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EXDOSE
A COMPUTER PROGRAM
FOR CALCULATING
THE EXTERNAL GAMMA DOSE
FROM AIRBORNE FISSION PRODUCTS

M. M. HENDRICKSON

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ABSTRACT

The EXDOSE program calculates the external gamma radiation dose to the total body from a half-infinite cloud of fission products. It is designed primarily for estimating accident consequences.

The code calculates a fission product inventory according to specified input parameters. Any fraction of these fission products may then be released to the atmosphere at a desired rate. The subsequent downwind dispersion and resulting dose to individuals is then calculated.

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INTRODUCTION

EXDOSE is a computer program for calculating the external gamma dose to tissue (in rads) from airborne fission products.

The user describes the amount of fuel involved in the hypothetical problem, the duration and conditions of the irradiation, the atmospheric conditions, and the distances to the points at which dose calculations are desired.

Based on this input, the code calculates the dose at specified downwind points after it calculates fission product inventories, amount of activity released, dispersion of the plume as it travels downwind, and gamma energy deposition at the dose point. At the exposure point, it is assumed that the individual is immersed in a uniform radiation field of the ground level concentration. The cloud has half-infinite dimensions, and perfect plume reflection has occurred at the ground surface (Figure 1).

Internal libraries contain all data essential to the inventory calculation. The inventory calculation is accomplished by an adaption of the computer program RIBD. The user has ready access to the library to change any data.

FIGURE 1. EXDOSE Calculates the External Gamma Dose from Immersion in a Plume

DESCRIPTION OF CODE

EXDOSE calculates the whole body dose received from gamma emissions external to the body from airborne radionuclides.

The sequential operation of the code includes:

- 1) A subroutine for generating fission product inventory as a function of flux and time.
- 2) A means of adjusting the fission product inventory after irradiation is over to account for plate-out and filtration in a confinement system prior to release.
- 3) A method of accounting for the radionuclide decay during all times of interest including cloud transit.
- 4) The release of fission products at a specified rate.
- 5) A calculation of the dilution of the released plume using either the bivariate normal mode and Simpson-Fuquay equations or Sutton's equations.
- 6) The dose calculation at a downwind point.

More detailed information is given in the following appendices:

- Appendix A, EXDOSE Input Data Instructions
- Appendix B, Atmospheric Dispersion Model
- Appendix C, Code Listings
- Appendix D, Code Libraries
- Appendix E, Sample Case Listings.

THEORY

The fission product inventory calculation is accomplished by a straightforward adaptation of the RIBD (Reactor Inventory, Burn-up, and Decay) code. This adaptation comprises Link 1 of EXDOSE. The second link accomplishes the atmospheric dispersion and dose calculations.

For Link 1 of EXDOSE the RIBD code was modified to include two factors pertinent to hazards calculations.

- 1) Release of the fission products at an exponential rate.
- 2) Inclusion of arbitrary factors at up to two decay times, as appropriate, to account for only partial release of fission products from fuel and to account for filtration. The advantage of including these factors in Link 1 is that buildup of daughters following plate-out or filtration may thus be accurately accounted for.

Link 1 generates integrals, for each nuclide, for the distances and exposure times desired. The integrals are of the form

$$\int_{T+\tau_{i-1}}^{T+\tau_i} E_{\gamma} q e^{L(T+\tau_e-t)} dt$$

A list of symbols and a figure explaining the notation for the various times is given on pages 10 and 11.

The integrals are the effective γ energy from radioactive decay for each isotope during each time period $\Delta\tau_i$. These integrals are then adjusted to account for dispersion following release and the energy deposited at the dose point is converted to radiation dose.

The integrals are calculated for a series of time periods, $\Delta\tau_i$, so that different degrees of atmospheric dilution can be applied; the dilution increases progressively for each time period according to the applicable wind variability.

The quantity q_j of an isotope which is the j^{th} member of a mass chain is

$$q_j(t) = \lambda_j \sum_{k=1}^j C_{k,j} e^{-\lambda_k t} \quad (1)$$

where j signifies the j^{th} member of a mass chain, λ_j is the decay constant of this member, and C_k is a series coefficient determined by RIBD.

Energy released W_γ in time $\Delta\tau_i$ is

$$\begin{aligned}
 W_\gamma &= \int_{T+\tau_e+\tau_{i-1}}^{T+\tau_e+\tau_i} \bar{E}_j q_j(t) e^{L(T+\tau_e-t)} dt \\
 &= e^{L(T+\tau_e)} \int_{T+\tau_e+\tau_{i-1}}^{T+\tau_e+\tau_i} \bar{E}_j q_j(t) e^{-Lt} dt
 \end{aligned} \tag{2}$$

where $\bar{E}_j$ is the average effective energy released per disintegration of nuclide j .

Substituting Equation (1) into Equation (2) gives

$$\begin{aligned}
 W_\gamma &= e^{L(T+\tau_e)} \lambda_j \bar{E}_j \int_{t_{i-1}}^{t_i} \sum_{k=1}^j C_k e^{-(L+\lambda_k)t} dt \\
 &= e^{L(T+\tau_e)} \left(\lambda_j \bar{E}_j \sum_{k=1}^j C_k \frac{e^{-(L+\lambda_k)t_{i-1}} - e^{-(L+\lambda_k)t_i}}{(L + \lambda_k)} \right)
 \end{aligned}$$

where

$$t_{i-1} = T + \tau_e + \tau_{i-1}$$

$$t_i = T + \tau_e + \tau_i$$

The bracketed quantity is calculated as the variable DATA 2(I,KI) for all $\Delta\tau_i$ times in RIBD. In the EXDOSE modification of RIBD the entire term above is developed in Link 1. The coefficients C_k are developed for each step of the chain in a family according to methods described in the RIBD document.⁽¹⁾

After the fission product generation calculation, the radionuclides may be released at a constant fractional rate L where

$$L = \frac{\ell}{v} = \text{fraction of container volume released per minute}$$

$$\ell = \text{leakage from the container (ft}^3/\text{min)}$$

$$v = \text{volume of container (ft}^3\text{)}$$

It is assumed that fission products released from the fuel are continuously uniformly mixed throughout the container volume and are released at a uniform volumetric rate ℓ .

In terms of initial activity, the amount remaining, q , after any time t is

$$q = q_0 e^{-Lt}$$

Upon release, the fission product dispersion and resultant downwind concentration at ground level is calculated using the bivariate normal mode dispersion equation (Appendix B).

$$\frac{E}{q} = \frac{\exp\left(-\frac{1}{2}\right) \left[\frac{y^2}{\sigma_y^2} + \frac{(h^2)}{\sigma_z^2} \right]}{\pi \sigma_y \sigma_z \bar{u}}$$

where

$$\sigma_y = \left\{ A \left[t + \alpha (e^{-T/\alpha} - 1) \right] \right\}^{1/2}$$

$$\sigma_z = \left[a \left(1 - e^{-k^2 T^2} \right) + bT \right]^{1/2}$$

DOSE RATE IN A SEMI-INFINITE CLOUD

The radiation dose rate to an individual immersed in a fission product cloud of large dimensions can be closely approximated by correcting the dose rate in air the dose rate in tissue. For a uniform radiation field in air the dose rate is:

$$\begin{aligned}
 D_r &= \frac{C_a \left(\frac{\mu\text{Ci}}{\text{cm}^3} \right) E_\gamma \left(\frac{\text{MeV}}{\text{dis}} \right) k_i \left(\frac{\text{erg}}{\text{MeV}} \right) k_2 \left(\frac{\text{dis}}{\mu\text{Ci-sec}} \right)}{k^3 \left(\frac{\text{erg}}{\text{g rad}} \right) k_4 \left(\frac{\text{g air}}{\text{cm}^3} \right)} \\
 &= C_a E_\gamma \left[\frac{\left(1.6 \times 10^{-6} \frac{\text{erg}}{\text{MeV}} \right) \left(3.7 \times 10^4 \frac{\text{dis}}{\mu\text{Ci-sec}} \right)}{\left(\frac{100 \text{ erg}}{\text{g rad}} \right) \left(1.293 \times 10^{-3} \frac{\text{g air}}{\text{cm}^3} \right)} \right] \\
 &= 0.46 C_a E_\gamma \left(\frac{\text{rad}}{\text{sec}} \right) \left/ \left(\frac{\mu\text{Ci MeV}}{\text{cm}^3 \text{ dis}} \right) \right.
 \end{aligned}$$

C_a = airborne concentration of nuclide in a uniform field-infinite cloud, $\frac{\mu\text{Ci}}{\text{cm}^3}$

E_γ = effective gamma decay energy per disintegration, MeV

At the interface of the ground and a one-half infinite cloud (neglecting reflection) the dose rate would be one-half that at the center of an infinite cloud:

$$D_r = \frac{0.46 C_a E_\gamma}{2} = 0.23 C_a E_\gamma \quad \begin{array}{l} (\text{rad/sec}) \\ \text{at standard temperature} \\ \text{and pressure} \end{array}$$

DOSE RATE IN TISSUE

Tissue submerged in a radiation field would receive a higher dose rate because of its higher mass stopping power. So the dose rate in tissue becomes:

$$D_r = 0.23 C_a E_\gamma P_t$$

P_t = mass stopping power of tissue relative to air, 1.13

The dose rate in tissue at the edge of a half-infinite cloud of uniform radiation is:

$$D_r = 0.26 C_a E_\gamma \left(\frac{\text{rad}}{\text{sec}} \right)$$

DOSE CALCULATION

The dose (D) that results during the time period t_{i-1} to t_i from a dose rate D_r is

$$D = \int_{t_{i-1}}^{t_i} D_r dt = 0.26 \int_{t_{i-1}}^{t_i} C_a E_\gamma dt \quad (\text{rad})$$

For a uniform continuous release, the downwind concentration C_a at anytime t is

$$C_a = Lq(t) \left(\frac{E}{Q} \right) (\mu\text{Ci}/\text{cm}^3)$$

The discharge for a period $\Delta\tau$ at a rate Lq results in a net release of Q Ci so

$$Q = L \int_{\tau_e}^{t_e + \Delta\tau} q(t) dt \quad (\text{Ci})$$

and

$$C_a = \left(\frac{Q}{\Delta\tau} \right) \left(\frac{E}{q} \right) = Lq(t) \left(\frac{E}{Q} \right)$$

where

Q = curies released

Δt = time of release

$\left(\frac{E}{Q} \right)$ = normalized time integrated air concentration for release of Q curies

The dose from an isotope is:

$$D = 0.26 L \left(\frac{E}{Q} \right) \int E_\gamma q(t) dt \quad (\text{rads})$$

$$q(t) = q_e^{L(T + \tau_e - t)}$$

Summed over all isotopes j and time periods $\Delta\tau_i$ the dose in rads is calculated by

$$\text{Dose} = \left\{ 0.26 \sum_{i=1}^n \left(\frac{E}{q} \right)_{\Delta\tau_i} \left(\sum_{j=1}^m k_j \int_{t_{i-1}}^{t_i} E_{\gamma_j} q_j e^{L(T+\tau_e-t)} dt \right) \right\}$$

t = total time of the problem (min)

L = fractional release rate (min^{-1})

n = number of $\Delta\tau$ (time periods in min)

m = number of isotopes considered

T = cloud travel time

τ_e = emission delay time

E_{γ_j} = gamma disintegration energy for j^{th} isotope

q_j = activity of isotope as a function of time (Ci)

k_j = a constant to account for partial release of any isotope

Methods used in the code for calculating E/Q are given in Appendix B.

EXDOSE is programmed in Fortran II for use on the IBM 7090 computer under the control of the Fortran monitor master program.

SYMBOL DEFINITIONS

- $\frac{E}{Q}$ = time integrated air concentration $\left(\frac{\mu\text{Ci sec}}{\text{cm}^3 \text{ Ci}} \right)$,
 normalized
- σ_y = standard deviation of the lateral plume growth (m)
- σ_z = standard deviation of the vertical plume growth (m)
- A, α = dispersion parameters for the lateral variance, σ_y^2
- a, b, k^2 = dispersion parameters for the vertical variance, σ_z^2
- θ = wind direction (radians)
- σ_θ = standard deviation of the wind direction at the source (radians)
- $\bar{u}$ = average wind speed at the source (m/sec)
- y = lateral distance from plume centerline (m)
- h = release height at source (m)
- z = height of exposure point above ground (m)
- BNDT = boundary time for the problem, this is equal to the sum of $\tau_e + T + \sum_i \Delta\tau_i$
- D_r = exposure rate (rad/sec)
- L = fractional release rate (min^{-1})
- ℓ = volumetric release rate (cm^3/min)
- V = container volume (cm^3)
- $E_{\gamma j}$ = effective gamma decay energy per disintegration for isotope j (MeV)
- q_j = activity of isotope j (Ci)
- k_j = dimensionless scaling factor (may have any positive value including zero)
- C_a = airborne concentration of nuclide j ($\mu\text{Ci}/\text{cm}^3$)
- Density of dry air = 1.2047 g/l, 20 °C; 1.2929 g/l, 0 °C and 760 mm of Hg

$E_{\gamma j}$ = effective gamma decay energy per disintegration for an isotope

q = quantity (activity) of a radionuclide, also referred to as q_j and $q(t)$

$$E_{\gamma j} = \sum_i p_i E_i$$

p_i = probability of photon of energy E_i being produced per disintegration

E_i = energy of photon with probability p_i

T = travel time from release point to exposure point

t = time after shutdown i.e. time after end of irradiation of fuel

$\Delta\tau_i$ = time period during which a release occurs, is also equal to the duration of the exposure

τ_e = emission delay time; time from shutdown until release to the environs begins

BNDT = boundary time for this problem;

$$\tau_e + T + \sum_i \Delta\tau_i$$

ACKNOWLEDGEMENTS

R. O. Gumprecht, the author of the computer code RIBD generously assisted in the modification of RIBD so it would fit into Link 1 of EXDOSE.

E. C. Watson was the source of many of the basic ideas that are programmed into EXDOSE. We have used his published work liberally, in particular Reference 2.

APPENDIX A

INPUT PREPARATION

APPENDIX A

EXDOSE INPUT DATA INSTRUCTIONSINPUT DATA

The input data for this program is handled by J. R. Lilley's Generalized Fortran Input Routine.*

The program is comprised of two links, Link 1 and Link 2. The program usually requires:

- 4 data cards to describe the fuel irradiation (Link 1)
- Additional cards as desired to describe the emission delay time, cloud travel time, and boundary time (Link 1)
- A card to signal that a Link 2 dispersion and dose calculation is desired
- Cards to describe dispersion parameters, to select the fission products (or groups) for which dose calculations are desired, and to control the automatic plotter.

The entries in Columns 1, 2 to 3, and 5 to 10 of a card are used to describe the type of data, number of data words, and memory location on the particular card. If there is a blank in the first column then the format specified in the previous card will be used. If Columns 2 and 3 are blank, the input routine scans all the data on the card. When Columns 5 through 10 are blank the first data word on the card is addressed to the location following that to which the last word read on the previous card was addressed. Input data is entered in Columns 11 to 72.

* J. R. Lilley. *Generalized FORTRAN Input Routine, HW-70893. Available from Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia, August 29, 1961.*

The following gives information on Column 1; the column which controls the kind of data on a card, information on word length and the amount of data which can be entered on each data card.

<u>Type of Data</u> (In Columns 11-72)	<u>Column 1</u>	<u>Maximum Data, Words/Card</u>	<u>Columns/ Word</u>
Floating point	0	6	10
Integer	1	12	5
Hollerith	2	10	6
End of input record for a given case	9		

The data card Column 1 entries for the Link 1 are described in the following list.

Column 1 Names

- 0 FACTOR, DELTAU, BIGL, PO, TIME, T, SIGA25, DEL, TRVT, BNDT, and EDT (Floating point variables)
- 1 NSIG, NEDL, and LINK (Control integers)
- 2 CASE (Hollerith input to identify cases)

Lilley's input routine is used with this program because it will read the major portion of the input data once for any number of case runs. For each new case run only the desired parameters need be changed, without having to re-enter the entire input data again.

<u>Program Name</u>	<u>Memory Location</u>	<u>Meaning</u>
FACTOR (I), I=1, 450	1-450	The array FACTOR is initialized to 1 at the start of Link 1. Just before fuel melting the FACTOR values may be changed with the following results: When FACTOR = 1 this means total escape of isotope from fuel and when FACTOR=0 this means total retention of isotope by fuel.

<u>Program Name</u>	<u>Memory Location</u>	<u>Meaning</u>
		Just before filtering the FACTOR values may be changed with the following results. When FACTOR = 1 this means the isotope goes through the filter and when FACTOR = 0 this means the isotope is blocked by the filter
DELTAU(I), I=1,8	581-588	Time increments for delta tau in minutes
BIGL	589	Leakage rate, in per minutes
PO	590	Power (MW)
TIME	591	This is the time interval, in days, that the above power (PO) level is maintained.
T	592	No units.
SIGA25	593	Absorption cross section of ^{235}U in barns.
DEL	594	DEL = fast fissions in ^{238}U divided by thermal fissions.
TRVT	595	Time of travel (in minutes) from emission delay time to point of exposure.
BNDT	596	Boundary time in minutes.
EDT	597	Emmission delay time in minutes.
NSIG	598	A.) If NSIG = 0 on the first CALL LISTIN then FACTOR values will not be put in as data on a future CALL LISTIN. B.) When NSIG = 1 on the first CALL LISTIN then FACTOR values may be put in as data on only the last two CALL LISTIN's of the power step section in this system. The second CALL LISTIN must set NSIG = 0 and the last CALL LISTIN must set NSIG = 1 again.

<u>Program Name</u>	<u>Memory Location</u>	
NEDL	599	<p>A.) When Link 1 is used as part of the chain job then the first CALL LISTIN will put NEDL = 0 and then after all the cases are run there will be one more CALL LISTIN to put NEDL = 1 and this will start Link 2 into operation.</p> <p>B.) When Link 1 is used as an independent program the first CALL LISTIN will set NEDL = x where x is the number of extra decay lists.</p>
LINK	600	<p>A.) When LINK = 0 then Link 1 is part of the chain job.</p> <p>B.) When LINK = 1 then Link 1 is an independent program.</p>
CASE (I), I=1,57	601	Identification (57 words)

LINK 1

Link 1 may be used as part of the chain job or it may be used as an independent program.

When Link 1 is used as part of the chain job, it calculates the integrals and curies for each isotope and transmits them to Link 2 on tape unit B7. This link can be set up by controls to run in two ways.

- 1) One method will have a power level (PO) and a time interval (TIME) in days that the power level is maintained put in as data; at shutdown the decay time lists are given.
- 2) The other method will have a stepwise buildup history made up of power levels with their corresponding time intervals. The last interval must not be a zero power level but it can be 1.0×10^{-6} MW, etc.

The initial separation of isotopes from fuel takes place during fuel melting, and the secondary separation of isotopes takes place during the filtering action. Link 1 has an array

called FACTOR, and when the FACTOR values are read into the program before the fuel melting period, they will tell what percent of an isotope escapes from the fuel during the melting period. That is, FACTOR = 1 means total escape of an isotope from the fuel; FACTOR = 0 means total retention of the isotope by the fuel. When the FACTOR values are read into the program just before the filtering action, they will tell what percent of an isotope is blocked by the filter from the filtering action. That is, FACTOR = 1 means the isotope goes through the filter, and FACTOR = 0 means the isotope is blocked by the filter.

The stepwise buildup method is used for the separation system. After shutdown occurs, then the power level may be put equal to zero ($PO = 0$), the time interval (TIME) would be put equal to the initial separations time, and the FACTOR values would be put into the program for the fuel melting separation. In the next set of data cards the power level must not be put equal to zero, the time interval would be put equal to the secondary separations time minus the initial separations time, and the FACTOR values would be put into the program for the filtering action.

The following limits apply for various travel times, boundary times, and leakage rate combinations.

When Link 1 is used as part of the chain job, its capacity consists of a maximum of 350 cases per run. A maximum of 10 travel times may be used for each boundary time, 20 boundary times may be used for each L, and 20 L values (leakage rates) may be used per run.

When L is changed, then the boundary time must also be changed.

LINK 2

Link 2 calculates total body dose using the following equation:

$$\text{DOSE} = \left\{ 0.259L \sum_{i=1}^n f(T, \tau_i) \left(\frac{E}{q} \right)_{\Delta\tau_i} \right. \\ \left. \sum_{j=1}^m k_j \int_{T+\tau_{i-1}}^{T+\tau_i} E_{\gamma_j} q_j e^{L(T+\tau_e-t)} dt \right\}$$

where

- t = boundary time
- L = leakage factor
- n = number of $\Delta\tau$
- m = number of isotopes considered
- T = travel time
- τ_e = emission delay time
- E_{γ_j} = average energy in MeV/dis
- q_j = activity of isotope j (curies)
- k_j = an arbitrary constant to provide program flexibility

The integrals in the above equation are calculated in Link 1 and transmitted between links on tape unit B. Link 1 also calculates the curies for each isotope. Link 2 in addition to calculating the dose, sums the curies for specified isotopes, calculates the change in curies, and calculates the total grams of material specified.

A selection of isotopes is specified by card input to Link 2, using Lilley's generalized input routine. The following common locations are used to specify isotope selection. The value to submit is the factor (k_j) in the above equation.

- 1-450 are used to specify individual isotopes. The actual location (1 through 450) corresponds to the location of the particular isotope in the EXDOSE isotope library list.
- 576-580 specify all isotopes in the library which belong to a particular group to be used. The groups are as follows:
- 576 Group 1, Noble gases (Xe, Kr)
 - 577 Group 2, Halogens (I, Br)
 - 578 Group 3, Volatiles (Se, Te, Cs)
 - 579 Group 4, All isotopes not in Groups 1, 2 or 3.
 - 580 Group 5, All isotopes in the library

For each selection of isotopes, up to 5 sets of (E/Q) equations will be calculated, using the following input variables.

- 451-456 specifies A6, A7, A8, A9, A10 and 8 for first set
- 466-480 specifies A6, A7, A8, A9, A10 and 8 for second set
- 481-495 specifies A6, A7, A8, A9, A10 and 8 for third set
- 496-510 specifies A6, A7, A8, A9, A10 and 8 for fourth set
- 511-525 specifies A6, A7, A8, A9, A10 and 8 for fifth set
- 451 specifies A6, the choice of atmospheric model
- 452 specifies A7, $\bar{u}$, the wind speed
- 453 specifies A8, vertical diffusion coefficient, a
- 454 specifies A9, vertical diffusion coefficient, b
- 455 specifies A10, vertical diffusion coefficient, k^2
- 456-465 specifies σ_θ $\bar{u}_i$ values to be used with successive time periods $\Delta\tau_i$
- 658 CY Sutton's lateral diffusion coefficient
- 659 CZ Sutton's vertical diffusion coefficient
- 660 TN Sutton's power coefficient for X^{2-n} ($n = TN$)
- 661 Y Lateral distance from plume centerline (usually 0.0)
- 662 TH source release height (meters)
- 663 DEPCO the coefficient $\left(\frac{v_\Delta}{\mu_0}\right)$ used in the calculation of ADCO, the cloud depletion by ground deposition factor

- 664 WINDR wind speed ratio, $\bar{u}_o/u_h$
 665 SIGY σ_y , normally not specified
 666 SIGZ σ_z , normally not specified
 and σ_y and σ_z are normally calculated based on the
 values of a, b, k^2 , C, d, and $\sigma_\theta \bar{u}$ that are submitted.
 If SIGY and SIGZ are submitted, they override the
 internal calculation
 668 Z subject height (meters)
 669 DCO optional user supplied depletion coefficient replaces
 the internal calculation for ADCO
 670 CLITLC A coefficient for C in σ_y equation (normally 13.0
 for Hanford)
 671 CLITLD a coefficient for d in σ_y equation (normally
 232.5 for Hanford)

Choice of atmospheric dispersion model.

A6 specifies the choice of the atmospheric dispersion model. Four choices are available with A6 = 3, 4, 5, or 6.

A6 = 3.0 specifies Sutton's model.

This is programmed as

$$\text{EQ (1-5)} = \frac{2 \cdot \text{ADCO} \cdot \exp \left(- \left(\frac{y^2}{C_y^2} + \frac{TH^2}{C_z^2} \right) \right) (x)^{TN-2}}{\pi \cdot C_y \cdot C_z \cdot A7 \cdot x^{2-TN}}$$

where x = distance in meters

$$\text{ADCO} = \exp \left(\frac{-2 \cdot \text{DEPCO} \cdot \text{WINDR} \cdot \text{AINTL}}{\sqrt{\pi} \cdot TN \cdot C_z} \right)$$

$$\text{where } \text{AINTL} = \int_0^x S^{(TN-2)/2} \exp \left(\frac{-TH^2}{C_z^2 \cdot S^{(2-TN)}} \right) dS$$

A6 = 4 specifies the dispersion equation

$$EQCURV_i = \frac{ADCO \cdot \exp^{-1/2 \left(\frac{y_i^2}{\sigma_{y_i}^2} + \frac{(2-TH)^2}{\sigma_z^2} \right)}}{\pi \sigma_{y_i} \sigma_z A^7}$$

where

$$\sigma_{y_1} = \sqrt{0.016 x^{1.6}}$$

$$\sigma_{y_2} = \sqrt{0.04 x^{1.6}}$$

x = distance in meters

for i = 3, 5

$$\sigma_{y_i} = \sqrt{A[T + \alpha (e^{-T/\alpha} - 1)]}$$

where

T = travel time in seconds

$$A = C + d \cdot (\sigma_\theta \bar{u})_i$$

$$\alpha = \frac{A}{2 \cdot (\sigma_\theta \bar{u})_i^2}$$

$$\sigma_z = \sqrt{a - ae^{-k^2 T^2} + bT}$$

$$- \sqrt{2/\pi} \cdot DEPCO \cdot WINDR \cdot A^7 \cdot AINTL$$

$$ADCO = e$$

where

$$AINTL = \int_0^T \frac{e^{-\frac{TH^2}{2F(S)}}}{\sqrt{F(S)}} ds$$

where

$$F(S) = a - ae^{-k^2 S^2} + bS$$

A6 = 5 specifies dispersion equations, like A6 - 4 except

$$\sigma_{y_i} = \sqrt{A(T + \alpha(e^{-T/\alpha} - 1))}$$

for all i = 1, 5.

The calculation of cloud deposition factor (ADCO) may be suppressed by submitting a value for DCO and no value for DEPCO (location 669). ADCO the cloud depletion factor is automatically set = 1.0 when DEPCO is 0 and no value has been supplied for DCO.

One selection of isotopes and the associated (E/Q) variables constitute one case of data into Link 2. Any number of cases may be processed per run, but they must be separated by a card with a 9 in Column 1. All of the Link 1 cases (change in L or boundary time) will be processed for each isotope selection.

One additional variable may be input to this link, but should only be entered for the first case. It is an integer with location 667, and is the case number for the first case input to Link 1. The case number for following cases is then calculated and reported for each case.

At the end of each batch of cases the following are zeroed out.

<u>Locations</u>	<u>Variable</u>
1-450	Group switches - selection and weight factors for individual isotopes
451-525	E/q array
575-580	Isotope group selection and weight factors

This requires that each Link 2 case (for a batch of Link 1 cases) specify values for these variables.

PLOTTING FOR EXDOSE

The data generated by the program may be read out on tape and then plotted by the Benson-Lerner plotter. K&E 8 1/2 x 11 in. graph paper must be used. Specify K&E #467400 drawing paper, full logarithmic, 3 x 3 cycles (each cycle 2 1/2 x 2 1/2 in. in size).

Plotting for the program is controlled by 5 input switches, common locations 571-575. The switches are initialized to zero only once, at the beginning of Link 2. The switches may then be changed when an isotope selection (Link 2 case) criterion is being read. The switch will cause creation of plots whenever they contain any positive value. Once on, the switches remain on until zeroed out by input data. No more than 50 plots will be produced per machine processing. Tape output is on unit B5.

571 plots E/Q curves as a function of travel time.

One plot will be produced for each set of E/Q curves specified for that case. Each plot will contain one curve for each delta tau. E/Q plots will be produced only once per machine processing, and will be plotted for the first case in Link 2 that has switch 571 turned on.

572 plots the unweighted E/Q curve, exactly the same way as the E/Q values were plotted.

573 plots dose as a function of exposure time. These values are plotted whenever a change in the leakage constant, or change in isotope selection, is encountered. Dosage for up to 20 exposure times will be plotted for each travel time, with up to 5 travel times plotted on a single page, and a maximum of 10 travel times per case. Each E/Q specification will be plotted separately, so up to 10 plots could be created for each change in leakage constant or isotope selection.

574 plots dose as a function of travel time. Each E/Q specification will be plotted as a separated curve, and each boundary time will form a separate plot.

575 is currently not used.

APPENDIX B

ATMOSPHERIC DISPERSION MODEL

APPENDIX B

ATMOSPHERIC DISPERSION MODELINTRODUCTION

The calculation of the radiation dose from airborne particulate matter requires a knowledge of the distribution of the particles in time and space. O. G. Sutton^(4,5) has developed equations usable for unstable and neutral atmospheric conditions. Work at Hanford has led to the development of a mathematical model⁽⁶⁾ describing the dispersion of aerosols in stable atmospheres. This model includes the effect of variations in wind speed and direction on the dispersion of the aerosol. The effect of wind direction variations is to reduce the downwind concentration.

Earlier mathematical models have assumed invariant wind speed and direction during the entire period of emission. Evaluation of local meteorological data and atmospheric dispersion studies indicate that variation in wind speed and direction is more significant than atmospheric diffusion as a dispersal mechanism in stable atmospheres. This is especially true when releases are prolonged over a period of several hours.

SUMMARY

The EXDOSE program contains a subroutine designed to calculate E/q , the downwind normalized time-integrated air concentration (in $\mu\text{Ci} \cdot \text{sec})/(\text{cm}^3 \cdot \text{Ci released})$ of an aerosol which results from a continuous point source release. Two options are available for calculating E/Q . These are:

- 1) Sutton's equations.
- 2) Hanford bivariate normal mode dispersion equations. (Fuquay-Simpson equations).

Sutton's equations have usually been used for calculating dispersion for neutral or unstable atmospheric conditions.⁽⁷⁾ The Fuquay-Simpson equations⁽⁶⁾ are normally used for moderately stable or stable conditions.^(2, 8)

For Sutton's equations input for a typical case includes emission height (stack height), cloud travel time, average wind speed, and values for Sutton's constants which define the degree of atmospheric stability. Also required input are the X, Y coordinates of the point at which the calculation is desired. The downwind distance, X, is specified in terms of travel time t and average wind speed $\bar{u}$.

$$X = \bar{u} t$$

The crosswind distance Y is specified in meters. Multiple input values of t and $\bar{u}$ are permissible, thus the user can conveniently vary these input parameters.

For the Fuquay-Simpson equations somewhat different input is required since both atmospheric stability and wind variability parameter values are needed for the calculations.

Cloud depletion by ground deposition is an optional calculation for either Sutton's equations or the Fuquay-Simpson equations. Commonly used values for all parameters are given in tables that follow.

Output of the E/q subroutine.

- 1) The normalized time-integrated air concentration. $\frac{\mu\text{Ci} \cdot \text{sec}}{\text{cm}^3 \cdot \text{Ci}}$
- 2) Cloud travel distance; $X = \bar{u}t$
- 3) Cloud depletion fraction
- 4) Depletion integral
- 5) Values of intermediate variables which are part of the final (E/q) calculation
- 6) Values of input variables used in the case

Computer time used is nominal if cloud depletion is not included, and is about 5 sec per group of 50 (E/q) calculations if the Fuquay-Simpson equations are used, 5 sec per group of 10 (E/q) calculations if Sutton's equations are used.

DISCUSSION

In order to calculate the radiation dose to individuals in the environs following release and subsequent dispersion of radioactive material, it is necessary to know the concentration of the material in the atmosphere at the point of exposure. Considerable work has been done to develop mathematical models to describe the dispersion of gases and particles in the atmosphere under various atmospheric conditions.

Sutton's equations have long been used to describe dispersion of aerosols in unstable and neutral atmospheres. However, recent work has centered on developing a model to more accurately describe dispersion following prolonged release in stable atmospheres where variation in wind speed and direction appears to be an important dispersal mechanism.

Experiments at the Hanford Laboratories by Simpson, Fuquay, and Hinds⁽⁶⁾ have led to the development of a mathematical model to represent the dispersion of aerosols in stable atmospheres which gives good correlation with experimental results. Since the constants in the equations have been derived experimentally and are directly related to observable and measurable phenomenon, it should be possible to interpolate and to some degree extrapolate from the experimental results.

In the Fuquay-Simpson model dispersed matter in a plume is assumed to acquire a normal distribution (Gaussian distribution) in both the lateral and vertical plane. The

variance in the lateral plane is a function of time and is controlled by variations in wind speed and direction. The variance in the vertical direction is also a function of time but depends also on the stability of the atmosphere. The atmospheric stability is in turn determined by the vertical temperature profile.

The Dispersion Equations

Sutton's equations for the air concentration at ground level ($z = 0$) at any point downwind from a continuous point source are:

$$E/q(x,y,0) = \frac{2 \exp \left[-X^{n-2} \left(\frac{y^2}{C_y^2} + \frac{h^2}{C_z^2} \right) \right]}{\pi C_y C_z \bar{u} X^{2-n}} \quad (B.1)$$

where

$$C_y = \frac{\sqrt{2} \sigma_y}{X^{(2-n)/2}}, \quad C_z = \frac{\sqrt{2} \sigma_z}{X^{(2-n)/2}} \quad (B.2)$$

If Equation (B.1) is written in terms of the standard deviations σ_y and σ_z by solving (B.2) for σ_y and σ_z and substituting in (B.1) the equation becomes:

$$E/q(x,y,0) = \frac{\exp \left[-\frac{1}{2} \left(\frac{y^2}{\sigma_y^2} + \frac{(z-h)^2}{\sigma_z^2} \right) \right]}{\pi \sigma_y \sigma_z \bar{u}} \quad (B.3)$$

The Fuquay-Simpson equations for the variances σ_y^2 and σ_z^2 are defined as:

$$\begin{aligned} \sigma_y^2 &= A[t - \alpha(1 - e^{-t/\alpha})] \\ \sigma_z^2 &= a(1 - e^{-k^2 t^2}) + bt \end{aligned} \quad (B.4)$$

Parameters in σ_y^2 and σ_z^2

The constants A and α in the Fuquay-Simpson equation for σ_z are

$$A = [c + d (\sigma_\theta \bar{u})] \quad (m^2/sec) \quad (B.5)$$

$$\alpha = \frac{[c + d (\sigma_\theta \bar{u})]}{2(\sigma_\theta \bar{u})^2} \quad (B.6)$$

Table B.I gives values of c and d for Hanford terrain. Values of c and d are related to the surface roughness of the site and for sites with different terrain would have to be determined experimentally.

The value of $\sigma_\theta \bar{u}$ depends on the variations in wind speed and direction which occur at the source during a release.

Simultaneous measurements have been made of the average wind direction, θ , and the average wind speed, $\bar{u}$. From these data, σ_θ , the standard deviation in the wind direction has been calculated. These tabulated values are used in estimating radionuclide dispersion. Values of $\sigma_\theta \bar{u}$ are chosen for time intervals which correspond to the assumed release duration.

The values of the stability constants a, b, and k^2 commonly used for Hanford site hazards analysis are in Table B.I.

TABLE B.I. *Hanford Values of Meteorological Parameters for the Fuquay-Simpson Equations⁽⁴⁾*

<u>Dimensions</u>	<u>Moderately Stable Conditions</u>	<u>Very Stable Atmospheric Conditions</u>
c m ² /sec	13.0	13.0
d seconds	232.5	232.5
a m ²	97	34
b m ² /sec	0.33	0.025
k ² sec ⁻²	2.5 x 10 ⁻⁴	8.8 x 10 ⁻⁴

Values of $(\sigma_{\theta} \bar{u})$ are tabulated in Tables B.II and B.III. The frequency of occurrence of these values is given for 2, 4 and 8 hr periods for each of four windspeed intervals. Table B.II is prepared from observations made during the winter season and Table B.III for the period March through November.

The values normally used in hazards calculations (using 1 m/sec wind speed) are based on the eight observations of minimum $\sigma_{\theta} \bar{u}$ (Table B.II, $\sigma_{\theta} \bar{u}$ range 0.02 to 0.08) taken during one year of observations. Table B.IV contains the actual values of σ_{θ} , and $\bar{u}$ observed for these eight extreme cases.

The wind variability model for the variance:

$$\sigma_y^2 = A[t - \alpha(1 - e^{t/\alpha})]$$

and the Healy⁽⁶⁾ expression

$$\sigma_y^2 = \beta x^{1.6} \quad (B.7)$$

give good agreement for short emission times; i.e. releases where wind variability is a small factor in dispersal, specifically where $\sigma_{\theta} \bar{u} = 0.024$.

Healy's values for β were:

$\beta = 0.016$ for short (approximately 10 min emissions)

$\beta = 0.04$ for longer emissions (1/2 to 1 hr)

If the lowest observed values of $\sigma_{\theta} \bar{u}$ (Tables B.II and B.III), 1 m/sec wind speed, and moderately stable dispersion conditions are used, the calculated concentrations would probably be greater than would actually occur from release. In this respect, exposure calculations using Table B.V values are very conservative. The values in Table B.V are commonly used in hazards analyses at Hanford.

Wind Speed	2 hr Observation				4 hr Observation				8 hr Observation			
Interval- mph:	0-3	4-6	7-15	16-28	0-3	4-6	7-15	6-28	0-3	4-6	7-15	16-28
$\sigma_{\theta\bar{u}}$ Range:												
0.00	0.08	8			2							
0.08	0.15	12		1	4				1			
0.15	0.25	17	2		4				4			
0.25	0.35	7	1	3	12							
0.35	0.45	3		1	4	1	2		3			
0.45	0.55	1	2	2	1	6	1	4	2		1	
0.55	0.65	2	2	1	2	4	2	1	1	3	2	2
0.65	0.75	1	2		2	3	2		1	5	1	1
0.75	0.85		1	2	1	2			2	2		
0.85	0.95			1	2	3	4		4		2	1
0.95	1.05		1	1	1		1		1	2	3	
1.05	1.15			1	1	1	2		1		2	
1.15	1.25			1		2			1	2	2	
1.25	1.35			2					1	1	1	
1.35	1.45					1			1	2	2	
1.45	1.55		1		1				2	2	3	
1.55	1.65								1	1	3	
1.65	1.75					1			1	1	1	
1.75	1.85						1			1		1
1.85	1.95					1				2	1	1
1.95	2.05					1					1	
2.05	2.15						1					1
2.15	2.25						1					
2.25	2.35											
2.35	2.45											
2.45	2.55											
2.55	2.65										1	1
2.65	2.75									1	2	
2.75	2.85										1	1
2.85	2.95											
2.95	3.05										1	
3.05	3.15											
3.15	3.25											
3.25	3.35											
3.35	3.45											
3.45	3.55											
3.55	3.65										1	
3.65	3.75										1	1
3.75	3.85											
3.85	3.95											
3.95												

TABLE B.III. *Frequency of $\sigma_{\theta}\bar{u}$ for Speed Intervals
in Period March - November*

Wind Speed Interval- mph:	2 hr Observation				4 hr Observation				8 hr Observation			
	0-3	4-6	7-15	16-28	0-3	4-6	7-15	16-28	0-3	4-6	7-15	16-28
<u>$\sigma_{\theta}\bar{u}$ Range:</u>												
0.00	0.08											
0.08	0.15	5		1								
0.15	0.25	8	3	2	1							
0.25	0.35	6	13	13	1	1	1					
0.35	0.45	7	8	15	4	3	2					
0.45	0.55	1	6	13	1	3	2			1		
0.55	0.65	4	4	22	4	4	11		1			
0.65	0.75		5	18	2	4	12	1		1	2	
0.75	0.85	1	2	14	7		7	3	1			
0.85	0.95		1	13	4		16	2		2	8	1
0.95	1.05		4	9	2		12		1	2	5	
1.05	1.15		1	6	7		22	2	2	3	3	1
1.15	1.25			4	4		7	3		3	4	1
1.25	1.35			4	1		11	6		1	4	1
1.35	1.45			4	2	1	14	3		2	12	2
1.45	1.55			1			6	7		1	2	1
1.55	1.65			3	4		7	3			14	6
1.65	1.75			2			7	7			7	
1.75	1.85				1		5	2			5	2
1.85	1.95				1		4	4		4	12	4
1.95	2.05						2	7		1	11	5
2.05	2.15				1		1	3		2	10	5
2.15	2.25				1		1	3			3	7
2.25	2.35							2		4	6	1
2.35	2.45										4	2
2.45	2.55						2				6	
2.55	2.65										2	2
2.65	2.75							1		1	2	3
2.75	2.85							1		1	2	1
2.85	2.95						1				4	2
2.95	3.05										3	1
3.05	3.15										3	1
3.15	3.25										1	
3.25	3.35							1			3	3
3.35	3.45										3	2
3.45	3.55										1	1
3.55	3.65							1				
3.65	3.75										4	2
3.75	3.85										2	1
3.85	3.95										2	
3.95							1	1			9	5

TABLE B.IV. Lowest Observed Values of $\sigma_{\theta}\bar{u}$, for 2 hr Observation

<u>Observation</u>	<u>$\sigma_{\theta}\bar{u}$, rad m/sec</u>	<u>Wind Speed, mph^a</u>
1	0.02	<1/2
2	0.03	<1/2
3	0.05	<1/2
4	0.06	<1/2
5	0.07	1
6	0.07	1
7	0.07	1
8	0.08	1

a For observations 1 through 4 the wind speed was less than 1/2 mph; for observations 4 to 8, 1 mph or less.

TABLE B.V. Commonly Used Values for $\sigma_{\theta}\bar{u}$

<u>Assumed Duration of Release, min</u>	<u>Average Wind Speed, $\sigma_{\theta}\bar{u}$</u>			
	<u>1 m/sec</u>	<u>2.5 m/sec</u>	<u>5 m/sec</u>	<u>10 m/sec</u>
10	0.024	0.15	0.25	0.35
60	0.04	0.15	0.25	0.35
120	0.08	0.25	0.35	0.45
240	0.10	0.40	0.5	0.60
480	0.18	0.60	0.7	0.90

If one wishes to estimate the probable consequences from a release rather than the limiting values, it is necessary to choose $\sigma_{\theta}\bar{u}$ values with greater probability of occurrence; i.e. larger values of $\sigma_{\theta}\bar{u}$ than those shown in Table B.V. Curves of the time integrated air concentration for several values of $\sigma_{\theta}\bar{u}$ are shown in Figure B.1

FIGURE B.1. Time Integrated Air Concentration, E/Q , as a Function of Distance from the Source. Simpson-Fuquay Equations

FIGURE B.2. Sutton's Equations Time Integrated Air Concentration, E/Q , as a Function of Distance from the Source

In addition to the dispersion calculation made by the code, an optional calculation is available to estimate depletion of the cloud by deposition of material on the ground cover. Little experimental data is available giving values of deposition coefficients for conditions encountered outdoors. Values commonly used for halogens and some particulates are given in Table B.VI.

TABLE B.VI. *Ground Deposition Parameters*

Atmospheric Conditions	Deposition Coefficient (DEPCO)		Wind Speed (WINDR) Ratio
	$\left(\frac{V}{\bar{u}_o}\right)$		$\left(\frac{U_o}{\bar{u}_h}\right)$
	Particulates	Halogens	
Highly Stable	1.5×10^{-4}	2.4×10^{-3}	0.17
Moderately Stable	2.2×10^{-4}	3.4×10^{-3}	0.35
Neutral	3.0×10^{-4}	4.6×10^{-3}	0.50
Unstable	6.0×10^{-4}	8.0×10^{-3}	0.70

Cloud Depletion

The aerosol concentration in a plume after depletion by deposition on ground cover is

$$\frac{E}{q_x} = \frac{E}{q} D_x$$

The cloud depletion factor, D_x , is defined by:

$$D_x = \exp - \left[\sqrt{\frac{2}{\pi}} \left(\frac{V_{\Delta}}{\bar{u}_o} \right) \left(\frac{\bar{u}_o}{\bar{u}_h} \right) \int_0^x \frac{\exp(-h^2/2 \sigma_z^2)}{\sigma_z} dx \right]$$

$$x = \frac{\bar{u}}{t} =$$

V_{Δ} = deposition velocity in m^2/sec

$\bar{u}_o$ = the average wind speed at ground level

$\bar{u}_h$ = the average wind speed at the level of emission

$\left(\frac{V_\Delta}{\bar{u}_o}\right)$ = deposition coefficient

$\left(\frac{\bar{u}_o}{\bar{u}_n}\right)$ = wind speed ratio

The integral in the function $D(x)$ is evaluated by Simpson's rule.

Sutton's Equation - Cloud Depletion Correction

Option 3 of the code allows the calculations of E/q by Sutton's equations. Sutton's equation is:

$$E/q = \frac{2}{C_y C_z \bar{u} x^{2-n}} \exp \left[-\frac{1}{x^{2-n}} \left(\frac{y^2}{C_y^2} + \frac{h^2}{C_z^2} \right) \right] \frac{\bar{u} C_i \cdot \text{sec}}{\text{cm}^3 \cdot C_i}$$

x = downwind distance in meters.

C_y , C_z and n are Sutton's parameters. Typical values are given in Table B.VII.

y and h are as previously defined.

Corrected for cloud depletion by ground deposition
Sutton's E/q is:

$$E/q \text{ depleted} = E/q D(x)$$

$$D(x) = \exp \left\{ -\frac{2}{C_z \sqrt{\pi}} \frac{V_\Delta}{\bar{u}_o} \frac{\bar{u}_o}{\bar{u}_n} \int_1^x \left[x^{(n-2)/2} \exp \left(\frac{-h^2}{C_z^2 x^{2-n}} \right) \right] dx \right\}$$

TABLE B.VII. *Numerical Values of Atmospheric Dispersion Parameters for Neutral and Unstable Atmospheres*

<u>Parameter</u>	<u>Release Level</u>	<u>Wind Speed, m/sec</u>	<u>Unstable</u>	<u>Neutral</u>
C_y	Ground	1	0.35	0.21
		5	0.30	0.15
		10	0.28	0.14
	Elevated	1	0.30	0.15
		5	0.26	0.12
		10	0.24	0.11
C_z	Ground	1	0.35	0.17
		5	0.30	0.14
		10	0.28	0.13
	Elevated	1	0.30	0.15
		5	0.26	0.12
		10	0.24	0.11
n			0.20	0.25

E/q Averaging Method

The time weighting method for E/q developed by E. C. Watson states that for any time period up to 8 hr the following relations hold.

For short releases the effect of wind variation in stable conditions is small; so

$$\frac{E}{q} \text{ effective} = \frac{E}{q} \text{ calculated (for a time period 0-10 min)}$$

For longer releases:

$$\frac{E}{q_{\Delta\tau_i}} = \frac{E}{q_i} \left(\frac{\tau_i}{\Delta\tau_i} \right) - \frac{E}{q_{i-1}} \left(\frac{\tau_{i-1}}{\Delta\tau_i} \right)$$

$\frac{E}{q_{\Delta\tau_i}}$ is the $\frac{E}{q}$ effective for the time period $\Delta\tau_i$.

$\frac{E}{q_i}$ is the time integrated air concentration from 0 to time τ_i .

$\frac{E}{q_{i-1}}$ is the time integrated air concentration for the preceding time period τ_{i-1} measured from 0 to time τ_{i-1} .

$\Delta\tau_i$ is the time increment beginning at τ_{i-1} and ending at time τ_i .

The E/q subroutine both E/q nonweighted (Program name ECURV) and E/q weighted to apply for a time period $\Delta\tau_i$. The latter is used in EXDOSE program dose calculations.

Figures B.1 and B.2 contain representative solutions obtained with the E/q calculation routine.

Simpson-Fuquay Equations

Figure B.1 is plotted from successive solutions of Equation (B.1) at different distances.

Moderately stable atmospheric conditions were assumed (Table B.I).

Other parameters were:

75 m	= h	Release height
0.0	= $\frac{V\Delta}{\bar{u}_0}$	Deposition coefficient
1.0 m/sec	= $\bar{u}_h$	Average wind speed at 75 m
0.35	= $\frac{\bar{u}_0}{\bar{u}_h}$	Ratio of ground level wind speed to $\bar{u}_h$.
0.0 m	= y	Distance from cloud centerline
0.0 m	= z	Height of exposure point above ground level.

$\sigma_\theta \bar{u}$ values were varied from 0.024 (top curve in Figure B.1) to 4.0 (bottom curve in Figure B.1).

Sutton's Equations

Figure B.2 is plotted from solutions of Sutton's equations for neutral and unstable atmospheric conditions. The parameter values used in the calculations are shown on Figure B.2.

APPENDIX C

CODE LISTING

C	EXDOSE SIGMA 8- SOURCE DECK LISTING	
*	IDENT CUS000 MDC	
*	LIST8	
*	SYMBOL TABLE	
*	LABEL	00000
CRIBD		000
	DIMENSION FEED(450,10),ISO(450),REC(450),LISTM(10,96),	001
	XLISTA(25,40),NRM(96),NRA(40),Y(5),DT(9),TERM(10),SUM2(10),	002
	XSUM3(10),ML(450),FX(15),TM(15),WL(15),WM(15),FM(10),FR(10),TF(11),	003
	XTX(11),FXT(11),DATA1(10,450),DATA2(10,450),DATA3(10,450),FLAM(9),	004
	XSEMLT(9),EMLT(9,9),TLN(9),TLH(9),POIS(10),GROS(10,2),TOTL(10,40,2)	005
	DIMENSION DELTAU(8),CASE(57),FACTOR(450)	006
	DIMENSION ITRVT(20,20),IBT(20)	
	DIMENSION CMLT(9,9)	
	COMMON FACTOR,TERM,SUM2,SUM3,EMLT,FLAM,FM	007
	COMMON DELTAU,BIGL,PO,TIME,T,SIGA25	008
	COMMON DEL,TRVT,BNDT,EDT,NSIG,NEDL,LINK,CASE	
	COMMON CY,CZ,TN,Y,TH,DEPCO	
	COMMON Z,DCO,CLITLC,CLITLD	
	COMMON FEED,REC,LISTM,LISTA,NRM,NRA,NCD,LOWA,NAT,NDT,NTRVT	010
	COMMON NBL,ITRVT,IBT	
	DO 4 KF = 1,450	
	FACTOR(KF) = 1.0	
4	CONTINUE	
	READ INPUT TAPE 2,1020,NCD	015
	READ INPUT TAPE 2,1000,((FEED(J,1),1=1,10),REC(J),ISO(J),J=1,NCD)	016
	LOWM=FEED(1,1)-1.	021
	ALOW=FEED(1,2)-1.	022
	LOWA=ALOW	023
	DO 3 J=1,NCD	024
	FEED(J,3)=.693/FEED(J,3)	025
	ML(J)=FEED(J,1)	026
	KM=ML(J)-LOWM	027
	KA=FEED(J,2)-ALOW	028
	IF(KM-1)6,1,1	029
1	IF(KA-1)6,2,2	030
6	WRITE OUTPUT TAPE 2,1002,REC(J-1),FEED(J-1,1)	031
	GO TO 3	032
2	NRM(KM)=NRM(KM)+1	033
	NRA(KA)=NRA(KA)+1	034
	JM=NRM(KM)	035
	JA=NRA(KA)	036
	LISTM(JM,KM)=J	037
	LISTA(JA,KA)=J	038
	NMA=XMAXOF(NMA,KM)	039
	NAT=XMAXOF(NAT,KA)	040
3	CONTINUE	041
9	WRITE OUTPUT TAPE 3,1006	042

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C	READ INPUT DATA (CASE,NEDL,SIGL,PO,TIME,T,SIGA25,DEL,NSIG,LINK)	043
	CALL LISTIN	044
	IF(SENSE LIGHT 1)46,47	045
46	CALL LISTIN	046
	GO TO 46	047
47	CONTINUE	048
	FLUX=T/(SIGA25*TIME)	049
	THETA=TIME	050
	XBAR=1./EXP(T)	051
	PXBAR=XBAR	052
	P=PO*8.436E+5	053
	TFISS=P*TIME*.53076E-8	054
	X=FLUX*SIGA25	055
	RATIO=FLUX/PO	056
	NSTEP=1	057
	TET=TIME	058
	FMWD=PO*TIME	059
	P25=P/(1.+DEL)	060
	IF(NSIG)31,31,32	062
31	JS1=2	063
	GO TO 33	064
32	WRITE OUTPUT TAPE 3,1050,NSTEP	065
	JS1=1	066
33	NBAD=0	067
	FX(1)=-X	068
	ADD=1.	069
	TM(1)=THETA	070
	WL(1)=THETA	071
	SSUM=THETA	072
	DO 8 L=2,15	073
	ADD=ADD+1.	074
	TM(L)=TM(L-1)*THETA/ADD	075
	FX(L)=-FX(L-1)*X	076
	WL(L)=FX(L-1)*TM(L)	077
8	SSUM=SSUM+WL(L)	078
	TX(1)=SSUM	079
	DO 11 L=2,10	080
	ADD=L	081
	SSUM=0.	082
	DO 12 I=1,15	083
	WL(I)=WL(I)*THETA/ADD	084
	ADD=ADD+1.	085
12	SSUM=SSUM+WL(I)	086
11	TX(L)=SSUM	087
	DO 290 K=1,NMA	088
	N1=0	089
	N2=0	090
	N3=0	091

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JM=NRM(K)	092
DO 290 J=1,JM	093
Y(1)=0.	094
Y(2)=0.	095
Y(3)=0.	096
Y(4)=0.	097
Y(5)=0.	098
KI=LISTM(J,K)	099
IS=ISO(KI)	100
KA=FEED(KI,2)-ALOW	101
LM=NRA(KA)	102
F=FLUX*FEED(KI,6)+FEED(KI,3)	103
I1=KI	104
I2=KI	105
I3=KI	106
I4=KI	107
I5=KI	108
PM=FEED(KI,1)-1.	109
DO 10 L=1,LM	110
NP=LISTA(L,KA)	111
IF(FEED(NP,1)-PM)10,100,170	112
10 CONTINUE	113
100 I4=NP	114
I5=I4+1	115
GO TO (110,140),IS	116
110 IF(ISO(NP)-2)120,130,130	117
120 Y(4)=FLUX*FEED(I4,6)*FEED(I4,7)	118
GO TO 135	119
130 I5=NP	120
135 Y(5)=FLUX*FEED(I5,6)*FEED(I5,7)	121
GO TO 170	122
140 IF(ISO(NP)-2)150,160,160	123
150 Y(4)=FLUX*FEED(I4,6)*(1.-FEED(I4,7))	124
GO TO 165	125
160 I5=NP	126
165 Y(5)=FLUX*FEED(I5,6)*(1.-FEED(I5,7))	127
170 IF(N1-1)240,180,210	128
180 I1=KI-1	129
Y(1)=FEED(I1,3)*(1.-FEED(I1,8))	130
IF(N2-1)240,185,190	131
185 WRITE OUTPUT TAPE 3,1002,REC(KI-1),FEED(KI-1,1)	132
GO TO 240	133
190 I2=I1-1	134
Y(2)=FEED(I2,3)*(1.-FEED(I2,8))	135
IF(N3-1)240,200,240	136
200 I3=I2-1	137
Y(3)=FEED(I3,3)*FEED(I3,8)	138
GO TO 240	139

210	I2=KI-1	140
	GO TO (220,230),IS	141
220	Y(2)=FEED(I2,3)*FEED(I2,8)	142
	GO TO 240	143
230	Y(2)=FEED(I2,3)*(1.-FEED(I2,8))	144
	IF(N2-1)240,200,240	145
240	N3=N2	146
	N2=N1	147
	N1=IS	148
	A=P*FEED(KI,5)/100.	149
	B=P25*(FEED(KI,4)-FEED(KI,5))/100.	150
	DO 241 L=1,10	151
	SUM2(L)=Y(1)*DATA2(L,I1)+	152
X	Y(2)*DATA2(L,I2)+	153
X	Y(3)*DATA2(L,I3)+	154
X	Y(4)*DATA2(L,I4)+	155
X	Y(5)*DATA2(L,I5)	156
241	SUM3(L)=Y(1)*DATA3(L,I1)+	157
X	Y(2)*DATA3(L,I2)+	158
X	Y(3)*DATA3(L,I3)+	159
X	Y(4)*DATA3(L,I4)+	160
X	Y(5)*DATA3(L,I5)	161
	F1=A/F	162
	F2=B/(F-X)	163
	F3=F2*XBAR	164
	F4=DATA1(1,KI)-F1-F2	165
	ARG=F*THETA	166
	SUM=0.	167
	FM(1)=1.	168
	FR(1)=1./F	169
	DO 242 L=2,10	170
	FM(L)=-FM(L-1)*F	171
	FR(L)=-FR(L-1)/F	172
242	TERM(L)=0.	173
	IF(ARG-79.)260,243,243	174
243	NT=1	175
	DO 244 L=1,10	176
	TERM(L)=SUM2(L)*FR(L)	177
	SUM=SUM+TERM(L)	178
	IF(.0001-ABS(F(TERM(L)/SUM)))244,245,245	179
244	CONTINUE	180
245	DATA2(1,KI)=F1+F3+SUM	181
	EMFT=0.	182
	DO 247 L=2,10	183
	SSUM=0.	184
	DO 246 I=L,10	185
	N=I-L+1	186
246	SSUM=SSUM+FR(N)*SUM2(I)	187

247	DATA2(L,K1)=F3*FX(L-1)+SSUM	188
249	FMULT=(1.-EMFT)/F	189
	SSUM=SUM	190
	DO 250 L=1,10	191
	SSUM=(SUM3(L)-SSUM)/F	192
	FA=TM(L)	193
	DATA3(L,K1)=FMULT*F4+FA*F1+F2*TX(L)+SSUM	194
250	FMULT=(FA-FMULT)/F	195
	GO TO 300	196
260	EFT=EXPF(ARG)	197
	EMFT=1./EFT	198
	F5=F4*EMFT	199
	IF(ARG-1.)261,261,291	200
261	NT=2	201
267	DO 265 L=1,10	202
	TERM(L)=SUM3(L)*FM(L)	203
	SUM=SUM+TERM(L)	204
	IF(.0001-ABSF(TERM(L)/SUM))265,266,266	205
265	CONTINUE	206
266	SS2=THETA	207
	SSUM=THETA	208
	FNUM=1.	209
	WL(1)=THETA	210
	FF=1.	211
	WM(1)=THETA	212
	DO 262 L=2,15	213
	FNUM=-F*FNUM+FX(L-1)	214
	FA=TM(L)	215
	WL(L)=FNUM*FA	216
	SSUM=SSUM+WL(L)	217
	FF=-FF*F	218
	WM(L)=FF*FA	219
262	SS2=SS2+WM(L)	220
	FXT(1)=SSUM	221
	TF(1)=SS2	222
	DO 264 L=2,11	223
	SSUM=0.	224
	SS2=0.	225
	ADD=L	226
	DO 263 I=1,15	227
	WL(I)=WL(I)*THETA/ADD	228
	WM(I)=WM(I)*THETA/ADD	229
	ADD=ADD+1.	230
	SSUM=SSUM+WL(I)	231
263	SS2=SS2+WM(I)	232
	FXT(L)=SSUM	233
264	TF(L)=SS2	234
	DATA2(1,K1)=DATA1(1,K1)*EMFT+A*TF(1)+B*FXT(1)+SUM	235

269 DO 272 L=2,10	236
SSUM=0.	237
DO 270 I=2,L	238
N=L-I+1	239
270 SSUM=SSUM+FM(I-1)*SUM2(N)	240
DO 271 I=5,10	241
N=I-L+1	242
271 SSUM=SSUM+FM(I)*SUM3(N)	243
272 DATA2(L,KI)=FM(L)*F5+F3*FX(L-1)+SSUM	244
DO 281 L=1,10	245
SSUM=0.	246
LIM=10-L	247
IF(LIM)281,281,282	248
282 DO 280 I=1,LIM	249
N=I+L	250
280 SSUM=SSUM+FM(I)*SUM3(N)	251
281 DATA3(L,KI)=DATA1(1,KI)*TF(L)+A*TF(L+1)+B*FXT(L+1)+SSUM	252
GO TO 300	253
291 FA=1.	254
ADD=1.	255
NT=3	256
FNUM=EFT-1.	257
DO 292 L=1,10	258
TERM(L)=FR(L)*FNUM*SUM2(L)/EFT	259
FA=FA*ARG/ADD	260
FNUM=FNUM-FA	261
ADD=ADD+1.	262
SUM=SUM+TERM(L)	263
IF(.0001-ABSF(TERM(L)/SUM))292,293,293	264
292 CONTINUE	265
293 IF(ABSF(TERM(10)/SUM)-.001)298,298,296	266
296 IF(ARG-2.)297,297,298	267
297 NT=4	268
SUM=0.	269
DO 299 L=1,10	270
299 TERM(L)=0.	271
GO TO 267	272
298 DATA2(1,KI)=DATA1(1,KI)*EMFT+F1*(1.-EMFT)+F2*(XBAR-EMFT)+SUM	273
SSUM=0.	274
DO 294 L=2,10	275
294 SSUM=SSUM+TERM(L)	276
DER=EMFT*SUM2(1)-F*SSUM	277
DO 295 L=2,10	278
DATA2(L,KI)=FM(L)*F5+F3*FX(L-1)+DER	279
295 DER=SUM2(L)-F*DER	280
GO TO 249	281
300 IF(DATA2(1,KI))302,301,301	282
301 IF(ABSF(TERM(10)/DATA2(1,KI))-0.001)305,305,302	283

302	NBAD=NBAD+1	284
	WRITE OUTPUT TAPE 3,1060,REC(KI),ML(KI),TERM,DATA2(1,KI),NT	285
305	FLAM(J)=FEED(KI,3)	286
	DATA2(1,KI) = DATA2(1,KI) * FACTOR(KI)	286 1
	SSUM=0.	287
	LIM=J-1	288
	IF(LIM)403,403,400	289
400	DO 401 L=1,LIM	290
401	DATA1(L+1,KI)=(Y(1)*DATA1(L+1,I1)+Y(2)*DATA1(L+1,I2)+Y(3)*	291
	XDATA1(L+1,I3))/(FLAM(J)-FLAM(L))	292
	DO 402 L=1,LIM	293
402	SSUM=SSUM+DATA1(L+1,KI)	294
403	DATA1(J+1,KI)=DATA2(1,KI)-SSUM	295
	DATA1(1,KI)=DATA2(1,KI)	296
290	CONTINUE	297
	GO TO (600,699),JS1	
600	NSTEP=NSTEP+1	299
	WRITE OUTPUT TAPE 3,1006	300
C	READ INPUT DATA (PO,TIME,NSIG,FACTOR)	301
	CALL LISTIN	302
	IF(SENSE LIGHT 1)606,607	303
606	CALL LISTIN	304
	GO TO 606	305
607	CONTINUE	306
	WRITE OUTPUT TAPE 3,1050,NSTEP	307
	TET=TET+TIME	308
	IF(PO)650,650,610	309
610	FLUX=RATIO*PO	310
	FMWD=FMWD+PO*TIME	311
	X=FLUX*SIGA25	312
	P=PO*8.436E+5	313
	TFISS=TFISS+P*TIME*.53076E-8	314
	P25=PXBAR*P/(1.+DEL)	315
	XBAR=1./EXPF(X*TIME)	316
	PXBAR=PXBAR*XBAR	317
	THETA=TIME	318
	IF(NSIG)33,33,620	319
620	JS1=2	320
	GO TO 33	321
650	DO 670 K=1,NMA	322
	JM=NRM(K)	323
	DO 670 J=1,JM	324
	KI=LISTM(J,K)	325
	ARG=TIME*FEED(KI,3)	326
	IF(79.-ARG)651,651,652	327
651	SEMLT(J)=0.	328
	GO TO 655	329
652	IF(ARG)653,653,654	330

653	SEMLT(J)=1.	331
	GO TO 655	332
654	SEMLT(J)=1./EXP(ARG)	333
655	SSUM=0.	334
	DO 660 I=1,J	335
660	SSUM=SSUM+SEMLT(I)*DATA1(I+1,KI)	336
670	DATA1(I,KI) = SSUM * FACTOR(KI)	337
	GO TO 660	338
699	ISW = 0	
	NSW = 0	
	WRITE OUTPUT TAPE 3,1006	339
700	CONTINUE	
C	READ INPUT DATA (TRVT,BNDT,EDT,DELTAU,BIGL,NEDL)	340
	CALL LISTIN	341
	IF(SENSE LIGHT 1)706,707	342
706	CALL LISTIN	343
	GO TO 706	344
707	CONTINUE	345
800	IF(BNDT-TRVT-EDT)801,801,804	
801	WRITE OUTPUT TAPE 3,1015	
	CALL LISTIN	
	IF(NEDL)800,800,830	
804	CONTINUE	
	IF(DELTAU(1))805,805,806	
805	WRITE OUTPUT TAPE 3,1016	
	GO TO 706	
806	CONTINUE	
	IF(LINK)815,815,880	345 1
815	CONTINUE	345 2
	IF(ISW)816,816,818	
816	BT = BNDT	
	BL = BIGL	
818	IF(BT-BNDT)820,821,820	
820	ITRVT(NBT,NBL) = NTRVT	
	NTRVT = 0	
821	IF(BL-BIGL)824,826,824	
824	IBT(NBL) = NPT	
	NPT = 0	
	IF(BT-BNDT)826,825,826	
825	CONTINUE	
	WRITE OUTPUT TAPE 3,1014	
	NBT = IBT(NBL)	
827	CALL LISTIN	
	IF(NEDL)827,827,830	
826	CONTINUE	
	IF(NEDL)840,840,830	
830	ITRVT(NBT,NBL) = NTRVT	
833	IBT(NBL) = NBT	

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835 END FILE 12
      REWIND 12
      CALL CHAIN(2,4)
840 NTRVT = NTRVT + 1
      IF(NTRVT-10)860,860,850
850 CONTINUE
      WRITE OUTPUT TAPE 3,1011
      NTRVT = NTRVT - 1
852 CALL LISTIN
      IF(NEDL)852,852,830
860 IF(NTRVT-8)870,870,880
870 BT = BNDT
      NBT = NBT + 1
      IF(NBT-20)872,872,871
871 CONTINUE
      WRITE OUTPUT TAPE 3,1012
      NBT = NBT - 1
873 CALL LISTIN
      IF(NEDL)873,873,833
872 IF(NBT-1)874,874,880
874 BL = BIGL
      NBL = NBL + 1
      IF(NBL-20)880,880,876
876 CONTINUE
      WRITE OUTPUT TAPE 3,1013
      NBL = NBL - 1
878 CALL LISTIN
      IF(NEDL)878,878,835
880 CONTINUE
      IF(NSW)884,884,700
884 NDT = 1
      DT(1) = EDT + TRVT
      DO 720 KL = 2,9
      NDT = NDT + 1
      DT(KL) = DT(KL-1) + DELTAU(KL-1)
      IF( DT(KL)-BNDT )720,730,710
710 DT(KL) = BNDT
      GO TO 730
720 CONTINUE
730 DO 740 KB = 1,NDT
      DT(KB) = DT(KB) * 60.0
740 CONTINUE
      DO 22 L=1,9
      TRY=DT(L)/100.
      IF(TRY-1.)14,14,15
14 TLN(L)=DT(L)
      TLH(L)=5H SEC.
      GO TO 22

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15 TRY=DT(L)/3600.	364
IF (TRY-1.)16,16,17	365
16 TLN(L)=TRY*60.	366
TLH(L)=5H MIN.	367
GO TO 22	368
17 TRY=TRY/24.	369
IF (TRY-1.)18,19,19	370
18 TLN(L)=TRY*24.	371
TLH(L)=5H HR.	372
GO TO 22	373
19 TRY=TRY/365.	374
IF (TRY-1.)20,21,21	375
20 TLN(L)=TRY*365.	376
TLH(L)=5H DAYS	377
GO TO 22	378
21 TLN(L)=TRY	379
TLH(L)=5H YRS.	380
22 DT(L)=DT(L)/86400.	381
900 NPTS=2	382
IF (DT(2)-DT(1))812,812,901	383
901 DO 902 L=8,7	384
IF (DT(NPTS+1)-DT(NPTS))903,903,902	385
902 NPTS=NPTS+1	386
903 LIM=NPTS-1	387
ADDRG = DT(1) * BIGL * 1440.0	
DO 930 K=1,NMA	388
JM=NRM(K)	389
DO 930 J=1,JM	390
KI=LISTM(J,K)	391
ARG=FEED(KI,3)+BIGL * 1440.0	392
OLDARG=DT(1)*ARG	393
OLDT = EXPF(ADDRGR-OLDARG)	
CMLT(J,1) = EXPF(-FEED(KI,3)*DT(1))	394
DO 910 L=2,NPTS	395
THISRG=DT(L)*ARG	396
THIST = EXPF(ADDRGR-THISRG)	
IF (THISRG-OLDARG-1.E-4)907,907,908	398
907 EMLT(J,L-1)=OLDT*(DT(L)-DT(L-1))	399
GO TO 906	400
908 EMLT(J,L-1)=(OLDT-THIST)/ARG	401
906 OLDARG=THISRG	402
CMLT(J,L) = EXPF(-FEED(KI,3)*DT(L))	403 1
910 OLDT=THIST	403
CSUM = 0.0	403 2
DO 914 IA = 1,J	403 3
914 CSUM = CSUM + DATA1(IA+1,KI) * CMLT(IA,NDT)	403 4
DATA3(NDT,KI) = CSUM * FEED(KI,3)	403 5
DO 930 L=1,LIM	404

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CSUM = 0.0	404	1
SSUM=0.	405	
DO 920 I=1,J	406	
CSUM = CSUM + DATA1(I+1,KI) * CMLT(I,L)	406	1
920 SSUM=SSUM+DATA1(I+1,KI)*EMLT(I,L)	407	
DATA3(L,KI) = CSUM * FEED(KI,3)	407	1
930 DATA2(L,KI)=SSUM*FEED(KI,3)*FEED(KI,10)	408	
DO 931 LA = 1,450		
DATA3(2,LA) = DATA3(NDT,LA)		
931 CONTINUE		
IF(LINK)932,932,939	409	
932 CONTINUE	410	
DATA2(10,1) = TRVT	412	
DATA2(10,2) = NDT - .1	413	
DATA2(10,3) = BNDT	413	1
DATA2(10,4) = BIGL	413	2
DATA2(10,5) = EDT	413	3
DO 935 LB = 11,67		
DATA2(10,LB) = CASE(LB-10)		
935 CONTINUE		
IF(ISW)934,934,936	411	
934 REWIND 12	417	
WRITE TAPE12,DATA2,(DATA3(1,LC),DATA3(2,LC),LC=1,450)		
ISW = 1	418	1
GO TO 700		
936 WRITE TAPE12,DATA2,(DATA3(1,LC),DATA3(2,LC),LC=1,450)	421	
GO TO 700	424	
939 DO 940 L=1,LIM	425	
940 GROS(L,1)=0.	426	
DO 955 K=1,NAT	427	
JM=NRA(K)	428	
LAT=K+LOWA	429	
LF=LISTA(1,K)	430	
WRITE OUTPUT TAPE 3,9000,(CASE(LR),LR=1,6)	431	
WRITE OUT*UT TAPE 3,5010,LAT,REC(LF)	432	
WRITE OUTPUT TAPE 3,5012	433	
WRITE OUTPUT TAPE 3,9013,(TLN(I),TLH(I),I=1,NPTS)	434	
DO 950 L=1,LIM	435	
950 TOTL(L,K,1)=0.	436	
DO 952 J=1,JM	437	
KI=LISTA(J,K)	438	
WRITE OUTPUT TAPE 3,9002,REC(KI),ML(KI),(DATA2(I,KI),I=1,LIM)	439	
DO 952 L=1,LIM	440	
952 TOTL(L,K,1)=TOTL(L,K,1)+DATA2(L,KI)	441	
955 WRITE OUTPUT TAPE 3,9003,(TOTL(L,K,1),L=1,LIM)	442	
WRITE OUTPUT TAPE 3,9000,(CASE(LR),LR=1,6)	443	
WRITE OUTPUT TAPE 3,5004	444	
WRITE OUTPUT TAPE 3,5016	445	

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WRITE OUTPUT TAPE 3,9013,(TLN(I),TLH(I),I=1,NPTS)	446
DO 960 K=1,NAT	447
LAT=K+LOWA	448
LF=LISTA(1,K)	449
WRITE OUTPUT TAPE 3,9017,LAT,REC(LF),(TOTL(L,K,1),L=1,LIM)	450
DO 960 L=1,LIM	451
960 GROS(L,1)=GROS(L,1)+TOTL(L,K,1)	452
WRITE OUTPUT TAPE 3,9003,(GROS(L,1),L=1,LIM)	453
812 IF(NEDL)808,809,808	454
808 NEDL=NEDL-1	455
WRITE OUTPUT TAPE 3,1010,(CASE(LR),LR=1,6)	456
GO TO 700	457
809 DO 810 KL=1,NCD	458
810 DATA(1,KL)=0.	459
GO TO 9	460
1000 FORMAT(F3.0,F2.0,4E9.3,4F5.3,7X,A3,I1)	461
1001 FORMAT(6A6,I1,E10.4,25X,75E10.4,I1)	462
1002 FORMAT(1H13X,25HTROUBLE IN INPUT DATA AT A3,F5.0)	463
1006 FORMAT(1H1 7,54X,10HINPUT DATA///)	467
1010 FORMAT(1H1,6H6,2X,I1,18H EXTRA DECAY LISTSP1E15.4/1H 5E15.4,0P15)	469
1011 FORMAT(1H0 6X,109HTHERE ARE MORE THAN 10 TRAVEL TIMES FOR THE LAST BOUNDARY TIME READ IN. THIS IS MORE THAN THE MAXIMUM LIMIT.///)	
1012 FORMAT(1H0 6X,110HTHERE ARE MORE THAN 20 BOUNDARY TIMES FOR THE LAST LEAKAGE RATE READ IN. THIS IS MORE THAN THE MAXIMUM LIMIT./// 2)	
1013 FORMAT(1H0 6X, 91HTHERE ARE MORE THAN 20 LEAKAGE RATES, L, IN THIS IS RUN. THIS IS MORE THAN THE MAXIMUM LIMIT.///)	
1014 FORMAT(1H0 6X, 87HTHE LEAKAGE RATE WAS CHANGED BUT THE BOUNDARY TIME WAS NOT AND IT MUST BE CHANGED ALSO.///)	
1015 FORMAT(1H0 6X,104H(BOUNDARY TIME) = OR LESS THAN (TRAVEL TIME + E MISSION DELAY TIME). THE BOUNDARY TIME MUST BE GREATER.///)	
1016 FORMAT(1H0 6X, 92HTHE DELTAU(1) VALUE WAS LEFT OUT OF THE INPUT DATA OR IT WAS NOT PUT IN MEMORY LOCATION 581.///)	
1020 FORMAT(I3)	470
1050 FORMAT(1H+102X,4HSTEP13)	471
1060 FORMAT(1H A3,I3,2X,1P11E10.3,I2)	472
1070 FORMAT(2F10.4,30X,I1)	473
1080 FORMAT(1H 2F19.9,57X,I5)	474
1090 FORMAT(9E8.3)	475
1091 FORMAT(1H 1P9E10.3,23H DECAY POINTS - SECONDS)	476
5004 FORMAT(1H+106X,8H SUMMARY)	477
5010 FORMAT(1HH106X,7HAT. NO.I3,1X,A2)	478
5012 FORMAT(8H0ISOTOPE)	479
5016 FORMAT(8H0ELEMENT)	480
9000 FORMAT(1H16A6, 55H INTEGRATED GAMMA ENERGY - MEV, IN UNITS OF CUR XIE-DAYS)	481
9002 FORMAT(2H A3,I3,7X,1P8E11.3)	482
9003 FORMAT(7H TOTAL,8X,1P8E11.3)	483
	484

9013	FORMAT(1H+9X,F6.1,A5,F6.1,A5,F6.1,A5,F6.1,A5,F6.1,A5,F6.1,A5,	485
	XF6.1,A5,F6.1,A5,F6.1,A5)	486
9017	FORMAT(1H 12,1X,A2,9X,1P8E11.3)	487
	END	488

```

*      LABEL
C      MAIN PROGRAM TO CALCULATE BODY DOSE
COMMON WGHT,EOQSW,DUMMY,IPLOT ,GRPSW,DELTAU,BIGL,PO,TIME,T,SIGA25
COMMON DEL,TRVT,BNDT,EDT,NSIG,NEDL,LINK,CASE
COMMON CY,CZ,TN,Y,TH,DEPCO,WINDR,SIGY,SIGZ,NCASE
COMMON Z,DCO,CLITLC,CLITLD
COMMON FEED,REC,LISTM,LISTA,NRM,NRA,NCD,LOWA,NAT,NDT,NTRVT
COMMON NBL,ITRVT,IBT
COMMON EQ,TT,A6,A7,A8,A9,A10,ADCO
COMMON CLITLA,CLITLB,AKSQ,SIGTUB
COMMON EQCURV,PLOT3,EQCV,EOQ,EXPT,NEXPT,P3TT,NTP3,NPLOTS
COMMON DOSE,NEOQ
COMMON XX,YY
DIMENSION WGHT(450),EOQSW(15,5),GRPSW(5),DELTAU(8),CASE(57),
1  FEED(450,10),REC(450),LISTM(10,96),LISTA(25,40),NRM(96) ,
2  NRA(40),EQ(8),TT(10),DUMMY(45),IPLOT(5)
DIMENSION ITRVT(20,20),IBT(20)
DIMENSION SIGTUB(8)
DIMENSION EQCURV(10),PLOT3(20,10,5),EQCV(8,5,10),EOQ(8,5,10)
DIMENSION EXPT(20,10),NEXPT(10),P3TT(10),DOSE(5,10)
DIMENSION XX(30),YY(30)
DIMENSION ELMT(450),MASS(450),ISOGRP(3,5),SUM(8),
1  TAU(8),DATA2(10,450),DATA3(2,450)
DIMENSION CURIES(10,2),GRAMS(10)
DIMENSION IRUNIN(2)
B      BLANK = 6J6060606060
C      DEFINE GROUP ATOMIC NUMBERS ARRAY
DO      3 I=1,15                                001
3  ISOGRP(I) = 0                                002
ISOGRP (1,1) = 54                                003
ISOGRP (1,2) = 36                                004
ISOGRP (2,1) = 53                                005
ISOGRP (2,2) = 35                                006
ISOGRP (3,1) = 34                                007
ISOGRP (3,2) = 52                                008
ISOGRP (3,3) = 55                                009
DO 29 I=1,8                                010
TAU(I) = 0.                                025
DO 28 J=1,I                                026
28 TAU(I) = TAU(I) + DELTAU(J)                027
29 CONTINUE                                028
NPLOTS = 0                                029
DO 35 I=1,10                                030
P3TT(I) = 0.                                032
35 NEXPT(I) = 0                                034
DO 40 I=1,5                                035
40 IPLOT(I)=0
IRUNIN(1) = 1

```

IRUNIN(2) = 1	
C INITIALIZE INPUT ARRAYS	
101 DO 110 I=1, 5	101
GRPSW (I)= 0.	103
DO 110 J=1,15	
110 EOGSW (J,I) = 0.	110
DO 115 I =1,450	112
115 WGHT (I) = 0.	115
LCNT = 1	116
NRTPL = 1	1161
NCS = NCASE - 1	1162
C READ ONE CASE OF ISOTOPE SELECTION DATA	117
WRITE OUTPUT TAPE 3,120	118
120 FORMAT (1H140X, 10HINPUT DATA)	120
125 CALL LISTIN	125
IF (WGHT) 126,128,128	1255
126 IF (NPLOTS) 125,125,127	126
127 CALL HALT	127
GO TO 125	1275
128 IF (SENSE LIGHT 1)130,140	128
130 WRITE OUTPUT TAPE 3,135	130
135 FORMAT (1H020X,26HTHIS CASE WILL BE BYPASSED)	135
GO TO 101	137
C PLACE NAMES AND MASSES OF INDIVIDUAL ISOTOPES INTO ARRAYS	138
C FOR REPORTING	139
140 NISOT =0	140
DO150 I=1, NCD	141
IF (WGHT(I))150,150,145	142
145 NISOT = NISOT + 1	145
ELMT (NISOT) = REC(I)	147
MASS (NISOT) = FEED (I,1)	148
150 CONTINUE	150
C CHECK ISOTOPE GROUP SWITCHES - FILL IN WGHT ARRAY ACCORDINGLY	152
IF (GRPSW(5))170,170,160	155
C GROUP 5 ALL ISOTOPES	159
160 DO 165 I=1, NCD	160
165 WGHT(I) = GRPSW(5)	165
GO TO 196	167
170 DO195 I=1, NAT	170
DO 180 J=1,3	171
DO 180 K=1,5	172
IF (ISOGKP(J,K) - LOWA - I) 180,175,180	173
175 IF (GRPSW (J)) 195,195,185	175
180 CONTINUE	180
IF (GRPSW(4)) 195,195,183	182
183 J = 4	183
185 JK = NRA(I)	185
DO 190 K=1,JK	187

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ISUB = LISTA (K,I)	188
190 WGHT(ISUB) = GRPSW(J)	190
195 CONTINUE	195
196 REWIND 12	196
197 READ TAPE 12, DATA2, DATA3	197
BNDT = DATA2 (10,3)	1971
BIGL = DATA2 (10,4)	198
EDT = DATA2(10,5)	1981
DO 1989 I =1,57	1982
IF (DATA2(10,I+10)) 1986,1984,1986	
1984 CASE (I) = BLANK	1984
GO TO 1989	1985
1986 CASE (I) = DATA2(10,I+10)	1986
1989 CONTINUE	1989
NTRVT = ITRVT (NRTPL,LCNT)	199
200 DO 330 I=1,NTRVT	200
CURIES(I,1) = 0.	2007
CURIES(I,2) = 0.	2008
GRAMS (I) = 0.	2009
C READ INTEGRALS FROM TAPE B7	2009
IF (I-1) 203,203,201	
201 READ TAPE12, DATA2, DATA3	201
203 IT(I) = DATA2 (10,1)	203
NDT = DATA2(10,2) + .005	204
TRVT = DATA2(10,1)	2041
C BUILD E/Q EQUATIONS INTO AN ARRAY	205
DO 240 K= 1,5	206
IF (EQSW(1,K)) 225,210,225	207
210 IF (K -1) 215,215,260	210
215 WRITE OUTPUT TAPE 3, 220	215
220 FORMAT (75H0 THIS CASE IS BEING BYPASSED BECAUSE NO E OVER Q EQUAT	220
ITIONS WERE SPECIFIED)	2201
GO TO 101	221
225 A6 = EQSW(1,K)	225
A7 = EQSW(2,K)	226
A8 = EQSW(3,K)	227
A9 = EQSW(4,K)	227
A10 = EQSW(5,K)	228
DO 229 L=1,NDT	
229 SIGTUB(L) = EQSW(L+5,K)	9
CALL EOVRQ	230
DO 235 J= 1,NDT	
EQCV(J,K,I) = EQCURV(J)	233
235 EQ(J,K,I) = EQ(J)	235
NEOQ = K	237
240 CONTINUE	240
C CALCULATE TOTAL BODY DOSE	249
260 DO 261 J=1,NDT	260

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261	SUM(J) = 0.	261
	DO 271 K=1, NCD	262
	IF (WGHT(K)) 271,271,264	263
264	CURIES (I,1) = CURIES(I,1) + DATA3(1,K) * WGHT(K)	264
	CURIES (I,2) = CURIES(I,2) +(DATA3(2,K)- DATA3(1,K))* WGHT(K)	265
	GRAMS (I) = GRAMS(I) + WGHT(K) * DATA3(1,K) * FEED(K,1) *	2651
1	.53076E-8 / FEED(K,3)	2652
	DO 270 J=1,NDT	266
	SUM(J) = SUM(J) + WGHT(K) * DATA2(J,K)	267
270	CONTINUE	270
271	CONTINUE	271
	DO 310 J=1,NEOQ	280
	DOSE (J,I) = 0.	285
	DO 300 K=1,NDT	290
300	DOSE (J,I) = DOSE (J,I) + FUNCT(TT(I),TAU(K)) * EQQ(K,J,I)*SUM(K)	300
310	DOSE (J,I) = DOSE (J,I) * 0.259 * BIGL * 1440.	310
C	IF PLOT OF DOSE VS EXPOSURE TIME IS REQUESTED - STORE DOSE	3139
C	NTTP3 = NUMBER OF TRAVEL TIMES SAVED FOR PLOTTING	31391
C	P3TT(L) = TRAVEL TIME FOR LTH CURVE	31392
C	NEXPT(L)= NUMBER OF POINTS TO PLOT FOR LTH TRAVEL TIME	31393
C	PLOT3 ARRAY IS THE DOSE	31394
C	EXPT ARRAY IS EXPOSURE TIMES	31394
	IF (TRVT) 330,330,314	31395
314	IF (IPLOT(3)) 315,330,315	314
315	DO 325 L=1,10	315
	IF (P3TT(L)) 318,317,318	316
317	NTTP3= L	317
	GO TO 319	3175
318	IF (TRVT - P3TT(L)) 325,320,325	318
319	P3TT(L) = TRVT	319
320	NEXPT(L) = NEXPT (L) + 1	320
	IF (NEXPT(L)-20) 321,330,330	3205
321	ISUB = NEXPT(L)	321
	DO 323 J= 1,NEOQ	322
323	PLOT3 (ISUB,L,J) = DOSE(J,I)	323
	EXPT (ISUB,L) = BNDT - EDT - TRVT	324
	GO TO 330	3245
325	CONTINUE	325
330	CONTINUE	330
	NCS = NCS + 1	334
	NBTPL = NBTPL + 1	335
	ITRANS = 1	3351
	IF (NBTPL - IBT(LCNT)) 340,340,336	3352
C	NEXT BIGL	3359
336	LCNT = LCNT + 1	336
	NRTPL = 1	3361
	IF (LCNT - NBL) 340,340,337	3362
C	END OF TAPE ON B7	3369

337 REWIND 12	337
ITRANS = 2	3371
LCNT = 1	3372
C PRINT OUT	339
340 DO 560 I=1,NFOQ	340
WRITE OUTPUT TAPE 3, 345, NCS, CASE, BIGL, FOOSW(2,1),EDT, BNDT	342
345 FORMAT (1H1 40X, 8HEXPOSURE, 10X 5HCASE, 16, /3(1H 19A6/)	345
X /1PE10.4,75H = LEAKAGE CONSTANT (LEAKA	345
XGE IN CUBIC FELT PER MINUTE/CONTAINMENT VOLUME)//1PE10.4,24H = AVE	346
XRAGE WIND VELOCITY,10X1PE9.4,22H = EMISSION DELAY TIME,10X1PE9.4,	347
X16H = BOUNDARY TIME)	348
IF (EQGSW(1,I) -3.) 3482, 421, 422	3481
3482 WRITE OUTPUT TAPE 3, 3483	3482
3483 FORMAT (1H0, 12X, 20HCLIMATIC CONDITIONS)	3483
IF (ABSF (EQGSW(1,I))-1.1370,355,370	350
355 WRITE OUTPUT TAPE 3,360	355
360 FORMAT (1H+, 32X,7HWINTER)	360
GO TO 380	365
370 WRITE OUTPUT TAPE 3, 375	370
375 FORMAT (1H+, 32X, 7HSUMMER)	375
380 IF (EQGSW(1,I)) 385,385,400	380
385 WRITE OUTPUT TAPE 3,390	385
390 FORMAT (1H+, 39X 6HSTABLE)	390
GO TO 410	395
400 WRITE OUTPUT TAPE 3,405	400
405 FORMAT (1H+, 39X 8HVARIALE)	405
410 A = EQGSW(3,I) - 100.	410
WRITE OUTPUT TAPE 3,420, A	415
420 FORMAT (1H+, 60X 15H CERTAINTY = , 1PE9.4)	420
GO TO 423	4201
4211 FORMAT (1H0,13X, 30HSUITONS EQUATION CALCULATIONS	4211
1 , 10X 6HDCO = , 1PE10.4)	4212
421 WRITE OUTPUT TAPE 3,4211, ADCO	421
GO TO 423	4213
422 WRITE OUTPUT TAPE 3, 4221, ADCO	422
4221 FORMAT (1H0, 13X, 20H DISPERSION EQUATION	4221
1 , 10X 6HDCO = , 1PE9.4)	4222
423 WRITE OUTPUT TAPE 3, 424	423
424 FORMAT (1H0,6X,8HDISTANCE, 13X,11HTRAVEL TIME, 7X 9HDOSE TIME, 5X,	424
1 5HGRAMS, 7X, 7HINITIAL, 10X, 5HDELTA, 11X, 4HDOSE / 3X, 6HMETERS,	4241
26X, 5HMILES, 58X, 6HCURIES, 10X, 6HCURIES)	4242
DO 450 J=1,NTRVT	425
DME = TT(J) * EQGSW(2,I) * 60.	430
DMI = DME * .62137E-3	435
DOST = BNDT - TT(J) - EDT	438
WRITE OUTPUT TAPE 3,445,DME,DMI, TT(J),DOST, GRAMS(J), CURIES(J,1)	440
1 ,CURIES(J,2), DOSE (I,J)	441
445 FORMAT (1H0,1PE10.4,2X 1PE10.4, 6(6X1PE10.4))	445

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450	CONTINUE	450
	WRITE OUTPUT TAPE 3, 460	455
460	FORMAT (25H0 ISOTOPES CONSIDERED ARE)	460
	IF (GRPSW(5)) 485,485,470	465
470	WRITE OUTPUT TAPE 3, 475	470
475	FORMAT (1H+,25X 3HALL)	475
	GO TO 555	480
485	IF (GRPSW(1)) 500,500,490	485
490	WRITE OUTPUT TAPE 3, 495	490
495	FORMAT (26X12HNOBLE GASES)	495
500	IF (GRPSW(2)) 515,515,505	500
505	WRITE OUTPUT TAPE 3, 510	505
510	FORMAT (26X,8HHALOGENS)	510
515	IF (GRPSW(3)) 530,530,520	515
520	WRITE OUTPUT TAPE 3,525	520
525	FORMAT (26X14HVOLATILE GROUP)	525
530	IF (GRPSW(4))542 ,542,535	530
535	WRITE OUTPUT TAPE 3, 540	535
540	FORMAT (26X 56HALL EXCEPT THE NOBLE GASES, HALOGENS, AND VOLATILE	540
	1 GROUP)	
542	IF (NISOT) 555,555,545	542
545	WRITE OUTPUT TAPE 3, 550, (ELMT(JK), MASS(JK), JK=1,NISOT)	545
550	FORMAT (26X (10(A3,13,2X)))	550
551	FORMAT (27H0 E OVR Q VALUES USED ARE)	
555	WRITE OUTPUT TAPE 3,551	
	DO 556 L=1,NTRVT	
552	FORMAT(27X1P8E11,4)	
	WRITE OUTPUT TAPE 3,552, (EQQ(KL,1,L),KL=1,NDT)	
556	CONTINUE	
560	CONTINUE	560
	IF (IPLOT(4)) 563,565,563	
C	PLOT DOSE VS TRAVEL TIME IF REQUESTED	5619
563	CALL SUBPLT (4)	563
565	DO 569 I=1,2	
	IF (IPLOT(1))569,569,567	
567	IF(IRUNIN(I)) 569,569,568	
568	CALL SUBPLT(I)	
	IRUNIN(I) = 0	
569	CONTINUE	
C	PLOT DOSE VS EXPOSURE TIME IF REQUESTED	569
	IF (NBTPL-1)580,570,580	
570	IF (IPLOT(2)) 575,580,575	570
575	CALL SUBPLT(3)	575
	DO 578 I =1,10	576
	P3TT(I) = 0.	577
578	NEXPT(I) = 0	578
580	GO TO (197,101),ITRANS	
	END	

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*      SYMBOL TABLE
*      LIST 8
*      LABEL
CEOVRO
      SUBROUTINE EOVRQ
F      DISP,SUTDEF
      COMMON WGHT,EOQSW,DUMMY,IPLOT,GRPSW,DELTAU,BICL,PO,TIME,T,SIGA25
      COMMON DEL,TRVT,BNDT,EDT,NSIG,NEDL,LINK,CASE
      COMMON CY,CZ,TR,Y,TH,DEPCO,WINDR,SIGY,SIGZ,NCASE
      COMMON Z,DCO,CLITLC,CLITLD
      COMMON FELB,REC,LISTM,LISTA,NRM,NRA,NCB,LOWA,HAT,NDT,NTRVT
      COMMON NRL,ITRVT,IBT
      COMMON EQ,TT,A6,A7,A8,A9,A10,ADCO
      COMMON CLITLA,CLITLB,AKSQ,SIGTUB
      COMMON EQCURV,PLOT3,EQCV,EOQ,EXPT,NEXPT,P3TT,NTP3,NPLOTS
      COMMON DOSE,NEOQ
      COMMON XX,YY
      DIMENSION WGHT(450),EOQSW(15,5),GRPSW(5),DELTAU(8),CASE(57),
1      FEED(450,10),REC(450),LISTM(10,96),LISTA(25,40),NRM(96),
2      NRA(40),EQ(8),TT(10),DUMMY(45),IPLOT(5)
      DIMENSION ITRVT(20,20),IBT(20)
      DIMENSION SIGTUB(8)
      DIMENSION EQCURV(10),PLOT3(20,10,5),EQCV(8,5,10),EOQ(8,5,10)
      DIMENSION EXPT(20,10),NEXPT(10),P3TT(10),DOSE(5,10)
      DIMENSION XX(30),YY(30)
      DIMENSION TAU(8)
      DO 50 I=1,8
30      EQ(I) = 0.
      X = A7 * TRVT * 60.
      IA6 = A6 + .005
      IA8 = A8 + .005
      IF (IA6-1) 610,100,90
90      IF (IA6-2) 610,199,650
100      IF (IA8-10) 300,350,399
199      IF (IA8-10) 200,250,610
200      CONTINUE
C      CALCULATION OF E/Q FOR A SPECIFIC TRAVEL TIME,TT,SUMMER OPERCENT
202      EQCURV(1)=1.60E-05
203      XMAX=5.0E+03
204      IF(X-XMAX)206,206,205
205      EQCURV(1)=-3.34611E-06+3.22517E-09*X-2.85827E-13*X**2.0+2.78868E-1
18*X**3.0-4.47582E-24*X**4.0
206      EQCURV(2)=1.50E-05
207      XMAX=5.0E+03
208      IF(X-XMAX)210,210,209
209      EQCURV(2)=-2.11213E-06+3.30079E-09*X-1.80407E-13*X**2.0+1.76012E-1
18*X**3.0-2.82498E-24*X**4.0
210      EQCURV(3)=5.40E-06

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211 XMAX=5.0E+03
212 IF(X-XMAX)214,214,213
213 EQCURV(3)=-9.09122E-07+1.56013E-09*X-8.18029E-14*X**2.0+7.91312E-1
19*X**3.0-1.26787E-08*X**4.0
214 EQCURV(4)=3.5E-06
215 XMAX=7.0E+03
216 IF(X-XMAX)218,218,217
217 EQCURV(4)=-5.29492E-07+8.51247E-10*X-4.21590E-14*X**2.0+4.02639E-1
19*X**3.0-6.43436E-25*X**4.0
218 EQCURV(5)=2.2E-06
219 XMAX=7.0E+03
220 IF(X-XMAX)222,222,221
221 EQCURV(5)=-3.91050E-07+5.47995E-10*X-2.72061E-14*X**2.0+2.60009E-1
19*X**3.0-4.15567E-25*X**4.0
222 GO TO 600
250 CONTINUE
C
C SUMMER 10PERCENT
300 CONTINUE
C CALCULATION OF E/Q FOR A SPECIFIC TRAVEL TIME,TT,WINTER,0PERCENT
302 EQCURV(1)=1.60E-05
303 XMAX=5.0E+03
304 IF(X-XMAX)306,306,305
305 EQCURV(1)=-5.34611E-06+5.22917E-09*X-2.85827E-13*X**2.0+2.78868E-1
18*X**3.0-4.47582E-24*X**4.0
306 EQCURV(2)=1.00E-05
307 XMAX=5.0E+03
308 IF(X-XMAX)310,310,309
309 EQCURV(2)=-2.11213E-06+3.30079E-09*X-1.80407E-13*X**2.0+1.76012E-1
18*X**3.0-2.82498E-24*X**4.0
310 EQCURV(3)=-.9E-06
311 XMAX=6.0E+03
312 IF(X-XMAX)314,314,313
313 EQCURV(3)=-1.19944E-06+2.16325E-09*X-1.15032E-13*X**2.0+1.22621E-1
18*X**3.0-2.82498E-24*X**4.0
314 EQCURV(4)=5.40E-06
315 XMAX=5.9E+03
316 IF(X-XMAX)318,318,317
317 EQCURV(4)=-8.69884E-07+1.49694E-09*X-7.60124E-14*X**2.0+7.53612E-2
12*X**3.0-1.20713E-24*X**4.0
318 EQCURV(5)=4.5E-06
319 XMAX=7.0E+03
320 IF(X-XMAX)322,322,321
321 EQCURV(5)=-4.03378E-07+8.20969E-10*X-1.76577E-14*X**2.0+6.38950E-2
10*X**3.0-4.70576E-26*X**4.0
322 GO TO 600
350 CONTINUE
399 IF(A8-50.)400,450,610
C
C WINTER 10PERCENT

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C 400 CONTINUE
C 450 CONTINUE
C 500 CONTINUE
C 550 CONTINUE
C 600 TAU(1) = DELTAU(1)
EQ(1) = EQCURV(1)
DO 601 I=2,NDT
TAU(I) = TAU(I-1) + DELTAU(I)
601 EQ(I) = (EQCURV(I)*TAU(I)-EQCURV(I-1)*TAU(I-1))/DELTAU(I)
610 RETURN
C 620 SUBROUTINE DISPERION METHOD CALCULATE DCO
650 PI=3.1415927
SRPI=1.7724539
SRPOV2= 1.2533141
SR20VP=0.7978846
A=0.0
CLITLA = A8
CLITLB = A9
AKSQ = A10
DELTA=0.001
655 TRTS =TRVT*60.
SIGZ = SIGZEE (TRTS)
C 660 CALCULATE CLOUD DEPOSITION FACTOR, DCO
ADCO=DCO
IF (DEPCO) 658,658,660
658 IF (ADCO) 659,659,680
659 ADCO = 1.0
GO TO 680
660 IF (IA6-3) 670,670,665
C 670 CALCULATE CLOUD DEPLETION FOR STABLE CONDITIONS
665 AINTL= SIMPS (A,TRTS,DELTA,DISP)
ADCO=EXP(-SR20VP*DEPCO*WINDR*A7*AINTL)
GO TO 680
C 680 CALCULATE CLOUD DEPLETION FOR NEUTRAL CONDITIONS
670 AINTL = SIMPS (A,X,DELTA,SUTDEP)
ADCO= EXP(-2./(SRPI *CZ)*DEPCO*WINDR*AINTL)
680 CONTINUE
IF (IA6-3) 800,800,750
750 DO 760 I=1,NDT
IF (IA6-5) 7509,753,753
7509 IF(I-2) 751,752,753
751 SIGY= SQR,F( .016*X**1.6 )
GO TO 755
752 SIGY= SQRTF( .04*X**1.6 )
GO TO 755
C 760 CALCULATE BIGA
753 BIGA=CLITLC+CLITLD*SIGTUB(I)

```

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```

C      CALCULATE ALPHA
      ALPHA=BIGA/(2.*SIGTUB(I) **2.)
C      CALCULATE ARG3
      ARG3 = TRTS/ALPHA
C      CALCULATE SIGYSQ
      SIGYSQ=BIGA*TRTS-BIGA*ALPHA+BIGA*ALPHA*EXP(-ARG3)
      SIGY=SQRTF (SIGYSQ)
755 EQCURV (I) =1./ (PI*SIGY*SIGZ*A7) *EXP(-0.5*(Y**2./SIGY**
1 2. + (Z-TH)**2. / SIGZ**2.))*ADCO
760 CONTINUE
      GO TO 600
C      CALCULATE E/Q USING SUTTONS METHOD
800 EQ(1) = (2. / (PI * CY * CZ* A7 * X**(2.-TN))) *EXP(-1.*(
1 Y**2. / CY**2. + TH**2. / CZ**2.)*X**(TN-2.)) * ADCO
      DO 810 I=2,8
810 EQ(I) = EQ(1)
      GO TO 610
      END
*      LIST 8

```



```

*      LABEL
SUBROUTINE LBL (MINX,MINY,NPLOTS)
CSCAL  LABELS 3X3 LOG LOG PLOT PAPER AND PLOTS 2 DIGIT PLOT NUMBER
COMMON WGT,EOQSW,DUMMY,IPLOT,GRPSW,DELTAU,BIGL,PO,TIME,T,SIGAZ5
COMMON DEL,TRVT,BNDT,EDT,NSIG,NEDL,LINK,CASE
COMMON CY,CZ,TN,Y,TH,DEPCO,WINDR,SIGY,SIGZ,NCASE
COMMON Z,DCO,CLITLC,CLITLD
COMMON FEED,REC,LISTM,LISTA,NRM,NRA,NCD,LOWA,NAT,NDT,NTRVT
COMMON NBL,ITRVT,IBT
COMMON EQ,TT,A6,A7,A8,A9,A10,ADCO
COMMON CLITLA,CLITLB,AKSQ,SIGTUB
COMMON EQCURV,PLOT3,EQCV,EOQ,EXPT,NEXPT,P3TT,NTP3,NPLOTS
COMMON DOSE,NEOQ
COMMON XX,YY
DIMENSION WGT(450),EOQSW(15,5),GRPSW(5),DELTAU(8),CASE(57),
1 FEED(450,10),REC(450),LISTM(10,96),LISTA(25,40),NRM(96),
2 NRA(40),EQ(8),TT(10),DUMMY(45),IPLOT(5)
DIMENSION ITRVT(20,20),IBT(20)
DIMENSION SIGTUB(8)
DIMENSION EQCURV(10),PLOT3(20,10,5),EQCV(8,5,10),EOQ(8,5,10)
DIMENSION EXPT(20,10),NEXPT(10),P3TT(10),DOSE(5,10)
DIMENSION XX(30),YY(30)
DIMENSION X(5)
C      PLOT X + Y AXIS
DO 720 I=1,3
X(I) = 0.
720 YY(I) = FLOATF((I-1)*3750)
DO 722 I=4,5
YY(I) = 0.
722 X(I) = FLOATF((I-3)*3750)
CALL MODE(2,0)
CALL TOLP(YY,X,5)
C      LABEL X + Y AXIS
DO 865 I=1,4
YY(I) = FLOATF((I-1)*2500)
J = MINX + I -1
IF (J) 860,8628,8621
860 CALL MODE(4,11)
CALL TOLP(YY-200.,-100.,1)
8621 J2 = XABSF(J/10)
IF (J2) 8623,8623,8624
8623 J2 = 10
8624 CALL MODE(4,J2)
CALL TOLP(YY-100.,-100.,1)
J2 = XABSF(XMODF(J,10))
IF (J2) 8628,8628,8629
8628 J2 = 10
8629 CALL MODE(4,J2)

```

L 000
L 001

L 699
L 700
L 710
L 720

L 725

L 829

L 840
L 845
L 855
L 860
L 862
L 8621
L 8622
L 8623
L 8624
L 8625
L 8626
L 8627
L 8628
L 8629

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CALL TOLP (YY,-100.,1)	L 8630
865 CONTINUE	
DO 895 I=1,4	
YY = FLOATF((I-1)*2500)	
K = MINY + I -1	L 850
IF(K) 870,890,885	L 865
870 CALL MODE (4,11)	L 870
CALL TOLP (-300.,YY,1)	L 875
885 K2 =XABSF (K/10)	L 885
IF(K2) 886,886,887	L 8855
886 K2 = 10	L 886
887 CALL MODE (4,K2)	L 887
CALL TOLP (-200.,YY,1)	L 8872
K2 =XABSF(XMODF(K,10))	L 8875
IF(K2) 890,890,891	L 8878
890 K2 =10	L 890
891 CALL MODE (4,K2)	L 891
892 CALL TOLP (-100.,YY,1)	L 892
895 CONTINUE	L 895
C PLOT PLOT NUMBER	L 899
J = NPLOTS /10	L 900
IF (J) 905,905,908	L 902
905 J =10	L 905
908 CALL MODE (4,J)	L 908
910 CALL TOLP (7500.,7600.,1)	L 910
J = XMODF (NPLOTS,10)	L 912
IF (J) 915,915, 920	L 913
915 J = 10	L 915
920 CALL MODE (4,J)	L 920
CALL TOLP (7600.,7600.,1)	L 925
RETURN	L 930
END	

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```

*      SYMBOL TABLE
*      LIST 8
*      LABEL
SUBROUTINE PLTR (A,ISW)
C      SUBROUTINE TO PRODUCE NEOQ PLOTS WITH NDT CURVES PER PLOT
COMMON WGHT,EOQSW,DUMMY,IPLT,GRPSW,DELTAU,BIGL,PO,TIME,T,SIGA25
COMMON DEL,TRVT,BNDF,EDT,NSIG,NEDL,LINK,CASE
COMMON CY,CZ,TN,Y,TH,DEPCO,WINDR,SIGY,SIGZ,NCASE
COMMON Z,DCO,CLITLC,CLITLD
COMMON FEED,REC,LISTH,LISTA,NRM,NRA,RCD,LOWA,NAT,NDT,NTRVT
COMMON NBL,ITRVT,IBT
COMMON EQ,TT,A6,A7,A8,A9,A10,ADCO
COMMON CLITLA,CLITLB,AKSQ,SIGTUB
COMMON EQCURV,PLOT3,EQCV,EOQ,EXPT,NEXPT,P3TT,NTP3,NPLOTS
COMMON DOSE,NEOQ
COMMON XX,YY
DIMENSION WGHT(450),EOQSW(15,5),GRPSW(5),DELTAU(8),CASE(57),
1  FEED(450,10),REC(450),LISTH(10,96),LISTA(25,40),NRM(96),
2  NRA(40),EQ(8),TT(10),DUMMY(45),IPLT(5)
DIMENSION ITRVT(20,20),IBT(20)
DIMENSION SIGTUB(8)
DIMENSION EQCURV(10),PLOT3(20,10,5),EQCV(8,5,10),EOQ(8,5,10)
DIMENSION EXPT(20,10),NEXPT(10),P3TT(10),DOSE(5,10)
DIMENSION XX(30),YY(30)
DIMENSION X(3)
DIMENSION A(8,5,10)
B      EOVERQ= 254665255150
B      EQC = 255023645165
      IF (ISW-1) 116,116,118
116  BB = EOVERQ
      GO TO 120
118  BB = EQC
120  WRITE OUTPUT TAPE 3,121
121  FORMAT (1H1)
129  DO 770 I=1,NEOQ
      KMAX = 1
      YMAX = 0.
      DO 180 J=1,NDT
      DO 180 K=1,NTRVT
      IF (A(J,I,K) -YMAX) 180,180,170
170  KMAX=K
      YMAX = MAX1F (YMAX,A(J,I,K))
180  CONTINUE
C      FIND SMALLEST I SUCH THAT 10 **I IS LARGER THAN OR = YMAX
      IF (YMAX) 780,780,190
190  MIN = MAXEXP (YMAX) - 3
      MINX = MINEXP(TT(KMAX)) - 1
199  NPLOTS = NPLOTS + 1

```

PL 100

PL 101

PL

PL 113

PL 114

PL 115

PL 116

PL 117

PL 118

PL 120

PL 121

PL 129

PL 140

PL 160

PL 165

PL 170

PL 179

PL 180

PL 1808

PL 185

PL 190

PL 195

PL 199

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200	WRITE OUTPUT TAPE 3,210, NPLOTS, BB , I,(EQSW(K,I),K=1,10)	PL 200
210	FORMAT (8H0 PLOT , 12, 14H IS A PLOT OF ,A6 , 9H5 FOR THE, 12,	PL 210
	118H E/Q SPECIFICATION // 5X 2HA6,10X2HA7,10X2HA8,10X2HA9,9X3HA10,	PL 211
	2 10X18HSIGMA THETA J BARS // 10(1PE12.4))	PL 212
	IF (NPLOTS) 240,240,230	PL 220
230	CALL WAIT	PL 230
240	CONTINUE	PL 240
	DO 420 J=1,NDT	
C	BUILD VALUES INTO Y ARRAY	PL 360
	DO 380 K=1,NTRVT	PL 370
380	YY(K) = MAX1F(0.,LOGF (A(J,I,K) /10.**MIN) *1085.734)	PL 380
	IF (J-1) 382,382, 390	PL 381
382	DO 384 K=1,NTRVT	PL 382
384	XX(K) = MIN1F(7500., LOGF(TT (K)/10.**MINX)*1085.734)	PL 384
390	CALL MODE (4, J)	PL 390
	CALL TOLP(XX,YY,NTRVT)	PL 400
	CALL MODE (4,0)	PL 410
420	CALL TOLP(XX,YY,NTRVT)	PL 420
C	PLOT AND LABEL X + Y AXIS AND PLOT PLOT NUMBER	PL 599
C	PLOT + LABEL X - Y AXIS	PL 599
	CALL LBL (MINX,MIN,NPLOTS)	PL 600
770	CONTINUE	PL 770
780	RETURN	PL 780
	END	

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```

*      SYMBOL TABLE
*      LIST 8
*      LABEL
SUBROUTINE SUBPLT (ISW)
C      SUBROUTINE SUBPLT (ISW) MAKES VARIOUS PLOTS DEPENDING ON
C      THE SETTING OF ISW
COMMON WGHT,EOQSW,DUMMY,IPLT ,GRPSW,DELTAU,BIGL,PO,TIME,T,SIGA25
COMMON DEL,TRVT,BNDT,EDT,NSIG,NEDL,LINK,CASE
COMMON CY,CZ,TN,Y,TH,DEPCO,WINDR,SIGY,SIGZ,NCASE
COMMON Z,DCO,CLITLC,CLITLD
COMMON FEED,REC,LISTM,LISTA,NRM,NRA,NCD,LOWA,NAT,NDT,NTRVT
COMMON NBL,ITRVT,IBT
COMMON EQ,TT,A6,A7,A8,A9,A10,ADCO
COMMON CLITLA,CLITLB,AKSQ,SIGTUB
COMMON EQCURV,PLOT3,EQCV,EOQ,EXPT,NEXPT,P3TT,NTP3,NPLOTS
COMMON DOSE,NEOQ
COMMON XX,YY
DIMENSION WGHT(450),EOQSW(15,5),GRPSW(5),DELTAU(8),CASE(57),
1 FEED(450,10),REC(450),LISTM(10,96),LISTA(25,40),NRM(96) ,
2 NRA(40),EQ(8),TT(10),DUMMY(45),IPLT(5)
DIMENSION ITRVT(20,20),IBT(20)
DIMENSION SIGTUB(8)
DIMENSION EQCURV(10),PLOT3(20,10,5),EQCV(8,5,10),EOQ(8,5,10)
DIMENSION EXPT(20,10),NEXPT(10),P3TT(10),DOSE(5,10)
DIMENSION XX(30),YY(30)
IF (NPLOT - 50) 125,110,120
110 WRITE OUTPUT TAPE 3,115
115 FORMAT ( 71H1 THE NUMBER OF PLOTS EXCEEDS 50. NO ADDITIONAL PLOTS
1S WILL BE PRODUCED)
120 RETURN
125 IF (NPLOTS)130,130,140
130 CALL ORIGIN(0,0)
CALL SCALE (10,10)
C      BRANCH TO DESIRED PLOT
140 GO TO (150,160,180,650),ISW
C      ISW = 1, PLOT E/Q CURVES VS DISTANCE
150 CALL PLTR (EQQ, 1 )
GO TO 120
C      ISW =2 , PLOT EQCURVES VS DISTANCE
160 CALL PLTR (EQCV,2)
GO TO 120
C      ISW = 3 - PLOT DOSE AS A FUNCTION OF EXPOSURE TIME
180 DO 640 I=1,NEOQ
IBEG = 1
IF (NTP3-5) 200,200,210
200 IEND = NTP3
GO TO 211
C      MORE THAN 5 CURVES - MAKE TWO PLOTS

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210 IEND = NTP3/2 S 210
211 NPLOTS = NPLOTS + 1 S 211
    IF (NPLOTS-1) 214,214,213 S 212
213 CALL WAIT S 213
214 NC = IEND - IBEG + 1 S 214
    WRITE OUTPUT TAPE 3 , 216, NPLOTS, NC, I, BIGL S 215
216 FORMAT ( 6H1 PLOT, I3, 53H IS A PLOT OF DOSE AS A FUNCTION OF EXPOSURE TIME FOR, I2, 13H TRAVEL TIMES / 51H0 FOR THE PRECEDING ISOTOPS 2161
    2ES, AND E/Q SPECIFICATION, I2, 10X18HLEAKAGE CONSTANT -, 1PE12.4S 2162
    3 // 10X5H CURVE, 10X12H TRAVEL TIMES) S 2163
C    FIND MAXIMUM DOSE FOR THIS PLOT S 219
    JM = 1 S 220
    KM = 1 S 230
    DMAX = PLOT3(1,1,I) S 240
    DO 320 J=IBEG, IEND S 250
    NEX = NEXPT(J) S 260
    DO 320 K=1, NEX S 270
    IF (DMAX - PLOT3(K,J,I)) 290, 320, 320 S 280
290 DMAX = PLOT3 (K,J,I) S 290
    JM = J S 300
    KM = K S 310
320 CONTINUE S 320
    MINDS = MAXEXP (DMAX) - 3 S 325
    MINEX = MINEXP (EXPT(KM,JM)) - 1 S 330
    DO 400 J=IBEG, IEND S 335
    NEX = NEXPT (J) S 340
    DO 390 K=1, NEX S 345
    YY(K) = MAX1F (0., LOGF(PLOT3(K,J,I)/10.**MINDS)*1085.734) S 350
    XCOORD = LOGF (EXPT(K,J)/10.**MINEX) * 1085.734 S 355
    IF(XCOORD) 365, 365, 375 S 360
365 XX(K) = 0 S 365
    GO TO 390 S 370
375 XX(K) = MIN1F(XCOORD, 7500.) S 375
390 CONTINUE S 390
    CALL MODE (4,J) S 391
    CALL TOLP (XX, YY, NEX) S 3915
    CALL MODE (4,0) S 392
    CALL TOLP (XX, YY, NEX) S 395
    WRITE OUTPUT TAPE 3, 398, J, P3TT(J) S 396
398 FORMAT ( I14, 1PE21.4) S 397
400 CONTINUE S 398
C    PLOT + LABEL X - Y AXIS S 400
    CALL LBL (MINEX, MINDS, NPLOTS) S 469
    IF (IEND - NTP3) 625, 640, 640 S 470
625 IBEG = IEND + 1 S 620
    IEND = NTP3 S 625
    GO TO 211 S 628
    S 630

```

640	CONTINUE	S 640
	GO TO 120	S 645
C	PLOT 4 - PLOT DOSE AS A FUNCTION OF TRAVEL TIME	S 649
650	IF (NPLOTS)670,670,660	S 650
660	CALL WAIT	S 660
670	NPLOTS = NPLOTS + 1	S 670
	WRITE OUTPUT TAPE 3, 730, NPLOTS	S 725
730	FORMAT (6H1 PLOT,13,99H IS A PLOT OF DOSE AS A FUNCTION OF TRAVEL TIME OF THE RESULTS REPORTED ON THIS AND PRECEDING PAGES/ 99H0 TS	S 730
	2HE CURVE NUMBERED I REPRESENTS THE ITH E/Q SPECIFICATION)	S 732
C	FIND MAXIMUM DOSE AND CORRESPONDING TRAVEL TIME	S 739
	IM = 1	S 740
	JM = 1	S 750
	DMAX = DOSE	S 755
	DO 820 I=1,NTRVT	S 760
	DO 820 J=1,NEOQ	S 770
	IF (DOSE(J,I)- DMAX) 820 ,820,790	S 780
790	IM = I	S 790
	JM = J	S 800
	DMAX = DOSE (J,I)	S 810
820	CONTINUE	S 820
C	FIND MIN EXPONENTS FOR PLOT	S 829
	MINDS = MAXEXP(DMAX) - 3	S 830
	MINTT = MINEXP(TT(IM)) -1	S 840
C	PLOT DOSE CURVES FOR ALL E/Q	S 849
	DO 900 I=1,NTRVT	S 850
	XCOORD = LOGF (TT(I) / 10.**MINTT) * 1085.734	S 860
	IF (XCOORD)880,880, 890	S 870
880	XX(I) = 0.	S 880
	GO TO 900	S 885
890	XX(I) = MIN1F (XCOORD,7500.)	S 890
900	CONTINUE	S 900
	DO 940 I=1,NEOQ	S 905
	CALL MODE(4,I)	S 910
	DO 920 J=1,NTRVT	S 915
920	YY(J) = MAX1F (0.,LOGF(DOSE(I,J) /10.**MINDS) * 1085.734)	S 920
	CALL TOLP (XX,YY,NTRVT)	S 925
	CALL MODE (4,0)	S 930
	CALL TOLP (XX,YY,NTRVT)	S 935
940	CONTINUE	S 940
	CALL LBL (MINTT,MINDS,NPLOTS)	S 950
	GO TO 120	S 960
	END	

*	LIST 8	
*	LABEL	
	FUNCTION MAXEXP (ARG)	
C	FIND SMALLEST I SUCH THAT 10.**I GREATER THAN OR = ARG	MX 10
	DO 600 J=1,35	MX 20
	IF (ARG-1.) 100, 650 ,300	MX 30
100	MJ= - J	MX 100
	IF (ARG = 10.**MJ) 600, 250,200	MX 150
200	MJ = MJ +1	MX 200
250	MAXEXP = MJ	MX 250
	GO TO 700	MX 270
300	IF (ARG -10.**J) 400,400,600	MX 300
400	MAXEXP = J	MX 400
	GO TO 700	MX 500
600	CONTINUE	MX 600
650	MAXEXP = 0	MX 650
700	RETURN	MX 700
	END	

<pre> * LIST 2 * LABEL FUNCTION MINEXP(ARG) C FIND LARGEST I SUCH THAT 10.**J IS LESS OR EQUAL ARG DO 600 J=1,35 IF (ARG -1.) 100,650,300 100 MJ = -J IF (ARG - 10.**MJ) 600,200,200 200 MINEXP = MJ GO TO 700 300 IF (ARG - 10.** J) 500,400,600 400 MINEXP = J GO TO 700 500 MINEXP = J-1 GO TO 700 600 CONTINUE 650 MINEXP = 0 700 RETURN END </pre>	<pre> M M 10 M 20 M 30 M 100 M 150 M 200 M 250 M 300 M 400 M 450 M 500 M 550 M 600 M 650 M 700 </pre>
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*      LIST 2
*      LABEL
      FUNCTION FUNCT(A,B)
      A = A
      B = B
      FUNCT= 1.
      RETURN
      END

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```

*      LIST 8
*      LABEL
      FUNCTION SIGZEE (ARG)
      COMMON WGHT,EOQSW,DUMMY,INSERT,GRPSW,DELTAU,BIGL,PO,TIME,T,SIGA25
      COMMON DEL,TRVT,BNDT,EDT,NSIG,NEDL,LINK,CASE
      COMMON CY,CZ,TN,Y,TH,DEPCO,WINDR,SIGY,SIGZ,NCASE
      COMMON Z,DCO,CLITLC,CLITLD
      COMMON FEED,REC,LISTM,LISTA,NRM,NRA,NCD,LOWA,NAT,NDT,NTRVT
      COMMON NBL,ITRVT,IBT
      COMMON EQ,TT,A6,A7,A8,A9,A10,ADCO
      COMMON CLITLA,CLITLB,AKSQ,SIGTUB
      COMMON EQCURV,PLOT3,EQCV,EOQ,EXPT,NEXPT,P3TT,NTP3,NPLOTS
      COMMON DOSE,NEOQ
      COMMON XX,YY
      DIMENSION WGHT(450),EOQSW(15,5),GRPSW(5),DELTAU(8),CASE(57),
1  FEED(450,10),REC(450),LISTM(10,96),LISTA(25,40),NRM(96) ,
2  NRA(40),EQ(8),TT(10),DUMMY(45),IPLOT(5)
      DIMENSION ITRVT(20,20),IBT(20)
      DIMENSION SIGTUB(8)
      DIMENSION EQCURV(10),PLOT3(20,10,5),EQCV(8,5,10),EOQ(8,5,10)
      DIMENSION EXPT(20,10),NEXPT(10),P3TT(10),DOSE(5,10)
      DIMENSION XX(30),YY(30)
      SIGZSQ=CLITLA*(1.-EXP(-AKSQ*ARG **2.))+CLITLB*ARG
      SIGZEE = SQRTF(SIGZSQ)
      RETURN
      END

```

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```

*      LIST 8
*      LABEL
      FUNCTION DISP (ARG)
      COMMON WCHT,EOQSW,DUMMY,INSRT,GRPSW,DELTAU,RIGL,PO,TIME,T,SIGA25
      COMMON DEL,TRVT,BNDT,EDT,NSIC,NEOL,LINK,CASE
      COMMON CY,CL,TN,Y,TH,DEPCO,WINDR,SIGY,SIGZ,NCASE
      COMMON Z,ECG,CLITLC,CLITLD
      COMMON FEED,REC,LISTM,LISTA,NRM,NRA,NCD,LOWA,NAT,NDT,NTRVT
      COMMON NDL,ITRVT,IPT
      COMMON EQ,TT,A6,A7,A8,A9,A10,ADCO
      COMMON CLITLA,CLITLB,AKSG,SIGTUB
      COMMON EQCURV,PLOT3,EQCV,EOG,EXPT,NEXPT,P3TT,NTP3,NPLOTS
      COMMON DOSE,NEOQ
      COMMON XX,YY
      DIMENSION WCHT(450),EOQSW(15,5),GRPSW(5),DELTAU(6),CASE(57),
1  FEED(450,10),REC(450),LISTM(10,96),LISTA(25,40),NRM(96),
2  NRA(40),EQ(8),TT(10),DUMMY(45),IPLOT(5)
      DIMENSION ITRVT(20,20),IPT(20)
      DIMENSION SIGTUB(8)
      DIMENSION EQCURV(10),PLOT3(20,10,5),EQCV(8,5,10),EOG(8,5,10)
      DIMENSION EXPT(20,10),NEXPT(10),P3TT(10),DOSE(5,10)
      DIMENSION XX(30),YY(30)
      DISP = EXPF(-TH**2./2./SIGZLF(ARG)**2.) / SIGZLF(ARG)
      RETURN
      END

```

```

*      LIST 8
*      LABEL
      FUNCTION SUTDEP(ARG)
      COMMON WGHT,EOQSW,DUMMY,INSERT,GRPSW,DELTAU,BIGL,PO,TIME,T,SIGA25
      COMMON DEL,TRVT,BNDT,EDT,NSIG,NLUL,LINK,CASE
      COMMON CY,CZ,TN,Y,TH,DEPCO,WINDR,SIGY,SIGZ,NCASE
      COMMON Z,DCO,CLITLC,CLITLD
      COMMON FEED,REC,LISTM,LISTA,NRM,NRA,NCD,LOWA,NAT,NDT,NTRVT
      COMMON NBL,ITRVT,IBT
      COMMON EQ,TT,A6,A7,A8,A9,A10,ADCO
      COMMON CLITLA,CLITLB,AKSQ,SIGTUB
      COMMON EQCURV,PLOT3,EQCV,EOQ,EXPT,NEXPT,P3TT,NTP3,NPLOTS
      COMMON DOSE,NEOQ
      COMMON XX,YY
      DIMENSION WGHT(450),EOQSW(15,5),GRPSW(5),DELTAU(8),CASE(57),
1  FEED(450,10),REC(450),LISTM(10,96),LISTA(25,40),NRM(96) ,
2  NRA(40),EQ(8),TT(10),DUMMY(45),IPLOT(5)
      DIMENSION ITRVT(20,20),IBT(20)
      DIMENSION SIGTUB(8)
      DIMENSION EQCURV(10),PLOT3(20,10,5),EQCV(8,5,10),EOQ(8,5,10)
      DIMENSION EXPT(20,10),NEXPT(10),P3TT(10),DOSE(5,10)
      DIMENSION XX(30),YY(30)
      SUTDEP = ARG**((TN/2.-1.) * EXPF(-TH**2./(CZ**2.*ARG**(2.-TN)))
      RETURN
      END

```

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*	REVISION NO. 1	PROGRAM NO.	114
*	FAP		
	COUNT 50		114-1001
	ENTRY (100)		114-1002
*	MONITOR SCRATCH TAPES MAY NOT BE REMOVED OR PRINTED		114-1003
	PZE PRINT		114-1004
	PZE PUNCH		114-1005
	PZE READ		114-1006
(100)	PZE NTAPES		114-1007
	PZE B5	1 - PLOTTER TAPE	114-1008
	PZE A2	2 - MONITOR INPUT TAPE	114-1009
	PZE A3	3 - MONITOR OUTPUT TAPE	114-1010
	PZE A4	4 - MONITOR SCRATCH (AVAILABLE IF NOT CHAIN)	114-1011
	PZE A5	5 -	114-1012
	PZE B6	6 -	114-1013
	PZE B7	7 -	114-1014
	PZE B8	8 -	114-1015
	PZE B9	9 -	114-1016
	PZE B0	10 -	114-1017
	PZE A6	11 - SPAC INPUT TAPE	114-1018
	PZE B1	12 - MONITOR SCRATCH TAPE (AVAILABLE)	114-1019
	PZE B2	13 - MONITOR SCRATCH TAPE (AVAILABLE)	114-1020
	PZE B3	14 - MONITOR SCRATCH TAPE (AVAILABLE)	114-1021
	PZE A5	15 -	114-1022
	PZE B5	16 -	114-1023
	PZE A7	17 -	114-1024
*	THE FOLLOWING TAPE UNITS ARE NOT AVAILABLE,		114-1025
*	AND ARE NOT INCLUDED IN THIS TABLE		114-1026
*	A1 - MONITOR SYSTEMS TAPE		114-1027
*	A9 - MONITOR SYSTEMS TAPE		114-1028
*	A0 - IBSYS TAPE		114-1029
*	B4 - MONITOR OFF-LINE PUNCH TAPE		114-1030
	NTAPES EQU	*(100)-1	114-1031
	READ BOOL	1321	114-1032
	PUNCH BOOL	1341	114-1033
	PRINT BOOL	1361	114-1034
	A2 BOOL	1202	114-1035
	A3 BOOL	1203	114-1036
	A4 BOOL	1204	114-1037
	A5 BOOL	1205	114-1038
	A6 BOOL	1206	114-1039
	A7 BOOL	1207	114-1040
	A8 BOOL	1210	114-1041
	B1 BOOL	2201	114-1042
	B2 BOOL	2202	114-1043
	B3 BOOL	2203	114-1044
	B5 BOOL	2205	114-1045
	B6 BOOL	2206	114-1046

B7 BOOL 2207
B8 BOOL 2210
B9 BOOL 2211
B0 BOOL 2212
 END

114-1047
114-1048
114-1049
114-1050

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APPENDIX D

CODE LIBRARIES

APPENDIX D

CODE LIBRARIES

Two libraries which are used with EXDOSE are listed in this appendix.

A library is part of the input data for a case and immediately follows the data card. The first library (pages D-4 to D-16) is used for fast reactor calculations. The second, pages D-17 to D-29, is for thermal reactor cases.

APPENDIX D

CODE LIBRARIESINPUT DATA1. Library Format

Columns 1 through 3 of the first card of the library are used to designate the number of data cards to follow. A maximum of 450 is allowed. Smaller libraries may be substituted in place of the standard library provided the card count registered on the lead card agrees with the number of data cards following it.

Library data card field definitions are as follows:

<u>Column</u>	<u>Units</u>	<u>Field</u>	<u>Definitions</u>
1-3	AMU	I3	Nuclide mass
4-5		I2	Atomic number
6-14	Days	E9.3	Half life (leave blank for stable nuclides)
15-23	%	E9.3	Direct fission yield, first species (^{235}U)
24-32	%	E9.3	Direct fission yield, second species (^{239}Pu)
33-41	Barns	E9.3	Spectrum weighted neutron absorption cross section
42-46		F5.3	Fraction of neutron captures resulting in an isomeric state
47-51		F5.3	Fraction of β decay events resulting in an isomeric state (For an isomeric nuclide, this field represents the fraction of decay events which skip the isomeric transition.)
52-56	MeV	F5.3	Mean β energy released per disintegration
57-61	MeV	F5.3	Mean γ energy released per disintegration
69-70		A2	Chemical symbol of nuclide
71		A1	Mark for isomeric state. Blank = ground state
72	Integer	I1	Integer - 1 designates isomer; 2 = ground state

The remainder of the card may be used for the card sequence number if desired

2. Isotope Library Card Arrangement

Cards are arranged by mass chains in order of increasing mass. Within each chain, cards are in order of increasing atomic number. Isomers precede ground states. A maximum of 96 mass chains is allowed. A maximum spread of 39 is allowed between the lowest and highest atomic number. A maximum of 25 members all having the same atomic number is allowed. A maximum of 9 members in any mass chain is allowed.

450 FAST FLUX RIBD LIBRARY OF 5-26-66				WL BUNCH SPECIAL				
72301.938E-00	.160-02	.120-02	.500	0.	0.	.12	1.235	ZN 2 001
72315.875E-01	.000	.000	.500			.43	2.869	GA 2 002
7232	.000	.000	.500					GE 2 003
73301.390E-03	.980-02	.000	.500			2.25		ZN 2 004
73312.000E-01	.200-03	-.000	.500			.42	.409	GA 2 005
73320.	.000	.000	.500					GE 2 006
74315.555E-03	.350-01	.000	.500			1.01	3.149	GA 2 007
7432	.000	.000	.500	.4				GE 2 008
75311.389E-03	.400-01	-.000	.500			1.43	.58	GA 2 009
75325.671E-04	.400-01	-.000	.500				.139	GE*1 010
75325.694E-02	-.000	-.000	.500			.42	.038	GE 2 011
7533	.000	.000	.500					AS 2 012
76313.704E-04	.100-01	-.000	.500			2.74	1.	GA 2 013
7632	.100-01	-.000	.500	.5				GE 2 014
76331.104E-00	.000	.000	.500			1.09	0.404	AS 2 015
7634	.000	.000	.500	.259				SE 2 016
77326.250E-04	.540-01	.000	.500		0.640	.77	0.096	GE*1 017
77324.583E-01	.370-01	.000	.500			.64	1.134	GF 2 018
77331.625E-00	.000	.000	.500			.22	0.022	AS 2 019
77342.083E-04	-.000	-.000	.500				.16	SE*1 020
7734	.000	.000	.500					SE 2 021
78328.750E-02	.180	.000	.500			.32	0.300	GE 2 022
78336.319E-03	.200-01	.000	.500			1.47	0.888	AS 2 023
7834	.000	.000	.500	.875				SE 2 024
79336.250E-03	.400	.000	.500		1.	.90		AS 2 025
79342.708E-03	.000	.000	.500				0.096	SE*1 026
79342.555E-07	.000	.000	.500			.04		SE 2 027
79350.	.000	.000	.500	0.2540.				BR 2 028
80331.736E-04	.160	-.000	.500			2.73	.5	AS 2 029
8034	-.000	-.000	.500	.2				SE 2 030
80351.875E-01	.000	.000	.500				0.085	BR*1 031
80351.250E-02	.000	.000	.500			.72	.116	BR 2 032
8036	.000	.000	.500					KR 2 033
81333.819E-04	.250	.000	.500			1.66		AS 2 034
81343.958E-02	.168-01	.000	.500				0.103	SE*1 035
81341.250E-02	.000	.000	.500			.53		SE 2 036

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8135	.000	.000	.500				BR 2	037
8136	.000	.000	.500				KR 2	038
8234	.760-04	.000	.500	0.9200.			SE 2	039
82351.471E 00	-.000	-.000	.500		.14	2.648	BR 2	040
8236	.000	.000	.500	1.			KR 2	041
83347.986E-04	.600	.240	.500		1.000	1.55 0.200	SE*1	042
83341.736E-02	.360	.172	.500			.69 1.000	SE 2	043
83351.000E-01	.000	.168	.500	0.	1.000	.34 0.010	BR 2	044
83367.750E-02	.000	.000	.500	0.	0.	0.041	KR*1	045
8336	.000	.000	.500				KR 2	046
84342.083E-03	.122+00	.600-01	.500			.49	SE 2	047
84354.167E-03	.380-01	.200-01	.500		1.	.71 3.396	BR*1	048
84352.222E-02	1.840	.860	.500			1.23 1.863	BR 2	049
8436	.000	.000	.500	.714			KR 2	050
85334.977E-06	.550	.126	.500			1.28 5.0	AS 2	051
85344.514E-04	.550	.126	.500			2.24	SE 2	052
85352.083E-03	.400	.160	.500		1.	1.04	BR 2	053
85361.833E-01	.000	.000	.500		0.810	.29 .179	KR*1	054
85363.927E 03	.000	.127	.500			.25 0.004	KR 2	055
8537	.000	.000	.500	0.1			RB 2	056
86341.852E-04	1.010	.380	.500			1.76	SE 2	057
86356.250E-04	1.010	.380	.500			3.23 .9	BR 2	058
8636	-.000	-.000	.500				KR 2	059
86377.222E-04	.000	.000	.500			0.56	RB*1	060
86371.870E 01	.280-04	.230-04	.500			.66 0.097	RB 2	061
8638	.000	.000	.500	1.			SR 2	062
87341.852E-04	2.70	.920	.500			3.73	SE 2	063
87356.366E-04	.000	.000	.500			1.87 3.780	BR 2	064
87365.278E-02	.000	.000	.500			1.34 1.089	KR 2	065
8737	.000	.000	.500				RB 2	066
87381.167E-01	.000	.000	.500			0.388	SR*1	067
8738	.000	.000	.500				SR 2	068
88351.852E-04	2.90	1.100	.500			3.22 .035	BR 2	069
88361.167E-01	.800	.320	.500			.38 1.922	KR 2	070
88371.250E-02	.000	.000	.500			1.99 .748	RB 2	071
8838	.000	.000	.500				SR 2	072
89355.208E-05	.200	.700-01	.500			3. .075	BR 2	073

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89362.222E-03	4.40	1.640	.500		1.39	2.265	KR 2	074
89371.042E-02	.200	.000	.500		.60	2.455	RR 2	075
89385.04 E 01	.000	.000	.500		.0002	.58	SR 2	076
89391.852E-04	-.000	-.000	.500			.915	Y*1	077
8939	.000	.000	.500	.00080.			Y 2	078
90351.852E-05	2.60	.980	.500		3.	.075	BR 2	079
90363.819E-04	2.60	.980	.500		1.37	2.23	KR 2	080
90372.014E-03	.700	.290	.500		2.05	4.15	RB 2	081
90381.022E 04	.000	.000	.500		.20		SR 2	082
90391.333E-01	-.000	-.000	.500			.68	Y* 1	083
90392.675E 00	.000	.000	.500		.94	.0003	Y 2	084
9040	.000	.000	.500				ZR 2	085
91361.157E-04	3.70	1.260	.500		.5	1.56	KR 2	086
91379.722E-03	.200	.700-01	.500		1.	1.27	RB*1	087
91378.338E-04	2.00	1.100	.500			2.04	RB 2	088
91384.042E-01	.000	.000	.500		.590	.63	SR 2	089
91393.472E-02	.000	.000	.500			0.742	Y* 1	090
91395.900E 01	.000	.000	.500			0.551	Y 2	091
9140	.000	.000	.500		.61	0.004	ZR 2	092
92363.471E-05	2.70	1.530	.500				KR 2	093
92375.787E-05	2.80	1.540	.500		2.73		RB 2	094
92381.125E-01	.600	.700-01	.500		2.97		SR 2	095
92391.471E-01	.000	.000	.500		2.26	1.274	Y 2	096
9240	.000	.000	.500		1.44	0.266	ZR 2	097
93362.315E-05	1.300	.770	.500				KR 2	098
93376.944E-05	3.10	1.820	.500		3.82		RB 2	099
93385.764E-03	2.00	1.320	.500		2.83		SR 2	100
93394.208E-01	.100+00	.600-01	.500		1.40	1.0	Y 2	101
93403.468E 08	.000	.000	.500		1.18	0.102	ZR 2	102
93411.351E 03	.000	.000	.500		.25	.015	NR*1	103
9341	.000	.000	.500	.909		0.029	NR 2	104
94361.620E-05	.600	.600	.500				KR 2	105
94373.472E-05	2.30	1.500	.500		2.70		RB 2	106
94388.333E-04	2.90	1.640	.500		4.57		SR 2	107
94391.389E-02	.700	.740	.500		1.46		Y 2	108
9440	.000	.000	.500		2.23	1.	ZR 2	109
94414.583E-03	.000	.000	.500		.001	.00050.042	NR*1	110

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94417.300E 06	.000	.000	.500		.16	1.570	NB 2	111
9442	.000	.000	.500				MO 2	112
95361.157E-05	3.20	2.90	.500		4.57		KR 2	113
95372.314E-05	3.20	2.90	.500		3.58		RB 2	114
95385.556E-04	-.000	-.000	.500		2.72		SR 2	115
95397.292E-03	-.000	-.000	.500		2.09		Y 2	116
95406.500E 01	.000	.000	.500	.02	.12	0.728	ZR 2	117
95413.750E 00	.000	.000	.500			0.235	NB*1	118
95413.500E 01	.000	.000	.500		.043	0.760	NB 2	119
9542	.000	.000	.500				MO 2	120
96391.597E-03	3.20	2.58	.500		1.55	1.7	Y 2	121
9640	3.20	2.58	.500				ZR 2	122
96419.583E-01	.570-03	.360-02	.500		.22	2.456	NB 2	123
9642	.000	.000	.500				MO 2	124
97361.157E-05	2.40	2.21	.500		4.20		KR 2	125
97372.315E-05	2.40	2.21	.500		4.39		RB 2	126
97383.472E-05	-.000	-.000	.500		3.57		SR 2	127
97394.630E-05	-.000	-.000	.500		2.31		Y 2	128
97407.083E-01	1.400	1.230	.500	.9	.70	0.221	ZR 2	129
97416.944E-04	.000	.000	.500			0.75	NB*1	130
97415.000E-02	.000	.000	.500		.47	.673	NB 2	131
9742	.000	.000	.500				MO 2	132
98406.944E-04	.200	.100+00	.500		1.99		ZR 2	133
98413.576E-02	.640-01	.100+00	.500	1.	1.31	2.	NB*1	134
98411.806E-02	3.00	2.84	.500		1.26	1.2	NB 2	135
9842	2.52	2.84	.500				MO 2	136
99401.852E-05	3.05	3.05	.500		1.55		ZR 2	137
99411.736E-03	3.05	3.05	.500		1.36	.26	NB 2	138
99422.750E 00	-.000	-.000	.500	.92	.41	0.124	MO 2	139
99432.500E-01	.000	.000	.500			.1423	TC*1	140
99437.665E 07	.000	.000	.500		.084		TC 2	141
9944	.000	.000	.500				RU 2	142
100412.083E-03	6.30	7.10	.500		3.39	1.05	NB 2	143
10042	.000	.000	.500				MO 2	144
100431.968E-04	.000	.000	.500		1.44	.114	TC 2	145
10044	.000	.000	.500				RU 2	146
101416.944E-04	2.50	2.95	.500		1.03		NB 2	147

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101421.014E-02	2.50	2.95	.500		.42	1.649	MO 2	148
101439.722E-03	.000	.000	.500		.47	0.362	TC 2	149
10144	.000	.000	.500				RU 2	150
102427.981E-03	4.20	5.99	.500		.44	1.3	MO 2	151
102435.787E-05	.000	.000	.500		1.79		TC 2	152
10244	.000	.000	.500				RU 2	153
103435.787E-04	1.550	2.83	.500		1.03		TC 2	154
103444.000E+01	1.450	2.83	.500	.995	.063	0.488	RU 2	155
103453.958E-02	.000	.000	.500			0.040	RH*1	156
10345	.000	.000	.500	.071			RH 2	157
104421.111E-03	1.800	5.93	.500		1.08	1.	MO 2	158
104431.250E-02	.000	.000	.500		.98	3.1	TC 2	159
10444	.000	.000	.500				RU 2	160
104453.056E-03	.000	.000	.500		.0013	.0002.131	RH*1	161
104454.861E-04	.000	.000	.500		.98	0.013	RH 2	162
10446	.000	.000	.500				PD 2	163
105424.630E-04	1.200	2.60	.500		2.54		MO 2	164
105435.556E-03	.600	1.300	.500		2.09		TC 2	165
105441.846E-01	.000	.000	.500		.2690	.42	RU 2	166
105453.472E-04	.000	.000	.500			0.129	RH*1	167
105451.500E 00	.000	.000	.500	.715	0.	.17	RH 2	168
10546	.000	.000	.500			0.032	PD 2	169
106443.650E 02	.950	4.57	.500		.01		RU 2	170
106459.167E-02	-.000	-.000	.500	1.	.35	2.627	RH*1	171
106453.472E-04	.000	.000	.500		1.40	.222	RH 2	172
10646	.000	.000	.500				PD 2	173
107431.042E-03	.640	3.60	.500		2.71		TC 2	174
107442.917E-03	.160	.000	.500		1.67	.144	RU 2	175
107451.507E-02	.000	.000	.500		.42	0.328	RH 2	176
107462.555E 09	.000	.000	.500		.014		PD 2	177
10747	.000	.000	.500	0.0100.			AG 2	178
108443.125E-03	.320	2.10	.500		.54	0.059	RU 2	179
108451.968E-04	.000	.000	.500		1.74	0.553	RH 2	180
10846	.000	.000	.500	.016			PD 2	181
108471.825E 03	.000	.000	.500	.9		1.605	AG*1	182
108471.667E-03	.000	.000	.500		.62	.017	AG 2	183
10848	.000	.000	.500				CD 2	184

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109453.472E-04	.112+00	2.80	.500	1.	1.16	.31	RH 2	185
109463.333E-03	.000	.000	.500			0.18	PD*1	186
109465.625E-01	.000	.000	.500	1.	.36	.0002	PD 2	187
109474.630E-04	.000	.000	.500			0.088	AG*1	188
10947	.000	.000	.500	.0326			AG 2	189
11046	.800-01	.000	.500	.167			PD 2	190
110472.600E 02	.000	.000	.500	0.98	.069	2.722	AG*1	191
110472.778E-04	.000	.000	.500		1.17	0.033	AG 2	192
11048	.800-06	.000	.500	.0322			CD 2	193
111462.292E-01	.400-02	.200-01	.500	0.32	.048	.676	PD*1	194
111461.528E-02	.720-01	.440	.500	1.	.85	.3	PD 2	195
111478.565E-04	-.000	-.000	.500			.065	AG*1	196
111477.500E 00	-.000	-.000	.500		.36	0.025	AG 2	197
111483.403E-02	.000	.000	.500			0.397	CD*1	198
11148	.000	.000	.500				CD 2	199
112468.750E-01	.440-01	.240	.500		.08	0.018	PD 2	200
112471.333E-01	.000	.000	.500		1.44	0.695	AG 2	201
11248	.000	.000	.500	1.			CD 2	202
113461.042E-03	.440-01	.200-01	.500	1.	1.40		PD 2	203
113478.333E-04	.000	.000	.500	.1	.08	0.200	AG*1	204
113472.208E-01	.000	.000	.500		.79	0.030	AG 2	205
113485.110E 03	.000	.000	.500	0.999	.18	.0003	CD*1	206
11348	.000	.000	.500				CD 2	207
11349	-.000	-.000	.500	.67			IN 2	208
114461.667E-03	.400-01	.200-01	.500		.52		PD 2	209
114475.787E-05	.000	.000	.500		2.02	0.5	AG 2	210
11448	.000	.000	.500	0.1130.			CD 2	211
114495.000E 01	-.000	-.000	.500			.192	IN*1	212
114498.333E-04	-.000	-.000	.500		.779	.002	IN 2	213
115465.208E-04	.400-01	.760-02	.500	.28	1.91		PD 2	214
115472.315E-04	-.000	-.000	.500	1.	1.49		AG*1	215
115471.458E-02	.200-02	.600-03	.500	.09	1.21	.2	AG 2	216
115484.300E 01	.000	.000	.500	1.	.61	0.036	CD*1	217
115482.300E 00	.000	.000	.500	1.	.32	0.192	CD 2	218
115491.833E-01	.000	.000	.500	.055	.015	0.317	IN*1	219
11549	.000	.000	.500	.78	.15		IN 2	220
11550	.000	.000	.500				SN 2	221

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116463.472E-04	.400-01	.000	.500		.93		PD 2	222	
116471.736E-03	.000	.000	.500		2.21	1.217	AG 2	223	
11648	.000	.000	.500				CD 2	224	
116493.750E-02	.000	.000	.500	1.	.29	2.495	IN*1	225	
116491.620E-04	.000	.000	.500		1.39		IN 2	226	
11650	.120-01	.000	.500	1.			SN 2	227	
117477.639E-04	.440-01	.220-01	.500		.5	1.63	AG 2	228	
117481.208E-01	.000	.000	.500		1.	.35	1.6	CD*1	229
117483.472E-02	.000	.000	.500		1.	.70	0.49	CD 2	230
117497.917E-02	.000	.000	.500	0.8	.52	.132	IN*1	231	
117493.125E-02	.000	.000	.500		.24	.73	IN 2	232	
117501.400E 01	.000	.000	.500			0.32	SN*1	233	
11750	.000	.000	.500				SN 2	234	
118483.472E-02	.400-01	.200-02	.500		.27	.2	CD 2	235	
118495.903E-05	.000	.000	.500		1.85	0.244	IN 2	236	
11850	.000	.000	.500	1.			SN 2	237	
119481.875E-03	.400-01	.800-02	.500		.99	1.56	CD*1	238	
119486.597E-03	-.000	-.000	.500		1.	1.44	.1	CD 2	239
119491.250E-02	-.000	-.000	.500		.96	1.04	0.066	IN*1	240
119491.389E-03	-.000	-.000	.500		.1	.61	.84	IN 2	241
119502.500E+02	-.000	-.000	.500				.089	SN*1	242
11950	.000	.000	.500					SN 2	243
120495.787E-04	.200-01	.100-02	.500		.88	3.2	IN 2	244	
12050	.200-01	.100-02	.500	.007			SN 2	245	
121482.431E-03	.100-02	.500-02	.500		1.73	0.85	CD 2	246	
121492.153E-03	.100-02	.500-02	.500	1.	1.58		IN*1	247	
121493.472E-04	.200-02	.106-01	.500		1.20	.94	IN 2	248	
121509.125E+03	.200-02	.100-01	.500	1.	.15	.01	SN*1	249	
121501.125E 00	.560-01	.600-01	.500		.11		SN 2	250	
12151	.000	.000	.500	.01			SB 2	251	
122498.681E-05	.260-01	.100-02	.500		2.68	2.14	IN 2	252	
12250	.260-01	.100-02	.500	.005			SN 2	253	
122512.847E-03	.000	.000	.500			0.136	SB*1	254	
122512.750E 00	.000	.000	.500		.58	.405	SP 2	255	
12252	.000	.000	.500	.333			TE 2	256	
123491.157E-04	.240-02	.100-02	.500		1.39	1.1	IN 2	257	
123501.250E+02	.240-02	.100-02	.500	1.	.52	0.022	SN*1	258	

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123502.778E-02	.560-01	.000	.500		.46	0.160	SN 2	259
12351	.000	.000	.500	.0135			SB 2	260
123521.040E+02	-.000	-.000	.500			.248	TE*1	261
12352	.000	.000	.500				TE 2	262
12450	.800-01	.000	.500	.962			SN 2	263
124511.458E-02	.000	.000	.500		.982	.97 0.427	SB*1	264
124516.020E+01	.000	.000	.500			.38 1.899	SB 2	265
12452	.000	.000	.500	.714			TE 2	266
125506.736E-03	.440-01	.200-02	.500		1.	.79 0.361	SN*1	267
125509.400E 00	.480-01	.142	.500			.92 0.094	SN 2	268
125519.855E 02	.000	.000	.500		.26	.096 .415	SB 2	269
125525.800E 01	.000	.000	.500			0.145	TE*1	270
12552	.000	.000	.500				TE 2	271
126503.650E+07	.250	.400	.500		1.	.12 .09	SN 2	272
126511.319E-02	.000	.000	.500		.01	.00780.117	SB*1	273
126511.250E 01	.000	.000	.500			.74 1.780	SB 2	274
12652	.000	.000	.500	.1			TE 2	275
127508.750E-02	.600	.780	.500			1.34 1.	SN 2	276
127513.900E 00	.250-01	.200-01	.500		.2	.38 0.505	SB 2	277
127521.050E 02	.000	.000	.500		.015	.00410.088	TE*1	278
127523.875E-01	.000	.000	.500			.23 0.004	TE 2	279
12753	.000	.000	.500				I 2	280
128504.306E-02	.925	.800	.500		.03	3.85 3.27	SN 2	281
128514.000E-01	.125+00	.000	.500		1.	.35 3.6	SB*1	282
128516.944E-03	.200	.200	.500			1.20 1.7	SB 2	283
12852	.000	.000	.500	.108			TE 2	284
128531.736E-02	.750-04	.400-03	.500			.77 0.093	I 2	285
12854	.000	.000	.500				XE 2	286
129511.792E-01	2.00	2.00	.500		.36	.542 .916	SB 2	287
129523.300E 01	.000	.000	.500			0.106	TE*1	288
129524.653E-02	.000	.000	.500			.45 .238	TE 2	289
129535.840E 09	.000	.000	.500			.050 .040	I 2	290
12954	.000	.000	.500				XE 2	291
130501.806E-03	2.00	2.00	.500			4.23	SN 2	292
130512.292E-02	.000	.000	.500			1.72 1.0	SB 2	293
13052	.000	.000	.500	.13			TE 2	294
130535.208E-01	.500-03	.520-02	.500			.27 2.123	I 2	295

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137532.778E-04	4.90	5.10	.500		2.19	.71	I	2	333
137542.708E-03	1.300	1.530	.500		1.48	1.	XE	2	334
137551.095E+04	.000	.000	.500	.92	.20	0.662	CS	2	335
137561.806E-03	.000	.000	.500				BA*	1	336
13756	.000	.000	.500				BA	2	337
138537.292E-05	3.40	3.70	.500		3.10	1.5	I	2	338
138549.722E-03	2.10	2.21	.500		.96	0.420	XE	2	339
138552.236E-02	.300	.400	.500		1.10	2.153	CS	2	340
13856	.000	.000	.500				BA	2	341
139532.314E-05	1.800	1.700	.500		2.40		I	2	342
139544.745E-04	2.90	2.80	.500		2.00	.4	XE	2	343
139556.597E-03	1.200	1.230	.500		1.74	0.232	CS	2	344
139565.764E-02	.100+00	.140	.500		.91	.053	BA	2	345
13957	.000	.000	.500				LA	2	346
140541.852E-04	3.70	3.30	.500		1.09		XE	2	347
140557.639E-04	2.30	2.10	.500		2.66	.59	CS	2	348
140561.280E 01	.300	.000	.500		.30	.222	BA	2	349
140571.675E 00	.000	.200	.500		.48	2.468	LA	2	350
14058	.000	.000	.500				CE	2	351
141541.968E-05	1.800	1.100	.500		2.36		XE	2	352
141552.778E-04	2.90	3.70	.500		1.72		CS	2	353
141561.250E-02	1.200	.900	.500		1.14	.46	BA	2	354
141571.625E-01	.100+00	.000	.500		.96	.0272	LA	2	355
141583.250E 01	.000	.000	.500		.15	0.101	CE	2	356
14159	.000	.000	.500				PR	2	357
142541.736E-05	.350	.310	.500		1.70		XE	2	358
142552.662E-05	3.05	2.87	.500		2.98		CS	2	359
142567.639E-03	2.20	1.830	.500		.78	.112	BA	2	360
142575.833E-02	.300	.000	.500		1.42	1.164	LA	2	361
14258	.000	.000	.500				CE	2	362
142598.000E-01	.000	.000	.500		.83	.063	PR	2	363
14260	.000	.000	.500				ND	2	364
143541.157E-05	3.10	2.65	.500		2.91		XE	2	365
143552.314E-05	3.10	2.65	.500		2.32		CS	2	366
143561.389E-04	-.000	-.000	.500		1.47		BA	2	367
143579.722E-03	-.000	-.000	.500		1.33	1.	LA	2	368
143581.375E 00	.000	.000	.500		.37	.377	CE	2	369

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143591.370E 01	.000	.000	.500		.32	PR 2	370
14360	.000	.000	.500			ND 2	371
144541.157E-05	2.90	1.600	.500		2.19	XE 2	372
144552.315E-05	2.90	1.600	.500		3.50	CS 2	373
144563.472E-05	-.000	-.000	.500		1.00	BA 2	374
144574.630E-05	-.000	-.000	.500		2.23	LA 2	375
144582.850E 02	.300	.590	.500		.080 0.030	CE 2	376
144591.201E-02	.000	.140	.500		1.22 .031	PR 2	377
14460	.000	.000	.500			ND 2	378
145582.083E-03	4.20	3.13	.500		.77	CE 2	379
145592.458E-01	.000	.000	.500		.68 .056	PR 2	380
14560	.000	.000	.500			ND 2	381
146589.722E-03	3.20	2.60	.500		.22 0.320	CE 2	382
146591.667E-02	.100+00	.000	.500		1.27 1.107	PR 2	383
14660	.000	.000	.500			ND 2	384
147588.333E-04	.650	.550	.500		1.55	CE 2	385
147598.333E-03	.650	.550	.500		1.12 1.	PR 2	386
147601.110E+01	1.300	1.100	.500		.23 0.196	ND 2	387
147619.855E 02	.000	.000	.500	.522	.059	PM 2	388
14762	.000	.000	.500			SM 2	389
148584.861E-04	1.710	1.730	.500		.95	CE 2	390
148591.354E-03	.000	.000	.500		2.17 0.300	PR 2	391
14860	.000	.000	.500			ND 2	392
148615.400E 00	.000	.000	.500	1.	.39 1.343	PM*1	393
148614.100E 01	.000	.000	.500		.41 1.227	PM 2	394
14862	.000	.000	.500			SM 2	395
149607.500E-02	1.300	1.320	.500		.55 .5	ND 2	396
149612.208E 00	.000	.000	.500		.36 .035	PM 2	397
14962	.000	.000	.500			SM 2	398
15060	.740	1.010	.500			ND 2	399
15062	.000	.000	.500			SM 2	400
151608.333E-03	.480	.800	.500		.63 0.717	ND 2	401
151611.183E 00	.200-01	.000	.500		.38 .715	PM 2	402
151623.285E 04	.000	.000	.500		.019 .0004	SM 2	403
15163	.000	.000	.500	.322		EU 2	404
152614.167E-03	.150	.310	.500		.86 2.8	PM 2	405
15262	.150	.310	.500			SM 2	406

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152633.875E-01	.000	.000	.500	1.	.60	.238	EU*1	407
152634.745E 03	.000	.000	.500		.19	1.209	EU 2	408
15264	.000	.000	.500				GD 2	409
153613.819E-03	.750-01	.185	.500		.62	.3	PM 2	410
153621.958E 00	.750-01	.185	.500		.22	.108	SM 2	411
15363	.000	.000	.500				EU 2	412
154611.736E-03	.450-01	.145	.500	1.			PM 2	413
15462	.450-01	.145	.500				SM 2	414
154635.840E 03	.000	.000	.500		.20	1.351	EU 2	415
15464	.000	.000	.500				GD 2	416
155621.528E-02	.620-01	.460	.500		.60	0.115	SM 2	417
155636.570E 02	.000	.000	.500		.046	0.072	EU 2	418
15564	.000	.000	.500				GD 2	419
156623.917E-01	.260-01	.220	.500		.30		SM 2	420
156631.500E 01	.000	.000	.500		.70	1.2	EU 2	421
15664	.000	.000	.500				GD 2	422
157636.417E-01	.148-01	.148	.500		.42	0.525	EU 2	423
15764	.000	.000	.500				GD 2	424
158633.194E-02	.200-01	.400	.500		1.04	0.600	EU 2	425
15864	.000	.000	.500				GD 2	426
159631.319E-02	.550-02	.105+00	.500		.86	.2	EU 2	427
159647.500E-01	.550-02	.105+00	.500		.29	0.075	GD 2	428
15965	.000	.000	.500				TB 2	429
160631.736E-02	.135-01	.810-02	.500		1.5		EU 2	430
16064	.135-01	.810-02	.500				GD 2	431
160657.300E 01	.000	.000	.500		.20	1.193	TB 2	432
16066	.000	.000	.500				DY 2	433
161642.569E-03	.800-01	.390-01	.500		.59	0.428	GD 2	434
161656.900E 00	.000	.000	.500		.15	0.037	TB 2	435
16166	.000	.000	.500				DY 2	436
162643.650E+02	-.000	.180-01	.500		.34	1.	GD 2	437
162658.333E-02	-.000	-.000	.500		1.68		TB 2	438
16266	-.000	-.000	.500				DY 2	439
163652.917E-01	-.000	.400-02	.500		1.22	.2	TB 2	440
16366	-.000	.400-02	.500				DY 2	441
16466	.000	.300-02	.500	.714			DY 2	442
165668.727E-04	.000	.120-02	.500	.03	.00840	.120	DY*1	443

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165669.583E-02	.000	.000	.500		.44	.0269	DY 2	444
16567	.000	.000	.500				HO 2	445
166663.333E 00	.000	.680-03	.500		.12	0.088	DY 2	446
166671.133E 00	.000	.000	.500		.67	.0558	HO 2	447
16668	.000	.000	.500	.01			ER 2	448
167682.892E-05	.000	.000	.500			0.208	ER*1	449
16768	.000	.000	.500				ER 2	450

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72301.938E 001.600E-051.200E-040.	0.	0.	.12	1.235	ZN 2	001
72315.875E-010.	0.	0.	.43	2.869	GA 2	002
7232	0.	0.			GE 2	003
73301.390E-039.800E-050.			2.25		ZN 2	004
73312.000E-012.000E-06			.42	.409	GA 2	005
73320.	0.	0.			GE 2	006
74315.555E-033.500E-040.			1.01	3.149	GA 2	007
7432	0.	0.			GE 2	008
75311.389E-034.000E-04	.5	.4	1.43	.58	GA 2	009
75325.671E-044.000E-04				.139	GE*1	010
75325.694E-02			.42	.038	GE 2	011
7533	0.	0.			AS 2	012
76313.704E-04 .001			2.74	1.	GA 2	013
7632	.001	.2			GE 2	014
76331.104E 000.	0.		1.09	0.404	AS 2	015
7634	0.	0.			SE 2	016
77326.250E-045.400E-030.			0.640	0.77 0.096	GE*1	017
77324.583E-013.700E-030.			.64	1.134	GE 2	018
77331.625E 000.	0.		.22	0.022	AS 2	019
77342.083E-04				.16	SE*1	020
7734	0.	0.			SE 2	021
78328.750E-021.800E-020.			.32	0.300	GE 2	022
78336.319E-032.000E-030.			1.47	0.888	AS 2	023
7834	0.	0.	.41	.875	SE 2	024
79336.250E-034.000E-020.			1.	.90	AS 2	025
79342.708E-030.	0.			0.096	SE*1	026
79342.555E 070.	0.				SE 2	027
79350.	0.	0.	1.140E 010.2540.	.04	BR 2	028
80331.736E-04 .08			2.73	.5	AS 2	029
8034	.6	.2			SE 2	030
80351.875E-010.	0.			0.085	BR*1	031
80351.250E-020.	0.		.72	.116	BR 2	032
8036	0.	0.			KR 2	033
81333.819E-041.250E-010.	15.		1.66		AS 2	034
81343.958E-028.400E-030.				0.103	SE*1	035
81341.250E-020.	0.		.53		SE 2	036

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8135	0.	0.	3.				BR 2	037
8136	0.	0.					KR 2	038
8234	3.800E-050.		5.400E-020.9200.				SE 2	039
82351.471E 00					.14	2.648	BR 2	040
8236	0.	0.	45.	1.			KR 2	041
83347.986E-043.000E-011.200E-01					1.0001.55	0.200	SE*1	042
83341.736E-021.800E-018.600E-02					.69	1.000	SE 2	043
83351.000E-010.		8.400E-020.		0.	1.000.34	0.010	BR 2	044
83367.750E-020.		0.	0.	0.	0.	0.041	KR*1	045
8336	0.	0.	180.				KR 2	046
84342.083E-036.100E-023.000E-02					.49		SE 2	047
84354.167E-031.900E-021.000E-02				1.	.71	3.396	BR*1	048
84352.222E-029.200E-014.300E-01					1.23	1.863	BR 2	049
8436	0.	0.	.14	.714			KR 2	050
85334.977E-065.500E-011.260E-01					1.28	5.0	AS 2	051
85344.514E-045.500E-011.260E-01					2.24		SE 2	052
85352.083E-034.000E-011.600E-01				1.	1.04		BR 2	053
85361.833E-010.		0.		0.810.29	.179		KR*1	054
85363.927E 030.		1.270E-0115.			.25	0.004	KR 2	055
8537	0.	0.	1.000E 000.1				RB 2	056
86341.852E-041.010E 003.800E-01					1.76		SE 2	057
86356.250E-041.010E 003.800E-01					3.23	.9	BR 2	058
8636			.06				KR 2	059
86377.222E-040.		0.				0.56	RB*1	060
86371.870E 012.800E-052.300E-05					.66	0.097	RB 2	061
8638	0.	0.	.006	1.			SR 2	062
87341.852E-042.700E 009.200E-01					3.73		SE 2	063
87356.366E-040.		0.			1.87	3.780	BR 2	064
87365.278E-020.		0.	600.		1.34	1.089	KR 2	065
8737	0.	0.	.12				RB 2	066
87381.167E-010.		0.				0.388	SR*1	067
8738	0.	0.					SR 2	068
88351.852E-042.900E 001.100E 00					3.22	.035	BR 2	069
88361.167E-018.000E-013.200E-01					.38	1.922	KR 2	070
88371.250E-020.		0.	1.		1.99	.748	RB 2	071
8838	0.	0.	.005				SR 2	072
89355.208E-052.000E-017.000E-02					3.	.075	BR 2	073

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89362.222E-034.400E 001.640E 00		1.39	2.265	KR 2	074
89371.042E-022.000E-010.	.55	.60	2.455	RB 2	075
89385.04 E 010.	0.	.4	.0002	SR 2	076
89391.852E-04			.915	Y*1	077
8939 0.	0.	1.301	.00080.	Y 2	078
90351.852E-052.600E 009.800E-01		3.	.075	BR 2	079
90363.819E-042.600E 009.800E-01		1.37	2.23	KR 2	080
90372.014E-037.000E-012.900E-01		2.05	4.15	RB 2	081
90381.022E 040.	0.	1.	.20	SR 2	082
90391.333E-01			.68	Y* 1	083
90392.675E 000.	0.		.94	Y 2	084
9040 0.	0.	.1		ZR 2	085
91361.157E-043.700E 001.260E 00		.5	1.56 2.	KR 2	086
91379.722E-032.000E-017.000E-02		1.	1.27 2.8	RB*1	087
91378.338E-042.000E 001.100E 00			2.04 0.4	RB 2	088
91384.042E-010.	0.	.590	.63 0.742	SR 2	089
91393.472E-020.	0.		0.551	Y* 1	090
91395.900E 010.	0.	1.4	.61 0.004	Y 2	091
9140 0.	0.	1.		ZR 2	092
92363.471E-052.700E 001.530E 00			2.73	KR 2	093
92375.787E-052.800E 001.540E 00			2.97	RB 2	094
92381.125E-016.000E-017.000E-02			2.26 1.274	SR 2	095
92391.471E-010.	0.		1.44 0.266	Y 2	096
9240 0.	0.	.2		ZR 2	097
93362.315E-051.300E 007.700E-01			3.82	KR 2	098
93376.944E-053.100E 001.820E 00			2.83	RB 2	099
93385.764E-032.000E 001.320E 00			1.40 1.0	SR 2	100
93394.208E-011.000E-016.000E-02			1.18 0.102	Y 2	101
93403.468E 080.	0.	4.	.25 .015	ZR 2	102
93411.351E 030.	0.		0.029	NB*1	103
9341 0.	0.	1.1	.909	NB 2	104
94361.620E-056.000E-016.000E-01			2.70	KR 2	105
94373.472E-052.300E 001.500E 00			4.57	RB 2	106
94388.333E-042.900E 001.640E 00			1.46	SR 2	107
94391.389E-027.000E-017.400E-01			2.23 1.	Y 2	108
9440 0.	0.	.08		ZR 2	109
94414.583E-030.	0.		.001 .00050.042	NB*1	110

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94417.300E 060.	0.	15.	.16	1.570	NB 2	111
9442	0.	0.			MO 2	112
95361.157E-053.200E 002.900E 00			4.57		KR 2	113
95372.314E-053.200E 002.900E 00			3.58		RB 2	114
95385.556E-04			2.72		SR 2	115
95397.292E-03			2.09		Y 2	116
95406.500E 010.	0.		.02	.12 0.728	ZR 2	117
95413.750E 000.	0.			0.235	NB*1	118
95413.500E 010.	0.	7.	.043	0.760	NB 2	119
9542	0.	0.			MO 2	120
96391.597E-033.200E 002.585E 00			1.55	1.7	Y 2	121
9640	3.200E 002.585E 00.05				ZR 2	122
96419.583E-015.700E-043.600E-03			.22	2.456	NB 2	123
9642	0.	0.			MO 2	124
97361.157E-052.400E 002.210E 00			4.20		KR 2	125
97372.315E-052.400E 002.210E 00			4.39		RB 2	126
97383.472E-05			3.57		SR 2	127
97394.630E-05			2.31		Y 2	128
97407.083E-011.400E 001.230E 00			.9	.70 0.221	ZR 2	129
97416.944E-040.	0.			0.75	NB*1	130
97415.000E-020.	0.		.47	.673	NB 2	131
9742	0.	0.			MO 2	132
98406.944E-04 .2	1.000E-01		1.99		ZR 2	133
98413.576E-02 .064	1.000E-01		1.	1.31 2.	NB*1	134
98411.806E-02 3.	2.845E 00		1.26	1.2	NB 2	135
9842	2.516 2.845E 00.15				MO 2	136
99401.852E-053.050E 003.050E 00			1.55		ZR 2	137
99411.736E-033.050E 003.050E 00			1.36	.26	NB 2	138
99422.750E 00			.92	.41 0.124	MO 2	139
99432.500E-010.	0.			.1423	TC*1	140
99437.665E 070.	0.	22.	.084		TC 2	141
9944	0.	0.			RU 2	142
100412.083E-036.300E 007.100E 00			3.39	1.05	NB 2	143
10042	0.	0.			MO 2	144
100431.968E-040.	0.		1.44	.114	TC 2	145
10044	0.	0.			RU 2	146
101416.944E-042.500E 002.950E 00			1.03		NB 2	147

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101421.014E-022.500E 002.950E 00	.42	1.649	MO 2	148
101439.722E-030. 0.	.47	0.362	TC 2	149
10144 0. 0.			RU 2	150
102427.981E-034.200E 005.990E 00	.44	1.3	MO 2	151
102435.787E-050. 0.	1.79		TC 2	152
10244 0. 0. 1.4			RU 2	153
103435.787E-041.550E 002.835E 00	1.03		TC 2	154
103444.000E+011.450E 002.835E 00	.995	.063 0.488	RU 2	155
103453.958E-020. 0.		0.040	RH*1	156
10345 0. 0. 155. .071			RH 2	157
104421.111E-031.800E 005.930E 00	1.08	1.	MO 2	158
104431.250E-020. 0.	.98	3.1	TC 2	159
10444 0. 0. .7			RU 2	160
104453.056E-030. 0. 800.	.0013	.0002.131	RH*1	161
104454.861E-040. 0. 40.	.98	0.013	RH 2	162
10446 0. 0.			PD 2	163
105424.630E-046.000E-012.600E 00	2.54		MO 2	164
105435.556E-033.000E-011.300E 00	2.09		TC 2	165
105441.846E-010. 0. .2	.2690	.42 .7680	RU 2	166
105453.472E-040. 0.		0.129	RH*1	167
105451.500E 000. 0. 2.100E+04.715 0.	.17	0.032	RH 2	168
10546 0. 0.			PD 2	169
106443.650E 023.800E-014.570E 00.1	.01		RU 2	170
106459.167E-02 0.	1. .35	2.627	RH*1	171
106453.472E-040. 0.	1.40	.222	RH 2	172
10646 0. 0.			PD 2	173
107431.042E-031.600E-013.600E 00	2.71		TC 2	174
107442.917E-034.000E-020. 0.	1.67	.144	RU 2	175
107451.507E-020. 0.	.42	0.328	RH 2	176
107462.555E 090. 0.	.014		PD 2	177
10747 0. 0. 35. 0.0100.			AG 2	178
108443.125E-038.000E-022.100E 00	.54	0.059	RU 2	179
108451.968E-040. 0.	1.74	0.553	RH 2	180
10846 0. 0. 12.2 .016			PD 2	181
108471.825E 030. 0. .9		1.605	AG*1	182
108471.667E-030. 0.	.62	.017	AG 2	183
10848 0. 0. 10.			CD 2	184

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109453.472E-042.800E-021.400E 00	1.	1.16	.31		RH 2	185
109463.333E-030. 0.			0.18		PD*1	186
109465.625E-010. 0.	1.	.36	.0002		PD 2	187
109474.630E-040. 0.			0.088		AG*1	188
10947 0. 0. 92.	.0326				AG 2	189
11046 2.000E-020. .24	.167				PD 2	190
110472.600E 020. 0. 80.	0.98	.069	2.722		AG*1	191
110472.778E-040. 0.		1.17	0.033		AG 2	192
11048 2.000E-070. 3.1	.0322				CD 2	193
111462.292E-011.000E-031.000E-02	0.32	.048	.676		PD*1	194
111461.528E-021.800E-022.200E-01	1.	.85	.3		PD 2	195
111478.565E-04			.065		AG*1	196
111477.500E 00		.36	0.025		AG 2	197
111483.403E-020. 0.			0.397		CD*1	198
11148 0. 0.					CD 2	199
112468.750E-011.100E-021.200E-01		.08	0.018		PD 2	200
112471.333E-010. 0.		1.44	0.695		AG 2	201
11248 0. 0. .03	1.				CD 2	202
113461.042E-031.100E-021.000E-02	1.	1.40			PD 2	203
113478.333E-040. 0.	.1	.08	0.200		AG*1	204
113472.208E-010. 0.		.79	0.030		AG 2	205
113485.110E 030. 0.	0.999	.18	.0003		CD*1	206
11348 0. 0. 2.000E 04					CD 2	207
11349 12. .67					IN 2	208
114461.667E-031.000E-021.000E-02		.52			PD 2	209
114475.787E-050. 0.		2.02	0.5		AG 2	210
11448 0. 0. 1.24	0.1130.				CD 2	211
114495.000E 01			.192		IN*1	212
114498.333E-04		.779	.002		IN 2	213
115465.208E-04 .01 .0038	.28	1.91			PD 2	214
115472.315E-04	1.	1.49			AG*1	215
115471.458E-02 .0005 3.000E-04	.09	1.21	.2		AG 2	216
115484.300E 010. 0.	1.	.61	0.036		CD*1	217
115482.300E 000. 0.	1.	.32	0.192		CD 2	218
115491.833E-010. 0.	.055	.015	0.317		IN*1	219
11549 0. 0. 203.	.78	.15			IN 2	220
11550 0. 0.					SN 2	221

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116463.472E-041.000E-020.			.93		PD 2	222
116471.736E-030.	0.		2.21	1.217	AG 2	223
11648	0.	0.			CD 2	224
116493.750E-020.	0.	1.4	1.	.29	IN*1	225
116491.620E-040.	0.			2.495	IN 2	226
11650	3.000E-030.	.006	1.	1.39	SN 2	227
117477.639E-041.100E-021.100E-02			.5	1.63	AG 2	228
117481.208E-010.	0.		1.	.35	CD*1	229
117483.472E-020.	0.		1.	.70	CD 2	230
117497.917E-020.	0.		0.8	.52	IN*1	231
117493.125E-020.	0.			.132	IN 2	232
117501.400E 010.	0.			.24	SN*1	233
11750	0.	0.		.73	SN 2	234
118483.472E-021.000E-021.000E-03				0.32	CD 2	235
118495.903E-050.	0.		.27	.2	IN 2	236
11850	0.	0.	1.85	0.244	SN 2	237
119481.875E-03 .01	4.000E-03		.99	1.56	CD*1	238
119486.597E-03			1.	1.44	CD 2	239
119491.250E-02			.96	1.04	IN*1	240
119491.389E-03			.1	.61	IN 2	241
119502.500E+02				.84	SN*1	242
11950	0.	0.		.089	SN 2	243
120495.787E-040.500E-020.500E-03			.88	3.2	IN 2	244
12050	0.500E-020.500E-03.141	.007			SN 2	245
121482.431E-032.500E-042.500E-03			1.73	0.85	CD 2	246
121492.153E-032.500E-042.500E-03			1.	1.58	IN*1	247
121493.472E-04 .0005 .0053				1.20	IN 2	248
121509.125E+030.500E-030.500E-02			1.	.15	SN*1	249
121501.125E 001.400E-023.000E-02				.01	SN 2	250
12151	0.	0.	.11		SB 2	251
122498.681E-050.650E-020.500E-03		6.06	.01		IN 2	252
12250	0.650E-020.500E-03.201	.005		2.68	SN 2	253
122512.847E-030.	0.			2.14	SB*1	254
122512.750E 000.	0.		.58	.405	SB 2	255
12252	0.	0.	.333		TE 2	256
123491.157E-040.600E-030.500E-03				0.136	IN 2	257
123501.250E+020.600E-030.500E-03			1.	1.39	SN*1	258
				1.1		
			1.	.52		0.022

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123502.778E-021.400E-020.				.46	0.160	SN 2	259
12351 0. 0.	3.345	.0135				SB 2	260
123521.040E+02				.248		TE*1	261
12352 0. 0.	400.					TE 2	262
12450 2.000E-020.	.104	.962				SN 2	263
124511.458E-020.	0.	.982	.97	0.427		SB*1	264
124516.020E+010.	0.		.38	1.899		SB 2	265
12452 0. 0.	7.	.714				TE 2	266
125506.736E-031.100E-021.000E-03		1.	.79	0.361		SN*1	267
125509.400E 001.200E-027.100E-02			.92	0.094		SN 2	268
125519.855E 020.	0.	.26	.096	.415		SB 2	269
125525.800E 010.	0.			0.145		TE*1	270
12552 0. 0.	1.5					TE 2	271
126503.650E+071.000E-012.000E-01		1.	.12	.09		SN 2	272
126511.319E-020.	0.	.01	.00780	.117		SB*1	273
126511.250E 010.	0.		.74	1.780		SB 2	274
12652 0. 0.	1.	.1				TE 2	275
127508.750E-022.400E-013.900E-01			1.34	1.		SN 2	276
127513.900E 001.000E-021.000E-02		.2	.38	0.505		SB 2	277
127521.050E 020.	0.	.015	.00410	.088		TE*1	278
127523.875E-010.	0.		.23	0.004		TE 2	279
12753 0. 0.	6.4					I 2	280
128504.306E-023.700E-014.000E-01		.03	3.85	3.27		SN 2	281
128514.000E-015.000E-020.		1.	.35	3.6		SB*1	282
128516.944E-038.000E-021.000E-01			1.20	1.7		SB 2	283
12852 0. 0.	.157	.108				TE 2	284
128531.736E-023.000E-052.000E-04			.77	0.093		I 2	285
12854 0. 0.	5.					XE 2	286
129511.792E-011.000E 001.000E 00		.36	.542	.916		SB 2	287
129523.300E 010.	0.			0.106		TE*1	288
129524.653E-020.	0.		.45	.238		TE 2	289
129535.840E 090.	0.		.050	.040		I 2	290
12954 0. 0.	25.					XE 2	291
130501.806E-032.000E 002.000E 00			4.23			SN 2	292
130512.292E-020.	0.		1.72	1.0		SB 2	293
13052 0. 0.	.23	.13				TE 2	294
130535.208E-01 .0005 .0052 18.			.27	2.123		I 2	295

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137532.778E-044.800E 003.100E 00	2.19 .71	I 2	333
137542.708E-031.300E 001.530E 00	1.48 1.	XE 2	334
137551.095E+040. 0. .11	.92 .20	CS 2	335
137561.806E-030. 0.	0.662	BA*1	336
13756 0. 0. 4.		BA 2	337
138537.292E-013.400E 003.700E 00	3.10 1.5	I 2	338
138549.722E-032.100E 002.210E 00	.96 0.420	XE 2	339
138552.236E-023.000E-014.000E-01	1.10 2.153	CS 2	340
13856 0. 0. .4		BA 2	341
139532.314E-051.800E 001.700E 00	2.40	I 2	342
139544.745E-042.900E 002.800E 00	2.00 .4	XE 2	343
139556.597E-031.200E 001.230E 00	1.74 0.232	CS 2	344
139565.754E-021.000E-011.400E-014.	.91 .053	BA 2	345
13957 0. 0. 8.9		LA 2	346
140541.852E-043.700E 003.300E 00	1.09	XE 2	347
140557.639E-042.300E 002.100E 00	2.66 .59	CS 2	348
140561.280E-013.000E-010. 20.	.30 .222	BA 2	349
140571.675E-000. 2.000E-01	.48 2.468	LA 2	350
14058 0. 0. .6		CE 2	351
141541.968E-051.800E 001.100E 00	2.36	XE 2	352
141552.778E-042.900E 003.700E 00	1.72	CS 2	353
141561.250E-021.200E 000.000E-01	1.14 .46	BA 2	354
141571.625E-011.000E-010.	.96 .0272	LA 2	355
141583.250E 010. 0. 30.	.15 0.101	CE 2	356
14159 0. 0. 12.		PR 2	357
142541.736E-053.500E-013.100E-01	1.70	XE 2	358
142552.662E-053.050E 002.870E 00	2.98	CS 2	359
142567.639E-032.200E 001.830E 00	.78 .112	BA 2	360
142575.833E-023.000E-010.	1.42 1.164	LA 2	361
14258 0. 0. 1.		CE 2	362
142592.000E-010. 0. 20.	.83 .063	PR 2	363
14260 0. 0. 17.		ND 2	364
143541.157E-053.100E 002.650E 00	2.91	XE 2	365
143552.314E-053.100E 002.650E 00	2.32	CS 2	366
143561.389E-04	1.47	BA 2	367
143579.722E-03	1.33 1.	LA 2	368
143581.375E 000. 0. 6.	.37 .377	CE 2	369

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143591.370E 010.	0.	89.		.32	PR 2	370
14360	0.	0.	330.		ND 2	371
144541.157E-052.900E 001.600E 00				2.19	XE 2	372
144552.315E-052.900E 001.600E 00				3.50	CS 2	373
144563.472E-05				1.00	BA 2	374
144574.630E-05				2.23	LA 2	375
144582.850E 023.000E-015.900E-011.				.080 0.030	CE 2	376
144591.201E-020.	1.400E-01			1.22 .031	PR 2	377
14460	0.	0.	5.		ND 2	378
145582.083E-034.200E 003.130E 00				.77	CE 2	379
145592.458E-010.	0.			.68 .056	PR 2	380
14560	0.	0.	50.		ND 2	381
146589.722E-033.200E 002.600E 00				.22 0.320	CE 2	382
146591.667E-021.000E-010.				1.27 1.107	PR 2	383
14660	0.	0.	2.		ND 2	384
147588.333E-040.650E 000.550E 00				1.55	CE 2	385
147598.333E-030.650E 000.550E 00				1.12 1.	PR 2	386
147601.110E+011.300E 001.100E 00				.23 0.196	ND 2	387
147619.855E 020.	0.	230.	.522	.059	PM 2	388
14762	0.	0.	90.		SM 2	389
148584.861E-041.710E 001.730E 00				.95	CE 2	390
148591.354E-030.	0.			2.17 0.300	PR 2	391
14860	0.	0.	4.		ND 2	392
148615.400E 000.	0.	2000.	1.	.39 1.343	PM*1	393
148614.100E 010.	0.	3.000E+04		.41 1.227	PM 2	394
14862	0.	0.			SM 2	395
149607.500E-021.300E 001.320E 00				.55 .5	ND 2	396
149612.208E 000.	0.			.36 .035	PM 2	397
14962	0.	0.	4.150E 04		SM 2	398
15060	7.400E-011.010E 001.5				ND 2	399
15062	0.	0.	100.		SM 2	400
151608.333E-034.800E-018.000E-01				.63 0.717	ND 2	401
151611.183E 002.000E-020.				.38 .715	PM 2	402
151623.285E 040.	0.	1.500E 04		.019 .0004	SM 2	403
15163	0.	0.	8.700E 03.322		EU 2	404
152614.167E-031.500E-013.100E-01				.86 2.8	PM 2	405
15262	1.500E-013.100E-01210.				SM 2	406

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152633.875E-010.	0.		1.	.60	.238	EU*1	407
152634.745E 030.	0.	5000.		.19	1.209	EU 2	408
15264 0.	0.	180.				GD 2	409
153613.819E-03 .075	.185			.62	.3	PM 2	410
153621.958E 00 .075	.185			.22	.108	SM 2	411
15363 0.	0.	320.				EU 2	412
154611.736E-03 .045	.145		1.			PM 2	413
15462 .045	.145	5.				SM 2	414
154635.840E 030.	0.	1400.		.20	1.351	EU 2	415
15464 0.	0.					GD 2	416
155621.528E-023.100E-022.300E-01				.60	0.115	SM 2	417
155636.570E 020.	0.	1.300E 04		.046	0.072	EU 2	418
15564 0.	0.	5.800E 04				GD 2	419
156623.917E-011.300E-021.100E-01				.30		SM 2	420
156631.500E 010.	0.			.70	1.2	EU 2	421
15664 0.	0.					GD 2	422
157636.417E-017.400E-037.400E-02				.42	0.525	EU 2	423
15764 0.	0.	2.400E 05				GD 2	424
158633.194E-022.000E-034.000E-02				1.04	0.600	EU 2	425
15864 0.	0.	3.4				GD 2	426
159631.319E-02.00055	.0105			.86	.2	EU 2	427
159647.500E-01.00055	.0105			.29	0.075	GD 2	428
15965 0.	0.	46.				TB 2	429
160631.736E-02.00135	.00081			1.5		EU 2	430
16064 .00135	.00081	.8				GD 2	431
160657.300E 010.	0.	525.		.20	1.193	TB 2	432
16066 0.	0.					DY 2	433
161642.569E-03 .008	3.900E-03			.59	0.428	GD 2	434
161656.900E 000.	0.			.15	0.037	TB 2	435
16166 0.	0.	580.				DY 2	436
162643.650E+02	1.800E-03			.34	1.	GD 2	437
162658.333E-02				1.68		TB 2	438
16266 140.						DY 2	439
163652.917E-01	4.000E-04			1.22	.2	TB 2	440
16366 4.000E-04	120.					DY 2	441
16466 0.	3.000E-04	2800.	.714			DY 2	442
165668.727E-040.	1.200E-04		.03	.00840.120		DY*1	443

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165669.583E-020.	0.	4700.		.44	.0269	DY 2	444
16567 0.	0.	65.				HO 2	445
166663.333E 000.	6.800E-05			.12	0.088	DY 2	446
166671.133E 000.	0.			.67	.0558	HO 2	447
16668 0.	0.	12.	.01			ER 2	448
167682.892E-050.	0.				0.208	ER*1	449
16768 0.	0.	700.				ER 2	450

APPENDIX E

SAMPLE CASE LISTINGS

APPENDIX E

SAMPLE CASE LISTINGS

This appendix provides two sample listings illustrating how data is submitted for cases to be run on the IBM 7090.

In the first illustration a complete set of data cards (except for the library) are listed to produce the following cases:

- Inventory based on 1 MW of power for 358 days
- Fractional release rate of 6.94×10^{-5} /min
- Simulated removal by filters of all the radionuclides except noble gases prior to release
- The dose calculated for exposure periods of 1, 2, 4, and 8 have distances corresponding to 1 to 10,000 min plume travel time at 1 m/sec
- Calculation of the dose from (1) the noble gases, (2) any halogens (3) any volatile solids and (4) any remaining fission products. The latter 3 categories would be expected to be negligible since everything but noble gases was filtered out at 0.05 min after shutdown.
- Atmospheric dispersion parameters for Hanford (moderately stable conditions) ground level release.

The second illustration is for a fast reactor case. The fast reactor library should be used and must precede the listed data cards.

At the end of the listing are two 9 in. cards. This would result in terminating the program after Link 1. The user would get only the Link 1 integrals printed out and no Link 2 dispersion and dose calculation.

To get the Link 2 calculations would require the addition of cards similar to illustration 1.

Sample Data Listing - Illustration 1

2 6	601PRTR 1 MW FOR 358 DAYS L=6.94-5 NG				
0 5	581 10.	50.	60.	120.	240.
0 6	589 6.94-5	1.	358.	1.0	642.
1 3	599 0 0 0				.0689
1 1	598 1				
9					
0 1	590 0.0				
0 1	591 3.4722E-5				
1 1	598 0				
9					
0 1	590 1.0000E-6				
0 1	591 1.0000E-6				
1 1	598 1				
0501	1 0.0				
0501	51 0.0				
0501	101 0.0				
0501	151 0.0				
0501	201 0.0				
0501	251 0.0				
0501	301 0.0				
0501	351 0.0				
0491	401 0.0				
0 1	1241.0				
0 1	1121.0				
0 1	1041.0				
0 1	971.0				
0 1	921.0				
0 1	851.0				
0 1	791.0				
0 1	731.0				
0 1	671.0				
0 1	641.0				
0 1	581.0				
0 1	541.0				
0 1	521.0				
0 1	401.0				
0 1	451.0				

POWER
TIME IN DAYS, .05 MIN

1WATT
.1SEC

E-2

BNWL-811

0	1	441.0
0	1	401.0
0	1	371.0
0	1	321.0
0	1	3691.0
0	1	3621.0
0	1	3551.0
0	1	3491.0
0	1	3441.0
0	1	3401.0
0	1	3361.0
0	1	3311.0
0	1	3271.0
0	1	3221.0
0	1	3211.0
0	1	3141.0
0	1	3091.0
0	1	3081.0
0	1	3031.0
0	1	2991.0
0	1	2981.0
0	1	2931.0
0	1	2881.0
0	1	2831.0

0	3	595	1.	66.	5.	1HP	1MIN
0	1	596	126.			2HP	1MIN
0	1	596	246.			4HP	1MIN
0	1	596	486.			8HP	1MIN
0	3	595	5.	70.	5.	1HP	5MIN
0	1	596	130.			2HP	5MIN

E-3

BNWL-811

0	1	596	250.			4HR	5MIN
9							
0	1	596	490.			8HR	5MIN
9							
0	3	595	10.	75.	5.	1HR	10MIN
9							
0	1	596	135.			2HR	10MIN
9							
0	1	596	255.			4HR	10MIN
9							
0	1	596	495.			8HR	10MIN
9							
0	3	595	25.	90.	5.	1HR	25MIN
9							
0	1	596	150.			2HR	25MIN
9							
0	1	596	270.			4HR	25MIN
9							
0	1	596	510.			8HR	25MIN
9							
0	3	595	50.	115.	5.	1HR	50MIN
9							
0	1	596	175.			2HR	50MIN
9							
0	1	596	295.			4HR	50MIN
9							
0	1	596	535.			8HR	50MIN
9							
2	6	601PRTR 1 MW FOR 358 DAYS L=6.94-5 NG					
0	1	589	6.9401-5				
0	3	595	70.	135.	5.	1HR	70MIN
9							
0	1	596	195.			2HR	70MIN
9							
0	1	596	315.			4HR	70MIN
9							
0	1	596	555.			8HR	70MIN

E-4

BNWL-811

9							
0	3	595	100.	165.	5.	1HR	100MIN
9							
0	1	596	225.			2HR	100MIN
9							
0	1	596	345.			4HR	100MIN
9							
0	1	596	585.			8HR	100MIN
9							
0	3	595	500.	565.	5.	1HR	500MIN
9							
0	1	596	625.			2HR	500MIN
9							
0	1	596	745.			4HR	500MIN
9							
0	1	596	985.			8HR	500MIN
9							
0	3	595	1000.	1065.	5.	1HR	1000MIN
9							
0	1	596	1125.			2HR	1000MIN
9							
0	1	596	1245.			4HR	1000MIN
9							
0	1	596	1485.			8HR	1000MIN
9							
0	3	595	5000.	5065.	5.	1HR	5000MIN
9							
0	1	596	5125.			2HR	5000MIN
9							
0	1	596	5245.			4HR	5000MIN
9							
0	1	596	5485.			8HR	5000MIN
9							
2	6	601PRTR 1 MW FOR 358 DAYS L=6.94-5 NG					
0	1	589	6.94-5				
0	3	595	10000.	10065.	5.	1HR	10000MIN
9							

E-5

BNWL-811

0	1	596	10125.				2HR10000MIN
0	1	596	10245.				4HR10000MIN
0	1	596	10485.				8HR10000MIN
1	1	599	1				
0	1	576	1.0				NORLE CASES
0	5	451	5.0	1.0	97.	.33	2.5-4
0	5	456	0.024	0.04	0.06	0.10	0.18
0	5	461	5.	1.	97.	.33	2.5-4
0	5	466	.024	.024	.024	.024	.024
1	5	571	0	0	1	0	PLOTTER CONTROL
0	4	661	0.0	0.0	0.0	1.0	NG MOD STABLE
0	4	668	0.0	1.0	13.0	232.5	
0	1	577	1.0				HALOGENS
0	5	451	5.0	1.0	97.	.33	2.5-4
0	5	456	0.024	0.04	0.06	0.10	0.18
0	5	461	5.	1.	97.	.33	2.5-4
0	5	466	.024	.024	.024	.024	.024
1	5	571	0	0	1	0	PLOTTER CONTROL
0	4	661	0.0	0.0	3.4-3	.35	HAL MOD STABLE
0	4	668	0.0	1.0	13.0	232.5	
0	1	578	1.0				VOLATILE SOLIDS
0	5	451	5.0	1.0	97.	.33	2.5-4
0	5	456	0.024	0.04	0.06	0.10	0.18
0	5	461	5.	1.	97.	.33	2.5-4
0	5	466	.024	.024	.024	.024	.024
1	5	571	0	0	1	0	PLOTTER CONTROL
0	4	661	0.0	0.0	2.2-4	.35	VS MOD STABLE
0	4	668	0.0	1.0	13.0	232.5	
0	1	579	1.0				ALL REMAINING EP
0	5	451	5.0	1.0	97.	.33	2.5-4

E-6

BNWL-811

0 5	456	0.024	0.04	0.06	0.10	0.18
0 5	461	5.	1.	97.	.33	2.5-4
0 5	466	.024	.024	.024	.024	.024
1 5	571	0 0	1 0	PLOTTER CONTROL		
0 4	661	0.0	0.0	2.2-4	.35	ARFP MOD STABLE
0 4	668	0.0	1.0	13.0	232.5	
9						
0 1	1	-10.				
9						

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