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THE RADIOLOGICAL SAFETY ANALYSIS COMPUTER PROGRAM (RSAC-5) USER'S MANUAL

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February 1994

Westinghouse Idaho Nuclear Company, Inc.

PREPARED FOR THE
DEPARTMENT OF ENERGY
IDAHO OPERATIONS OFFICE
UNDER CONTRACT DE-AC07-84ID12435

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ABSTRACT

The Radiological Safety Analysis Computer Program (RSAC-5) calculates the consequences of the release of radionuclides to the atmosphere. Using a personal computer, a user can generate a fission product inventory from either reactor operating history or nuclear criticalities. RSAC-5 models the effects of high-efficiency particulate air filters or other cleanup systems and calculates decay and ingrowth during transport through processes, facilities, and the environment. Doses are calculated through the inhalation, immersion, ground surface, and ingestion pathways. RSAC+, a menu-driven companion program to RSAC-5, assists users in creating and running RSAC-5 input files.

This user's manual contains the mathematical models and operating instructions for RSAC-5 and RSAC+. Instructions, screens, and examples are provided to guide the user through the functions provided by RSAC-5 and RSAC+. These programs are designed for users who are familiar with radiological dose assessment methods.

ACKNOWLEDGMENTS

While there is only a single author's name on the cover of this manual, projects of the magnitude of RSAC-5 are not developed by a single person.

The author is grateful to the employees of the Scientific Computing Unit of EG&G Idaho, Inc. for their assistance in developing RSAC. In particular, thanks to Scott Matthews for his assistance in converting the program to the personal computer and his guidance on quality assurance, Neldon Marshall for static and dynamic testing of the program, and Mike Lintner and John Tolli for their assistance in preparing data libraries.

A heartfelt thanks to the staff of Shonka Research Associates for their superb assistance in performing the independent verification and validation RSAC—-particularly Dr. Joseph Shonka for his invaluable technical assistance, Deborah Shonka for her administration of the contract, and Thom Sukalac for his assistance on the RSAC+ program.

There are too many individuals who participated in the beta testing of RSAC-5 to individually acknowledge them all; however, to each of you a special thank you.

Lastly, a special thank you to the technical editors of this document, Sally Francis and Nancy Skinner.

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1. INTRODUCTION

The Radiological Safety Analysis Computer Program (RSAC-5) calculates the consequences of the release of radionuclides to the atmosphere. Using a personal computer with a math co-processor, a user can generate a fission product inventory; decay and ingrow the inventory during transport through processes, facilities, and the environment; model the downwind dispersion of the activity; and calculate doses to downwind individuals.

A fission product inventory can be calculated from the reactor operating history or to simulate a nuclear criticality accident. Radionuclide inventories can also be directly input into RSAC-5 if desired. Source term modeling allows for complete progeny ingrowth and decay during all accident phases. RSAC-5 release scenario modeling allows fractionation of the inventory by chemical group or element. RSAC-5 also models the effects of high-efficiency particulate air (HEPA) filters or other cleanup systems. RSAC-5's meteorological capabilities include Gaussian plume diffusion for Pasquill-Gifford, Hilsmeier-Gifford, and Markee models. RSAC-5 possesses the unique ability to model Class F fumigation conditions. Optionally, users can supply plume standard deviations (σs) or atmospheric diffusion (χ/Qs) to the code as input data. RSAC-5 also includes corrections for plume rise and building wake. Doses are calculated through inhalation, immersion, ground surface, and ingestion pathways, and cloud gamma dose from semi-infinite plume model and finite plume model. A fifty-mile population dose, including Regulatory Guide 1.109 modeling, is also available.

RSAC+, a menu-driven companion program to RSAC-5, assists users in creating and running RSAC-5 input files. RSAC+ is written in a fourth generation database language and runs on any personal computer that supports the RSAC-5 code. With RSAC+, a user can modify input files easily. It also allows the user to insert, edit, add, copy, move, or delete sets of instructions in RSAC-5. RSAC+ stores each problem set in a separate file, distinguished by a unique file extension. RSAC+ checks all fields to ensure that data are in an appropriate range for the variable and that there is consistency in an input series.

1.1 RSAC History

RSAC was originally developed and written in assembly language (MAP) for the IBM 7044/44 in 1966 by R. L. Coates and N. R. Horton (Coates and Horton 1966). In 1968, a FORTRAN version of the program was prepared by L. C. Richardson (Richardson 1968). Since 1968, RSAC has undergone substantial revision.

In 1973, RSAC-2 was issued by D. R. Wenzel (Wenzel 1973) to

- Add input and output options
- Change the inhalation dose calculations (lung and gastro-intestinal tract)

- Change the numerical integration methods for cloud gamma dose calculations
- Change the gamma-ray buildup factor model
- Revise radionuclide yields and half-lives in the standard library
- Refine output format for ease of reading
- Reduce computer memory requirements.

In 1982, RSAC-3 was issued (Wenzel 1982) to

- Add a fifty-mile population dose calculations
- Use the U.S. Nuclear Regulatory Commission (NRC) Regulatory Guide 1.109 (NRC 1977a) for ingestion dose calculations
- Use the International Commission for Radiological Protection (ICRP) Lung Dynamics Model for inhalation dose calculations
- Use the Dolphin and Eve Gastro-intestinal Tract Model
- Improve error detection.

After undergoing an extensive verification and validation, RSAC-4 (Wenzel 1990) was enhanced and issued in 1990 to

- Convert the program FORTRAN 77
- Execute RSAC-4 on a personal computer
- Use internal dose conversion factors from DOE/EH-0071 (DOE 1988a) and external dose-rate conversion factors from DOE/EH-0070 (DOE 1988b)
- Add dose summary tables
- Add an ingestion dose model for an acute release
- Increase the number of organs in the dose calculations
- Include water immersion dose calculations

- Program calculated plume rise for either jet or buoyant plume
- Revise fission yields and half-lives
- Add radionuclides to the standard library
- Update the photon data library
- Enhance error diagnostics
- Include validation and verification necessary to meet the additional requirements for software imposed by ASME-NQA-1, "Quality Assurance Program Requirements for Nuclear Facilities" (ASME 1989).

The fifth and current version, RSAC-5, modifies 15 areas to

- Add an option to calculate cloud-gamma doses expressed in external dose equivalent
- Add a variable particle size option for inhalation dose calculations
- Resolve the over depletion for ground level releases during stable meteorology that was observed in earlier versions of RSAC
- Add a reflective meteorological model to better model diffusion below the mixing depth
- Include additional radionuclides to more accurately model the U-235 fission chain
- Add a dose summing option
- Incorporate a simplified notation for radionuclide identification
- Include a capability to read radionuclide inventories from external files
- Correct errors observed in earlier versions of RSAC for the finite-plume model integration for cloud-gamma dose calculations and large plumes
- Add meteorological diffusion using Pasquill-Gifford parameters
- Include an option to simulate the release of fission products from an operating reactor
- Update forage and vegetation yields

- Include an option to read ingestion transfer parameters from an external file
- Refine the model for ingestion dose calculations from an acute release
- Add a companion program, RSAC+, that assists the user in preparing an input file for RSAC-5.

1.2 Summary of RSAC-5 Capabilities

RSAC-5 consists of nine program series. Each program series performs a type of calculation and operates together or independently of the others, depending on the analysis being performed. These series are identified by input series lines of multiples of 1000. A summary of each of the program series follows.

1000 Series—Fission Product Inventory Calculation

RSAC-5 allows the user to establish an inventory of fission products (and subsequent decay products) by simulating the operation of a thermal reactor. The user can simulate steady-state, transient, or cyclic reactor operation. A refueling option is also available. After establishing the reactor operating history, the user can then specify the fractional release of the radionuclide inventory by individual element; by groups of elements (solids, halogens, noble gases, cesium, or ruthenium); or by a single release fraction for the entire inventory.

RSAC-5 calculates inventories for fission products only. The RSAC-5 nuclear data library (see Appendix B) contains selected activation products, actinides, and the daughters of actinides in addition to the fission products. Inventories for activation products and actinides are not calculated by RSAC-5; however, they can be added to the inventory by using the radionuclide direct input section of the program. Subsequent sections of the program calculate the radioactive decay and doses from these additional radionuclides.

The model used by RSAC-5 to calculate fission product inventories is simple compared to the model used in the ORIGEN2 program (Croff 1980, RSIC 1991). RSAC-5 is simple to run and requires less computer time than ORIGEN2. In general, the RSAC-5 model calculates fission product inventories well. However, it does not calculate inventories for activation products or actinides. While the RSAC-5 model corrects for depletions of fission products by neutron activation, it does not calculate all of the subsequent radionuclides that are produced by the neutron activation of fission products. When irradiation times are long, the burnup is relatively high, or the enrichment of the fuel is low, inventories of radionuclides produced primarily by the activation of fission products (Cs-134, Pm-147, Sm-151, Eu-154 and Eu-155) can differ from ORIGEN2-calculated inventories by more than 20%. When doses from these radionuclides are significant compared to the other fission products, users should use a more sophisticated computer program such as ORIGEN2 and import the final inventory using the 2000 Series input to RSAC-5. RSAC-5 can then be used to decay the inventories and simulate additional reactor operation or fuel handling accidents such as a criticality.

The 1000 Series of RSAC-5 can be reentered as many times as desired to modify the radionuclide inventory. One of the options in this series is to fractionate the radionuclide inventory and to simulate removal of activity by cleanup systems such as HEPA filters. The inventory can be fractionated by chemical group, element, or entire inventory.

The capability of RSAC-5 to model the fission product inventory as a function of time during a hypothetical criticality accident is shown in Figure 1-1. The fission product inventories for solids, halogens, and noble gases are shown individually as a function of time. The RSAC-5 input for analyzing this accident is presented in Example 8 in Section 5. Initially, the radionuclide inventory in the aged reactor fuel involved in the criticality accident is constant. The criticality occurs during a short duration, during which large quantities of short-lived fission products are produced. The solid fission products are fractionated by a factor of 0.001 and the halogens are fractionated by a factor of 0.25 to give the activity released to a process off-gas system. All of the noble gases are assumed to be released. While the solids initially begin to decay, the ingrowth from the short-lived noble gases increases the activity of the solids by approximately a decade. The solids then decrease by three decades when passing through the first HEPA filter. The solids activity then increases by approximately two decades during the transport time to the final two HEPAs. The final two HEPAs decrease the activity of the solids by approximately five decades, after which decay of the short-lived noble gases again builds up the activity of the solids. After about 20 minutes during downwind transport, the solids activity reaches a maximum and slowly begins to decrease. RSAC-5 is the only program that models all aspects of a release to the atmosphere from source term generation to downwind dose.

2000 Series—Direct Radionuclide Input

This series allows users to input a radionuclide inventory from an external file or to directly input the amounts of radionuclides to be used in subsequent calculations.

3000 Series—Dose Summary Option

This series allows doses from different exposure pathways and multiple RSAC-5 calculations within the same input run to be summarized, added, and reported in summary tables. This option has strict operating guidelines [see Section 4.1, *Dose Summary Option Control Line (3000)*].

4000 Series—Radionuclide Data Constants Change

This series allows users to change standard data constants for radionuclides such as half-life, branching ratio, and fission yield. Changes are temporary for the current RSAC-5 run and do not make permanent changes to the RSAC-5 libraries. However, users cannot change photon energies for radionuclides or dose conversion factors.

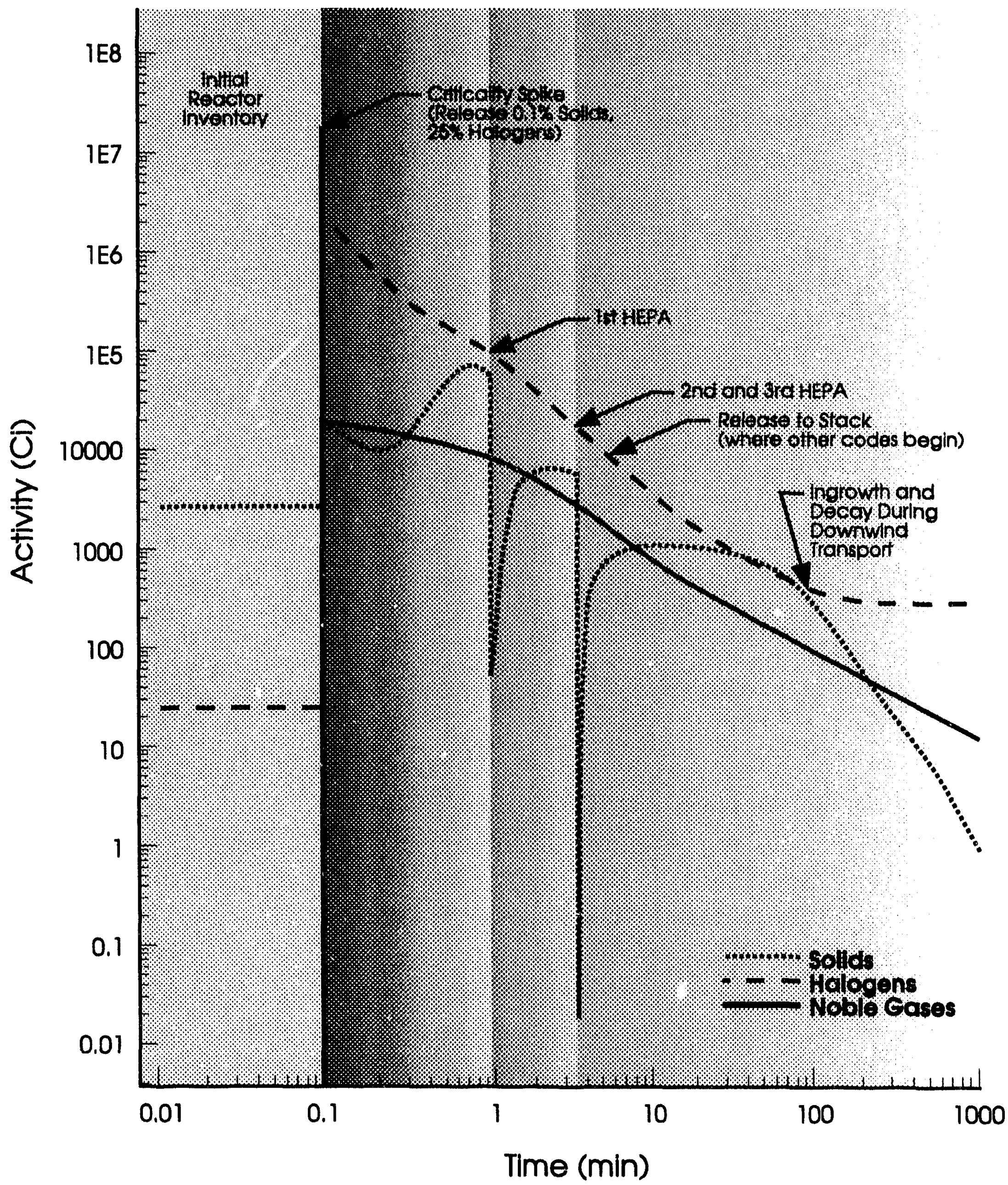

Figure 1-1. Changing inventory during criticality accident.

5000 Series—Meteorological Data Input

This series allows the user to specify meteorological conditions at the time of release and to calculate diffusion, dispersion, and depletion factors.

This input series of RSAC-5 must normally be entered before any dose calculations are requested. (The 8000 Series, Fifty-Mile Radius Dose, is an exception to this rule.) After establishing basic meteorological parameters (such as stack height, wind velocity, and mixing layer depth), the user specifies points of interest for dose calculations at downwind and/or crosswind positions.

RSAC-5 models the release of radioactivity from containment structures using exponential functions. Instantaneous and continuous releases are modeled using a single exponential function. Complex release scenarios can be modeled using a series of up to 10 exponential functions. These functions decay the radionuclide inventory while it is held up by the containment structure before it is released.

Atmospheric diffusion parameters can be input directly by the user or calculated by RSAC-5. RSAC-5 calculates plume standard deviations (σs) developed for three different conditions (see Appendix C). Hilsmeier-Gifford σs (Clawson et al. 1989) were developed for desert terrains and releases from a few to 15 minutes. Markee σs (Clawson et al. 1989) were also been developed for a desert terrain; however, they were developed for releases from 15 to 60 minutes in duration. Pasquill-Gifford σs are presented in the NRC Regulatory Guide 1.145 (NRC 1982) and by Slade (1968) from the Prairie Grass experiments for effluent releases with durations of 10 to 60 minutes.

Other meteorological options available in RSAC-5 are corrections for plume rise using models by Briggs (1969), building wake corrections (Yanskey et al. 1966), and plume depletion using modeling of Markee (1967) and Chamberlain (1953).

6000 Series—Radionuclide Inventory Decay and Printout

This series allows the user to calculate the radioactive decay of the entire radionuclide inventory or selected radionuclides. If downwind distances have been previously specified in the meteorological section of the program (5000 Series), decay times are calculated for each downwind position. Alternately, the user can directly specify decay times in this series. Radionuclide inventory printout options are then available. Inventories for activation products and actinides are printed only when 2000 Series input has been used to enter these radionuclides.

7000 Series—Internal/External Dose Calculation

This series allows the user to perform a variety of dose calculations. The radionuclide source term for these calculations is the radionuclide inventory created and operated on in the 1000 and 2000 Series. An internal dose can be calculated for up to 15 organs in addition to the committed effective dose equivalent (CEDE) for the inhalation or ingestion pathways. Internal doses are calculated using dose conversion factors from DOE/EH-0071 (DOE 1988a). Ingestion doses from a chronic release are calculated using models described in Regulatory Guide 1.109 (NRC 1977a). Because of the lack of a consensus model, equations for calculating ingestion doses from an acute release have been developed specifically for RSAC-5. Standard ingestion constants are provided in the program; however, the user can alter any of the constants. External dose can be calculated for up to 23 organs in addition to the external effective dose equivalent (EDE) for the ground surface, air immersion, and water immersion pathways. The air immersion model should be used with caution to ensure that the plume has diffused to the ground level and that the plume size is large compared to the mean free path of the gamma rays. Otherwise, using the air immersion model can result in significant error in the dose calculation. External doses are calculated using dose-rate conversion factors from DOE/EH-0070 (DOE 1988b).

8000 Series—Fifty-Mile Radius Dose Calculation

This series permits the user to calculate committed population doses within a fifty-mile radius of a nuclear facility. The same internal and external dose models available in the 7000 Series are available in the 8000 Series. The user must supply population and diffusion/dispersion coefficients for five, 10-mile radii in each of the 16 compass sectors as input.

9000 Series—Cloud Gamma Dose Calculation

RSAC-5 calculates cloud gamma doses (in addition to the air immersion model provided in the 7000 Series input) using either a finite plume model or a semi-infinite cloud gamma model. The finite plume model is accurate for any plume size, location, or release point. However, compared to the air immersion or semi-infinite models, it requires longer computer time to perform calculations. When the plume has diffused to ground level and is large compared to the mean free path of the gamma rays, both the semi-infinite and the air immersion models give accurate results. However, as noted in the 7000 Series discussion in this section, significant errors can result when the proper conditions for these simplified models do not exist. Appendix A, Section A-3.4, "Air Immersion Dose," contains discussion on the magnitude of errors that can result when either the air immersion or semi-infinite models are inappropriately used. Whenever in doubt, the user should use the finite plume cloud gamma model. By comparing the results of the finite plume model with the semi-infinite plume model, users can establish when the simplified models can be used.

RSAC+EP

A companion program, RSAC+EP (for Emergency Preparedness), has been written for emergency planning and response. It is written in C, for transportability from DOS to UNIX. A compilation of RSAC-5 input runs is listed for the user, permitting a choice of previously analyzed accident scenarios. Typically, these scenarios are RSAC-5 cases used in final safety analysis report calculations as the design basis of the facility. Using a graphical interface, RSAC-5 inputs can be easily modified by changing any of three key parameters: using actual meteorology rather than design basis, scaling the magnitude of release, and taking credit for nonsafety class cleanup systems known to be unimpaired at the time of the accident. These three modifications remove the excess conservatism in safety analyses and provide dose projections that more accurately model the incident. The RSAC-5 output file is read and used to fit isopleth curves over an electronic map of the site. The combination of RSAC-5, RSAC+, and RSAC+EP programs offers emergency planners new and more powerful tools to assess the consequences of an accident.

2. INSTALLING RSAC-5

This section describes the installation procedures for loading RSAC-5 onto a personal computer. The minimum hardware and software requirements are listed, along with a recommended configuration that will allow RSAC-5 to run faster.

The section also presents the point-of-contact for questions about the program and a summary of quality assurance activities conducted to ensure the integrity of RSAC.

2.1 Hardware and Software Requirements

RSAC-5 runs on an IBM personal computer or compatible, with the following minimum requirements:

- Math co-processor
- A personal computer with an 80386 processor
- 2.6 MB hard disk space
- 450K of available memory
- One RSAC-5 installation diskette [DS/HD (1.44 MB)].

The following hardware configuration will improve the efficiency and speed of RSAC-5:

- A personal computer with an 80486 processor
- Extended memory.

NOTE: Do not run RSAC-5 or RSAC+ in the Windows environment. In some PC configurations using Windows, problems have been encountered.

2.2 Loading Instructions

Place the RSAC-5 diskette in a floppy drive, change the DOS prompt to that drive, and type

INSTALL, and press **<Enter>**.

After pressing **<Enter>**, a screen will appear that identifies the installation disk drive and the path where RSAC-5 will be installed (see Figure 2-1). The install program will default to the installation drive. To change the drive default, type the letter of the disk drive directly over the default or use the left <←> or right <→> arrow keys to select the drive. Use the down <↓> arrow key or press **<Enter>** to move from the drive field to the path field. The default path for the hard disk is C:\RSAC5. You can enter your own path name by directly typing over the default. The program checks to ensure the path you entered exists. If the path provided does not exist, Figure 2-2 will appear.

```
Disk Drive that contains Installation Disk

A

Path RSAC-5 is to be installed in:

C:\RSAC5
```

Figure 2-1. Initial installation screen.

```
                    The path selected:
                         C:\RSAC5
                  does not currently exist.

       Should the install program create this path? Yes
```

Figure 2-2. Prompt to create new path.

At the "Should the install program create this path" prompt, if you use the arrow key <→> to select **No** and press **<Enter>** or enter **N**, the install program will return to Figure 2-1 to allow you to reenter the path name. Yes is the default, which establishes and creates the path. Press **<Enter>** to continue.

After you press **<Enter>** to continue, Figure 2-3 appears. On this screen, you must indicate whether you will be using conventional or extended memory. If you are not sure, select option **1** - conventional memory, and press **<Enter>**. Refer to your DOS manual for instructions to modify the CONFIG.SYS file to run extended memory programs. **CAUTION:** If you make an error while modifying the CONFIG.SYS file, you may have to use the original DOS backup diskettes to reboot your system.

```
RSAC-5 can be run in conventional memory or in extended
memory. The extended memory version runs up to twice
as fast as the conventional memory version. The extended
memory version is recommended when your system supports
it. If in doubt, use option 1.

You have an option to:

    1) Use conventional memory to run RSAC-5

    2) Use extended memory to run RSAC-5

Which option do you wish? 1
```

Figure 2-3. Select memory option.

After pressing **<Enter>**, the RSAC-5 files are extracted and copied onto your machine in the directory you specified in the previous step. Next, the final installation screen appears (see Figure 2-4). This screen allows you the option to copy nine RSAC-5 examples onto your system.

These examples are useful in learning how to run RSAC-5 (see Section 5). The examples must initially be run using the RSAC+ program. When ASCII files are created using RSAC+, the examples can be run directly from RSAC-5. The examples can be deleted using RSAC+.

```
RSAC-5 is provided with 9 examples that can be run using
the computer assisted input program, RSAC+.  You have an
option to copy these examples to the RSAC-5 directory if
you wish.

    1) Copy the examples to the RSAC-5 directory

    2) Do not copy the examples to the RSAC-5 directory

Which option do you wish? █
```

Figure 2-4. Copy examples onto your system.

When installation is completed, the RSAC-5 path name appears at the bottom of the screen. All of the files necessary to run RSAC-5 and RSAC+ are now loaded onto your hard disk.

2.3 Point-of-Contact

For information on how to obtain a copy of RSAC-5 or to resolve problems encountered running RSAC-5, contact

D. R. Wenzel
Westinghouse Idaho Nuclear Company, Inc.
P.O. Box 4000
Idaho Falls, ID 83415-5209
(208) 526-3463

2.4 Quality Assurance

2.4.1 Configuration Control

Configuration control is maintained by issuing copies of RSAC-5 with a unique serial number. Only binary copies of RSAC-5 and its libraries are issued to users to prevent user changes to the program that would invalidate the extensive validation and verification. Each page of RSAC-5 output contains the program version number, the program serial number, and the date and time the run was made.

2.4.2 Verification and Validation

RSAC-5 has been subjected to extensive independent verification and validation for use in performing safety-related dose calculations to support safety analysis reports. Shonka Research Associates, Inc. (SRA 1993) conducted this verificatic- and validation in accordance with the guidelines presented in ANSI/ANS-10.4, "American National Standard Guidelines for the Verification and Validation of Scientific and Engineering Programs for the Nuclear Industry" (ANSI/ANS 1987).

3. EXECUTING RSAC-5

RSAC-5 can be run directly using a user-supplied ASCII input file or RSAC+ can be used to build input files.

3.1 Using RSAC+

RSAC+ is a companion program to RSAC-5; RSAC+ assists you in creating and running RSAC-5 input files. RSAC+ will only edit files that have been created using RSAC+. Files created by RSAC+ have .DTT extensions. RSAC-5 can be run directly from RSAC+ without creating an ASCII RSAC-5 input file. However, to execute RSAC-5 from the DOS prompt using a file created by RSAC+, you must use the "Generate ASCII RSAC-5 input file option" under the Utilities portion of the *Operations menu* (see Section 3.2.3.1).

3.1.1 Special Function Keys

RSAC-5 provides functions keys that allow you to move easily throughout the program. Valid function keys are defined at the bottom of each screen. On many screens, the <Esc> key can be used to back out of a step or return to a previous menu.

3.1.2 Starting RSAC+

To invoke RSAC+, type **RP** from the directory containing the RSAC program (e.g., C:\RSAC5). When RSAC+ is initially started, an information screen will appear briefly. Next, you will be prompted to enter a filename (see Figure 3-1). The filename can consist of up to eight alphanumeric characters. No special characters or blanks are allowed in the filename. You can enter a new filename or select an existing file. RSAC-5 provides function keys to list existing files or change the current directory.

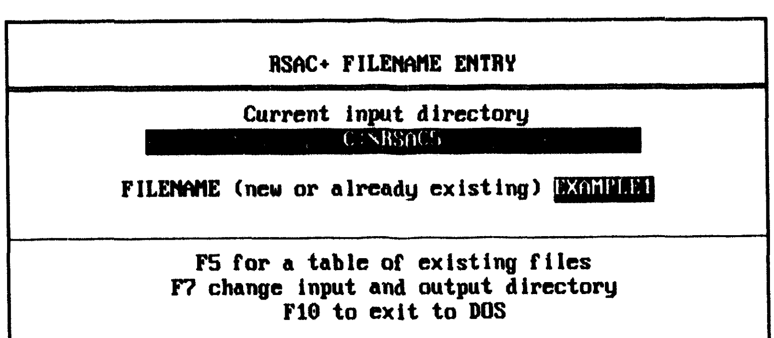

Figure 3-1. Filename prompt.

To change the directory for the output and input files, press **<F7>**. The default configuration menu will appear (see Figure 3-2). Type the desired directory name where the output and input files will be stored and press **<Enter>**. To display a list of files currently available, press **<F5>**. A screen similar to the one shown in Figure 3-3 appears. The first 50 characters in each file title are displayed. From this screen you can select a file to edit, delete a file from the database, or update the list to match DOS by using the following options:

```
                 Default configuration menu

          Directory where RSAC-5 output files are
                      to be routed.
          C:\RSAC5

          Directory where RSAC-5 input files and *.DTT
                      are to be routed.
          C:\RSAC5\
```

Figure 3-2. Default configuration menu.

```
                 List of all files currently in RSAC+

   Filename       Title
   EXAMPLE1       Simulated reactor operation
   EXAMPLE2       Calculation of inhalation dose
   EXAMPLE3       Ingestion dose calculation from an acute release
   EXAMPLE4       Ground surface dose calculation
   EXAMPLE5       Air immersion dose calculation
   EXAMPLE6       Fifty-mile radius dose calculation for a chronic r
   EXAMPLE7       Comparison of cloud gamma dose models
   EXAMPLE8       Hypothetical criticality accident
   EXAMPLE9       Dose calculations with changing meteorological con

        Strike the ESC key to return without selecting a file
 DEL to remove selected file from RSAC+     F6 to update list to match DOS
```

Figure 3-3. Current list of available files.

<Esc> - The <Esc> key terminates this option without selecting a file and returns you to Figure 3-1.

<Enter> - The <Enter> key allows you to select a file to edit. Press the <↑> and <↓> keys to highlight the filename to edit, and press **<Enter>** to select.

If you select a file that has already been written to, a warning message will be displayed (see Figure 3-4). From this screen, you can edit the file selected, copy the file selected, copy the selected file and edit the new file, or select a different file by using the following options:

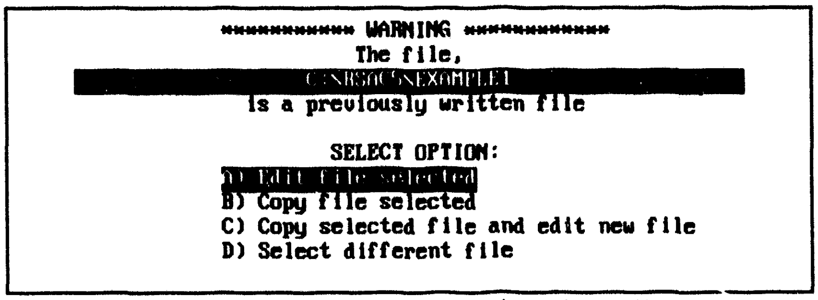

Figure 3-4. Editing options for previously written file.

Edit file selected. Use this option to alter the contents of the original file. When you invoke this option, the filename and title entry screen, shown in Figure 3-5, appears showing the file to be edited. At this point, you can edit the title. Press **<Enter>**. At this point, you can press **<Enter>** again to continue editing the original file or press the <↑> key to change the title.

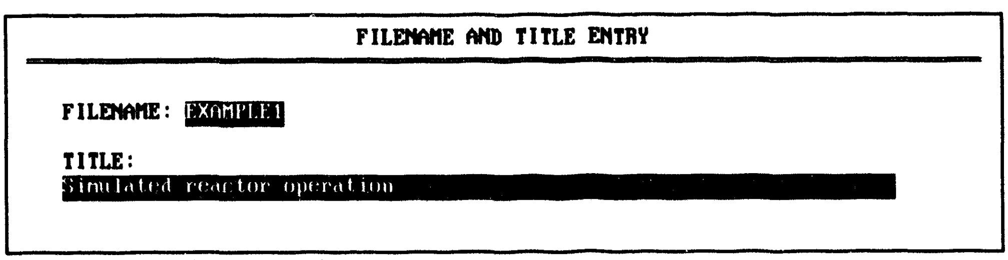

Figure 3-5. Filename and title entry screen.

Copy file selected. Use this option to edit the original file, with the new file serving as a backup containing the original data. When you select this option you will be prompted to enter a new filename (see Figure 3-6). At the prompt, enter a new filename containing up to eight alphanumeric characters. Press **<Enter>**. The contents of the original file will be copied to the new file. The filename and title entry screen, shown in Figure 3-5, will appear with the original filename and title displayed. At this point, press **<Enter>** again to edit the original file or press <↑> to change the title. The *Operations menu* shown in Figure 3-7 will appear. The *Operations menu* is described in detail in Section 3.2.

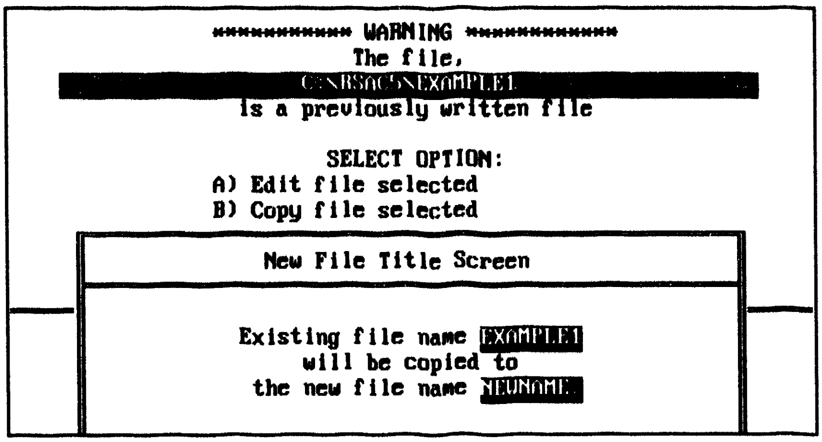

Figure 3-6. Enter new filename.

Copy selected file and edit new file. Use this option to edit a copy of the original file and keep the original file intact. When you select this option you will be prompted to enter a new filename (see Figure 3-6). At the prompt, enter a new filename containing up to eight alphanumeric characters. Press **<Enter>**. The contents of the original file will be copied to the new file. The filename and title entry screen, shown in Figure 3-5, will appear with the new filename and title displayed. At this point, press **<Enter>** again to edit the new file or press <↑> to change the title. The *Operations menu* shown in Figure 3-7 will appear. The *Operations menu* is described in detail in Section 3.2.

Select different file. Use this option to select a new file to edit. When you invoke this option, Figure 3-1 will be displayed. See page 3-1 for operating instructions.

<Del> - The <Del> key (see Figure 3-3) allows you to delete a file from the list. To delete a file, use the <↑> and <↓> keys to highlight the file to be deleted and press **<Del>**. A confirmation screen appears. To delete the file press **C**. You will return to Figure 3-3, and the file name will no longer appear. Press any other key to terminate this option without deleting a file.

<F6> - The <F6> key (see Figure 3-3) allows you to update the RSAC+ file list to reflect the files present in the DOS directory. Use this option when you have added or deleted files (with a *.DTT extension) from the DOS prompt. Even though the deleted files do not show in the DOS directory, their names still reside in the RSAC+ file list. Similarly, files added from the DOS prompt will not be present in the RSAC+ file list.

3.2 Operations Menu

The *Operations menu* is shown in Figure 3-7. This screen lists all the primary options you can perform using RSAC+. The *Operations menu* is divided into three areas: file functions, edit functions, and utilities. Use the arrow keys to highlight the desired option, and press **<Enter>**.

```
                              RSAC+
                  RSAC-5 Program Assisted Input
-------------------------------------------------------------------
                            Operations
-------------------------------------------------------------------
                         File functions:
                    Change FILENAME in memory
                   Change title of Input File
                  Advanced file function sub-menu

                         Edit functions:
          Create or Append a series          Move a series
           Edit a selected series            Copy a series
              Insert a series              Delete a series
                           Utilities:
                  Generate ASCII RSAC-5 input file
                       Browse file in memory
                    Browse or Print any ASCII file
              Run RSAC-5 with file currently in memory
                     Advanced utility functions
-------------------------------------------------------------------
 FILENAME: C:\RSAC5\EXAMPLE1                           F10 TO EXIT
    TITLE: Simulated reactor operation
```

Figure 3-7. Operations menu.

3.2.1 File Functions

3.2.1.1 Change FILENAME in Memory. When you invoke this option, Figure 3-1 appears. This option allows you to create a new file or change the name of the currently-selected file. The filename can consist of up to eight alphanumeric characters. Remember, no special characters or blanks are allowed.

If you create a new file, Figure 3-5 appears. Enter the title and press **<Enter>**. If you enter an existing filename, you return to Figure 3-4 to select an editing option.

3.2.1.2 Change Title of Input File. When you invoke this option, Figure 3-5 appears with the currently-selected filename and title displayed. Type in the new title and press **<Enter>**. At this point, press **<Enter>** again to edit the currently-selected file or press <↑> to change the title.

3.2.1.3 Advanced File Function Submenu. When you invoke this option, Figure 3-8 appears. As shown, the following three options are available:

```
RSAC+
Advanced File Handling Functions

Current input and *.DTT storage subdirectory
C:\RSAC5

Change default directories

Merge two files into a third file

Update the INPUT.DAT file in the current default directory

Return to Operations Menu
```

Figure 3-8. Advanced file handling functions.

Change default directories—When you invoke this option, Figure 3-2 appears. Type the name of the directory where you want the output and input files to be stored and press **<Enter>**. If the chosen directory does not exist, a prompt appears. At this prompt, press **<Enter>** (Yes) if you want to create the specified directory. To change the directory, enter **N** or use the arrow key <→> to highlight **No** and press **<Enter>** to return to Figure 3-2.

If the directory specified for the input files is different than the default directory, a prompt appears. At the prompt, press **<Enter>** (Yes) if the directory should be changed and the file closed. To terminate this option, enter **N** or use the arrow key <→> to highlight **No** and press **<Enter>**. You will return to Figure 3-2.

Merge two files into a third file—This option allows you to merge two source files into a destination file. When you invoke this option, Figure 3-9 appears. On this screen, supply the location (directory) and name of the two source files and the location, name, and title of the destination file. Press **<Enter>**. Review the screen content to verify your entries. Press **<Enter>** if your input is correct. If not, use the arrow key <↑> or press **<Esc>** to modify your input.

After pressing **<Enter>**, the two files are merged into the destination file and you return to Figure 3-8.

Update the INPUT.DAT file in the current default directory—This file maintenance option updates the INPUT.DAT file for the current directory to update the RSAC+ file list to reflect the files actually in the DOS directory. Use this option when you have added or deleted files (with a *.DTT extension) from the DOS prompt. Even though the deleted files do not show in the DOS directory, their names still reside in the RSAC+ file list. Similarly, files added from the DOS prompt will not be present in the RSAC+ file list. When the update is complete, you return to Figure 3-8.

```
                         File Merger

                    Source File Number 1
     Directory location: C:\RSAC5
               Filename:

                    Source File Number 2
     Directory location: C:\RSAC5
               Filename:

                 Destination File Number 3
     Directory location: C:\RSAC5
               Filename:
                 Enter new title for destination file:
```

Figure 3-9. File merger screen.

3.2.2 Edit Functions

Use the edit functions to create the input used by RSAC-5.

Depending upon the series selected, a number of data entry screens will appear. These screens contain fields that prompt you to enter additional information (e.g., data points) or select an item from a list. There are four types of data entry or selection screens: automatic lookup, data entry, lookup/entry tables, and external filename screens.

Automatic Lookup—This type of screen is a pop-up window that lists all valid entries for the field. Use the <**Tab**> or <↑> and <↓> keys to highlight the desired selection and press <**Enter**>. The selection is recorded automatically.

Data Entry Screen—In the data entry screen, two types of fields can be entered: real numbers and integers.

Real Numbers—In this type of field, enter a real number using decimals or scientific notation. If you make an error, press <**F7**> to clear the field and reenter the value.

Integers—In this type of field, enter an integer. The program will verify your entry and will not accept a noninteger. Again, if you make an error, press <**F7**> to clear the field and reenter the value.

Lookup/Entry Tables—Throughout RSAC+, tables are presented from which to select information. These tables contain lists of organs, elements, and radionuclides specific to the series. Use the <Tab> or arrow keys to position the cursor on the desired selection and follow the directions presented at the bottom of the screen. Many of these tables allow for multiple selections.

Radionuclide tables include an additional feature. By typing the mass number of the radionuclide desired, the first radionuclide with that mass number will be highlighted.

External Filename—In three locations in the program, you will be prompted to enter a filename containing either radionuclide inventories for the 2000 Series, ingestion transfer parameters for the 7000 Series, or meteorological and population data for a fifty-mile radius dose calculation in the 8000 Series.

The bottom of many data entry screens contains a list of available function keys for that screen. The following function keys perform standard functions on the data entry screens.

<F1> - Not used.

<F2> - Brings up the comment screen that allows you to input a comment about the line where you are currently positioned. This comment will be written and displayed in the generated input file.

<F3> - Displays the *Browse and Print File Selector menu.* On this menu, enter the location and name of the file you want to view and press **<Enter>**. The file contents will be displayed on the screen.

<F4> - Not used.

<F5> - Resets the current field value to the original program default value.

<F6> - Not used.

<F7> - Clears the contents of the current field.

<F8> - Not used.

<F9> - Terminates the current series and returns you to the series selection menu (Figure 3-10).

<F10> - Allows you to exit from RSAC+ when the *Operations Menu* is displayed.

<Esc> - Exists the current screen and returns you to the previous screen. This function is not available on all screens.

In addition, some screens offer a unique set of function keys. These keys are self-explanatory and are displayed at the bottom of the screen, along with the common function keys.

After completing a data entry screen, press **<Enter>** to continue. The message "Strike 'ENTER' to continue, '↑' to backup and change above" appears at the bottom of the screen. At this point, verify the contents of the screen. If the data are correct, press **<Enter>** to continue. If corrections need to be made, press <↑> to return to the necessary field and make changes. When the data are correct, press **<Enter>**.

3.2.2.1 Create or Append a Series. This option allows you to create a new series or append a series to the currently existing file. When you invoke this option, Figure 3-10 will appear. On this screen, select the type of calculational series to be appended or inserted in the input file. These series are identified in Section 1.2, "Summary of RSAC-5 Capabilities."

```
                              RSAC+
                   RSAC-5 Program Assisted Input
-------------------------------------------------------------------
                      Series selection menu
-------------------------------------------------------------------
    Series Number            Series Title
         1000        Fission Product Inventory Calculation
         2000        Direct Radionuclide Input
         3000        Dose Summary Option
         5000        Meteorological Data Input
         6000        Radionuclide Inventory Decay and Printout
         7000        Internal / External Dose Calculation
         8000        Fifty-Mile Radius Dose Calculation
         9000        Cloud Gamma Dose Calculation
        10000        Change Title and Continue Problem

                     Return to Operations Menu
-------------------------------------------------------------------
FILENAME :C:\RSAC5\EXAMPLE1
   TITLE :Simulated reactor operation
```

Figure 3-10. Series selection menu.

Use the **<Tab>** or <↑> and <↓> keys to highlight the desired series and press **<Enter>**. As mentioned earlier, data entry or prompt screens will appear. The RSAC-5 line number (see Section 4.1, "RSAC-5 Input"), which correlates with the screen, is often displayed in the upper right-hand corner of the screen. The screen sequence and description of the input required for each of the series shown in Figure 3-10 is presented in the following paragraphs.

1000 Series—Fission Product Inventory Calculation

Screen 1—Comment Screen. Enter a brief comment about the 1000 Series that is being appended and press **<Enter>**. This comment is used to distinguish between series and can make future editing sessions easier. This command will also appear in the generated RSAC-5 input file.

Screen 2—Initial Reactor Data. Indicate whether you want the calculation to start with no previous radionuclide inventory **(0)** or if the previous radionuclide inventory should be retained **(1)**. Use the **<Tab>** or **<↑>** and **<↓>** keys to highlight **0** or **1** and press **<Enter>**.

If you select **0**, the *Reactor Power Prompt (W)* will appear. Enter the reactor power and press **<Enter>**. You are then asked to supply the time in the current operating cycle and time units. In the operating cycle field, enter the time and press **<Enter>**. Next, use the **<Tab>** or **<↑>** and **<↓>** keys to highlight the desired time unit and press **<Enter>**.

After you supply the reactor power, operating cycle, and time unit, the program calculates the reactor operating time (in seconds) and writes it in the corresponding field. After you press **<Enter>**, the *Release During Fission Product Calculations* screen will appear.

If you select **1**, the *Operating History* screen will appear.

Screen 3—Release During Fission Product Calculations. On this screen, you are asked if you want to enter information that simulates fission product releases from the reactor while in operation. Use the **<↓>** or **<Tab>** key to highlight **YES** or **NO** and press **<Enter>**.

If you respond **YES**, the *Release During Fission Product* screen will appear. On this screen, enter the inventory to be retained for subsequent calculations. Specifically, supply the following:

- Number of reactor incremental release steps
- Radionuclide leak rate from the reactor for each of the following: solids, halogens, noble gases, cesium, and ruthenium.

If you respond **NO**, the *Operating History* screen will appear.

Screen 4—Operating History. Three screens are provided to establish the operating history data:

Refueling Information—On this screen, enter the percent of radionuclide inventory remaining after refueling.

Cycle Information—On this screen, enter the reactor shutdown time and units before the cycle and the reactor power (W). Based on these inputs, the program will calculate the reactor operating time (in seconds) at the specific reactor power for this cycle.

Fractionate Inventory—On this screen, enter the type of fractionation group, constant, or element, and corresponding constant or element. Depending on the type of fractionation chosen, subsequent screens will appear to enter release fractions.

To exit this screen, highlight "End Fission Product Calculation" and press **<Enter>**. You will return to the *Series selection menu.*

Screen 5—Series Selection Menu. When finished appending the series to the file and working through the subsequent data entry screens, you will be returned to the *Series selection menu,* where you can invoke another option.

2000 Series—Direct Radionuclide Input

Screen 1—Comment screen. Enter a brief comment about the 2000 Series that is being appended and press **<Enter>**. This comment is used to distinguish between series and can make future editing sessions easier. This command will also appear in the generated RSAC-5 input file.

Screen 2—Radionuclide input options. Use the **<Tab>** or <↑> and <↓> keys to highlight one of the following and press **<Enter>**.

0 - Tells RSAC-5 that you will be entering the radionuclide inventory and to delete any previous radionuclide inventory.

1 - Tells RSAC-5 to retain the previous radionuclide inventory and to change the inventory for the radionuclides selected on the subsequent screens to the new values entered.

-1 - Tells RSAC-5 to retain the previous radionuclide inventory and to add the inventory for the radionuclides selected on the subsequent screens to the previous values.

Screen 3—Direct Radionuclide Input (Part A). This screen provides the option of continuing a calculation even though input of a radionuclide not listed in the RSAC-5 library is requested. This option is useful when using an external data file generated by another computer program (e.g., ORIGEN). However, use caution when invoking this option to ensure that the ignored radionuclides are really not in the RSAC-5 library and not the result of an input error in radionuclide identification. Use the **<Tab>** or <↑> and <↓> keys to highlight **Yes** or **No** and press **<Enter>**.

Screen 4—Direct Radionuclide Input (Part B). On this screen, indicate whether you are using an external file (that contains the radionuclides and their curie content) or if you are going to select each radionuclide and curies content on the next screen. Use the **<Tab>** or <↑> and <↓> keys to highlight your choice and press **<Enter>**

Screen 5—Radionuclide Lookup-Curie Input. (This screen appears when you select the "Radionuclides will be selected on upcoming screen" option on Screen 4.) On this screen, select the radionuclide and the activity desired. Use the <↑> and <↓> keys to highlight the desired radionuclide. Speed up the search by entering the mass number of the radionuclide. The first radionuclide with that mass number will be highlighted. When the desired radionuclide is highlighted, press **<Enter>**. A pop-up screen will appear for entering the activity for the radionuclide. Each time you select a radionuclide and provide an activity, it is written to a summary file. Press **<F8>** to review the list in the summary file at any time during the selection process. When an erroneous inventory is inadvertently entered, use the **<F7>** key to clear the field and then press **<Enter>**. When complete, press the **<Ctrl>** **<Enter>** keys simultaneously to exit and return to Figure 3-10, *Series selection menu.*

Screen 6—External File for Radionuclide Entry. (This screen appears when you selected the "An external file will be specified" option on Screen 4.) Enter the name of the file that contains the list of radionuclides and curie content. If you enter a filename that does not exist, RSAC+ will display a message telling you this file must be created before you run the calculation.

Screen 7—Series Selection Menu - When finished with the data entry screen, you will be returned to the *Series selection menu*, where you can invoke another option.

3000 Series—Dose Summary Option

Before any dose summaries can be requested using the 3000 Series, the dose summary option must be initiated (option 1). Initiation of the dose summary option cannot be done until meteorological data (5000 Series) has been entered. In addition, downwind distances cannot be changed using subsequent 5000 Series input after the dose summary option has been initiated.

4000 Series—Radionuclide Data Constants Change

The 4000 Series is not included in RSAC+. This function is an advanced users function and must be done by editing the ASCII file using a text editor.

5000 Series—Meteorological Data Input

Screen 1—Comment screen. Enter a brief comment about the 5000 Series that is being appended and press **<Enter>**. This comment is used to distinguish between series and can make future editing sessions easier. This command will also appear in the generated RSAC-5 input file.

Screen 2—General Meteorological Information (A). Enter the average wind velocity and press **<Enter>**. Then select the velocity units from the selection list. RSAC-5 will calculate the average wind velocity (m/s).

Screen 3—General Meteorological Information (B). Enter the stack height, mixing depth, air density, and washout factor. Also, indicate whether the plume is depleted because of dry deposition.

Screen 4—Deposition Velocity. Select **Yes** if you want to enter deposition velocity information; otherwise, select **No**. Deposition velocities are required only when ingestion or ground surface dose calculations will be requested.

Screen 5—Deposition Velocities. This screen only appears when **YES** has been selected on Screen 4. Enter the deposition velocity of solids, halogens, noble gases, cesium, and ruthenium.

Screen 6—Downwind Distances. Enter a unique downwind distance. If a duplicate distance is entered, you will be alerted and the field in error will automatically be cleared. The entry of downwind distances is terminated when the distance field is left blank and **<Enter>** is pressed.

Be careful when editing downwind distances because the direct input of χ/Q values and the direct input of standard deviations must correspond to downwind distances.

Screen 7—Leakage Decay Constants. Enter linear or exponential constants (s). Up to 10 sets of constants can be entered. The leakage decay constants must be entered in sets of two.

Screen 8—Crosswind Distance. Select **Yes** if you want to enter crosswind distances; otherwise, select **No**.

Screen 9—Crosswind Distance. Enter the crosswind distances. Terminate entering crosswind distances by leaving the distance field blank and pressing **<Enter>**.

Screen 10—Diffusion Coefficient Control.

If you select **1**, then the *Coefficient of Standard Deviation screen* will appear. Enter the values for σ_y and σ_z. Standard deviations must be entered in sets of two.

If you select **2**, then the *Plume Standard Deviation Control* screen will appear. Enter the type of sigma, weather class, and plume rise indicator on a sequence of input screens.

If you select **3**, then the *Direct χ/Q Input* screen will appear. Enter the χ/Q associated with the downwind distance.

Screen 11—Series Selection Menu. When finished with the data entry screen, you will be returned to the *Series selection menu,* where you can invoke another option.

6000 Series—Radionuclide Inventory Decay and Printout

Screen 1—Comment screen. Enter a brief comment about the 6000 Series that is being appended and press **<Enter>**. This comment is used to distinguish between series and can make future editing sessions easier. This command will also appear in the generated RSAC-5 input file.

Screen 2—Decay Control. In this data entry screen sequence, you will be asked to provide the following information: whether all or selected radionuclides are to be decayed, whether inventories are to be printed, units of measure, and whether the exponential leakage decay option is desired.

Screen 3—Exponential Leakage Time. If you select the option for exponential leakage decay during the hold-up period prior to release on Screen 2, this screen appears. Enter the decay time (s) for the exponential decay function. A prompt will appear asking if you want to change the entered value.

Leakage Decay Constants—A prompt screen will initially appear giving the option to enter or change leakage decay constants. If the constants have been previously entered and do not need to be changed, press **<Enter>** to proceed. Otherwise use the <↓> key to select **Yes** and press **<Enter>**. A screen for the entry of leakage decay constants will then appear to enter linear and exponential constants (s^{-1}). Up to 10 sets of constants can be entered.

Screen 4—Radionuclide Selection. If you select to decay only selected radionuclides on Screen 2, this screen appears. Use the <↑> and <↓> keys to highlight the desired radionuclides to decay. Speed up the search by entering the mass number of the radionuclide. The first radionuclide with that mass number will be highlighted. When the desired radionuclide is highlighted, press **<Enter>**. A **X** will appear next to the chosen radionuclides. To remove a radionuclide from the selection list, press **<Enter>** again when the radionuclide is highlighted. Press **<F8>** to review the list in the summary file at any time during the selection process. When complete, press the **<Ctrl>** and **<Enter>** keys simultaneously to exit the screen to proceed.

Screen 5—Decay Times. You will be asked if you want to enter decay times directly. If **Yes**, a subsequent screen will appear with a pop-up window asking the decay time unit to be used. Use the <↑> and <↓> keys to select the desired decay time unit. When **<Enter>** is pressed, the pop-up window disappears and decay times may be entered. A maximum of eight decay times can be entered. However, when you want to see all of the output data on an unshifted screen or printed on a standard 80-column page, enter a maximum of three decay times. When **<Enter>** is pressed without entering a time, a prompt flashes at the bottom of the screen giving you the opportunity to change any of the entered times before continuing.

Screen 6—Summation Control Line. If the option to decay all radionuclides was chosen on Screen 2, a screen will appear asking you if you would like a summation of the radionuclide inventory by group (solids, halogens, noble gases, cesium, and ruthenium). You will then be given the option to sum the radionuclide inventory by element. If you select this option, a subsequent screen for selecting elements will appear. Use the <↑> and <↓> keys to highlight the desired element and press **<Enter>** to make the selection. Press **<Enter>** a second time to remove an element from the list. When all of the desired elements have been selected, press the **<Ctrl>** and **<Enter>** keys simultaneously to exit and proceed to the next screen.

Screen 7—Series Selection Menu. When finished with the data entry screen, you will be returned to the *Series selection menu*, where you can invoke another option.

7000 Series—Internal/External Dose Calculation

Screen 1—Comment screen. Enter a brief comment about the 7000 Series that is being appended and press **<Enter>**. This comment is used to distinguish between series and can make future editing sessions easier. This command will also appear in the generated RSAC-5 input file.

Screen 2—Dose Control Calculation. In this data entry screen sequence, you will be asked to provide the following information: type of dose calculation, amount of printed output, dose unit, whether all elements are to be used in the calculation, and whether all organs are to be included in the dose calculation. Based on the type of calculation, a different screen sequence is presented.

"0: ICRP-30 Inhalation, program default parameters"

Inhalation Dose Control—Enter breathing rate (m^3/s) and decay time (s) for exponential decay function.

"1: ICRP-30 Inhalation, parameters will be entered on a later screen"

Inhalation Dose Control—Enter breathing rate (m^3/s) and decay time (s) for exponential decay function.

Inhalation Parameters Dose Calculation—Enter activity median aerodynamic diameter (AMAD) (μ) and whether default lung clearance classes are to be used. If user input of lung clearance classes is chosen, the *Clearance Class Entry* screen will appear.

Clearance Class Entry—Use the <↑> and <↓> arrow keys to highlight the desired element and press **<Enter>**. A pop-up screen will appear showing the valid lung clearance classes for the chosen element. Use the <↑> and <↓> arrow keys to choose the desired lung clearance class and press **<Enter>**. When changes to lung clearance classes for all of the desired elements have been made, press the **<Ctrl>** and **<Enter>** keys simultaneously to continue.

"2: Ingestion, default to program calculated parameters"

Ingestion Dose Parameters—Enter decay time (s) for exponential decay function and the plant midpoint of operating life (y).

"3: Ingestion with parameters entered on a later screen"

Ingestion Dose Parameters—Enter decay time (s) for exponential decay function and the plant midpoint of operating life (y).

Ingestion Dose Control—Use this sequence of screens to choose whether to use default ingestion transfer parameters; whether the release is chronic, acute, or if ingestion parameters are to be user entered; the time period crops are exposed to contamination during the growing season when the release is not chronic; and the harvest duration period following the end of an acute release period. When you select to enter ingestion parameters, a series of three screens will appear that contain the RSAC-5 default ingestion parameters. The screens will initially contain the RSAC-5 default ingestion parameters. To change any of the parameters, use the <↑> and <↓> keys to select the parameter to be changed. When the flashing prompt appears at the bottom of the screen and the parameters are set, press **<Enter>** to continue.

"4: Ground Surface"

Ground Surface Dose Parameters—Enter the decay time (s) for exponential calculations, exposure time of the receptor to contaminated ground surface, and the building shielding factor.

"5: Air Immersion"

Air Immersion Dose Parameters—Enter decay time (s) for exponential decay functions.

"6: Water Immersion"

Water Immersion Dose Parameters—Enter the water volume (m^3), decay time (s), external exposure time (y), and swim time.

Screen 3—Series Selection Menu. When finished with the data entry screen, you will be returned to the *Series selection menu*, where you can invoke another option.

8000 Series—Fifty-Mile Radius Dose Calculation

Screen 1—Comment screen. Enter a brief comment about the 8000 Series that is being appended and press **<Enter>**. This comment is used to distinguish between series and can make future editing sessions easier. This command will also appear in the generated RSAC-5 input file.

Screen 2—Radionuclide Selection Data. Indicate whether radionuclides for dose calculations will be obtained from previous 1000 or 2000 Series entries (**0**) or will be selected on the subsequent screen (**1**).

If you select **0**, then *Model Control Line* screen appears.

If you select **1**, a radionuclide selection input screen appears. Use the <↑> and <↓> keys to highlight the desired radionuclide. Speed up the search by entering the mass number of the radionuclide. The first radionuclide with that mass number will be highlighted. Up to 100 radionuclides can be selected. When complete, press the **<Ctrl>** and **<Enter>** keys simultaneously to continue.

Screen 3—Model Control Line. The following series of pop-up windows will appear to assist you in preparing this line.

Clearance Class Selection. Indicate whether you want to default to program-generated lung clearance classes or modify them on an upcoming screen.

Dose Unit. Indicate whether the doses will be expressed in rem or Sv.

Input control for ingestion. Indicate whether the dose will be from a chronic release or if the ingestion dose calculations will be controlled by parameters you supply.

Input control for building shielding/exposure factors. Indicate whether the program default values are to be used or if you will provide shielding/exposure values.

You will be asked to also provide an average breathing rate, the plant midpoint of operation life, and the time that the receptor is exposed to the contaminated ground surface following initiation of the release.

Screen 4—Dose Organ Selection. Select the organs to be included in the dose calculation by using the <↑> and <↓> keys to highlight the organ and press **<Enter>**. A maximum of four organs can be selected. Doses can be calculated for additional organs by repeating the 8000 Series input. When the desired organs have been selected, press the **<Ctrl>** and **<Enter>** keys simultaneously to continue.

Screen 5—Building Shielding/Exposure. This screen appears only when you use the *Input control for building shielding/exposure factors* pop-up window of Screen 3 in this series to indicate that you will provide a shielding/exposure factor. Enter the building shielding factor for deposition calculations and the exposure factor for air immersion calculations.

Screen 6—Ingestion Dose Control. This screen appears only when you use the *Input control for ingestion* pop-up window of Screen 3 in this series to indicate that you will control ingestion dose calculations by providing constants. Two pop-up windows will appear.

Ingestion Transfer Parameter. Indicate whether program default transfer parameters are to be used, if they are to be printed, or if they are to be read from the external file **TRANCON**.

Ingestion calculation control. Indicate whether the release will be chronic, acute, or if you will enter ingestion parameters.

The next entry on Screen 6 is the time period that crops are exposed to contamination during the growing season. If the choice in the *Ingestion calculation control* window above was that the release is acute or if ingestion parameters would be entered by the user, the user will be requested to provide the harvest duration period following the end of the release time.

Screen 7—Exponential Leakage Rates. Indicate whether you will use program-calculated values or specify constants for the exponential leakage decay function. When the option for the user to provide constants is chosen, separate screens are provided.

> *Exponential Leakage Time*—Enter the release time (s) for exponential decay functions.
>
> *Leakage Decay Constants*—Enter linear and exponential constants (s^{-1}). Normally only one set of constants is entered; however, up to 10 sets of constants can be entered.

Screen 8—Clearance Class Entry. This screen appears only when you use the *Clearance Class Selection* pop-up window of Screen 3 in this series to indicate that default lung clearance classes will be modified. Use the <↑> and <↓> arrow keys to highlight the desired element and press **<Enter>**. A pop-up screen will appear showing the valid lung clearance classes for the chosen element. Use the <↑> and <↓> arrow keys to choose the desired lung clearance class and press **<Enter>**. When changes to lung clearance classes for all of the desired elements have been made, press the **<Ctrl>** and **<Enter>** keys simultaneously to continue.

Screen 9—External Files. Use this screen to specify whether an external file containing χ/Q, population, and wind velocity data will be used or if RSAC+ will be used to enter the information.

> If **Yes**, supply the file name on the screen provided.
>
> If **No**, you will be advised that subsequent screens require entry of almost 200 data points and given a chance to reconsider the option. If you choose to continue, 16 screens for each of the 16 compass sectors will be provided. On each of the screens, provide the average wind velocity toward the sector and the population and χ/Q for each of the five radii. Two additional screens will then appear.
>
> *Meteorological Data for Site Boundary*—Use this screen to provide the sector number that contains the maximum exposed individual, the χ/Q for the maximum exposed individual, the distance to the maximum exposed individual, and the average wind velocity toward the maximum exposed individual.
>
> *External File Generator*—This screen offers the option to create an external 8000 Series file with the data that have just been entered. If you will be making additional 8000 Series calculations using the same population and meteorological data, an external file eliminates the need to reenter all of the data or reedit the entire 8000 Series. Two files are written: an ASCII file that can be read by RSAC-5, and a RSAC+ file with a .DXT extension that can be read using the *Advanced Utility Function* on the *Operations menu.*

Screen 10—Deposition Velocities. Enter the deposition velocity of solids, halogens, noble gases, cesium, and ruthenium.

Screens 11,12 and 13-Ingestion Dose Control. These screens appear only when you choose the option to input ingestion parameters on the *Ingestion calculation control* pop-up window on Screen 6 in this series. The screens will initially contain the RSAC-5 default ingestion parameters. To change any of the parameters, use the <↑> and <↓> keys to select the parameter to be changed. When the flashing prompt appears at the bottom of the screen and the parameters are as desired, press **<Enter>** to continue.

Screen 14—Series Selection Menu. When finished with the data entry screen, you will be returned to the *Series selection menu,* where you can invoke another option.

9000 Series—Cloud Gamma Dose Calculation

Screen 1—Comment Screen. Enter a brief comment about the 9000 Series that is being appended and press **<Enter>**. This comment is used to distinguish between series and can make future editing sessions easier. This command will also appear in the generated RSAC-5 input file.

Screen 2—Cloud Gamma Dose Calculation. Initially, a window will appear asking whether calculations are to be made using the finite or semi-infinite plume model. Following entry of the decay time for the exponential decay function, another window appears asking you whether to calculate an air entrance dose or external EDE.

Screen 3—Series Selection Menu. When finished with the data entry screen, you will be returned to the *Series selection menu,* where you can invoke another option.

10000 Series—Change Title and Continue Problem

Use this option to show where different types of calculations are being performed. The radionuclide and meteorological data are retained.

Screen 1—New Title Entry. Use this screen to change the title that appears on every page of the output.

Screen 2—Series Selection Menu. When finished with the data entry screen, you will be returned to the *Series selection menu,* where you can invoke another option.

3.2.2.2 Edit a Selected Series. This option allows you to select a series from the currently-selected file and edit it. If no data have been input to the currently-selected file, RSAC+ will display a message and prompt you to return to the *Operations menu.* Use the **<Tab>** or arrow keys to highlight the series to be edited and press **<Enter>**. RSAC5+ returns to the appropriate data entry screens to allow you to edit the data. Refer to Section 3.2.2.1 for data entry screen information.

3.2.2.3 Insert a Series. This option allows you to insert a series into the currently-selected file. To select the location for the new series, use the **<Tab>** or arrow keys to highlight the series below where the new series will be inserted. The new series will be inserted on the line above the highlighted series. RSAC5+ returns to the *Series selection menu,* where you highlight and select the series to be inserted. After the series to be inserted has ben selected, the applicable data entry screen appears. Refer to Section 3.2.2.1 for data entry information.

3.2.2.4 Move a Series. This option allows you to move a series in the currently-selected file to another location in the file. **NOTE:** General sequence rules of RSAC-5 must be followed to prevent input errors. Section 4.2 contains RSAC+ sequence flowcharts that depict valid input sequences. Use the **<Tab>** and arrow keys to highlight the series to be moved (source) and press **<Enter>**. The source series is removed from the series displayed. Then highlight the line where you want to place the series (target). Press **<Enter>** to return to the *Operations menu.*

To append a series to the end of the file, highlight the source series and press **<F5>**.

3.2.2.5 Copy a Series. This option allows you to copy a series from the currently-selected file to another location in the file. Use the **<Tab>** and arrow keys to highlight the series to be copied and press **<Enter>**. Highlight the line where you want to place the copied series. Press **<Enter>** to return to the *Operations menu.*

To append a series to the end of the file, highlight the source series and press **<F5>**.

3.2.2.6 Delete a Series. This option allows you to delete a series from the currently-selected file. Use the **<Tab>** and arrow keys to highlight the series to be deleted and press **<Enter>**. A confirmation screen appears, listing the series and description. Type **C** to delete, or press any other key to return to the *Series selection menu.* Press **<Enter>** to return to the *Operations menu.*

3.2.3 Utilities

3.2.3.1 Generate ASCII RSAC-5 Input File. Information entered into RSAC+ is stored in an RSAC+ file. This file has a .DTT extension. An input file must be created to run RSAC-5 directly from DOS. This option will create the ASCII input file. The ASCII input file will not have a DOS extension.

3.2.3.2 Browse File in Memory. This option displays the contents of the RSAC-5 input file. Use the arrow, **<PgUp>**, **<PgDn>**, **<Home>**, and **<End>** keys to scroll through the file. The approximate position of the end of the displayed screen is indicated by percent in the upper right-hand portion of the screen. The function keys **<F1>** through **<F9>** can be used to speed up locating a desired position in the file. The **<F1>** key positions the bottom of the screen at the approximate 10% position, **<F2>** at 20%, etc. Press **<F10>** or **<Esc>** to exit the file.

3.2.3.3 Browse or Print Any ASCII File. This option allows you to print or view any ASCII file. When you invoke this option, the *Browse & Print File Selector* screen appears. On this screen, supply the directory and name of the file to be viewed or printed. The following two function keys are provided to allow you to view a list of files stored in the current directory:

<F6> - Lists all the files in the current directory.

<F8> - Prompts you to specify a DOS extension. Only those files with this extension will be displayed in this list.

After a filename has been selected, you must chose whether to browse, print, or both browse and print the file. Browse will display the file contents on the screen, while print will print a hard copy of the file on the specified printer.

3.2.3.4 Run RSAC-5 with File Currently in Memory. This option will run RSAC-5 with the currently-selected file. After completing the RSAC-5 run, you are asked to press any key to continue. Before pressing a key to continue, read any message displayed by RSAC-5. Press any key to continue. You are then given the option to return to RSAC+, browse the RSAC-5 output file, or exit RSAC+.

3.2.3.5 Advanced Utility Functions. This option is used to identify the name of an external file containing meteorological and population data for a fifty-mile radius dose calculation in the 8000 Series. When you invoke this option you are prompted to enter a directory and name of the file containing the data. The external file used by this function contains a *.DXT extension and must have originally been created using 8000 Series input created using RSAC+.

3.2.4 Using an ASCII Input File

The input for RSAC-5 program can be complex. Therefore, RSAC-5 has a companion program, RSAC+, which assists you in preparing an ASCII input file. Or, you can create your own ASCII input file. The flowcharts in Section 4.2 show you the proper line sequence for RSAC-5 input.

RSAC-5 performs extensive testing of the ASCII input file data to ensure that data are properly entered and within the expected range. If the program detects an input error, an error statement is displayed on screen. To determine the cause of the input error, browse the end of the output file (as discussed in Section 3.2.3.3). Error statements are printed showing the location and cause of the input error.

RSAC-5 output options are frequently chosen by entering an integer corresponding to the type and amount of output desired. When the choice has little affect on the results and is obvious from the printed output, RSAC does not terminate a run just because the option number entered is beyond the valid selection range. In this case, RSAC-5 defaults to the closest available option without giving any additional warning other than the amount and type of printed output.

To run RSAC-5 directly, you must build an ASCII input file. This can be done by following the instructions in Section 4.1 or creating an ASCII input file using RSAC+. RSAC-5 is executed directly by using the batch file RS.BAT by typing:

RS name

where "name" is the name of the data input file. The output file name is the same as the input name with .OUT appended (e.g., EXAMPLE1.OUT).

4. GENERATING RSAC-5 INPUT

4.1 RSAC-5 Input

A typical RSAC-5 input line includes

- word 1, integer, line number
- word 2, integer
- word 3, real number, 4.92×10^3
- word 4, real number, 12.2
- word 5, real number, 0.5
- at least 1 blank space before *
- optional * terminates data input and initiates a comment on the remainder of the line

```
5400,1,4.92+3,12.2,.5    *YOUR COMMENT ON LINE
```

Other variations of this same line include

```
5400, 1, 4.92E3, 12.2, 5.E-1 *YOUR COMMENT ON LINE

5400 1 492+4 1.22E+1 5.-1          *YOUR COMMENT ON LINE
```

You can use a comma or a blank space as delimiters between entries. Each integer or real number entry is referred to as a "word." The first word of every line is referred to as the "line number," which is used to check input sequences.

As shown in the third word of the last variation above (492+4), when a real number does not contain a decimal point, the decimal point is assumed to appear before the first digit. However, you are encouraged to place a decimal point in real numbers. The following RSAC-5 input descriptions assume that all words are real numbers unless noted.

The input descriptions in this section include word, program name, entry, and description information. The word column presents the location of the entry. The program name column identifies the name given to the variable in the source program and is not input on a line. The entry and description columns provide the entry numbers or type of entry and their corresponding descriptions.

To insert a comment line, type a # sign in the first column. There is no limit to the number of comment lines you can insert. Comment lines are printed in the RSAC-5 ASCII input file and appear in the list of input printed at the beginning of each output file.

The example runs in Section 5 will help you learn how to prepare ASCII input for the RSAC-5 program.

Calculation Title Line

Column	Entry
1	*
2-72	Page heading (alphanumeric)

RSAC-5 ignores all lines of input until it reads a line that contains an asterisk in column 1. This allows the program to start the next problem if an error is found in the input. If output is not received from an RSAC-5 run, check to see if a line contains an asterisk in column 1.

1000 Series—Fission Product Inventory Calculation

Use a *Fission Product Calculation Control Line (1000)* to initiate fission product inventory calculations. Input the following additional lines to describe the reactor operating history and the fractionation of the fission product inventory.

Fission Product Inventory Calculation Control Line (1000)

Word	Program Name	Entry	Description
1		1000	

Initial Reactor Data Line (1001)

The required *Initial Reactor Data Line (1001)* must immediately follow the *Fission Product Inventory Calculation Control Line (1000)*. Use the control word on this line to indicate whether you are calculating a new fission product inventory or modifying a previously-calculated fission product inventory. If you want to calculate a new fission product inventory, enter the reactor power, and operating time on this line. If you are modifying the previous radionuclide inventory, the remaining words on this line are ignored and the next line must be a *Refueling Line (1002), Cycle Line (1003)*, or *Fractionation Line (1004)*.

Word	Program Name	Entry	Description
1		1001	
2		Integer	Control word:
		0	Calculations start with no previous radionuclide inventory
		1	Previous radionuclide inventory is retained and the next line must be a *Refueling Line (1002)*, *Cycle Line (1003)*, or *Fractionation Line (1004)*. The values for the remaining words on this line are ignored; however values for each of the following words must be present.
3	POWER		Reactor power (W)
4	TROP		Reactor operating time at the above power (s)

Refueling Line (1002)

Word	Program Name	Entry	Description
1		1002	
2			The percent of radionuclide inventory remaining after refueling

Cycle Line (1003)

Word	Program Name	Entry	Description
1		1003	
2	TTROP		Reactor shutdown time before this cycle (s)
3	POWER		Reactor power for cycle (W). If zero, TROP below is set to zero and the next entry is ignored.
4	TROP		Reactor operating time at above reactor power for this cycle (s). This quantity is set to zero if reactor power above is zero.

Fractionation Control Line (1004)

Use this line to release a fraction of the radionuclide inventory and simulate removal of activity by cleanup systems such as HEPA filters. Use the control word on this line to determine whether the type of fractionation is by group, by a constant value, or by element. Specify fractionation by the following groups: solids, halogens, noble gases, cesium, and ruthenium. Enter the fractionation value for each group on this line. If the constant fractionation option is used, the entire radionuclide inventory is fractionated by the next value entered on this line. If fractionation by element is chosen, enter a fractionation value for those elements not described by a *Element Fractionation Lines (1101+)* on this line. Enter the *Element Fractionation Lines (1101+)*, describing the fractionation of each desired element.

Word	Entry	Description
1	1004	
2	-1	Fractionation by group as specified by the next five words
3		Fractionation for solids
4		Fractionation for halogens
5		Fractionation for noble gases
6		Fractionation for cesium
7		Fractionation for ruthenium
2	0	Fractionation is by a constant specified by the next word
3	FRAC	Fractionation for entire radionuclide inventory
2	1	Fractionation by element. Following lines will be *Element Fractionation Lines (1101+)*
3	FRAC	Fractionation for elements not described by *Element Fractionation Lines (1101+)*

Element Fractionation Lines (1101+)

Use these lines only if you want fractionation by element.

Word	Entry	Description
1	Integer	11XX (XX = 01, 02,..., etc.)
2	Integer	Atomic number of element
3		Fractionation for above element
.		.
.		.
2N	Integer	N^{th} atomic number
2N + 1		N^{th} fractionation

Enter additional sets of two values on this and following lines until all desired elements have been described. The number of sets per line is optional.

Release During Simulated Reactor Operations Line (1200)

Use this optional control line to simulate fission product releases from a reactor while it is operating. Insert a *Release During Fission Product Calculation Line (1200)* immediately following either the *Initial Reactor Data Line (1001)* or the *Cycle Line (1003)* to modify the reactor operations requested by the *(1001)* or *(1003)* lines. A *Reactor Linear Leak Rates Line (1201)* must immediately follow a *(1200)* line. Activity is removed from the reactor incrementally using the number of chosen steps (1 to 100) over the entire reactor operating cycle requested by a *(1001)* or *(1003)* line. The activities removed from the reactor during each release increment are summed to give the total amount of each radionuclide released from the reactor during the total operating period. You can choose whether the activity leaked from the reactor or that remaining in the reactor following operations is used in further calculations. After a *(1200)* line is encountered, it remains in effect on all subsequent reactor cycle operations [*Cycle Line (1003)*] until either another *(1200)* line or a *Fission Product Calculation End Line (1999)* is encountered.

RSAC-5 has two memory buffers for storing radionuclide inventories: main and hold. The activity remaining in the reactor is stored in a main memory buffer, and the activity released from the reactor is stored in a hold memory buffer. After activity is entered into the hold memory buffer, it cannot be decayed until after a *Fission Product Calculation End Line (1999)* is encountered. When you chose the option to retain the activity remaining in the reactor after encountering a *(1999)* line, the main memory buffer is retained for further calculations and the hold buffer is deleted. When you chose the option to retain the activity released from the reactor, the hold memory buffer is copied to the main memory buffer for subsequent calculations, and the radionuclide inventory that was remaining in the reactor is deleted.

When the *(1200)* line option is used, all fractionations of the radionuclide inventory using *(1004)* lines [until a *(1999)* line is encountered] are made on the inventory chosen to be retained for subsequent calculations. You can make further decay (and fractionation) by exiting the 1000 Series with a *(1999)* line and reentering the 1000 Series with another *(1000)* line.

Word	Program Name	Entry	Description
1		1200	
2	NCS	Integer	Number of reactor release steps (≤100)
3	KEEPFLAG	Integer	Inventory to be retained for subsequent calculations:
		0	Retain activity remaining in reactor
		1	Retain activity leaked from reactor

Reactor Linear Leak Rates Line (1201)

You must insert the *Reactor Linear Leak Rates Lines (1201)* immediately following a *(1200)* line to establish the leak rates for the different groups of fission products.

Word	Program Name	Entry	Description
1		1201	Radionuclide leak rate from the operating reactor (fraction/s)
2	RR(1)		Solids
3	RR(2)		Halogens
4	RR(3)		Noble gases
5	RR(4)		Cesium
6	RR(5)		Ruthenium

Fission Product Calculation End Line (1999)

Use this line to end the fission product inventory calculation requested by the last *Fission Product Calculation Line (1000)*.

Word	Entry
1	1999

2000 Series—Direct Radionuclide Input

Use the *Radionuclide Direct Input Control Line (2000)* to initiate directly entering the radionuclide inventory in curies instead of using a fission product inventory. All radionuclides are identified by the radionuclide identification number (NUCL) or by entering the element symbol followed by the atomic number.

Radionuclide Direct Input Control Line (2000)

This control line has one data word that identifies whether an existing radionuclide inventory should be deleted, changed, or appended.

Word	Entry	Description
1	2000	
2	0	Radionuclide inventory input option is chosen and the following lines. Any previous radionuclide inventory is deleted.
	1	Same as for entry 0 except the previous radionuclide inventory is retained and the activity of the chosen radionuclide is changed to that indicated on the following lines
	-1	Same as for entry 0 except previous radionuclide inventory is retained and the activity of the chosen radionuclide is added to that indicated on the following lines.

Optional Radionuclide Input Override Line (2001)

This optional line allows you to continue a calculation even though input was requested for a radionuclide that is not present in the RSAC-5 data library. When this line is present, it will immediately follow a *(2000)* line. This option is useful when reading an external file generated by another computer program, such as ORIGEN-2, that can contain radionuclides that are not present in the RSAC-5 data library. Caution should be used when using this option to ensure that the ignored radionuclides are really not in the RSAC-5 library and not the result of an input error in the radionuclide identification.

Word	Entry
1	2001

External Radionuclide File Control Line (2002)

This optional line allows you to specify an external file for inputing radionuclide inventories. This line will immediately follow a *(2001)* line if that option is selected; otherwise, it will follow Line *(2000)*. Data in the external file have the same format as that on the *Radionuclide Entry Lines* with one exception. The first line in the external file is used to identify the data set and is printed on the RSAC-5 output file. The program stops reading radionuclide inventories from an external file when it encounters either a blank line or the end of the file. An *Input End Line (2999)* must immediately follow a *(2002)* line.

Word	Program Name	Entry	Description
1		2002	
2	EXTFILE		Enter the name of the external file containing the radionuclide inventory input. The name entered must be a valid DOS filename with no extensions.

Radionuclide Entry Lines

Radionuclide Entry Lines are present only when the *(2002)* line option is not selected. Following the last entry of an inventory for a radionuclide, you must enter an *Input End Line (2999)*.

Word	Program Name	Entry	Description
1	NUCL	Integer	Radionuclide identification number (see 4000 Series, *Radionuclide Data Change Line*). An alternate entry can be made by replacing NUCL with the element symbol (in capital letters) followed by the mass number and metastable state indicator. Examples of allowable styles include CS137, CS-137, CS 137 BA137M, BA-137M, BA 137M
2			The amount in curies of this radionuclide

Make additional line entries until all desired radionuclides have been entered into the radionuclide inventory.

Radionuclide Direct Input End Line (2999)

Use this line to end the direct input of radionuclide inventory input.

Word	Entry
1	2999

3000 Series—Dose Summary Option

Use this option to summarize, add, and report in summary tables doses from different exposure pathways and multiple RSAC-5 calculations.

Dose Summary Option Control Line (3000)

To use the dose summary option, you must initiate the option (word 2 equals 1) after a 5000 Series has been entered and before making dose calculations using 7000 and 9000 Series entries. Following dose calculations for the pathways desired, enter additional *(3000)* lines to request dose summaries. Changes can be made in the 5000 Series (Meteorological Data Input) following initiation of the 3000 Series option; however, downwind distances cannot be changed.

Word	Program Name	Entry	Description
1		3000	
2	ITY	Integer	Type of calculation:
		1	Initiate the dose summary option
		2	Summary of dose by pathway
		3	Summary of dose by pathway and radionuclide
		4	Summary of dose by organ [requires a *(3001)* Line to follow]
		5	Summary of dose by organ and radionuclide [requires a *(3001)* line to follow]
		6	Contribution to EDE
		7	Contribution to EDE by radionuclide
		8	Contribution to EDE by radionuclide sorted by dose

Dose Summary Organ Selection (3001)

This line is present only if word 2 on the *(3000)* line is 4 or 5. Dose summaries for up to four organs can be entered. When additional dose summaries for organs are desired, add additional *(3000)* and *(3001)* lines.

Word	Program Name	Entry	Description
1		3001	
2	INORGAN(1)	Integer	Organ number
.	.	.	
.	.		
4	INORGAN(4)		
			Internal
		1	LUNGS
		2	S WALL
		3	SI WALL
		4	ULI WALL
		5	LLI WALL
		6	GONADS
		7	BREAST
		8	BONE SUR
		9	R MARROW
		10	THYROID
		11	KIDNEYS
		12	LIVER
		13	SPLEEN

4000 Series—Radionuclide Data Constants Change

Use this series to make changes to the RSAC-5 nuclear data library presented in Appendix B. This series should only be used by an experienced user and then only with caution. Changes made are temporary; they do not remain at the end of the run. Changes can be made for as many radionuclides as desired.

Word	Entry
1	4000

Radionuclide Data Change Lines

The number of radionuclides in a single decay chain sequence cannot exceed 20. The number of isomers in a single decay chain cannot exceed 2. Words 6 or 8 should not be changed from those values presented in Appendix B.

Word	Program Name	Entry	Description
1	NUCL	Integer	Radionuclide identification number equals $Z \times 10000 + A \times 10 + MS$ where
			Z = atomic number
			A = mass number
			MS = 0 for ground state 1 for metastable state
2	HALU	Integer	Half-life time unit code
		1	Second
		2	Minute
		3	Hour
		4	Day
		5	Year
3	HLIFE		Half-life of radionuclide, in units consistent with the above half-life code
4	YIELD		Percent fission yield for the radionuclide

Word	Program Name	Entry	Description
5	FRACT		Fraction of radionuclide decayed to the daughter indicated (IDATR). If FRACT <1.0 and the daughter indicated is not the next radionuclide in the library, an isomer is assumed. A fraction FRACT is decayed to the daughter indicated, and the fraction 1-FRACT is decayed to the next radionuclide in the library. A maximum of two isomers can be entered for a single decay chain.
6	IDATR	Integer	Daughter indicator:
		-1	No radioactive daughter
		0	Daughter is the next radionuclide in the library
		≥1	Number of radionuclides in the library that are to be skipped over before the daughter is found
7	NGROUP	Integer	Element group code:
		1	Solid
		2	Halogen
		3	Noble gas
		4	Cesium
		5	Ruthenium
8	ISTART	Integer	Pointer to beginning of chain. Subtract ISTART from library position to find beginning of chain
9	XSECT		Average neutron cross section (barns)

Radionuclide Data Constant Change End Line (4999)

Use this line to end the changes to the radionuclide data constants.

Word	Entry
1	4999

5000 Series—Meteorological Data Input

Use a *Meteorological Control Line (5000)* to initiate input of meteorological data, which is followed by the meteorological data lines.

Meteorological Control Line (5000)

Word	Entry
1	5000

General Meteorological Information Line (5001)

Word	Program Name	Entry	Description
1		5001	
2	UBAR		Average wind velocity (m/s)
3	SH		Stack height (m)
4	H		Mixing layer depth (m). If zero, defaults to 400 m.
5	ADEN		Air density (g/m^3). If zero, defaults to 1.099E+3 (average density for the Idaho National Engineering Laboratory).
6	AMBDA		Wet deposition scavenging coefficient (1/s). Set equal to zero when no plume depletion by wet deposition is desired.
7	SW1	Integer	Plume depletion by dry deposition:
		0	No
		1	Yes

Deposition Velocities Line (5002)

Entering this line is optional. However, the line must be present if you are making ingestion or ground surface dose calculations.

Word	Program Name	Entry	Description
1		5002	Deposition velocity (m/s) for:
2	DV(1)		Solids
3	DV(2)		Halogens
4	DV(3)		Noble gases
5	DV(4)		Cesium
6	DV(5)		Ruthenium

Downwind Distance Lines (5101+)

Word	Program Name	Entry	Description
1		Integer	510X (X = 1,2,..., etc.)
2	DIE(1)		Downwind distance (m)
.	.		
.	.		
.	.		
N	DIE(N)		

Enter a maximum of eight downwind distances. The valid range of downwind distances is 1.E+2 to 1.E+5 m.

Leakage Decay Constants Lines (5201+)

Use leakage decay constants to decay the radionuclide inventory before release to the environment. When the radionuclide inventory has already been decay corrected to the actual amount to be released, treat the release as an instantaneous release as described below to avoid double decay.

Word	Program Name	Entry	Description
1		Integer	52XX (XX = 01, 02, ..., etc.)
2	K1(1)		Linear constant in the leakage rate function (s^{-1})
3	K2(1)		Exponential constant in leakage rate function (s^{-1})

Enter additional sets of two values on this and following lines up to a maximum of 10 sets.

When an instantaneous release is desired, enter only one set of leakage constants and set K1 = 1., K2 = 0., and the exposure time to the plume to 1 second. When decay correction is desired for a constant release, set K1 = the reciprocal of the release time (s), K2 = 0., and the decay time for the leakage rate function = the time (s) over which the release occurs [see Appendix A, Equation (A-20)].

When an exponential release as a function of time is desired, set K2 = $0.69315/T_h$, where T_h is the release half-time (s) for the exponential decay function. K1 can be calculated using the following equation:

$$K1 = \frac{L_f\, K2}{1.- e^{-K2\, T}}$$

where L_f is the fraction of the total source volume to be released over the time T (s).

Decay times for the leakage rate function used with these constants are entered on lines *(6001)*, *(7001)*, *(8020)*, and *(9000)* lines. An option is provided for the program to automatically calculate the necessary decay times to give a 100% release if only one set of constants is entered (K1 > 0 and K1 > K2). When these conditions are not met, you must directly enter the decay time for the leakage rate function.

Crosswind Distance Lines (5301+)

You can omitted these lines if no crosswind calculations are desired.

Word	Program Name	Entry	Description
1		Integer	53XX (XX = 01, 02,..., etc.)
2	ELB(1)		Crosswind distance (m)
.			
.			
.			
N	ELB(N-1)		

Additional values on this and following lines are entered up to a maximum of 15 crosswind distances.

Diffusion Control Line (5400)

Word	Program Name	Entry	Description
1		5400	
2	NTRL	1	A set of standard deviations of plume concentrations are entered on the *Standard Deviation Lines (5401+)* for each downwind distance
		2	Program-calculated standard deviations of plume concentration. A *(5410)* line will immediately follow this line.
		3	χ/Q values are input directly. The remainder of this line is ignored, and χ/Q values are read from *(542X)* lines.
3	DUMMY		Building width (m)
4	DUMMZ		Building height (m)
5	KAPPA		Building wake coefficient. If zero, defaults to 1.

Standard Deviation Lines (5401+)

Enter these lines only if word 2 on the *Diffusion Control Line (5400)* is equal to 1.

Word	Program Name	Entry	Description
1		Integer	540X (X = 1, 2, ..., etc.)
2	SIGY(1)		The horizontal dispersion standard deviation for the first downwind distance (m)
3	SIGZ(1)		The vertical dispersion standard deviation for the first downwind distance (m)
.			
.			
.			
N			

Enter additional sets of standard deviations on this and following lines for the additional downwind distance until values have been entered corresponding to each downwind position entered on the *(5100+)* lines above. A set of standard deviations must be entered for each downwind distance.

Plume Standard Deviation Control Line (5410)

Enter this line only if word 2 on the *Diffusion Control Line (5400)* is 2. See Appendix C for information on the different sets of σs that are available. Hilsmeier-Gifford σs (Clawson et al. 1989) should be used for desert terrains (such as the Idaho National Engineering Laboratory) for effluent releases from a few minutes to 15 minute in duration. Markee σs (Clawson et al. 1989) should be used for desert terrains for effluent releases from 15 to 60 minute in duration. Pasquill-Gifford σs were developed from the Prairie Grass experiments for effluent releases from 10 to 60 minutes in duration. The Pasquill-Gifford σs are presented in Regulatory Guide 1.145 (NRC 1982) and by Slade (1968). Carefully evaluate the appropriateness of using the program-generated σs for effluent releases of different durations than noted above. When you consider the program-generated σs inappropriate, word 2 on the *Diffusion Control Line (5400)* should be set to 1, and σs should be entered directly using the *(540X)* lines.

Word	Program Name	Entry	Description
1		5410	
2	ITS	1	Hilsmeier-Gifford (H-G) σs
		2	Markee σs
		3	Pasquill-Gifford (P-G) σs
3	IWC	Integer	Weather class:
		1	A
		2	B
		3	C
		4	D
		5	E
		6	F
		7	F Fumigation [requires SH>O and H>=SH on a *(5001)* line]
		8	G (allowed only for P-G σs)
4	IPLRS	Integer	Plume rise indicator:
		0	No plume rise
		1	Jet plume rise. Requires a *(5411)* line
		2	Buoyant plume rise. Requires a *(5411)* line

Plume Rise Control Line (5411)

The *(5411)* line is present only when word 4 on the *(5410)* line is not equal to 0.

Word	Program Name	Entry	Description
1		5411	Plume rise parameters:
2	SDIA		Internal stack diameter (m)
3	RS		Restoring acceleration (s^{-2}). If zero, defaults to program calculated values of 8.7E-4 (s^{-2}) for a weak inversion and 1.75E-3 (s^{-2}) for a strong inversion.
4	WO		Efflux speed of gases from the stack (m/s)
5	QH		Stack gasses heat emission (cal/s) for buoyant plume rise. Enter zero for jet plume.

Direct χ/Q Input Lines (5421+)

Enter these lines only if word 2 on the *Diffusion Control Line (5400)* is 3. Cloud gamma calculations using the finite plume model and plume depletion by ground deposition are not allowed when using this option.

Word	Program Name	Entry	Description
1		Integer	542X (X = 1,2,..., etc.)
2		CQ	χ/Q for the lst downwind distance
.		.	
.		.	
.		.	
N		CQ	χ/Q for the N^{th} downwind distance

Enter additional values on this and following line for each downwind distance entered on the *(5101)* line.

Meteorological Data End Line (5999)

Use this line to end the meteorological data input and calculations as requested by the *Meteorological Control Line (5000)*.

Word	Entry
1	5999

6000 Series—Radionuclide Inventory Decay and Printout

Use the *Decay Control Line (6000)* to initiate radionuclide inventory decay calculations. Either the entire radionuclide inventory or selected radionuclides can be decayed. Decay times can be entered directly with *Decay Times Lines (6101+)* or they can be established from the 5000 Series meteorological downwind data lines. Individual radionuclides selected are printed. If desired, rather than printing the entire radionuclide inventory you can select, other printout options.

Decay Control Line (6000)

Word	Program Name	Entry	Description
1		6000	
2	NCH	Integer	Printout control:
		0	All radionuclides in the RSAC-5 library will be decayed
		1	Only radionuclides selected following a *(6021)* line will be printed
3	ISW2	Integer	Printout options:
		0	No individual radionuclide inventories are printed
		-1	Print all fission products and any activation products, actinides, and daughters of actinides with positive values
		1	Same as -1 option except suppress short-lived fission products that have no available dose conversion factors
		2	Print inventory of radionuclides that have positive values at or following the first requested decay time
4	ISW	Integer	Units control word:
		0	Curies
		1	MeV/s (gamma only)
		2	Grams
5	LEAK	Integer	Exponential leakage option
		0	No exponential leakage corrections are included
		1	Correction for exponential leakage decay included. A *(6001)* line must immediately follow this line. This option provides an inventory of the radionuclides reaching a downwind location following a release that varies exponentially as a function of time.

Decay Time for Leakage Rate Function (6001)

Use this line only when LEAK on the *(6000)* line is equal to 1. See Appendix A, Section A-2.4 for limitations on the use of this function.

Word	Program Name	Entry	Description
1		6001	
2	T		Decay time (s) for the exponential decay function. If zero, defaults to the time necessary to give 100% release.

Leakage Decay Constants (6002+)

Use these lines only when the exponential leakage option is requested (i.e., LEAK = 1). You can omit these lines if leak rate exponentials have been previously entered with *(5201+)* lines.

Word	Program Name	Entry	Description
1		Integer	60XX (XX = 02, 03,..., etc.)
2	K1(1)		Linear constant in leak rate function (s^{-1})
3	K2(1)		Exponential constant in leak rate function (s^{-1})

Enter additional sets of two values on this and following lines up to a maximum of 10 sets.

Radionuclide Selection Option Line (6021)

This line is required only if NCH (word 2) entered on the *Decay Control Line (6000)* is equal to 1. This line is followed by additional lines described as following:

Word	Program Name	Entry	Description
1	NUCL	Integer	Radionuclide identification number (see Series 4000, *Radionuclide Data Change Line*). An alternate entry can be made by replacing NUCL with the element symbol (in capital letters) followed by the mass number and metastable state indicator. Examples of allowable styles include CS137, CS-137, CS 137 BA137M, BA-137M, BA 137M

Make additional line entries until all desired radionuclides have been entered into the radionuclide inventory. A *(6101)* or *(6999)* line must follow last radionuclide identification entered.

Decay Times Lines (6101+)

You can omit these lines if decay times have been established using the *(5001+)* lines.

Word	Program Name	Entry	Description
1		Integer	61XX (XX = 01, 02, ..., etc.)
2	IUNIT	Integer	Decay time unit: 1 = Second 2 = Minute 3 = Hour 4 = Day 5 = Year
3	TIME(2)		Decay time
.	.		
.	.		
.	.		
N	TIME(N-1)		

Enter additional values on this and following lines up to a maximum of eight values. When you want to see all of the output data on an unshifted screen or printed on a standard 80-column page, a maximum of three decay times should be entered on each 6000 Series input.

Summation Control Line (6200)

This line is present only if the entire radionuclide inventory is decayed and can be deleted if desired. A summation of the radionuclide inventory by group (solids, halogens, noble gases, cesium, and ruthenium) and/or by element can be printed. If summation by element is requested, enter the *Element Summation Lines (6201+)* next, selecting the elements to be summed.

Word	Entry	Description
1	6200	
2		Group summation control word:
	0	No summation or printout
	1	The fission product inventory for each group (solids, halogens, noble gases, cesium, and ruthenium) is summed and printed
3	Integer	Element summation control word:
	0	No summation or printout
	1	The radionuclide inventory is summed for each element selected by the *Element Summation Lines (6201+)* that follow

Element Summation Lines (6201+)

These required lines are present only if the entire radionuclide inventory is decayed and if the element summation option on the *Summation Control Line (6200)* is chosen. Enter any number of these lines.

Word	Entry	Description
1	Integer	62XX (XX = 01, 02, ..., etc.)
2	Integer	Atomic number of element to be summed

Enter additional words on this and following lines until the desired elements have been selected for summation.

Decay End Line (6999)

Use this line to end the fission product inventory decay and printout as requested by the *Decay Control Line (6000)*.

Word	Entry
1	6999

7000 Series—Internal/External Dose Calculation

Use the initial line of this series to establish the type of dose calculation to be made and the amount of output data. Air-immersion doses are calculated using dose-rate conversion factors (DOE 1988b) developed for a semi-infinite plume. Use caution to ensure that the plume size is large compared to the mean free path of the gamma rays. If there is any doubt, make cloud gamma calculations (see 9000 Series in this section) using both the finite plume model and the semi-infinite plume model and ensure that the doses are converged.

Dose Calculation Control Line 1 (7000)

Word	Program Name	Entry	Description
1		7000	
2	IMOD	Integer	Type of calculation:
		0	ICRP-30 Inhalation, program default parameters
		1	ICRP-30 Inhalation, user-supplied parameters on the *(7003)* line
		2	Ingestion, default to program calculated chronic parameters
		3	Ingestion with user supplied parameters on the *(7004)* line
		4	Ground surface
		5	Air immersion (see caution above)
		6	Water immersion
3	ISW	Integer	Output control:
		-2	Only dose summaries
		-1	Above plus total organ doses
		0	Above plus doses for each element
		1	Above plus doses for each radionuclide
		2	Above plus total crosswind doses for each organ
4	IDU	Integer	Dose unit:
		1	rem
		2	Sv

Word	Program Name	Entry	Description
5	NCH	Integer	Number of elements for which calculation is done:
		0	All elements
		1	As indicated on *Optional Element Selection Lines (7081+)*
6	IONC	Integer	Organ number choice:
		1	Default to all organs
		2	As indicated on the *Optional Selection of Organs Line (7002)*

Dose Calculation Control Line 2 (7001)

Word	Program Name	Entry	Description
1		7001	IMOD on *(7000)* line <6
2	BREATH		Breathing rate (m^3/s) for inhalation calculations. If zero, defaults to 3.33E-4. Use 2.66E-4 for 24-h average breathing rate.
3	TINHA		Decay time (s) for the exponential decay function (see Appendix A, "Leakage Rate Function"). If zero, defaults to the time necessary to give 100% release.
4	TB		Values for the term "TB" depend the type of calculation being made: For acute releases: TB is the number of years that crops are grown on the contaminated soil. TB should be 1. year for dose during the year of intake. Values greater than 1. year give the dose from growing crops on the contaminated soil for the specified number of years. If zero, defaults to 15 years. Ingestion from chronic release: For chronic releases, TB is the years of long-term buildup of activity in the soil. TB should be equal to the plant mid-point of operating life (y). If zero, defaults to 15 years. Ground surface: TB is the time in years that the receptor is exposed to the contaminated ground surface following initiation of the release. If > 0 and <1, a warning that an exposure period of <1 year has been chosen. If zero, defaults to 1 year.
5	BS		Building shielding factor for ground surface calculations. If zero, defaults to 0.7.
			IMOD on *(7000)* line = 6
2	VOLUME		Volume of water (m^3) for water immersion calculations
3	RDTIME		Release duration time (s). If zero, defaults to the time necessary to give 100% [see Series 5000, *Leakage Decay Constants Lines (5201+)*].
4	EETIME		External exposure time period (yr). If zero, defaults to 1 year.
5	STF		Swim time fraction. If zero, defaults to 0.01.

Optional Selection of Organs Line (7002)

Word	Program Name	Entry	Description
1		7002	User selection of organs
2	IO(1)	Integer	Organ number:
.	.		
.	.		
.	.		
N+1	IO(N)		

	Internal	External
1	LUNGS	LUNGS
2	S WALL	STOMACH
3	SI WALL	S INT
4	ULI WALL	UL INT
5	LLI WALL	LL INT
6	GONADS	TESTES
7	BREAST	BREAST
8	BONE SUR	SKELETON
9	R MARROW	RED MARR
10	THYROID	THYROID
11	KIDNEYS	KIDNEYS
12	LIVER	LIVER
13	SPLEEN	SPLEEN
14	PANCREAS	ADRENALS
15	S TISSUE	PANCREAS
16	OTHER[a] (inhalation only)	SKIN
17	OTHER (ingestion only)	BRAIN
18	CEDE[b]	THYMUS
19		BLADDER
20		MARROW
21		HEART
22		OVARIES
23		UTERUS
24		EXT EDE

---

a. OTHER is the sum of other organs in addition to those for which doses are calculated that are included in the remainder (five highest other organs). An approximation of the remainder can be calculated by subtracting the weighted committed dose equivalent doses for the primary organs (gonads, breasts, red bone marrow, lungs, thyroid, and bone surfaces) from the CEDE.

b. When AMAD $\neq$ 1. [word 2 on the *(7003)* line], a request for CEDE automatically gives all organs.

Optional Inhalation Dose Calculation Control Line (7003)

This line is present only if IMOD (word 2) on the *(7000)* line is 1.

Word	Program Name	Entry	Description
1		7003	User-supplied inhalation parameters
2	AMAD		Activity median aerodynamic diameter (μ). If zero, defaults to 1. AMAD must be ≥0.1 μm.
3	ICCI		Clearance class indicator:
		1	Default to program-generated classes
		2	User input of classes on *(703X)* lines

Optional Ingestion Dose Calculation Control Line (7004)

This line is present only if IMOD (word 2) on the *(7000)* line is 3.

Word	Program Name	Entry	Description
1		7004	
2	ITRAN	Integer	Ingestion transfer parameter control: 0 = Program default transfer parameters used 1 = Program default transfer parameters are used and printed out 2 = Read ingestion transfer parameters from external file TRANCON
3	ITYPE	Integer	User control for ingestion calculations 0 = Chronic release with program default parameters 1 = Acute release with program default parameters. Requires ATIME below to be entered. 2 = User-supplied ingestion parameters on *(705X)* lines. Requires ATIME below to be entered.

Word	Program Name	Entry	Description
4	ATIME		Time period (d) that crops are exposed to contamination during the growing season. A time period of ≥60 days signifies a chronic release with vegetable and forage exposure times to the plume as indicated in Series 7000, Ingestion Constants Line 3 (7052). A time period of <60 days signifies an acute release. ITYPE = 0. Variable not used. ITYPE = 1. Time must be between 0.04167 day (1. hour) and <60. day. ITYPE = 2. If zero or > 60., defaults to 60. days. Otherwise, must not be <0.04167.
5	THD		Harvest duration time period (0. ≤ THD < 60.) following an acute release (d). If zero, defaults to 7 days. When the sum of ATIME and THD exceeds ETV [see *(7052)* line], the program automatically decreases the value input for THD to give a sum of ETV days for produce calculations. The program also automatically calculates a value for THD for forage calculations so that the sum of ATIME and THD do not exceed the value of ETM [see *(7052)* line].

Optional Clearance Class by Element Lines (7031+)

These lines are present only if ICCI (word 3) on the *(7003)* line is equal to 2. Make entries in pairs of two: the element's atomic number followed by the clearance class code. Refer to Appendix D for valid clearance classes.

Word	Program Name	Entry	Description
1		Integer	703X (X = 1, 2, ..., etc.).
2	NN	Integer	Atomic number for element.
3	ICI(NN)	Integer	1 = Class D 2 = Class W 3 = Class Y
.	.	.	
.	.	.	
.	.	.	
2N	NN	Integer	
2N+1	ICI(NN)	Integer	

Enter as many pairs of entries on this or following lines as desired.

Optional Ingestion Dose Constants Lines (7051+)

These lines are present only if ITYPE (word 3) on the *(7004)* line is equal to 2.

Ingestion Constants Line 1 (7051).

Word	Program Name	Description	Default Value	Variable Name
1		7051		
2	UFSV	Stored vegetable usage factor (kg/yr wet weight)	520.	U^v
3	UFFV	Fresh vegetable usage factor (kg/yr wet weight)	64.	U^L
4	UFMP	Meat usage factor (kg/yr wet weight)	110.	U^F
5	UFM	Milk usage factor (L/yr)	310.	U^m
6	FG	Fraction of stored vegetables from garden	0.76	f_g
7	FY	Fraction of fresh vegetables from garden	1.0	f_l

Ingestion Constants Line 2 (7052).

Word	Program Name	Description	Default Value	Variable Name
1		7052		
2	RF1	Retention factor for activity on forage	0.57	r
3	RF2	Retention factor for activity on vegetables	0.2	r
4	RFI	Retention factor for iodines on forage	1.0	r
5	RRC	Removal rate constant for crops (1/h)	0.0021	λ_w
6	ETV	Vegetable exposure time to plume for chronic release (d)	60.	t_e
7	ETM	Forage exposure time to plume for chronic release (d)	30.	t_e
8	HRHT	HTO removal half time (d)	1.	λ_p

Ingestion Constants Line 3 (7053).

Word	Program Name	Description	Default Value	Variable Name
1		7053		
2	SD	Effective surface density for soil (kg/m^2)	225.	P
3	THS	Stored vegetable holdup time after harvest (d)	60.	t_h
4	THF	Fresh vegetable holdup time after harvest (d)	1.	t_h
5	QF	Animals daily forage feed (kg/day dry weight)	16.	Q_F
6	TRAN	Feed-milk receptor transfer time (d)	2.	t_f
7	TSLA	Slaughter to consumption time (d)	20.	t_c

Ingestion Constants Line 4 (7054).

Word	Program Name	Description	Default Value	Variable Name
1		7054		
2	FPAST	Fraction of year that animals graze	0.4	f_p
3	FS	Fraction of feed that is pasture when animal grazes on pasture	.43	f_s
4	THSF	Stored feed holdup time (d)	90.	t_h
5	VYV	Vegetable vegetation yield (kg/m^2 wet weight)	2.	Y_v
6	VYM	Forage vegetation yield (kg/m^2 dry weight)	0.28	Y_v
7	HUM	Absolute humidity (g/m^3)	4.9	H

Optional Acute Ingestion Constants Line 4 (7055).

You can omit this line; however, when it is not entered, all acute ingestion constants are set equal to 1.

Word	Program Name	Description	Default Value	Variable Name
1		7055		
2	AFG	Fraction of annual stored vegetables that are contaminated by acute release	0.5[a] 1.0[b]	F_a
3	AFY	Fraction of annual fresh vegetables that are contaminated by acute release	0.33[a] 0.67[b]	F_a
4	AFFS	Fraction of annual stored forage that is contaminated by acute release	0.5[a] 1.0[b]	F_a
5	AFFF	Fraction of annual fresh forage that is contaminated by acute release	0.33[a] 0.67[b]	F_a

a. Crops exposed to contamination between 1 hour and <30 days.

b. Crops exposed to contamination between 30 days and <60 days.

Optional Element Selection Lines (7081+)

These lines are present only if word 5 (NCH) on the *(7000)* line is greater than zero.

Word	Program Name	Entry	Description
1		Integer	708X (X = 1, 2, ..., etc.).
2	NUMBER(1)	Integer	Atomic number of element
.	.		
.	.		
N	NUMBER(N)		

Enter additional values on this and following lines until the number of elements indicated on the *(7000)* line have been entered.

Dose Calculation End Line (7999)

Use this line to end the input for the calculations requested by a *Dose Calculation Control Line 1 (7001)*.

Word	Entry
1	7999

8000 Series—Fifty-Mile Radius Dose Calculation

Use the *Fifty-Mile Dose Selection Line (8000)* to initiate committed population doses within a fifty-file radius of a nuclear facility calculation.

Fifty-Mile Dose Selection Line (8000)

Word	Entry
1	8000

Radionuclide Selection Control (8001)

Word	Program Name	Entry	Description
1		8001	
2	INN	0	Doses are calculated from radionuclide inventory currently in memory from previous 1000 Series calculation or 2000 Series entry. Existing inventory can not contain more than 100 radionuclides with inventories greater than 0.
		1	*Nuclide Selection Lines* will immediately follow this line.

Nuclide Selection Lines

These lines are present only if INN on the *(8001)* line is equal to 1.

Word	Program Name	Entry	Description
1	NUCL	Integer	Radionuclide identification number (see 4000 Series, *Radionuclide Data Change Line*). An alternate entry can be made by replacing NUCL with the element symbol (in capital letters) followed by the mass number and metastable state indicator. Examples of allowable styles include CS137, CS-137, CS 137 BA137M, BA-137M, BA 137M

Make additional line entries until all desired radionuclides have been entered into the radionuclide inventory. The maximum number of radionuclides that can be entered in a fifty-mile dose calculation is 100. An *(8011)* line must follow last radionuclide identification entered.

Model Control Line (8011)

Word	Program Name	Entry	Description
1		8011	
2	ICCI	Integer	Inhalation clearance class indicator:
		0	Default to program generated lung clearance classes
		1	User input of lung clearance classes on *(804X)* lines
3	IDU	Integer	Dose unit:
		1	rem
		2	Sv
4	ING	Integer	Input control for ingestion calculations:
		0	Chronic ingestion dose with program default parameters
		1	Ingestion dose controlled with user supplied parameters on the *(8014)* line
5	IBSF	Integer	Input control for building shielding/exposure factors:
		0	Program-supplied standard parameters
		1	User-supplied factors on the *(8013)* line
6	BREATH		Average breathing rate (m^3/s). If zero, defaults to 2.66E-4 for 24-hour average breathing rate.
7	TB		Values for the term "TB" depend on the type of calculation being made: For acute releases: TB is the number of years that crops are grown on the contaminated soil. TB should be 1. year for dose during the year of intake. Values greater than 1. year give the dose from growing crops on the contaminated soil for the specified number of years. If zero, defaults to 15 years. Ingestion from chronic release: For chronic releases, TB is the years of chronic long-term buildup of activity in the soil. TB should be equal to plant mid-point of operating life (y). If zero, defaults to 15 years.

Word	Program Name	Entry	Description
8	TBG		Ground surface: The time in years that the receptor is exposed to the contaminated ground surface following initiation of the . If > 0 and <1, a warning that an exposure period of <1 year has been chosen. If zero, defaults to 1 year.

Organ Control Line (8012)

Fifty-mile dose calculations can be made for up to a maximum of four organs at a time. Calculations for additional organs can be made by repeating the 8000 Series lines.

Word	Program Name	Entry	Description
1		8012	
2	IO(1)	Integer	1st organ number
3	IO(2)	Integer	2nd organ number
4	IO(3)	Integer	3rd organ number
5	IO(4)	Integer	4th organ number

Organ numbers and names (taken from the internal list) that are valid for the fifty-mile dose calculation are:

Entry	Organ
1	LUNGS
2	S WALL
3	SI WALL
4	ULI WALL
5	LLI WALL
6	GONADS
7	BREAST
8	BONE SUR
9	R MARROW
10	THYROID
11	KIDNEYS
12	LIVER
13	SPLEEN
18	CEDE

Building Shielding/Exposure Factors Line (8013)

This line is present only if IBSF, word 5 on the *(8011)* line, is equal to 1.

Word	Program Name	Entry	Description
1		8013	User input for building shielding/exposure factors. This line is present only when word 5 on the *(8011)* line is equal to 1.
2	BSF		Building shielding factor for deposition calculations. If zero, defaults to 0.70.
3	ASF		Exposure factor for air immersion calculations. If zero, defaults to 1.

Optional Ingestion Dose Control Line (8014)

This line is present only if ING (word 4) on the *(8011)* line is 1.

Word	Program Name	Entry	Description
1		8014	
2	ITRAN	Integer	Ingestion transfer parameter control: 0 = Program default transfer parameters used 1 = Program default transfer parameters are used and printed out 2 = Read ingestion transfer parameters from external file TRANCON
3	ITYPE	Integer	User control for ingestion calculations 0 = Chronic release with program default parameters 1 = Acute release with program default parameters. Requires ATIME below to be entered. 2 = User-supplied ingestion parameters on *(705X)* lines. Requires ATIME below to be entered.
4	ATIME		Time period (d) that crops are exposed to contamination during the growing season. A time period of ≥60 days signifies a chronic release, while a time period of <60 days signifies an acute release.

Word	Program Name	Entry	Description
			ITYPE = 0 Variable not used
			ITYPE = 1 Time must be between 0.04167 day (1. hour) and <60. day
			ITYPE = 2 If zero or > 60., defaults to 60. day. Otherwise must not be <0.04167.
5	THD		Harvest duration time period following an acute release (d). If zero, defaults to 7 days. When the sum of ATIME and THD exceeds ETV [see *(7052)* line], the program automatically decreases the value input for THD to give a sum of ETV days for produce calculations. The program also automatically calculates a value for THD for forage calculations so that the sum of ATIME and THD do not exceed the value of ETM [see *(7052)* line].

Exponential Leakage Time Line (8020)

You can omit the *(8020)* and *(802X)* lines to give a default linear over 1 second.

Word	Program Name	Entry	Description
1		8020	
2	TINHA		Decay time for exponential decay function. If zero defaults to the time necessary to give 100% [see *(5201+)* lines].

Exponential Leakage Constants Lines (8021+)

If the *(8020)* line was omitted (giving default values), these lines also should be omitted.

Word	Program Name	Entry	Description
1		Integer	8021 (X = 1, 2, ...,etc.).
2	K1(1)		Linear constant in leakage rate function (s^{-1})
3	K2(1)		Exponential constant in leakage rate function (s^{-1})

Enter additional sets of two values on this and following lines up to a maximum of 10 sets.

Clearance Class by Element Lines (8041+)

These lines are present only if ICCI (word 2) on *(8011)* line is equal to 1. Make entries in pairs of two: the element's atomic number followed by the clearance class code. Refer to Appendix D for valid clearance classes.

Word	Program Name	Entry	Description
1		Integer	804X (X = 1, 2, ..., etc.).
2	IPOOL(5)	Integer	Atomic number for element.
3	NN	Integer	1 = Class D 2 = Class W 3 = Class Y
.	.	.	
.	.	.	
.	.	.	
2N	NN	Integer	
2N+1	ICC (N)	Integer	

Enter as many pairs of entries on this or following lines as desired.

External Population and Dispersion File Control Line (8050)

This line is present only when the data for the fifty-mile radius population, χ/Qs, and site boundary data [*(8051)* through *(8110)* lines] are read from an external file. Use the first line of the external file for descriptive information. The second line in the external file must be a *(8051)* line. The data in the external file are as described on the subsequent lines, and the next line expected following the *(8050)* line must be the *Deposition Velocity Input Line (8120)*.

Word	Program Name	Entry
1		8050
2	EXTFILE	External filename. The name entered must be a valid DOS file name with no extension.

Fifty-Mile Radius Population Lines (8051+)

You must enter 16 lines for the 16 compass sectors. Sector 1 begins with north, and the remaining sectors progress clockwise.

Word	Program Name	Entry	Description
1		Integer	8050+X (X = 1 to 16). Sector X population for:
2	P(X,1)		0-10 miles
3	P(X,2)		10-20 miles
4	P(X,3)		20-30 miles
5	P(X,4)		30-40 miles
6	P(X,5)		40-50 miles

Fifty-Mile Radius χ/Q Lines (8071+)

Enter the diffusion dispersion coefficients (s/m^3) on these lines for the 16 compass sectors.

Word	Program Name	Entry	Description
1		Integer	8070+X (X = 1 to 16). Sector χ/Q for:
2	CQ(X,1)		0-10 miles
3	CQ(X,2)		10-20 miles
4	CQ(X,3)		20-30 miles
5	CQ(X,4)		30-40 miles
6	CQ(X,5)		40-50 miles

Sector Average Wind Velocity Lines (8091+)

Enter the average wind velocities for the 16 compass sectors.

Word	Program Name	Entry	Description
1		Integer	809X (X = 1, 2, ..., etc.).
2	VEL(1)		Average wind velocity (m/s) for sector 1 (N)
3	VEL(2)		Average wind velocity (m/s) for sector 2 (NNE)
.	.		
.	.		
N	VEL(16)		Average wind velocity (m/s) for sector 16 (NNW)

Enter additional values on this and following lines until average wind velocities for each of the 16 sectors have been entered. All wind velocities must be greater than zero.

Site-Boundary Meteorological Data Line (8110)

Enter meteorological data for the maximum exposed individual located at the site boundary.

Word	Program Name	Entry	Description
1		8110	
2	NSEC	Integer	Sector number for the maximum exposed individual
3	CQSB		χ/Q for the maximum exposed individual (s/m^3)
4	SBD		Distance to the maximum exposed individual (m)
5	WIND		Average wind velocity toward the maximum exposed individual (m/s)

Deposition Velocity Input Line (8120)

Enter deposition velocities.

Word	Program Name	Entry	Description
1		8120	Deposition velocity (m/s) for:
2	DV(1)		solids
3	DV(2)		halogens
4	DV(3)		noble gases
5	DV(4)		cesium
6	DV(5)		ruthenium

Ingestion Dose Constant Lines (8201+)

These lines are present only if ITYPE (word 3) of the *(8014)* line is 2. Enter 5 lines. They are identical to the lines entered in *Optional Ingestion Dose Constants Lines (7051+)* except for word 1, which must be 8201, 8202, 8203, 8204, and 8205, respectively.

Fifty-Mile Radius Dose Calculation End Line (8999)

Use this line to end the input for the calculations initiated by the *(8000)* line.

Word	Entry
1	8999

9000 Series—Cloud Gamma Dose Calculation

Use a *(9000)* control line to initiate a cloud gamma dose calculation.

Word	Program Name	Entry	Description
1		9000	
2	IT	0	All calculations are made using the finite plume model
		1	All calculations are made using the semi-infinite model
3	T		Decay time for the leakage rate function (s). If zero defaults to the time necessary to give 100% [see *(5201+)* lines].
4	IDU	1	Calculate air entrance doses
		2	Calculate external EDE

10000 Series—Calculation End Line

Use this line to signify the end of the current calculation. This line is necessary only if a printout of the time required to run the problem is desired or if a new heading is desired at the top of each page of subsequent calculations. Additional calculations require a new *Calculation Title Line,* which contains an asterisk in column 1.

Word	Entry
1	10000

4.2 Input Line Sequence Flowcharts

RSAC-5 contains nine program series. Each program series performs a type of calculation and operates together or independently of the others, depending on the analysis being performed. These series are identified by input lines that are multiples of 1000. The allowable sequence of input series is shown in Figure 4-1. As the flow arrows show, most series can be input in any sequence. However, some general input sequences must be followed to run dose calculations, collect data, and print summary dose tables.

A radionuclide inventory must be established (Series 1000 and 2000) before the inventory can be decayed and printed out (Series 6000). In addition, a radionuclide inventory must be established before a dose calculation (Series 7000 and 9000, and sometimes 8000) is run.

The Series 3000 dose summary option must be requested at specific points in the input. RSAC-5 will not collect detailed dose summary data if you have not identified a need for the data. Therefore, if you want detailed dose summary data, you must instruct the program to collect it. The 3000 Series must be initiated after you input meteorological data (Series 5000). The 5000 Series can be changed after you initiate the 3000 Series; however, the downwind distance cannot be changed after you initiate the dose summary option. In addition, you must request the printing of summary dose tables after all of the dose calculations have been made.

Figures 4-2 through 4-9 present the allowable sequences of input lines for each series.

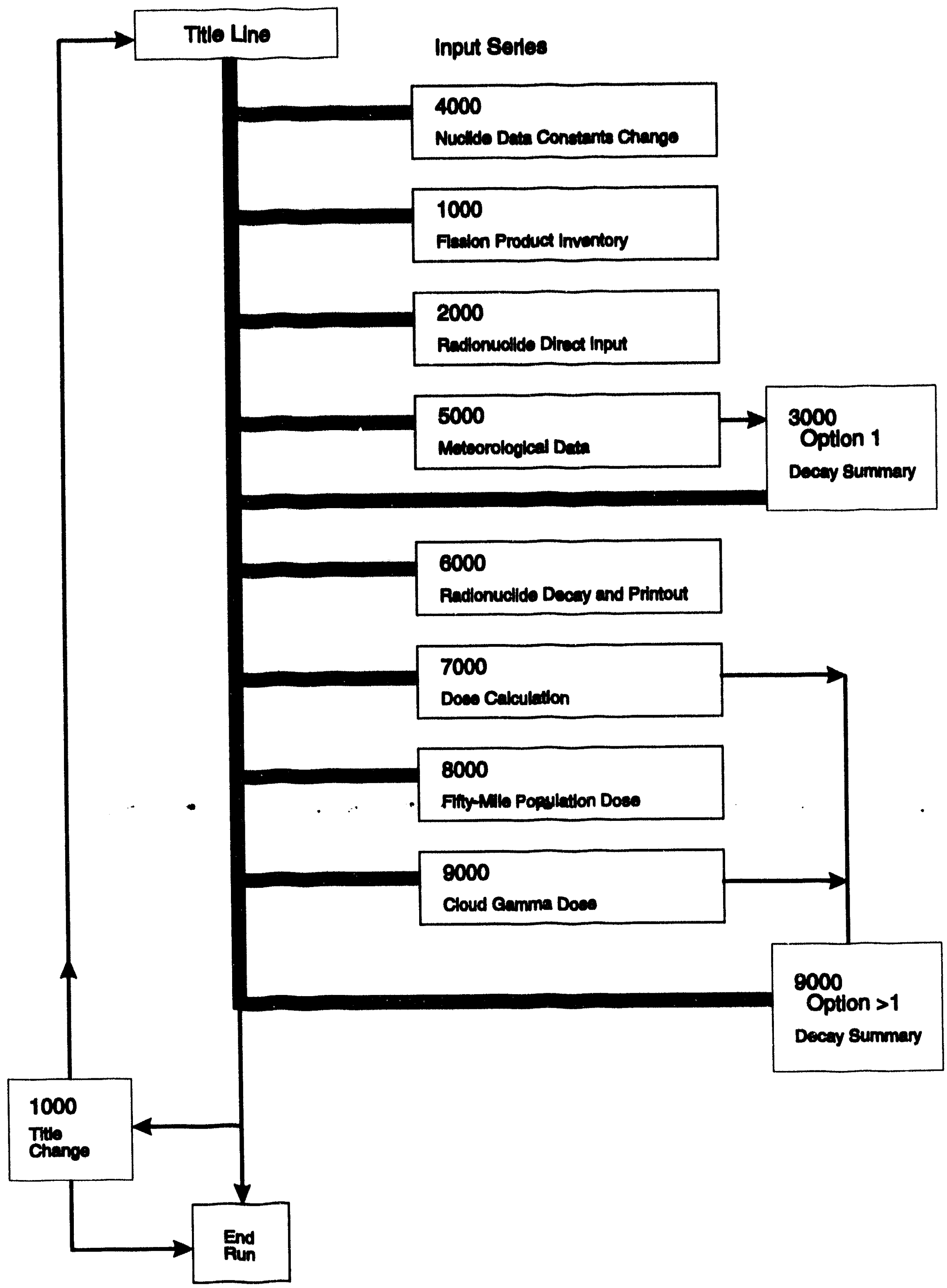

Figure 4-1. General sequences of RSAC-5 input.

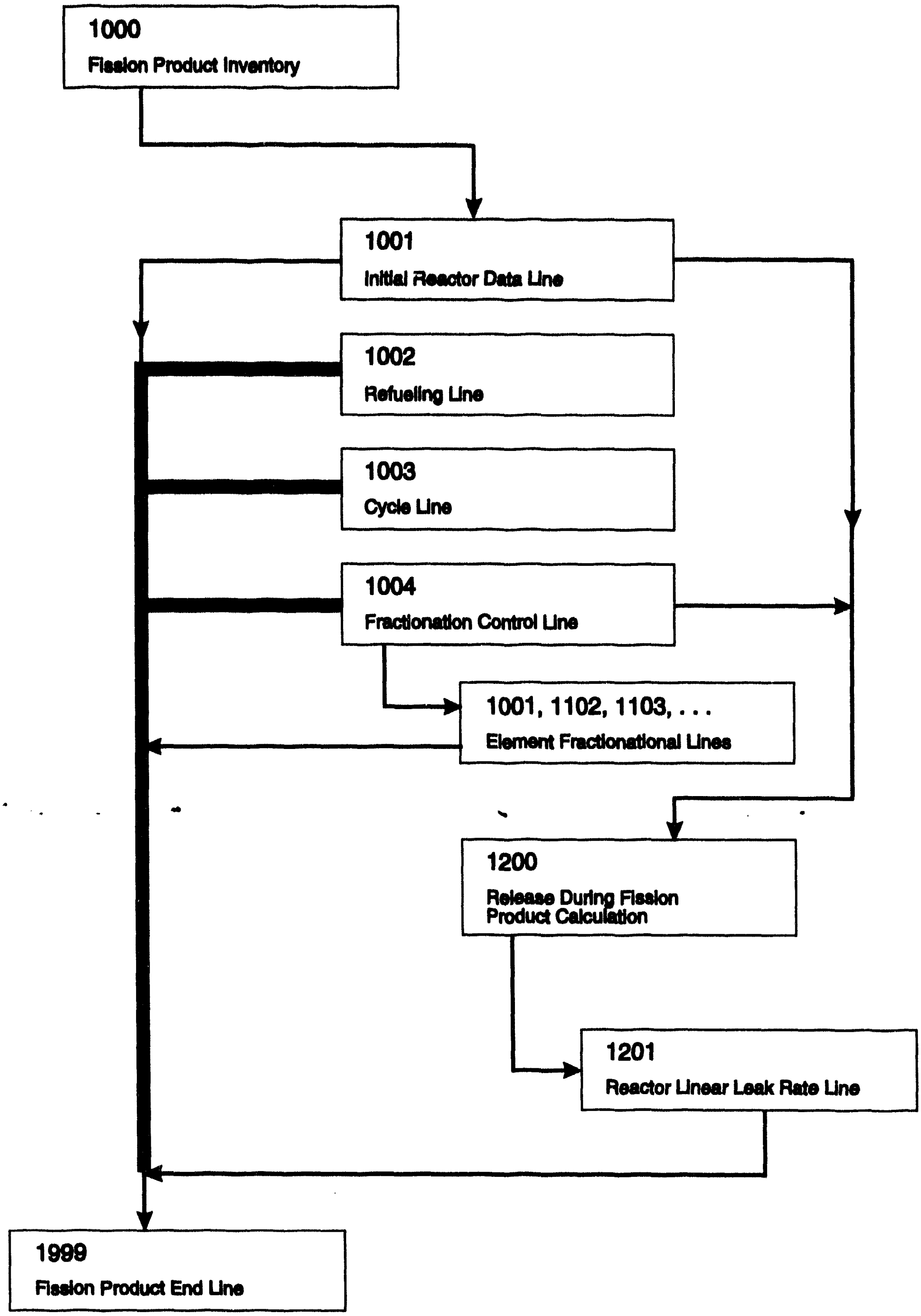

Figure 4-2. Sequence of fission product inventory calculation.

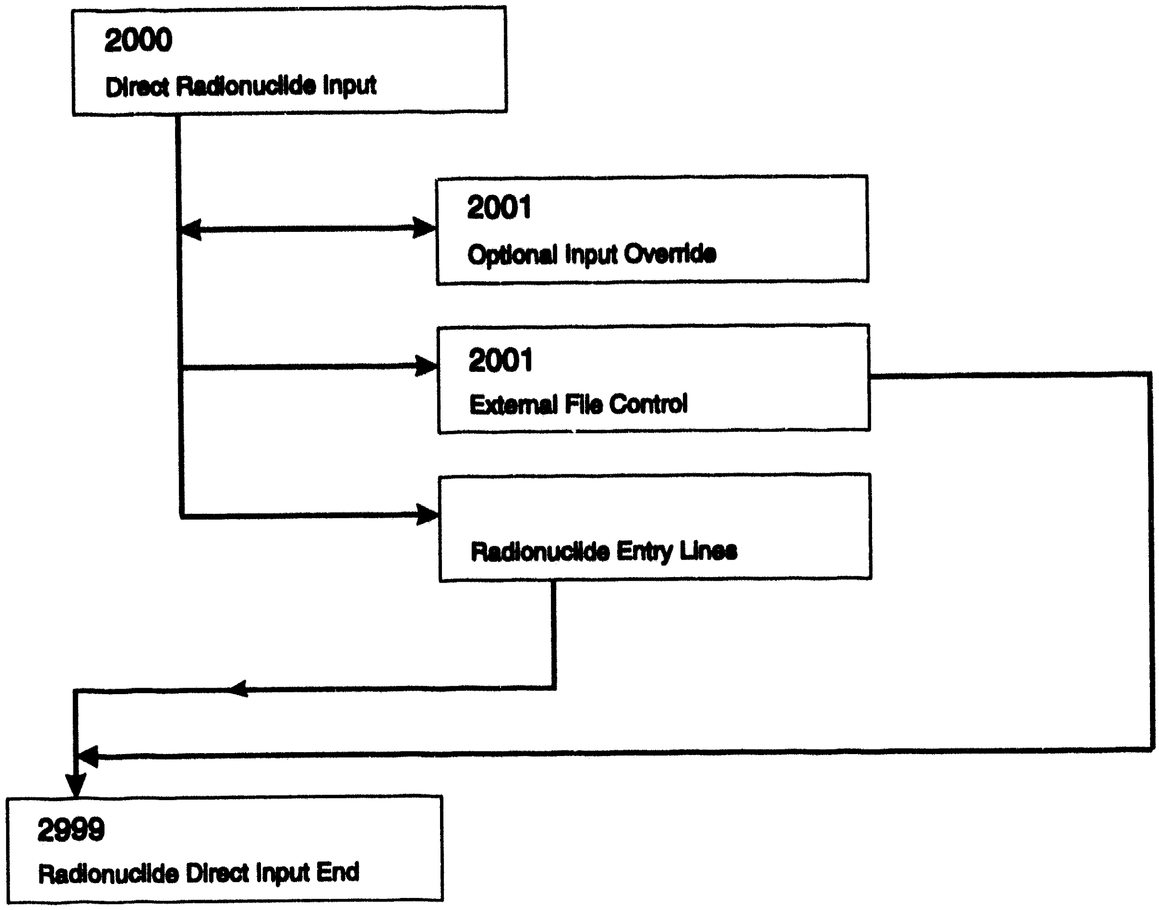

Figure 4-3. Sequence of direct radionuclide input.

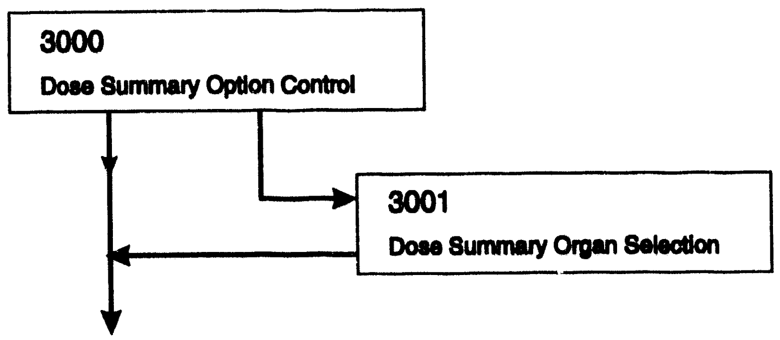

Figure 4-4. Sequence of dose summary option.

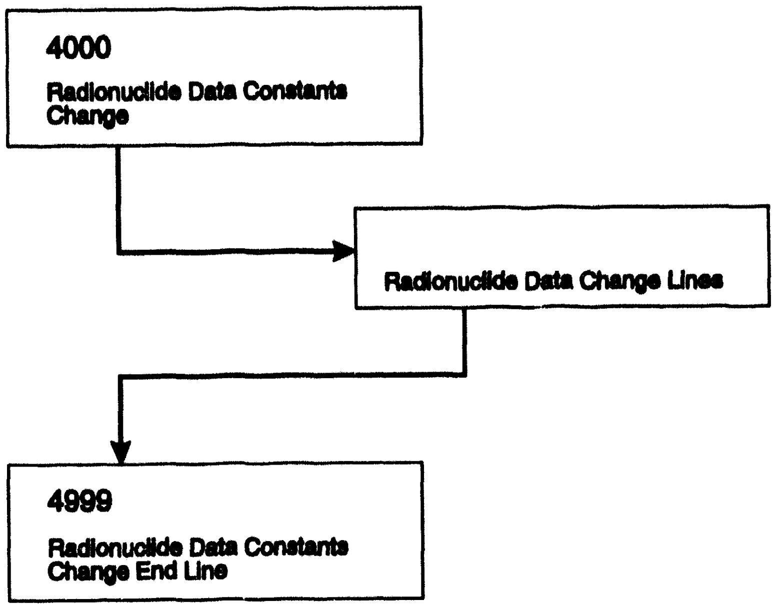

Figure 4-5. Sequence of radionuclide data constants change.

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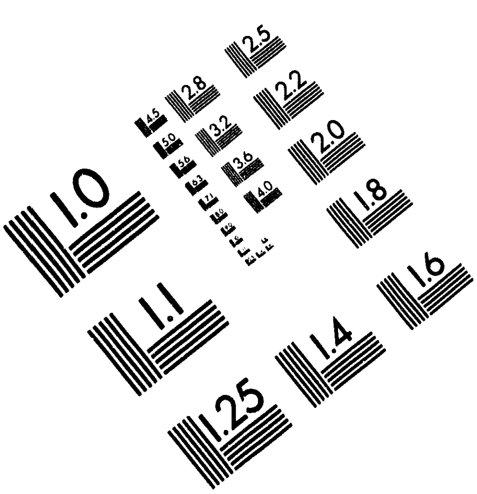

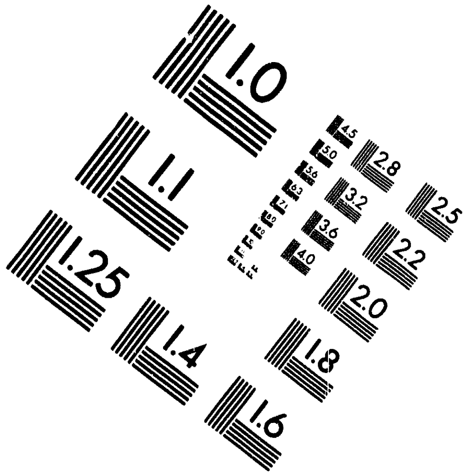

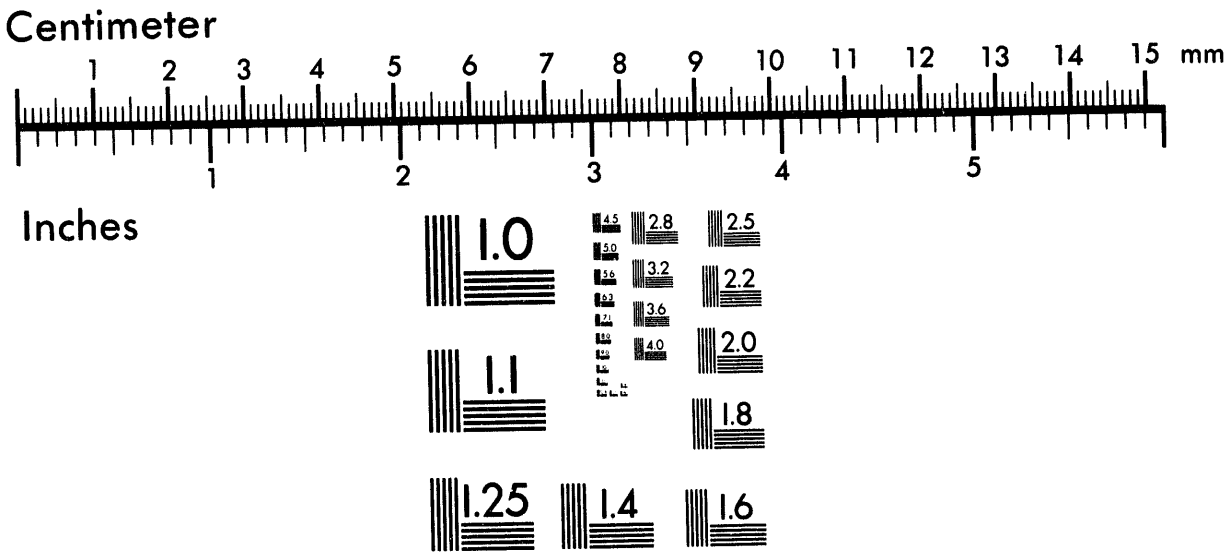

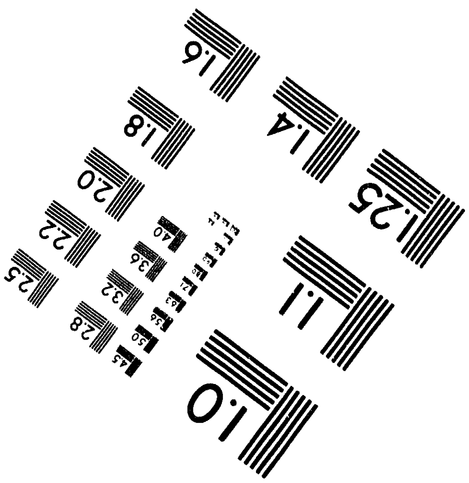

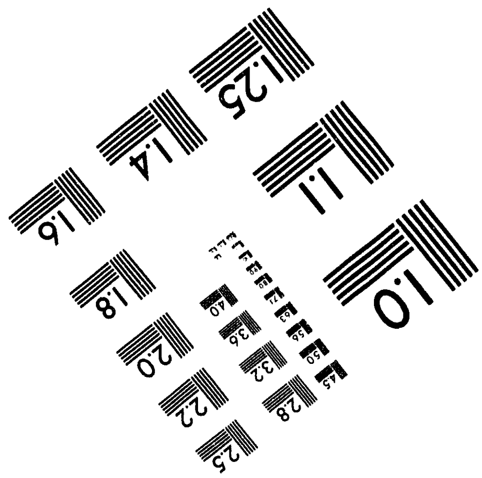

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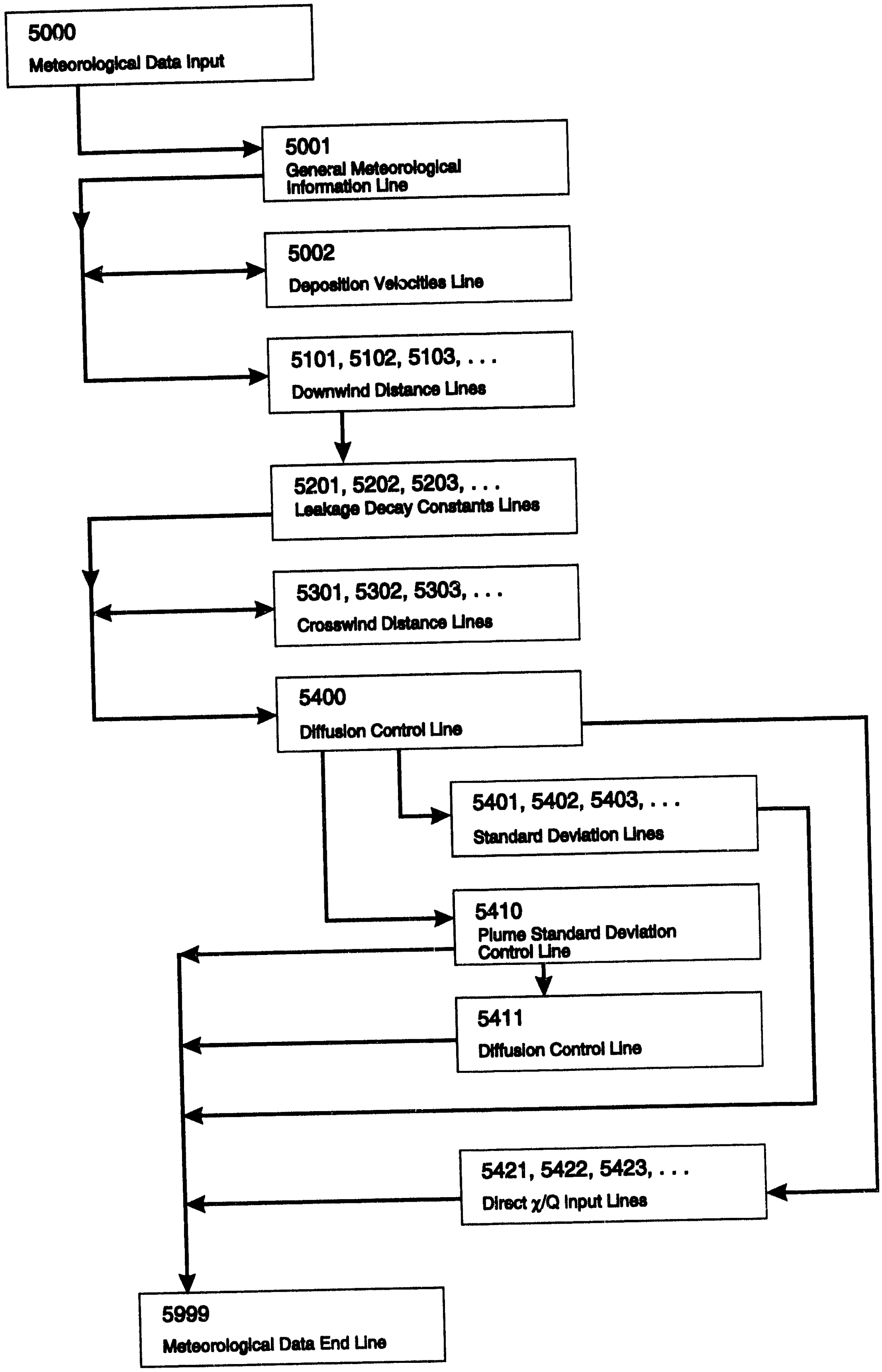

Figure 4-6. Sequence of meteorological data input.

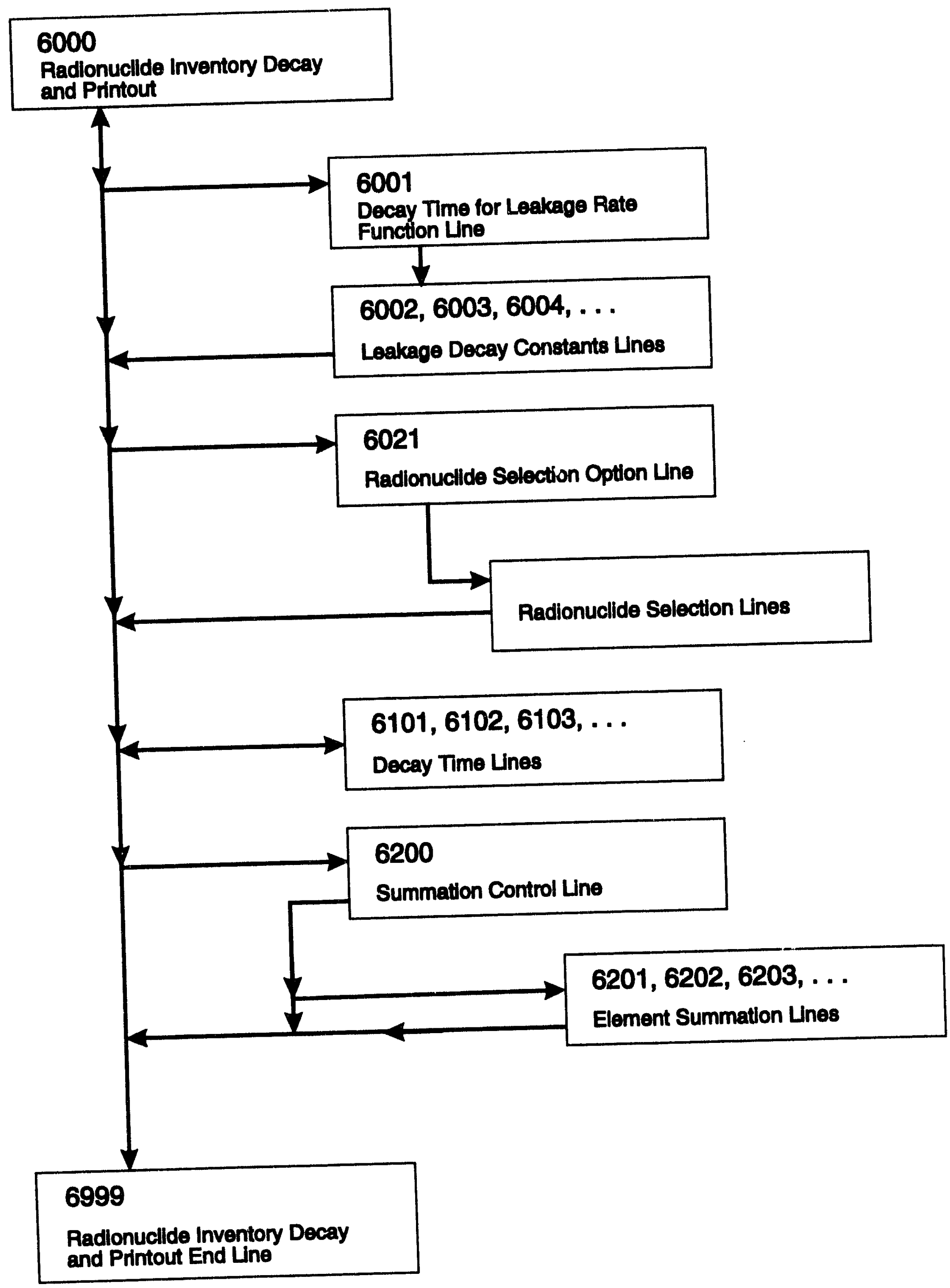

Figure 4-7. Sequence of radionuclide inventory decay and printout.

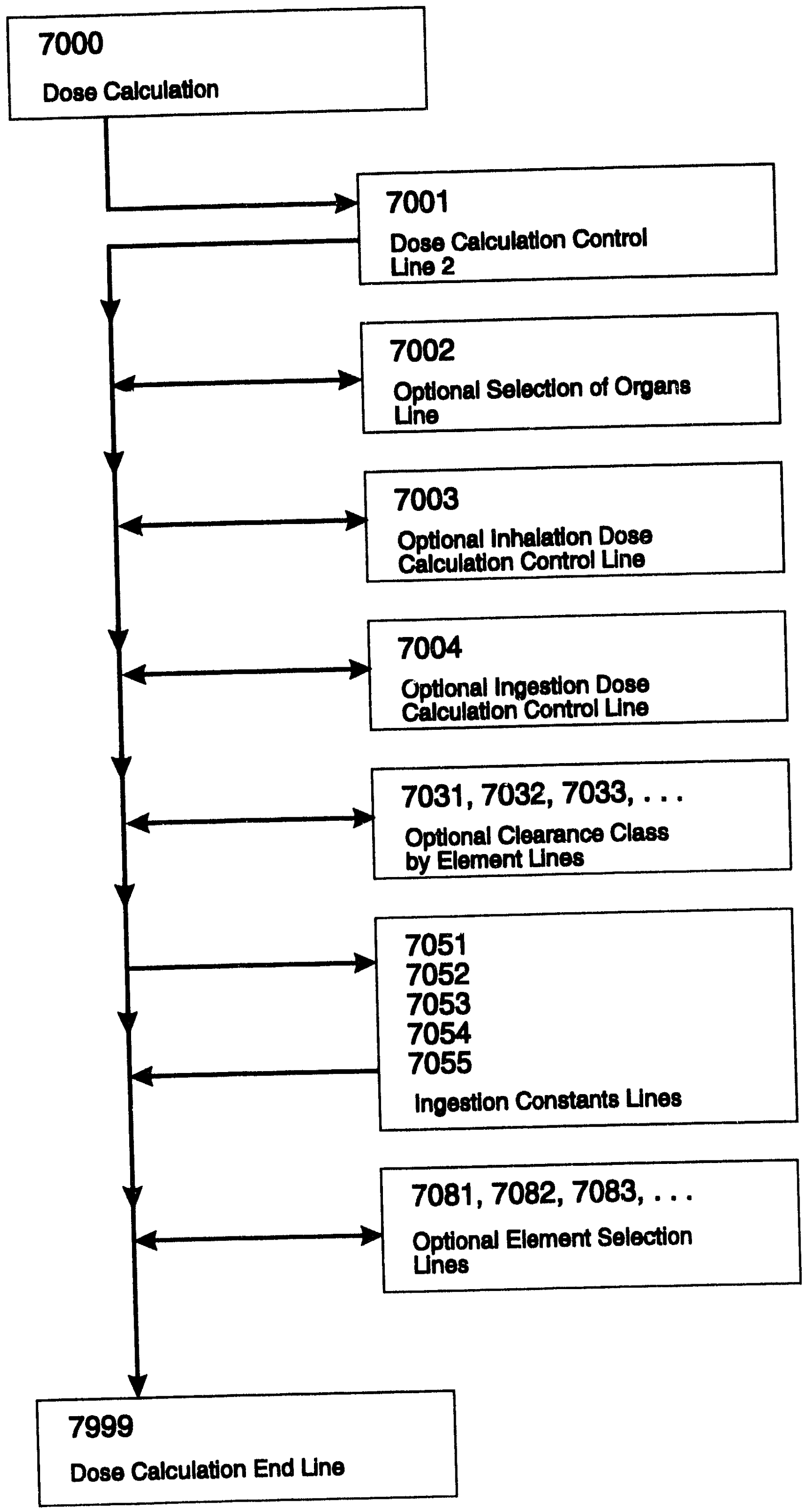

Figure 4-8. Sequence of dose calculation.

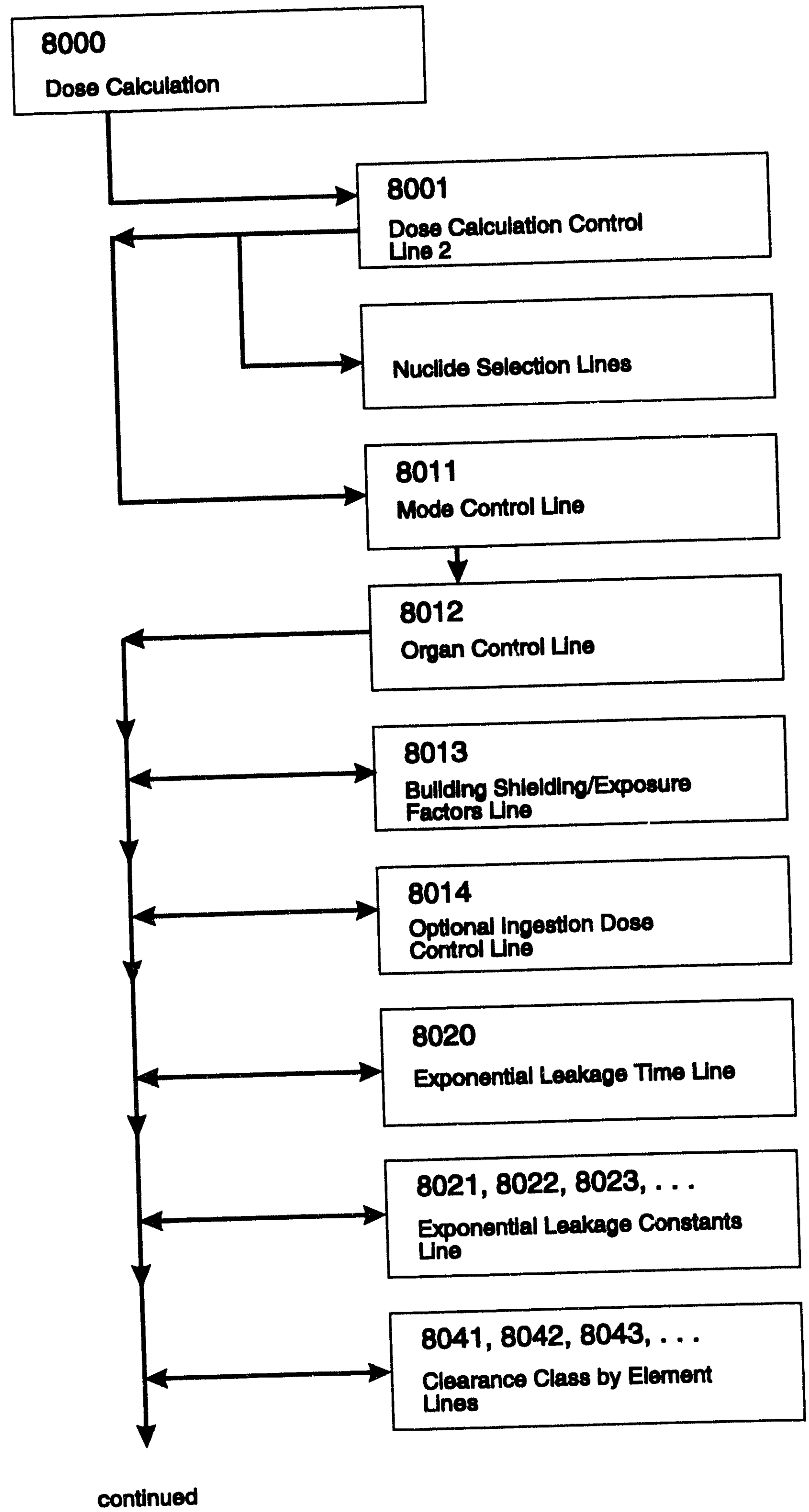

Figure 4-9. Sequence of fifty-mile radius dose calculations.

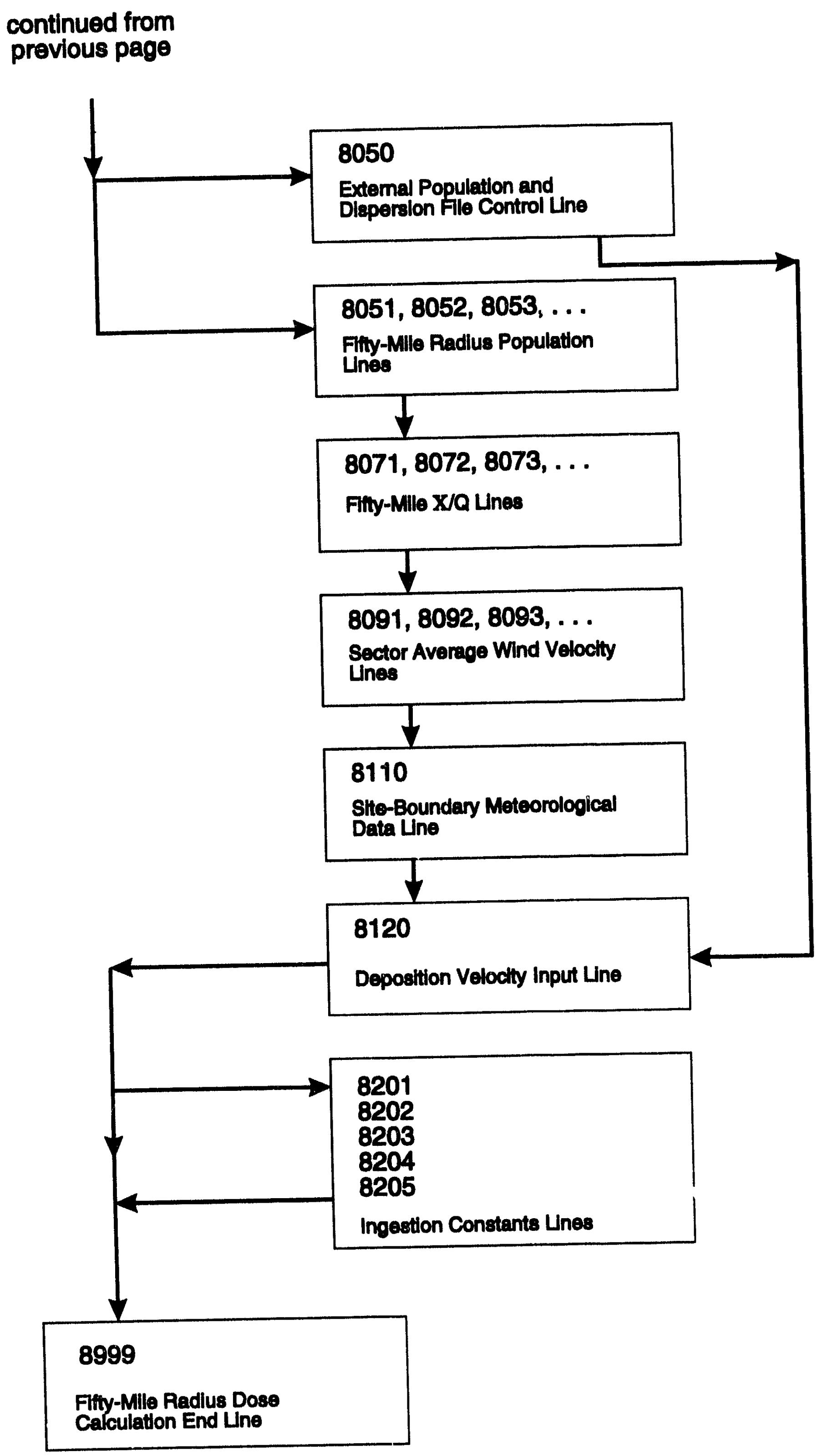

Figure 4-9. (continued)

5. EXAMPLE RSAC-5 RUNS

RSAC-5 is provided with nine examples that are useful in helping you learn how to run RSAC-5. Initially, the examples must be run using the RSAC+ program. After ASCII files have been created using RSAC+, the examples can be run directly with RSAC-5. The ASCII inputs printed in this section for the example runs have been annotated. Many of the steps in the examples have been added solely to demonstrate the capabilities of RSAC-5.

Example 1: Simulated Reactor Operation

This example demonstrates fission product inventory calculation for a reactor that operates at a power level of 50 MW for a period of 50 days (4.32E6 seconds). At the end of the reactor operation, the inventory is fractionated to retain 1% solids, 25% halogens, 100% noble gases, 1% cesium, and 1% ruthenium. A printout of the inventory of only iodines is requested for decay times of 7., 30. and 90. days. The inventory printout has been limited to only those radioiodines with positive values at or following the first decay time of 7. days.

```
 example1     RSAC-5 INPUT     09/15/93     15:13
0        1         2         3         4         5         6         7
1234567890123456789012345678901234567890123456789012345678901234567890123456789

* Simulated reactor operation
#
#                    Comments can be placed on data lines following
#                    an * when ASCII input files for RSAC-5 are prepared.
#                    There must be at least 1 blank space between the last
#                    character in the input and the *.  Additional comments
#                    may be inserted anywhere between the first and last lines
#                    by inserting # in column 1.  RSAC+ only inserts comments
#                    between input lines using the # sign in column 1.
#
1000                       * Requests a fission product inventory calculation
#
1001,0,5.E7,4320000.            * 5.E7 watts of power for 4.32E6 seconds
#
1004,-1,0.01,0.25,1.,0.01,0.01  * Fractionating inventory by group
#                                    1% solids, 25% halogens, 100% noble gases
#                                    1% Cs and 1% Ru
#
1999                       * End of fission product inventory calculation
#
6000,1,2,0,0         * Requests fission product inventory decay and printout
#
#                            Requesting listing of only selected radionuclides
#
#                            Limiting listing to only those radionuclides with
#                            positive values at or following the first
#                            requested decay time
#
6021                       * Initiates input of selected radionuclides
#
 I129                      * Entering iodines only for printout
 I130M
 I130
 I131
 I132
 I133M
 I134M
 I134
 I135
 I136M
 I136
 I137
 I138
 I139
 I140
 I141

0        1         2         3         4         5         6         7
1234567890123456789012345678901234567890123456789012345678901234567890123456789
```

```
 example1     RSAC-5 INPUT      09/15/93     15:13
0         1         2         3         4         5         6         7
1234567890123456789012345678901234567890123456789012345678901234567890123456789

 I142
 I143
 I144
#
6101,4,7.,30.,90.          * Decay times of 7., 30. and 90. days
#                              Zero time is automatically given
#
6999                   * End of fission product decay and printout
#
10000                  * End of the run

0         1         2         3         4         5         6         7
1234567890123456789012345678901234567890123456789012345678901234567890123456789
```

```
            RADIOLOGICAL SAFETY ANALYSIS COMPUTER PROGRAM (RSAC-5)
(RSAC-5E,REV 5.1,08/09/93) SERIAL  700  DATE  09/15/93  TIME 15:13  PAGE   1
example1:  Simulated reactor operation

***FISSION PRODUCT CALCULATION

    THE REACTOR HAS OPERATED AT  5.000E+07 WATTS FOR   4.320E+06 SECONDS
          BURNUP =  2.500E+03 MWd

    FRACTIONATION BY ELEMENT GROUP
      SOLIDS = 1.000E-02   HALOGENS = 2.500E-01   NOBLE GASES = 1.000E+00
      CESIUM = 1.000E-02   RUTHENIUM = 1.000E-02

    TOTAL RADIONUCLIDE RELEASE =  1.536E+18  D/s OR  4.153E+07 Ci

***DECAY CALCULATION
```

```
         RADIOLOGICAL SAFETY ANALYSIS COMPUTER PROGRAM (RSAC-5)
(RSAC-5E,REV 5.1,08/09/93) SERIAL  700  DATE  09/15/93  TIME 15:13  PAGE   2
example1:  Simulated reactor operation

          DECAY CALCULATION -- CURIES          DECAY TIMES IN DAYS

 SUPPRESSING NUCLIDES WITH ZERO INVENTORY AT AND FOLLOWING 7.00E+00 DAYS

     NUCLIDE        HALF LIFE         0.00E+00  7.00E+00  3.00E+01  9.00E+01
 -------------    --------------      --------  --------  --------  --------
 531290  I-129    1.57E+07  YRS       4.07E-04  4.07E-04  4.07E-04  4.08E-04
 531300  I-130    1.24E+01  HRS       8.51E+01  6.92E-03  0.00E+00  0.00E+00
 531310  I-131    8.04E+00  DAY       2.91E+05  1.60E+05  2.20E+04  1.25E+02
 531320  I-132    2.30E+00  HRS       4.40E+05  4.08E+03  3.06E+01  8.75E-05
 531350  I-135    6.61E+00  HRS       6.44E+05  1.44E-02  0.00E+00  0.00E+00

    EXECUTION TIME =  3.29E+00 SECONDS
```

Example 2: Calculation of Inhalation Dose

The radionuclide inventory for this example has been entered directly using the 2000 Series option. The inventory consists of 0.15 Ci of Sr-90 and Y-90. The short-lived daughters of radionuclides should be entered along with their parents unless sufficient decay time has been provided to allow the short-lived daughters to buildup to equilibrium. RSAC-5 will automatically decay and ingrow progeny during the downwind transport time. However, in this example, the transport time to the downwind receptor is insufficient to allow the Y-90 buildup into equilibrium.

The release is assumed to occur at ground level with an average wind velocity of 4.5 m/s. A mixing layer depth of 1,000 m has been entered along with the default air density for the Idaho National Engineering Laboratory. No credit for plume depletion has been taken. This option may only be requested when the program is requested to calculate the meteorological diffusion. However, in this example standard deviations of the plume are entered directly to demonstrate how to use the option. Thus, while deposition velocities have been entered, they do not have an affect on the calculation.

The release has been decay corrected for a linear release occurring over a period of 15 minutes. While decay correction has little affect on the results from this example, it can significantly affect the subsequent dose calculations when short-lived radionuclides are present.

Two downwind distances and three crosswind distances have been specified for the subsequent dose calculations. RSAC+ will not allow downwind distances of less than 100 meters to be entered. However, when standard deviations of the plume are entered directly by the user as in this example, any downwind distance may be selected if RSAC-5 is run directly from an ASCII input file. When this is done, the burden of certifying the validity of the meteorological diffusion is placed on the user.

In this example, doses from the inhalation pathway are requested for only selected organs. In addition, dose calculations are requested for only Sr and Y, which speeds up the calculation time. A standard high breathing rate of 3.33E-04 m^3/s is used and doses are calculated using rem units. Doses are also calculated using the default RSAC-5 lung clearance classes.

```
 example2     RSAC-5 INPUT      09/15/93      15:13
0        1         2         3         4         5         6         7
1234567890123456789012345678901234567890123456789012345678901234567890123456789

* Calculation of inhalation dose
#
2000,0                  * Entering radionuclides directly
SR 90,0.15                     * 0.15 Ci Sr-90
Y 90,0.15                      * 0.15 Ci  Y-90
2999                    * End of direct radionuclide input
#
5000                  * Requests input of meteorological data
5001,4.5,0,1000.,1.099E3,0,0     * 4.5 m/s average wind velocity
#                                  Ground level release
#                                  1000 m mixing layer depth
#                                  1099. g/cubic m air density
#                                  No plume depletion by wet deposition
#                                  No plume depletion by dry deposition
#
5002,0.001,0.01,0,0.001,0.001    * Entering deposition velocities
#                                      0.001 m/s for solids, Cs and Ru
#                                      0.01 for halogens
#                                      0.0 for noble gases
#
5101,1.E2,1.5E2                  * Requesting doses for 2 downwind distances
#                                      100. and 150. meters
#
5201,0.001111,0                  * Decay correct for a linear release over
#                                  15 minutes
#
5301,10.,20.,30.                 * Calculating crosswind doses for 3 distances
#
5400,1,60.,10.6,1.               * Using option for user input of plume standard
#                                  deviations
#                                        Requesting correction for building wake
#                                            60. meter wide by 10.6 meters high
#                                            Using building wake coef of 1.
#
5401,15.,8.,20.,11.              * Standard deviations inserted in pairs of 2
#                                        100 meter distance
#                                             sigy = 15. m, sigz = 8. m
#                                        150 meter distance
#                                             sigy = 20. m, sigz = 11. m
#
5999                         * End of meteorological input
#
7000,0,2,1,1,2               * Requesting inhalation dose calculation
#                                        Using program default parameters
#
#                                        Requesting dose printout for each

0        1         2         3         4         5         6         7
1234567890123456789012345678901234567890123456789012345678901234567890123456789
```

```
 example2     RSAC-5 INPUT     09/15/93     15:13
0         1         2         3         4         5         6         7
12345678901234567890123456789012345678901234567890123456789012345678901234567890

#                                       radionuclide and organ with crosswind
#                                       doses for each organ
#
#                                       Doses in rem, for selected elements
#                                       and organs
#
7001,3.33E-4,0,0,0              * High breathing rate of 3.33E-4 cubic m/s
#                                       Defaulting to program calculated
#                                       decay function time which gives a
#                                       100% release of the inventory
#
7002,1,4,5,18                   * Calculating dose for LUNGS, ULI WALL, LLI
#                                 WALL and CEDE
#
7081,38,39                      * Calculating dose for Sr and Y only
#
7999                       * End of dose calculation
#
10000                      * End of run

0         1         2         3         4         5         6         7
12345678901234567890123456789012345678901234567890123456789012345678901234567890
```

```
            RADIOLOGICAL SAFETY ANALYSIS COMPUTER PROGRAM (RSAC-5)
(RSAC-5E,REV 5.1,08/09/93) SERIAL  700  DATE  09/15/93  TIME 15:13  PAGE   1
example2:  Calculation of inhalation dose

***DIRECT RADIONUCLIDE INPUT

       ANY PREVIOUS INVENTORY HAS BEEN ZEROED

    NUCLIDE            HALF LIFE       CURIES

 380900   Sr 90    2.912E+01  yr    1.500E-01
 390900    Y 90    6.410E+01  h     1.500E-01

***METEOROLOGICAL DATA

       MEAN WIND SPEED = 4.500E+00 (m/s)    STACK HEIGHT = 0.000E+00 (m)
   MIXING LAYER HEIGHT = 1.000E+03 (m)       AIR DENSITY = 1.099E+03 (g/cu m)
   WET DEPOSITION SCAVENGING COEFFICIENT = 0.000E+00 (1/S)

   NO CORRECTION IS BEING MADE FOR CLOUD DEPLETION BY DRY DEPOSITION

   DEPOSITION VELOCITIES (m/s)
        SOLIDS = 1.000E-03    HALOGENS = 1.000E-02   NOBLE GASES = 0.000E+00
        CESIUM = 1.000E-03   RUTHENIUM = 1.000E-03

   THERE IS 1 SET OF LEAKAGE CONSTANTS (K1,K2)
         1.111E-03      0.000E+00

   CROSSWIND DISTANCES -- METERS

          1.000E+01       2.000E+01       3.000E+01


   BUILDING WIDTH =  6.000E+01 (m)   BUILDING HEIGHT =  1.060E+01 (m)
   BUILDING WAKE COEFFICIENT =  1.000E+00

   DOWNWIND DISTANCE  EFFECTIVE STACK   SIGY         SIGZ         CHI/Q
                         HEIGHT (m)      (m)          (m)        (s/cu m)
        1.000E+02         0.000E+00   1.500E+01   8.000E+00   2.096E-04
        1.500E+02         0.000E+00   2.000E+01   1.100E+01   1.602E-04

 *** INHALATION DOSE EQUIVALENT CALCULATION

                          BREATHING RATE =  3.330E-04 (cu m/s)
                  RELEASE TIME FOR EXPONENTIAL DECAY FUNCTION =  9.001E+02 (s)
      INTERNAL EXPOSURE TIME PERIOD  =  5.000E+01 (yr)

   PARTICLE SIZE =  1.0 MICRONS AMAD
   LUNG DEPOSITION FRACTIONS: N-P = 0.300  T-B = 0.080  P = 0.250

 LUNG CLEARANCE CLASSES USED IN CALCULATIONS
     ELEMENT     CLASS

     38   Sr       D
     39    Y       Y
```

```
             RADIOLOGICAL SAFETY ANALYSIS COMPUTER PROGRAM (RSAC-5)
(RSAC-5E,REV 5.1,08/09/93) SERIAL  700  DATE  09/15/93  TIME 15:13  PAGE   2
example2:  Calculation of inhalation dose

   DOWNWIND DISTANCE =  1.000E+02  (m)    PLUME TRAVEL TIME =  2.222E+01 (s)
                                          CHI/Q =  2.096E-04 (s/cu m)

       LUNGS     INHALATION     ISOTOPE     NUCLIDE     CDE(rem)    WCDE (rem)

                                Y -  90      390900     3.56E-04     4.27E-05

                           TOTAL  Y (ATOMIC NO 39)      3.56E-04     4.27E-05

                       TOTAL LUNGS    INHALATION =      3.56E-04     4.27E-05
                              CROSSWIND  DISTANCE        DOSE
                                         1.000E+01      3.17E-04
                                         2.000E+01      2.23E-04
                                         3.000E+01      1.24E-04

       ULI WALL INHALATION      ISOTOPE     NUCLIDE     CDE(rem)    WCDE (rem)

                                Y -  90      390900     2.09E-04     1.26E-05

                           TOTAL  Y (ATOMIC NO 39)      2.09E-04     1.26E-05

                       TOTAL ULI WALL INHALATION =      2.09E-04     1.26E-05
                              CROSSWIND  DISTANCE        DOSE
                                         1.000E+01      1.86E-04
                                         2.000E+01      1.31E-04
                                         3.000E+01      7.31E-05

       LLI WALL INHALATION      ISOTOPE     NUCLIDE     CDE(rem)    WCDE (rem)

                                Y -  90      390900     5.03E-04     3.02E-05

                           TOTAL  Y (ATOMIC NO 39)      5.03E-04     3.02E-05

                       TOTAL LLI WALL INHALATION =      5.03E-04     3.02E-05
                              CROSSWIND  DISTANCE        DOSE
                                         1.000E+01      4.47E-04
                                         2.000E+01      3.15E-04
                                         3.000E+01      1.75E-04

       CEDE      INHALATION     ISOTOPE     NUCLIDE    CEDE(rem)

                               Sr -  90      380900     2.41E-03

                           TOTAL Sr (ATOMIC NO 38)      2.41E-03

                                Y -  90      390900     8.59E-05
```

```
          RADIOLOGICAL SAFETY ANALYSIS COMPUTER PROGRAM (RSAC-5)
(RSAC-5E,REV 5.1,08/09/93) SERIAL  700  DATE  09/15/93  TIME 15:13  PAGE   3
example2:  Calculation of inhalation dose

    DOWNWIND DISTANCE =  1.000E+02    CEDE     INHALATION DOSE EQUIVALENT

       CEDE      INHALATION    ISOTOPE    NUCLIDE    CEDE(rem)


                         TOTAL  Y (ATOMIC NO 39)      8.59E-05

                     TOTAL CEDE     INHALATION =      2.49E-03
                            CROSSWIND  DISTANCE        DOSE
                                       1.000E+01      2.22E-03
                                       2.000E+01      1.56E-03
                                       3.000E+01      8.70E-04

   DOWNWIND DISTANCE =  1.500E+02 (m)     PLUME TRAVEL TIME =  3.333E+01 (s)
                                          CHI/Q =  1.602E-04 (s/cu m)

       LUNGS     INHALATION    ISOTOPE    NUCLIDE     CDE(rem)    WCDE (rem)

                               Y -  90     390900     2.72E-04     3.27E-05

                         TOTAL  Y (ATOMIC NO 39)      2.72E-04     3.27E-05

                     TOTAL LUNGS    INHALATION =      2.72E-04     3.27E-05
                            CROSSWIND  DISTANCE        DOSE
                                       1.000E+01      2.50E-04
                                       2.000E+01      1.95E-04
                                       3.000E+01      1.29E-04

       ULI WALL INHALATION    ISOTOPE    NUCLIDE     CDE(rem)    WCDE (rem)

                               Y -  90     390900     1.60E-04     9.60E-06

                         TOTAL  Y (ATOMIC NO 39)      1.60E-04     9.60E-06

                     TOTAL ULI WALL INHALATION =      1.60E-04     9.60E-06
                            CROSSWIND  DISTANCE        DOSE
                                       1.000E+01      1.47E-04
                                       2.000E+01      1.15E-04
                                       3.000E+01      7.58E-05
```

```
              RADIOLOGICAL SAFETY ANALYSIS COMPUTER PROGRAM (RSAC-5)
(RSAC-5E,REV 5.1,08/09/93) SERIAL  700  DATE  09/15/93  TIME 15:13  PAGE   4
example2:  Calculation of inhalation dose

    DOWNWIND DISTANCE =  1.500E+02    LLI WALL INHALATION DOSE EQUIVALENT

       LLI WALL INHALATION    ISOTOPE    NUCLIDE    CDE(rem)   WCDE (rem)

                              Y -  90     390900    3.84E-04     2.31E-05

                          TOTAL  Y (ATOMIC NO 39)   3.84E-04     2.31E-05

                      TOTAL LLI WALL INHALATION =   3.84E-04     2.31E-05
                             CROSSWIND  DISTANCE      DOSE
                                        1.000E+01   3.54E-04
                                        2.000E+01   2.76E-04
                                        3.000E+01   1.82E-04

       CEDE      INHALATION    ISOTOPE    NUCLIDE   CEDE(rem)

                             Sr -  90     380900    1.84E-03

                          TOTAL Sr (ATOMIC NO 38)   1.84E-03

                              Y -  90     390900    6.56E-05

                          TOTAL  Y (ATOMIC NO 39)   6.56E-05

                      TOTAL CEDE     INHALATION =   1.91E-03
                             CROSSWIND  DISTANCE      DOSE
                                        1.000E+01   1.75E-03
                                        2.000E+01   1.37E-03
                                        3.000E+01   9.03E-04

&&      INHALATION COMMITTED DOSE EQUIVALENTS ORDERED BY ORGAN (rem)

                DOWNWIND DISTANCES (m)
   ORGAN    NO.  1.00E+02  1.50E+02
 --------   ---  --------  --------
 LUNGS       1   3.56E-04  2.72E-04
 ULI WALL    4   2.09E-04  1.60E-04
 LLI WALL    5   5.03E-04  3.84E-04
```

```
             RADIOLOGICAL SAFETY ANALYSIS COMPUTER PROGRAM (RSAC-5)
(RSAC-5E,REV 5.1,08/09/93) SERIAL  700  DATE  09/15/93  TIME 15:13  PAGE   5
example2:  Calculation of inhalation dose

&&      INHALATION COMMITTED DOSE EQUIVALENCES ORDERED BY DOSE (rem)

                    DOWNWIND DISTANCES (m)
   ORGAN    NO.   1.00E+02  1.50E+02
 --------   ---   --------  --------
 LUNGS       1    3.56E-04  2.72E-04
 ULI WALL    4    2.09E-04  1.60E-04
 LLI WALL    5    5.03E-04  3.84E-04

&&      INHALATION WEIGHTED COMMITTED DOSE EQUIVALENTS (rem)

                    DOWNWIND DISTANCES (m)
   ORGAN    NO.   1.00E+02  1.50E+02
 --------   ---   --------  --------
 LUNGS       1    4.27E-05  3.27E-05
 ULI WALL    4    1.26E-05  9.60E-06
 LLI WALL    5    3.02E-05  2.31E-05
 CEDE       18    2.49E-03  1.91E-03

   EXECUTION TIME =  8.35E+00 SECONDS
```

Example 3: Ingestion Dose Calculation from an Acute Release

This example uses the 2000 Series option to directly input the radionuclide inventory. The release is assumed to occur at ground level with a 4 m/s average wind velocity.

Because no additional decay of the radionuclide inventory is desired during holdup before release, a linear release over a period of 1 second has been requested. In this example, χ/Q values are entered directly. When χ/Q values of standard deviations are entered directly, no plume depletion correction can be requested. However, in contrast to Example 2, deposition velocities must be entered to determine the amount of activity deposited on the ground and plant surfaces.

Ingestion doses have been requested for all organs and only selected elements. In this example, doses are calculated using the unit of Sv. The acute release is assumed to occur over a period of 1 day followed by a 7 day harvest period. The option for user supplied ingestion parameters has been requested to demonstrate how the standard default parameters can be changed.

```
 example3     RSAC-5 INPUT      09/15/93      15:13
0        1         2         3         4         5         6         7
1234567890123456789012345678901234567890123456789012345678901234567890123456789

* Ingestion dose calculation from an acute release
#
2000,0                    * Direct input of Pu and Am
PU238,0.72                      * 0.72 Ci of Pu-238
PU239,0.18                      * 0.18 Ci of Pu-239
AM241,0.045                     * 0.045 Ci of Am-241
#
2999                            * End of direct radionuclide input
#
5000                      * Input of meteorological data
#
5001,4.,0,2000.,1.099E3,0,0   * 4 m/s average wind velocity
#                               ground level release
#                               2000 m mixing layer depth
#                               1099. g/cubic m air density
#                               No plume depletion by wet deposition
#                               No plume depletion by dry deposition
#
5002,0.001,0.01,0,0.001,0.001 * Entering deposition velocities
#                                   0.001 m/s for solids, Cs and Ru
#                                   0.01 m/s for halogens
#                                   0.0 m/s for noble gases
#
5101,1.E4,5.E4            * Requesting doses for 2 downwind distances
#                                1000. and 5000. meters
#
5201,1.,0                 * No decay correction of inventory is desired during
#                                release period.  This is accomplished by simulating
#                                a puff release over a period of 1 second.
#
5400,3,0,0,0              * Using option to input chi/Q values directly
#                                Building wake option cannot be used with
#                                direct chi/Q input option
#
5421,2.1E-6,3.2E-7        * Entering chi/Q values matched to the 2 downwind
#                           distances
#
5999                      * End of meteorological data input
#
7000,3,-2,2,1,1           * Requesting ingestion dose calculation with user
#                           supplied parameters on Line 7003
#                               Printout of only dose summaries
#                               Requesting doses in Sv
#                               Requesting doses for only selected elements
#                               Calculating doses for all organs
#

0        1         2         3         4         5         6         7
1234567890123456789012345678901234567890123456789012345678901234567890123456789
```

```
 example3     RSAC-5 INPUT     09/15/93     15:13
0         1         2         3         4         5         6         7
1234567890123456789012345678901234567890123456789012345678901234567890123456789

7001,3.33E-4,0,0,0       * Breathing rate not used - defaulting to program
#                          calculated value
#
#                          Defaulting to program values for line remainder
#
7004,1,2,1.,7.                     * Requesting a printout of ingestion
#                                    transfer parameters
#
#                                    Requesting to input ingestion parameters
#
#                                    Calculating ingestion dose for an acute
#                                    release period occurring over 1 day
#
#                                    Requesting a harvest duration time period
#                                    of 7 days following the acute release
#
7051,520.,64.,110.,310.,0.5,0.75   * Changed the fraction of stored vegetables
#                                    from the default of 0.76 to 0.5
#
#                                    Changed the fraction of fresh vegetables
#                                    from the default of 1.0 to 0.75
#
7052,0.57,0.2,1.,0.0021,60.,30.,1.   * Retaining the default values on Lines
7053,225.,60.,1.,16.,2.,20.          * 7052 through 7055
7054,0.4,0.43,90.,2.,0.28,4.9
7055,.5,.33,0.5,.33
#
7081,94,95                         * Requesting doses for Pu and Am by entering
#                                    their atomic numbers of 94 and 95
#
7999                   * End of ingestion dose calculation input
#
10000                  * End of run

0         1         2         3         4         5         6         7
1234567890123456789012345678901234567890123456789012345678901234567890123456789
```

```
              RADIOLOGICAL SAFETY ANALYSIS COMPUTER PROGRAM (RSAC-5)
 (RSAC-5E,REV 5.1,08/09/93) SERIAL  700  DATE  09/15/93  TIME 15:13  PAGE   1
 example3:  Ingestion dose calculation from an acute release

***DIRECT RADIONUCLIDE INPUT

        ANY PREVIOUS INVENTORY HAS BEEN ZEROED

     NUCLIDE          HALF LIFE        CURIES

  942380   Pu238    8.775E+01  yr    7.200E-01
  942390   Pu239    2.413E+04  yr    1.800E-01
  952410   Am241    4.322E+02  yr    4.500E-02

***METEOROLOGICAL DATA

        MEAN WIND SPEED = 4.000E+00 (m/s)    STACK HEIGHT = 0.000E+00 (m)
    MIXING LAYER HEIGHT = 2.000E+03 (m)       AIR DENSITY = 1.099E+03 (g/cu m)
    WET DEPOSITION SCAVENGING COEFFICIENT = 0.000E+00 (1/S)

    NO CORRECTION IS BEING MADE FOR CLOUD DEPLETION BY DRY DEPOSITION

    DEPOSITION VELOCITIES (m/s)
         SOLIDS = 1.000E-03    HALOGENS = 1.000E-02   NOBLE GASES = 0.000E+00
         CESIUM = 1.000E-03   RUTHENIUM = 1.000E-03

    THERE IS 1 SET OF LEAKAGE CONSTANTS (K1,K2)
          1.000E+00        0.000E+00

    CHI/Q VALUES INPUT DIRECTLY

          DOWNWIND DISTANCE      CHI/Q
              1.000E+04        2.100E-06
              5.000E+04        3.200E-07

  ***  INGESTION DOSE EQUIVALENT CALCULATION

     RELEASE TIME FOR EXPONENTIAL DECAY FUNCTION =  1.000E+00 (s)
     INTERNAL EXPOSURE TIME PERIOD =  5.000E+01 (yr)

     INGESTION CALCULATIONS MADE USING USER SUPPLIED CONSTANTS

        INGESTION CONSTANTS:
            5.20E+02  STORED VEGETABLE USAGE FACTOR (Kg/yr)
            6.40E+01  FRESH VEGETABLE USAGE FACTOR (Kg/yr)
            1.10E+02  MEAT USAGE FACTOR (Kg/yr)
            3.10E+02  MILK USAGE FACTOR (L/yr)
            5.00E-01  FRACTION OF STORED VEGETABLES FROM GARDEN
            7.50E-01  FRACTION OF FRESH VEGETABLES FROM GARDEN
            5.70E-01  RETENTION FACTOR FOR ACTIVITY ON FORAGE
            2.00E-01  RETENTION FACTOR FOR ACTIVITY ON VEGETABLES
            1.00E+00  RETENTION FACTOR FOR IODINES
            2.10E-03  REMOVAL RATE CONSTANT FOR CROPS (1/h)
            6.00E+01  VEGETABLE EXPOSURE TIME TO PLUME FOR CHRONIC RELEASE (d)
            3.00E+01  FORAGE EXPOSURE TIME TO PLUME FOR CHRONIC RELEASE (d)
            1.00E+00  HTO REMOVAL HALF TIME (d)
```

```
                RADIOLOGICAL SAFETY ANALYSIS COMPUTER PROGRAM (RSAC-5)
(RSAC-5E,REV 5.1,08/09/93) SERIAL  700  DATE  09/15/93  TIME 15:13  PAGE   2
example3:  Ingestion dose calculation from an acute release
           2.25E+02  EFFECTIVE SURFACE SOIL DENSITY (Kg/sq m)
           6.00E+01  STORED VEGETABLE HOLDUP TIME AFTER HARVEST (d)
           1.00E+00  FRESH VEGETABLE HOLDUP TIME AFTER HARVEST (d)
           1.60E+01  ANIMALS DAILY FORAGE FEED (Kg/d)
           2.00E+00  FEED-MILK-RECEPTOR TRANSFER TIME (d)
           2.00E+01  SLAUGHTER TO CONSUMPTION TIME (d)
           4.00E-01  FRACTION OF YEAR ON PASTURE
           4.30E-01  PASTURE FEED FRACTION
           9.00E+01  STORED FEED STORAGE TIME
           2.00E+00  VEGETABLE VEGETATION YIELD (Kg/sq m)
           2.80E-01  FORAGE VEGETATION YIELD (Kg/sq m)
           4.90E+00  ABSOLUTE HUMIDITY (g/cu m)

    ACUTE RELEASE OVER   1.000E+00 (d)
    HARVEST DURATION TIME OF   7.000E+00 (d) AFTER ACUTE RELEASE
    CONSUMPTION OF CROPS GROWN ON CONTAMINATED SOIL FOR   1.500E+01 (Y)

       FRACTIONS OF ANNUAL VEGETABLES AND FORAGE CONTAMINATED BY ACUTE RELEASE
                          5.0E-01  STORED VEGETABLES
                          3.3E-01  FRESH VEGETABLES
                          5.0E-01  STORED FEED
                          3.3E-01  PASTURE FEED
```

INGESTION TRANSFER CONSTANTS

ELEMENT	BV1 FORAGE/ SOIL (dry)	BV2 VEG/SOIL (wet)	FM MILK (d/L)	FF MEAT (d/kg)	TRANS-LOCATION
H 1	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.0E+00
He 2	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.0E+00
Li 3	2.5E-02	1.7E-03	2.0E-02	1.0E-02	1.0E+00
Be 4	1.0E-02	6.4E-04	9.0E-07	1.0E-03	1.0E+00
B 5	4.0E+00	8.6E-01	1.5E-03	8.0E-04	1.0E+00
C 6	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.0E+00
N 7	3.0E+01	1.3E+01	2.5E-02	7.5E-02	1.0E+00
O 8	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.0E+00
F 9	6.0E-02	2.6E-03	1.0E-03	1.5E-01	1.0E+00
Ne 10	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.0E+00
Na 11	7.5E-02	2.4E-02	3.5E-02	5.5E-02	1.0E+00
Mg 12	1.0E+00	2.4E-01	4.0E-03	5.0E-03	1.0E+00
Al 13	4.0E-03	2.8E-04	2.0E-04	1.5E-03	1.0E+00
Si 14	3.5E-01	3.0E-02	2.0E-05	4.0E-05	1.0E+00
P 15	3.5E+00	1.5E+00	1.5E-02	5.5E-02	1.0E+00
S 16	1.5E+00	6.4E-01	1.5E-02	1.0E-01	1.0E+00
Cl 17	7.0E+01	3.0E+01	1.5E-02	8.0E-02	1.0E+00
Ar 18	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.0E+00
K 19	1.0E+00	2.4E-01	7.0E-03	2.0E-02	1.0E+00
Ca 20	3.5E+00	1.5E-01	1.0E-02	7.0E-04	1.0E+00
Sc 21	6.0E-03	4.3E-04	5.0E-06	1.5E-02	1.0E+00
Ti 22	5.5E-03	1.3E-03	1.0E-02	3.0E-02	1.0E+00
V 23	5.5E-03	1.3E-03	2.0E-05	2.5E-03	1.0E+00
Cr 24	7.5E-03	1.9E-03	1.5E-03	5.5E-03	1.0E+00
Mn 25	2.5E-01	2.1E-02	3.5E-04	4.0E-04	1.0E+00
Fe 26	4.0E-03	4.3E-04	2.5E-04	2.0E-02	1.0E+00
Co 27	2.0E-02	3.0E-03	2.0E-03	2.0E-02	1.0E+00

RADIOLOGICAL SAFETY ANALYSIS COMPUTER PROGRAM (RSAC-5)
(RSAC-5E,REV 5.1,08/09/93) SERIAL 700 DATE 09/15/93 TIME 15:13 PAGE 3
example3: Ingestion dose calculation from an acute release

ELEMENT	BV1 FORAGE/ SOIL (dry)	BV2 VEG/SOIL (wet)	FM MILK (d/L)	FF MEAT (d/kg)	TRANS-LOCATION
Ni 28	6.0E-02	2.6E-02	1.0E-03	6.0E-03	1.0E+00
Cu 29	4.0E-01	1.1E-01	1.5E-03	1.0E-02	1.0E+00
Zn 30	1.5E+00	3.9E-01	1.0E-02	1.0E-01	1.0E+00
Ga 31	4.0E-03	1.7E-04	5.0E-05	5.0E-04	1.0E+00
Ge 32	4.0E-01	3.4E-02	7.0E-02	7.0E-01	1.0E+00
As 33	4.0E-02	2.6E-03	6.0E-05	2.0E-03	1.0E+00
Se 34	2.5E-02	1.1E-02	4.0E-03	1.5E-02	1.0E+00
Br 35	1.5E+00	6.4E-01	2.0E-02	2.5E-02	1.0E+00
Kr 36	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.0E+00
Rb 37	1.5E-01	3.0E-02	1.0E-02	1.5E-02	1.0E+00
Sr 38	2.5E+00	1.1E-01	1.5E-03	3.0E-04	1.5E-01
Y 39	1.5E-02	2.6E-03	2.0E-05	3.0E-04	1.0E+00
Zr 40	2.0E-03	2.1E-04	3.0E-05	5.5E-03	1.0E+00
Nb 41	2.0E-02	2.1E-03	2.0E-02	2.5E-01	1.0E+00
Mo 42	2.5E-01	2.6E-02	1.5E-03	6.0E-03	1.0E+00
Tc 43	9.5E+00	6.4E-01	1.0E-02	8.5E-03	1.0E+00
Ru 44	7.5E-02	8.6E-03	6.0E-07	2.0E-03	5.0E-02
Rh 45	1.5E-01	1.7E-02	1.0E-02	2.0E-03	1.0E+00
Pd 46	1.5E-01	1.7E-02	1.0E-02	4.0E-03	1.0E+00
Ag 47	4.0E-01	4.3E-02	2.0E-02	3.0E-03	1.0E+00
Cd 48	5.5E-01	6.4E-02	1.0E-03	5.5E-04	1.0E+00
In 49	4.0E-03	1.7E-04	1.0E-04	8.0E-03	1.0E+00
Sn 50	3.0E-02	2.6E-03	1.0E-03	8.0E-02	1.0E+00
Sb 51	2.0E-01	1.3E-02	1.0E-04	1.0E-03	1.0E+00
Te 52	2.5E-02	1.7E-03	2.0E-04	1.5E-02	1.0E+00
I 53	1.5E-01	2.1E-02	1.0E-02	7.0E-03	1.0E-01
Xe 54	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.0E+00
Cs 55	8.0E-02	1.3E-02	7.0E-03	2.0E-02	5.0E-01
Ba 56	1.5E-01	6.4E-03	3.5E-04	1.5E-04	1.0E+00
La 57	1.0E-02	1.7E-03	2.0E-05	3.0E-04	1.0E+00
Ce 58	1.0E-02	1.7E-03	2.0E-05	7.5E-04	3.0E-01
Pr 59	1.0E-02	1.7E-03	2.0E-05	3.0E-04	1.0E+00
Nd 60	1.0E-02	1.7E-03	2.0E-05	3.0E-04	1.0E+00
Pm 61	1.0E-02	1.7E-03	2.0E-05	5.0E-03	1.0E+00
Sm 62	1.0E-02	1.7E-03	2.0E-05	5.0E-03	1.0E+00
Eu 63	1.0E-02	1.7E-03	2.0E-05	5.0E-03	1.0E+00
Gd 64	1.0E-02	1.7E-03	2.0E-05	3.5E-03	1.0E+00
Tb 65	1.0E-02	1.7E-03	2.0E-05	4.5E-03	1.0E+00
Dy 66	1.0E-02	1.7E-03	2.0E-05	5.5E-03	1.0E+00
Ho 67	1.0E-02	1.7E-03	2.0E-05	4.5E-03	1.0E+00
Er 68	1.0E-02	1.7E-03	2.0E-05	4.0E-03	1.0E+00
Tm 69	1.0E-02	1.7E-03	2.0E-05	4.5E-03	1.0E+00
Yb 70	1.0E-02	1.7E-03	2.0E-05	4.0E-03	1.0E+00
Lu 71	1.0E-02	1.7E-03	2.0E-05	4.5E-03	1.0E+00
Hf 72	3.5E-03	3.6E-04	5.0E-06	1.0E-03	1.0E+00
Ta 73	1.0E-02	1.1E-03	3.0E-06	6.0E-04	1.0E+00
W 74	4.5E-02	4.3E-03	3.0E-04	4.5E-02	1.0E+00
Re 75	1.5E+00	1.5E-01	1.5E-03	8.0E-03	1.0E+00

RADIOLOGICAL SAFETY ANALYSIS COMPUTER PROGRAM (RSAC-5)
(RSAC-5E,REV 5.1,08/09/93) SERIAL 700 DATE 09/15/93 TIME 15:13 PAGE 4
example3: Ingestion dose calculation from an acute release

ELEMENT	BV1 FORAGE/ SOIL (dry)	BV2 VEG/SOIL (wet)	FM MILK (d/L)	FF MEAT (d/kg)	TRANS- LOCATION
Os 76	1.5E-02	1.5E-03	5.0E-03	4.0E-01	1.0E+00
Ir 77	5.5E-02	6.4E-03	2.0E-06	1.5E-03	1.0E+00
Pt 78	9.5E-02	1.1E-02	5.0E-03	4.0E-03	1.0E+00
Au 79	4.0E-01	4.3E-02	5.5E-06	8.0E-03	1.0E+00
Hg 80	9.0E-01	8.6E-02	4.5E-04	2.5E-01	1.0E+00
Tl 81	4.0E-03	1.7E-04	2.0E-03	4.0E-02	1.0E+00
Pb 82	4.5E-02	3.9E-03	2.5E-04	3.0E-04	1.0E+00
Bi 83	3.5E-02	2.1E-03	5.0E-04	4.0E-04	1.0E+00
Po 84	2.5E-03	1.7E-04	3.5E-04	9.5E-05	1.0E+00
At 85	1.0E+00	6.4E-02	1.0E-02	1.0E-02	1.0E+00
Rn 86	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.0E+00
Fr 87	3.0E-02	3.4E-03	2.0E-02	2.5E-03	1.0E+00
Ra 88	1.5E-02	6.4E-04	4.5E-04	2.5E-04	1.0E+00
Ac 89	3.5E-03	1.5E-04	2.0E-05	2.5E-05	1.0E+00
Th 90	8.5E-04	3.6E-05	5.0E-06	6.0E-06	1.0E+00
Pa 91	2.5E-03	1.1E-04	5.0E-06	1.0E-05	1.0E+00
U 92	8.5E-03	1.7E-03	6.0E-04	2.0E-04	1.0E+00
Np 93	1.0E-01	4.3E-03	5.0E-06	5.5E-05	1.0E+00
Pu 94	4.5E-04	1.9E-05	1.0E-07	5.0E-07	1.0E-02
Am 95	5.5E-03	1.1E-04	4.0E-07	3.5E-06	3.0E-01
Cm 96	8.5E-04	6.4E-06	2.0E-05	3.5E-06	3.0E-01

DOWNWIND DISTANCE = 1.000E+04 (m)   PLUME TRAVEL TIME = 2.500E+03 (s)
CHI/Q = 2.100E-06 (s/cu m)

DOWNWIND DISTANCE = 5.000E+04 (m)   PLUME TRAVEL TIME = 1.250E+04 (s)
CHI/Q = 3.200E-07 (s/cu m)

&& INGESTION COMMITTED DOSE EQUIVALENTS ORDERED BY ORGAN (Sv)

ORGAN	NO.	DOWNWIND DISTANCES (m) 1.00E+04	5.00E+04
GONADS	6	2.81E-05	4.29E-06
BONE SUR	8	2.24E-03	3.41E-04
R MARROW	9	1.82E-04	2.77E-05
LIVER	12	4.88E-04	7.44E-05

ORGANS WITH NO CALCULATED DOSE HAVE BEEN SUPPRESSED FROM TABLE

```
                RADIOLOGICAL SAFETY ANALYSIS COMPUTER PROGRAM (RSAC-5)
(RSAC-5E,REV 5.1,08/09/93) SERIAL  700  DATE  09/15/93  TIME 15:13  PAGE   5
example3:  Ingestion dose calculation from an acute release

&&        INGESTION COMMITTED DOSE EQUIVALENCES ORDERED BY DOSE  (Sv)

                     DOWNWIND DISTANCES (m)
   ORGAN    NO.   1.00E+04  5.00E+04
 --------   ---   --------  --------
 BONE SUR    8    2.24E-03  3.41E-04
 LIVER      12    4.88E-04  7.44E-05
 R MARROW    9    1.82E-04  2.77E-05
 GONADS      6    2.81E-05  4.29E-06

 ----------
 ORGANS WITH NO CALCULATED DOSE HAVE BEEN SUPPRESSED FROM TABLE

&&        INGESTION WEIGHTED COMMITTED DOSE EQUIVALENTS  (Sv)

                     DOWNWIND DISTANCES (m)
   ORGAN    NO.   1.00E+04  5.00E+04
 --------   ---   --------  --------
 GONADS      6    7.03E-06  1.07E-06
 BONE SUR    8    6.72E-05  1.02E-05
 R MARROW    9    2.18E-05  3.32E-06
 LIVER      12    2.93E-05  4.47E-06
 CEDE       18    1.26E-04  1.92E-05

 ----------
 ORGANS WITH NO CALCULATED DOSE HAVE BEEN SUPPRESSED FROM TABLE

   EXECUTION TIME =  1.06E+01 SECONDS
```

Example 4: Ground Surface Dose Calculation

An inventory of only Co-60 is entered directly using the 2000 Series option. The 1000 Series option is used to demonstrate how the inventory can be fractionated at any time. In this case, the fractionation is used to remind users that when ground surface dose calculations are made for a controlled work area, workers are normally present only 40/168 hours a week. This correction could have been made several other ways such as changing the initial inventory entered or changing the building shielding factor on the *(7001)* line.

The release is assumed to occur at ground level during a Class C meteorological condition with a 2,000-m mixing layer depth. Diffusion is made using Hilsmeier-Gifford diffusion parameters.

In this example, the air density is changed to the standard sea level value. Ground surface doses are calculated in rem for all organs and the element Co only. A building shielding factor of 1. has been used to indicate that no reduction of the dose by buildings is desired.

```
 example4     RSAC-5 INPUT      09/15/93     15:13
0        1         2         3         4         5         6         7
1234567890123456789012345678901234567890123456789012345678901234567890123456789

* Ground surface dose calculation
#
2000,0                   * Direct input of Co-60
#
CO 60,75.                * Entering 75 Ci
#
2999                     * End of direct radionuclide input
#
1000                     * Using 1000 Series to fractionate inventory
#
1001,1,0,0                     * Retaining existing inventory
#
1004,0,0.2381                  * Receptors in a controlled work area are present
#                                only 40/168 hours a week.
#
1999                           * End of inventory fractionation
#
5000                     * Input of meteorological data
#
5001,6.,0,2000.,1.240E3,0,0        * 6 m/s average wind velocity
#                                    ground level release
#                                    2000. m mixing layer depth
#                                    1240. g/cubic m air density
#
5002,0.001,0.01,0,0.001,0.001      * Defaulting to program standard deposition
#                                    velocities
#
5101,3.5E3                         * Calculating dose for 1 downwind distance
#
5201,1.,0                          * Releasing as a puff
#
5400,2,0,0,0                       * Requesting program to calculate sigmas
#
5410,1,3,0                         * Hilsmeier-Gifford diffusion
#                                       Class C
#
#                                       Cannot request plume rise for ground
#                                       level release
#
5999                               * End of meteorological data
#
7000,4,-2,1,1,1            * Requesting ground surface dose calculation
#                                Printing only summary doses
#                                Calculating doses in rem
#                                Requesting doses for only selected elements
#                                Requesting doses for all organs

0        1         2         3         4         5         6         7
1234567890123456789012345678901234567890123456789012345678901234567890123456789
```

```
 example4     RSAC-5 INPUT     09/15/93     15:13
0         1         2         3         4         5         6         7
1234567890123456789012345678901234567890123456789012345678901234567890123456789

#
7001,3.33E-4,0,1.,1.   * Defaulting to program standard values except for
#                        the building shielding factor which has been
#                        changed to a factor of 1. indicating no reduction
#                        of the dose by buildings
#
7081,27                * Requesting dose calculation for only cobalt
#
7999                   * End of input for dose calculation
#
10000                  * End of run

0         1         2         3         4         5         6         7
1234567890123456789012345678901234567890123456789012345678901234567890123456789
```

```
             RADIOLOGICAL SAFETY ANALYSIS COMPUTER PROGRAM (RSAC-5)
(RSAC-5E,REV 5.1,08/09/93) SERIAL  700  DATE  09/15/93  TIME 15:13  PAGE   1
example4:  Ground surface dose calculation

***DIRECT RADIONUCLIDE INPUT

       ANY PREVIOUS INVENTORY HAS BEEN ZEROED

    NUCLIDE          HALF LIFE       CURIES

 270600  Co 60    5.271E+00  yr    7.500E+01

***FISSION PRODUCT CALCULATION

    FRACTION OF RADIONUCLIDE INVENTORY RELEASED =  2.381E-01

   TOTAL RADIONUCLIDE RELEASE =  6.607E+11  D/s OR  1.786E+01 Ci

***METEOROLOGICAL DATA

      MEAN WIND SPEED = 6.000E+00 (m/s)    STACK HEIGHT = 0.000E+00 (m)
   MIXING LAYER HEIGHT = 2.000E+03 (m)      AIR DENSITY = 1.240E+03 (g/cu m)
   WET DEPOSITION SCAVENGING COEFFICIENT = 0.000E+00 (1/S)

   NO CORRECTION IS BEING MADE FOR CLOUD DEPLETION BY DRY DEPOSITION

   DEPOSITION VELOCITIES (m/s)
        SOLIDS = 1.000E-03    HALOGENS = 1.000E-02   NOBLE GASES = 0.000E+00
        CESIUM = 1.000E-03   RUTHENIUM = 1.000E-03

   THERE IS 1 SET OF LEAKAGE CONSTANTS (K1,K2)
         1.000E+00        0.000E+00

   PASQUILL CLASS C METEOROLOGY,  H-G   SIGMA VALUES

   NO BUILDING WAKE CORRECTION MADE

   DOWNWIND DISTANCE  EFFECTIVE STACK   SIGY         SIGZ         CHI/Q
                         HEIGHT (m)      (m)          (m)        (s/cu m)
        3.500E+03         0.000E+00   3.546E+02   1.979E+02   7.560E-07

  *** GROUND SURFACE DEPOSITION DOSE EQUIVALENT CALCULATION

   TIME RECEPTOR IS EXPOSED TO CONTAMINATED SOIL =  1.000E+00 (yr)
   BUILDING SHIELDING FACTOR =  1.000E+00
   RELEASE TIME FOR EXPONENTIAL DECAY FUNCTION =  1.000E+00 SECONDS

   DOWNWIND DISTANCE =  3.500E+03 (m)    PLUME TRAVEL TIME =  5.833E+02 (s)
                                          CHI/Q =  7.560E-07 (s/cu m)
```

```
              RADIOLOGICAL SAFETY ANALYSIS COMPUTER PROGRAM (RSAC-5)
(RSAC-5E,REV 5.1,08/09/93) SERIAL  700  DATE  09/15/93  TIME 15:13  PAGE   2
example4:  Ground surface dose calculation

&& GROUND SURFACE  DOSE EQUIVALENTS ORDERED BY ORGAN (rem)

                DOWNWIND DISTANCES (m)
   ORGAN    NO.  3.50E+03
  --------  ---  --------
  LUNGS      1   2.45E-03
  STOMACH    2   2.26E-03
  S INT      3   2.11E-03
  UL INT     4   2.44E-03
  LL INT     5   2.24E-03
  TESTES     6   3.21E-03
  BREAST     7   2.89E-03
  SKELETON   8   2.62E-03
  RED MARR   9   2.47E-03
  THYROID   10   3.06E-03
  KIDNEYS   11   2.44E-03
  LIVER     12   2.32E-03
  SPLEEN    13   2.23E-03
  ADRENALS  14   2.33E-03
  PANCREAS  15   2.00E-03
  SKIN      16   3.70E-03
  BRAIN     17   2.62E-03
  THYMUS    18   2.57E-03
  BLADDER   19   2.32E-03
  MARROW    20   2.57E-03
  HEART     21   2.29E-03
  OVARIES   22   2.21E-03
  UTERUS    23   2.05E-03
```

```
                    RADIOLOGICAL SAFETY ANALYSIS COMPUTER PROGRAM (RSAC-5)
(RSAC-5E,REV 5.1,08/09/93) SERIAL  700  DATE  09/15/93  TIME 15:13  PAGE   3
example4:  Ground surface dose calculation

&& GROUND SURFACE  DOSE EQUIVALENCES ORDERED BY DOSE (rem)

                     DOWNWIND DISTANCES (m)
   ORGAN    NO.   3.50E+03
 --------   ---   --------
 SKIN       16    3.70E-03
 TESTES      6    3.21E-03
 THYROID    10    3.06E-03
 BREAST      7    2.89E-03
 SKELETON    8    2.62E-03
 BRAIN      17    2.62E-03
 THYMUS     18    2.57E-03
 MARROW     20    2.57E-03
 RED MARR    9    2.47E-03
 LUNGS       1    2.45E-03
 UL INT      4    2.44E-03
 KIDNEYS    11    2.44E-03
 ADRENALS   14    2.33E-03
 LIVER      12    2.32E-03
 BLADDER    19    2.32E-03
 HEART      21    2.29E-03
 STOMACH     2    2.26E-03
 LL INT      5    2.24E-03
 SPLEEN     13    2.23E-03
 OVARIES    22    2.21E-03
 S INT       3    2.11E-03
 UTERUS     23    2.05E-03
 PANCREAS   15    2.00E-03
```

```
                  RADIOLOGICAL SAFETY ANALYSIS COMPUTER PROGRAM (RSAC-5)
(RSAC-5E,REV 5.1,08/09/93) SERIAL  700  DATE  09/15/93  TIME 15:13  PAGE   4
example4:  Ground surface dose calculation

&& GROUND SURFACE  WEIGHTED DOSE EQUIVALENTS (rem)

                    DOWNWIND DISTANCES (m)
   ORGAN    NO.   3.50E+03
  --------  ---   --------
  LUNGS      1    2.94E-04
  STOMACH    2    1.35E-04
  S INT      3    1.27E-04
  UL INT     4    1.46E-04
  LL INT     5    1.35E-04
  TESTES     6    8.04E-04
  BREAST     7    4.33E-04
  SKELETON   8    7.86E-05
  RED MARR   9    2.97E-04
  THYROID   10    9.17E-05
  KIDNEYS   11    1.46E-04
  LIVER     12    1.39E-04
  SPLEEN    13    1.34E-04
  ADRENALS  14    1.40E-04
  PANCREAS  15    1.20E-04
  SKIN      16    3.70E-05
  BRAIN     17    1.57E-04
  THYMUS    18    1.54E-04
  BLADDER   19    1.39E-04
  MARROW    20    1.54E-04
  HEART     21    1.38E-04
  OVARIES   22    5.52E-04
  UTERUS    23    1.23E-04
  EXT EDE   24    2.74E-03

   EXECUTION TIME =  7.42E+00 SECONDS
```

Example 5: Air Immersion Dose Calculation

This example assumes the release of only Xe-133. The release is assumed to be from a 50-m stack during Class D meteorology (Markee diffusion parameters) with a 10 m/s average wind velocity. A mixing layer depth of 2,00 m has been chosen. The release is assumed to occur exponentially as a function of time with a release half-time of 3 days. The linear constant was adjusted to give 100% release of the remaining activity at the end of 5 days. Plume rise above the top of the stack was calculated for a jet plume being released from a 1.22- internal stack diameter discharging with a 20 m/s efflux speed.

Air immersion doses were calculated for all organs with the dose expressed in rem. The decay time for the exponential release function was set to 8 hours (2.88E4 seconds) to give the air immersion dose that would be received during the first 8 hours following the onset of the release. To alert the user, RSAC-5 prints a warning when less than 100% of the inventory has been released. In this case, the release was purposely adjusted to give less than a 100% release.

When using the air immersion model, be sure that the plume size is large compared to the mean free path of the gamma rays and that it has diffused to the ground level. The easiest way to confirm this is to make a calculation using the finite-plume cloud gamma model (Series 9000) to see if the EDE converges. In this case, it is a good exercise for the user to verify that the results for the two models converge to within 5% for the 1.E4 m downwind distance and to less than 1% for the 3.E4 m downwind distance.

```
  example5     RSAC-5 INPUT     09/15/93     15:13
0         1         2         3         4         5         6         7
1234567890123456789012345678901234567890123456789012345678901234567890123456789

* Air immersion dose calculation
#
2000,0                    * Direct input of Xe-133 only
#
XE133,1.E6                      * Entering 1.6E6 Ci
#
2999                      * End of direct radionuclide input
#
5000                      * Input of meteorological data
#
5001,10.,50.,2500.,1.099E3,0,0  * 10 m/s average wind velocity
#                                 50 m stack height
#                                 2500. m mixing layer depth
#                                 1099. g/cubic m air density
#
5101,1.E4,3.E4                  * 2 downwind distances entered
#
5201,3.33E-6,2.6742E-6          * Decay correcting for an exponential release
#
#                                     Exponential constant for the leakage
#                                     function adjusted to give a release
#                                     half-time of 3 days
#
#                                     Linear constant adjusted to give 100%
#                                     release of inventory at the end of 5 days
#
5400,2,0,0,0                    * Requesting program to calculate sigmas
#
#                                     No credit can be taken for building wake
#                                     when the release is from a stack
#
5410,2,4,1                      * Choosing Markee diffusion
#                                     Class D
#
#                                     Requesting plume rise calculation
#                                     for a jet plume
#
5411,1.22,0,20.,0               * 1.22 m internal stack diameter
#
#                                     Class D does not use a restoring
#                                     acceleration - defaulting to 0
#
#                                     20 m/s efflux speed of gases
#
#                                     Entering 0 for heat emission as it
#                                     is not used for a jet plume.  However,

0         1         2         3         4         5         6         7
1234567890123456789012345678901234567890123456789012345678901234567890123456789
```

```
 example5     RSAC-5 INPUT     09/15/93     15:13
0         1         2         3         4         5         6         7
1234567890123456789012345678901234567890123456789012345678901234567890123456789

#                                      RSAC-5 requires an entry for all words
#                                      on a line.
#
5999                * End of meteorological data input
#
7000,5,-2,1,1,1     * Requesting air immersion dose calculation which is a
#                     valid calculation because the plume is large compared
#                     to the mean free path of the photons
#
#                            Printing only summary doses
#                            Calculating doses in rem
#                            Requesting doses for only selected elements
#                            Requesting doses for all organs
#
7001,3.33E-4,2.88E4,0,0  * Breathing rate not used - defaulting to program
#                          calculated value
#
#                          Exposing the receptor for only 8 h (2.88E4 s)
#                               This does not release all of the inventory.
#                               The program prints a warning when less than
#                               100% of the inventory is released to be sure
#                               that is really what is desired.  This
#                               would represent evacuation of the downwind
#                               location after 8 hours or the release was
#                               terminated after 8 hours.
#
7081,54                  * Requesting dose calculation for only xenon.  A
#                          request could have been made for all elements;
#                          however, it would only take more computer time
#                          to get the same result.
#
7999                * End of dose calculation
#
10000               * End of run

0         1         2         3         4         5         6         7
123456789012345678901234567890123456789012345678901234567890123'567890123456789
```

```
          RADIOLOGICAL SAFETY ANALYSIS COMPUTER PROGRAM (RSAC-5)
(RSAC-5E,REV 5.1,08/09/93) SERIAL  700  DATE  09/15/93  TIME 15:13  PAGE   1
example5:  Air immersion dose calculation

***DIRECT RADIONUCLIDE INPUT

        ANY PREVIOUS INVENTORY HAS BEEN ZEROED

     NUCLIDE           HALF LIFE       CURIES

 541330  Xe133     5.245E+00  d      1.000E+06

***METEOROLOGICAL DATA

        MEAN WIND SPEED = 1.000E+01 (m/s)    STACK HEIGHT = 5.000E+01 (m)
    MIXING LAYER HEIGHT = 2.500E+03 (m)      AIR DENSITY = 1.099E+03 (g/cu m)
    WET DEPOSITION SCAVENGING COEFFICIENT = 0.000E+00 (1/S)

    NO CORRECTION IS BEING MADE FOR CLOUD DEPLETION BY DRY DEPOSITION

    DEPOSITION VELOCITIES (m/s)
         SOLIDS = 0.000E+00    HALOGENS = 0.000E+00    NOBLE GASES = 0.000E+00
         CESIUM = 0.000E+00   RUTHENIUM = 0.000E+00

    THERE IS 1 SET OF LEAKAGE CONSTANTS (K1,K2)
          3.330E-06        2.674E-06

    PASQUILL CLASS D METEOROLOGY, MARKEE SIGMA VALUES

    PLUME RISE CALCULATED USING JET CONDITIONS
                    STACK DIAMETER = 1.220E+00 (m)
                 EFFLUENT VELOCITY = 2.000E+01 (m/s)
          RESTORING ACCELERATION = 0.000E+00 (1/sq s)

    DOWNWIND DISTANCE  EFFECTIVE STACK   SIGY        SIGZ        CHI/Q
                         HEIGHT (m)      (m)         (m)        (s/cu m)
         1.000E+04       5.732E+01   3.841E+02   2.998E+02   2.714E-07
         3.000E+04       5.732E+01   8.322E+02   7.506E+02   5.081E-08

  *** AIR IMMERSION DOSE EQUIVALENT CALCULATION

    RELEASE TIME FOR EXPONENTIAL DECAY FUNCTION =  2.880E+04 SECONDS
  WARNING, EXPONENTIAL LEAKAGE CONSTANTS AND EXPONENTIAL DECAY TIME ARE NOT
           MATCHED,   9.23E+00 PERCENT OF INVENTORY RELEASED

    DOWNWIND DISTANCE =  1.000E+04 (m)    PLUME TRAVEL TIME =  1.000E+03 (s)
                                          CHI/Q =  2.714E-07 (s/cu m)

    DOWNWIND DISTANCE =  3.000E+04 (m)    PLUME TRAVEL TIME =  3.000E+03 (s)
                                          CHI/Q =  5.081E-08 (s/cu m)
```

```
                    RADIOLOGICAL SAFETY ANALYSIS COMPUTER PROGRAM (RSAC-5)
(RSAC-5E,REV 5.1,08/09/93) SERIAL  700  DATE  09/15/93  TIME 15:13  PAGE   2
example5:  Air immersion dose calculation

&&   AIR IMMERSION DOSE EQUIVALENTS ORDERED BY ORGAN (rem)

                       DOWNWIND DISTANCES (m)
   ORGAN     NO.   1.00E+04   3.00E+04
 --------    ---   --------   --------
 LUNGS        1    1.09E-04   2.04E-05
 STOMACH      2    9.23E-05   1.72E-05
 S INT        3    7.81E-05   1.46E-05
 UL INT       4    9.73E-05   1.82E-05
 LL INT       5    8.47E-05   1.58E-05
 TESTES       6    1.78E-04   3.32E-05
 BREAST       7    2.21E-04   4.12E-05
 SKELETON     8    1.93E-04   3.60E-05
 RED MARR     9    7.12E-05   1.33E-05
 THYROID     10    1.69E-04   3.15E-05
 KIDNEYS     11    1.10E-04   2.05E-05
 LIVER       12    9.73E-05   1.82E-05
 SPLEEN      13    9.06E-05   1.69E-05
 ADRENALS    14    9.48E-05   1.77E-05
 PANCREAS    15    6.81E-05   1.27E-05
 SKIN        16    4.88E-04   9.10E-05
 BRAIN       17    9.65E-05   1.80E-05
 THYMUS      18    1.28E-04   2.40E-05
 BLADDER     19    1.01E-04   1.88E-05
 MARROW      20    1.88E-04   3.51E-05
 HEART       21    8.73E-05   1.63E-05
 OVARIES     22    8.17E-05   1.53E-05
 UTERUS      23    7.74E-05   1.45E-05
```

RADIOLOGICAL SAFETY ANALYSIS COMPUTER PROGRAM (RSAC-5)
(RSAC-5E,REV 5.1,08/09/93) SERIAL 700 DATE 09/15/93 TIME 15:13 PAGE 3
example5: Air immersion dose calculation

&& AIR IMMERSION DOSE EQUIVALENCES ORDERED BY DOSE (rem)

		DOWNWIND DISTANCES (m)	
ORGAN	NO.	1.00E+04	3.00E+04
--------	---	--------	--------
SKIN	16	4.88E-04	9.10E-05
BREAST	7	2.21E-04	4.12E-05
SKELETON	8	1.93E-04	3.60E-05
MARROW	20	1.88E-04	3.51E-05
TESTES	6	1.78E-04	3.32E-05
THYROID	10	1.69E-04	3.15E-05
THYMUS	18	1.28E-04	2.40E-05
KIDNEYS	11	1.10E-04	2.05E-05
LUNGS	1	1.09E-04	2.04E-05
BLADDER	19	1.01E-04	1.88E-05
UL INT	4	9.73E-05	1.82E-05
LIVER	12	9.73E-05	1.82E-05
BRAIN	17	9.65E-05	1.80E-05
ADRENALS	14	9.48E-05	1.77E-05
STOMACH	2	9.23E-05	1.72E-05
SPLEEN	13	9.06E-05	1.69E-05
HEART	21	8.73E-05	1.63E-05
LL INT	5	8.47E-05	1.58E-05
OVARIES	22	8.17E-05	1.53E-05
S INT	3	7.81E-05	1.46E-05
UTERUS	23	7.74E-05	1.45E-05
RED MARR	9	7.12E-05	1.33E-05
PANCREAS	15	6.81E-05	1.27E-05

```
                RADIOLOGICAL SAFETY ANALYSIS COMPUTER PROGRAM (RSAC-5)
(RSAC-5E,REV 5.1,08/09/93) SERIAL  700  DATE  09/15/93  TIME 15:13  PAGE   4
example5:  Air immersion dose calculation

&&   AIR IMMERSION WEIGHTED DOSE EQUIVALENTS (rem)

                DOWNWIND DISTANCES (m)
  ORGAN    NO.  1.00E+04  3.00E+04
 --------  ---  --------  --------
 LUNGS       1  1.31E-05  2.44E-06
 STOMACH     2  5.54E-06  1.03E-06
 S INT       3  4.69E-06  8.75E-07
 UL INT      4  5.84E-06  1.09E-06
 LL INT      5  5.08E-06  9.49E-07
 TESTES      6  4.45E-05  8.30E-06
 BREAST      7  3.31E-05  6.18E-06
 SKELETON    8  5.79E-06  1.08E-06
 RED MARR    9  8.55E-06  1.60E-06
 THYROID    10  5.06E-06  9.44E-07
 KIDNEYS    11  6.60E-06  1.23E-06
 LIVER      12  5.84E-06  1.09E-06
 SPLEEN     13  5.44E-06  1.01E-06
 ADRENALS   14  5.69E-06  1.06E-06
 PANCREAS   15  4.09E-06  7.63E-07
 SKIN       16  4.88E-06  9.10E-07
 BRAIN      17  5.79E-06  1.08E-06
 THYMUS     18  7.70E-06  1.44E-06
 BLADDER    19  6.04E-06  1.13E-06
 MARROW     20  1.13E-05  2.11E-06
 HEART      21  5.24E-06  9.77E-07
 OVARIES    22  2.04E-05  3.81E-06
 UTERUS     23  4.65E-06  8.67E-07
 EXT EDE    24  1.46E-04  2.73E-05

   EXECUTION TIME =   1.28E+01 SECONDS
```

Example 6: Fifty-Mile Radius Dose Calculation for a Chronic Release

The radionuclide inventory for this fifty-mile radius dose calculation is entered directly through the 2000 Series lines. Doses from inhalation are calculated using a 24-hour average breathing rate of 2.66E-4 m^3/s and the RSAC-5 default lung clearance classes. Committed doses are calculated for the ingestion pathway assuming that crops are grown on the contaminated soil for a period of 15 years using RSAC-5 default ingestion parameters. Doses from the ground surface pathway assume that the receptor is exposed for a period of 1 year following initiation of the release.

The inventory entered using the 2000 Series lines is assumed to be the activity that is actually released during the chronic release period. As such, care must be exercised not to inadvertently decay correct the inventory again during the holdup period before release. This was done by omitting the *(8020)* and *(8021)* lines, thereby, defaulting to only 1-second holdup time for the exponential decay function. This essentially gives no additional decay before release.

Population and dispersion coefficients are read from an external file called "popcq". This external file was prepared by using RSAC+, and the input data was saved as an external file.

```
 example6     RSAC-5 INPUT     09/15/93     15:14
0         1         2         3         4         5         6         7
1234567890123456789012345678901234567890123456789012345678901234567890123456789

* Fifty-mile radius dose calculation for a chronic release
#
2000,0                    * Entering radionuclides directly
#                              Element symbols must be entered in capital letters
#
H  3,0.021
SR 89,3.1E-5
SR 90,3.5
Y 90,3.5
RU106,0.35
RH106M,0.35
I129,2.5E-6
CS134,2.1
CS137,3.7
BA137M,3.5
CE144,2.8
PR144M,2.8
PM147,2.2
EU154,0.21
TH228,5.3E-7
PU238,1.2E-3
PU239,1.8E-5
AM241,4.E-6
2999                      * End of direct radionuclide input
#
8000                      * Requesting a 50-mile population dose calculation
#
8001,0                    * The option chosen requests dose calculations for all
#                           radionuclides that were entered in the 2000 Series
#                           input.  When the user wants to be selective in which
#                           radionuclides, option 1 can be used with the desired
#                           radionuclides indicated on the following lines.
#
8011,0,1,0,0,2.66E-4,15.,1. * Using program default lung clearance classes
#
#                                Doses in rem with ingestion dose controlled by
#                                user provided parameters on Line 8014
#
#                                Using 24 hour average breathing rate
#
#                                Requesting calculation of dose from consumption
#                                of crops grown on the contaminated soil for a
#                                period of 15 years
#
#                                Requesting ground surface dose calculation time
#                                of 1 year following initiation of release

0         1         2         3         4         5         6         7
1234567890123456789012345678901234567890123456789012345678901234567890123456789
```

```
 example6      RSAC-5 INPUT      09/15/93      15:14
0         1         2         3         4         5         6         7
1234567890123456789012345678901234567890123456789012345678901234567890123456789

#
8012,1,8,10,18               * A maximum of 4 organs can be specified during
#                              a run.  Requesting dose to the lungs, bone surface,
#                              Thyroid and the CEDE.
#
8050,popcq                   * Signifying that population and dispersion
#                              coefficients are read from an external file with
#                              DOS name of popcq.  This is an ASCII file which
#                              contains Lines 8051 through 8100 proceeded by a
#                              single line of descriptive information that is
#                              printed in the run output.
#
8120,0.001,0.01,0,0.001,0.001  *Using the program default deposition velocities
#
8999                    * End of the input for a 50-mile dose calculation
#
10000                   * End of run

0         1         2         3         4         5         6         7
1234567890123456789012345678901234567890123456789012345678901234567890123456789
```

```
* POPULATION AND X/Q VALUES FOR EXAMPLE 6

8051,0,30.,3.,19.,12.                *POPULATION VS DISTANCE FOR SECTOR 1
8052,0,0,80.,440.,750.                          *SECTOR 2
8053,0,0,350.,780.,940.                         *SECTOR 3
8054,0,0,190.,530.,1.5E4                        *SECTOR 4
8055,0,30.,100.,850.,4.3E4                      *SECTOR 5
8056,0,0,100.,5.8E3,7.1E3                       *SECTOR 6
8057,0,7.,250.,1.6E3,4.4E4                      *SECTOR 7
8058,0,0,46.,610.,4.9E3                         *SECTOR 8
8059,0,0,0,100.,8.4E3                           *SECTOR 9
8060,0,0,0,0,130.                               *SECTOR 10
8061,0,0,0,0,0                                  *SECTOR 11
8062,0,6.,9.,130.,210.                          *SECTOR 12
8063,0,1.4E3,180.,120.,27.                      *SECTOR 13
8064,3.,110.,310.,66.,560.                      *SECTOR 14
8065,3.,24.,99.,140.,150.                       *SECTOR 15
8066,0,96.,99.,56.,78.                          *SECTOR 16
8071,2.E-8,6.E-9,2.E-9,2.E-9,1.E-9      *CHI/Q VS DISTANCE FOR SECTOR 1
8072,2.E-8,1.E-8,8.E-9,3.E-9,2.E-9      *SECTOR 2
8073,3.E-8,2.E-8,1.E-8,7.E-9,7.E-9      *SECTOR 3
8074,3.E-8,2.E-8,1.E-8,1.E-8,2.E-9      *SECTOR 4
8075,3.E-8,1.E-8,6.E-9,3.E-9,1.E-9      *SECTOR 5
8076,7.E-8,2.E-8,6.E-9,1.E-9,9.E-10     *SECTOR 6
8077,7.E-8,2.E-8,8.E-9,3.E-9,2.E-9      *SECTOR 7
8078,4.E-8,2.E-8,6.E-9,3.E-9,1.E-9      *SECTOR 8
8079,3.E-8,2.E-8,6.E-9,3.E-9,1.E-9      *SECTOR 9
8080,3.E-8,2.E-8,1.E-8,3.E-9,1.E-9      *SECTOR 10
8081,2.E-8,6.E-9,1.E-9,5.E-10,2.E-10    *SECTOR 11
8082,1.E-8,2.E-9,6.E-10,3.E-10,1.E-10   *SECTOR 12
8083,1.E-8,1.E-9,6.E-10,3.E-10,1.E-10   *SECTOR 13
8084,1.E-8,2.E-9,8.E-10,5.E-10,2.E-10   *SECTOR 14
8085,1.E-8,3.E-9,1.E-9,3.E-10,2.E-10    *SECTOR 15
8086,2.E-8,6.E-9,3.E-9,1.E-9,1.E-10     *SECTOR 16
8091,4.5,4.5,4.5,4.5
8092,4.5,4.5,4.5,4.5
8093,4.5,4.5,4.5,4.5
8094,4.5,4.5,4.5,4.5
8110,3,4.E-8,1.4E4,4.5
10000
```

```
                RADIOLOGICAL SAFETY ANALYSIS COMPUTER PROGRAM (RSAC-5)
(RSAC-5E,REV 5.1,08/09/93) SERIAL  700  DATE  09/15/93  TIME 15:14  PAGE   1
example6:  Fifty-mile radius dose calculation for a chronic release

***DIRECT RADIONUCLIDE INPUT

        ANY PREVIOUS INVENTORY HAS BEEN ZEROED

     NUCLIDE              HALF LIFE         CURIES

   10030    H  3      1.228E+01   yr     2.100E-02
  380890   Sr 89      5.049E+01   d      3.100E-05
  380900   Sr 90      2.912E+01   yr     3.500E+00
  390900    Y 90      6.410E+01   h      3.500E+00
  441060   Ru106      3.682E+02   d      3.500E-01
  451061   Rh106M     2.200E+00   h      3.500E-01
  531290    I129      1.570E+07   yr     2.500E-06
  551340   Cs134      2.062E+00   yr     2.100E+00
  551370   Cs137      3.000E+01   yr     3.700E+00
  561371   Ba137M     2.552E+00   m      3.500E+00
  581440   Ce144      2.843E+02   d      2.800E+00
  591441   Pr144M     7.200E+00   m      2.800E+00
  611470   Pm147      2.623E+00   yr     2.200E+00
  631540   Eu154      8.600E+00   yr     2.100E-01
  902280   Th228      1.913E+00   yr     5.300E-07
  942380   Pu238      8.775E+01   yr     1.200E-03
  942390   Pu239      2.413E+04   yr     1.800E-05
  952410   Am241      4.322E+02   yr     4.000E-06
```

```
           RADIOLOGICAL SAFETY ANALYSIS COMPUTER PROGRAM (RSAC-5)
(RSAC-5E,REV 5.1,08/09/93) SERIAL  700  DATE  09/15/93  TIME 15:14  PAGE    2
example6:  Fifty-mile radius dose calculation for a chronic release

***FIFTY MILE ANNUAL DOSE CALCULATIONS
    EXTERNAL DOSE-RATE CONVERSION FACTORS FROM DOE/EH-0070
    INTERNAL DOSE CONVERSION FACTORS FROM DOE/EH-0071
    BREATHING RATE = 2.6600E-04 cu m/s

    BUILDING SHIELDING/EXPOSURE FACTORS
          7.000E-01 DEPOSITION
          1.000E+00 AIR IMMERSION

    RELEASE TIME FOR EXPONENTIAL DECAY FUNCTION =  1.0000E+00 (s)

    POPULATION AND MET DATA FROM EXTERNAL USER FILE  popcq

      POPULATION AND CHI/Q VALUES FOR 50-MILE DOSE CALCULATION


    INGESTION CALCULATIONS MADE USING CODE CALCULATED CONSTANTS

       INGESTION CONSTANTS:
           5.20E+02  STORED VEGETABLE USAGE FACTOR (Kg/yr)
           6.40E+01  FRESH VEGETABLE USAGE FACTOR (Kg/yr)
           1.10E+02  MEAT USAGE FACTOR (Kg/yr)
           3.10E+02  MILK USAGE FACTOR (L/yr)
           7.60E-01  FRACTION OF STORED VEGETABLES FROM GARDEN
           1.00E+00  FRACTION OF FRESH VEGETABLES FROM GARDEN
           5.70E-01  RETENTION FACTOR FOR ACTIVITY ON FORAGE
           2.00E-01  RETENTION FACTOR FOR ACTIVITY ON VEGETABLES
           1.00E+00  RETENTION FACTOR FOR IODINES
           2.10E-03  REMOVAL RATE CONSTANT FOR CROPS (1/h)
           6.00E+01  VEGETABLE EXPOSURE TIME TO PLUME FOR CHRONIC RELEASE (d)
           3.00E+01  FORAGE EXPOSURE TIME TO PLUME FOR CHRONIC RELEASE (d)
           1.00E+00  HTO REMOVAL HALF TIME (d)
           2.25E+02  EFFECTIVE SURFACE SOIL DENSITY (Kg/sq m)
           6.00E+01  STORED VEGETABLE HOLDUP TIME AFTER HARVEST (d)
           1.00E+00  FRESH VEGETABLE HOLDUP TIME AFTER HARVEST (d)
           1.60E+01  ANIMALS DAILY FORAGE FEED (Kg/d)
           2.00E+00  FEED-MILK-RECEPTOR TRANSFER TIME (d)
           2.00E+01  SLAUGHTER TO CONSUMPTION TIME (d)
           4.00E-01  FRACTION OF YEAR ON PASTURE
           4.30E-01  PASTURE FEED FRACTION
           9.00E+01  STORED FEED STORAGE TIME
           2.00E+00  VEGETABLE VEGETATION YIELD (Kg/sq m)
           2.80E-01  FORAGE VEGETATION YIELD (Kg/sq m)
           4.90E+00  ABSOLUTE HUMIDITY (g/cu m)

    CHRONIC RELEASE - ANNUAL DOSE
       ACTIVITY BUILDUP IN SOIL OVER   1.500E+01 (yr)
```

```
                RADIOLOGICAL SAFETY ANALYSIS COMPUTER PROGRAM (RSAC-5)
(RSAC-5E,REV 5.1,08/09/93) SERIAL  700  DATE  09/15/93  TIME 15:14  PAGE   3
example6:  Fifty-mile radius dose calculation for a chronic release

    INTERNAL EXPOSURE INTEGRATION PERIOD = 50 yr

    GROUND SURFACE EXPOSURE PERIOD =  1.000E+00 yr

   DEPOSITION VELOCITIES (m/s)
    SOLIDS = 1.000E-03   HALOGENS = 1.000E-02   NOBLE GASES = 0.000E+00
        CESIUM =  1.000E-03   RUTHENIUM = 1.000E-03
```

NUCLIDE			BEFORE DECAY INVENTORY (Ci)	LUNG CLASS
1	10030	H- 3	2.100E-02	HTO
2	380890	Sr- 89	3.100E-05	D
3	380900	Sr- 90	3.500E+00	D
4	390900	Y- 90	3.500E+00	Y
5	441060	Ru-106	3.500E-01	Y
6	451061	Rh-106M	3.500E-01	Y
7	531290	I-129	2.500E-06	D
8	551340	Cs-134	2.100E+00	D
9	551370	Cs-137	3.700E+00	D
10	561371	Ba-137M	3.500E+00	D
11	581440	Ce-144	2.800E+00	Y
12	591441	Pr-144M	2.800E+00	Y
13	611470	Pm-147	2.200E+00	Y
14	631540	Eu-154	2.100E-01	W
15	952410	Am-241	4.000E-06	W
16	902280	Th-228	5.300E-07	Y
17	942380	Pu-238	1.200E-03	Y
18	942390	Pu-239	1.800E-05	Y

RADIOLOGICAL SAFETY ANALYSIS COMPUTER PROGRAM (RSAC-5)
(RSAC-5E,REV 5.1,08/09/93) SERIAL 700 DATE 09/15/93 TIME 15:14 PAGE 4
example6: Fifty-mile radius dose calculation for a chronic release

50 MILE POPULATION VALUES

SECTOR	DISTANCE (MILES) 0-10	10-20	20-30	30-40	40-50	SECTOR TOTAL
1 N	0.0E+00	3.0E+01	3.0E+00	1.9E+01	1.2E+01	6.4E+01
2 NNE	0.0E+00	0.0E+00	8.0E+01	4.4E+02	7.5E+02	1.3E+03
3 NE	0.0E+00	0.0E+00	3.5E+02	7.8E+02	9.4E+02	2.1E+03
4 ENE	0.0E+00	0.0E+00	1.9E+02	5.3E+02	1.5E+04	1.6E+04
5 E	0.0E+00	3.0E+01	1.0E+02	8.5E+02	4.3E+04	4.4E+04
6 ESE	0.0E+00	0.0E+00	1.0E+02	5.8E+03	7.1E+03	1.3E+04
7 SE	0.0E+00	7.0E+00	2.5E+02	1.6E+03	4.4E+04	4.6E+04
8 SSE	0.0E+00	0.0E+00	4.6E+01	6.1E+02	4.9E+03	5.6E+03
9 S	0.0E+00	0.0E+00	0.0E+00	1.0E+02	8.4E+03	8.5E+03
10 SSW	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.3E+02	1.3E+02
11 SW	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
12 WSW	0.0E+00	6.0E+00	9.0E+00	1.3E+02	2.1E+02	3.6E+02
13 W	0.0E+00	1.4E+03	1.8E+02	1.2E+02	2.7E+01	1.7E+03
14 WNW	3.0E+00	1.1E+02	3.1E+02	6.6E+01	5.6E+02	1.0E+03
15 NW	3.0E+00	2.4E+01	9.9E+01	1.4E+02	1.5E+02	4.2E+02
16 NNW	0.0E+00	9.6E+01	9.9E+01	5.6E+01	7.8E+01	3.3E+02
					50 MILE RADIUS TOTAL	1.4E+05

50 MILE CHI/Q (s/cu m)

SECTOR	DISTANCE (MILES) 0-10	10-20	20-30	30-40	40-50
1 N	2.0E-08	6.0E-09	2.0E-09	2.0E-09	1.0E-09
2 NNE	2.0E-08	1.0E-08	8.0E-09	3.0E-09	2.0E-09
3 NE	3.0E-08	2.0E-08	1.0E-08	7.0E-09	7.0E-09
4 ENE	3.0E-08	2.0E-08	1.0E-08	1.0E-08	2.0E-09
5 E	3.0E-08	1.0E-08	6.0E-09	3.0E-09	1.0E-09
6 ESE	7.0E-08	2.0E-08	6.0E-09	1.0E-09	9.0E-10
7 SE	7.0E-08	2.0E-08	8.0E-09	3.0E-09	2.0E-09
8 SSE	4.0E-08	2.0E-08	6.0E-09	3.0E-09	1.0E-09
9 S	3.0E-08	2.0E-08	6.0E-09	3.0E-09	1.0E-09
10 SSW	3.0E-08	2.0E-08	1.0E-08	3.0E-09	1.0E-09
11 SW	2.0E-08	6.0E-09	1.0E-09	5.0E-10	2.0E-10
12 WSW	1.0E-08	2.0E-09	6.0E-10	3.0E-10	1.0E-10
13 W	1.0E-08	1.0E-09	6.0E-10	3.0E-10	1.0E-10
14 WNW	1.0E-08	2.0E-09	8.0E-10	5.0E-10	2.0E-10
15 NW	1.0E-08	3.0E-09	1.0E-09	3.0E-10	2.0E-10
16 NNW	2.0E-08	6.0E-09	3.0E-09	1.0E-09	1.0E-10

RADIOLOGICAL SAFETY ANALYSIS COMPUTER PROGRAM (RSAC-5)
(RSAC-5E,REV 5.1,08/09/93) SERIAL 700 DATE 09/15/93 TIME 15:14 PAGE 5
example6: Fifty-mile radius dose calculation for a chronic release

50 MILE CHI/Q * POPULATION VALUES (person-s/cu m)

SECTOR	DISTANCE (MILES) 0-10	10-20	20-30	30-40	40-50	SECTOR TOTAL
1 N	0.0E+00	1.8E-07	6.0E-09	3.8E-08	1.2E-08	2.4E-07
2 NNE	0.0E+00	0.0E+00	6.4E-07	1.3E-06	1.5E-06	3.5E-06
3 NE	0.0E+00	0.0E+00	3.5E-06	5.5E-06	6.6E-06	1.6E-05
4 ENE	0.0E+00	0.0E+00	1.9E-06	5.3E-06	3.0E-05	3.7E-05
5 E	0.0E+00	3.0E-07	6.0E-07	2.6E-06	4.3E-05	4.6E-05
6 ESE	0.0E+00	0.0E+00	6.0E-07	5.8E-06	6.4E-06	1.3E-05
7 SE	0.0E+00	1.4E-07	2.0E-06	4.8E-06	8.8E-05	9.5E-05
8 SSE	0.0E+00	0.0E+00	2.8E-07	1.8E-06	4.9E-06	7.0E-06
9 S	0.0E+00	0.0E+00	0.0E+00	3.0E-07	8.4E-06	8.7E-06
10 SSW	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.3E-07	1.3E-07
11 SW	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
12 WSW	0.0E+00	1.2E-08	5.4E-09	3.9E-08	2.1E-08	7.7E-08
13 W	0.0E+00	1.4E-06	1.1E-07	3.6E-08	2.7E-09	1.5E-06
14 WNW	3.0E-08	2.2E-07	2.5E-07	3.3E-08	1.1E-07	6.4E-07
15 NW	3.0E-08	7.2E-08	9.9E-08	4.2E-08	3.0E-08	2.7E-07
16 NNW	0.0E+00	5.8E-07	3.0E-07	5.6E-08	7.8E-09	9.4E-07
				50 MILE RADIUS TOTAL		2.3E-04

AVERAGE WIND VELOCITY FOR EACH SECTOR

SECTOR	(m/s)
1 N	4.5E+00
2 NNE	4.5E+00
3 NE	4.5E+00
4 ENE	4.5E+00
5 E	4.5E+00
6 ESE	4.5E+00
7 SE	4.5E+00
8 SSE	4.5E+00
9 S	4.5E+00
10 SSW	4.5E+00
11 SW	4.5E+00
12 WSW	4.5E+00
13 W	4.5E+00
14 WNW	4.5E+00
15 NW	4.5E+00
16 NNW	4.5E+00

LOCATION OF MAXIMUM EXPOSED INDIVIDUAL:
SECTOR = 3 NE
DISTANCE = 1.4E+04 m
CHI/Q = 4.0E-08 s/cu m
AVERAGE WIND VELOCITY = 4.5E+00 m/s

RADIOLOGICAL SAFETY ANALYSIS COMPUTER PROGRAM (RSAC-5)
(RSAC-5E,REV 5.1,08/09/93) SERIAL 700 DATE 09/15/93 TIME 15:14 PAGE 6
example6: Fifty-mile radius dose calculation for a chronic release

INTERNAL DOSES (rem) FOR THE MAXIMUM EXPOSED INDIVIDUAL FROM INHALATION

	ORGAN			
NUCLIDE	LUNGS	BONE SUR	THYROID	CEDE
H- 3	0.0E+00	0.0E+00	0.0E+00	2.1E-11
Sr- 89	2.7E-12	1.0E-11	0.0E+00	1.9E-12
Sr- 90	0.0E+00	1.0E-04	0.0E+00	8.6E-06
Y- 90	1.3E-06	0.0E+00	0.0E+00	3.1E-07
Ru-106	1.4E-05	0.0E+00	0.0E+00	1.6E-06
Rh-106M	2.6E-09	0.0E+00	0.0E+00	4.3E-10
I-129	0.0E+00	0.0E+00	1.6E-10	4.8E-12
Cs-134	9.8E-07	9.2E-07	9.2E-07	1.1E-06
Cs-137	1.3E-06	1.1E-06	1.1E-06	1.3E-06
Ba-137M	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Ce-144	8.6E-05	0.0E+00	0.0E+00	1.0E-05
Pr-144M	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Pm-147	6.6E-06	0.0E+00	0.0E+00	8.0E-07
Eu-154	6.5E-07	4.2E-06	0.0E+00	5.8E-07
Am-241	0.0E+00	4.0E-07	0.0E+00	2.2E-08
Th-228	1.5E-08	0.0E+00	0.0E+00	1.7E-09
Pu-238	1.5E-05	4.0E-05	0.0E+00	3.8E-06
Pu-239	2.3E-07	6.7E-07	0.0E+00	6.3E-08
TOTALS	1.3E-04	1.5E-04	2.1E-06	2.9E-05

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RADIOLOGICAL SAFETY ANALYSIS COMPUTER PROGRAM (RSAC-5)
(RSAC-5E,REV 5.1,08/09/93) SERIAL  700  DATE  09/15/93  TIME 15:14  PAGE   7
example6:  Fifty-mile radius dose calculation for a chronic release
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EXTERNAL DOSES (rem) FOR THE MAXIMUM EXPOSED INDIVIDUAL FROM AIR IMMERSION

	ORGAN			
NUCLIDE	LUNGS	SKELETON	THYROID	EXT EDE
H- 3	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Sr- 89	2.7E-17	2.9E-17	3.4E-17	3.0E-17
Sr- 90	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Y- 90	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Ru-106	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Rh-106M	0.0E+00	0.0E+00	0.0E+00	0.0E+00
I-129	7.1E-17	1.2E-16	1.4E-16	1.4E-16
Cs-134	2.0E-08	2.3E-08	2.5E-08	2.3E-08
Cs-137	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Ba-137M	1.3E-08	1.5E-08	1.6E-08	1.5E-08
Ce-144	2.7E-10	4.5E-10	3.9E-10	3.5E-10
Pr-144M	1.2E-12	2.2E-12	2.3E-12	2.1E-12
Pm-147	4.4E-14	7.2E-14	6.2E-14	5.5E-14
Eu-154	1.6E-09	1.8E-09	2.1E-09	1.9E-09
Am-241	3.8E-16	7.0E-16	6.0E-16	5.1E-16
Th-228	5.7E-18	9.2E-18	8.0E-18	7.1E-18
Pu-238	1.9E-16	3.4E-16	2.8E-16	7.2E-16
Pu-239	6.0E-18	9.9E-18	8.4E-18	1.0E-17
TOTALS	3.5E-08	4.0E-08	4.4E-08	4.0E-08

RADIOLOGICAL SAFETY ANALYSIS COMPUTER PROGRAM (RSAC-5)
(RSAC-5E,REV 5.1,08/09/93) SERIAL 700 DATE 09/15/93 TIME 15:14 PAGE 8
example6: Fifty-mile radius dose calculation for a chronic release

EXTERNAL DOSES (rem) FOR THE MAXIMUM EXPOSED INDIVIDUAL FROM GROUND SURFACE

	ORGAN			
NUCLIDE	LUNGS	SKELETON	THYROID	EXT EDE
H- 3	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Sr- 89	2.2E-15	2.4E-15	2.8E-15	2.5E-15
Sr- 90	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Y- 90	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Ru-106	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Rh-106M	0.0E+00	0.0E+00	0.0E+00	0.0E+00
I-129	8.1E-13	1.4E-12	1.6E-12	1.6E-12
Cs-134	7.5E-06	8.4E-06	9.4E-06	8.5E-06
Cs-137	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Ba-137M	5.6E-06	6.4E-06	7.0E-06	6.4E-06
Ce-144	9.4E-08	1.5E-07	1.4E-07	1.2E-07
Pr-144M	4.5E-10	8.1E-10	8.8E-10	8.0E-10
Pm-147	1.9E-11	3.1E-11	2.7E-11	2.4E-11
Eu-154	6.5E-07	7.3E-07	8.2E-07	7.3E-07
Am-241	2.4E-13	4.5E-13	3.8E-13	3.6E-13
Th-228	2.5E-15	4.0E-15	3.5E-15	3.7E-15
Pu-238	4.4E-13	7.4E-13	5.5E-13	3.1E-12
Pu-239	4.9E-15	8.0E-15	6.3E-15	2.1E-14
TOTALS	1.4E-05	1.6E-05	1.7E-05	1.6E-05

RADIOLOGICAL SAFETY ANALYSIS COMPUTER PROGRAM (RSAC-5)
(RSAC-5E,REV 5.1,08/09/93) SERIAL 700 DATE 09/15/93 TIME 15:14 PAGE 9
example6: Fifty-mile radius dose calculation for a chronic release

INTERNAL DOSES (rem) FOR THE MAXIMUM EXPOSED INDIVIDUAL FROM INGESTION

	ORGAN			
NUCLIDE	LUNGS	BONE SUR	THYROID	CEDE
H- 3	0.0E+00	0.0E+00	0.0E+00	5.9E-11
Sr- 89	0.0E+00	1.4E-11	0.0E+00	6.5E-12
Sr- 90	0.0E+00	1.2E-03	0.0E+00	9.6E-05
Y- 90	0.0E+00	0.0E+00	0.0E+00	3.4E-06
Ru-106	0.0E+00	0.0E+00	0.0E+00	2.0E-07
Rh-106M	0.0E+00	0.0E+00	0.0E+00	1.1E-17
I-129	0.0E+00	0.0E+00	1.2E-07	3.7E-09
Cs-134	3.9E-05	3.7E-05	3.9E-05	4.3E-05
Cs-137	5.7E-05	5.7E-05	5.7E-05	5.9E-05
Ba-137M	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Ce-144	0.0E+00	0.0E+00	0.0E+00	2.1E-06
Pr-144M	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Pm-147	0.0E+00	0.0E+00	0.0E+00	2.5E-07
Eu-154	0.0E+00	4.5E-07	0.0E+00	2.4E-07
Am-241	0.0E+00	1.2E-08	0.0E+00	6.8E-10
Th-228	0.0E+00	4.2E-10	0.0E+00	1.8E-11
Pu-238	0.0E+00	1.1E-06	0.0E+00	6.4E-08
Pu-239	0.0E+00	2.0E-08	0.0E+00	1.1E-09
TOTALS	9.6E-05	1.3E-03	9.6E-05	2.0E-04

RADIOLOGICAL SAFETY ANALYSIS COMPUTER PROGRAM (RSAC-5)
(RSAC-5E,REV 5.1,08/09/93) SERIAL 700 DATE 09/15/93 TIME 15:14 PAGE 10
example6: Fifty-mile radius dose calculation for a chronic release

TOTAL EXPOSURES FOR THE MAXIMUM EXPOSED INDIVIDUAL (rem)

	ORGAN			
NUCLIDE	LUNGS	BONE SUR	THYROID	CEDE
H- 3	0.0E+00	0.0E+00	0.0E+00	8.0E-11
Sr- 89	2.7E-12	2.4E-11	2.8E-15	8.4E-12
Sr- 90	0.0E+00	1.3E-03	0.0E+00	1.0E-04
Y- 90	1.3E-06	0.0E+00	0.0E+00	3.7E-06
Ru-106	1.4E-05	0.0E+00	0.0E+00	1.8E-06
Rh-106M	2.6E-09	0.0E+00	0.0E+00	4.3E-10
I-129	8.1E-13	1.4E-12	1.2E-07	3.7E-09
Cs-134	4.8E-05	4.6E-05	4.9E-05	5.3E-05
Cs-137	5.8E-05	5.8E-05	5.8E-05	6.0E-05
Ba-137M	5.6E-06	6.4E-06	7.1E-06	6.4E-06
Ce-144	8.6E-05	1.5E-07	1.4E-07	1.3E-05
Pr-144M	4.5E-10	8.1E-10	8.8E-10	8.0E-10
Pm-147	6.6E-06	3.2E-11	2.7E-11	1.0E-06
Eu-154	1.3E-06	5.4E-06	8.2E-07	1.6E-06
Am-241	2.4E-13	4.1E-07	3.8E-13	2.3E-08
Th-228	1.5E-08	4.2E-10	3.5E-15	1.8E-09
Pu-238	1.5E-05	4.1E-05	5.5E-13	3.9E-06
Pu-239	2.3E-07	6.9E-07	6.3E-15	6.4E-08
TOTALS	2.4E-04	1.4E-03	1.2E-04	2.5E-04

TOTAL EXPOSURE FOR EACH RADIONUCLIDE IS THE SUMMATION OF THE DOSE RESULTING FROM INHALATION, AIR IMMERSION, GROUND SURFACE AND INGESTION

RADIOLOGICAL SAFETY ANALYSIS COMPUTER PROGRAM (RSAC-5)
(RSAC-5E,REV 5.1,08/09/93) SERIAL 700 DATE 09/15/93 TIME 15:14 PAGE 11
example6: Fifty-mile radius dose calculation for a chronic release

INTERNAL 50-MILE DOSES (person-rem) FROM INHALATION

	ORGAN			
NUCLIDE	LUNGS	BONE SUR	THYROID	CEDE
H- 3	0.0E+00	0.0E+00	0.0E+00	1.2E-07
Sr- 89	1.5E-08	5.9E-08	0.0E+00	1.1E-08
Sr- 90	0.0E+00	5.8E-01	0.0E+00	4.9E-02
Y- 90	7.3E-03	0.0E+00	0.0E+00	1.8E-03
Ru-106	7.9E-02	0.0E+00	0.0E+00	9.4E-03
Rh-106M	6.3E-06	0.0E+00	0.0E+00	1.0E-06
I-129	0.0E+00	0.0E+00	9.0E-07	2.8E-08
Cs-134	5.7E-03	5.3E-03	5.3E-03	6.0E-03
Cs-137	7.5E-03	6.6E-03	6.6E-03	7.2E-03
Ba-137M	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Ce-144	5.0E-01	0.0E+00	0.0E+00	6.0E-02
Pr-144M	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Pm-147	3.8E-02	0.0E+00	0.0E+00	4.6E-03
Eu-154	3.7E-03	2.4E-02	0.0E+00	3.3E-03
Am-241	0.0E+00	2.3E-03	0.0E+00	1.3E-04
Th-228	8.4E-05	0.0E+00	0.0E+00	1.0E-05
Pu-238	8.8E-02	2.3E-01	0.0E+00	2.2E-02
Pu-239	1.3E-03	3.9E-03	0.0E+00	3.6E-04
TOTALS	7.3E-01	8.5E-01	1.2E-02	1.6E-01

RADIOLOGICAL SAFETY ANALYSIS COMPUTER PROGRAM (RSAC-5)
(RSAC-5E,REV 5.1,08/09/93) SERIAL 700 DATE 09/15/93 TIME 15:14 PAGE 12
example6: Fifty-mile radius dose calculation for a chronic release

EXTERNAL 50-MILE DOSES (person-rem) FROM AIR IMMERSION

	ORGAN			
NUCLIDE	LUNGS	SKELETON	THYROID	EXT EDE
H- 3	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Sr- 89	1.5E-13	1.7E-13	2.0E-13	1.7E-13
Sr- 90	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Y- 90	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Ru-106	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Rh-106M	0.0E+00	0.0E+00	0.0E+00	0.0E+00
I-129	4.1E-13	7.1E-13	8.2E-13	8.1E-13
Cs-134	1.2E-04	1.3E-04	1.5E-04	1.3E-04
Cs-137	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Ba-137M	7.4E-05	8.4E-05	9.3E-05	8.4E-05
Ce-144	1.6E-06	2.6E-06	2.3E-06	2.0E-06
Pr-144M	4.8E-09	8.6E-09	9.3E-09	8.4E-09
Pm-147	2.5E-10	4.1E-10	3.6E-10	3.1E-10
Eu-154	9.5E-06	1.1E-05	1.2E-05	1.1E-05
Am-241	2.2E-12	4.0E-12	3.5E-12	2.9E-12
Th-228	3.3E-14	5.3E-14	4.6E-14	4.1E-14
Pu-238	1.1E-12	2.0E-12	1.6E-12	4.2E-12
Pu-239	3.4E-14	5.7E-14	4.8E-14	5.8E-14
TOTALS	2.0E-04	2.3E-04	2.5E-04	2.3E-04

RADIOLOGICAL SAFETY ANALYSIS COMPUTER PROGRAM (RSAC-5)
(RSAC-5E,REV 5.1,08/09/93) SERIAL 700 DATE 09/15/93 TIME 15:14 PAGE 13
example6: Fifty-mile radius dose calculation for a chronic release

EXTERNAL 50-MILE DOSES (person-rem) FROM GROUND SURFACE

	ORGAN			
NUCLIDE	LUNGS	SKELETON	THYROID	EXT EDE
H- 3	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Sr- 89	1.3E-11	1.4E-11	1.6E-11	1.4E-11
Sr- 90	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Y- 90	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Ru-106	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Rh-106M	0.0E+00	0.0E+00	0.0E+00	0.0E+00
I-129	4.7E-09	8.1E-09	9.4E-09	9.4E-09
Cs-134	4.3E-02	4.8E-02	5.4E-02	4.9E-02
Cs-137	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Ba-137M	3.2E-02	3.7E-02	4.0E-02	3.7E-02
Ce-144	5.4E-04	8.8E-04	7.8E-04	6.9E-04
Pr-144M	1.8E-06	3.2E-06	3.5E-06	3.2E-06
Pm-147	1.1E-07	1.8E-07	1.6E-07	1.4E-07
Eu-154	3.7E-03	4.2E-03	4.7E-03	4.2E-03
Am-241	1.4E-09	2.6E-09	2.2E-09	2.0E-09
Th-228	1.4E-11	2.3E-11	2.0E-11	2.1E-11
Pu-238	2.5E-09	4.3E-09	3.1E-09	1.8E-08
Pu-239	2.8E-11	4.6E-11	3.6E-11	1.2E-10
TOTALS	8.0E-02	9.0E-02	1.0E-01	9.0E-02

RADIOLOGICAL SAFETY ANALYSIS COMPUTER PROGRAM (RSAC-5)
(RSAC-5E,REV 5.1,08/09/93) SERIAL 700 DATE 09/15/93 TIME 15:14 PAGE 14
example6: Fifty-mile radius dose calculation for a chronic release

INTERNAL 50-MILE DOSES (person-rem) FROM INGESTION

	ORGAN			
NUCLIDE	LUNGS	BONE SUR	THYROID	CEDE
H- 3	0.0E+00	0.0E+00	0.0E+00	3.4E-07
Sr- 89	0.0E+00	8.1E-08	0.0E+00	3.7E-08
Sr- 90	0.0E+00	6.8E+00	0.0E+00	5.5E-01
Y- 90	0.0E+00	0.0E+00	0.0E+00	2.0E-02
Ru-106	0.0E+00	0.0E+00	0.0E+00	1.2E-03
Rh-106M	0.0E+00	0.0E+00	0.0E+00	2.6E-14
I-129	0.0E+00	0.0E+00	7.1E-04	2.1E-05
Cs-134	2.2E-01	2.1E-01	2.2E-01	2.5E-01
Cs-137	3.3E-01	3.3E-01	3.3E-01	3.4E-01
Ba-137M	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Ce-144	0.0E+00	0.0E+00	0.0E+00	1.2E-02
Pr-144M	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Pm-147	0.0E+00	0.0E+00	0.0E+00	1.4E-03
Eu-154	0.0E+00	2.6E-03	0.0E+00	1.4E-03
Am-241	0.0E+00	7.1E-05	0.0E+00	3.9E-06
Th-228	0.0E+00	2.4E-06	0.0E+00	1.0E-07
Pu-238	0.0E+00	6.5E-03	0.0E+00	3.7E-04
Pu-239	0.0E+00	1.1E-04	0.0E+00	6.3E-06
TOTALS	5.5E-01	7.3E+00	5.5E-01	1.2E+00

RADIOLOGICAL SAFETY ANALYSIS COMPUTER PROGRAM (RSAC-5)
(RSAC-5E,REV 5.1,08/09/93) SERIAL 700 DATE 09/15/93 TIME 15:14 PAGE 15
example6: Fifty-mile radius dose calculation for a chronic release

TOTAL RADIONUCLIDE EXPOSURE WITHIN 50-MILE RADIUS (person-rem)

	ORGAN			
NUCLIDE	LUNGS	BONE SUR	THYROID	CEDE
H- 3	0.0E+00	0.0E+00	0.0E+00	4.6E-07
Sr- 89	1.5E-08	1.4E-07	1.6E-11	4.8E-08
Sr- 90	0.0E+00	7.3E+00	0.0E+00	6.0E-01
Y- 90	7.3E-03	0.0E+00	0.0E+00	2.1E-02
Ru-106	7.9E-02	0.0E+00	0.0E+00	1.1E-02
Rh-106M	6.3E-06	0.0E+00	0.0E+00	1.0E-06
I-129	4.7E-09	8.1E-09	7.1E-04	2.1E-05
Cs-134	2.7E-01	2.6E-01	2.8E-01	3.0E-01
Cs-137	3.3E-01	3.3E-01	3.3E-01	3.5E-01
Ba-137M	3.2E-02	3.7E-02	4.1E-02	3.7E-02
Ce-144	5.0E-01	8.8E-04	7.9E-04	7.3E-02
Pr-144M	1.8E-06	3.2E-06	3.5E-06	3.2E-06
Pm-147	3.8E-02	1.8E-07	1.6E-07	6.0E-03
Eu-154	7.5E-03	3.1E-02	4.7E-03	8.9E-03
Am-241	1.4E-09	2.3E-03	2.2E-09	1.3E-04
Th-228	8.4E-05	2.4E-06	2.0E-11	1.0E-05
Pu-238	8.8E-02	2.3E-01	3.1E-09	2.2E-02
Pu-239	1.3E-03	4.0E-03	3.6E-11	3.7E-04
TOTALS	1.4E+00	8.2E+00	6.6E-01	1.4E+00

TOTAL EXPOSURE FOR EACH RADIONUCLIDE IS THE SUMMATION OF THE DOSE RESULTING FROM INHALATION, AIR IMMERSION, GROUND SURFACE AND INGESTION

RADIOLOGICAL SAFETY ANALYSIS COMPUTER PROGRAM (RSAC-5)
(RSAC-5E,REV 5.1,08/09/93) SERIAL 700 DATE 09/15/93 TIME 15:14 PAGE 16
example6: Fifty-mile radius dose calculation for a chronic release

TOTAL SECTOR EXPOSURES (person-rem) WITHIN 50-MILE RADIUS FOR THE LUNGS

	DISTANCE (MILES)					
SECTOR	0-10	10-20	20-30	30-40	40-50	SECTOR TOTAL
1 N	0.0E+00	1.1E-03	3.5E-05	2.2E-04	7.1E-05	1.4E-03
2 NNE	0.0E+00	0.0E+00	3.8E-03	7.8E-03	8.9E-03	2.0E-02
3 NE	0.0E+00	0.0E+00	2.1E-02	3.2E-02	3.9E-02	9.2E-02
4 ENE	0.0E+00	0.0E+00	1.1E-02	3.1E-02	1.8E-01	2.2E-01
5 E	0.0E+00	1.8E-03	3.5E-03	1.5E-02	2.5E-01	2.7E-01
6 ESE	0.0E+00	0.0E+00	3.5E-03	3.4E-02	3.8E-02	7.6E-02
7 SE	0.0E+00	8.3E-04	1.2E-02	2.8E-02	5.2E-01	5.6E-01
8 SSE	0.0E+00	0.0E+00	1.6E-03	1.1E-02	2.9E-02	4.1E-02
9 S	0.0E+00	0.0E+00	0.0E+00	1.8E-03	5.0E-02	5.1E-02
10 SSW	0.0E+00	0.0E+00	0.0E+00	0.0E+00	7.7E-04	7.7E-04
11 SW	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
12 WSW	0.0E+00	7.1E-05	3.2E-05	2.3E-04	1.2E-04	4.6E-04
13 W	0.0E+00	8.3E-03	6.4E-04	2.1E-04	1.6E-05	9.1E-03
14 WNW	1.8E-04	1.3E-03	1.5E-03	1.9E-04	6.6E-04	3.8E-03
15 NW	1.8E-04	4.3E-04	5.8E-04	2.5E-04	1.8E-04	1.6E-03
16 NNW	0.0E+00	3.4E-03	1.8E-03	3.3E-04	4.6E-05	5.5E-03

50 MILE RADIUS TOTAL 1.4E+00

RADIOLOGICAL SAFETY ANALYSIS COMPUTER PROGRAM (RSAC-5)
(RSAC-5E,REV 5.1,08/09/93) SERIAL 700 DATE 09/15/93 TIME 15:14 PAGE 17
example6: Fifty-mile radius dose calculation for a chronic release

TOTAL SECTOR EXPOSURES (person-rem) WITHIN 50-MILE RADIUS FOR THE BONE SUR

	DISTANCE (MILES)					
SECTOR	0-10	10-20	20-30	30-40	40-50	SECTOR TOTAL
1 N	0.0E+00	6.5E-03	2.2E-04	1.4E-03	4.3E-04	8.5E-03
2 NNE	0.0E+00	0.0E+00	2.3E-02	4.7E-02	5.4E-02	1.2E-01
3 NE	0.0E+00	0.0E+00	1.3E-01	2.0E-01	2.4E-01	5.6E-01
4 ENE	0.0E+00	0.0E+00	6.8E-02	1.9E-01	1.1E+00	1.3E+00
5 E	0.0E+00	1.1E-02	2.2E-02	9.1E-02	1.5E+00	1.7E+00
6 ESE	0.0E+00	0.0E+00	2.2E-02	2.1E-01	2.3E-01	4.6E-01
7 SE	0.0E+00	5.0E-03	7.2E-02	1.7E-01	3.2E+00	3.4E+00
8 SSE	0.0E+00	0.0E+00	9.9E-03	6.6E-02	1.8E-01	2.5E-01
9 S	0.0E+00	0.0E+00	0.0E+00	1.1E-02	3.0E-01	3.1E-01
10 SSW	0.0E+00	0.0E+00	0.0E+00	0.0E+00	4.7E-03	4.7E-03
11 SW	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
12 WSW	0.0E+00	4.3E-04	1.9E-04	1.4E-03	7.5E-04	2.8E-03
13 W	0.0E+00	5.0E-02	3.9E-03	1.3E-03	9.7E-05	5.5E-02
14 WNW	1.1E-03	7.9E-03	8.9E-03	1.2E-03	4.0E-03	2.3E-02
15 NW	1.1E-03	2.6E-03	3.6E-03	1.5E-03	1.1E-03	9.8E-03
16 NNW	0.0E+00	2.1E-02	1.1E-02	2.0E-03	2.8E-04	3.4E-02
				50 MILE RADIUS TOTAL		8.2E+00

RADIOLOGICAL SAFETY ANALYSIS COMPUTER PROGRAM (RSAC-5)
(RSAC-5E,REV 5.1,08/09/93) SERIAL 700 DATE 09/15/93 TIME 15:14 PAGE 18
example6: Fifty-mile radius dose calculation for a chronic release

TOTAL SECTOR EXPOSURES (person-rem) WITHIN 50-MILE RADIUS FOR THE THYROID

	DISTANCE (MILES)					
SECTOR	0-10	10-20	20-30	30-40	40-50	SECTOR TOTAL
1 N	0.0E+00	5.2E-04	1.7E-05	1.1E-04	3.5E-05	6.8E-04
2 NNE	0.0E+00	0.0E+00	1.8E-03	3.8E-03	4.3E-03	1.0E-02
3 NE	0.0E+00	0.0E+00	1.0E-02	1.6E-02	1.9E-02	4.5E-02
4 ENE	0.0E+00	0.0E+00	5.5E-03	1.5E-02	8.7E-02	1.1E-01
5 E	0.0E+00	8.7E-04	1.7E-03	7.4E-03	1.2E-01	1.3E-01
6 ESE	0.0E+00	0.0E+00	1.7E-03	1.7E-02	1.8E-02	3.7E-02
7 SE	0.0E+00	4.0E-04	5.8E-03	1.4E-02	2.5E-01	2.7E-01
8 SSE	0.0E+00	0.0E+00	8.0E-04	5.3E-03	1.4E-02	2.0E-02
9 S	0.0E+00	0.0E+00	0.0E+00	8.7E-04	2.4E-02	2.5E-02
10 SSW	0.0E+00	0.0E+00	0.0E+00	0.0E+00	3.7E-04	3.7E-04
11 SW	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
12 WSW	0.0E+00	3.5E-05	1.6E-05	1.1E-04	6.1E-05	2.2E-04
13 W	0.0E+00	4.0E-03	3.1E-04	1.0E-04	7.8E-06	4.5E-03
14 WNW	8.7E-05	6.3E-04	7.2E-04	9.5E-05	3.2E-04	1.9E-03
15 NW	8.7E-05	2.1E-04	2.9E-04	1.2E-04	8.7E-05	7.9E-04
16 NNW	0.0E+00	1.7E-03	8.6E-04	1.6E-04	2.2E-05	2.7E-03

50 MILE RADIUS TOTAL 6.6E-01

RADIOLOGICAL SAFETY ANALYSIS COMPUTER PROGRAM (RSAC-5)
(RSAC-5E,REV 5.1,08/09/93) SERIAL 700 DATE 09/15/93 TIME 15:14 PAGE 19
example6: Fifty-mile radius dose calculation for a chronic release

TOTAL SECTOR EXPOSURES (person-rem) WITHIN 50-MILE RADIUS FOR THE CEDE

SECTOR	DISTANCE (MILES) 0-10	10-20	20-30	30-40	40-50	SECTOR TOTAL
1 N	0.0E+00	1.1E-03	3.7E-05	2.4E-04	7.4E-05	1.5E-03
2 NNE	0.0E+00	0.0E+00	4.0E-03	8.2E-03	9.3E-03	2.1E-02
3 NE	0.0E+00	0.0E+00	2.2E-02	3.4E-02	4.1E-02	9.6E-02
4 ENE	0.0E+00	0.0E+00	1.2E-02	3.3E-02	1.9E-01	2.3E-01
5 E	0.0E+00	1.9E-03	3.7E-03	1.6E-02	2.7E-01	2.9E-01
6 ESE	0.0E+00	0.0E+00	3.7E-03	3.6E-02	4.0E-02	7.9E-02
7 SE	0.0E+00	8.7E-04	1.2E-02	3.0E-02	5.5E-01	5.9E-01
8 SSE	0.0E+00	0.0E+00	1.7E-03	1.1E-02	3.0E-02	4.3E-02
9 S	0.0E+00	0.0E+00	0.0E+00	1.9E-03	5.2E-02	5.4E-02
10 SSW	0.0E+00	0.0E+00	0.0E+00	0.0E+00	8.1E-04	8.1E-04
11 SW	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
12 WSW	0.0E+00	7.4E-05	3.4E-05	2.4E-04	1.3E-04	4.8E-04
13 W	0.0E+00	8.7E-03	6.7E-04	2.2E-04	1.7E-05	9.6E-03
14 WNW	1.9E-04	1.4E-03	1.5E-03	2.0E-04	7.0E-04	4.0E-03
15 NW	1.9E-04	4.5E-04	6.1E-04	2.6E-04	1.9E-04	1.7E-03
16 NNW	0.0E+00	3.6E-03	1.8E-03	3.5E-04	4.8E-05	5.8E-03
				50 MILE RADIUS TOTAL		1.4E+00

EXECUTION TIME = 1.89E+01 SECONDS

Example 7: Comparison of Cloud Gamma Dose Models

This example demonstrates cloud gamma dose calculations using the finite plume model. This example cautions users on the use of the air immersion model when the plume size is not large compared to the mean free path of the gamma rays.

The example consists of the release of Cs-137 and its daughter Ba-137m at ground level during Class F meteorology (Hilsmeier-Gifford diffusion). Four downwind distances ranging from 1.E2 to 1.E5 m have been chosen to show the magnitude of error in the use of the air immersion model when improperly used. At the 1.E2-m distance, the air immersion model over estimates the dose by approximately a factor of 50. Even at the 1.E5 meter distance, the air immersion model still overestimates the dose by a factor of 1.5. During stable meteorology, plumes never diffuse to sufficient size to allow use of the commonly used air immersion model. The finite plume model should always be used to test results for convergence before using the air immersion or semi-infinite models.

```
 example7     RSAC-5 INPUT     02/22/94     07:57
0         1         2         3         4         5         6         7
1234567890123456789012345678901234567890123456789012345678901234567890123456789

* Comparison of cloud gamma dose models
#
#    Comparing the finite, semi-infinite and air immersion models
#
#        This sample problem demonstrates the difference between the models
#        that can be used to calculate cloud gamma doses.  Both the air
#        immersion and the semi-infinite models require the plume size to be
#        large compared to the mean free path of the photons.  When it is not
#        as in this sample problem, significant errors can occur.  Both the
#        air immersion and semi-infinite models are very good when the
#        conditions are proper.  These models do not require as much computer
#        time as the finite plume model.  The air immersion and semi-infinite
#        models can, however, over estimate doses from ground level release by
#        up to 2 decades and under estimate doses from elevated releases by
#        more than 2 decades.  When in doubt, either use the finite plume model
#        or test the results for convergence before using the air immersion or
#        semi-infinite models.
#
2000,0                    * Entering inventory for Cs-137 and Ba-137m
#
CS137,100.
BA137M,94.6               * RSAC-5 will automatically build in progeny when the
#                           inventory is decayed sufficiently long prior to release
#                           or when the transport time is adequate.  However, in
#                           this case, the transport time is not adequate to build
#                           in the Ba-137m, the source of the photons.  When in
#                           doubt, enter the correct amount of the progeny.
#
2999                      * End of direct radionuclide input
#
5000                      *Input of meteorological data
#
5001,0.5,0,400.,1.099E3,0,0        * 0.5 m/s average wind velocity
#                                  * ground level release
#                                  * 400. m mixing layer depth
#                                  * 1099. g/cubic m air density
#
5101,1.E2,1.E3,1.E4,1.E5           * 4 downwind distances have been entered to
#                                    show how the models converge when the plume
#                                    size becomes larger.  Even at 1.E5 m the
#                                    models have yet to really converge well.
#                                    Plumes released during Class F or G Classes
#                                    are simply to small to get good results from
#                                    either the air immersion or the simi-infinite
#                                    models.  When plumes are adequately large,
#                                    the doses calculated between the models should

0         1         2         3         4         5         6         7
1234567890123456789012345678901234567890123456789012345678901234567890123456789
```

```
 example7     RSAC-5 INPUT     02/22/94     07:57
0         1         2         3         4         5         6         7
1234567890123456789012345678901234567890123456789012345678901234567890123456789

#                                  converge to better than a factor of 1.2.  In
#                                  this sample problem, the doses only agree to
#                                  to a factor of 1.6.
#
5201,1.,0                        * Releasing as a puff
#
5400,2,0,0,0                     * Requesting the program to calculate sigmas
#
5410,1,6,0                       * Hilsmeier-Gifford diffusion
#                                      Class F
#
5999                     * End of meteorological data
#
9000,0,0,2               * Calculating cloud gamma doses using the finite plume
#                          model
#
#                              Requesting doses in EDE so that the models can
#                              be compared.
#
9000,1,0,2               * Calculating cloud gamma doses using the simi-infinite
#                          model
#
7000,5,-2,1,1,2          * Calculating cloud gamma doses using the air immersion
#                          model.
#
7001,3.33E-4,0,0,0       * Defaulting to program values
#
7002,24                       * Requesting only EDE
#
7081,55,56                    * Calculating doses for only Cs and Ba
#
7999                      * End of air immersion calculation
#
10000                     * End of run

0         1         2         3         4         5         6         7
1234567890123456789012345678901234567890123456789012345678901234567890123456789
```

```
              RADIOLOGICAL SAFETY ANALYSIS COMPUTER PROGRAM (RSAC-5)
(RSAC-5E,REV 5.2,02/22/94) SERIAL  800  DATE  02/22/94  TIME 07:57  PAGE   1
example7:  Comparison of cloud gamma dose models

***DIRECT RADIONUCLIDE INPUT

        ANY PREVIOUS INVENTORY HAS BEEN ZEROED

     NUCLIDE           HALF LIFE        CURIES

  551370  Cs137    3.000E+01  yr    1.000E+02
  561371  Ba137M   2.552E+00  m     9.460E+01

***METEOROLOGICAL DATA

        MEAN WIND SPEED = 5.000E-01 (m/s)    STACK HEIGHT = 0.000E+00 (m)
    MIXING LAYER HEIGHT = 4.000E+02 (m)      AIR DENSITY = 1.099E+03 (g/cu m)
    WET DEPOSITION SCAVENGING COEFFICIENT = 0.000E+00 (1/S)

    NO CORRECTION IS BEING MADE FOR CLOUD DEPLETION BY DRY DEPOSITION

    DEPOSITION VELOCITIES (m/s)
         SOLIDS = 0.000E+00    HALOGENS = 0.000E+00   NOBLE GASES = 0.000E+00
         CESIUM = 0.000E+00   RUTHENIUM = 0.000E+00

    THERE IS 1 SET OF LEAKAGE CONSTANTS (K1,K2)
          1.000E+00        0.000E+00

    PASQUILL CLASS F METEOROLOGY,  H-G   SIGMA VALUES

    NO BUILDING WAKE CORRECTION MADE

    DOWNWIND DISTANCE  EFFECTIVE STACK   SIGY         SIGZ         CHI/Q
                         HEIGHT (m)      (m)          (m)         (s/cu m)
         1.000E+02        0.000E+00   4.011E+00   2.372E+00   6.691E-02
         1.000E+03        0.000E+00   3.531E+01   1.290E+01   1.398E-03
         1.000E+04        0.000E+00   2.876E+02   4.818E+01   4.594E-05
         1.000E+05        0.000E+00   1.952E+03   9.108E+01   3.581E-06

***GAMMA DOSE CALCULATION WITH EXPOSURE TIME =  1.0000E+00 (s)
          CALCULATIONS MADE USING THE FINITE MODEL

                                                  EXTERNAL EDE

     DOWNWIND DISTANCE =  1.000E+02 (m)            DOSE =  1.39E-02 (rem)

     DOWNWIND DISTANCE =  1.000E+03 (m)            DOSE =  1.57E-03 (rem)

     DOWNWIND DISTANCE =  1.000E+04 (m)            DOSE =  1.95E-04 (rem)

     DOWNWIND DISTANCE =  1.000E+05 (m)            DOSE =  2.30E-05 (rem)

***GAMMA DOSE CALCULATION WITH EXPOSURE TIME =  1.0000E+00 (s)
          CALCULATIONS MADE USING THE SEMI-INFINITE MODEL

                                                  EXTERNAL EDE
```

```
              RADIOLOGICAL SAFETY ANALYSIS COMPUTER PROGRAM (RSAC-5)
(RSAC-5E,REV 5.2,02/22/94) SERIAL  800  DATE  02/22/94  TIME 07:57  PAGE   2
example7:  Comparison of cloud gamma dose models

    DOWNWIND DISTANCE =  1.000E+02 (m)          DOSE =  6.26E-01 (rem)

    DOWNWIND DISTANCE =  1.000E+03 (m)          DOSE =  1.31E-02 (rem)

    DOWNWIND DISTANCE =  1.000E+04 (m)          DOSE =  4.30E-04 (rem)

    DOWNWIND DISTANCE =  1.000E+05 (m)          DOSE =  3.35E-05 (rem)

 *** AIR IMMERSION DOSE EQUIVALENT CALCULATION

   RELEASE TIME FOR EXPONENTIAL DECAY FUNCTION =  1.000E+00 SECONDS

   DOWNWIND DISTANCE =  1.000E+02 (m)     PLUME TRAVEL TIME =  2.000E+02 (s)
                                          CHI/Q =  6.691E-02 (s/cu m)

   DOWNWIND DISTANCE =  1.000E+03 (m)     PLUME TRAVEL TIME =  2.000E+03 (s)
                                          CHI/Q =  1.398E-03 (s/cu m)

   DOWNWIND DISTANCE =  1.000E+04 (m)     PLUME TRAVEL TIME =  2.000E+04 (s)
                                          CHI/Q =  4.594E-05 (s/cu m)

   DOWNWIND DISTANCE =  1.000E+05 (m)     PLUME TRAVEL TIME =  2.000E+05 (s)
                                          CHI/Q =  3.581E-06 (s/cu m)

&&   AIR IMMERSION DOSE EQUIVALENTS ORDERED BY ORGAN (rem)

                DOWNWIND DISTANCES (m)
   ORGAN    NO.  1.00E+02  1.00E+03  1.00E+04  1.00E+05
 --------   ---  --------  --------  --------  --------
 NO DOSE CALCULATED (NO DOE DRCF FOR REQUESTED RADIONUCLIDES)

&&   AIR IMMERSION DOSE EQUIVALENCES ORDERED BY DOSE (rem)

                DOWNWIND DISTANCES (m)
   ORGAN    NO.  1.00E+02  1.00E+03  1.00E+04  1.00E+05
 --------   ---  --------  --------  --------  --------
 NO DOSE CALCULATED (NO DOE DRCF FOR REQUESTED RADIONUCLIDES)
```

```
            RADIOLOGICAL SAFETY ANALYSIS COMPUTER PROGRAM (RSAC-5)
(RSAC-5E,REV 5.2,02/22/94) SERIAL  800  DATE  02/22/94  TIME 07:57  PAGE   3
example7:  Comparison of cloud gamma dose models

&&   AIR IMMERSION WEIGHTED DOSE EQUIVALENTS (rem)

                  DOWNWIND DISTANCES (m)
   ORGAN    NO.  1.00E+02  1.00E+03  1.00E+04  1.00E+05
 --------   ---  --------  --------  --------  --------
 EXT EDE    24   6.62E-01  1.38E-02  4.54E-04  3.54E-05

   EXECUTION TIME =  3.73E+00 SECONDS
```

Example 8: Hypothetical Criticality Accident

This example demonstrates how to model a complex scenario following a hypothetical criticality accident in a single RSAC-5 run. The initial radionuclide inventory is established by running the reactor at 250 MW for a period of 30 days. The reactor is assumed to be shut down for a period of 3 years before a criticality accident involving only 10% of the reactor inventory.

Because RSAC-5 does not calculate actinides, the 2000 Series option is used to show how actinide inventories can be added to the calculated fission product inventory.

The 1000 Series is used to calculate the additional fission product inventory produced immediately following a 3.E18 fissions criticality occurring over a period of 0.001 second. Following the criticality, 0.1% of the solids are assumed to be released along with 100% of the noble gases.

One of the concerns from a criticality accident is the amount of iodines released. The direct fission yield of most of the iodines is small compared to the chain yield. Thus, it is necessary to calculate the ingrowth of iodines for a period of time following the criticality accident until either off-gas ventilation systems can be isolated or the energy present has dissipated sufficiently to reduce continued release of iodines to the off-gas system. The amount of iodines that would continue to be released during a 20-minute period subsequent to the criticality excursion are calculated using the option that allows releases from an operating reactor to be calculated. While a reactor is not really being operated, the modeling can be used by assuming a reactor that operates at a very low power level during the 20-minute period. An insignificant operating power level of 1.E-6 W is used to incrementally release the iodines that buildup during the 20-minute period. At the end of this operation, the iodines are fractionated to release only 25% to the total amount. The remaining iodines are assumed to remain with the initial uranium fuel or to plate out on the inside of process vessels and piping.

At this stage of the accident, further refinement of the source term can be made by fractionating the inventory by individual element. To demonstrate this option, H-3 is fractionated to 0.9.

The inventory is now released to the off-gas system. It is decayed for 50 seconds until the first HEPA filter is reached. At that time the solids are reduced by a factor of 1.E-3, which gives a decontamination factor of 1,000 for the HEPA filter. After emerging from the first HEPA filter, the inventory is decayed for 2.5 minutes until the final two HEPA filters are reached. A decontamination factor of 500 is taken for each of these two HEPA filters yielding a net reduction in the solids by a factor of 4.E-6.

At this stage of the accident analysis, the activity is discharged to a 76-m stack. For worst case meteorology, the release is assumed to occur during Class F (Markee diffusion) with a 2 m/s average wind velocity. It is further assumed that the release occurs at about daylight and that the plume fumigates when the downwind receptor location is reached. Plume rise from the stack is calculated for a jet plume and a 2.44-m stack internal diameter and a 10.16 m/s efflux speed.

For this accident, it is desired to sum the doses from each of the dose pathways. Therefore, the 3000 Series option is initiated telling the program to save the calculated doses for later summary requests.

The doses from inhalation are initially calculated followed by cloud gamma EDE using the finite plume model. The 1000 Series is then used again to fractionate the inventory to correct for 40/168-hour occupancy for ground surface dose calculations. This is done because the downwind receptor is located onsite in a controlled area where workers normally only work 40-hour weeks.

The final request is for a summary dose of the EDE by pathway. A warning is printed that no ingestion dose calculations were made. Ingestion dose calculations are not applicable because the calculation was done for a controlled onsite location.

The radionuclides inventory as a function of time for this example is presented in Figure 1-1 (see page 1-7).

```
 example8      RSAC-5 INPUT      02/22/94      07:57
0         1         2         3         4         5         6         7
1234567890123456789012345678901234567890123456789012345678901234567890123456789

*Hypothetical criticality accident
#
#       This sample problem demonstrates how to correct for the buildup of
#       halogens following a criticality accident and their release over an
#       extended period of time following the end of the criticality.  Doses
#       have been calculated by the inhalation, cloud gamma and ground surface
#       pathways.  The ingestion pathway was not calculated simulating a
#       calculation for a controlled area.  A dose summary was requested for
#       the different pathways.
#
1000                     * Building an initial fission product inventory for
#                          the fissionable material
#
1001,0,2.5+8,2592000.          * Reactor operates at 250 MW power for 30 days
#
1003,94672800.,0,0             * Decay the inventory after shutdown of the
#                                reactor for a period of 3 years
#
1004,0,0.1                     * Accident involves 10% of the original reactor
#                                inventory
#
1999                           * End of initial inventory calculation
#
2000,-1                  * Add actinides directly to the previously calculated
#                          fission product inventory.  The RSAC-5 fission product
#                          calculation model does not calculate actinides.
#                          Actinides and activation products calculated using
#                          other means such as using the ORIGEN2 code can be
#                          added to the RSAC-5 calculated inventory
#
942380,0.28                    * .28 Ci of Pu-238
942390,1.4                     * 1.4 Ci of Pu-239
#
2999                           * End of the addition of additional inventory
#
1000                     * Add fission product inventory from the criticality
#                          accident
#
1001,1,0,0                     * Retaining previous inventory
#
1003,0,9.901E10,0.001          * 3E18 Fissions in 0.001 second
#                                     3.E18 (fis) / 3.03E10 (W per fis)
#                                     / 0.001 (s) =   9.901E+10 W
#
1200,1,1                       * Even though the criticality is assumed to last
#                                only 0.001 second, not all of the activity is

0         1         2         3         4         5         6         7
1234567890123456789012345678901234567890123456789012345678901234567890123456789
```

```
 example8      RSAC-5 INPUT      02/22/94      07:57
0         1         2         3         4         5         6         7
1234567890123456789012345678901234567890123456789012345678901234567890123456789

#                                immediately released from a process.  It is not
#                                uncommon for the halogens to continue to evolve
#                                from the process for a period of time.  In this
#                                sample problem, this continued evolution of the
#                                halogens is assumed to last for an additional
#                                20 minutes.
#
#                                Using the incremental release option, a fraction
#                                all of the noble gases and a fraction of the
#                                the solids are assumed to promptly be released
#                                to the off gas system.  The activity for the
#                                released noble gases and solids is moved to a
#                                hold buffer from which they can be decayed and
#                                fractionated in a subsequent program step.  All
#                                of the halogens are temporarily retained with
#                                the original activity to be released in a
#                                subsequent step of the program.
#
#                                The last entry on the 1200 line being equal to 1
#                                signifies that the activity leaked from original
#                                inventory is being retained for further
#                                calculations.
#
1201,1.,0,1.E3,1.,1.                 * Releasing .1% solids and 100% noble gases
#                                      present in the inventory after the
#                                      criticality to the hold buffer.  Calculate
#                                      the release rate by dividing the total
#                                      release fraction by the operating time.
#                                                  Fraction   Time     Rate
#                                          Solids     .001   / .001  =  1.
#                                         Halogens    0.     / .001  =  0.
#                                       Noble Gases   1.     / .001  =  1.E3
#
1003,0,1.E-6,1200.              * This step operates the fissioning at a very
#                                 low level which contributes little to the
#                                 fission product inventory but yet allows the
#                                 halogens to continue to build up from their
#                                 precursors.
#
1200,20,1                       * Releasing the halogens incrementally using 20
#                                 steps over the subsequent 20 minute period.
#                                 The activity is being added to the hold buffer
#                                 which already contains the inventory for the
#                                 solids and the noble gasses.  The total inventor
#                                 in the hold buffer is then being used in

0         1         2         3         4         5         6         7
1234567890123456789012345678901234567890123456789012345678901234567890123456789
```

```
 example8     RSAC-5 INPUT      02/22/94     07:57
0         1         2         3         4         5         6         7
1234567890123456789012345678901234567890123456789012345678901234567890123456789

#                                   subsequent calculations.
#
1201,0,1.,0,0,0                   * Releasing 100% of the halogens that ingrow
#                                   during each of the 20 one-minute incremental
#                                   release periods from their precursors.  RSAC-5
#                                   will not release more than 100% of the remaining
#                                   inventory even though too large of a release
#                                   rate is requested.  While a release rate of
#                                   1.67E-2 (1/s) would actually give 100% release a
#                                   the end of each one-minute incremental release
#                                   period, a value of 1. was used for simplicity.
#
#                                   We now have the halogens added to the noble
#                                   gases and solids fraction that was originally
#                                   released to the hold buffer in a previous step.
#
1999
#
#                         The 1000 Series is being exited and reentered.  This
#                         copies the inventory that was released in the previous
#                         steps to the hold buffer to be moved to the main buffer
#                         so that further decay and fractionating of the inventory
#                         can be made prior to performing dose calculations.
#
1000                    * The 1000 Series is again being reentered to decay and
#                         fractionate the inventory to simulate movement through
#                         the process prior to being released to the atmosphere.
#
1001,1,0,0                          * Retaining the previous inventory
#
1004,-1,1.,0.25,1.,1.,1.          * A correction is now being made to the halogens
#                                   to reduce the release from 100% to 25%
#
1004,1,1.                         * This step demonstrates how additional refinement
#                                   can be made to the inventory by individual
#                                   element
#
1101,1,0.9                          * Corrects the tritium release to 90%
#
1003,50.,0,0                        * Decaying the entire inventory for 50 seconds
#                                     until the first HEPA filter is reached
#
1004,-1,1.E-3,1.,1.,1.E-3,1.E-3   * The decontamination factor for the first
#                                       HEPA filter is 99.9% for solids, or a
#                                       fraction of 1.E-3

0         1         2         3         4         5         6         7
1234567890123456789012345678901234567890123456789012345678901234567890123456789
```

```
 example8     RSAC-5 INPUT     02/22/94     07:57
0        1         2         3         4         5         6         7
1234567890123456789012345678901234567890123456789012345678901234567890123456789

#
1003,150.,0,0                  * Decay the inventory for 2.5 minutes for
#                                transport time to reach the final 2 HEPA
#                                filters
#
1004,-1,4.E-6,1.,1.,4.E-6,4.E-6  * The acceptable decontamination factor for
#                                  successive HEPA filters is 99.8% each.  For
#                                  2 additional filters this amounts to a
#                                  fraction for solids of 4.E-6.
#
1999                   * End of inventory decay and fractionation
#
5000                   * Input of meteorological parameters
#
5001,2.,76.,380.,1.099E3,0,1   * 2. m/s average wind velocity
#                                76. m stack height
#                                380. m mixing layer depth
#                                Depletion of the plume by dry deposition
#
5002,0.001,0.01,0,0.001,0.001  * Using standard deposition velocities
#
5101,2.89E3                    * Calculating doses for 1 downwind distances
#
5201,1.,0                      * No further decay correction is desired prior to
#                                the release from the stack to the atmosphere.
#
5400,2,0,0,0                   * Requesting the program to calculate sigmas
#
5410,2,7,1                     * Markee diffusion
#                                   Class F fumigation
#                                   Requesting jet plume rise
#
5411,2.44,0,10.16,0            * 2.44 m stack internal diameter
#                                10.16 m/s efflux speed
#
5999                   * End of meteorological data input
#
3000,1                 * Initiating the dose summary option
#                             This must be done after entry of the meteorological
#                             data.  Subsequent 3000 Series Lines entered after
#                             all of the dose calculations are completed will
#                             indicate the type of summary desired.
#
7000,0,-2,1,0,1        * Requesting an inhalation dose calculation for all organs
#                             Printing out only dose summaries for all elements

0        1         2         3         4         5         6         7
1234567890123456789012345678901234567890123456789012345678901234567890123456789
```

```
 example8     RSAC-5 INPUT     02/22/94     07:57
0         1         2         3         4         5         6         7
1234567890123456789012345678901234567890123456789012345678901234567890123456789

#                                 Requesting doses for all organs
#
7001,3.33E-4,0,0,0          * Defaulting to program calculated release time
#
7999                      * End of inhalation dose calculation
#
9000,0,0.,2               * Requesting calculation of the cloud gamma dose using the
#                           finite plume model with doses in EDE
#
1000                      * Before the ground surface dose calculation is made, a
#                           correction is made to the inventory to account for the
#                           fact that workers do not reside full time at their work
#                           area.
#
1001,1,0,0                * Retaining the previous inventory
#
1004,0,0.2381               * Correction for 40/168 hour occupancy
#
1999                      * End of inventory correction
#
7000,4,-2,1,0,1           * Requesting ground surface dose calculation for all organ
#
7001,3.33E-4,0,0,0          * Defaulting to a 1 year exposure period following
#                             the release.  This would simulate continued
#                             downwind activities with no cleanup action.
#
7999                      * End of ground surface dose calculation
#
3000,2                    * A request is being made for a dose summary by pathway.
#                           A warning is printed at the bottom of the dose summary
#                           stating that the dose summary does not include ingestion
#                           dose calculations.  When the receptor is in a controlled
#                           area, there would be no dose from ingestion.
#
10000                     * End of run

0         1         2         3         4         5         6         7
1234567890123456789012345678901234567890123456789012345678901234567890123456789
```

```
                    RADIOLOGICAL SAFETY ANALYSIS COMPUTER PROGRAM (RSAC-5)
 (RSAC-5E,REV 5.2,02/22/94) SERIAL  800  DATE  02/22/94  TIME 07:57  PAGE   1
 example8: Hypothetical criticality accident

***FISSION PRODUCT CALCULATION

    THE REACTOR HAS OPERATED AT  2.500E+08 WATTS FOR   2.592E+06 SECONDS
          BURNUP =  7.500E+03 MWd

    REACTOR HAS BEEN SHUT DOWN FOR  9.467E+07 SECONDS

     FRACTION OF RADIONUCLIDE INVENTORY RELEASED =  1.000E-01

    TOTAL RADIONUCLIDE RELEASE =  1.007E+15  D/s OR  2.720E+04 Ci

***DIRECT RADIONUCLIDE INPUT

        PREVIOUS INVENTORY INCREASED BY THE FOLLOWING VALUES

     NUCLIDE           HALF LIFE       CURIES

  942380  Pu238    8.775E+01  yr    2.800E-01
  942390  Pu239    2.413E+04  yr    1.400E+00

***FISSION PRODUCT CALCULATION

    REACTOR HAS BEEN SHUT DOWN FOR  0.000E+00 SECONDS

    THE OPTION HAS BEEN CHOSEN TO RELEASE ACTIVITY DURING REACTOR OPERATION
       CALCULATING WITH   1 REACTOR OPERATING STEP OF 1.000E-03 s
       RELEASE RATE (fraction/s)
                    SOLID 1.000E+00
                  HALOGEN 0.000E+00
                NOBLE GAS 1.000E+03
                   CESIUM 1.000E+00
                RUTHENIUM 1.000E+00

    THE REACTOR HAS OPERATED AT  9.901E+10 WATTS FOR   1.000E-03 SECONDS
          BURNUP =  1.146E-03 MWd

    REACTOR HAS BEEN SHUT DOWN FOR  0.000E+00 SECONDS

    PARAMETERS FOR THE RELEASE OF ACTIVITY DURING REACTOR OPERATION HAVE
    BEEN CHANGED
       CALCULATING WITH  20 REACTOR OPERATING STEPS OF 6.000E+01 s EACH
       RELEASE RATE (fraction/s)
                    SOLID 0.000E+00
                  HALOGEN 1.000E+00
                NOBLE GAS 0.000E+00
                   CESIUM 0.000E+00
                RUTHENIUM 0.000E+00

    THE REACTOR HAS OPERATED AT  1.000E-06 WATTS FOR   1.200E+03 SECONDS
          BURNUP =  1.146E-03 MWd
```

```
                RADIOLOGICAL SAFETY ANALYSIS COMPUTER PROGRAM (RSAC-5)
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example8: Hypothetical criticality accident

     RETAINING FISSION PRODUCT INVENTORY RELEASED DURING REACTOR OPERATION

    TOTAL RADIONUCLIDE RELEASE =  9.480E+16  D/s OR  2.562E+06 Ci

***FISSION PRODUCT CALCULATION

    FRACTIONATION BY ELEMENT GROUP
      SOLIDS = 1.000E+00   HALOGENS = 2.500E-01   NOBLE GASES = 1.000E+00
      CESIUM = 1.000E+00   RUTHENIUM = 1.000E+00

    FRACTIONATION (ELEMENT, VALUE)
     H  9.000E-01
    FRACTIONATION FOR THE REST OF THE RADIONUCLIDE INVENTORY =  1.000E+00

    REACTOR HAS BEEN SHUT DOWN FOR  5.000E+01 SECONDS

    FRACTIONATION BY ELEMENT GROUP
      SOLIDS = 1.000E-03   HALOGENS = 1.000E+00   NOBLE GASES = 1.000E+00
      CESIUM = 1.000E-03   RUTHENIUM = 1.000E-03

    REACTOR HAS BEEN SHUT DOWN FOR  1.500E+02 SECONDS

    FRACTIONATION BY ELEMENT GROUP
      SOLIDS = 4.000E-06   HALOGENS = 1.000E+00   NOBLE GASES = 1.000E+00
      CESIUM = 4.000E-06   RUTHENIUM = 4.000E-06

    TOTAL RADIONUCLIDE RELEASE =  6.082E+14  D/s OR  1.644E+04 Ci

***METEOROLOGICAL DATA

        MEAN WIND SPEED = 2.000E+00 (m/s)    STACK HEIGHT = 7.600E+01 (m)
    MIXING LAYER HEIGHT = 3.800E+02 (m)       AIR DENSITY = 1.099E+03 (g/cu m)
    WET DEPOSITION SCAVENGING COEFFICIENT = 0.000E+00 (1/S)

    CLOUD DEPLETION BY FALLOUT IS INCLUDED

    DEPOSITION VELOCITIES (m/s)
         SOLIDS = 1.000E-03    HALOGENS = 1.000E-02    NOBLE GASES = 0.000E+00
         CESIUM = 1.000E-03   RUTHENIUM = 1.000E-03

    THERE IS 1 SET OF LEAKAGE CONSTANTS (K1,K2)
          1.000E+00        0.000E+00

    PASQUILL CLASS F FUMIGATION METEOROLOGY WITH MARKEE SIGY(S)

    PLUME RISE CALCULATED USING JET CONDITIONS
                   STACK DIAMETER = 2.440E+00 (m)
                EFFLUENT VELOCITY = 1.016E+01 (m/s)
           RESTORING ACCELERATION = 1.750E-03 (1/sq s)
```

```
                RADIOLOGICAL SAFETY ANALYSIS COMPUTER PROGRAM (RSAC-5)
(RSAC-5E,REV 5.2,02/22/94) SERIAL  800  DATE  02/22/94  TIME 07:57  PAGE   3
example8: Hypothetical criticality accident

   DOWNWIND DISTANCE  EFFECTIVE STACK   SIGY        SIGZ        CHI/Q
                         HEIGHT (m)      (m)         (m)       (s/cu m)
        2.890E+03        1.449E+02   4.240E+02   9.278E+00   1.238E-06

 *** INITIATING DOSE SUMMARY OPTION

 *** INHALATION DOSE EQUIVALENT CALCULATION

                         BREATHING RATE =  3.330E-04 (cu m/s)
                 RELEASE TIME FOR EXPONENTIAL DECAY FUNCTION =  1.000E+00 (s)
      INTERNAL EXPOSURE TIME PERIOD  =  5.000E+01 (yr)

   PARTICLE SIZE =  1.0 MICRONS AMAD
   LUNG DEPOSITION FRACTIONS: N-P = 0.300  T-B = 0.080  P = 0.250

 LUNG CLEARANCE CLASSES USED IN CALCULATIONS
     ELEMENT      CLASS

      1    H       HTO
      4    Be       Y
      6    C       ORG
     11    Na       D
     14    Si       W
     15    P        D
     16    S        D
     17    Cl       D
     19    K        D
     20    Ca       W
     21    Sc       Y
     24    Cr       Y
     25    Mn       W
     26    Fe       W
     27    Co       Y
     28    Ni       W
     29    Cu       Y
     30    Zn       Y
     32    Ge       W
     34    Se       W
     35    Br       D
     37    Rb       D
     38    Sr       D
     39    Y        Y
     40    Zr       W
     41    Nb       Y
     42    Mo       Y
     43    Tc       W
     44    Ru       Y
     45    Rh       Y
     46    Pd       Y
     47    Ag       Y
```

```
                RADIOLOGICAL SAFETY ANALYSIS COMPUTER PROGRAM (RSAC-5)
(RSAC-5E,REV 5.2,02/22/94) SERIAL  800  DATE  02/22/94  TIME 07:57  PAGE   4
example8: Hypothetical criticality accident

 LUNG CLEARANCE CLASSES USED IN CALCULATIONS
     ELEMENT      CLASS

     48   Cd        Y
     49   In        W
     50   Sn        W
     51   Sb        D
     52   Te        W
     53    I        D
     55   Cs        D
     56   Ba        D
     57   La        W
     58   Ce        Y
     59   Pr        Y
     60   Nd        Y
     61   Pm        Y
     62   Sm        W
     63   Eu        W
     64   Gd        W
     73   Ta        Y
     77   Ir        Y
     81   Tl        D
     82   Pb        D
     83   Bi        W
     84   Po        W
     85   At        D
     88   Ra        W
     89   Ac        Y
     90   Th        Y
     91   Pa        Y
     92    U        Y
     93   Np        W
     94   Pu        Y
     95   Am        W
     96   Cm        W

   DOWNWIND DISTANCE =  2.890E+03 (m)     PLUME TRAVEL TIME =  1.445E+03 (s)
                                          CHI/Q =  1.238E-06 (s/cu m)
```

RADIOLOGICAL SAFETY ANALYSIS COMPUTER PROGRAM (RSAC-5)
(RSAC-5E,REV 5.2,02/22/94) SERIAL 800 DATE 02/22/94 TIME 07:57 PAGE 5
example8: Hypothetical criticality accident

&& INHALATION COMMITTED DOSE EQUIVALENTS ORDERED BY ORGAN (rem)

ORGAN	NO.	DOWNWIND DISTANCES (m) 2.89E+03
LUNGS	1	2.57E-04
S WALL	2	1.01E-04
SI WALL	3	1.20E-06
ULI WALL	4	1.16E-06
LLI WALL	5	5.43E-07
GONADS	6	7.84E-08
BREASTS	7	1.17E-08
BONE SUR	8	1.30E-06
R MARROW	9	8.81E-07
THYROID	10	1.38E-03
KIDNEYS	11	1.15E-17
LIVER	12	2.18E-12
SPLEEN	13	1.72E-19
PANCREAS	14	1.50E-19
S TISSUE	15	3.08E-07
OTHER	16	1.42E-08

&& INHALATION COMMITTED DOSE EQUIVALENCES ORDERED BY DOSE (rem)

ORGAN	NO.	DOWNWIND DISTANCES (m) 2.89E+03
THYROID	10	1.38E-03
LUNGS	1	2.57E-04
S WALL	2	1.01E-04
BONE SUR	8	1.30E-06
SI WALL	3	1.20E-06
ULI WALL	4	1.16E-06
R MARROW	9	8.81E-07
LLI WALL	5	5.43E-07
S TISSUE	15	3.08E-07
GONADS	6	7.84E-08
OTHER	16	1.42E-08
BREASTS	7	1.17E-08
LIVER	12	2.18E-12
KIDNEYS	11	1.15E-17
SPLEEN	13	1.72E-19
PANCREAS	14	1.50E-19

```
                RADIOLOGICAL SAFETY ANALYSIS COMPUTER PROGRAM (RSAC-5)
(RSAC-5E,REV 5.2,02/22/94) SERIAL  800  DATE  02/22/94  TIME 07:57  PAGE   6
example8: Hypothetical criticality accident

&&      INHALATION WEIGHTED COMMITTED DOSE EQUIVALENTS (rem)

                   DOWNWIND DISTANCES (m)
   ORGAN    NO.   2.89E+03
 --------   ---   --------
 LUNGS       1    3.08E-05
 S WALL      2    6.07E-06
 SI WALL     3    7.18E-08
 ULI WALL    4    6.94E-08
 LLI WALL    5    3.26E-08
 GONADS      6    1.96E-08
 BREASTS     7    1.76E-09
 BONE SUR    8    3.91E-08
 R MARROW    9    1.06E-07
 THYROID    10    4.14E-05
 KIDNEYS    11    6.91E-19
 LIVER      12    1.31E-13
 SPLEEN     13    1.03E-20
 PANCREAS   14    9.01E-21
 S TISSUE   15    3.08E-07
 OTHER      16    1.71E-09
 CEDE       18    7.86E-05

***GAMMA DOSE CALCULATION WITH EXPOSURE TIME =  1.0000E+00 (s)
          CALCULATIONS MADE USING THE FINITE MODEL

                                                     EXTERNAL EDE

    DOWNWIND DISTANCE =  2.890E+03 (m)               DOSE =  9.37E-04 (rem)

***FISSION PRODUCT CALCULATION

    FRACTION OF RADIONUCLIDE INVENTORY RELEASED =  2.381E-01

   TOTAL RADIONUCLIDE RELEASE =  1.448E+14  D/s OR  3.914E+03 Ci

  *** GROUND SURFACE DEPOSITION DOSE EQUIVALENT CALCULATION

   TIME RECEPTOR IS EXPOSED TO CONTAMINATED SOIL =  1.000E+00 (yr)
   BUILDING SHIELDING FACTOR =  7.000E-01
   RELEASE TIME FOR EXPONENTIAL DECAY FUNCTION =  1.000E+00 SECONDS
```

```
              RADIOLOGICAL SAFETY ANALYSIS COMPUTER PROGRAM (RSAC-5)
(RSAC-5E,REV 5.2,02/22/94) SERIAL  800  DATE  02/22/94  TIME 07:57  PAGE   7
example8: Hypothetical criticality accident

   DOWNWIND DISTANCE =  2.890E+03 (m)     PLUME TRAVEL TIME =  1.445E+03 (s)
                                          CHI/Q =  1.238E-06 (s/cu m)

&& GROUND SURFACE  DOSE EQUIVALENTS ORDERED BY ORGAN (rem)

                  DOWNWIND DISTANCES (m)
   ORGAN    NO.  2.89E+03
  --------  ---  --------
  LUNGS      1   2.91E-05
  STOMACH    2   2.69E-05
  S INT      3   2.48E-05
  UL INT     4   2.88E-05
  LL INT     5   2.66E-05
  TESTES     6   3.83E-05
  BREAST     7   3.48E-05
  SKELETON   8   3.18E-05
  RED MARR   9   2.95E-05
  THYROID   10   3.60E-05
  KIDNEYS   11   2.88E-05
  LIVER     12   2.73E-05
  SPLEEN    13   2.64E-05
  ADRENALS  14   2.79E-05
  PANCREAS  15   2.37E-05
  SKIN      16   1.90E-04
  BRAIN     17   3.08E-05
  THYMUS    18   3.02E-05
  BLADDER   19   2.74E-05
  MARROW    20   3.13E-05
  HEART     21   2.70E-05
  OVARIES   22   2.60E-05
  UTERUS    23   2.41E-05
```

```
             RADIOLOGICAL SAFETY ANALYSIS COMPUTER PROGRAM (RSAC-5)
(RSAC-5E,REV 5.2,02/22/94) SERIAL  800  DATE  02/22/94  TIME 07:57  PAGE   8
example8: Hypothetical criticality accident

&& GROUND SURFACE  DOSE EQUIVALENCES ORDERED BY DOSE (rem)

                DOWNWIND DISTANCES (m)
   ORGAN    NO.  2.89E+03
 --------   ---  --------
 SKIN       16   1.90E-04
 TESTES      6   3.83E-05
 THYROID    10   3.60E-05
 BREAST      7   3.48E-05
 SKELETON    8   3.18E-05
 MARROW     20   3.13E-05
 BRAIN      17   3.08E-05
 THYMUS     18   3.02E-05
 RED MARR    9   2.95E-05
 LUNGS       1   2.91E-05
 KIDNEYS    11   2.88E-05
 UL INT      4   2.88E-05
 ADRENALS   14   2.79E-05
 BLADDER    19   2.74E-05
 LIVER      12   2.73E-05
 HEART      21   2.70E-05
 STOMACH     2   2.69E-05
 LL INT      5   2.66E-05
 SPLEEN     13   2.64E-05
 OVARIES    22   2.60E-05
 S INT       3   2.48E-05
 UTERUS     23   2.41E-05
 PANCREAS   15   2.37E-05
```

```
              RADIOLOGICAL SAFETY ANALYSIS COMPUTER PROGRAM (RSAC-5)
(RSAC-5E,REV 5.2,02/22/94) SERIAL  800  DATE  02/22/94  TIME 07:57  PAGE   9
example8: Hypothetical criticality accident

&& GROUND SURFACE  WEIGHTED DOSE EQUIVALENTS (rem)

                DOWNWIND DISTANCES (m)
   ORGAN    NO.  2.89E+03
 --------   ---  --------
 LUNGS       1   3.49E-06
 STOMACH     2   1.61E-06
 S INT       3   1.49E-06
 UL INT      4   1.73E-06
 LL INT      5   1.59E-06
 TESTES      6   9.59E-06
 BREAST      7   5.21E-06
 SKELETON    8   9.54E-07
 RED MARR    9   3.53E-06
 THYROID    10   1.08E-06
 KIDNEYS    11   1.73E-06
 LIVER      12   1.64E-06
 SPLEEN     13   1.59E-06
 ADRENALS   14   1.67E-06
 PANCREAS   15   1.42E-06
 SKIN       16   1.90E-06
 BRAIN      17   1.85E-06
 THYMUS     18   1.81E-06
 BLADDER    19   1.65E-06
 MARROW     20   1.88E-06
 HEART      21   1.62E-06
 OVARIES    22   6.49E-06
 UTERUS     23   1.45E-06
 EXT EDE    24   3.27E-05

 PATHWAY CONTRIBUTION TO THE EDE (rem), DOWNWIND DISTANCE =  2.89E+03 (m)

    NUCLIDE      INHALATION  INGESTION   GROUND SUR  AIR IMMERS    TOTAL
 -------------   ----------  ----------  ----------  ----------  ----------
    SUBTOTALS     7.86E-05       -        3.27E-05       -        1.11E-04
                                     FINITE MODEL CLOUD GAMMA     9.37E-04
                                                                 ----------
                                                        TOTAL     1.05E-03

  WARNINGS
  --------
    NO INGESTION DOSE CALCULATIONS WERE MADE

   EXECUTION TIME =  4.83E+01 SECONDS
```

Example 9: Dose Calculations with Changing Meteorological Conditions

This example demonstrates how to sum the doses from a release that occurs during a changing meteorological condition. The release is assumed to occur over a period of 8 hours with the first hour during a Class F fumigation condition and the remaining 7 hours during a Class C condition.

In this example, the radionuclide inventory is read from an external file called "ex9src". After reading the inventory, the 1000 Series option is used to fractionate the inventory by a factor of 1/8 for that released during the first hour. After completing dose calculations for the inhalation pathway from the first hour of release, the 1000 Series option is again used to first decay the original inventory for a period of 1 hour. The inventory is then multiplied by a factor of 7 to give the inventory that is released during the final 7 hours of the release. The 5000 Series for meteorological data is reentered to change to Class C meteorology. The only data that cannot be changed are the downwind distance.

After completing dose calculations for the inhalation pathway for the last 7 hours of the release, the 3000 Series summary option is used to request dose summaries by pathway and radionuclide. Because only doses from the inhalation dose pathway were calculated, a warning is printed indicating that doses were not calculated for the other pathways.

```
 example9     RSAC-5 INPUT      09/15/93      15:16
0         1         2         3         4         5         6         7
1234567890123456789012345678901234567890123456789012345678901234567890123456789

* Dose calculations with changing meteorological conditions
#
#      The example consists of a release over an eight hour period.  The first
#      hour of the release is assumed to occur during a Class F fumigation
#      condition.  The final 7 hours are assumed to be during a Class C
#      condition.  At the end of the calculation, the doses from both periods
#      of release are summed and displayed by radionuclide and pathway.
#
2000,0                 * Reading fission product inventory from external file
#
2002,ex9src                 * External file must have one line of descriptive
#                             information at the beginning
#
2999                   * End of direct fission product input
#
1000                   * The radionuclide inventory is first fractionated for
#                        the amount release during the initial hour of release
#
1001,1,0,0                  * Previously entered inventory is retained
#
1004,0,0.125                * 1/8 = 0.125
#
1999                   * End of fission product fractionation
#
5000                   * Entering meteorological data for first hour of release
#
5001,2.,70.,380.,1.099E3,0,0    * 2 m/s average wind velocity
#                                 70. m stack height
#                                 380. m mixing layer depth
#                                 1099. g/cubic m air density
#
5002,0.001,0.01,0,0.001,0.001   * Defaulting to program standard deposition
#                                 velocities
#
5101,2.E4                       * Calculating dose for only 1 downwind distance
#
5201,2.778E-4,0                 * Decay correcting for a linear release over
#                                 1 hour.
#
5400,2,0,0,0                    * Requesting the program to calculate sigmas
#
5410,2,7,1                      * Markee diffusion, Class F fumigation with
#                                 jet plume rise
#
5411,2.,0,8.5,0                 * 2. m internal stack diameter, 8.5 m/s efflux
#                                 speed

0         1         2         3         4         5         6         7
1234567890123456789012345678901234567890123456789012345678901234567890123456789
```

```
 example9     RSAC-5 INPUT      09/15/93      15:16
0         1         2         3         4         5         6         7
1234567890123456789012345678901234567890123456789012345678901234567890123456789

#
5999                    * End of initial meteorological data input
#
3000,1                  * Initiating dose summary option
#
7000,0,-2,1,0,1         * Calculating inhalation dose summaries only for all
#                         elements and organs for the first hour of release
#
7001,3.33E-4,0,0,0            * Defaulting to program calculated values
#
7999                    * End of inhalation dose calculation
#
1000                    * Fractionating the fission product inventory for the
#                         last 7 hours of release
#
1001,1,0,0                    * Retaining the previous inventory
#
1004,0,7.                     * Multiplying the previous inventory for a 1 hour
#                               release by 7. to give the amount released during
#                               the next 7 hours of release
#
1003,3600.,0,0                * Decaying the original inventory for a period of
#                               1 hour
#
1999                    * End of fission product inventory fractionation
#
5000                    * Entering meteorological data for the final 7 hours of
#                         release.  Because the dose summary option has been
#                         previously initiated, the downwind distance cannot be
#                         changed.
#
5001,5.,70.,2000.,1.099E3,0,0    * Only changes are for a 5 m/s wind velocity
#                                  and a 2000. m mixing layer depth
#
5002,0.001,0.01,0,0.001,0.001
5101,2.E4
5201,3.978E-5,0                  * Changed linear constant for 7 hour release
5400,2,0,0,0
5410,2,3,1                       * Changed to Class C
5411,2.,0,8.5,0
5999
#
#                        All of the subsequent dose calculation entries are the
#                        same as previously used for the first hour of release
#

0         1         2         3         4         5         6         7
1234567890123456789012345678901234567890123456789012345678901234567890123456789
```

```
 example9     RSAC-5 INPUT      09/15/93      15:16
0         1         2         3         4         5         6         7
1234567890123456789012345678901234567890123456789012345678901234567890123456789

7000,0,-2,1,0,1        * Inhalation dose for the last 7 hours of release
7001,3.33E-4,0,0,0
7999
#
3000,3                 * Requesting dose summaries by pathway and radionuclide
#
10000                  * End of run

0         1         2         3         4         5         6         7
1234567890123456789012345678901234567890123456789012345678901234567890123456789
```

```
Fission product inventory for Example9

SR-89    7.34E-04
SR-90    1.77E-03
Y-90     1.77E-03
Y-91     1.74E-03
NB-94    4.00E-13
ZR-95    2.68E-03
NB-95    5.80E-03
RU-106   1.62E-03
RH-106   1.62E-03
SB-125   9.99E-05
CS-137   1.89E-03
BA-137M  1.79E-03
CE-144   2.11E-02
PR-144   2.11E-02
PM-147   5.87E-03
```

```
                RADIOLOGICAL SAFETY ANALYSIS COMPUTER PROGRAM (RSAC-5)
(RSAC-5E,REV 5.1,08/09/93) SERIAL  700  DATE  09/15/93  TIME 15:16  PAGE   1
example9:  Dose calculations with changing meteorological conditions

***DIRECT RADIONUCLIDE INPUT

        ANY PREVIOUS INVENTORY HAS BEEN ZEROED


     RADIONUCLIDE INPUT READ FROM EXTERNAL USER FILE  ex9src

     Fission product inventory for Example9


     NUCLIDE            HALF LIFE         CURIES

  380890   Sr 89    5.049E+01  d      7.340E-04
  380900   Sr 90    2.912E+01  yr     1.770E-03
  390900    Y 90    6.410E+01  h      1.770E-03
  390910    Y 91    5.851E+01  d      1.740E-03
  410940   Nb 94    2.030E+04  yr     4.000E-13
  400950   Zr 95    6.398E+01  d      2.680E-03
  410950   Nb 95    3.506E+01  d      5.800E-03
  441060   Ru106    3.682E+02  d      1.620E-03
  451060   Rh106    2.992E+01  s      1.620E-03
  511250   Sb125    2.770E+00  yr     9.990E-05
  551370   Cs137    3.000E+01  yr     1.890E-03
  561371   Ba137M   2.552E+00  m      1.790E-03
  581440   Ce144    2.843E+02  d      2.110E-02
  591440   Pr144    1.728E+01  m      2.110E-02
  611470   Pm147    2.623E+00  yr     5.870E-03

***FISSION PRODUCT CALCULATION

     FRACTION OF RADIONUCLIDE INVENTORY RELEASED =  1.250E-01

    TOTAL RADIONUCLIDE RELEASE =  3.218E+08  D/s OR  8.698E-03 Ci

***METEOROLOGICAL DATA

        MEAN WIND SPEED = 2.000E+00 (m/s)    STACK HEIGHT = 7.000E+01 (m)
    MIXING LAYER HEIGHT = 3.800E+02 (m)      AIR DENSITY = 1.099E+03 (g/cu m)
    WET DEPOSITION SCAVENGING COEFFICIENT = 0.000E+00 (1/S)

    NO CORRECTION IS BEING MADE FOR CLOUD DEPLETION BY DRY DEPOSITION

    DEPOSITION VELOCITIES (m/s)
         SOLIDS = 1.000E-03    HALOGENS = 1.000E-02   NOBLE GASES = 0.000E+00
         CESIUM = 1.000E-03   RUTHENIUM = 1.000E-03

    THERE IS 1 SET OF LEAKAGE CONSTANTS (K1,K2)
          2.778E-04       0.000E+00

    PASQUILL CLASS F FUMIGATION METEOROLOGY WITH MARKEE SIGY(S)
```

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            RADIOLOGICAL SAFETY ANALYSIS COMPUTER PROGRAM (RSAC-5)
(RSAC-5E,REV 5.1,08/09/93) SERIAL  700  DATE  09/15/93  TIME 15:16  PAGE   2
example9:  Dose calculations with changing meteorological conditions

   PLUME RISE CALCULATED USING JET CONDITIONS
                    STACK DIAMETER = 2.000E+00 (m)
                 EFFLUENT VELOCITY = 8.500E+00 (m/s)
          RESTORING ACCELERATION = 1.750E-03 (1/sq s)

   DOWNWIND DISTANCE  EFFECTIVE STACK    SIGY         SIGZ         CHI/Q
                        HEIGHT (m)       (m)          (m)        (s/cu m)
       2.000E+04         1.270E+02   1.917E+03    1.681E+01    2.738E-07

 *** INITIATING DOSE SUMMARY OPTION

 *** INHALATION DOSE EQUIVALENT CALCULATION

                           BREATHING RATE =  3.330E-04 (cu m/s)
                  RELEASE TIME FOR EXPONENTIAL DECAY FUNCTION =  3.600E+03 (s)
      INTERNAL EXPOSURE TIME PERIOD  =  5.000E+01 (yr)

   PARTICLE SIZE =  1.0 MICRONS AMAD
   LUNG DEPOSITION FRACTIONS: N-P = 0.300  T-B = 0.080  P = 0.250

 LUNG CLEARANCE CLASSES USED IN CALCULATIONS
     ELEMENT      CLASS

      1    H       HTO
      4   Be        Y
      6    C       ORG
     11   Na        D
     14   Si        W
     15    P        D
     16    S        D
     17   Cl        D
     19    K        D
     20   Ca        W
     21   Sc        Y
     24   Cr        Y
     25   Mn        W
     26   Fe        W
     27   Co        Y
     28   Ni        W
     29   Cu        Y
     30   Zn        Y
     32   Ge        W
     34   Se        W
     35   Br        D
     37   Rb        D
     38   Sr        D
     39    Y        Y
     40   Zr        W
     41   Nb        Y
```

```
              RADIOLOGICAL SAFETY ANALYSIS COMPUTER PROGRAM (RSAC-5)
(RSAC-5E,REV 5.1,08/09/93) SERIAL  700  DATE  09/15/93  TIME 15:16  PAGE    3
example9:  Dose calculations with changing meteorological conditions

 LUNG CLEARANCE CLASSES USED IN CALCULATIONS
     ELEMENT      CLASS

     42   Mo        Y
     43   Tc        W
     44   Ru        Y
     45   Rh        Y
     46   Pd        Y
     47   Ag        Y
     48   Cd        Y
     49   In        W
     50   Sn        W
     51   Sb        D
     52   Te        W
     53    I        D
     55   Cs        D
     56   Ba        D
     57   La        W
     58   Ce        Y
     59   Pr        Y
     60   Nd        Y
     61   Pm        Y
     62   Sm        W
     63   Eu        W
     64   Gd        W
     73   Ta        Y
     77   Ir        Y
     81   Tl        D
     82   Pb        D
     83   Bi        W
     84   Po        W
     85   At        D
     88   Ra        W
     89   Ac        Y
     90   Th        Y
     91   Pa        Y
     92    U        Y
     93   Np        W
     94   Pu        Y
     95   Am        W
     96   Cm        W

   DOWNWIND DISTANCE =  2.000E+04  (m)      PLUME TRAVEL TIME =  1.000E+04  (s)
                                            CHI/Q =  2.738E-07  (s/cu m)
```

```
              RADIOLOGICAL SAFETY ANALYSIS COMPUTER PROGRAM (RSAC-5)
(RSAC-5E,REV 5.1,08/09/93) SERIAL  700  DATE  09/15/93  TIME 15:16  PAGE   4
example9:  Dose calculations with changing meteorological conditions

&&      INHALATION COMMITTED DOSE EQUIVALENTS ORDERED BY ORGAN (rem)

                       DOWNWIND DISTANCES (m)
   ORGAN     NO.   2.00E+04
 --------    ---   --------
 LUNGS        1    7.97E-07
 SI WALL      3    7.34E-10
 ULI WALL     4    1.16E-09
 LLI WALL     5    2.76E-09
 GONADS       6    8.31E-10
 BREASTS      7    6.26E-10
 BONE SUR     8    5.78E-08
 R MARROW     9    2.54E-08
 THYROID     10    6.25E-10
 LIVER       12    4.67E-12
 OTHER       16    7.55E-10

 ----------
 ORGANS WITH NO CALCULATED DOSE HAVE BEEN SUPPRESSED FROM TABLE

&&      INHALATION COMMITTED DOSE EQUIVALENCES ORDERED BY DOSE (rem)

                       DOWNWIND DISTANCES (m)
   ORGAN     NO.   2.00E+04
 --------    ---   --------
 LUNGS        1    7.97E-07
 BONE SUR     8    5.78E-08
 R MARROW     9    2.54E-08
 LLI WALL     5    2.76E-09
 ULI WALL     4    1.16E-09
 GONADS       6    8.31E-10
 OTHER       16    7.55E-10
 SI WALL      3    7.34E-10
 BREASTS      7    6.26E-10
 THYROID     10    6.25E-10
 LIVER       12    4.67E-12

 ----------
 ORGANS WITH NO CALCULATED DOSE HAVE BEEN SUPPRESSED FROM TABLE
```

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             RADIOLOGICAL SAFETY ANALYSIS COMPUTER PROGRAM (RSAC-5)
(RSAC-5E,REV 5.1,08/09/93) SERIAL  700  DATE  09/15/93  TIME 15:16  PAGE   5
example9:  Dose calculations with changing meteorological conditions

&&       INHALATION WEIGHTED COMMITTED DOSE EQUIVALENTS (rem)

              DOWNWIND DISTANCES (m)
   ORGAN    NO.  2.00E+04
 --------   ---  --------
 LUNGS       1   9.57E-08
 SI WALL     3   4.40E-11
 ULI WALL    4   6.98E-11
 LLI WALL    5   1.66E-10
 GONADS      6   2.08E-10
 BREASTS     7   9.39E-11
 BONE SUR    8   1.73E-09
 R MARROW    9   3.05E-09
 THYROID    10   1.87E-11
 LIVER      12   2.80E-13
 OTHER      16   9.06E-11
 CEDE       18   1.02E-07

 ----------
 ORGANS WITH NO CALCULATED DOSE HAVE BEEN SUPPRESSED FROM TABLE

***FISSION PRODUCT CALCULATION

    FRACTION OF RADIONUCLIDE INVENTORY RELEASED =  7.000E+00

   REACTOR HAS BEEN SHUT DOWN FOR  3.600E+03 SECONDS

   TOTAL RADIONUCLIDE RELEASE =  2.262E+09  D/s OR  6.112E-02 Ci

***METEOROLOGICAL DATA

       MEAN WIND SPEED = 5.000E+00 (m/s)   STACK HEIGHT = 7.000E+01 (m)
   MIXING LAYER HEIGHT = 2.000E+03 (m)      AIR DENSITY = 1.099E+03 (g/cu m)
   WET DEPOSITION SCAVENGING COEFFICIENT = 0.000E+00 (1/S)

   NO CORRECTION IS BEING MADE FOR CLOUD DEPLETION BY DRY DEPOSITION

   DEPOSITION VELOCITIES (m/s)
        SOLIDS = 1.000E-03    HALOGENS = 1.000E-02   NOBLE GASES = 0.000E+00
        CESIUM = 1.000E-03   RUTHENIUM = 1.000E-03

   THERE IS 1 SET OF LEAKAGE CONSTANTS (K1,K2)
         3.978E-05        0.000E+00

   PASQUILL CLASS C METEOROLOGY, MARKEE SIGMA VALUES
```

```
            RADIOLOGICAL SAFETY ANALYSIS COMPUTER PROGRAM (RSAC-5)
(RSAC-5E,REV 5.1,08/09/93) SERIAL  700  DATE  09/15/93  TIME 15:16  PAGE   6
example9:  Dose calculations with changing meteorological conditions

   PLUME RISE CALCULATED USING JET CONDITIONS
                 STACK DIAMETER = 2.000E+00 (m)
              EFFLUENT VELOCITY = 8.500E+00 (m/s)
        RESTORING ACCELERATION = 0.000E+00 (1/sq s)

   DOWNWIND DISTANCE  EFFECTIVE STACK   SIGY         SIGZ          CHI/Q
                         HEIGHT (m)      (m)          (m)         (s/cu m)
        2.000E+04        8.020E+01    2.050E+03   2.000E+03    1.946E-08

 *** INHALATION DOSE EQUIVALENT CALCULATION

                        BREATHING RATE =  3.330E-04 (cu m/s)
                RELEASE TIME FOR EXPONENTIAL DECAY FUNCTION =  2.514E+04 (s)
        INTERNAL EXPOSURE TIME PERIOD  =  5.000E+01 (yr)

   PARTICLE SIZE =  1.0 MICRONS AMAD
   LUNG DEPOSITION FRACTIONS: N-P = 0.300  T-B = 0.080  P = 0.250

 LUNG CLEARANCE CLASSES USED IN CALCULATIONS
     ELEMENT      CLASS

      1    H       HTO
      4    Be       Y
      6    C       ORG
     11    Na       D
     14    Si       W
     15    P        D
     16    S        D
     17    Cl       D
     19    K        D
     20    Ca       W
     21    Sc       Y
     24    Cr       Y
     25    Mn       W
     26    Fe       W
     27    Co       Y
     28    Ni       W
     29    Cu       Y
     30    Zn       Y
     32    Ge       W
     34    Se       W
     35    Br       D
     37    Rb       D
     38    Sr       D
     39    Y        Y
     40    Zr       W
     41    Nb       Y
     42    Mo       Y
     43    Tc       W
```

RADIOLOGICAL SAFETY ANALYSIS COMPUTER PROGRAM (RSAC-5)
(RSAC-5E,REV 5.1,08/09/93) SERIAL 700 DATE 09/15/93 TIME 15:16 PAGE 7
example9: Dose calculations with changing meteorological conditions

LUNG CLEARANCE CLASSES USED IN CALCULATIONS

ELEMENT		CLASS
44	Ru	Y
45	Rh	Y
46	Pd	Y
47	Ag	Y
48	Cd	Y
49	In	W
50	Sn	W
51	Sb	D
52	Te	W
53	I	D
55	Cs	D
56	Ba	D
57	La	W
58	Ce	Y
59	Pr	Y
60	Nd	Y
61	Pm	Y
62	Sm	W
63	Eu	W
64	Gd	W
73	Ta	Y
77	Ir	Y
81	Tl	D
82	Pb	D
83	Bi	W
84	Po	W
85	At	D
88	Ra	W
89	Ac	Y
90	Th	Y
91	Pa	Y
92	U	Y
93	Np	W
94	Pu	Y
95	Am	W
96	Cm	W

DOWNWIND DISTANCE = 2.000E+04 (m) PLUME TRAVEL TIME = 4.000E+03 (s)
CHI/Q = 1.946E-08 (s/cu m)

```
              RADIOLOGICAL SAFETY ANALYSIS COMPUTER PROGRAM (RSAC-5)
(RSAC-5E,REV 5.1,08/09/93) SERIAL  700  DATE  09/15/93  TIME 15:16  PAGE    8
example9:  Dose calculations with changing meteorological conditions

&&      INHALATION COMMITTED DOSE EQUIVALENTS ORDERED BY ORGAN (rem)

                  DOWNWIND DISTANCES (m)
  ORGAN    NO.  2.00E+04
 --------  ---  --------
 LUNGS       1  3.97E-07
 SI WALL     3  3.65E-10
 ULI WALL    4  5.78E-10
 LLI WALL    5  1.37E-09
 GONADS      6  4.13E-10
 BREASTS     7  3.11E-10
 BONE SUR    8  2.88E-08
 R MARROW    9  1.26E-08
 THYROID    10  3.11E-10
 LIVER      12  2.32E-12
 OTHER      16  3.76E-10

 ----------
 ORGANS WITH NO CALCULATED DOSE HAVE BEEN SUPPRESSED FROM TABLE

&&      INHALATION COMMITTED DOSE EQUIVALENCES ORDERED BY DOSE (rem)

                  DOWNWIND DISTANCES (m)
  ORGAN    NO.  2.00E+04
 --------  ---  --------
 LUNGS       1  3.97E-07
 BONE SUR    8  2.88E-08
 R MARROW    9  1.26E-08
 LLI WALL    5  1.37E-09
 ULI WALL    4  5.78E-10
 GONADS      6  4.13E-10
 OTHER      16  3.76E-10
 SI WALL     3  3.65E-10
 BREASTS     7  3.11E-10
 THYROID    10  3.11E-10
 LIVER      12  2.32E-12

 ----------
 ORGANS WITH NO CALCULATED DOSE HAVE BEEN SUPPRESSED FROM TABLE
```

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              RADIOLOGICAL SAFETY ANALYSIS COMPUTER PROGRAM (RSAC-5)
(RSAC-5E,REV 5.1,08/09/93) SERIAL  700  DATE  09/15/93  TIME 15:16  PAGE    9
example9:  Dose calculations with changing meteorological conditions

&&      INHALATION WEIGHTED COMMITTED DOSE EQUIVALENTS (rem)

                  DOWNWIND DISTANCES (m)
  ORGAN    NO.  2.00E+04
 --------  ---  --------
 LUNGS      1   4.76E-08
 SI WALL    3   2.19E-11
 ULI WALL   4   3.47E-11
 LLI WALL   5   8.25E-11
 GONADS     6   1.03E-10
 BREASTS    7   4.67E-11
 BONE SUR   8   8.63E-10
 R MARROW   9   1.52E-09
 THYROID   10   9.32E-12
 LIVER     12   1.39E-13
 OTHER     16   4.51E-11
 CEDE      18   5.06E-08

 ----------
 ORGANS WITH NO CALCULATED DOSE HAVE BEEN SUPPRESSED FROM TABLE

 PATHWAY CONTRIBUTION TO THE EDE (rem), DOWNWIND DISTANCE =  2.00E+04 (m)

    NUCLIDE      INHALATION  INGESTION   GROUND SUR  AIR IMMERS    TOTAL
 -------------   ----------  ----------  ----------  ----------  ----------
 380890 Sr- 89    7.37E-11       -           -           -        7.37E-11
 380900 Sr- 90    6.95E-09       -           -           -        6.95E-09
 390900  Y- 90    2.48E-10       -           -           -        2.48E-10
 390910  Y- 91    1.30E-09       -           -           -        1.30E-09
 410940 Nb- 94    2.25E-18       -           -           -        2.25E-18
 400950 Zr- 95    5.94E-10       -           -           -        5.94E-10
 410950 Nb- 95    4.45E-10       -           -           -        4.45E-10
 441060 Ru-106    1.22E-08       -           -           -        1.22E-08
 511250 Sb-125    3.58E-12       -           -           -        3.58E-12
 521251 Te-125M   5.34E-15       -           -           -        5.34E-15
 551370 Cs-137    1.03E-09       -           -           -        1.03E-09
 581440 Ce-144    1.26E-07       -           -           -        1.26E-07
 591440 Pr-144    1.51E-11       -           -           -        1.51E-11
 611470 Pm-147    3.41E-09       -           -           -        3.41E-09
 621470 Sm-147    1.95E-20       -           -           -        1.95E-20
 -------------   ----------  ----------  ----------  ----------  ----------
    TOTALS        1.52E-07       -           -           -        1.52E-07

  WARNINGS
  --------
    NO INGESTION DOSE CALCULATIONS WERE MADE
    NO GROUND SURFACE DOSE CALCULATIONS WERE MADE
    NO AIR IMMERSION OR CLOUD GAMMA DOSE CALCULATIONS WERE MADE

   EXECUTION TIME =  3.19E+01 SECONDS
```

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Appendix A

Mathematical Models

Appendix A
Mathematical Models

A-1. FISSION PRODUCT INVENTORY

The calculation of a fission product inventory for a given operating history is divided into two parts: fission product buildup and radionuclide decay.

A-1.1 Fission Product Buildup

The rate of buildup or fission product generation of the various radionuclides of a decay chain is described by a set of simultaneous differential equations of the first order:

$$\frac{dQ_1}{dt} = S_1 - \mu_1 Q_1 \qquad \text{(A-1)}$$

$$\frac{dQ_2}{dt} = s_2 - \mu_2 Q_2 + \lambda_1 Q_1 \qquad \text{(A-2)}$$

$$\frac{dQ_i}{dt} = s_i - \mu_i Q_i + \lambda_{i-1} Q_{i-1} \qquad \text{(A-3)}$$

where

Q_i = the number of atoms for the i^{th} radio nuclide of the decay chain

t = operating time (s)

s_i = the source rate at which atoms are being produced by fission for the i^{th} radionuclide (atoms/s).

μ_i = $\lambda_i + \sigma_{ci}\, \emptyset$

- λ_i = the decay constant for the i^{th} radionuclide (s^{-1})
- σ_{ci} = neutron capture cross section for the i^{th} radionuclide (cm^{-2})
- $\emptyset$ = neutron flux (n/cm^2-s)

$$S_i = (CONV)(POWER)(Yield_i) \tag{A-4}$$

where

CONV	=	the conversion factor from power to fission (fissions/W-s)
POWER	=	the reactor power (W)
$Yield_i$	=	the fission yield for the i^{th} radionuclide of the decay chain (atoms/fission).

The general solution as formulated by Rubinson (1949) for the contribution to the n^{th} radionuclide from the m^{th} radionuclide precursor is

$$Q_n(t) = S_m \left[\prod_{i=m}^{n-1} (\lambda_i)\right] \sum_{i=m}^{n} \left[\frac{1 - e^{-\lambda_i t}}{\lambda_i \prod\limits_{\substack{j=m \\ j\neq i}}^{n} (\mu_j - \mu_i)}\right] \tag{A-5}$$

By summing all the precursors of a particular nuclide, the general solution for the total number of atoms for the k^{th} radionuclide of the decay chain is obtained:

$$Q_k(t) = \sum_{m=1}^{k} \left[S_m \prod_{i=m}^{k-1} (\lambda_i)\right] \sum_{i=m}^{k} \left[\frac{1 - e^{-\lambda_i t}}{\lambda_i \prod\limits_{\substack{j=m \\ j\neq i}}^{k} (\mu_j - \mu_i)}\right] \tag{A-6}$$

For convenience the linear operator, E_k, is defined as follows:

$$E_k = \sum_{m=1}^{k} \left[S_m \prod_{i=m}^{k-1} (\lambda_i)\right] \sum_{i=m}^{k} \left[\frac{1}{\prod\limits_{\substack{j=m \\ j\neq i}}^{k} (\mu_j - \mu_i)}\right] \tag{A-7}$$

Therefore, the buildup equation can be written as

$$Q_k(t) = E_k \left[\frac{1 - e^{-\lambda_i t}}{\lambda_i} \right] \qquad \text{(A-8)}$$

A-1.2 Radionuclide Decay

The differential equations for the decay rate are similar to those for fission product buildup, except the source rate is considered to be zero. The general solution for the decay equation is

$$N_k(t) = E_k(e^{-\lambda_i t}) \qquad \text{(A-9)}$$

where

$N_k(t)$ = the total number of atoms for the k[th] radionuclide of the decay chain

$$E_k(e^{-\lambda_i t}) = \sum_{m=1}^{k} Q_m \left[\prod_{i=m}^{k-1} (\lambda_i) \right] \sum_{i=m}^{k} \left[\frac{e^{-\lambda_i t}}{\prod_{\substack{j=m \\ j \neq i}}^{k} (\mu_j - \mu_i)} \right] \qquad \text{(A-10)}$$

Q_m = the total number of atoms for the m[th] radionuclide immediately following reactor shutdown as defined above.

t = the time after reactor shutdown (s).

RSAC-5 automatically decays all radioactivity during transport from the point of release to the environment to the downwind receptor location. For simplicity, subsequent equations used in dose calculations do not show the operator E_k. However, RSAC-5 programming includes the buildup and decay of all progeny in each of the decay chains.

A-2. CONCENTRATION FUNCTION

A-2.1 Atmospheric Diffusion

Atmospheric diffusion at ground level for a continuous point source can be expressed using the time-integrated form of the universal diffusion equation (Slade 1986; Clawson et al. 1989) as follows:

$$\frac{\chi}{Q}(x,y,0) = \frac{1}{\pi \bar{u}\, \sigma_y \sigma_z} \exp\left[-\frac{1}{2}\left[\frac{y^2}{\sigma_y^2} + \frac{h^2}{\sigma_z^2}\right]\right] \quad \text{(A-11)}$$

where

$\frac{\chi}{Q}(x,y,0)$	=	ground-level atmospheric diffusion relative to the initial point of release (s/m^3)
x	=	distance downwind (m)
y	=	horizontal distance from plume centerline (m)
$\bar{u}$	=	average windspeed at the release level (m/s)
σ_y,σ_z	=	standard deviations of effluent concentration of the plume in the horizontal and vertical directions (m)
h	=	elevation of the point of release above the ground plane (m).

Airborne material freely diffuses the atmosphere near the ground level in what is known as the mixing depth. A stable layer exists above the mixing depth that restricts vertical diffusion. The depth of the mixed layer is a function of the heat energy exchange between the air and the ground; it is influenced by cloud cover, time of day, and season. Seasonal and annual mixing depths have been estimated for the Idaho National Engineering Laboratory (Clawson et al. 1989) and are presented in Table A-1.

RSAC-5 treats the ground and the height of the mixing depth as plume reflectors. When σ_z becomes large compared to the mixing depth, the plume becomes uniformly distributed between the

Table A-1. Estimated seasonal and annual mixing depths (m) for mornings and afternoons at the Idaho National Engineering Laboratory.

Season	Morning	Afternoon
Spring	480	2330
Summer	260	2900
Autumn	330	1550
Winter	400	730
ANNUAL	370	2090

ground and the height of the mixing depth. Atmospheric diffusion is then calculated using Equation (A-12) (Turner 1970, Yanskey et al. 1966).

$$\frac{\chi}{Q}(x,y,z) = \frac{1}{\sqrt{2\pi}\,\sigma_y H \bar{u}} \exp\left[-\frac{1}{2}\left[\frac{y^2}{\sigma_y^2}\right]\right] \tag{A-12}$$

where

H = height of the mixing depth (m).

An option is provided for ground-level releases to adjust the plume standard deviations to correct for an initial mixing of the effluent plume within a building wake. An effective σ_y and σ_z can be used to correct for building turbulence (Islitzer 1965, Yanskey et al. 1966) using the following equations:

$$\sigma_y'^2 = \frac{D^2}{\pi k} + \sigma_y^2 \tag{A-13}$$

$$\sigma_y'^2 = \frac{D^2}{\pi k} + \sigma_y^2 \tag{A-14}$$

where

D^2 = $D_y D_z$

D_y = width of building (m)

D_z = height of building (m)

k = dilution factor ranging from 0.5 to 2.0.

The value for k is a function of the actual building configuration and atmospheric stability. When a measured value is not available for k, a value of 1.0 is recommended.

When the release is from an elevated point during stable meteorological conditions, significant concentrations of the plume often do not reach ground level until the stability change occurs. The most common breakup of stable meteorology (inversion) is through a phenomenon known as fumigation, which can result in increased ground-level concentrations. While fumigation is often ignored in other codes, it is a well documented phenomena (NRC 1982, Slade 1968, Turner 1970, Yanskey et al. 1966). Fumigation occurs when the nocturnal temperature inversion at the surface is being broken up by surface heating shortly after sunrise. The plume may be transported large downwind distances during the stable meteorology condition before a fumigation breakup occurs. The length of time that a fumigation condition lasts is a function of the release height and the downwind terrain. Fumigations typically last approximately 30 minutes for stacks in the 30 to 50-meter heights and approximately 60 minutes for stacks in the 75 to 100-meter heights. The inversion breakup creates moderately unstable conditions under an inversion lid, thereby, limiting vertical dispersion to the area between the ground and the base of the inversion (see Figure A-1).

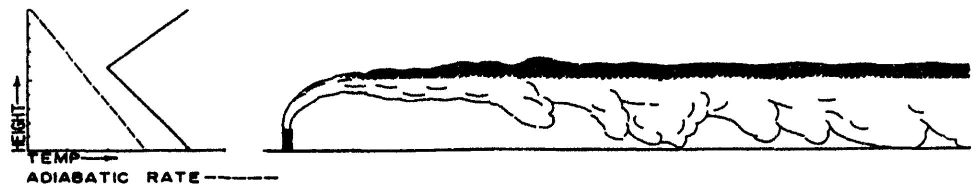

Figure A-1. Fumigating plume.

Based on the assumption that the concentration is distributed uniformly in the vertical to the inversion base (Yanskey et al. 1966), diffusion for a fumigating plume can be calculated using Equation (A-12).

Atmospheric dispersion at various heights above the ground level must be calculated to calculate cloud-gamma doses from a finite plume. The form of the time-integrated universal diffusion equation then becomes

$$\frac{\chi}{Q}(x,y,z) = \frac{1}{2\pi \bar{u}\, \sigma_y \sigma_z} \exp\left[-\frac{1}{2}\left\{\frac{y^2}{\sigma_y^2} + \frac{(z-h)^2}{\sigma_z^2} + \frac{(z+h)^2}{\sigma_z^2}\right\}\right] \quad \text{(A-15)}$$

where

z = vertical distance from the plume centerline (m)

A-2.2 Plume Deposition

An estimate of the amount of radioactivity that is deposited on the ground must be made to calculate ground surface and ingestion doses. Dry deposition calculations in RSAC-5 are made using a deposition velocity defined by Chamberlain (1953) as

$$V_d = -\frac{F}{\chi} \quad \text{(A-16)}$$

where

V_d = dry deposition velocity (m/s)

F = deposition flux (Ci/m^2s)

χ = airborne concentration (Ci/m^3).

The quantity of deposited radioactive material, ω, is then calculated using the following equation:

$$\omega(x,0,0) = \frac{\chi}{Q} V_d t \qquad \text{(A-17)}$$

where

ω	=	surface contamination (Ci/m^2)
V_d	=	deposition velocity (m/s)
t	=	time that the ground is exposed to the plume (s).

Dry deposition velocities are a function of particle size and chemical species. Values recommended for use in RSAC-5 are published by Schmel (1980).

A-2.3 Plume Depletion

RSAC-5 has options for depleting plumes by both dry and wet deposition. Plume depletion by dry deposition is based on the modeling of Markee (1967) as recommended in Regulatory Guide 1.111 (NRC 1977b). Plume depletion by wet deposition in RSAC-5 is based on the modeling summarized by Hanna et al. (1982). The modeling assumes the plume concentration (C) decreases exponentially with time:

$$C(t) = C(0) \exp\left[-\Lambda t\right] \qquad \text{(A-18)}$$

where

Λ	=	scavenging coefficient (s^{-1})
t	=	time since precipitation began (s).

When it is assumed that the rain falls completely through the plume, the fraction of the plume depleted (F_{wet}) is given by

$$F_{wet} = \frac{\Lambda}{\sqrt{2\pi}\,\sigma_y \bar{u}} \exp\left[-\frac{1}{2}\left(\frac{y^2}{\sigma_y^2}\right)\right] \qquad \text{(A-19)}$$

A-2.4 Leakage Rate Function

RSAC-5 can decay correct the radionuclide inventory during holdup before leaking from a building, stack, or containment vessel to the atmosphere. Leakage is expressed in the form of a series of exponential approximations of the following form:

$$L(t-x/\bar{u}) = \sum_{j=1}^{n} K1_j \exp\left[-K2_j(t-x/\bar{u})\right] \qquad \text{(A-20)}$$

where

$L(t-x/\bar{u})$	=	leakage rate function (s^{-1})
t	=	time following the initiation of the release (s)
$x/\bar{u}$	=	time required to reach any downwind receptor location (s)
n	=	number of exponential approximations ($1 \leq n \leq 10$)
$K1_j$	=	linear constant (s^{-1})
$K2_j$	=	exponential constant (s^{-1}).

Values of $K1_j$ and $K2_j$ can be either positive or negative. If a constant leakage rate is desired, set $K2_j = 0.$ and $K1_1$ = the reciprocal of the time that it takes for the activity to be released to the atmosphere. The use of one set of leakage constants is normally sufficient for most calculations.

It is important not to decay the radionuclide inventory twice before its release to the atmosphere. This can inadvertently occur when the total activity of each radionuclide to be released to the atmosphere over an extended period of time is entered directly into RSAC-5 rather than using RSAC-5 to calculate the radionuclide inventory. When this is the case, no additional decay of the activity before release is desired even though the total activity entered may represent a release over an extended period of time. When the total activity to be released to the atmosphere is entered directly into RSAC-5, the user should set $K1_1 = 1.$, $K2_1 = 0$, and the time over which the activity is released to the atmosphere to 1 second.

Proper selection of the leakage constants $K1_j$ and $K2_j$ can be evaluated by integrating each of the leakage terms over the period of release. The sum of the integrated terms should equal the total release fraction before correction for radioactive decay. Additional information on the use of the RSAC-5 leakage function is presented in Section 4.1, *Leakage Decay Constants Lines (5201+)*.

A-2.5 Plume Rise

Plume rise in RSAC-5 is calculated for either jet or buoyant plumes using the methodology developed by Briggs (1969). For jet plumes in neutral, windy, or lapse conditions, the jet centerline plume rise is given by

$$\frac{\Delta h}{D} = 1.44 \left[\frac{\omega_o}{\bar{u}}\right]^{2/3} \left[\frac{x}{D}\right]^{1/3} \tag{A-21}$$

where

Δh	=	plume rise above the top of the stack (m)
D	=	internal stack diameter (m)
w_o	=	efflux speed of gases from stack (m/s)
$\bar{u}$	=	average windspeed at the stack level (m/s)
x	=	downwind distance (m).

Equation (A-21) is used up to the point that

$$\Delta h = 3 \frac{\omega_o}{\bar{u}} D \tag{A-22}$$

as long as $\omega_o/\bar{u} \geq 4$.

When stable meteorological conditions exist, plume rise is calculated using

$$\Delta h = 1.5 \left(\frac{F_m}{\bar{u}}\right)^{1/3} s^{-1/6} \tag{A-23}$$

where

F_m	=	$\omega_o^2 \left(\frac{D}{2}\right)^2$
S	=	restoring acceleration per unit vertical displacement (s^{-2}).

RSAC-5 default values for S are 8.7E-04 (s^{-2}) for a weak inversion and 1.75E-03 (s^{-2}) for a strong inversion.

Plume rise for a buoyant plume is calculated using

$$\Delta h = \frac{1.6}{\bar{u}} F^{\frac{1}{3}} x^{\frac{2}{3}} \qquad \text{(A-25)}$$

where

F	=	$3.7 \times 10^{-5}\, Q_H$
Q_H	=	stack gasses heat emission (cal/s).

Equation (A-25) is used up to a distance $x_e/x_e^* = 1$, where

x_e	=	downwind distance (ft)

$$x_e^* = 0.52\, F_e^{\frac{2}{5}}\, h_e^{\frac{3}{5}} \qquad \text{(A-26)}$$

F_e	=	$4.3 \times 10^{-3}\, Q_H$
h_e	=	elevation of the point of release above the ground plane (ft)
Δh	=	$0.3048\, \Delta h_e$ (m).

Beyond this distance, plume rise is calculated using

$$\Delta h_e = 1.6 F_e^{\frac{1}{3}}\, \bar{u}_e^{-1}\, x_e^{*\frac{2}{3}} \left[\frac{2}{5} + \frac{16}{25}\frac{x_e}{x_e^*} + \frac{11}{5}\left(\frac{x_e}{x_e^*}\right)^2 \right] \left(1 + \frac{4}{5}\frac{x_e}{x_e^*}\right)^{-2} \qquad \text{(A-27)}$$

where

$\bar{u}_e$	=	average windspeed at the elevation of the point of release above the ground plane (ft/s)

and allowing x_e/x_e^* to increase to a maximum value of 5.

A-3 DOSE CALCULATIONS

A-3.1 Inhalation Dose

RSAC-5 calculates inhalation doses using the ICRP 30 (1979) model with DOE (1988a) dose conversion factors (DCFs). The committed dose equivalent (CDE) is calculated for individual organs and tissues over a 50-year period after inhalation. The CDE for each organ or tissue is multiplied by the appropriate ICRP 26 (1977) weighting factor to calculate what is called the weighted committed dose equivalent (WCDE) in RSAC-5. The ICRP 26 weighting factors are presented in Table A-2. The committed effective dose equivalent (CEDE) is then the sum of the WCDEs for the organs and tissues listed in Table A-2.

RSAC-5 calculates CEDE for the default 1 μm activity median aerodynamic diameter (AMAD) directly using the DOE (1988a) DCFs. The DOE DCFs factors are available with only two places of accuracy. Thus, a summing of the individual WCDE may not exactly equal the CEDE because of rounding errors. Because of these rounding errors and other uncertainties in the ICRP 30 modeling, all final doses calculated should be reported to only one significant digit.

Table A-2. Weighting factors for stochastic risks.

Organ or tissue	Weighting factor
Gonads	0.25
Breast	0.15
Red bone marrow	0.12
Lungs	0.12
Thyroid	0.03
Bone surfaces	0.03
Remainder[a]	0.30

a. A weighting factor of 0.06 is applied to each of the five organs or tissues of the remaining organs receiving the greatest dose equivalents.

For particle sizes other than the default 1 μm AMAD, DCFs are corrected according deposition in the three regions of the respiratory system; the nasal passage (NP), the trachea and bronchial tree (TB), and the pulmonary parenchyma (P). DCFs are modified according to the following equation:

$$\frac{DCF_{(New)}}{DCF_{(1\ \mu m)}} = f_{NP}\frac{D_{NP_{(New)}}}{D_{NP_{(1\ \mu m)}}} + f_{TB}\frac{D_{TB_{(New)}}}{D_{TB_{(1\ \mu m)}}} + f_{P}\frac{D_{P_{(New)}}}{D_{TB_{(1\ \mu m)}}} \qquad \text{(A-28)}$$

where

f_{NP}, f_{TB}, and f_P	=	fraction of the CDE in the reference tissue, resulting from deposition in the N-P, T-B, and P regions, respectively as shown in Table A-3.
D_{NP}, D_{TB}, and D_P	=	deposition probabilities in the respiratory regions as a function of AMAD as shown in Figure A-2.

The model is intended for use with aerosol distributions with AMADs between 0.2 and 10 μm. Provisional estimates of deposition further extending the size range are given by the dashed lines. The minimum allowable particle size is 0.1 μm AMAD. The model assumes complete deposition in the NP region for all AMAD of greater than 20 μm.

Correction is made for the chemical state of each radionuclide according to the ICRP-30 designated clearance classes of D, W and Y as shown in Table A-3 for the clearance pathways shown in Figure A-3. The allowable clearance classes for each element and the RSAC-5 default classes are presented in Appendix D.

Table A-3. ICRP-30 mathematical model used to describe clearance from the respiratory system.

		Class[a]					
		D		W		Y	
Region	Compartment	T day	F	T day	F	T day	F
NP	a	0.01	0.5	0.01	0.1	0.01	0.01
(D_{NP} = 0.30)	b	0.01	0.5	0.40	0.9	0.40	0.99
TB	c	0.01	0.95	0.01	0.5	0.01	0.01
(D_{TB} = 0.08)	d	0.2	0.05	0.2	0.4	0.2	0.99
	e	0.5	0.8	50	0.15	500	0.05
P	f	NA[b]	NA	1.0	0.4	1.0	0.4
(D_P = 0.25)	g	NA	NA	50	0.4	500	0.4
	h	0.5	0.2	50	0.05	500	0.15
L	i	0.5	1.0	50	1.0	1000	0.9
	j	NA	NA	NA	NA	∞	0.1

a. D, W, and Y refer to lung retention classes with clearance half-times of 0.5, 50 and 500 days, respectively. T refers to the removal half-times, and F refers to the compartmental fractions. The values given for D_{NP}, D_{TB}, and D_P (left column) are the regional depositions for an aerosol with an AMAD of 1 µm.

b. NA = not applicable.

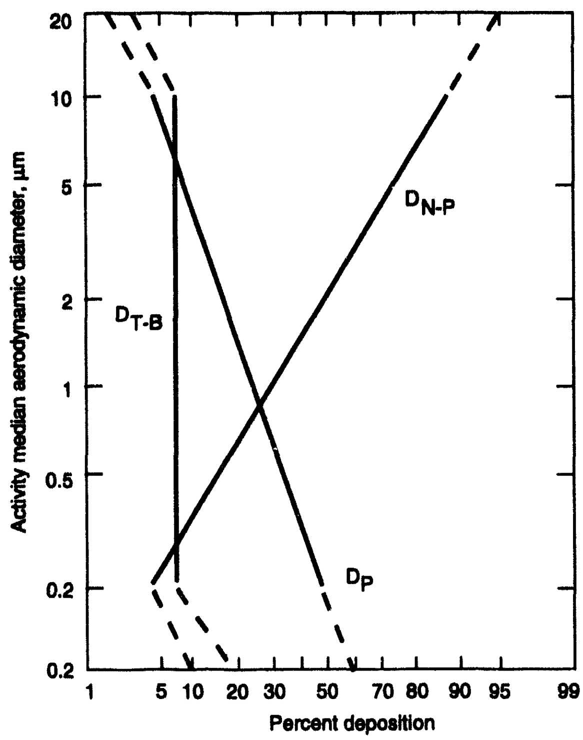

Figure A-2. Deposition of dust in the respiratory system.

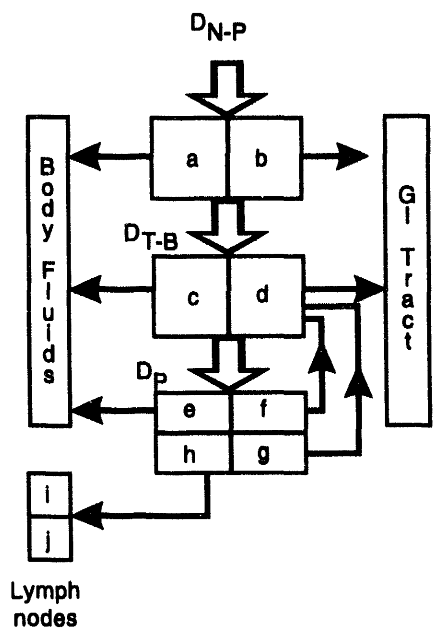

Figure A-3. Clearance pathways for the ICRP-30 model.

A-3.3 Ingestion Dose

A-3.3.1 Chronic Release

The calculation of ingestion dose from a chronic release is based on the models and equations from Regulatory Guide 1.109 (NRC 1977a). Dose pathways from the ingestion of vegetation, meat, and milk have been included for activity deposited on the ground plane. The equation used to calculate the total ingestion dose from the pathways is

$$D_{ij} = DFI_{ij} \left[U^v f_g C_i^v + U^m C_i^m + U^F C_i^F + U^L f_l C_i^L \right] \qquad \text{(A-29)}$$

where

D_{ij}	=	annual dose equivalent to organ j from ingestion of food contaminated from the atmospheric release and subsequent deposition of radionuclide i (rem/yr)
DFI_{ij}	=	ingestion dose factor for radionuclide i and organ j (rem/pCi)
U^v,U^m,U^F,U^L	=	usage factors for produce (nonleafy), milk, meat, and leafy vegetables (kg/yr and L/yr for milk)
f_g, f_l	=	respective fractions of the ingestion rates of produce and leafy vegetables that are produced in the garden of interest
C_i^v,C_i^m,C_i^F,C_i^L	=	concentrations of radionuclide i in produce (nonleafy vegetables), milk, meat and fresh vegetables, respectively (pCi/kg).

The default dietary ingestion rates for adults (U^v, U^m, U^F, and U^L) used in RSAC-5 are presented in Table A-4.

Table A-4. Default annual dietary ingestion rates for adults.

Parameter	Value	Units	Symbol
Leafy vegetables	64.	kg/yr	U^L
Meat	110.	kg/yr	U^F
Milk	310.	L/yr	U^m
Produce	520.	kg/yr	U^v

The concentration of radionuclide i in and on vegetation is a function of the rate of deposition upon the plant foliage and the rate of uptake from the soil. The equation used to estimate the concentration in and on vegetation from all radioiodines and particulate radionuclides, except tritium and carbon-14 is

$$C_i^v = d_i \left\{ \frac{r\, F_T \left[1 - e^{-\lambda_{Ei} t_e} \right]}{Y_v \lambda_{Ei}} + \frac{B_{iv} \left[1 - e^{-\lambda_i t_b} \right]}{P \lambda_i} \right\} e^{-\lambda_i t_h} \tag{A-30}$$

where

C_i^v = concentration of radionuclide i in and on vegetation (pCi/kg)

d_i = deposition rate of radionuclide i (pCi/m^2-h)

r = fraction of deposited activity retained on foliage

F_T = fraction of deposited radioactivity translocated from plant surface to edible portion of crop

λ_{Ei} = effective removal rate constant for radionuclide i from foliage surfaces (h^{-1}),

$\lambda_{Ei} = \lambda_i + \lambda_w$

λ_i = decay constant for radionuclide i (s^{-1})

λ_w = rate constant for removal of activity on plant or leaf surfaces by weathering (h^{-1})

t_e = time period that crops are exposed to contamination during the growing season (h)

Y_v = agricultural productivity (yield) (kg/m^2)

B_{iv} = concentration factor for root uptake of radionuclide i from soil to edible parts of crops (pCi/kg wet weight per pCi/kg dry soil)

t_b = period of long-term buildup for activity in soil (h)

P = effective surface density for soil (kg/m^2 dry)

t_h = holdup time between harvest and consumption by either humans or livestock (h).

The units of t_b, t_e and t_h are expressed in hours in Equation (A-30) for convenience; however, user input of t_b in Table A-5 and Section 4.1, *Dose Calculation Control Line 2 (7001)*, is in years; and t_e and t_h in Table A-5 and Section 4.1, *Ingestion Constants Line 2 (7052)* and *Ingestion Constants Line 3 (7053)* are in days.

A summary of element independent default parameters used to calculate the concentration of radioactivity in crops from chronic releases are presented in Table A-5. Element dependent parameters (Baes et al. 1984) are presented in Table A-6.

Table A-5. RSAC-5 default radionuclide independent parameters used to calculate concentrations in crops from chronic releases.

Parameter	Value	Units	Symbol
Fraction grown in garden			
Produce	0.76	--	f_g
Leafy vegetables	1.0	--	f_l
Fallout interception fractions			r
Pasture	0.57	--	
Vegetables	0.2	--	
Iodines on forage	1.0	--	
Removal rate constant	0.0021	h^{-1}	λ_w
Period of crop exposure during growing season			t_e
Vegetables	60.	d	
Forage	30.	d	
Vegetation yield			Y_v
Vegetables	2.	kg/m^2 (dry)	
Forage	0.28	kg/m^2 (wet)	
Time of activity buildup in soil	1.315E+5 (15.)	h (yr)	t_b
Soil surface density	225.	kg/m^2	P
Time delays			t_h
Fresh vegetables	1.	d	
Stored vegetables	60.	d	
Feed-milk-person	2.	d	
Slaughter-consumption	20.	d	

Table A-6. RSAC-5 element-dependent parameters used to calculate concentrations in crops.

		Root uptake factors		Transfer coefficients		
	Element	Forage B_{iv1}	Produce B_{iv2}	Milk F_m	Meat F_f	Translocation factor F_T
1	H	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.0E+00
2	He	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.0E+00
3	Li	2.5E-02	1.7E-03	2.0E-02	1.0E-02	1.0E+00
4	Be	1.0E-02	6.4E-04	9.0E-07	1.0E-03	1.0E+00
5	B	4.0E+00	8.6E-01	1.5E-03	8.0E-04	1.0E+00
6	C	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.0E+00
7	N	3.0E+01	1.3E+01	2.5E-02	7.5E-02	1.0E+00
8	O	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.0E+00
9	F	6.0E-02	2.6E-03	1.0E-03	1.5E-01	1.0E+00
10	Ne	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.0E+00
11	Na	7.5E-02	2.4E-02	3.5E-02	5.5E-02	1.0E+00
12	Mg	1.0E+00	2.4E-01	4.0E-03	5.0E-03	1.0E+00
13	Al	4.0E-03	2.8E-04	2.0E-04	1.5E-03	1.0E+00
14	Si	3.5E-01	3.0E-02	2.0E-05	4.0E-05	1.0E+00
15	P	3.5E+00	1.5E+00	1.5E-02	5.5E-02	1.0E+00
16	S	1.5E+00	6.4E-01	1.5E-02	1.0E-01	1.0E+00
17	Cl	7.0E+01	3.0E+01	1.5E-02	8.0E-02	1.0E+00
18	Aa	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.0E+00
19	K	1.0E-00	2.4E-01	7.0E-03	2.0E-02	1.0E+00
20	Ca	3.5E+00	1.5E-01	1.0E-02	7.0E-04	1.0E+00
21	Sc	6.0E-03	4.3E-04	5.0E-06	1.5E-02	1.0E+00
22	Ti	5.5E-03	1.3E-03	1.0E-02	3.0E-02	1.0E+00
23	V	5.5E-03	1.3E-03	2.0E-05	2.5E-03	1.0E+00
24	Cr	7.5E-03	1.9E-03	1.5E-03	5.5E-03	1.0E+00
25	Mn	2.5E-01	2.1E-02	3.5E-04	4.0E-04	1.0E+00
26	Fe	4.0E-03	4.3E-04	2.5E-04	2.0E-02	1.0E+00
27	Co	2.0E-02	3.0E-03	2.0E-03	2.0E-02	1.0E+00
28	Ni	6.0E-02	2.6E-02	1.0E-03	6.0E-03	1.0E+00
29	Cu	4.0E-01	1.1E-01	1.5E-03	1.0E-02	1.0E+00
30	Zn	1.5E+00	3.9E-01	1.0E-02	1.0E-01	1.0E+00
31	Ga	4.0E-03	1.7E-04	5.0E-05	5.0E-04	1.0E+00
32	Ge	4.0E-01	3.4E-02	7.0E-02	7.0E-01	1.0E+00
33	As	4.0E-02	2.6E-03	6.0E-05	2.0E-03	1.0E+00
34	Se	2.5E-02	1.1E-02	4.0E-03	1.5E-02	1.0E+00
35	Br	1.5E+00	6.4E-01	2.0E-02	2.5E-02	1.0E+00
36	Kr	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.0E+00
37	Rb	1.5E-01	3.0E-02	1.0E-02	1.5E-02	1.0E+00
38	Sr	2.5E+00	1.1E-01	1.5E-03	3.0E-04	1.0E+00
39	Y	1.5E-02	2.6E-03	2.0E-05	3.0E-04	1.0E+00
40	Zr	2.0E-03	2.1E-04	3.0E-05	5.5E-03	1.0E+00
41	Nb	2.0E-02	2.1E-03	2.0E-02	2.5E-01	1.0E+00
42	Mo	2.5E-01	2.6E-02	1.5E-03	6.0E-03	1.0E+00
43	Tc	9.5E+00	6.4E-01	1.0E-02	8.5E-03	1.0E+00
44	Ru	7.5E-02	8.6E-03	6.0E-07	2.0E-03	5.0E-02
45	Rh	1.5E-01	1.7E-02	1.0E-02	2.0E-03	1.0E+00

Table A-6. (continued).

	Element	Root uptake factors: Forage B_{iv1}	Root uptake factors: Produce B_{iv2}	Transfer coefficients: Milk F_m	Transfer coefficients: Meat F_f	Translocation factor F_T
46	Pd	1.5E-01	1.7E-02	1.0E-02	4.0E-03	1.0E+00
48	Cd	5.5E-01	6.4E-02	1.0E-03	5.5E-04	1.0E+00
49	In	4.0E-03	1.7E-04	1.0E-04	8.0E-03	1.0E+00
50	Sn	3.0E-02	2.6E-03	1.0E-03	8.0E-02	1.0E+00
51	Sb	2.0E-01	1.3E-02	1.0E-04	1.0E-03	1.0E+00
52	Te	2.5E-02	1.7E-03	2.0E-04	1.5E-02	1.0E+00
53	I	1.5E-01	2.1E-02	1.0E-02	7.0E-03	1.0E-01
54	Xe	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.0E+00
55	Cs	8.0E-02	1.3E-02	7.0E-03	2.0E-02	5.0E-01
56	Ba	1.5E-01	6.4E-03	3.5E-04	1.5E-04	1.0E+00
57	La	1.0E-02	1.7E-03	2.0E-05	3.0E-04	1.0E+00
58	Ce	1.0E-02	1.7E-03	2.0E-05	7.5E-04	3.0E-01
59	Pr	1.0E-02	1.7E-03	2.0E-05	3.0E-04	1.0E+00
60	Nd	1.0E-02	1.7E-03	2.0E-05	3.0E-04	1.0E+00
61	Pm	1.0E-02	1.7E-03	2.0E-05	5.0E-03	1.0E+00
62	Sm	1.0E-02	1.7E-03	2.0E-05	5.0E-03	1.0E+00
63	Eu	1.0E-02	1.7E-03	2.0E-05	5.0E-03	1.0E+00
64	Gd	1.0E-02	1.7E-03	2.0E-05	3.5E-03	1.0E+00
65	Tb	1.0E-02	1.7E-03	2.0E-05	4.5E-03	1.0E+00
66	Dy	1.0E-02	1.7E-03	2.0E-05	5.5E-03	1.0E+00
67	Ho	1.0E-02	1.7E-03	2.0E-05	4.5E-03	1.0E+00
68	Er	1.0E-02	1.7E-03	2.0E-05	4.0E-03	1.0E+00
69	Tm	1.0E-02	1.7E-03	2.0E-05	4.5E-03	1.0E+00
70	Yb	1.0E-02	1.7E-03	2.0E-05	4.0E-03	1.0E+00
71	Lu	1.0E-02	1.7E-03	2.0E-05	4.5E-03	1.0E+00
72	Hf	3.5E-03	3.6E-04	5.0E-06	1.0E-03	1.0E+00
73	Ta	1.0E-02	1.1E-03	3.0E-06	6.0E-04	1.0E+00
74	W	4.5E-02	4.3E-03	3.0E-04	4.5E-02	1.0E+00
75	Re	1.5E+00	1.5E-01	1.5E-03	8.0E-03	1.0E+00
76	Os	1.5E-02	1.5E-03	5.0E-03	4.0E-01	1.0E+00
77	Ir	5.5E-02	6.4E-03	2.0E-06	1.5E-03	1.0E+00
78	Pt	9.5E-02	1.1E-02	5.0E-03	4.0E-03	1.0E+00
79	Au	4.0E-01	4.3E-02	5.5E-06	8.0E-03	1.0E+00
80	Hg	9.0E-01	8.6E-02	4.5E-04	2.5E-01	1.0E+00
81	Tl	4.0E-03	1.7E-04	2.0E-03	4.0E-02	1.0E+00
82	Pb	4.5E-02	3.9E-03	2.5E-04	3.0E-04	1.0E+00
83	Bi	3.5E-02	2.1E-03	5.0E-04	4.0E-04	1.0E+00
84	Po	2.5E-03	1.7E-04	3.5E-04	9.5E-05	1.0E+00
85	At	1.0E+00	6.4E-02	1.0E-02	1.0E-02	1.0E+00
86	Rn	0.0E+00	0.0E+00	0.0E+00	0.0E-00	1.0E+00
87	Fr	3.0E-02	3.4E-03	2.0E-02	2.5E-03	1.0E+00
88	Ra	1.5E-02	6.4E-04	4.5E-04	2.5E-04	1.0E+00
89	Ac	3.5E-03	1.5E-04	2.0E-05	2.5E-05	1.0E+00
90	Th	8.5E-04	3.6E-05	5.0E-06	6.0E-06	1.0E+00
91	Pa	2.5E-03	1.1E-04	5.0E-06	1.0E-05	1.0E+00

Table A-6. (continued).

		Root uptake factors		Transfer coefficients		
Element		Forage B_{iv1}	Produce B_{iv2}	Milk F_m	Meat F_f	Translocation factor F_T
92	U	8.5E-03	1.7E-03	6.0E-04	2.0E-04	1.0E+00
95	Am	5.5E-03	1.1E-04	4.0E-07	3.5E-06	3.0E-01
96	Cm	8.5E-04	6.4E-06	2.0E-05	3.5E-06	3.0E-01

Equation (A-30) is expressed in the same format as presented in Regulatory Guide 1.109 (NRC 1977a). As such, it is expressed for only a single radionuclide. However, when the radionuclide of interest is the progeny of other radionuclides, RSAC-5 corrects for decay chain ingrowth.

Equation (A-30) contains a translocation factor, F_T, which is not included in the original formulation of the NRC Regulatory Guide 1.109 model. This parameter corrects for the translocation of activity deposited on plant leaves to the edible portion of the crop. Translocation factors for leafy vegetables and forage are set to 1. Translocation factors to the edible portions of produce crops are taken from Boone et al. (1981).

The concentration factor for root uptake, B_{iv}, is element dependent. Root uptake factors have been taken from literature developed to update the NRC Regulatory Guide 1.109 model published by Baes et al. (1984). The root uptake factors in Table A-6 are dimensionless and express pCi/kg_{plant} per pCi/kg_{soil}. The soil weight is for dry soil. Root uptake factors for forage (B_{iv1}) are for forage measured in dry weight while root uptake factors for produce (B_{iv2}) are for produce measured in wet weight.

Both C_i^m, the concentration of milk, and C_i^F, the concentration in meat, depend upon the fraction of the year that the livestock is grazing on pasture as opposed to consuming stored feed. The equation used to calculate the concentration of radionuclide i in the animal's feed is

$$C_i^{fd} = f_p f_s C_i^p + (1-f_p)C_i^s + f_p(1-f_s)C_i^s \tag{A-31}$$

where

C_i^{fd} = concentration of radionuclide i animals' feed (pCi/kg)

f_p = fraction of the year that animals graze on pasture

f_s = fraction of daily feed that is pasture grass when the animal grazes on pasture

C_i^p = concentration of radionuclide i on pasture grass (pCi/kg)

C_i^s = concentration of radionuclide i in stored feed (pCi/kg).

Both C_i^p and C_i^s are calculated using Equation (A-30) with appropriate constants.

The concentration of radionuclide i in milk is dependent on the concentration in the feed and the quantity of feed consumed by the animal. The equation used to calculate the concentration in milk is

$$C_i^m = F_m \, C_i^{fd} \, Q_F \, e^{-\lambda_i t_f} \qquad \text{(A-32)}$$

where

C_i^m	=	concentration of radionuclide i in milk (pCi/L)
F_m	=	average fraction of the animal's daily intake of radionuclide i that appears in milk (d/L)
Q_F	=	amount of feed consumed by the animal (normally 16 kg/d dry weight)
t_f	=	average transport time of the activity from the feed into the milk and to the receptor (d).

The equation used to calculate the concentration in milk is

$$C_i^F = F_f C_i^{fd} Q_F \exp(-\lambda_i t_c) \qquad \text{(A-33)}$$

where

C_i^F	=	concentration of radionuclide i in meat (pCi/kg)
F_f	=	average fraction of the animal's daily intake of radionuclide i that appears in each kilogram of flesh (d/kg)
t_c	=	average time between slaughter and consumption (d).

The equation used to calculate the concentration of tritium in vegetation from chronic releases is

$$C_T^V = 3.169 \times 10^7 \, Q_T \, \frac{\chi}{Q} \left[\frac{(0.75)\,(0.5)}{H} \right] \qquad \text{(A-34)}$$

where

C_T^V	=	concentration of tritium in vegetation (pCi/kg)

$$3.169 \times 10^7 = \frac{(1.0 \times 10^{12}\ \text{pCi/Ci})\ (1.0 \times 10^3\ \text{g/kg})}{3.156 \times 10^7\ \text{s/yr}} \tag{A-35}$$

Q_T = annual release of tritium (Ci/yr)

$\frac{\chi}{Q}$ = atmospheric diffusion relative to the initial point of release (s/m^3)

0.75 = fraction of total plant mass that is water

0.50 = ratio of tritium concentration in plant water to tritium concentration in atmospheric water

H = absolute humidity (g/m^3).

The equation used to calculate the concentration to carbon-14 in vegetation from chronic releases is

$$C_{14}^{V} = 3.169 \times 10^7\ Q_{14}\ \frac{\chi}{Q} \left[\frac{0.11}{0.16}\right] \tag{A-36}$$

where

C_{14}^{V} = concentration of carbon-14 in vegetation (pCi/kg)

Q_{14} = annual release of carbon-14 (Ci/yr)

0.11 = fraction of total plant mass that is natural carbon

0.16 = concentration of natural carbon in the atmosphere (g/m^3).

A-3.3.2 Acute Release

The ingestion equations presented in Regulatory Guide 1.109 (NRC 1977a) apply to chronic releases. Unfortunately, there is no consensus model for the calculation of ingestion doses from an acute release. Therefore, it was necessary to develop the model used in RSAC-5. The model assumes that consumption of contaminated vegetation from an acute release occurs at a constant rate during the acute release period and during the harvest duration time that follows the acute release period. The activity on vegetation (pCi/m^2) collected during the acute release period for radionuclide i can be calculated using the following equation:

$$A_D = d_i \int_0^{t_a} e^{-\lambda_{Ei} t} dt \qquad \text{(A-37)}$$

where

A_D = activity on vegetation collected during the acute release period

d_i = deposition rate of radionuclide i (pCi/m^2-h)

t_a = acute release period (h)

λ_{Ei} = effective removal rate constant for radionuclide i from foliage surfaces (h^{-1}),

$\lambda_{Ei} = \lambda_i + \lambda_w$

Integrating Equation (A-37), the equation for A_D becomes

$$A_D = \frac{d_i}{\lambda_{Ei}}\left[1 - e^{-\lambda_{Ei} t_a}\right] \qquad \text{(A-38)}$$

Assuming that produce collection is constant during the acute release period (t_a) and during the harvest duration time period following the acute release (t_{hd}), the fraction of the uptake that is collected during the acute release period is

$$\frac{t_a}{t_a + t_{hd}} \qquad \text{(A-39)}$$

The concentration in produce collected during the acute release period is then

$$C_{iD}^{v} = \frac{r F_T F_a}{Y_v}\left(\frac{t_a}{t_a + t_{hd}}\right) A_D \qquad \text{(A-40)}$$

where

r = fraction of deposited activity retained on foliage

F_T = fraction of deposited radioactivity translocated from plant surface to edible portion of crop

F_a = fraction of annual crop that is contaminated by the acute release

Y_v = agricultural productivity (yield) (kg/m^2).

Inserting Equation (A-38) into Equation (A-39), the equation for the concentration in produce collected during the acute release period becomes

$$C_{iD}^{v} = \frac{d_i \, r \, F_T \, F_a \, t_a}{Y_v \, \lambda_{Ei} \, (t_a + t_{hd})} \left[1 - e^{-\lambda_{Ei} t_a}\right] \tag{A-41}$$

By assuming that the deposition is constant during the acute release period, the equation for calculating the activity on vegetation at the end of the release period is the same as that for the calculation of A_D. The activity on vegetation at any time following the acute release is

$$A_F = A_D \, e^{-\lambda_{Ei} t} \tag{A-42}$$

where

A_F	=	activity on vegetation at any time following the acute release
t_a	=	hours following the end of the acute release period.

The average activity on vegetation (pCi/m^2) collected during the harvest period is calculated using the following equation:

$$A_F = \frac{A_D}{t_{hd}} \int_0^{t_{hd}} e^{-\lambda_{Ei} t} dt \tag{A-43}$$

Integrating Equation (A-43), the equation for A_F becomes

$$A_F = \frac{A_D}{t_{hd} \, \lambda_{Ei}} \left[1 - e^{-\lambda_{Ei} t_{hd}}\right] \tag{A-44}$$

Multiplying by the appropriate conversion factors and the fraction of the harvest collected during the period following the acute release period, the equation for calculating the activity on produce collected during the harvest period following the acute release is

$$C_{iF}^{v} = \frac{r F_T \, F_a}{Y_v} \left(\frac{A_D}{t_{hd} \, \lambda_{Ei}}\right) \left(\frac{t_{hd}}{t_a + t_{hd}}\right) \left[1 - e^{-\lambda_{Ei} t_{hd}}\right] \tag{A-45}$$

Replacing A_D using Equation (A-38) and reorganizing terms, the concentration on produce collected during the harvest period following the acute release is

$$C_{iF}^{v} = \frac{d_i r F_T\, F_a \left[1 - e^{-\lambda_{Ei} t_a}\right]}{Y_v\, \lambda_{Ei}(t_a + t_{hd})} \left[\frac{1 - e^{-\lambda_{Ei} t_{hd}}}{\lambda_{Ei}}\right] \tag{A-46}$$

The remaining term to be developed is for the concentration of activity in vegetation from the soil uptake pathway. Only slight modifications are required in the equation used for continuous releases. The equation for activity in produce (pCi/kg) for continuous releases for the soil pathway, using the subscript s to denote the soil pathway, is

$$C_{is}^{v} = d_i B_{iv} \frac{\left[1 - e^{-\lambda_i t_b}\right]}{P \lambda_i} \tag{A-47}$$

where

B_{iv} = concentration factor for root uptake of radionuclide i from soil to edible parts of crops (pCi/kg wet weight per pCi/kg dry soil)

P = effective surface density for soil (kg/m^2 dry)

t_b = period of long-term buildup for activity in soil (h).

This equation is changed to the acute release form by changing the soil buildup time (t_b to t_a) and adding a term to account for the effect of the acute release on future crops grown on the contaminated soil in subsequent years (β_t). The equation for the concentration of activity in vegetation from the soil uptake pathway from an acute release is then

$$C_{is}^{v} = d_i B_{iv}\ \beta_t \frac{\left[1 - e^{-\lambda_i t_a}\right]}{P \lambda_i} \tag{A-48}$$

where β_t is defined as

$$\beta_t = F_a + \sum_{j=2}^{N_{tb}} e^{-\lambda_i j} \tag{A-49}$$

and N_{tb} is the integer of the number of years that crops are assumed to be grown on the contaminated soil.

The total concentration in an on produce from an acute release is

$$C_i^v = \left[C_{id}^v + C_{iF}^v + C_{is}^v\right] e^{-\lambda_i t_h} \qquad \text{(A-50)}$$

where

t_h = holdup time between harvest and consumption by either humans or livestock (h).

When Equations (A-40), (A-45), and (A-48) are inserted into Equation (A-50), the equation for calculating the concentration of radionuclide i in and on vegetation following an acute release becomes

$$C_i^v = d_i \left\{ \frac{r F_T F_a \left[1 - e^{-\lambda_{Ei} t_a}\right] \left[t_a + \frac{1 - e^{-\lambda_{Ei} t_{hd}}}{\lambda_{Ei}}\right]}{Y_v \lambda_{Ei} (t_a + t_{hd})} + \frac{B_{iv}\, \beta_t \left[1 - e^{-\lambda_i t_a}\right]}{P \lambda_i} \right\} e^{-\lambda_i t_h} \qquad \text{(A-51)}$$

where

F_a = fraction of annual crop that is contaminated by acute release.

When t_{hd} is set equal to zero, complete harvest of the produce is assumed to occur immediately following the end of the acute release period. As t_{hd} increases in magnitude, Equation (A-51) models continued consumption from the garden for a period of time following the end of the acute release time. However, limitations are placed on the maximum value for t_{hd} so that the sum of t_a and t_{hd} do not exceed the vegetable exposure time to the plume for a chronic release [see t_e in Equation (A-30)].

It is assumed that cattle would continue to graze following an acute release of radioactivity. The value for t_{hd} used to calculate the concentration in and on forage is therefore automatically adjusted by RSAC-5 so that the sum of t_a and t_{hd} equals the forage exposure time for a chronic release.

Tritium is released from vegetation following an acute release with a nominal 1 day half-time. The acute tritium ingestion model assumes that the harvest occurs at a constant rate beginning when the acute release is initiated. The equation used to calculate the concentration of tritium in vegetation during and following an acute release is

$$C_{Ta}^V = 2.778 \times 10^{11}\, F_a\, Q_{Ta}\, \frac{\chi}{Q} \left[\frac{(0.75)(0.5)}{H(t_a + t_{hd})}\right] \left[t_a + \frac{1 - e^{-\lambda_p t_{hd}}}{\lambda_p}\right] \qquad \text{(A-52)}$$

where

C_{Ta}^V = concentration of tritium in vegetation following an acute release (pCi/kg)

2.778×10^{11} = $(1.0 \times 10^{12}$ pCi/Ci$)$ $(1.0 \times 10^{3}$ g/kg$)$ / $(3.6 \times 10^{3}$ s/h$)$

F_a = fraction of annual crop that is contaminated by acute release

Q_{T_a} = acute release rate of tritium (Ci/h)

λ_p = release rate of tritium in vegetation following termination of release (h^{-1})

t_{hd} = harvest duration time after acute release (h).

The remaining variables and constants used in Equation (A-37) are as defined in Equation (A-34). The units for t_a and t_{hd} are expressed in hours in Equation (A-52) for convenience; however, user input of these variables in Section 4.1, *Optional Ingestion Dose Calculation Control Line (7004)* is in days.

The equation used to calculate concentration of carbon-14 in vegetation following an acute release is

$$C_{14a}^{V} = 2.778 \times 10^{11}\, F_a\, Q_{14a}\, \frac{\chi}{Q} \left[\frac{0.11}{0.16}\right] \qquad \text{(A-53)}$$

where

C_{14a}^{V} = concentration of C-14 in vegetation following an acute release (pCi/kg)

F_a = fraction of annual crop that is contaminated by acute release

Q_{14a} = acute release rate of C-14 (Ci/h).

A-3.3 Ground Surface Dose

The dose from radioactivity deposited on the ground surface is calculated using DOE (1988b) dose-rate conversion factors (DRCFs). This requires integration of the activity on the ground over the exposure period. While this is a very simple integration for a single radionuclide, it can become complex when the radionuclide is the progeny of a long chain of precursors. RSAC-5 uses a very subtle relationship that makes this integration simple. When there is only a single radionuclide in a chain, the equation used to calculate the dose to an individual from the activity deposited on the ground is

$$D_i^G = DRCF_i \frac{\chi}{Q} V_d F_{bs} \int_0^{t_b} A_i dt \qquad \text{(A-54)}$$

where

D_i^G = dose from radionuclide i deposited on the ground surface (rem)

$DRCF_i$ = dose rate conversion factor (rem-m²/dis)

$\frac{\chi}{Q}$ = ground-level atmospheric diffusion relative to the initial point of release (s/m^3)

V_d = dry deposition velocity (m/s)

F_{bs} = building shielding factor

t_b = exposure time to radioactivity deposited on the ground surface (s)

A_i = activity of radionuclide i in the plume that reaches the downwind location of the receptor (dis/s).

A_i can be replaced using the following equation:

$$A_i = N_{i0} \, \lambda_i \, e^{\lambda_i t} \tag{A-55}$$

where

N_{i0} = number of atoms of radionuclide i released to the atmosphere

λ_i = decay constant for radionuclide i (s^{-1}).

Substituting Equation (A-55) into Equation (A-54), the equation for the dose becomes

$$D_i^G = DRCF_i \, \frac{\chi}{Q} \, V_d \, F_{bs} \, N_{i0} \, \lambda_i \int_0^{t_b} e^{-\lambda_i t} dt \tag{A-56}$$

This integrates to

$$D_i^G = DRCF_i \frac{\chi}{Q} V_d \, F_{bs} \, N_{i0} \left[1 - e^{-\lambda_i t_b}\right] \tag{A-57}$$

Defining N_{i1} as the number of the original atoms of radionuclide i that were in the plume that reached the downwind location of the receptor and remain undecayed at the end of the exposure, the following relationship exists:

$$N_{i1} = N_{i0} \, e^{-\lambda_i t_b} \tag{A-58}$$

Substituting Equation (A-58) into Equation (A-57), the equation can be simplified to

$$D_i^G = DRCF_i \frac{\chi}{Q} V_d \, F_{bs} \left[N_{i0} - N_{i1}\right] \tag{A-59}$$

Thus, when the release to the atmosphere is expressed in atoms, the integration of Equation (A-54) reduces to the multiplication of the different conversion factors by the number of atoms of radionuclide i that decay during the exposure period. The generalized equation when radionuclide i is the progeny of a long decay chain is

$$D_i^G = DRCF_i \frac{\chi}{Q} V_d \, F_{bs} \sum_{j=1}^{i} [N_{j0} - N_{j1}] \tag{A-60}$$

where

N_{j0} = number of atoms of radionuclide j in the plume that reaches the downwind location of the receptor

N_{j1} = number of atoms of radionuclide j that exist at the end of the exposure period, including those that ingrow from precursors in the decay chain.

The ground surface dose calculated by RSAC-5 is the dose that a receptor would receive if they are present for the entire exposure period. When a ground surface dose is being calculated for work area, it should be remembered that work normally occurs for only 40 hours during a 168-hour week and appropriate corrections should be made.

The time t_b has been expressed in seconds in the above equations for convenience; however, user input of the variable in Section 4.1, *Dose Calculation Control Line 2 (7001)* is in years.

A-3.4 Air Immersion Dose

RSAC-5 contains an option to calculate air immersion doses using DOE (1988b) DRCFs. This model accurately calculates the plume gamma dose when the plume size is large compared to the mean free path of the gamma rays. However, when the plume size is small compared to the mean free path of the gamma rays, this model can overestimate doses by several decades. When the plume has not diffused to the ground level, the model can underestimate doses by several decades. Before this model is used, an evaluation should be using the finite plume cloud gamma model to ensure that the two models have reasonably converged.

The equation used to calculate the air immersion dose is

$$D_i^A = A_i \frac{\chi}{Q} DRCF_i \tag{A-61}$$

where

D_i^A = dose from radionuclide from air immersion (rem)

A_i = activity of radionuclide i decayed to the downwind location (Ci)

$\frac{\chi}{Q}$ = ground-level atmospheric diffusion relative to the initial point of release (s/m^3)

$DRCF_i$ = dose rate conversion factor ($rem\text{-}m^3/Ci\text{-}s$).

A-3.5 Water Immersion Dose

Water immersion doses are calculated using DOE (1988b) DRCFs. The equation used to calculate the water immersion dose is

$$D_i^W = A_i \frac{\chi}{Q} V_d \, F_{st} \, DRCF_i \tag{A-62}$$

where

D_i^W = dose from radionuclide from water immersion (rem)

A_i = activity of radionuclide i decayed to the downwind location (Ci)

$\frac{\chi}{Q}$ = ground-level atmospheric diffusion relative to the initial point of release (s/m^3)

F_{st} = fraction of the time spent swimming

$DRCF_i$ = dose rate conversion factor (rem-m^3/Ci-s).

A-3.6 Cloud Gamma Dose

Two models are provided for calculating cloud gamma doses: a finite plume model and a semi-infinite model (Slade 1968). The results of both models converge when the plume is relatively large and has diffused to ground level. At relatively short downwind distances the semi- infinite model overestimates the dose for ground-level releases during stable meteorological conditions and underestimates the dose from stack releases. While caution must be used when using the semi-infinite model, it requires little computer time for calculations.

A-3.6.1 Finite Plume Model

Dose calculations using the finite plume model are made using the equation:

$$D_k = \sum_{j=1}^{n} Kl_j f_k \lambda_k \int_0^{\infty} k(x) E_k \left[GEXP_j(x) \right] \left[\int_{-\infty}^{\infty} \int_{-\infty}^{\infty} \frac{\chi}{Q}(x,y,z) G_i(r) \, dz \, dy \right] dx \tag{A-63}$$

where

D_k = the air entrance dose from the kth radionuclide

n = number of exponential leakage approximations

Kl_j = linear approximation to leakage rate curve (s^{-1})

f_k = number of photons from the k^{th} radionuclide released per disintegration

λ_k = decay constant for the k^{th} radionuclide (s^{-1})

k(x) = cloud depletion factor

E_k = decay operator equal to:

$$\sum_{m=1}^{k} Q_m \left[\prod_{j=m}^{k-1} \lambda_i\right] \sum_{i=m}^{k} \left[\frac{1}{\prod_{\substack{j=m \\ j\neq i}}^{k} (\lambda_j - \lambda_i)}\right] \tag{A-64}$$

where

Q_m = the total number of atoms for the m^{th} radionuclide immediately following reactor shut down

$$GEXP_j(x) = \frac{e^{-\lambda_i \frac{x}{\bar{u}}}}{\lambda_i + K2_j} \left[1 - e^{-(\lambda_i + K2_j)T}\right] \tag{A-65}$$

where

x = downwind distance (m)

$\bar{u}$ = average wind velocity (m/s)

$K2_j$ = leakage rate decay constant (s^{-1})

T = period of exposure to cloud (s).

$$G_i(r) = \nu_i \, B(E_i r) \frac{e^{-\mu_i r}}{4\pi r^2} \tag{A-66}$$

where

r = distance from a source to the receptor

ν = flux to dose conversion factor for the i^{th} energy group (m^{-1})

$B(E_i,r)$ = dose buildup factor as a function of the i^{th} energy group and the distance traveled by the gamma ray.

μ_i = linear absorption coefficient for air for the i^{th} energy group (m^{-1}).

Buildup factors for air used in RSAC-5 have been developed from those published by Berger et al. (1968). The Berger buildup factors for air change very rapidly in the 60 to 300 keV energy range when the travel distance exceeds four mean free paths. Traditional equations used to calculate buildup factors for shielding applications do not model buildup factors well in this energy range. The Berger buildup factors for air were therefore approximated in RSAC-5 using an equation of the form:

$$B(E,\mu r) = 1 + a(E)\mu r + b(E)\,[\mu r]^2 + c(E)\,[\mu r]^3 \qquad \text{(A-67)}$$

A comparison of buildup factors for air calculated using Equation (A-45) with those published by Berger is presented in Table A-7.

An exact solution to Equation (A-41) does not exist. The equation is solved using numerical integration techniques. An examination of the function being integrated showed that the function can vary rapidly near the receptor. Therefore, integration is accomplished by breaking the integral in the X, Y, and Z directions each into three separate regions, each using the Gaussian quadrature for an arbitrary interval (Abramowitz and Stegum 1964). This allows the regions closest to the receptor or near the plume centerline to be integrated using closely spaced mesh points while the outer regions are integrated using a coarser distribution of mesh points. When the dose is being calculated for an elevated release and at a crosswind distance from the plume centerline, up to 15 integration regions may be used. However, whenever possible, problem symmetry is used to reduce the number of integration regions and thereby the computer running time.

RSAC-5 integrates the activity in the plume using gamma rays distributed the nine energy groups presented in Table A-8. The RSAC-5 photon library was developed using photon energies published by Kocher (RSIC 1981). Photons were energy weighted in each of the nine energy groups.

A-3.6.2 Semi-infinite Model

This model is very similar to that used to calculate air immersion doses (see Section 4.1, *Radionuclide Entry Lines*); its use requires caution. The semi-infinite model accurately calculates the plume gamma dose when the plume size is large compared to the mean free path of the gamma rays. As with the air immersion model, the semi-infinite model can overestimate doses by several decades when the plume size is small compared to the mean free path of the gamma rays. When the plume has not diffused to the ground level, the model can underestimate doses by several decades. Before this model is used, an evaluation should be using the finite plume cloud gamma model to ensure that the two models have reasonably converged.

Table A-7. Comparison of calculated buildup factors for air to Berger's buildup factors.

Energy (MeV)	Mean free paths: 1		2		4		7		10	
	C[a]	B[b]	C[a]	B[b]	C[a]	B[b]	C[a]	B[b]	C[a]	B[b]
0.015	1.17	1.17	1.28	1.25	1.37	1.36	1.43	1.46	1.52	1.54
0.02	1.41	1.41	1.69	1.62	1.94	1.94	2.15	2.25	2.49	2.51
0.03	2.24	2.24	3.29	3.19	4.85	4.87	6.93	7.09	9.19	9.21
0.04	3.33	3.33	5.87	5.86	11.53	11.5	21.17	21.1	32.00	32.2
0.05	4.25	4.25	8.65	8.72	20.85	20.8	46.59	46.1	80.80	80.7
0.06	4.75	4.75	10.69	10.8	29.22	29.4	75.55	74.6	145.00	144.0
0.08	4.81	4.81	12.14	12.0	37.96	38.2	117.75	115.0	253.0	252.0
0.1	4.48	4.48	11.51	11.4	37.18	38.5	126.22	124.0	286.00	285.0
0.15	3.72	3.72	9.47	9.20	31.03	31.7	109.44	106.0	253.00	252.0
0.2	3.27	3.27	7.80	7.73	24.42	25.6	85.07	83.9	196.50	196.0
0.3	2.85	2.85	6.25	6.22	18.01	18.6	54.32	54.4	116.00	116.0
0.4	2.60	2.60	5.39	5.37	14.66	14.9	40.38	40.3	81.50	81.5
0.5	2.44	2.44	4.83	4.82	12.47	12.5	31.42	31.3	59.50	59.5
0.6	2.33	2.33	4.43	4.45	10.93	10.9	26.14	26.0	47.80	47.7
0.8	2.18	2.18	3.90	3.94	8.91	8.86	19.53	19.3	33.50	33.4
1.0	2.08	2.08	3.56	3.60	7.63	7.59	15.72	15.6	25.80	25.7
1.5	1.92	1.92	3.05	3.09	5.89	5.85	10.96	10.8	16.70	16.6
2.0	1.81	1.81	2.74	2.78	4.94	4.92	8.66	8.53	12.70	12.5
3.0	1.68	1.68	2.40	2.41	3.95	3.93	6.36	6.32	8.81	8.80
4.0	1.59	1.59	2.18	2.19	3.38	3.38	5.20	5.20	7.03	7.03
5.0	1.52	1.52	2.03	2.03	3.03	3.03	4.51	4.51	5.97	5.97
6.0	1.47	1.47	1.92	1.92	2.78	2.78	4.02	4.04	5.26	5.26
8.0	1.39	1.39	1.76	1.75	2.43	2.44	3.40	3.43	4.38	4.38
10.0	1.33	1.33	1.64	1.64	2.21	2.21	3.01	3.01	3.78	3.79

a. C = Calculated buildup factor.

b. B = Berger's reported buildup factor.

The equation used to calculate cloud-gamma doses using the semi-infinite model (Slade 1968) is

$$DG_i^S = 0.25\ \overline{E_\gamma}\ \Psi \qquad \text{(A-68)}$$

where

DG_i^S = cloud gamma dose from radionuclide i

$\overline{E_\gamma}$ = average gamma energy (MeV)

Ψ = concentration time integral (Ci-s/m^3).

Table A-8. Photon energy groups and dose conversion factors.

Energy group	Energy (MeV)/γ	Energy range (MeV)	Air entrance dose conversion (rem-m^2/γ)	Dose ratio EDE/air entrance
1	2.5E-02	0.02 to 0.03	1.080E-14	0.1276
2	4.0E-02	0.03 to 0.05	4.800E-15	0.3443
3	7.5E-02	0.05 to 0.10	3.360E-15	0.6228
4	2.0E-01	0.10 to 0.30	9.280E-15	0.6501
5	4.0E-01	0.30 to 0.50	2.048E-14	0.6361
6	6.5E-01	0.50 to 0.80	3.328E-14	0.6528
7	9.0E-01	0.80 to 1.00	4.392E-14	0.6696
8	1.5E+00	1.00 to 2.00	6.480E-14	0.6570
9	3.7E+00	2.00 to 3.70	1.243E-13	0.7739

Appendix B

RSAC-5 Nuclear Data Library

Appendix B
RSAC-5 Nuclear Data Library

This appendix contains a table of constants used to calculate and decay radionuclide inventories. The radionuclide column contains the radionuclide identification number and radionuclide name. The radionuclide identification number equals the sum of the radionuclide

(atomic number × 10,000) + (mass number × 10) + (0 for ground state or 1 for metastable state).

The half-life column contains the element's half-life. The yield column provides the percent fission yield for the radionuclide. The FRACT column describes the fraction of the radionuclide decayed to the daughter indicated (IDATR). If FRACT <1.0 and the daughter indicated is not the next radionuclide in the library, an isomer is assumed. A fraction FRACT is decayed to the daughter indicated and the fraction 1-FRACT is decayed to the next radionuclide in the library.

The IDATR column contains an integer daughter indicator where

-1	=	no radioactive daughter
0	=	daughter is the next radionuclide in the library
≥1	=	number of radionuclides in the library that are to be skipped over before the daughter is found.

The NGROUP column contains an integer element group code where

1	=	solid
2	=	halogen
3	=	nobel gas
4	=	cesium
5	=	ruthenium.

The ISTART column contains an integer that points to the beginning of the chain. Subtract ISTART from the library position to find the beginning of a chain. The XSECT column contains the average neutron cross section (in barns).

Half-lives and decay schemes primarily were derived from a computer data file prepared by D. C. Kocher (RSIC 1981). When the Kocher file did not contain data for the desired radionuclide or it was found to be outdated, data were obtained from either ICRP 38 (ICRP 1983) or derived from the ORIGEN2 (RSIC 1991) library for enriched U-235 in a pressurized water reactor. Fission yields and cross sections were derived from the data in the ORIGEN2 file. Pseudo radionuclides used to correct for activation of fission products were suppressed.

Activation products, actinides, and the daughters of actinides are signified by a cross section value of -1. Inventories for these radionuclides are not calculated by RSAC-5; however, you may input them directly for dose calculations.

Many short-lived fission products decay to longer-lived daughter products. Often these short-lived fission products do not have available dose conversion factors. Therefore, RSAC-5 only uses them to correct fission product inventories calculated by RSAC-5 to match those calculated by ORIGEN-2. Many of these short-lived fission products have never been observed experimentally, and their decay-related properties are derived from calculations based on nuclear systematics (Croff et al. 1979). These short-lived fission products, which are precursors to longer-lived daughters, are signified by a cross section value of -0.3. An option is provided in the fission product printout section of RSAC-5 to suppress printing these radionuclides.

Radionuclide		Half-life		Yield	FRACT	IDATR	NGROUP	ISTART	XSECT
10030	H 3	1.228E+01	YR	1.100E-02	1.000E+0	-1	3	0	5.518E-7
40070	BE 7	5.344E+01	DAY	0.000E+00	1.000E+0	-1	1	0	-1.000E+0
60140	C 14	5.730E+03	YR	1.300E-06	1.000E+0	-1	1	0	9.197E-8
110220	NA 22	2.602E+00	YR	0.000E+00	1.000E+0	-1	1	0	-1.000E+0
110240	NA 24	1.500E+01	HR	0.000E+00	1.000E+0	-1	1	0	-1.000E+0
140310	SI 31	1.573E+02	MIN	0.000E+00	1.000E+0	-1	1	0	-1.000E+0
150320	P 32	1.429E+01	DAY	0.000E+00	1.000E+0	-1	1	0	-1.000E+0
150330	P 33	2.540E+01	DAY	0.000E+00	1.000E+0	-1	1	0	-1.000E+0
160350	S 35	8.744E+01	DAY	0.000E+00	1.000E+0	-1	1	0	-1.000E+0
170360	CL 36	3.010E+05	YR	0.000E+00	1.000E+0	-1	2	0	-1.000E+0
180370	AR 37	3.502E+01	DAY	0.000E+00	1.000E+0	-1	3	0	-1.000E+0
180390	AR 39	2.690E+02	YR	0.000E+00	1.000E+0	-1	3	0	-1.000E+0
180410	AR 41	1.827E+00	HR	0.000E+00	1.000E+0	-1	3	0	-1.000E+0
190400	K 40	1.277E+09	YR	0.000E+00	1.000E+0	-1	1	0	-1.000E+0
190420	K 42	1.236E+01	HR	0.000E+00	1.000E+0	-1	1	0	-1.000E+0
200450	CA 45	1.627E+02	DAY	0.000E+00	1.000E+0	-1	1	0	-1.000E+0
200470	CA 47	4.535E+00	DAY	0.000E+00	1.000E+0	0	1	0	-1.000E+0
210470	SC 47	3.422E+00	DAY	0.000E+00	1.000E+0	-1	1	1	-1.000E+0
210460	SC 46	8.383E+01	DAY	0.000E+00	1.000E+0	-1	1	0	-1.000E+0
210480	SC 48	4.381E+01	HR	0.000E+00	1.000E+0	-1	1	0	-1.000E+0
240510	CR 51	2.770E+01	DAY	0.000E+00	1.000E+0	-1	1	0	-1.000E+0
250540	MN 54	3.127E+02	DAY	0.000E+00	1.000E+0	-1	1	0	-1.000E+0
250560	MN 56	2.579E+00	HR	0.000E+00	1.000E+0	-1	1	0	-1.000E+0
260550	FE 55	2.700E+00	YR	0.000E+00	1.000E+0	-1	1	0	-1.000E+0
260590	FE 59	4.463E+01	DAY	0.000E+00	1.000E+0	-1	1	0	-1.000E+0
270570	CO 57	2.709E+02	DAY	0.000E+00	1.000E+0	-1	1	0	-1.000E+0
270580	CO 58	7.080E+01	DAY	0.000E+00	1.000E+0	-1	1	0	-1.000E+0
270600	CO 60	5.271E+00	YR	0.000E+00	1.000E+0	-1	1	0	-1.000E+0
280590	NI 59	7.500E+04	YR	0.000E+00	1.000E+0	-1	1	0	-1.000E+0
280630	NI 63	1.001E+02	YR	0.000E+00	1.000E+0	-1	1	0	-1.000E+0
280650	NI 65	2.520E+00	HR	0.000E+00	1.000E+0	-1	1	0	-1.000E+0
290640	CU 64	1.270E+01	HR	0.000E+00	1.000E+0	-1	1	0	-1.000E+0
300650	ZN 65	2.444E+02	DAY	0.000E+00	1.000E+0	-1	1	0	-1.000E+0
300691	ZN 69M	1.376E+01	HR	0.000E+00	1.000E+0	0	1	0	-1.000E+0
300690	ZN 69	5.560E+01	MIN	0.000E+00	1.000E+0	-1	1	1	-1.000E+0
320710	GE 71	1.180E+01	DAY	0.000E+00	1.000E+0	-1	1	0	-1.000E+0
270720	CO 72	1.227E-01	SEC	8.870E-07	1.000E+0	0	1	0	-3.000E-1
280720	NI 72	2.420E+00	SEC	2.850E-05	1.000E+0	0	1	1	-3.000E-1
290720	CU 72	6.000E+00	SEC	3.360E-05	1.000E+0	0	1	2	-3.000E-1
300720	ZN 72	4.650E+01	HR	6.760E-06	1.000E+0	0	1	3	0.000E+0
310720	GA 72	1.410E+01	HR	4.220E-08	1.000E+0	-1	1	4	0.000E+0
270730	CO 73	1.155E-01	SEC	9.070E-08	1.000E+0	0	1	0	-3.000E-1
280730	NI 73	3.936E-01	SEC	1.490E-05	1.000E+0	0	1	1	-3.000E-1
290730	CU 73	3.947E+00	SEC	9.860E-05	1.000E+0	0	1	2	-3.000E-1
300730	ZN 73	2.350E+01	SEC	1.280E-04	1.000E+0	0	1	3	-3.000E-1
310730	GA 73	4.880E+00	HR	6.880E-06	1.000E+0	-1	1	4	0.000E+0
270740	CO 74	1.075E-01	SEC	7.320E-08	1.000E+0	0	1	0	-3.000E-1
280740	NI 74	6.484E-01	SEC	2.420E-05	1.000E+0	0	1	1	-3.000E-1
290740	CU 74	5.733E-01	SEC	2.310E-04	1.000E+0	0	1	2	-3.000E-1
300740	ZN 74	9.500E+01	SEC	3.620E-04	1.000E+0	0	1	3	-3.000E-1
310740	GA 74	8.100E+00	MIN	2.190E-05	1.000E+0	-1	1	4	0.000E+0

Radionuclide		Half-life	Yield	FRACT	IDATR	NGROUP	ISTART	XSECT
270750	CO 75	8.016E-02 SEC	9.620E-09	1.000E+0	0	1	0	-3.000E-1
280750	NI 75	1.796E-01 SEC	9.940E-06	1.000E+0	0	1	1	-3.000E-1
290750	CU 75	7.666E-01 SEC	2.710E-04	1.000E+0	0	1	2	-3.000E-1
300750	ZN 75	9.000E+00 SEC	1.090E-03	1.000E+0	0	1	3	-3.000E-1
310750	GA 75	1.900E+00 MIN	1.790E-04	9.600E-1	1	1	4	-3.000E-1
320751	GE 75M	4.892E+01 SEC	2.060E-06	1.000E+0	0	1	1	-3.000E-1
320750	GE 75	1.380E+00 HR	2.060E-06	1.000E+0	-1	1	2	4.139E-1
340750	SE 75	1.198E+02 DAY	0.000E+00	1.000E+0	-1	1	0	-1.000E+0
280760	NI 76	2.683E-01 SEC	3.260E-06	1.000E+0	0	1	0	-3.000E-1
290760	CU 76	2.210E-01 SEC	2.700E-04	1.000E+0	0	1	1	-3.000E-1
300760	ZN 76	5.400E+00 SEC	2.950E-03	1.000E+0	0	1	2	-3.000E-1
310760	GA 76	2.710E+01 SEC	1.280E-03	1.000E+0	-1	1	3	0.000E+0
330760	AS 76	2.632E+01 HR	2.230E-07	1.000E+0	-1	1	1	0.000E+0
280770	NI 77	1.030E-01 SEC	4.510E-07	1.000E+0	0	1	0	-3.000E-1
290770	CU 77	2.946E-01 SEC	1.170E-04	1.000E+0	0	1	1	-3.000E-1
300770	ZN 77	1.400E+00 SEC	3.620E-03	1.000E+0	0	1	2	-3.000E-1
310770	GA 77	1.300E+01 SEC	5.320E-03	1.200E-1	1	1	3	-3.000E-1
320771	GE 77M	5.430E+01 SEC	4.780E-04	7.900E-1	1	1	1	0.000E+0
320770	GE 77	1.130E+01 HR	6.890E-04	1.000E+0	0	1	2	0.000E+0
330770	AS 77	3.880E+01 HR	1.270E-05	1.000E+0	-1	1	3	0.000E+0
280780	NI 78	1.376E-01 SEC	5.060E-08	1.000E+0	0	1	0	-3.000E-1
290780	CU 78	1.200E-01 SEC	4.450E-05	1.000E+0	0	1	1	-3.000E-1
300780	ZN 78	2.430E+00 SEC	4.250E-03	1.000E+0	0	1	2	-3.000E-1
310780	GA 78	4.900E+00 SEC	1.420E-02	1.000E+0	0	1	3	-3.000E-1
320780	GE 78	1.450E+00 HR	2.000E-03	1.000E+0	0	1	4	0.000E+0
330780	AS 78	1.510E+00 HR	2.180E-04	1.000E+0	-1	1	5	0.000E+0
290790	CU 79	1.474E-01 SEC	5.180E-06	1.000E+0	0	1	0	-3.000E-1
300790	ZN 79	3.820E-01 SEC	1.650E-03	1.000E+0	0	1	1	-3.000E-1
310790	GA 79	2.860E+00 SEC	1.520E-02	1.000E+0	0	1	2	-3.000E-1
320790	GE 79	4.300E+01 SEC	2.660E-02	1.000E+0	0	1	3	-3.000E-1
330790	AS 79	9.000E+00 MIN	9.410E-03	1.000E+0	0	1	4	0.000E+0
340791	SE 79M	3.890E+00 MIN	8.050E-06	1.000E+0	0	1	5	0.000E+0
340790	SE 79	6.500E+04 YR	8.030E-06	1.000E+0	-1	1	6	3.630E-1
290800	CU 80	9.110E-02 SEC	7.030E-07	1.000E+0	0	1	0	-3.000E-1
300800	ZN 80	7.113E-01 SEC	7.550E-04	1.000E+0	0	1	1	-3.000E-1
310800	GA 80	1.700E+00 SEC	2.130E-02	1.000E+0	0	1	2	-3.000E-1
320800	GE 80	2.400E+01 SEC	8.880E-02	1.000E+0	0	1	3	-3.000E-1
330800	AS 80	1.650E+01 SEC	1.490E-02	1.000E+0	-1	1	4	0.000E+0
290810	CU 81	7.447E-02 SEC	3.670E-08	1.000E+0	0	1	0	-3.000E-1
300810	ZN 81	1.294E-01 SEC	1.320E-04	1.000E+0	0	1	1	-3.000E-1
310810	GA 81	7.053E-01 SEC	1.160E-02	1.000E+0	0	1	2	-3.000E-1
320810	GE 81	1.010E+01 SEC	1.330E-01	1.000E+0	0	1	3	-3.000E-1
330810	AS 81	3.200E+01 SEC	5.980E-02	1.000E+0	1	1	4	0.000E+0
340811	SE 81M	5.730E+01 MIN	6.850E-03	1.000E+0	0	1	5	0.000E+0
340810	SE 81	1.850E+01 MIN	2.190E-03	1.000E+0	-1	1	6	0.000E+0
350821	BR 82M	6.130E+00 MIN	8.000E-05	9.760E-1	0	2	4	0.000E+0
350820	BR 82	3.530E+01 HR	5.920E-05	1.000E+0	-1	2	5	0.000E+0
300830	ZN 83	8.386E-02 SEC	1.020E-06	1.000E+0	0	1	0	-3.000E-1
310830	GA 83	1.477E-01 SEC	9.540E-04	1.000E+0	0	1	1	-3.000E-1
320830	GE 83	1.900E+00 SEC	9.740E-02	1.000E+0	0	1	2	-3.000E-1
330830	AS 83	1.350E+01 SEC	3.220E-01	3.600E-1	1	1	3	-3.000E-1
340831	SE 83M	7.000E+01 SEC	6.400E-02	1.000E+0	1	1	4	0.000E+0

Radionuclide		Half-life	Yield	FRACT	IDATR	NGROUP	ISTART	XSECT
340830	SE 83	2.250E+01 MIN	4.830E-02	1.000E+0	0	1	5	0.000E+0
350830	BR 83	2.390E+00 HR	3.710E-03	9.997E-1	0	2	2	0.000E+0
360831	KR 83M	1.830E+00 HR	3.990E-06	1.000E+0	-1	3	3	0.000E+0
310840	GA 84	9.887E-02 MIN	5.490E-05	1.000E+0	0	1	0	-3.000E-1
320840	GE 84	1.200E+00 SEC	1.910E-02	1.000E+0	0	1	1	-3.000E-1
330840	AS 84	5.800E+00 SEC	3.000E-01	1.000E+0	0	1	2	-3.000E-1
340840	SE 84	3.300E+00 MIN	6.621E-01	1.000E+0	1	1	3	0.000E+0
350841	BR 84M	6.000E+00 MIN	1.900E-02	1.000E+0	-1	2	4	0.000E+0
350840	BR 84	3.180E+01 MIN	1.800E-02	1.000E+0	-1	2	5	0.000E+0
320850	GE 85	2.342E-01 SEC	6.440E-03	1.000E+0	0	1	0	-3.000E-1
330850	AS 85	2.030E+00 SEC	2.010E-01	8.000E-1	0	1	1	-3.000E-1
340850	SE 85	3.900E+01 SEC	4.600E-01	1.000E+0	1	1	2	-3.000E-1
340851	SE 85M	1.900E+01 SEC	4.600E-01	1.000E+0	0	1	3	-3.000E-1
350850	BR 85	1.720E+02 SEC	1.690E-01	1.000E+0	0	2	4	0.000E+0
360851	KR 85M	4.480E+00 HR	1.370E-02	2.110E-1	0	3	5	0.000E+0
360850	KR 85	1.072E+01 YR	2.280E-03	1.000E+0	-1	3	6	1.840E-1
320860	GE 86	2.590E-01 SEC	1.140E-03	1.000E+0	0	1	0	-3.000E-1
330860	AS 86	9.000E-01 SEC	1.130E-01	1.000E+0	0	1	1	-3.000E-1
340860	SE 86	1.660E+01 SEC	1.190E+00	5.000E-1	1	1	2	-3.000E-1
350861	BR 86M	4.500E+00 SEC	3.020E-01	1.000E+0	-1	2	3	-3.000E-1
350860	BR 86	5.500E+01 SEC	2.920E-01	1.000E+0	-1	2	4	0.000E+0
320870	GE 87	1.255E-01 SEC	1.830E-04	1.000E+0	0	1	0	-3.000E-1
330870	AS 87	3.000E-01 SEC	6.440E-02	1.000E+0	0	1	1	-3.000E-1
340870	SE 87	5.600E+00 SEC	9.340E-01	1.000E+0	0	1	2	-3.000E-1
350870	BR 87	5.580E+01 SEC	1.190E+00	1.000E+0	0	2	3	0.000E+0
360870	KR 87	7.630E+01 MIN	3.420E-01	1.000E+0	0	3	4	5.518E+1
370870	RB 87	4.730E+10 YR	1.000E-01	1.000E+0	-1	1	5	7.690E-2
320880	GE 88	1.427E-01 SEC	2.080E-06	1.000E+0	0	1	0	-3.000E-1
330880	AS 88	1.300E-01 SEC	2.630E-03	1.000E+0	0	1	1	-3.000E-1
340880	SE 88	1.500E+00 SEC	3.550E-01	1.000E+0	0	1	2	-3.000E-1
350880	BR 88	1.630E+01 SEC	2.140E+00	1.000E+0	0	2	3	0.000E+0
360880	KR 88	2.840E+00 HR	1.090E+00	1.000E+0	0	3	4	0.000E+0
370880	RB 88	1.780E+01 MIN	3.200E-02	1.000E+0	-1	1	5	9.197E-2
330890	AS 89	1.294E-01 SEC	2.070E-04	1.000E+0	0	1	0	-3.000E-1
340890	SE 89	4.100E-01 SEC	9.270E-02	1.000E+0	0	1	1	-3.000E-1
350890	BR 89	4.500E+00 SEC	1.800E+00	1.000E+0	0	2	2	-3.000E-1
360890	KR 89	3.160E+00 MIN	2.740E+00	1.000E+0	0	3	3	0.000E+0
370890	RB 89	1.520E+01 MIN	1.700E-01	1.000E+0	0	1	4	0.000E+0
380890	SR 89	5.049E+01 DAY	2.580E-03	1.000E+0	-1	1	5	5.264E-2
340900	SE 90	5.545E-01 SEC	3.220E-02	1.000E+0	0	1	0	-3.000E-1
350900	BR 90	1.600E+00 SEC	1.240E+00	8.800E-1	0	2	1	-3.000E-1
360900	KR 90	3.232E+01 SEC	3.450E+00	8.810E-1	1	3	2	0.000E+0
370901	RB 90M	2.580E+02 SEC	4.280E-01	9.770E-1	1	1	3	0.000E+0
370900	RB 90	1.530E+02 SEC	6.760E-01	1.000E+0	0	1	4	0.000E+0
380900	SR 90	2.912E+01 YR	2.820E-02	1.000E+0	3	1	5	8.739E-2
390901	Y 90M	3.190E+00 HR	1.250E-05	1.000E+0	0	1	8	0.000E+0
390900	Y 90	6.410E+01 HR	2.300E-04	1.000E+0	-1	1	9	5.920E-1
340910	SE 91	1.845E-01 SEC	3.220E-03	1.000E+0	0	1	0	-3.000E-1
350910	BR 91	6.000E-01 SEC	3.910E-01	1.000E+0	0	2	1	-3.000E-1
360910	KR 91	8.700E+00 SEC	3.020E+00	1.000E+0	0	3	2	0.000E+0
370910	RB 91	5.820E+01 SEC	2.230E+00	1.000E+0	0	1	3	0.000E+0
380910	SR 91	9.500E+00 HR	2.290E-01	4.260E-1	1	1	4	0.000E+0

Radionuclide		Half-life	Yield	FRACT	IDATR	NGROUP	ISTART	XSECT
390911	Y 91M	4.971E+01 MIN	2.720E-04	1.000E+0	0	1	5	0.000E+0
390910	Y 91	5.851E+01 DAY	6.240E-04	1.000E+0	-1	1	6	1.651E-1
340920	SE 92	2.478E-01 SEC	4.770E-05	1.000E+0	0	1	0	-3.000E-1
350920	BR 92	3.000E-01 SEC	1.890E-02	1.000E+0	0	2	1	-3.000E-1
360920	KR 92	1.840E+00 SEC	1.470E+00	1.000E+0	0	3	2	0.000E+0
370920	RB 92	4.480E+00 SEC	3.260E+00	1.000E+0	0	1	3	0.000E+0
380920	SR 92	2.710E+00 HR	1.180E+00	1.000E+0	0	1	4	0.000E+0
390920	Y 92	3.540E+00 HR	9.810E-03	1.000E+0	-1	1	5	0.000E+0
350930	BR 93	2.012E-01 SEC	4.710E-03	1.000E+0	0	2	0	-3.000E-1
360930	KR 93	1.270E+00 SEC	5.000E-01	1.000E+0	0	3	1	0.000E+0
370930	RB 93	5.800E+00 SEC	3.030E+00	1.000E+0	0	1	2	0.000E+0
380930	SR 93	7.500E+00 MIN	2.700E+00	1.000E+0	0	1	3	0.000E+0
390930	Y 93	1.010E+01 HR	9.810E-02	1.000E+0	0	1	4	0.000E+0
400930	ZR 93	1.530E+06 YR	2.500E-01	1.000E+0	2	1	5	1.029E+0
410931	NB 93M	1.360E+01 YR	9.370E-09	1.000E+0	-1	1	8	0.000E+0
420930	MO 93	3.500E+03 YR	0.000E+00	1.000E+0	-1	1	0	-1.000E+0
350940	BR 94	1.105E-01 SEC	3.270E-04	1.000E+0	0	2	0	-3.000E-1
360940	KR 94	2.100E-01 SEC	2.270E-01	1.000E+0	0	3	1	-3.000E-1
370940	RB 94	2.690E+00 SEC	1.520E+00	1.000E+0	0	1	2	-3.000E-1
380940	SR 94	1.260E+00 MIN	4.250E+00	1.000E+0	0	1	3	0.000E+0
390940	Y 94	1.910E+01 MIN	3.520E-01	1.000E+0	-1	1	4	0.000E+0
410941	NB 94M	6.260E+00 MIN	4.380E-07	9.952E-1	0	1	0	0.000E+0
410940	NB 94	2.030E+04 YR	4.350E-07	1.000E+0	-1	1	1	-1.000E+0
350950	BR 95	1.166E-01 SEC	7.330E-06	1.000E+0	0	2	0	-3.000E-1
360950	KR 95	5.000E-01 SEC	1.020E-02	1.000E+0	0	3	1	0.000E+0
370950	RB 95	3.600E-01 SEC	8.960E-01	1.000E+0	0	1	2	0.000E+0
380950	SR 95	2.600E+01 SEC	4.570E+00	1.000E+0	0	1	3	-3.000E-1
390950	Y 95	1.050E+01 MIN	9.480E-01	1.000E+0	0	1	4	0.000E+0
400950	ZR 95	6.398E+01 DAY	2.950E-02	1.000E+0	2	1	5	2.325E-1
410951	NB 95M	8.660E+01 HR	1.290E-04	9.450E-1	0	1	7	0.000E+0
410950	NB 95	3.506E+01 DAY	4.000E-05	1.000E+0	-1	1	8	8.508E-1
410960	NB 96	2.335E+01 HR	6.100E-04	1.000E+0	-1	1	3	0.000E+0
360970	KR 97	1.485E-01 SEC	4.060E-05	1.000E+0	0	3	0	-3.000E-1
370970	RB 97	1.700E-01 SEC	3.640E-02	1.000E+0	0	1	1	-3.000E-1
380970	SR 97	2.000E-01 SEC	1.900E+00	1.000E+0	0	1	2	0.000E+0
390970	Y 97	1.110E+00 SEC	3.120E+00	1.000E+0	0	1	3	0.000E+0
400970	ZR 97	1.690E+01 HR	8.740E-01	5.300E-2	1	1	4	0.000E+0
410971	NB 97M	6.000E+01 SEC	6.860E-03	1.000E+0	0	1	5	0.000E+0
410970	NB 97	7.210E+01 MIN	1.680E-02	1.000E+0	-1	1	6	0.000E+0
360980	KR 98	2.243E-01 SEC	4.240E-06	1.000E+0	0	3	0	-3.000E-1
370980	RB 98	1.400E-01 SEC	5.260E-03	1.000E+0	0	1	1	-3.000E-1
380980	SR 98	8.500E-01 SEC	6.980E-01	1.000E+0	0	1	2	-3.000E-1
390980	Y 98	3.000E-01 SEC	2.920E+00	1.000E+0	0	1	3	-3.000E-1
400980	ZR 98	3.100E+01 SEC	2.100E+00	1.000E+0	1	1	4	-3.000E-1
410981	NB 98M	5.150E+01 MIN	2.720E-02	1.000E+0	-1	1	0	0.000E+0
410980	NB 98	2.800E+00 SEC	4.480E-02	1.000E+0	-1	1	5	0.000E+0
370990	RB 99	7.600E-02 SEC	4.060E-04	1.000E+0	0	1	0	-3.000E-1
380990	SR 99	5.600E-01 SEC	1.540E-01	1.000E+0	0	1	1	-3.000E-1
390990	Y 99	8.000E-01 SEC	1.860E+00	1.000E+0	0	1	2	-3.000E-1
400990	ZR 99	2.400E+00 SEC	3.770E+00	1.000E+0	0	1	3	0.000E+0
410990	NB 99	1.430E+01 SEC	1.370E-01	1.000E+0	1	1	4	0.000E+0
410991	NB 99M	2.600E+00 MIN	1.490E-01	1.000E+0	0	1	0	0.000E+0

Radionuclide		Half-life	Yield	FRACT	IDATR	NGROUP	ISTART	XSECT
420990	MO 99	6.602E+01 HR	2.870E-03	1.140E-1	1	1	6	1.013E+0
430991	TC 99M	6.020E+00 HR	3.340E-07	1.000E+0	0	1	7	0.000E+0
430990	TC 99	2.130E+05 YR	7.500E-02	1.000E+0	-1	1	9	9.136E+0
371000	RB 100	1.006E-01 SEC	1.700E-05	1.000E+0	0	1	0	-3.000E-1
381000	SR 100	1.046E+00 SEC	2.380E-02	1.000E+0	0	1	1	-3.000E-1
391000	Y 100	7.563E-01 SEC	8.570E-01	1.000E+0	0	1	2	-3.000E-1
401000	ZR 100	7.100E+00 SEC	4.450E+00	5.000E-1	1	1	3	-3.000E-1
411001	NB 100M	2.410E+00 SEC	4.690E-01	1.000E+0	-1	1	4	-3.000E-1
411000	NB 100	2.400E+00 SEC	4.690E-01	1.000E+0	-1	1	5	-3.000E-1
381010	SR 101	2.519E-01 SEC	2.960E-03	1.000E+0	0	1	0	-3.000E-1
391010	Y 101	9.763E-01 SEC	2.690E-01	1.000E+0	0	1	1	-3.000E-1
401010	ZR 101	3.300E+00 SEC	3.200E+00	1.000E+0	0	1	2	-3.000E-1
411010	NB 101	7.000E+00 SEC	1.500E+00	1.000E+0	0	1	3	0.000E+0
421010	MO 101	1.461E+01 MIN	1.120E-01	1.000E+0	0	1	4	0.000E+0
431010	TC 101	1.420E+01 MIN	2.340E-04	1.000E+0	-1	1	5	0.000E+0
381020	SR 102	4.148E-01 SEC	1.970E-04	1.000E+0	0	1	0	-3.000E-1
391020	Y1 02	2.726E-01 SEC	5.370E-02	1.000E+0	0	1	1	-3.000E-1
401020	ZR 102	4.770E-01 MIN	1.730E+00	1.000E+0	0	1	2	-3.000E-1
411020	NB 102	3.000E+00 SEC	2.040E+00	1.000E+0	0	1	3	-3.000E-1
421020	MO 102	1.110E+01 MIN	4.140E-01	1.000E+0	1	1	4	-3.000E-1
431021	TC 102M	4.350E+00 MIN	1.290E-03	5.000E-1	0	1	5	0.000E+0
431020	TC 102	5.280E+00 SEC	1.290E-03	1.000E+0	-1	1	6	0.000E+0
381030	SR 103	1.386E-01 SEC	4.800E-06	1.000E+0	0	1	0	-3.000E-1
391030	Y1 03	3.660E-01 SEC	5.340E-03	1.000E+0	0	1	1	-3.000E-1
401030	ZR 103	1.770E+00 SEC	5.260E-01	1.000E+0	0	1	2	-3.000E-1
411030	NB 103	1.567E+01 SEC	1.680E+00	1.000E+0	0	1	3	-3.000E-1
421030	MO 103	1.000E+00 MIN	9.230E-01	1.000E+0	0	1	4	-3.000E-1
431030	TC 103	5.000E+01 SEC	1.800E-02	1.000E+0	0	1	5	-3.000E-1
441030	RU 103	3.935E+01 DAY	4.000E-05	9.006E-1	0	5	6	2.666E+0
451031	RH 103M	5.612E+01 MIN	1.050E-09	1.000E+0	-1	1	7	0.000E+0
381040	SR 104	1.925E-01 SEC	8.230E-08	1.000E+0	0	1	0	-3.000E-1
391040	Y 104	1.442E-01 SEC	2.540E-04	1.000E+0	0	1	1	-3.000E-1
401040	ZR 104	3.784E+00 SEC	8.010E-02	1.000E+0	0	1	2	-3.000E-1
411040	NB 104	1.000E+00 SEC	7.320E-01	1.000E+0	0	1	3	-3.000E-1
421040	MO 104	1.600E+00 MIN	1.020E+00	1.000E+0	0	1	4	-3.000E-1
431040	TC 104	1.820E+01 MIN	5.750E-02	1.000E+0	-1	1	5	0.000E+0
391050	Y 105	1.736E-01 SEC	2.250E-05	1.000E+0	0	1	0	-3.000E-1
401050	ZR 105	5.585E-01 SEC	1.030E-02	1.000E+0	0	1	1	-3.000E-1
411050	NB 105	1.800E+00 SEC	2.030E-01	1.000E+0	0	1	2	-3.000E-1
421050	MO 105	5.400E+01 SEC	7.210E-01	1.000E+0	0	1	3	-3.000E-1
431050	TC 105	8.000E+00 MIN	9.690E-02	1.000E+0	0	1	4	-3.000E-1
441050	RU 105	4.440E+00 HR	2.340E-03	7.550E-1	1	5	5	2.908E-1
451051	RH 105M	4.500E+01 SEC	7.300E-07	8.000E-1	0	1	6	0.000E+0
451050	RH 105	3.536E+01 HR	5.200E-03	1.000E+0	-1	1	7	2.800E-1
401060	ZR 106	9.800E-01 SEC	2.480E-03	1.000E+0	0	1	0	-3.000E-1
411060	NB 106	5.352E-01 SEC	7.000E-02	1.000E+0	0	1	1	-3.000E-1
421060	MO 106	9.000E+00 SEC	2.940E-01	1.000E+0	0	1	2	-3.000E-1
431060	TC 106	3.700E+01 SEC	4.980E-02	1.000E+0	0	1	3	-3.000E-1
441060	RU 106	3.682E+02 DAY	1.200E-03	1.000E+0	3	5	4	7.708E-1
451061	RH 106M	2.200E+00 HR	3.400E-03	1.000E+0	-1	1	7	0.000E+0
451060	RH 106	2.992E+01 SEC	8.300E-03	7.519E-1	-1	1	8	0.000E+0
391070	Y 107	1.046E-01 SEC	3.740E-08	1.000E+0	0	1	0	-3.000E-1

Radionuclide		Half-life	Yield	FRACT	IDATR	NGROUP	ISTART	XSECT
401070	ZR 107	2.485E-01 SEC	1.190E-04	1.000E+0	0	1	1	-3.000E-1
411070	NB 107	6.700E-01 SEC	1.140E-02	1.000E+0	0	1	2	-3.000E-1
421070	MO 107	6.388E+00 SEC	1.240E-01	1.000E+0	0	1	3	-3.000E-1
431070	TC 107	2.900E+01 SEC	5.380E-02	1.000E+0	0	1	4	-3.000E-1
451070	RH 107	2.170E+01 MIN	7.240E-06	1.000E+0	2	1	5	0.000E+0
461071	PD 107M	2.130E+01 SEC	7.640E-10	1.000E+0	0	1	7	0.000E+0
461070	PD 107	6.500E+06 YR	7.403E-10	1.000E+0	-1	1	8	2.816E+0
401080	ZR 108	4.075E-01 SEC	2.640E-06	1.000E+0	0	1	0	-3.000E-1
411080	NB 108	2.220E-01 SEC	8.490E-04	1.000E+0	0	1	1	-3.000E-1
421080	MO 108	1.500E+00 SEC	3.270E-02	1.000E+0	0	1	2	-3.000E-1
431080	TC 108	5.200E+00 SEC	4.640E-02	1.000E+0	0	1	3	-3.000E-1
441080	RU 108	4.500E+00 MIN	1.150E-02	1.000E+0	2	5	4	0.000E+0
451081	RH 108M	5.900E+00 MIN	4.580E-05	1.000E+0	-1	1	5	0.000E+0
451080	RH 108	1.680E+01 SEC	4.580E-05	1.000E+0	-1	1	6	0.000E+0
401090	ZR 109	1.387E-01 SEC	1.750E-08	1.000E+0	0	1	0	-3.000E-1
411090	NB 109	2.861E-01 SEC	2.620E-05	1.000E+0	0	1	1	-3.000E-1
421090	MO 109	1.033E+00 SEC	4.050E-03	1.000E+0	0	1	2	-3.000E-1
431090	TC 109	5.100E+01 SEC	2.100E-02	1.000E+0	0	1	3	-3.000E-1
441090	RU 109	3.500E+01 SEC	1.890E-02	5.000E-1	1	5	4	-3.000E-1
451091	RH 109M	5.000E+01 SEC	3.170E-04	1.000E+0	0	1	5	-3.000E-1
451090	RH 109	9.000E+01 SEC	3.170E-04	5.000E-1	2	1	6	-3.000E-1
461091	PD 109M	4.690E+00 MIN	1.300E-06	1.000E+0	1	1	7	0.000E+0
461090	PD 109	1.345E+01 HR	1.300E-06	9.995E-1	0	1	9	0.000E+0
471091	AG 109M	3.960E+01 SEC	1.330E-10	1.000E+0	-1	1	10	0.000E+0
471101	AG 110M	2.499E+02 DAY	4.000E-09	1.330E-2	1	1	2	0.000E+0
471100	AG 110	2.457E+01 SEC	3.700E-09	1.000E+0	-1	1	3	0.000E+0
411110	NB 111	1.562E-01 SEC	1.410E-08	1.000E+0	0	1	1	-3.000E-1
421110	MO 111	3.916E-01 SEC	3.770E-05	1.000E+0	0	1	2	-3.000E-1
431110	TC 111	1.336E+00 SEC	2.490E-03	1.000E+0	0	1	3	-3.000E-1
441110	RU 111	2.570E-01 MIN	1.800E-02	1.000E+0	0	5	4	-3.000E-1
451110	RH 111	1.050E+00 MIN	5.560E-03	9.960E-1	1	1	5	-3.000E-1
461111	PD 111M	5.500E+00 HR	1.250E-04	3.200E-1	1	1	6	-3.000E-1
461110	PD 111	2.200E+01 MIN	1.260E-04	1.000E+0	0	1	7	0.000E+0
471111	AG 111M	6.500E+01 SEC	1.620E-07	1.000E+0	0	1	8	0.000E+0
471110	AG 111	7.460E+00 DAY	1.580E-07	1.000E+0	-1	1	9	3.461E+0
481111	CD 111M	4.870E+01 MIN	2.500E-11	1.000E+0	-1	1	2	0.000E+0
421120	MO 112	6.890E-01 SEC	4.155E-06	1.000E+0	0	1	0	-3.000E-1
431120	TC 112	3.553E-01 SEC	5.350E-04	1.000E+0	0	1	1	-3.000E-1
441120	RU 112	7.000E-01 SEC	9.880E-03	1.000E+0	0	5	2	-3.000E-1
451120	RH 112	4.700E+00 SEC	7.530E-03	1.000E+0	0	1	3	-3.000E-1
461120	PD 112	2.010E+01 HR	8.990E-04	1.000E+0	0	1	4	0.000E+0
471120	AG 112	3.130E+00 HR	1.700E-04	1.000E+0	-1	1	5	0.000E+0
421130	MO 113	1.970E-01 SEC	2.702E-07	1.000E+0	0	1	0	-3.000E-1
431130	TC 113	4.584E-01 SEC	1.130E-04	1.000E+0	0	1	1	-3.000E-1
441130	RU 113	2.766E+00 SEC	5.500E-03	1.000E+0	0	5	2	-3.000E-1
451130	RH 113	9.000E-01 SEC	9.750E-03	1.000E+0	0	1	3	-3.000E-1
461130	PD 113	1.500E+00 MIN	3.020E-03	9.000E-1	1	1	4	-3.000E-1
471131	AG 113M	1.100E+00 MIN	1.520E-05	1.000E+0	-1	1	5	-3.000E-1
471130	AG 113	5.300E+00 HR	1.520E-05	1.300E-1	-1	1	6	-3.000E-1
421140	MO 114	3.215E-01 SEC	1.728E-08	1.000E+0	0	1	0	-3.000E-1
431140	TC 114	1.734E-01 SEC	1.630E-05	1.000E+0	0	1	1	-3.000E-1
441140	RU 114	5.052E+00 SEC	2.040E-03	1.000E+0	0	5	2	-3.000E-1

Radionuclide		Half-life		Yield	FRACT	IDATR	NGROUP	ISTART	XSECT
451140	RH 114	1.700E+00	SEC	8.640E-03	1.000E+0	0	1	3	-3.000E-1
461140	PD 114	2.400E+00	MIN	6.390E-03	1.000E+0	0	1	4	-3.000E-1
471140	AG 114	4.520E+00	SEC	1.670E-04	1.000E+0	-1	1	5	0.000E+0
461150	PD 115	3.800E+01	SEC	1.512E-02	7.300E-1	0	1	0	-3.000E-1
471150	AG 115	2.000E+01	MIN	4.670E-04	1.000E-4	0	1	1	0.000E+0
481151	CD 115M	4.460E+01	DAY	1.460E-03	1.000E+0	-1	1	2	8.225E+0
481150	CD 115	5.347E+01	HR	1.460E-02	1.000E+0	0	1	0	0.000E+0
491151	IN 115M	4.360E+00	HR	4.055E-05	9.630E-1	-1	1	1	0.000E+0
471170	AG 117	1.220E+00	MIN	8.219E-03	1.000E+0	0	1	0	-3.000E-1
481170	CD 117	2.600E+00	HR	2.555E-03	9.000E-1	2	1	1	0.000E+0
481171	CD 117M	3.400E+00	HR	4.550E-03	4.800E-1	0	1	2	0.000E+0
491171	IN 117M	1.940E+00	HR	1.000E-02	9.000E-3	0	1	3	9.196E-1
491170	IN 117	4.380E+01	MIN	6.330E-10	1.000E+0	-1	1	4	9.196E-1
501171	SN 117M	1.360E+01	DAY	0.000E+00	1.000E+0	-1	1	2	0.000E+0
441180	RU 118	6.160E-01	SEC	8.436E-07	1.000E+0	0	5	1	-3.000E-1
451180	RH 118	2.953E-01	SEC	2.320E-04	1.000E+0	0	1	2	-3.000E-1
461180	PD 118	3.100E+00	SEC	6.380E-03	5.000E-1	1	1	3	-3.000E-1
471181	AG 118M	3.700E+00	SEC	3.580E-03	5.900E-1	1	1	4	-3.000E-1
471180	AG 118	2.800E+00	SEC	6.570E-03	1.000E+0	0	1	5	-3.000E-1
481180	CD 118	5.030E+01	MIN	1.380E-03	1.000E+0	1	1	6	-3.000E-1
491181	IN 118M	4.450E+00	MIN	4.150E-06	1.000E+0	-1	1	7	0.000E+0
491180	IN 118	5.000E+00	SEC	4.150E-06	1.000E+0	-1	1	8	0.000E+0
451190	RH 119	4.478E-01	SEC	4.170E-05	1.000E+0	0	1	0	-3.000E-1
461190	PD 119	1.712E+00	SEC	3.390E-03	1.000E+0	0	1	1	-3.000E-1
471190	AG 119	1.000E-01	MIN	9.260E-03	5.000E-1	2	1	2	-3.000E-1
481190	CD 119	9.400E+00	MIN	2.230E-03	1.000E+0	0	1	3	-3.000E-1
491191	IN 119M	1.804E+01	MIN	4.000E-03	1.000E+0	-1	1	4	-3.000E-1
481191	CD 119M	3.200E+00	MIN	2.230E-03	1.000E+0	-1	1	5	0.000E+0
501191	SN 119M	2.930E+02	DAY	2.650E-04	1.000E+0	-1	1	0	0.000E+0
441200	RU 120	2.932E-01	SEC	3.070E-09	1.000E+0	0	5	0	-3.000E-1
451200	RH 120	1.624E-01	SEC	5.482E-06	1.000E+0	0	1	1	-3.000E-1
461200	PD 120	4.270E+00	SEC	1.140E-03	1.000E+0	0	1	2	-3.000E-1
471200	AG 120	1.170E+00	SEC	7.650E-03	1.000E+0	0	1	3	-3.000E-1
481200	CD 120	5.082E+01	SEC	8.710E-03	5.000E-1	1	1	4	-3.000E-1
491201	IN 120M	3.080E+00	SEC	1.850E-04	1.000E+0	-1	1	5	1.476E-3
491200	IN 120	4.440E+01	SEC	1.850E-04	1.000E+0	-1	1	6	1.476E-3
451210	RH 121	2.210E-01	SEC	5.344E-07	1.000E+0	0	1	0	-3.000E-1
461210	PD 121	6.222E-01	SEC	2.920E-04	1.000E+0	0	1	1	-3.000E-1
471210	AG 121	3.000E+00	SEC	4.800E-03	1.000E+0	0	1	2	-3.000E-1
481210	CD 121	1.280E+01	SEC	1.210E-02	8.200E-1	1	1	3	-3.000E-1
491211	IN 121M	3.300E+00	MIN	9.580E-04	1.000E+0	2	1	4	-3.000E-1
491210	IN 121	2.800E+01	SEC	6.280E-04	1.000E+0	1	1	5	-3.000E-1
501211	SN 121M	5.000E+01	YR	8.780E-06	1.000E+0	-1	1	6	0.000E+0
501210	SN 121	2.680E+01	HR	8.750E-06	1.000E+0	-1	1	7	0.000E+0
451230	RH 123	1.335E-01	SEC	5.115E-09	1.000E+0	0	1	0	-3.000E-1
461230	PD 123	3.100E-01	SEC	1.540E-05	1.000E+0	0	1	1	-3.000E-1
471230	AG 123	8.627E-01	SEC	1.280E-03	1.000E+0	0	1	2	-3.000E-1
481230	CD 123	1.400E-01	MIN	1.390E-02	7.700E-1	2	1	3	-3.000E-1
491231	IN 123M	4.800E+01	SEC	3.130E-03	3.800E-1	2	1	4	-3.000E-1
501230	SN 123	1.292E+02	DAY	1.620E-03	1.000E+0	-1	1	5	0.000E+0
491230	IN 123	5.970E+00	SEC	3.210E-03	1.000E+0	0	1	6	0.000E+0
501231	SN 123M	4.010E+01	MIN	2.940E-04	1.000E+0	-1	1	7	0.000E+0

Radionuclide		Half-life	Yield	FRACT	IDATR	NGROUP	ISTART	XSECT
461240	PD 124	5.600E-01 SEC	3.030E-06	1.000E+0	0	1	0	-3.000E-1
471240	AG 124	2.685E-01 SEC	5.850E-04	1.000E+0	0	1	1	-3.000E-1
481240	CD 124	1.717E+01 SEC	1.410E-02	1.000E+0	0	1	2	-3.000E-1
491240	IN 124	3.200E+00 SEC	1.350E-02	1.000E+0	-1	1	3	-3.000E-1
471250	AG 125	3.820E-01 SEC	1.390E-04	1.000E+0	0	1	0	-3.000E-1
481250	CD 125	1.622E+00 SEC	7.780E-03	7.000E-1	1	1	1	-3.000E-1
491251	IN 125M	1.200E+00 SEC	7.960E-03	1.000E+0	1	1	2	-3.000E-1
491250	IN 125	2.330E+00 SEC	1.350E-02	3.000E-1	1	1	3	-3.000E-1
501251	SN 125M	9.520E+00 MIN	5.000E-03	1.000E+0	1	1	4	0.000E+0
501250	SN 125	9.640E+00 DAY	1.000E-02	1.000E+0	0	1	5	5.443E-1
511250	SB 125	2.770E+00 YR	1.200E-04	2.310E-1	0	1	6	7.621E-1
521251	TE 125M	5.800E+01 DAY	1.380E-07	1.000E+0	-1	1	7	0.000E+0
531250	I 125	6.014E+01 DAY	0.000E+00	1.000E+0	-1	2	0	-1.000E+0
461260	PD 126	2.870E-01 SEC	3.780E-08	1.000E+0	0	1	0	-3.000E-1
471260	AG 126	1.555E-01 SEC	5.320E-05	1.000E+0	0	1	1	-3.000E-1
481260	CD 126	3.765E+00 SEC	8.160E-03	1.000E+0	0	1	2	-3.000E-1
491260	IN 126	1.530E+00 SEC	4.120E-02	1.000E+0	0	1	3	-3.000E-1
501260	SN 126	1.000E+05 YR	2.500E-02	1.000E+0	1	1	4	4.442E-2
511261	SB 126M	1.900E+01 MIN	5.020E-04	1.400E-1	0	1	6	0.000E+0
511260	SB 126	1.240E+01 DAY	9.740E-04	1.000E+0	-1	1	7	1.871E+0
481270	CD 127	6.590E-01 SEC	4.100E-03	5.000E-1	1	1	0	-3.000E-1
491270	IN 127	2.000E+00 SEC	2.490E-02	1.000E+0	1	1	1	-3.000E-1
491271	IN 127M	3.640E+00 SEC	2.500E-02	1.000E+0	0	1	2	-3.000E-1
501270	SN 127	2.100E+00 HR	4.720E-02	1.000E+0	1	1	4	0.000E+0
501271	SN 127M	4.133E+00 MIN	5.040E-02	1.000E+0	0	1	3	0.000E+0
511270	SB 127	3.850E+00 DAY	7.460E-03	8.310E-1	1	1	5	0.000E+0
521271	TE 127M	1.090E+02 DAY	9.800E-05	9.817E-1	0	1	6	2.053E+0
521270	TE 127	9.350E+00 HR	4.000E-03	1.000E+0	-1	1	7	0.000E+0
471280	AG 128	1.024E-01 SEC	1.380E-06	1.000E+0	0	1	0	-3.000E-1
481280	CD 128	1.290E+00 SEC	1.820E-03	1.000E+0	0	1	1	-3.000E-1
491280	IN 128	3.700E+00 SEC	6.200E-02	1.000E+0	0	1	2	-3.000E-1
501280	SN 128	5.900E+01 MIN	3.060E-01	1.000E+0	0	1	3	0.000E+0
511281	SB 128M	1.040E+01 MIN	1.210E-02	1.000E+0	-1	1	4	0.000E+0
511280	SB 128	9.010E+00 HR	1.600E-02	1.000E+0	-1	1	5	0.000E+0
481290	CD 129	3.376E-01 SEC	3.060E-04	1.000E+0	0	1	0	-3.000E-1
491290	IN 129	8.000E-01 SEC	3.940E-02	5.000E-1	1	1	1	-3.000E-1
501291	SN 129M	2.500E+00 MIN	3.300E-01	1.000E+0	1	1	2	-3.000E-1
501290	SN 129	7.500E+00 MIN	2.030E-01	1.000E+0	0	1	3	-3.000E-1
511290	SB 129	4.319E+00 HR	1.140E-01	8.693E-1	1	1	4	0.000E+0
521291	TE 129M	3.360E+01 DAY	1.200E-02	6.500E-1	0	1	5	2.900E-1
521290	TE 129	6.960E+01 MIN	1.480E-02	1.000E+0	0	1	6	0.000E+0
531290	I 129	1.570E+07 YR	2.500E-02	1.000E+0	-1	2	7	5.272E+0
541291	XE 129M	8.890E+00 DAY	5.821E-09	1.000E+0	-1	3	1	0.000E+0
481300	CD 130	5.239E-01 SEC	8.100E-04	1.000E+0	0	1	0	-3.000E-1
491300	IN 130	5.300E-01 SEC	7.340E-02	1.000E+0	0	1	1	-3.000E-1
501300	SN 130	3.720E+00 MIN	8.720E-01	1.000E+0	0	1	2	0.000E+0
511301	SB 130M	6.300E+00 MIN	3.020E-01	1.000E+0	-1	1	3	0.000E+0
511300	SB 130	4.000E+01 MIN	2.180E-01	1.000E+0	-1	1	0	0.000E+0
531301	I 130M	1.500E-01 HR	1.050E-04	8.300E-1	0	2	4	0.000E+0
531300	I 130	1.236E+01 HR	1.970E-04	1.000E+0	-1	2	5	0.000E+0
481310	CD 131	1.193E-01 SEC	7.700E-05	1.000E+0	0	1	0	-3.000E-1
491310	IN 131	3.000E-01 SEC	2.440E-02	1.000E+0	0	1	1	-3.000E-1

Radionuclide		Half-life	Yield	FRACT	IDATR	NGROUP	ISTART	XSECT
501310	SN 131	6.300E+01 SEC	9.590E-01	1.000E+0	0	1	2	-3.000E-1
511310	SB 131	2.300E+01 MIN	1.590E+00	9.320E-1	1	1	3	0.000E+0
521311	TE 131M	3.000E+01 HR	1.900E-01	7.780E-1	1	1	4	0.000E+0
521310	TE 131	2.500E+01 MIN	1.190E-01	1.000E+0	0	1	5	0.000E+0
531310	I 131	8.040E+00 DAY	4.150E-03	1.086E-2	0	2	6	3.229E-1
541311	XE 131M	1.184E+01 DAY	1.040E-06	1.000E+0	-1	3	7	0.000E+0
481320	CD 132	1.448E-01 SEC	6.140E-06	1.000E+0	0	1	0	-3.000E-1
491320	IN 132	1.200E-01 SEC	6.620E-03	1.000E+0	0	1	1	-3.000E-1
501320	SN 132	4.000E+01 SEC	5.860E-01	1.000E+0	1	1	2	0.000E+0
511321	SB 132M	4.200E+00 MIN	1.070E+00	1.000E+0	1	1	3	0.000E+0
511320	SB 132	2.800E+00 MIN	1.080E+00	1.000E+0	0	1	4	0.000E+0
521320	TE 132	7.820E+01 HR	1.540E+00	1.000E+0	0	1	5	4.890E-4
531320	I 132	2.300E+00 HR	2.060E-02	1.000E+0	-1	2	6	0.000E+0
491330	IN 133	1.140E-01 SEC	3.950E-04	1.000E+0	0	1	0	-3.000E-1
501330	SN 133	1.470E+00 SEC	1.690E-01	1.000E+0	0	1	1	-3.000E-1
511330	SB 133	2.400E+00 MIN	2.080E+00	9.780E-1	1	1	2	0.000E+0
521331	TE 133M	5.540E+01 MIN	2.880E+00	1.300E-1	0	1	3	0.000E+0
521330	TE 133	1.245E+01 MIN	3.520E+00	1.000E+0	1	2	4	0.000E+0
531331	I 133M	9.000E+00 SEC	1.290E-01	1.000E+0	0	2	5	0.000E+0
531330	I 133	2.080E+01 HR	0.000E+00	9.712E-1	1	2	6	0.000E+0
541331	XE 133M	2.190E+00 DAY	2.670E-03	1.000E+0	0	3	7	0.000E+0
541330	XE 133	5.245E+00 DAY	8.790E-04	1.000E+0	-1	3	8	2.440E+1
491340	IN 134	7.754E-02 SEC	6.960E-06	1.000E+0	0	1	0	-3.000E-1
501340	SN 134	8.447E-01 SEC	1.190E-02	1.000E+0	1	1	1	-3.000E-1
511341	SB 134M	1.070E+01 SEC	2.580E-01	1.000E+0	1	1	2	-3.000E-1
511340	SB 134	1.100E+01 SEC	2.580E-01	1.000E+0	0	1	3	0.000E+0
521340	TE 134	4.180E+01 MIN	6.180E+00	1.000E+0	1	1	4	9.197E-3
531341	I 134M	3.700E+00 MIN	4.520E-01	9.800E-1	0	2	5	0.000E+0
531340	I 134	5.260E+01 MIN	4.570E-01	1.000E+0	-1	2	6	0.000E+0
541341	XE 134M	2.900E-01 SEC	2.380E-02	1.000E+0	-1	3	0	-3.000E-1
551341	CS 134M	2.900E+00 HR	5.300E-05	1.000E+0	3	4	2	0.000E+0
551340	CS 134	2.062E+00 YR	1.380E-05	1.000E+0	-1	4	6	2.298E+1
501350	SN 135	2.910E-01 SEC	1.240E-03	1.000E+0	0	1	0	-3.000E-1
511350	SB 135	1.700E+00 SEC	1.960E-01	1.000E+0	0	1	1	-3.000E-1
521350	TE 135	1.920E+01 SEC	3.110E+00	1.000E+0	0	1	2	0.000E+0
531350	I 135	6.610E+00 HR	2.980E+00	8.350E-1	1	2	3	2.119E-3
541351	XE 135M	1.536E+01 MIN	1.518E-01	1.000E+0	1	3	4	0.000E+0
541350	XE 135	9.090E+00 HR	9.780E-02	1.000E+0	4	3	6	2.090E+5
551351	CS 135M	5.300E+01 MIN	6.250E-04	1.000E+0	1	4	9	0.000E+0
551350	CS 135	2.300E+06 YR	9.010E-04	1.000E+0	-1	4	11	2.391E+0
501360	SN 136	4.131E-01 SEC	5.430E-05	1.000E+0	0	1	0	-3.000E-1
511360	SB 136	2.313E-01 SEC	2.990E-02	1.000E+0	0	1	1	-3.000E-1
521360	TE 136	2.100E+01 SEC	1.850E+00	1.000E+0	1	1	2	-3.000E-1
531361	I 136M	4.600E+01 SEC	1.950E+00	1.000E+0	-1	2	0	-3.000E-1
531360	I 136	8.300E+01 SEC	1.190E+00	1.000E+0	-1	2	3	0.000E+0
551360	CS 136	1.310E+01 DAY	7.510E-03	1.000E+0	-1	4	2	0.000E+0
511370	SB 137	2.837E-01 SEC	2.130E-03	1.000E+0	0	1	0	-3.000E-1
521370	TE 137	3.500E+00 SEC	4.200E-01	1.000E+0	0	1	1	-3.000E-1
531370	I 137	2.460E+01 SEC	2.840E+00	1.000E+0	0	2	2	-3.000E-1
541370	XE 137	3.830E+00 MIN	2.870E+00	1.000E+0	0	3	3	0.000E+0
551370	CS 137	3.000E+01 YR	1.250E-01	9.460E-1	0	4	4	2.559E-2
561371	BA 137M	2.552E+00 MIN	2.580E-04	1.000E+0	-1	1	5	0.000E+0

Radionuclide		Half-life	Yield	FRACT	IDATR	NGROUP	ISTART	XSECT
511380	SB 138	1.304E-01 SEC	1.320E-04	1.000E+0	0	1	0	-3.000E-1
521380	TE 138	1.640E+00 SEC	8.720E-02	1.000E+0	0	1	1	-3.000E-1
531380	I 138	6.400E+00 SEC	1.570E+00	1.000E+0	0	2	2	0.000E+0
541380	XE 138	1.417E+01 MIN	4.560E+00	1.000E+0	1	3	3	0.000E+0
551381	CS 138M	2.900E+00 MIN	2.480E-01	7.500E-1	0	4	0	0.000E+0
551380	CS 138	3.220E+01 MIN	3.010E-01	1.000E+0	-1	4	5	0.000E+0
511390	SB 139	1.720E-01 SEC	5.870E-06	1.000E+0	0	1	0	-3.000E-1
521390	TE 139	4.237E-01 SEC	1.300E-02	1.000E+0	0	1	1	-3.000E-1
531390	I 139	2.400E+00 SEC	7.230E-01	1.000E+0	0	2	2	0.000E+0
541390	XE 139	3.950E+01 SEC	4.350E+00	1.000E+0	0	3	3	0.000E+0
551390	CS 139	9.400E+00 MIN	1.310E+00	1.000E+0	0	4	4	0.000E+0
561390	BA 139	8.310E+01 MIN	6.710E-02	1.000E+0	-1	1	5	5.518E-1
521400	TE 140	7.520E-01 SEC	1.210E-03	1.000E+0	0	1	0	-3.000E-1
531400	I 140	8.600E-01 SEC	2.150E-01	1.000E+0	0	2	0	-3.000E-1
541400	XE 140	1.360E+01 SEC	3.400E+00	1.000E+0	0	3	0	0.000E+0
551400	CS 140	6.383E+01 SEC	2.230E+00	1.000E+0	0	4	1	0.000E+0
561400	BA 140	1.279E+01 DAY	4.290E-01	1.000E+0	0	1	2	5.285E-1
571400	LA 140	4.022E+01 HR	6.040E-03	1.000E+0	-1	1	3	2.210E+0
521410	TE 141	2.358E-01 SEC	4.190E-05	1.000E+0	0	1	0	-3.000E-1
531410	I 141	4.000E-01 SEC	3.080E-02	1.000E+0	0	2	1	-3.000E-1
541410	XE 141	1.720E+00 SEC	1.150E+00	1.000E+0	0	3	2	0.000E+0
551410	CS 141	2.500E+01 SEC	3.240E+00	1.000E+0	0	4	3	1.518E-3
561410	BA 141	1.827E+01 MIN	1.460E+00	1.000E+0	0	1	4	0.000E+0
571410	LA 141	3.940E+00 HR	1.940E-02	1.000E+0	0	1	5	0.000E+0
581410	CE 141	3.250E+01 DAY	2.430E-05	1.000E+0	-1	1	6	2.971E+0
521420	TE 142	4.912E-01 SEC	8.030E-07	1.000E+0	0	1	0	-3.000E-1
531420	I 142	1.960E-01 SEC	2.230E-03	1.000E+0	0	2	1	-3.000E-1
541420	XE 142	1.220E+00 SEC	3.800E-01	1.000E+0	0	3	2	-3.000E-1
551420	CS 142	1.700E+00 SEC	2.460E+00	1.000E+0	0	4	3	-3.000E-1
561420	BA 142	1.070E+01 MIN	2.930E+00	1.000E+0	0	1	4	0.000E+0
571420	LA 142	9.540E+01 MIN	1.000E-01	1.000E+0	-1	1	5	0.000E+0
531430	I 143	3.280E-01 SEC	9.080E-05	1.000E+0	0	2	0	-3.000E-1
541430	XE 143	3.000E-01 SEC	5.200E-02	1.000E+0	0	3	1	-3.000E-1
551430	CS 143	1.700E+00 SEC	1.470E+00	1.000E+0	0	4	2	-3.000E-1
561430	BA 143	1.360E+01 SEC	3.780E+00	1.000E+0	0	1	3	-3.000E-1
571430	LA 143	1.400E+01 MIN	6.010E-01	1.000E+0	0	1	4	0.000E+0
581430	CE 143	3.300E+01 HR	2.850E-02	1.000E+0	0	1	5	1.755E+0
591430	PR 143	1.356E+01 DAY	2.950E-06	1.000E+0	-1	1	6	1.214E+1
531440	I 144	1.327E-01 SEC	3.420E-06	1.000E+0	0	2	0	-3.000E-1
541440	XE 144	1.000E+00 SEC	6.570E-03	1.000E+0	0	3	1	-3.000E-1
551440	CS 144	1.020E+00 SEC	3.110E-01	1.000E+0	0	4	2	0.000E+0
561440	BA 144	1.100E+01 SEC	3.930E+00	1.000E+0	0	1	3	0.000E+0
571440	LA 144	4.000E+01 SEC	1.110E+00	1.000E+0	0	1	4	0.000E+0
581440	CE 144	2.843E+02 DAY	6.090E-02	9.857E-1	1	1	5	1.491E-1
591441	PR 144M	7.200E+00 MIN	6.678E-05	9.994E-1	0	1	6	0.000E+0
591440	PR 144	1.728E+01 MIN	8.250E-05	1.000E+0	-1	1	7	0.000E+0
541450	XE 145	9.000E-01 SEC	1.480E-04	1.000E+0	0	3	0	-3.000E-1
551450	CS 145	5.600E-01 SEC	7.180E-02	1.000E+0	0	4	1	-3.000E-1
561450	BA 145	6.200E+00 SEC	1.920E+00	1.000E+0	0	1	2	-3.000E-1
571450	LA 145	2.900E+01 SEC	1.690E+00	1.000E+0	0	1	3	-3.000E-1
581450	CE 145	3.000E+00 MIN	2.300E-01	1.000E+0	0	1	4	0.000E+0
591450	PR 145	5.980E+00 HR	9.320E-04	1.000E+0	-1	1	5	0.000E+0

Radionuclide		Half-life	Yield	FRACT	IDATR	NGROUP	ISTART	XSECT
541460	XE 146	9.372E-01 SEC	1.380E-05	1.000E+0	0	3	0	-3.000E-1
551460	CS 146	1.920E-01 SEC	8.100E-03	1.000E+0	0	4	1	-3.000E-1
561460	BA 146	2.200E+00 SEC	6.680E-01	1.000E+0	0	1	2	-3.000E-1
571460	LA 146	8.300E+00 SEC	1.620E+00	1.000E+0	0	1	3	-3.000E-1
581460	CE 146	1.420E+01 MIN	6.730E-01	1.000E+0	0	1	4	0.000E+0
591460	PR 146	2.420E+01 MIN	8.540E-03	1.000E+0	-1	1	5	0.000E+0
541470	XE 147	2.638E-01 SEC	2.393E-07	1.000E+0	0	1	0	-3.000E-1
551470	CS 147	5.576E-01 SEC	5.900E-04	1.000E+0	0	4	1	-3.000E-1
561470	BA 147	2.227E+00 SEC	1.300E-01	1.000E+0	0	1	2	-3.000E-1
571470	LA 147	1.000E+01 SEC	9.370E-01	1.000E+0	0	1	3	-3.000E-1
581470	CE 147	7.000E+01 SEC	1.160E+00	1.000E+0	0	1	4	-3.000E-1
591470	PR 147	1.200E+01 MIN	5.380E-02	1.000E+0	0	1	5	0.000E+0
601470	ND 147	1.098E+01 DAY	2.960E-04	1.000E+0	2	1	6	2.006E+1
611470	PM 147	2.623E+00 YR	0.000E+00	1.000E+0	1	1	9	6.192E+2
621470	SM 147	1.070E+11 YR	1.010E-06	1.000E+0	-1	1	11	0.000E+0
551480	CS 148	2.016E-01 SEC	1.810E-05	1.000E+0	0	4	0	-3.000E-1
561480	BA 148	5.900E+00 SEC	1.520E-02	1.000E+0	0	1	1	-3.000E-1
571480	LA 148	1.300E+00 SEC	3.420E-01	1.000E+0	0	1	2	-3.000E-1
581480	CE 148	4.300E+01 SEC	1.170E+00	1.000E+0	0	1	3	-3.000E-1
591480	PR 148	2.300E+00 MIN	1.610E-01	1.000E+0	-1	1	4	0.000E+0
611481	PM 148M	4.130E+01 DAY	7.420E-07	4.200E-2	1	1	1	0.000E+0
611480	PM 148	5.370E+00 DAY	5.100E-06	1.000E+0	-1	1	3	0.000E+0
561490	BA 149	9.175E-01 SEC	9.270E-04	1.000E+0	0	1	0	-3.000E-1
571490	LA 149	2.864E+00 SEC	7.020E-02	1.000E+0	0	1	1	-3.000E-1
581490	CE 149	1.000E+00 SEC	7.100E-01	1.000E+0	0	1	2	-3.000E-1
591490	PR 149	2.300E+00 MIN	2.890E-01	1.000E+0	0	1	3	0.000E+0
601490	ND 149	1.730E+00 HR	1.810E-02	1.000E+0	1	1	4	0.000E+0
611490	PM 149	5.309E+01 HR	3.120E-05	1.000E+0	-1	1	6	1.324E+2
611500	PM 150	2.680E+00 HR	2.820E-07	1.000E+0	-1	1	1	0.000E+0
571510	LA 151	9.536E-01 SEC	8.950E-04	1.000E+0	0	1	0	-3.000E-1
581510	CE 151	1.000E+00 SEC	7.580E-02	1.000E+0	0	1	1	-3.000E-1
591510	PR 151	4.000E+00 SEC	2.240E-01	1.000E+0	0	1	2	-3.000E-1
601510	ND 151	1.240E+01 MIN	1.190E-01	1.000E+0	0	1	3	0.000E+0
611510	PM 151	2.840E+01 HR	1.770E-03	1.000E+0	0	1	4	1.031E+2
621510	SM 151	9.000E+01 YR	3.800E-06	1.000E+0	-1	1	5	7.260E+2
561520	BA 152	7.548E-01 SEC	1.960E-08	1.000E+0	0	1	0	-3.000E-1
571520	LA 152	3.094E-01 SEC	4.980E-05	1.000E+0	0	1	1	-3.000E-1
581520	CE 152	1.403E+01 SEC	1.360E-02	1.000E+0	0	1	2	-3.000E-1
591520	PR 152	8.318E+00 SEC	1.080E-01	1.000E+0	0	1	3	-3.000E-1
601520	ND 152	1.150E+01 MIN	1.450E-01	1.000E+0	1	1	4	-3.000E-1
611521	PM 152M	7.500E+00 MIN	3.670E-03	1.000E+0	0	1	5	-3.000E-1
611520	PM 152	4.100E+00 MIN	3.670E-03	1.000E+0	-1	1	6	0.000E+0
631520	EU 152	1.360E+01 YR	0.000E+00	1.000E+0	-1	1	2	1.914E+2
571530	LA 153	4.370E-01 SEC	1.460E-06	1.000E+0	0	1	0	-3.000E-1
581530	CE 153	1.725E+00 SEC	1.310E-03	1.000E+0	0	1	1	-3.000E-1
591530	PR 153	1.290E-01 MIN	3.130E-02	1.000E+0	0	1	2	-3.000E-1
601530	ND 153	1.126E+00 MIN	1.170E-01	1.000E+0	0	1	3	-3.000E-1
611530	PM 153	5.400E+00 MIN	1.650E-02	1.000E+0	1	1	4	0.000E+0
621530	SM 153	4.670E+01 HR	3.340E-04	1.000E+0	-1	1	6	8.977E+1
641530	GD 153	2.416E+02 DAY	9.700E-12	1.000E+0	-1	1	2	0.000E+0
571540	LA 154	1.753E-01 SEC	3.135E-08	1.000E+0	0	1	0	-3.000E-1
581540	CE 154	3.590E-01 SEC	8.090E-05	1.000E+0	0	1	1	-3.000E-1

Radionuclide		Half-life	Yield	FRACT	IDATR	NGROUP	ISTART	XSECT
591540	PR 154	1.307E+00 SEC	5.530E-03	1.000E+0	0	1	2	-3.000E-1
601540	ND 154	4.000E+01 SEC	5.100E-02	1.000E+0	1	1	3	-3.000E-1
611541	PM 154M	1.800E+00 MIN	9.400E-03	1.000E-1	0	1	4	-3.000E-1
611540	PM 154	2.800E+00 MIN	9.400E-03	1.000E+0	-1	1	5	0.000E+0
631540	EU 154	8.600E+00 YR	1.730E-06	1.000E+0	-1	1	2	1.286E+2
581550	CE 155	7.125E-01 SEC	3.310E-06	1.000E+0	0	1	0	-3.000E-1
591550	PR 155	1.890E+00 SEC	6.840E-04	1.000E+0	0	1	1	-3.000E-1
601550	ND 155	2.606E+01 SEC	1.720E-02	1.000E+0	0	1	2	-3.000E-1
611550	PM 155	3.656E+01 SEC	1.570E-02	1.000E+0	0	1	3	-3.000E-1
621550	SM 155	2.220E+01 MIN	2.590E-03	1.000E+0	1	1	4	0.000E+0
631550	EU 155	4.960E+00 YR	2.000E-08	1.000E+0	-1	1	6	3.655E+2
581560	CE 156	1.162E+00 SEC	9.134E-08	1.000E+0	0	1	0	-3.000E-1
591560	PR 156	5.104E-01 SEC	5.080E-05	1.000E+0	0	1	1	-3.000E-1
601560	ND 156	5.850E+01 SEC	3.500E-03	1.000E+0	0	1	2	-3.000E-1
611560	PM 156	1.310E+01 SEC	8.040E-03	1.000E+0	1	1	3	-3.000E-1
621560	SM 156	9.400E+00 HR	3.340E-03	1.000E-3	0	1	5	0.000E+0
631560	EU 156	1.519E+01 DAY	4.540E-05	1.000E+0	-1	1	6	7.378E+2
581570	CE 157	3.618E-01 SEC	2.450E-09	1.000E+0	0	1	0	-3.000E-1
591570	PR 157	6.780E-01 SEC	3.100E-06	1.000E+0	0	1	1	-3.000E-1
601570	ND 157	4.150E+00 SEC	5.940E-04	1.000E+0	0	1	2	-3.000E-1
611570	PM 157	6.800E+01 SEC	3.470E-03	1.000E+0	0	1	3	-3.000E-1
621570	SM 157	8.000E+00 MIN	3.530E-03	1.000E-3	0	1	4	-3.000E-1
631570	EU 157	1.520E+01 HR	8.121E-03	1.000E+0	-1	1	5	4.609E+2
591580	PR 158	2.630E-01 SEC	1.280E-07	1.000E+0	0	1	0	-3.000E-1
601580	ND 158	7.890E+00 SEC	6.660E-05	1.000E+0	0	1	1	-3.000E-1
611580	PM 158	3.800E+00 SEC	1.040E-03	1.000E+0	0	1	2	-3.000E-1
621580	SM 158	4.400E+01 MIN	2.580E-03	1.000E+0	0	1	3	-3.000E-1
631580	EU 158	4.590E+01 MIN	2.580E-04	1.000E+0	-1	1	4	0.000E+0
591590	PR 159	3.140E-01 SEC	2.104E-09	1.000E+0	0	1	0	-3.000E-1
601590	ND 159	1.410E+00 SEC	3.080E-06	1.000E+0	0	1	1	-3.000E-1
611590	PM 159	4.230E+00 SEC	1.430E-04	1.000E+0	0	1	2	-3.000E-1
621590	SM 159	2.704E+00 MIN	9.040E-04	1.000E+0	0	1	3	-3.000E-1
631590	EU 159	1.810E+01 MIN	2.620E-04	1.000E+0	1	1	4	0.000E+0
641590	GD 159	1.856E+01 HR	1.220E-05	1.000E+0	-1	1	6	0.000E+0
731820	TA 182	1.147E+02 DAY	0.000E+00	1.000E+0	-1	1	0	-1.000E+0
771920	IR 192	7.402E+01 DAY	0.000E+00	1.000E+0	-1	1	0	-1.000E+0
982490	CF 249	3.506E+02 YR	0.000E+00	1.000E+0	0	1	0	-1.000E+0
962450	CM 245	8.500E+03 YR	0.000E+00	1.000E+0	0	1	1	-1.000E+0
942410	PU 241	1.440E+01 YR	0.000E+00	1.000E+0	0	1	2	-1.000E+0
952410	AM 241	4.322E+02 YR	0.000E+00	1.000E+0	1	1	3	-1.000E+0
922370	U 237	6.750E+00 DAY	0.000E+00	1.000E+0	0	1	0	-1.000E+0
932370	NP 237	2.140E+06 YR	0.000E+00	1.000E+0	0	1	5	-1.000E+0
912330	PA 233	2.700E+01 DAY	0.000E+00	1.000E+0	0	1	6	-1.000E+0
922330	U 233	1.592E+05 YR	0.000E+00	1.000E+0	0	1	7	-1.000E+0
902290	TH 229	7.340E+03 YR	0.000E+00	1.000E+0	0	1	8	-1.000E+0
882250	RA 225	1.480E+01 DAY	0.000E+00	1.000E+0	0	1	9	-1.000E+0
892250	AC 225	1.000E+01 DAY	0.000E+00	1.000E+0	0	1	10	-1.000E+0
872210	FR 221	4.800E+00 MIN	0.000E+00	1.000E+0	0	1	11	-1.000E+0
852170	AT 217	3.230E-02 SEC	0.000E+00	1.000E+0	0	1	12	-1.000E+0
832130	BI 213	4.565E+01 MIN	0.000E+00	2.160E-2	1	1	13	-1.000E+0
842130	PO 213	4.200E-06 SEC	0.000E+00	1.000E+0	1	1	14	-1.000E+0
812090	TL 209	2.200E+00 MIN	0.000E+00	1.000E+0	0	1	15	-1.000E+0

Radionuclide		Half-life	Yield	FRACT	IDATR	NGROUP	ISTART	XSECT
822090	PB 209	3.253E+00 HR	0.000E+00	1.000E+0	-1	1	16	-1.000E+0
982520	CF 252	2.639E+00 YR	0.000E+00	1.000E+0	0	1	0	-1.000E+0
962480	CM 248	3.390E+05 YR	0.000E+00	1.000E+0	0	1	1	-1.000E+0
942440	PU 244	8.260E+07 YR	0.000E+00	1.000E+0	0	1	2	-1.000E+0
922400	U 240	1.410E+01 HR	0.000E+00	1.000E+0	0	1	3	-1.000E+0
932401	NP 240M	7.400E+00 MIN	0.000E+00	9.989E-1	3	1	4	-1.000E+0
932400	NP 240	6.500E+01 MIN	0.000E+00	1.000E+0	2	1	5	-1.000E+0
942360	PU 236	2.851E+00 YR	0.000E+00	1.000E+0	0	1	0	-1.000E+0
922320	U 232	7.200E+01 YR	0.000E+00	1.000E+0	5	1	1	-1.000E+0
942400	PU 240	6.569E+03 YR	0.000E+00	1.000E+0	0	1	8	-1.000E+0
922360	U 236	2.342E+07 YR	0.000E+00	1.000E+0	0	1	9	-1.000E+0
902320	TH 232	1.405E+10 YR	0.000E+00	1.000E+0	0	1	10	-1.000E+0
882280	RA 228	5.750E+00 YR	0.000E+00	1.000E+0	0	1	11	-1.000E+0
892280	AC 228	6.130E+00 HR	0.000E+00	1.000E+0	0	1	12	-1.000E+0
902280	TH 228	1.913E+00 YR	0.000E+00	1.000E+0	0	1	13	-1.000E+0
882240	RA 224	3.620E+00 DAY	0.000E+00	1.000E+0	0	1	14	-1.000E+0
862200	RN 220	5.561E+01 SEC	0.000E+00	1.000E+0	0	3	15	-1.000E+0
842160	PO 216	1.460E-01 SEC	0.000E+00	1.000E+0	0	1	16	-1.000E+0
822120	PB 212	1.064E+01 HR	0.000E+00	1.000E+0	0	1	17	-1.000E+0
832120	BI 212	6.055E+01 MIN	0.000E+00	3.593E-1	0	1	18	-1.000E+0
812080	TL 208	3.053E+00 MIN	0.000E+00	1.000E+0	-1	1	19	-1.000E+0
982500	CF 250	1.308E+01 YR	0.000E+00	1.000E+0	0	1	0	-1.000E+0
962460	CM 246	4.750E+03 YR	0.000E+00	1.000E+0	0	1	1	-1.000E+0
942420	PU 242	3.758E+05 YR	0.000E+00	1.000E+0	1	1	2	-1.000E+0
942380	PU 238	8.775E+01 YR	0.000E+00	1.000E+0	4	1	0	-1.000E+0
922380	U 238	4.470E+09 YR	0.000E+00	1.000E+0	0	1	4	-1.000E+0
902340	TH 234	2.410E+01 DAY	0.000E+00	1.000E+0	0	1	5	-1.000E+0
912341	PA 234M	1.170E+00 MIN	0.000E+00	9.987E-1	1	1	6	-1.000E+0
912340	PA 234	6.700E+00 HR	0.000E+00	1.000E+0	0	1	7	-1.000E+0
922340	U 234	2.445E+05 YR	0.000E+00	1.000E+0	0	1	8	-1.000E+0
902300	TH 230	7.700E+04 YR	0.000E+00	1.000E+0	0	1	9	-1.000E+0
882260	RA 226	1.600E+03 YR	0.000E+00	1.000E+0	0	1	10	-1.000E+0
862220	RN 222	3.824E+00 DAY	0.000E+00	1.000E+0	0	3	11	-1.000E+0
842180	PO 218	3.050E+00 MIN	0.000E+00	1.000E+0	0	1	12	-1.000E+0
822140	PB 214	2.680E+01 MIN	0.000E+00	1.000E+0	0	1	13	-1.000E+0
832140	BI 214	1.990E+01 MIN	0.000E+00	2.000E-4	1	1	14	-1.000E+0
842140	PO 214	1.637E-04 SEC	0.000E+00	1.000E+0	1	1	15	-1.000E+0
812100	TL 210	1.300E+00 MIN	0.000E+00	1.000E+0	0	1	16	-1.000E+0
822100	PB 210	2.226E+01 YR	0.000E+00	1.000E+0	0	1	17	-1.000E+0
832100	BI 210	5.013E+00 DAY	0.000E+00	1.000E+0	0	1	18	-1.000E+0
842100	PO 210	1.384E+02 DAY	0.000E+00	1.000E+0	-1	1	19	-1.000E+0
982510	CF 251	9.000E+02 YR	0.000E+00	1.000E+0	0	1	0	-1.000E+0
962470	CM 247	1.560E+07 YR	0.000E+00	1.000E+0	0	1	1	-1.000E+0
942430	PU 243	4.956E+00 HR	0.000E+00	1.000E+0	0	1	2	-1.000E+0
952430	AM 243	7.380E+03 YR	0.000E+00	1.000E+0	0	1	3	-1.000E+0
932390	NP 239	2.355E+00 DAY	0.000E+00	1.000E+0	0	1	4	-1.000E+0
942390	PU 239	2.413E+04 YR	0.000E+00	1.000E+0	0	1	5	-1.000E+0
922350	U 235	7.038E+08 YR	0.000E+00	1.000E+0	0	1	6	-1.000E+0
902310	TH 231	2.552E+01 HR	0.000E+00	1.000E+0	0	1	7	-1.000E+0
912310	PA 231	3.726E+04 YR	0.000E+00	1.000E+0	0	1	8	-1.000E+0
892270	AC 227	2.177E+01 YR	0.000E+00	9.862E-1	1	1	9	-1.000E+0
872230	FR 223	2.180E+01 MIN	0.000E+00	1.000E+0	1	1	10	-1.000E+0

Radionuclide		Half-life	Yield	FRACT	IDATR	NGROUP	ISTART	XSECT
902270	TH 227	1.872E+01 DAY	0.000E+00	1.000E+0	0	1	11	-1.000E+0
882230	RA 223	1.143E+01 DAY	0.000E+00	1.000E+0	0	1	12	-1.000E+0
862190	RN 219	3.960E+00 SEC	0.000E+00	1.000E+0	0	3	13	-1.000E+0
842150	PO 215	1.778E-03 SEC	0.000E+00	1.000E+0	0	1	14	-1.000E+0
822110	PB 211	3.610E+01 MIN	0.000E+00	1.000E+0	0	1	15	-1.000E+0
832110	BI 211	2.130E+00 MIN	0.000E+00	9.973E-1	1	1	16	-1.000E+0
842110	PO 211	5.160E-01 SEC	0.000E+00	1.000E+0	0	1	17	-1.000E+0
812070	TL 207	4.770E+00 MIN	0.000E+00	1.000E+0	-1	1	18	-1.000E+0

Appendix C

Meteorological Diffusion Parameters

Appendix C
Meteorological Diffusion Parameters

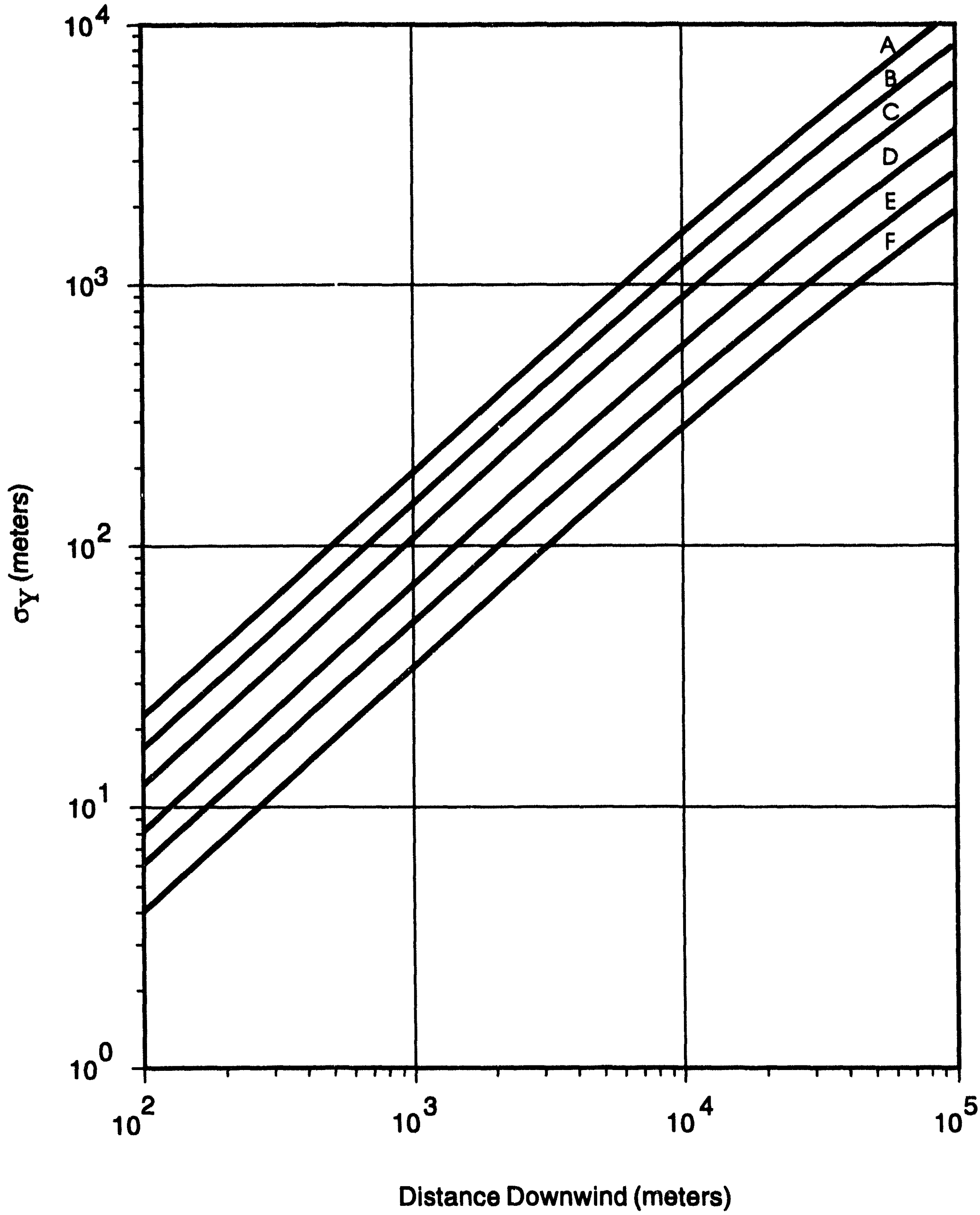

Figure C-1. σ_y versus distance downwind by stability class (Hilsmeier-Gifford).

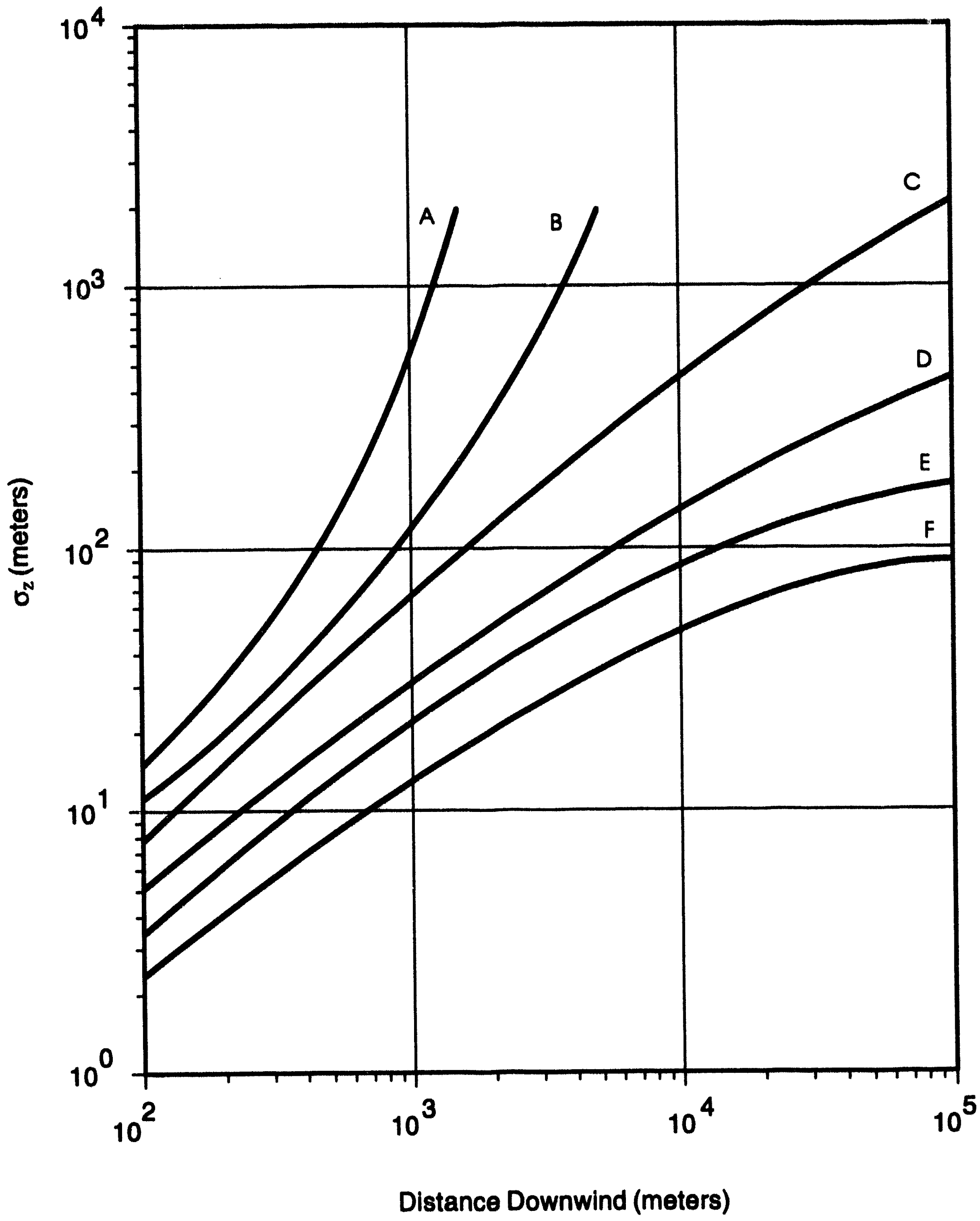

Figure C-2. σ_z versus distance downwind by stability class (Hilsmeier-Gifford).

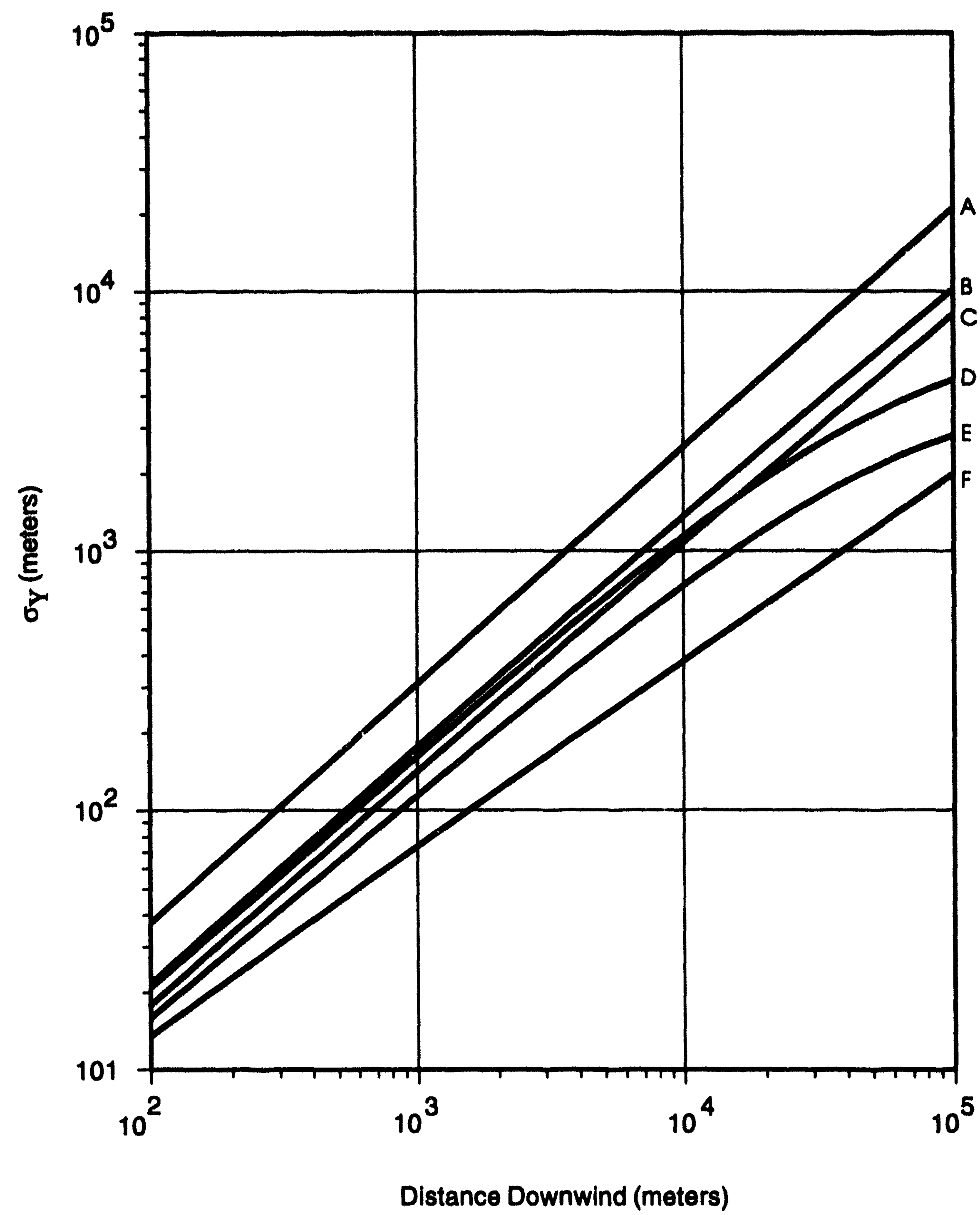

Figure C-3. σ_y versus distance downwind by stability class (Markee).

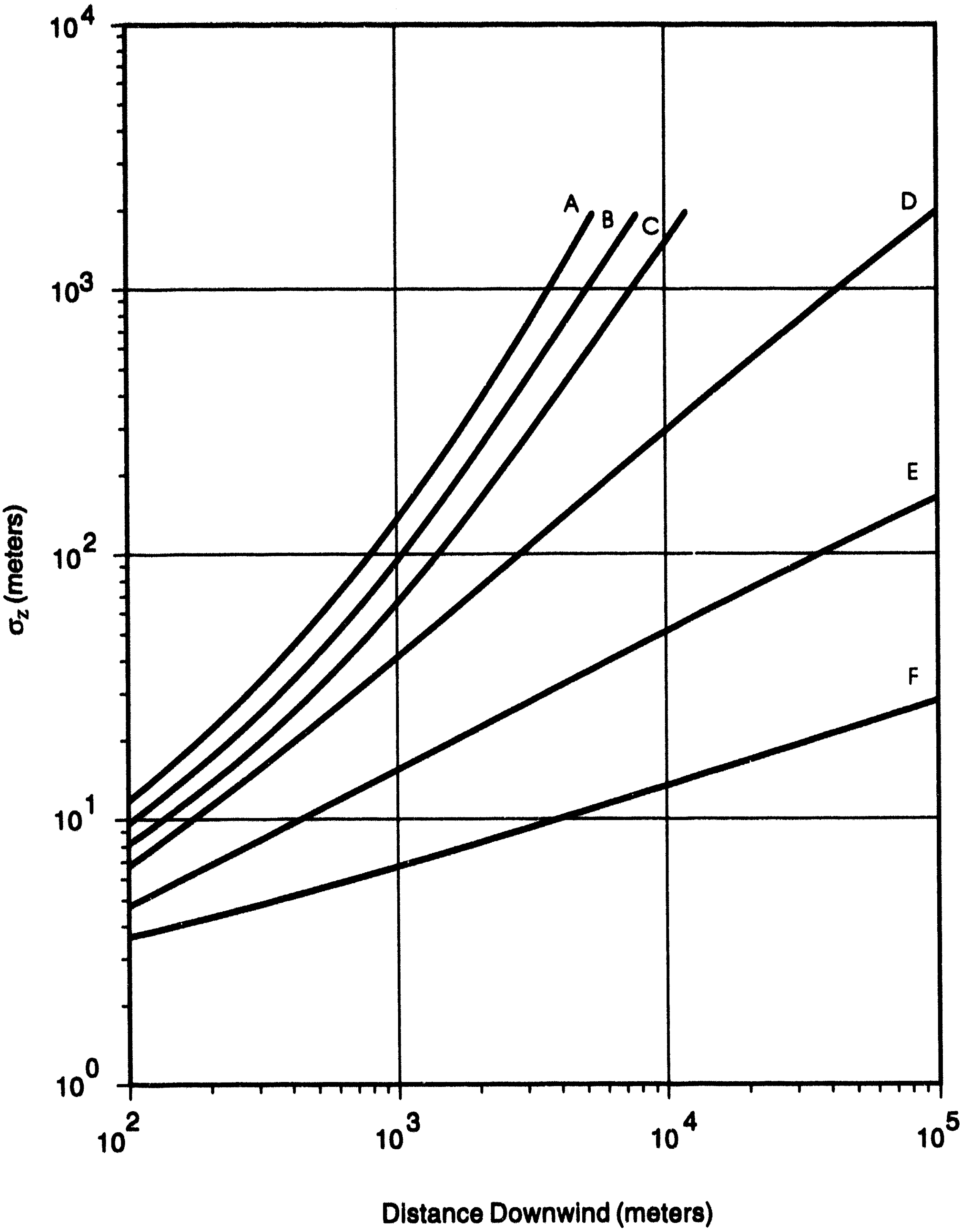

Figure C-4. σ_z versus distance downwind by stability class (Markee).

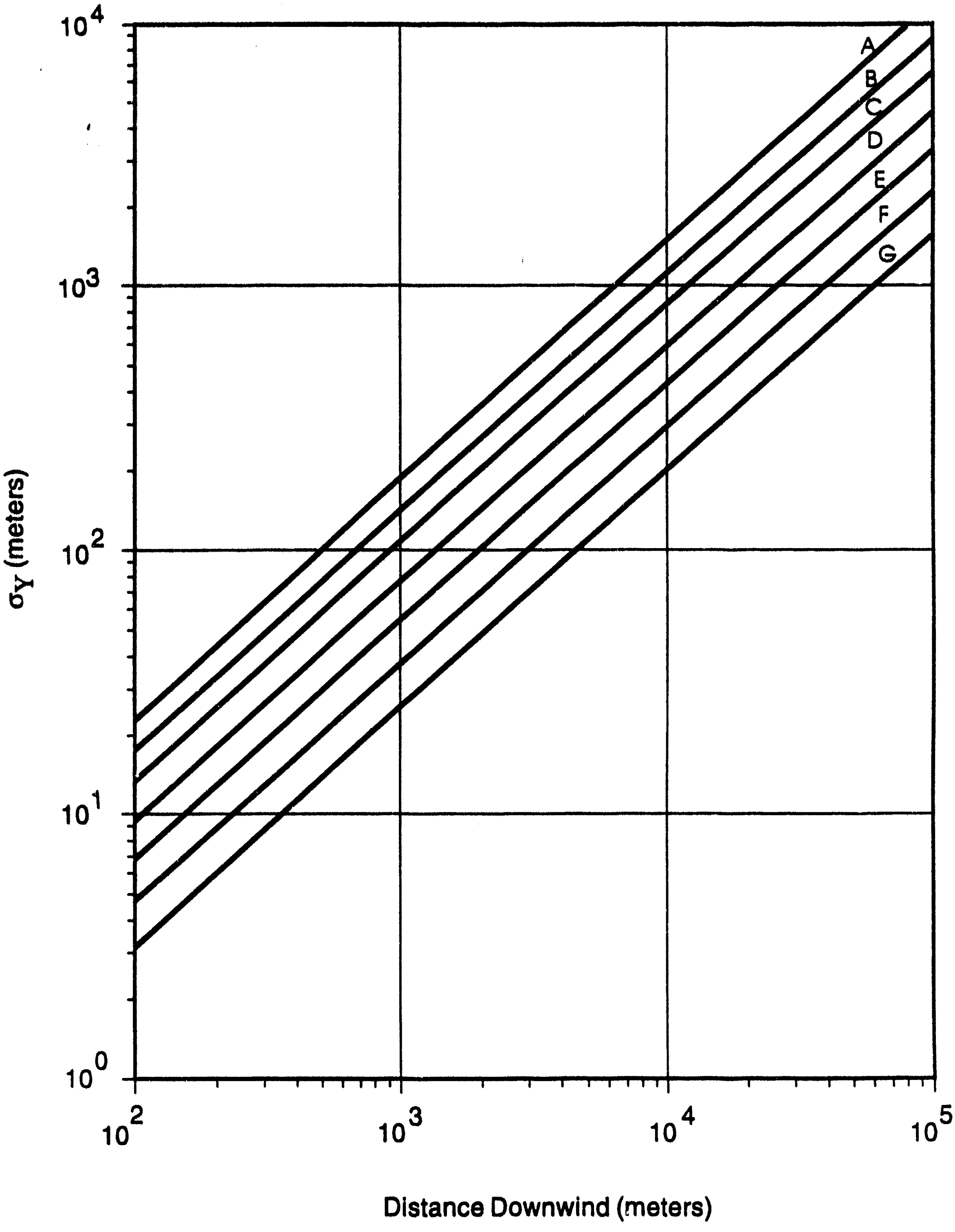

Figure C-5. σ_y versus distance downwind by stability class (Pasquill-Gifford).

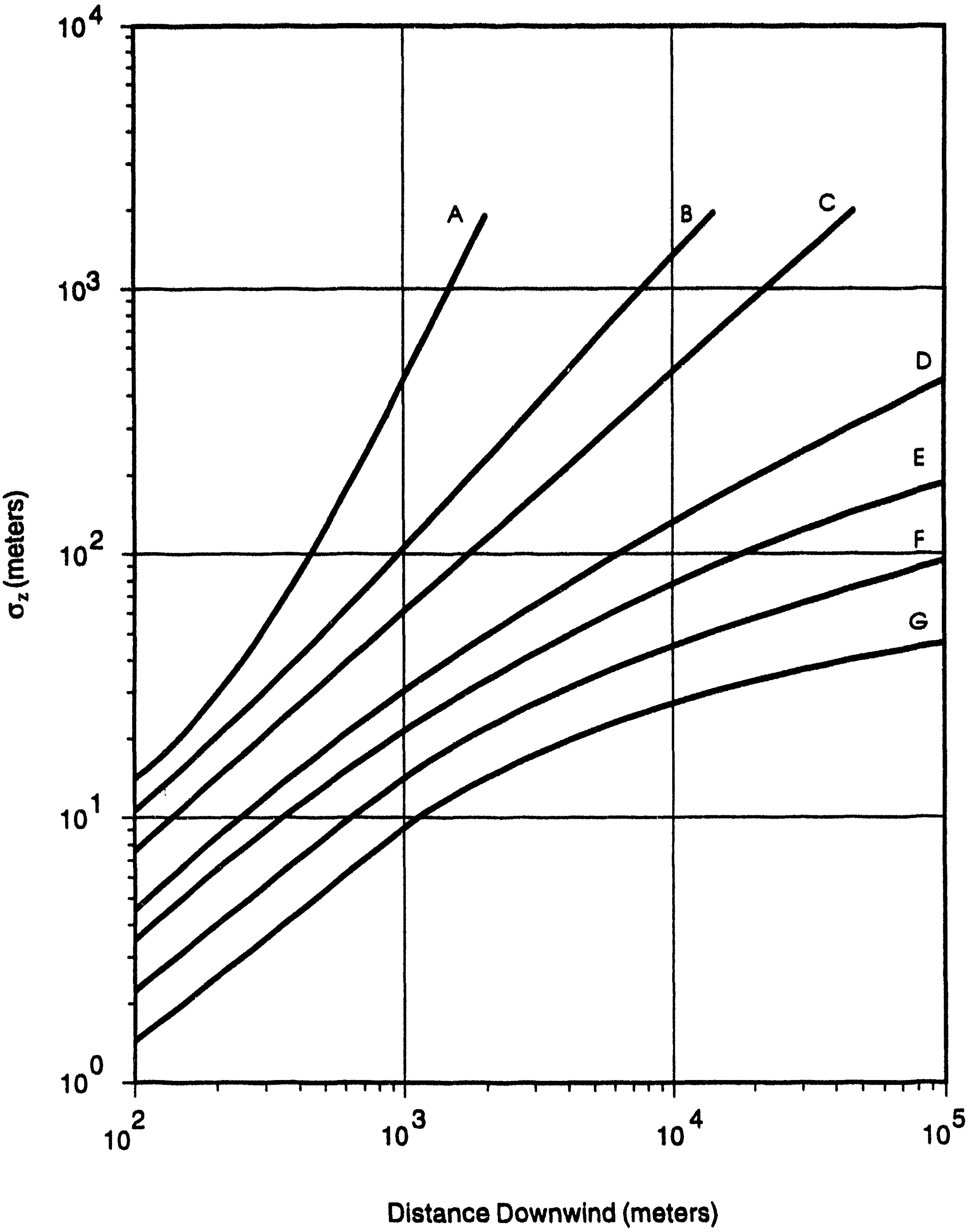

Figure C-6. σ_z versus distance downwind by stability class (Pasquill-Gifford).

Appendix D

Lung Clearance Classes

Appendix D
Lung Clearance Classes[a]

Z	Element	Allowable Clearance Classes			Z	Element	Allowable Clearance Classes		
1	H[b]	H_2	<u>HTO</u>		48	Cd	D	W	<u>Y</u>
4	Be			<u>Y</u>	49	In	D	<u>W</u>	
6	C[b]	CO	<u>ORG</u>	CO_2	50	Sn	D	<u>W</u>	
11	Na	<u>D</u>			51	Sb	<u>D</u>	W	
14	Si	D	<u>W</u>	Y	52	Te	D	<u>W</u>	
15	P	<u>D</u>	W		53	I	<u>D</u>		
16	S	<u>D</u>	W		55	Cs	<u>D</u>		
17	Cl	<u>D</u>	W	Y	56	Ba	D		
19	K	<u>D</u>			57	La	D	<u>W</u>	
20	Ca		<u>W</u>		58	Ce		W	<u>Y</u>
21	Sc			<u>Y</u>	59	Pr		W	<u>Y</u>
24	Cr	D	W	<u>Y</u>	60	Nd		W	<u>Y</u>
25	Mn	D	<u>W</u>		61	Pm		W	<u>Y</u>
26	Fe	D	<u>W</u>		62	Sm		<u>W</u>	
27	Co		W	<u>Y</u>	63	Eu		<u>W</u>	
28	Ni	D	<u>W</u>		64	Gd	D	<u>W</u>	
29	Cu	D	W	<u>Y</u>	73	Ta		W	<u>Y</u>
30	Zn			<u>Y</u>	77	Ir	D	W	<u>Y</u>
32	Ge	D	<u>W</u>		81	Tl	<u>D</u>		
34	Se	D	<u>W</u>		82	Pb	<u>D</u>		
35	Br	<u>D</u>	W		83	Bi	D	<u>W</u>	
37	Rb	<u>D</u>			84	Po	D	<u>W</u>	
38	Sr	<u>D</u>		Y	85	At	<u>D</u>	W	
39	Y		W	<u>Y</u>	88	Ra		<u>W</u>	
40	Zr	D	<u>W</u>	Y	89	Ac	D	W	<u>Y</u>
41	Nb		W	<u>Y</u>	90	Th		W	<u>Y</u>
42	Mo	D		<u>Y</u>	91	Pa		W	<u>Y</u>
43	Tc	D	<u>W</u>		92	U	D	W	<u>Y</u>
44	Ru	D	W	<u>Y</u>	93	Np		<u>W</u>	
45	Rh	D	W	<u>Y</u>	94	Pu		W	<u>Y</u>
46	Pd	D	W	<u>Y</u>	95	Am		<u>W</u>	
47	Ag	D	W	<u>Y</u>	96	Cm		<u>W</u>	

a. Default lung clearance classes are underlined.

b. Chemical species rather than clearance classes are indicated for hydrogen and carbon.

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