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EXREM AND INREM COMPUTER CODES FOR ESTIMATING RADIATION DOSES TO POPULATIONS FROM CONSTRUCTION OF A SEA-LEVEL CANAL WITH NUCLEAR EXPLOSIVES

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This report describes the use of the codes EXREM and INREM. EXREM is a computer code to estimate the dose equivalent rate and the total dose equivalent from both beta and gamma radiation resulting from submersion in contaminated water, submersion in contaminated air, and exposure to a contaminated surface. There can be more than one environmental release, and exposure can begin at any time after the first release. INREM is a computer code to estimate the cumulative dose equivalent to body organs resulting from a continuous intake. The organ parameters are dependent on the age of the individual, and the intake is a function of post-detonation time and the individual's age.

Although the codes were specifically written to estimate doses to populations from construction of a sea-level canal, they may be useful in other dose-estimation studies involving releases of radioactive materials to the environment.

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EXREM AND INREM COMPUTER CODES FOR ESTIMATING RADIATION DOSES TO POPULATIONS FROM CONSTRUCTION OF A SEA-LEVEL CANAL WITH NUCLEAR EXPLOSIVES

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1. INTRODUCTION

Evaluation of the radiation hazard to a population living in an environment contaminated with radioactive material requires estimates of the total dose equivalents received by individuals of all ages. The total dose has two components. One component results from radionuclides outside the body (external exposure), and the other one results from radionuclides deposited within the body (internal exposure). Internal exposure is considered in Sect. 2, and external exposure is discussed in Sect. 3. Individuals making up a population under consideration for dose estimation may be described by parameters which are either age independent or age dependent.

The generalized models and the mathematical techniques required to program the models for several types of problems are presented. Descriptions of the FORTRAN programs, INREM (internal exposure) and EXREM (external exposure) are included in this report.

2. INTERNAL EXPOSURE

2.1 Development of the Problem

The models used to calculate the accumulated dose to the body organs were modified from the models presented in reference 1. There are two basic models to consider; one for all of the body organs except the gastrointestinal (G.I.) tract, and one for the G.I. tract. The remaining portion of this section is devoted to developing algorithms from these two models to handle various problems that arise in internal dose estimation studies.

2.1.1 All Organs Except the G.I. Tract

The general model for the accumulated dose to a body organ resulting from an intake of a radionuclide is

$$D_{ik}(t_1,t_2,t_b) = 51 \int_{t_1}^{t_2} I_i(t,t-t_b) f_{ik}(t-t_b) \left\{ \int_{t}^{t_2} \frac{\varepsilon_{ik}(s-t_b)}{m_k(s-t_b)} \exp\left[-\int_{t-t_b}^{s-t_b} \lambda_{ik}(r)dr\right] ds \right\} dt \;, \qquad (2.1)$$

where

$D_{ik}(t_1,t_2,t_b)$ = the cumulative dose equivalent (rem) received during the time interval t_1 to t_2 from the ith radionuclide in the kth organ resulting from intake during this time interval by an individual born at t_b,

i = radionuclide index,

k = organ index,

t_1 = time (days) of initial intake relative to time of reference detonation,

t_2 = time (days) at end of period of interest relative to time of reference detonation,

t_b = time (days) of birth relative to time of reference detonation,

$I_i(t,x)$ = intake (μCi/day) of the ith radionuclide at time t by an individual of age x,

$m_k(x)$ = mass (g) of the kth organ of an individual of age x,

$f_{ik}(x)$ = fractional absorption (dimensionless) of the ith radionuclide in the kth organ of an individual of age x,

$\varepsilon_{ik}(x)$ = effective absorbed energy (MeV) of the ith radionuclide in the kth organ of an individual of age x, and

$\lambda_{ik}(x)$ = effective elimination constant ($days^{-1}$) of the ith radionuclide in the kth organ of an individual of age x.

When the following transformations are made,

$$\tau = s - t_b \qquad (2.2)$$

and

$$x = t - t_b \ ,$$

$$x_1 = t_1 - t_b \ ,$$

$$x_2 = t_2 - t_b \ , \text{ and} \qquad (2.3)$$

$$\hat{D}_{ik}(x_1,x_2,t_b) = D_{ik}(t_1,t_2,t_b) \ ,$$

Eq. (2.1) can be rewritten as

$$\hat{D}_{ik}(x_1,x_2,t_b) = 51 \int_{x_1}^{x_2} I_i(x+t_b,x) f_{ik}(x) \left\{ \int_x^{x_2} \frac{\varepsilon_{ik}(\tau)}{m_k(\tau)} \exp\left[-\int_x^{\tau} \lambda_{ik}(r)dr\right] d\tau \right\} dx \ . \qquad (2.4)$$

Equation (2.4) can be used for either age-dependent or age-independent dose estimates. Both types of dose estimates are considered in the following two sections.

<u>Age-Independent Individual</u>

In this case the parameters, $f_{ik}(x)$, $\varepsilon_{ik}(x)$, $m_k(x)$, $\lambda_{ik}(x)$, and $I_i(t,x)$, are independent of the individual's age x. Thus,

$$f_{ik}(x) = f_{ik} ,$$

$$\varepsilon_{ik}(x) = \varepsilon_{ik} ,$$

$$m_k(x) = m_k , \tag{2.5}$$

$$\lambda_{ik}(x) = \lambda_{ik} , \text{ and}$$

$$I_i(t,x) = I_i(t) ,$$

for $x_1 \leq x \leq x_2$ and $t_1 \leq t \leq t_2$. From Eqs. (2.4) and (2.5) one obtains

$$\hat{D}_{ik}(x_1,x_2,t_b) = \frac{51 f_{ik}\varepsilon_{ik}}{m_k \lambda_{ik}} \int_{x_1}^{x_2} I_i(x+t_b)[1 - e^{-\lambda_{ik}(x_2-x)}]dx . \tag{2.6}$$

This form of the model leads to the following subcases:

(1) Time-Dependent Intake.

The total dose for this case is given by Eq. (2.6), and the integral in the equation may be evaluated numerically.

(2) Time-Independent Intake.

For this case

$$I_i(t) = I_i$$

for $t_1 \leq t \leq t_2$. In a more generalized model the last intake occurs at age $\hat{x}_2$, where $\hat{x}_2 \leq x_2$. An analytical expression can be obtained for the integral in Eq. (2.6), and the cumulative dose equivalent is

$$\hat{D}_{ik}(x_1,\hat{x}_2,x_2,t_b) = \frac{51 f_{ik}\varepsilon_{ik}\, I_i}{m_k\lambda^2_{ik}}$$

$$\left\{\lambda_{ik}(\hat{x}_2-x_1) - e^{-\lambda_{ik}(x_2-\hat{x}_2)}\left[1 - e^{-\lambda_{ik}(\hat{x}_2-x_1)}\right]\right\} \quad . \tag{2.7}$$

Age-Dependent Individual

The parameters $f_{ik}(x)$, $\varepsilon_{ik}(x)$, $m_k(x)$, $\lambda_{ik}(x)$, and $I_i(t,x)$ are functions of the age of the individual in this case. However, assume that the age scale can be divided into n intervals,

$$[y_1,y_2),[y_2,y_3),\cdots,[y_{n-1},y_n),[y_n,y_{n+1}) \ ,$$

so that the above parameters are constant in each age group. Now, for a particular radionuclide i and organ k,

$$f_{ik}(x) = f_{ik\ell} \ ,$$

$$\varepsilon_{ik}(x) = \varepsilon_{ik\ell} \ ,$$

$$m_k(x) = m_{k\ell} \ , \tag{2.8}$$

$$\lambda_{ik}(x) = \lambda_{ik\ell} \ , \text{ and}$$

$$I_i(t,x) = I_{i\ell}(t)$$

for $y_\ell \le x < y_{\ell+1}$, $t_1 \le t \le t_2$, and $\ell = 1, 2, \ldots, n$. Again consider Eq. (2.4) and let

$$F(x,x_2) = \int_x^{x_2} \frac{\varepsilon_{ik}(\tau)}{m_k(\tau)} \exp[-\int_x^{\tau} \lambda_{ik}(r)dr]d\tau. \qquad (2.9)$$

Next, by using Eqs. (2.8), an analytic expression can be obtained for Eq. (2.9) which when combined with Eq. (2.4) gives

$$\hat{D}_{ik}(x_1,x_2,t_b) = 51 \int_{x_1}^{x_2} I_i(x+t_b,x)f_{ik}(x)F(x,x_2)dx . \qquad (2.10)$$

Since $I_i(x+t_b,x)$ and $f_{ik}(x)$ are known functions for $x_1 \leq x \leq x_2$, and since $F(x,x_2)$ can be evaluated for any x in the interval $[x_1,x_2]$, the value of the integrand can be determined for any x where $x_1 \leq x \leq x_2$. Then the total dose for this case can be obtained by a numerical evaluation of the integral in Eq. (2.10).

2.1.2 G.I. Tract

In the most generalized case, the parameters $\hat{f}_{ik}(x)$, $\hat{\varepsilon}_{ik}(x)$, $\hat{m}_k(x)$, and $I_i(t,x)$ are functions of the age of the individual. As in Sect. 2.1.1, assume that the age scale can be divided into n intervals,

$$[y_1,y_2),[y_2,y_3),\cdots,[y_{n-1},y_n),[y_n,y_{n+1}) \ ,$$

so that the above parameters are constant in each age group. These parameters can then be defined by Eqs. (2.8), and the general model for the accumulated dose to the G.I. tract resulting from an intake of a radionuclide is

$$D_{ij\alpha}(t_1,\hat{t}_2,t_b) = \frac{0.3}{7A_{jn}(MPC)_{ij\alpha}} \int_{t_1}^{\hat{t}_2} I_i(t,t-t_b)P_\kappa(t-t_b)Q_{i\alpha}(t-t_b)$$

$$R_{ij\alpha}(t-t_b)S_j(t-t_b)dt \ , \qquad (2.11)$$

where

$$P_\kappa(t-t_b) = \hat{m}_{\kappa n}/\hat{m}_{\kappa \ell} \ ,$$

$$Q_{i\alpha}(t-t_b) = \hat{\varepsilon}_{i\ell\alpha}/\hat{\varepsilon}_{in\alpha} \ , \qquad (2.12)$$

$$R_{ij\alpha}(t-t_b) = \hat{f}_{i\ell j\alpha}/\hat{f}_{inj\alpha} \ , \text{ and}$$

$$S_j(t-t_b) = A_{j\ell}/A_{jn}$$

for $y_\ell \leq t-t_b < y_{\ell+1}$, and where

$D_{ij\alpha}(t_1,\hat{t}_2,t_b)$ = the cumulative dose equivalent (rem) received during the time interval t_1 to $\hat{t}_2$ from the ith radionuclide (α=1 for soluble; α=2 for insoluble) in the critical segment $\kappa(i,\alpha)$ of the G.I. tract resulting from continuous intake via inhalation (j=1) or ingestion (j=2) during this time interval by an individual born at t_b,

i = radionuclide index,

j = index for intake via inhalation (j=1) or ingestion (j=2),

α = index to indicate that the ith radionuclide is either soluble (α=1) or insoluble (α=2),

$\kappa=\kappa(i,\alpha)$ = index for the critical segment of the G. I. tract for the ith radionuclide of type α,

$A_{j\ell}$ = intake (cm^3/day) of air (j=1) or water (j=2) for an individual in the ℓth age group,

$(MPC)_{ij\alpha}$ = the maximum permissible concentration ($\mu Ci/cm^3$) of the ith radionuclide in air (j=1) or water (j=2) where the ith radionuclide is soluble (α=1) or insoluble (α=2),

0.3/7 = the dose rate (rem/day) delivered to the critical segment of the G.I. tract from a daily intake at the MPC,

t_1 = time (days) of the initial intake relative to time of reference detonation,

$\hat{t}_2$ = time (days) of the final intake relative to time of reference detonation,

$I_i(t,t-t_b)$ = intake (μCi/day) of the ith radionuclide at time t by an individual of age $t-t_b$,

$\hat{m}_{\kappa\ell}$ = mass (g) of the critical segment κ of the G.I. tract of an individual in the ℓth age group,

$\hat{\varepsilon}_{i\ell\alpha}$ = effective absorbed energy (MeV) of the ith radionuclide of type α in the critical segment of the G.I. tract of an individual in the ℓth age group, and

$\hat{f}_{i\ell j\alpha}$ = fractional absorption (dimensionless) from inhalation (j=1) or ingestion (j=2) of the ith radionuclide of type α reaching the critical segment of the G.I. tract of an individual in the ℓth age group.

In order to transform the model for the G. I. tract into a form consistent with the models that were developed in Sect. 2.1.1, the transformations

$$x = t-t_b ,$$

$$x_1 = t_1-t_b ,$$

$$\hat{x}_2 = \hat{t}_2-t_b , \text{ and}$$

$$\hat{D}_{ij\alpha}(x_1,\hat{x}_2,t_b) = D_{ij\alpha}(t_1,\hat{t}_2,t_b)$$

were used to obtain

$$\hat{D}_{ij\alpha}(x_1,\hat{x}_2,t_b) = \frac{0.3}{7A_{jn}(MPC)_{ij\alpha}} \int_{x_1}^{\hat{x}_2} I_i(x+t_b,x)P_\kappa(x)Q_{i\alpha}(x) R_{ij\alpha}(x)S_j(x)dx . \quad (2.13)$$

The individual for whom the dose is calculated is either age-independent or age-dependent, and each of these cases is discussed in the following two sections.

Age-Independent Individual

In this case $P_\kappa(x) = Q_{i\alpha}(x) = R_{ij\alpha}(x) = S_j(x) = 1$ and $I_i(x+t_b, x) = I_i(x+t_b)$ for all i, j, and α and any x in the interval $[x_1, \hat{x}_2]$. Thus, Eq. (2.13) reduces to

$$\hat{D}_{ij\alpha}(x_1, \hat{x}_2, t_b) = \frac{0.3}{7A_{jn}(MPC)_{ij\alpha}} \int_{x_1}^{\hat{x}_2} I_i(x+t_b)dx \ . \qquad (2.14)$$

Consider the following subcases:

(1) Variable Intake.

For this case the total dose is given by Eq. (2.14), and the integral in the equation may be evaluated numerically.

(2) Constant Intake

Here, $I_i(x+t_b) = I_i$ for $x_1 \leq x \leq \hat{x}_2$, and

$$\hat{D}_{ij\alpha}(x_1, \hat{x}_2, t_b) = \frac{0.3 I_i}{7A_{jn}(MPC)_{ij\alpha}} (\hat{x}_2 - x_1) \ . \qquad (2.15)$$

Age-Dependent Individual

Equation (2.13) gives the total dose for the age-dependent individual. Numerical integration may be used to evaluate the integral in this equation.

2.2 The Computer Code

This section describes the computer code, INREM, which was written in FORTRAN IV for the IBM 360/75. INREM calculates the total cumulative dose at a specified time in various organs of standard man or an individual of a specified age at the time of the first intake via either inhalation or ingestion of radionuclides which continues over a specified time interval. This section considers the computer solutions for the equations derived in Sect. 2.1, the assumptions used by the code, the logical flow of the program, the definition of the program variables, and the input format.

2.2.1 The Computer Solution

The computer code INREM is programmed to solve Eqs. (2.6), (2.7), (2.10), (2.13), (2.14), and (2.15). The program examines the data and chooses the appropriate equation to estimate the total dose accumulated by the organ of interest. In Eqs. (2.6), (2.10), (2.13), and (2.14), the interval of integration is divided into subintervals. The end points of each subinterval are chosen to be either a point where the intake is known or a point which separates the age groups of the individual. For Eqs. (2.6) and (2.10), the integral in each subinterval is evaluated by using Simpson's Integration Method with equal spacing. The number of points used in each subinterval depends on the number of subintervals and the size of the interval of integration. For Eqs. (2.13) and (2.14), the integral over each subinterval is evaluated by using a trapezoidal approximation.

A modified version of Eq. (2.7) was developed and programmed in order to avoid a loss of significance for certain values of x_1, $\hat{x}_2$, and x_2.

INREM calculates the total cumulative dose resulting from inhalation and ingestion of soluble radionuclides. If the organ of interest is the lungs, the code also calculates the total cumulative dose resulting from inhalation of insoluble radionuclides. If the organ of interest is the G.I. tract, the code calculates the total cumulative dose in the critical segment of the G.I. tract from inhalation and ingestion of soluble and insoluble radionuclides.

2.2.2 Assumptions

Calculation of the total cumulative dose to the lungs from inhalation of an insoluble radionuclide is a special case [reference (1)]. Here, the fractional absorption $f_{i\kappa\ell 1}$ is 0.125 for all radionuclides i and all age groups ℓ, and the effective elimination constant $\lambda_{i\kappa\ell}$ is calculated by assuming that the biological half-time in the lungs is 120 days for all radionuclides i and all age groups ℓ (the plutonium radioisotopes, with a biological half-time of one year, are exceptions). The effective absorbed energy $\varepsilon_{i\kappa\ell}$ of the ith insoluble radionuclide in the lungs must be part of the input data. These assumptions are programmed in the code.

The program assumes that a table will be supplied by the user to describe the intake of each radionuclide by an individual in each age group. Each table must include the number of points, the time (days) at each of these points, and the intake (μCi/day) at each point. The times must be in chronological order and are measured relative to the reference detonation. In the code, NPT(I,L) contains the number of points in the table for the Ith radionuclide and for an individual in the Lth age group, TINTAK(I,L,J) contains the time at the Jth point, and AINTAK(I,L,J) contains the intake at the Jth point. The code calculates the intake at any time t by performing a linear interpolation on the data in the table of concern. The code assumes that the intake is zero for any time greater than the last time entry in a table. However, if there is only one entry in a table, then the code assumes that the intake is constant for all time. If a table is not furnished, the program assumes that the intake function is constant (currently, DOSIN = 1.0 μCi/day).

2.2.3 Logical Flow of the Code

The subroutine AINPUT reads the input parameters for the problem, the subroutine AMTIN reads the intake function, the subroutine PRINT lists the input parameters (if LIST $\neq$ 0), and then the work subroutine CALCUL is initialized.

For each case the program follows the sequence listed below. The main program reads the case parameters which include the integration limits and the intake interval. These time parameters are then converted to the age of the individual so that they will be consistent with the limits in the equations derived in Sect. 2.1. Entry AMTIN1 in subroutine AMTIN transforms the independent variable in the intake function from post-detonation time to age of the individual. The subroutine CALAGE determines the age group that the individual must pass through as the age increases from the lower limit of integration to the upper limit.

The subroutine CALC is an entry point in the subroutine CALCUL. In CALC the actual equations to be used for this case are determined. Then, for each radionuclide, the total cumulative dose is determined for each organ for intakes from both inhalation and ingestion. The subroutine OUTPUT writes the array for the cumulative dose equivalents. The columns and the rows are identified by the organ and radionuclide, respectively. The time parameters are written to aid in the identification of the case. The title card is written at the top of the first page. If they are present in the input, the results for the lungs and the G.I. tract are written on a separate page. The results are written for intake via inhalation and then for intake via ingestion. When the data are insufficient to calculate the total dose for a certain radionuclide in a certain organ, the words NO DATA are printed in the output array in place of a numerical answer. Also, if the calculated total dose is less than TEST (currently TEST = 1.0×10^{-6}), then 0.0 is printed in place of the actual answer. When the output is printed, entry AMTIN2 in subroutine AMTIN transforms the independent variable in the intake function from age of the individual to post-detonation time. Then the program returns to read the time parameters for the next case and repeats the steps previously stated.

After solving all of the cases for the current problem, the program returns to the subroutine AINPUT to read the input parameters for the next problem.

2.2.4 Definition of Program Variables

The FORTRAN variables used in INREM are defined in this section. These variables are divided into three groups: the input variables, the more important internal variables, and the output variables. In each case the variables are listed in alphabetical order. The subscript I denotes the Ith radionuclide, the subscript K denotes the Kth organ, and the subscript L denotes the Lth age group.

Input Variables

A(J): An array containing the title of the problem.

AGE(L): Ages (yrs.), y_ℓ, defining the individual's age groups (see Sect. 2.1.1).

AGEDET: Age (yrs.) of the individual at the reference detonation.

AINTAK(I,L,J): Intake (μCi/day), $I_i(t,x)$, of the Ith radionuclide by an individual in the Lth age group at the Jth time entry, TINTAK(I,L,J).

AOW(J,L): Intake of air or water (cm^3/day), $A_{j\ell}$, defined in Sect. 2.1.2.

DECAY(I,K,L): For input, the effective half-time (days). After input, the effective elimination constant $\lambda_{ik\ell}$, defined in Sect. 2.1.1.

ENERGY(I,K,L): Effective absorbed energy (MeV), $\varepsilon_{ik\ell}$, defined in Sect. 2.1.1.

FRACT(I,K,L,J): Fractional absorption (dimensionless), $f_{ik\ell j}$, defined in Sect. 2.1.1 (J = 1 for inhalation; J = 2 for ingestion).

GIENER(I,L,M): Effective absorbed energy (MeV), $\hat{\varepsilon}_{i\ell m}$, defined in Section 2.1.2.

GIFRAC(I,L,J,M): Fractional absorption (dimensionless), $\hat{f}_{i\ell jm}$, defined in Sect. 2.1.2.

GIMASS(K,L): Mass (g), $\hat{m}_{\kappa\ell}$, defined in Sect. 2.1.2.

INFLAG: Flag for the intake function. INFLAG = 0 when the intake function is part of the input. INFLAG = 1 when the intake function is supplied by the code.

IORG: Flag to indicate the presence of the organs, lungs (special case) and G. I. tract (special case). If IORG = 0, neither the lungs nor the G.I. tract are present. If IORG = 1, the lungs are present. If IORG = 2, the G.I. tract is present. If IORG = 3, both the lungs and the G.I. tract are present.

JINSOL(I): Index for the critical segment of the G.I. tract for the <u>ith</u> insoluble radionuclide (JINSOL(I) $\leq$ 4).

JSOL(I): Index for the critical segment of the G.I. tract for the <u>ith</u> soluble radionuclide (JSOL(I) $\leq$ 4).

LIST: Output flag. If LIST $\neq$ 0, a listing of the input data is printed. If LIST = 0, this listing is deleted.

NAGE: Number of organ age groups (NAGE $\leq$ MAXAGE).

NCASES: Number of cases for this problem.

NDETON: Detonation reference number. All time parameters entered as input should be measured relative to the time of this detonation (t = 0 at detonation NDETON).

NONUC(I): An index used to identify the Ith radionuclide.

NORGAN: Number of organs.

$$\text{NORGAN} \leq \begin{cases} \text{MAXORG-2, if IORG = 0,} \\ \text{MAXORG-1, if IORG = 1, or IORG = 2,} \\ \text{MAXORG, if IORG = 3.} \end{cases}$$

NPT(I,L): Number of points in the array AINTAK for the Ith radionuclide and the Lth age group (NPT(I,L) $\leq$ MAXIN).

NRNUC: Number of radionuclides (NRNUC $\leq$ MAXNUC).

ORGAN(K,1), ORGAN(K,2): These two variables contain the name of the Kth organ (REAL*8).

RADNUC(I): The name of the Ith radionuclide (REAL*8).

RHLIFE(I): The radiological half-life (days) of the Ith radionuclide.

T1: Lower limit of integration (yrs.), t_1, defined in Eq. (2.1).

T2: Upper limit of integration (yrs.), t_2, defined in Eq. (2.1).

TINTAK(I,L,J): Time (days) at which the intake function has the value AINTAK(I,L,J).

XIN: Time (yrs.) of initial intake of a radionuclide by an organ.

XMASS(K,L): Mass (g), $m_{k\ell}$, defined in Sect. 2.1.1.

XMPC(I,J,M): Maximum permissible concentration ($\mu Ci/cm^3$), $(MPC)_{ij\alpha}$, defined in Eq. (2.11).

XOUT: Time (yrs.), $\hat{t}_2$, of final intake of a radionuclide.

Internal Variables

AGEGP(L): Ages defining the age groups of the individuals for the current case.

BDECAY: Biological elimination constant (1/days) for each insoluble radionuclide (except the plutonium radioisotopes) in the lungs (currently, BDECAY = 0.8333333E-2).

BDECPU: Biological elimination constant (1/days) for each insoluble plutonium radioisotope in the lungs (currently, BDECPU = 0.2739726E-2).

C(I,K,L): The value of $\varepsilon_{ik\ell}/(m_{k\ell}\lambda_{ik\ell})$.

CGI: Constant used in G.I. tract model (0.3/7 = 0.42857143E-1).

CON(I,K,L,J): The value of $(51\, f_{ik\ell j}\, \varepsilon_{ik\ell})/(m_{k\ell}\, \lambda^2_{ik\ell})$.

DELR: Interval for Simpson's Integration.

FILUNG: Fraction of intake via inhalation of insoluble radionuclides reaching the lungs (currently, FILUNG = 0.125).

FUDGEF(I,L,J,M): The value of $(\hat{m}_{kn}\hat{\varepsilon}_{i\ell m}\hat{f}_{i\ell jm}A_{j\ell})/(\hat{m}_{k\ell}\hat{\varepsilon}_{inm}\hat{f}_{injm}A_{jn})$.

IC: A flag to indicate the combination of organs present in the problem.

IDATA(I,K,J): A flag to indicate whether or not there is sufficient data available to calculate the total cumulative dose for the I<u>th</u> radionuclide, K<u>th</u> organ and J<u>th</u> type of intake. (IDATA = 0 means insufficient data, IDATA = 1 means sufficient data.)

IL: Maximum number of lines to be printed on each page of output (currently, IL = 55).

ILUNG: Index for lungs.

IORGAN: Number of organs that apply to the standard organ model.

ITRACT: Index for G.I. tract.

JORGAN: Number of organs for which the dose is to be printed according to the standard output format.

KORGAN: Number of organs not including the G.I. tract.

LOAGE: Minimum age group for the current case.

MAXAGE: Maximum number of age groups (MAXAGE = 25).

MAXIN: Maximum number of points for the intake tables (MAXIN = 100).

MAXNUC: Maximum number of radionuclides (MAXNUC = 10).

MAXORG: Maximum number of organs (MAXORG = 11).

MOAGE: Maximum age group for the current case.

NA(IM): Age group of an individual whose age is in the IMth subinterval of integration. If NA(IM) < 0, the intake is zero for the IMth subinterval.

R(IM): Lower end point (days) of the IMth subinterval of integration.

T(J): T(1) = AMAX1(T1,XIN), T(2) = AMIN1(T2,XOUT), T(3) = T2.

TBORN: -365*AGEDET.

Output Variables

DELX: XOUT-XIN.

DOSE(I,K,J): Cumulative dose equivalent (rem), D_{ik}, defined by Eq. (2.1). (J = 1 for inhalation, J = 2 for ingestion.)

GIDOSE(I,J,M): Cumulative dose equivalent (rem), D_{ijm}, defined by Eq. (2.11).

PERIOD: T2 - T1.

TOTAL(K): $\sum_{i=1}^{n} D_{ik}$ or $\sum_{i=1}^{n} D_{ijm}$ where n = NRNUC.

The output variables A(J), AGEDET, NDETON, NONUC(1), ORGAN(K,J), RADNUC(I), T1, T2, XIN and XOUT were previously defined in this section.

2.2.5 Description of Input

A description of the card input for INREM is presented in this section. The entire deck for a problem is divided into seven groups which are listed below. Except for the TITLE card, columns 71 through 80 are reserved for identification to aid the user in the preparation and handling of the data. Examples of suggested identification for each card are also presented in this section.

Input Categories

1. Group 1
   a. TITLE card
   b. LIMIT card
   c. AGEGP card(s)
2. Group 2

   NUCLID card(s)
3. Group 3

   ORGAN card(s)
4. Group 4
   a. TAU card(s)
   b. ENG card(s)
   c. HAL card(s)
   d. GES card(s)
5. Group 5
   a. INTAKA card(s)
   b. INTAKW card(s)

5. Continued
   c. GIMASS card(s)
   d. SEG card(s)
   e. E/F card(s)
   f. MPC card(s)
6. Group 6
   a. NPOINT card(s)
   b. TIM card(s)
   c. IN card(s)
7. Group 7

   CASE card(s)

Description of Each Group

Each card is described by listing the order in which the variables are to be entered, by giving the FORTRAN format used to read the card, and by suggesting identification to be used. The input variables were defined in Sect. 2.2.4.

1. Group 1
   a. TITLE card

      Variables Read: A(J) for J = 1,2,...,20.

      Format: (20A4),

      This card contains the title for the problem which can be from 1 to 80 alphanumeric characters and which should be centered on the card.

b. LIMIT card

Variables Read: NRNUC, NAGE, NORGAN, IORG, INFLAG, NCASES, LIST.

Format: (14I5).

Identification: Enter the word LIMIT in columns 76-80.

c. AGEGP card

Variables Read: AGE(L) for L = 1,2,...,NAGE+1

Format: (7E10.0).

Identification: Enter the word AGEGP in columns 76-80.

There can be 7 AGE entries per card. The code continues to read AGEGP cards until all NAGE+1 age variables have been read.

2. Group 2

$NUCLID_i$ cards for i = 1,2,...,NRNUC.

Variables Read: NONUC(I), RADNUC(I),RHLIFE(I) for I = i.

Format: (I3,2X,A8,2X,E10.0).

Identification: Enter the word NUCLID in columns 75-80.

Note: The radionuclide names should be left-adjusted in columns 6-13. In order for a plutonium radioisotope to be treated as described in Sect. 2.2.2, its index, NONUC(I), must be greater than 279 and less than 284.

3. Group 3

$ORGAN_k$ cards for k = 1,2,...,KORGAN.

Variables Read: ORGAN(K,1), ORGAN(K,2), XMASS(K,L) for L = 1,2,...,NAGE and for K = k.

Format: (2A5,6E10.0) if NAGE $\leq$ 6.

(2A5,6E10.0/(7E10.0)) if NAGE > 6.

Identification: Enter the word ORGAN in columns 76-80.

If NAGE > 6, then an additional card or cards will be needed in order to read the organ mass for each age group. The additional cards will have a format of (7E10.0) which can hold 7 XMASS entries per card. Thus, the second $ORGAN_k$ card will contain XMASS(K,7) in columns 1-10, XMASS(K,8) in columns 11-20, etc.

Note: The organ name should be left-adjusted in columns 1-10. If the lungs are present in the input, their ORGAN card must always be the last card in Group 2. An ORGAN card is not entered for the G. I. tract. Group 3 is omitted if the only organ in the input is the G.I. tract.

4. Group 4

This group consists of decks of TAU cards, ENG cards, HAL cards, and GES cards containing information for one radionuclide. The entire group is repeated for each radionuclide i, where i = 1,2,...,NRNUC, and must appear in the same sequence as the radionuclides appeared in Group 2. Data concerning the G.I. tract are not entered in this group. On each card, the data for the organs must appear in the same sequence as the organs appeared in Group 3.

a. TAU_ℓ cards for $\ell = 1,2,...,NAGE$.

Variables Read: DECAY(I,K,L) for K = 1,2,...,KORGAN and for I = i and L = ℓ.

Format: (10E7.0)

Identification: Enter the value of L in columns 71-72, the value of NONUC(I) in columns 74-76 and the word TAU in columns 78-80.

b. ENG_ℓ cards for $\ell = 1,2,...,NAGE$.

Variables Read: ENERGY(I,K,L) for K = 1,2,...,IORGAN and for I = i and L = ℓ.

Format: (10E7.0)

Identification: Enter the value of L in columns 71-72, the value of NONUC(I) in columns 74-76 and the word ENG in columns 78-80.

Note: If the lungs are part of the input, the effective absorbed energy of the insoluble radionuclide in the lungs must be entered after the effective absorbed energy of the soluble radionuclide in the lungs.

c. HAL_ℓ cards for $\ell = 1,2,...,NAGE$.

Variables Read: FRACT(I,K,L,1) for K = 1,2,...,KORGAN and for I = i and L = ℓ.

Format: (10E7.0)

Identification: Enter the value of L in columns 71-72, the value of NONUC(I) in columns 74-76 and the word HAL in columns 78-80.

d. GES_ℓ cards for $\ell = 1,2,\ldots,NAGE$.

Variables Read: FRACT(I,K,L,2) for K = 1,2,...,KORGAN and for I = i and L = ℓ.

Format: (10E7.0).

Identification: Enter the value of L in columns 71-72, the value of NONUC(I) in columns 74-76 and the word GES in columns 78-80.

Note: Group 4 is omitted if the only organ in the input is the G.I. tract.

5. Group 5

a. INTAKA card.

Variables Read: AOW(1,L) for L = 1,2,...,NAGE.

Format: (7E10.0).

Identification: Enter the word INTAKA in columns 75-80.

There can be 7 AOW entries per card. The code continues to read INTAKA cards until all NAGE air intake variables have been read.

b. INTAKW card.

Variables Read: AOW(2,L) for L = 1,2,...,NAGE.

Format: (7E10.0).

Identification: Enter the word INTAKW in columns 75-80.

There can be 7 AOW entries per card. The code continues to read INTAKW cards until all NAGE water intake variables have been read.

c. $GIMASS_k$ cards for k = 1,2,3,4.

Variables Read: GIMASS(K,L) for L = 1,2,...,NAGE and for K = k.

Format: (7E10.0).

Identification: Enter the value for K in columns 71-72 and the word GIMASS in columns 75-80.

There can be 7 entries per card. For each segment of the G.I. tract, the code continues to read GIMASS cards until all NAGE mass variables have been read.

Note: The GIMASS cards are omitted when NAGE = 1.

d. SEG_i cards for i = 1,2,...,NRNUC.

Variables Read: JSOL(I) and JINSOL(I) for I = i.

Format: (14I5).

Identification: Enter the value for NONUC(I) in columns 74-76 and the word SEG in columns 78-80.

The cards must appear in the same sequence as the radionuclides appeared in Group 2.

Note: The SEG cards are omitted when NAGE = 1.

e. $E/F_{i\ell}$ cards for i = 1,2,...,NRNUC and ℓ = 1,2,...,NAGE.

Variables Read: GIENER(I,L,1), GIFRAC(I,L,1,1), GIFRAC(I,L,2,1), GIENER(I,L,2), GIFRAC(I,L,1,2), GIFRAC(I,L,2,2).

Format: (7E10.0).

Identification: Enter the value of L in columns 71-72, the value of NONUC(I) in columns 74-76 and the word E/F in columns 78-80.

For each radionuclide i, where i = 1,2,...,NRNUC, the code reads NAGE of the E/F cards. The data for the radionuclides must appear in the same sequence as the radionuclides appeared in Group 2.

Note: The E/F cards are omitted when NAGE = 1.

f. MPC_i cards for i = 1,2,...,NRNUC.

Variables Read: XMPC(I,1,1), XMPC(I,2,1), XMPC(I,1,2), XMPC(I,2,2) for I = i.

Format: (7E10.0).

Identification: Enter the value of NONUC(I) in columns 74-76 and the word MPC in columns 78-80.

The data for the radionuclides must appear in the same sequence as the radionuclides appeared in Group 2.

Note: Group 5 must be omitted when IORG $\leq$ 1.

6. Group 6

a. $NPOINT_i$ cards for i = 1,2,...,NRNUC.

Variables Read: NPT(I,L) for L = 1,2,...,NAGE and for I = i.

Format: (14I5).

Identification: Enter the value of NONUC(I) in columns 71-73 and the word NPOINT in columns 75-80.

There can be 14 NPT entries per card. For each radionuclide i, the code continues to read NPOINT cards until all NAGE numbers have been read. The data for the radionuclides must appear in the same sequence as the radionuclides appeared in Group 2.

b. $TIM_{i\ell}$ cards for i = 1,2,...,NRNUC and for ℓ = 1,2,..., NAGE.

Variables Read: TINTAK(I,L,J) for J = 1,2,...,NPT(I,L) and for I = i and L = ℓ.

Format: (7E10.0).

Identification: Enter the value of L in columns 71-72, the value of NONUC(I) in columns 74-76, and the word TIM in columns 78-80.

For each radionuclide i, where i = 1,2,...,NRNUC, the code reads the TIM cards for each age group ℓ, where ℓ = 1,2,...,NAGE. For a particular i and a particular ℓ, the code continues to read TIM cards until all NPT(I,L) time values have been read. The data for the radionuclides must appear in the same sequence as the radionuclides appeared in Group 2.

c. $IN_{i\ell}$ cards for i = 1,2,...,NRNUC and for ℓ = 1,2,...,NAGE.

Variables Read: AINTAK(I,L,J) for J = 1,2,...,NPT(I,L) and for I = i and L = ℓ.

Format: (7E10.0).

Identification: Enter the value of L in columns 71-72, the value of NONUC(I) in columns 74-76 and the word IN in columns 79-80.

For each radionuclide i, where i = 1,2,...,NRNUC, the code reads the IN cards for each age group ℓ, where ℓ = 1,2,...,NAGE. For a particular i and a particular ℓ, the code continues to read IN cards until all NPT(I,L) intake values have been read. The data for the radionuclides must appear in the same sequence as the radionuclides appeared in Group 2.

Note: Group 6 is omitted when INFLAG = 1, and the code assumes that AINTAK is constant and equal to DOSIN for each radionuclide and each age group (currently, DOSIN = 1.0 μCi/day).

7. Group 7

$CASE_j$ cards for j = 1,2,...,NCASES.

Variables Read: NDETON, AGEDET, T1, T2, XIN, XOUT.

Format: (I5,6E10.0).

Identification: Enter the word CASE in columns 77-80.

3. EXTERNAL EXPOSURE

3.1 Development of the Problem

As in the case of internal exposure, the models used to calculate the dose rates and the total doses to individuals as a result of external exposure were derived from the models presented in reference 1. It is assumed that an individual can be exposed from external sources by three modes of exposure: submersion in contaminated water, submersion in contaminated air, and exposure to a contaminated land surface. The equations used to estimate the dose rate and the total dose from both beta radiation and gamma radiation for each of these three modes of exposure are presented in this section.

3.1.1 Submersion in Contaminated Water

Dose Rate from Beta Radiation

The dose-equivalent rate (rem/hr) from beta radiation at the ℓth location resulting from submersion at time t in water contaminated with the ith radionuclide is denoted by $DR_{w\beta i\ell}(t)$ and is given by

$$DR_{w\beta i\ell}(t) = \sum_{k=1}^{K'} \left[Y_{ik}\, e^{-\lambda_{ri}(t-\tau_k)}\, gw_{i\ell k} \left(\frac{25.6}{24.0} \sum_{n=1}^{N_{\beta i}} f_{\beta in}\, \bar{E}_{\beta in} \right) \right], \quad (3.1)$$

where

t = time (hrs.) of submersion in water relative to time of reference detonation,

i = radionuclide index,

ℓ = location index,

k = detonation index,

K' = maximum k such that $\tau_k \le t$,

Y_{ik} = yield (μCi) of the ith radionuclide vented in the kth detonation,

λ_{ri} = radiological decay constant (1/hrs) of the ith radionuclide,

τ_k = time (hrs) of the kth detonation relative to time of reference detonation ($\tau_k < \tau_{k+1}$ for all k),

$gw_{i\ell k}$ = location correction factor (cm^{-3}) for submersion in water contaminated by the ith radionuclide and the kth detonation at the ℓth location,

n = beta particle index,

$N_{\beta i}$ = number of beta particles emitted by the ith radionuclide,

$f_{\beta in}$ = abundance (dimensionless) of the nth beta particle emitted by the ith radionuclide, and

$\bar{E}_{\beta in}$ = average energy (MeV) of the nth beta particle emitted by the ith radionuclide.

Let

$$Gw_{i\ell k} = Y_{ik} gw_{i\ell k}. \tag{3.2}$$

Then Eq. (3.1) can be rewritten as

$$DR_{w\beta i\ell}(t) = \frac{25.6}{24.0} \left(\sum_{n=1}^{N_{\beta i}} f_{\beta in} \bar{E}_{\beta in} \right) \sum_{k=1}^{K'} \left[Gw_{i\ell k} \, e^{-\lambda_{ri}(t-\tau_k)} \right] . \tag{3.3}$$

Total Dose from Beta Radiation

The total dose equivalent (rem) from beta radiation accumulated from t_1 to t_2 at the ℓth location resulting from submersion during the above interval in water contaminated with the $i\underline{th}$ radionuclide is denoted by $TD_{w\beta i\ell}(t_1,t_2)$ and is given by

$$TD_{w\beta i\ell}(t_1,t_2) = \int_{t_1}^{t_2} DR_{w\beta i\ell}(t)dt , \qquad (3.4)$$

where

t_1 = time (hrs.) of submersion relative to time of reference detonation, and

t_2 = time (hrs.) of emergence relative to time of reference detonation.

Let KO = maximum k such that $\tau_k \leq t_1$ and K1 = maximum k such that $\tau_k < t_2$. Then by substituting Eq. (3.3) into Eq. (3.4), one obtains

$$TD_{w\beta i\ell}(t_1,t_2) = \frac{25.6}{24.0}\left[\sum_{n=1}^{N_{\beta i}} f_{\beta in}\,\overline{E}_{\beta in}\right]\left\{\int_{t_1}^{\tau_{KO+1}} \sum_{k=1}^{KO} Gw_{i\ell k}\, e^{-\lambda_{ri}(t-\tau_k)}dt \right. \qquad (3.5)$$

$$\left. + \sum_{m=KO+1}^{K1-1} \int_{\tau_m}^{\tau_{m+1}} \sum_{k=1}^{m} Gw_{i\ell k}\, e^{-\lambda_{ri}(t-\tau_k)}dt + \int_{\tau_{K1}}^{t_2} \sum_{k=1}^{K1} Gw_{i\ell k}\, e^{-\lambda_{ri}(t-\tau_k)}dt \right\} .$$

Let

$$\hat{\tau}_{KO} = t_1 ,$$

$$\hat{\tau}_k = \tau_k \text{ for } k = KO+1, KO+2, \ldots, K1, \text{ and} \qquad (3.6)$$

$$\hat{\tau}_{K1+1} = t_2 .$$

From Eqs. (3.5) and (3.6) the total dose is

$$TD_{w\beta i\ell}(t_1,t_2) = \frac{25.6}{24.0}\left\{\sum_{n=1}^{N_{\beta i}} f_{\beta in}\,\overline{E}_{\beta in}\right\} \sum_{m=KO}^{K1}\left[\int_{\hat{\tau}_m}^{\hat{\tau}_{m+1}} \sum_{k=1}^{m} Gw_{i\ell k}\, e^{-\lambda_{ri}(t-\tau_k)}\,dt\right] , \qquad (3.7)$$

or by performing the indicated integration, one obtains

$$TD_{w\beta i\ell}(t_1,t_2) = \frac{25.6}{24.0}\left\{\sum_{n=1}^{N_{\beta i}} f_{\beta in}\,\overline{E}_{\beta in}\right\} \sum_{m=KO}^{K1}\left\{\left[\frac{1-e^{-\lambda_{ri}(\hat{\tau}_{m+1}-\hat{\tau}_m)}}{\lambda_{ri}}\right] \sum_{k=1}^{m} Gw_{i\ell k}\, e^{-\lambda_{ri}(\hat{\tau}_m-\tau_k)}\right\} . \qquad (3.8)$$

Dose Rate from Gamma Radiation

The dose-equivalent rate (rem/hr) from gamma radiation at the ℓth location resulting from submersion at time t in water contaminated with the ith radionuclide is given by Eq. (3.1) where $DR_{w\beta i\ell}(t)$, $N_{\beta i}$, $f_{\beta in}$, $\overline{E}_{\beta in}$, and the constant 25.6 are replaced by $DR_{w\gamma i\ell}(t)$, $N_{\gamma i}$, $f_{\gamma in}$, $E_{\gamma in}$, and the constant 51.2, respectively. By using Eq. (3.2), the dose rate equation for gamma radiation can be rewritten as

$$DR_{w\gamma i\ell}(t) = \frac{51.2}{24.0}\left\{\sum_{n=1}^{N_{\gamma i}} f_{\gamma in}\,E_{\gamma in}\right\} \sum_{k=1}^{K'}\left[Gw_{i\ell k}\, e^{-\lambda_{ri}(t-\tau_k)}\right] , \qquad (3.9)$$

where

$N_{\gamma i}$ = number of gamma photons emitted by the ith radionuclide,

$f_{\gamma in}$ = abundance (dimensionless) of the nth gamma photon emitted by the ith radionuclide, and

$E_{\gamma in}$ = energy (MeV) of the nth gamma photon emitted by the ith radionuclide.

The remaining variables in Eq. (3.9) were previously defined.

Total Dose from Gamma Radiation

The total dose equivalent (rem) from gamma radiation accumulated from t_1 to t_2 at the ℓth location resulting from submersion during the above interval in water contaminated with the ith radionuclide is denoted by

$$TD_{w\gamma i\ell}(t_1,t_2) = \int_{t_1}^{t_2} DR_{w\gamma i\ell}(t)dt \ . \qquad (3.10)$$

By using the method outlined above, the following analytic expression is obtained for Eq. (3.10):

$$TD_{w\gamma i\ell}(t_1,t_2) = \frac{51.2}{24.0}\left(\sum_{n=1}^{N_{\gamma i}} f_{\gamma in}\ E_{\gamma in}\right)$$

$$\sum_{m=KO}^{K1}\left\{\left[\frac{1-e^{-\lambda_{ri}(\hat{\tau}_{m+1}-\hat{\tau}_m)}}{\lambda_{ri}}\right]\sum_{k=1}^{m} Gw_{i\ell k}\ e^{-\lambda_{ri}(\hat{\tau}_m-\tau_k)}\right\} \ . \qquad (3.11)$$

3.1.2 Submersion in Contaminated Air

The models for the dose rates resulting from submersion in contaminated air are similar to the dose-rate models which were developed in Sect. 3.1.1. However, the models for the total doses resulting from submersion in contaminated air are somewhat different from the total-dose models which were developed in Sect. 3.1.1. In estimating the total dose resulting from submersion in air from t_1 to t_2, it is assumed that the air is contaminated only during the time, T_m, in which the radioactive cloud from the mth detonation is passing over the ℓth location. Thus, the dose rate is integrated only over the time required for the cloud from each detonation occurring between t_1 and t_2 to pass the ℓth location.

Dose Rate from Beta Radiation

The dose-equivalent rate (rem/hr) from beta radiation at the ℓth location resulting from submersion at time t in air contaminated with the ith radionuclide is given by Eq. (3.1) where $DR_{w\beta i\ell}(t)$ is replaced by $DR_{a\beta i\ell}(t)$, $gw_{i\ell k}$ is replaced by $ga_{i\ell k}$, and the constant 25.6 is replaced by the constant 29.2. By using a substitution similar to Eq. (3.2), the dose-rate equation for beta radiation can be rewritten as

$$DR_{a\beta i\ell}(t) = \frac{29.2}{24.0}\left(\sum_{n=1}^{N_{\beta i}} f_{\beta in}\,\overline{E}_{\beta in}\right)\sum_{k=1}^{K'}\left[Ga_{i\ell k}\, e^{-\lambda_{ri}(t-\tau_k)}\right] \tag{3.12}$$

where $ga_{i\ell k}$ = location correction factor (cm^{-3}) for submersion in air contaminated by the ith radionuclide and the kth detonation at the ℓth location.

Total Dose from Beta Radiation

The total dose equivalent (rem) from beta radiation accumulated from t_1 to t_2 at the ℓth location resulting from submersion during the above interval in air contaminated with the ith radionuclide is given by

$$TD_{a\beta i\ell}(t_1,t_2) = A + \sum_{m=KO+1}^{K1-1} \left[\int_{\tau_m}^{\tau_m+T_m} DR_{a\beta i\ell}(t)dt \right] + \int_{\tau_{K1}}^{\alpha} DR_{a\beta i\ell}(t)dt \quad ,(3.13)$$

where

T_m = time (hrs.) required for the cloud from the mth detonation to pass the ℓth location,

$$\alpha = \begin{cases} \tau_{K1} + T_{K1} & \text{if} \quad \tau_{K1} + T_{K1} < t_2 , \\ t_2 & \text{if} \quad \tau_{K1} + T_{K1} \geq t_2 , \text{ and} \end{cases}$$

$$A = \begin{cases} 0 \quad \text{if} \quad \tau_{KO} + T_{KO} \leq t_1 , \\ \int_{t_1}^{\tau_{KO}+T_{KO}} DR_{a\beta i\ell}(t)dt \quad \text{if } \tau_{KO} + T_{KO} > t_1 . \end{cases}$$

By using the procedure outlined in Sect. 3.1.1, Eq. (3.13) can be rewritten as

$$TD_{a\beta i\ell}(t_1,t_2) = \frac{29.2}{24.0}\left(\sum_{n=1}^{N_{\beta i}} f_{\beta in}\,\overline{E}_{\beta in}\right)\left\{\hat{A} + \sum_{m=KO+1}^{K1-1}\left(\left[\frac{1-e^{-\lambda_{ri}T_m}}{\lambda_{ri}}\right]\sum_{k=1}^{m}\left[Ga_{i\ell k}\,e^{-\lambda_{ri}(\tau_m-\tau_k)}\right]\right) + \left[\frac{1-e^{-\lambda_{ri}(\alpha-\tau_{K1})}}{\lambda_{ri}}\right]\sum_{k=1}^{K1}\left[Ga_{i\ell k}\,e^{-\lambda_{ri}(\tau_{K1}-\tau_k)}\right]\right\}, \quad (3.14)$$

where

$$\hat{A} = \begin{cases} 0 & \text{if } \tau_{KO} + T_{KO} \leq t_1, \\ \left[\dfrac{1 - e^{-\lambda_{ri}(\tau_{KO}+T_{KO}-t_1)}}{\lambda_{ri}}\right]\displaystyle\sum_{k=1}^{KO}\left[Ga_{i\ell k}\,e^{-\lambda_{ri}(t_1-\tau_k)}\right] & \text{if } \tau_{KO} + T_{KO} > t_1. \end{cases} \quad (3.15)$$

Dose Rate from Gamma Radiation

The dose-equivalent rate (rem/hr) from gamma radiation at the ℓth location resulting from submersion at time t in air contaminated with the ith radionuclide is given by Eq. (3.1) where $DR_{w\beta i\ell}(t)$, $N_{\beta i}$, $f_{\beta in}$, $\overline{E}_{\beta in}$, $gw_{i\ell k}$, and the constant 25.6 are replaced by $DR_{a\gamma i\ell}(t)$, $N_{\gamma i}$, $f_{\gamma in}$, $E_{\gamma in}$, $ga_{i\ell k}$, and the constant 29.2, respectively. By using a substitution similar to Eq. (3.2), the dose-rate equation for gamma radiation can be rewritten as

$$DR_{a\gamma i\ell}(t) = \frac{29.2}{24.0}\left[\sum_{n=1}^{N_{\gamma i}} f_{\gamma in}\,E_{\gamma in}\right]\sum_{k=1}^{K'}\left[Ga_{i\ell k}\,e^{-\lambda_{ri}(t-\tau_k)}\right] . \quad (3.16)$$

Total Dose from Gamma Radiation

The total dose equivalent (rem) from gamma radiation accumulated from t_1 to t_2 are the ℓth location resulting from submersion during the above interval in air contaminated with the ith radionuclide is given by

$$TD_{a\gamma i\ell}(t_1,t_2) = B + \sum_{m=KO+1}^{K1-1} \left[\int_{\tau_m}^{\tau_m+T_m} DR_{a\gamma i\ell}(t)dt \right] + \int_{\tau_{K1}}^{\alpha} DR_{a\gamma i\ell}(t)dt \ , \quad (3.17)$$

where

$$B = \begin{cases} 0 \quad \text{if} \quad \tau_{KO} + T_{KO} \leq t_1 \ , \\ \int_{t_1}^{\tau_{KO}+T_{KO}} DR_{a\gamma i\ell}(t)dt \quad \text{if} \quad \tau_{KO} + T_{KO} > t_1 \ . \end{cases} \quad (3.18)$$

The following analytic expression is obtained for Eq. (3.17):

$$TD_{a\gamma i\ell}(t_1,t_2) = \frac{29.2}{24.0} \left(\sum_{n=1}^{N_{\gamma i}} f_{\gamma in} \ E_{\gamma in} \right) \left\{ \hat{A} + \sum_{m=KO+1}^{K1-1} \left(\left[\frac{1 - e^{-\lambda_{ri} T_m}}{\lambda_{ri}} \right] \sum_{k=1}^{m} \left[Ga_{i\ell k} \ e^{-\lambda_{ri}(\tau_m - \tau_k)} \right] \right) + \left[\frac{1 - e^{-\lambda_{ri}(\alpha - \tau_{K1})}}{\tau_{ri}} \right] \sum_{k=1}^{K1} \left[Ga_{i\ell k} \ e^{-\lambda_{ri}(\tau_{K1} - \tau_k)} \right] \right\} , \quad (3.19)$$

where $\hat{A}$ was defined by Eq. (3.15).

3.1.3 Exposure to a Contaminated Surface

Dose Rate from Beta Radiation

The dose-equivalent rate (rem/hr) from beta radiation at the ℓth location resulting from exposure at time t at a distance x cm above a surface contaminated with the ith radionuclide is given by

$$DR_{s\beta i\ell}(t,x) = \sum_{k=1}^{K'} \Bigg\{ Y_{ik}\, e^{-\lambda_{ri}(t-\tau_k)}\, gs_{i\ell k}$$

$$1.07 \sum_{n=1}^{N_{\beta i}} \nu\alpha \left(F[C,\nu,a(x)] + e^{[1-\nu a(x)]} \right) f_{\beta in}\, \overline{E}_{\beta in} \Bigg\}, \quad (3.20)$$

where

x = the distance (cm) from the exposed individual to the contaminated surface,

$$C = \begin{cases} 3.0, & E_{\beta in} < 0.17, \\ 2.0, & 0.17 \le E_{\beta in} < 0.5, \\ 1.5, & 0.5 \le E_{\beta in} < 1.5, \\ 1.0, & 1.5 \le E_{\beta in}, \end{cases}$$

$E_{\beta in}$ = maximum energy (MeV) of the nth beta particle emitted by the ith radionuclide,

$gs_{i\ell k}$ = location correction factor (cm^{-2}) for exposure to a surface contaminated by the ith radionuclide and the kth detonation at the ℓth location,

$$\alpha = \begin{cases} 0.190, & E_{\beta in} < 0.17, \\ 0.260, & 0.17 \le E_{\beta in} < 0.5, \\ 0.297, & 0.5 \le E_{\beta in} < 1.5, \\ 0.333, & 1.5 \le E_{\beta in}, \end{cases}$$

$$\nu = \begin{cases} \dfrac{(18.6)}{(E_{\beta in} - 0.036)^{1.37}} & \text{if the radionuclide is not SR-90,} \\ \dfrac{(0.83)(18.6)}{(E_{\beta in} - 0.036)^{1.37}} & \text{if the radionuclide is SR-90,} \end{cases}$$

$$F(C,\nu,a(x)) = \begin{cases} C\{1 + \ln[\frac{C}{\nu a(x)}] - e^{[1-(\frac{\nu a(x)}{C})]}\} & \text{if } \nu a(x) < C, \\ 0 \quad \text{if} \quad \nu a(x) \ge C, \text{ and} \end{cases}$$

$a(x)$ = distance from the contaminated surface multiplied by the density of air (g/cm^2).

$\overline{E}_{\beta in} = 0$ if $E_{\beta in} \le 0.036$ MeV.

By using the substitution

$$Gs_{i\ell k} = Y_{i\ell} gs_{i\ell k} ,$$

one can rewrite Eq. (3.20) as

$$DR_{s\beta i\ell}(t,x) = 1.07 \left\{ \sum_{n=1}^{N_{\beta i}} \nu\alpha \left\{ F[C,\nu,a(x)] + e^{[1-\nu a(x)]} \right\} f_{\beta in} \overline{E}_{\beta in} \right\}$$

$$\sum_{k=1}^{K'} \left[Gs_{i\ell k} \; e^{-\lambda_{ri}(t-\tau_k)} \right] . \tag{3.21}$$

Total Dose from Beta Radiation

The total dose equivalent (rem) from beta radiation accumulated from t_1 to t_2 at the ℓth location resulting from exposure during the above interval at a distance x cm above a surface contaminated with the ith radionuclide is given by

$$TD_{s\beta i\ell}(t_1,t_2,x) = \int_{t_1}^{t_2} DR_{s\beta i\ell}(t,x)dt \ . \tag{3.22}$$

By using the procedure outlined in Sect. 3.1.1, Eq. (3.22) can be rewritten as

$$TD_{s\beta i\ell}(t_1,t_2,x) = 1.07 \left[\sum_{n=1}^{N_{\beta i}} \nu\alpha\left\{F[C,\nu,a(x)] + e^{[1-\nu a(x)]}\right\} f_{\beta in}\ \overline{E}_{\beta in}\right]$$

$$\sum_{m=KO}^{K1}\left\{\left[\frac{1 - e^{-\lambda_{ri}(\hat{\tau}_{m+1}-\hat{\tau}_m)}}{\lambda_{ri}}\right]\sum_{k=1}^{m}\left[Gs_{i\ell k}\ e^{-\lambda_{ri}(\hat{\tau}_m-\tau_k)}\right]\right\} \ . \tag{3.23}$$

Dose Rate from Gamma Radiation

The dose-equivalent rate (rem/hr) from gamma radiation at the ℓth location resulting from exposure at time t at a distance x cm above a surface contaminated with the ith radionuclide is given by

$$DR_{s\gamma i\ell}(t,x) = \sum_{k=1}^{K'}\left\{Y_{ik}\ e^{-\lambda_{ri}(t-\tau_k)}\ gs_{i\ell k}\right.$$

$$\left. 827\ Bs \sum_{n=1}^{N_{\gamma i}}\left[\sigma_{in}E_1(\sigma_{in}\cdot x)\ f_{\gamma in}\ E_{\gamma in}\right]\right\} \ , \tag{3.24}$$

where

Bs = backscatter correction (dimensionless) for a body immersed in air,

σ_{in} = linear energy absorption coefficient (cm^{-1}) [$\sigma = \sigma(E_{\gamma in})$], and

$E_1(\sigma \cdot x)$ = E-function of the first order.

By using the substitution

$$Gs_{i\ell k} = Y_{ik}\, gs_{i\ell k} \ ,$$

the dose-rate equation can be rewritten as

$$DR_{s\gamma i\ell}(t,x) = 827\ Bs \left\{ \sum_{n=1}^{N_{\gamma i}} \left[\sigma_{in} E_1(\sigma_{in} \cdot x)\ f_{\gamma in}\ E_{\gamma in} \right] \right\} \sum_{k=1}^{K'} \left[Gs_{i\ell k}\ e^{-\lambda_{ri}(t-\tau_k)} \right] . \qquad (3.25)$$

Total Dose from Gamma Radiation

The total dose equivalent (rem) from gamma radiation accumulated from t_1 to t_2 at the ℓth location resulting from exposure during the above interval at a distance x cm above a surface contaminated with the ith radionuclide is given by

$$TD_{s\gamma i\ell}(t_1,t_2,x) = \int_{t_1}^{t_2} DR_{s\gamma i\ell}(t,x)dt \ . \qquad (3.26)$$

By using the method outlined in Sect. 3.1.1, the following analytical expression can be obtained for Eq. (3.26):

$$TD_{s\gamma i\ell}(t_1,t_2,x) = 827\ Bs \left\{ \sum_{n=1}^{N_{\gamma i}} \left[\sigma_{in} E_1(\sigma_{in}\cdot x)\ f_{\gamma in}\ E_{\gamma in} \right] \right\}$$

$$\sum_{m=KO}^{K1} \left\{ \left[\frac{1 - e^{-\lambda_{ri}(\hat{\tau}_{m+1}-\hat{\tau}_m)}}{\lambda_{ri}} \right] \sum_{k=1}^{m} \left[Gs_{i\ell k}\ e^{-\lambda_{ri}(\hat{\tau}_m-\tau_k)} \right] \right\} . \quad (3.27)$$

3.2 Computer Code

This section describes the computer code, EXREM, written in FORTRAN IV for the IBM 360/75. The code calculates the dose rates at a specified time and the total doses accumulated during a specified time interval resulting from submersion in contaminated water, submersion in contaminated air, and exposure to a contaminated surface. For each of the modes of exposure, the code performs the calculations for contamination from both beta and gamma radiation. This section considers the computer solutions for the equations derived in Sect. 3.1, the special calculations and assumptions used by the code, the logical flow of the program, the definition of the program variables, and the input format.

3.2.1 The Computer Solution

The computer code EXREM is programmed to solve Eqs. (3.3), (3.8), (3.9), (3.11), (3.12), (3.14), (3.16), (3.19), (3.21), (3.23), (3.25), and (3.27).

A term of the form

$$f(x) = \frac{1 - e^{-\lambda x}}{\lambda}$$

appears in Eqs. (3.8), (3.11), (3.14), (3.19), (3.23), and (3.27). If $0<\lambda x<<1$, then a loss of significance can occur when the expression is evaluated on a digital computer. However, if the expression is rewritten as

$$f(x) = x \cdot \frac{1 - e^{-\lambda x}}{\lambda x} = x\, g(x),$$

then

$$g(x) = \frac{1 - e^{-\lambda x}}{\lambda x}$$

can be expanded in a power series to obtain

$$g(x) = 1 - \frac{x}{2!} + \frac{x^2}{3!} - \frac{x^3}{4!} + \ldots \quad .$$

By choosing a sufficient number of terms, g(x), and hence f(x), can be evaluated accurately. The code uses this procedure to evaluate expressions containing terms of the form f(x).

3.2.2 Special Calculations and Assumptions

The maximum energy of the nth beta particle emitted by the ith radionuclide, $E_{\beta in}$, and the atomic number of the ith radionuclide, Z_i, are part of the input for EXREM. The code uses these data to calculate the average beta energy, $\overline{E}_{\beta in}$, by the following approximation:

$$\overline{E}_{\beta in} = 1/3\ E_{\beta in}\left(1 - \frac{\sqrt{Z_i}}{50}\right)\left(1 + \frac{\sqrt{E_{\beta in}}}{4}\right). \qquad (3.28)$$

A table containing values for the linear energy absorption coefficient, σ, as a function of energy is stored in the subroutine CALCUL. The table consists of two arrays: the energies, which are the independent variables, are contained in the array, E; the array, SIGMA, contains the linear energy absorption coefficients and is in one-to-one correspondence with the energy array. There are 22 entries in each array, and the largest and smallest entries in the energy array are 5.0 MeV and 0.01 MeV, respectively. From this table the code uses the subroutine LAGRAN (reference 2) to generate a second table, TABLE, (currently, containing 1001 entries) by means of Lagrangian log-log interpolation. Then, for each $E_{\gamma in}$, the code chooses the appropriate value for σ from the generated table by the following method:

$$\sigma = \mathrm{TABLE}(K)$$

where

$$K = \frac{\ln\left(\frac{E_{\gamma in}}{0.01}\right)}{\mathrm{DELX}} + 1.49.$$

DELX is the spacing of the generated table, TABLE.
If $E_{\gamma in} < 0.01$ MeV, the code chooses the value of σ for $E_{\gamma in} = 0.01$ MeV.
If $E_{\gamma in} > 5.0$ MeV, EXREM chooses the value of σ for $E_{\gamma in} = 5.0$ MeV.

The backscatter correction Bs is equal to 1.14 (dimensionless). The density of air is stored as 1.29×10^{-3} g/cm^3.

3.2.3 Logical Flow of the Code

In this section the general logical flow for the code EXREM is described. The subroutine AINPUT reads the input data for a problem, and the subroutine PRINT lists these data if the input variable LIST is nonzero. The code then executes the first portion of the subroutine CALCUL where the time independent terms from the equations developed in Sect. 3.1 are evaluated.

For each case in the problem, the program follows the sequence listed below. The subroutine CALTAU determines the values for K0, K1, and $\hat{\tau}_k$. CALTIM, an entry point in subroutine CALCUL, evaluates certain time parameters. CALC1, CALC2, and CALC3, entry points in subroutine

CALCUL, evaluate the dose-rate and total-dose equations for submersion in water, submersion in air, and exposure to a surface, respectively. OUT1, OUT2, and OUT3, entry points in subroutine OUTPUT, print the dose-rate and total-dose arrays for submersion in water, submersion in air, and exposure to a surface, respectively. When the data are insufficient to calculate the dose rate or total dose for a certain radionuclide, the words NO DATA are printed in the output array in place of a numerical answer. Also, if the calculated total dose is less than TEST (currently TEST = 1.0×10^{-6}), then 0.0 is printed in place of the actual answer. After the output is listed for the last case in the current problem, the program returns to the subroutine AINPUT to read the input data for the next problem.

The subroutine ENOFX evaluates the E-function. The subroutine LAGRAN and G3R3G3 generate a table of data by means of Lagrangian interpolation from a smaller table. The subroutine PGMMSK allows underflows to occur. The subroutine EXFCT1 evaluates $\frac{1 - e^{-x}}{x}$. The subroutine ORDER arranges the entries in the output arrays in descending order.

3.2.4 Definition of Program Variables

The FORTRAN variables used in EXREM are defined in this section. These variables, listed in alphabetical order, are divided into three groups: the input variables, the more important internal variables, and the output variables. The subscript I denotes the I*th* radionuclide, the subscript J denotes beta (J=1) or gamma (J=2) radiation, the subscript K denotes the K*th* detonation, the subscript L denotes the L*th* location, and the subscript N denotes the N*th* beta particle or gamma photon.

Input Variables

BPROB(I,N): Abundance (dimensionless), $f_{\beta in}$, defined in Sect. 3.1.1.

CLOUDT(M): Time (hours), T_m, required for the cloud from the mth detonation to pass the area of concern (defined in Sect. 3.1.2).

EO(I,N): Maximum energy (MeV), $E_{\beta in}$, defined in Sect. 3.1.3.

GA(I,L,K): Location correction factor (cm^{-3}), $ga_{i\ell k}$, defined in Sect. 3.1.2.

GENERY(I,N): Energy (MeV), $E_{\gamma in}$, defined in Sect. 3.1.1.

GPROB(I,N): Abundance (dimensionless), $f_{\gamma in}$, defined in Sect. 3.1.1.

GS(I,L,K): Location correction factor (cm^{-2}), $gs_{i\ell k}$, defined in Sect. 3.1.3.

GW(I,L,K): Location correction factor (cm^{-3}), $gw_{i\ell k}$, defined in Sect. 3.1.1.

IAIR: Flag for submersion in air. If IAIR≠0, the dose rates and total doses for submersion in air are calculated. If IAIR=0, the calculations are omitted.

IATOM(I): Atomic number, Z_i, defined in Sect. 3.2.2.

IDET: Detonation reference number. All time parameters entered as input should be measured relative to the time of this detonation (t=0 at detonation IDET).

ISUR: Flag for exposure to a surface. If ISUR≠0, the dose rates and total doses for exposure to a contaminated surface are calculated. If ISUR=0, the calculations are omitted.

IWATER: Flag for submersion in water. If IWATER≠0, the dose rates and total doses for submersion in water are calculated. If IWATER=0, the calculations are omitted.

LIST: Output flag. If LIST≠0, a listing of the input data is printed. If LIST=0, this listing is omitted.

NBETA(I): Number of beta particles, $N_{\beta i}$, defined in Sect. 3.1.1 (NBETA(I) $\leq$ MAXB).

NCASES: Number of cases for the problem (NCASES $\leq$ MAXCAS).

NEXP: Number of detonations (NEXP $\leq$ MAXEXP).

NGAMMA(I): Number of gamma photons, $N_{\gamma i}$, defined in Sect. 3.1.1 (NGAMMA(I) $\leq$ MAXG).

NHTS: Number of distances from a contaminated surface for which the dose is to be calculated (NHTS $\leq$ MAXHTS).

NLOC: Number of locations (NLOC $\leq$ MAXLOC).

NONUC(I): An index used to identify the Ith radionuclide (NONUC(I) $\leq$ MAXNUM).

NRNUC: Number of radionuclides (NRNUC $\leq$ MAXNUC).

RADNUC(I): The name of the Ith radionuclide (REAL*8).

RDECAY(I): The radiological decay constant, (hrs^{-1}), λ_{ri}, defined in Sect. 3.1.1.

T(IH): The IH*th* distance (cm), x, of an individual from a contaminated surface (see Sect. 3.1.3).

TAU(K): Time of the k*th* detonation (hrs), τ_k, defined in Sect. 3.1.1.

TIME(IC): Time for dose-rate calculation (yrs), t, for the IC*th* case.

TITLE: An array containing the title of the problem.

T1(IC): Lower limit of integration (yrs), t_1, for the calculation of the total dose for the IC*th* case.

T2(IC): Upper limit of integration (yrs), t_2, for the calculation of the total dose for the IC*th* case.

Y(I,K): Yield vented (μCi), Y_{ik}, defined in Sect. 3.1.1.

Internal Variables

A(IH): T(IH) * 1.29E-3, (g/cm^2).

BENERY(I,N): Average energy (MeV), $\overline{E}_{\beta in}$, defined in Sect. 3.1.1 and in Eq. (3.28) in Sect. 3.2.2.

BS: Backscatter correction, Bs, defined in Sect. 3.1.3.

CON(J,IT): An array containing the coefficients $\frac{25.6}{24.0}$, $\frac{51.2}{24.0}$, $\frac{29.2}{24.0}$, and $\frac{29.2}{24.0}$. (IT=1, for submersion in water; IT=2, for submersion in air).

DELT(M): Contains the value of $\hat{\tau}_{m+1} - \hat{\tau}_m$.

DELTA(M,K): Contains the value of $\hat{\tau}_m - \tau_k$.

DELTAU(K): Contains the value of $t - \tau_k$.

DTAU(M,K): Contains the value of $\tau_m - \tau_k$.

E1(1):	Contains the value of $E_1(\sigma.x)$.
KO:	Contains the value of KO defined in Sect. 3.1.1.
K1:	Contains the value of K1 defined in Sect. 3.1.1.
MAXB:	Maximum number of beta particles (MAXB=15).
MAXCAS:	Maximum number of cases for a problem (MAXCAS=20).
MAXEXP:	Maximum number of detonations (MAXEXP=25).
MAXG:	Maximum number of gamma photons (MAXG=30).
MAXHTS:	Maximum number of heights above a contaminated surface (MAXHTS=3).
MAXLOC:	Maximum number of locations (MAXLOC=2).
MAXNUC:	Maximum number of radionuclides (MAXNUC=250).
MAXNUM:	Maximum radionuclide index (MAXNUM=350).
TAUP(K):	Contains the value of $\hat{\sigma}_k$ defined in Eqs. (3.6).

Output Variables

DRA(I,J):	Dose-equivalent rate (rem/hr) for submersion in contaminated air.
DRS(I,J,IH):	Dose-equivalent rate (rem/hr) for exposure to a contaminated surface from the IHth distance.
DRW(I,J):	Dose-equivalent rate (rem/hr) for submersion in contaminated water.
L:	The Lth location.
TDA(I,J):	Total dose equivalent (rem) for submersion in contaminated air.
TDS(I,J,IH):	Total dose equivalent (rem) for exposure to a contaminated surface from the IHth distance.

TDW(I,J): Total dose equivalent (rem) for submersion in contaminated water.

TOTAL: An array containing the sum of the dose rates or total doses for all radionuclides.

The output variables IDET, NONUC(I), RADNUC(I), T(IH), TIME(IC), TITLE(IA), T1(IC), and T2(IC) were defined above.

3.2.5 Description of Input

A description of the card input for EXREM is presented in this section. The entire deck for a problem is divided into seven groups which are listed below. Except for the TITLE card, columns 73 through 80 are reserved for identification to aid the user in the preparation and handling of the data. Examples are given to suggest identification for each card.

Input Categories

1. Group 1
   a. TITLE card
   b. LIMIT card
   c. HEIGHT card
   d. DETON card
2. Group 2

   NUCLID cards
3. Group 3

   PROD cards

4. Group 4

   a. WLOC cards

   b. ALOC cards

   c. SLOC cards

5. Group 5

   a. B cards

   b. G cards

6. Group 6

   CLOUD card

7. Group 7

   CASE cards

Description of Each Group

Each card is described by listing the variables in the order in which they are to be entered, by giving the FORTRAN format used to read the card, and by suggesting identification to be used. The input variables were defined in Sect. 3.2.4.

1. Group 1

   a. TITLE card

      Variables Read: TITLE(J) for J=1, 2, ..., 20.

      Format: (20A4)

      This card contains the title for the problem which can be from 1 to 80 alphanumeric characters and which should be centered on the card.

   b. LIMIT card

      Variables Read: NRNUC, NEXP, NLOC, NHTS, NCASES, LIST, IDET, IWATER, IAIR, ISUR.

1. Group 1

   b. continued

      Format: (14I5).

      Identification: Enter the word LIMIT in columns 76-80.

   c. HEIGHT card

      Variables Read: T(I) for I=1, 2, ..., NHTS.

      Format: (7E10.0).

      Identification: Enter the word HEIGHT in columns 75-80.

      NOTE: If ISUR=0, then the HEIGHT card is omitted.

   d. DETON card

      Variables Read: TAU(K) for K=1, 2, ..., NEXP.

      Format: (7E10.0).

      Identification: Enter the word DETON in columns 76-80.

      There can be 7 TAU entries per card. The code continues to read DETON cards until all NEXP detonation times have been read.

2. Group 2

   $NUCLID_i$ cards for i=1, 2, ..., NRNUC.

   Variables Read: NONUC(I), IATOM(I), RADNUC(I), RDECAY(I), NBETA(I), NGAMMA(I) for I=i.

   Format: (2I3, A8, 1X, E10.0, 2I5).

   Identification: Enter the word NUCLID in columns 75-80. The radionuclide names should be left-adjusted in columns 6-13. In order for the radionuclide SR-90 to be treated as described in Sect. 3.1.3, the index, NONUC(I), must equal 42.

3. Group 3

$PROD_i$ cards for i=1, 2, ..., NRNUC.

Variables Read: Y(I,K) for K=1, 2, ..., NEXP and for I=i.

Format: (7E10.0).

Identification: Enter the value of NONUC(I) in columns 74-76 and the word PROD in columns 77-80.

There can be seven entries per card. For each radionuclide i, the code continues to read PROD cards until all NEXP productions have been read. The data for the radionuclides must appear in the same sequence as the radionuclides appeared in Group 2.

4. Group 4

This group consists of decks of WLOC, ALOC, and SLOC cards containing the location correction factors for submersion in water, submersion in air, and exposure to a surface, respectively. The entire group is repeated for each location ℓ, where ℓ = 1, 2, ..., NLOC.

a. $WLOC_{i\ell}$ cards for i=1, 2, ..., NRNUC.

Variables Read: GW(I,L,K) for K=1, 2, ..., NEXP and for I=i and L=ℓ.

Format: (7E10.0).

Identification: Enter the value of L in column 73, the value of NONUC(I) in columns 74-76, and the word WLOC in columns 77-80.

For each radionuclide i, the code continues to read WLOC cards until all NEXP factors have been read. The data for the radionuclides must appear in the same sequence as the radionuclides appeared in Group 2.

NOTE: If IWATER=0, the WLOC cards are omitted.

b. $ALOC_{i\ell}$ cards for i=1, 2, ..., NRNUC.

Variables Read: GA(I,L,K) for K=1, 2, ..., NEXP and for I=i and L=ℓ.

Format: (7E10.0).

Identification: Enter the value of L in column 73, the value of NONUC(I) in columns 74-76, and the word ALOC in columns 77-80.

For each radionuclide i, the code continues to read ALOC cards until all NEXP factors have been read. The data for the radionuclides must appear in the same sequence as the radionuclides appeared in Group 2.

NOTE: If IAIR=0, the ALOC cards are omitted.

c. $SLOC_{i\ell}$ cards for i=1, 2, ..., NRNUC.

Variables Read: GS(I,L,K) for K=1, 2, ..., NEXP and for I=i and L=ℓ.

Format: (7E10.0).

Identification: Enter the value of L in column 73, the value of NONUC(I) in columns 74-76, and the word SLOC in columns 77-80.

For each radionuclide i, the code continues to read SLOC cards until all NEXP factors have been read. The data for the radionuclides must appear in the same sequence as the radionuclides appeared in Group 2.

NOTE: If ISUR=0, the SLOC cards are omitted.

NOTE: If NLOC<0, then Group 4 is omitted, and the code assumes that the location correction factor for each mode of exposure is constant and equal to XLOC (currently, XLOC=1.0).

5. Group 5

a. B_i cards for i=1, 2, ..., NRNUC.

Variables Read: (E0(I,IP), BPROB(I,IP) for IP=1, 2, ..., NBETA(I) and for I=i.

Format: (12E6.0).

Identification: Enter B in column 73 and the value of NONUC(I) in columns 78-80.

There can be six sets of energies and abundances per card. For each radionuclide i, the code continues to read B cards until all NBETA(I) of these sets have been read. If NBETA(I)=0 for a particular I, then the B card corresponding to that radionuclide is omitted. The data for the radionuclides must appear in the same sequence as the radionuclides appeared in Group 2.

b. G_i cards for i=1, 2, ..., NRNUC.

Variables Read: (GENERY(I,IP), GPROB(I,IP)) for IP=1, 2, ..., NGAMMA(I) and for I=i.

Format: (12E6.0).

b. continued

Identification: Enter G in column 73 and the value of NONUC(I) in columns 78-80.

There can be six sets of energies and abundances per card. For each radionuclide i, the code continues to read G cards until all NGAMMA(I) of these sets have been read. If NGAMMA(I)=0 for a particular I, then the G card corresponding to that radionuclide is omitted. The data for the radionuclides must appear in the same sequence as the radionuclides appeared in Group 2.

6. Group 6

CLOUD card

Variables Read: CLOUDT(K) for K=1, 2, ..., NEXP.

Format: (7E10.0).

Identification: Enter the word CLOUD in columns 76-80.

There can be seven CLOUDT entries per card. The code continues to read CLOUD cards until all NEXP of the CLOUDT times have been read.

NOTE: If NEXP < 0, then Group 6 is omitted, and the code assumes that CLOUDT=CLOUD for each detonation (currently, CLOUD=1.0 hour).

NOTE: If IAIR=0, then Group 6 is omitted.

7. Group 7

CASE$_j$ cards for j=1, 2, ..., NCASES.

Variables Read: TIME(J), T1(J), T2(J) for J=j.

Format: (7E10.0).

Identification: Enter the word CASE in columns 77-80.

REFERENCES

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2. Penny, S. K., and Emmett, M. B., An IBM-7090 Subroutine Package for Lagrangian Interpolation, Oak Ridge National Laboratory, Oak Ridge, Tennessee, May 2, 1963, (ORNL-3428).

3. Penny, S. K.; Trubey, D. K.; and Emmett, M. B., OGRE, A Monte Carlo System for Gamma-Ray Transport Studies, Including an Example (OGRE-P1) for Transmission Through Laminated Slabs, Oak Ridge National Laboratory, Oak Ridge, Tennessee, April, 1966, (ORNL-3805).

APPENDIX A

LISTING OF THE INREM CODE

```
C ****** INREM ******
C  PROGRAM AUTHOR  W.D. TURNER
C  COMPUTING TECHNOLOGY CENTER, UNION CARBIDE CORP., NUCLEAR DIV.,
C  OAK RIDGE, TENN.
C **** MAIN PROGRAM
C
C        TO MODIFY THE DIMENSIONS IN THE ARRAYS IN THIS CODE, THE
C   FOLLOWING CONDITIONS MUST BE SATISFIED.
C   LET
C     MAXAGE = MAXIMUM NUMBER OF AGE GROUPS FOR AN INDIVIDUAL,
C     MAXIN  = MAXIMUM NUMBER OF ENTRIES IN AN INTAKE TABLE,
C     MAXNUC = MAXIMUM NUMBER OF RADIONUCLIDES, AND
C     MAXORG = MAXIMUM NUMBER OF ORGANS. (IF MAXORG > 11, A CHANGE MUST
C   BE MADE IN THE PRINT-OUTS IN SUBROUTINES PRINT AND OUTPUT.)
C
C   THESE VARIABLES ARE LOCATED IN A DATA (INTEGER) STATEMENT IN
C   SUBROUTINE AINPUT.
C       IF MAXAGE IS CHANGED, DIMENSIONS MUST BE MODIFIED AS INDICATED
C   IN SUBROUTINES AINPUT, PRINT, OUTPUT, CALCUL, CALAGE, AND AMTIN.
C       IF MAXIN IS CHANGED, DIMENSIONS MUST BE MODIFIED AS INDICATED IN
C   SUBROUTINES PRINT, CALCUL, AND AMTIN.
C       IF MAXNUC IS CHANGED, DIMENSIONS MUST BE MODIFIED AS INDICATED
C   IN SUBROUTINES AINPUT, PRINT, OUTPUT, CALCUL, AND AMTIN.
C       IF MAXORG IS CHANGED, DIMENSIONS MUST BE MODIFIED AS INDICATED
C   IN SUBROUTINES AINPUT, PRINT, OUTPUT, AND CALCUL.
C
      COMMON /OUTTWO/AGEDET,T1,T2,XIN,XOUT,NDETON
      COMMON /XAGE/T(3),NT,TBORN
      NT=3
C
C **** DELETE PROGRAM INTERRUPT MESSAGES FOR EXPONENTIAL UNDERFLOW.
      CALL PGMMSK(1,0,0,0)
    1 CONTINUE
      CALL AINPUT(NCASES)
      IF(NCASES.LT.0)RETURN
      CALL PRINT
      CALL CALCUL
      DO 30 I=1,NCASES
C **** READ DETONATION REFERENCE NUMBER, AGE (YEARS) OF ORGAN AT THIS
C         DETONATION, LOWER AND UPPER LIMITS (YEARS) FOR WHICH THE
C         ACCUMULATED DOSAGE IS TO BE CALCULATED, TIME (YEARS) OF INITIAL
C         INTAKE AND TIME (YEARS) OF FINAL INTAKE.
      READ(5,1006)NDETON,AGEDET,T1,T2,XIN,XOUT
 1006 FORMAT(I5,6E10.0)
      IF(T1.LT.T2) GO TO 5
      WRITE(6,9001)T1,T2
 9001 FORMAT('1 THE LOWER LIMIT OF INTEGRATION ',1PE11.4,' IS GREATER TH
     1AN OR EQUAL TO THE UPPER LIMIT ',1PE11.4)
      GO TO 1
    5 IF(XIN.LT.XOUT) GO TO 10
      WRITE(6,9002)XIN,XOUT
 9002 FORMAT('1THE TIME OF INITIAL INTAKE ',1PE11.4,' IS GREATER THAN OR
     1 EQUAL TO THE TIME OF FINAL INTAKE ',1PE11.4)
      GO TO 1
   10 IF(XIN.LT.T2)GO TO 15
```

```
      WRITE(6,9003)XIN,T2
 9003 FORMAT('1THE TIME OF INITIAL INTAKE ',1PE11.4,' IS GREATER THAN OR
     1 EQUAL TO THE UPPER LIMIT OF INTEGRATION ',1PE11.4)
      GO TO 1
   15 IF(XOUT.GT.T1)GO TO 20
      WRITE(6,9004)XOUT,T1
 9004 FORMAT('1THE TIME OF FINAL INTAKE ',1PE11.4,' IS LESS THAN OR EQUA
     1L TO THE LOWER LIMIT OF INTEGRATION ',1PE11.4)
      GO TO 1
   20 CONTINUE
      TBORN=-365.00*AGEDET
      T(1)=T1
      IF(XIN.GT.T1)T(1)=XIN
      T(2)=XOUT
      IF(XOUT.GT.T2)T(2)=T2
      T(3)=T2
      DO 25 K=1,NT
   25 T(K)=365.00*(T(K)+AGEDET)
      CALL AMTIN1
      CALL CALAGE(T(1),T(NT))
      CALL CALC
      CALL OUTPUT
      CALL AMTIN2
   30 CONTINUE
      GO TO 1
      END
```

```
      SUBROUTINE AINPUT(NCASES)
C  THIS SUBROUTINE READS THE INPUT DATA FOR INREM.
C
C IN CHANGING DIMENSIONS, THE FOLLOWING CONDITIONS MUST BE SATISFIED.
C      COMMON /OUTONE/ORGAN(MAXORG+1,2),RADNUC(MAXNUC),IDATA(MAXNUC,
C     1MAXORG+2,2),NONUC(MAXNUC),JORGAN,IC,A(20)
C      COMMON /PARM/FRACT(MAXNUC,MAXORG,MAXAGE,2),GIFRAC(MAXNUC,MAXAGE,
C     12,2),DECAY(MAXNUC,MAXORG,MAXAGE),ENERGY(MAXNUC,MAXORG,MAXAGE),
C     2GIENER(MAXNUC,MAXAGE,2),GIDOSE(MAXNUC,2,2),GIMASS(4,MAXAGE),
C     3XMPC(MAXNUC,2,2),DOSE(MAXNUC,MAXORG,2),AOW(2,MAXAGE),XMASS(MAXORG,
C     4MAXAGE),JSOL(MAXNUC),JINSOL(MAXNUC),ILUNG,INFLAG,IORGAN,ITRACT,
C     5NRNUC
C      COMMON /AGEPAR/AGE(MAXAGE+1),AGEGP(MAXAGE+1),LOAGE,MAGE,NAGE
C      COMMON /OUT3/RHLIFE(MAXNUC),KORGAN,LIST,NORGAN
C
      COMMON /OUTONE/ORGAN(12,2),RADNUC( 10),IDATA( 10,13,2)
     1,NONUC( 10),JORGAN,IC,A(20)
      COMMON/PARM/FRACT( 10,11,25,2),GIFRAC( 10,25,2,2),DECAY( 10,11,25)
     1,ENERGY( 10,11,25),GIENER( 10,25,2),GIDOSE( 10,2,2),GIMASS(4,25)
     2,XMPC( 10,2,2),DOSE( 10,11,2),AOW(2,25),XMASS(11,25),JSOL( 10)
     3,JINSOL( 10),ILUNG,INFLAG,IORGAN,ITRACT,NRNUC
      COMMON /AGEPAR/AGE(26),AGEGP(26),LOAGE,MAGE,NAGE
      COMMON /OUT3/RHLIFE( 10),KORGAN,LIST,NORGAN
      REAL*8 ORGAN,RADNUC,GI/'G.I.   '/,TRACT/'TRACT'/
      REAL BDECAY/.8333333E-2/,BDECPU/.2739726E-2/,FILUNG/.125/
      INTEGER IPULO/280/,IPUHI/283/
      INTEGER MAXAGE/25/,MAXIN/100/,MAXNUC/ 10/,MAXORG/11/
      MORGM1=MAXORG-1
      MORGM2=MAXORG-2
C
C **** READ TITLE CARD.
```

```
      READ(5,1000)(A(I),I=1,20)
 1000 FORMAT(20A4)
C **** READ NO. OF RADIONUCLIDES, NO. OF AGE GROUPS, NO. OF ORGANS,
C        ORGAN FLAG, INTAKE FLAG, NO. OF CASES, OUTPUT FLAG.
      READ(5,1001)NRNUC,NAGE,NORGAN,IORG,INFLAG,NCASES,LIST
 1001 FORMAT(14I5)
      IF(NRNUC.LE.MAXNUC)GO TO 2
      NCASES=-1
      WRITE(6,9001)MAXNUC
 9001 FORMAT('1THE NUMBER OF RADIONUCLIDES EXCEEDS ',I3)
      RETURN
    2 IF(NAGE.LE.MAXAGE)GO TO 3
      NCASES=-1
      WRITE(6,9002)MAXAGE
 9002 FORMAT('1THE NUMBER OF AGE GROUPS EXCEEDS',I3)
      RETURN
    3 IF(IORG.EQ.3 .AND. NORGAN.GT.MAXORG)GO TO 4
      IF(IORG.EQ.1 .OR. IORG.EQ.2 .AND. NORGAN.GT.MORGM1)GO TO 4
      IF(IORG.EQ.0 .AND. NORGAN.GT.MORGM2)GO TO 4
      GO TO 5
    4 NCASES=-1
      WRITE(6,9003)MAXORG
 9003 FORMAT('1THE NUMBER OF ORGANS EITHER EXCEEDS ',I2,' OR IS TOO GREA
     1T TO BE LISTED IN THE CURRENT OUTPUT SUBROUTINES.')
      RETURN
    5 CONTINUE
C **** IORG IS A FLAG TO INDICATE WHETHER OR NOT THE SPECIAL ORGANS
C        LUNGS OR G.I. TRACT ARE PRESENT.
C          IORG = 0 MEANS NEITHER,
C               = 1 MEANS LUNGS BUT NOT G.I. TRACT,
C               = 2 MEANS G.I. TRACT BUT NOT LUNGS,
C               = 3 MEANS BOTH ARE PRESENT.
C
C **** INFLAG IS A FLAG TO INDICATE WHETHER THE INTAKE RATE WILL BE
C        CONSTANT, (DOSEIN), FOR EACH NUCLIDE OR WHETHER IT WILL BE READ
C        IN AS A STEP FUNCTION.
C      INFLAG = 0 MEANS STEP-FUNCTION (INPUT),
C             = 1 MEANS CONSTANT (IN MACHINE).
C
C **** WHEN LIST = 1, THE INPUT DATA ARE PRINTED.
C      WHEN LIST = 0, THE INPUT DATA ARE NOT PRINTED.
C
C **** ILUNG IS INDEX FOR LUNGS,
C      ITRACT IS INDEX FOR G.I. TRACT,
C      IORGAN INDICATES THE NUMBER OF ORGANS TO BE HANDLED WITH THE
C        REGULAR MODEL,
C      JORGAN INDICATES THE NUMBER OF ORGANS (EXCEPT LUNGS AND G.I.
C        TRACT),
C      KORGAN INDICATES THE NUMBER OF ORGANS (EXCEPT G.I. TRACT).
      IF(IORG.EQ.3)GO TO 25
      IF(IORG.EQ.2)GO TO 20
      IF(IORG.EQ.1)GO TO 15
      ILUNG=0
      ITRACT=0
      IORGAN=NORGAN
      KORGAN=NORGAN
      JORGAN=NORGAN
      GO TO 35
   15 ILUNG=NORGAN
      ITRACT=0
```

```
      IORGAN=NORGAN+1                                                   AINP0920
      KORGAN=NORGAN                                                     AINP0930
      JORGAN=NORGAN-1                                                   AINP0940
      GO TO 35                                                          AINP0950
   20 ILUNG=0                                                           AINP0960
      ITRACT=NORGAN                                                     AINP0970
      IORGAN=NORGAN-1                                                   AINP0980
      KORGAN=NORGAN-1                                                   AINP0990
      JORGAN=IORGAN                                                     AINP1000
      GO TO 35                                                          AINP1010
   25 ILUNG=NORGAN-1                                                    AINP1020
      ITRACT=NORGAN+1                                                   AINP1030
      IORGAN=NORGAN                                                     AINP1040
      KORGAN=NORGAN-1                                                   AINP1050
      JORGAN=NORGAN-2                                                   AINP1060
   35 CONTINUE                                                          AINP1070
      NAGEP1=NAGE+1                                                     AINP1080
C **** READ AGE GROUP DIVISION (IN YEARS).                               AINP1090
      READ(5,1002)(AGE(L),L=1,NAGEP1)                                   AINP1100
 1002 FORMAT(7E10.0)                                                    AINP1110
C **** FOR EACH RADIONUCLIDE, READ LABEL, NAME AND RADIOLOGICAL          AINP1120
C          HALF-LIFE (DAYS).                                            AINP1130
      DO 45 I=1,NRNUC                                                   AINP1140
      READ(5,1004)NONUC(I),RADNUC(I),RHLIFE(I)                          AINP1150
 1004 FORMAT(I3,2X,A8,2X,E10.0)                                         AINP1160
   45 CONTINUE                                                          AINP1170
      IF(KORGAN.EQ.0)GO TO 145                                          AINP1180
C **** READ EACH ORGAN'S NAME AND ITS WEIGHT (GRAMS) FOR EACH AGE GROUP.AINP1190
      DO 10 K=1,KORGAN                                                  AINP1200
      IF(NAGE.LE.6)GO TO 8                                              AINP1210
      READ(5,1003)(ORGAN(K,J),J=1,2),(XMASS(K,L),L=1,NAGE)              AINP1220
 1003 FORMAT(2A5,6E10.0/(7E10.0))                                       AINP1230
      GO TO 10                                                          AINP1240
    8 READ(5,1033)(ORGAN(K,J),J=1,2),(XMASS(K,L),L=1,NAGE)              AINP1250
 1033 FORMAT(2A5,6E10.0)                                                AINP1260
   10 CONTINUE                                                          AINP1270
      DO 90 I=1,NRNUC                                                   AINP1280
      DO 60 L=1,NAGE                                                    AINP1290
C **** READ EFFECTIVE HALF-LIFE (DAYS) FOR EACH ORGAN.                   AINP1300
      READ(5,1005)(DECAY(I,K,L),K=1,KORGAN)                             AINP1310
 1005 FORMAT(10E7.0)                                                    AINP1320
   60 CONTINUE                                                          AINP1330
      DO 70 L=1,NAGE                                                    AINP1340
C **** READ EFFECTIVE ABSORBED ENERGY (MEV) FOR EACH ORGAN.              AINP1350
      READ(5,1005)(ENERGY(I,K,L),K=1,IORGAN)                            AINP1360
   70 CONTINUE                                                          AINP1370
      DO 80 L=1,NAGE                                                    AINP1380
C **** READ FRACTION OF INTAKE FROM INHALATION REACHING EACH ORGAN.      AINP1390
      READ(5,1005)(FRACT(I,K,L,1),K=1,KORGAN)                           AINP1400
   80 CONTINUE                                                          AINP1410
      DO 90 L=1,NAGE                                                    AINP1420
C **** READ FRACTION OF INTAKE FROM INGESTION REACHING ORGAN.            AINP1430
      READ(5,1005)(FRACT(I,K,L,2),K=1,KORGAN)                           AINP1440
   90 CONTINUE                                                          AINP1450
      IF(ILUNG.EQ.0)GO TO 145                                           AINP1460
C **** GENERATE PARAMETERS FOR LUNGS FOR INSOLUBLE RADIONUCLIDES.        AINP1470
      DO 105 L=1,NAGE                                                   AINP1480
  105 XMASS(IORGAN,L)=XMASS(ILUNG,L)                                    AINP1490
      DO 140 I=1,NRNUC                                                  AINP1500
      IF(RHLIFE(I).EQ.0)GO TO 140                                       AINP1510
```

```
      RDECAY=1.0/RHLIFE(I)
      DO 115 L=1,NAGE
      FRACT(I,IORGAN,L,1)=FILUNG
  115 FRACT(I,IORGAN,L,2)=0.0
      IF(NONUC(I).LT.IPULO .OR. NONUC(I).GT.IPUHI)GO TO 130
      DO 125 L=1,NAGE
  125 DECAY(I,IORGAN,L)=0.6931472*(RDECAY+BDECPU)
      GO TO 140
  130 DO 135 L=1,NAGE
  135 DECAY(I,IORGAN,L)=0.6931472*(RDECAY+BDECAY)
  140 CONTINUE
  145 IF(ITRACT.EQ.0)GO TO 170
C **** READ AND DEVELOP THE PARAMETERS FOR G.I. TRACT.
      ORGAN(ITRACT,1)=GI
      ORGAN(ITRACT,2)=TRACT
C **** READ DAILY INTAKES FOR AIR AND WATER FOR EACH AGE GROUP.
      DO 150 J=1,2
  150 READ(5,1002)(AOW(J,L),L=1,NAGE)
      IF(NAGE.EQ.1)GO TO 160
C **** READ THE WEIGHT (GRAMS) FOR EACH OF THE FOUR SEGMENTS OF THE
C         G.I. TRACT.
      DO 152 K=1,4
  152 READ(5,1002)(GIMASS(K,L),L=1,NAGE)
C **** READ THE INDEX FOR THE CRITICAL SEGMENT OF THE G.I. TRACT FOR
C         SOLUBLE AND INSOLUBLE RADIONUCLIDES.
      DO 153 I=1,NRNUC
  153 READ(5,1001)JSOL(I),JINSOL(I)
C **** FOR EACH RADIONUCLIDE AND EACH AGE GROUP, READ EFFECTIVE ABSORBED
C         ENERGY, FRACTION OF INTAKE FROM INHALATION AND FRACTION OF
C         INTAKE FROM INGESTION REACHING ORGAN.
      DO 155 I=1,NRNUC
      DO 155 L=1,NAGE
  155 READ(5,1002)(GIENER(I,L,JJ),(GIFRAC(I,L,J,JJ),J=1,2),JJ=1,2)
C **** READ MPC.
  160 DO 165 I=1,NRNUC
  165 READ(5,1002)((XMPC(I,J,K),J=1,2),K=1,2)
  170 CONTINUE
C **** CALL THE ROUTINE WHICH READS AND DEVELOPS THE INTAKE FUNCTIONS.
      CALL AMTIN(INFLAG,NRNUC,MAXIN)
C **** IDATA = 0 MEANS INSUFFICIENT DATA,
C      IDATA = 1 MEANS SUFFICIENT DATA.
C **** INITILIZE IDATA ARRAY.
      KK=NORGAN+2
      DO 200 I=1,NRNUC
      DO 200 K=1,KK
      DO 200 J=1,2
  200 IDATA(I,K,J)=1
C **** DETERMINE WHICH NUCLIDES AND ORGANS HAVE INSUFFICIENT DATA.
      IF(IORGAN.EQ.0)GO TO 242
      DO 241 K=1,IORGAN
      DO 210 L=1,NAGE
      IF(XMASS(K,L).NE.0.0)GO TO 210
      DO 205 I=1,NRNUC
      IDATA(I,K,1)=0
  205 IDATA(I,K,2)=0
      GO TO 241
  210 CONTINUE
      DO 240 I=1,NRNUC
      DO 220 L=1,NAGE
      IF(DECAY(I,K,L).EQ.0.0)GO TO 215
```

```
      IF(ENERGY(I,K,L).NE.0.0)GO TO 220
  215 IDATA(I,K,1)=0
      IDATA(I,K,2)=0
      GO TO 240
  220 CONTINUE
      DO 225 L=1,NAGE
      IF(FRACT(I,K,L,1).NE.0.0)GO TO 225
      IDATA(I,K,1)=0
      GO TO 230
  225 CONTINUE
  230 DO 235 L=1,NAGE
      IF(FRACT(I,K,L,2).NE.0.0)GO TO 235
      IDATA(I,K,2)=0
      GO TO 240
  235 CONTINUE
  240 CONTINUE
  241 CONTINUE
      IF(ITRACT.EQ.0)GO TO 300
  242 KTRACT=ITRACT+1
      DO 295 J=1,2
      DO 250 L=1,NAGE
      IF(AOW(J,L).NE.0.0)GO TO 250
      DO 245 K=ITRACT,KTRACT
      DO 245 I=1,NRNUC
  245 IDATA(I,K,J)=0
      GO TO 295
  250 CONTINUE
      DO 290 JJ=1,2
      DO 290 I=1,NRNUC
      IF(XMPC(I,J,JJ).NE.0.0)GO TO 255
      IDATA(I,IORGAN+JJ,J)=0
      GO TO 290
  255 IF(NAGE.EQ.1)GO TO 290
      GO TO (260,265),JJ
  260 K=JSOL(I)
      GO TO 270
  265 K=JINSOL(I)
  270 DO 285 L=1,NAGE
      IF(GIFRAC(I,L,J,JJ).EQ.0.0)GO TO 275
      IF(GIENER(I,L,JJ).EQ.0.0)GO TO 275
      IF(GIMASS(K,L).NE.0.0)GO TO 285
  275 IDATA(I,IORGAN+JJ,J)=0
  285 CONTINUE
  290 CONTINUE
  295 CONTINUE
  300 CONTINUE
C **** IC IS A FLAG WHICH INDICATES THE COMBINATION OF ORGANS PRESENT IN
C          THE CASE. DETERMINE IC.
      IF(NORGAN.GE.3 .AND. IORG.EQ.3)GO TO 307
      IF(IORG.EQ.0)GO TO 306
      IF(NORGAN.GE.2 .AND. IORG.EQ.2)GO TO 305
      IF(NORGAN.GE.2 .AND. IORG.EQ.1)GO TO 304
      IF(NORGAN.EQ.2 .AND. IORG.EQ.3)GO TO 303
      IF(NORGAN.EQ.1 .AND. IORG.EQ.2)GO TO 302
      IC=7
      GO TO 310
  302 IC=6
      GO TO 310
  303 IC=5
      GO TO 310
```

```
  304 IC=4
      GO TO 310
  305 IC=3
      GO TO 310
  306 IC=2
      GO TO 310
  307 IC=1
  310 CONTINUE
      RETURN
      END
```

```
      SUBROUTINE PRINT
C  THIS SUBROUTINE LISTS THE INPUT DATA FOR INREM.
C
C IN CHANGING DIMENSIONS, THE FOLLOWING CONDITIONS MUST BE SATISFIED.
C      COMMON /OUTONE/ORGAN(MAXORG+1,2),RADNUC(MAXNUC),IDATA(MAXNUC,
C     1MAXORG+2,2),NONUC(MAXNUC),JORGAN,IC,A(20)
C      COMMON /PARM/FRACT(MAXNUC,MAXORG,MAXAGE,2),GIFRAC(MAXNUC,MAXAGE,
C     12,2),DECAY(MAXNUC,MAXORG,MAXAGE),ENERGY(MAXNUC,MAXORG,MAXAGE),
C     2GIENER(MAXNUC,MAXAGE,2),GIDOSE(MAXNUC,2,2),GIMASS(4,MAXAGE),
C     3XMPC(MAXNUC,2,2),DOSE(MAXNUC,MAXORG,2),AOW(2,MAXAGE),XMASS(MAXORG,
C     4MAXAGE),JSOL(MAXNUC),JINSOL(MAXNUC),ILUNG,INFLAG,IORGAN,ITRACT,
C     5NRNUC
C      COMMON /AGEPAR/AGE(MAXAGE+1),AGEGP(MAXAGE+1),LOAGE,MAGE,NAGE
C      COMMON /TABLE/TINTAK(MAXNUC,MAXAGE,MAXIN),AINTAK(MAXNUC,MAXAGE,
C     1MAXIN),NPT(MAXNUC,MAXAGE)
C      COMMON /OUT3/RHLIFE(MAXNUC),KORGAN,LIST,NORGAN
C
      COMMON /OUTONE/ORGAN(12,2),RADNUC( 10),IDATA( 10,13,2)
     1,NONUC( 10),JORGAN,IC,A(20)
      COMMON/PARM/FRACT( 10,11,25,2),GIFRAC( 10,25,2,2),DECAY( 10,11,25)
     1,ENERGY( 10,11,25),GIENER( 10,25,2),GIDOSE( 10,2,2),GIMASS(4,25)
     2,XMPC( 10,2,2),DOSE( 10,11,2),AOW(2,25),XMASS(11,25),JSOL( 10)
     3,JINSOL( 10),ILUNG,INFLAG,IORGAN,ITRACT,NRNUC
      COMMON /AGEPAR/AGE(26),AGEGP(26),LOAGE,MAGE,NAGE
      COMMON /TABLE/TINTAK( 10,25,100),AINTAK( 10,25,100),NPT( 10,25)
      COMMON /OUT3/RHLIFE( 10),KORGAN,LIST,NORGAN
      REAL*8 ORGAN,RADNUC,LUNGS/'LUNGS'/,SOL/' (S) '/,INSOL/' (I)'/
C
C **** LIST = 0 MEANS DO NOT LIST THE INPUT DATA.
C         OTHERWISE, LIST THE INPUT DATA.
      IF(LIST.EQ.0)RETURN
      WRITE(6,3001)
 3001 FORMAT('1',44X,'LISTING OF THE INPUT PARAMETERS FOR INREM'//)
      WRITE(6,3002)(A(I),I=1,20)
 3002 FORMAT('0',25X,20A4/)
      WRITE(6,3003)NRNUC
 3003 FORMAT('0TOTAL NUMBER OF RADIONUCLIDES = ',I3)
      WRITE(6,3004)NAGE
 3004 FORMAT(' TOTAL NUMBER OF AGE GROUPS    = ',I3)
      WRITE(6,3005)NORGAN
 3005 FORMAT(' TOTAL NUMBER OF ORGANS        = ',I3)
      WRITE(6,3006)
 3006 FORMAT('-AGE GROUPS.'/'0   GROUP',4X,'LOWER LIMIT',4X,'UPPER LIMIT
     1'/5X,'NO.',8X,'(YRS)',10X,'(YRS)')
      DO 10 L=1,NAGE
      LP1=L+1
      WRITE(6,3007)L,AGE(L),AGE(LP1)
```

```
3007 FORMAT(' ',4X,I2,5X,E12.5,' TO',E12.5)
  10 CONTINUE
     WRITE(6,3008)
3008 FORMAT('-RADIONUCLIDE IDENTIFICATION.'/'0',3X,'NUMBER',3X,'INDEX',
    13X,'NAME',8X,'HALF-LIFE'/34X,'(DAYS)')
     DO 20 I=1,NRNUC
     WRITE(6,3009)I,NONUC(I),RADNUC(I),RHLIFE(I)
3009 FORMAT(' ',4X,I3,6X,I3,4X,A8,E14.5)
  20 CONTINUE
     IF(KORGAN.EQ.0)GO TO 100
     WRITE(6,3010)((ORGAN(K,J),J=1,2),K=1,KORGAN)
3010 FORMAT('-ORGAN MASS (GRAMS).'/'0',6X,'NAME ',10(2X,2A5))
     WRITE(6,3011)
3011 FORMAT('  AGE'/' GROUP')
     DO 30 L=1,NAGE
     WRITE(6,3012)L,(XMASS(K,L),K=1,KORGAN)
3012 FORMAT(' ',I3,8X,1P10E12.4)
  30 CONTINUE
     WRITE(6,3013)((ORGAN(K,J),J=1,2),K=1,KORGAN)
3013 FORMAT('-EFFECTIVE HALF-LIFE (DAYS).'/'0ORGAN NAME ',10(1X,2A5))
     WRITE(6,3014)
3014 FORMAT('0NUCLIDE AGE'/'  INDEX GROUP')
     DO 40 I=1,NRNUC
     WRITE(6,3015)NONUC(I)
3015 FORMAT(' ',I5)
     DO 40 L=1,NAGE
     WRITE(6,3016)L,(DECAY(I,K,L),K=1,KORGAN)
3016 FORMAT(' ',8X,I2,1P11E11.3)
  40 CONTINUE
     IF(ILUNG.EQ.0)GO TO 50
     KK=KORGAN-1
     WRITE(6,3017)((ORGAN(K,J),J=1,2),K=1,KK),LUNGS,SOL,LUNGS,INSOL
3017 FORMAT('-EFFECTIVE ABSORBED ENERGY (MEV).'/'0ORGAN NAME ',
    110(1X,2A5),1X,A5,A4)
     WRITE(6,3014)
     DO 45 I=1,NRNUC
     WRITE(6,3015)NONUC(I)
     DO 45 L=1,NAGE
     WRITE(6,3016)L,(ENERGY(I,K,L),K=1,IORGAN)
  45 CONTINUE
     GO TO 75
  50 WRITE(6,3017)((ORGAN(K,J),J=1,2),K=1,KORGAN)
  60 WRITE(6,3014)
     DO 70 I=1,NRNUC
     WRITE(6,3015)NONUC(I)
     DO 70 L=1,NAGE
     WRITE(6,3016)L,(ENERGY(I,K,L),K=1,KORGAN)
  70 CONTINUE
  75 WRITE(6,3018)((ORGAN(K,J),J=1,2),K=1,KORGAN)
3018 FORMAT('-FRACTIONAL ABSORPTION FROM INHALATION (DIMENSIONLESS).'/
    1'0ORGAN NAME ',10(1X,2A5))
     WRITE(6,3014)
     DO 80 I=1,NRNUC
     WRITE(6,3015)NONUC(I)
     DO 80 L=1,NAGE
     WRITE(6,3016)L,(FRACT(I,K,L,1),K=1,KORGAN)
  80 CONTINUE
     WRITE(6,3019)((ORGAN(K,J),J=1,2),K=1,KORGAN)
3019 FORMAT('-FRACTIONAL ABSORPTION FROM INGESTION (DIMENSIONLESS).'/
    1'0ORGAN NAME ',10(1X,2A5))
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```
      WRITE(6,3014)
      DO 90 I=1,NRNUC
      WRITE(6,3015)NONUC(I)
      DO 90 L=1,NAGE
      WRITE(6,3016)L,(FRACT(I,K,L,2),K=1,KORGAN)
   90 CONTINUE
      IF(ITRACT.EQ.0)GO TO 150
  100 WRITE(6,3020)
 3020 FORMAT('-G.I.  TRACT PARAMETERS.')
      WRITE(6,3021)
 3021 FORMAT('0',3X,'INTAKE (CC/DAY) OF AIR AND WATER FOR AN INDIVIDUAL.
     1'/7X,'AGE GROUP',8X,'AIR',9X,'WATER')
      DO 110 L=1,NAGE
      WRITE(6,3022)L,AOW(1,L),AOW(2,L)
 3022 FORMAT(' ',9X,I2,6X,1P2E13.4)
  110 CONTINUE
      IF(NAGE.EQ.1)GO TO 135
      WRITE(6,3023)(I,I=1,4)
 3023 FORMAT('0',3X,'MASS (GRAMS) OF THE SEGMENTS OF THE G.I. TRACT.'/
     113X,'SEGMENT',5X,I1,3(11X,I1)/8X,'AGE'/7X,'GROUP')
      DO 120 L=1,NAGE
      WRITE(6,3024)L,(GIMASS(K,L),K=1,4)
 3024 FORMAT(' ',7X,I2,9X,1P4E12.4)
  120 CONTINUE
      WRITE(6,3025)
 3025 FORMAT('0',3X,'EFFECTIVE ABSORBED ENERGIES AND FRACTIONAL ABSORPTI
     1ONS.'/'0',40X,'SOLUBLE',40X,'INSOLUBLE')
      WRITE(6,3026)
 3026 FORMAT(' ',6X,'NUCLIDE  AGE ',2(5X,'CRITICAL    ENERGY    INHALATIO
     1N  INGESTION ')/' ',7X,'INDEX  GROUP',2(5X,'SEGMENT      (MEV)',4X,
     2'ABSORPTION  ABSORPTION'))
      DO 130 I=1,NRNUC
      WRITE(6,3027)NONUC(I),JSOL(I),JINSOL(I)
 3027 FORMAT(' ',8X,I3,16X,I1,47X,I1)
      DO 130 L=1,NAGE
      WRITE(6,3028)L,(GIENER(I,L,JJ),(GIFRAC(I,L,J,JJ),J=1,2),JJ=1,2)
 3028 FORMAT(' ',15X,I2,2X,2(12X,1P3E12.4))
  130 CONTINUE
  135 WRITE(6,3029)
 3029 FORMAT('0',3X,'MAXIMUM PERMISSIBLE CONCENTRATIONS (MICROCURIES/CUB
     1IC CENTIMETER).'/
     2'0',25X,'SOLUBLE',18X,'INSOLUBLE'/' ',6X,'NUCLIDE',2(5X,'INHALATIO
     3N  INGESTION')/' ',7X,'INDEX')
      DO 140 I=1,NRNUC
      WRITE(6,3030)NONUC(I),((XMPC(I,J,K),J=1,2),K=1,2)
 3030 FORMAT(' ',8X,I3,3X,2(2X,1P2E12.4))
  140 CONTINUE
  150 IF(INFLAG.EQ.0)GO TO 160
      WRITE(6,3031)AINTAK(1,1,1)
 3031 FORMAT('-THE INTAKE =',1PE11.4,' MICROCURIES/DAY FOR ALL RADIONUCL
     1IDES.')
      GO TO 180
  160 WRITE(6,3032)
 3032 FORMAT('-INTAKE.'/'0   NUCLIDE    AGE    NUMBER     TIME',11X,
     1'INTAKE'/'    INDEX    GROUP',14X,'(HR)       (MICROCURIES/DAY)')
      DO 170 I=1,NRNUC
      WRITE(6,3033)NONUC(I)
 3033 FORMAT(' ',5X,I3)
      DO 170 L=1,NAGE
      N=NPT(I,L)
```

```
      WRITE(6,3034)L,(J,TINTAK(I,L,J),AINTAK(I,L,J),J=1,N)
 3034 FORMAT(' ',14X,I2,6X,I3,1PE14.4,1PE16.4/(' ',22X,I3,1PE14.4,1PE16.
     14))
  170 CONTINUE
  180 RETURN
      END


      SUBROUTINE OUTPUT
C  THIS SUBROUTINE LISTS THE OUTPUT DATA FOR INREM.
C
C IN CHANGING DIMENSIONS, THE FOLLOWING CONDITIONS MUST BE SATISFIED.
C     COMMON /OUTONE/ORGAN(MAXORG+1,2),RADNUC(MAXNUC),IDATA(MAXNUC,
C    1MAXORG+2,2),NONUC(MAXNUC),JORGAN,IC,A(20)
C     COMMON /PARM/FRACT(MAXNUC,MAXORG,MAXAGE,2),GIFRAC(MAXNUC,MAXAGE,
C    12,2),DECAY(MAXNUC,MAXORG,MAXAGE),ENERGY(MAXNUC,MAXORG,MAXAGE),
C    2GIENER(MAXNUC,MAXAGE,2),GIDOSE(MAXNUC,2,2),GIMASS(4,MAXAGE),
C    3XMPC(MAXNUC,2,2),DOSE(MAXNUC,MAXORG,2),AOW(2,MAXAGE),XMASS(MAXORG,
C    4MAXAGE),JSOL(MAXNUC),JINSOL(MAXNUC),ILUNG,INFLAG,IORGAN,ITRACT,
C    5NRNUC
C     DIMENSION TOTAL(MAXORG-2)
C
      COMMON /OUTONE/ORGAN(12,2),RADNUC( 10),IDATA( 10,13,2)
     1,NONUC( 10),JORGAN,IC,A(20)
      COMMON /OUTTWO/AGEDET,T1,T2,XIN,XOUT,NDETON
      COMMON/PARM/FRACT( 10,11,25,2),GIFRAC( 10,25,2,2),DECAY( 10,11,25)
     1,ENERGY( 10,11,25),GIENER( 10,25,2),GIDOSE( 10,2,2),GIMASS(4,25)
     2,XMPC( 10,2,2),DOSE( 10,11,2),AOW(2,25),XMASS(11,25),JSOL( 10)
     3,JINSOL( 10),ILUNG,INFLAG,IORGAN,ITRACT,NRNUC
      REAL*8 ORGAN,RADNUC
C **** IL DETERMINES THE NUMBER OF LINES PRINTED ON EACH PAGE.
      INTEGER IL/55/
      REAL TEST/1.0E-06/,DATA/'DATA'/,BLANK/'    '/
      REAL FMT(42)/'(1H ',',I3,','2X,A','8,I5',',2X '/
      REAL F(8)/',E12','.3  ',',6H ','  NO',' ,A4',',2X ',')   ',',5X '/
      DIMENSION TOTAL(9)
C
      IF(ITRACT.EQ.1)GO TO 6
C **** IF THE CALCULATED DOSE IS LESS THAN TEST, THEN LET DOSE = 0.0.
      DO 5 I=1,NRNUC
      DO 5 ITYPE=1,2
      DO 5 K=1,IORGAN
      IF(DOSE(I,K,ITYPE).LT.TEST)DOSE(I,K,ITYPE)=0.0
    5 CONTINUE
      IF(ITRACT.EQ.0)GO TO 12
    6 DO 10 I=1,NRNUC
      DO 10 ITYPE=1,2
      DO 10 JJ=1,2
      IF(GIDOSE(I,ITYPE,JJ).LT.TEST)GIDOSE(I,ITYPE,JJ)=0.0
   10 CONTINUE
   12 PERIOD=T2-T1
      DELX=XOUT-XIN
C **** ITYPE = 1 MEANS INHALATION,
C       ITYPE = 2 MEANS INGESTION.
      DO 500 ITYPE=1,2
      WRITE(6,2000)(A(I),I=1,20)
 2000 FORMAT(1H1,25X,20A4//)
      GO TO (18,20),ITYPE
   18 WRITE(6,2001)
```

```
 2001 FORMAT(1H ,38X,'DOSE COMMITMENT (REMS) FROM INHALATION OF RADIONUC
     1LIDES')
      GO TO 25
   20 WRITE(6,2002)
 2002 FORMAT(1H ,38X,'DOSE COMMITMENT (REMS) FROM INGESTION OF RADIONUCL
     1IDES')
   25 WRITE(6,2003)NDETON
 2003 FORMAT('ONUMBER OF THE REFERENCE DETONATION = ',I2,' .')
      WRITE(6,2004)AGEDET
 2004 FORMAT(' AGE OF THE INDIVIDUAL AT TIME OF DETONATION = ',F6.3,' YE
     1ARS.')
      WRITE(6,2005) XIN
 2005 FORMAT(' TIME AFTER DETONATION WHEN INTAKE BEGINS = ',F6.3,
     1' YEARS.')
      WRITE(6,2006) XOUT
 2006 FORMAT(' TIME AFTER DETONATION WHEN INTAKE ENDS = ',F6.3,
     1' YEARS.')
      WRITE(6,2007) DELX
 2007 FORMAT(' DURATION OF THE INTAKE PERIOD = ',F6.3,' YEARS.')
      WRITE(6,2008)T1
 2008 FORMAT(' TIME AFTER DETONATION WHEN DOSE INTEGRATION BEGINS = ',F6
     1.3,' YEARS.')
      WRITE(6,2009)T2
 2009 FORMAT(' TIME AFTER DETONATION WHEN DOSE INTEGRATION ENDS = ',F6.3
     1,' YEARS.')
      WRITE(6,2010)PERIOD
 2010 FORMAT(' DURATION OF DOSE INTEGRATION = ',F6.3,' YEARS.'//)
      LINE=19
      GO TO (30,30,30,30,60,170,110),IC
C
C **** OUTPUT FOR ALL ORGANS EXCEPT LUNGS AND G.I. TRACT.
   30 CONTINUE
      KK=1
      KKK=JORGAN
      LINE=17
      WRITE(6,2011)((ORGAN(K,J),J=1,2),K=KK,KKK)
 2011 FORMAT('0NO.   NUCLIDE   LABEL   ',9(2X,2A5))
      DO 55 K=KK,KKK
      TOTAL(K)=0.0
      DO 55 I=1,NRNUC
   55 TOTAL(K)=TOTAL(K)+DOSE(I,K,ITYPE)
      DO 50 I=1,NRNUC
      DO 33 J=6,42
   33 FMT(J)=BLANK
      L=5
      DO 35 K=KK,KKK
      CALL FMTGEN(FMT,F,DOSE(I,K,ITYPE),DATA,IDATA(I,K,ITYPE),L)
   35 CONTINUE
      L=L+1
      FMT(L)=F(7)
      WRITE(6,FMT)I,RADNUC(I),NONUC(I),(DOSE(I,K,ITYPE),K=KK,KKK)
      LINE=LINE+1
      IF(LINE.LT.IL)GO TO 50
      WRITE(6,3000)
      WRITE(6,2011)((ORGAN(K,J),J=1,2),K=KK,KKK)
      LINE=2
   50 CONTINUE
      WRITE(6,2013)(TOTAL(K),K=KK,KKK)
 2013 FORMAT(1H0,5X,'TOTAL',10X,9E12.3)
      GO TO (58,500,165,108),IC
```

```
   58 WRITE(6,3000)
 3000 FORMAT(1H1)
      LINE=4
C
C **** OUTPUT FOR LUNGS AND G.I. TRACT.
   60 GO TO (63,85),ITYPE
   63 WRITE(6,2017)(ORGAN(ILUNG,J),J=1,2),(ORGAN(ITRACT,J),J=1,2)
 2017 FORMAT(1H0,31X,2A5,16X,2A5//' NO.   NUCLIDE   LABEL',4X,2('SOLUBLE
     1    INSOLUBLE',8X))
      K=0
      DO 75 L=ILUNG,IORGAN
      K=K+1
      TOTAL(K)=0.0
      DO 75 I=1,NRNUC
   75 TOTAL(K)=TOTAL(K)+DOSE(I,L,ITYPE)
      KT=ITRACT-1
      DO 80 J=1,2
      K=K+1
      KT=KT+1
      TOTAL(K)=0.0
      DO 80 I=1,NRNUC
      IF(IDATA(I,KT,ITYPE).EQ.0)GO TO 80
      TOTAL(K)=TOTAL(K)+GIDOSE(I,ITYPE,J)
   80 CONTINUE
      DO 70 I=1,NRNUC
      DO 65 J=6,42
   65 FMT(J)=BLANK
      L=5
      DO 66 K=ILUNG,IORGAN
   66 CALL FMTGEN(FMT ,F,DOSE(I,K,ITYPE),DATA,IDATA(I,K,ITYPE),L)
      L=L+1
      FMT(L)=F(8)
      K=ITRACT-1
      DO 68 J=1,2
      K=K+1
   68 CALL FMTGEN(FMT ,F,GIDOSE(I,ITYPE,J),DATA,IDATA(I,K,ITYPE),L)
      L=L+1
      FMT(L)=F(7)
      WRITE(6,FMT) I,RADNUC(I),NONUC(I),(DOSE(I,K,ITYPE),K=ILUNG,IORGAN)
     1,(GIDOSE(I,ITYPE,J),J=1,2)
      LINE=LINE+1
      IF(LINE.LT.IL)GO TO 70
      WRITE(6,3000)
      WRITE(6,2017)(ORGAN(ILUNG,L),L=1,2),(ORGAN(ITRACT,L),L=1,2)
      LINE=4
   70 CONTINUE
      WRITE(6,2019)(TOTAL(K),K=1,4)
 2019 FORMAT(1H0,5X,'TOTAL',10X,2(2E12.3,5X))
      GO TO 500
   85 WRITE(6,2020)(ORGAN(ILUNG,L),L=1,2),(ORGAN(ITRACT,L),L=1,2)
 2020 FORMAT(1H0,23X,2A5,12X,2A5//' NO.   NUCLIDE   LABEL',4X,'SOLUBLE',10
     1X,'SOLUBLE',5X,'INSOLUBLE')
      K=1
      TOTAL(K)=0.0
      DO 95 I=1,NRNUC
   95 TOTAL(K)=TOTAL(K)+DOSE(I,ILUNG,ITYPE)
      KT=ITRACT-1
      DO 100 J=1,2
      K=K+1
      KT=KT+1
```

```
      TOTAL(K)=0.0
      DO 100 I=1,NRNUC
      IF(IDATA(I,KT,ITYPE).EQ.0)GO TO 100
      TOTAL(K)=TOTAL(K)+GIDOSE(I,ITYPE,J)
  100 CONTINUE
      DO 90 I=1,NRNUC
      DO 87 J=6,42
   87 FMT(J)=BLANK
      L=5
      K=ILUNG
      CALL FMTGEN(FMT ,F,DOSE(I,K,ITYPE),DATA,IDATA(I,K,ITYPE),L)
      L=L+1
      FMT(L)=F(8)
      K=ITRACT-1
      DO 88 J=1,2
      K=K+1
   88 CALL FMTGEN(FMT,F,GIDOSE(I,ITYPE,J),DATA,IDATA(I,K,ITYPE),L)
      L=L+1
      FMT(L)=F(7)
      WRITE(6,FMT) I,RADNUC(I),NONUC(I),DOSE(I,ILUNG,ITYPE),(GIDOSE(I,
     1ITYPE,J),J=1,2)
      LINE=LINE+1
      IF(LINE.LT.IL)GO TO 90
      WRITE(6,3000)
      WRITE(6,2020)(ORGAN(ILUNG,L),L=1,2),(ORGAN(ITRACT,L),L=1,2)
      LINE=4
   90 CONTINUE
      WRITE(6,2022)(TOTAL(K),K=1,3)
 2022 FORMAT(1H0,5X,'TOTAL',10X,E12.3,5X,2E12.3)
      GO TO 500
  108 WRITE(6,3000)
C
C **** OUTPUT FOR LUNGS ONLY.
  110 GO TO (115,140),ITYPE
C **** INHALATION.
  115 WRITE(6,2023)(ORGAN(ILUNG,L),L=1,2)
 2023 FORMAT(1H0,31X,2A5//' NO.   NUCLIDE   LABEL',4X,'SOLUBLE      INSOLUB
     1LE')
      K=0
      DO 135 L=ILUNG,IORGAN
      K=K+1
      TOTAL(K)=0.0
      DO 135 I=1,NRNUC
  135 TOTAL(K)=TOTAL(K)+DOSE(I,L,ITYPE)
      DO 130 I=1,NRNUC
      DO 120 J=6,42
  120 FMT(J)=BLANK
      L=5
      DO 125 K=ILUNG,IORGAN
      CALL FMTGEN(FMT,F,DOSE(I,K,ITYPE),DATA,IDATA(I,K,ITYPE),L)
  125 CONTINUE
      L=L+1
      FMT(L)=F(7)
      WRITE(6,FMT)I,RADNUC(I),NONUC(I),(DOSE(I,K,ITYPE),K=ILUNG,IORGAN)
      LINE=LINE+1
      IF(LINE.LT.IL)GO TO 130
      WRITE(6,3000)
      WRITE(6,2023)(ORGAN(ILUNG,L),L=1,2)
      LINE=4
  130 CONTINUE
```

```
      WRITE(6,2019)(ITOTAL(K),K=1,2)                                    OUTP2320
      GO TO 500                                                         OUTP2330
C **** INGESTION.                                                       OUTP2340
  140 WRITE(6,2024)(ORGAN(ILUNG,L),L=1,2)                               OUTP2350
 2024 FORMAT(1H0,23X,2A5//' NO.  NUCLIDE  LABEL',4X,'SOLUBLE')          OUTP2360
      K=1                                                               OUTP2370
      TOTAL(K)=0.0                                                      OUTP2380
      DO 155 I=1,NRNUC                                                  OUTP2390
  155 TOTAL(K)=TOTAL(K)+DOSE(I,ILUNG,ITYPE)                             OUTP2400
      DO 150 I=1,NRNUC                                                  OUTP2410
      DO 145 J=6,42                                                     OUTP2420
  145 FMT(J)=BLANK                                                      OUTP2430
      L=5                                                               OUTP2440
      K=ILUNG                                                           OUTP2450
      CALL FMTGEN(FMT,F,DOSE(I,K,ITYPE),DATA,IDATA(I,K,ITYPE),L)        OUTP2460
      L=L+1                                                             OUTP2470
      FMT(L)=F(7)                                                       OUTP2480
      WRITE(6,FMT)I,RADNUC(I),NONUC(I),DOSE(I,ILUNG,ITYPE)              OUTP2490
      LINE=LINE+1                                                       OUTP2500
      IF(LINE.LT.IL)GO TO 150                                           OUTP2510
      WRITE(6,3000)                                                     OUTP2520
      WRITE(6,2024)(ORGAN(ILUNG,L),L=1,2)                               OUTP2530
      LINE=4                                                            OUTP2540
  150 CONTINUE                                                          OUTP2550
      WRITE(6,2022)TOTAL(1)                                             OUTP2560
      GO TO 500                                                         OUTP2570
  165 WRITE(6,3000)                                                     OUTP2580
C                                                                       OUTP2590
C **** OUTPUT FOR G.I. TRACT ONLY.                                      OUTP2600
  170 WRITE(6,2025)(ORGAN(ITRACT,L),L=1,2)                              OUTP2610
 2025 FORMAT(1H0,28X,2A5/'0NO.  NUCLIDE  LABEL',4X,'SOLUBLE     INSOLUBLOUTP2620
     1E')                                                               OUTP2630
      K=0                                                               OUTP2640
      KT=ITRACT-1                                                       OUTP2650
      DO 190 J=1,2                                                      OUTP2660
      K=K+1                                                             OUTP2670
      KT=KT+1                                                           OUTP2680
      TOTAL(K)=0                                                        OUTP2690
      DO 190 I=1,NRNUC                                                  OUTP2700
      IF(IDATA(I,KT,ITYPE).EQ.0)GO TO 190                               OUTP2710
      TOTAL(K)=TOTAL(K)+GIDOSE(I,ITYPE,J)                               OUTP2720
  190 CONTINUE                                                          OUTP2730
      DO 185 I=1,NRNUC                                                  OUTP2740
      DO 175 J=6,42                                                     OUTP2750
  175 FMT(J)=BLANK                                                      OUTP2760
      L=5                                                               OUTP2770
      K=ITRACT-1                                                        OUTP2780
      DO 180 J=1,2                                                      OUTP2790
      K=K+1                                                             OUTP2800
      CALL FMTGEN(FMT,F,GIDOSE(I,ITYPE,J),DATA,IDATA(I,K,ITYPE),L)      OUTP2810
  180 CONTINUE                                                          OUTP2820
      L=L+1                                                             OUTP2830
      FMT(L)=F(7)                                                       OUTP2840
      WRITE(6,FMT)I,RADNUC(I),NONUC(I),(GIDOSE(I,ITYPE,J),J=1,2)        OUTP2850
      LINE=LINE+1                                                       OUTP2860
      IF(LINE.LT.IL)GO TO 185                                           OUTP2870
      WRITE(6,3000)                                                     OUTP2880
      WRITE(6,2025)(ORGAN(ITRACT,L),L=1,2)                              OUTP2890
      LINE=4                                                            OUTP2900
  185 CONTINUE                                                          OUTP2910
```

```
      WRITE(6,2019)(TOTAL(K),K=1,2)
  500 CONTINUE
      RETURN
      END


      SUBROUTINE FMTGEN(FMT,F,DOSE,DATA,IDATA,L)
C  THIS SUBROUTINE GENERATES THE FORMAT FOR THE LISTING OF THE OUTPUT
C      ARRAYS.
C
      DIMENSION FMT(1),F(1)
      IF(IDATA.EQ.0)GO TO 10
      DO 5 I=1,2
      L=L+1
    5 FMT(L)=F(I)
      RETURN
   10 DOSE=DATA
      DO 15 I=3,6
      L=L+1
   15 FMT(L)=F(I)
      RETURN
      END


      SUBROUTINE CALCUL
C
C  THIS SUBROUTINE CALCULATES THE ACCUMULATED DOSAGE IN ALL ORGANS FOR
C      BOTH TIME INDEPENDENT AND TIME DEPENDENT ORGANS.
C
C IN CHANGING DIMENSIONS, THE FOLLOWING CONDITIONS MUST BE SATISFIED.
C      COMMON /PARM/FRACT(MAXNUC,MAXORG,MAXAGE,2),GIFRAC(MAXNUC,MAXAGE,
C     12,2),DECAY(MAXNUC,MAXORG,MAXAGE),ENERGY(MAXNUC,MAXORG,MAXAGE),
C     2GIENER(MAXNUC,MAXAGE,2),GIDOSE(MAXNUC,2,2),GIMASS(4,MAXAGE),
C     3XMPC(MAXNUC,2,2),DOSE(MAXNUC,MAXORG,2),AOW(2,MAXAGE),XMASS(MAXORG,
C     4MAXAGE),JSOL(MAXNUC),JINSOL(MAXNUC),ILUNG,INFLAG,NORGAN,ITRACT,
C     5NRNUC
C      COMMON /AGEPAR/AGE(MAXAGE+1),AGEGP(MAXAGE+1),LOAGE,MAGE,NAGE
C      COMMON /TABLE/TINTAK(MAXNUC,MAXAGE,MAXIN),AINTAK(MAXNUC,MAXAGE,
C     1MAXIN),NPT(MAXNUC,MAXAGE)
C      DIMENSION C(MAXNUC,MAXORG+1,MAXAGE),CON(MAXNUC,MAXORG+1,MAXAGE,2),
C     1FUDGEF(MAXNUC,MAXAGE,2,2),DELTAT(MAXAGE),R(151),G(201),NA(151)
C
      COMMON/PARM/FRACT( 10,11,25,2),GIFRAC( 10,25,2,2),DECAY( 10,11,25)
     1,ENERGY( 10,11,25),GIENER( 10,25,2),GIDOSE( 10,2,2),GIMASS(4,25)
     2,XMPC( 10,2,2),DOSE( 10,11,2),AOW(2,25),XMASS(11,25),JSOL( 10)
     3,JINSOL( 10),ILUNG,INFLAG,NORGAN,ITRACT,NRNUC
      COMMON /AGEPAR/AGE(26),AGEGP(26),LOAGE,MAGE,NAGE
      COMMON /XAGE/T(3),NT,TBORN
      COMMON /TABLE/TINTAK( 10,25,100),AINTAK( 10,25,100),NPT( 10,25)
      DIMENSION C( 10,12,25),CON( 10,12,25,2),FUDGEF( 10,25,2,2),
     1DELTAT(25),R(151),G(201),NA(151)
      DATA CGI/.42857143E-1/
      INTEGER MAXM/151/
      LOGICAL FIX,VAR
C
      FIX=.FALSE.
      VAR=.FALSE.
C **** CONVERT AGE GROUP DIVISION FROM YEARS TO DAYS.
```

```
      NAGEP1=NAGE+1
      DO 5 L=1,NAGEP1
    5 AGE(L)=365.00*AGE(L)
      IF(NORGAN.EQ.0)GO TO 15
C **** CONVERT EFFECTIVE HALF-TIME TO EFFECTIVE ELIMINATION CONSTANT.
      II=NORGAN
      IF(ILUNG.NE.0)II=ILUNG
      DO 10 I=1,NRNUC
      DO 10 L=1,NAGE
      DO 10 K=1,II
      IF(DECAY(I,K,L).EQ.0.0)GO TO 10
      DECAY(I,K,L)=0.6931472/DECAY(I,K,L)
   10 CONTINUE
   15 IF(ITRACT.EQ.0)RETURN
C  CALCULATE CONSTANTS TO BE USED WITH G.I. TRACT.
      IF(NAGE.EQ.1)GO TO 60
      NAGEM1=NAGE-1
C **** FOR SOLUBLE RADIONUCLIDES.
      DO 35 I=1,NRNUC
      K=JSOL(I)
      DO 35 L=1,NAGEM1
      TEMP=GIMASS(K,L)*GIENER(I,NAGE,1)
      IF(TEMP.NE.0.0)GO TO 20
      FUDGE=0.0
      GO TO 25
   20 FUDGE=(GIMASS(K,NAGE)*GIENER(I,L,1))/TEMP
   25 DO 35 J=1,2
      TEMP=GIFRAC(I,NAGE,J,1)*AOW(J,NAGE)
      IF(TEMP.NE.0.0)GO TO 30
      FUDGEF(I,L,J,1)=0.0
      GO TO 35
   30 FUDGEF(I,L,J,1)=(FUDGE*GIFRAC(I,L,J,1)*AOW(J,L))/TEMP
   35 CONTINUE
C **** FOR INSOLUBLE RADIONUCLIDES.
      DO 55 I=1,NRNUC
      K=JINSOL(I)
      DO 55 L=1,NAGEM1
      TEMP=GIMASS(K,L)*GIENER(I,NAGE,2)
      IF(TEMP.NE.0.0)GO TO 40
      FUDGE=0.0
      GO TO 45
   40 FUDGE=(GIMASS(K,NAGE)*GIENER(I,L,2))/TEMP
   45 DO 55 J=1,2
      TEMP=GIFRAC(I,NAGE,J,2)*AOW(J,NAGE)
      IF(TEMP.NE.0.0)GO TO 50
      FUDGEF(I,L,J,2)=0.0
      GO TO 55
   50 FUDGEF(I,L,J,2)=(FUDGE*GIFRAC (I,L,J,2)*AOW(J,L))/TEMP
   55 CONTINUE
   60 DO 65 I=1,NRNUC
      DO 65 J=1,2
      DO 65 JJ=1,2
   65 FUDGEF(I,NAGE,J,JJ)=1.0
      RETURN
C ********************************************************************
      ENTRY CALC
      MOAGE=MAGE-1
      IF(LOAGE.LT.MOAGE .OR. INFLAG.EQ.0)GO TO 200
C **** CALCULATE ACCUMULATED DOSAGE FOR TIME-INDEPENDENT CASES.
      IF(ITRACT.EQ.1)GO TO 115
```

```
C **** FOR ALL ORGANS EXCEPT THE G.I. TRACT.
      IF(FIX)GO TO 80
C **** CONSTANTS TO BE USED WITH TIME-INDEPENDENT CASES.
      FIX=.TRUE.
      DO 75 I=1,NRNUC
      DO 75 K=1,NORGAN
      DO 75 L=1,NAGE
      DO 75 J=1,2
      IF(XMASS(K,L).NE.0.0 .AND. DECAY(I,K,L).NE.0.0)GO TO 70
      CON(I,K,L,J)=0.0
      GO TO 75
   70 CON(I,K,L,J)=(51.0*FRACT(I,K,L,J)*ENERGY(I,K,L))/
     1(XMASS(K,L)*(DECAY(I,K,L)**2))
   75 CONTINUE
   80 IAGE=LOAGE
      DO 110 I=1,NRNUC
      DO 110 K=1,NORGAN
      X=DECAY(I,K,IAGE)*(T(2)-T(1))
      Y=DECAY(I,K,IAGE)*(T(3)-T(2))
      IF(X.LT.13.0)GO TO 85
      F=X-1.0
      GO TO 100
   85 IF(X.LE.1.0E-1)GO TO 90
      F=EXP(-X)+X-1.0
      GO TO 100
   90 IF(X.LE.1.0E-3)GO TO 95
      X2=X*X
      X3=X2*X
      X4=X3*X
      X5=X4*X
      F=X2/2.0+X4/24.0-X3/6.0-X5/120.0
      GO TO 100
   95 X2=X*X
      X3=X2*X
      F=X2/2.0-X3/6.0
  100 IF(Y.EQ.0)GO TO 105
      CALL EXFCT(Y,H)
      F=X*H+EXP(-Y)*F
  105 F=F*AINTAK(I,IAGE,1)
      DO 110 J=1,2
      DOSE(I,K,J)=F*CON(I,K,IAGE,J)
  110 CONTINUE
      IF(ITRACT.EQ.0)RETURN
C **** FOR THE G.I. TRACT.
  115 T2MT1=T(2)-T(1)
      DO 120 I=1,NRNUC
      DO 120 J=1,2
      DO 120 JJ=1,2
      TEMP=AOW(J,NAGE)*XMPC(I,J,JJ)
      IF(TEMP.EQ.0.0)GO TO 120
      GIDOSE(I,J,JJ)=CGI*AINTAK(I,IAGE,1)*T2MT1*FUDGEF(I,IAGE,J,JJ)/TEMP
  120 CONTINUE
      RETURN
C **** CALCULATE ACCUMULATED DOSAGE FOR TIME-DEPENDENT CASES.
  200 CONTINUE
      IF(ITRACT.EQ.1)GO TO 220
      IF(VAR)GO TO 220
C **** CONSTANTS TO BE USED WITH TIME-DEPENDENT CASES.
      VAR=.TRUE.
      DO 210 I=1,NRNUC
```

```
      DO 210 K=1,NORGAN                                                 CALC1550
      DO 210 L=1,NAGE                                                   CALC1560
      IF(XMASS(K,L).NE.0.0 .AND. DECAY(I,K,L).NE.0.0)GO TO 205         CALC1570
      C(I,K,L)=0.0                                                      CALC1580
      GO TO 210                                                         CALC1590
  205 C(I,K,L)=ENERGY(I,K,L)/(XMASS(K,L)*DECAY(I,K,L))                 CALC1600
  210 CONTINUE                                                          CALC1610
  220 CONTINUE                                                          CALC1620
      DO 500 I=1,NRNUC                                                  CALC1630
C **** FOR EACH RADIONUCLIDE, SET UP THE SUBINTERVALS OF INTEGRATION.   CALC1640
C         CHOOSE THE END POINTS FOR EACH SUBINTERVAL AS EITHER A POINT  CALC1650
C         WHERE THE INTAKE IS GIVEN OR WHERE THE ORGAN CHANGES AGE GROUPSCALC1660
      XL=T(1)                                                           CALC1670
      XU=T(2)                                                           CALC1680
C **** DETERMINE INDIVIDUAL'S AGE GROUP AT DESIRED INITIAL INTAKE.      CALC1690
      DO 230 L=2,NAGEP1                                                 CALC1700
      LLO=L-1                                                           CALC1710
      IF(XL.LT.AGEGP(L))GO TO 240                                       CALC1720
  230 CONTINUE                                                          CALC1730
C **** DETERMINE INDIVIDUAL'S AGE GROUP AT DESIRED FINAL INTAKE.        CALC1740
  240 DO 250 L=2,NAGEP1                                                 CALC1750
      LHI=L-1                                                           CALC1760
      IF(XU.LE.AGEGP(L))GO TO 260                                       CALC1770
  250 CONTINUE                                                          CALC1780
  260 LL=LLO                                                            CALC1790
C **** DETERMINE INDIVIDUAL'S AGE AND AGE GROUP AT INITIAL NON-ZERO     CALC1800
C         INTAKE.                                                       CALC1810
  270 IF(TINTAK(I,LL,1).LT.AGEGP(LL+1))GO TO 300                        CALC1820
      IF(LL.LT.NAGE)GO TO 290                                           CALC1830
  275 DO 280 K=1,NORGAN                                                 CALC1840
      DO 280 JP=1,2                                                     CALC1850
  280 DOSE(I,K,JP)=0.0                                                  CALC1860
      IF(ITRACT.EQ.0)GO TO 500                                          CALC1870
      DO 285 JP=1,2                                                     CALC1880
      DO 285 JJP=1,2                                                    CALC1890
  285 GIDOSE(I,JP,JJP)=0.0                                              CALC1900
      GO TO 500                                                         CALC1910
  290 LL=LL+1                                                           CALC1920
      XL=AGEGP(LL)                                                      CALC1930
      GO TO 270                                                         CALC1940
  300 XL=AMAX1(XL,TINTAK(I,LL,1))                                       CALC1950
      M=1                                                               CALC1960
      R(M)=XL                                                           CALC1970
      NA(M)=LL                                                          CALC1980
      N=NPT(I,LL)                                                       CALC1990
  310 DO 320 J=1,N                                                      CALC2000
      IF(R(M).LT.TINTAK(I,LL,J))GO TO 330                               CALC2010
  320 CONTINUE                                                          CALC2020
      NA(M)=-LL                                                         CALC2030
      M=M+1                                                             CALC2040
      IF(M.LE.MAXM)GO TO 325                                            CALC2050
      WRITE(6,1001)I,MAXM                                               CALC2060
 1001 FORMAT('1FOR THE ',I3,'TH RADIONUCLIDE, THE NUMBER OF SUBINTERVALSCALC2070
     1 IN THE INTERVAL OF INTEGRATION EXCEEDS ',I3,' .  EITHER MODIFY THCALC2080
     2E CORRESPONDING '/' INTAKE FUNCTION SO THAT THE INTAKE VALUES ARE CALC2090
     3SPECIFIED AT ABOUT THE SAME TIMES OR INCREASE THE VALUE OF MAXM ANCALC2100
     4D THE '/' DIMENSIONS OF R AND NA IN SUBROUTINE CALCUL.')          CALC2110
      GO TO 275                                                         CALC2120
  325 IF(LL.LT.LHI)GO TO 360                                            CALC2130
      M=M-1                                                             CALC2140
```

```
      NA(M)=0
      GO TO 400
  330 IJ=J-1
      IF(IJ.LT.1)NA(M)=-LL
  340 TEMP=TINTAK(I,LL,IJ+1)
      M=M+1
      IF(M.LE.MAXM)GO TO 345
      WRITE(6,1001)I,MAXM
      GO TO 275
  345 IF(TEMP.LT.XU)GO TO 350
      TEMP=XU
      IF(TEMP.GE.AGEGP(LL+1))GO TO 360
      R(M)=TEMP
      NA(M)=0
      GO TO 400
  350 IF(TEMP.LT.AGEGP(LL+1))GO TO 370
  360 LL=LL+1
      IF(LL.GT.LHI)GO TO 365
      R(M)=AGEGP(LL)
      NA(M)=LL
      GO TO 310
  365 R(M)=XU
      NA(M)=0
      GO TO 400
  370 R(M)=TEMP
      NA(M)=LL
      IJ=IJ+1
      IF(IJ.LT.NPT(I,LL))GO TO 340
      IF(LL.EQ.LHI)GO TO 380
      NA(M)=-LL
      M=M+1
      IF(M.LE.MAXM)GO TO 360
      WRITE(6,1001)I,MAXM
      GO TO 275
  380 XU=R(M)
      NA(M)=0
  400 CONTINUE
      MM1=M-1
C **** MM = NUMBER OF SUBINTERVALS WITH NON-ZERO INTAKE.
      MM=0
      DO 405 IA=1,MM1
      IF(NA(IA).LE.0)GO TO 405
      MM=MM+1
  405 CONTINUE
      IF(MM.LE.50)GO TO 410
C **** MAXINT = MAXIMUM NUMBER OF INTERVALS IN EACH SUBINTERVAL OF
C         INTEGRATION.
      MAXINT=2
      GO TO 415
  410 MAXINT=2*(100/MM)
      IF(ITRACT.EQ.1)GO TO 600
C **** FOR ALL ORGANS EXCEPT THE G.I. TRACT.
  415 DO 495 K=1,NORGAN
      SUM1=0.0
      SUM2=0.0
      DO 490 IM=1,MM1
C **** FOR THE IMTH SUBINTERVAL OF INTEGRATION.
      IF(NA(IM).LE.0)GO TO 490
C **** CALCULATE NUMBER OF INTERVALS.
      DELTAR=R(IM+1)-R(IM)
```

```
      IF(DELTAR.GE.200.0)GO TO 420
      DEL=1.0
      GO TO 455
  420 IF(DELTAR.GE.400.0)GO TO 425
      DEL=2.0
      GO TO 455
  425 IF(DELTAR.GE.800.0)GO TO 430
      DEL=4.0
      GO TO 455
  430 IF(DELTAR.GE.1600.0)GO TO 435
      DEL=8.0
      GO TO 455
  435 IF(DELTAR.GE.3200.0)GO TO 440
      DEL=16.0
      GO TO 455
  440 IF(DELTAR.GE.6400.0)GO TO 445
      DEL=32.0
      GO TO 455
  445 IF(DELTAR.GE.12800.0)GO TO 450
      DEL=64.0
      GO TO 455
  450 DEL=128.0
  455 NINT=2*IFIX(DELTAR/(2.0*DEL))
      NINT=MIN0(NINT,MAXINT)
C **** NINT = NUMBER OF INTERVALS.
      NINT=MAX0(NINT,2)
      NPTS=NINT+1
C **** DELR = LENGTH OF THE INTERVALS.
      DELR=DELTAR/NINT
      L=NA(IM)
      X=R(IM)
      N=NPT(I,L)
C **** BRACKET THE INTAKE FOR THE LOWER END POINT OF THE SUBINTERVAL.
      DO 460 IN=2,N
      INP1=IN
      IF(X.LT.TINTAK(I,L,IN))GO TO 465
  460 CONTINUE
  465 IN=INP1-1
      LP1=L+1
      IF(L.GE.MOAGE)GO TO 472
      DO 470 IL=LP1,MOAGE
  470 DELTAT(IL)=AGEGP(IL+1)-AGEGP(IL)
  472 FACTOR=(AINTAK(I,L,INP1)-AINTAK(I,L,IN))/(TINTAK(I,L,INP1)-
     1TINTAK(I,L,IN))
      DO 485 II=1,NPTS
C **** DETERMINE INTAKE AT EACH POINT.
      DOSEIN=AINTAK(I,L,IN)+FACTOR*(X-TINTAK(I,L,IN))
      DELTAT(L)=AGEGP(LP1)-X
      EXPON=DECAY(I,K,L)*DELTAT(L)
      CALL EXFCT(EXPON,FCT)
      G(II)=C(I,K,L)*FCT
      IF(L.EQ.MOAGE)GO TO 480
      Z=0.0
      DO 475 IL=LP1,MOAGE
      Z=Z+EXPON
      EXPON=DECAY(I,K,IL)*DELTAT(IL)
      CALL EXFCT(EXPON,FCT)
  475 G(II)=G(II)+C(I,K,IL)*FCT*EXP(-Z)
  480 G(II)=G(II)*DOSEIN
  485 X=R(IM)+FLOAT(II)*DELR
```

```
      CALL SIMP(DELR,G,NPTS,DOS)                                        CALC3350
      SUM1=SUM1+DOS*FRACT(I,K,L,1)                                      CALC3360
      SUM2=SUM2+DOS*FRACT(I,K,L,2)                                      CALC3370
  490 CONTINUE                                                          CALC3380
      DOSE(I,K,1)=51.0*SUM1                                             CALC3390
      DOSE(I,K,2)=51.0*SUM2                                             CALC3400
  495 CONTINUE                                                          CALC3410
      IF(ITRACT.EQ.0)GO TO 500                                          CALC3420
C **** FOR THE G.I. TRACT.                                              CALC3430
  600 DO 610 J=1,2                                                      CALC3440
      DO 610 JJ=1,2                                                     CALC3450
  610 GIDOSE(I,J,JJ)=0.0                                                CALC3460
      DO 650 IM=1,MM1                                                   CALC3470
C **** FOR THE IMTH SUBINTERVAL OF INTEGRATION.                         CALC3480
      IF(NA(IM).LE.0)GO TO 650                                          CALC3490
      L=NA(IM)                                                          CALC3500
      X=R(IM)                                                           CALC3510
      IMP1=IM+1                                                         CALC3520
      N=NPT(I,L)                                                        CALC3530
C **** BRACKET THE INTAKE FOR THE LOWER END POINT OF THE SUBINTERVAL.   CALC3540
      DO 620 IN=2,N                                                     CALC3550
      INP1=IN                                                           CALC3560
      IF(X.LT.TINTAK(I,L,IN))GO TO 630                                  CALC3570
  620 CONTINUE                                                          CALC3580
  630 IN=INP1-1                                                         CALC3590
C **** DETERMINE INTAKE AT END POINTS OF THE SUBINTERVAL.               CALC3600
      FACTOR=(AINTAK(I,L,INP1)-AINTAK(I,L,IN))/(TINTAK(I,L,INP1)-       CALC3610
     1TINTAK(I,L,IN))                                                   CALC3620
      AIN1=AINTAK(I,L,IN)+FACTOR*(X-TINTAK(I,L,IN))                     CALC3630
      AIN2=AINTAK(I,L,IN)+FACTOR*(R(IM+1)-TINTAK(I,L,IN))               CALC3640
C **** INTEGRATE (TRAPEZOIDAL).                                         CALC3650
      DOS=(R(IM+1)-R(IM))*(AIN1+AIN2)                                   CALC3660
      DO 640 J=1,2                                                      CALC3670
      DO 640 JJ=1,2                                                     CALC3680
  640 GIDOSE(I,J,JJ)=GIDOSE(I,J,JJ)+DOS*FUDGEF(I,L,J,JJ)                CALC3690
  650 CONTINUE                                                          CALC3700
      FACTOR=0.5*CGI                                                    CALC3710
      DO 660 J=1,2                                                      CALC3720
      DO 660 JJ=1,2                                                     CALC3730
  660 GIDOSE(I,J,JJ)=(FACTOR*GIDOSE(I,J,JJ))/(AOW(J,NAGE)*XMPC(I,J,JJ)) CALC3740
  500 CONTINUE                                                          CALC3750
      RETURN                                                            CALC3760
      END                                                               CALC3770


      SUBROUTINE CALAGE(AGEIN,AGEDIE)                                   CALA0010
C  THIS SUBROUTINE CALCULATES AGE GROUPS OF ORGANS FOR THE ACCUMULATED  CALA0020
C        DOSAGE INTERVAL.                                               CALA0030
C                                                                       CALA0040
C IN CHANGING DIMENSIONS, THE FOLLOWING CONDITIONS MUST BE SATISFIED.   CALA0050
C     COMMON /AGEPAR/AGE(MAXAGE+1),AGEGP(MAXAGE+1),LOAGE,MAGE,NAGE      CALA0060
C                                                                       CALA0070
      COMMON /AGEPAR/AGE(26),AGEGP(26),LOAGE,MAGE,NAGE                  CALA0080
      IF(NAGE.GT.1)GO TO 1                                              CALA0090
      LOAGE=1                                                           CALA0100
      MAGE=2                                                            CALA0110
      GO TO 22                                                          CALA0120
    1 MAGE=NAGE                                                         CALA0130
      DO 5 I=2,NAGE                                                     CALA0140
```

```
      IF(AGEIN.LT.AGE(I))GO TO 10
    5 MAGE=MAGE-1
   10 LOAGE=NAGE-MAGE+1
      MAGE=1
      L=LOAGE+1
      DO 15 I=L,NAGE
      IF(AGEDIE.LE.AGE(I))GO TO 20
   15 MAGE=MAGE+1
   20 MAGE=LOAGE+MAGE
   22 K=MAGE-1
      AGEGP(LOAGE)=AGEIN
      IF(K.EQ.LOAGE)GO TO 30
      DO 25 I=L,K
   25 AGEGP(I)=AGE(I)
   30 AGEGP(MAGE)=AGEDIE
      RETURN
      END


      SUBROUTINE EXFCT(X,F)
C  THIS SUBROUTINE EVALUATES THE FUNCTION (1.0-EXP(-X)).
      IF(X.LT.17.0)GO TO 1
      F=1.0
      RETURN
    1 IF(X.LE.1.0E-2)GO TO 2
      F=1.0-EXP(-X)
      RETURN
    2 X2=X*X
      X3=X2*X
      F=X+X3/6.0-X2/2.0
      RETURN
      END


      SUBROUTINE AMTIN(INFLAG,NRNUC,MAXIN)
C **** THIS ROUTINE READS AND DEVELOPS THE INTAKE FUNCTIONS.
C **** THIS ROUTINE ASSUMES THAT THE DAILY INTAKE DEPENDS ON THE
C         NUCLIDE, AGE OF THE ORGAN AND TIME AFTER REFERENCE DETONATION.
C IN CHANGING DIMENSIONS, THE FOLLOWING CONDITIONS MUST BE SATISFIED.
C     COMMON /AGEPAR/AGE(MAXAGE+1),AGEGP(MAXAGE+1),LOAGE,MAGE,NAGE
C     COMMON /TABLE/TINTAK(MAXNUC,MAXAGE,MAXIN),AINTAK(MAXNUC,MAXAGE,
C    1MAXIN),NPT(MAXNUC,MAXAGE)
C
      COMMON /AGEPAR/AGE(26),AGEGP(26),LOAGE,MAGE,NAGE
      COMMON /XAGE/T(3),NT,TBORN
      COMMON /TABLE/TINTAK( 10,25,100),AINTAK( 10,25,100),NPT( 10,25)
      REAL DOSIN /1.0/
C **** READ OR DEVELOP THE INTAKE FUNCTION.
      IF(INFLAG.EQ.0)GO TO 10
      DO 5 I=1,NRNUC
      DO 5 L=1,NAGE
      NPT(I,L)=1
    5 AINTAK(I,L,1)=DOSIN
      GO TO 30
   10 DO 15 I=1,NRNUC
   15 READ(5,1001)(NPT(I,L),L=1,NAGE)
 1001 FORMAT(14I5)
      DO 20 I=1,NRNUC
```

```
      DO 20 L=1,NAGE                                                    AMTI0250
      N=NPT(I,L)                                                        AMTI0260
      IF(N.LE.MAXIN)GO TO 20                                            AMTI0270
      WRITE(6,9004)I,L,MAXIN                                            AMTI0280
 9004 FORMAT('1THE NUMBER OF INTAKE ENTRIES FOR THE ',I3,'TH RADIONUCLIDAMTI0290
     1E AND THE ',I2,'TH AGE GROUP EXCEEDS ',I3)                        AMTI0300
      STOP                                                              AMTI0310
   20 READ(5,1002)(TINTAK(I,L,J),J=1,N)                                 AMTI0320
 1002 FORMAT(7E10.0)                                                    AMTI0330
      DO 25 I=1,NRNUC                                                   AMTI0340
      DO 25 L=1,NAGE                                                    AMTI0350
      N=NPT(I,L)                                                        AMTI0360
   25 READ(5,1002)(AINTAK(I,L,J),J=1,N)                                 AMTI0370
   30 DO 35 I=1,NRNUC                                                   AMTI0380
      DO 35 L=1,NAGE                                                    AMTI0390
      N=NPT(I,L)                                                        AMTI0400
      IF(NPT(I,L).GT.1)GO TO 35                                         AMTI0410
      NPT(I,L)=2                                                        AMTI0420
      TINTAK(I,L,1)=0.0                                                 AMTI0430
      TINTAK(I,L,2)=36500.0                                             AMTI0440
      AINTAK(I,L,2)=AINTAK(I,L,1)                                       AMTI0450
   35 CONTINUE                                                          AMTI0460
      RETURN                                                            AMTI0470
C ***********************************************************************AMTI0480
      ENTRY AMTIN1                                                      AMTI0490
      DO 50 I=1,NRNUC                                                   AMTI0500
      DO 50 L=1,NAGE                                                    AMTI0510
      N=NPT(I,L)                                                        AMTI0520
      DO 50 J=1,N                                                       AMTI0530
   50 TINTAK(I,L,J)=TINTAK(I,L,J)-TBORN                                 AMTI0540
      RETURN                                                            AMTI0550
C ***********************************************************************AMTI0560
      ENTRY AMTIN2                                                      AMTI0570
      DO 75 I=1,NRNUC                                                   AMTI0580
      DO 75 L=1,NAGE                                                    AMTI0590
      N=NPT(I,L)                                                        AMTI0600
      DO 75 J=1,N                                                       AMTI0610
   75 TINTAK(I,L,J)=TINTAK(I,L,J)+TBORN                                 AMTI0620
      RETURN                                                            AMTI0630
      END                                                               AMTI0640
```

```
      SUBROUTINE SIMP(DELX,F,N,D)                                       SIMP0010
C **** THIS ROUTINE IS SIMPSON'S INTEGRATION METHOD FOR EQUAL SPACING.  SIMP0020
C        DELX IS THE SPACING BETWEEN POINTS,                            SIMP0030
C        N     IS THE NUMBER OF POINTS (N MUST BE ODD AND GREATER THAN 2)SIMP0040
C        F     IS AN ARRAY CONTAINING THE INTEGRAND VALUES AT THE       SIMP0050
C              POINTS Y, Y+X, Y+2*X, Y+3*X, ... , Y+(N-1)*X , AND       SIMP0060
C        D     CONTAINS THE VALUE OF THE INTEGRAL FROM Y TO Y+(N-1)*X.  SIMP0070
C                                                                       SIMP0080
      DIMENSION F(1)                                                    SIMP0090
      G1=0.0                                                            SIMP0100
      G2=0.0                                                            SIMP0110
      DO 1 I=2,N,2                                                      SIMP0120
      G1=G1+F(I-1)+F(I+1)                                               SIMP0130
    1 G2=G2+F(I)                                                        SIMP0140
      D =((G1+4.0*G2)*DELX)/3.0                                         SIMP0150
      RETURN                                                            SIMP0160
      END                                                               SIMP0170
```

```
PGMM TITLE 'SUBROUTINE PGMMSK (I,J,K,L) -- TO SET PROGRAM MASK'
*      PROGRAM MASK SETTING ROUTINE
*
*      ACCEPTS CALLING SEQUENCE
*
*                CALL PGMMSK (IFXPTO,IDECO,IEXPU,ISIG)
*
*           A ZERO VALUE FOR ANY ARGUMENT DISABLES THE CORRESPONDING
*                     INTERUPT.
*           NON-ZERO VALUES ALLOW THE INTERUPT TO OCCUR.
*
*      IFXPTO -- FIXED-POINT OVERFLOW.
*      IDECO  -- DECIMAL OVERFLOW.
*      IEXPU  -- EXPONENT UNDERFLOW.
*      ISIG -- LOSS OF SIGNIFICANCE.   (ZERO FRACTION IN A FLOATING
*                                       POINT NUMBER)
*
*       FOR EXAMPLE,
*        CALL PGMMSK (1,1,0,0)
*            CAUSES UNDERFLOWS AND LOSS OF SIGNIFICANCE TO BE IGNORED
*            AND FIXED AND DECIMAL  OVERFLOW TO BE HANDLED AS USUAL.
*
*       PROGRAM AUTHOR -- R. K. GRYDER
*                         COMPUTING TECHNOLOGY CENTER
*                         OAK RIDGE, TENNESSEE
*
PGMMSKRG CSECT
         ENTRY PGMMSK
         USING *,15
PGMMSK   SAVE (14,12),,*
         SR    0,0
         LM    5,8,0(1)
         L     3,=X'08000000'
         SR    4,4
         CL    0,0(0,5)
         BE    I1
         LR    4,3
I1       SRA   3,1
         CL    0,0(0,6)
         BE    I2
         OR    4,3
I2       SRA   3,1
         CL    0,0(0,7)
         BE    I3
         OR    4,3
I3       SRA   3,1
         CL    0,0(0,8)
         BE    I4
         OR    4,3
I4       SPM   4
         RETURN (14,12),T
         END
```

APPENDIX B

Tabulation of Some Special Input Data for INREM

This listing contains information on 101 radionuclides obtained from the ICRP Report by Committee II on Permissible Dose for Internal Radiation.[1] These radionuclides have been of interest in the radiological safety-feasibility study for excavating a sea-level canal with nuclear explosives. No data on age-dependent parameters are included here because these parameters will be characteristic of each ethnic population.

---

[1] International Commission on Radiological Protection. 1959. Report of Committee II on Permissible Dose for Internal Radiation. ICRP Publ. 2, Pergamon Press, London, 233 pp.

RADIONUCLIDE IDENTIFICATION.

NUMBER	INDEX	NAME	HALF-LIFE (DAYS)
1	303	H-3	0.45000E 04
2	302	BE-7	0.53600E 02
3	314	C-14	0.20000E 07
4	312	NA-22	0.95000E 03
5	309	NA-24	0.63000E 00
6	310	P-32	0.14300E 02
7	318	S-35	0.87100E 02
8	317	CL-36	0.12000E 09
9	315	K-42	0.52000E 00
10	311	CA-45	0.16400E 03
11	322	SC-48	0.18300E 01
12	305	MN-54	0.30000E 03
13	306	MN-56	0.11000E 00
14	307	FE-55	0.11000E 04
15	308	FE-59	0.45100E 02
16	323	CO-60	0.19000E 04
17	324	CU-64	0.53000E 00
18	325	ZN-65	0.24500E 03
19	326	RB-87	0.18000E 14
20	38	SR-89	0.50500E 02
21	42	SR-90	0.10000E 05
22	46	SR-91	0.40000E 00
23	51	SR-92	0.11000E 00
24	43	Y-90	0.26800E 01
25	47	Y-91M	0.35000E-01
26	48	Y-91	0.58000E 02
27	52	Y-92	0.15000E 00
28	56	Y-93	0.42000E 00
29	57	ZR-93	0.40000E 09
30	65	ZR-95	0.63300E 02
31	69	ZR-97	0.71000E 00
32	58	NB-93M	0.37000E 04
33	67	NB-95	0.35000E 02
34	71	NB-97	0.51000E-01
35	77	MO-99	0.27900E 01
36	78	TC-99M	0.36000E-01
37	79	TC-99	0.77000E 08
38	88	RU-103	0.41000E 02
39	94	RU-105	0.19000E 00
40	97	RU-106	0.36500E 03
41	89	RH-103M	0.38000E-01
42	108	PD-109	0.57000E 00
43	114	AG-111	0.75000E 01
44	127	IN-115M	0.19000E 00
45	128	IN-115	0.22000E 18
46	161	SN-125	0.95000E 01
47	162	SB-125	0.87600E 03
48	163	TE-125M	0.58000E 02
49	169	TE-127M	0.10500E 03
50	170	TE-127	0.39000E 00
51	176	TE-129M	0.33000E 02
52	177	TE-129	0.51000E-01
53	185	TE-131M	0.12500E 01
54	191	TE-132	0.32000E 01
55	178	I-129	0.63000E 10
56	187	I-131	0.80500E 01

RADIONUCLIDE IDENTIFICATION.

NUMBER	INDEX	NAME	HALF-LIFE (DAYS)
57	192	I-132	0.97000E-01
58	196	I-133	0.87000E 00
59	200	I-134	0.36000E-01
60	202	I-135	0.28000E 00
61	327	CS-134	0.84000E 03
62	205	CS-135	0.11000E 10
63	210	CS-137	0.11000E 05
64	221	BA-140	0.12800E 02
65	222	LA-140	0.16800E 01
66	227	CE-141	0.32000E 02
67	236	CE-143	0.13300E 01
68	238	CE-144	0.29000E 03
69	237	PR-143	0.13700E 02
70	246	ND-147	0.11300E 02
71	250	ND-149	0.83000E-01
72	247	PM-147	0.92000E 03
73	251	PM-149	0.22000E 01
74	255	SM-151	0.37000E 05
75	258	SM-153	0.19600E 01
76	328	EU-152	0.47000E 04
77	262	EU-155	0.62100E 03
78	289	W-181	0.14000E 03
79	290	W-185	0.74000E 02
80	291	W-187	0.10000E 01
81	295	PB-203	0.21700E 01
82	296	PB-204M	0.47000E-01
83	287	AU-196	0.56000E 01
84	288	AU-198	0.27000E 01
85	301	HG-203	0.45800E 02
86	329	TL-201	0.30000E 01
87	300	TL-204	0.11000E 04
88	299	PB-210	0.71000E 04
89	330	NP-239	0.23300E 01
90	280	PU-238	0.33000E 05
91	281	PU-239	0.89000E 07
92	282	PU-240	0.24000E 07
93	283	PU-241	0.48000E 04
94	331	BI-207	0.29000E 04
95	304	CR-51	0.27800E 02
96	125	CD-115M	0.43000E 02
97	126	CD-115	0.22000E 01
98	207	CS-136	0.13000E 02
99	4	AS-77	0.16200E 01
100	96	RH-105	0.15200E 01
101	270	GD-159	0.75000E 00

EFFECTIVE HALF-LIFE (DAYS).

ORGAN NAME / NUCLIDE INDEX	AGE GROUP	TOTAL BODY	BONE	MUSCLE	THYROID	LIVER	KIDNEYS	SPLEEN	TESTES	OVARIES	LUNGS
303	1	1.200E 01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
302	1	4.100E 01	4.800E 01	0.0	0.0	4.500E 01	3.700E 01	4.900E 01	0.0	0.0	0.0
314	1	1.000E 01	4.000E 01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
312	1	1.100E 01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
309	1	6.000E-01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
310	1	1.350E 01	1.410E 01	0.0	0.0	8.000E 00	0.0	0.0	0.0	0.0	0.0
318	1	4.430E 01	7.610E 01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
317	1	2.900E 01	0.0	0.0	0.0	0.0	0.0	0.0	7.640E 01	0.0	0.0
315	1	5.200E-01	0.0	5.200E-01	0.0	0.0	0.0	0.0	0.0	0.0	0.0
311	1	1.620E 02	1.620E 02	0.0	0.0	5.200E-01	0.0	5.200E-01	0.0	0.0	0.0
322	1	1.700E 00	1.700E 00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
305	1	1.620E 01	0.0	0.0	0.0	1.700E 00	1.800E 00	0.0	0.0	0.0	0.0
306	1	1.100E-01	0.0	0.0	0.0	2.300E 01	0.0	0.0	0.0	0.0	0.0
307	1	4.630E 02	6.650E 02	0.0	0.0	1.100E-01	0.0	0.0	0.0	0.0	0.0
308	1	4.270E 01	0.0	0.0	0.0	3.680E 02	0.0	3.880E 02	0.0	0.0	8.190E 02
323	1	9.500E 00	0.0	0.0	0.0	4.170E 01	0.0	4.190E 01	0.0	0.0	4.450E 01
324	1	5.300E-01	0.0	0.0	0.0	9.500E 00	9.500E 00	9.500E 00	0.0	0.0	0.0
325	1	1.940E 02	2.060E 02	2.180E 02	0.0	5.300E-01	5.100E-01	4.200E-01	0.0	0.0	0.0
326	1	4.500E 01	0.0	8.000E 01	0.0	6.600E 01	9.300E 01	0.0	1.280E 02	7.400E 01	0.0
38	1	5.030E 01	5.040E 01	0.0	0.0	6.300E 01	0.0	4.500E 01	0.0	0.0	0.0
42	1	5.700E 03	6.400E 03	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
46	1	4.000E-01	4.000E-01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
51	1	1.100E-01	1.100E-01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
43	1	2.680E 00	2.680E 00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
47	1	3.500E-02	3.500E-02	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
48	1	5.800E 01	5.800E 01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
52	1	1.500E-01	1.500E-01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
56	1	4.200E-01	4.200E-01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
57	1	4.500E 02	1.000E 03	0.0	0.0	3.200E 02	9.000E 02	9.000E 02	0.0	0.0	0.0
65	1	5.550E 01	5.950E 01	0.0	0.0	5.300E 01	5.900E 01	5.900E 01	0.0	0.0	0.0
69	1	7.100E-01	7.100E-01	0.0	0.0	7.100E-01	7.100E-01	7.100E-01	0.0	0.0	0.0
58	1	6.300E 02	7.870E 02	0.0	0.0	6.880E 02	6.400E 02	7.560E 02	0.0	0.0	0.0
67	1	3.350E 01	3.380E 01	0.0	0.0	3.360E 01	3.350E 01	3.380E 01	0.0	0.0	0.0
71	1	5.100E-02	5.100E-02	0.0	0.0	5.100E-02	5.100E-02	5.100E-02	0.0	0.0	0.0
77	1	1.800E 00	0.0	0.0	0.0	2.660E 00	1.500E 00	0.0	0.0	0.0	0.0
78	1	3.600E-02	3.600E-02	0.0	0.0	3.600E-02	3.600E-02	0.0	0.0	0.0	0.0
79	1	1.000E 00	2.500E 01	0.0	0.0	3.000E 01	2.000E 01	0.0	0.0	0.0	3.600E-02
88	1	6.200E 00	1.200E 01	0.0	0.0	0.0	2.400E 00	0.0	0.0	0.0	5.000E 00
94	1	1.900E-01	1.900E-01	0.0	0.0	0.0	1.800E-01	0.0	0.0	0.0	0.0
97	1	7.200E 00	1.500E 01	0.0	0.0	0.0	2.480E 00	0.0	0.0	0.0	0.0
89	1	3.800E-02	3.800E-02	0.0	0.0	3.800E-02	3.800E-02	3.800E-02	0.0	0.0	0.0
108	1	5.100E-01	0.0	0.0	0.0	5.500E-01	5.600E-01	5.500E-01	0.0	0.0	0.0
114	1	3.000E 00	6.000E 00	0.0	0.0	5.000E 00	4.000E 00	0.0	0.0	0.0	0.0
127	1	1.900E-01	1.900E-01	0.0	1.900E-01	1.900E-01	1.900E-01	1.900E-01	0.0	0.0	0.0
128	1	4.800E 01	5.700E 01	0.0	8.400E 00	5.800E 01	6.000E 01	4.800E 01	0.0	0.0	0.0
161	1	7.500E 00	8.700E 00	0.0	8.400E 00	8.400E 00	0.0	0.0	0.0	0.0	0.0
162	1	3.600E 01	9.000E 01	0.0	4.000E 00	0.0	0.0	0.0	0.0	0.0	0.0
163	1	1.200E 01	2.000E 01	0.0	7.800E 00	2.000E 01	2.000E 01	2.000E 01	2.000E 01	0.0	9.000E 01
169	1	1.300E 01	2.300E 01	0.0	8.300E 00	2.300E 01	2.300E 01	2.300E 01	2.300E 01	0.0	0.0
170	1	3.800E-01	3.900E-01	0.0	3.700E-01	3.900E-01	3.900E-01	3.900E-01	3.900E-01	0.0	0.0
176	1	1.000E 01	1.600E 01	0.0	7.100E 00	1.600E 01	1.600E 01	1.600E 01	1.600E 01	0.0	0.0
177	1	5.100E-02	5.100E-02	0.0	5.100E-02	5.100E-02	5.100E-02	5.100E-02	5.100E-02	0.0	0.0
185	1	1.150E 00	1.200E 00	0.0	1.100E 00	1.200E 00	1.200E 00	1.200E 00	1.200E 00	0.0	0.0
191	1	2.600E 00	2.900E 00	0.0	2.400E 00	2.900E 00	2.900E 00	2.900E 00	2.900E 00	0.0	0.0

EFFECTIVE HALF-LIFE (DAYS).

ORGAN NAME NUCLIDE INDEX	AGE GROUP	TOTAL BODY	BONE	MUSCLE	THYROID	LIVER	KIDNEYS	SPLEEN	TESTES	OVARIES	LUNGS
178	1	1.380E 02	0.0	0.0	1.380E 02	0.0	0.0	0.0	0.0	0.0	0.0
187	1	7.600E 00	0.0	0.0	7.600E 00	0.0	0.0	0.0	0.0	0.0	0.0
192	1	9.700E-02	0.0	0.0	9.700E-02	0.0	0.0	0.0	0.0	0.0	0.0
196	1	8.700E-01	0.0	0.0	8.700E-01	0.0	0.0	0.0	0.0	0.0	0.0
200	1	3.600E-02	0.0	0.0	3.600E-02	0.0	0.0	0.0	0.0	0.0	0.0
202	1	2.800E-01	0.0	0.0	2.800E-01	0.0	0.0	0.0	0.0	0.0	0.0
327	1	6.500E 01	1.200E 02	1.200E 02	0.0	8.100E 01	4.000E 01	8.800E 01	0.0	0.0	1.200E 02
205	1	7.000E 01	1.400E 02	1.400E 02	0.0	9.000E 01	4.200E 01	9.800E 01	0.0	0.0	1.400E 02
210	1	7.000E 01	1.380E 02	1.380E 02	0.0	8.900E 01	4.200E 01	9.700E 01	0.0	0.0	1.380E 02
221	1	1.070E 01	1.070E 01	1.270E 01	0.0	1.260E 01	5.100E 00	6.400E 00	0.0	0.0	1.280E 01
222	1	1.680E 00	1.680E 00	0.0	0.0	1.680E 00	0.0	0.0	0.0	0.0	0.0
227	1	3.000E 01	3.100E 01	0.0	0.0	2.900E 01	3.000E 01	0.0	0.0	0.0	0.0
236	1	1.330E 00	1.330E 00	0.0	0.0	1.320E 00	1.330E 00	0.0	0.0	0.0	0.0
238	1	1.910E 02	2.430E 02	0.0	0.0	1.460E 02	1.910E 02	0.0	0.0	0.0	0.0
237	1	1.350E 01	1.360E 01	0.0	0.0	1.320E 01	1.350E 01	0.0	0.0	0.0	0.0
246	1	1.110E 01	1.120E 01	0.0	0.0	1.000E 01	1.110E 01	0.0	0.0	0.0	0.0
250	1	8.300E-02	8.300E-02	0.0	0.0	8.300E-02	8.300E-02	0.0	0.0	0.0	0.0
247	1	3.830E 02	5.700E 02	0.0	0.0	3.830E 02	3.830E 02	0.0	0.0	0.0	0.0
251	1	2.200E 00	2.200E 00	0.0	0.0	2.200E 00	2.200E 00	0.0	0.0	0.0	0.0
255	1	6.450E 02	1.442E 03	0.0	0.0	1.860E 02	6.450E 02	0.0	0.0	0.0	0.0
258	1	1.950E 00	1.960E 00	0.0	0.0	1.940E 00	1.950E 00	0.0	0.0	0.0	0.0
328	1	5.590E 02	1.137E 03	0.0	0.0	1.240E 02	1.125E 03	0.0	0.0	0.0	0.0
262	1	3.140E 02	4.390E 02	0.0	0.0	1.050E 02	4.380E 02	0.0	0.0	0.0	0.0
289	1	1.000E 00	8.500E 00	0.0	0.0	3.900E 00	0.0	0.0	0.0	0.0	0.0
290	1	1.000E 00	8.000E 00	0.0	0.0	3.800E 00	0.0	0.0	0.0	0.0	0.0
291	1	5.000E-01	9.000E-01	0.0	0.0	8.000E-01	0.0	0.0	0.0	0.0	0.0
295	1	2.170E 00	2.170E 00	0.0	0.0	2.170E 00	2.160E 00	0.0	0.0	0.0	0.0
296	1	4.700E-02	4.700E-02	0.0	0.0	4.700E-02	4.700E-02	0.0	0.0	0.0	0.0
287	1	5.400E 00	0.0	0.0	0.0	5.500E 00	5.500E 00	5.500E 00	0.0	0.0	0.0
288	1	2.600E 00	0.0	0.0	0.0	2.700E 00	2.700E 00	2.700E 00	0.0	0.0	0.0
301	1	8.200E 00	0.0	0.0	0.0	1.040E 01	1.100E 01	8.200E 00	0.0	0.0	0.0
329	1	1.900E 00	2.100E 00	1.900E 00	0.0	1.900E 00	2.100E 00	0.0	0.0	0.0	2.000E 00
300	1	5.000E 00	7.000E 00	5.500E 00	0.0	5.000E 00	7.000E 00	0.0	0.0	0.0	6.000E 00
299	1	1.200E 03	2.400E 03	0.0	0.0	1.500E 03	4.940E 02	0.0	0.0	0.0	0.0
330	1	2.330E 00	2.330E 00	0.0	0.0	2.330E 00	2.330E 00	0.0	0.0	0.0	0.0
280	1	2.200E 04	2.300E 04	0.0	0.0	1.600E 04	1.600E 04	0.0	0.0	0.0	0.0
281	1	6.400E 04	7.200E 04	0.0	0.0	3.000E 04	3.200E 04	0.0	0.0	0.0	0.0
282	1	6.300E 04	7.100E 04	0.0	0.0	3.000E 04	3.200E 04	0.0	0.0	0.0	0.0
283	1	4.500E 03	4.500E 03	0.0	0.0	4.100E 03	4.200E 03	0.0	0.0	0.0	0.0
331	1	5.000E 00	1.320E 01	0.0	0.0	1.490E 01	6.000E 00	1.000E 01	0.0	0.0	0.0
304	1	2.660E 01	0.0	0.0	2.660E 01	0.0	2.660E 01	0.0	0.0	0.0	2.660E 01
125	1	3.500E 01	0.0	0.0	0.0	3.500E 01	3.800E 01	0.0	0.0	0.0	0.0
126	1	2.200E 00	0.0	0.0	0.0	2.200E 00	2.200E 00	0.0	0.0	0.0	0.0
207	1	1.100E 01	1.190E 01	1.190E 01	0.0	1.140E 01	1.000E 01	1.150E 01	0.0	0.0	1.190E 01
4	1	1.600E 00	0.0	0.0	0.0	1.600E 00	1.600E 00	0.0	0.0	0.0	0.0
96	1	1.330E 00	1.390E 00	0.0	0.0	1.400E 00	1.440E 00	1.420E 00	0.0	0.0	0.0
270	1	7.500E-01	7.500E-01	0.0	0.0	7.500E-01	0.0	0.0	0.0	0.0	0.0

EFFECTIVE ABSORBED ENERGY (MEV).

ORGAN NAME NUCLIDE INDEX	AGE GROUP	TOTAL BODY	BONE	MUSCLE	THYROID	LIVER	KIDNEYS	SPLEEN	TESTES	OVARIES	LUNGS (S)	LUNGS (I)
303	1	1.000E-02	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.000E-02
302	1	3.500E-02	8.500E-03	0.0	0.0	1.600E-02	1.200E-02	1.200E-02	0.0	0.0	0.0	1.600E-02
314	1	5.400E-02	2.700E-01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.400E-02
312	1	1.600E 00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.000E-01
309	1	2.700E 00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.500E 00
310	1	6.900E-01	3.500E 00	0.0	0.0	6.900E-01	0.0	0.0	0.0	0.0	0.0	6.900E-01
318	1	5.600E-02	2.800E-01	0.0	0.0	0.0	0.0	0.0	5.600E-02	0.0	0.0	5.600E-02
317	1	2.600E-01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.600E-01
315	1	1.600E 00	0.0	1.600E 00	0.0	1.500E 00	0.0	1.500E 00	0.0	0.0	0.0	1.500E 00
311	1	8.600E-02	4.300E-01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.600E-02
322	1	2.200E 00	1.600E 00	0.0	0.0	1.100E 00	8.500E-01	0.0	0.0	0.0	0.0	1.100E 00
305	1	5.100E-01	0.0	0.0	0.0	2.300E-01	0.0	0.0	0.0	0.0	0.0	2.300E-01
306	1	1.900E 00	0.0	0.0	0.0	1.300E 00	0.0	0.0	0.0	0.0	0.0	1.300E 00
307	1	6.500E-03	6.500E-03	0.0	0.0	6.500E-03	0.0	6.500E-03	0.0	0.0	6.500E-03	6.500E-03
308	1	8.100E-01	0.0	0.0	0.0	4.200E-01	0.0	3.400E-01	0.0	0.0	4.200E-01	4.200E-01
323	1	1.500E 00	0.0	0.0	0.0	7.200E-01	5.600E-01	5.600E-01	0.0	0.0	0.0	7.200E-01
324	1	2.500E-01	0.0	0.0	0.0	1.900E-01	1.700E-01	1.700E-01	0.0	0.0	0.0	1.900E-01
325	1	3.200E-01	9.400E-02	3.200E-01	0.0	1.500E-01	1.100E-01	0.0	5.600E-02	5.600E-02	0.0	1.500E-01
326	1	9.000E-02	0.0	9.000E-02	0.0	9.000E-02	0.0	9.000E-02	0.0	0.0	0.0	9.000E-02
38	1	5.500E-01	2.800E 00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.500E-01
42	1	1.100E 00	5.500E 00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.100E 00
46	1	2.100E 00	6.200E 00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.500E 00
51	1	2.600E 00	8.000E 00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.000E 00
43	1	8.900E-01	4.400E 00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.900E-01
47	1	9.300E-01	3.000E 00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.500E-01
48	1	5.900E-01	2.900E 00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.900E-01
52	1	1.600E 00	6.900E 00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.500E 00
56	1	1.700E 00	6.500E 00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.500E 00
57	1	2.200E-02	1.000E-01	0.0	0.0	2.200E-02	2.200E-02	2.200E-02	0.0	0.0	0.0	2.000E-01
65	1	1.100E 00	1.100E 00	0.0	0.0	5.700E-01	4.600E-01	4.600E-01	0.0	0.0	0.0	5.200E-01
69	1	2.100E 00	6.200E 00	0.0	0.0	1.600E 00	1.500E 00	1.500E 00	0.0	0.0	0.0	1.600E 00
58	1	3.800E-02	1.200E-01	0.0	0.0	3.800E-02	3.800E-02	3.800E-02	0.0	0.0	0.0	3.800E-02
67	1	5.100E-01	3.700E-01	0.0	0.0	2.600E-01	2.000E-01	2.000E-01	0.0	0.0	0.0	2.600E-01
71	1	8.700E-01	2.400E 00	0.0	0.0	6.400E-01	6.000E-01	6.000E-01	0.0	0.0	0.0	6.400E-01
77	1	5.400E-01	0.0	0.0	0.0	4.700E-01	4.600E-01	0.0	0.0	0.0	0.0	4.800E-01
78	1	8.000E-02	2.000E-02	0.0	0.0	3.500E-02	2.600E-02	0.0	0.0	0.0	3.500E-02	3.500E-02
79	1	9.400E-02	4.700E-01	0.0	0.0	9.400E-02	9.400E-02	0.0	0.0	0.0	9.400E-02	9.400E-02
88	1	4.400E-01	6.200E-01	0.0	0.0	0.0	2.200E-01	0.0	0.0	0.0	0.0	2.700E-01
94	1	1.200E 00	3.500E 00	0.0	0.0	0.0	8.400E-01	0.0	0.0	0.0	0.0	9.100E-01
97	1	1.400E 00	6.500E 00	0.0	0.0	0.0	1.300E 00	0.0	0.0	0.0	0.0	1.400E 00
89	1	5.500E-02	1.900E-01	0.0	0.0	5.500E-02	5.400E-02	5.400E-02	0.0	0.0	0.0	5.500E-02
108	1	4.200E-01	0.0	0.0	0.0	4.200E-01	4.200E-01	4.200E-01	0.0	0.0	0.0	4.200E-01
114	1	4.000E-01	1.800E 00	0.0	0.0	3.800E-01	3.700E-01	0.0	0.0	0.0	0.0	3.800E-01
127	1	2.600E-01	7.400E-01	0.0	1.600E-01	2.000E-01	1.900E-01	1.900E-01	0.0	0.0	0.0	2.000E-01
128	1	1.700E-01	8.500E-01	0.0	1.700E-01	1.700E-01	1.700E-01	1.700E-01	0.0	0.0	0.0	1.700E-01
161	1	9.400E-01	4.800E 00	0.0	9.300E-01	9.400E-01	0.0	0.0	0.0	0.0	0.0	9.600E-01
162	1	3.600E-01	6.200E-01	0.0	1.400E-01	2.300E-01	0.0	0.0	0.0	0.0	2.300E-01	2.500E-01
163	1	1.500E-01	5.100E-01	0.0	1.100E-01	1.400E-01	1.400E-01	1.400E-01	1.100E-01	0.0	0.0	1.400E-01
169	1	3.200E-01	1.500E 00	0.0	3.000E-01	3.200E-01	3.200E-01	3.200E-01	3.100E-01	0.0	0.0	3.200E-01
170	1	2.400E-01	1.200E 00	0.0	2.400E-01	2.400E-01	2.400E-01	2.400E-01	2.400E-01	0.0	0.0	2.400E-01
176	1	1.100E 00	3.200E 00	0.0	6.800E-01	8.300E-01	7.800E-01	7.800E-01	6.900E-01	0.0	0.0	8.300E-01
177	1	9.800E-01	2.800E 00	0.0	6.000E-01	7.300E-01	6.800E-01	6.800E-01	6.000E-01	0.0	0.0	7.300E-01
185	1	1.600E 00	2.600E 00	0.0	6.900E-01	9.700E-01	8.100E-01	8.000E-01	0.0	0.0	0.0	1.000E 00
191	1	1.900E 00	3.100E 00	0.0	7.400E-01	1.100E 00	9.600E-01	9.600E-01	7.300E-01	0.0	0.0	1.100E 00

EFFECTIVE ABSORBED ENERGY (MEV).

ORGAN NAME NUCLIDE INDEX	AGE GROUP	TOTAL BODY	BONE	MUSCLE	THYROID	LIVER	KIDNEYS	SPLEEN	TESTES	OVARIES	LUNGS (S)	LUNGS (I)
178	1	8.900E-02	0.0	0.0	6.800E-02	0.0	0.0	0.0	0.0	0.0	0.0	8.200E-02
187	1	4.400E-01	0.0	0.0	2.300E-01	0.0	0.0	0.0	0.0	0.0	0.0	3.000E-01
192	1	1.700E 00	0.0	0.0	6.500E-01	0.0	0.0	0.0	0.0	0.0	0.0	1.000E 00
196	1	8.400E-01	0.0	0.0	5.400E-01	0.0	0.0	0.0	0.0	0.0	0.0	6.400E-01
200	1	1.500E 00	0.0	0.0	8.200E-01	0.0	0.0	0.0	0.0	0.0	0.0	1.100E 00
202	1	1.300E 00	0.0	0.0	5.200E-01	0.0	0.0	0.0	0.0	0.0	0.0	7.700E-01
327	1	1.100E 00	9.900E-01	1.100E 00	0.0	5.700E-01	4.600E-01	4.600E-01	0.0	0.0	5.700E-01	5.700E-01
205	1	6.600E-02	3.300E-01	6.600E-02	0.0	6.600E-02	6.600E-02	6.600E-02	0.0	0.0	6.600E-02	6.600E-02
210	1	5.900E-01	1.400E 00	5.900E-01	0.0	4.100E-01	3.700E-01	3.700E-01	0.0	0.0	4.100E-01	4.100E-01
221	1	2.300E 00	4.200E 00	2.300E 00	0.0	1.400E 00	1.200E 00	1.200E 00	0.0	0.0	1.400E 00	1.400E 00
222	1	1.900E 00	2.700E 00	0.0	0.0	1.100E 00	0.0	0.0	0.0	0.0	0.0	1.100E 00
227	1	2.100E-01	8.100E-01	0.0	0.0	1.800E-01	1.800E-01	0.0	0.0	0.0	0.0	1.800E-01
236	1	9.700E-01	3.800E 00	0.0	0.0	8.500E-01	8.200E-01	0.0	0.0	0.0	0.0	8.300E-01
238	1	1.300E 00	6.300E 00	0.0	0.0	1.300E 00	1.300E 00	0.0	0.0	0.0	0.0	1.300E 00
237	1	3.200E-01	1.600E 00	0.0	0.0	3.200E-01	3.200E-01	0.0	0.0	0.0	0.0	3.200E-01
246	1	4.000E-01	1.400E 00	0.0	0.0	3.200E-01	3.100E-01	0.0	0.0	0.0	0.0	3.000E-01
250	1	1.100E 00	4.700E 00	0.0	0.0	9.900E-01	9.700E-01	0.0	0.0	0.0	0.0	9.900E-01
247	1	6.900E-02	3.500E-01	0.0	0.0	6.900E-02	6.900E-02	0.0	0.0	0.0	0.0	6.900E-02
251	1	5.400E-01	1.900E 00	0.0	0.0	4.400E-01	4.200E-01	0.0	0.0	0.0	0.0	4.400E-01
255	1	4.200E-02	1.300E-01	0.0	0.0	4.200E-02	4.200E-02	0.0	0.0	0.0	0.0	4.200E-02
258	1	3.000E-01	1.100E 00	0.0	0.0	2.600E-01	2.500E-01	0.0	0.0	0.0	0.0	2.600E-01
328	1	6.600E-01	4.500E-01	0.0	0.0	3.300E-01	2.500E-01	0.0	0.0	0.0	0.0	3.300E-01
262	1	1.600E-01	2.800E-01	0.0	0.0	9.500E-02	8.300E-02	0.0	0.0	0.0	0.0	9.500E-02
289	1	2.000E-01	4.700E-02	0.0	0.0	8.700E-02	0.0	0.0	0.0	0.0	0.0	8.700E-02
290	1	1.400E-01	6.800E-01	0.0	0.0	1.400E-01	0.0	0.0	0.0	0.0	0.0	1.400E-01
291	1	6.800E-01	1.400E 00	0.0	0.0	4.400E-01	0.0	0.0	0.0	0.0	0.0	4.400E-01
295	1	2.200E-01	5.100E-02	0.0	0.0	9.400E-02	6.900E-02	0.0	0.0	0.0	0.0	9.400E-02
296	1	1.340E 00	3.100E-01	0.0	0.0	5.900E-01	4.400E-01	0.0	0.0	0.0	0.0	5.900E-01
287	1	4.600E-01	0.0	0.0	0.0	2.100E-01	1.500E-01	1.500E-01	0.0	0.0	0.0	2.100E-01
288	1	5.800E-01	0.0	0.0	0.0	4.400E-01	4.100E-01	4.100E-01	0.0	0.0	0.0	4.400E-01
301	1	2.500E-01	0.0	0.0	0.0	1.700E-01	1.500E-01	1.500E-01	0.0	0.0	0.0	1.700E-01
329	1	1.700E-01	4.400E-01	1.700E-01	0.0	1.200E-01	1.100E-01	0.0	0.0	0.0	1.200E-01	1.200E-01
300	1	2.500E-01	1.300E 00	2.500E-01	0.0	2.500E-01	2.500E-01	0.0	0.0	0.0	2.500E-01	2.500E-01
299	1	5.200E 00	2.900E 01	0.0	0.0	1.000E 01	1.000E 01	0.0	0.0	0.0	0.0	2.500E 01
330	1	2.900E-01	9.800E-01	0.0	0.0	2.200E-01	2.100E-01	0.0	0.0	0.0	0.0	1.600E-01
280	1	5.700E 01	2.800E 02	0.0	0.0	5.700E 01	5.700E 01	0.0	0.0	0.0	0.0	5.700E 01
281	1	5.300E 01	2.700E 02	0.0	0.0	5.300E 01	5.300E 01	0.0	0.0	0.0	0.0	5.300E 01
282	1	5.300E 01	2.700E 02	0.0	0.0	5.300E 01	5.300E 01	0.0	0.0	0.0	0.0	5.300E 01
283	1	2.300E 00	1.400E 01	0.0	0.0	1.000E 00	2.500E 00	0.0	0.0	0.0	0.0	5.300E-02
331	1	1.000E 00	2.400E-01	0.0	0.0	4.500E-01	3.300E-01	3.300E-01	0.0	0.0	0.0	4.500E-01
304	1	2.500E-02	0.0	0.0	8.400E-03	0.0	1.200E-02	0.0	0.0	0.0	1.400E-02	1.400E-02
125	1	6.100E-01	0.0	0.0	0.0	6.100E-01	6.100E-01	0.0	0.0	0.0	0.0	6.100E-01
126	1	7.100E-01	0.0	0.0	0.0	5.800E-01	5.600E-01	0.0	0.0	0.0	0.0	5.800E-01
207	1	6.500E-01	7.200E-01	6.500E-01	0.0	3.500E-01	2.900E-01	2.900E-01	0.0	0.0	3.500E-01	3.500E-01
4	1	2.400E-01	0.0	0.0	0.0	2.400E-01	2.400E-01	0.0	0.0	0.0	0.0	2.400E-01
96	1	2.000E-01	9.500E-01	0.0	0.0	1.900E-01	1.900E-01	1.900E-01	0.0	0.0	0.0	1.900E-01
270	1	3.600E-01	7.500E-01	0.0	0.0	3.300E-01	0.0	0.0	0.0	0.0	0.0	3.300E-01

FRACTIONAL ABSORPTION FROM INHALATION (DIMENSIONLESS).

ORGAN NAME NUCLIDE INDEX	AGE GROUP	TOTAL BODY	BONE	MUSCLE	THYROID	LIVER	KIDNEYS	SPLEEN	TESTES	OVARIES	LUNGS
303	1	1.000E 00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
302	1	2.500E-01	8.000E-02	0.0	0.0	2.500E-02	7.500E-03	5.000E-04	0.0	0.0	0.0
314	1	7.500E-01	2.000E-02	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
312	1	7.500E-01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
309	1	7.500E-01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
310	1	6.300E-01	3.200E-01	0.0	0.0	4.000E-02	0.0	0.0	0.0	0.0	0.0
318	1	7.500E-01	2.000E-02	0.0	0.0	0.0	0.0	0.0	9.800E-04	0.0	0.0
317	1	7.500E-01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
315	1	7.500E-01	0.0	4.900E-01	0.0	1.500E-02	0.0	3.000E-03	0.0	0.0	0.0
311	1	5.500E-01	5.000E-01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
322	1	2.500E-01	5.000E-02	0.0	0.0	4.000E-02	5.000E-03	0.0	0.0	0.0	0.0
305	1	3.000E-01	0.0	0.0	0.0	7.000E-02	0.0	0.0	0.0	0.0	0.0
306	1	3.000E-01	0.0	0.0	0.0	7.000E-02	0.0	0.0	0.0	0.0	0.0
307	1	3.000E-01	3.000E-02	0.0	0.0	4.000E-02	0.0	6.000E-03	0.0	0.0	6.000E-03
308	1	3.000E-01	0.0	0.0	0.0	4.000E-02	0.0	6.000E-03	0.0	0.0	6.000E-03
323	1	4.000E-01	0.0	0.0	0.0	2.000E-02	8.000E-04	5.600E-04	0.0	0.0	0.0
324	1	3.900E-01	0.0	0.0	0.0	3.000E-02	2.000E-02	3.000E-02	0.0	0.0	0.0
325	1	3.000E-01	4.000E-03	9.000E-02	0.0	1.100E-01	1.200E-02	0.0	2.700E-04	1.200E-04	0.0
326	1	7.500E-01	0.0	3.400E-01	0.0	4.000E-02	0.0	3.000E-03	0.0	0.0	0.0
38	1	4.000E-01	1.200E-01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
42	1	4.000E-01	1.200E-01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
46	1	4.000E-01	2.800E-01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
51	1	4.000E-01	2.800E-01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
43	1	2.500E-01	1.900E-01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
47	1	2.500E-01	1.900E-01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
48	1	2.500E-01	1.900E-01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
52	1	2.500E-01	1.900E-01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
56	1	2.500E-01	1.900E-01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
57	1	2.500E-01	9.000E-02	0.0	0.0	2.000E-02	5.000E-03	1.500E-03	0.0	0.0	0.0
65	1	2.500E-01	9.000E-02	0.0	0.0	2.000E-02	5.000E-03	1.500E-03	0.0	0.0	0.0
69	1	2.500E-01	9.000E-02	0.0	0.0	2.000E-02	5.000E-03	1.500E-03	0.0	0.0	0.0
58	1	2.500E-01	1.000E-01	0.0	0.0	2.000E-02	5.000E-03	2.000E-03	0.0	0.0	0.0
67	1	2.500E-01	1.000E-01	0.0	0.0	2.000E-02	5.000E-03	2.000E-03	0.0	0.0	0.0
71	1	2.500E-01	1.000E-01	0.0	0.0	2.000E-02	5.000E-03	2.000E-03	0.0	0.0	0.0
77	1	6.500E-01	0.0	0.0	0.0	6.500E-02	5.000E-02	0.0	0.0	0.0	0.0
78	1	5.000E-01	1.000E-03	0.0	0.0	1.500E-03	5.000E-03	0.0	0.0	0.0	4.500E-04
79	1	5.000E-01	1.000E-03	0.0	0.0	1.500E-03	5.000E-03	0.0	0.0	0.0	4.500E-04
88	1	2.700E-01	2.000E-02	0.0	0.0	0.0	5.000E-02	0.0	0.0	0.0	0.0
94	1	2.700E-01	2.000E-02	0.0	0.0	0.0	5.000E-02	0.0	0.0	0.0	0.0
97	1	2.700E-01	2.000E-02	0.0	0.0	0.0	5.000E-02	0.0	0.0	0.0	0.0
89	1	3.500E-01	2.000E-02	0.0	0.0	1.400E-02	1.000E-02	3.500E-03	0.0	0.0	0.0
108	1	3.500E-01	0.0	0.0	0.0	3.000E-02	3.000E-02	3.500E-03	0.0	0.0	0.0
114	1	2.600E-01	1.300E-02	0.0	0.0	7.700E-03	5.000E-03	0.0	0.0	0.0	0.0
127	1	2.500E-01	4.000E-02	0.0	1.000E-04	4.000E-02	1.000E-02	5.000E-03	0.0	0.0	0.0
128	1	2.500E-01	4.000E-02	0.0	1.000E-04	4.000E-02	1.000E-02	5.000E-03	0.0	0.0	0.0
161	1	2.800E-01	8.000E-02	0.0	2.800E-05	2.800E-03	0.0	0.0	0.0	0.0	0.0
162	1	2.700E-01	3.000E-02	0.0	8.000E-06	0.0	0.0	0.0	0.0	0.0	8.000E-03
163	1	3.800E-01	3.400E-02	0.0	3.800E-04	2.000E-02	3.000E-02	3.800E-03	1.100E-03	0.0	0.0
169	1	3.800E-01	3.400E-02	0.0	3.800E-04	2.000E-02	3.000E-02	3.800E-03	1.100E-03	0.0	0.0
170	1	3.800E-01	3.400E-02	0.0	3.800E-04	2.000E-02	3.000E-02	3.800E-03	1.100E-03	0.0	0.0
176	1	3.800E-01	3.400E-02	0.0	3.800E-04	2.000E-02	3.000E-02	3.800E-03	1.100E-03	0.0	0.0
177	1	3.800E-01	3.400E-02	0.0	3.800E-04	2.000E-02	3.000E-02	3.800E-03	1.100E-03	0.0	0.0
185	1	3.800E-01	3.400E-02	0.0	3.800E-04	2.000E-02	3.000E-02	3.800E-03	1.100E-03	0.0	0.0
191	1	3.800E-01	3.400E-02	0.0	3.800E-04	2.000E-02	3.000E-02	3.800E-03	1.100E-03	0.0	0.0

FRACTIONAL ABSORPTION FROM INHALATION (DIMENSIONLESS).

NUCLIDE INDEX	AGE GROUP	TOTAL BODY	BONE	MUSCLE	THYROID	LIVER	KIDNEYS	SPLEEN	TESTES	OVARIES	LUNGS
178	1	7.500E-01	0.0	0.0	2.300E-01	0.0	0.0	0.0	0.0	0.0	0.0
187	1	7.500E-01	0.0	0.0	2.300E-01	0.0	0.0	0.0	0.0	0.0	0.0
192	1	7.500E-01	0.0	0.0	2.300E-01	0.0	0.0	0.0	0.0	0.0	0.0
196	1	7.500E-01	0.0	0.0	2.300E-01	0.0	0.0	0.0	0.0	0.0	0.0
200	1	7.500E-01	0.0	0.0	2.300E-01	0.0	0.0	0.0	0.0	0.0	0.0
202	1	7.500E-01	0.0	0.0	2.300E-01	0.0	0.0	0.0	0.0	0.0	0.0
327	1	7.500E-01	3.000E-02	3.000E-01	0.0	5.000E-02	7.500E-03	3.800E-03	0.0	0.0	0.0
205	1	7.500E-01	3.000E-02	3.000E-01	0.0	5.000E-02	7.500E-03	3.800E-03	0.0	0.0	2.300E-03
210	1	7.500E-01	3.000E-02	3.000E-01	0.0	5.000E-02	7.500E-03	3.800E-03	0.0	0.0	2.300E-03
221	1	2.800E-01	1.900E-01	8.300E-04	0.0	1.700E-04	2.800E-05	1.400E-05	0.0	0.0	2.300E-03
222	1	2.500E-01	1.000E-01	0.0	0.0	4.000E-02	0.0	0.0	0.0	0.0	5.500E-05
227	1	2.500E-01	7.500E-02	0.0	0.0	6.000E-02	5.000E-03	0.0	0.0	0.0	0.0
236	1	2.500E-01	7.500E-02	0.0	0.0	6.000E-02	5.000E-03	0.0	0.0	0.0	0.0
238	1	2.500E-01	7.500E-02	0.0	0.0	6.000E-02	5.000E-03	0.0	0.0	0.0	0.0
237	1	2.500E-01	1.000E-01	0.0	0.0	5.000E-02	5.000E-03	0.0	0.0	0.0	0.0
246	1	2.500E-01	9.000E-02	0.0	0.0	1.300E-01	1.000E-02	0.0	0.0	0.0	0.0
250	1	2.500E-01	9.000E-02	0.0	0.0	1.300E-01	1.000E-02	0.0	0.0	0.0	0.0
247	1	2.500E-01	9.000E-02	0.0	0.0	2.000E-02	5.000E-03	0.0	0.0	0.0	0.0
251	1	2.500E-01	9.000E-02	0.0	0.0	2.000E-02	5.000E-03	0.0	0.0	0.0	0.0
255	1	2.500E-01	9.000E-02	0.0	0.0	2.000E-02	5.000E-03	0.0	0.0	0.0	0.0
258	1	2.500E-01	9.000E-02	0.0	0.0	9.000E-02	5.000E-03	0.0	0.0	0.0	0.0
328	1	2.500E-01	9.000E-02	0.0	0.0	9.000E-02	5.000E-03	0.0	0.0	0.0	0.0
262	1	2.500E-01	9.000E-02	0.0	0.0	6.000E-02	7.500E-03	0.0	0.0	0.0	0.0
289	1	2.500E-01	9.000E-02	0.0	0.0	6.000E-02	7.500E-03	0.0	0.0	0.0	0.0
290	1	3.000E-01	2.000E-02	0.0	0.0	2.000E-02	0.0	0.0	0.0	0.0	0.0
291	1	3.000E-01	2.000E-02	0.0	0.0	2.000E-02	0.0	0.0	0.0	0.0	0.0
295	1	3.000E-01	2.000E-02	0.0	0.0	2.000E-02	0.0	0.0	0.0	0.0	0.0
296	1	2.900E-01	8.000E-02	0.0	0.0	2.300E-02	4.000E-02	0.0	0.0	0.0	0.0
287	1	2.900E-01	8.000E-02	0.0	0.0	2.300E-02	4.000E-02	0.0	0.0	0.0	0.0
288	1	3.000E-01	0.0	0.0	0.0	1.000E-02	9.000E-03	1.500E-03	0.0	0.0	0.0
301	1	3.000E-01	0.0	0.0	0.0	1.000E-02	9.000E-03	1.500E-03	0.0	0.0	0.0
329	1	6.300E-01	0.0	0.0	0.0	9.000E-02	2.200E-01	1.000E-02	0.0	0.0	0.0
300	1	4.800E-01	2.600E-02	2.600E-01	0.0	2.000E-02	2.400E-02	0.0	0.0	0.0	2.900E-03
299	1	4.800E-01	2.600E-02	2.600E-01	0.0	2.000E-02	2.400E-02	0.0	0.0	0.0	2.900E-03
330	1	2.900E-01	8.000E-02	0.0	0.0	2.300E-02	4.000E-02	0.0	0.0	0.0	0.0
280	1	2.500E-01	1.100E-01	0.0	0.0	1.300E-02	7.500E-03	0.0	0.0	0.0	0.0
281	1	2.500E-01	2.000E-01	0.0	0.0	3.800E-02	5.000E-03	0.0	0.0	0.0	0.0
282	1	2.500E-01	2.000E-01	0.0	0.0	3.800E-02	5.000E-03	0.0	0.0	0.0	0.0
283	1	2.500E-01	2.000E-01	0.0	0.0	3.800E-02	5.000E-03	0.0	0.0	0.0	0.0
331	1	2.500E-01	2.000E-01	0.0	0.0	3.800E-02	5.000E-03	0.0	0.0	0.0	0.0
304	1	2.600E-01	7.700E-03	0.0	0.0	4.000E-02	8.000E-02	2.600E-03	0.0	0.0	0.0
125	1	2.500E-01	0.0	0.0	2.300E-04	0.0	6.800E-04	0.0	0.0	0.0	1.000E-02
126	1	2.500E-01	0.0	0.0	0.0	1.900E-01	2.500E-02	0.0	0.0	0.0	0.0
207	1	2.500E-01	0.0	0.0	0.0	1.900E-01	2.500E-02	0.0	0.0	0.0	0.0
4	1	7.500E-01	3.000E-02	3.000E-01	0.0	5.000E-02	7.500E-03	3.800E-03	0.0	0.0	2.300E-03
96	1	2.700E-01	0.0	0.0	0.0	8.000E-03	2.700E-03	0.0	0.0	0.0	0.0
270	1	3.500E-01	2.000E-02	0.0	0.0	1.400E-02	1.000E-02	3.500E-03	0.0	0.0	0.0
		2.500E-01	1.100E-01	0.0	0.0	3.000E-02	0.0	0.0	0.0	0.0	0.0

FRACTIONAL ABSORPTION FROM INGESTION (DIMENSIONLESS).

NUCLIDE INDEX	AGE GROUP	TOTAL BODY	BONE	MUSCLE	THYROID	LIVER	KIDNEYS	SPLEEN	TESTES	OVARIES	LUNGS
303	1	1.000E 00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
302	1	2.000E-03	6.400E-04	0.0	0.0	2.000E-04	6.000E-05	4.000E-06	0.0	0.0	0.0
314	1	1.000E 00	2.500E-02	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
312	1	1.000E 00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
309	1	1.000E 00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
310	1	7.500E-01	3.750E-01	0.0	0.0	5.000E-02	0.0	0.0	0.0	0.0	0.0
318	1	1.000E 00	3.000E-02	0.0	0.0	0.0	0.0	0.0	1.300E-03	0.0	0.0
317	1	1.000E 00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
315	1	1.000E 00	0.0	6.500E-01	0.0	2.000E-02	0.0	4.000E-03	0.0	0.0	0.0
311	1	6.000E-01	5.400E-01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
322	1	1.000E-04	2.000E-05	0.0	0.0	1.500E-05	2.000E-06	0.0	0.0	0.0	0.0
305	1	1.000E-01	0.0	0.0	0.0	2.000E-02	0.0	0.0	0.0	0.0	0.0
306	1	1.000E-01	0.0	0.0	0.0	2.000E-02	0.0	0.0	0.0	0.0	0.0
307	1	1.000E-01	1.000E-02	0.0	0.0	1.300E-02	0.0	2.000E-03	0.0	0.0	2.000E-03
308	1	1.000E-01	0.0	0.0	0.0	1.300E-02	0.0	2.000E-03	0.0	0.0	2.000E-03
323	1	3.000E-01	0.0	0.0	0.0	7.000E-03	6.000E-04	4.200E-04	0.0	0.0	0.0
324	1	2.800E-01	0.0	0.0	0.0	2.000E-02	1.000E-02	2.000E-02	0.0	0.0	0.0
325	1	1.000E-01	1.500E-02	3.000E-02	0.0	3.500E-02	4.000E-03	0.0	9.000E-05	4.000E-05	0.0
326	1	1.000E 00	0.0	4.500E-01	0.0	5.000E-02	0.0	4.000E-03	0.0	0.0	0.0
38	1	3.000E-01	9.000E-02	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
42	1	3.000E-01	9.000E-02	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
46	1	3.000E-01	2.100E-01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
51	1	3.000E-01	2.100E-01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
43	1	1.000E-04	7.500E-05	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
47	1	1.000E-04	7.500E-05	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
48	1	1.000E-04	7.500E-05	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
52	1	1.000E-04	7.500E-05	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
56	1	1.000E-04	7.500E-04	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
57	1	1.000E-04	3.600E-05	0.0	0.0	7.000E-06	2.000E-06	6.000E-07	0.0	0.0	0.0
65	1	1.000E-04	3.600E-05	0.0	0.0	7.000E-06	2.000E-06	6.000E-07	0.0	0.0	0.0
69	1	1.000E-04	3.600E-05	0.0	0.0	7.000E-06	2.000E-06	6.000E-07	0.0	0.0	0.0
58	1	1.000E-04	3.800E-05	0.0	0.0	9.000E-06	2.000E-06	8.000E-07	0.0	0.0	0.0
67	1	1.000E-04	3.800E-05	0.0	0.0	9.000E-06	2.000E-06	8.000E-07	0.0	0.0	0.0
71	1	1.000E-04	3.800E-05	0.0	0.0	9.000E-06	2.000E-06	8.000E-07	0.0	0.0	0.0
77	1	8.000E-01	0.0	0.0	0.0	8.000E-02	6.000E-02	0.0	0.0	0.0	0.0
78	1	5.000E-01	1.000E-03	0.0	0.0	1.500E-03	5.000E-03	0.0	0.0	0.0	0.0
79	1	5.000E-01	1.000E-03	0.0	0.0	1.500E-03	5.000E-03	0.0	0.0	0.0	4.500E-04
88	1	3.000E-02	2.400E-03	0.0	0.0	0.0	6.000E-03	0.0	0.0	0.0	4.500E-04
94	1	3.000E-02	2.400E-03	0.0	0.0	0.0	6.000E-03	0.0	0.0	0.0	0.0
97	1	3.000E-02	2.400E-03	0.0	0.0	0.0	6.000E-03	0.0	0.0	0.0	0.0
89	1	2.000E-01	1.000E-02	0.0	0.0	8.000E-03	6.000E-03	2.000E-03	0.0	0.0	0.0
108	1	2.000E-01	0.0	0.0	0.0	2.000E-02	2.000E-02	2.000E-03	0.0	0.0	0.0
114	1	1.000E-02	5.000E-04	0.0	0.0	3.000E-04	2.000E-04	0.0	0.0	0.0	0.0
127	1	2.000E-03	3.400E-04	0.0	8.000E-07	2.800E-04	8.000E-05	4.000E-05	0.0	0.0	0.0
128	1	2.000E-03	3.400E-04	0.0	8.000E-07	2.800E-04	8.000E-05	4.000E-05	0.0	0.0	0.0
161	1	5.000E-02	2.000E-02	0.0	5.000E-06	5.000E-04	0.0	0.0	0.0	0.0	0.0
162	1	3.000E-02	3.000E-03	0.0	9.000E-07	0.0	0.0	0.0	0.0	0.0	0.0
163	1	2.500E-01	2.300E-02	0.0	2.500E-04	1.000E-02	2.000E-02	2.500E-03	7.500E-04	0.0	9.000E-04
169	1	2.500E-01	2.300E-02	0.0	2.500E-04	1.000E-02	2.000E-02	2.500E-03	7.500E-04	0.0	0.0
170	1	2.500E-01	2.300E-02	0.0	2.500E-04	1.000E-02	2.000E-02	2.500E-03	7.500E-04	0.0	0.0
176	1	2.500E-01	2.300E-02	0.0	2.500E-04	1.000E-02	2.000E-02	2.500E-03	7.500E-04	0.0	0.0
177	1	2.500E-01	2.300E-02	0.0	2.500E-04	1.000E-02	2.000E-02	2.500E-03	7.500E-04	0.0	0.0
185	1	2.500E-01	2.300E-02	0.0	2.500E-04	1.000E-02	2.000E-02	2.500E-03	7.500E-04	0.0	0.0
191	1	2.500E-01	2.300E-02	0.0	2.500E-04	1.000E-02	2.000E-02	2.500E-03	7.500E-04	0.0	0.0

FRACTIONAL ABSORPTION FROM INGESTION (DIMENSIONLESS).

NUCLIDE INDEX	AGE GROUP	TOTAL BODY	BONE	MUSCLE	THYROID	LIVER	KIDNEYS	SPLEEN	TESTES	OVARIES	LUNGS
178	1	1.000E 00	0.0	0.0	3.000E-01	0.0	0.0	0.0	0.0	0.0	0.0
187	1	1.000E 00	0.0	0.0	3.000E-01	0.0	0.0	0.0	0.0	0.0	0.0
192	1	1.000E 00	0.0	0.0	3.000E-01	0.0	0.0	0.0	0.0	0.0	0.0
196	1	1.000E 00	0.0	0.0	3.000E-01	0.0	0.0	0.0	0.0	0.0	0.0
200	1	1.000E 00	0.0	0.0	3.000E-01	0.0	0.0	0.0	0.0	0.0	0.0
202	1	1.000E 00	0.0	0.0	3.000E-01	0.0	0.0	0.0	0.0	0.0	0.0
327	1	1.000E 00	4.000E-02	4.000E-01	0.0	7.000E-02	1.000E-02	5.000E-03	0.0	0.0	3.000E-03
205	1	1.000E 00	4.000E-02	4.000E-01	0.0	7.000E-02	1.000E-02	5.000E-03	0.0	0.0	3.000E-03
210	1	1.000E 00	4.000E-02	4.000E-01	0.0	7.000E-02	1.000E-02	5.000E-03	0.0	0.0	3.000E-03
221	1	5.000E-02	3.500E-02	1.500E-04	0.0	3.000E-05	5.000E-06	2.500E-06	0.0	0.0	1.000E-05
222	1	1.000E-04	4.000E-05	0.0	0.0	1.500E-05	0.0	0.0	0.0	0.0	0.0
227	1	1.000E-04	3.000E-05	0.0	0.0	2.500E-05	2.000E-06	0.0	0.0	0.0	0.0
236	1	1.000E-04	3.000E-05	0.0	0.0	2.500E-05	2.000E-06	0.0	0.0	0.0	0.0
238	1	1.000E-04	3.000E-05	0.0	0.0	2.500E-05	2.000E-06	0.0	0.0	0.0	0.0
237	1	1.000E-04	4.000E-05	0.0	0.0	2.000E-05	2.000E-06	0.0	0.0	0.0	0.0
246	1	1.000E-04	3.500E-05	0.0	0.0	5.000E-05	5.000E-06	0.0	0.0	0.0	0.0
250	1	1.000E-04	3.500E-05	0.0	0.0	5.000E-05	5.000E-06	0.0	0.0	0.0	0.0
247	1	1.000E-04	3.500E-05	0.0	0.0	6.000E-06	2.000E-06	0.0	0.0	0.0	0.0
251	1	1.000E-04	3.500E-05	0.0	0.0	6.000E-06	2.000E-06	0.0	0.0	0.0	0.0
255	1	1.000E-04	3.500E-05	0.0	0.0	3.500E-05	2.000E-06	0.0	0.0	0.0	0.0
258	1	1.000E-04	3.500E-05	0.0	0.0	3.500E-05	2.000E-06	0.0	0.0	0.0	0.0
328	1	1.000E-04	3.600E-05	0.0	0.0	2.500E-05	3.000E-06	0.0	0.0	0.0	0.0
262	1	1.000E-04	3.600E-05	0.0	0.0	2.500E-05	3.000E-06	0.0	0.0	0.0	0.0
289	1	1.000E-01	7.000E-03	0.0	0.0	6.000E-03	0.0	0.0	0.0	0.0	0.0
290	1	1.000E-01	7.000E-03	0.0	0.0	6.000E-03	0.0	0.0	0.0	0.0	0.0
291	1	1.000E-01	7.000E-03	0.0	0.0	6.000E-03	0.0	0.0	0.0	0.0	0.0
295	1	8.000E-02	2.000E-02	0.0	0.0	6.400E-03	1.000E-02	0.0	0.0	0.0	0.0
296	1	8.000E-02	2.000E-02	0.0	0.0	6.400E-03	1.000E-02	0.0	0.0	0.0	0.0
287	1	1.000E-01	0.0	0.0	0.0	4.000E-03	3.000E-03	5.000E-04	0.0	0.0	0.0
288	1	1.000E-01	0.0	0.0	0.0	4.000E-03	3.000E-03	5.000E-04	0.0	0.0	0.0
301	1	7.500E-01	0.0	0.0	0.0	1.100E-01	2.600E-01	2.000E-02	0.0	0.0	0.0
329	1	4.500E-01	2.500E-02	2.400E-01	0.0	2.000E-02	2.300E-02	0.0	0.0	0.0	2.700E-03
300	1	4.500E-01	2.500E-02	2.400E-01	0.0	2.000E-02	2.300E-02	0.0	0.0	0.0	2.700E-03
299	1	8.000E-02	2.000E-02	0.0	0.0	6.400E-03	1.000E-02	0.0	0.0	0.0	0.0
330	1	1.000E-04	5.400E-05	0.0	0.0	5.000E-06	3.000E-06	0.0	0.0	0.0	0.0
280	1	3.000E-05	2.400E-05	0.0	0.0	4.500E-06	6.000E-07	0.0	0.0	0.0	0.0
281	1	3.000E-05	2.400E-05	0.0	0.0	4.500E-06	6.000E-07	0.0	0.0	0.0	0.0
282	1	3.000E-05	2.400E-05	0.0	0.0	4.500E-06	6.000E-07	0.0	0.0	0.0	0.0
283	1	3.000E-05	2.400E-05	0.0	0.0	4.500E-06	6.000E-07	0.0	0.0	0.0	0.0
331	1	1.000E-02	3.000E-04	0.0	0.0	1.500E-03	3.000E-03	1.000E-04	0.0	0.0	0.0
304	1	5.000E-03	0.0	0.0	4.500E-06	0.0	1.300E-05	0.0	0.0	0.0	2.000E-04
125	1	2.500E-03	0.0	0.0	0.0	1.900E-03	2.500E-04	0.0	0.0	0.0	0.0
126	1	2.500E-03	0.0	0.0	0.0	1.900E-03	2.500E-04	0.0	0.0	0.0	0.0
207	1	1.000E 00	4.000E-02	4.000E-01	0.0	7.000E-02	1.000E-02	5.000E-03	0.0	0.0	3.000E-03
4	1	3.000E-02	0.0	0.0	0.0	9.000E-04	3.000E-04	0.0	0.0	0.0	0.0
96	1	2.000E-01	1.000E-02	0.0	0.0	8.000E-03	6.000E-03	2.000E-03	0.0	0.0	0.0
270	1	1.000E-04	4.500E-05	0.0	0.0	1.200E-05	0.0	0.0	0.0	0.0	0.0

MAXIMUM PERMISSIBLE CONCENTRATIONS (MICROCURIES/CUBIC CENTIMETER).

NUCLIDE INDEX	SOLUBLE INHALATION	SOLUBLE INGESTION	INSOLUBLE INHALATION	INSOLUBLE INGESTION
303	1.0000E-04	5.0000E-01	2.0000E-06	1.0000E-02
302	4.0000E-06	2.0000E-02	3.0000E-06	2.0000E-02
314	2.0000E-05	9.0000E-02	4.0000E-07	2.0000E-03
312	7.0000E-07	3.0000E-03	5.0000E-08	3.0000E-04
309	4.0000E-07	2.0000E-03	5.0000E-08	3.0000E-04
310	2.0000E-07	9.0000E-04	4.0000E-08	2.0000E-04
318	1.0000E-05	5.0000E-02	5.0000E-07	3.0000E-03
317	3.0000E-06	1.0000E-02	1.0000E-07	6.0000E-04
315	7.0000E-07	3.0000E-03	4.0000E-08	2.0000E-04
311	1.0000E-06	4.0000E-03	3.0000E-07	2.0000E-03
322	6.0000E-08	3.0000E-04	5.0000E-08	3.0000E-04
305	3.0000E-07	1.0000E-03	2.0000E-07	1.0000E-03
306	3.0000E-07	1.0000E-03	2.0000E-07	1.0000E-03
307	6.0000E-06	3.0000E-02	4.0000E-06	2.0000E-02
308	1.0000E-07	6.0000E-04	9.0000E-08	5.0000E-04
323	1.0000E-07	5.0000E-04	6.0000E-08	3.0000E-04
324	7.0000E-07	3.0000E-03	4.0000E-07	2.0000E-03
325	4.0000E-07	2.0000E-03	3.0000E-07	2.0000E-03
326	8.0000E-06	3.0000E-02	3.0000E-07	2.0000E-03
38	9.0000E-08	4.0000E-04	5.0000E-08	3.0000E-04
42	1.0000E-07	5.0000E-04	6.0000E-08	4.0000E-04
46	2.0000E-07	7.0000E-04	9.0000E-08	5.0000E-04
51	2.0000E-07	7.0000E-04	1.0000E-07	6.0000E-04
43	4.0000E-08	2.0000E-04	3.0000E-08	2.0000E-04
47	8.0000E-06	3.0000E-02	6.0000E-06	3.0000E-02
48	6.0000E-08	3.0000E-04	5.0000E-08	3.0000E-04
52	1.0000E-07	6.0000E-04	1.0000E-07	6.0000E-04
56	6.0000E-08	3.0000E-04	5.0000E-08	3.0000E-04
57	2.0000E-06	8.0000E-03	1.0000E-06	8.0000E-03
65	1.0000E-07	6.0000E-04	1.0000E-07	6.0000E-04
69	4.0000E-08	2.0000E-04	3.0000E-08	2.0000E-04
58	9.0000E-07	4.0000E-03	7.0000E-07	4.0000E-03
67	2.0000E-07	1.0000E-03	2.0000E-07	1.0000E-03
71	2.0000E-06	9.0000E-03	2.0000E-06	9.0000E-03
77	5.0000E-07	2.0000E-03	7.0000E-08	4.0000E-04
78	1.0000E-05	6.0000E-02	5.0000E-06	3.0000E-02
79	7.0000E-07	3.0000E-03	3.0000E-07	2.0000E-03
88	2.0000E-07	8.0000E-04	1.0000E-07	8.0000E-04
94	3.0000E-07	1.0000E-03	2.0000E-07	1.0000E-03
97	3.0000E-08	1.0000E-04	2.0000E-08	1.0000E-04
89	3.0000E-05	1.0000E-01	2.0000E-05	1.0000E-01
108	2.0000E-07	9.0000E-04	1.0000E-07	7.0000E-04
114	1.0000E-07	4.0000E-04	8.0000E-08	4.0000E-04
127	8.0000E-07	4.0000E-03	6.0000E-07	4.0000E-03
128	2.0000E-07	9.0000E-04	2.0000E-07	9.0000E-04
161	4.0000E-08	2.0000E-04	3.0000E-08	2.0000E-04
162	2.0000E-07	1.0000E-03	2.0000E-07	1.0000E-03
163	1.0000E-07	2.0000E-03	2.0000E-07	1.0000E-03
169	2.0000E-07	8.0000E-04	9.0000E-08	5.0000E-04
170	6.0000E-07	3.0000E-03	3.0000E-07	2.0000E-03
176	7.0000E-08	3.0000E-04	4.0000E-08	2.0000E-04
177	2.0000E-06	8.0000E-03	1.0000E-06	8.0000E-03
185	1.0000E-07	6.0000E-04	6.0000E-08	4.0000E-04
191	7.0000E-08	3.0000E-04	4.0000E-08	2.0000E-04
178	9.0000E-06	4.0000E-02	4.0000E-07	2.0000E-03

MAXIMUM PERMISSIBLE CONCENTRATIONS (MICROCURIES/CUBIC CENTIMETER).

NUCLIDE INDEX	SOLUBLE INHALATION	SOLUBLE INGESTION	INSOLUBLE INHALATION	INSOLUBLE INGESTION
187	2.0000E-06	1.0000E-02	1.0000E-07	6.0000E-04
192	9.0000E-07	4.0000E-03	3.0000E-07	2.0000E-03
196	1.0000E-06	6.0000E-03	7.0000E-08	4.0000E-04
200	1.0000E-06	6.0000E-03	1.0000E-06	6.0000E-03
202	1.0000E-06	5.0000E-03	1.0000E-07	7.0000E-04
327	1.0000E-06	5.0000E-03	7.0000E-08	4.0000E-04
205	1.0000E-05	5.0000E-02	4.0000E-07	2.0000E-03
210	2.0000E-06	8.0000E-03	8.0000E-08	4.0000E-04
221	6.0000E-08	3.0000E-04	4.0000E-08	2.0000E-04
222	5.0000E-08	2.0000E-04	4.0000E-08	2.0000E-04
227	2.0000E-07	9.0000E-04	2.0000E-07	9.0000E-04
236	9.0000E-08	4.0000E-04	7.0000E-08	4.0000E-04
238	3.0000E-06	1.0000E-04	2.0000E-08	1.0000E-04
237	1.0000E-07	5.0000E-04	9.0000E-08	5.0000E-04
246	1.0000E-07	6.0000E-04	1.0000E-07	6.0000E-04
250	6.0000E-07	3.0000E-03	5.0000E-07	3.0000E-03
247	5.0000E-07	2.0000E-03	4.0000E-07	2.0000E-03
251	1.0000E-07	4.0000E-04	8.0000E-08	4.0000E-04
255	8.0000E-07	4.0000E-03	7.0000E-07	4.0000E-03
258	2.0000E-07	8.0000E-04	1.0000E-07	8.0000E-04
328	2.0000E-07	8.0000E-04	1.0000E-07	8.0000E-04
262	4.0000E-07	2.0000E-03	4.0000E-07	2.0000E-03
289	8.0000E-07	4.0000E-03	6.0000E-07	3.0000E-03
290	3.0000E-07	1.0000E-03	2.0000E-07	1.0000E-03
291	2.0000E-07	7.0000E-04	1.0000E-07	6.0000E-04
295	9.0000E-07	4.0000E-03	6.0000E-07	4.0000E-03
296	1.0000E-07	4.0000E-04	8.0000E-08	4.0000E-04
287	4.0000E-07	2.0000E-03	3.0000E-07	1.0000E-03
288	1.0000E-07	5.0000E-04	8.0000E-08	5.0000E-04
301	1.0000E-06	4.0000E-03	2.0000E-07	1.0000E-03
329	7.0000E-07	3.0000E-03	3.0000E-07	2.0000E-03
300	2.0000E-07	1.0000E-03	1.0000E-07	6.0000E-04
299	4.0000E-07	2.0000E-03	3.0000E-07	2.0000E-03
330	3.0000E-07	1.0000E-03	2.0000E-07	1.0000E-03
280	6.0000E-08	3.0000E-04	5.0000E-08	3.0000E-04
281	6.0000E-08	3.0000E-04	5.0000E-08	3.0000E-04
282	6.0000E-08	3.0000E-04	5.0000E-08	3.0000E-04
283	3.0000E-06	1.0000E-02	2.0000E-06	1.0000E-02
331	1.0000E-07	6.0000E-04	1.0000E-07	6.0000E-04
304	4.0000E-06	2.0000E-02	3.0000E-06	2.0000E-02
125	6.0000E-08	3.0000E-04	4.0000E-08	3.0000E-04
126	8.0000E-08	3.0000E-04	6.0000E-08	4.0000E-04
207	2.0000E-06	8.0000E-03	1.0000E-07	6.0000E-04
4	2.0000E-07	8.0000E-04	1.0000E-07	8.0000E-04
96	3.0000E-07	1.0000E-03	2.0000E-07	1.0000E-03
270	2.0000E-07	8.0000E-04	1.0000E-07	8.0000E-04

ORGAN MASS (GRAMS).

NAME	MASS
TOTAL BODY	7.0000E 04
BONE	7.0000E 03
MUSCLE	3.0000E 04
THYROID	2.0000E 01
LIVER	1.7000E 03
KIDNEYS	3.0000E 02
SPLEEN	1.5000E 02
TESTES	4.0000E 01
OVARIES	8.0000E 00
LUNGS	1.0000E 03

INTAKE (CC/DAY) OF AIR AND WATER FOR AN INDIVIDUAL.

AGE GROUP	AIR	WATER
1	2.0000E 07	2.2000E 03

APPENDIX C

SAMPLE PROBLEM FOR INREM

In this section, an example problem is presented to illustrate the input format that is required to solve a problem using the code INREM.

The problem is to determine the dose commitments received during the time interval 0 years to 50 years after the reference detonation from ingestion of the radionuclides I-131 and CS-137 in the total body and the thyroid gland of an individual who was born at the time of the reference detonation. Each of the radionuclides was ingested for a period of one year and for a period of 50 years after the reference detonation. Data are available to describe the individual in the six age groups: 0-1, 1-5, 5-10, 10-15, 15-20, and 20-70 years.

The format of the input cards containing the data necessary to describe the problem is given in Table 1, and the computer output for the problem is found in Table 2.

TABLE I

INPUT FOR INREM SAMPLE PROBLEM

1–5	6–10	11–15	16–20	21–25	26–30	31–35	36–40	41–45	46–50	51–55	56–60	61–65	66–70	71	73–80
					SAM	PLE P	ROBLE	M FOR	INRE	M					
2	6	2	0	0	2	1									
	0.0		1.0		5.0		10.0		15.0		20.0		70.0		AGEGP
187	I-131			8.05											NUCLID
210	CS-137		0	.11E5											NUCLID
TOTAL	BODY		8000	1	.54E4	2	.51E4		4.1E4		6.5E4	6	.97E4		ORGAN
THYRO	ID		2		3		5		12		15		18.0		ORGAN
4	.0	4.0												1	187 TAU
4	.5	4.5												2	187 TAU
5	.5	5.5												3	187 TAU
6	.0	6.0												4	187 TAU
6	.5	6.5												5	187 TAU
7	.0	7.0												6	187 TAU
0.	44	0.21												1	187 ENG
0.	44	0.21												2	187 ENG
0.	44	0.22												3	187 ENG
0.	44	0.22												4	187 ENG
0.	44	0.23												5	187 ENG
0.	44	0.23												6	187 ENG
														1	187 HAL
														2	187 HAL
														3	187 HAL
														4	187 HAL
														5	187 HAL
														6	187 HAL

1–5	6–10	11–15	16–20	21–25	26–30	31–35	36–40	41–45	46–50	51–55	56–60	61–65	66–70	71	73–80
1	.0	0.2												1	187 GES
1	.0	0.2												2	187 GES
1	.0	0.2												3	187 GES
1	.0	0.2												4	187 GES
1	.0	0.2												5	187 GES
1	.0	0.2												6	187 GES
	17													1	210 TAU
	18													2	210 TAU
	30													3	210 TAU
	46													4	210 TAU
	54													5	210 TAU
	61													6	210 TAU
0.	48													1	210 ENG
0.	52													2	210 ENG
0.	54													3	210 ENG
0.	55													4	210 ENG
0.	57													5	210 ENG
0.	59													6	210 ENG
														1	210 HAL
														2	210 HAL
														3	210 HAL
														4	210 HAL
														5	210 HAL
														6	210 HAL
1	.0													1	210 GES

1–5	6–10	11–15	16–20	21–25	26–30	31–35	36–40	41–45	46–50	51–55	56–60	61–65	66–70	71–72	73–80
1	.0													2	210 GES
1	.0													3	210 GES
1	.0													4	210 GES
1	.0													5	210 GES
1	.0													6	210 GES
4	4	4	4	4	4									18	7 NPOINT
6	6	6	6	6	6									21	0 NPOINT
	0.0		30.0		60.0		120.0							1	187 TIM
	0.0		30.0		60.0		120.0							2	187 TIM
	0.0		30.0		60.0		120.0							3	187 TIM
	0.0		30.0		60.0		120.0							4	187 TIM
	0.0		30.0		60.0		120.0							5	187 TIM
	0.0		30.0		60.0		120.0							6	187 TIM
	0.0		60.0		100.0		360.0		700.0	25	550.0			1	210 TIM
	0.0		60.0		100.0		360.0		700.0	25	550.0			2	210 TIM
	0.0		60.0		100.0		360.0		700.0	25	550.0			3	210 TIM
	0.0		60.0		100.0		360.0		700.0	25	550.0			4	210 TIM
	0.0		60.0		100.0		360.0		700.0	25	550.0			5	210 TIM
	0.0		60.0		100.0		360.0		700.0	25	550.0			6	210 TIM
5	.0E-2	2	.0E-3	5	.0E-5		0.0							1	187 IN
6	.0E-2	2	.5E-3	5	.2E-5		0.0							2	187 IN
6	.0E-2	2	.3E-3	5	.5E-5		0.0							3	187 IN
7	.5E-2	2	.6E-3	5	.6E-5		0.0							4	187 IN
1	.0E-2	4	.0E-3	8	.0E-5		0.0							5	187 IN
6	.0E-2	2	.4E-3	5	.0E-5		0.0							6	187 IN

1–5	6–10	11–15	16–20	21–25	26–30	31–35	36–40	41–45	46–50	51–55	56–60	61–65	66–70	71–72	73–80
6	.0E-3	7	.5E-3	1	.0E-3	2	.0E-5	1	.0E-6	1	.0E-6			1	210 IN
7	.0E-3	8	.0E-3	1	.5E-3	3	.0E-5	1	.0E-6	1	.0E-6			2	210 IN
8	.0E-3	1	.2E-2	3	.0E-3	2	.5E-5	1	.0E-6	1	.0E-6			3	210 IN
9	.0E-3	1	.5E-2	4	.0E-3	3	.0E-5	1	.0E-6	1	.0E-6			4	210 IN
1	.0E-2	1	.7E-2	4	.0E-3	2	.0E-5	1	.0E-6	1	.0E-6			5	210 IN
2	.0E-2	4	.0E-2	8	.0E-3	2	.0E-5	1	.0E-6	1	.0E-6			6	210 IN
1		0.0		0.0		50.0		0.0		1.0					CASE
1		0.0		0.0		50.0		0.0		50.0					CASE

TABLE II

OUTPUT FOR INREM SAMPLE PROBLEM

LISTING OF THE INPUT PARAMETERS FOR INREM

SAMPLE PROBLEM FOR INREM

TOTAL NUMBER OF RADIONUCLIDES = 2
TOTAL NUMBER OF AGE GROUPS = 6
TOTAL NUMBER OF ORGANS = 2

AGE GROUPS.

GROUP NO.	LOWER LIMIT (YRS)		UPPER LIMIT (YRS)
1	0.0	TO	0.10000E 01
2	0.10000E 01	TO	0.50000E 01
3	0.50000E 01	TO	0.10000E 02
4	0.10000E 02	TO	0.15000E 02
5	0.15000E 02	TO	0.20000E 02
6	0.20000E 02	TO	0.7C000E 02

RADIONUCLIDE IDENTIFICATION.

NUMBER	INDEX	NAME	HALF-LIFE (DAYS)
1	187	I-131	0.80500E 01
2	210	CS-137	0.11000E 05

ORGAN MASS (GRAMS).

NAME / AGE GROUP	TOTAL BODY	THYROID
1	8.0000E 03	2.0000E 00
2	1.5400E 04	3.0000E 00
3	2.5100E 04	5.0000E 00
4	4.1000E 04	1.2000E 01
5	6.5000E 04	1.5000E 01
6	6.9700E 04	1.8000E 01

EFFECTIVE HALF-LIFE (DAYS).

NUCLIDE INDEX	AGE GROUP	TOTAL BODY	THYROID
187			
	1	4.000E 00	4.000E 00
	2	4.500E 00	4.500E 00
	3	5.500E 00	5.500E 00
	4	6.000E 00	6.000E 00
	5	6.500E 00	6.500E 00
	6	7.000E 00	7.000E 00
210			
	1	1.700E 01	0.0
	2	1.800E 01	0.0
	3	3.000E 01	0.0
	4	4.600E 01	0.0
	5	5.400E 01	0.0
	6	6.100E 01	0.0

EFFECTIVE ABSORBED ENERGY (MEV).

ORGAN NAME TOTAL BODY THYROID

NUCLIDE INDEX	AGE GROUP	TOTAL BODY	THYROID
187			
	1	4.400E-01	2.100E-01
	2	4.400E-01	2.100E-01
	3	4.400E-01	2.200E-01
	4	4.400E-01	2.200E-01
	5	4.400E-01	2.300E-01
	6	4.400E-01	2.300E-01
210			
	1	4.800E-01	0.0
	2	5.200E-01	0.0
	3	5.400E-01	0.0
	4	5.500E-01	0.0
	5	5.700E-01	0.0
	6	5.900E-01	0.0

FRACTIONAL ABSORPTION FROM INHALATION (DIMENSIONLESS).

ORGAN NAME TOTAL BODY THYROID

NUCLIDE INDEX	AGE GROUP	TOTAL BODY	THYROID
187			
	1	0.0	0.0
	2	0.0	0.0
	3	0.0	0.0
	4	0.0	0.0
	5	0.0	0.0
	6	0.0	0.0
210			
	1	0.0	0.0
	2	0.0	0.0
	3	0.0	0.0
	4	0.0	0.0
	5	0.0	0.0
	6	0.0	0.0

FRACTIONAL ABSORPTION FROM INGESTION (DIMENSIONLESS).

ORGAN NAME TOTAL BODY THYROID

NUCLIDE INDEX	AGE GROUP	TOTAL BODY	THYROID
187			
	1	1.000E 00	2.000E-01
	2	1.000E 00	2.000E-01
	3	1.000E 00	2.000E-01
	4	1.000E 00	2.000E-01
	5	1.000E 00	2.000E-01
	6	1.000E 00	2.000E-01
210			
	1	1.000E 00	0.0
	2	1.000E 00	0.0
	3	1.000E 00	0.0
	4	1.000E 00	0.0
	5	1.000E 00	0.0
	6	1.000E 00	0.0

INTAKE.

NUCLIDE INDEX	AGE GROUP	NUMBER	TIME (HR)	INTAKE (MICROCURIES/DAY)
187	1	1	0.0	5.0000E-02
		2	3.0000E 01	2.0000E-03
		3	6.0000E 01	5.0000E-05
		4	1.2000E 02	0.0
	2	1	0.0	6.0000E-02
		2	3.0000E 01	2.5000E-03
		3	6.0000E 01	5.2000E-05
		4	1.2000E 02	0.0
	3	1	0.0	6.0000E-02
		2	3.0000E 01	2.3000E-03
		3	6.0000E 01	5.5000E-05
		4	1.2000E 02	0.0
	4	1	0.0	7.5000E-02
		2	3.0000E 01	2.6000E-03
		3	6.0000E 01	5.6000E-05
		4	1.2000E 02	0.0
	5	1	0.0	1.0000E-02
		2	3.0000E 01	4.0000E-03
		3	6.0000E 01	8.0000E-05
		4	1.2000E 02	0.0
	6	1	0.0	6.0000E-02
		2	3.0000E 01	2.4000E-03
		3	6.0000E 01	5.0000E-05
		4	1.2000E 02	0.0
210				
	1	1	0.0	6.0000E-03
		2	6.0000E 01	7.5000E-03
		3	1.0000E 02	1.0000E-03
		4	3.6000E 02	2.0000E-05
		5	7.0000E 02	1.0000E-06
		6	2.5550E 04	1.0000E-06
	2	1	0.0	7.0000E-03
		2	6.0000E 01	8.0000E-03
		3	1.0000E 02	1.5000E-03
		4	3.6000E 02	3.0000E-05
		5	7.0000E 02	1.0000E-06
		6	2.5550E 04	1.0000E-06
	3	1	0.0	8.0000E-03
		2	6.0000E 01	1.2000E-02
		3	1.0000E 02	3.0000E-03
		4	3.6000E 02	2.5000E-05
		5	7.0000E 02	1.0000E-06
		6	2.5550E 04	1.0000E-06
	4	1	0.0	9.0000E-03
		2	6.0000E 01	1.5000E-02
		3	1.0000E 02	4.0000E-03
		4	3.6000E 02	3.0000E-05
		5	7.0000E 02	1.0000E-06
		6	2.5550E 04	1.0000E-06
	5	1	0.0	1.0000E-02
		2	6.0000E 01	1.7000E-02
		3	1.0000E 02	4.0000E-03
		4	3.6000E 02	2.0000E-05
		5	7.0000E 02	1.0000E-06
		6	2.5550E 04	1.0000E-06
	6	1	0.0	2.0000E-02
		2	6.0000E 01	4.0000E-02
		3	1.0000E 02	8.0000E-03
		4	3.6000E 02	2.0000E-05
		5	7.0000E 02	1.0000E-06
		6	2.5550E 04	1.0000E-06

SAMPLE PROBLEM FOR INREM

DOSE COMMITMENT (REMS) FROM INHALATION OF RADIONUCLIDES

NUMBER OF THE REFERENCE DETONATION = 1 .
AGE OF THE INDIVIDUAL AT TIME OF DETONATION = 0.0 YEARS.
TIME AFTER DETONATION WHEN INTAKE BEGINS = 0.0 YEARS.
TIME AFTER DETONATION WHEN INTAKE ENDS = 1.000 YEARS.
DURATION OF THE INTAKE PERIOD = 1.000 YEARS.
TIME AFTER DETONATION WHEN DOSE INTEGRATION BEGINS = 0.0 YEARS.
TIME AFTER DETONATION WHEN DOSE INTEGRATION ENDS = 50.000 YEARS.
DURATION OF DOSE INTEGRATION = 50.000 YEARS.

NO.	NUCLIDE	LABEL	TOTAL BODY	THYROID
1	I-131	187	NO DATA	NO DATA
2	CS-137	210	NO DATA	NO DATA
	TOTAL		0.0	0.0

SAMPLE PROBLEM FOR INREM

DOSE COMMITMENT (REMS) FROM INGESTION OF RADIONUCLIDES

```
NUMBER OF THE REFERENCE DETONATION =  1 .
AGE OF THE INDIVIDUAL AT TIME OF DETONATION =  0.0   YEARS.
TIME AFTER DETONATION WHEN INTAKE BEGINS =  0.0   YEARS.
TIME AFTER DETONATION WHEN INTAKE ENDS =  1.000 YEARS.
DURATION OF THE INTAKE PERIOD =  1.000 YEARS.
TIME AFTER DETONATION WHEN DOSE INTEGRATION BEGINS =  0.0   YEARS.
TIME AFTER DETONATION WHEN DOSE INTEGRATION ENDS = 50.000 YEARS.
DURATION OF DOSE INTEGRATION = 50.000 YEARS.
```

NO.	NUCLIDE	LABEL	TOTAL BODY	THYROID
1	I-131	187	0.131E-01	0.502E 01
2	CS-137	210	0.530E-01	NO DATA
	TOTAL		0.662E-01	0.502E 01

SAMPLE PROBLEM FOR INREM

DOSE COMMITMENT (REMS) FROM INHALATION OF RADIONUCLIDES

```
NUMBER OF THE REFERENCE DETONATION =  1 .
AGE OF THE INDIVIDUAL AT TIME OF DETONATION =  0.0   YEARS.
TIME AFTER DETONATION WHEN INTAKE BEGINS =  0.0   YEARS.
TIME AFTER DETONATION WHEN INTAKE ENDS = 50.000 YEARS.
DURATION OF THE INTAKE PERIOD = 50.000 YEARS.
TIME AFTER DETONATION WHEN DOSE INTEGRATION BEGINS =  0.0   YEARS.
TIME AFTER DETONATION WHEN DOSE INTEGRATION ENDS = 50.000 YEARS.
DURATION OF DOSE INTEGRATION = 50.000 YEARS.
```

NO.	NUCLIDE	LABEL	TOTAL BODY	THYROID
1	I-131	187	NO DATA	NO DATA
2	CS-137	210	NO DATA	NO DATA
	TOTAL		0.0	0.0

SAMPLE PROBLEM FOR INREM

DOSE COMMITMENT (REMS) FROM INGESTION OF RADIONUCLIDES

NUMBER OF THE REFERENCE DETONATION = 1 .
AGE OF THE INDIVIDUAL AT TIME OF DETONATION = 0.0 YEARS.
TIME AFTER DETONATION WHEN INTAKE BEGINS = 0.0 YEARS.
TIME AFTER DETONATION WHEN INTAKE ENDS = 50.000 YEARS.
DURATION OF THE INTAKE PERIOD = 50.000 YEARS.
TIME AFTER DETONATION WHEN DOSE INTEGRATION BEGINS = 0.0 YEARS.
TIME AFTER DETONATION WHEN DOSE INTEGRATION ENDS = 50.000 YEARS.
DURATION OF DOSE INTEGRATION = 50.000 YEARS.

NO.	NUCLIDE	LABEL	TOTAL BODY	THYROID
1	I-131	187	0.131E-01	0.502E 01
2	CS-137	210	0.540E-01	NO DATA
	TOTAL		0.671E-01	0.502E 01

APPENDIX D

LISTING OF THE EXREM CODE

```
C ****** EXREM ******
C  PROGRAM AUTHOR  W.D. TURNER
C  COMPUTING TECHNOLOGY CENTER, UNION CARBIDE CORP., NUCLEAR DIV.,
C  OAK RIDGE, TENN.
C **** MAIN PROGRAM
C
C          TO MODIFY THE DIMENSIONS IN THE ARRAYS IN THIS CODE, THE
C   FOLLOWING CONDITIONS MUST BE SATISFIED.
C   LET
C      MAXB   = MAXIMUM NUMBER OF BETA PARTICLES,
C      MAXCAS = MAXIMUM NUMBER OF CASES PER PROBLEM,
C      MAXEXP = MAXIMUM NUMBER OF DETONATIONS,
C      MAXG   = MAXIMUM NUMBER OF GAMMA PHOTONS,
C      MAXHTS = MAXIMUM NUMBER OF HEIGHTS ABOVE A CONTAMINATED SURFACE,
C      MAXLOC = MAXIMUM NUMBER OF LOCATIONS,
C      MAXNUC = MAXIMUM NUMBER OF RADIONUCLIDES, AND
C      MAXNUM = MAXIMUM NUMBER FOR THE RADIONUCLIDE INDEX.
C
C   THESE VARIABLES ARE LOCATED IN A DATA (INTEGER) STATEMENT IN
C   SUBROUTINE AINPUT.
C       IF MAXB IS CHANGED, DIMENSIONS MUST BE MODIFIED AS INDICATED IN
C   SUBROUTINES MAIN, AINPUT, PRINT, OUTPUT, AND CALCUL.
C       IF MAXCAS IS CHANGED, DIMENSIONS MUST BE MODIFIED AS INDICATED
C   IN SUBROUTINES MAIN, AINPUT, AND OUTPUT.
C       IF MAXEXP IS CHANGED, DIMENSIONS MUST BE MODIFIED AS INDICATED
C   IN SUBROUTINES MAIN, AINPUT, PRINT, OUTPUT, CALCUL, AND CALTAU.
C       IF MAXG IS CHANGED, DIMENSIONS MUST BE MODIFIED AS INDICATED IN
C   SUBROUTINES MAIN, AINPUT, PRINT, OUTPUT, AND CALCUL.
C       IF MAXHTS IS CHANGED, DIMENSIONS MUST BE MODIFIED AS INDICATED
C   IN SUBROUTINES MAIN, AINPUT, PRINT, OUTPUT, AND CALCUL.
C       IF MAXLOC IS CHANGED, DIMENSIONS MUST BE MODIFIED AS INDICATED
C   IN SUBROUTINES MAIN, AINPUT, PRINT, OUTPUT, AND CALCUL.
C       IF MAXNUC IS CHANGED, DIMENSIONS MUST BE MODIFIED AS INDICATED
C   IN SUBROUTINES MAIN, AINPUT, PRINT, OUTPUT, AND CALCUL.
C       IF MAXNUM IS CHANGED, DIMENSIONS MUST BE MODIFIED AS INDICATED
C   IN SUBROUTINES MAIN, AINPUT, PRINT, OUTPUT, AND CALCUL.
C
C IN CHANGING DIMENSIONS, THE FOLLOWING CONDITIONS MUST BE SATISFIED.
C     COMMON /XTIME/TIME(MAXCAS),T1(MAXCAS),T2(MAXCAS),IDET
C     COMMON /INPUT/RADNUC(MAXNUC),GA(MAXNUC,MAXLOC,MAXEXP),GS(MAXNUC,
C    1MAXLOC,MAXEXP),GW(MAXNUC,MAXLOC,MAXEXP),BPROB(MAXNUC,MAXB),
C    2EO(MAXNUC,MAXB),GENERY(MAXNUC,MAXG),GPROB(MAXNUC,MAXG),
C    3Y(MAXNUC,MAXEXP),CLOUDT(MAXEXP),RDECAY(MAXNUC),T(MAXHTS),TITLE(20)
C    4,IATOM(MAXNUC),IDATA(MAXNUM,2,3),NONUC(MAXNUC),NBETA(MAXNUC),
C    5NGAMMA(MAXNUC),IAIR,ISUR,IWATER,NHTS,NRNUC,NRPART
C
      COMMON /XTIME/TIME(20),T1(20),T2(20),IDET
      COMMON /INPUT/RADNUC(250),GA(250, 2,25),GS(250, 2,25),GW(250, 2,25
     1),BPROB(250,15),EO(250,15),GENERY(250,30),GPROB(250,30),Y(250,25),
     2CLOUDT(25),RDECAY(250),T(3),TITLE(20),IATOM(250),IDATA(350,2,3),
     3NONUC(250),NBETA(250),NGAMMA(250),IAIR,ISUR,IWATER,NHTS,NRNUC,
     4NRPART
      REAL*8 RADNUC
      CALL PGMMSK(1,0,0,0)
    1 CONTINUE
```

```
      CALL AINPUT(NCASES,NLOC,LIST,ILOC)
      IF(NCASES.LT.0)RETURN
      CALL PRINT(LIST,NLOC,ILOC)
      CALL CALCUL(NLOC)
      DO 20 I=1,NCASES
      CALL CALTAU(T1(I),T2(I))
      CALL CALTIM(TIME(I))
      DO 20 L=1,NLOC
      CALL OUTPUT(I,L)
      IF(IWATER.EQ.0)GO TO 5
      CALL CALC1(L)
      CALL OUT1
    5 IF(IAIR.EQ.0)GO TO 10
      CALL CALC2(L)
      CALL OUT2
   10 IF(ISUR.EQ.0)GO TO 20
      CALL CALC3(L)
      CALL OUT3
   20 CONTINUE
      GO TO 1
      END


      SUBROUTINE AINPUT(NCASES,NLOC,LIST,ILOC)
C **** THIS ROUTINE READS THE INPUT PARAMETERS FROM CARDS.
C
C IN CHANGING DIMENSIONS, THE FOLLOWING CONDITIONS MUST BE SATISFIED.
C     COMMON /XTIME/TIME(MAXCAS),T1(MAXCAS),T2(MAXCAS),IDET
C     COMMON /XPL/TAU(MAXEXP),TAUP(MAXEXP+1),NEXP,K0,K1
C     COMMON /INPUT/RADNUC(MAXNUC),GA(MAXNUC,MAXLOC,MAXEXP),GS(MAXNUC,
C    1MAXLOC,MAXEXP),GW(MAXNUC,MAXLOC,MAXEXP),BPROB(MAXNUC,MAXB),
C    2E0(MAXNUC,MAXB),GENERY(MAXNUC,MAXG),GPROB(MAXNUC,MAXG),
C    3Y(MAXNUC,MAXEXP),CLOUDT(MAXEXP),RDECAY(MAXNUC),T(MAXHTS),TITLE(20)
C    4,IATOM(MAXNUC),IDATA(MAXNUM,2,3),NONUC(MAXNUC),NBETA(MAXNUC),
C    5NGAMMA(MAXNUC),IAIR,ISUR,IWATER,NHTS,NRNUC,NRPART
C
      COMMON /XTIME/TIME(20),T1(20),T2(20),IDET
      COMMON /XPL/TAU(25),TAUP(26),NEXP,K0,K1
      COMMON /INPUT/RADNUC(250),GA(250, 2,25),GS(250, 2,25),GW(250, 2,25
     1),BPROB(250,15),E0(250,15),GENERY(250,30),GPROB(250,30),Y(250,25),
     2CLOUDT(25),RDECAY(250),T(3),TITLE(20),IATOM(250),IDATA(350,2,3),
     3NONUC(250),NBETA(250),NGAMMA(250),IAIR,ISUR,IWATER,NHTS,NRNUC,
     4NRPART
      REAL*8 RADNUC
      INTEGER MAXB/15/,MAXCAS/20/,MAXEXP/25/,MAXG/30/,MAXHTS/3/,
     1MAXLOC/2/,MAXNUC/250/,MAXNUM/350/
      NRPART=2
      CLOUD=1.0
      IEXP=1
      XLOC=1.0
      ILOC=1
C **** READ TITLE CARD.
      READ(5,1000)(TITLE(I),I=1,20)
 1000 FORMAT(20A4)
C **** READ NO. NUCLIDES, NO. DETONATIONS, NO. LOCATIONS, NO. HEIGHTS
C      ABOVE GROUND SURFACE, NO. CASES, OUTPUT PARAMETER, NO. OF THE
C      DETONATION FROM WHICH ALL TIMES ARE MEASURED, SUBMERSION-IN-WATER
C      FLAG, SUBMERSION-IN-AIR FLAG, EXPOSURE-TO-SURFACE FLAG.
      READ(5,1001)NRNUC,NEXP,NLOC,NHTS,NCASES,LIST,IDET,IWATER,IAIR,ISUR
```

```
 1001 FORMAT(14I5)
C **** LIST = 0 DELETES THE LISTING OF THE INPUT DATA.
C **** IWATER = 0 DELETES THE DOSE CALCULATIONS FOR SUBMERSION IN WATER.
C **** IAIR = 0 DELETES THE DOSE CALCULATIONS FOR SUBMERSION IN AIR.
C **** ISUR = 0 DELETES THE DOSE CALCULATIONS FOR EXPOSURE TO A SURFACE.
      IF(NEXP.GT.0)GO TO 8
      NEXP=-NEXP
      IEXP=0
    8 IF(NLOC.GT.0)GO TO 9
      NLOC=-NLOC
      ILOC=0
    9 CONTINUE
      IF(NRNUC.LE.MAXNUC)GO TO 2
      NCASES=-1
      WRITE(6,9001)MAXNUC
 9001 FORMAT('1THE NUMBER OF RADIONUCLIDES EXCEEDS ',I3)
      RETURN
    2 IF(NEXP.LE.MAXEXP) GO TO 3
      NCASES=-1
      WRITE(6,9002)MAXEXP
 9002 FORMAT('1THE NUMBER OF DETONATIONS EXCEEDS ',I2)
      RETURN
    3 IF(NLOC.LE.MAXLOC)GO TO 4
      NCASES=-1
      WRITE(6,9003)MAXLOC
 9003 FORMAT('1THE NUMBER OF LOCATIONS EXCEEDS ',I2)
      RETURN
    4 IF(NHTS.LE.MAXHTS)GO TO 5
      NCASES=-1
      WRITE(6,9004)MAXHTS
 9004 FORMAT('1THE NUMBER OF HEIGHTS ABOVE A CONTAMINATED SURFACE EXCEED
     1S ',I2)
      RETURN
    5 IF(NCASES.LE.MAXCAS)GO TO 6
      NCASES=-1
      WRITE(6,9005)MAXCAS
 9005 FORMAT('1THE NUMBER OF CASES EXCEEDS ',I2)
      RETURN
    6 CONTINUE
      DO 225 I=1,NRNUC
      DO 225 L=1,NLOC
      DO 225 K=1,NEXP
      GW(I,L,K)=0.0
      GA(I,L,K)=0.0
  225 GS(I,L,K)=0.0
      DO 230 K=1,NEXP
  230 CLOUDT(K)=0.0
      IF(ISUR.EQ.0)GO TO 11
C **** READ HEIGHT (CM) ABOVE GROUND SURFACE.
      READ(5,1005)(T(I),I=1,NHTS)
 1005 FORMAT(7E10.0)
C **** READ THE TIME (HRS) OF EACH DETONATION.
   11 READ(5,1005)(TAU(K),K=1,NEXP)
C **** FOR EACH RADIONUCLIDE, READ INDEX, ATOMIC WEIGHT, NAME,
C      RADIOLOGICAL DECAY CONSTANT (1/HR), NO. OF BETA PARTICLES AND
C      NO. OF GAMMA PARTICLES.
      DO 10 I=1,NRNUC
      READ(5,1002)NONUC(I),IATOM(I),RADNUC(I),RDECAY(I),NBETA(I),
     1NGAMMA(I)
 1002 FORMAT(2I3,A8,1X,E10.0,2I5)
```

```
      IF(NBETA(I).LE.MAXB)GO TO 12
      NCASES=-1
      WRITE(6,9007)NONUC(I),MAXB
 9007 FORMAT('1THE NUMBER OF BETA PARTICLES FOR THE RADIONUCLIDE WITH INA
     1DEX ',I3,' EXCEEDS ',I2)
      RETURN
   12 IF(NGAMMA(I).LE.MAXG)GO TO 13
      NCASES=-1
      WRITE(6,9008)NONUC(I),MAXG
 9008 FORMAT('1THE NUMBER OF GAMMA PARTICLES FOR THE RADIONUCLIDE WITH IA
     1NDEX ',I3,' EXCEEDS ',I2)
      RETURN
   13 IF(NONUC(I).LE.MAXNUM)GO TO 10
      NCASES=-1
      WRITE(6,9006)NONUC(I),MAXNUM
 9006 FORMAT('1THE RADIONUCLIDE INDEX ',I3,' EXCEEDS ',I3)
      RETURN
   10 CONTINUE
C **** FOR EACH RADIONUCLIDE, READ THE YIELD VENTED (MC) FOR EACH
C       DETONATION.
      DO 15 I=1,NRNUC
   15 READ(5,1005)(Y(I,K),K=1,NEXP)
C **** ILOC=0 MEANS THE LOCATION CORRECTION FACTOR IS XLOC.
C       OTHERWISE, READ THE FACTOR.
      IF(ILOC.NE.0)GO TO 18
      DO 16 I=1,NRNUC
      DO 16 L=1,NLOC
      DO 16 K=1,NEXP
      GW(I,L,K)=XLOC
      GA(I,L,K)=XLOC
      GS(I,L,K)=XLOC
   16 CONTINUE
      GO TO 25
C **** FOR EACH LOCATION AND FOR EACH RADIONUCLIDE, READ THE LOCATION
C       CORRECTION FACTOR FOR EACH DETONATION.
   18 DO 24 L=1,NLOC
      IF(IWATER.EQ.0)GO TO 20
      DO 19 I=1,NRNUC
   19 READ(5,1005)(GW(I,L,K),K=1,NEXP)
   20 IF(IAIR.EQ.0)GO TO 22
      DO 21 I=1,NRNUC
   21 READ(5,1005)(GA(I,L,K),K=1,NEXP)
   22 IF(ISUR.EQ.0)GO TO 24
      DO 23 I=1,NRNUC
   23 READ(5,1005)(GS(I,L,K),K=1,NEXP)
   24 CONTINUE
 1003 FORMAT(12E6.0)
C **** FOR EACH RADIONUCLIDE, READ THE MAXIMUM ENERGY (MEV) AND
C       PROBABILITY FOR EACH BETA PARTICLE.
   25 DO 27 I=1,NRNUC
      M=NBETA(I)
      IF(M.EQ.0)GO TO 27
      READ(5,1003)(E0(I,IP),BPROB(I,IP),IP=1,M)
   27 CONTINUE
C **** FOR EACH RADIONUCLIDE, READ THE AVERAGE ENERGY (MEV) AND
C       PROBABILITY FOR EACH GAMMA PARTICLE.
      DO 30 I=1,NRNUC
      M=NGAMMA(I)
      IF(M.EQ.0)GO TO 30
      READ(5,1003)(GENERY(I,IP),GPROB(I,IP),IP=1,M)
```

```
   30 CONTINUE
      IF(IAIR.EQ.0)GO TO 65
C **** IEXP=0 MEANS THE TIME REQUIRED FOR A RADIOACTIVE CLOUD TO PASS A
C       GIVEN LOCATION IS CLOUD (HRS).  OTHERWISE, FOR EACH DETONATION,
C       READ THE ACTUAL TIME (HRS).
      IF(IEXP.NE.0)GO TO 60
      DO 55 K=1,NEXP
   55 CLOUDT(K)=CLOUD
      GO TO 65
   60 READ(5,1005)(CLOUDT(K),K=1,NEXP)
C **** FOR EACH CASE, READ THE TIME FOR DOSE RATE CALCULATION AND THE
C       TIME INTERVAL FOR TOTAL DOSE CALCULATION.
   65 DO 70 I=1,NCASES
   70 READ(5,1005)TIME(I),T1(I),T2(I)
C **** CONVERT TIME FROM YEARS TO HOURS.
      DO 75 I=1,NCASES
      TIME(I)=8760.0*TIME(I)
      T1(I)=8760.0*T1(I)
   75 T2(I)=8760.0*T2(I)
C **** IDATA = 0 MEANS INSUFFICIENT DATA,
C       IDATA = 1 MEANS SUFFICIENT DATA.
C **** INITILIZE IDATA ARRAY.
      DO 100 I=1,NRNUC
      N=NONUC(I)
      DO 100 J=1,2
      DO 100 IT=1,3
  100 IDATA(N,J,IT)=1
C **** DETERMINE WHICH NUCLIDES HAVE INSUFFICIENT DATA.
      IF(NEXP.EQ.1)GO TO 120
      S=TAU(1)
      DO 105 K=2,NEXP
      IF(TAU(K).LE.S)GO TO 110
  105 S=TAU(K)
      GO TO 120
  110 DO 115 I=1,NRNUC
      N=NONUC(I)
      DO 115 J=1,2
      DO 115 IT=1,3
  115 IDATA(N,J,IT)=0
      GO TO 200
  120 DO 170 I=1,NRNUC
      N=NONUC(I)
      IF(RDECAY(I).GT.0.0)GO TO 130
      DO 125 J=1,2
      DO 125 IT=1,3
  125 IDATA(N,J,IT)=0
      GO TO 170
  130 IF(IATOM(I).EQ.0)GO TO 140
      M=NBETA(I)
      IF(M.EQ.0)GO TO 150
      DO 135 IP=1,M
      IF(E0(I,IP).EQ.0.0)GO TO 140
      IF(BPROB(I,IP).EQ.0.0) GO TO 140
  135 CONTINUE
      GO TO 150
  140 DO 145 IT=1,3
  145 IDATA(N,1,IT)=0
  150 M=NGAMMA(I)
      IF(M.EQ.0)GO TO 170
      DO 155 IP=1,M
```

```
      IF(GENERY(I,IP).EQ.0.0)GO TO 160                                  AINP2170
      IF(GPROB(I,IP).EQ.0.0)GO TO 160                                   AINP2180
  155 CONTINUE                                                          AINP2190
      GO TO 170                                                         AINP2200
  160 DO 165 IT=1,3                                                     AINP2210
  165 IDATA(N,2,IT)=0                                                   AINP2220
      IF(IAIR.EQ.0)GO TO 200                                            AINP2230
  170 CONTINUE                                                          AINP2240
      DO 175 K=1,NEXP                                                   AINP2250
      IF(CLOUDT(K).EQ.0.0)GO TO 180                                     AINP2260
  175 CONTINUE                                                          AINP2270
      GO TO 200                                                         AINP2280
  180 DO 185 I=1,NRNUC                                                  AINP2290
      N=NONUC(I)                                                        AINP2300
      DO 185 J=1,2                                                      AINP2310
  185 IDATA(N,J,2)=0                                                    AINP2320
  200 RETURN                                                            AINP2330
      END                                                               AINP2340
```

```
      SUBROUTINE PRINT(LIST,NLOC,ILOC)                                  PRIN0010
C ****** THIS ROUTINE PRINTS THE BASIC INPUT PARAMETERS FOR THE PROBLEM.PRIN0020
C                                                                       PRIN0030
C IN CHANGING DIMENSIONS, THE FOLLOWING CONDITIONS MUST BE SATISFIED.   PRIN0040
C     COMMON /XPL/TAU(MAXEXP),TAUP(MAXEXP+1),NEXP,K0,K1                 PRIN0050
C     COMMON /INPUT/RADNUC(MAXNUC),GA(MAXNUC,MAXLOC,MAXEXP),GS(MAXNUC,  PRIN0060
C    1MAXLOC,MAXEXP),GW(MAXNUC,MAXLOC,MAXEXP),BPROB(MAXNUC,MAXB),       PRIN0070
C    2EO(MAXNUC,MAXB),GENERY(MAXNUC,MAXG),GPROB(MAXNUC,MAXG),           PRIN0080
C    3Y(MAXNUC,MAXEXP),CLOUDT(MAXEXP),RDECAY(MAXNUC),T(MAXHTS),TITLE(20)PRIN0090
C    4,IATOM(MAXNUC),IDATA(MAXNUM,2,3),NONUC(MAXNUC),NBETA(MAXNUC),     PRIN0100
C    5NGAMMA(MAXNUC),IAIR,ISUR,IWATER,NHTS,NRNUC,NRPART                 PRIN0110
C                                                                       PRIN0120
      COMMON /XPL/TAU(25),TAUP(26),NEXP,K0,K1                           PRIN0130
      COMMON /INPUT/RADNUC(250),GA(250, 2,25),GS(250, 2,25),GW(250, 2,25PRIN0140
     1),BPROB(250,15),EO(250,15),GENERY(250,30),GPROB(250,30),Y(250,25),PRIN0150
     2CLOUDT(25),RDECAY(250),T(3),TITLE(20),IATOM(250),IDATA(350,2,3),  PRIN0160
     3NONUC(250),NBETA(250),NGAMMA(250),IAIR,ISUR,IWATER,NHTS,NRNUC,    PRIN0170
     4NRPART                                                            PRIN0180
      REAL*8 RADNUC                                                     PRIN0190
C **** LIST=0 MEANS -- DO NOT PRINT THE INPUT.                          PRIN0200
C       OTHERWISE, PRINT THE BASIC INPUT PARAMETERS.                    PRIN0210
      IF(LIST.EQ.0)RETURN                                               PRIN0220
      WRITE(6,3001)                                                     PRIN0230
 3001 FORMAT('1',18X,'LISTING OF BASIC INPUT PARAMETERS FOR EXREM'//)   PRIN0240
      WRITE(6,3000)(TITLE(I),I=1,20)                                    PRIN0250
 3000 FORMAT('0',20A4)                                                  PRIN0260
      WRITE(6,3002)NRNUC,NEXP,NLOC                                      PRIN0270
 3002 FORMAT('OTOTAL NO. OF RADIONUCLIDES =',I3/' TOTAL NO. OF DETONATIOPRIN0280
     1NS    =',I3/' TOTAL NO. OF LOCATIONS      =',I3/)                 PRIN0290
      IF(IWATER.NE.0)WRITE(6,3030)                                      PRIN0300
 3030 FORMAT('OESTIMATE DOSES FOR SUBMERSION IN WATER.')                PRIN0310
      IF(IAIR.NE.0)WRITE(6,3031)                                        PRIN0320
 3031 FORMAT('OESTIMATE DOSES FOR SUBMERSION IN AIR.')                  PRIN0330
      IF(ISUR.NE.0)WRITE(6,3032)                                        PRIN0340
 3032 FORMAT('OESTIMATE DOSES FOR EXPOSURE TO A SURFACE.')              PRIN0350
      WRITE(6,3003)                                                     PRIN0360
 3003 FORMAT('ORADIONUCLIDE IDENTIFICATION.'/'    INDEX   ATOMIC   NAME',PRIN0370
     16X,'DECAY CONSTANT',5X,          'NO. BETA    NO. GAMMA'/1H ,10X,'PRIN0380
     2NUMBER',15X,'(1/HRS)',9X,          'PARTICLES    PHOTONS ')       PRIN0390
```

```
      DO 605 I=1,NRNUC
  605 WRITE(6,3004)NONUC(I), IATOM(I),RADNUC(I),RDECAY(I),       NBETA(I),
     1NGAMMA(I)
 3004 FORMAT(1H ,4X,I3,4X,I3,4X,A8,2X,E12.5,4X,       6X,I2,9X,I2)
      WRITE(6,3005)
 3005 FORMAT('OYIELD.'/'    INDEX  RADIONUCLIDE  DETONATION  YIELD VENTE
     1D' /' ',36X,'(MICROCURIES)')
      DO 610 I=1,NRNUC
  610 WRITE(6,3006)NONUC(I),RADNUC(I),(K,Y(I,K),K=1,NEXP)
 3006 FORMAT(' ',4X,I3,3X,A8,10X,I2,6X,E12.5/(' ',28X,I2,6X,E12.5))
      IF(ILOC.EQ.0)GO TO 618
      WRITE(6,3007)
 3007 FORMAT('OLOCATION CORRECTION FACTOR.'/
     1'    LOCATION   NUCLIDE   DETONATION    SUBMERSION   SUBMERSION
     2 EXPOSURE'/'     NUMBER      INDEX       NUMBER',7X,    'IN WATER
     3  IN AIR      TO SURFACE'/41X,'(1/CC)',7X,'(1/CC)',6X,'(1/SQ CM)')
      DO 615 L=1,NLOC
      WRITE(6,3020)L
 3020 FORMAT(5X,I3)
      DO 615 I=1,NRNUC
      WRITE(6,3008)NONUC(I)
 3008 FORMAT(17X,I3)
      DO 615 K=1,NEXP
      WRITE(6,3010)K,GW(I,L,K),GA(I,L,K),GS(I,L,K)
 3010 FORMAT(29X,I2,5X,1P3E13.4)
  615 CONTINUE
      GO TO 619
  618 WRITE(6,3013)
 3013 FORMAT('OLOCATION CORRECTION FACTOR FOR ALL RADIONUCLIDES AND DETO
     1NATIONS.')
      WRITE(6,3014)GW(1,1,1),GA(1,1,1),GS(1,1,1)
 3014 FORMAT(6X,'SUBMERSION  SUBMERSION   EXPOSURE'/7X,'IN WATER      IN
     1AIR     TO SURFACE'/8X,'(1/CC)',6X,'(1/CC)',5X,'(1/SQ CM)'/
     24X,1P3E12.4)
  619 WRITE(6,3009)
 3009 FORMAT('OENERGY AND ABUNDANCE FOR EACH BETA PARTICLE.'/'    INDEX
     1 RADIONUCLIDE  NO.  MAXIMUM ENERGY    ABUNDANCE'/' ',33X,'(MEV)')
      DO 620 I=1,NRNUC
      M=NBETA(I)
      IF(M.EQ.0)GO TO 620
      WRITE(6,3012)NONUC(I),RADNUC(I),(J,EO(I,J),BPROB(I,J),J=1,M)
  620 CONTINUE
      WRITE(6,3011)
 3011 FORMAT('OENERGY AND ABUNDANCE FOR EACH GAMMA PHOTON.  '/'    INDEX
     1  RADIONUCLIDE  NO.      ENERGY        ABUNDANCE'/' ',33X,'(MEV)')
      DO 625 I=1,NRNUC
      M=NGAMMA(I)
      IF(M.EQ.0)GO TO 625
      WRITE(6,3012)NONUC(I),RADNUC(I),(J,GENERY(I,J),GPROB(I,J),J=1,M)
  625 CONTINUE
 3012 FORMAT(' ',4X,I3,3X,A8,6X,I2,4X,E11.4,7X,F5.3/(' ',24X,I2,4X,E11.4
     1,7X,F5.3))
      WRITE(6,3015)
 3015 FORMAT('OTIME OF EACH DETONATION.'/'     NO.    DETONATION  CLOUD
     1TIME'/12X,'TIME (HRS)',5X,'(HRS)')
      DO 640 I=1,NEXP
  640 WRITE(6,3016)I,TAU(I),CLOUDT(I)
 3016 FORMAT(' ',I7,4X,F10.1,2X,F10.1)
      IF(ISUR.EQ.0)RETURN
      WRITE(6,3017)
```

```
3017 FORMAT('OHEIGHT ABOVE GROUND SURFACE.'/'       NO.   HEIGHT'/' ',10X,
    1'(CM)')
     DO 645 I=1,NHTS
 645 WRITE(6,3018)I,T(I)
3018 FORMAT(' ',I6,F10.3)
     RETURN
     END


     SUBROUTINE OUTPUT(ICASE,L)
C ****** THIS ROUTINE WRITES OUT THE DOSE RATES AND TOTAL DOSES FOR
C      THE NUCLIDES.
C
C IN CHANGING DIMENSIONS, THE FOLLOWING CONDITIONS MUST BE SATISFIED.
C     COMMON /XTIME/TIME(MAXCAS),T1(MAXCAS),T2(MAXCAS),IDET
C     COMMON /XPL/TAU(MAXEXP),TAUP(MAXEXP+1),NEXP,K0,K1
C     COMMON /INPUT/RADNUC(MAXNUC),GA(MAXNUC,MAXLOC,MAXEXP),GS(MAXNUC,
C    1MAXLOC,MAXEXP),GW(MAXNUC,MAXLOC,MAXEXP),BPROB(MAXNUC,MAXB),
C    2E0(MAXNUC,MAXB),GENERY(MAXNUC,MAXG),GPROB(MAXNUC,MAXG),
C    3Y(MAXNUC,MAXEXP),CLOUDT(MAXEXP),RDECAY(MAXNUC),T(MAXHTS),TITLE(20)
C    4,IATOM(MAXNUC),IDATA(MAXNUM,2,3),NONUC(MAXNUC),NBETA(MAXNUC),
C    5NGAMMA(MAXNUC),IAIR,ISUR,IWATER,NHTS,NRNUC,NRPART
C     COMMON /ANSWER/DRS(MAXNUC,2,MAXHTS),TDS(MAXNUC,2,MAXHTS),
C    1DRA(MAXNUC,2),DRW(MAXNUC,2),TDA(MAXNUC,2),TDW(MAXNUC,2)
C     DIMENSION LABEL1(MAXNUC),LABEL2(MAXNUC),LABEL3(MAXNUC),
C    1VALUE1(MAXNUC),VALUE2(MAXNUC),VALUE3(MAXNUC)
C     REAL*8 ANAME1(MAXNUC),ANAME2(MAXNUC),ANAME3(MAXNUC)
C
      COMMON /XTIME/TIME(20),T1(20),T2(20),IDET
      COMMON /XPL/TAU(25),TAUP(26),NEXP,K0,K1
      COMMON /INPUT/RADNUC(250),GA(250, 2,25),GS(250, 2,25),GW(250, 2,25
     1),BPROB(250,15),E0(250,15),GENERY(250,30),GPROB(250,30),Y(250,25),
     2CLOUDT(25),RDECAY(250),T(3),TITLE(20),IATOM(250),IDATA(350,2,3),
     3NONUC(250),NBETA(250),NGAMMA(250),IAIR,ISUR,IWATER,NHTS,NRNUC,
     4NRPART
      COMMON /ANSWER/DRS(250,2,3),TDS(250,2,3),DRA(250,2),DRW(250,2),
     1TDA(250,2),TDW(250,2)
      REAL*8 RADNUC
      REAL FMT(27)/'(1H ,I3 ,7X ,I3 ,4X ,A8 '/
      REAL TEST/1.0E-06/,BLANK/'    '/
C **** IL = MAXIMUM NUMBER OF LINES ON EACH PAGE OF OUTPUT.
      INTEGER IL/55/
      DIMENSION TOTAL(3)
      DIMENSION LABEL1(250),LABEL2(250),LABEL3(250),VALUE1(250),
     1VALUE2(250),VALUE3(250)
      REAL*8 ANAME1(250),ANAME2(250),ANAME3(250)
      DO 20 I=1,NRNUC
      N=NONUC(I)
      DO 5 K=1,NEXP
      IF(GW(I,L,K).NE.0.0)GO TO 5
      DO 3 J=1,2
    3 IDATA(N,J,1)=0
      GO TO 6
    5 CONTINUE
    6 DO 10 K=1,NEXP
      IF(GA(I,L,K).NE.0.0)GO TO 10
      DO 8 J=1,2
    8 IDATA(N,J,2)=0
      GO TO 11
```

```
   10 CONTINUE
   11 DO 15 K=1,NEXP
      IF(GS(I,L,K).NE.0.0)GO TO 15
      DO 13 J=1,2
   13 IDATA(N,J,3)=0
      GO TO 20
   15 CONTINUE
   20 CONTINUE
      RETURN
C***********************************************************************
      ENTRY OUT1
C **** OUTPUT FOR SUBMERSION IN WATER.
      IT=1
      DO 50 I=1,NRNUC
      N=NONUC(I)
      DO 50 J=1,2
      IF(IDATA(N,J,1).NE.0)GO TO 50
      DRW(I,J)=0.0
      TDW(I,J)=0.0
   50 CONTINUE
      DO 55 I=1,NRNUC
      DO 55 J=1,2
      IF(DRW(I,J).LT.TEST)DRW(I,J)=0.0
      IF(TDW(I,J).LT.TEST)TDW(I,J)=0.0
   55 CONTINUE
      WRITE(6,2000)(TITLE(I),I=1,20)
 2000 FORMAT('1', 9X,20A4/)
      WRITE(6,2001)
 2001 FORMAT(1H0,13X,'LISTING OF RADIONUCLIDES FOR SUBMERSION DOSE RATES
     1 IN CONTAMINATED WATER')
      WRITE(6,2002)L
 2002 FORMAT('OLOCATION NUMBER = ',I1)
      WRITE(6,2003)IDET,TIME(ICASE)
 2003 FORMAT(' TIME AFTER DETONATION ',I2,' =',E12.5,' HOURS.')
      WRITE(6,2004)
 2004 FORMAT('0',14X,'BETA DOSE RATE',18X,'GAMMA DOSE RATE',17X,'TOTAL D
     1OSE RATE'/'ONO.',3(5X,'NUCLIDE  NUCLIDE  DOSE RATE')/5X,3(5X,'LABE
     2L    NAME     REMS/HR  ')/)
      DO 110 I=1,NRNUC
      LABEL1(I)=NONUC(I)
      ANAME1(I)=RADNUC(I)
      VALUE1(I)=DRW(I,1)
      LABEL2(I)=NONUC(I)
      ANAME2(I)=RADNUC(I)
      VALUE2(I)=DRW(I,2)
      LABEL3(I)=NONUC(I)
      ANAME3(I)=RADNUC(I)
  110 VALUE3(I)=DRW(I,1)+DRW(I,2)
      IC=0
  120 CONTINUE
      CALL ORDER(LABEL1,ANAME1,VALUE1,NRNUC)
      CALL ORDER(LABEL2,ANAME2,VALUE2,NRNUC)
      CALL ORDER(LABEL3,ANAME3,VALUE3,NRNUC)
      TOTAL(1)=0.0
      TOTAL(2)=0.0
      LINE=14
      DO 140 I=1,NRNUC
      TOTAL(1)=TOTAL(1)+VALUE1(I)
      TOTAL(2)=TOTAL(2)+VALUE2(I)
      IF(LINE.LT.IL)GO TO 130
```

```
      WRITE(6,3004)
 3004 FORMAT('1')
      IF(IC.EQ.0)WRITE(6,2004)
      IF(IC.EQ.1)WRITE(6,2009)
      LINE=7
  130 DO 135 N=7,27
  135 FMT(N)=BLANK
      N=6
      ID1=IDATA(LABEL1(I),1,IT)
      ID2=IDATA(LABEL2(I),2,IT)
      ID3=IDATA(LABEL3(I),1,IT)
      ID4=IDATA(LABEL3(I),2,IT)
      CALL FMTGEN(VALUE1(I),VALUE2(I),VALUE3(I),ID1,ID2,ID3,ID4,N,FMT)
      WRITE(6,FMT) I,LABEL1(I),ANAME1(I),VALUE1(I),LABEL2(I),ANAME2(I),
     1VALUE2(I),LABEL3(I),ANAME3(I),VALUE3(I)
      LINE=LINE+1
  140 CONTINUE
      TOTAL(3)=TOTAL(1)+TOTAL(2)
      IF(LINE.LT.IL-1)GO TO 150
      WRITE(6,3004)
      IF(IC.EQ.0)WRITE(6,2004)
      IF(IC.EQ.1)WRITE(6,2009)
  150 WRITE(6,2006)(TOTAL(K),K=1,3)
 2006 FORMAT('0TOTAL',20X,E10.3,2(22X,E10.3))
      IF(IC.EQ.1)RETURN
      WRITE(6,2000)(TITLE(I),I=1,20)
      GO TO (180,220),IT
  180 WRITE(6,2007)
 2007 FORMAT(1H0,10X,'LISTING OF RADIONUCLIDES FOR ACCUMULATED SUBMERSIO
     1N DOSES IN CONTAMINATED WATER')
      WRITE(6,2002)L
      WRITE(6,2008)T1(ICASE),T2(ICASE)
 2008 FORMAT(' INTEGRATION PERIOD --',E12.5,' TO',E12.5,' HOURS.')
      WRITE(6,2009)
 2009 FORMAT('0',17X,'BETA DOSE',23X,'GAMMA DOSE',22X,'TOTAL DOSE'/'ONO.
     1',3(5X,'NUCLIDE  NUCLIDE      DOSE     ')/' ',3(9X,'LABEL     NAME
     2 REMS')/)
      DO 190 I=1,NRNUC
      LABEL1(I)=NONUC(I)
      ANAME1(I)=RADNUC(I)
      VALUE1(I)=TDW(I,1)
      LABEL2(I)=NONUC(I)
      ANAME2(I)=RADNUC(I)
      VALUE2(I)=TDW(I,2)
      LABEL3(I)=NONUC(I)
      ANAME3(I)=RADNUC(I)
  190 VALUE3(I)=TDW(I,1)+TDW(I,2)
      IC=1
      GO TO 120
C***********************************************************************
      ENTRY OUT2
C **** OUTPUT FOR SUBMERSION IN AIR.
      IT=2
      DO 200 I=1,NRNUC
      N=NONUC(I)
      DO 200 J=1,2
      IF(IDATA(N,J,2).NE.0)GO TO 200
      DRA(I,J)=0.0
      TDA(I,J)=0.0
  200 CONTINUE
```

```
      DO 205 I=1,NRNUC
      DO 205 J=1,2
      IF(DRA(I,J).LT.TEST)DRA(I,J)=0.0
      IF(TDA(I,J).LT.TEST)TDA(I,J)=0.0
  205 CONTINUE
      WRITE(6,2000)(TITLE(I),I=1,20)
      WRITE(6,2010)
 2010 FORMAT(1H0,14X,'LISTING OF RADIONUCLIDES FOR SUBMERSION DOSE RATES
     1 IN CONTAMINATED AIR')
      WRITE(6,2002)L
      WRITE(6,2003)IDET,TIME(ICASE)
      WRITE(6,2004)
      DO 210 I=1,NRNUC
      LABEL1(I)=NONUC(I)
      ANAME1(I)=RADNUC(I)
      VALUE1(I)=DRA(I,1)
      LABEL2(I)=NONUC(I)
      ANAME2(I)=RADNUC(I)
      VALUE2(I)=DRA(I,2)
      LABEL3(I)=NONUC(I)
      ANAME3(I)=RADNUC(I)
  210 VALUE3(I)=DRA(I,1)+DRA(I,2)
      IC=0
      GO TO 120
  220 WRITE(6,2011)
 2011 FORMAT(1H0,11X,'LISTING OF RADIONUCLIDES FOR ACCUMULATED SUBMERSIO
     1N DOSES IN CONTAMINATED AIR')
      WRITE(6,2002)L
      WRITE(6,2008)T1(ICASE),T2(ICASE)
      WRITE(6,2009)
      DO 230 I=1,NRNUC
      LABEL1(I)=NONUC(I)
      ANAME1(I)=RADNUC(I)
      VALUE1(I)=TDA(I,1)
      LABEL2(I)=NONUC(I)
      ANAME2(I)=RADNUC(I)
      VALUE2(I)=TDA(I,2)
      LABEL3(I)=NONUC(I)
      ANAME3(I)=RADNUC(I)
  230 VALUE3(I)=TDA(I,1)+TDA(I,2)
      IC=1
      GO TO 120
C***********************************************************************
      ENTRY OUT3
C **** OUTPUT FOR CONTAMINATED GROUND SURFACE.
      IT=3
      DO 285 I=1,NRNUC
      N=NONUC(I)
      DO 285 J=1,2
      IF(IDATA(N,J,3).NE.0)GO TO 285
      DO 280 IH=1,NHTS
      DRS(I,J,IH)=0.0
  280 TDS(I,J,IH)=0.0
  285 CONTINUE
      DO 300 I=1,NRNUC
      DO 300 J=1,2
      DO 300 IH=1,NHTS
      IF(DRS(I,J,IH).LT.TEST)DRS(I,J,IH)=0.0
      IF(TDS(I,J,IH).LT.TEST)TDS(I,J,IH)=0.0
  300 CONTINUE
```

```
      DO 345 IH=1,NHTS
      WRITE(6,2000)(TITLE(I),I=1,20)
      WRITE(6,2012)
 2012 FORMAT(1H0,12X,'LISTING OF RADIONUCLIDES FOR DOSE RATES ABOVE A CO
     1NTAMINATED GROUND SURFACE')
      WRITE(6,2002)L
      WRITE(6,2013)T(IH)
 2013 FORMAT(' HEIGHT = ',F7.3,' CM.')
      WRITE(6,2003)IDET,TIME(ICASE)
      IF(T(IH).NE.0.0)GO TO 304
      WRITE(6,9001)IH
 9001 FORMAT('0HEIGHT ENTRY',I2,' IS 0.0. THE OUTPUT FOR DOSE RATES AND
     1TOTAL DOSES IS DELETED')
      GO TO 345
  304 WRITE(6,2004)
      DO 305 I=1,NRNUC
      LABEL1(I)=NONUC(I)
      ANAME1(I)=RADNUC(I)
      VALUE1(I)=DRS(I,1,IH)
      LABEL2(I)=NONUC(I)
      ANAME2(I)=RADNUC(I)
      VALUE2(I)=DRS(I,2,IH)
      LABEL3(I)=NONUC(I)
      ANAME3(I)=RADNUC(I)
  305 VALUE3(I)=DRS(I,1,IH)+DRS(I,2,IH)
      IC=0
  308 CONTINUE
      CALL ORDER(LABEL1,ANAME1,VALUE1,NRNUC)
      CALL ORDER(LABEL2,ANAME2,VALUE2,NRNUC)
      CALL ORDER(LABEL3,ANAME3,VALUE3,NRNUC)
      TOTAL(1)=0.0
      TOTAL(2)=0.0
      LINE=15
      DO 310 I=1,NRNUC
      TOTAL(1)=TOTAL(1)+VALUE1(I)
      TOTAL(2)=TOTAL(2)+VALUE2(I)
      IF(LINE.LT.IL)GO TO 315
      WRITE(6,3004)
      IF(IC.EQ.0)WRITE(6,2004)
      IF(IC.EQ.1)WRITE(6,2009)
      LINE=7
  315 DO 320 N=7,27
  320 FMT(N)=BLANK
      N=6
      ID1=IDATA(LABEL1(I),1,IT)
      ID2=IDATA(LABEL2(I),2,IT)
      ID3=IDATA(LABEL3(I),1,IT)
      ID4=IDATA(LABEL3(I),2,IT)
      CALL FMTGEN(VALUE1(I),VALUE2(I),VALUE3(I),ID1,ID2,ID3,ID4,N,FMT)
      WRITE(6,FMT) I,LABEL1(I),ANAME1(I),VALUE1(I),LABEL2(I),ANAME2(I),
     1VALUE2(I),LABEL3(I),ANAME3(I),VALUE3(I)
      LINE=LINE+1
  310 CONTINUE
      TOTAL(3)=TOTAL(1)+TOTAL(2)
      IF(LINE.LT.IL-1)GO TO 390
      WRITE(6,3004)
      IF(IC.EQ.0)WRITE(6,2004)
      IF(IC.EQ.1)WRITE(6,2009)
  390 WRITE(6,2006)(TOTAL(K),K=1,3)
      IF(IC.EQ.1)GO TO 345
```

```
      WRITE(6,2000)(TITLE(I),I=1,20)
      WRITE(6,2014)
 2014 FORMAT(1H0, 8X,'LISTING OF RADIONUCLIDES FOR ACCUMULATED DOSES ABO
     1VE A CONTAMINATED GROUND SURFACE')
      WRITE(6,2002)L
      WRITE(6,2013)T(IH)
      WRITE(6,2008)T1(ICASE),T2(ICASE)
      WRITE(6,2009)
      DO 330 I=1,NRNUC
      LABEL1(I)=NONUC(I)
      ANAME1(I)=RADNUC(I)
      VALUE1(I)=TDS(I,1,IH)
      LABEL2(I)=NONUC(I)
      ANAME2(I)=RADNUC(I)
      VALUE2(I)=TDS(I,2,IH)
      LABEL3(I)=NONUC(I)
      ANAME3(I)=RADNUC(I)
  330 VALUE3(I)=TDS(I,1,IH)+TDS(I,2,IH)
      IC=1
      GO TO 308
  345 CONTINUE
      RETURN
      END
```

```
      SUBROUTINE FMTGEN(D1,D2,D3,ID1,ID2,ID3,ID4,N,FMT)
      REAL F(11)/',7X ,I3 ,4X ,A8 ,E10.3  ,4H NO  ,A4 ,2X )    '/
      REAL DATA/'DATA'/
      DIMENSION FMT(1)
      IT=1
    5 IF(ID1.NE.0)GO TO 20
      D1=DATA
   10 DO 15 I=7,10
      N=N+1
   15 FMT(N)=F(I)
      GO TO (35,35,55),IT
   20 DO 25 I=5,6
      N=N+1
   25 FMT(N)=F(I)
   30 GO TO (35,35,55),IT
   35 IT=IT+1
      DO 40 I=1,4
      N=N+1
   40 FMT(N)=F(I)
      GO TO (5,45,50),IT
   45 IF(ID2.NE.0)GO TO 20
      D2=DATA
      GO TO 10
   50 IF(ID3.NE.0 .AND. ID4.NE.0)GO TO 20
      D3=DATA
      GO TO 10
   55 N=N+1
      FMT(N)=F(11)
      RETURN
      END
```

```
      SUBROUTINE CALCUL(NLOC)
C ****** THIS IS THE WORK ROUTINE FOR THE PROGRAM.
C
C IN CHANGING DIMENSIONS, THE FOLLOWING CONDITIONS MUST BE SATISFIED.
C     COMMON /XPL/TAU(MAXEXP),TAUP(MAXEXP+1),NEXP,K0,K1
C     COMMON /INPUT/RADNUC(MAXNUC),GA(MAXNUC,MAXLOC,MAXEXP),GS(MAXNUC,
C    1MAXLOC,MAXEXP),GW(MAXNUC,MAXLOC,MAXEXP),BPROB(MAXNUC,MAXB),
C    2E0(MAXNUC,MAXB),GENERY(MAXNUC,MAXG),GPROB(MAXNUC,MAXG),
C    3Y(MAXNUC,MAXEXP),CLOUDT(MAXEXP),RDECAY(MAXNUC),T(MAXHTS),TITLE(20)
C    4,IATOM(MAXNUC),IDATA(MAXNUM,2,3),NONUC(MAXNUC),NBETA(MAXNUC),
C    5NGAMMA(MAXNUC),IAIR,ISUR,IWATER,NHTS,NRNUC,NRPART
C     COMMON /ANSWER/DRS(MAXNUC,2,MAXHTS),TDS(MAXNUC,2,MAXHTS),
C    1DRA(MAXNUC,2),DRW(MAXNUC,2),TDA(MAXNUC,2),TDW(MAXNUC,2)
C     DIMENSION SUBDOS(MAXNUC,2,2),GDDOSE(MAXNUC,2,MAXHTS),
C    1BENERY(MAXNUC,MAXB),DELTA(MAXEXP+1,MAXEXP+1),DTAU(MAXEXP+1,
C    2MAXEXP+1),A(MAXHTS),DELT(MAXEXP+1),DELTAU(MAXEXP+1),E1(10),
C    3TABLE(1001)
C
      COMMON /XPL/TAU(25),TAUP(26),NEXP,K0,K1
      COMMON /INPUT/RADNUC(250),GA(250, 2,25),GS(250, 2,25),GW(250, 2,25
     1),BPROB(250,15),E0(250,15),GENERY(250,30),GPROB(250,30),Y(250,25),
     2CLOUDT(25),RDECAY(250),T(3),TITLE(20),IATOM(250),IDATA(350,2,3),
     3NONUC(250),NBETA(250),NGAMMA(250),IAIR,ISUR,IWATER,NHTS,NRNUC,
     4NRPART
      COMMON /ANSWER/DRS(250,2,3),TDS(250,2,3),DRA(250,2),DRW(250,2),
     1TDA(250,2),TDW(250,2)
      REAL*8 RADNUC
      DIMENSION SUBDOS(250,2,2),GDDOSE(250,2,3),BENERY(250,15),
     1DELTA(26,26),DTAU(26,26),A(3),DELT(26),DELTAU(26),E1(10),
     2TABLE(1001)
      REAL BS/1.14/
      REAL CON(2,2)/1.0666667,2.1333334,1.2166667,1.2166667/
      REAL E(24)/.01,.015,.02,.03,.04,.05,.06,.08,.1,.15,.2,.3,.4,.5,.6,
     1.8,1.,1.5,2.,3.,4.,5./
      REAL SIGMA(24)/591.114,162.,65.02,18.695,8.037,4.87,3.703,2.978,
     13.001,3.246,3.466,3.727,3.818,3.833,3.826,3.729,3.612,3.305,3.036,
     22.728,2.499,2.338/
      INTEGER ISR90/42/
      DO 3 I=1,NRNUC
      DO 3 K=1,NEXP
      DO 3 L=1,NLOC
      IF(IWATER.NE.0)GW(I,L,K)=Y(I,K)*GW(I,L,K)
      IF(IAIR.NE.0)GA(I,L,K)=Y(I,K)*GA(I,L,K)
      IF(ISUR.NE.0)GS(I,L,K)=Y(I,K)*GS(I,L,K)
    3 CONTINUE
C **** CALCULATE AVERAGE BETA PARTICLE ENERGY.
      DO 8 I=1,NRNUC
      M=NBETA(I)
      IF(M.EQ.0)GO TO 8
      ATOMIC=IATOM(I)
      ATOMIC=0.333333*(1.0-0.02*SQRT(ATOMIC))
      DO 7 IP=1,M
    7 BENERY(I,IP)=ATOMIC*E0(I,IP)*(1.0+0.25*SQRT(E0(I,IP)))
    8 CONTINUE
      IF(IWATER.EQ.0 .AND. IAIR.EQ.0)GO TO 22
C **** CALCULATE SUBMERSION DOSE RATES FOR BETA AND GAMMA RADIATION.
      DO 15 I=1,NRNUC
      SUM=0.0
      M=NBETA(I)
      IF(M.EQ.0)GO TO 12
```

```
      DO 10 IP=1,M
   10 SUM=SUM+BPROB(I,IP)*BENERY(I,IP)
   12 CONTINUE
      DO 15 ITYPE=1,2
   15 SUBDOS(I,1,ITYPE)=CON(1,ITYPE)*SUM
      DO 20 I=1,NRNUC
      SUM=0.0
      M=NGAMMA(I)
      IF(M.EQ.0)GO TO 18
      DO 16 IP=1,M
   16 SUM=SUM+GPROB(I,IP)*GENERY(I,IP)
   18 CONTINUE
      DO 20 ITYPE=1,2
   20 SUBDOS(I,2,ITYPE)=CON(2,ITYPE)*SUM
   22 IF(ISUR.EQ.0)RETURN
      DO 5 I=1,NHTS
    5 A(I)=T(I)*1.29E-3
      NX=22
      NOX=1000
      NOXP1=NOX+1
      AA=0.01
      BB=5.0
      DO 6 I=1,NX
    6 SIGMA(I)=SIGMA(I)*1.0E-5
      CALL LAGRAN(3,2,0.0,DELX,AA,BB,NOX,TABLE,NX,E,SIGMA)
C **** CALCULATE CONTAMINATED SURFACE DOSE RATES FOR BETA RADIATION.
      J=1
      C1=1.07
      DO 43 I=1,NRNUC
      M=NBETA(I)
      DO 43 IH=1,NHTS
      GDDOSE(I,J,IH)=0.0
      IF(T(IH).EQ.0.0)GO TO 43
      IF(M.EQ.0)GO TO 43
      DO 40 IB=1,M
      TERM=0.0
      IF(E0(I,IB).LE.0.036)GO TO 40
      C=1.0
      ALPHA=0.333
      IF(E0(I,IB).GE.1.5)GO TO 25
      C=1.5
      ALPHA=0.297
      IF(E0(I,IB).GE.0.5)GO TO 25
      C=2.0
      ALPHA=0.260
      IF(E0(I,IB).GE.0.17)GO TO 25
      C=3.0
      ALPHA=0.190
   25 CONTINUE
   35 XNU=18.6/((E0(I,IB)-0.036)**1.37)
      IF(NONUC(I).EQ.ISR90)XNU=0.83*XNU
      ANU=A(IH)*XNU
      IF(ANU.GE.C)GO TO 38
      TERM=C*((1.0+ALOG(C/ANU))-EXP(1.0-(ANU/C)))
   38 TERM=ALPHA*XNU*BENERY(I,IB)*BPROB(I,IB)*(TERM+EXP(1.0-ANU))
   40 GDDOSE(I,J,IH)=GDDOSE(I,J,IH)+TERM
      GDDOSE(I,J,IH)=GDDOSE(I,J,IH)*C1
   43 CONTINUE
C **** CALCULATE CONTAMINATED SURFACE DOSE RATES FOR GAMMA RADIATION.
      J=2
```

```
      C=827.0*BS
      DO 54 I=1,NRNUC
      M=NGAMMA(I)
      DO 51 IH=1,NHTS
      GDDOSE(I,J,IH)=0.0
      IF(T(IH).EQ.0.0)GO TO 51
      IF(M.EQ.0)GO TO 51
      DO 50 IG=1,M
      K=ALOG(GENERY(I,IG)/AA)/DELX+1.49
      IF(K.LT.1)K=1
      IF(K.GT.NOXP1)K=NOXP1
      VAR=TABLE(K)*T(IH)
      CALL ENOFX(1,VAR,E1(1))
   50 GDDOSE(I,J,IH)=GDDOSE(I,J,IH)+C *TABLE(K)*GENERY(I,IG)*GPROB(I,IG)
     1*E1(1)
   51 CONTINUE
   54 CONTINUE
      RETURN
C***********************************************************************
      ENTRY CALTIM(TIME)
C
C         CALCULATE TIME PARAMETERS.
      KOP1=K0+1
      K1M1=K1-1
      KPRIME=NEXP
      GO TO 56
   55 KPRIME=KPRIME-1
   56 IF(TIME.LT.TAU(KPRIME))GO TO 55
      DO 60 K=1,KPRIME
   60 DELTAU(K)=TIME-TAU(K)
      DO 65 M=K0,K1
      DELT(M)=TAUP(M+1)-TAUP(M)
      DO 65 K=1,K1
      DTAU(M,K)=TAU(M)-TAU(K)
   65 DELTA(M,K)=TAUP(M)-TAU(K)
      RETURN
C***********************************************************************
      ENTRY CALC1(L)
C***** DOSE CALCULATIONS FOR SUBMERSION IN WATER.
      DO 130 I=1,NRNUC
C **** CALCULATE DOSE RATES.
      SUM=0.0
      DO 105 K=1,KPRIME
  105 SUM=SUM+GW(I,L,K)*EXP(-RDECAY(I)*DELTAU(K))
      DO 110 J=1,NRPART
  110 DRW(I,J)=SUM*SUBDOS(I,J,1)
C **** CALCULATE TOTAL DOSES.
      TSUM=0.0
      DO 120 M=K0,K1
      SUM=0.0
      DO 115 K=1,M
  115 SUM=SUM+GW(I,L,K)*EXP(-RDECAY(I)*DELTA(M,K))
      X=RDECAY(I)*DELT(M)
      CALL EXFCT1(X,FCT)
  120 TSUM=TSUM+FCT*DELT(M)*SUM
      DO 125 J=1,NRPART
  125 TDW(I,J)=TSUM*SUBDOS(I,J,1)
  130 CONTINUE
      RETURN
C***********************************************************************
```

```
      ENTRY CALC2(L)
C **** DOSE CALCULATIONS FOR SUBMERSION IN AIR.
      DO 210 I=1,NRNUC
C **** CALCULATE DOSE RATES.
      SUM=0.0
      DO 155 K=1,KPRIME
  155 SUM=SUM+GA(I,L,K)*EXP(-RDECAY(I)*DELTAU(K))
      DO 160 J=1,NRPART
  160 DRA(I,J)=SUM*SUBDOS(I,J,2)
C **** CALCULATE TOTAL DOSES.
      AHAT=0.0
      DEL=TAU(KO)+CLOUDT(KO)-TAUP(KO)
      IF(DEL.LE.0.0)GO TO 170
      SUM=0.0
      DO 165 K=1,KO
  165 SUM=SUM+GA(I,L,K)*EXP(-RDECAY(I)*DELTA(KO,K))
      X=RDECAY(I)*DEL
      CALL EXFCT1(X,FCT)
      AHAT=DEL*FCT*SUM
  170 TSUM=AHAT
      IF(KO.EQ.K1)GO TO 200
      IF(KO.EQ.K1M1)GO TO 185
      DO 180 M=KOP1,K1M1
      SUM=0.0
      DO 175 K=1,M
  175 SUM=SUM+GA(I,L,K)*EXP(-RDECAY(I)*DELTA(M,K))
      X=RDECAY(I)*CLOUDT(M)
      CALL EXFCT1(X,FCT)
  180 TSUM=TSUM+CLOUDT(M)*FCT*SUM
  185 SUM=0.0
      DO 190 K=1,K1
  190 SUM=SUM+GA(I,L,K)*EXP(-RDECAY(I)*DELTA(K1,K))
  195 DEL=TAU(K1)+CLOUDT(K1)
      ALP=AMIN1(DEL,TAUP(K1+1))
      DEL=ALP-TAU(K1)
      X=RDECAY(I)*DEL
      CALL EXFCT1(X,FCT)
      TSUM=TSUM+FCT*DEL*SUM
  200 DO 205 J=1,NRPART
  205 TDA(I,J)=TSUM*SUBDOS(I,J,2)
  210 CONTINUE
      RETURN
C************************************************************************
      ENTRY CALC3(L)
C **** DOSE CALCULATIONS FOR EXPOSURE TO SURFACE.
      DO 230 I=1,NRNUC
C **** CALCULATE DOSE RATES.
      SUM=0.0
      DO 212 K=1,KPRIME
  212 SUM=SUM+GS(I,L,K)*EXP(-RDECAY(I)*DELTAU(K))
      DO 213 J=1,NRPART
      DO 213 IH=1,NHTS
  213 DRS(I,J,IH)=SUM*GDDOSE(I,J,IH)
C **** CALCULATE TOTAL DOSES.
      TSUM=0.0
      DO 220 M=KO,K1
      SUM=0.0
      DO 215 K=1,M
  215 SUM=SUM+GS(I,L,K)*EXP(-RDECAY(I)*DELTA(M,K))
      X=RDECAY(I)*DELT(M)
```

```
      CALL EXFCT1(X,FCT)
  220 TSUM=TSUM+FCT*DELT(M)*SUM
      DO 225 J=1,NRPART
      DO 225 IH=1,NHTS
  225 TDS(I,J,IH)=TSUM*GDDOSE(I,J,IH)
  230 CONTINUE
      RETURN
      END


      SUBROUTINE CALTAU(T1,T2)
C ****** THIS ROUTINE CALCULATES THE INTEGRATION INTERVALS.
C
C IN CHANGING DIMENSIONS, THE FOLLOWING CONDITIONS MUST BE SATISFIED.
C     COMMON /XPL/TAU(MAXEXP),TAUP(MAXEXP+1),NEXP,K0,K1
C
      COMMON /XPL/TAU(25),TAUP(26),NEXP,K0,K1
      K0=NEXP
      K1=NEXP
      IF(T1.GE.TAU(NEXP))GO TO 20
      IF(NEXP.GT.1)GO TO 5
      TAUP(1)=TAU(K0)
      TAUP(2)=T2
      RETURN
    5 K0=K0-1
      IF(T1.LT.TAU(K0))GO TO 5
      GO TO 15
   10 K1=K1-1
   15 IF(T2.LE.TAU(K1))GO TO 10
   20 TAUP(K0)=T1
      TAUP(K1+1)=T2
      IF(K0.EQ.K1)RETURN
      KOP1=K0+1
      DO 25 I=KOP1,K1
   25 TAUP(I)=TAU(I)
      RETURN
      END


      SUBROUTINE EXFCT1(X,F)
C
C        CALCULATE ((1.0-EXP(-X))/X).
      IF(X.LT.17.0)GO TO 1
      F=1.0/X
      RETURN
    1 IF(X.LE.1.0E-2)GO TO 2
      F=(1.0-EXP(-X))/X
      RETURN
    2 X2=X*X
      F=1.0+X2/6.0-X/2.0
      RETURN
      END


      SUBROUTINE ORDER(LABEL,ANAME,VALUE,N)
C ****** THIS ROUTINE ORDERS THE NUCLIDES FOR OUTPUT.
      DIMENSION LABEL(1),ANAME(1),VALUE(1)
```

```
      REAL*8 ANAME,SAVE2
      IN=N
      IF(IN.EQ.1)RETURN
    5 IC=0
      IN=IN-1
      DO 20 I=1,IN
      IF(VALUE(I).GE.VALUE(I+1))GO TO 20
      SAVE=VALUE(I)
      VALUE(I)=VALUE(I+1)
      VALUE(I+1)=SAVE
      SAVE2=ANAME(I)
      ANAME(I)=ANAME(I+1)
      ANAME(I+1)=SAVE2
      ISAVE=LABEL(I)
      LABEL(I)=LABEL(I+1)
      LABEL(I+1)=ISAVE
      IC=1
   20 CONTINUE
      IF(IC.EQ.1)GO TO 5
      RETURN
      END


      SUBROUTINE ENOFX(N,X,XINT)
C  THIS SUBROUTINE IS DESCRIBED IN ORNL-3805
C  TITLE: OGRE, A MONTE CARLO SYSTEM FOR GAMMA-RAY TRANSPORT STUDIES,
C    INCLUDING AN EXAMPLE (OGRE,P1) FOR TRANSMISSION THROUGH LAMINATED
C    SLABS, BY S.K. PENNY, D.K. TRUBEY, AND M.B. EMMETT, OAK RIDGE
C    NATIONAL LABORATORY, OAK RIDGE, TENNESSEE.
      DIMENSION B(10),XINT(10)
      IF(X-.5)9,9,8
    9 IF(B(10)-3.6288E7)10,100,10
   10 B(1)=1.0
      B(2)=4.0
      B(3)=18.0
      B(4)=96.0
      B(5)=6.0E2
      B(6)=4.32E3
      B(7)=3.528E4
      B(8)=3.2256E5
      B(9)=3.26592E6
      B(10)=3.6288E7
  100 A=-.5772156649-ALOG(X)
      SUM=0.0
      DO 1 I=1,10
      M=11-I
    1 SUM=SUM+(-X)**M/B(M)
      XINT(1)=A-SUM
      EXX=EXP(-X)
      DO 7 J=2,N
    7 XINT(J)=1.0/FLOAT(J-1)*(EXX-X*XINT(J-1))
      RETURN
    8 XN=1.0
      A=X+XN
      B1=A
      F1=1./A
      G=F1
      B2=A+2.
      R=-XN/(B1*B2)
```

```
      RHO=1./(1.+R)-1.                                                  ENOF0370
      F1=F1+F1*RHO                                                      ENOF0380
      G=G*RHO                                                           ENOF0390
      B1=B2                                                             ENOF0400
      DO 4 I=1,100                                                      ENOF0410
      A1=-(I+1)*(1+I)                                                   ENOF0420
      BB=(I+1)*2                                                        ENOF0430
      B2=A+BB                                                           ENOF0440
      R=A1/(B1*B2)                                                      ENOF0450
      RHO=1./(1.+R*(1.+RHO))-1.                                         ENOF0460
      G=G*RHO                                                           ENOF0470
      F2=F1+G                                                           ENOF0480
      IF(G-1.0E-06)5,5,6                                                ENOF0490
    6 B1=B2                                                             ENOF0500
      F1=F2                                                             ENOF0510
    4 CONTINUE                                                          ENOF0520
    5 EXX=EXP(-X)                                                       ENOF0530
      XINT(1)=F2*EXX                                                    ENOF0540
      DO 11 J=2,N                                                       ENOF0550
   11 XINT(J)=1.0/FLOAT(J-1)*(EXX-X*XINT(J-1))                          ENOF0560
      RETURN                                                            ENOF0570
      END                                                               ENOF0580
```

```
      SUBROUTINE LAGRAN(ITYPE,NPT ,XC  ,DELX,A,B,NOX,  TABLE,NX,X,FX)   LAGR0010
C     LAGRANGIAN INTERPOLATION                                          LAGR0020
C  THIS SUBROUTINE IS DESCRIBED IN ORNL-3428                            LAGR0030
C    TITLE: AN IBM-7090 SUBROUTINE PACKAGE FOR LAGRANGIAN INTERPOLATION,LAGR0040
C    BY S.K. PENNY AND M.B. EMMETT, OAK RIDGE NATIONAL LABORATORY,      LAGR0050
C    OAK RIDGE, TENNESSEE.                                              LAGR0060
      DIMENSION X(1),FX(1),TABLE(1)                                     LAGR0070
      XCUT = XC                                                         LAGR0080
      NPTS = NPT                                                        LAGR0090
      I = 1                                                             LAGR0100
      KNOX = NOX+1                                                      LAGR0110
      IF(NPTS-NX)31,31,30                                               LAGR0120
   30 NPTS = NX                                                         LAGR0130
   31 XN = NOX                                                          LAGR0140
      JMAX = NX-NPTS+1                                                  LAGR0150
      IF(B-A)13,9,9                                                     LAGR0160
   13 T = B                                                             LAGR0170
      B = A                                                             LAGR0180
      A = T                                                             LAGR0190
    9 IF(X(NX)-A)3,3,12                                                 LAGR0200
   12 IF(X(I+1)-A)2,3,3                                                 LAGR0210
    2 I = I+1                                                           LAGR0220
      GO TO 12                                                          LAGR0230
    3 GO TO (4,4,5),ITYPE                                               LAGR0240
    4 V    = A                                                          LAGR0250
      DELX = (B-A)/XN                                                   LAGR0260
      GO TO 50                                                          LAGR0270
    5 V    = ALOG(A)                                                    LAGR0280
      DELX = ALOG(B/A)/XN                                               LAGR0290
      IF(XC)36,36,37                                                    LAGR0300
   36 XCUT = X(1)                                                       LAGR0310
   37 XCUT = ALOG(XCUT)                                                 LAGR0320
   50 IODD = NPTS/2                                                     LAGR0330
      IODD = 2* IODD                                                    LAGR0340
      DO 10 M=1,KNOX                                                    LAGR0350
```

```
18  GO TO(6,6,7),ITYPE                                                  LAGR0360
6   Q = X(I+1)                                                          LAGR0370
    GO TO 8                                                             LAGR0380
7   Q = ALOG(X(I+1))                                                    LAGR0390
8   IF(Q-V)17,19,19                                                     LAGR0400
17  I = I+1                                                             LAGR0410
    IF(I-NX)18,29,24                                                    LAGR0420
29  I = I-1                                                             LAGR0430
19  IF(NPTS-IODD)28,27,28                                               LAGR0440
28  IF(V-XCUT)20,20,21                                                  LAGR0450
20  J = I-(NPTS-3)/2                                                    LAGR0460
    GO TO 32                                                            LAGR0470
21  J = I-(NPTS-1)/2                                                    LAGR0480
    GO TO 32                                                            LAGR0490
27  J = I-(NPTS-2)/2                                                    LAGR0500
32  IF(J-1)33,14,34                                                     LAGR0510
33  J = 1                                                               LAGR0520
    GO TO 14                                                            LAGR0530
34  IF(J-JMAX)14,14,35                                                  LAGR0540
35  J = JMAX                                                            LAGR0550
14  CALL G3R3G3(ITYPE,NPTS,V    ,J,X,FX,TABLE(M))                       LAGR0560
10  V = V+DELX                                                          LAGR0570
24  RETURN                                                              LAGR0580
    END                                                                 LAGR0590
```

```
      SUBROUTINE G3R3G3(ITYPE,NPTS,X1,KJ,Y,FY,F)                        G3R30010
C     LAGRANGIAN INTERPOLATION                                          G3R30020
C  THIS SUBROUTINE IS DESCRIBED IN ORNL-3428                            G3R30030
C    TITLE: AN IBM-7090 SUBROUTINE PACKAGE FOR LAGRANGIAN INTERPOLATION,G3R30040
C    BY S.K. PENNY AND M.B. EMMETT, OAK RIDGE NATIONAL LABORATORY,      G3R30050
C    OAK RIDGE, TENNESSEE.                                              G3R30060
      DIMENSION Y(1),FY(1),X(10)                                        G3R30070
      J = KJ                                                            G3R30080
      DO 100 M=1,NPTS                                                   G3R30090
      X(M) = Y(J)                                                       G3R30100
  100 J = J+1                                                           G3R30110
      GO TO(1,1,3),ITYPE                                                G3R30120
    3 DO 101 M=1,NPTS                                                   G3R30130
  101 X(M) = ALOG(X(M))                                                 G3R30140
    1 F = 0.                                                            G3R30150
      J = KJ                                                            G3R30160
      DO 11 K = 1,NPTS                                                  G3R30170
      P = 1.                                                            G3R30180
      DO 10 L = 1,NPTS                                                  G3R30190
      IF(L-K)12,10,12                                                   G3R30200
   12 P = P*(X1-X(L))/(X(K)-X(L))                                       G3R30210
   10 CONTINUE                                                          G3R30220
      GO TO(4,2,2),ITYPE                                                G3R30230
    4 F= F+P*FY(J)                                                      G3R30240
      GO TO 11                                                          G3R30250
    2 F= F+P*ALOG(FY(J))                                                G3R30260
   11 J = J+1                                                           G3R30270
      GO TO(6,7,7),ITYPE                                                G3R30280
    7 F = EXP (F)                                                       G3R30290
    6 RETURN                                                            G3R30300
      END                                                               G3R30310
```

```
PGMM TITLE 'SUBROUTINE PGMMSK (I,J,K,L) -- TO SET PROGRAM MASK'
*    PROGRAM MASK SETTING ROUTINE
*
*    ACCEPTS CALLING SEQUENCE
*
*              CALL PGMMSK (IFXPTO,IDECO,IEXPU,ISIG)
*
*         A ZERO VALUE FOR ANY ARGUMENT DISABLES THE CORRESPONDING
*                   INTERUPT.
*         NON-ZERO VALUES ALLOW THE INTERUPT TO OCCUR.
*
*    IFXPTO -- FIXED-POINT OVERFLOW.
*    IDECO -- DECIMAL OVERFLOW.
*    IEXPU -- EXPONENT UNDERFLOW.
*    ISIG -- LOSS OF SIGNIFICANCE.  (ZERO FRACTION IN A FLOATING
*                                    POINT NUMBER)
*
*     FOR EXAMPLE,
*      CALL PGMMSK (1,1,0,0)
*          CAUSES UNDERFLOWS AND LOSS OF SIGNIFICANCE TO BE IGNORED
*          AND FIXED AND DECIMAL  OVERFLOW TO BE HANDLED AS USUAL.
*
*     PROGRAM AUTHOR -- R. K. GRYDER
*                       COMPUTING TECHNOLOGY CENTER
*                       OAK RIDGE, TENNESSEE
*
PGMMSKRG CSECT
         ENTRY PGMMSK
         USING *,15
PGMMSK   SAVE (14,12),,*
         SR    0,0
         LM    5,8,0(1)
         L     3,=X'08000000'
         SR    4,4
         CL    0,0(0,5)
         BE    I1
         LR    4,3
I1       SRA   3,1
         CL    0,0(0,6)
         BE    I2
         OR    4,3
I2       SRA   3,1
         CL    0,0(0,7)
         BE    I3
         OR    4,3
I3       SRA   3,1
         CL    0,0(0,8)
         BE    I4
         OR    4,3
I4       SPM   4
         RETURN (14,12),T
         END
```

APPENDIX E

Tabulation of Some Special Input Data for EXREM

On the following pages of this appendix are listed the principal nuclear properties of 179 radionuclides which have been of interest in the radiological safety-feasibility study for excavating a sea-level canal with nuclear explosives. Radionuclides of interest in other studies will, in many cases, be found among this list of 179; therefore, potential users of EXREM can save considerable time in searching reference sources by using the nuclear properties in this listing.

The major source of fission product energies and intensities was Crocker and Connors,[1] while Crocker and Wong[2] was used as the major reference source for induced activities. When the desired data for a radionuclide could not be found in these two reports, the Table of Isotopes by Lederer *et al.*[3] was used. The absolute percentages of the total decay for each beta-emitter should add up to 100 percent, but both Crocker and Lederer list some beta emissions for which the total is less than 100 percent. The compilation was limited to X-rays, γ-rays, and

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[1] G. R. Crocker and M. A. Connors. Gamma-Emission Data for the Calculation of Exposure Rates From Nuclear Debris. Volume I. Fission Products. USNRDL-TR-876 (1965).

[2] G. R. Crocker and D. T. Wong. Gamma-Emission Data for the Calculation of Exposure Rates From Nuclear Debris. Volume II. Induced Activities. USNRDL-TR-888 (1965).

[3] C. M. Lederer, J. M. Hollander, and I. Perlman. Table of Isotopes. Sixth Edition. John Wiley and Sons, Inc., New York. (1967).

β-particles of 10 KeV or greater. Electrons with discrete energies and all α-particles were omitted. Decay constants were calculated from the physical half-lives listed in the Table of Isotopes.

No data are listed for "Yield Vented" and "Location Correction Factor" which will depend on the physical and biological conditions of each detonation or release. When these data are supplied as input to EXREM, they will be listed in tabular form similar to the nuclear properties of the radionuclides.

RADIONUCLIDE IDENTIFICATION.

INDEX	ATOMIC NUMBER	NAME	DECAY CONSTANT (1/HRS)	NO. BETA PARTICLES	NO. GAMMA PHOTONS
3	32	GE77	0.61300E-01	7	18
4	33	AS77	0.17800E-01	4	4
5	32	GE78	0.33000E 00	1	2
6	33	AS78	0.45700E 00	7	14
12	34	SE81M	0.73000E 00	0	1
13	34	SE81	0.23100E 01	2	4
14	35	BR82	0.19600E-01	1	8
16	35	BR83	0.30100E 00	2	4
17	36	KR83M	0.36500E 00	0	2
18	34	SE83	0.16600E 01	3	9
21	35	BR84	0.13100E 01	8	22
25	36	KR85M	0.15800E 00	1	3
26	36	KR85	0.74600E-05	2	1
31	36	KR87	0.53300E 00	3	4
33	36	KR88	0.24800E 00	3	8
34	37	RB88	0.23100E 01	3	10
37	37	RB89	0.27100E 01	7	8
38	38	SR89	0.57800E-03	1	0
42	38	SR90	0.28300E-05	1	0
43	39	Y90	0.10760E-01	1	0
46	38	SR91	0.71500E-01	5	5
47	39	Y91M	0.83200E 00	0	2
48	39	Y91	0.49000E-03	2	1
51	38	SR92	0.26700E 00	1	3
52	39	Y92	0.19300E 00	6	10
56	39	Y93	0.69300E-01	5	10
62	39	Y94	0.21900E 01	0	10
65	40	ZR95	0.44400E-03	4	4
66	41	NB95M	0.77000E-02	0	1
67	41	NB95	0.82500E-03	2	1
69	40	ZR97	0.40800E-01	3	4
70	41	NB97M	0.41600E 02	0	2
71	41	NB97	0.56200E 00	2	2
74	41	NB98	0.81500E 00	1	9
77	42	MO99	0.10300E-01	3	6
78	43	TC99M	0.11460E 00	0	4
82	42	MO101	0.27700E 01	6	18
83	43	TC101	0.29700E 01	2	9
84	42	MO102	0.36200E 01	1	0
85	43	TC102M	0.92400E 01	1	1
86	43	TC102	0.49910E 03	1	0
88	44	RU103	0.72200E-03	3	6
89	45	RH103M	0.73000E 00	0	2
94	44	RU105	0.15800E 00	5	11
95	45	RH105M	0.83200E 02	0	2
96	45	RH105	0.19300E-01	2	2
97	44	RU106	0.79100E-04	1	0
98	45	RH106	0.83200E 02	4	5
102	45	RH107	0.19200E 01	5	8
106	45	RH108	0.14900E 03	4	4
109	47	AG109M	0.64000E 02	0	2
111	46	PD111M	0.12600E 00	0	2
112	46	PD111	0.18900E 01	0	25
113	47	AG111M	0.33300E 02	0	1
114	47	AG111	0.38500E-02	3	4
115	46	PD112	0.33000E-01	1	2
116	47	AG112	0.21700E 00	4	20

RADIONUCLIDE IDENTIFICATION.

INDEX	ATOMIC NUMBER	NAME	DECAY CONSTANT (1/HRS)	NO. BETA PARTICLES	NO. GAMMA PHOTONS
124	47	AG115	0.19700E 01	9	22
125	48	CD115M	0.67200E-03	4	3
126	48	CD115	0.12400E-01	4	6
127	49	IN115M	0.15300E 00	1	2
133	48	CD117M	0.23900E 00	0	6
134	48	CD117	0.28900E-02	8	11
135	49	IN117M	0.36500E 00	3	5
136	49	IN117	0.92400E 00	1	3
138	48	CD118	0.83200E 00	1	0
139	49	IN118	0.49900E 03	2	1
140	49	IN118M	0.92400E 01	1	4
143	49	IN119	0.18100E 02	1	3
144	49	IN119M	0.23100E 01	1	2
145	48	CD120	0.34700E 01	1	1
146	49	IN120	0.56700E 02	8	11
154	50	SN123	0.10100E 01	1	2
155	50	SN123M	0.23100E-03	2	1
159	51	SB124	0.48100E-03	7	16
161	50	SN125	0.30700E-02	5	7
162	51	SB125	0.29300E-04	8	18
166	51	SB126	0.23100E-02	1	3
167	50	SN127	0.26700E 00	1	1
168	51	SB127	0.78100E-02	4	5
169	52	TE127M	0.27500E-03	0	2
170	52	TE127	0.74500E-01	2	4
171	50	SN128	0.73000E 00	0	5
172	51	SB128M	0.72200E-01	1	3
173	51	SB128	0.37800E 01	1	3
175	51	SB129	0.15100E 00	3	5
176	52	TE129M	0.87500E-03	0	2
177	52	TE129	0.57800E 00	3	4
184	51	SB131	0.18100E 01	1	1
185	52	TE131M	0.24100E-01	4	16
186	52	TE131	0.16600E 01	4	5
187	53	I131	0.35700E-02	4	9
191	52	TE132	0.88900E-02	1	2
192	53	I132	0.30100E 00	6	25
194	52	TE133M	0.78500E 00	2	12
195	52	TE133	0.33270E 01	2	2
196	53	I133	0.33000E-01	2	3
197	54	XE133M	0.12600E-01	0	2
198	54	XE133	0.54500E-02	2	4
199	52	TE134	0.99000E 00	1	1
200	53	I134	0.78500E 00	8	23
202	53	I135	0.10300E 00	3	11
203	54	XE135M	0.26000E 01	0	2
204	54	XE135	0.76200E-01	2	4
207	55	CS136	0.22200E-02	2	8
210	55	CS137	0.26400E-05	2	0
211	56	BA137M	0.16000E 02	0	2
213	54	XE138	0.24500E 01	1	3
214	55	CS138	0.13000E 01	7	12
218	56	BA139	0.48900E 00	3	3
221	56	BA140	0.22600E-02	4	5
222	57	LA140	0.17300E-01	6	12
225	56	BA141	0.23100E 01	1	1
226	57	LA141	0.18200E 00	2	1

RADIONUCLIDE IDENTIFICATION.

INDEX	ATOMIC NUMBER	NAME	DECAY CONSTANT (1/HRS)	NO. BETA PARTICLES	NO. GAMMA PHOTONS
227	58	CE141	0.87500E-03	2	2
230	56	BA142	0.37800E 01	1	6
231	57	LA142	0.48900E 00	9	12
235	57	LA143	0.29700E 01	1	14
236	58	CE143	0.21000E-01	5	9
237	59	PR143	0.20900E-02	1	0
238	58	CE144	0.10200E-03	3	8
239	59	PR144	0.24500E 01	3	3
241	59	PR145	0.11600E 00	1	0
242	58	CE146	0.29700E 01	3	9
243	59	PR146	0.16600E 01	2	3
245	59	PR147	0.34700E 01	4	8
246	60	ND147	0.26000E-02	3	11
247	61	PM147	0.30400E-04	1	0
250	60	ND149	0.38500E 00	3	10
251	61	PM149	0.13100E-01	5	2
252	61	PM150	0.25700E 00	2	12
253	60	ND151	0.34700E 01	1	8
254	61	PM151	0.24800E-01	6	25
258	62	SM153	0.14700E-01	4	7
261	62	SM155	0.17300E 01	2	4
262	63	EU155	0.46500E-04	4	4
263	62	SM156	0.73700E-01	2	5
264	63	EU156	0.19300E-02	3	21
266	63	EU157	0.45000E-01	2	3
268	63	EU158	0.69300E 00	1	2
269	63	EU159	0.21900E 01	6	9
270	64	GD159	0.38500E-01	3	4
272	65	TB160	0.39900E-03	6	19
274	65	TB161	0.41900E-02	3	5
279	79	AU195	0.15800E-03	0	2
280	94	PU238	0.91580E-06	0	1
281	94	PU239	0.32440E-08	0	1
282	94	PU240	0.12030E-07	0	1
283	94	PU241	0.59950E-05	1	0
287	79	AU196	0.46600E-02	1	4
289	74	W181	0.22200E-03	0	2
290	74	W185	0.39000E-03	1	0
291	74	W187	0.28881E-01	3	16
292	74	W188	0.41900E-03	3	3
294	82	PB202	0.26400E-09	0	1
295	82	PB203	0.13300E-01	0	4
296	82	PB204M	0.62100E 00	0	4
297	82	PB205	0.26400E-11	0	1
298	82	PB209	0.21000E 00	1	0
299	82	PB210	0.36000E-05	2	1
300	81	TL204	0.20800E-04	1	0
301	80	HG203	0.61400E-03	1	2
302	4	BE7	0.53880E-03	0	1
303	1	H3	0.64330E-05	1	0
304	24	CR51	0.10400E-02	0	3
305	25	MN54	0.95300E-04	0	1
306	25	MN56	0.26900E 00	4	7
307	26	FE55	0.29300E-04	0	1
308	26	FE59	0.64200E-03	4	5
309	11	NA24	0.46200E-01	1	2
310	15	P32	0.20200E-02	1	0

RADIONUCLIDE IDENTIFICATION.

INDEX	ATOMIC NUMBER	NAME	DECAY CONSTANT (1/HRS)	NO. BETA PARTICLES	NO. GAMMA PHOTONS
311	20	CA45	0.17500E-03	1	0
312	11	NA22	0.30700E-04	1	1
313	92	U237	0.42800E-02	1	11
314	6	C14	0.13810E-07	1	0
315	19	K42	0.55900E-01	5	3
316	21	SC46	0.34500E-03	1	2
317	17	CL36	0.25690E-09	1	0
318	16	S35	0.33300E-03	1	0

ENERGY AND ABUNDANCE FOR EACH BETA PARTICLE.

INDEX	RADIONUCLIDE	NO.	MAXIMUM ENERGY (MEV)	ABUNDANCE
3	GE77	1	0.3800E 00	0.030
		2	0.7600E 00	0.150
		3	0.1200E 01	0.110
		4	0.1300E 01	0.040
		5	0.1560E 01	0.240
		6	0.2120E 01	0.290
		7	0.2270E 01	0.140
4	AS77	1	0.1600E 00	0.028
		2	0.4380E 00	0.001
		3	0.4380E 00	0.027
		4	0.6840E 00	0.944
5	GE78	1	0.9000E 00	1.000
6	AS78	1	0.1420E 01	0.022
		2	0.1490E 01	0.021
		3	0.1600E 01	0.140
		4	0.1860E 01	0.062
		5	0.2960E 01	0.097
		6	0.3650E 01	0.190
		7	0.4270E 01	0.470
13	SE81	1	0.1560E 01	0.990
		2	0.1000E 01	0.010
14	BR82	1	0.4440E 00	1.000
16	BR83	1	0.9100E 00	0.200
		2	0.9600E 00	0.800
18	SE83	1	0.4500E 00	0.130
		2	0.1000E 01	0.830
		3	0.1700E 01	0.040
21	BR84	1	0.5000E 00	0.030
		2	0.8300E 00	0.190
		3	0.9800E 00	0.020
		4	0.1390E 01	0.140
		5	0.1810E 01	0.015
		6	0.2800E 01	0.150
		7	0.3830E 01	0.140
		8	0.4680E 01	0.320
25	KR85M	1	0.8240E 00	0.810
26	KR85	1	0.1500E 00	0.007
		2	0.6720E 00	0.990
31	KR87	1	0.1250E 01	0.250
		2	0.3300E 01	0.100
		3	0.3800E 01	0.650
33	KR88	1	0.5200E 00	0.700
		2	0.9000E 00	0.100
		3	0.2700E 01	0.200

ENERGY AND ABUNDANCE FOR EACH BETA PARTICLE.

INDEX	RADIONUCLIDE	NO.	MAXIMUM ENERGY (MEV)	ABUNDANCE
34	RB88	1	0.2500E 01	0.140
		2	0.3400E 01	0.040
		3	0.5200E 01	0.760
37	RB89	1	0.4000E 00	0.020
		2	0.6700E 00	0.280
		3	0.1170E 01	0.030
		4	0.1330E 01	0.020
		5	0.1610E 01	0.530
		6	0.2870E 01	0.050
		7	0.3920E 01	0.070
38	SR89	1	0.1463E 01	1.000
42	SR90	1	0.5460E 00	1.000
43	Y90	1	0.2270E 01	1.000
46	SR91	1	0.6100E 00	0.070
		2	0.1090E 01	0.330
		3	0.1360E 01	0.290
		4	0.2030E 01	0.040
		5	0.2670E 01	0.270
48	Y91	1	0.3300E 00	0.003
		2	0.1540E 01	0.997
51	SR92	1	0.5450E 00	0.900
52	Y92	1	0.2150E 01	0.015
		2	0.2260E 01	0.023
		3	0.2710E 01	0.031
		4	0.1320E 01	0.062
		5	0.1590E 01	0.003
		6	0.1810E 01	0.008
56	Y93	1	0.4500E 00	0.001
		2	0.1470E 01	0.009
		3	0.1950E 01	0.030
		4	0.2620E 01	0.039
		5	0.2890E 01	0.900
65	ZR95	1	0.3600E 00	0.430
		2	0.3960E 00	0.550
		3	0.3850E 00	0.020
		4	0.1130E 01	0.004
67	NB95	1	0.1600E 00	0.990
		2	0.9300E 00	0.010
69	ZR97	1	0.1910E 01	0.030
		2	0.7600E 00	0.025
		3	0.2490E 01	0.945
71	NB97	1	0.9300E 00	0.010
		2	0.1267E 01	0.990

Y AND ABUNDANCE FOR EACH BETA PARTICLE.

)EX	RADIONUCLIDE	NO.	MAXIMUM ENERGY (MEV)	ABUNDANCE
74	NB98	1	0.3100E 01	1.000
77	MO99	1	0.4500E 00	0.140
		2	0.8700E 00	0.010
		3	0.1230E 01	0.850
32	MO101	1	0.6000E 00	0.030
		2	0.7000E 00	0.380
		3	0.8000E 00	0.130
		4	0.1200E 01	0.110
		5	0.1600E 01	0.250
		6	0.2230E 01	0.100
83	TC101	1	0.1070E 01	0.080
		2	0.1320E 01	0.900
84	MO102	1	0.1200E 01	1.000
85	TC102M	1	0.3700E 01	1.000
86	TC102	1	0.4400E 01	1.000
88	RU103	1	0.1000E 00	0.070
		2	0.2120E 00	0.890
		3	0.7100E 00	0.030
94	RU105	1	0.5200E 00	0.040
		2	0.7700E 00	0.020
		3	0.1115E 01	0.400
		4	0.1180E 01	0.500
		5	0.1220E 01	0.050
96	RH105	1	0.2500E 00	0.100
		2	0.5600E 00	0.900
97	RU106	1	0.3900E-01	1.000
98	RH106	1	0.3550E 01	0.672
		2	0.3050E 01	0.125
		3	0.2390E 01	0.170
		4	0.2000E 01	0.020
102	RH107	1	0.8300E 00	0.070
		2	0.9300E 00	0.020
		3	0.1100E 01	0.080
		4	0.1200E 01	0.710
		5	0.1510E 01	0.170
106	RH108	1	0.3500E 01	0.220
		2	0.3600E 01	0.050
		3	0.4100E 01	0.170
		4	0.4500E 01	0.510
114	AG111	1	0.6900E 00	0.062
		2	0.7900E 00	0.011
		3	0.1050E 01	0.927

ENERGY AND ABUNDANCE FOR EACH BETA PARTICLE.

INDEX	RADIONUCLIDE	NO.	MAXIMUM ENERGY (MEV)	ABUNDANCE
115	PD112	1	0.2800E 00	1.000
116	AG112	1	0.3940E 01	0.540
		2	0.3350E 01	0.220
		3	0.1960E 01	0.100
		4	0.2780E 01	0.140
124	AG115	1	0.3300E 01	0.170
		2	0.3070E 01	0.080
		3	0.2820E 01	0.050
		4	0.2650E 01	0.090
		5	0.1170E 01	0.380
		6	0.8000E 00	0.100
		7	0.2920E 01	0.010
		8	0.2200E 01	0.030
		9	0.5000E 00	0.090
125	CD115M	1	0.2000E 00	0.003
		2	0.3350E 00	0.010
		3	0.6870E 00	0.020
		4	0.1630E 01	0.967
126	CD115	1	0.5900E 00	0.244
		2	0.6300E 00	0.126
		3	0.8500E 00	0.009
		4	0.1110E 01	0.621
127	IN115M	1	0.8400E 00	0.055
134	CD117	1	0.5000E 00	0.030
		2	0.6300E 00	0.380
		3	0.8300E 00	0.090
		4	0.1470E 01	0.060
		5	0.1770E 01	0.160
		6	0.1860E 01	0.090
		7	0.1930E 01	0.070
		8	0.2230E 01	0.120
135	IN117M	1	0.9500E 00	0.040
		2	0.1620E 01	0.230
		3	0.1770E 01	0.530
136	IN117	1	0.7400E 00	1.000
138	CD118	1	0.8000E 00	1.000
139	IN118	1	0.3300E 01	0.200
		2	0.4500E 01	0.800
140	IN118M	1	0.2000E 01	1.000
143	IN119	1	0.1600E 01	1.000
144	IN119M	1	0.2700E 01	1.000
145	CD120	1	0.1900E 01	1.000

ENERGY AND ABUNDANCE FOR EACH BETA PARTICLE.

INDEX	RADIONUCLIDE	NO.	MAXIMUM ENERGY (MEV)	ABUNDANCE
146	IN120	1	0.1490E 01	0.020
		2	0.1760E 01	0.010
		3	0.1910E 01	0.030
		4	0.2130E 01	0.060
		5	0.2240E 01	0.410
		6	0.2650E 01	0.060
		7	0.3120E 01	0.270
		8	0.3430E 01	0.140
154	SN123	1	0.1260E 01	1.000
155	SN123M	1	0.3400E 00	0.020
		2	0.1420E 01	0.980
159	SB124	1	0.5100E-01	0.020
		2	0.2250E 00	0.110
		3	0.6210E 00	0.510
		4	0.9540E 00	0.050
		5	0.1016E 01	0.015
		6	0.1590E 01	0.050
		7	0.2313E 01	0.230
161	SN125	1	0.3700E 00	0.021
		2	0.4700E 00	0.015
		3	0.9300E 00	0.001
		4	0.1300E 01	0.013
		5	0.2330E 01	0.950
162	SB125	1	0.9000E-01	0.019
		2	0.1050E 00	0.007
		3	0.1180E 00	0.060
		4	0.1240E 00	0.307
		5	0.2330E 00	0.010
		6	0.2950E 00	0.404
		7	0.4370E 00	0.058
		8	0.6120E 00	0.134
166	SB126	1	0.1900E 01	1.000
167	SN127	1	0.3000E 01	1.000
168	SB127	1	0.8000E 00	0.350
		2	0.8600E 00	0.100
		3	0.1110E 01	0.350
		4	0.1500E 01	0.200
170	TE127	1	0.2700E 00	0.010
		2	0.6950E 00	0.990
172	SB128M	1	0.2450E 01	1.000
173	SB128	1	0.2600E 01	1.000
175	SB129	1	0.1250E 01	0.250
		2	0.1560E 01	0.550
		3	0.1870E 01	0.200

RGY AND ABUNDANCE FOR EACH BETA PARTICLE.

INDEX	RADIONUCLIDE	NO.	MAXIMUM ENERGY (MEV)	ABUNDANCE
177	TE129	1	0.6900E 00	0.037
		2	0.9890E 00	0.154
		3	0.1453E 01	0.805
184	SB131	1	0.3000E 01	1.000
185	TE131M	1	0.2150E 00	0.036
		2	0.4200E 00	0.430
		3	0.5700E 00	0.310
		4	0.2457E 01	0.038
186	TE131	1	0.1150E 01	0.100
		2	0.1360E 01	0.050
		3	0.1680E 01	0.250
		4	0.2140E 01	0.600
187	I131	1	0.2500E 00	0.028
		2	0.3300E 00	0.091
		3	0.6060E 00	0.875
		4	0.8100E 00	0.007
191	TE132	1	0.2200E 00	1.000
192	I132	1	0.8000E 00	0.210
		2	0.1040E 01	0.150
		3	0.1220E 01	0.120
		4	0.1490E 01	0.120
		5	0.1610E 01	0.210
		6	0.2140E 01	0.180
194	TE133M	1	0.1300E 01	0.700
		2	0.2400E 01	0.170
195	TE133	1	0.1300E 01	0.700
		2	0.2400E 01	0.300
196	I133	1	0.4900E 00	0.070
		2	0.1340E 01	0.930
198	XE133	1	0.2680E 00	0.001
		2	0.3470E 00	0.990
199	TE134	1	0.3000E 00	1.000
200	I134	1	0.5000E 00	0.065
		2	0.1050E 01	0.010
		3	0.1250E 01	0.230
		4	0.1490E 01	0.150
		5	0.1680E 01	0.075
		6	0.1810E 01	0.095
		7	0.2210E 01	0.120
		8	0.2410E 01	0.250
202	I135	1	0.4700E 00	0.035
		2	0.1000E 01	0.040
		3	0.1400E 01	0.250

ENERGY AND ABUNDANCE FOR EACH BETA PARTICLE.

INDEX	RADIONUCLIDE	NO.	MAXIMUM ENERGY (MEV)	ABUNDANCE
204	XE135	1	0.5500E 00	0.030
		2	0.9100E 00	0.970
207	CS136	1	0.3410E 00	0.926
		2	0.6570E 00	0.074
210	CS137	1	0.1176E 01	0.065
		2	0.5140E 00	0.935
213	XE138	1	0.2400E 01	1.000
214	CS138	1	0.1490E 01	0.015
		2	0.2200E 01	0.100
		3	0.2390E 01	0.360
		4	0.2530E 01	0.050
		5	0.2620E 01	0.160
		6	0.2940E 01	0.120
		7	0.3400E 01	0.210
218	BA139	1	0.9100E 00	0.003
		2	0.2170E 01	0.280
		3	0.2340E 01	0.720
221	BA140	1	0.5000E 00	0.250
		2	0.6000E 00	0.100
		3	0.9000E 00	0.050
		4	0.1000E 01	0.600
222	LA140	1	0.4200E 00	0.160
		2	0.8300E 00	0.120
		3	0.1100E 01	0.260
		4	0.1380E 01	0.450
		5	0.1710E 01	0.100
		6	0.2200E 01	0.070
225	BA141	1	0.2300E 01	1.000
226	LA141	1	0.2510E 01	0.950
		2	0.9100E 00	0.050
227	CE141	1	0.4350E 00	0.700
		2	0.5800E 00	0.300
230	BA142	1	0.1700E 01	1.000
231	LA142	1	0.4520E 01	0.120
		2	0.3850E 01	0.024
		3	0.2980E 01	0.017
		4	0.2310E 01	0.070
		5	0.2110E 01	0.240
		6	0.1980E 01	0.190
		7	0.1790E 01	0.110
		8	0.1230E 01	0.050
		9	0.8700E 00	0.130
235	LA143	1	0.3300E 01	1.000

ENERGY AND ABUNDANCE FOR EACH BETA PARTICLE.

INDEX	RADIONUCLIDE	NO.	MAXIMUM ENERGY (MEV)	ABUNDANCE
236	CE143	1	0.3000E 00	0.060
		2	0.5420E 00	0.050
		3	0.7300E 00	0.050
		4	0.1100E 01	0.400
		5	0.1400E 01	0.370
237	PR143	1	0.9330E 00	1.000
238	CE144	1	0.3200E 00	0.760
		2	0.2400E 00	0.045
		3	0.1860E 00	0.195
239	PR144	1	0.8000E 00	0.010
		2	0.2290E 01	0.013
		3	0.2980E 01	0.977
241	PR145	1	0.1800E 01	1.000
242	CE146	1	0.6600E 00	0.090
		2	0.7000E 00	0.680
		3	0.8800E 00	0.230
243	PR146	1	0.3700E 01	0.560
		2	0.2300E 01	0.440
245	PR147	1	0.2700E 01	0.050
		2	0.2100E 01	0.550
		3	0.1400E 01	0.250
		4	0.1000E 01	0.150
246	ND147	1	0.2120E 00	0.030
		2	0.3680E 00	0.200
		3	0.8100E 00	0.770
247	PM147	1	0.2250E 00	1.000
250	ND149	1	0.9500E 00	0.160
		2	0.1100E 01	0.430
		3	0.1500E 01	0.310
251	PM149	1	0.1900E 00	0.002
		2	0.2400E 00	0.001
		3	0.4700E 00	0.001
		4	0.7840E 00	0.030
		5	0.1071E 01	0.970
252	PM150	1	0.2000E 01	0.800
		2	0.3000E 01	0.200
253	ND151	1	0.1930E 01	1.000

ENERGY AND ABUNDANCE FOR EACH BETA PARTICLE.

INDEX	RADIONUCLIDE	NO.	MAXIMUM ENERGY (MEV)	ABUNDANCE
254	PM151	1	0.1200E 01	0.110
		2	0.1130E 01	0.130
		3	0.1030E 01	0.120
		4	0.8500E 00	0.440
		5	0.7500E 00	0.110
		6	0.4250E 00	0.090
258	SM153	1	0.1300E 00	0.001
		2	0.6400E 00	0.380
		3	0.6980E 00	0.400
		4	0.8030E 00	0.220
261	SM155	1	0.1500E 01	0.070
		2	0.1650E 01	0.930
262	EU155	1	0.1500E 00	0.300
		2	0.1600E 00	0.400
		3	0.1900E 00	0.100
		4	0.2500E 00	0.200
263	SM156	1	0.7200E 00	0.450
		2	0.4300E 00	0.550
264	EU156	1	0.2430E 01	0.330
		2	0.1195E 01	0.140
		3	0.4850E 00	0.360
266	EU157	1	0.1000E 01	0.750
		2	0.1600E 01	0.250
268	EU158	1	0.2600E 01	1.000
269	EU159	1	0.2570E 01	0.260
		2	0.2350E 01	0.210
		3	0.1900E 01	0.210
		4	0.1750E 01	0.110
		5	0.1500E 01	0.110
		6	0.1000E 01	0.100
270	GD159	1	0.5900E 00	0.200
		2	0.8900E 00	0.060
		3	0.9480E 00	0.740
272	TB160	1	0.3000E 00	0.120
		2	0.4600E 00	0.190
		3	0.5600E 00	0.380
		4	0.7600E 00	0.110
		5	0.8600E 00	0.200
		6	0.1710E 01	0.004
274	TB161	1	0.4600E 00	0.320
		2	0.5250E 00	0.590
		3	0.6100E 00	0.090
283	PU241	1	0.2100E-01	1.000

ENERGY AND ABUNDANCE FOR EACH BETA PARTICLE.

INDEX	RADIONUCLIDE	NO.	MAXIMUM ENERGY (MEV)	ABUNDANCE
287	AU196	1	0.2590E 00	0.060
290	W185	1	0.4290E 00	1.000
291	W187	1	0.3250E 00	0.080
		2	0.6250E 00	0.740
		3	0.1329E 01	0.180
292	W188	1	0.3490E 00	0.986
		2	0.2850E 00	0.005
		3	0.5900E-01	0.008
298	PB209	1	0.6350E 00	1.000
299	PB210	1	0.6100E-01	0.190
		2	0.1500E-01	0.810
300	TL204	1	0.7660E 00	1.000
301	HG203	1	0.2120E 00	1.000
303	H3	1	0.1900E-01	1.000
306	MN56	1	0.3000E 00	0.010
		2	0.7180E 00	0.180
		3	0.1028E 01	0.340
		4	0.2838E 01	0.470
308	FE59	1	0.1300E 00	0.010
		2	0.2710E 00	0.460
		3	0.4620E 00	0.540
		4	0.1560E 01	0.003
309	NA24	1	0.3910E 00	1.000
310	P32	1	0.1708E 01	1.000
311	CA45	1	0.2540E 00	1.000
312	NA22	1	0.5440E 00	0.898
313	U237	1	0.2480E 00	0.960
314	C14	1	0.1550E 00	1.000
315	K42	1	0.9000E-01	0.001
		2	0.1110E 01	0.001
		3	0.1710E 01	0.002
		4	0.2030E 01	0.177
		5	0.3550E 01	0.820
316	SC46	1	0.3570E 00	1.000
317	CL36	1	0.7140E 00	1.000
318	S35	1	0.1670E 00	1.000

ENERGY AND ABUNDANCE FOR EACH GAMMA PHOTON.

INDEX	RADIONUCLIDE	NO.	ENERGY (MEV)	ABUNDANCE
3	GE77	1	0.2320E 01	0.007
		2	0.1960E 01	0.024
		3	0.1740E 01	0.004
		4	0.9200E 00	0.058
		5	0.2020E 01	0.024
		6	0.1500E 01	0.011
		7	0.1370E 01	0.037
		8	0.8000E 00	0.108
		9	0.1080E 01	0.072
		10	0.1190E 01	0.037
		11	0.7090E 00	0.108
		12	0.5630E 00	0.180
		13	0.6320E 00	0.108
		14	0.4160E 00	0.252
		15	0.3680E 00	0.158
		16	0.2100E 00	0.355
		17	0.2650E 00	0.262
		18	0.2150E 00	0.504
4	AS77	1	0.8600E-01	0.003
		2	0.1590E 00	0.002
		3	0.2450E 00	0.023
		4	0.5250E 00	0.007
5	GE78	1	0.4500E 00	0.990
		2	0.1100E-01	0.010
6	AS78	1	0.6150E 00	0.420
		2	0.6950E 00	0.155
		3	0.8300E 00	0.079
		4	0.9900E 00	0.025
		5	0.1100E 01	0.029
		6	0.1210E 01	0.042
		7	0.1310E 01	0.108
		8	0.1490E 01	0.021
		9	0.1700E 01	0.017
		10	0.1820E 01	0.014
		11	0.1940E 01	0.015
		12	0.2050E 01	0.010
		13	0.2240E 01	0.010
		14	0.2650E 01	0.014
12	SE81M	1	0.1030E 00	0.080
13	SE81	1	0.3000E-01	0.001
		2	0.2800E 00	0.009
		3	0.5600E 00	0.003
		4	0.8300E 00	0.002

ENERGY AND ABUNDANCE FOR EACH GAMMA PHOTON.

INDEX	RADIONUCLIDE	NO.	ENERGY (MEV)	ABUNDANCE
14	BR82	1	0.5540E 00	0.727
		2	0.6190E 00	0.454
		3	0.6980E 00	0.309
		4	0.7770E 00	0.909
		5	0.8270E 00	0.273
		6	0.1044E 01	0.318
		7	0.1317E 01	0.309
		8	0.1475E 01	0.182
16	BR83	1	0.4600E-01	0.160
		2	0.3200E-01	1.000
		3	0.9000E-02	1.000
		4	0.1300E-01	0.040
17	KR83M	1	0.3200E-01	1.000
		2	0.9000E-02	1.000
18	SE83	1	0.2250E 00	0.607
		2	0.3580E 00	0.953
		3	0.5240E 00	0.823
		4	0.7120E 00	0.347
		5	0.8330E 00	0.563
		6	0.1058E 01	0.217
		7	0.1309E 01	0.347
		8	0.1880E 01	0.217
		9	0.2294E 01	0.130
21	BR84	1	0.3280E 01	0.024
		2	0.3930E 01	0.104
		3	0.3030E 01	0.030
		4	0.2050E 01	0.158
		5	0.2700E 00	0.005
		6	0.1570E 01	0.010
		7	0.1210E 01	0.032
		8	0.2820E 01	0.019
		9	0.2470E 01	0.078
		10	0.2170E 01	0.016
		11	0.6100E 00	0.024
		12	0.1900E 01	0.150
		13	0.4300E 00	0.022
		14	0.1010E 01	0.087
		15	0.7400E 00	0.016
		16	0.5200E 00	0.024
		17	0.8790E 00	0.417
		18	0.8100E 00	0.062
		19	0.3500E 00	0.010
		20	0.1740E 01	0.020
		21	0.1470E 01	0.017
		22	0.4700E 00	0.009
25	KR85M	1	0.3050E 00	0.135
		2	0.1490E 00	0.778
		3	0.1400E-01	0.087
26	KR85	1	0.5140E 00	0.010

ENERGY AND ABUNDANCE FOR EACH GAMMA PHOTON.

INDEX	RADIONUCLIDE	NO.	ENERGY (MEV)	ABUNDANCE
31	KR87	1	0.4030E 00	0.524
		2	0.8470E 00	0.100
		3	0.2050E 01	0.031
		4	0.2570E 01	0.220
33	KR88	1	0.1660E 00	0.070
		2	0.1910E 00	0.350
		3	0.3600E 00	0.049
		4	0.8450E 00	0.227
		5	0.1190E 01	0.035
		6	0.1550E 01	0.140
		7	0.2190E 01	0.175
		8	0.2400E 01	0.350
34	RB88	1	0.9080E 00	0.145
		2	0.1390E 01	0.014
		3	0.1850E 01	0.230
		4	0.2110E 01	0.010
		5	0.2680E 01	0.025
		6	0.3010E 01	0.003
		7	0.3240E 01	0.003
		8	0.3520E 01	0.002
		9	0.3680E 01	0.001
		10	0.4870E 01	0.003
37	RB89	1	0.6630E 00	0.150
		2	0.1050E 01	0.750
		3	0.1260E 01	0.530
		4	0.1550E 01	0.040
		5	0.2200E 01	0.140
		6	0.2590E 01	0.130
		7	0.2750E 01	0.030
		8	0.3530E 01	0.020
46	SR91	1	0.6450E 00	0.150
		2	0.7480E 00	0.270
		3	0.9300E 00	0.030
		4	0.1025E 01	0.300
		5	0.1413E 01	0.150
47	Y91M	1	0.5510E 00	0.956
		2	0.1500E-01	0.044
48	Y91	1	0.1208E 01	0.003
51	SR92	1	0.2300E 00	0.035
		2	0.4400E 00	0.041
		3	0.1370E 01	0.900

ENERGY AND ABUNDANCE FOR EACH GAMMA PHOTON.

INDEX	RADIONUCLIDE	NO.	ENERGY (MEV)	ABUNDANCE
52	Y92	1	0.4480E 00	0.023
		2	0.4900E 00	0.004
		3	0.5600E 00	0.026
		4	0.8400E 00	0.011
		5	0.9040E 00	0.008
		6	0.9320E 00	0.135
		7	0.1120E 01	0.002
		8	0.1120E 01	0.002
		9	0.1395E 01	0.047
		10	0.1830E 01	0.004
56	Y93	1	0.2180E 01	0.004
		2	0.1900E 01	0.018
		3	0.1420E 01	0.007
		4	0.1150E 01	0.002
		5	0.9350E 00	0.023
		6	0.6650E 00	0.007
		7	0.2670E 00	0.064
		8	0.1200E 01	0.001
		9	0.1620E 01	0.001
		10	0.1600E-01	0.001
62	Y94	1	0.5600E 00	0.060
		2	0.9200E 00	0.430
		3	0.1130E 01	0.050
		4	0.1650E 01	0.024
		5	0.1900E 01	0.016
		6	0.2130E 01	0.024
		7	0.2570E 01	0.015
		8	0.2840E 01	0.007
		9	0.3060E 01	0.013
		10	0.3530E 01	0.011
65	ZR95	1	0.7260E 00	0.550
		2	0.7600E 00	0.430
		3	0.2350E 00	0.020
		4	0.1700E-01	0.001
66	NB95M	1	0.2350E 00	1.000
67	NB95	1	0.7680E 00	0.990
69	ZR97	1	0.1020E 01	0.010
		2	0.1150E 01	0.020
		3	0.1720E 01	0.005
		4	0.1770E 01	0.005
70	NB97M	1	0.7500E 00	0.986
		2	0.1700E-01	0.014
71	NB97	1	0.1020E 01	0.010
		2	0.6650E 00	0.990

ENERGY AND ABUNDANCE FOR EACH GAMMA PHOTON.

INDEX	RADIONUCLIDE	NO.	ENERGY (MEV)	ABUNDANCE
74	NB98	1	0.3300E 00	0.090
		2	0.7200E 00	0.750
		3	0.7800E 00	1.000
		4	0.1160E 01	0.300
		5	0.1440E 01	0.100
		6	0.1520E 01	0.040
		7	0.1680E 01	0.100
		8	0.1880E 01	0.040
		9	0.1930E 01	0.080
77	MO99	1	0.7400E 00	0.100
		2	0.7800E 00	0.040
		3	0.3720E 00	0.010
		4	0.1810E 00	0.037
		5	0.1400E 00	0.068
		6	0.1900E-01	0.009
78	TC99M	1	0.1420E 00	0.004
		2	0.2000E-02	0.986
		3	0.1400E 00	0.900
		4	0.1900E-01	0.086
82	MO101	1	0.8000E-01	0.030
		2	0.1910E 00	0.250
		3	0.1930E 00	0.020
		4	0.3000E 00	0.070
		5	0.4000E 00	0.020
		6	0.5100E 00	0.150
		7	0.5900E 00	0.210
		8	0.7040E 00	0.110
		9	0.8900E 00	0.150
		10	0.9500E 00	0.020
		11	0.1020E 01	0.250
		12	0.1180E 01	0.110
		13	0.1280E 01	0.030
		14	0.1380E 01	0.090
		15	0.1560E 01	0.110
		16	0.1660E 01	0.030
		17	0.2080E 01	0.160
		18	0.1460E 01	0.010
83	TC101	1	0.9390E 00	0.002
		2	0.3850E 00	0.016
		3	0.8460E 00	0.003
		4	0.7200E 00	0.011
		5	0.6350E 00	0.009
		6	0.5450E 00	0.076
		7	0.2350E 00	0.007
		8	0.4100E 00	0.004
		9	0.3070E 00	0.910
85	TC102M	1	0.1100E 01	1.000

ENERGY AND ABUNDANCE FOR EACH GAMMA PHOTON.

INDEX	RADIONUCLIDE	NO.	ENERGY (MEV)	ABUNDANCE
88	RU103	1	0.6100E 00	0.065
		2	0.5550E 00	0.005
		3	0.4980E 00	0.880
		4	0.4400E 00	0.005
		5	0.5300E-01	0.007
		6	0.2100E-01	0.013
89	RH103M	1	0.4000E-01	0.024
		2	0.2100E-01	0.976
94	RU105	1	0.1300E 00	0.011
		2	0.2100E 00	0.050
		3	0.2600E 00	0.065
		4	0.3170E 00	0.130
		5	0.4000E 00	0.070
		6	0.4750E 00	0.210
		7	0.6700E 00	0.175
		8	0.7250E 00	0.500
		9	0.8700E 00	0.040
		10	0.9700E 00	0.025
		11	0.2100E-01	0.044
95	RH105M	1	0.1290E 00	0.476
		2	0.2100E-01	0.524
96	RH105	1	0.3220E 00	0.097
		2	0.2200E-01	0.003
98	RH106	1	0.5130E 00	0.315
		2	0.6240E 00	0.139
		3	0.8600E 00	0.005
		4	0.1060E 01	0.019
		5	0.1140E 01	0.006
102	RH107	1	0.1150E 00	0.005
		2	0.2850E 00	0.025
		3	0.3070E 00	0.730
		4	0.3650E 00	0.015
		5	0.3900E 00	0.107
		6	0.4700E 00	0.010
		7	0.5700E 00	0.018
		8	0.6750E 00	0.027
106	RH108	1	0.4300E 00	0.430
		2	0.5100E 00	0.100
		3	0.6200E 00	0.220
		4	0.1520E 01	0.051
109	AG109M	1	0.8800E-01	0.046
		2	0.2300E-01	0.436
111	PD111M	1	0.1700E 00	0.300
		2	0.2200E-01	0.380

ENERGY AND ABUNDANCE FOR EACH GAMMA PHOTON.

INDEX	RADIONUCLIDE	NO.	ENERGY (MEV)	ABUNDANCE
112	PD111	1	0.6700E-01	0.036
		2	0.1080E 00	0.007
		3	0.1290E 00	0.011
		4	0.1480E 00	0.019
		5	0.2930E 00	0.009
		6	0.3670E 00	0.011
		7	0.3950E 00	0.046
		8	0.4350E 00	0.019
		9	0.4790E 00	0.010
		10	0.5230E 00	0.015
		11	0.5840E 00	0.027
		12	0.6500E 00	0.033
		13	0.7270E 00	0.017
		14	0.8280E 00	0.011
		15	0.8650E 00	0.004
		16	0.9630E 00	0.002
		17	0.1030E 01	0.004
		18	0.1140E 01	0.009
		19	0.1220E 01	0.003
		20	0.1315E 01	0.003
		21	0.1400E 01	0.004
		22	0.1600E 01	0.001
		23	0.1690E 01	0.008
		24	0.1780E 01	0.004
		25	0.1990E 01	0.003
113	AG111M	1	0.6500E-01	1.000
114	AG111	1	0.2470E 00	0.011
		2	0.3420E 00	0.060
		3	0.9500E-01	0.001
		4	0.2400E-01	0.002
115	PD112	1	0.1800E-01	0.200
		2	0.2300E-01	0.800
116	AG112	1	0.2950E 01	0.001
		2	0.1810E 01	0.008
		3	0.2830E 01	0.006
		4	0.2240E 01	0.008
		5	0.1490E 01	0.012
		6	0.2710E 01	0.004
		7	0.2110E 01	0.032
		8	0.2540E 01	0.010
		9	0.1930E 01	0.008
		10	0.1810E 01	0.008
		11	0.1090E 01	0.012
		12	0.1620E 01	0.032
		13	0.9800E 00	0.012
		14	0.1400E 01	0.053
		15	0.1210E 01	0.006
		16	0.8550E 00	0.016
		17	0.7850E 00	0.009
		18	0.1310E 01	0.014
		19	0.6900E 00	0.045
		20	0.6150E 00	0.400

ENERGY AND ABUNDANCE FOR EACH GAMMA PHOTON.

INDEX	RADIONUCLIDE	NO.	ENERGY (MEV)	ABUNDANCE
124	AG115	1	0.1100E 00	0.010
		2	0.1400E 00	0.090
		3	0.1700E 00	0.020
		4	0.2200E 00	0.420
		5	0.2400E 00	0.070
		6	0.2800E 00	0.130
		7	0.3600E 00	0.100
		8	0.4200E 00	0.070
		9	0.4500E 00	0.010
		10	0.4700E 00	0.100
		11	0.6200E 00	0.010
		12	0.6400E 00	0.030
		13	0.1040E 01	0.020
		14	0.1080E 01	0.020
		15	0.1480E 01	0.110
		16	0.1660E 01	0.080
		17	0.1760E 01	0.020
		18	0.1860E 01	0.030
		19	0.1900E 01	0.070
		20	0.2030E 01	0.020
		21	0.2120E 01	0.130
		22	0.2500E 01	0.010
125	CD115M	1	0.4850E 00	0.003
		2	0.1300E 01	0.010
		3	0.9350E 00	0.023
126	CD115	1	0.5230E 00	0.240
		2	0.2630E 00	0.002
		3	0.3300E-01	0.002
		4	0.4900E 00	0.122
		5	0.2300E 00	0.006
		6	0.2600E 00	0.017
127	IN115M	1	0.3350E 00	0.516
		2	0.2500E-01	0.361
133	CD117M	1	0.2810E 00	0.570
		2	0.4300E 00	0.120
		3	0.8400E 00	0.140
		4	0.1270E 01	0.700
		5	0.1550E 01	0.150
		6	0.2400E-01	0.320
134	CD117	1	0.8900E-01	0.070
		2	0.2730E 00	0.310
		3	0.3140E 00	0.160
		4	0.3450E 00	0.180
		5	0.4340E 00	0.130
		6	0.8320E 00	0.040
		7	0.8800E 00	0.030
		8	0.9500E 00	0.040
		9	0.1052E 01	0.050
		10	0.1303E 01	0.190
		11	0.1577E 01	0.170

ENERGY AND ABUNDANCE FOR EACH GAMMA PHOTON.

INDEX	RADIONUCLIDE	NO.	ENERGY (MEV)	ABUNDANCE
135	IN117M	1	0.3100E 00	0.087
		2	0.8220E 00	0.020
		3	0.6220E 00	0.020
		4	0.1610E 00	0.221
		5	0.2500E-01	0.142
136	IN117	1	0.5650E 00	1.000
		2	0.1610E 00	0.885
		3	0.2600E-01	0.115
139	IN118	1	0.1220E 01	0.200
140	IN118M	1	0.6900E 00	0.410
		2	0.1050E 01	0.800
		3	0.1230E 01	0.970
		4	0.2040E 01	0.030
143	IN119	1	0.7960E 00	0.950
		2	0.7310E 00	0.050
		3	0.2400E-01	0.050
144	IN119M	1	0.3000E 00	0.023
		2	0.9070E 00	0.050
145	CD120	1	0.5000E 00	1.000
146	IN120	1	0.9000E-01	0.120
		2	0.1980E 00	0.090
		3	0.7100E 00	0.120
		4	0.8600E 00	0.340
		5	0.9400E 00	0.120
		6	0.1020E 01	0.610
		7	0.1171E 01	1.000
		8	0.1280E 01	0.140
		9	0.1470E 01	0.060
		10	0.1870E 01	0.070
		11	0.2010E 01	0.060
154	SN123	1	0.1600E 00	0.885
		2	0.2700E-01	0.115
155	SN123M	1	0.1080E 01	0.020

ENERGY AND ABUNDANCE FOR EACH GAMMA PHOTON.

INDEX	RADIONUCLIDE	NO.	ENERGY (MEV)	ABUNDANCE
159	SB124	1	0.6030E 00	0.976
		2	0.6450E 00	0.072
		3	0.7140E 00	0.037
		4	0.7220E 00	0.105
		5	0.9700E 00	0.020
		6	0.1050E 01	0.020
		7	0.1298E 01	0.012
		8	0.1320E 01	0.020
		9	0.1366E 01	0.030
		10	0.1450E 01	0.020
		11	0.1500E 01	0.010
		12	0.1540E 01	0.006
		13	0.1690E 01	0.480
		14	0.1900E 01	0.004
		15	0.2090E 01	0.063
		16	0.2260E 01	0.006
161	SN125	1	0.3420E 00	0.004
		2	0.4680E 00	0.005
		3	0.8110E 00	0.010
		4	0.9040E 00	0.009
		5	0.1068E 01	0.036
		6	0.1410E 01	0.001
		7	0.1970E 01	0.012
162	SB125	1	0.3500E-01	0.064
		2	0.1090E 00	0.040
		3	0.1710E 00	0.003
		4	0.1760E 00	0.068
		5	0.2030E 00	0.002
		6	0.2060E 00	0.003
		7	0.2550E 00	0.015
		8	0.2900E 00	0.015
		9	0.3190F 00	0.008
		10	0.3790E 00	0.012
		11	0.4270E 00	0.310
		12	0.4620E 00	0.100
		13	0.5980E 00	0.190
		14	0.6040E 00	0.052
		15	0.6330E 00	0.110
		16	0.6520E 00	0.007
		17	0.6680E 00	0.016
		18	0.2800E-01	0.921
166	SB126	1	0.4150E 00	1.000
		2	0.6950E 00	1.000
		3	0.6650E 00	1.000
167	SN127	1	0.5000E 00	1.000
168	SB127	1	0.6000E-01	0.040
		2	0.2480E 00	0.140
		3	0.3100E 00	0.060
		4	0.4630E 00	0.540
		5	0.7720E 00	0.240

ENERGY AND ABUNDANCE FOR EACH GAMMA PHOTON.

INDEX	RADIONUCLIDE	NO.	ENERGY (MEV)	ABUNDANCE
169	TE127M	1	0.8900E-01	0.985
		2	0.5900E-01	0.015
170	TE127	1	0.4180E 00	0.008
		2	0.3600E 00	0.001
		3	0.5900E-01	0.001
		4	0.2900E-01	0.002
171	SN128	1	0.4400E-01	0.070
		2	0.7200E-01	0.181
		3	0.4970E 00	0.598
		4	0.5700E 00	0.216
		5	0.2700E-01	0.210
172	SB128M	1	0.3200E 00	0.810
		2	0.7540E 00	1.960
		3	0.1074E 01	0.040
173	SB128	1	0.3200E 00	0.830
		2	0.7500E 00	2.000
		3	0.1070E 01	0.040
175	SB129	1	0.1650E 00	0.580
		2	0.3080E 00	0.550
		3	0.5340E 00	1.000
		4	0.7880E 00	0.250
		5	0.2800E-01	0.170
176	TE129M	1	0.1060E 00	0.050
		2	0.2800E-01	0.950
177	TE129	1	0.1120E 01	0.104
		2	0.7200E 00	0.037
		3	0.4750E 00	0.154
		4	0.2700E-01	0.963
184	SB131	1	0.6000E 00	1.000
185	TE131M	1	0.2240E 01	0.006
		2	0.2400E 00	0.030
		3	0.2000E 01	0.040
		4	0.1220E 01	0.170
		5	0.1080E 01	0.050
		6	0.8000E-01	0.040
		7	0.1920E 01	0.020
		8	0.1000E 00	0.080
		9	0.2000E 00	0.080
		10	0.1140E 01	0.285
		11	0.3350E 00	0.160
		12	0.1620E 01	0.030
		13	0.8400E 00	0.400
		14	0.9200E 00	0.050
		15	0.7800E 00	0.800
		16	0.2900E-01	0.372

ENERGY AND ABUNDANCE FOR EACH GAMMA PHOTON.

INDEX	RADIONUCLIDE	NO.	ENERGY (MEV)	ABUNDANCE
186	TE131	1	0.1130E 01	0.100
		2	0.9200E 00	0.050
		3	0.6000E 00	0.050
		4	0.4540E 00	0.200
		5	0.1450E 00	0.800
187	I131	1	0.7240E 00	0.028
		2	0.6380E 00	0.091
		3	0.3640E 00	0.810
		4	0.2840E 00	0.055
		5	0.1560E 00	0.010
		6	0.2100E 00	0.010
		7	0.1640E 00	0.007
		8	0.8000E-01	0.063
		9	0.3000E-01	0.127
191	TE132	1	0.2330E 00	0.935
		2	0.2900E-01	0.905
192	I132	1	0.2400E 00	0.013
		2	0.3750E 00	0.046
		3	0.4600E 00	0.022
		4	0.5230E 00	0.190
		5	0.6240E 00	0.052
		6	0.6470E 00	0.090
		7	0.6500E 00	0.170
		8	0.6700E 00	0.990
		9	0.7200E 00	0.065
		10	0.7750E 00	0.820
		11	0.9500E 00	0.190
		12	0.1142E 01	0.045
		13	0.1300E 01	0.031
		14	0.1400E 01	0.083
		15	0.1450E 01	0.014
		16	0.1500E 01	0.018
		17	0.1660E 01	0.007
		18	0.1750E 01	0.004
		19	0.1910E 01	0.009
		20	0.1990E 01	0.010
		21	0.2070E 01	0.007
		22	0.2180E 01	0.002
		23	0.2350E 01	0.001
		24	0.2420E 01	0.001
		25	0.2540E 01	0.001

ENERGY AND ABUNDANCE FOR EACH GAMMA PHOTON.

INDEX	RADIONUCLIDE	NO.	ENERGY (MEV)	ABUNDANCE
194	TE133M	1	0.3340E 00	0.041
		2	0.3090E 00	0.207
		3	0.3870E 00	0.057
		4	0.4320E 00	0.500
		5	0.4680E 00	0.220
		6	0.5570E 00	0.350
		7	0.6320E 00	0.180
		8	0.6980E 00	0.240
		9	0.7540E 00	0.850
		10	0.9100E 00	0.570
		11	0.9730E 00	0.100
		12	0.2800E-01	0.089
195	TE133	1	0.8000E 00	1.000
		2	0.1100E 01	0.700
196	I133	1	0.5300E 00	0.980
		2	0.8500E 00	0.050
		3	0.1380E 01	0.020
197	XE133M	1	0.2330E 00	0.184
		2	0.3000E-01	0.816
198	XE133	1	0.1600E 00	0.001
		2	0.7900E-01	0.008
		3	0.8100E-01	0.410
		4	0.3200E-01	0.590
199	TE134	1	0.1500E 01	1.000
200	I134	1	0.1400E 00	0.030
		2	0.2100E 00	0.044
		3	0.3900E 00	0.070
		4	0.4100E 00	0.005
		5	0.4300E 00	0.030
		6	0.5100E 00	0.010
		7	0.5400E 00	0.080
		8	0.6100E 00	0.180
		9	0.6900E 00	0.070
		10	0.7500E 00	0.010
		11	0.7720E 00	0.062
		12	0.8480E 00	0.950
		13	0.8600E 00	0.045
		14	0.8900E 00	0.705
		15	0.9600E 00	0.020
		16	0.1000E 01	0.045
		17	0.1070E 01	0.180
		18	0.1280E 01	0.016
		19	0.1340E 01	0.017
		20	0.1460E 01	0.035
		21	0.1490E 01	0.010
		22	0.1620E 01	0.050
		23	0.1790E 01	0.050

ENERGY AND ABUNDANCE FOR EACH GAMMA PHOTON.

INDEX	RADIONUCLIDE	NO.	ENERGY (MEV)	ABUNDANCE
202	I135	1	0.4200E 00	0.144
		2	0.5330E 00	0.277
		3	0.6200E 00	0.416
		4	0.7000E 00	0.194
		5	0.8510E 00	0.116
		6	0.1040E 01	0.198
		7	0.1800E 01	0.183
		8	0.1140E 01	0.532
		9	0.1270E 01	0.554
		10	0.1470E 01	0.198
		11	0.1690E 01	0.256
203	XE135M	1	0.5280E 00	0.830
		2	0.3000E-01	0.170
204	XE135	1	0.6040E 00	0.030
		2	0.3600E 00	0.001
		3	0.2500E 00	0.970
		4	0.3200E-01	0.052
207	CS136	1	0.3370E 00	0.590
		2	0.1520E 00	0.190
		3	0.2700E 00	0.220
		4	0.1255E 01	0.210
		5	0.1065E 01	0.840
		6	0.8300E 00	1.000
		7	0.1700E 00	0.230
		8	0.2000E 00	0.030
211	BA137M	1	0.6620E 00	0.910
		2	0.3300E-01	0.090
213	XE138	1	0.4200E 00	1.000
		2	0.5100E 00	0.200
		3	0.1780E 01	0.200
214	CS138	1	0.3340E 01	0.005
		2	0.2630E 01	0.090
		3	0.1930E 00	0.008
		4	0.1010E 01	0.250
		5	0.5500E 00	0.080
		6	0.2290E 00	0.016
		7	0.1390E 00	0.020
		8	0.8700E 00	0.040
		9	0.4110E 00	0.030
		10	0.2210E 01	0.180
		11	0.4630E 00	0.230
		12	0.1426E 01	0.730
218	BA139	1	0.1430E 01	0.003
		2	0.1660E 00	0.233
		3	0.3400E-01	0.047

ENERGY AND ABUNDANCE FOR EACH GAMMA PHOTON.

INDEX	RADIONUCLIDE	NO.	ENERGY (MEV)	ABUNDANCE
221	BA140	1	0.5370E 00	0.250
		2	0.4300E 00	0.045
		3	0.3060E 00	0.033
		4	0.1620E 00	0.073
		5	0.3000E-01	1.050
222	LA140	1	0.1597E 01	1.000
		2	0.3290E 00	0.224
		3	0.4310E 00	0.040
		4	0.4860E 00	0.432
		5	0.7520E 00	0.034
		6	0.8150E 00	0.280
		7	0.8680E 00	0.050
		8	0.9260E 00	0.110
		9	0.2343E 01	0.008
		10	0.2550E 01	0.050
		11	0.3000E 01	0.001
		12	0.3500E-01	0.018
225	BA141	1	0.7000E 00	1.000
226	LA141	1	0.1370E 01	0.020
227	CE141	1	0.1450E 00	0.519
		2	0.3700E-01	0.157
230	BA142	1	0.8000E-01	0.300
		2	0.2600E 00	1.000
		3	0.8900E 00	0.400
		4	0.9700E 00	0.150
		5	0.1080E 01	0.100
		6	0.1200E 01	0.350
231	LA142	1	0.6400E 00	0.550
		2	0.9000E 00	0.120
		3	0.1055E 01	0.060
		4	0.1540E 01	0.040
		5	0.1750E 01	0.025
		6	0.1920E 01	0.060
		7	0.2080E 01	0.030
		8	0.2400E 01	0.110
		9	0.2615E 01	0.030
		10	0.3000E 01	0.040
		11	0.3300E 01	0.007
		12	0.3650E 01	0.012

ENERGY AND ABUNDANCE FOR EACH GAMMA PHOTON.

INDEX	RADIONUCLIDE	NO.	ENERGY (MEV)	ABUNDANCE
235	LA143	1	0.2000E 00	0.080
		2	0.4400E 00	0.130
		3	0.6200E 00	1.000
		4	0.8000E 00	0.440
		5	0.9200E 00	0.080
		6	0.1070E 01	0.260
		7	0.1170E 01	0.570
		8	0.1580E 01	0.280
		9	0.1700E 01	0.190
		10	0.1980E 01	0.350
		11	0.2220E 01	0.060
		12	0.2460E 01	0.130
		13	0.2560E 01	0.270
		14	0.2850E 01	0.150
236	CE143	1	0.5600E-01	0.243
		2	0.2930E 00	0.935
		3	0.2300E 00	0.062
		4	0.3410E 00	0.065
		5	0.4880E 00	0.058
		6	0.6650E 00	0.130
		7	0.7180E 00	0.160
		8	0.8700E 00	0.017
		9	0.3500E-01	1.629
238	CE144	1	0.1330E 00	0.100
		2	0.5300E-01	0.001
		3	0.3400E-01	0.012
		4	0.1000E 00	0.001
		5	0.4100E-01	0.013
		6	0.8000E-01	0.025
		7	0.5900E-01	0.012
		8	0.3700E-01	0.112
239	PR144	1	0.2180E 01	0.008
		2	0.6910E 00	0.015
		3	0.1490E 01	0.002
242	CE146	1	0.5000E-01	0.010
		2	0.1100E 00	0.090
		3	0.1420E 00	0.200
		4	0.2100E 00	0.160
		5	0.2200E 00	0.070
		6	0.2500E 00	0.020
		7	0.2700E 00	0.050
		8	0.3200E 00	0.470
		9	0.3700E-01	0.230
243	PR146	1	0.1490E 01	0.330
		2	0.7500E 00	0.460
		3	0.4600E 00	1.000

ENERGY AND ABUNDANCE FOR EACH GAMMA PHOTON.

INDEX	RADIONUCLIDE	NO.	ENERGY (MEV)	ABUNDANCE
245	PR147	1	0.7800E-01	0.170
		2	0.1270E 00	0.090
		3	0.3100E 00	0.200
		4	0.3400E 00	0.250
		5	0.5600E 00	0.390
		6	0.6100E 00	0.100
		7	0.6500E 00	0.240
		8	0.1260E 01	0.110
246	ND147	1	0.5320E 00	0.168
		2	0.4410E 00	0.019
		3	0.1200E 00	0.006
		4	0.6880E 00	0.010
		5	0.6000E 00	0.003
		6	0.2770E 00	0.014
		7	0.1970E 00	0.003
		8	0.4000E 00	0.016
		9	0.3210E 00	0.032
		10	0.9100E-01	0.280
		11	0.4000E-01	0.513
250	ND149	1	0.1120E 00	0.024
		2	0.1140E 00	0.144
		3	0.1240E 00	0.017
		4	0.1880E 00	0.021
		5	0.1980E 00	0.019
		6	0.2100E 00	0.327
		7	0.2260E 00	0.014
		8	0.2400E 00	0.267
		9	0.2660E 00	0.089
		10	0.4000E-01	0.623
251	PM149	1	0.2860E 00	0.017
		2	0.4100E-01	0.003
252	PM150	1	0.2750E 01	0.090
		2	0.1950E 01	0.020
		3	0.1680E 01	0.070
		4	0.8200E 00	0.190
		5	0.1330E 01	0.200
		6	0.5100E 00	0.100
		7	0.1170E 01	0.200
		8	0.8200E 00	0.190
		9	0.4000E 00	0.200
		10	0.3400E 00	0.800
		11	0.5700E 00	0.020
		12	0.7000E 00	0.050
253	ND151	1	0.8500E-01	0.090
		2	0.1090E 00	0.120
		3	0.1100E 00	0.120
		4	0.1170E 00	0.120
		5	0.4210E 00	0.250
		6	0.7200E 00	0.500
		7	0.1140E 01	0.500
		8	0.4000E-01	0.550

ENERGY AND ABUNDANCE FOR EACH GAMMA PHOTON.

INDEX	RADIONUCLIDE	NO.	ENERGY (MEV)	ABUNDANCE
254	PM151	1	0.1430E 00	0.008
		2	0.1520E 00	0.004
		3	0.1630E 00	0.024
		4	0.1680E 00	0.110
		5	0.1770E 00	0.052
		6	0.2020E 00	0.013
		7	0.2090E 00	0.018
		8	0.2320E 00	0.014
		9	0.2370E 00	0.014
		10	0.2400E 00	0.030
		11	0.2750E 00	0.063
		12	0.3240E 00	0.009
		13	0.3400E 00	0.210
		14	0.3450E 00	0.015
		15	0.3530E 00	0.005
		16	0.4390E 00	0.009
		17	0.4450E 00	0.033
		18	0.6370E 00	0.012
		19	0.6700E 00	0.012
		20	0.7170E 00	0.035
		21	0.7350E 00	0.008
		22	0.7520E 00	0.001
		23	0.7720E 00	0.001
		24	0.9500E 00	0.001
		25	0.4100E-01	0.271
258	SM153	1	0.5400E 00	0.001
		2	0.1730E 00	0.003
		3	0.7000E-01	0.029
		4	0.8400E-01	0.006
		5	0.9700E-01	0.014
		6	0.1030E 00	0.143
		7	0.4200E-01	0.297
261	SM155	1	0.2460E 00	0.060
		2	0.1410E 00	0.010
		3	0.1050E 00	0.940
		4	0.4200E-01	0.256
262	EU155	1	0.6000E-01	0.013
		2	0.8700E-01	0.268
		3	0.1050E 00	0.170
		4	0.4400E-01	0.181
263	SM156	1	0.8700E-01	0.400
		2	0.1650E 00	0.180
		3	0.2030E 00	0.290
		4	0.2500E 00	0.050
		5	0.2900E 00	0.030

ENERGY AND ABUNDANCE FOR EACH GAMMA PHOTON.

INDEX	RADIONUCLIDE	NO.	ENERGY (MEV)	ABUNDANCE
264	EU156	1	0.8900E-01	0.084
		2	0.1990E 00	0.007
		3	0.6000E 00	0.015
		4	0.6460E 00	0.065
		5	0.7200E 00	0.056
		6	0.8120E 00	0.092
		7	0.8670E 00	0.001
		8	0.9610E 00	0.003
		9	0.1065E 01	0.061
		10	0.1153E 01	0.057
		11	0.1154E 01	0.056
		12	0.1231E 01	0.092
		13	0.1242E 01	0.061
		14	0.1366E 01	0.001
		15	0.1877E 01	0.002
		16	0.1937E 01	0.002
		17	0.1966E 01	0.005
		18	0.2026E 01	0.003
		19	0.2098E 01	0.004
		20	0.2184E 01	0.006
		21	0.4400E-01	0.190
266	EU157	1	0.2000E 00	0.830
		2	0.6000E 00	0.750
		3	0.4400E-01	0.170
268	EU158	1	0.4000E 00	1.000
		2	0.8000E 00	1.000
269	EU159	1	0.7000E-01	0.420
		2	0.9000E-01	0.180
		3	0.1500E 00	0.140
		4	0.2200E 00	0.050
		5	0.6700E 00	0.210
		6	0.7300E 00	0.100
		7	0.8000E 00	0.110
		8	0.1100E 01	0.110
		9	0.5000E 00	0.050
270	GD159	1	0.3620E 00	0.192
		2	0.3050E 00	0.001
		3	0.2250E 00	0.005
		4	0.4500E-01	0.002

ENERGY AND ABUNDANCE FOR EACH GAMMA PHOTON.

INDEX	RADIONUCLIDE	NO.	ENERGY (MEV)	ABUNDANCE
272	TB160	1	0.8700E-01	0.072
		2	0.1970E 00	0.012
		3	0.2150E 00	0.013
		4	0.2980E 00	0.084
		5	0.3930E 00	0.005
		6	0.6820E 00	0.003
		7	0.7640E 00	0.007
		8	0.8790E 00	0.114
		9	0.9620E 00	0.036
		10	0.9660E 00	0.084
		11	0.9850E 00	0.003
		12	0.1070E 01	0.004
		13	0.1080E 01	0.006
		14	0.1112E 01	0.006
		15	0.1179E 01	0.054
		16	0.1200E 01	0.008
		17	0.1272E 01	0.029
		18	0.1314E 01	0.008
		19	0.4700E-01	0.020
274	TB161	1	0.5700E-01	0.040
		2	0.7400E-01	0.072
		3	0.4900E-01	0.290
		4	0.2600E-01	0.240
		5	0.4700E-01	0.294
279	AU195	1	0.9900E-01	0.100
		2	0.1290E 00	0.010
280	PU238	1	0.2200E-01	0.130
281	PU239	1	0.2200E-01	0.024
282	PU240	1	0.2200E-01	0.110
287	AU196	1	0.3580E 00	0.900
		2	0.3330E 00	0.270
		3	0.4260E 00	0.060
		4	0.6800E-01	0.990
289	W181	1	0.1530E 00	0.001
		2	0.5900E-01	1.000

ENERGY AND ABUNDANCE FOR EACH GAMMA PHOTON.

INDEX	RADIONUCLIDE	NO.	ENERGY (MEV)	ABUNDANCE
291	W187	1	0.7200E-01	0.147
		2	0.1070E 00	0.001
		3	0.1140E 00	0.001
		4	0.1340E 00	0.119
		5	0.2060E 00	0.002
		6	0.2390E 00	0.001
		7	0.2460E 00	0.002
		8	0.4790E 00	0.304
		9	0.5110E 00	0.008
		10	0.5520E 00	0.064
		11	0.6180E 00	0.079
		12	0.6250E 00	0.013
		13	0.6860E 00	0.353
		14	0.7730E 00	0.049
		15	0.8670E 00	0.005
		16	0.6300E-01	0.387
292	W188	1	0.6600E-01	0.002
		2	0.2270E 00	0.002
		3	0.2900E 00	0.004
294	PB202	1	0.1500E-01	0.240
295	PB203	1	0.6800E 00	0.008
		2	0.4010E 00	0.039
		3	0.2790E 00	0.853
		4	0.7500E-01	1.143
296	PB204M	1	0.9120E 00	0.950
		2	0.3750E 00	0.960
		3	0.8990E 00	0.990
		4	0.7700E-01	0.100
297	PB205	1	0.1500E-01	0.240
299	PB210	1	0.4700E-01	1.000
301	HG203	1	0.2790E 00	0.860
		2	0.7500E-01	0.140
302	BE7	1	0.4770E 00	0.115
304	CR51	1	0.6450E 00	0.001
		2	0.3200E 00	0.001
		3	0.3220E 00	0.091
305	MN54	1	0.8420E 00	1.000
306	MN56	1	0.8450E 00	1.000
		2	0.1810E 01	0.333
		3	0.2120E 01	0.175
		4	0.2520E 01	0.009
		5	0.2660E 01	0.007
		6	0.2960E 01	0.005
		7	0.3390E 01	0.002

ENERGY AND ABUNDANCE FOR EACH GAMMA PHOTON.

INDEX	RADIONUCLIDE	NO.	ENERGY (MEV)	ABUNDANCE
307	FE55	1	0.1000E-01	1.000
308	FE59	1	0.3370E 00	0.003
		2	0.1450E 00	0.008
		3	0.1290E 01	0.440
		4	0.1910E 00	0.030
		5	0.1100E 01	0.570
309	NA24	1	0.1368E 01	1.000
		2	0.2750E 01	1.000
312	NA22	1	0.1274E 01	1.000
313	U237	1	0.6000E-01	0.360
		2	0.6500E-01	0.023
		3	0.1650E 00	0.036
		4	0.2080E 00	0.240
		5	0.3320E 00	0.014
		6	0.3350E 00	0.002
		7	0.1030E 00	0.631
		8	0.2200E-01	0.190
		9	0.2200E-01	0.179
		10	0.1800E-01	0.057
		11	0.6000E-02	0.110
315	K42	1	0.1920E 01	0.001
		2	0.3200E 00	0.002
		3	0.1520E 01	0.180
316	SC46	1	0.1119E 01	1.000
		2	0.8870E 00	1.000

APPENDIX F

SAMPLE PROBLEM FOR EXREM

In this section, an example problem is presented to illustrate the input format that is required to solve a problem using the code EXREM.

The problem is to determine the dose-equivalent rates and the total dose equivalents from both beta and gamma radiation resulting from exposure from submersion in water, submersion in air and exposure to a surface contaminated with the radionuclides K-42, W-187, and PU-238. The radionuclides are the results of two detonations. One occurs 1440 hours after the other. It is desired to calculate the dose rate at the time of the first detonation and the total dose accumulated from the time of the first detonation to 50 years later.

The format of the input cards containing the data necessary to describe the problem is given in Table 3, and the computer output for the problem is given in Table 4.

TABLE III

INPUT FOR EXREM SAMPLE PROBLEM

1 5	6 10	11 15	16 20	21 25	26 30	31 35	36 40	41 45	46 50	51 55	56 60	61 65	66 70	71	73 80
					SAMPLE PRØBLEM FØR EXREM										
3	2	1	2	1	1	1	1	1	1						LIMIT
	2.286		100.0												HEIGHT
	0.0		1440.0												DETØN
280	94PU238		0.9158E-06		0	1									NUCLID
291	74W187		0.28881E-1		3	16									NUCLID
315	19K42		0.5590E-01		5	3									NUCLID
	6.4E6		3.5E6												280PRØD
	5.8E6		9.7E5												291PRØD
	4.2E6		6.9E5												315PRØD
	1.0E-6		5.0E-5												1280WLØC
	1.0E-6		5.0E-5												1291WLØC
	1.0E-6		5.0E-5												1315WLØC
	1.1E-6		6.0E-5												1280ALØC
	1.2E-6		6.0E-5												1291ALØC
	1.2E-6		6.0E-5												1315ALØC
	1.3E-6		5.7E-5												1280SLØC
	1.1E-6		5.5E-5												1291SLØC
	1.1E-6		5.5E-5												1315SLØC
0.325	0.080	0.625	0.740	1.329	0.180										B 291
0.090	0.001	1.110	0.001	1.710	0.002	2.030	0.177	3.550	0.820						B 315
0.022	0.130														G 280
0.072	0.147	0.107	0.001	0.114	0.001	0.134	0.119	0.206	0.002	0.239	0.001				G 291
0.246	0.002	0.479	0.304	0.511	0.008	0.552	0.064	0.618	0.079	0.625	0.013				G 291
0.686	0.353	0.773	0.049	0.867	0.005	0.063	0.387								G 291

1–5	6–10	11–15	16–20	21–25	26–30	31–35	36–40	73–80
1.920	0.001	0.320	0.002	1.520	0.180			G 315
	1.5		2.5					CLØUD
	0.0		0.0		50.0			CASE

TABLE IV

OUTPUT FOR EXREM SAMPLE PROBLEM

LISTING OF BASIC INPUT PARAMETERS FOR EXREM

SAMPLE PROBLEM FOR EXREM

```
TOTAL NO. OF RADIONUCLIDES =  3
TOTAL NO. OF DETONATIONS   =  2
TOTAL NO. OF LOCATIONS     =  1
```

ESTIMATE DOSES FOR SUBMERSION IN WATER.

ESTIMATE DOSES FOR SUBMERSION IN AIR.

ESTIMATE DOSES FOR EXPOSURE TO A SURFACE.

RADIONUCLIDE IDENTIFICATION.

INDEX	ATOMIC NUMBER	NAME	DECAY CONSTANT (1/HRS)	NO. BETA PARTICLES	NO. GAMMA PHOTONS
280	94	PU238	0.91580E-06	0	1
291	74	W187	0.28881E-01	3	16
315	19	K42	0.55900E-01	5	3

YIELD.

INDEX	RADIONUCLIDE	DETONATION	YIELD VENTED (MICROCURIES)
280	PU238	1	0.64000E 07
		2	0.35000E 07
291	W187	1	0.58000E 07
		2	0.97000E 06
315	K42	1	0.42000E 07
		2	0.69000E 06

LOCATION CORRECTION FACTOR.

LOCATION NUMBER	NUCLIDE INDEX	DETONATION NUMBER	SUBMERSION IN WATER (1/CC)	SUBMERSION IN AIR (1/CC)	EXPOSURE TO SURFACE (1/SQ CM)
1					
	280				
		1	1.0000E-06	1.1000E-06	1.3000E-06
		2	5.0000E-05	6.0000E-05	5.7000E-05
	291				
		1	1.0000E-06	1.2000E-06	1.1000E-06
		2	5.0000E-05	6.0000E-05	5.5000E-05
	315				
		1	1.0000E-06	1.2000E-06	1.1000E-06
		2	5.0000E-05	6.0000E-05	5.5000E-05

ENERGY AND ABUNDANCE FOR EACH BETA PARTICLE.

INDEX	RADIONUCLIDE	NO.	MAXIMUM ENERGY (MEV)	ABUNDANCE
291	W187	1	0.3250E 00	0.080
		2	0.6250E 00	0.740
		3	0.1329E 01	0.180
315	K42	1	0.9000E-01	0.001
		2	0.1110E 01	0.001
		3	0.1710E 01	0.002
		4	0.2030E 01	0.177
		5	0.3550E 01	0.820

ENERGY AND ABUNDANCE FOR EACH GAMMA PHOTON.

INDEX	RADIONUCLIDE	NO.	ENERGY (MEV)	ABUNDANCE
280	PU238	1	0.2200E-01	0.130
291	W187	1	0.7200E-01	0.147
		2	0.1070E 00	0.001
		3	0.1140E 00	0.001
		4	0.1340E 00	0.119
		5	0.2060E 00	0.002
		6	0.2390E 00	0.001
		7	0.2460E 00	0.002
		8	0.4790E 00	0.304
		9	0.5110E 00	0.009
		10	0.5520E 00	0.064
		11	0.6180E 00	0.079
		12	0.6250E 00	0.013
		13	0.6860E 00	0.353
		14	0.7730E 00	0.049
		15	0.8670E 00	0.005
		16	0.6300E-01	0.387
315	K42	1	0.1920E 01	0.001
		2	0.3200E 00	0.002
		3	0.1520E 01	0.180

TIME OF EACH DETONATION.

NO.	DETONATION TIME (HRS)	CLOUD TIME (HRS)
1	0.0	1.5
2	1440.0	2.5

HEIGHT ABOVE GROUND SURFACE.

NO.	HEIGHT (CM)
1	2.286
2	100.000

SAMPLE PROBLEM FOR EXREM

LISTING OF RADIONUCLIDES FOR SUBMERSION DOSE RATES IN CONTAMINATED WATER

LOCATION NUMBER = 1
TIME AFTER DETONATION 1 = 0.0 HOURS.

NO.	BETA DOSE RATE			GAMMA DOSE RATE			TOTAL DOSE RATE		
	NUCLIDE LABEL	NUCLIDE NAME	DOSE RATE REMS/HR	NUCLIDE LABEL	NUCLIDE NAME	DOSE RATE REMS/HR	NUCLIDE LABEL	NUCLIDE NAME	DOSE RATE REMS/HR
1	315	K42	0.651E 01	291	W187	0.716E 01	315	K42	0.898E 01
2	291	W187	0.152E 01	315	K42	0.247E 01	291	W187	0.868E 01
3	280	PU238	0.0	280	PU238	0.390E-01	280	PU238	0.390E-01
TOTAL			0.803E 01			0.967E 01			0.177E 02

SAMPLE PROBLEM FOR EXREM

LISTING OF RADIONUCLIDES FOR ACCUMULATED SUBMERSION DOSES IN CONTAMINATED WATER

LOCATION NUMBER = 1
INTEGRATION PERIOD -- 0.0 TO 0.43800E 06 HOURS.

	BETA DOSE			GAMMA DOSE			TOTAL DOSE		
NO.	NUCLIDE LABEL	NUCLIDE NAME	DOSE REMS	NUCLIDE LABEL	NUCLIDE NAME	DOSE REMS	NUCLIDE LABEL	NUCLIDE NAME	DOSE REMS
1	315	K42	0.107E 04	280	PU238	0.398E 06	280	PU238	0.398E 06
2	291	W187	0.494E 03	291	W187	0.232E 04	291	W187	0.281E 04
3	280	PU238	0.0	315	K42	0.408E 03	315	K42	0.148E 04
TOTAL			0.157E 04			0.401E 06			0.403E 06

SAMPLE PROBLEM FOR EXREM

LISTING OF RADIONUCLIDES FOR SUBMERSION DOSE RATES IN CONTAMINATED AIR

LOCATION NUMBER = 1
TIME AFTER DETONATION 1 = 0.0 HOURS.

NO.	BETA DOSE RATE			GAMMA DOSE RATE			TOTAL DOSE RATE		
	NUCLIDE LABEL	NUCLIDE NAME	DOSE RATE REMS/HR	NUCLIDE LABEL	NUCLIDE NAME	DOSE RATE REMS/HR	NUCLIDE LABEL	NUCLIDE NAME	DOSE RATE REMS/HR
1	315	K42	0.891E 01	291	W187	0.490E 01	315	K42	0.106E 02
2	291	W187	0.208E 01	315	K42	0.169E 01	291	W187	0.699E 01
3	280	PU238	0.0	280	PU238	0.245E-01	280	PU238	0.245E-01
TOTAL			0.110E 02			0.662E 01			0.176E 02

SAMPLE PROBLEM FOR EXREM

LISTING OF RADIONUCLIDES FOR ACCUMULATED SUBMERSION DOSES IN CONTAMINATED AIR

LOCATION NUMBER = 1
INTEGRATION PERIOD -- 0.0 TO 0.43800E 06 HOURS.

	BETA DOSE			GAMMA DOSE			TOTAL DOSE		
NO.	NUCLIDE LABEL	NUCLIDE NAME	DOSE REMS	NUCLIDE LABEL	NUCLIDE NAME	DOSE REMS	NUCLIDE LABEL	NUCLIDE NAME	DOSE REMS
1	315	K42	0.184E 03	291	W187	0.106E 03	315	K42	0.218E 03
2	291	W187	0.451E 02	315	K42	0.349E 02	291	W187	0.151E 03
3	280	PU238	0.0	280	PU238	0.192E 01	280	PU238	0.192E 01
TOTAL			0.229E 03			0.143E 03			0.372E 03

SAMPLE PROBLEM FOR EXREM

LISTING OF RADIONUCLIDES FOR DOSE RATES ABOVE A CONTAMINATED GROUND SURFACE

LOCATION NUMBER = 1
HEIGHT = 2.286 CM.
TIME AFTER DETONATION 1 = 0.0 HOURS.

NO.	BETA DOSE RATE NUCLIDE LABEL	BETA DOSE RATE NUCLIDE NAME	BETA DOSE RATE DOSE RATE REMS/HR	GAMMA DOSE RATE NUCLIDE LABEL	GAMMA DOSE RATE NUCLIDE NAME	GAMMA DOSE RATE DOSE RATE REMS/HR	TOTAL DOSE RATE NUCLIDE LABEL	TOTAL DOSE RATE NUCLIDE NAME	TOTAL DOSE RATE DOSE RATE REMS/HR
1	291	W187	0.652E 02	291	W187	0.115E 01	291	W187	0.664E 02
2	315	K42	0.488E 02	315	K42	0.353E 00	315	K42	0.492E 02
3	280	PU238	0.0	280	PU238	0.676E-01	280	PU238	0.676E-01
TOTAL			0.114E 03			0.157E 01			0.116E 03

SAMPLE PROBLEM FOR EXREM

LISTING OF RADIONUCLIDES FOR ACCUMULATED DOSES ABOVE A CONTAMINATED GROUND SURFACE

LOCATION NUMBER = 1
HEIGHT = 2.286 CM.
INTEGRATION PERIOD -- 0.0 TO 0.438000E 06 HOURS.

NO.	BETA DOSE NUCLIDE LABEL	BETA DOSE NUCLIDE NAME	BETA DOSE DOSE REMS	GAMMA DOSE NUCLIDE LABEL	GAMMA DOSE NUCLIDE NAME	GAMMA DOSE DOSE REMS	TOTAL DOSE NUCLIDE LABEL	TOTAL DOSE NUCLIDE NAME	TOTAL DOSE DOSE REMS
1	291	W187	0.211E 05	280	PU238	0.608E 06	280	PU238	0.608E 06
2	315	K42	0.805E 04	291	W187	0.373E 03	291	W187	0.215E 05
3	280	PU238	0.0	315	K42	0.582E 02	315	K42	0.811E 04
TOTAL			0.292E 05			0.606E 06			0.638E 06

SAMPLE PROBLEM FOR EXREM

LISTING OF RADIONUCLIDES FOR DOSE RATES ABOVE A CONTAMINATED GROUND SURFACE

LOCATION NUMBER = 1
HEIGHT = 100.000 CM.
TIME AFTER DETONATION 1 = 0.0 HOURS.

	BETA DOSE RATE			GAMMA DOSE RATE			TOTAL DOSE RATE		
NO.	NUCLIDE LABEL	NUCLIDE NAME	DOSE RATE REMS/HR	NUCLIDE LABEL	NUCLIDE NAME	DOSE RATE REMS/HR	NUCLIDE LABEL	NUCLIDE NAME	DOSE RATE REMS/HR
1	315	K42	0.151E 02	291	W187	0.656E 00	315	K42	0.153E 02
2	291	W187	0.136E 01	315	K42	0.204E 00	291	W187	0.202E 01
3	280	PU238	0.0	280	PU238	0.271E-01	280	PU238	0.271E-01
TOTAL			0.164E 02			0.886E 00			0.173E 02

SAMPLE PROBLEM FOR EXREM

LISTING OF RADIONUCLIDES FOR ACCUMULATED DOSES ABOVE A CONTAMINATED GROUND SURFACE

LOCATION NUMBER = 1
HEIGHT = 100.000 CM.
INTEGRATION PERIOD -- 0.0 TO 0.43800E 06 HOURS.

	BETA DOSE			GAMMA DOSE			TOTAL DOSE		
NO.	NUCLIDE LABEL	NUCLIDE NAME	DOSE REMS	NUCLIDE LABEL	NUCLIDE NAME	DOSE REMS	NUCLIDE LABEL	NUCLIDE NAME	DOSE REMS
1	315	K42	0.249E 04	280	PU238	0.244E 06	280	PU238	0.244E 06
2	291	W187	0.442E 03	291	W187	0.213E 03	315	K42	0.252E 04
3	280	PU238	0.0	315	K42	0.336E 02	291	W187	0.654E 03
TOTAL			0.293E 04			0.244E 06			0.247E 06