIMP(K1),TIME(K5),(ACTTOT(I), (GAMMA(I,L,FPI 286
    1), L=1,4), GAMTOT(I), (BETA(I,L), L =1,5), BETTOT(I), I=2,NO),      FPI 287
    2 ACTIV(K), (GAMSUB(L,K), L=1,4), GTOTAL(K), (BETSUB(L,K), L=1,5)      FPI 288
    3, BTOTAL(K)                                                    FPI 289
380 CONTINUE                                                        FPI 290
1001 FORMAT(5X12,5(F7.4,F6.4)/(7XF7.4,F6.4,F7.4,F6.4,F7.4,F6.4,      FPI 291
    1F7.4,F6.4,F7.4,F6.4))                                          FPI 292
1002 FORMAT(1H1,18X,12A6///,16H INPUT LIBRARIES,////////)          FPI 293
1003 FORMAT(26H0TOTAL NUMBER OF NUCLIDES=I4)                        FPI 294
1004 FORMAT(12H0NUCLIDE NO.,2X15HCHEMICAL SYMBOL,2X18HDIS. CONST.(MIN-1FPI 295
    1),2X13HFISSION YIELD,2X14HDIRECT PARENTS,2X16HBRANCHING RATIOS//) FPI 296
1005 FORMAT(1H 4XI3,10XA6,9XE12.4,7XE10.3,4X3I4,3X3F6.3)          FPI 297
1006 FORMAT(14H1GAMMA SPECTRA)                                      FPI 298
1007 FORMAT(12H0NUCLIDE NO.,2X6HSYMBOL,1X6(14H (MEV) FRACT.))//)    FPI 299
1008 FORMAT(1H 4XI3,6XA6,6(F8.3,F6.3)/(20XF8.3,F6.3,F8.3,F6.3,F8.3,F6.3FPI 300
    1,F8.3,F6.3,F8.3,F6.3,F8.3,F6.3))                              FPI 301
1009 FORMAT(13H1BETA SPECTRA)                                       FPI 302
1013 FORMAT(5(4X,E10.4))                                            FPI 303
    RETURN                                                            FPI 304
    END                                                                FPI 305

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TABLE E-19

FORTRAN LISTING - SUBROUTINE CHAINS

CHAINS	SUBROUTINE	CHA	1
	SUBROUTINE CHAINS	CHA	2
C		CHA	3
C****	SUBROUTINE CHAINS CALCULATES THE SUBCHAINS REPRESENTING THE	CHA	4
C****	FORMATION OF EACH NUCLIDE FROM ALL ITS PARENTS.	CHA	5
C		CHA	6
C	COMMON TO LINK ONE AND LINK TWO	CHA	7
	COMMON TIMIMP,XMASS,DIAIMP,KASE,TITLE,ISET2	CHA	8
	DIMENSION TIMIMP(200),XMASS(200),DIAIMP(200),TITLE(12)	CHA	9
C	COMMON TO LINK TWO	CHA	10
	COMMON A, ACTIV,ACTO,ACTTOT,BETSUB,BTOTAL,BETA,BETTOT,D,DIS,EGAM,	CHA	11
	1 EG1,EG2,EB1,EB2,EBETA,FGAM,FR,F1,F2,F3,GAMSUB,GTOTAL,GAMMA,ICASE	CHA	12
	2,J1,J2,J3,LINK,LLAST,M,N,NTIME,NOP,NO,SYMBOL,TIME,YIELD,FBETA	CHA	13
	3,TSTART,POWER,Y,D,ACTIN,ALFA,NB,NG,G,B,GECONV,BECONV,N5,N6,N11,N9	CHA	14
	4,TD,DELT,LIBCHS,INPUT,MICRO,CORMAS,NOC,IWANT,ICASE2	CHA	15
	5,TIME2,N12,IALL,JT	CHA	16
	DIMENSION A(1448),ACTIV(200),ACTTOT(274),BETSUB(5,200),BTOTAL(200)	CHA	17
	1,DIS(274),EGAM(25),EG1(5),EG2(4),EB1(6),EB2(5),EBETA(25),FGAM(25)	CHA	18
	2,FR(1448),F1(274),F2(274),F3(274),GAMSUB(4,200),GTOTAL(200)	CHA	19
	3,ICASE(200),J1(274),J2(274),J3(274),LINK(645),M(275),N(645)	CHA	20
	4,SYMBOL(274),TIME(200),YIELD(274),FBETA(25),TSTART(10),POWER(10)	CHA	21
	5,Y(645),D(1448),ACTIN(274),ALFA(1448),ACTO(645),G(5),B(5)	CHA	22
	6,GECONV(274,5),BECONV(274,5),BETA(274,5),GAMMA(274,4),BETTOT(274)	CHA	23
	7,GAMTOT(274),IWANT(200),ICASE2(200),TIME2(200)	CHA	24
	IF(NO) 105,100,105	CHA	25
100	READ INPUT TAPE N5,101,NO	CHA	26
105	DO 115 I=1,NO	CHA	27
	READ INPUT TAPE 5,103,SYMBOL(I),DIS(I),YIELD(I),J1(I),J2(I),J3(I),	CHA	28
	1F1(I),F2(I),F3(I)	CHA	29
115	CONTINUE	CHA	30
	JL=0	CHA	31
	M(1)=0	CHA	32
	M(2)=0	CHA	33
	DO 170 I=2,NO	CHA	34
	K1=J1(I)	CHA	35
	K2=J2(I)	CHA	36
	K3=J3(I)	CHA	37
	M(I+1)=1+M(I)+M(K1+1)-M(K1)+M(K2+1)-M(K2)+M(K3+1)-M(K3)	CHA	38
	IF(YIELD(I))125,125,130	CHA	39

TABLE E-19 (Cont'd)

125	M(I+1)=M(I+1)-1	CHA	40
130	MM=0	CHA	41
	L2=M(I)	CHA	42
	L1=L2+1	CHA	43
	K=M(K1)	CHA	44
	F=F1(I)	CHA	45
	L2=L2+M(K1+1)-K	CHA	46
133	IF(L2-L1)160,135,135	CHA	47
135	DO 150 L=L1,L2	CHA	48
	KK=0	CHA	49
	IF(K-1)145,140,140	CHA	50
140	DO 143 LS=1,K	CHA	51
143	KK=KK+N(LS)	CHA	52
145	K=K+1	CHA	53
	N(L)=1+N(K)	CHA	54
	Y(L)=Y(K)	CHA	55
	LINK(L)=K	CHA	56
	JF=JL+1	CHA	57
	JL=JL+N(L)-1	CHA	58
	DO 148 J=JF,JL	CHA	59
	KK=KK+1	CHA	60
	D(J)=D(KK)	CHA	61
148	FR(J)=FR(KK)	CHA	62
	JL=JL+1	CHA	63
	D(JL)=DIS(I)	CHA	64
150	FR(JL)=F	CHA	65
	MM=MM+1	CHA	66
	L1=L2+1	CHA	67
	GO TO(153,155,160),MM	CHA	68
153	K=M(K2)	CHA	69
	F=F2(I)	CHA	70
	L2=L2+M(K2+1)-K	CHA	71
	GO TO 133	CHA	72
155	K=M(K3)	CHA	73
	F=F3(I)	CHA	74
	L2=L2+M(K3+1)-K	CHA	75
	GO TO 133	CHA	76
160	IF(YIELD(I))170,170,165	CHA	77
165	JL=JL+1	CHA	78
	N(L1)=1	CHA	79
	Y(L1)=YIELD(I)	CHA	80

TABLE E-19 (Cont'd)

	LINK(L1)=0	CHA 81
	D(JL)=DIS(I)	CHA 82
	FR(JL)=1.	CHA 83
170	CONTINUE	CHA 84
	JL=0	CHA 85
	LLAST=M(NO+1)	CHA 86
	DO 190 L=1,LLAST	CHA 87
	JF=JL+1	CHA 88
	JL=JL+N(L)-1	CHA 89
	ILAST=JL+1	CHA 90
	IF(JL-JF)185,175,175	CHA 91
175	DO 180 J=JF,JL	CHA 92
	IFIRST=J+1	CHA 93
	A(J+1)=1.	CHA 94
	DO 180 I=IFIRST,ILAST	CHA 95
180	A(J+1)=A(J+1)*D(I)*FR(I)/(D(I)-D(J))	CHA 96
185	JL=JL+1	CHA 97
	A(JF)=Y(L)	CHA 98
	DO 190 I=JF,JL	CHA 99
190	A(JF)=A(JF)*FR(I)	CHA 100
	JT=JL	CHA 101
101	FORMAT (I4)	CHA 102
103	FORMAT(5XA6,2E12.4,3I4,3F7.3)	CHA 103
	RETURN	CHA 104
	END	CHA 105

TABLE E-20
FORTRAN LISTING - SUBROUTINE ALFAS

ALFAS SUBROUTINE	ALF	1
SUBROUTINE ALFAS(GAM)	ALF	2
C	ALF	3
C**** SUBROUTINE ALFAS GENERATES THE FISSION POWER COEFFICIENT FOR	ALF	4
C**** EACH OPERATING AND SHUTDOWN PERIOD.	ALF	5
C	ALF	6
C COMMON TO LINK ONE AND LINK TWO	ALF	7
COMMON TIMIMP,XMASS,DIAIMP,KASE,TITLE,ISET2	ALF	8
DIMENSION TIMIMP(200),XMASS(200),DIAIMP(200),TITLE(12)	ALF	9
C COMMON TO LINK TWO	ALF	10
COMMON A, ACTIV,ACTO,ACTTOT,BETSUB,BTOTAL,BETA,BETTOT,D,DIS,EGAM,	ALF	11
1 EG1,EG2,EB1,EB2,EBETA,FGAM,FR,F1,F2,F3,GAMSUB,GTOTAL,GAMMA,ICASE	ALF	12
2,J1,J2,J3,LINK,LLAST,M,N,NTIME,NOP,NO,SYMBOL,TIME,YIELD,FBETA	ALF	13
3,TSTART,POWER,Y,D,ACTIN,ALFA,NB,NG,G,B,GECONV,BECONV,N5,N6,N11,N9	ALF	14
4,TD,DELT,LIBCHS,INPUT,MICRO,CORMAS,NOC,IWANT,ICASE2	ALF	15
5,TIME2,N12,IALL,JT	ALF	16
DIMENSION A(1448),ACTIV(200),ACTTOT(274),BETSUB(5,200),BTOTAL(200)	ALF	17
1,DIS(274),EGAM(25),EG1(5),EG2(4),EB1(6),EB2(5),EBETA(25),FGAM(25)	ALF	18
2,FR(1448),F1(274),F2(274),F3(274),GAMSUB(4,200),GTOTAL(200)	ALF	19
3,ICASE(200),J1(274),J2(274),J3(274),LINK(645),M(275),N(645)	ALF	20
4,SYMBOL(274),TIME(200),YIELD(274),FBETA(25),TSTART(10),POWER(10)	ALF	21
5,Y(645),D(1448),ACTIN(274),ALFA(1448),ACTO(645),G(5),B(5)	ALF	22
6,GECONV(274,5),BECONV(274,5),BETA(274,5),GAMMA(274,4),BETTOT(274)	ALF	23
7,GAMTOT(274),IWANT(200),ICASE2(200),TIME2(200)	ALF	24
JL=0	ALF	25
DO 295 L=1,LLAST	ALF	26
JF=JL+1	ALF	27
JL=JL+N(L)-1	ALF	28
LC=LINK(L)-1	ALF	29
KK=0	ALF	30
IF(LC)290,220,210	ALF	31
210 DO 215 K=1,LC	ALF	32
215 KK=KK+N(K)	ALF	33
220 K1=KK	ALF	34
DO 230 J=JF,JL	ALF	35
K1=K1+1	ALF	36
230 ALFA(J)=ALFA(K1)	ALF	37
JL=JL+1	ALF	38
T1=KK+1	ALF	39

TABLE E-20 (Cont'd)

I2=KK+N(LC+1)	ALF	40
ALFA(JL)=ACTO(LC+1)	ALF	41
DO 250 I=I1,I2	ALF	42
250 ALFA(JL)=ALFA(JL)-ALFA(I)*A(I)	ALF	43
GO TO 295	ALF	44
290 JL=JL+1	ALF	45
ALFA(JL)=GAM	ALF	46
295 CONTINUE	ALF	47
RETURN	ALF	48
END	ALF	49

TABLE E-21
FORTRAN LISTING - SUBROUTINE SCRIB

SCRIB	SUBROUTINE	SCR	1
	SUBROUTINE SCRIB	SCR	2
C		SCR	3
C****	SUBROUTINE SCRIB WRITES OUT COMPLETE DATA STORED ON TAPE 9.	SCR	4
C****	THIS DATA CONTAINS FISSION PRODUCT ACTIVITY AND SOURCE STRENGTH	SCR	5
C****	ENERGIES OF EACH NUCLIDE FOR EVERY CASE.	SCR	6
C		SCR	7
C	COMMON TO LINK ONE AND LINK TWO	SCR	8
	COMMON TIMIMP,XMASS,DIAIMP,KASE,TITLE,ISET2	SCR	9
	DIMENSION TIMIMP(200),XMASS(200),DIAIMP(200),TITLE(12)	SCR	10
C	COMMON TO LINK TWO	SCR	11
	COMMON A, ACTIV,ACTO,ACTTOT,BETSUB,BTOTAL,BETA,BETTOT,D,DIS,EGAM,	SCR	12
	1 EG1,EG2,EB1,EB2,EBETA,FGAM,FR,F1,F2,F3,GAMSUB,GTOTAL,GAMMA,ICASE	SCR	13
	2,J1,J2,J3,LINK,LLAST,M,N,NTIME,NOP,NO,SYMBOL,TIME,YIELD,FBETA	SCR	14
	3,TSTART,POWER,Y,D,ACTIN,ALFA,NB,NG,G,B,GECONV,BECONV,N5,N6,N11,N9	SCR	15
	4,TD,DELT,LIBCHS,INPUT,MICRO,CORMAS,NOC,IWANT,ICASE2	SCR	16
	5,TIME2,N12,IALL,JT	SCR	17
	DIMENSION A(1448),ACTIV(200),ACTTOT(274),BETSUB(5,200),BTOTAL(200)	SCR	18
	1,DIS(274),EGAM(25),EG1(5),EG2(4),EB1(6),EB2(5),EBETA(25),FGAM(25)	SCR	19
	2,FR(1448),F1(274),F2(274),F3(274),GAMSUB(4,200),GTOTAL(200)	SCR	20
	3,ICASE(200),J1(274),J2(274),J3(274),LINK(645),M(275),N(645)	SCR	21
	4,SYMBOL(274),TIME(200),YIELD(274),FBETA(25),TSTART(10),POWER(10)	SCR	22
	5,Y(645),D(1448),ACTIN(274),ALFA(1448),ACTO(645),G(5),B(5)	SCR	23
	6,GECONV(274,5),BECONV(274,5),BETA(274,5),GAMMA(274,4),BETTOT(274)	SCR	24
	7,GAMTOT(274),IWANT(200),ICASE2(200),TIME2(200)	SCR	25
C*	IFOL = CONTROL TO SEARCH MORE THAN 1 SET OF PROBLEMS ON TAPE N9	SCR	26
C*	1 = MORE SETS TO FOLLOW, 0= NO SETS TO FOLLOW	SCR	27
C*	ISET3 = PROBLEM SET NUMBER AS STORED ON TAPE N9	SCR	28
C	IALL = OPTION TO PRINT ALL CASES 0= NO, 1= YES	SCR	29
C	NOC = NUMBER OF CASES YOU WISH PRINTED	SCR	30
C*	IWANT = CASE NUMBERS OF THOSE YOU WISH PRINTED	SCR	31
	K=1	SCR	32
10	READ INPUT TAPE N5,1009,IFOL,ISET3,IALL,NOC,(IWANT(I),I=1,NOC)	SCR	33
15	READ TAPE N9,ISET2,ISET,TITLE	SCR	34
	IF(ISET2-ISET3)20,30,20	SCR	35
20	READ TAPEN9,KASE,(EG1(L),EG2(L),L=1,3),EG1(4),(EB1(L),EB2(L),	SCR	36
	1L=1,4),EB1(5),NO,(SYMBOL(I),I=2,NO)	SCR	37
	DO 25 K=1,KASE	SCR	38
25	READ TAPEN9, ICASE(K), TIMIMP(K), TIME(K), (ACTTOT(I), (GAMMA(I,L	SCR	39

TABLE E-21 (Cont'd)

1), L=1,4), GAMTOT(I), (BETA(I,L), L =1,5), BETTOT(I), I=2,NO),	SCR	40
2 ACTIV(K), (GAMSUB(L,K), L=1,4), GTOTAL(K), (BETSUB(L,K), L=1,5)	SCR	41
3, BTOTAL(K)	SCR	42
IF(ISET)15,140,15	SCR	43
30 IF (IALL)55,55,35	SCR	44
35 READ TAPEN9,KASE,(EG1(L),EG2(L),L=1,3),EG1(4),(EB1(L),EB2(L),	SCR	45
1L=1,4),EB1(5),NO,(SYMBOL(I),I=2,NO)	SCR	46
ICONT = KASE	SCR	47
DO 50 K=1,KASE	SCR	48
READ TAPEN9, ICASE(K), TIMIMP(K), TIME(K), (ACTTOT(I), (GAMMA(I,L	SCR	49
1), L=1,4), GAMTOT(I), (BETA(I,L), L =1,5), BETTOT(I), I=2,NO),	SCR	50
2 ACTIV(K), (GAMSUB(L,K), L=1,4), GTOTAL(K), (BETSUB(L,K), L=1,5)	SCR	51
3, BTOTAL(K)	SCR	52
WRITE OUTPUT TAPEN6,1000,ISET2,TITLE	SCR	53
WRITE OUTPUT TAPE N6,1001,ICASE(K),TIMIMP(K),TIME(K)	SCR	54
WRITE OUTPUT TAPEN6,1002,(EG1(L),EG2(L),L=1,3),EG1(4)	SCR	55
DO 40 I=2,NO	SCR	56
WRITE OUTPUT TAPE N6,1003,I,SYMBOL(I),ACTTOT(I),(GAMMA(I,L),L=1,4)	SCR	57
1, GAMTOT(I)	SCR	58
40 CONTINUE	SCR	59
WRITE OUTPUT TAPE N6,1004,ACTIV(K),(GAMSUB(L,K),L=1,4),GTOTAL(K)	SCR	60
WRITE OUTPUT TAPEN6,1005,(EB1(L),EB2(L),L=1,4),EB1(5)	SCR	61
DO 45 I=2,NO	SCR	62
WRITE OUTPUT TAPE N6,1006,I,SYMBOL(I),ACTTOT(I),(BETA(I,L),L=1,5),	SCR	63
1 BETTOT(I)	SCR	64
45 CONTINUE	SCR	65
WRITE OUTPUT TAPE N6,1007,ACTIV(K),(BETSUB(L,K),L=1,5),BTOTAL(K)	SCR	66
50 CONTINUE	SCR	67
IF (IFOL) 140,140,120	SCR	68
55 ICONT =0	SCR	69
IREAD = 0	SCR	70
DO 115 J=1,NOC	SCR	71
IF (IREAD) 65,60,65	SCR	72
60 READ TAPEN9,KASE,(EG1(L),EG2(L),L=1,3),EG1(4),(EB1(L),EB2(L),	SCR	73
1L=1,4),EB1(5),NO,(SYMBOL(I),I=2,NO)	SCR	74
IREAD =1	SCR	75
65 IF (KASE - IWANT(J)) 70,75,75	SCR	76
70 WRITE OUTPUT TAPEN6,1008,IWANT(J),N9	SCR	77
GO TO 115	SCR	78
75 READ TAPEN9, ICASE(K), TIMIMP(K), TIME(K), (ACTTOT(I), (GAMMA(I,L	SCR	79
1), L=1,4), GAMTOT(I), (BETA(I,L), L =1,5), BETTOT(I), I=2,NO),	SCR	80

TABLE E-21 (Cont'd)

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2  ACTIV(K), (GAMSUB(L,K), L=1,4), GTOTAL(K), (BETSUB(L,K), L=1,5) SCR 81
3,BTOTAL(K) SCR 82
  ICONT = ICONT + 1 SCR 83
  IF(ICASE(K)-IWANT(J)) 80,85,80 SCR 84
80 IF (KASE - ICONT) 75,105,75 SCR 85
85 WRITE OUTPUT TAPEN6,1000,ISET2,TITLE SCR 86
  WRITE OUTPUT TAPE N6,1001,ICASE(K),TIMIMP(K),TIME( K) SCR 87
  WRITE OUTPUT TAPEN6,1002,(EG1(L),EG2(L),L=1,3),EG1(4) SCR 88
  DO 90 I=2,NO SCR 89
  WRITE OUTPUT TAPE N6,1003,I,SYMBOL(I),ACTTOT(I),(GAMMA(I,L),L=1,4) SCR 90
1,  GAMTOT(I) SCR 91
90 CONTINUE SCR 92
  WRITE OUTPUT TAPE N6,1004,ACTIV( K),(GAMSUB(L,K),L=1,4),GTOTAL(K) SCR 93
  WRITE OUTPUT TAPEN6,1005,(EB1(L),EB2(L),L=1,4),EB1(5) SCR 94
  DO 95 I=2,NO SCR 95
  WRITE OUTPUT TAPE N6,1006,I,SYMBOL(I),ACTTOT(I),(BETA(I,L),L=1,5), SCR 96
1  BETTOT(I) SCR 97
95 CONTINUE SCR 98
  WRITE OUTPUT TAPE N6,1007,ACTIV( K),(BETSUB(L,K),L=1,5),BTOTAL(K) SCR 99
  IF(KASE-ICONT) 115,100,115 SCR 100
100 IF(J - NOC)105,115,105 SCR 101
105 DO 110 I=1,KASE SCR 102
110 BACKSPACE N9 SCR 103
  ICONT = 0 SCR 104
  IF(ICASE(K)-IWANT(J)) 75,115,75 SCR 105
115 CONTINUE SCR 106
  IF (IFOL) 140,140,120 SCR 107
120 IF (ISET)140,140,125 SCR 108
125 IF( KASE - ICONT)130,10,130 SCR 109
130 ICONT = ICONT + 1 SCR 110
  DO 135 I = ICONT,KASE SCR 111
135 READ TAPEN9, ICASE(K), TIMIMP(K), TIME(K), (ACTTOT(I), (GAMMA(I,L) SCR 112
1, L=1,4), GAMTOT(I), (BETA(I,L), L =1,5), BETTOT(I), I=2,NO), SCR 113
2 ACTIV(K), (GAMSUB(L,K), L=1,4), GTOTAL(K), (BETSUB(L,K), L=1,5) SCR 114
3, BTOTAL(K) SCR 115
  GO TO 10 SCR 116
140 REWIND N9 SCR 117
  RETURN SCR 118
1000 FORMAT(1H1, 9HSET NO. = ,I3, 10X12A6 /// 59H ACTIVITY OF PARTICLE SCR 119
1BY INDIVIDUAL FISSION PRODUCT NUCLIDE) SCR 120
1001 FORMAT (1H0,9HCASE NO. ,I3,8X,21HGROUND IMPACT TIME = 1PE10.4,1X, SCR 121

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TABLE E-21 (Cont'd)

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14HMIN.,5X, 18HDECAY TIME USED = ,1PE10.4,1X,4HMIN.//)          SCR 122
1002 FORMAT ( 23X      ,40HPARTICLE GAMMA SOURCE ENERGIES (MEV/SEC)// 8H SCR 123
1NUCLIDE, 1X, 8HCHEMICAL,4X,9H ACTIVITY,27X, 13HENERGY GROUPS,24X, SCR 124
2 11HTOTAL GAMMA / 3X, 3HNO., 4X, 6HSYMBOL,2X, 14H(MICRO-CURIES), SCR 125
3 1X, 3(F6.2,1H-F4.2,3HMEV),F6.2,2H--,3X,3HMEV,3X,16HENERGY (MEV/SESCR 126
4C)////)          SCR 127
1003 FORMAT (1H ,1X,I3,5X,A6,4X,E10.4,2X,4E14.4,6X,E10.4)          SCR 128
1004 FORMAT (7HOTOTALS,13X,E10.4,2X,4E14.4,6X,E10.4)          SCR 129
1005 FORMAT (1H1,21X,39HPARTICLE BETA SOURCE ENERGIES (MEV/SEC)//8H NUCSCR 130
1LIDE,1X,8HCHEMICAL,4X,8HACTIVITY,29X,13HENERGY GROUPS,28X, 11HBETSCR 131
2A ENERGY/ 3X,3HNO., 4X, 6HSYMBOL,2X,14H(MICRO-CURIES),4(F5.2,1H-, SCR 132
3 F4.2,3HMEV),F5.2,2H--,3X,3HMEV,4X,9H(MEV/SEC)////)          SCR 133
1006 FORMAT (1H ,1X,I3,5X,A6,4X,E10.4,1X,5E13.4,4X,E10.4)          SCR 134
1007 FORMAT (7HOTOTALS,13X,E10.4,1X,5E13.4,4X,E10.4////////)          SCR 135
1008 FORMAT(20H0***ERROR***CASE NO.,I3, 16H  IS NOT ON TAPE , I3)          SCR 136
1009 FORMAT (12I6)          SCR 137
1010 FORMAT(12A6)          SCR 138
      END          SCR 139

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TABLE E-22
FORTRAN LISTING - T9S SCRIB

T9S	MAIN SCRIB PROGRAM	T9S	1
C		T9S	2
C****	MAIN SCRIB (T9S) WRITES OUT COMPLETE DATA STORED ON TAPE 9.	T9S	3
C****	THIS DATA CONTAINS FISSION PRODUCT ACTIVITY AND SOURCE STRENGTH	T9S	4
C****	ENERGIES OF EACH NUCLIDE FOR EVERY CASE.	T9S	5
C		T9S	6
	DIMENSION TIMIMP(200),XMASS(200),DIAIMP(200),TITLE(12)	T9S	7
	DIMENSION A(1448),ACTIV(200),ACTTOT(274),BETSUB(5,200),BTOTAL(200)	T9S	8
	1,DIS(274),EGAM(25),EG1(5),EG2(4),EB1(6),EB2(5),EBETA(25),FGAM(25)	T9S	9
	2,FR(1448),F1(274),F2(274),F3(274),GAMSUB(4,200),GTOTAL(200)	T9S	10
	3,ICASE(200),J1(274),J2(274),J3(274),LINK(645),M(275),N(645)	T9S	11
	4,SYMBOL(274),TIME(200),YIELD(274),FBETA(25),TSTART(10),POWER(10)	T9S	12
	5,Y(645),D(1448),ACTIN(274),ALFA(1448),ACTO(645),G(5),B(5)	T9S	13
	6,GECONV(274,5),BECONV(274,5),BETA(274,5),GAMMA(274,4),BETTOT(274)	T9S	14
	7,GAMTOT(274),IWANT(200),ICASE2(200),TIME2(200)	T9S	15
C*	IFOL = CONTROL TO SEARCH MORE THAN 1 SET OF PROBLEMS ON TAPE N9	T9S	16
C*	1 = MORE SETS TO FOLLOW, 0= NO SETS TO FOLLOW	T9S	17
C*	ISSET3 = PROBLEM SET NUMBER AS STORED ON TAPE N9	T9S	18
C	IALL = OPTION TO PRINT ALL CASES 0= NO, 1= YES	T9S	19
C	NOC = NUMBER OF CASES YOU WISH PRINTED	T9S	20
C*	IWANT = CASE NUMBERS OF THOSE YOU WISH PRINTED	T9S	21
	N5=5	T9S	22
	N6=6	T9S	23
	N9=9	T9S	24
	K=1	T9S	25
10	READ INPUT TAPE N5,1009,IFOL,ISSET3,IALL,NOC,{IWANT(I),I=1,NOC}	T9S	26
15	READ TAPE N9,ISSET2,ISSET,TITLE	T9S	27
	IF(ISSET2-ISSET3)20,30,20	T9S	28
20	READ TAPEN9,KASE,{EG1(L),EG2(L),L=1,3},EG1(4),(EB1(L),EB2(L),	T9S	29
	1L=1,4),EB1(5),NO,{SYMBOL(I),I=2,NO}	T9S	30
	DO 25 K=1,KASE	T9S	31
25	READ TAPEN9, ICASE(K), TIMIMP(K), TIME(K), {ACTTOT(I), {GAMMA(I,L	T9S	32
	1), L=1,4), GAMTOT(I), {BETA(I,L), L =1,5), BETTOT(I), I=2,NO),	T9S	33
	2 ACTIV(K), {GAMSUB(L,K), L=1,4), GTOTAL(K), {BETSUB(L,K), L=1,5)	T9S	34
	3, BTOTAL(K)	T9S	35
	IF(ISSET)15,140,15	T9S	36
30	IF (IALL)55,55,35	T9S	37
35	READ TAPEN9,KASE,{EG1(L),EG2(L),L=1,3},EG1(4),(EB1(L),EB2(L),	T9S	38
	1L=1,4),EB1(5),NO,{SYMBOL(I),I=2,NO}	T9S	39

TABLE E-22 (Cont'd)

ICONT = KASE	T9S	40
DO 50 K=1,KASE	T9S	41
READ TAPEN9, ICASE(K), TIMIMP(K), TIME(K), (ACTTOT(I), (GAMMA(I,L	T9S	42
1), L=1,4), GAMTOT(I), (BETA(I,L), L =1,5), BETTOT(I), I=2,NO),	T9S	43
2 ACTIV(K), (GAMSUB(L,K), L=1,4), GTOTAL(K), (BETSUB(L,K), L=1,5)	T9S	44
3, BTOTAL(K)	T9S	45
WRITE OUTPUT TAPEN6,1000, ISET2, TITLE	T9S	46
WRITE OUTPUT TAPE N6,1001, ICASE(K), TIMIMP(K), TIME(K)	T9S	47
WRITE OUTPUT TAPEN6,1002, (EG1(L), EG2(L), L=1,3), EG1(4)	T9S	48
DO 40 I=2,NO	T9S	49
WRITE OUTPUT TAPE N6,1003, I, SYMBOL(I), ACTTOT(I), (GAMMA(I,L), L=1,4)	T9S	50
1, GAMTOT(I)	T9S	51
40 CONTINUE	T9S	52
WRITE OUTPUT TAPE N6,1004, ACTIV(K), (GAMSUB(L,K), L=1,4), GTOTAL(K)	T9S	53
WRITE OUTPUT TAPEN6,1005, (EB1(L), EB2(L), L=1,4), EB1(5)	T9S	54
DO 45 I=2,NO	T9S	55
WRITE OUTPUT TAPE N6,1006, I, SYMBOL(I), ACTTOT(I), (BETA(I,L), L=1,5),	T9S	56
1 BETTOT(I)	T9S	57
45 CONTINUE	T9S	58
WRITE OUTPUT TAPE N6,1007, ACTIV(K), (BETSUB(L,K), L=1,5), BTOTAL(K)	T9S	59
50 CONTINUE	T9S	60
IF (IFOL) 140,140,120	T9S	61
55 ICONT =0	T9S	62
IREAD = 0	T9S	63
DO 115 J=1,NOC	T9S	64
IF (IREAD) 65,60,65	T9S	65
60 READ TAPEN9, KASE, (EG1(L), EG2(L), L=1,3), EG1(4), (EB1(L), EB2(L),	T9S	66
1L=1,4), EB1(5), NO, (SYMBOL(I), I=2,NO)	T9S	67
IREAD =1	T9S	68
65 IF (KASE - IWANT(J)) 70,75,75	T9S	69
70 WRITE OUTPUT TAPEN6,1008, IWANT(J), N9	T9S	70
GO TO 115	T9S	71
75 READ TAPEN9, ICASE(K), TIMIMP(K), TIME(K), (ACTTOT(I), (GAMMA(I,L	T9S	72
1), L=1,4), GAMTOT(I), (BETA(I,L), L =1,5), BETTOT(I), I=2,NO),	T9S	73
2 ACTIV(K), (GAMSUB(L,K), L=1,4), GTOTAL(K), (BETSUB(L,K), L=1,5)	T9S	74
3, BTOTAL(K)	T9S	75
ICONT =ICONT +1	T9S	76
IF(ICASE(K)-IWANT(J))80,85,80	T9S	77
80 IF (KASE - ICONT) 75,105,75	T9S	78
85 WRITE OUTPUT TAPEN6,1000, ISET2, TITLE	T9S	79
WRITE OUTPUT TAPE N6,1001, ICASE(K), TIMIMP(K), TIME(K)	T9S	80

TABLE E-22 (Cont'd)

WRITE OUTPUT TAPEN6,1002,(EG1(L),EG2(L),L=1,3),EG1(4)	T9S	81
DO 90 I=2,NO	T9S	82
WRITE OUTPUT TAPE N6,1003,I,SYMBOL(I),ACTTOT(I),(GAMMA(I,L),L=1,4)	T9S	83
1, GAMTOT(I)	T9S	84
90 CONTINUE	T9S	85
WRITE OUTPUTTAPE N6,1004,ACTIV(K),(GAMSUB(L,K),L=1,4),GTOTAL(K)	T9S	86
WRITE OUTPUT TAPEN6,1005,(EB1(L),EB2(L),L=1,4),EB1(5)	T9S	87
DO 95 I=2,NO	T9S	88
WRITE OUTPUT TAPE N6,1006,I,SYMBOL(I),ACTTOT(I),(BETA(I,L),L=1,5),	T9S	89
1 BETTOT(I)	T9S	90
95 CONTINUE	T9S	91
WRITE OUTPUT TAPE N6,1007,ACTIV(K),(BETSUB(L,K),L=1,5),BTOTAL(K)	T9S	92
IF(KASE-ICONT) 115,100,115	T9S	93
100 IF(J - NOC)105,115,105	T9S	94
105 DO 110 I=1,KASE	T9S	95
110 BACKSPACE N9	T9S	96
ICONT =0	T9S	97
IF(ICASE(K)-IWANT(J)) 75,115,75	T9S	98
115 CONTINUE	T9S	99
IF (IFOL) 140,140,120	T9S	100
120 IF (ISET)140,140,125	T9S	101
125 IF(KASE - ICONT)130,10,130	T9S	102
130 ICONT = ICONT + 1	T9S	103
DO 135 I = ICONT,KASE	T9S	104
135 READ TAPEN9, ICASE(K), TIMIMP(K), TIME(K), (ACTTOT(I), (GAMMA(I,L	T9S	105
1), L=1,4), GAMTOT(I), (BETA(I,L), L =1,5), BETTOT(I), I=2,NO),	T9S	106
2 ACTIV(K), (GAMSUB(L,K), L=1,4), GTOTAL(K), (BETSUB(L,K), L=1,5)	T9S	107
3, BTOTAL(K)	T9S	108
GO TO 10	T9S	109
140 REWIND N9	T9S	110
CALL EXIT	T9S	111
1000 FORMAT(1H1, 9HSET NO. = ,I3, 10X12A6 /// 59H ACTIVITY OF PARTICLE	T9S	112
1BY INDIVIDUAL FISSION PRODUCT NUCLIDE)	T9S	113
1001 FORMAT (1H0,9HCASE NO. ,I3,8X,21HGROUND IMPACT TIME = 1PE10.4,1X,	T9S	114
14HMIN.,5X, 18HDECAY TIME USED = ,1PE10.4,1X,4HMIN.//)	T9S	115
1002 FORMAT (23X ,40HPARTICLE GAMMA SOURCE ENERGIES (MEV/SEC)// 8H	T9S	116
1NUCLIDE, 1X, 8HCHEMICAL,4X,9H ACTIVITY,27X, 13HENERGY GROUPS,24X,	T9S	117
2 11HTOTAL GAMMA / 3X, 3HNO., 4X, 6HSYMBOL,2X, 14H(MICRO-CURIES),	T9S	118
3 1X, 3(F6.2,1H-F4.2,3HMEV),F6.2,2H--,3X,3HMEV,3X,16HENERGY (MEV/SET	T9S	119
4C)///)	T9S	120
1003 FORMAT (1H ,1X,I3,5X,A6,4X,E10.4,2X,4E14.4,6X,E10.4)	T9S	121

TABLE E-22 (Cont'd)

1004	FORMAT (7H0TOTALS,13X,E10.4,2X,4E14.4,6X,E10.4)	T9S 122
1005	FORMAT (1H1,21X,39HPARTICLE BETA SOURCE ENERGIES (MEV/SEC)//8H NUCT	T9S 123
	1LIDE,1X,8HCHEMICAL,4X,8HACTIVITY,29X,13HENERGY GROUPS,28X, 11HBETT	T9S 124
	2A ENERGY/ 3X,3HNO., 4X, 6HSYMBOL,2X,14H(MICRO-CURIES),4(F5.2,1H-,	T9S 125
	3 F4.2,3HMEV),F5.2,2H--,3X,3HMEV,4X,9H(MEV/SEC)///)	T9S 126
1006	FORMAT (1H ,1X,13,5X,A6,4X,E10.4,1X,5E13.4,4X,E10.4)	T9S 127
1007	FORMAT (7H0TOTALS,13X,E10.4,1X,5E13.4,4X,E10.4/////)	T9S 128
1008	FORMAT(20H0***ERROR***CASE NO.,13, 16H IS NOT ON TAPE , 13)	T9S 129
1009	FORMAT (12I6)	T9S 130
1010	FORMAT(12A6)	T9S 131
	END	T9S 132