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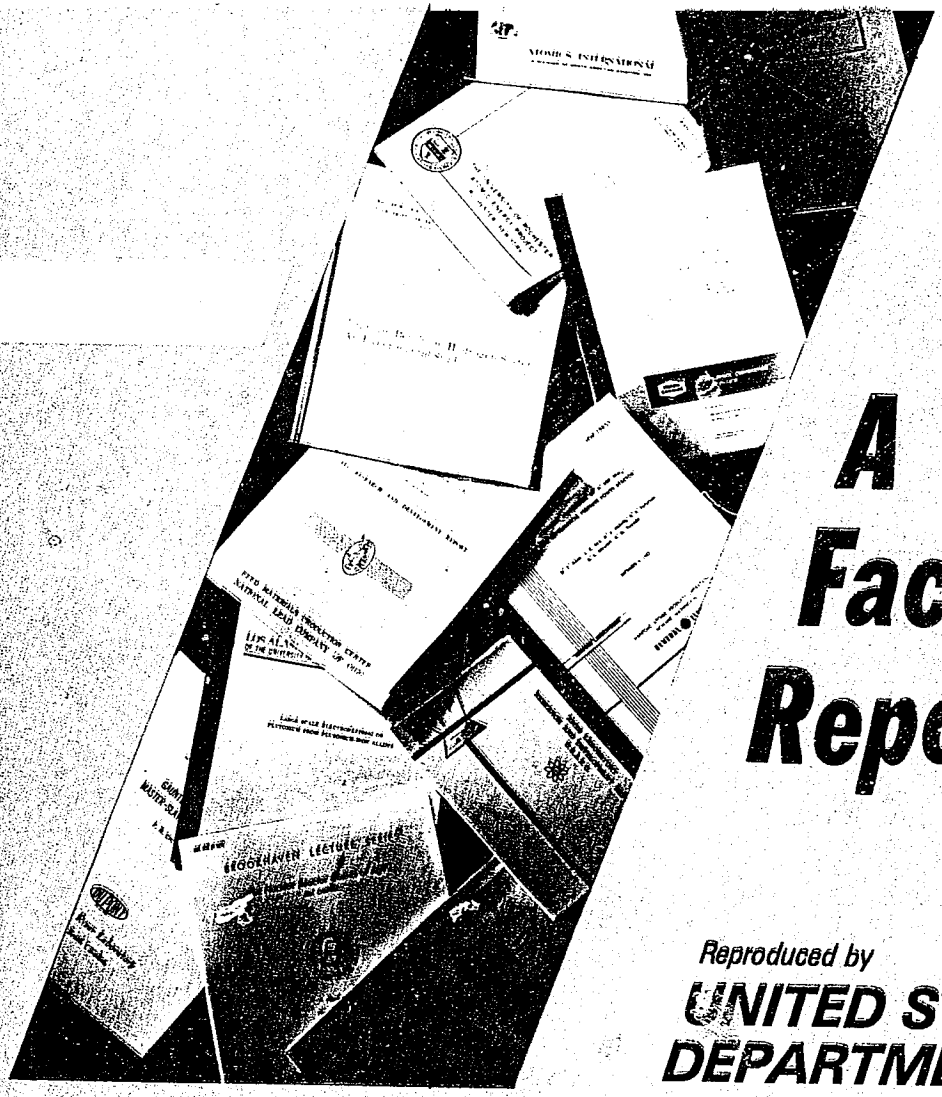

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RADTRAN 4: VOLUME 3

USER GUIDE

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ABSTRACT

This RADTRAN 4 User Guide specifies and describes the required data and control inputs, input sequences, user options, program limitations, and other activities necessary for successful execution of the RADTRAN 4 computer code. The RADTRAN 4 computer code combines user-determined meteorological, demographic, transportation, packaging, and material factors with health physics data to calculate the expected radiological consequences and accident risk of transporting radioactive material.

FOREWORD

The RADTRAN 4 computer code has been developed and maintained by Sandia National Laboratories (SNL) for the U.S. Department of Energy (DOE). This RADTRAN 4 User Guide is to be used in conjunction with the RADTRAN 4 Technical Manual (Neuhauser and Kanipe, in preparation [b]). The name RADTRAN 4 will be used to describe the latest release of the computer code. The name RADTRAN will be used to describe all releases of the code.

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1.0 INTRODUCTION

This User Guide is Volume 3 in a series of four volumes of the documentation of the RADTRAN 4 computer code for transportation risk analysis. The other three volumes are Volume 1, the Executive Summary; Volume 2, the Technical Manual; and Volume 4, the Programmer's Manual (Neuhauser and Kanipe, in preparation [a]; Neuhauser and Kanipe, in preparation [b]; Kanipe and Neuhauser, in preparation). The theoretical and calculational basis for the operations performed by RADTRAN 4 are discussed in Volume 2. Throughout this User Guide the reader will be referred to Volume 2 for detailed discussions of certain RADTRAN features. This User Guide supersedes the document "RADTRAN III" by Madsen et al. (1983). This RADTRAN 4 User Guide specifies and describes the required data, control inputs, input sequences, user options, program limitations, and other activities necessary for execution of the RADTRAN 4 computer code.

Sandia National Laboratories (SNL) developed the original RADTRAN code in 1977 in conjunction with the preparation of NUREG-0170, "Final Environmental Statement on the Transportation of Radioactive Material by Air and Other Modes" (NRC, 1977; Taylor and Daniel, 1977). The analytical capabilities of the code were expanded and refined in subsequent versions (Madsen et al., 1986; Taylor and Daniel, 1982). RADTRAN 4 is used to evaluate radiological consequences of incident-free transportation, as well as the radiological risks from vehicular accidents occurring during transportation.

RADTRAN 4 contains advances in the handling of route-related data and in the treatment of multiple-isotope materials. In both cases, methods used formerly may still be used. Input data may continue to be in aggregate form, and the user also may continue to use RADTRAN 4 to generate unit-risk factors. However, "route-specific" analysis also may be performed. That is, a route now may be subdivided into segments with independent, user-assigned values for population density and other route-specific parameters. Regarding complex materials, RADTRAN 4 contains improvements involving the handling of multiple-isotope materials, and for the first time permits direct analysis of multiple-package shipments made up of dissimilar packages. RADTRAN 4 also contains improvements of old features. For example, RADTRAN 4 now calculates and prints the maximum individual in-transit dose. An internal library of isotope-related parameter values has been added, which contains data on over 50 of the most commonly transported radioisotopes. The user, however, may continue to independently define isotopes. Also, the accident-severity category matrix has been expanded to permit up to 20 accident-severity categories.

RADTRAN 4 contains idealized mathematical models of transportation environments; these models have been formulated to yield conservative estimates of integrated population dose in a way that can be supported by available data. These models neglect features of the transportation environment that either do not affect the calculated risk values or reduce conservatism (e.g., the "divider width" of divided highways).

Wherever possible, RADTRAN combines calculational simplicity with general conservatism. For example, all routes by all modes are modeled as infinitely long straight lines without grade or curves. In addition to ease of calculation for the integrated incident-free off-link and on-link doses for a moving source, this model also yields conservative estimates of these doses that are applicable to all routes by all modes. Similarly, all highway and rail links are treated as being one lane (or track) wide for the purpose of estimating distances to off-link population but as being two lanes wide (one lane or track in each direction) for the purpose of estimating on-link doses (overtaking vehicles on highways are treated separately). The first treatment is used to achieve symmetry (and, hence, mathematical simplicity) around the lane in which the shipment is located, and is also slightly conservative. The second treatment (one lane each direction) yields the smallest perpendicular distance to the traffic traveling in the opposite direction, which again is conservative. The latter treatment also means that all rail routes are modeled as having double tracks, which is another small increment of conservatism for rail-mode calculations.

In RADTRAN 4, the required degree of specificity may be introduced into an analysis with user-defined parameter values. Since the vast majority of RADTRAN parameters are user-definable, the user has a great deal of flexibility in performing analyses. Analysis strategies are addressed in Chapter 4.

The code is written in VAX FORTRAN 77 and is operational on DEC VAX computers at SNL in Albuquerque, New Mexico. The word size is 32 bits. Execution time for a single problem is usually a few seconds, but can take several minutes. Data can be input in free format only. There are a total of 76 subroutines in RADTRAN 4. The main routine is RADIN4. Two files named FILE2.DAT and FILE4.DAT are used for input and output, respectively. Instructions on creating input files and saving and renaming output files are given in Chapter 3. The results of intermediate accident-risk calculations (probability and consequence pairs) are written to FILE10.DAT, FILE11.DAT, and FILE12.DAT for later plotting.

Chapter 2 defines five essential terms used throughout this guide that have specific meanings in transportation risk analysis: package, packaging, material, shipment, and mode. Chapter 3 provides instructions for installation and data entry to create a RADTRAN 4 input file. Chapter 4 discusses user options and constraints to consider when performing analyses using RADTRAN 4. Subroutine RADIN4, the library routines, and all other subroutines in RADTRAN 4 are listed and described in Appendix A. Appendix B is a glossary of common-block variables. Appendix C explains the probability-consequence data from intermediate calculations written to output files FILE10.DAT, FILE11.DAT, and FILE12.DAT. Appendix D contains a list of RADTRAN 4 error messages and suggested error correction strategies.

2.0 DEFINITION OF TERMS

Essential terms used throughout this guide that have specific meanings for transportation risk analysis are package, packaging, material, shipment, and mode. These terms are defined and explained below.

Package and Packaging. Packages and packaging are formally defined in Volume 10 of the Code of Federal Regulations, Title 71.4 (10 CFR 71.4). Briefly, a package consists of a packaging and its radioactive contents. A packaging consists of one or more receptacles and wrappers and their contents, excluding radioactive materials but including absorbent material, spacing structures, thermal insulation, radiation shielding, devices for cooling and absorbing mechanical shock, external fittings, neutron moderators, nonfissible neutron absorbers, and other supplementary equipment.

Material. The radioactive contents of a package are defined as a radioactive material (10 CFR 71.4). For the purposes of RADTRAN 4 analyses, a radioactive material consists of one or more isotopes, each in a specified physical-chemical form. Examples of materials are spent fuel, low-level waste, radiopharmaceuticals, industrial radiography sources, and uranium ore. Examples of isotopes are carbon-14, cobalt-60, and uranium-235. Examples of physical-chemical forms are monolithic solids, divided solids (powders), liquids, and gases. RADTRAN 4 permits the user to distinguish between a material and its constituent isotopes. The user assigns a separate name to each material.

Shipment. A shipment is defined as all the packages in a conveyance because more than one package of radioactive material may be transported together in a single conveyance (tractor trailer, commercial delivery van, railcar, barge, etc.).

Mode. Mode is determined by a combination of the medium in which the transportation event occurs (land, water, or air) and the type of conveyance used. For example, a terrestrial or overland mode is rail, a waterborne mode is barge, and an air mode is commercial air cargo plane. The modes available in RADTRAN 4 are listed in Table 2-1.

In each analysis performed with RADTRAN 4, one or more mode identifiers must be used. Each of the ten transportation modes available in RADTRAN 4 is assigned a numerical identifier shown in Table 2-1. The modes that operate on highways are combination truck (tractor-trailer), commercial delivery van, and passenger van. The two air modes--cargo air and passenger air--are also treated separately. However, generic designations are used with other modes: rail, ship, and barge. Potential operational differences within a mode (e.g., the differences between general rail freight and dedicated rail) may be addressed with user-assigned parameter values.

Table 2-1

RADTRAN 4 Transportation Modes

Mode Name	Mode Number	Mode Description
TRUCK	1	Combination Truck
RAIL	2	Rail*
BARGE	3	Barge
SHIP	4	Ocean-going ship (>3,000 gross tons)
CARGO AIR	5	Cargo air
PASS AIR	6	Passenger air
P-VAN	7	Passenger van or small truck
CVAN-T	8	Cargo van/delivery truck as secondary mode with truck
CVAN-R	9	Cargo van/delivery truck as secondary mode with rail
CVAN-CA	10	Cargo van/delivery truck as secondary mode with cargo air

*One or more railcars in a single train.

3.0 INSTALLATION AND DATA ENTRY

This chapter provides instructions for installing RADTRAN 4 on a mainframe computer and creating RADTRAN 4 input files. These instructions apply only to direct use of RADTRAN 4 on a mainframe computer. Input files also may be created by TRANSNET users with the RADTRAN input file generator (Cashwell, 1989). Data entry in RADTRAN 4 is in free format and is keyword-based. The keyword-based system allows most of a data set to be input in any order. Keywords and data can appear anywhere in an 80-character line.

The options available for creating a useful data set are related to the characteristics of the material to be shipped, the way the material is packaged, and the mode of shipment. Defaults are available for some parameters. If the user does not enter values for parameters for which default values are available, then default values are automatically used.

3.1 RADTRAN 4 Installation and Use on a Mainframe Computer

Installation

Users may request an executable version of RADTRAN 4 for installation on a mainframe computer. RADTRAN 4 is resident on a Digital Equipment Corporation (DEC) VAX computer at SNL, and the following systems requirements list is based on the configuration that supports RADTRAN at SNL:

- DEC VAX 3800 with VMS 5.4 Operating System and at least 16 megabytes of memory
- DEC VT100 terminal (or any other DEC terminal)
- Any compatible keyboard
- Any printer capable of text printing (e.g., DEC LN03)

Other systems also will support RADTRAN, but the installation procedure and other features may differ from those given here. Users with other system configurations are encouraged to contact SNL for assistance.

Unless special arrangements have been made, the user receives a copy of RADTRAN 4 on tape in DEC VAX/VMS BACKUP utility format. A hard copy listing of the exact command used to back up the file is provided. This listing will show the file name of the executable file on the tape and the label name. To install RADTRAN on a DEC VAX VMS Version 5.0 or higher, the user must first load the tape (or have the System Manager load the tape) on a tape drive connected to the user's system. After logging on to the system, the user or System Manager must retrieve the file by typing the following:

```
MOUNT/FOREIGN tape_drive_name:<carriage return [↵]>
BACKUP/REWIND/IGNORE=LABEL -
tape_drive_name:radtran_file_name/SAVE_SET -
user"s_disk:[directory_path]radtran_file_name [↵]
DISMOUNT tape_drive_name:[↵]
```

EXAMPLE: If the tape drive name is MUA0, the RADTRAN file name is RT4.EXE, and the user"s disk is DUB0, then the preceeding instructions would appear as follows:

```
MOUNT/FOREIGN MUA0:[↵]
BACKUP/REWIND/IGNORE=LABEL MUA0:RT4.EXE/SAVE_SET -
DUB0:[directory_path]RT4.EXE[↵]
DISMOUNT MUA0:[↵]
```

Note that the [directory_path] is user-dependent and cannot be specified in advance. All RADTRAN files will appear in the directory created by the user.

After the file has been retrieved, the tape should be removed by the user or System Manager. The user then sets the default directory to the directory that now contains the RADTRAN executable file:

```
SET DEFAULT user"s_disk:[directory_path][↵]
```

In the example given above, the command would appear as follows:

```
SET DEFAULT DUB0:[directory_path][↵]
```

In case of an aborted installation, repeat the procedure outlined above. If the second attempt fails, then contact personnel at SNL.

Creating an Input File

After installation is completed, the next step is to create an input data file, which should be an ordinary text file in the directory created by the user during installation. Any available editor (e.g., EDT) may be used to create such a file. To begin creating a text file named MYFILE.DAT with EDT, the first command is:

```
EDIT/EDT MYFILE.DAT[↵]
```

Enter subsequent lines of text in MYFILE.DAT according to the guidance given elsewhere in this User Guide. The next step is to copy your file to the RADTRAN input file name:

```
COPY MYFILE.DAT FILE2.DAT[↵]
```

Running RADTRAN 4

After copying your input file to the RADTRAN input file name, you are ready to run your input file on RADTRAN 4 using the following command:

RUN RT4[↵]

The file should take only a few moments to run. When the run is complete, the user will see the words FORTRAN STOP, and then the prompt will appear on the screen. The name of the main RADTRAN output file is FILE4.DAT. No instructions are provided for obtaining a printed copy of the output file because the commands vary greatly from system to system. To review the output on the screen, use the following command:

EDIT/EDT FILE4.DAT[↵]

This filename applies only to RADTRAN 4 run on a mainframe computer. Users of RADTRAN 4 on TRANSNET see this same file under the name RADTRAN4.OUT. The user is advised to review the output on-screen in case there are any error messages. Error messages are described in Appendix D.

Saving Output Files

If the user wishes to save an output file, then it should be copied and renamed. Otherwise, the file could be overwritten after subsequent runs. The user should be aware that additional output files are generated for each run which are not normally displayed but which the user may wish to save. They contain the probability-consequence data pairs used to generate accident risk estimates. These data also may be used to generate tabular or graphic displays of probability-consequence relationships, as discussed in Appendix C. These output files are:

- FILE6.DAT, which contains all the probability-consequence pairs that are sorted into three separate categories in FILE10.DAT, FILE11.DAT, and FILE12.DAT, respectively;
- FILE10.DAT, which contains the sorted dose (person-rem) or latent cancer fatality consequences with summed probabilities;
- FILE11.DAT, which contains the sorted genetic effects consequences with summed probabilities; and
- FILE12.DAT, which contains the sorted economic impact consequences with summed probabilities.

These files also must be copied and renamed if the user wishes to save them.

3.2 Data Fields and Delimiters

The user must create and enter an input file into the RADTRAN 4 code containing all required user-defined parameters. Table 3-1 lists the array index symbols and values used in Table 3-2. Table 3-2 charts the procedure for creating a user input file in RADTRAN 4 and gives the description and parameters of each type of data to be input.

A RADTRAN input file is an ASCII text file consisting of keywords, numbers, and alphanumeric labels entered as fields of ten characters or

less and separated by one or more of the following delimiters: a blank space, comma, equal sign, or right and left parentheses. Fields can appear anywhere in the 80-character line, but may not be split and continued on the next line. Field values (i.e., keywords, numbers, or labels) must not contain embedded blanks, commas, equal signs, or parentheses because these are delimiter characters that denote the end of a field.

The first-level keywords, which are listed in the first column of Table 3-2, must be input before each category of data. Following the entry of a first-level keyword and a space, second-level keywords followed by third-level keywords are entered on the same line or the following line, and then are followed by the required data. These second and third-level keywords are shown in the second and third columns of Table 3-2. A first-level keyword is not always followed by a second- or third-level keyword. As illustrated in the DIMEN category in Table 3-2, the data directly follow the first-level keyword, separated by spaces or other delimiters. The "or" separating two keywords in Table 3-2 indicates that the user may choose one of the keywords, but not both, in a single analysis.

The fourth column in Table 3-2 gives the code name of the type of data to be entered, but it is not entered by the user. This column and the Description column also include array index values, indicated by letters in parentheses, that refer to the Table 3-1 key. The Description column describes the data to be entered after each keyword and, when appropriate, the units of the variables.

Integer data can be input as floating-point numbers with truncation. Floating-point variables can be entered as integers and converted internally to floating-point numbers. Entry formats for exponentials can be either 9.99E+1 or 99.9. Field values (keyword, number, or label) must not contain embedded blanks, commas, equal signs, or parentheses because these are delimiter characters that denote the end of a field.

A special delimiter character, the asterisk (*), is entered only in numeric-array fields to designate a repeat character. For example, to repeat the number 10.1 six times, enter 6*10.1. Blanks cannot appear in the field. The asterisk must not be used in the data for DIMEN or PARM or in any alphanumeric-label field. A special field consisting of two ampersands (&&) followed by a delimiter causes all subsequent information on that line to be entered as a comment.

3.3 Getting Started

To begin building a data set, four first-level keywords are usually entered by the user: TITLE, FORM, DIMEN and PARM. TITLE, FORM, and DIMEN are always entered. Default values are available for the PARM flags; therefore, this keyword is only entered if the user does not wish to accept the default values. Each of these keywords is discussed below.

TITLE. The first input line must be a title record. The line must begin with the keyword TITLE followed by at least one space. Thus, the

Table 3-1

Array Index Symbols and Values for Creating an Input File in RADTRAN 4

Key to Array Index Values
I = 1 to NISO
J = 1 to NGROUP
K = 1 to 3, where 1 = rural 2 = suburban 3 = urban
L = 1 to 25
M = 1 to NSEV
N = 1 to NAREAS
P = 1 to 5
Q = 1 to 8, For NONUNIT only, where 1 = lung (1-year) 2 = marrow (1-year) 3 = gonads 4 = large lower intestine 5 = thyroid 6 = bone (50-year) 7 = lung (50-year) 8 = marrow (50-year)
R = 1 to 6
S = 1 to NRAD
U = 1 to 4
i = isotope index (maximum = 65)
k = isotope index in internal library (maximum = 125)
j = route-segment index (maximum = 40)
m = material index (maximum = 12)

Table 3-2

Creating an Input File in RADTRAN 4

Keyword			Name of Array or Variable To Be Filled	Description
1st Level	2nd Level	3rd Level		
TITLE				80-character alphanumeric title
FORM	UNIT			UNIT = population dose calculation
	NONUNIT			NONUNIT = health effects calculation
DIMEN			NISO	Number of isotopes (maximum = 65); no default
			NSEV	Number of accident-severity categories (maximum = 20); no default
			NGROUP	Number of physical-chemical groups (maximum = 15); no default
			NRAD	Number of radial areas used for nondispersal accident analysis (maximum = 15); no default
			NAREAS	Number of areas used in dispersion accident analysis (maximum = 30); no default
PARM			IRNKC	Flag for placing data on file 6; default = 1 1 = yes; (any other integer) = no

Table 3-2 (Continued)

Creating an Input File in RADTRAN 4

Keyword			Name of Array or Variable To Be Filled	Description
1st Level	2nd Level	3rd Level		
			IANA	Analysis flag; default = 3 1 = incident-free only 2 = accident only 3 = both
			IUOPT	Shielding option flag; default = 2 1 = persons in buildings fully shielded 2 = persons in buildings exposed at reduced level 3 = no shielding is considered.
			ISEN	Flag for printing sensitivity analysis and input tables; default = 3 1 = incident-free and accident output tables 2 = incident-free and accident output output tables, and early effects and ground contamination tables ≥ 3 = incident-free and accident-output tables, early effects and ground contamination tables, and sensitivity and consequence tables
			IPSQSB	Dispersal Accident Flag; default = 0 1 = Pasquill stability frequencies of preset dilution factors (Any other integer) = user-supplied time-integrated concentration isopleths and areas

Table 3-2 (Continued)

Creating an Input File in RADTRAN 4

Keyword			Name of Array or Variable To Be Filled	Description
1st Level	2nd Level	3rd Level		
POPDEN			POPDEN(1)	Rural population density (people/km^2); default = 6
			POPDEN(2)	Suburban population density (people/km^2); default = 719
			POPDEN(3)	Urban population density (people/km^2); default = 3,861
PACKAGE	LABGRP or LABPKG		LABGRP(J)	Alphanumeric identifiers for physical-chemical groups
	PKGSZ1		PKGSZ1	First package-size threshold (m); if PKGSIZ ≤ PKGSZ1, then package is moved by hand; default = 0.5
	PKGSZ2		PKGSZ2	Second package-size threshold (m); if PKGSZ1 < PKGSIZ ≤ PKGSZ2, then the package is handled with a forklift; if PKGSIZ > PKGSZ2, then the package is handled with heavy equipment; default = 1.0
SHIPMENT	LABISO or LABMAT		LABISO(I)	Alphanumeric isotope designators

Table 3-2 (Continued)

Creating an Input File in RADTRAN 4

Keyword			Name of Array or Variable To Be Filled	Description
1st Level	2nd Level	3rd Level		
NORMAL	NMODE		NM	Mode number (see Table 2.1)
			DNORML (NM,L)	Normal (incident-free) transportation parameters for mode = NM; defaults in Chapter 3.0
	or			
	FTZNR	NMODE	NM DNORML (NM,1)	Fraction of travel in rural zone for mode = NM
	FTZNS	NMODE	NM DNORML (NM,2)	Fraction of travel in suburban zone for mode = NM
	FTZNU	NMODE	NM DNORML (NM,3)	Fraction of travel in urban zone for mode = NM
	VELR	NMODE	NM DNORML (NM,4)	Velocity in rural zone for mode = NM (km/hr)
	VELS	NMODE	NM DNORML (NM,5)	Velocity in suburban zone for mode = NM (km/hr)
	VELU	NMODE	NM DNORML (NM,6)	Velocity in urban zone for mode = NM (km/hr)
	CREWNO	NMODE	NM DNORML (NM,7)	Number of crew on a shipment by mode = NM

Table 3-2 (Continued)

Creating an Input File in RADTRAN 4

Keyword			Name of Array or Variable To Be Filled	Description
1st Level	2nd Level	3rd Level		
	ADSTCW	NMODE	NM DNORML (NM,8)	Average distance from radiation source to crew during shipment by mode = NM (m)
	HANDNO	NMODE	NM DNORML (NM,9)	Number of handlings per shipment by mode = NM
	STOPTIM	NMODE	NM DNORML (NM,10)	Stop time for shipment by mode = NM (hr/km)
	MINST	NMODE	NM DNORML (NM,11)	Minimum stop time per trip for shipment by mode = NM (hr)
	TIMZR	NMODE	NM DNORML (NM,12)	Distance-independent stop time per trip; used only for rail mode (hr)
	FMINCL	NMODE	NM DNORML (NM,13)	Minimum number of rail inspections or classifications; rail mode only
	PDST	NMODE	NM DNORML (NM,14)	Number of persons exposed during shipment by mode = NM is stopped
	RST	NMODE	NM DNORML (NM,15)	Average exposure distance when stopped during shipment by mode = NM is stopped (m)
	DTSTOR	NMODE	NM DNORML (NM,16)	Storage time per shipment by mode = NM (hr)

Table 3-2 (Continued)

Creating an Input File in RADTRAN 4

Keyword			Name of Array or Variable To Be Filled	Description
1st Level	2nd Level	3rd Level		
	PDSTOR	NMODE	NM DNORML (NM,17)	Number of persons exposed during storage for shipment by mode = NM
	RSTOR	NMODE	NM DNORML (NM,18)	Average exposure distance during shipment by mode = NM when shipment is stored (m)
	PPV	NMODE	NM DNORML (NM,19)	Number of persons per vehicle sharing the transport link for mode = NM
	FRSHR	NMODE	NM DNORML (NM,20)	Fraction of urban travel during rush hour by mode = NM
	FCTST	NMODE	NM DNORML (NM,21)	Fraction of urban travel on city streets by mode = NM
	FTLFWY	NMODE	NM DNORML (NM,22)	Fraction of rural and suburban travel on freeways by mode = NM
	TCNTPR	NMODE	NM DNORML (NM,23)	One-way traffic count in rural zones for travel by mode = NM (vehicle/hr)
	TCNTPS	NMODE	NM DNORML (NM,24)	One-way traffic count in suburban zones for travel by mode = NM (vehicle/hr)

Table 3-2 (Continued)

Creating an Input File in RADTRAN 4

Keyword			Name of Array or Variable To Be Filled	Description
1st Level	2nd Level	3rd Level		
	TCNTPU	NMODE	NM DNORML (NM,25)	One-way traffic count in urban zones for travel by mode = NM (vehicles/hr)
	RPD		RPD	Ratio of pedestrian density to residential population density in urban areas; default = 6.0
	RR		RR	Building shielding factor for rural zones; default = 1.0
	RS		RS	Building shielding factor for suburban zones; default = 0.87
	RU		RU	Building shielding factor for urban zones; default = 0.018
	FNOATT		FNOATT	Number of flight attendants for commercial passenger-air mode; default = 4
TRANSFER	GAMMA NEUTRON		COEF(1,P) COEF(2,P)	P = 1,5 P = 1,5

Table 3-2 (Continued)

Creating an Input File in RADTRAN 4

Keyword			Name of Array or Variable To Be Filled	Description
1st Level	2nd Level	3rd Level		
ACCIDENT	ARATMZ	NMODE	NM ARATMZ (NM,K)	Accident rates for mode = NM in three population densities (accidents/km): defaults in Chapter 3.0
	SEVFRC	NPOP NMODE	NP NM SEVFRC (NM,M,NP)	Number of Population Density Zone Number of Mode Fraction of accidents for mode = NM for population zone = NP, for each severity; defaults in Chapter 3.0
MATERIAL	RPCVAL	NISO or NMAT	ISO RPCVAL (ISO,Q)	Factors that determine dose to eight organs per unit of radioactivity of isotope = ISO in LABISO inhaled (rem/Ci isotope inhaled/Ci released); all values initialized to 0
	INGVAL	NISO or NMAT	ISO INGVAL (ISO,Q)	Factors that determine dose to 8 organs per unit of radioactivity of isotope = ISO in LABISO ingested (rem/Ci ingested); all values initialized to 0

Table 3-2 (Continued)

Creating an Input File in RADTRAN 4

Keyword			Name of Array or Variable To Be Filled	Description
1st Level	2nd Level	3rd Level		
DEFINE				Used to store isotope specific data in internal data library; only used for isotopes not already defined or to redefine an isotope already present
			ISONAM (k)	Name of isotope
			ACCDNT (1,k)	Half-life of isotope (days)
			ACCDNT (2,k)	Photon energy (MeV)
			ACCDNT (3,k)	Cloudshine-dose factor (rem-m^3/Ci-sec)
			ACCDNT (4,k)	Effective dose equivalent for inhalation (rem/Ci inhaled)
			ACCDNT (5,k)	Effective dose equivalent for ingestion (rem/Ci ingested)
			ACCDNT (6,k)	Food transfer factor (Ci ingested/Ci incorporated in food)
			ACCDNT (7,k)	Soil transfer factor (Ci ingested/Ci deposited on food)
			ACCDNT (8,k)	Deposition velocity of aerosol (m/sec)
			ACCDNT (9,k)	Numerical designator that assigns an acute pulmonary dose-response curve to the isotope 1 = short half-life (<365 days) 2 = long half-life; low LET 3 = long half-life; high LET

Table 3-2 (Continued)

Creating an Input File in RADTRAN 4

Keyword			Name of Array or Variable To Be Filled	Description
1st Level	2nd Level	3rd Level		
			ACCDNT (10,k)	One-year inhalation dose to lung (rem/ Ci inhaled)
			ACCDNT (11,k)	One-year inhalation dose to marrow (rem/ Ci inhaled)
RELEASE	RFRAC	GROUP or NPTYPE	IGRP RFRAC (IGRP,M)	Fraction of each physical-chemical group released in accident of each severity; all values initialized at 0
	AERSOL	DISP or NIM	IDSP AERSOL (IDSP,M)	Fraction of isotope of each dispersion category that is released in aerosol form in an accident of each severity; defaults in Chapter 3.0
	RESP	DISP or NIM	IDSP RESP (IDSP,M)	Fraction of aerosolized isotope of each dispersion category that is respirable in an accident of each severity
	AREADA		AREADA(N)	Area (m^2) of each isodose area; not required if IPSQSB = 1; defaults in Chapter 3.0

Table 3-2 (Continued)

Creating an Input File in RADTRAN 4

Keyword			Name of Array or Variable To Be Filled	Description
1st Level	2nd Level	3rd Level		
	DFLEV		DFLEV (N)	Time-integrated concentration of radionuclide in aerosol in each isodose area; not required if IPSQSB = 1; defaults in Chapter 3.0
	PSPROB		PSPROB(R)	Probability of occurrence of each of six Pasquill atmospheric stability categories; only required if IPSQB = 1
OTHER	RADIST	NPOP	NP RADIST (S,NP)	Radii that define the exposure annuli used in nondispersal accident model in population zone (NP) (in m)
	BDF		BDF	Building dose factor; default value in Chapter 3.0
	XFARM		XFARM	Fraction of rural land under cultivation; default in Chapter 3.0
	CULVL		CULVL	Cleanup level following an accident (uCi/m^2); default in Chapter 3.0
	BRATE		BRATE	Breathing rate (m^3/s); default in Chapter 3.0

Table 3-2 (Continued)

Creating an Input File in RADTRAN 4

Keyword			Name of Array or Variable To Be Filled	Description
1st Level	2nd Level	3rd Level		
	ITRAIN		ITRAIN	For rail mode only; If general freight, ITRAIN = 1 (exposure factor is set to 0.16) If dedicated rail, ITRAIN = 2 (exposure factor is set to 0.01)
ECONOMIC	ECONF		ECONF	Economic factor to account for inflation; basic output is in 1980 dollars; default is 0.0.
	ONSCST		ONSCST(U)	Cost associated with transport link restoration; four values correspond to the following release fraction (RF) ranges: RF = 0; 0 < RF ≤ .01; .01 < RF ≤ 0.1; RF > 0.1. Defaults are 0.0.
	EMRCST		EMRCST(M)	Immediate response cost for one accident of each severity. NSEV values are required. Defaults are 0.0.
EOF				

Table 3-2 (Continued)

Creating an Input File in RADTRAN 4

Keyword			Name of Array or Variable To Be Filled	Description
1st Level	2nd Level	3rd Level		
ISOTOPES	[Repeat entire ISOTOPES sequence for each mode and material in analysis.]			
			NM	Transport mode to be analyzed (negative value = exclusive use)
			TABSPY(NM)	Number of shipments
			PKGSHP(NM,m)	Number of packages per shipment (must be identical packages)
			TIPKG(NM,m)	Package dose rate at 1 m (mrem/hr)
			FRGAMA (m)	Fraction of effective dose rate that is gamma radiation
			FRNEUT (m)	Fraction of effective dose rate that is neutron radiation (must equal 1-FRGAMMA)
			LABMAT (m)	Material label entered here (followed by [↵])

Table 3-2 (Continued)

Creating an Input File in RADTRAN 4

Keyword			Name of Array or Variable To Be Filled	Description
1st Level	2nd Level	3rd Level		
			LIBSAV (i)	Name of ith isotope; must be equivalent to name in LABISO array; must be a name in internal data library or defined by user with DEFINE
			CIPKG (i)	Isotope-specific curies per package for isotope i
			IPCGRP (i)	Isotope-specific physical-chemical group for isotope i; must be identical to a group label entered in LABGRP
			IDISP (i)	Isotope-specific dispersability category for isotope i (followed by [↵])
For each isotope in material, repeat the sequence [LIBSAV (i), CIPKG (i), IPCGRP (i), IDISP (i) (followed by [↵])				
	PKGSIZ	[material name]	PKGSIZ (m)	Characteristic package dimension for material m (m); note that the actual material name must be used, followed by the package dimension
For each material in shipment, repeat the sequence [PKGSIZ name of mth material, PKGSIZ (m)]; maximum number of materials = 12.				

Table 3-2 (Continued)

Creating an Input File in RADTRAN 4

Keyword			Name of Array or Variable To Be Filled	Description
1st Level	2nd Level	3rd Level		
	DISTKM or	NMODE	NM DISTKM(NM)	Distance for mode NM (km)
Use DISTKM as alternative to LINK for aggregated data; repeat sequence [NMODE, NM, DISTKM(NM)] for each mode.				
	LINK		LMODE (j)	Numerical mode designator for travel on jth route segment (link j)
			LDIST (j)	Length of jth route segment (link j) (km)
			LSPED (j)	Speed of vehicle on jth route segment (link j) (km/hr)
			LPOPD (j)	Population density along jth route segment (link j) (persons/km^2)
			LVDEN (j)	One-way vehicle density (traffic count) on jth route segment (link j) (vehicles/hr)
			LARAT (j)	Accident rate on jth route segment (link j) (accidents/km)

Table 3-2 (Concluded)

Creating an Input File in RADTRAN 4

Keyword			Name of Array or Variable To Be Filled	Description
1st Level	2nd Level	3rd Level		
			LZONE (j)	Zone type designator for jth route segment (link j) R = rural S = suburban U = urban
			LTYPE (j)	Link type designator for jth route segment (link j) 1 = freeway (for LMODE = 1,7,8,9,10) 2 = nonfreeway (for LMODE = 1,7,8,9,10 3 = all other (for LMODE = 2,3,4,5,6)
Repeat LINK sequence [LINK, LMODE(j) through LTYPE(j)] for each route-segment analyzed; maximum number of segments = 40				
EOF				
EOI				

actual user-assigned title may not exceed 74 alphanumeric characters in length.

FORM. The second line must start with the keyword FORM followed by at least one space and either UNIT or NONUNIT (second-level keywords). As indicated in Table 3-2, this determines the form of the output: either UNIT for population dose or NONUNIT for health effects.

DIMEN. With DIMEN the dimensions of five arrays are specified. The dimensions are NISO, NSEV, NGROUP, NRAD, and NAREAS. NISO is the total number of isotopes in the array entered under the keyword LABISO. The maximum NISO value is 65. NSEV is the number of accident-severity categories that will be used in the analysis (maximum = 20). NGROUP is the number of physical-chemical isotope groups (maximum = 15). NRAD is the number of radial distances to be used in nondispersal accident analysis (maximum = 15), and NAREAS is the number of downwind dose and deposition areas to be used in dispersal accident analysis (maximum = 30). DIMEN must be entered on the third line and is followed by five ordered, numeric fields specifying the dimensions of the arrays.

PARM. With PARM, the user sets the following five flags that control certain parameter sets:

1. IRNKC is the flag for placing data in output files FILE6.DAT, FILE10.DAT, FILE11.DAT, and FILE12.DAT for probability-consequence plots; the default is yes (IRNKC = 1);

2. IANA is the flag with which the user selects incident-free analysis, accident analysis, or both; the default is both (IANA = 3);

3. IUOPT is the urban building flag for selecting the building shielding option; the default accounts for shielding with a building shielding factor (IUOPT = 2);

4. ISEN is the flag for choosing the level of output; the default is the full output (ISEN = 3); and

5. IPSQSB is the flag for selecting Pasquill stability categories or user-supplied time-integrated concentration isopleths and areas; the default is user-supplied data (IPSQSB = 0).

If the user wishes to alter the default value for any parameter(s) subordinate to PARM, the keyword PARM should be entered on the fourth line of the data set followed by the string of values. If the user omits PARM, then the default settings for all subordinate parameters are used.

3.4 Building a Data Set

After TITLE, FORM, DIMEN, and PARM have been entered, any other keywords, with the exception of ISOTOPES, DISTKM, PKGSIZ, and LINK, may follow in any order as long as the hierarchical relationship between the keywords is observed. After a keyword is entered, data arrays of the proper size are entered (Table 3-2). ISOTOPES, LINK, DISTKM, and PKGSIZ

are discussed in the following section. For any analysis, values must be entered by the user for the following types of parameters:

- parameters without default values, and
- parameters with default values that must be changed for the problem being analyzed.

If values are not entered by the user for any parameter for which default values are available, then the default values are used in the analysis. Clearly, altering the value of a variable possessing a default value has no effect on the result of a calculation if that parameter is not used in the calculation. See the RADTRAN 4 Technical Manual for detailed descriptions of RADTRAN 4 calculations (Neuhauser and Kanipe, in preparation [b]).

Optional Economic Parameters

Three parameter arrays are included under the first-level keyword ECONOMIC. These parameter arrays may be used to generate an estimate of the immediate costs associated with various severities of accidents. The second-level keyword ECONF (from ECONomic Factor) calls for a single value that may be used to adjust for inflation. This and all other ECONOMIC parameters have default values of zero, and use of the RADTRAN 4 economic model is optional. If no values are entered by the user, no cost estimates will be included in the output. The economic model itself is discussed in the RADTRAN 4 Technical Manual (Neuhauser and Kanipe, in preparation [b]). ECONF may be set to 1.0 to reproduce results of earlier analyses, but it may also be used to upwardly adjust these results to present-day dollar values.

The second-level keyword ONSCST is used to specify an array of four material-specific values for on-scene costs (ON-Scene CoST). These are the costs of decontamination and restoration of the area surrounding hypothetical accident sites. These values increase as the release fraction (and hence the level of contamination) increases. The first value is a basic cost for accidents in which there was no release [release fraction (RF) = 0]; it represents the minimal cost of determining that there was in fact no release and dispersal. The second value in the array is a cost estimate for accident in which $0 < RF \leq 0.01$; the third value is a cost estimate for accident in which $0.01 < RF \leq 0.10$; and the fourth value is a cost estimate for accidents in which $RF > 0.10$.

The third and final second-level keyword under ECONOMIC is EMRCST, which calls for an array of M values (where M = the number of accident severity categories, NSEV). These values represent estimates of emergency response costs (EMergency Response CoST); that is, the cost of law enforcement, fire prevention, health service personnel, and equipment that would respond to an accident of each severity. These estimates are mode-specific, but unlike the values entered under ONSCST, they have little or no relationship to the radioactive material content of the shipment. One should also be aware that other unquantifiable costs such as those that might be associated with litigation, government actions, loss of business

income, etc., cannot be accounted for with a code such as RADTRAN even though they might be significant.

3.5 ISOTOPES, LINK, DISTKM, and PKGSIZ

The keyword EOF (end of file) must appear after all data are entered except for the following instances:

- values entered with ISOTOPES,
- route-specific information entered under LINK or nonroute-specific trip length entered under DISTKM, and
- characteristic package dimension (PKGSIZ) for each material.

ISOTOPES is a first-order keyword that leads to arrays of material-level and isotope-level information for the package(s) being analyzed. After the keyword EOF, the user must enter the keyword ISOTOPES and all required parameter values. If more than one mode or material is analyzed, then the entire sequence (i.e., keyword ISOTOPES followed by all required parameter values) must be repeated for each mode or material.

If a route-specific analysis is performed, then the first-order keyword LINK is also entered after the keyword EOF, followed by the appropriate segment-specific data for each route segment. If the analysis is not route-specific, then the full trip length must be entered under the keyword DISTKM for each mode used in the analysis.

For all analyses, the characteristic package dimension for each material must be entered under PKGSIZ.

There are two restrictions on the order in which these four keywords are entered (with their associated subordinate keywords and parameter-value arrays) after the first EOF. These restrictions are that (1) ISOTOPES must be the first keyword entered, and (2) PKGSIZ cannot be entered until after all materials and isotopes have been identified. Entry of data under these keywords is terminated with a second EOF. If the user wishes to evaluate a second route in the same run with either LINK or DISTKM, then the second set of parameters may be entered after the second EOF. Entry of these data must be terminated with a third EOF. This procedure may be repeated several times. The entire data set is always terminated with the keyword EOI (end of input).

3.6 Output Format and Echo Check

The first part of the output for any RADTRAN 4 run is the echo check, which repeats or "echoes" the input data set. The echo check shows the following:

- the user-defined values of parameters without defaults, and
- the values of parameters with defaults which the analyst altered.

If no value appears in the echo check for a particular parameter, then a default value was used. The echo check, therefore, preserves directly or indirectly all parameter values used in an input data set and, thus, is useful for performing a quality-assurance function. The echo check portion of the output may not be suppressed by the user, and any RADTRAN 4 output lacking the echo check pages should be considered incomplete and unsuitable for either publication or quality-assurance purposes.

3.7 Default Input Data

3.7.1 RADTRAN 4 Radionuclide Library Data

As shown in Appendix B, Common Block P contains data arrays for all isotopes in the internal data library. Each array contains eleven numbers. These correspond to the following:

1--half-life (days),
2--photon energy (MeV/disintegration),
3--cloudshine dose factor (rem-m^3/Ci-sec),
4--50-yr committed effective dose equivalent for inhalation (rem/Ci inhaled),
5--50-yr committed effective dose equivalent for ingestion (rem/Ci ingested),
6--food transfer factor (Ci ingested/Ci deposited),
7--soil transfer factor (Ci ingested/Ci deposited),
8--deposition velocity of aerosol particles (m/sec),
9--lung type for early effects calculations,,
10--1-yr lung dose for inhalation (rem/Ci inhaled), and
11--1-yr marrow dose for inhalation (rem/Ci inhaled).

Each parameter is defined and discussed briefly below. The units of each parameter are given and sources are cited. Special treatment of particular isotopes are also identified.

Half-life. The term half-life is used to describe the radioactive decay of an isotope. The units are days. All values are taken from Radionuclide Transformations, Energy and Intensity of Emissions, Publication 38 of the International Commission on Radiological Protection (ICRP) (ICRP, 1983).

Photon Energy. The energy of the photons emitted by an isotope is used to calculate the groundshine dose for that isotope. The units are MeV/disintegration. All values are taken from ICRP 38 (1983). To simplify the analysis, each decay, regardless of whether it is a single photon or a cascade, is treated as a single photon decay with an energy equal to the difference between the initial and ground states of the radionuclide. The values given are taken from the column titled "y(i)xE(i)" (i.e., the average energy emitted per transformation) in Section 3 of Radionuclide Transformations, Energy and Intensity of Emissions (ICRP, 1983).

Photons emitted by short-lived daughter products of certain isotopes have been added to the nominal photon energy (if any) of the parent isotope, but the half-life of the daughter is neglected. In other words, the parent isotope is treated as though every transformation produced a

photon equal in energy to that of the parent (if any) plus that of the daughter. Because the isotopes for which this approach was used have half-lives that are large in comparison with the half-lives of the daughter nuclides, this gives a suitably realistic value for photon energy for the analyses performed by RADTRAN 4. In several cases, the daughters are gamma emitters while the parent nuclides are not. Thus important sources of gamma radiation are adequately accounted for in the groundshine dose estimation.

Isotopes with short-lived daughters included are the following:

- molybdenum-99, which has a daughter, technetium-99m (87.6 percent yield), with a half-life of 6 hr and a photon energy of 1.26E-01 MeV/transformation;
- ruthenium-103, which has a daughter, rhodium-103m (99.7 percent yield), with a half-life of 56 min and a photon energy of 1.75E-03 MeV/transformation;
- ruthenium-106, which has a daughter, rhodium-106, (100 percent yield), with a half-life of 29.9 sec and a photon energy of 2.01E-01 MeV/transformation;
- cesium-137, which has a daughter, barium-137m (94.6 percent yield), with a half-life of 2.6 min and a photon energy of 5.96E-01 MeV/transformation; and
- cerium-144, which has a daughter, praseodymium-144 (98.2 percent yield), with a half-life of 17.3 min and a photon energy of 3.18E-02 MeV/transformation. The remainder of the yield is also a short-lived isotope, praseodymium-144m, but its photon energy is very low and is neglected here.

Cloud Dose Factor. The units of this parameter are rem-m^3/Ci-sec. This factor is the effective dose-rate factor for immersion in air contaminated with the specified isotope, and it is used to calculate cloudshine dose. All values are taken from DOE-0070 (1988a) and converted from mrem-m^3/μCi-yr to rem-m^3/Ci-sec.

Committed Effective Dose Equivalent for Inhalation. This parameter describes internal radiation exposure (50-yr dose commitment) resulting from inhalation of respirable aerosol particles of each isotope. Units are rem/Ci of respirable aerosol inhaled. Most values are for 0.3 micron activity mean aerodynamic diameter (AMAD) particle size. The values for this parameter were taken from Dunning (1983) and calculated from equations in Section 1.2.2 of the Internal Dose Conversion Factors for Calculation of Dose to the Public (DOE, 1988b; previously published in ICRP, 1981). Values were also taken from fractions provided by DOE-0071 (1988b) for the highest lung retention class for each isotope.

A population of aerosol particles of plutonium or other dense material with a mean aerodynamic diameter of 0.3 micron has a particle-size distribution such that virtually all the particles could lodge in the pulmonary region of the lung (i.e., they could be less than 10 microns and

greater than 0.1 micron in diameter). This particle-size assumption is conservative for dense materials, and since uranium, plutonium, other transuranics, and spent fuel particulates are all both relatively dense and among the materials most frequently analyzed for transportation risk, the 0.3-micron AMAD values were used as defaults. With DEFINE, the user may redefine an isotope already in the library for a new particle-size distribution, if desired.

Particle size is not a factor for those radionuclides that would be in the gaseous state under accident conditions: tritium gas (H3GAS), carbon-14 dioxide gas (C14GAS), and the noble gases. A 1.0-micron AMAD particle size was used for these low-density liquids and solids: tritiated water (H3WTR) and organic forms of carbon-14 (C14ORG).

Committed Effective Dose Equivalent for Ingestion. This parameter describes internal radiation exposure (50-yr dose commitment) from ingestion of foodstuffs contaminated with the isotope. Units are rem/Ci ingested. All values are taken from the DOE (1988b) or Dunning (1983) and converted from rem/μCi ingested to rem/Ci ingested. The ingestion pathway is used only for dispersal accidents in rural areas because agricultural land use is generally restricted to rural areas. The resulting ingestion dose is a societal dose, however (Ostmeyer, 1986a).

Food Transfer Factor. This parameter describes the relationship between the societal ingestion dose and radionuclides incorporated into food grown or reared on contaminated land. The units are Ci incorporated into food ingested per Ci deposited per m^2 of land under cultivation. Land under cultivation includes all food-chain land uses (dairy pasture, forage crops, cereal grains, leafy vegetable crops, etc.). In anticipation of the development of an external data base that will contain a series of state- or region-specific values for this transfer factor, all values are presently defaulted to zero and the XFARM parameter (fraction of land under cultivation) had been disabled for this calculation. In the interim, users wishing to calculate ingestion doses may employ the DEFINE function to redefine isotopes with nonzero values for food transfer factors (Ostmeyer, 1986a).

Soil Transfer Factor. This parameter describes the relationship between the societal ingestion dose and radionuclides deposited on food grown on contaminated land by dry- and wet-deposition mechanisms. The units are Ci deposited on food ingested per total Ci deposited per m^2 of land under cultivation. In anticipation of the development of an external data base that will contain a series of state- or region-specific values for this transfer factor, all values are presently defaulted to zero and the XFARM parameter (fraction of rural land under cultivation) has been disabled. In the interim, users wishing to calculate ingestion doses may employ the DEFINE function to redefine isotopes with nonzero values for soil transfer factors (Ostmeyer, 1986a).

Deposition Velocity of Aerosol Particles. This parameter describes the settling of dispersed material as it moves downwind from the accident site. It is used to calculate depletion of the aerosol cloud and ground contamination levels. The units are m/sec. Except for tritiated water

(vapor), tritium gas, carbon-14 dioxide gas, and the noble gases, the deposition velocity for aerosol particles of all other isotopes is set to 0.01 m/sec (1 cm/sec). This is the median terminal velocity for 10-micron spherical particles (actual diameter) of densities between one and 10 in air at STP (see Figure 9-6 in Shleien and Terpilak, 1987).

Lung Type for Early Effects Calculations. There are three isotope types for early effects calculations. These calculations determine which dose-response relationship is selected. All isotopes with a half-life less than 365 days are lung type 1. For longer-lived nuclides, a distinction is made between those isotopes that emit only low linear energy transfer (LET) radiation (e.g., gamma photons) and those that emit high LET radiation (e.g., alpha particles). The former are lung type 2 isotopes and the latter are lung type 3. Note that a lung type 3 isotope may produce low LET radiation as well, but the high LET radiation is more biologically damaging when they are in close contact with biological tissue (e.g., when inhaled or ingested) and predominates when present. Lung-type designations were made on the basis of the half-life and radiation type data taken from ICRP 38 (1983).

One-Year Lung Dose for Inhalation. This parameter describes the 1-yr committed dose to the lung from inhalation of respirable aerosol of the given isotope. It is used to calculate early fatalities and early morbidities. The units are rem/Ci inhaled. The values are taken from Dunning (1983) for the highest lung retention class for which values were given for each isotope.

One-Year Marrow Dose for Inhalation. This parameter describes the 1-yr committed dose to bone marrow from inhalation of respirable aerosol of the given isotope. It is used to calculate early fatalities and early morbidities. The units are rem/Ci inhaled. The values were taken from Dunning (1983) for the highest lung retention class for which values were given for each isotope.

3.7.2 Default Data for Incident-Free Dose Calculation by Mode

Twenty-five of the parameters used in the incident-free dose calculation are listed under the first-level keyword NORMAL. The values entered under NORMAL are entered into the DNORML array. Table 3-3 shows the default data in the DNORML array by mode and second-level keyword. The second-level keywords are defined in Table 3-2.

There are two ways to enter data into the DNORML array under first-level keyword NORMAL. The user can enter a second-level keyword (Table 3-3) followed by third-level keyword NMODE and the mode number then the appropriate value. The third-level keyword NMODE, mode numbers, and values can be repeated for all modes if desired. This method is useful if the user wants only to change a few of the default parameters and keep the other default data intact.

Table 3-3

DNORML Array Default Data

Keyword*	Truck	Rail	Barge	Ship	Cargo Air	Passenger Air	Passenger Van	Cargo Vans
FTZNR	0.90	0.90	0.90	0.99	0.88	0.88	0.0	0.0
FTZNS	0.05	0.05	0.09	0.009	0.10	0.10	0.60	0.60
FTZNR	0.05	0.05	0.01	0.001	0.02	0.02	0.40	0.40
VELR	88.49	64.37	16.09	24.16	691.90	691.90	88.49	88.49
VELS	40.25	40.25	8.06	8.06	691.90	691.90	56.34	56.34
VELU	24.16	24.16	3.20	3.20	691.90	691.90	24.16	24.16
CREWNO	2.00	5.00	2.00	10.00	3.00	3.00	1.00	1.00
ADSTCW	3.10	152.40	45.70	61.00	6.10	15.20	2.13	2.13
HANDNO	0.0	2.00	2.00	2.00	4.00	4.00	2.00	6.00
STOPTIM	0.011	0.033	0.01	0.01	0.0016	0.0008	0.0004	0.0004
MINST	0.0	10.00	10.00	10.00	1.00	1.00	0.15	0.15
TIMZR	0.0	60.00	0.0	0.0	0.0	0.0	0.0	0.0
FMINCL	0.0	2.00	0.0	0.0	0.0	0.0	0.0	0.0
PDST	50.0	100.00	50.00	50.00	10.00	1000.00	100.00	100.00
RST	20.0	20.00	50.00	50.00	50.00	50.00	10.00	10.00
DTSTOR	0.0	4.00	24.00	48.00	0.0	0.0	4.00	10.00
PDSTOR	100.0	100.00	100.00	100.00	100.00	100.00	100.00	100.00
RSTOR	100.0	100.00	100.00	100.00	100.00	100.00	100.00	100.00
PPV	2.0	3.00	0.0	0.0	0.0	78.00	2.00	2.00
FRSHR	0.08	0.0	0.0	0.0	0.0	0.0	0.08	0.08
FCTST	0.05	1.00	0.0	0.0	0.0	0.0	0.65	0.65
FTLFWY	0.85	0.0	0.0	0.0	0.0	0.0	0.25	0.25
TCNTPR	470.00	1.00	0.0	0.0	0.0	0.0	470.0	470.0
TCNTPS	780.00	5.00	0.0	0.0	0.0	0.0	780.0	780.0
TCNTPU	2800.00	5.00	0.0	0.0	0.0	0.0	2800.0	2800.0

*Keywords are defined in Table 3-2.

The second method for entering data into the DNORML array is to enter second-level keyword NMODE followed by the mode number and the twenty-five values for the mode. These values must be entered in the order that they appear in Table 3-3. With this method no third-level keywords are required, but all twenty-five values must be entered and all default data for the mode chosen will be overwritten.

When the route-specific LINK option is chosen, the values for velocity, vehicle density, fraction of travel in population density zones, and fraction of rush-hour travel in the DNORML array are ignored. These values are taken instead from the data input after the keyword LINK. To account for rush-hour travel with the LINK option, the user must create links that represent the distance traveled under rush-hour conditions in urban and suburban links. In effect, urban and suburban route segments must be subdivided to indicate what fraction of time they are traversed in rush-hour conditions and what fraction of time they are traversed in nonrush-hour conditions. This is also discussed in Section 4-10.

In addition to the DNORML array, the following lists other flags and variables with default values that may also be used in an incident-free dose calculation.

1. Shielding Option Flag (IUOPT). The default is 2. For this flag, persons in buildings are exposed at reduced rates and dose rates are calculated with the following shielding factors (Finley et al., 1988):

   - Rural Shielding Factor (RR)--the default is 1.0 (i.e., no shielding), which represents a frame dwelling;
   - Suburban Shielding Factor (RS)--the default is 0.87, which is equivalent to a suburban residential structure of masonry construction; and
   - Urban Shielding Factor (RU)--the default is 0.018, which is equivalent to an urban commercial building constructed of reinforced concrete or concrete block.

This system allows a great deal of flexibility. The user may select 1, 2, or 3 for the shielding option flag. Setting the option flag to 1 (full shielding) is equivalent to setting all shielding factors to 0 (everyone indoors receives no exposure). Setting the option flag to 3 is equivalent to setting all shielding factors to 1 (this means being indoors is the same as being outdoors). Further, if the default (flag is 2) is accepted, the user may still separately alter the values of the individual shielding factor values (RR, RS, and RU).

2. Ratio of Pedestrian Density (RPD). This parameter is the ratio of pedestrian density to population density that is used to determine number of unshielded persons exposed in urban areas when IUOPT is not equal to 3. The default value is 6 (Finley et al., 1988).

3. Number of Flight Attendants (FNOATT). This parameter is used for passenger air modes only. The default value is 4 (NRC, 1977).

4. Package Size Thresholds (PKGSZ1 and PKGSZ2). This parameter is used to determine the handling method that will be used for a package, which, in turn, is used in the calculation of handler dose. Defaults for PKGSZ1 and PKGSZ2 are 0.5 m and 1.0 m, respectively. Although it is unlikely that these values will need to be altered, the user has the option do so.

5. ITRAIN Flag. This parameter is used only for rail mode to denote whether shipment is by general freight (ITRAIN = 1) or by dedicated rail (ITRAIN = 2). The difference between the two options is the exposure factor value (EF), which is used to calculate the close-proximity rail workers dose. The EF is defined as the sum of the time and distance ratios for all close-proximity rail workers, which is used in the line-source dose calculation, as described by Ostmeyer (1986b). For general freight, the default value for EF by 0.16 hr/m, and for dedicated rail, 0.01 hr/m.

3.7.3 Default Data for Accident Risk Calculation by Mode and Material Type

Few of the parameters used in the accident risk calculation have default values. Neither of the two most important arrays have defaults: accident-severity fractions and release fractions. The two subordinate arrays specified by dispersibility category (IDISP) do have defaults. Defaults are also available for certain options in the dispersion model. In the latter case, one of two alternative analytical models is selected with the IPSQB flag. If IPSQB = 1, then six sets of tabular data (area and time-integrated concentration) for Pasquill atmospheric stability categories A through F are called up, and the user must assign probabilities of occurrence for each. The values in these tables are fixed and may not be changed, but there are no default values for the probabilities of occurrence. If IPSQB = 2 (or any integer other than 1), then a table of user-definable areas and time-integrated concentrations is called up. In this option, default values from national averages are supplied for the areas and time-integrated concentrations; both may be altered by the user. Since only one set of dispersion values may be used in this option, there is no need to specify a probability of occurrence. The default dispersion values are listed in Table 3-4.

The method of generating the tabular data for Pasquill atmospheric stability categories A through F and the set of national-average time-integrated concentrations is described in the RADTRAN 4, Volume 2, Technical Manual (Neuhauser and Kaniper, in preparation [b]).

There are four additional accident risk parameters for which default values are available:

1. Building Dose Factor (BDF). This factor describes the entrainment of aerosol particles in building ventilation systems (i.e., the fraction of particles of an external aerosol that remain in

Table 3-4

Isopleth Areas and Time-Integrated Concentrations

AREADA (M_SQ)	Time-Integrated Concentration (TIC)*
4.590E+02	3.420E-03
1.530E+03	1.720E-03
3.940E+03	8.580E-04
1.250E+04	3.420E-04
3.040E+04	1.720E-04
6.850E+04	8.580E-05
1.760E+05	3.420E-05
4.450E+05	1.720E-05
8.590E+05	8.580E-06
2.550E+06	3.420E-06
4.450E+06	1.720E-06
1.030E+07	8.580E-07
2.160E+07	3.420E-07
5.520E+07	1.720E-07
1.770E+08	8.580E-08
4.890E+08	5.420E-08
8.120E+08	4.300E-08
1.350E+09	3.420E-08

*TIC units are (Ci-sec/M**3/Ci-released).

aerosol form after passing through a ventilation system) (Finley et al., 1980). The BDF is used to modify inhalation doses to persons in urban structures. The default value is 8.60E-03.

2. Clean-Up Level (CULVL). This factor describes the required level to which contaminated surfaces must be cleaned up (EPA, 1977). The default value is set to the proposed guideline of 0.2 $\mu Ci/m^2$. Note that this value applies to the sum of deposited activity over all isotopes of a multi-isotope material and that the default cleanup value is not widely accepted.

3. Breathing Rate (BRATE). This factor is used to calculate volume of air inhaled (ICRP, 1975). The breathing rate of a standard adult male (3.30E-04 m^3/sec) has been used as the default value.

4. Land Under Cultivation (XFARM). This factor is the fraction of land in areas designated as rural that are devoted to food-chain land uses, including pasture, forage crops, cereal grains, leafy vegetables, etc. (U.S. Bureau of the Census, 1988). The default value is 0.5.

4.0 OPTIONS AND CONSTRAINTS TO CONSIDER WHEN PERFORMING ANALYSES USING RADTRAN 4

RADTRAN 4 requires a relatively large amount of input data. For this reason and because obtaining appropriate values for certain parameters can be difficult, this User Guide provides RADTRAN 4 users with a concise outline of the data requirements (Table 3-2) and default data provided to minimize searching for information (Table 3-3). In addition, some of the analysis strategies developed at SNL are described below to assist the user in selecting the best method for analyzing a particular problem and in reducing the amount of data that must be entered. As a complement to this discussion, representative data sets taken from studies performed at SNL have been annotated and reproduced in Chapter 5.0 of this report.

4.1 Analysis Strategies

Commonly encountered shipment configurations are listed in Table 4-1. Each shipment must contain at least one package.

Table 4-1

Shipment Configurations and Analysis Method

Number of Packages per Conveyance	Analysis Method
1	Isotopes are listed individually; Section 4.3.
≥ 2	Contents of all packages are identical; isotopes are listed individually; Section 4.5.2.
≥ 2	Contents of all packages are not identical; isotopes are listed individually; Section 4.5.4.

In the calculation of incident-free risks, the dose rate in mrem/hr at 1 m from the package or from the vehicle (also called the effective dose rate) is used to estimate the radiation field strength around the package or shipment. This, in turn, is used to calculate doses to persons beside the transport link (off-link) and doses to persons sharing the transport link (on-link).

If the shipment consists of a single package, then the package and shipment dose rates are the same and no adjustments are required. In a multiple-package shipment, the user may enter an individual package dose

rate for each material and allow RADTRAN 4 automatically to sum the individual package dose rates for the number of packages of each type per shipment (PPS). Because of shielding of packages by one another, this will often overestimate the shipment dose rate and the user may wish to make an adjustment. One way to avoid this problem is to treat the shipment as a single effective package. In this case, a single effective dose rate can be measured or calculated and the number of packages per shipment is set to unity (see Section 4.5.1). Doses to handlers and warehouse personnel, however, are always calculated on the package level. If calculation of worker doses is desired and if a shipment-level analysis has been performed to obtain other doses, then a separate package-level run is required to obtain proper values for handler and warehouse worker doses.

Although accidents usually involve an entire shipment (i.e., a vehicle and the package[s] it carries), accident risk calculations must consider the effect of the forces in an accident on each package-material combination, because each combination of package and material type may respond differently. RADTRAN 4 accepts data concerning shipment, package, material, and isotope. The user must be aware of these distinctions when entering data. In Sections 4.2 through 4.8, parameter arrays of special concern are described and additional information is given on the shipment analysis strategies outlined above.

4.2 Importance of the LABISO Array

When analyzing a multiple-isotope material, remember that the LABISO ("label isotope") array (see Table 3-2) must contain the names (labels) of every important constituent isotope in each material considered in the analysis. LABISO is a second-order keyword under SHIPMENT (Table 3-2). The maximum size of the LABISO array is 65. Data entry under the keyword ISOTOPES is closely related to and dependent on the LABISO array. Therefore, care should be taken to ensure that the isotope labels are spelled identically in both places. See Table 4-2 for the isotopes which are included in the RADTRAN 4 default data.

4.3 Shipment Configurations

The shipment configuration selected by the user is determined, in part, by characteristics of the shipment itself and, in part, by the level of detail desired.

After entering the keyword ISOTOPES, the user first enters an ordered array of numbers on the same line (termed the material line). The array specifies the following parameters listed in the required order:

- mode number and the exclusive-use flag (sign of number),
- number of shipments,
- number of packages per shipment,
- effective dose rate (mrem/hr) (at 1 m from package or conveyance),

Table 4-2

Isotopes That Are Included in the RADTRAN 4
Default Data
(Arranged in Order of Increasing Atomic Weight)

Isotope Label	Description	Isotope Label	Description
H3WTR	tritiated water	NB95	niobium-95
H3GAS	tritium gas	MO99	molybdenum-99[a]
C14ORG	carbon-14 in organic form	TC99	technetium-99
C14GAS	carbon-14 dioxide gas	RU103	ruthenium-103[b]
P32	phosphorus-32	RU106	ruthenium-106[c]
S35	sulfur-35	SB125	antimony-125
CA45	calcium-45	TE125M	tellurium-125M
CR51	chromium-51	TE127M	tellurium-127M
MN54	manganese-54	TE127	tellurium-127
FE55	iron-55	TE129M	tellurium-129M
FE59	iron-59	TE129	tellurium-129
CO58	cobalt-58	I125	iodine-125
CO60	cobalt-60	I129	iodine-129
ZN65	zinc-65	I131	iodine-131
GA67	gallium-67	XE133	xenon-133
KR85	krypton-85	CS134	cesium-134
SR89	strontium-89	CS137	cesium-137[d]
SR90	strontium-90	CE141	cerium-141[e]
Y91	yttrium-91	CE144	cerium-144[f]
ZR95	zirconium-95	PR144	cerium-144[g]
NB94	niobium-94	PM147	promethium-147

[a]This includes the short half-life daughter technetium-99m.
[b]This includes the short half-life daughter rhodium-103m.
[c]This includes the short half-life daughter rhodium-106.
[d]This includes the short half-life daughter barium-137m.
[e]This includes the short half-life daughter praseodymium-144.
[f]This includes the short half-life daughter praseodymium-144.

Table 4-2 (Concluded)

Isotopes That Are Included in the RADTRAN 4 Default Data

Isotope Label	Description	Isotope Label	Description
SM151	samarium-151	PU239	plutonium-239
EU152	europium-152	PU240	plutonium-240
EU154	europium-154	PU241	plutonium-241
EU155	europium-155	PU242	plutonium-242
U233	uranium-233	AM241	americium-241
U235	uranium-235	AM243	americium-243
U238	uranium-238	CM242	curium-242
NP237	neptunium-237	CM244	curium-244
PU236	plutonium-236	CF252	californium-252
PU238	plutonium-238		

- fraction of dose rate represented by gamma radiation,
- fraction of dose rate represented by neutron radiation, and
- material name (followed by a [↵]).

Then a list of the isotopes in the material is entered, one isotope per line (isotope lines). For each isotope on each line, the user enters the following parameters:

- isotope name,
- number of curies (Ci),
- physical-chemical group label, and
- dispersibility category (followed by a ↵).

Recall that the isotope names in the LABISO array must be the same as those used in ISOTOPES. This rule applies even to the simplest possible shipment

configuration: a single package containing a material consisting of a single isotope. In this case, only one isotope line appears below the material line. There must be at least one isotope line for each material. The only restriction on the material name is that it may not exceed ten letters in length, but isotope names must be in standardized format to call the proper values for half-life, photon energy, etc., from the internal radionuclide data library. The standard names of all isotopes available in the isotopes library are listed in Table 4-2.

If an analysis is being performed on a package containing isotopes not found in the internal library, then the user may use the DEFINE option to add the new isotopes to the internal data library. The DEFINE option may also be used to define (1) isotope forms that differ significantly either physically or chemically from the form described in the data library or (2) composite isotopes that are actually weighted-averages of several isotopes. The latter approach may allow simplified analyses, but is of limited usefulness. The assignment of physical-chemical groups and dispersibility categories is discussed in Section 4.8.

Multiple-package shipments in which the packages can be treated as if they are identical may be treated as a single effective package for analytical purposes, as described in Section 4.5.

4.4 Characteristic Package Dimension

In every analysis the user must enter a value for characteristic package dimension (PKGSIZ) in meters for each package type. For example, for cylindrical packages, PKGSIZ is usually length (see Chapter 4.0 in the RADTRAN 4 Technical Manual [Neuhauser and Kanipe, in preparation [b]]). In RADTRAN 4 each package, regardless of shape, is modeled as an isotropically radiating point source for most incident-free dose calculations. The calculation includes a package coefficient, K_o, which is a function of package dimension.*

For some exposure groups, a line-source model is used (see Chapter 4 in the RADTRAN 4 Technical Manual [Neuhauser and Kanipe, in preparation [b]]).

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*For analysis of a package with a characteristic dimension greater than 4 m (e.g., a spent fuel cask), the basic formula for calculating K_o overestimates gamma dose rates and RADTRAN 4 automatically makes an adjustment. For a package dimension greater than 4 m, the value for the actual characteristic package dimension (PKGSIZ) is replaced with a value for an effective package dimension (EFFSIZ), which is calculated by RADTRAN 4 according to the following equation:

$$D_{eff} = 2 \cdot (1 + 0.5\, D_{act})^{3/4} - 0.55$$

where

D_{eff} = effective package dimension
D_{act} = actual dimension.

4.5 Input Strategy for Multiple-Package Shipments

4.5.1 The Effective Dose Rate and the Transport Index

The effective dose rate is an important RADTRAN input parameter. It is defined as the dose rate at 1 m in millirem/hr from either the surface of the package (package dose rate) or from the vertical planes projected by the outer lateral surfaces of the transportation vehicle (shipment dose rate). Although the symbol for this parameter is TIPKG (the "transport index of the package"), not all packages have a transport index (TI). The TI is a regulatory quantity defined in regulations of the International Atomic Energy Agency, the U.S. Department of Transportation, and the Nuclear Regulatory Commission (NRC) (49 CFR 173 and 10 CFR 71). In 10 CFR 71, the TI is defined as the maximum radiation level in millirem/hr at 1 m from the external surface of the package. For exclusive-use shipments however, the regulations do not use the TI concept; instead, they regulate the dose rate at 2 m from the vertical planes projected by the outer lateral surfaces of the railcar or vehicle. One must still enter a value for dose rate at 1 m for these packages, however. Thus, in RADTRAN 4 the values entered in the TIPKG array must be the dose rate at 1 m from either the package or the shipment conveyance, depending on the analysis being performed and regardless of the wording of the regulations governing that package or shipment type.

4.5.2 Similar Packages

Multiple-package configurations in which all packages are identical are analyzed in approximately the same manner as a single-package shipment of the same material. An example of this type of shipment is a truck filled with drums of low-level waste. A shipment of this type often may be treated as if all the drums were identical and each contained a representative isotope inventory for the waste form. As noted above, RADTRAN 4 uses package dose rate x PPS (packages per shipment) or analogous products for gammas and neutrons separately to estimate the shipment source strength for shipments of this type. Since directly accounting for shielding of packages by one another is not possible with this method, the incident-free dose may be overestimated for multiple-package shipments and the user must account for this, as described in this section.

The package coefficient, K_o, is calculated from the input value for the characteristic package dimension (PKGSIZ), which either is used directly or is converted to an effective package dimension, EFFSIZ (see Section 4.4). Since package dose rate x PPS and the calculated K_o are combined in several equations and since both of these terms could result in an overestimate of dose rate, the user must carefully examine each shipment configuration for these sources of error and apply the measures described below to compensate. However, the dose rate overestimate cannot be infinitely large. RADTRAN 4 has an internal check that compares the package dose rate x PPS to the regulatory limit of 50 mrem/hr (10 CFR 71). The regulatory checks performed by RADTRAN 4 are discussed fully in the RADTRAN 4 Technical Manual (Neuhauser and Kanipe, in preparation [b]).

4.5.3 Application of the Effective Shipment Dose Rate

Even if the package dose rate x PPS does not exceed regulatory limits, it may still be a significant overestimate of the radiation field around the shipment. To avoid overestimation from the latter cause, the user can measure or calculate an effective shipment dose rate (i.e., the maximum exposure level at 1 m from any accessible surface of the transport vehicle). For exclusive-use shipments, this may be obtained by extrapolation from measurements performed to determine compliance with regulations that restrict the dose rate to 10 mrem/hr or less at 2 m from the conveyance. In this method, the entire shipment is treated as an effective single package. Thus the value for PPS is set to 1 and the package dose rate is replaced by a shipment dose rate. The product then becomes shipment dose rate x 1, and given that the shipment dose rate is properly estimated, this produces a better estimate of incident-free doses. This method is also useful when analyzing multiple-package shipments consisting of dissimilar packages, as described below.

4.5.4 Dissimilar Packages

For shipments in which the packages are not identical, ISOTOPES must be used sequentially to describe each package type. The user must enter the keyword ISOTOPES and all associated data separately for each material, continuing until all packages have been described. The maximum number of distinct material and packaging combinations that may be analyzed simultaneously is 12. For multiple-package shipments made up of nonidentical packages, the package dose rate x PPS for each set of identical packages is first calculated. Then incident-free doses are calculated separately for each of these products. The values for all package types are summed and this sum is given in the output tables along with the individual values for each package type. The problem of overestimation from self-shielding remains, however, and may be accounted for in the same way as described above for shipments of similar packages.

Treating a shipment containing packages of widely different sizes and contents as a single effective package is often the best method for analyzing this shipment type. When using this approach, the analyst should take care to perform the following:

- properly determine the radiation field around the vehicle (i.e., the effective shipment dose rate, and
- correctly describe the behavior of the shipment in accidents (if necessary, in a separate RADTRAN 4 run).

An example of a dissimilar-package shipment is a tractor-trailer loaded with radiopharmaceuticals in which the dimensions and contents of the various packages vary. An effective shipment dose rate can be either measured directly or calculated by considering the geometry of the package array and accounting for self-shielding (Finley et al., 1988). Since all packages in the shipment are Type A, all packages can be expected to have comparable failure behavior in the event of an accident so that the entire shipment can be assigned release fractions that are characteristic of Type

A packages. Also, historical data for shipments of this type can be used to estimate a package-failure fraction. Thus both conditions outlined above are satisfied, and the user can proceed with the analysis. Note again that if handler doses are desired, then the user must perform a separate RADTRAN 4 analysis in which package dose rates and dimensions are used.

4.6 Accounting for Crew Shielding

Crew shielding is not specifically modeled in RADTRAN 4. However, if the user must account for shielding, the source-to-crew distance may be artificially increased to reduce the dose rate to that which would be achieved with shielding in place. The value of the distance that will yield the desired dose rate (i.e., the dose rate with shielding) must be externally calculated by the user. The source-to-crew distance can be defined by the user in the data input file in the DNORML array (Table 3-2).

4.7 Gamma and Neutron Components of Dose Rate

The default values for a neutron component of dose rate in RADTRAN 4 are for fission neutrons and are discussed in detail in the RADTRAN 4 Technical Manual. To summarize briefly, they were obtained with neutron cross-section data from the ENDF/B-V (Magurno, 1983) cross-section data library generated with the NJOY code (MacFarlane et al., 1982). The source was assigned an energy spectrum obtained from Oak Ridge National Laboratory calculations of the neutron flux at the surface of a lead-shielded spent fuel shipping cask. The neutron transport calculations were performed with the ONEDANT code, which solves the one-dimensional, multigroup, Boltzmann transport equation by the discrete ordinates method (O'Dell et al., 1982). The ENDF library, NJOY, and ONEDANT are discussed and evaluated by Parks et al. (1988).

To be compatible with the RADTRAN calculational strategy, the neutron rate as a function of distance is expressed in the following form

$$DR(x) = K\, e^{-\mu x} \left(1 + a_1 x + a_2 x^2 + a_3 x^3 + a_4 x^4\right) / x^2 \quad .$$

where DR(x) is the dose rate as a function of x
x = distance in meters from the source
K = constant, and
μ = linear absorption coefficient for the surrounding medium (air).

The linear absorption coefficient for air (μ_{air}) was assigned a value of 7.42E-03 m^{-1} (Madsen et al., 1986, p. 43). Four unitless coefficients (a_1, a_2, a_3, and a_4) are then derived for fitting the shape of the dose rate-vs.-distance curve to the shape of the selected neutron transport curve in air at 50 percent relative humidity. These values are:

a_1 = 2.02E-02

a_2 = 6.17E-05

a_3 = 3.17E-08

a_4 = 0.0.

These values are available as defaults in RADTRAN 4. If another neutron transport curve is preferred, then the user may generate new values for the coefficients and enter them into the input data file as the last four numbers in the COEF array under the second-level keyword NEUTRON and the first-level keyword TRANSFER (Table 3-2). The first number in this array is the linear absorption coefficient (μ), which also may be redefined by the user. A similar treatment is possible for gamma radiation (second-level keyword GAMMA under TRANSFER), but the atmospheric effect (i.e., attenuation and buildup in air) is insignificant. Therefore, for gamma radiation the default values of μ, a_1, a_2, a_3, and a_4 are set to zero in order to reduce the exponential term in the dose rate equation to unity. The equation for gamma thus reduces to the form used for a gamma point source in RADTRAN calculational strategy (Madsen et al., 1986, p. 13). Namely, $DR = K/x^2$.

Separation of dose rate into neutron and gamma components is useful only for packages in which a significant fraction of the external dose rate is attributable to neutrons. The default coefficient values for the neutron component are acceptable for the most frequently encountered shipments of this type (e.g., aged spent fuel). For most other materials, the user should treat the entire external radiation field as the result of gamma radiation. However, the user always has the option of performing external transport calculations and curve-fitting to obtain new coefficients. Note that the coefficient values are not included in the ISOTOPES array. To alter the default values the user must do so under the keyword TRANSFER, as shown in Table 3-2. Any analysis of a multiple-package shipment containing dissimilar packages should not use a package-by-package gamma-neutron breakdown, and the shipment dose rate should only be split into gamma and neutron components when the neutron coefficients can be used to describe the shipment as a whole.

4.8 Multiple-Isotope Materials

4.8.1 Assignment of Physical-Chemical Groups

Many radioactive materials consist of mixtures of isotopes. The physical and chemical properties of radioisotopes vary widely, and the behavior of the isotopes in response to mechanical and thermal forces potentially encountered during accidents depend strongly on these properties. The best way to account for these differences is to list all important isotopes under the ISOTOPES keyword. Since isotope-specific data may be taken directly from the internal isotope library, data entry is simplified and input errors are reduced. Complex materials containing up to 65 isotopes can be modeled realistically with this method.

To account for differences in physical-chemical properties of the constituent isotopes, the user first should determine what groups of physically and chemically distinct isotopes are represented. Examples of these groups are noble gases, volatiles (e.g., cesium), and transuranic oxides (e.g., PUO2); each of which would exhibit distinct release and

aerosol-formation behavior in at least some accident-severity categories. Thus an important feature of RADTRAN 4 is that each such group may be treated separately. A maximum of 15 physically and chemically distinct groups of isotopes may be used in a single analysis.

After each radioisotope is assigned to a group on the basis of physical and chemical properties, each group is independently assigned appropriate values for the release fraction (RFRAC), aerosol fraction (AERSOL), and respirable aerosol fraction (RESP) arrays for each accident-severity category. The latter two are specified indirectly by the dispersibility category assignment. In previous RADTRAN documentation, the term Index of Material (IM) category was used as a synonym for dispersibility category. This parameter has been renamed and is now termed IDISP. Default values are available for typical physical-chemical material forms (Table 4-3), but the user may also redefine all but the first of these categories, if desired. The values in Table 4-3 were adapted from NUREG 0170 (NRC, 1977, Table A-7) for use in RADTRAN 2 (Madsen et al., 1983) and in RADTRAN 3 (Madsen et al., 1986). Note, however, that the first IDISP category is used only for modeling loss-of-shielding accidents in which no material is dispersed, and the user may not alter this category.

For shipments carrying more than one package containing multiple isotopes, the approach is similar to that outlined above if the packages are identical. The behavior of a multiple-package array in potential accident conditions may be different from the behavior of a single package of the same type; it must be evaluated on a shipment-specific basis. When the packages are not identical, differences in their radioisotope contents as well as their behavior in possible accident conditions must be evaluated on a case-by-case basis.

4.8.2 Reducing the Number of Isotopes Analyzed

If the number of isotopes in a material is large, then isotopes that contribute less than a predetermined percentage of the overall hazard (e.g., 10, 1.0, or 0.1 percent) may be disregarded to simplify the analysis. Some type of relative hazard index must be calculated to use this method. An example is discussed in the annotated output discussion in Chapter 5.0.

4.8.3 Weighted-Average Method

A multiple-isotope shipment may be analyzed with the weighted-average method, although this approach has very limited application. When the health hazard associated with a material is clearly dominated by one constituent isotope or when a package contains a material made up of a few very similar isotopes, then this method may be used to simplify an analysis without loss of meaningfulness. The DEFINE option is used to simulate what is, in effect, an artificial isotope to represent a multiple-isotope material. This is accomplished with input parameters that are weighted averages of values for all isotopes present. Dose rate is assigned under ISOTOPES, and only one physical-chemical group is used per package. To apply the DEFINE option with this method, artificial values for weighted-average half-life, weighted-average photon energy, and so forth must be

Table 4-3

Dispersibility Category Default Values

IDISP Category	Description	Aerosol Fraction	Respirable Fraction
1	Undispersed*	[none]	[none]
2	Immobile	1.0E-06	0.05
3	Loose Chunks	1.0E-02	0.05
4	Large Powder	5.0E-02	0.05
5	Small Powder**	1.0E-01	0.05
6	Spent Fuel Particulates	1.0E+00	0.05
7	Volatile Solid	1.0E+00	1.00
8	Liquid	1.0E+00	1.00
9	Other	1.0E+00	1.00
10	Gas	1.0E+00	1.00
11	Flammable	1.0E+00	1.00

*For loss-of-shielding analyses only.
**Also used for nonvolatile liquids.

entered. No automatic call to the isotope data library is possible. This method has been used to simplify analyses of complex-material shipments (NRC, 1977).

The input parameters for which weighted values are required with this method are half-life, photon energy, cloudshine dose factor, 50-yr effective dose equivalent for inhalation, 50-yr effective dose equivalent for ingestion, food and soil transfer factors, particle deposition velocity, a select table for calculation of acute inhalation effects, acute inhalation effects of 1-yr lung dose, and acute inhalation effects of the 1-yr dose to bone marrow. These parameters are used only in accident risk calculations. A weighted average for all of the parameters except half-life should be calculated by using the activity of each of the isotopes as the basis for weighting. The basis for half-life weighting should be the number of moles or the number of atoms. Values for other parameters should be given for the predominant isotope. In addition, the value for curies per package should be the true total activity of the shipment.

4.9 Use of Aggregate Route Data

RADTRAN 4 allows aggregate data to be used for route-related parameters. Aggregate data are defined as the values that result from treating all portions of a route which lie within some predefined range of

values for a set of characteristics as a single aggregate segment. The single aggregate segment is equal in length to the sum of all individual segments that satisfy the conditions. Analyses in which LINK is not used are restricted to three sets of aggregated route data. Historically, these have been defined in terms of a single characteristic--population density--and classified as rural, suburban, and urban, but they are not required to be. Input parameters such as traffic density and accident rate are indexed to population density in non-LINK runs. To perform this type of analysis, the user enters the total distance (trip length) under the keyword DISTKM and represents each of the three aggregated segments as a fraction of travel in the appropriate population-density zone in the DNORML array (FTZNR, FTZNS, FTZNU in Tables 3-2 and 3-3).

Data for many route-related parameters are often only available in aggregate form. When cross-country routes are analyzed by the non-LINK method, it is appropriate to use national average data for the indexed parameters. The actual values of population density in the three zones are also in the POPDEN array and are user-definable. Table 4-4 shows the population-density zones used for many SNL analyses.

These values along with associated national average data are available in RADTRAN 4 as POPDEN- and DNORML-array defaults for non-LINK analyses. Even when LINK is used, an aggregate run should be performed to provide a baseline for comparison. These population-density zones clearly are not applicable to certain modes (in-flight air travel and maritime transport on the high seas), and RADTRAN 4 does not calculate off-link population doses for these types of transportation.

Table 4-4

Aggregate Data for Population-Density Zones

	Mean Density	Range
Rural	6 persons/km^2	1 to 66 persons/km^2
Suburban	719 persons/km^2	67 to 1,670 persons/km^2
Urban	3,861 persons/km^2	>1,670 persons/km^2

4.10 Route-Specific Analysis With LINK

LINK may also be used to enter aggregate data and must be used for aggregate data with more than three population-density classes. In this application, a link is created for each population-density zone and is assigned a length equal to the aggregated value of distance traveled in this zone. Various refinements are possible as well. For example, in highway mode, one may account for rush-hour travel in a particular zone by creating two links for this zone. One link is assigned a length equal to

the calculated amount of travel in rush-hour conditions in this zone, and the other link is assigned a length equal to the calculated amount of travel in this zone in nonrush-hour conditions. The sum of the two links must be equal in length to the total distance traveled in this zone.

The LINK option enhances the usefulness of RADTRAN 4 for route-related transportation risk applications. The LINK option allows the user to independently analyze up to 40 separate route segments (or data aggregates) in a single computer run. For each segment, the user must assign values to the following route-related parameters:

- mode (numerical designator),
- segment length (km),
- vehicle velocity (km/hr),
- population density (persons/km^2),
- one-way traffic count (vehicles/hr for all lanes),
- accident rate (accidents/km),
- character designation (rural, suburban, or urban), and
- link type (1 = freeway, 2 = nonfreeway, or 3 = other modes).

There are no default values for these parameters in LINK. When LINK is used for route-specific analysis, the sum of the segment lengths should equal the total route length. Because there can be no internal check to ensure that this condition is satisfied, the user must perform this check.

One of the most significant features of LINK is that population-density data for each segment are entered independently. The user is not required to use arbitrary population-density zones. However, the user still must indicate whether each segment is rural, suburban, or urban in character so that proper values will be used for the building-shielding factor and other parameters. This is performed with the character designation parameter in which the user enters R, S, or U to indicate rural, suburban, or urban, respectively.

The parameters controlled by character designation include the building-shielding factors RR, RS, and RU (see Table 3-2). The treatment of segments is the same as in non-LINK runs. In other words, if the segment is designated R, then the ingestion pathway is included, but if a segment is designated as S or U, then ingestion is not calculated. In addition, if the segment is designated U, then the expected values of long-term dose are multiplied by 0.52 x the building dose factor (BDF). The multiplier of 0.52 is taken from Finley et al., 1980. The BDF accounts for the partial removal of particulates by building ventilation systems (Finley et al., 1980). This parameter is user-definable, but has a default value of 8.60E-03. Another term to account for pedestrians is also added for urban areas. In this term the dose value is multiplied by 0.1 x the ratio

ratio of pedestrian density to residential population density. The multiplier of 0.1 for urban areas represents the fraction of an urban area (New York City) occupied by sidewalks (Finley et al., 1980). Application of this factor to all urban areas in the U.S. is conservative. The default value for this ratio of population densities (RPD) is 6.0. A similar calculation is performed to estimate early effects.

Link type is used to distinguish between various roadway types for highway modes only (truck, commercial van, and passenger van). If the user sets the link type to 1, the segment is modeled as an Interstate Highway (i.e., any limited-access, divided highway built to the same engineering standards as Interstate Highways). If the link type is set to 2, then the combination of zone designation and link type determines how the roadway is modeled. If the link type is set to 2 and the zone is designated R or S, then the roadway is modeled as a non-Interstate highway (e.g., a U.S. highway). If the link type is set to 2 and the segment is designated as U in character, then the roadway in that segment is modeled as a city street. For all other modes, the link type is set to 3.

Segments defined with the LINK option may be used to represent actual sequential route segments. However, they also may be used to represent aggregates of like segments in the same way that aggregate data are used in non-LINK applications of RADTRAN 4. LINK also can be used to analyze the same route segment(s) in a variety of conditions such as daytime and nighttime population densities, rush-hour and nonrush-hour traffic conditions, current and projected population densities, etc. In short, the LINK option is a powerful analytical tool limited only by the data available to the user.

4.11 Output Options

Radiological risks may be summarized in terms of either expected population dose in person-rem (FORM UNIT) or expected stochastic effects (e.g., latent cancer fatalities and genetic effects) (FORM NONUNIT). In the latter case, organ doses are calculated and used to estimate health effects by organ, which are summed and given in tabular form for each isotope and exposure pathway. In the former case the committed effective dose equivalent is calculated for each isotope and exposure pathway and then summed. Note that the user may multiply these dose estimates by a conversion factor to estimate health effects. With either option, early radiological fatalities from accidents are calculated.

In RADTRAN 4 the population-dose output format is selected by using the keyword UNIT on the FORM line. For each isotope in a material, effective dose equivalents for inhalation (RPCVAL), cloudshine (CLDOSF), and ingestion (INGVAL) are given in the radionuclide library.

Organ-specific dose factors are not presently available from the radionuclide library. This omission is intentional since it is anticipated that recent re-analysis of the Japanese atomic bomb survivors will result in changes to the health effects model currently accepted by the DOE. The current health effects model will be adjusted accordingly in the next version of RADTRAN. However, NONUNIT calculations may be performed with

user-supplied organ-specific dose factors. The calculation of economic impacts is not affected, nor is the estimation of early mortalities. Early morbidities are not estimated when output is requested in terms of population dose.

4.12 Unit-Risk Factors

In some cases the analyst may wish to evaluate several alternatives that differ only in route characteristics and/or numbers of shipments traversing particular segments of a network of potential routes. Unit-risk factors are often useful in analyses of this type (Wilmot et al., 1983; Neuhauser et al., 1984; Cashwell et al., 1986). A radiological unit-risk factor is usually defined as the risk in some appropriate metric (e.g., person-rem, health effects) of transporting a given radioactive material shipment for a unit distance of travel, usually 1 km. Unit-risk factors are only useful if route subclasses can be identified. A route subclass can be defined as a route segment or group of route segments sharing a distinct combination of route parameters (population density, traffic count, etc.). With non-LINK applications the route subclasses are rural, suburban, and urban; with LINK applications a maximum of 40 route subclasses per run may be defined by the user.

Separate unit-risk factors for each mode and shipment type must be calculated for each route subclass with input data that are held constant for all other parameters. The distance traveled and the number of shipments (DISTKM and SPY parameters) are usually set to unity. The result is a set of unit-risk factors that give risk per unit of travel for each route subclass for (1) incident-free dose to transportation workers, (2) incident-free dose to the public, and (3) accident risk. They may be used for direct comparisons of the unit risks of transport for various shipment types. It is more common, however, to calculate the risk per shipment by multiplying each set of unit-risk factors by the total distance traveled in the appropriate route subclass; these results can, in turn, be multiplied by the expected number of shipments and summed to give total risks.

This technique is best suited for the calculation of risks for a major shipping campaign involving many identical shipments. The method also can provide useful information about alternative shipping options. For example, if a certain material may be shipped by one mode in two distinct packagings with differing capacities, then the unit risks for the low-capacity package are likely to be the smallest. However, because an increased number of shipments are required to transport the same amount of material to the same destination, the total risk associated with use of the low-capacity package might exceed that for the high-capacity package. Thus, the unit-risk factor approach permits quantitative representation of various facets of a problem with relative ease.

A note of caution: To use the unit-risk factor approach properly, one must separately handle certain exposures associated with stops, especially during rail transport. Unit-risk factors for stops ordinarily are given in the output as risk per time at stops, where stop time is a linear function of distance and is calculated from the user-definable parameters of stop time per distance traveled (hr/km) and distance traveled (km). Distance traveled is usually set to 1 km in a unit-risk factor run. However, the

inspection stops that occur at the beginning and end of many forms of rail transport are distance-independent and cannot be expressed in terms of risk per distance traveled. Thus, the user is urged to make every effort to identify potential risk components of this type prior to analysis. They must be calculated in a separate computer run and must be handled on a per trip basis rather than a per kilometer basis.

4.13 Sensitivity Analysis

A sensitivity analysis is performed for input parameters affecting incident-free risk each time RADTRAN 4 is run. With the exception of the expression for neutron dose versus distance, all equations used in the calculation of incident-free risk are linear. Therefore, the influence of an individual input parameter can be determined by taking partial derivatives of the equations containing that parameter. The partial derivative method is fully described in the RADTRAN 4 Technical Manual (Neuhauser and Kanipe, in preparation [b]). For a non-LINK run, the analysis is for the entire route. For a LINK run, a separate analysis is performed for each link. In the latter case, for example, the relative influence of a parameter such as speed in various types of route segments can be readily determined. The annotated sample runs in Chapter 5 contain examples of incident-free sensitivity analyses. If a non-zero value is used for the fraction of package dose rate represented by neutron radiation (FRNEUT, sixth array value on material line after keyword ISOTOPES), then a nonlinear equation is introduced into the set of equations for incident-free risk. A sensitivity analysis is still performed, but the calculational basis is 100% gamma radiation. That is, the package (or shipment) dose rate is treated as if 100% of it were from gamma radiation (i.e., FRGAMA = 1.0). This means that the sensitivity analysis results will be incorrect. An external method of assessing the effects of parameter variation may be used instead. A wide variety of complex approaches based on Monte Carlo or Latin Hypercube methods may be used. However, the simplest alternative is to generate sets of multiple runs in which the parameters of interest are varied. Because many parameters have only a small effect on risk, the first step should always be to generate two runs in which all parameters of interest assume their lowest and highest values, respectively. This procedure will usually establish the maximum range of variation and provide a basis for assessing the influence of individual parameters.

5.0 UNDERSTANDING CODE OUTPUTS

In this chapter four complete output files are reproduced and annotated to familiarize the user with RADTRAN 4 Echo Check and output file format. These files also illustrate the various types of problems that can be addressed with RADTRAN 4. The first three output files illustrate three different analytical approaches to transportation of the same material traveling by the same mode from the same origin point to the same destination. They are the aggregate-data method, the route-specific (LINK) method, and a sample unit-risk factor calculation illustrating the unit-risk-factor method, respectively.

The example selected for the first three Echo Check and output files represents a hypothetical truck shipment of a single package (cask) of a multiple-isotope material (spent fuel) from the San Onofre commercial nuclear power plant in California to the Yucca Mountain candidate repository site in Nevada. Output File 1 is annotated in great detail (see p. 5-22). Where subsequent files are the same as Output File 1, no additional annotations are included (Output File 2 is discussed beginning on p. 5-53). The results of the first three output files are compared in the discussion of Output File 3 (p. 5-76). This comparison illustrates the essential robustness of the RADTRAN methodology.

Output File 4 (discussion begins on p. 5-102) represents a multiple-package shipment consisting of 12 distinct package types, each of which contains a different isotope traveling from a fabrication point in the New England area to a distribution point 1895 km away. The data are taken from Finley et al. (1988). Both shipment examples are used solely for the purposes of illustration, and no attempt has been made to preserve a realistic representation of any actual shipment.

The intent of this section is to familiarize the user with the full range of tables and lists available in the output. The user may also request output in summary form (not illustrated here). The summary contains the same echo check and summary tables as those in the full length output, but the tables of input default values, importance analyses, and most of the intermediate calculational results are omitted.

```
RRRR    AAA   DDDD   TTTTT  RRRR    AAA   N   N
R   R  A   A  D   D    T    R   R  A   A  NN  N
R   R  A   A  D   D    T    R   R  A   A  N N N
RRRR   A   A  D   D    T    RRRR   A   A  N  NN
R R    AAAAA  D   D    T    R R    AAAAA  N   N
R  R   A   A  D   D    T    R  R   A   A  N   N
R   R  A   A  DDDD     T    R   R  A   A  N   N
```

```
    4
4   4
4   4
44444
    4
    4
    4
```

RADTRAN 4.0.12 VERSION DATE: NOVEMBER 19,1991

MODE DESCRIPTIONS

NUMBER	NAME	CHARACTERIZATION
1	TRUCK	LONG HAUL VEHICLE
2	RAIL	COMMERCIAL TRAIN
3	BARGE	INLAND VESSEL
4	SHIP	OPEN SEA VESSEL
5	CARGO AIR	CARGO AIRCRAFT
6	PASS AIR	PASSENGER AIRCRAFT
7	P-VAN	PASSENGER VAN
8	CVAN-T	COMMERCIAL VAN
9	CVAN-R	COMMERCIAL VAN
10	CVAN-CA	COMMERCIAL VAN

ECHO CHECK

```
TITLE  SAN ONOFRE IN SAN CLEMENTE TO YUCCA MOUNTAIN NEVADA  AGGREGATE
FORM   UNIT
DIMEN  15  6  5  10 18
PARM  0 3 2 3 0
PACKAGE  LABGRP HIGH NOBLE VOL_A OTHER VOL_B
SHIPMENT
        LABISO   CO60      KR85      SR90      RU106     CS134
                 CS137     CE144     EU154     PU238     PU239     PU240
                 PU241     AM241     AM243     CM244
NORMAL   NMODE=1   7.96E-01  1.76E-01  2.80E-02  8.86E+01  4.03E+01  2.41E+01
                   2.00E+00  1.00E+01  0.00E+00  1.10E-02  0.00E+00  0.00E+00
                   0.00E+00  5.00E+01  2.00E+01  0.00E+00  1.00E+02  1.00E+02
                   2.00E+00  0.00E+00  0.00E+00  1.00E+00  4.70E+02  7.80E+02
                   2.80E+03
ACCIDENT ARATMZ NMODE=1 2.08E-08 4.06E-07 2.34E-06
        SEVFRC NPOP=1 NMODE=1 0.603 0.394 3.E-3 3.E-6 5.E-6 7.E-6
               NPOP=2 NMODE=1 0.602 0.394 4.E-3 4.E-6 3.E-6 2.E-6
               NPOP=3 NMODE=1 0.604 0.395 3.8E-4 3.8E-7 2.5E-7 1.3E-7
RELEASE RFRAC GROUP=1 2*0.0 4*1.2E-2
              GROUP=2 3*0.0 0.01 0.1 0.11
              GROUP=3 3*0.0 1.0E-8 2.0E-4 2.8E-4
              GROUP=4 3*0.0 1.0E-8 5.0E-8 5.0E-8
              GROUP=5 3*0.0 1.0E-8 1.0E-6 4.2E-5
        AERSOL DISP=2 2*0 4*1.0
               DISP=3 3*0 3*1.0
               DISP=4 3*0 3*1.0
               DISP=5 3*0 3*1.0
        RESP   DISP=2 2*0 4*.05
               DISP=3 3*0 3*1.0
               DISP=4 3*0 0.05 2*1.0
               DISP=5 3*0 3*.05
OTHER CULVL=0.2
EOF
ISOTOPES  -1  1.0  1.0  13.68  1.0 0.0  SFUEL
CO60  9.22E+01 HIGH 2
KR85  6.10E+03 NOBLE 3
SR90  5.96E+04 OTHER 5
RU106 1.62E+04 VOL_B 5
CS134 2.74E+04 VOL_A 4
CS137 8.76E+04 VOL_A 4
CE144 1.22E+04 OTHER 4
EU154 7.00E+03 OTHER 4
PU238 2.96E+03 OTHER 5
PU239 4.10E+02 OTHER 5
PU240 4.68E+02 OTHER 5
PU241 1.26E+05 OTHER 5
AM241 1.29E+03 OTHER 5
AM243 1.99E+01 OTHER 5
CM244 1.79E+03 OTHER 5
DISTKM  NMODE=1  610.0
PKGSIZ  SFUEL 5.2
EOF
```

SAN ONOFRE IN SAN CLEMENTE TO YUCCA MOUNTAIN NEVADA AGGREGATE

ZONE	POPULATION DENSITY (PERSONS PER SQ KM)
RURAL	6.
SUBURBAN	719.
URBAN	3861.

PACKAGE CHARACTERISTICS

FOR MATERIAL	DIMENSION (METERS)	EFFECTIVE DIMENSION	K(0) METERS SQ.
SFUEL	5.200E+00	4.677E+00	1.115E+01

K(0) IS TI TO DOSE RATE CONVERSION FACTOR

PACKAGE HANDLING THRESHOLDS (METERS)
PKGSZ1= 5.000E-01
PKGSZ2= 1.000E+00
PACKAGES .LE. PKGSZ1 ARE HAND CARRIED
PACKAGES .GT. PKGSZ1 AND .LE. PKGSZ2 ARE HANDLED BY SMALL EQUIPMENT
PACKAGES .GT. PKGSZ2 ARE HANDLED BY HEAVY EQUIPMENT

MATERIAL CHARACTERISTICS

MATERIAL	FRACTION OF GAMMA	FRACTION OF NEUTRON
SFUEL	1.000E+00	0.000E+00

SAN ONOFRE IN SAN CLEMENTE TO YUCCA MOUNTAIN NEVADA AGGREGATE

MODE CHARACTERISTICS

MODE	DISTANCE TRAVELED	EXCLUSIVE USE	NUMBER OF SHIPMENTS	MATERIALS	TRANSPORT INDEX (TI)	PACKAGES/ SHIPMENT
TRUCK	6.10E+02	YES	1.00E+00			
				SFUEL	1.37E+01	1.00E+00

BUILDING SHIELDING OPTION= 2
(1=TOTAL SHIELDING, 2=PARTIAL SHIELDING, 3=NO SHIELDING)

RPD= 6.000E+00
(RATIO OF PEDESTRIAN DENSITY (PEDESTRIAN/KM SQ OF SIDEWALK)
TO POPULATION DENSITY (PEOPLE/KM SQ IN URBAN AREAS)

RR = 1.000E+00
(TRANSMISSION FACTOR FOR RURAL AREAS)

RS = 8.700E-01
(TRANSMISSION FACTOR FOR SUBURBAN AREAS)

RU = 1.800E-02
(TRANSMISSION FACTOR FOR URBAN AREAS)

SAN ONOFRE IN SAN CLEMENTE TO YUCCA MOUNTAIN NEVADA AGGREGATE

DNORML INPUT

NO		TRUCK
1	FRACTION OF TRAVEL IN RURAL POPULATION ZONE	7.960E-01
2	FRACTION OF TRAVEL IN SUBURBAN POPULATION ZONE	1.760E-01
3	FRACTION OF TRAVEL IN URBAN POPULATION ZONE	2.800E-02
4	VELOCITY IN RURAL POPULATION ZONE (KILOMETERS/HOUR)	8.860E+01
5	VELOCITY IN SUBURBAN POP. ZONE (KILOMETERS/HOUR)	4.030E+01
6	VELOCITY IN URBAN POPULATION ZONE (KILOMETERS/HOUR)	2.410E+01
7	NUMBER OF CREWMEN	2.000E+00
8	DISTANCE FROM SOURCE TO CREW (METERS)	1.000E+01
9	NUMBER OF HANDLINGS	0.000E+00
10	STOP TIME PER KM (HR/KM)	1.100E-02
11	MINIMUM STOP TIME PER TRIP (HR)	0.000E+00
12	ZERO STOP TIME PER TRIP (HR)	0.000E+00
13	MINIMUM NUMBER OF RAIL CLASSIFICATIONS/INSPECTIONS	0.000E+00
14	PERSONS EXPOSED WHILE STOPPED	5.000E+01
15	AVERAGE EXPOSURE DISTANCE WHILE STOPPED (METERS)	2.000E+01
16	STORAGE TIME PER SHIPMENT (HR)	0.000E+00
17	NUMBER OF EXPOSED PERSONS DURING STORAGE	1.000E+02
18	AVERAGE EXPOSURE DISTANCE WHILE IN STORAGE (METERS)	1.000E+02
19	NUMBER OF PEOPLE PER VEHICLE ON LINK	2.000E+00
20	FRACTION OF URBAN TRAVEL DURING RUSH HOUR TRAFFIC	0.000E+00
21	FRACTION OF URBAN TRAVEL ON CITY STREETS	0.000E+00
22	FRACTION OF RURAL-SUBURBAN TRAVEL ON FREEWAYS	1.000E+00
23	*TRAFFIC COUNT PASSING A SPECIFIC POINT-RURAL ZONE	4.700E+02
24	*TRAFFIC COUNT PASSING A SPECIFIC POINT-SUBURBAN ZONE	7.800E+02
25	*TRAFFIC COUNT PASSING A SPECIFIC POINT-URBAN ZONE	2.800E+03

*(ONE WAY VEHICLES/HR)

SAN ONOFRE IN SAN CLEMENTE TO YUCCA MOUNTAIN NEVADA AGGREGATE

ISOTOPE RELATED DATA

NUCLIDE	CURIES PER PKG	RELEASE GROUP	RESUSP FACTOR	LUNG TYPE	DISPERS. CATEGORY	1YR INHAL LUNG	REM/CI MARROW
SFUEL							
CO60	9.22E+01	HIGH	4.83E+00	2	2	7.90E+05	3.80E+04
KR85	6.10E+03	NOBLE	1.00E+00	2	3	0.00E+00	0.00E+00
SR90	5.96E+04	OTHER	5.41E+00	2	5	4.50E+06	3.80E+03
RU106	1.62E+04	VOL_B	3.28E+00	2	5	4.30E+06	4.50E+03
CS134	2.74E+04	VOL_A	4.07E+00	2	4	4.10E+04	3.90E+04
CS137	8.76E+04	VOL_A	5.41E+00	2	4	3.10E+04	2.60E+04
CE144	1.22E+04	OTHER	2.99E+00	1	4	3.60E+06	4.20E+03
EU154	7.00E+03	OTHER	5.09E+00	2	4	0.00E+00	0.00E+00
PU238	2.96E+03	OTHER	5.51E+00	3	5	4.50E+08	1.10E+06
PU239	4.10E+02	OTHER	5.57E+00	3	5	4.20E+08	1.10E+06
PU240	4.68E+02	OTHER	5.56E+00	3	5	4.20E+08	1.10E+06
PU241	1.26E+05	OTHER	5.26E+00	3	5	3.60E+05	1.30E+03
AM241	1.29E+03	OTHER	5.55E+00	3	5	1.20E+08	1.70E+07
AM243	1.99E+01	OTHER	5.56E+00	3	5	1.10E+08	1.60E+07
CM244	1.79E+03	OTHER	5.32E+00	3	5	1.20E+08	1.70E+07

NUCLIDE	HALF LIFE	GAMMA ENERGY	CLOUD FACTOR	TRANSFER CROPS	TRANSFER SOIL	DEPOS SPEED
SFUEL						
CO60	1.93E+03	2.50E+00	4.12E-01	0.00E+00	0.00E+00	1.00E-02
KR85	3.92E+03	2.21E-03	3.55E-04	0.00E+00	0.00E+00	0.00E+00
SR90	1.06E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.00E-02
RU106	3.68E+02	2.01E-01	0.00E+00	0.00E+00	0.00E+00	1.00E-02
CS134	7.53E+02	1.55E+00	2.54E-01	0.00E+00	0.00E+00	1.00E-02
CS137	1.10E+04	5.96E-01	0.00E+00	0.00E+00	0.00E+00	1.00E-02
CE144	2.84E+02	5.25E-02	2.88E-03	0.00E+00	0.00E+00	1.00E-02
EU154	3.21E+03	1.22E+00	2.06E-01	0.00E+00	0.00E+00	1.00E-02
PU238	3.21E+04	1.81E-03	1.40E-05	0.00E+00	0.00E+00	1.00E-02
PU239	8.79E+06	7.96E-04	1.30E-05	0.00E+00	0.00E+00	1.00E-02
PU240	2.39E+06	1.73E-03	1.37E-05	0.00E+00	0.00E+00	1.00E-02
PU241	5.26E+03	2.54E-06	0.00E+00	0.00E+00	0.00E+00	1.00E-02
AM241	1.58E+05	3.24E-02	3.01E-03	0.00E+00	0.00E+00	1.00E-02
AM243	2.70E+06	5.59E-02	8.11E-03	0.00E+00	0.00E+00	1.00E-02
CM244	6.62E+03	1.70E-03	1.33E-05	0.00E+00	0.00E+00	1.00E-02

SAN ONOFRE IN SAN CLEMENTE TO YUCCA MOUNTAIN NEVADA AGGREGATE

ISOTOPE RELATED DATA

NUCLIDE	50-YR EFFECTIVE REM/CI	
	INHALE	INGEST
SFUEL		
CO60	2.80E+05	2.60E+04
KR85	0.00E+00	0.00E+00
SR90	2.40E+06	1.30E+05
RU106	8.00E+05	2.10E+04
CS134	4.60E+04	7.40E+04
CS137	3.20E+04	5.00E+04
CE144	6.30E+05	2.00E+04
EU154	3.10E+05	9.10E+03
PU238	5.30E+08	3.80E+06
PU239	5.70E+08	4.30E+06
PU240	5.70E+08	4.30E+06
PU241	9.90E+06	8.60E+04
AM241	5.90E+08	4.50E+06
AM243	5.90E+08	4.50E+06
CM244	3.10E+08	2.30E+06

SAN ONOFRE IN SAN CLEMENTE TO YUCCA MOUNTAIN NEVADA AGGREGATE

RELEASE RELATED DATA

ACCIDENT RATES (PER KM)

MODE	RURAL	SUBURBAN	URBAN
TRUCK	2.080E-08	4.060E-07	2.340E-06

RELEASE FRACTIONS

GROUP	SEVER: 1	SEVER: 2	SEVER: 3	SEVER: 4	SEVER: 5	SEVER: 6
1	0.00E+00	0.00E+00	1.20E-02	1.20E-02	1.20E-02	1.20E-02
2	0.00E+00	0.00E+00	0.00E+00	1.00E-02	1.00E-01	1.10E-01
3	0.00E+00	0.00E+00	0.00E+00	1.00E-08	2.00E-04	2.80E-04
4	0.00E+00	0.00E+00	0.00E+00	1.00E-08	5.00E-08	5.00E-08
5	0.00E+00	0.00E+00	0.00E+00	1.00E-08	1.00E-06	4.20E-05

ACCIDENT SEVERITY FRACTIONS FOR TRUCK

ZONE	SEVER: 1	SEVER: 2	SEVER: 3	SEVER: 4	SEVER: 5	SEVER: 6
1	6.03E-01	3.94E-01	3.00E-03	3.00E-06	5.00E-06	7.00E-06
2	6.02E-01	3.94E-01	4.00E-03	4.00E-06	3.00E-06	2.00E-06
3	6.04E-01	3.95E-01	3.80E-04	3.80E-07	2.50E-07	1.30E-07

SAN ONOFRE IN SAN CLEMENTE TO YUCCA MOUNTAIN NEVADA AGGREGATE

AEROSOLIZED FRACTION OF RELEASED MATERIAL

DISP CAT	SEVER: 1	SEVER: 2	SEVER: 3	SEVER: 4	SEVER: 5	SEVER: 6
1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
2	0.00E+00	0.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
3	0.00E+00	0.00E+00	0.00E+00	1.00E+00	1.00E+00	1.00E+00
4	0.00E+00	0.00E+00	0.00E+00	1.00E+00	1.00E+00	1.00E+00
5	0.00E+00	0.00E+00	0.00E+00	1.00E+00	1.00E+00	1.00E+00
6	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
7	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
8	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
9	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
10	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
11	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00

FRACTION OF AEROSOLS BELOW 10 MICRONS AED

DISP CAT	SEVER: 1	SEVER: 2	SEVER: 3	SEVER: 4	SEVER: 5	SEVER: 6
1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
2	0.00E+00	0.00E+00	5.00E-02	5.00E-02	5.00E-02	5.00E-02
3	0.00E+00	0.00E+00	0.00E+00	1.00E+00	1.00E+00	1.00E+00
4	0.00E+00	0.00E+00	0.00E+00	5.00E-02	1.00E+00	1.00E+00
5	0.00E+00	0.00E+00	0.00E+00	5.00E-02	5.00E-02	5.00E-02
6	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02
7	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
8	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
9	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
10	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
11	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00

SAN ONOFRE IN SAN CLEMENTE TO YUCCA MOUNTAIN NEVADA AGGREGATE

COST RELATED DATA

EMERGENCY RESPONSE COST

	SEVER: 1	SEVER: 2	SEVER: 3	SEVER: 4	SEVER: 5	SEVER: 6
1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

ON-SCENE COSTS
(RF=RELEASE FRACTION)

RF=0.	0.<RF<=.01	.01<RF<=0.1	.1<RF<=1.
0.	0.	0.	0.

SAN ONOFRE IN SAN CLEMENTE TO YUCCA MOUNTAIN NEVADA AGGREGATE

HEALTH RELATED DATA

EARLY FATALITY PROBABILITIES

DOSE(REM)	LUNG-1	LUNG-2	LUNG-3	MARROW
100000.000	1.000E+00	1.000E+00	1.000E+00	1.000E+00
80000.000	1.000E+00	8.500E-01	8.000E-01	1.000E+00
70000.000	1.000E+00	8.000E-01	5.000E-01	1.000E+00
40000.000	1.000E+00	7.000E-01	0.000E+00	1.000E+00
30000.000	1.000E+00	5.000E-01	0.000E+00	1.000E+00
25000.000	1.000E+00	2.000E-01	0.000E+00	1.000E+00
20000.000	1.000E+00	8.000E-02	0.000E+00	1.000E+00
10000.000	6.000E-01	0.000E+00	0.000E+00	1.000E+00
8000.000	1.000E-01	0.000E+00	0.000E+00	1.000E+00
6000.000	6.000E-02	0.000E+00	0.000E+00	1.000E+00
4000.000	3.000E-02	0.000E+00	0.000E+00	1.000E+00
3000.000	0.000E+00	0.000E+00	0.000E+00	1.000E+00
2000.000	0.000E+00	0.000E+00	0.000E+00	1.000E+00
1000.000	0.000E+00	0.000E+00	0.000E+00	1.000E+00
800.000	0.000E+00	0.000E+00	0.000E+00	9.960E-01
700.000	0.000E+00	0.000E+00	0.000E+00	9.000E-01
600.000	0.000E+00	0.000E+00	0.000E+00	4.000E-01
500.000	0.000E+00	0.000E+00	0.000E+00	5.000E-02
400.000	0.000E+00	0.000E+00	0.000E+00	0.000E+00
300.000	0.000E+00	0.000E+00	0.000E+00	0.000E+00
100.000	0.000E+00	0.000E+00	0.000E+00	0.000E+00
75.000	0.000E+00	0.000E+00	0.000E+00	0.000E+00
50.000	0.000E+00	0.000E+00	0.000E+00	0.000E+00
30.000	0.000E+00	0.000E+00	0.000E+00	0.000E+00
15.000	0.000E+00	0.000E+00	0.000E+00	0.000E+00
5.000	0.000E+00	0.000E+00	0.000E+00	0.000E+00
1.000	0.000E+00	0.000E+00	0.000E+00	0.000E+00
0.100	0.000E+00	0.000E+00	0.000E+00	0.000E+00
0.010	0.000E+00	0.000E+00	0.000E+00	0.000E+00
0.010	0.000E+00	0.000E+00	0.000E+00	0.000E+00

SAN ONOFRE IN SAN CLEMENTE TO YUCCA MOUNTAIN NEVADA AGGREGATE

DISPERSAL ACCIDENT INPUT

AREADA (M SQ)	DILUTION FACTOR*
4.590E+02	3.420E-03
1.530E+03	1.720E-03
3.940E+03	8.580E-04
1.250E+04	3.420E-04
3.040E+04	1.720E-04
6.850E+04	8.580E-05
1.760E+05	3.420E-05
4.450E+05	1.720E-05
8.590E+05	8.580E-06
2.550E+06	3.420E-06
4.450E+06	1.720E-06
1.030E+07	8.580E-07
2.160E+07	3.420E-07
5.520E+07	1.720E-07
1.770E+08	8.580E-08
4.890E+08	5.420E-08
8.120E+08	4.300E-08
1.350E+09	3.420E-08

* DILUTION FACTOR UNITS ARE (CI-SEC/M**3/CI-RELEASED)

NON-DISPERSAL ACCIDENT INPUT

RADIST(M)		
RURAL	SUBURBAN	URBAN
3.050E+00	3.050E+00	3.050E+00
6.100E+00	6.100E+00	6.100E+00
9.100E+00	9.100E+00	9.100E+00
1.220E+01	1.220E+01	1.220E+01
1.520E+01	1.520E+01	1.520E+01
3.050E+01	3.050E+01	3.050E+01
6.100E+01	6.100E+01	6.100E+01
9.140E+01	9.140E+01	9.140E+01
1.524E+02	1.524E+02	1.524E+02
3.050E+02	3.050E+02	3.050E+02

BUILDING DOSE FACTOR	= 8.600E-03
FRACTION OF LAND UNDER CULTIVATION	= 5.000E-01
CONTAMINATION CLEAN UP LEVEL (UCI/M**2)	= 2.000E-01
BREATHING RATE (M**3/SEC)	= 3.300E-04

SAN ONOFRE IN SAN CLEMENTE TO YUCCA MOUNTAIN NEVADA AGGREGATE

REGULATORY CHECKS

FOR THE SHIPMENT OF SFUEL BY MODE 1
THE DOSE RATE AT 2 METERS COULD EXCEED 10 MR/HR
PPS*TI HAS BEEN RESET TO EQUAL 13.00

SAN ONOFRE IN SAN CLEMENTE TO YUCCA MOUNTAIN NEVADA AGGREGATE

MODE TRUCK

1-YEAR LUNG DOSE - INHALATION PATHWAY
BDF = 1 (REM)

AREA #	SEVER: 1	SEVER: 2	SEVER: 3	SEVER: 4	SEVER: 5	SEVER: 6
1	0.00E+00	0.00E+00	4.93E-02	5.07E-02	9.29E-01	1.44E+00
2	0.00E+00	0.00E+00	2.48E-02	2.55E-02	4.66E-01	7.21E-01
3	0.00E+00	0.00E+00	1.20E-02	1.24E-02	2.27E-01	3.51E-01
4	0.00E+00	0.00E+00	4.65E-03	4.79E-03	8.77E-02	1.36E-01
5	0.00E+00	0.00E+00	2.23E-03	2.30E-03	4.20E-02	6.50E-02
6	0.00E+00	0.00E+00	1.06E-03	1.09E-03	2.00E-02	3.10E-02
7	0.00E+00	0.00E+00	4.04E-04	4.15E-04	7.60E-03	1.18E-02
8	0.00E+00	0.00E+00	1.91E-04	1.97E-04	3.60E-03	5.57E-03
9	0.00E+00	0.00E+00	8.89E-05	9.15E-05	1.67E-03	2.59E-03
10	0.00E+00	0.00E+00	3.36E-05	3.45E-05	6.33E-04	9.78E-04
11	0.00E+00	0.00E+00	1.53E-05	1.57E-05	2.88E-04	4.46E-04
12	0.00E+00	0.00E+00	7.26E-06	7.47E-06	1.37E-04	2.12E-04
13	0.00E+00	0.00E+00	2.68E-06	2.76E-06	5.06E-05	7.82E-05
14	0.00E+00	0.00E+00	1.27E-06	1.30E-06	2.38E-05	3.69E-05
15	0.00E+00	0.00E+00	5.78E-07	5.95E-07	1.09E-05	1.68E-05
16	0.00E+00	0.00E+00	3.09E-07	3.18E-07	5.82E-06	8.99E-06
17	0.00E+00	0.00E+00	1.88E-07	1.94E-07	3.55E-06	5.49E-06
18	0.00E+00	0.00E+00	1.23E-07	1.27E-07	2.32E-06	3.59E-06

1-YEAR MARROW DOSE - INHALATION PATHWAY
BDF = 1 (REM)

AREA #	SEVER: 1	SEVER: 2	SEVER: 3	SEVER: 4	SEVER: 5	SEVER: 6
1	0.00E+00	0.00E+00	2.37E-03	2.41E-03	7.58E-01	1.06E+00
2	0.00E+00	0.00E+00	1.19E-03	1.21E-03	3.81E-01	5.32E-01
3	0.00E+00	0.00E+00	5.79E-04	5.87E-04	1.85E-01	2.59E-01
4	0.00E+00	0.00E+00	2.24E-04	2.27E-04	7.15E-02	1.00E-01
5	0.00E+00	0.00E+00	1.07E-04	1.09E-04	3.43E-02	4.80E-02
6	0.00E+00	0.00E+00	5.12E-05	5.19E-05	1.63E-02	2.29E-02
7	0.00E+00	0.00E+00	1.94E-05	1.97E-05	6.20E-03	8.68E-03
8	0.00E+00	0.00E+00	9.19E-06	9.32E-06	2.94E-03	4.11E-03
9	0.00E+00	0.00E+00	4.28E-06	4.34E-06	1.37E-03	1.91E-03
10	0.00E+00	0.00E+00	1.62E-06	1.64E-06	5.16E-04	7.22E-04
11	0.00E+00	0.00E+00	7.36E-07	7.47E-07	2.35E-04	3.29E-04
12	0.00E+00	0.00E+00	3.49E-07	3.54E-07	1.12E-04	1.56E-04
13	0.00E+00	0.00E+00	1.29E-07	1.31E-07	4.12E-05	5.77E-05
14	0.00E+00	0.00E+00	6.09E-08	6.18E-08	1.94E-05	2.72E-05
15	0.00E+00	0.00E+00	2.78E-08	2.82E-08	8.88E-06	1.24E-05
16	0.00E+00	0.00E+00	1.49E-08	1.51E-08	4.74E-06	6.64E-06
17	0.00E+00	0.00E+00	9.06E-09	9.19E-09	2.89E-06	4.05E-06
18	0.00E+00	0.00E+00	5.92E-09	6.01E-09	1.89E-06	2.65E-06

SAN ONOFRE IN SAN CLEMENTE TO YUCCA MOUNTAIN NEVADA AGGREGATE

MODE TRUCK

GROUND SURFACE CONTAMINATION TABLE (MICRO CI/M**2)
BEFORE CLEANUP

AREA #	SEVER: 1	SEVER: 2	SEVER: 3	SEVER: 4	SEVER: 5	SEVER: 6
1	0.00E+00	0.00E+00	3.78E+01	3.80E+01	8.25E+02	1.16E+03
2	0.00E+00	0.00E+00	1.90E+01	1.91E+01	4.14E+02	5.84E+02
3	0.00E+00	0.00E+00	9.23E+00	9.26E+00	2.01E+02	2.84E+02
4	0.00E+00	0.00E+00	3.57E+00	3.58E+00	7.79E+01	1.10E+02
5	0.00E+00	0.00E+00	1.71E+00	1.72E+00	3.73E+01	5.26E+01
6	0.00E+00	0.00E+00	8.16E-01	8.19E-01	1.78E+01	2.51E+01
7	0.00E+00	0.00E+00	3.10E-01	3.11E-01	6.76E+00	9.52E+00
8	0.00E+00	0.00E+00	1.47E-01	1.47E-01	3.20E+00	4.50E+00
9	0.00E+00	0.00E+00	6.82E-02	6.84E-02	1.49E+00	2.10E+00
10	0.00E+00	0.00E+00	2.58E-02	2.58E-02	5.62E-01	7.92E-01
11	0.00E+00	0.00E+00	1.17E-02	1.18E-02	2.56E-01	3.61E-01
12	0.00E+00	0.00E+00	5.57E-03	5.59E-03	1.22E-01	1.71E-01
13	0.00E+00	0.00E+00	2.06E-03	2.07E-03	4.49E-02	6.33E-02
14	0.00E+00	0.00E+00	9.71E-04	9.74E-04	2.12E-02	2.98E-02
15	0.00E+00	0.00E+00	4.44E-04	4.45E-04	9.67E-03	1.36E-02
16	0.00E+00	0.00E+00	2.37E-04	2.38E-04	5.17E-03	7.28E-03
17	0.00E+00	0.00E+00	1.44E-04	1.45E-04	3.15E-03	4.44E-03
18	0.00E+00	0.00E+00	9.45E-05	9.48E-05	2.06E-03	2.90E-03

SAN ONOFRE IN SAN CLEMENTE TO YUCCA MOUNTAIN NEVADA AGGREGATE

INCIDENT-FREE SUMMARY
******** **** *******

INCIDENT-FREE POPULATION EXPOSURE IN PERSON-REM

	PASSENGR	CREW	HANDLERS	OFF LINK	ON LINK	STOPS	STORAGE	TOTALS
LINK 1	0.00E+00	2.72E-02	0.00E+00	2.42E-03	6.36E-03	1.21E-01	0.00E+00	1.57E-01
TOTALS:	0.00E+00	2.72E-02	0.00E+00	2.42E-03	6.36E-03	1.21E-01	0.00E+00	1.57E-01

MAXIMUM INDIVIDUAL IN-TRANSIT DOSE

LINK 1 5.83E-07 REM

SAN ONOFRE IN SAN CLEMENTE TO YUCCA MOUNTAIN NEVADA AGGREGATE

INCIDENT-FREE IMPORTANCE ANALYSIS SUMMARY FOR LINK 1
****

INDEX	DESCRIPTION OF PARAMETER	IMPORTANCE
1	DISTANCE TRAVELED	1.575E-03
2	NUMBER OF SHIPMENTS	1.575E-03
3	PACKAGES PER SHIPMENT	1.575E-03
4	DOSE RATE (TRANSPORT INDEX)	1.575E-03
5	K ZERO	1.575E-03
6	STOP TIME	1.215E-03
7	PERSONS EXPOSED WHILE STOPPED	1.215E-03
8	NUMBER OF CREW MEMBERS	2.721E-04
9	FRACTION OF TRAVEL - RURAL	2.098E-04
10	FRACTION OF TRAVEL - SUBURBAN	1.195E-04
11	NUMBER OF PEOPLE PER VEHICLE	6.356E-05
12	TRAFFIC COUNT - RURAL	4.032E-05
13	FRACTION OF TRAVEL - URBAN	3.064E-05
14	SUBURBAN SHIELDING FACTOR (RS)	2.283E-05
15	POPULATION DENSITY - SUBURBAN	2.283E-05
16	TRAFFIC COUNT - SUBURBAN	1.479E-05
17	TRAFFIC COUNT - URBAN	8.449E-06
18	POPULATION DENSITY - RURAL	9.904E-07
19	RURAL SHIELDING FACTOR (RR)	9.904E-07
20	POPULATION DENSITY - URBAN	4.035E-07
21	URBAN SHIELDING FACTOR (RU)	4.035E-07
22	STORAGE TIME PER SHIPMENT	0.000E+00
23	HANDLER EXPOSURE DISTANCE	0.000E+00
24	FRACTION OF RUSH HOUR TRAVEL	0.000E+00
25	FRACTION OF TRAVEL ON CITY STREETS	0.000E+00
26	NUMBER OF FLIGHT ATTENDANTS	0.000E+00
27	PERSONS EXPOSED PER HANDLING	0.000E+00
28	EXPOSURE TIME FOR HANDLERS	0.000E+00
29	NUMBER OF HANDLINGS	0.000E+00
30	STORAGE EXPOSURE DISTANCE	0.000E+00
31	NUMBER OF PERSONS EXPOSED DURING STORAGE	0.000E+00
32	RATIO OF PEDESTRIAN DENSITY (RPD)	-1.347E-12
33	VELOCITY - URBAN	-2.178E-05
34	VELOCITY - SUBURBAN	-8.189E-05
35	FRACTION OF TRAVEL ON FREEWAYS	-2.922E-04
36	VELOCITY - RURAL	-3.198E-04
37	DISTANCE FROM SOURCE TO CREW	-5.170E-04
38	EXPOSURE DISTANCE WHILE STOPPED	-2.430E-03

THE IMPORTANCE VALUE ESTIMATES THE PERSON-REM INFLUENCE
OF A ONE PERCENT INCREASE IN THE PARAMETER

SAN ONOFRE IN SAN CLEMENTE TO YUCCA MOUNTAIN NEVADA AGGREGATE

ACCIDENT SUMMARY
******** *******

NUMBER OF EXPECTED ACCIDENTS -- MODE TRUCK

CATEGORY	RURAL	SUBURB	URBAN
1	6.09E-06	2.62E-05	2.41E-05
2	3.98E-06	1.72E-05	1.58E-05
3	3.03E-08	1.74E-07	1.52E-08
4	3.03E-11	1.74E-10	1.52E-11
5	5.05E-11	1.31E-10	9.99E-12
6	7.07E-11	8.72E-11	5.20E-12

EARLY FATALITY CONSEQUENCES -- MODE TRUCK

CATEGORY	RURAL	SUBURB	URBAN
1	0.00E+00	0.00E+00	0.00E+00
2	0.00E+00	0.00E+00	0.00E+00
3	0.00E+00	0.00E+00	0.00E+00
4	0.00E+00	0.00E+00	0.00E+00
5	0.00E+00	0.00E+00	0.00E+00
6	0.00E+00	0.00E+00	0.00E+00

ECONOMIC CONSEQUENCES -- MODE TRUCK

CATEGORY	RURAL	SUBURB	URBAN
1	0.00E+00	0.00E+00	0.00E+00
2	0.00E+00	0.00E+00	0.00E+00
3	0.00E+00	0.00E+00	0.00E+00
4	0.00E+00	0.00E+00	0.00E+00
5	0.00E+00	0.00E+00	0.00E+00
6	0.00E+00	0.00E+00	0.00E+00

RADIOLOGICAL CONSEQUENCES -- MODE TRUCK
50 YEAR POPULATION DOSE IN PERSON REM

CATEGORY	RURAL	SUBURB	URBAN
1	0.00E+00	0.00E+00	0.00E+00
2	0.00E+00	0.00E+00	0.00E+00
3	2.53E+00	3.03E+02	9.84E+02
4	2.53E+00	3.03E+02	9.85E+02
5	2.74E+01	3.28E+03	1.06E+04
6	3.63E+01	4.35E+03	1.41E+04

SAN ONOFRE IN SAN CLEMENTE TO YUCCA MOUNTAIN NEVADA AGGREGATE

EXPECTED VALUES OF POPULATION RISK IN PERSON REM

SFUEL	GROUND	INHALED	RESUSPD	CLOUDSH	*INGESTION	TOTAL
CO60	6.77E-05	5.69E-08	2.18E-07	5.08E-09	0.00E+00	6.80E-05
KR85	0.00E+00	0.00E+00	0.00E+00	5.95E-12	0.00E+00	5.95E-12
SR90	0.00E+00	1.83E-12	8.08E-12	0.00E+00	0.00E+00	9.92E-12
RU106	3.14E-10	4.84E-11	1.11E-10	0.00E+00	0.00E+00	4.73E-10
CS134	9.82E-08	1.28E-09	3.93E-09	2.14E-11	0.00E+00	1.03E-07
CS137	8.13E-07	2.85E-09	1.26E-08	0.00E+00	0.00E+00	8.28E-07
CE144	1.87E-13	1.70E-12	3.39E-12	2.73E-17	0.00E+00	5.28E-12
EU154	1.68E-11	4.81E-13	1.97E-12	1.12E-15	0.00E+00	1.92E-11
PU238	2.99E-14	2.01E-11	9.07E-11	3.22E-20	0.00E+00	1.11E-10
PU239	2.16E-15	3.00E-12	1.37E-11	4.14E-21	0.00E+00	1.67E-11
PU240	5.35E-15	3.42E-12	1.56E-11	4.98E-21	0.00E+00	1.90E-11
PU241	8.97E-16	1.60E-11	6.81E-11	0.00E+00	0.00E+00	8.41E-11
AM241	2.67E-13	9.76E-12	4.44E-11	3.02E-18	0.00E+00	5.45E-11
AM243	7.35E-15	1.51E-13	6.87E-13	1.25E-19	0.00E+00	8.45E-13
CM244	9.83E-15	7.11E-12	3.07E-11	1.85E-20	0.00E+00	3.78E-11
TOTALS:	6.86E-05	6.12E-08	2.35E-07	5.11E-09	0.00E+00	6.89E-05

* NOTE THAT INGESTION RISK IS A SOCIETAL RISK;
THE USER MAY WISH TO TREAT THIS VALUE SEPARATELY.

SAN ONOFRE IN SAN CLEMENTE TO YUCCA MOUNTAIN NEVADA AGGREGATE

EXPECTED RISK VALUES - OTHER

LINK	ECON $$	EARLY FATALITY
1	0.00E+00	0.00E+00
TOTAL	0.00E+00	0.00E+00

EOI
END OF RUN

5.1 Output File 1 (The page numbers of the output pages are printed in the upper right-hand corner of the printout.)

Page 1 — Page 1 is always a cover page. The page number and run date are printed at the top of the page. The code name RADTRAN 4 is printed in large letters in the middle of the page along with the the last date when code revisions were made in small print. A table containing the numbers, names, and descriptions of all transportation modes that can be analyzed with RADTRAN 4 appears at the bottom of the page.

Page 2 — The Echo Check is the input echo, which always starts on page 2 of a RADTRAN 4 output and continues to additional pages if needed. The echo check page of this output file is described in some detail to illustrate data requirements.

Echo Check Page Features

1. The first line of the input is a TITLE line. The title is SAN ONOFRE IN SAN CLEMENTE TO YUCCA MOUNTAIN NEVADA AGGREGATE. The word aggregate indicates that this run will use aggregate data for route characteristics. This title will appear at the top of all subsequent pages of the output.

2. The second line of the input is a FORM line. FORM UNIT indicates that the output will be in doses rather than health effects.

3. The third line of the input is a DIMEN line, in which dimensions are assigned to five arrays as indicated: namely, 15 isotopes, six accident-severity categories, five physical-chemical groups, 10 radial areas, and 18 downwind dispersal areas. The six-category accident-severity scheme described by Wilmot et al. (1983) was used in this analysis.

4. On the fourth line, the keyword PARM is used to set flags as described in Section 3.3.

5. Recall that except for four parameter arrays (ISOTOPES, LINK, DISTKM, and PKGSIZ), the order of input after the first four lines is not important for data entry. The keyword PACKAGE appears on the fifth line in this input data set, but it could have been entered by the user during data entry in any order after line five and before the first EOF. The second-level keyword LABGRP, which is used under the first-level keyword PACKAGE to assign labels to the five physical-chemical groups of isotopes identified in this analysis, illustrates the way in which second- and third-level keywords are required to be subordinate to first-level keywords.

6. Under the keyword SHIPMENT, the important LABISO array in which each isotope is labeled is entered. The 15 isotopes used here represent those that contribute to 99% of the dispersion health hazard of the spent fuel. The method of determination was based on normalization of the ratios of the amount of each isotope in spent fuel (from an ORIGEN run) to the maximum permissible concentration in air (in Ci). The user may employ this or any other suitable method of selecting isotopes.

7. Under the keyword NORMAL, for the truck mode (NMODE = 1) the 25 truck-specific parameter values in the DNORML array are entered. The entire array is shown here for clarity. In practice, it is only necessary to enter DNORML parameters when the user does not wish to accept the available default values, and only the parameters that the user wishes to redefine need to be entered. The entire array will appear in the Echo Check, however.

8. Two second-level keywords and associated data arrays are under the first-level keyword ACCIDENT:

   - ARATMZ: for the three population-density zones, truck accident rate data are entered;

   - SEVFRC: for the truck mode (NMODE = 1), six conditional probabilities of occurrence for the six accident-severity categories for each population-density zone are entered. Note that the sum of the values for each population-density zone should be approximately equal to 1.0.

9. Under the first-level keyword RELEASE, three second-level keywords are entered:

   - RFRAC: for each of the five physical-chemical groups identified by the user, six release fraction values are entered;

   - AERSOL: for each dispersibility category identified by the user, six aerosol fraction values are entered. (This means that defaults were not used and that IDISP categories 2,3,4, and 5 were redefined for this analysis.)

   - RESP: for each dispersibility category identified by the user, six respirable aerosol fraction values are entered. Again, default values were not used.

10. Under the keyword OTHER is listed the clean-up level parameter value (CULVL).

11. As shown in the echo, the user has entered an EOF after completing this part of the data entry, and then has proceeded to enter values for three additional parameter arrays.

12. The material line immediately follows the first-level keyword ISOTOPES. The material line consists of a string of numbers that specify shipment- and material-level characteristics. In this example, the values are the following:

    -1 = exclusive-use truck,

    1.0 = number of shipments,

    1.0 = number of packages per shipment,

    13.68 = dose rate at 1 m from the shipment (mrem/hr),

    1.0 = fraction of dose that is treated as gamma radiation,

    0.0 = fraction of dose that is treated as neutron radiation, and

    SFUEL = material label.

13. Following the ISOTOPES material line, 15 isotope lines are entered, one for each isotope in the analysis. On each line the user must enter one isotope label, the number of curies of that isotope in the package, the physical-chemical group to which that isotope has been assigned, and the dispersibility category to which that isotope has been assigned.

14. Since this is a non-LINK run, the total distance in kilometers is entered under the keyword DISTKM. Note that the fractions of travel in each of the three population-density zones for this conveyance are entered elsewhere; they are the first three parameter values in the DNORML array.

15. The package size in meters is entered after the keyword PKGSIZ. In this case it is the length of a present-generation spent fuel cask.

16. The final EOF appears in the echo check, but the terminal EOI that is entered when the data set is created by the user is not shown here. It is printed on the last page of the output.

Pages 3 through 12 These pages contain tables of input data. Unlike the Echo Check, which does not show defaults, these tables give the values of all data used in the analysis including both default and user-defined data. Further, the organization of these tables is not directly related to the organization of the input data. Tables of input values used in the incident-free calculation are on pages 3 through 5, including the important DNORML array (page 5). All data taken from the internal isotope data library are shown (pages 6 through 7). Input data on package behavior and physical-chemical isotope groups are given (page 8). In addition, all values for aerosol fraction, respirable fraction, and on-scene costs are shown (pages 9 through 10), regardless of whether all categories were used in the analysis. Similarly, the early fatality probability table used in RADTRAN 4 is printed (page 11), regardless of whether any doses of these magnitudes were calculated in the analysis. Data for calculation of dispersal and nondispersal accident effects are given on page 12.

Page 13 The regulatory check messages, if any, are printed on page 13. The regulatory checks performed by RADTRAN 4 are fully described in the RADTRAN 4 Technical Manual [Neuhauser and Kanipe in preparation [b]]. In this example the check was for whether the dose rate at 2 m from the conveyance exceeded 10 mrem/hr. Recall that the user must enter a value for the dose rate at 1 m. The entered value of 13.68 mrem/hr at 1 m gave a calculated dose rate at 2 m of more than 10 mrem/hr and the dose rate at 1 m was reset to 13 mrem/hr to give an acceptable value at 2 m. This check is performed for shipments designated exclusive-use.

Pages 14 through 15 Page 14 contains tables of 1-yr lung and marrow doses from inhalation calculated for the analysis, and calculated preclean-up ground contamination levels are shown in the table on page 15 for each isodose area used in the analysis.

Page 16 Incident-Free Summary. On page 16 the doses for each mode and exposure group are given for each material in each link or mode. In this case, there is only one material shipped by only one mode, so there is only one line in the summary. The maximum individual in-transit dose is also given below the summary.

Page 17 Incident-Free Importance Analysis Summary. The importance value, i.e., the effect in person-rem of a 1% change in the value of the input parameter, is listed for each parameter used in the incident-free calculations. Note that the list is in rank order.

Pages 18 through 20 Accident Risk Summary. Page 18 contains separate tables of values for each consequence type broken down by mode,

population-density zone or link, and severity category. The units of the first table on p. 18 are the number of accidents. The units of the second table are the number of fatalities. The units of the third table is dollars, and the units of the last table are person-rem. All zero values appearing in any of these tables may indicate that no calculation was performed, because the user is not required to enter data for all calculations (e.g., economic parameters may be omitted). The results of the actual risk calculations are shown on page 19. In this table, risk estimates are shown for each exposure pathway and each isotope in each material. The ingestion risk, which is a societal risk value (as discussed in the RADTRAN 4 Technical Manual), is included in the total column, but is also flagged to remind the user that the value is not analogous to the others and may be subtracted from the total for certain analyses. On the last page of the output is a short table showing the estimated number of early fatalities. Because no data were entered for the economic parameters, the economic risk table contains only zeros. Note that the EOI input echo is printed at the end of the output.

```
RRRR    AAA   DDDD   TTTTT  RRRR    AAA   N   N
R   R  A   A  D   D    T    R   R  A   A  NN  N
R   R  A   A  D   D    T    R   R  A   A  N N N
RRRR   A   A  D   D    T    RRRR   A   A  N  NN
R R    AAAAA  D   D    T    R R    AAAAA  N   N
R  R   A   A  D   D    T    R  R   A   A  N   N
R   R  A   A  DDDD     T    R   R  A   A  N   N
```

```
    4
 4  4
 4  4
 44444
    4
    4
    4
```

RADTRAN 4.0.12 VERSION DATE: NOVEMBER 19,1991

MODE DESCRIPTIONS

NUMBER	NAME	CHARACTERIZATION
1	TRUCK	LONG HAUL VEHICLE
2	RAIL	COMMERCIAL TRAIN
3	BARGE	INLAND VESSEL
4	SHIP	OPEN SEA VESSEL
5	CARGO AIR	CARGO AIRCRAFT
6	PASS AIR	PASSENGER AIRCRAFT
7	P-VAN	PASSENGER VAN
8	CVAN-T	COMMERCIAL VAN
9	CVAN-R	COMMERCIAL VAN
10	CVAN-CA	COMMERCIAL VAN

ECHO CHECK

```
TITLE  SAN ONOFRE IN SAN CLEMENTE TO YUCCA MOUNTAIN NEVADA  ROUTE-SPECIFIC
FORM   UNIT
DIMEN  15  6  5  10 18
PARM  0 3 2 3 0
PACKAGE  LABGRP HIGH NOBLE VOL_A OTHER VOL_B
SHIPMENT
         LABISO   CO60      KR85      SR90      RU106     CS134
                  CS137     CE144     EU154     PU238     PU239     PU240
                  PU241     AM241     AM243     CM244
NORMAL   NMODE=1   7.96E-01  1.76E-01  2.80E-02  8.86E+01  4.03E+01  2.41E+01
                   2.00E+00  1.00E+01  0.00E+00  1.10E-02  0.00E+00  0.00E+00
                   0.00E+00  5.00E+01  2.00E+01  0.00E+00  1.00E+02  1.00E+02
                   2.00E+00  0.00E+00  0.00E+00  1.00E+00  4.70E+02  7.80E+02
                   2.80E+03
ACCIDENT ARATMZ NMODE=1 2.08E-08 4.06E-07 2.34E-06
         SEVFRC NPOP=1 NMODE=1 0.603 0.394 3.E-3 3.E-6 5.E-6 7.E-6
                NPOP=2 NMODE=1 0.602 0.394 4.E-3 4.E-6 3.E-6 2.E-6
                NPOP=3 NMODE=1 0.604 0.395 3.8E-4 3.8E-7 2.5E-7 1.3E-7
RELEASE RFRAC GROUP=1 2*0.0 4*1.2E-2
              GROUP=2 3*0.0 0.01 0.1 0.11
              GROUP=3 3*0.0 1.0E-8 2.0E-4 2.8E-4
              GROUP=4 3*0.0 1.0E-8 5.0E-8 5.0E-8
              GROUP=5 3*0.0 1.0E-8 1.0E-6 4.2E-5
        AERSOL DISP=2 2*0 4*1.0
               DISP=3 3*0 3*1.0
               DISP=4 3*0 3*1.0
               DISP=5 3*0 3*1.0
        RESP   DISP=2 2*0 4*.05
               DISP=3 3*0 3*1.0
               DISP=4 3*0 0.05 2*1.0
               DISP=5 3*0 3*.05
OTHER CULVL=0.2
EOF
ISOTOPES  -1  1.0  1.0  13.68  1.0 0.0  SFUEL
CO60  9.22E+01 HIGH 2
KR85  6.10E+03 NOBLE 3
SR90  5.96E+04 OTHER 5
RU106 1.62E+04 VOL_B 5
CS134 2.74E+04 VOL_A 4
CS137 8.76E+04 VOL_A 4
CE144 1.22E+04 OTHER 4
EU154 7.00E+03 OTHER 4
PU238 2.96E+03 OTHER 5
PU239 4.10E+02 OTHER 5
PU240 4.68E+02 OTHER 5
PU241 1.26E+05 OTHER 5
AM241 1.29E+03 OTHER 5
AM243 1.99E+01 OTHER 5
CM244 1.79E+03 OTHER 5
PKGSIZ  SFUEL 5.2
LINK 1 335  88.6  6.00E+00 4.70E+02 1.08E-08 R 1
LINK 1  81  88.6  7.19E+02 7.80E+02 2.11E-07 S 1
LINK 1  14  88.6  3.86E+03 2.80E+03 1.22E-06 U 1
LINK 1 157  88.6  6.00E+00 4.70E+02 4.45E-08 R 1
LINK 1  22  88.6  7.19E+02 7.80E+02 8.68E-07 S 1
LINK 1   2  88.6  3.86E+03 2.80E+03 5.01E-06 U 1
EOF
```

SAN ONOFRE IN SAN CLEMENTE TO YUCCA MOUNTAIN NEVADA ROUTE-SPECIFIC

PACKAGE CHARACTERISTICS

FOR MATERIAL	DIMENSION (METERS)	EFFECTIVE DIMENSION	K(0) METERS SQ.
SFUEL	5.200E+00	4.677E+00	1.115E+01

K(0) IS TI TO DOSE RATE CONVERSION FACTOR

PACKAGE HANDLING THRESHOLDS (METERS)
PKGSZ1= 5.000E-01
PKGSZ2= 1.000E+00
PACKAGES .LE. PKGSZ1 ARE HAND CARRIED
PACKAGES .GT. PKGSZ1 AND .LE. PKGSZ2 ARE HANDLED BY SMALL EQUIPMENT
PACKAGES .GT. PKGSZ2 ARE HANDLED BY HEAVY EQUIPMENT

MATERIAL CHARACTERISTICS

MATERIAL	FRACTION OF GAMMA	FRACTION OF NEUTRON
SFUEL	1.000E+00	0.000E+00

SAN ONOFRE IN SAN CLEMENTE TO YUCCA MOUNTAIN NEVADA ROUTE-SPECIFIC

MODE CHARACTERISTICS

MODE	EXCLUSIVE USE	NUMBER OF SHIPMENTS	MATERIALS	TRANSPORT INDEX (TI)	PACKAGES/ SHIPMENT
TRUCK	YES	1.00E+00			
			SFUEL	1.37E+01	1.00E+00

BUILDING SHIELDING OPTION= 2
(1=TOTAL SHIELDING, 2=PARTIAL SHIELDING, 3=NO SHIELDING)

RPD= 6.000E+00
(RATIO OF PEDESTRIAN DENSITY (PEDESTRIAN/KM SQ OF SIDEWALK)
TO POPULATION DENSITY (PEOPLE/KM SQ IN URBAN AREAS)

RR = 1.000E+00
(TRANSMISSION FACTOR FOR RURAL AREAS)

RS = 8.700E-01
(TRANSMISSION FACTOR FOR SUBURBAN AREAS)

RU = 1.800E-02
(TRANSMISSION FACTOR FOR URBAN AREAS)

SAN ONOFRE IN SAN CLEMENTE TO YUCCA MOUNTAIN NEVADA ROUTE-SPECIFIC

SEGMENT RELATED DATA

	LINK 1	LINK 2	LINK 3	LINK 4	LINK 5	LINK 6
MODE	TRUCK	TRUCK	TRUCK	TRUCK	TRUCK	TRUCK
DISTANCE (KM)	3.35E+02	8.10E+01	1.40E+01	1.57E+02	2.20E+01	2.00E+00
SPEED (KM/HR)	8.86E+01	8.86E+01	8.86E+01	8.86E+01	8.86E+01	8.86E+01
POPULATION DENSITY	6.00E+00	7.19E+02	3.86E+03	6.00E+00	7.19E+02	3.86E+03
VEHICLE DENSITY	4.70E+02	7.80E+02	2.80E+03	4.70E+02	7.80E+02	2.80E+03
ACCIDENT RATE/KM	1.08E-08	2.11E-07	1.22E-06	4.45E-08	8.68E-07	5.01E-06
ZONE	RURAL	SUBURBAN	URBAN	RURAL	SUBURBAN	URBAN
ROAD TYPE	FREEWAY	FREEWAY	FREEWAY	FREEWAY	FREEWAY	FREEWAY

MODE RELATED DATA

	LINK 1	LINK 2	LINK 3	LINK 4	LINK 5	LINK 6
PEOPLE IN CREW	2.00E+00	2.00E+00	2.00E+00	2.00E+00	2.00E+00	2.00E+00
CREW EXPOSURE DIST	1.00E+01	1.00E+01	1.00E+01	1.00E+01	1.00E+01	1.00E+01
PEOPLE AT STOPS	5.00E+01	5.00E+01	5.00E+01	5.00E+01	5.00E+01	5.00E+01
STOP EXPOSURE DIST	2.00E+01	2.00E+01	2.00E+01	2.00E+01	2.00E+01	2.00E+01
STOP TIME PER KM	1.10E-02	1.10E-02	1.10E-02	1.10E-02	1.10E-02	1.10E-02
MINIMUM STOP TIME	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
END POINT STOP TIME	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PEOPLE AT STORAGE	1.00E+02	1.00E+02	1.00E+02	1.00E+02	1.00E+02	1.00E+02
STOR. EXPOSURE DIST	1.00E+02	1.00E+02	1.00E+02	1.00E+02	1.00E+02	1.00E+02
NUMBER OF HANDLINGS	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

SAN ONOFRE IN SAN CLEMENTE TO YUCCA MOUNTAIN NEVADA ROUTE-SPECIFIC

ISOTOPE RELATED DATA

NUCLIDE	CURIES PER PKG	RELEASE GROUP	RESUSP FACTOR	LUNG TYPE	DISPERS. CATEGORY	1YR INHAL LUNG	REM/CI MARROW
SFUEL							
CO60	9.22E+01	HIGH	4.83E+00	2	2	7.90E+05	3.80E+04
KR85	6.10E+03	NOBLE	1.00E+00	2	3	0.00E+00	0.00E+00
SR90	5.96E+04	OTHER	5.41E+00	2	5	4.50E+06	3.80E+03
RU106	1.62E+04	VOL_B	3.28E+00	2	5	4.30E+06	4.50E+03
CS134	2.74E+04	VOL_A	4.07E+00	2	4	4.10E+04	3.90E+04
CS137	8.76E+04	VOL_A	5.41E+00	2	4	3.10E+04	2.60E+04
CE144	1.22E+04	OTHER	2.99E+00	1	4	3.60E+06	4.20E+03
EU154	7.00E+03	OTHER	5.09E+00	2	4	0.00E+00	0.00E+00
PU238	2.96E+03	OTHER	5.51E+00	3	5	4.50E+08	1.10E+06
PU239	4.10E+02	OTHER	5.57E+00	3	5	4.20E+08	1.10E+06
PU240	4.68E+02	OTHER	5.56E+00	3	5	4.20E+08	1.10E+06
PU241	1.26E+05	OTHER	5.26E+00	3	5	3.60E+05	1.30E+03
AM241	1.29E+03	OTHER	5.55E+00	3	5	1.20E+08	1.70E+07
AM243	1.99E+01	OTHER	5.56E+00	3	5	1.10E+08	1.60E+07
CM244	1.79E+03	OTHER	5.32E+00	3	5	1.20E+08	1.70E+07

NUCLIDE	HALF LIFE	GAMMA ENERGY	CLOUD FACTOR	TRANSFER CROPS	TRANSFER SOIL	DEPOS SPEED
SFUEL						
CO60	1.93E+03	2.50E+00	4.12E-01	0.00E+00	0.00E+00	1.00E-02
KR85	3.92E+03	2.21E-03	3.55E-04	0.00E+00	0.00E+00	0.00E+00
SR90	1.06E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.00E-02
RU106	3.68E+02	2.01E-01	0.00E+00	0.00E+00	0.00E+00	1.00E-02
CS134	7.53E+02	1.55E+00	2.54E-01	0.00E+00	0.00E+00	1.00E-02
CS137	1.10E+04	5.96E-01	0.00E+00	0.00E+00	0.00E+00	1.00E-02
CE144	2.84E+02	5.25E-02	2.88E-03	0.00E+00	0.00E+00	1.00E-02
EU154	3.21E+03	1.22E+00	2.06E-01	0.00E+00	0.00E+00	1.00E-02
PU238	3.21E+04	1.81E-03	1.40E-05	0.00E+00	0.00E+00	1.00E-02
PU239	8.79E+06	7.96E-04	1.30E-05	0.00E+00	0.00E+00	1.00E-02
PU240	2.39E+06	1.73E-03	1.37E-05	0.00E+00	0.00E+00	1.00E-02
PU241	5.26E+03	2.54E-06	0.00E+00	0.00E+00	0.00E+00	1.00E-02
AM241	1.58E+05	3.24E-02	3.01E-03	0.00E+00	0.00E+00	1.00E-02
AM243	2.70E+06	5.59E-02	8.11E-03	0.00E+00	0.00E+00	1.00E-02
CM244	6.62E+03	1.70E-03	1.33E-05	0.00E+00	0.00E+00	1.00E-02

SAN ONOFRE IN SAN CLEMENTE TO YUCCA MOUNTAIN NEVADA ROUTE-SPECIFIC

ISOTOPE RELATED DATA

NUCLIDE	50-YR EFFECTIVE REM/CI	
	INHALE	INGEST
SFUEL		
CO60	2.80E+05	2.60E+04
KR85	0.00E+00	0.00E+00
SR90	2.40E+06	1.30E+05
RU106	8.00E+05	2.10E+04
CS134	4.60E+04	7.40E+04
CS137	3.20E+04	5.00E+04
CE144	6.30E+05	2.00E+04
EU154	3.10E+05	9.10E+03
PU238	5.30E+08	3.80E+06
PU239	5.70E+08	4.30E+06
PU240	5.70E+08	4.30E+06
PU241	9.90E+06	8.60E+04
AM241	5.90E+08	4.50E+06
AM243	5.90E+08	4.50E+06
CM244	3.10E+08	2.30E+06

SAN ONOFRE IN SAN CLEMENTE TO YUCCA MOUNTAIN NEVADA ROUTE-SPECIFIC

RELEASE RELATED DATA

RELEASE FRACTIONS

GROUP	SEVER: 1	SEVER: 2	SEVER: 3	SEVER: 4	SEVER: 5	SEVER: 6
1	0.00E+00	0.00E+00	1.20E-02	1.20E-02	1.20E-02	1.20E-02
2	0.00E+00	0.00E+00	0.00E+00	1.00E-02	1.00E-01	1.10E-01
3	0.00E+00	0.00E+00	0.00E+00	1.00E-08	2.00E-04	2.80E-04
4	0.00E+00	0.00E+00	0.00E+00	1.00E-08	5.00E-08	5.00E-08
5	0.00E+00	0.00E+00	0.00E+00	1.00E-08	1.00E-06	4.20E-05

ACCIDENT SEVERITY FRACTIONS
FOR TRUCK

ZONE	SEVER: 1	SEVER: 2	SEVER: 3	SEVER: 4	SEVER: 5	SEVER: 6
1	6.03E-01	3.94E-01	3.00E-03	3.00E-06	5.00E-06	7.00E-06
2	6.02E-01	3.94E-01	4.00E-03	4.00E-06	3.00E-06	2.00E-06
3	6.04E-01	3.95E-01	3.80E-04	3.80E-07	2.50E-07	1.30E-07

FICHE # 2

SAN ONOFRE IN SAN CLEMENTE TO YUCCA MOUNTAIN NEVADA ROUTE-SPECIFIC

AEROSOLIZED FRACTION OF RELEASED MATERIAL

DISP CAT	SEVER: 1	SEVER: 2	SEVER: 3	SEVER: 4	SEVER: 5	SEVER: 6
1	0..00E+00	0..00E+00	0..00E+00	0..00E+00	0..00E+00	0..00E+00
2	0..00E+00	0..00E+00	1..00E+00	1..00E+00	1..00E+00	1..00E+00
3	0..00E+00	0..00E+00	0..00E+00	1..00E+00	1..00E+00	1..00E+00
4	0..00E+00	0..00E+00	0..00E+00	1..00E+00	1..00E+00	1..00E+00
5	0..00E+00	0..00E+00	0..00E+00	1..00E+00	1..00E+00	1..00E+00
6	1..00E+00	1..00E+00	1..00E+00	1..00E+00	1..00E+00	1..00E+00
7	1..00E+00	1..00E+00	1..00E+00	1..00E+00	1..00E+00	1..00E+00
8	1..00E+00	1..00E+00	1..00E+00	1..00E+00	1..00E+00	1..00E+00
9	1..00E+00	1..00E+00	1..00E+00	1..00E+00	1..00E+00	1..00E+00
10	1..00E+00	1..00E+00	1..00E+00	1..00E+00	1..00E+00	1..00E+00
11	1..00E+00	1..00E+00	1..00E+00	1..00E+00	1..00E+00	1..00E+00

FRACTION OF AEROSOLS BELOW 10 MICRONS AED

DISP CAT	SEVER: 1	SEVER: 2	SEVER: 3	SEVER: 4	SEVER: 5	SEVER: 6
1	0..00E+00	0..00E+00	0..00E+00	0..00E+00	0..00E+00	0..00E+00
2	0..00E+00	0..00E+00	5..00E-02	5..00E-02	5..00E-02	5..00E-02
3	0..00E+00	0..00E+00	0..00E+00	1..00E+00	1..00E+00	1..00E+00
4	0..00E+00	0..00E+00	0..00E+00	5..00E-02	1..00E+00	1..00E+00
5	0..00E+00	0..00E+00	0..00E+00	5..00E-02	5..00E-02	5..00E-02
6	5..00E-02	5..00E-02	5..00E-02	5..00E-02	5..00E-02	5..00E-02
7	1..00E+00	1..00E+00	1..00E+00	1..00E+00	1..00E+00	1..00E+00
8	1..00E+00	1..00E+00	1..00E+00	1..00E+00	1..00E+00	1..00E+00
9	1..00E+00	1..00E+00	1..00E+00	1..00E+00	1..00E+00	1..00E+00
10	1..00E+00	1..00E+00	1..00E+00	1..00E+00	1..00E+00	1..00E+00
11	1..00E+00	1..00E+00	1..00E+00	1..00E+00	1..00E+00	1..00E+00

SAN ONOFRE IN SAN CLEMENTE TO YUCCA MOUNTAIN NEVADA ROUTE-SPECIFIC

COST RELATED DATA

EMERGENCY RESPONSE COST

	SEVER: 1	SEVER: 2	SEVER: 3	SEVER: 4	SEVER: 5	SEVER: 6
1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

ON-SCENE COSTS
((RF=RELEASE FRACTION)

RF=0.	0.<RF<=.01	.01<RF<=0.1	.1<RF<=1.
0.	0.	0.	0.

SAN ONOFRE IN SAN CLEMENTE TO YUCCA MOUNTAIN NEVADA ROUTE-SPECIFIC

HEALTH RELATED DATA

EARLY FATALITY PROBABILITIES

DOSE(REM)	LUNG-1	LUNG-2	LUNG-3	MARROW
100000..000	1..000E+00	1..000E+00	1..000E+00	1..000E+00
80000..000	1..000E+00	8..500E-01	8..000E-01	1..000E+00
70000..000	1..000E+00	8..000E-01	5..000E-01	1..000E+00
40000..000	1..000E+00	7..000E-01	0..000E+00	1..000E+00
30000..000	1..000E+00	5..000E-01	0..000E+00	1..000E+00
25000..000	1..000E+00	2..000E-01	0..000E+00	1..000E+00
20000..000	1..000E+00	8..000E-02	0..000E+00	1..000E+00
10000..000	6..000E-01	0..000E+00	0..000E+00	1..000E+00
8000..000	1..000E-01	0..000E+00	0..000E+00	1..000E+00
6000..000	6..000E-02	0..000E+00	0..000E+00	1..000E+00
4000..000	3..000E-02	0..000E+00	0..000E+00	1..000E+00
3000..000	0..000E+00	0..000E+00	0..000E+00	1..000E+00
2000..000	0..000E+00	0..000E+00	0..000E+00	1..000E+00
1000..000	0..000E+00	0..000E+00	0..000E+00	1..000E+00
800..000	0..000E+00	0..000E+00	0..000E+00	9..960E-01
700..000	0..000E+00	0..000E+00	0..000E+00	9..000E-01
600..000	0..000E+00	0..000E+00	0..000E+00	4..000E-01
500..000	0..000E+00	0..000E+00	0..000E+00	5..000E-02
400..000	0..000E+00	0..000E+00	0..000E+00	0..000E+00
300..000	0..000E+00	0..000E+00	0..000E+00	0..000E+00
100..000	0..000E+00	0..000E+00	0..000E+00	0..000E+00
75..000	0..000E+00	0..000E+00	0..000E+00	0..000E+00
50..000	0..000E+00	0..000E+00	0..000E+00	0..000E+00
30..000	0..000E+00	0..000E+00	0..000E+00	0..000E+00
15..000	0..000E+00	0..000E+00	0..000E+00	0..000E+00
5..000	0..000E+00	0..000E+00	0..000E+00	0..000E+00
1..000	0..000E+00	0..000E+00	0..000E+00	0..000E+00
0..100	0..000E+00	0..000E+00	0..000E+00	0..000E+00
0..010	0..000E+00	0..000E+00	0..000E+00	0..000E+00
0..010	0..000E+00	0..000E+00	0..000E+00	0..000E+00

SAN ONOFRE IN SAN CLEMENTE TO YUCCA MOUNTAIN NEVADA ROUTE-SPECIFIC

DISPERSAL ACCIDENT INPUT

AREADA (M SQ)	DILUTION FACTOR*
4.590E+02	3.420E-03
1.530E+03	1.720E-03
3.940E+03	8.580E-04
1.250E+04	3.420E-04
3.040E+04	1.720E-04
6.850E+04	8.580E-05
1.760E+05	3.420E-05
4.450E+05	1.720E-05
8.590E+05	8.580E-06
2.550E+06	3.420E-06
4.450E+06	1.720E-06
1.030E+07	8.580E-07
2.160E+07	3.420E-07
5.520E+07	1.720E-07
1.770E+08	8.580E-08
4.890E+08	5.420E-08
8.120E+08	4.300E-08
1.350E+09	3.420E-08

* DILUTION FACTOR UNITS ARE ((CI-SEC/M**3)/CI-RELEASED))

NON-DISPERSAL ACCIDENT INPUT

RADIST(M)		
RURAL	SUBURBAN	URBAN
3.050E+00	3.050E+00	3.050E+00
6.100E+00	6.100E+00	6.100E+00
9.100E+00	9.100E+00	9.100E+00
1.220E+01	1.220E+01	1.220E+01
1.520E+01	1.520E+01	1.520E+01
3.050E+01	3.050E+01	3.050E+01
6.100E+01	6.100E+01	6.100E+01
9.140E+01	9.140E+01	9.140E+01
1.524E+02	1.524E+02	1.524E+02
3.050E+02	3.050E+02	3.050E+02

BUILDING DOSE FACTOR	= 8.600E-03
FRACTION OF LAND UNDER CULTIVATION	= 5.000E-01
CONTAMINATION CLEAN UP LEVEL ((UCI/M**2)	= 2.000E-01
BREATHING RATE ((M**3/SEC)	= 3.300E-04

REGULATORY CHECKS

FOR THE SHIPMENT OF SFUEL BY MODE 1
THE DOSE RATE AT 2 METERS COULD EXCEED 10 MR/HR
PPS*TI HAS BEEN RESET TO EQUAL 13.00

FOR THE SHIPMENT OF SFUEL BY MODE 1
THE DOSE RATE AT 2 METERS COULD EXCEED 10 MR/HR
PPS*TI HAS BEEN RESET TO EQUAL 13.00

FOR THE SHIPMENT OF SFUEL BY MODE 1
THE DOSE RATE AT 2 METERS COULD EXCEED 10 MR/HR
PPS*TI HAS BEEN RESET TO EQUAL 13.00

FOR THE SHIPMENT OF SFUEL BY MODE 1
THE DOSE RATE AT 2 METERS COULD EXCEED 10 MR/HR
PPS*TI HAS BEEN RESET TO EQUAL 13.00

FOR THE SHIPMENT OF SFUEL BY MODE 1
THE DOSE RATE AT 2 METERS COULD EXCEED 10 MR/HR
PPS*TI HAS BEEN RESET TO EQUAL 13.00

FOR THE SHIPMENT OF SFUEL BY MODE 1
THE DOSE RATE AT 2 METERS COULD EXCEED 10 MR/HR
PPS*TI HAS BEEN RESET TO EQUAL 13.00

SAN ONOFRE IN SAN CLEMENTE TO YUCCA MOUNTAIN NEVADA ROUTE-SPECIFIC

MODE TRUCK

1-YEAR LUNG DOSE - INHALATION PATHWAY
BDF = 1 ((REM)

AREA #	SEVER: 1	SEVER: 2	SEVER: 3	SEVER: 4	SEVER: 5	SEVER: 6
1	0.00E+00	0.00E+00	4.93E-02	5.07E-02	9.29E-01	1.44E+00
2	0.00E+00	0.00E+00	2.48E-02	2.55E-02	4.66E-01	7.21E-01
3	0.00E+00	0.00E+00	1.20E-02	1.24E-02	2.27E-01	3.51E-01
4	0.00E+00	0.00E+00	4.65E-03	4.79E-03	8.77E-02	1.36E-01
5	0.00E+00	0.00E+00	2.23E-03	2.30E-03	4.20E-02	6.50E-02
6	0.00E+00	0.00E+00	1.06E-03	1.09E-03	2.00E-02	3.10E-02
7	0.00E+00	0.00E+00	4.04E-04	4.15E-04	7.60E-03	1.18E-02
8	0.00E+00	0.00E+00	1.91E-04	1.97E-04	3.60E-03	5.57E-03
9	0.00E+00	0.00E+00	8.89E-05	9.15E-05	1.67E-03	2.59E-03
10	0.00E+00	0.00E+00	3.36E-05	3.45E-05	6.33E-04	9.78E-04
11	0.00E+00	0.00E+00	1.53E-05	1.57E-05	2.88E-04	4.46E-04
12	0.00E+00	0.00E+00	7.26E-06	7.47E-06	1.37E-04	2.12E-04
13	0.00E+00	0.00E+00	2.68E-06	2.76E-06	5.06E-05	7.82E-05
14	0.00E+00	0.00E+00	1.27E-06	1.30E-06	2.38E-05	3.69E-05
15	0.00E+00	0.00E+00	5.78E-07	5.95E-07	1.09E-05	1.68E-05
16	0.00E+00	0.00E+00	3.09E-07	3.18E-07	5.82E-06	8.99E-06
17	0.00E+00	0.00E+00	1.88E-07	1.94E-07	3.55E-06	5.49E-06
18	0.00E+00	0.00E+00	1.23E-07	1.27E-07	2.32E-06	3.59E-06

1-YEAR MARROW DOSE - INHALATION PATHWAY
BDF = 1 ((REM)

AREA #	SEVER: 1	SEVER: 2	SEVER: 3	SEVER: 4	SEVER: 5	SEVER: 6
1	0.00E+00	0.00E+00	2.37E-03	2.40E-03	7.58E-01	1.06E+00
2	0.00E+00	0.00E+00	1.19E-03	1.21E-03	3.81E-01	5.32E-01
3	0.00E+00	0.00E+00	5.79E-04	5.87E-04	1.85E-01	2.59E-01
4	0.00E+00	0.00E+00	2.24E-04	2.27E-04	7.15E-02	1.00E-01
5	0.00E+00	0.00E+00	1.07E-04	1.09E-04	3.43E-02	4.80E-02
6	0.00E+00	0.00E+00	5.12E-05	5.19E-05	1.63E-02	2.29E-02
7	0.00E+00	0.00E+00	1.94E-05	1.97E-05	6.20E-03	8.68E-03
8	0.00E+00	0.00E+00	9.19E-06	9.32E-06	2.94E-03	4.11E-03
9	0.00E+00	0.00E+00	4.28E-06	4.34E-06	1.37E-03	1.91E-03
10	0.00E+00	0.00E+00	1.62E-06	1.64E-06	5.16E-04	7.22E-04
11	0.00E+00	0.00E+00	7.36E-07	7.47E-07	2.35E-04	3.29E-04
12	0.00E+00	0.00E+00	3.49E-07	3.54E-07	1.12E-04	1.56E-04
13	0.00E+00	0.00E+00	1.29E-07	1.31E-07	4.12E-05	5.77E-05
14	0.00E+00	0.00E+00	6.09E-08	6.18E-08	1.94E-05	2.72E-05
15	0.00E+00	0.00E+00	2.78E-08	2.82E-08	8.88E-06	1.24E-05
16	0.00E+00	0.00E+00	1.49E-08	1.51E-08	4.74E-06	6.64E-06
17	0.00E+00	0.00E+00	9.06E-09	9.19E-09	2.89E-06	4.05E-06
18	0.00E+00	0.00E+00	5.92E-09	6.01E-09	1.89E-06	2.65E-06

SAN ONOFRE IN SAN CLEMENTE TO YUCCA MOUNTAIN NEVADA ROUTE-SPECIFIC

MODE TRUCK

GROUND SURFACE CONTAMINATION TABLE ((MICRO CI//M**2)
BEFORE CLEANUP

AREA #	SEVER: 1	SEVER: 2	SEVER: 3	SEVER: 4	SEVER: 5	SEVER: 6
1	0..00E+00	0..00E+00	3..78E+01	3..80E+01	8..25E+02	1..16E+03
2	0..00E+00	0..00E+00	1..90E+01	1..91E+01	4..14E+02	5..84E+02
3	0..00E+00	0..00E+00	9..23E+00	9..26E+00	2..01E+02	2..84E+02
4	0..00E+00	0..00E+00	3..57E+00	3..58E+00	7..79E+01	1..10E+02
5	0..00E+00	0..00E+00	1..71E+00	1..72E+00	3..73E+01	5..26E+01
6	0..00E+00	0..00E+00	8..16E-01	8..19E-01	1..78E+01	2..51E+01
7	0..00E+00	0..00E+00	3..10E-01	3..11E-01	6..76E+00	9..52E+00
8	0..00E+00	0..00E+00	1..47E-01	1..47E-01	3..20E+00	4..50E+00
9	0..00E+00	0..00E+00	6..82E-02	6..84E-02	1..49E+00	2..10E+00
10	0..00E+00	0..00E+00	2..58E-02	2..58E-02	5..62E-01	7..92E-01
11	0..00E+00	0..00E+00	1..17E-02	1..18E-02	2..56E-01	3..61E-01
12	0..00E+00	0..00E+00	5..57E-03	5..59E-03	1..22E-01	1..71E-01
13	0..00E+00	0..00E+00	2..06E-03	2..07E-03	4..49E-02	6..33E-02
14	0..00E+00	0..00E+00	9..71E-04	9..74E-04	2..12E-02	2..98E-02
15	0..00E+00	0..00E+00	4..44E-04	4..45E-04	9..67E-03	1..36E-02
16	0..00E+00	0..00E+00	2..37E-04	2..38E-04	5..17E-03	7..28E-03
17	0..00E+00	0..00E+00	1..44E-04	1..45E-04	3..15E-03	4..44E-03
18	0..00E+00	0..00E+00	9..45E-05	9..48E-05	2..06E-03	2..90E-03

SAN ONOFRE IN SAN CLEMENTE TO YUCCA MOUNTAIN NEVADA ROUTE-SPECIFIC

INCIDENT-FREE SUMMARY
******** **** *******

INCIDENT-FREE POPULATION EXPOSURE IN PERSON-REM

	PASSENGR	CREW	HANDLERS	OFF LINK	ON LINK	STOPS	STORAGE	TOTALS
LINK 1	0.00E+00	1.16E-02	0.00E+00	6.83E-05	2.78E-03	6.67E-02	0.00E+00	8.12E-02
LINK 2	0.00E+00	2.81E-03	0.00E+00	1.72E-03	1.12E-03	1.61E-02	0.00E+00	2.18E-02
LINK 3	0.00E+00	4.86E-04	0.00E+00	3.31E-05	6.93E-04	2.79E-03	0.00E+00	4.00E-03
LINK 4	0.00E+00	5.45E-03	0.00E+00	3.20E-05	1.30E-03	3.13E-02	0.00E+00	3.81E-02
LINK 5	0.00E+00	7.63E-04	0.00E+00	4.68E-04	3.03E-04	4.38E-03	0.00E+00	5.92E-03
LINK 6	0.00E+00	6.94E-05	0.00E+00	4.72E-06	9.89E-05	3.98E-04	0.00E+00	5.71E-04
RURAL	0.00E+00	1.71E-02	0.00E+00	1.00E-04	4.09E-03	9.80E-02	0.00E+00	1.19E-01
SUBURB	0.00E+00	3.57E-03	0.00E+00	2.19E-03	1.42E-03	2.05E-02	0.00E+00	2.77E-02
URBAN	0.00E+00	5.55E-04	0.00E+00	3.78E-05	7.92E-04	3.19E-03	0.00E+00	4.57E-03
TOTALS:	0.00E+00	2.12E-02	0.00E+00	2.33E-03	6.30E-03	1.22E-01	0.00E+00	1.52E-01

MAXIMUM INDIVIDUAL IN-TRANSIT DOSE

LINK 1 5.83E-07 REM
LINK 2 5.83E-07 REM
LINK 3 5.83E-07 REM
LINK 4 5.83E-07 REM
LINK 5 5.83E-07 REM
LINK 6 5.83E-07 REM

SAN ONOFRE IN SAN CLEMENTE TO YUCCA MOUNTAIN NEVADA ROUTE-SPECIFIC

INCIDENT-FREE IMPORTANCE ANALYSIS SUMMARY FOR LINK 1
****

INDEX	DESCRIPTION OF PARAMETER	IMPORTANCE
1	DISTANCE TRAVELED	8.119E-04
2	NUMBER OF SHIPMENTS	8.119E-04
3	PACKAGES PER SHIPMENT	8.119E-04
4	DOSE RATE ((TRANSPORT INDEX)	8.119E-04
5	K ZERO	8.119E-04
6	STOP TIME	6.672E-04
7	PERSONS EXPOSED WHILE STOPPED	6.672E-04
8	FRACTION OF TRAVEL - RURAL	1.447E-04
9	NUMBER OF CREW MEMBERS	1.162E-04
10	NUMBER OF PEOPLE PER VEHICLE	2.782E-05
11	TRAFFIC COUNT - RURAL	2.782E-05
12	RURAL SHIELDING FACTOR ((RR)	6.833E-07
13	POPULATION DENSITY - RURAL	6.833E-07
14	HANDLER EXPOSURE DISTANCE	0.000E+00
15	PERSONS EXPOSED PER HANDLING	0.000E+00
16	SUBURBAN SHIELDING FACTOR ((RS)	0.000E+00
17	NUMBER OF HANDLINGS	0.000E+00
18	EXPOSURE TIME FOR HANDLERS	0.000E+00
19	FRACTION OF TRAVEL ON FREEWAYS	0.000E+00
20	FRACTION OF RUSH HOUR TRAVEL	0.000E+00
21	NUMBER OF FLIGHT ATTENDANTS	0.000E+00
22	TRAFFIC COUNT - URBAN	0.000E+00
23	TRAFFIC COUNT - SUBURBAN	0.000E+00
24	RATIO OF PEDESTRIAN DENSITY ((RPD)	0.000E+00
25	FRACTION OF TRAVEL - SUBURBAN	0.000E+00
26	URBAN SHIELDING FACTOR ((RU)	0.000E+00
27	FRACTION OF TRAVEL ON CITY STREETS	0.000E+00
28	VELOCITY - SUBURBAN	0.000E+00
29	POPULATION DENSITY - URBAN	0.000E+00
30	FRACTION OF TRAVEL - URBAN	0.000E+00
31	POPULATION DENSITY - SUBURBAN	0.000E+00
32	VELOCITY - URBAN	0.000E+00
33	STORAGE TIME PER SHIPMENT	0.000E+00
34	STORAGE EXPOSURE DISTANCE	0.000E+00
35	NUMBER OF PERSONS EXPOSED DURING STORAGE	0.000E+00
36	VELOCITY - RURAL	-1.725E-04
37	DISTANCE FROM SOURCE TO CREW	-2.208E-04
38	EXPOSURE DISTANCE WHILE STOPPED	-1.334E-03

THE IMPORTANCE VALUE ESTIMATES THE PERSON-REM INFLUENCE
OF A ONE PERCENT INCREASE IN THE PARAMETER

SAN ONOFRE IN SAN CLEMENTE TO YUCCA MOUNTAIN NEVADA ROUTE-SPECIFIC

INCIDENT-FREE IMPORTANCE ANALYSIS SUMMARY FOR LINK 2
****

INDEX	DESCRIPTION OF PARAMETER	IMPORTANCE
1	DISTANCE TRAVELED	2.178E-04
2	K ZERO	2.178E-04
3	NUMBER OF SHIPMENTS	2.178E-04
4	PACKAGES PER SHIPMENT	2.178E-04
5	DOSE RATE ((TRANSPORT INDEX)	2.178E-04
6	PERSONS EXPOSED WHILE STOPPED	1.613E-04
7	STOP TIME	1.613E-04
8	FRACTION OF TRAVEL - SUBURBAN	5.649E-05
9	NUMBER OF CREW MEMBERS	2.810E-05
10	POPULATION DENSITY - SUBURBAN	1.723E-05
11	SUBURBAN SHIELDING FACTOR ((RS)	1.723E-05
12	TRAFFIC COUNT - SUBURBAN	1.116E-05
13	NUMBER OF PEOPLE PER VEHICLE	1.116E-05
14	NUMBER OF FLIGHT ATTENDANTS	0.000E+00
15	NUMBER OF HANDLINGS	0.000E+00
16	FRACTION OF RUSH HOUR TRAVEL	0.000E+00
17	TRAFFIC COUNT - URBAN	0.000E+00
18	EXPOSURE TIME FOR HANDLERS	0.000E+00
19	PERSONS EXPOSED PER HANDLING	0.000E+00
20	TRAFFIC COUNT - RURAL	0.000E+00
21	FRACTION OF TRAVEL ON FREEWAYS	0.000E+00
22	HANDLER EXPOSURE DISTANCE	0.000E+00
23	STORAGE EXPOSURE DISTANCE	0.000E+00
24	NUMBER OF PERSONS EXPOSED DURING STORAGE	0.000E+00
25	FRACTION OF TRAVEL - URBAN	0.000E+00
26	RATIO OF PEDESTRIAN DENSITY ((RPD)	0.000E+00
27	VELOCITY - RURAL	0.000E+00
28	POPULATION DENSITY - RURAL	0.000E+00
29	FRACTION OF TRAVEL - RURAL	0.000E+00
30	POPULATION DENSITY - URBAN	0.000E+00
31	VELOCITY - URBAN	0.000E+00
32	STORAGE TIME PER SHIPMENT	0.000E+00
33	URBAN SHIELDING FACTOR ((RU)	0.000E+00
34	RURAL SHIELDING FACTOR ((RR)	0.000E+00
35	FRACTION OF TRAVEL ON CITY STREETS	0.000E+00
36	VELOCITY - SUBURBAN	-2.810E-05
37	DISTANCE FROM SOURCE TO CREW	-5.339E-05
38	EXPOSURE DISTANCE WHILE STOPPED	-3.226E-04

THE IMPORTANCE VALUE ESTIMATES THE PERSON-REM INFLUENCE
OF A ONE PERCENT INCREASE IN THE PARAMETER

SAN ONOFRE IN SAN CLEMENTE TO YUCCA MOUNTAIN NEVADA ROUTE-SPECIFIC

INCIDENT-FREE IMPORTANCE ANALYSIS SUMMARY FOR LINK 3
****

INDEX	DESCRIPTION OF PARAMETER	IMPORTANCE
1	PACKAGES PER SHIPMENT	4.000E-05
2	DOSE RATE (TRANSPORT INDEX)	4.000E-05
3	K ZERO	4.000E-05
4	NUMBER OF SHIPMENTS	4.000E-05
5	DISTANCE TRAVELED	4.000E-05
6	STOP TIME	2.788E-05
7	PERSONS EXPOSED WHILE STOPPED	2.788E-05
8	FRACTION OF TRAVEL - URBAN	1.211E-05
9	NUMBER OF PEOPLE PER VEHICLE	6.926E-06
10	TRAFFIC COUNT - URBAN	6.926E-06
11	NUMBER OF CREW MEMBERS	4.857E-06
12	URBAN SHIELDING FACTOR (RU)	3.307E-07
13	POPULATION DENSITY - URBAN	3.307E-07
14	EXPOSURE TIME FOR HANDLERS	0.000E+00
15	NUMBER OF HANDLINGS	0.000E+00
16	PERSONS EXPOSED PER HANDLING	0.000E+00
17	HANDLER EXPOSURE DISTANCE	0.000E+00
18	NUMBER OF FLIGHT ATTENDANTS	0.000E+00
19	TRAFFIC COUNT - SUBURBAN	0.000E+00
20	FRACTION OF RUSH HOUR TRAVEL	0.000E+00
21	TRAFFIC COUNT - RURAL	0.000E+00
22	FRACTION OF TRAVEL ON FREEWAYS	0.000E+00
23	STORAGE EXPOSURE DISTANCE	0.000E+00
24	NUMBER OF PERSONS EXPOSED DURING STORAGE	0.000E+00
25	FRACTION OF TRAVEL - SUBURBAN	0.000E+00
26	RATIO OF PEDESTRIAN DENSITY (RPD)	0.000E+00
27	VELOCITY - RURAL	0.000E+00
28	POPULATION DENSITY - RURAL	0.000E+00
29	FRACTION OF TRAVEL - RURAL	0.000E+00
30	POPULATION DENSITY - SUBURBAN	0.000E+00
31	VELOCITY - SUBURBAN	0.000E+00
32	SUBURBAN SHIELDING FACTOR (RS)	0.000E+00
33	STORAGE TIME PER SHIPMENT	0.000E+00
34	FRACTION OF TRAVEL ON CITY STREETS	0.000E+00
35	RURAL SHIELDING FACTOR (RR)	0.000E+00
36	VELOCITY - URBAN	-4.857E-06
37	DISTANCE FROM SOURCE TO CREW	-9.228E-06
38	EXPOSURE DISTANCE WHILE STOPPED	-5.576E-05

THE IMPORTANCE VALUE ESTIMATES THE PERSON-REM INFLUENCE
OF A ONE PERCENT INCREASE IN THE PARAMETER

SAN ONOFRE IN SAN CLEMENTE TO YUCCA MOUNTAIN NEVADA ROUTE-SPECIFIC

INCIDENT-FREE IMPORTANCE ANALYSIS SUMMARY FOR LINK 4
****

INDEX	DESCRIPTION OF PARAMETER	IMPORTANCE
1	DISTANCE TRAVELED	3.805E-04
2	DOSE RATE ((TRANSPORT INDEX)	3.805E-04
3	NUMBER OF SHIPMENTS	3.805E-04
4	PACKAGES PER SHIPMENT	3.805E-04
5	K ZERO	3.805E-04
6	STOP TIME	3.127E-04
7	PERSONS EXPOSED WHILE STOPPED	3.127E-04
8	FRACTION OF TRAVEL - RURAL	6.783E-05
9	NUMBER OF CREW MEMBERS	5.447E-05
10	NUMBER OF PEOPLE PER VEHICLE	1.304E-05
11	TRAFFIC COUNT - RURAL	1.304E-05
12	RURAL SHIELDING FACTOR ((RR)	3.202E-07
13	POPULATION DENSITY - RURAL	3.202E-07
14	HANDLER EXPOSURE DISTANCE	0.000E+00
15	PERSONS EXPOSED PER HANDLING	0.000E+00
16	SUBURBAN SHIELDING FACTOR ((RS)	0.000E+00
17	NUMBER OF HANDLINGS	0.000E+00
18	EXPOSURE TIME FOR HANDLERS	0.000E+00
19	FRACTION OF TRAVEL ON FREEWAYS	0.000E+00
20	FRACTION OF RUSH HOUR TRAVEL	0.000E+00
21	NUMBER OF FLIGHT ATTENDANTS	0.000E+00
22	TRAFFIC COUNT - URBAN	0.000E+00
23	TRAFFIC COUNT - SUBURBAN	0.000E+00
24	RATIO OF PEDESTRIAN DENSITY ((RPD)	0.000E+00
25	FRACTION OF TRAVEL - SUBURBAN	0.000E+00
26	URBAN SHIELDING FACTOR ((RU)	0.000E+00
27	FRACTION OF TRAVEL ON CITY STREETS	0.000E+00
28	VELOCITY - SUBURBAN	0.000E+00
29	POPULATION DENSITY - URBAN	0.000E+00
30	FRACTION OF TRAVEL - URBAN	0.000E+00
31	POPULATION DENSITY - SUBURBAN	0.000E+00
32	VELOCITY - URBAN	0.000E+00
33	STORAGE TIME PER SHIPMENT	0.000E+00
34	STORAGE EXPOSURE DISTANCE	0.000E+00
35	NUMBER OF PERSONS EXPOSED DURING STORAGE	0.000E+00
36	VELOCITY - RURAL	-8.086E-05
37	DISTANCE FROM SOURCE TO CREW	-1.035E-04
38	EXPOSURE DISTANCE WHILE STOPPED	-6.254E-04

THE IMPORTANCE VALUE ESTIMATES THE PERSON-REM INFLUENCE
OF A ONE PERCENT INCREASE IN THE PARAMETER

SAN ONOFRE IN SAN CLEMENTE TO YUCCA MOUNTAIN NEVADA ROUTE-SPECIFIC

INCIDENT-FREE IMPORTANCE ANALYSIS SUMMARY FOR LINK 5
****

INDEX	DESCRIPTION OF PARAMETER	IMPORTANCE
1	DISTANCE TRAVELED	5.916E-05
2	K ZERO	5.916E-05
3	NUMBER OF SHIPMENTS	5.916E-05
4	PACKAGES PER SHIPMENT	5.916E-05
5	DOSE RATE ((TRANSPORT INDEX)	5.916E-05
6	PERSONS EXPOSED WHILE STOPPED	4.381E-05
7	STOP TIME	4.381E-05
8	FRACTION OF TRAVEL - SUBURBAN	1.534E-05
9	NUMBER OF CREW MEMBERS	7.633E-06
10	SUBURBAN SHIELDING FACTOR ((RS))	4.678E-06
11	POPULATION DENSITY - SUBURBAN	4.678E-06
12	NUMBER OF PEOPLE PER VEHICLE	3.032E-06
13	TRAFFIC COUNT - SUBURBAN	3.032E-06
14	NUMBER OF FLIGHT ATTENDANTS	0.000E+00
15	NUMBER OF HANDLINGS	0.000E+00
16	FRACTION OF RUSH HOUR TRAVEL	0.000E+00
17	TRAFFIC COUNT - URBAN	0.000E+00
18	EXPOSURE TIME FOR HANDLERS	0.000E+00
19	PERSONS EXPOSED PER HANDLING	0.000E+00
20	TRAFFIC COUNT - RURAL	0.000E+00
21	FRACTION OF TRAVEL ON FREEWAYS	0.000E+00
22	HANDLER EXPOSURE DISTANCE	0.000E+00
23	STORAGE EXPOSURE DISTANCE	0.000E+00
24	NUMBER OF PERSONS EXPOSED DURING STORAGE	0.000E+00
25	FRACTION OF TRAVEL - URBAN	0.000E+00
26	RATIO OF PEDESTRIAN DENSITY ((RPD))	0.000E+00
27	VELOCITY - RURAL	0.000E+00
28	POPULATION DENSITY - RURAL	0.000E+00
29	FRACTION OF TRAVEL - RURAL	0.000E+00
30	POPULATION DENSITY - URBAN	0.000E+00
31	VELOCITY - URBAN	0.000E+00
32	STORAGE TIME PER SHIPMENT	0.000E+00
33	URBAN SHIELDING FACTOR ((RU))	0.000E+00
34	RURAL SHIELDING FACTOR ((RR))	0.000E+00
35	FRACTION OF TRAVEL ON CITY STREETS	0.000E+00
36	VELOCITY - SUBURBAN	-7.633E-06
37	DISTANCE FROM SOURCE TO CREW	-1.450E-05
38	EXPOSURE DISTANCE WHILE STOPPED	-8.763E-05

THE IMPORTANCE VALUE ESTIMATES THE PERSON-REM INFLUENCE
OF A ONE PERCENT INCREASE IN THE PARAMETER

SAN ONOFRE IN SAN CLEMENTE TO YUCCA MOUNTAIN NEVADA ROUTE-SPECIFIC

INCIDENT-FREE IMPORTANCE ANALYSIS SUMMARY FOR LINK 6
****

INDEX	DESCRIPTION OF PARAMETER	IMPORTANCE
1	DISTANCE TRAVELED	5.7114E-06
2	NUMBER OF SHIPMENTS	5.7114E-06
3	PACKAGES PER SHIPMENT	5.7114E-06
4	DOSE RATE ((TRANSPORT INDEX)	5.7114E-06
5	K ZERO	5.7114E-06
6	PERSONS EXPOSED WHILE STOPPED	3.9833E-06
7	STOP TIME	3.9833E-06
8	FRACTION OF TRAVEL - URBAN	1.7330E-06
9	TRAFFIC COUNT - URBAN	9.8944E-07
10	NUMBER OF PEOPLE PER VEHICLE	9.8944E-07
11	NUMBER OF CREW MEMBERS	6.9939E-07
12	POPULATION DENSITY - URBAN	4.7244E-08
13	URBAN SHIELDING FACTOR ((RU)	4.7244E-08
14	EXPOSURE TIME FOR HANDLERS	0.0000E+00
15	NUMBER OF HANDLINGS	0.0000E+00
16	PERSONS EXPOSED PER HANDLING	0.0000E+00
17	HANDLER EXPOSURE DISTANCE	0.0000E+00
18	NUMBER OF FLIGHT ATTENDANTS	0.0000E+00
19	TRAFFIC COUNT - SUBURBAN	0.0000E+00
20	FRACTION OF RUSH HOUR TRAVEL	0.0000E+00
21	TRAFFIC COUNT - RURAL	0.0000E+00
22	FRACTION OF TRAVEL ON FREEWAYS	0.0000E+00
23	STORAGE EXPOSURE DISTANCE	0.0000E+00
24	NUMBER OF PERSONS EXPOSED DURING STORAGE	0.0000E+00
25	FRACTION OF TRAVEL - SUBURBAN	0.0000E+00
26	RATIO OF PEDESTRIAN DENSITY ((RPD))	0.0000E+00
27	VELOCITY - RURAL	0.0000E+00
28	POPULATION DENSITY - RURAL	0.0000E+00
29	FRACTION OF TRAVEL - RURAL	0.0000E+00
30	POPULATION DENSITY - SUBURBAN	0.0000E+00
31	VELOCITY - SUBURBAN	0.0000E+00
32	SUBURBAN SHIELDING FACTOR ((RS)	0.0000E+00
33	STORAGE TIME PER SHIPMENT	0.0000E+00
34	FRACTION OF TRAVEL ON CITY STREETS	0.0000E+00
35	RURAL SHIELDING FACTOR ((RR)	0.0000E+00
36	VELOCITY - URBAN	-6.9939E-07
37	DISTANCE FROM SOURCE TO CREW	-1.3178E-06
38	EXPOSURE DISTANCE WHILE STOPPED	-7.9666E-06

THE IMPORTANCE VALUE ESTIMATES THE PERSON-REM INFLUENCE
OF A ONE PERCENT INCREASE IN THE PARAMETER

SAN ONOFRE IN SAN CLEMENTE TO YUCCA MOUNTAIN NEVADA ROUTE-SPECIFIC

ACCIDENT SUMMARY
******** *******

NUMBER OF EXPECTED ACCIDENTS

CATEGORY	LINK 1	LINK 2	LINK 3	LINK 4	LINK 5	LINK 6
1	2.18E-06	1.03E-05	1.03E-05	4.21E-06	1.15E-05	6.05E-06
2	1.43E-06	6.73E-06	6.75E-06	2.75E-06	7.52E-06	3.96E-06
3	1.09E-08	6.84E-08	6.49E-09	2.10E-08	7.64E-08	3.81E-09
4	1.09E-11	6.84E-11	6.49E-12	2.10E-11	7.64E-11	3.81E-12
5	1.81E-11	5.13E-11	4.27E-12	3.49E-11	5.73E-11	2.50E-12
6	2.53E-11	3.42E-11	2.22E-12	4.89E-11	3.82E-11	1.30E-12

EARLY FATALITY CONSEQUENCES

CATEGORY	LINK 1	LINK 2	LINK 3	LINK 4	LINK 5	LINK 6
1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
3	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
4	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
5	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
6	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

SAN ONOFRE IN SAN CLEMENTE TO YUCCA MOUNTAIN NEVADA ROUTE-SPECIFIC

ECONOMIC CONSEQUENCES

CATEGORY	LINK 1	LINK 2	LINK 3	LINK 4	LINK 5	LINK 6
1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
3	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
4	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
5	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
6	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

RADIOLOGICAL CONSEQUENCES
50 YEAR POPULATION DOSE IN PERSON REM

CATEGORY	LINK 1	LINK 2	LINK 3	LINK 4	LINK 5	LINK 6
1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
3	2.53E+00	3.03E+02	9.83E+02	2.53E+00	3.03E+02	9.83E+02
4	2.53E+00	3.03E+02	9.85E+02	2.53E+00	3.03E+02	9.85E+02
5	2.74E+01	3.28E+03	1.06E+04	2.74E+01	3.28E+03	1.06E+04
6	3.63E+01	4.35E+03	1.41E+04	3.63E+01	4.35E+03	1.41E+04

SAN ONOFRE IN SAN CLEMENTE TO YUCCA MOUNTAIN NEVADA ROUTE-SPECIFIC

EXPECTED VALUES OF POPULATION RISK IN PERSON REM

	GROUND	INHALED	RESUSPD	CLOUDSH	*INGESTION	TOTAL
LINK 1	2..87E-08	2..92E-11	1..13E-10	2..10E-12	0..00E+00	2..89E-08
LINK 2	2..10E-05	1..87E-08	7..20E-08	1..56E-09	0..00E+00	2..11E-05
LINK 3	6..44E-06	5..68E-09	2..18E-08	4..80E-10	0..00E+00	6..47E-06
LINK 4	5..55E-08	5..64E-11	2..18E-10	4..05E-12	0..00E+00	5..58E-08
LINK 5	2..34E-05	2..09E-08	8..04E-08	1..74E-09	0..00E+00	2..35E-05
LINK 6	3..78E-06	3..33E-09	1..28E-08	2..81E-10	0..00E+00	3..79E-06
RURAL	8..43E-08	8..56E-11	3..30E-10	6..15E-12	0..00E+00	8..47E-08
SUBURB	4..44E-05	3..97E-08	1..52E-07	3..30E-09	0..00E+00	4..46E-05
URBAN	1..02E-05	9..02E-09	3..46E-08	7..61E-10	0..00E+00	1..03E-05
TOTALS::	5..47E-05	4..88E-08	1..87E-07	4..07E-09	0..00E+00	5..49E-05

* NOTE THAT INGESTION RISK IS A SOCIETAL RISK;
THE USER MAY WISH TO TREAT THIS VALUE SEPARATELY..

SAN ONOFRE IN SAN CLEMENTE TO YUCCA MOUNTAIN NEVADA ROUTE-SPECIFIC

EXPECTED RISK VALUES - OTHER

LINK	ECON $$	EARLY FATALITY
1	0..00E+00	0..00E+00
2	0..00E+00	0..00E+00
3	0..00E+00	0..00E+00
4	0..00E+00	0..00E+00
5	0..00E+00	0..00E+00
6	0..00E+00	0..00E+00
TOTAL	0..00E+00	0..00E+00

EOI
END OF RUN

5.2 Output File 2

Page 1 The cover page is the same as for Output File 1.

Page 2 Note the following important differences in the echo check page:

1. The TITLE line now reads SAN ONOFRE IN SAN CLEMENTE TO YUCCA MOUNTAIN NEVADA ROUTE-SPECIFIC. The word AGGREGATE, which was used in Output File 1, has been replaced by the word ROUTE-SPECIFIC. The LINK option was used in this run to describe route characteristics.

2. There are no changes in the input data used to describe the package, the material, and its constituent isotopes. However, the user should note that certain of the values in the normal array, such as fractions of travel, are not used in a LINK calculation.

3. The ARAIMZ array appears on the echo page, but since this is a LINK run, the accident rate values assigned for each link will override any values that may have been entered in ARAIMZ. Thus this array could have been deleted. This again illustrates unused input data appearing in the input echo. Note that these values do not appear in the remainder of the output.

4. As in Output File 1, the package size in meters is entered for the material after the keyword PKGSIZ.

5. Since this is a LINK run, the total distance in kilometers is not entered separately and the keyword DISTKM is not used in this analysis. LINK input is used in place of the DISTKM keyword. For each link in the analysis, there is a line of input data beginning with the keyword LINK. After LINK on each line, the following route-specific values are entered:

   - mode number (truck = 1),
   - link length (km),
   - vehicle speed (km/hr),
   - link population density (persons/km^2),
   - one-way vehicle density on link (vehicles/hr),
   - link accident rate (accidents/km),
   - zone type (R = rural, S = suburban, U = urban), and
   - link type (1 = freeway, 2 = nonfreeway, 3 = all other)

Each value listed above is separated by a delimiter ((in this case,, a space)).. In this analysis a set of state-level links has been constructed rather than actual sequential route segments to demonstrate the flexibility of the LINK option.. The first three links represent aggregate data for travel within the State of California along an Interstate Highway route from the origin,, San Onofre,, to the state''s border with Nevada.. The first link represents aggregate rural travel in California for the route being analyzed,, the second link is aggregate suburban travel,, and the third link is aggregate urban travel.. The last three links represent similar aggregate data for travel over that part of the total route that lies within the State of Nevada;; namely,, for the part commencing at the state''s border with California and continuing to the final destination,, Yucca Mountain..

This is a simple two-state example.. If a route crossed several states,, each could be handled in the same way.. Note that the mode number,, vehicle speed,, and link type are the same for all links because this route lies entirely on Interstate Highways.. The link lengths are route-specific,, the accident rates are taken from state data,, and the population-densities zones and vehicles speeds are equal to the RADTRAN 4 defaults,, which are based on national average data.. This approach could be refined,, for example,, by subdividing urban travel into the basic urban configuration shown and some expected number of miles traveled in urban rush-hour traffic ((decrease vehicle speed and increased vehicle density)).. However,, the sample data set is intended to demonstrate a technique rather than to achieve verisimilitude..

Pages 3 through 15 — The majority of these pages are similar to those in Output File 1.. However,, the DNORML array no longer appears on page 5.. The array is replaced by two tables containing segment- and mode-related data.. The former gives the user-defined values for each link while the latter explicitly prints all remaining values taken from the DNORML array that are used in the calculation and are not overwritten by the LINK routine..

Page 16 — Incident-Free Summary.. On this page the doses for each mode and exposure group in the incident-free calculations are given separately by link and character ((rural,, suburban,, and urban)).. Maximum individual in-transit dose for each link is also printed.. Because mode and shipment parameters are the same for every link in this example,, the maximum individual dose is the same for every link..

Pages 17 through 22 — Incident-Free Importance Analysis Summary.. An importance analysis is performed for each link.. The results of these calculations are given on these pages,, with the parameters listed separately and in rank order for each link..

Pages 23 through 26 Accident Risk Summary. On these pages the values for each consequence type are broken down by severity category and link rather than severity category, mode, and population-density zone as in Output File 1. The results of the risk calculations are given on page 26. In this table, risk estimates are shown for each exposure pathway and link. This table differs from that given in Output File 1 in that individual isotope contributions are not shown separately. However, all links designated as rural are summed, and the total is shown at the bottom of the table on the line labeled "RURAL." Similar sums for suburban and urban links are given. On the last page of the output the table shows estimated early fatalities and economic risks for each link.

```
RRRR     AAA    DDDD    TTTTT   RRRR     AAA    N   N
R   R   A   A   D   D     T     R   R   A   A   NN  N
R   R   A   A   D   D     T     R   R   A   A   N N N
RRRR    A   A   D   D     T     RRRR    A   A   N  NN
R R     AAAAA   D   D     T     R R     AAAAA   N   N
R  R    A   A   D   D     T     R  R    A   A   N   N
R   R   A   A   DDDD      T     R   R   A   A   N   N
```

```
    4
4   4
4   4
44444
    4
    4
    4
```

RADTRAN 4.0.12 VERSION DATE:: NOVEMBER 19, 1991

MODE DESCRIPTIONS

NUMBER	NAME	CHARACTERIZATION
1	TRUCK	LONG HAUL VEHICLE
2	RAIL	COMMERCIAL TRAIN
3	BARGE	INLAND VESSEL
4	SHIP	OPEN SEA VESSEL
5	CARGO AIR	CARGO AIRCRAFT
6	PASS AIR	PASSENGER AIRCRAFT
7	P-VAN	PASSENGER VAN
8	CVAN-T	COMMERCIAL VAN
9	CVAN-R	COMMERCIAL VAN
10	CVAN-CA	COMMERCIAL VAN

ECHO CHECK

```
TITLE  SAN ONOFRE IN SAN CLEMENTE TO YUCCA MOUNTAIN NEVADA   UNIT-RISK
FORM   UNIT
DIMEN  15  6  5  10 18
PARM  0 3 2 3 0
PACKAGE  LABGRP HIGH NOBLE VOL_A OTHER VOL_B
SHIPMENT
          LABISO   CO60       KR85       SR90       RU106      CS134
                   CS137      CE144      EU154      PU238      PU239      PU240
                   PU241      AM241      AM243      CM244
NORMAL    NMODE=1   1.00E+00  0.00E+00  0.00E+00  8.86E+01  4.03E+01  2.41E+01
                    2.00E+00  1.00E+01  0.00E+00  1.10E-02  0.00E+00  0.00E+00
                    0.00E+00  5.00E+01  2.00E+01  0.00E+00  1.00E+02  1.00E+02
                    2.00E+00  0.00E+00  0.00E+00  1.00E+00  4.70E+02  7.80E+02
                    2.80E+03
ACCIDENT ARATMZ NMODE=1 2.08E-08 4.06E-07 2.34E-06
          SEVFRC NPOP=1 NMODE=1 0.603 0.394 3.E-3 3.E-6 5.E-6 7.E-6
                 NPOP=2 NMODE=1 0.602 0.394 4.E-3 4.E-6 3.E-6 2.E-6
                 NPOP=3 NMODE=1 0.604 0.395 3.8E-4 3.8E-7 2.5E-7 1.3E-7
RELEASE RFRAC GROUP=1 2*0.0 4*1.2E-2
              GROUP=2 3*0.0 0.01 0.1 0.11
              GROUP=3 3*0.0 1.0E-8 2.0E-4 2.8E-4
              GROUP=4 3*0.0 1.0E-8 5.0E-8 5.0E-8
              GROUP=5 3*0.0 1.0E-8 1.0E-6 4.2E-5
        AERSOL DISP=2 2*0 4*1.0
               DISP=3 3*0 3*1.0
               DISP=4 3*0 3*1.0
               DISP=5 3*0 3*1.0
        RESP   DISP=2 2*0 4*.05
               DISP=3 3*0 3*1.0
               DISP=4 3*0 0.05 2*1.0
               DISP=5 3*0 3*.05
OTHER CULVL=0.2
EOF
ISOTOPES  -1  1.0  1.0  13.68  1.0 0.0  SFUEL
CO60  9.22E+01 HIGH 2
KR85  6.10E+03 NOBLE 3
SR90  5.96E+04 OTHER 5
RU106 1.62E+04 VOL_B 5
CS134 2.74E+04 VOL_A 4
CS137 8.76E+04 VOL_A 4
CE144 1.22E+04 OTHER 4
EU154 7.00E+03 OTHER 4
PU238 2.96E+03 OTHER 5
PU239 4.10E+02 OTHER 5
PU240 4.68E+02 OTHER 5
PU241 1.26E+05 OTHER 5
AM241 1.29E+03 OTHER 5
AM243 1.99E+01 OTHER 5
CM244 1.79E+03 OTHER 5
DISUKM  NMODE=1  1.0
PKGSIZ  SFUEL 5.2
EOF
```

SAN ONOFRE IN SAN CLEMENTE TO YUCCA MOUNTAIN NEVADA UNIT-RISK

ZONE	POPULATION DENSITY (PERSONS PER SQ KM)
RURAL	6.
SUBURBAN	719.
URBAN	3861.

PACKAGE CHARACTERISTICS

FOR MATERIAL	DIMENSION (METERS)	EFFECTIVE DIMENSION	K(0) METERS SQ.
SFUEL	5.200E+00	4.677E+00	1.115E+01

K(0) IS TI TO DOSE RATE CONVERSION FACTOR

PACKAGE HANDLING THRESHOLDS (METERS)
PKGSZ1= 5.000E-01
PKGSZ2= 1.000E+00
PACKAGES .LE. PKGSZ1 ARE HAND CARRIED
PACKAGES .GT. PKGSZ1 AND .LE. PKGSZ2 ARE HANDLED BY SMALL EQUIPMENT
PACKAGES .GT. PKGSZ2 ARE HANDLED BY HEAVY EQUIPMENT

MATERIAL CHARACTERISTICS

MATERIAL	FRACTION OF GAMMA	FRACTION OF NEUTRON
SFUEL	1.000E+00	0.000E+00

SAN ONOFRE IN SAN CLEMENTE TO YUCCA MOUNTAIN NEVADA UNIT-RISK

MODE CHARACTERISTICS

MODE	DISTANCE TRAVELED	EXCLUSIVE USE	NUMBER OF SHIPMENTS	MATERIALS	TRANSPORT INDEX (TI)	PACKAGES/ SHIPMENT
TRUCK	1.00E+00	YES	1.00E+00			
				SFUEL	1.37E+01	1.00E+00

BUILDING SHIELDING OPTION= 2
(1=TOTAL SHIELDING, 2=PARTIAL SHIELDING, 3=NO SHIELDING)

RPD= 6.000E+00
(RATIO OF PEDESTRIAN DENSITY (PEDESTRIAN/KM SQ OF SIDEWALK)
TO POPULATION DENSITY (PEOPLE/KM SQ IN URBAN AREAS)

RR = 1.000E+00
(TRANSMISSION FACTOR FOR RURAL AREAS)

RS = 8.700E-01
(TRANSMISSION FACTOR FOR SUBURBAN AREAS)

RU = 1.800E-02
(TRANSMISSION FACTOR FOR URBAN AREAS)

SAN ONOFRE IN SAN CLEMENTE TO YUCCA MOUNTAIN NEVADA UNIT-RISK

DNORML INPUT

NO		TRUCK
1	FRACTION OF TRAVEL IN RURAL POPULATION ZONE	1.000E+00
2	FRACTION OF TRAVEL IN SUBURBAN POPULATION ZONE	0.000E+00
3	FRACTION OF TRAVEL IN URBAN POPULATION ZONE	0.000E+00
4	VELOCITY IN RURAL POPULATION ZONE ((KILOMETERS/HOUR)	8.860E+01
5	VELOCITY IN SUBURBAN POP., ZONE ((KILOMETERS/HOUR)	4.030E+01
6	VELOCITY IN URBAN POPULATION ZONE ((KILOMETERS/HOUR)	2.410E+01
7	NUMBER OF CREWMEN	2.000E+00
8	DISTANCE FROM SOURCE TO CREW ((METERS)	1.000E+01
9	NUMBER OF HANDLINGS	0.000E+00
10	STOP TIME PER KM ((HR//KM)	1.100E-02
11	MINIMUM STOP TIME PER TRIP ((HR)	0.000E+00
12	ZERO STOP TIME PER TRIP ((HR)	0.000E+00
13	MINIMUM NUMBER OF RAIL CLASSIFICATIONS/INSPECTIONS	0.000E+00
14	PERSONS EXPOSED WHILE STOPPED	5.000E+01
15	AVERAGE EXPOSURE DISTANCE WHILE STOPPED ((METERS)	2.000E+01
16	STORAGE TIME PER SHIPMENT ((HR)	0.000E+00
17	NUMBER OF EXPOSED PERSONS DURING STORAGE	1.000E+02
18	AVERAGE EXPOSURE DISTANCE WHILE IN STORAGE ((METERS)	1.000E+02
19	NUMBER OF PEOPLE PER VEHICLE ON LINK	2.000E+00
20	FRACTION OF URBAN TRAVEL DURING RUSH HOUR TRAFFIC	0.000E+00
21	FRACTION OF URBAN TRAVEL ON CITY STREETS	0.000E+00
22	FRACTION OF RURAL-SUBURBAN TRAVEL ON FREEWAYS	1.000E+00
23	*TRAFFIC COUNT PASSING A SPECIFIC POINT-RURAL ZONE	4.700E+02
24	*TRAFFIC COUNT PASSING A SPECIFIC POINT-SUBURBAN ZONE	7.800E+02
25	*TRAFFIC COUNT PASSING A SPECIFIC POINT-URBAN ZONE	2.800E+03

*((ONE WAY VEHICLES/HR)

SAN ONOFRE IN SAN CLEMENTE TO YUCCA MOUNTAIN NEVADA UNIT-RISK

ISOTOPE RELATED DATA

NUCLIDE	CURIES PER PKG	RELEASE GROUP	RESUSP FACTOR	LUNG TYPE	DISPERS. CATEGORY	1YR INHAL LUNG	REM/CI MARROW
SFUEL							
CO60	9.22E+01	HIGH	4.83E+00	2	2	7.90E+05	3.80E+04
KR85	6.10E+03	NOBLE	1.00E+00	2	3	0.00E+00	0.00E+00
SR90	5.96E+04	OTHER	5.41E+00	2	5	4.50E+06	3.80E+03
RU106	1.62E+04	VOL_B	3.28E+00	2	5	4.30E+06	4.50E+03
CS134	2.74E+04	VOL_A	4.07E+00	2	4	4.10E+04	3.90E+04
CS137	8.76E+04	VOL_A	5.41E+00	2	4	3.10E+04	2.60E+04
CE144	1.22E+04	OTHER	2.99E+00	1	4	3.60E+06	4.20E+03
EU154	7.00E+03	OTHER	5.09E+00	2	4	0.00E+00	0.00E+00
PU238	2.96E+03	OTHER	5.51E+00	3	5	4.50E+08	1.10E+06
PU239	4.10E+02	OTHER	5.57E+00	3	5	4.20E+08	1.10E+06
PU240	4.68E+02	OTHER	5.56E+00	3	5	4.20E+08	1.10E+06
PU241	1.26E+05	OTHER	5.26E+00	3	5	3.60E+05	1.30E+03
AM241	1.29E+03	OTHER	5.55E+00	3	5	1.20E+08	1.70E+07
AM243	1.99E+01	OTHER	5.56E+00	3	5	1.10E+08	1.60E+07
CM244	1.79E+03	OTHER	5.32E+00	3	5	1.20E+08	1.70E+07

NUCLIDE	HALF LIFE	GAMMA ENERGY	CLOUD FACTOR	TRANSFER CROPS	TRANSFER SOIL	DEPOS SPEED
SFUEL						
CO60	1.93E+03	2.50E+00	4.12E-01	0.00E+00	0.00E+00	1.00E-02
KR85	3.92E+03	2.21E-03	3.55E-04	0.00E+00	0.00E+00	0.00E+00
SR90	1.06E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.00E-02
RU106	3.68E+02	2.01E-01	0.00E+00	0.00E+00	0.00E+00	1.00E-02
CS134	7.53E+02	1.55E+00	2.54E-01	0.00E+00	0.00E+00	1.00E-02
CS137	1.10E+04	5.96E-01	0.00E+00	0.00E+00	0.00E+00	1.00E-02
CE144	2.84E+02	5.25E-02	2.88E-03	0.00E+00	0.00E+00	1.00E-02
EU154	3.21E+03	1.22E+00	2.06E-01	0.00E+00	0.00E+00	1.00E-02
PU238	3.21E+04	1.81E-03	1.40E-05	0.00E+00	0.00E+00	1.00E-02
PU239	8.79E+06	7.96E-04	1.30E-05	0.00E+00	0.00E+00	1.00E-02
PU240	2.39E+06	1.73E-03	1.37E-05	0.00E+00	0.00E+00	1.00E-02
PU241	5.26E+03	2.54E-06	0.00E+00	0.00E+00	0.00E+00	1.00E-02
AM241	1.58E+05	3.24E-02	3.01E-03	0.00E+00	0.00E+00	1.00E-02
AM243	2.70E+06	5.59E-02	8.11E-03	0.00E+00	0.00E+00	1.00E-02
CM244	6.62E+03	1.70E-03	1.33E-05	0.00E+00	0.00E+00	1.00E-02

ISOTOPE RELATED DATA

NUCLIDE	50-YR EFFECTIVE REM/CI	
	INHALE	INGEST
SFUEL		
CO60	2.80E+05	2.60E+04
KR85	0.00E+00	0.00E+00
SR90	2.40E+06	1.30E+05
RU106	8.00E+05	2.10E+04
CS134	4.60E+04	7.40E+04
CS137	3.20E+04	5.00E+04
CE144	6.30E+05	2.00E+04
EU154	3.10E+05	9.10E+03
PU238	5.30E+08	3.80E+06
PU239	5.70E+08	4.30E+06
PU240	5.70E+08	4.30E+06
PU241	9.90E+06	8.60E+04
AM241	5.90E+08	4.50E+06
AM243	5.90E+08	4.50E+06
CM244	3.10E+08	2.30E+06

SAN ONOFRE IN SAN CLEMENTE TO YUCCA MOUNTAIN NEVADA UNIT-RISK

RELEASE RELATED DATA

ACCIDENT RATES (PER KM)

MODE	RURAL	SUBURBAN	URBAN
TRUCK	2.080E-08	4.060E-07	2.340E-06

RELEASE FRACTIONS

GROUP	SEVER: 1	SEVER: 2	SEVER: 3	SEVER: 4	SEVER: 5	SEVER: 6
1	0.00E+00	0.00E+00	1.20E-02	1.20E-02	1.20E-02	1.20E-02
2	0.00E+00	0.00E+00	0.00E+00	1.00E-02	1.00E-01	1.10E-01
3	0.00E+00	0.00E+00	0.00E+00	1.00E-08	2.00E-04	2.80E-04
4	0.00E+00	0.00E+00	0.00E+00	1.00E-08	5.00E-08	5.00E-08
5	0.00E+00	0.00E+00	0.00E+00	1.00E-08	1.00E-06	4.20E-05

ACCIDENT SEVERITY FRACTIONS FOR TRUCK

ZONE	SEVER: 1	SEVER: 2	SEVER: 3	SEVER: 4	SEVER: 5	SEVER: 6
1	6.03E-01	3.94E-01	3.00E-03	3.00E-06	5.00E-06	7.00E-06
2	6.02E-01	3.94E-01	4.00E-03	4.00E-06	3.00E-06	2.00E-06
3	6.04E-01	3.95E-01	3.80E-04	3.80E-07	2.50E-07	1.30E-07

SAN ONOFRE IN SAN CLEMENTE TO YUCCA MOUNTAIN NEVADA UNIT-RISK

AEROSOLIZED FRACTION OF RELEASED MATERIAL

DISP CAT	SEVER: 1	SEVER: 2	SEVER: 3	SEVER: 4	SEVER: 5	SEVER: 6
1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
2	0.00E+00	0.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
3	0.00E+00	0.00E+00	0.00E+00	1.00E+00	1.00E+00	1.00E+00
4	0.00E+00	0.00E+00	0.00E+00	1.00E+00	1.00E+00	1.00E+00
5	0.00E+00	0.00E+00	0.00E+00	1.00E+00	1.00E+00	1.00E+00
6	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
7	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
8	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
9	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
10	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
11	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00

FRACTION OF AEROSOLS BELOW 10 MICRONS AED

DISP CAT	SEVER: 1	SEVER: 2	SEVER: 3	SEVER: 4	SEVER: 5	SEVER: 6
1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
2	0.00E+00	0.00E+00	5.00E-02	5.00E-02	5.00E-02	5.00E-02
3	0.00E+00	0.00E+00	0.00E+00	1.00E+00	1.00E+00	1.00E+00
4	0.00E+00	0.00E+00	0.00E+00	5.00E-02	1.00E+00	1.00E+00
5	0.00E+00	0.00E+00	0.00E+00	5.00E-02	5.00E-02	5.00E-02
6	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02
7	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
8	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
9	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
10	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
11	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00

SAN ONOFRE IN SAN CLEMENTE TO YUCCA MOUNTAIN NEVADA UNIT-RISK

COST RELATED DATA

EMERGENCY RESPONSE COST

	SEVER: 1	SEVER: 2	SEVER: 3	SEVER: 4	SEVER: 5	SEVER: 6
1	0..00E+00	0..00E+00	0..00E+00	0..00E+00	0..00E+00	0..00E+00

ON-SCENE COSTS
(RF=RELEASE FRACTION)

RF=0..	0..<RF<=..01	..01<RF<=0..1	..1<RF<=1..
0..	0..	0..	0..

SAN ONOFRE IN SAN CLEMENTE TO YUCCA MOUNTAIN NEVADA UNIT-RISK

HEALTH RELATED DATA

EARLY FATALITY PROBABILITIES

DOSE((REM)	LUNG-1	LUNG-2	LUNG-3	MARROW
100000..000	1..000E+00	1..000E+00	1..000E+00	1..000E+00
80000..000	1..000E+00	8..500E-01	8..000E-01	1..000E+00
70000..000	1..000E+00	8..000E-01	5..000E-01	1..000E+00
40000..000	1..000E+00	7..000E-01	0..000E+00	1..000E+00
30000..000	1..000E+00	5..000E-01	0..000E+00	1..000E+00
25000..000	1..000E+00	2..000E-01	0..000E+00	1..000E+00
20000..000	1..000E+00	8..000E-02	0..000E+00	1..000E+00
10000..000	6..000E-01	0..000E+00	0..000E+00	1..000E+00
8000..000	1..000E-01	0..000E+00	0..000E+00	1..000E+00
6000..000	6..000E-02	0..000E+00	0..000E+00	1..000E+00
4000..000	3..000E-02	0..000E+00	0..000E+00	1..000E+00
3000..000	0..000E+00	0..000E+00	0..000E+00	1..000E+00
2000..000	0..000E+00	0..000E+00	0..000E+00	1..000E+00
1000..000	0..000E+00	0..000E+00	0..000E+00	1..000E+00
800..000	0..000E+00	0..000E+00	0..000E+00	9..960E-01
700..000	0..000E+00	0..000E+00	0..000E+00	9..000E-01
600..000	0..000E+00	0..000E+00	0..000E+00	4..000E-01
500..000	0..000E+00	0..000E+00	0..000E+00	5..000E-02
400..000	0..000E+00	0..000E+00	0..000E+00	0..000E+00
300..000	0..000E+00	0..000E+00	0..000E+00	0..000E+00
100..000	0..000E+00	0..000E+00	0..000E+00	0..000E+00
75..000	0..000E+00	0..000E+00	0..000E+00	0..000E+00
50..000	0..000E+00	0..000E+00	0..000E+00	0..000E+00
30..000	0..000E+00	0..000E+00	0..000E+00	0..000E+00
15..000	0..000E+00	0..000E+00	0..000E+00	0..000E+00
5..000	0..000E+00	0..000E+00	0..000E+00	0..000E+00
1..000	0..000E+00	0..000E+00	0..000E+00	0..000E+00
0..100	0..000E+00	0..000E+00	0..000E+00	0..000E+00
0..010	0..000E+00	0..000E+00	0..000E+00	0..000E+00
0..010	0..000E+00	0..000E+00	0..000E+00	0..000E+00

DISPERSAL ACCIDENT INPUT

AREADA (M SQ)	DILUTION FACTOR*
4.590E+02	3.420E-03
1.530E+03	1.720E-03
3.940E+03	8.580E-04
1.250E+04	3.420E-04
3.040E+04	1.720E-04
6.850E+04	8.580E-05
1.760E+05	3.420E-05
4.450E+05	1.720E-05
8.590E+05	8.580E-06
2.550E+06	3.420E-06
4.450E+06	1.720E-06
1.030E+07	8.580E-07
2.160E+07	3.420E-07
5.520E+07	1.720E-07
1.770E+08	8.580E-08
4.890E+08	5.420E-08
8.120E+08	4.300E-08
1.350E+09	3.420E-08

* DILUTION FACTOR UNITS ARE ((CI-SEC/M**3)/CI-RELEASED))

NON-DISPERSAL ACCIDENT INPUT

RADIST(M)		
RURAL	SUBURBAN	URBAN
3.050E+00	3.050E+00	3.050E+00
6.100E+00	6.100E+00	6.100E+00
9.100E+00	9.100E+00	9.100E+00
1.220E+01	1.220E+01	1.220E+01
1.520E+01	1.520E+01	1.520E+01
3.050E+01	3.050E+01	3.050E+01
6.100E+01	6.100E+01	6.100E+01
9.140E+01	9.140E+01	9.140E+01
1.524E+02	1.524E+02	1.524E+02
3.050E+02	3.050E+02	3.050E+02

BUILDING DOSE FACTOR	= 8.600E-03
FRACTION OF LAND UNDER CULTIVATION	= 5.000E-01
CONTAMINATION CLEAN UP LEVEL ((UCI/M**2))	= 2.000E-01
BREATHING RATE ((M**3)/SEC)	= 3.300E-04

REGULATORY CHECKS

FOR THE SHIPMENT OF SFUEL BY MODE 1
THE DOSE RATE AT 2 METERS COULD EXCEED 10 MR/HR
PPS*TI HAS BEEN RESET TO EQUAL 13.00

SAN ONOFRE IN SAN CLEMENTE TO YUCCA MOUNTAIN NEVADA UNIT-RISK

MODE TRUCK

1-YEAR LUNG DOSE - INHALATION PATHWAY
BDF = 1 (REM)

AREA #	SEVER: 1	SEVER: 2	SEVER: 3	SEVER: 4	SEVER: 5	SEVER: 6
1	0.00E+00	0.00E+00	4.93E-02	5.07E-02	9.29E-01	1.44E+00
2	0.00E+00	0.00E+00	2.48E-02	2.55E-02	4.66E-01	7.21E-01
3	0.00E+00	0.00E+00	1.20E-02	1.24E-02	2.27E-01	3.51E-01
4	0.00E+00	0.00E+00	4.65E-03	4.79E-03	8.77E-02	1.36E-01
5	0.00E+00	0.00E+00	2.23E-03	2.30E-03	4.20E-02	6.50E-02
6	0.00E+00	0.00E+00	1.06E-03	1.09E-03	2.00E-02	3.10E-02
7	0.00E+00	0.00E+00	4.04E-04	4.15E-04	7.60E-03	1.18E-02
8	0.00E+00	0.00E+00	1.91E-04	1.97E-04	3.60E-03	5.57E-03
9	0.00E+00	0.00E+00	8.89E-05	9.15E-05	1.67E-03	2.59E-03
10	0.00E+00	0.00E+00	3.36E-05	3.45E-05	6.33E-04	9.78E-04
11	0.00E+00	0.00E+00	1.53E-05	1.57E-05	2.88E-04	4.46E-04
12	0.00E+00	0.00E+00	7.26E-06	7.47E-06	1.37E-04	2.12E-04
13	0.00E+00	0.00E+00	2.68E-06	2.76E-06	5.06E-05	7.82E-05
14	0.00E+00	0.00E+00	1.27E-06	1.30E-06	2.38E-05	3.69E-05
15	0.00E+00	0.00E+00	5.78E-07	5.95E-07	1.09E-05	1.68E-05
16	0.00E+00	0.00E+00	3.09E-07	3.18E-07	5.82E-06	8.99E-06
17	0.00E+00	0.00E+00	1.88E-07	1.94E-07	3.55E-06	5.49E-06
18	0.00E+00	0.00E+00	1.23E-07	1.27E-07	2.32E-06	3.59E-06

1-YEAR MARROW DOSE - INHALATION PATHWAY
BDF = 1 (REM)

AREA #	SEVER: 1	SEVER: 2	SEVER: 3	SEVER: 4	SEVER: 5	SEVER: 6
1	0.00E+00	0.00E+00	2.37E-03	2.41E-03	7.58E-01	1.06E+00
2	0.00E+00	0.00E+00	1.19E-03	1.21E-03	3.81E-01	5.32E-01
3	0.00E+00	0.00E+00	5.79E-04	5.87E-04	1.85E-01	2.59E-01
4	0.00E+00	0.00E+00	2.24E-04	2.27E-04	7.15E-02	1.00E-01
5	0.00E+00	0.00E+00	1.07E-04	1.09E-04	3.43E-02	4.80E-02
6	0.00E+00	0.00E+00	5.12E-05	5.19E-05	1.63E-02	2.29E-02
7	0.00E+00	0.00E+00	1.94E-05	1.97E-05	6.20E-03	8.68E-03
8	0.00E+00	0.00E+00	9.19E-06	9.32E-06	2.94E-03	4.11E-03
9	0.00E+00	0.00E+00	4.28E-06	4.34E-06	1.37E-03	1.91E-03
10	0.00E+00	0.00E+00	1.62E-06	1.64E-06	5.16E-04	7.22E-04
11	0.00E+00	0.00E+00	7.36E-07	7.47E-07	2.35E-04	3.29E-04
12	0.00E+00	0.00E+00	3.49E-07	3.54E-07	1.12E-04	1.56E-04
13	0.00E+00	0.00E+00	1.29E-07	1.31E-07	4.12E-05	5.77E-05
14	0.00E+00	0.00E+00	6.09E-08	6.18E-08	1.94E-05	2.72E-05
15	0.00E+00	0.00E+00	2.78E-08	2.82E-08	8.88E-06	1.24E-05
16	0.00E+00	0.00E+00	1.49E-08	1.51E-08	4.74E-06	6.64E-06
17	0.00E+00	0.00E+00	9.06E-09	9.19E-09	2.89E-06	4.05E-06
18	0.00E+00	0.00E+00	5.92E-09	6.01E-09	1.89E-06	2.65E-06

SAN ONOFRE IN SAN CLEMENTE TO YUCCA MOUNTAIN NEVADA UNIT-RISK

MODE TRUCK

GROUND SURFACE CONTAMINATION TABLE ((MICRO CI/M**2))
BEFORE CLEANUP

AREA #	SEVER: 1	SEVER: 2	SEVER: 3	SEVER: 4	SEVER: 5	SEVER: 6
1	0..00E+00	0..00E+00	3..78E+01	3..80E+01	8..25E+02	1..16E+03
2	0..00E+00	0..00E+00	1..90E+01	1..91E+01	4..14E+02	5..84E+02
3	0..00E+00	0..00E+00	9..23E+00	9..26E+00	2..01E+02	2..84E+02
4	0..00E+00	0..00E+00	3..57E+00	3..58E+00	7..79E+01	1..10E+02
5	0..00E+00	0..00E+00	1..71E+00	1..72E+00	3..73E+01	5..26E+01
6	0..00E+00	0..00E+00	8..16E-01	8..19E-01	1..78E+01	2..51E+01
7	0..00E+00	0..00E+00	3..10E-01	3..11E-01	6..76E+00	9..52E+00
8	0..00E+00	0..00E+00	1..47E-01	1..47E-01	3..20E+00	4..50E+00
9	0..00E+00	0..00E+00	6..82E-02	6..84E-02	1..49E+00	2..10E+00
10	0..00E+00	0..00E+00	2..58E-02	2..58E-02	5..62E-01	7..92E-01
11	0..00E+00	0..00E+00	1..17E-02	1..18E-02	2..56E-01	3..61E-01
12	0..00E+00	0..00E+00	5..57E-03	5..59E-03	1..22E-01	1..71E-01
13	0..00E+00	0..00E+00	2..06E-03	2..07E-03	4..49E-02	6..33E-02
14	0..00E+00	0..00E+00	9..71E-04	9..74E-04	2..12E-02	2..98E-02
15	0..00E+00	0..00E+00	4..44E-04	4..45E-04	9..67E-03	1..36E-02
16	0..00E+00	0..00E+00	2..37E-04	2..38E-04	5..17E-03	7..28E-03
17	0..00E+00	0..00E+00	1..44E-04	1..45E-04	3..15E-03	4..44E-03
18	0..00E+00	0..00E+00	9..45E-05	9..48E-05	2..06E-03	2..90E-03

SAN ONOFRE IN SAN CLEMENTE TO YUCCA MOUNTAIN NEVADA UNIT-RISK

INCIDENT-FREE SUMMARY
******** **** *******

INCIDENT-FREE POPULATION EXPOSURE IN PERSON-REM

	PASSENGR	CREW	HANDLERS	OFF LINK	ON LINK	STOPS	STORAGE	TOTALS
LINK 1	0.00E+00	3.47E-05	0.00E+00	2.04E-07	8.30E-06	1.99E-04	0.00E+00	2.42E-04
TOTALS:	0.00E+00	3.47E-05	0.00E+00	2.04E-07	8.30E-06	1.99E-04	0.00E+00	2.42E-04

MAXIMUM INDIVIDUAL IN-TRANSIT DOSE

LINK 1 5.83E-07 REM

SAN ONOFRE IN SAN CLEMENTE TO YUCCA MOUNTAIN NEVADA UNIT-RISK

INCIDENT-FREE IMPORTANCE ANALYSIS SUMMARY FOR LINK 1
****

INDEX	DESCRIPTION OF PARAMETER	IMPORTANCE
1	K ZERO	2.424E-06
2	DOSE RATE ((TRANSPORT INDEX)	2.424E-06
3	DISTANCE TRAVELED	2.424E-06
4	NUMBER OF SHIPMENTS	2.424E-06
5	PACKAGES PER SHIPMENT	2.424E-06
6	PERSONS EXPOSED WHILE STOPPED	1.992E-06
7	STOP TIME	1.992E-06
8	FRACTION OF TRAVEL - RURAL	4.320E-07
9	NUMBER OF CREW MEMBERS	3.469E-07
10	NUMBER OF PEOPLE PER VEHICLE	8.304E-08
11	TRAFFIC COUNT - RURAL	8.304E-08
12	POPULATION DENSITY - RURAL	2.040E-09
13	RURAL SHIELDING FACTOR ((RR)	2.040E-09
14	FRACTION OF TRAVEL - URBAN	0.000E+00
15	PERSONS EXPOSED PER HANDLING	0.000E+00
16	EXPOSURE TIME FOR HANDLERS	0.000E+00
17	NUMBER OF HANDLINGS	0.000E+00
18	HANDLER EXPOSURE DISTANCE	0.000E+00
19	FRACTION OF RUSH HOUR TRAVEL	0.000E+00
20	NUMBER OF FLIGHT ATTENDANTS	0.000E+00
21	TRAFFIC COUNT - URBAN	0.000E+00
22	TRAFFIC COUNT - SUBURBAN	0.000E+00
23	FRACTION OF TRAVEL - SUBURBAN	0.000E+00
24	STORAGE EXPOSURE DISTANCE	0.000E+00
25	VELOCITY - SUBURBAN	0.000E+00
26	FRACTION OF TRAVEL ON CITY STREETS	0.000E+00
27	SUBURBAN SHIELDING FACTOR ((RS)	0.000E+00
28	POPULATION DENSITY - URBAN	0.000E+00
29	URBAN SHIELDING FACTOR ((RU)	0.000E+00
30	VELOCITY - URBAN	0.000E+00
31	STORAGE TIME PER SHIPMENT	0.000E+00
32	POPULATION DENSITY - SUBURBAN	0.000E+00
33	NUMBER OF PERSONS EXPOSED DURING STORAGE	0.000E+00
34	RATIO OF PEDESTRIAN DENSITY ((RPD)	-4.682E-17
35	FRACTION OF TRAVEL ON FREEWAYS	-1.462E-07
36	VELOCITY - RURAL	-5.151E-07
37	DISTANCE FROM SOURCE TO CREW	-6.591E-07
38	EXPOSURE DISTANCE WHILE STOPPED	-3.983E-06

THE IMPORTANCE VALUE ESTIMATES THE PERSON-REM INFLUENCE
OF A ONE PERCENT INCREASE IN THE PARAMETER

SAN ONOFRE IN SAN CLEMENTE TO YUCCA MOUNTAIN NEVADA UNIT-RISK

ACCIDENT SUMMARY
******** *******

NUMBER OF EXPECTED ACCIDENTS -- MODE TRUCK

CATEGORY	RURAL	SUBURB	URBAN
1	1.25E-08	0.00E+00	0.00E+00
2	8.20E-09	0.00E+00	0.00E+00
3	6.24E-11	0.00E+00	0.00E+00
4	6.24E-14	0.00E+00	0.00E+00
5	1.04E-13	0.00E+00	0.00E+00
6	1.46E-13	0.00E+00	0.00E+00

EARLY FATALITY CONSEQUENCES -- MODE TRUCK

CATEGORY	RURAL	SUBURB	URBAN
1	0.00E+00	0.00E+00	0.00E+00
2	0.00E+00	0.00E+00	0.00E+00
3	0.00E+00	0.00E+00	0.00E+00
4	0.00E+00	0.00E+00	0.00E+00
5	0.00E+00	0.00E+00	0.00E+00
6	0.00E+00	0.00E+00	0.00E+00

ECONOMIC CONSEQUENCES -- MODE TRUCK

CATEGORY	RURAL	SUBURB	URBAN
1	0.00E+00	0.00E+00	0.00E+00
2	0.00E+00	0.00E+00	0.00E+00
3	0.00E+00	0.00E+00	0.00E+00
4	0.00E+00	0.00E+00	0.00E+00
5	0.00E+00	0.00E+00	0.00E+00
6	0.00E+00	0.00E+00	0.00E+00

RADIOLOGICAL CONSEQUENCES -- MODE TRUCK
50 YEAR POPULATION DOSE IN PERSON REM

CATEGORY	RURAL	SUBURB	URBAN
1	0.00E+00	0.00E+00	0.00E+00
2	0.00E+00	0.00E+00	0.00E+00
3	2.53E+00	3.03E+02	9.84E+02
4	2.53E+00	3.03E+02	9.85E+02
5	2.74E+01	3.28E+03	1.06E+04
6	3.63E+01	4.35E+03	1.41E+04

SAN ONOFRE IN SAN CLEMENTE TO YUCCA MOUNTAIN NEVADA UNIT-RISK

EXPECTED VALUES OF POPULATION RISK IN PERSON REM

SFUEL	GROUND	INHALED	RESUSPD	CLOUDSH	*INGESTION	TOTAL
CO60	1.58E-10	1.33E-13	5.08E-13	1.18E-14	0.00E+00	1.58E-10
KR85	0.00E+00	0.00E+00	0.00E+00	4.46E-17	0.00E+00	4.46E-17
SR90	0.00E+00	1.28E-17	5.65E-17	0.00E+00	0.00E+00	6.93E-17
RU106	3.57E-15	5.51E-16	1.26E-15	0.00E+00	0.00E+00	5.38E-15
CS134	8.08E-13	1.06E-14	3.25E-14	1.78E-16	0.00E+00	8.51E-13
CS137	6.69E-12	2.36E-14	1.04E-13	0.00E+00	0.00E+00	6.82E-12
CE144	1.25E-18	1.31E-17	2.62E-17	1.91E-22	0.00E+00	4.06E-17
EU154	1.12E-16	3.71E-18	1.52E-17	7.83E-21	0.00E+00	1.31E-16
PU238	2.00E-19	1.41E-16	6.34E-16	2.25E-25	0.00E+00	7.75E-16
PU239	1.45E-20	2.09E-17	9.56E-17	2.89E-26	0.00E+00	1.17E-16
PU240	3.59E-20	2.39E-17	1.09E-16	3.48E-26	0.00E+00	1.33E-16
PU241	6.01E-21	1.12E-16	4.76E-16	0.00E+00	0.00E+00	5.88E-16
AM241	1.79E-18	6.82E-17	3.10E-16	2.11E-23	0.00E+00	3.80E-16
AM243	4.93E-20	1.05E-18	4.80E-18	8.76E-25	0.00E+00	5.90E-18
CM244	6.59E-20	4.97E-17	2.15E-16	1.29E-25	0.00E+00	2.64E-16
TOTALS:	1.65E-10	1.68E-13	6.48E-13	1.21E-14	0.00E+00	1.66E-10

* NOTE THAT INGESTION RISK IS A SOCIETAL RISK;
THE USER MAY WISH TO TREAT THIS VALUE SEPARATELY.

SAN ONOFRE IN SAN CLEMENTE TO YUCCA MOUNTAIN NEVADA UNIT-RISK

EXPECTED RISK VALUES - OTHER

LINK	ECON $$	EARLY FATALITY
1	0.00E+00	0.00E+00
TOTAL	0.00E+00	0.00E+00

EOI
END OF RUN

5.3 Output File 3

Page 1 — The cover page is the same as for Output Files 1 and 2.

Page 2 — Note the following important differences in the Echo Check page:

1. The TITLE line now reads SAN ONOFRE IN SAN CLEMENTE TO YUCCA MOUNTAIN NEVADA UNIT-RISK. The words AGGREGATE, which was used in Output File 1, and ROUTE-SPECIFIC, which was used in Output File 2, have been replaced by the word UNIT-RISK to indicate that this run will be used to generate unit-risk factors for transport of spent fuel from San Onofre to Yucca Mountain.

2. There are no changes in the input data used to describe the package, the material, and its constituent isotopes. The DNORML array has been changed to indicate that 100 percent of travel analyzed in this run is rural; i.e., the first value in the DNORML array (fraction of rural travel) for NMODE = 1 is set to 1.0, and the next two values, which represent fractions of travel in suburban and urban areas, respectively, are set to 0. If these three values do not sum to 1.0, an error message is printed; the calculation cannot continue until the user had corrected the problem (see Appendix D).

3. As in Output File 1, the package size in meters is entered for each material after the keyword PKGSIZ.

4. Since this is a non-LINK unit-risk run, the total distance in kilometers is entered after the keyword DISTKM. For unit-risk runs, the total distance is usually set to 1.0 so that the output risk values will directly give risk associated with 1 km of travel on the specified mode and link type, which is in this case, truck transport on rural Interstate Highways.

Pages 3 through 15 — The majority of these pages are similar to those in Output File 1. In the DNORML array that appears on page 5, the fraction of travel values are reiterated.

Page 16 — Incident-Free Summary. On this page the incident-free doses for rural truck travel in each exposure group are given.

Page 17 — Incident-Free Importance Analysis Summary. The importance values are given for Interstate rural transport by truck only.

Pages 18 through 20 — Accident Risk Summary. On page 18 the values given for expected numbers of accidents are nonzero only for rural travel. The consequence tables are broken down by mode, severity category, and population-density zone. Since only rural values have nonzero probabilities of occurrence (i.e., expected numbers of accidents greater than zero), the actual

risk calculations will be nonzero only for rural risks. The results of the risk calculations are given on page 19 for each exposure pathway and isotope. These values represent the accident risks associated with transport of spent fuel by truck along 1 km of rural Interstate Highway at the vehicle speed, etc., indicated in the DNORML array. On the last page of the output, the table shows estimated early fatalities for a similar 1 km of travel.

To apply the unit-risk factor method, at least two additional runs must be generated (for suburban and urban travel, respectively). Any number of such risk factor sets can be generated depending on the subdivision of route characteristics defined by the user. Note that (1) for unit-distance factors the user must multiply all factors in each set by the number of kilometers of travel in the associated route subclass, (2) the resulting products must be summed to give a total, and (3) neither of these manipulations is performed by RADTRAN 4.

The user can compare the results obtained with all three methods. Using the value of 492 km taken from Output File 2 for total rural distance traveled, the unit-risk factors in Output File 3 combined with the distance term give a value for total rural incident-free risk of 1.19E-01 ((492 km x 2.42E-04) and a value of 8.17E-08 for total rural accident risk ((492 x 1.66E-10)). 2.42E-04 and 1.66E-10 are from pages 16 and 19 of Output File 3, respectively. To obtain estimates of rural risks from Output File 1, the fraction of travel in the rural population-density zone ((0.796) was multiplied by the total incident-free risk ((1.57E-01) and the total accident risk ((6.89E-05)). Recall that the accident risks are not calculated on exactly the same basis. However, as the accompanying table illustrates, all methods give roughly comparable results for both risk types.

Table 5-1

RADTRAN 4 Methodology Comparison

Output File #	Rural Incident-Free Risk	Rural Accident Risk
1	1.25E-01	5.48E-05
2	1.19E-01	5.49E-05
3	1.19E-01	8.17E-08

```
RRRR    AAA   DDDD   TTTTT  RRRR    AAA   N   N
R   R  A   A  D   D    T    R   R  A   A  NN  N
R   R  A   A  D   D    T    R   R  A   A  N N N
RRRR   A   A  D   D    T    RRRR   A   A  N  NN
R R    AAAAA  D   D    T    R R    AAAAA  N   N
R  R   A   A  D   D    T    R  R   A   A  N   N
R   R  A   A  DDDD     T    R   R  A   A  N   N
```

```
    4
   44
  4 4
 4  4
 44444
    4
    4
    4
```

RADTRAN 4.0.12 VERSION DATE: NOVEMBER 19,1991

MODE DESCRIPTIONS

NUMBER	NAME	CHARACTERIZATION
1	TRUCK	LONG HAUL VEHICLE
2	RAIL	COMMERCIAL TRAIN
3	BARGE	INLAND VESSEL
4	SHIP	OPEN SEA VESSEL
5	CARGO AIR	CARGO AIRCRAFT
6	PASS AIR	PASSENGER AIRCRAFT
7	P-VAN	PASSENGER VAN
8	CVAN-T	COMMERCIAL VAN
9	CVAN-R	COMMERCIAL VAN
10	CVAN-CA	COMMERCIAL VAN

ECHO CHECK

```
TITLE  MULTIPLE TYPE A PACKAGES - DEDICATED TRUCK, PACKED ARRAY
FORM UNIT
DIMEN 12 8 2 10 18
PARM 0 3 2 3 0
PACKAGE LABGRP  A  B
SHIPMENT LABISO  H3WTR C14ORG    P32    S35    CA45    CR51
                   GA67   MO99   I125   I131   XE133   TL201
NORMAL FTZNR  NMODE=1 ..64
       FTZNS  NMODE=1 ..34
       FTZNJ  NMODE=1 ..02
       ADSTCW NMODE=1 6..76
       HANDNO NMODE=1 0..0
       DTSTOR NMODE=1 0..0
ECONOMIC
       ECONF 1..0
       ONSCST 250 2400 2400 5000
       EMRCST 20 400 500 600 1500 1700 2100 2500
RELEASE RFRAC GROUP=1 0..00 0..01 0..10 0..10 5*1..0
              GROUP=2 0..00 0..00 0..01 0..10 4*1..0
DEFINE TL201 3..044 9..325-02 1..39E-02 2..6E+02 2..9E+02 0..0 0..0 ..01 1 0..0 0..0
EOF
ISOTOPES -1 1 7 0..0 1..0 0..0 H3WTR
  H3WTR ..063 A 9
ISOTOPES -1 1 3 0..0  1..0 0..0 C14ORG
 C14ORG ..003 A 9
ISOTOPES -1 1 8 0..0  1..0 0..0 P32
 P32 ..094 A 9
ISOTOPES -1 1 2 0..0  1..0 0..0 S35
 S35 ..210 A 9
ISOTOPES -1 1 1 25..4  1..0 0..0 CA45
 CA45 ..003 A 9
ISOTOPES -1 1 8 0..0  1..0 0..0 CR51
 CR51 ..171 A 9
ISOTOPES -1 1 11 0..0  1..0 0..0 GA67
 GA67 ..024 A 9
ISOTOPES -1 1 30 0..0  1..0 0..0 MO99
 MO99 5..53 B 9
ISOTOPES -1 1 36 0..0  1..0 0..0 I125
 I125 ..001 A 9
ISOTOPES -1 1 29 0..0  1..0 0..0 I131
 I131 ..017 A 9
ISOTOPES -1 1 14 0..0  1..0 0..0 XE133
 XE133 ..359 A 10
ISOTOPES -1 1 20 0..0  1..0 0..0 TL201
 TL201 ..015 A 9
PKGSIZ H3WTR   ..61
      C14ORG   ..61
         P32   ..61
         S35   ..61
        CA45 12..20
        CR51   ..61
        GA67   ..61
        MO99   ..61
        I125   ..61
        I131   ..61
       XE133   ..61
       TL201   ..61
DISTKM NMODE=1 1895..0
EOF
```

MULTIPLE TYPE A PACKAGES - DEDICATED TRUCK, PACKED ARRAY

ZONE	POPULATION DENSITY (PERSONS PER SQ KM)
RURAL	6.
SUBURBAN	719.
URBAN	3861.

PACKAGE CHARACTERISTICS

FOR MATERIAL	DIMENSION (METERS)	EFFECTIVE DIMENSION	K(0) METERS SQ.
H3WTR	6.100E-01	6.100E-01	1.703E+00
C14ORG	6.100E-01	6.100E-01	1.703E+00
P32	6.100E-01	6.100E-01	1.703E+00
S35	6.100E-01	6.100E-01	1.703E+00
CA45	1.220E+01	8.149E+00	2.575E+01
CR51	6.100E-01	6.100E-01	1.703E+00
GA67	6.100E-01	6.100E-01	1.703E+00
MO99	6.100E-01	6.100E-01	1.703E+00
I125	6.100E-01	6.100E-01	1.703E+00
I131	6.100E-01	6.100E-01	1.703E+00
XE133	6.100E-01	6.100E-01	1.703E+00
TL201	6.100E-01	6.100E-01	1.703E+00

K(0) IS TI TO DOSE RATE CONVERSION FACTOR

PACKAGE HANDLING THRESHOLDS (METERS)
PKGSZ1= 5.000E-01
PKGSZ2= 1.000E+00
PACKAGES .LE. PKGSZ1 ARE HAND CARRIED
PACKAGES .GT. PKGSZ1 AND .LE. PKGSZ2 ARE HANDLED BY SMALL EQUIPMENT
PACKAGES .GT. PKGSZ2 ARE HANDLED BY HEAVY EQUIPMENT

MATERIAL CHARACTERISTICS

MATERIAL	FRACTION OF GAMMA	FRACTION OF NEUTRON
H3WTR	1.000E+00	0.000E+00
C14ORG	1.000E+00	0.000E+00
P32	1.000E+00	0.000E+00
S35	1.000E+00	0.000E+00
CA45	1.000E+00	0.000E+00
CR51	1.000E+00	0.000E+00
GA67	1.000E+00	0.000E+00
MO99	1.000E+00	0.000E+00
I125	1.000E+00	0.000E+00
I131	1.000E+00	0.000E+00
XE133	1.000E+00	0.000E+00
TL201	1.000E+00	0.000E+00

MULTIPLE TYPE A PACKAGES - DEDICATED TRUCK, PACKED ARRAY

MODE CHARACTERISTICS

MODE	DISTANCE TRAVELED	EXCLUSIVE USE	NUMBER OF SHIPMENTS	MATERIALS	TRANSPORT INDEX (TI)	PACKAGES/ SHIPMENT
TRUCK	1.90E+03	YES	1.00E+00			
				H3WTR	0.00E+00	7.00E+00
				C14ORG	0.00E+00	3.00E+00
				P32	0.00E+00	8.00E+00
				S35	0.00E+00	2.00E+00
				CA45	2.54E+01	1.00E+00
				CR51	0.00E+00	8.00E+00
				GA67	0.00E+00	1.10E+01
				MO99	0.00E+00	3.00E+01
				I125	0.00E+00	3.60E+01
				I131	0.00E+00	2.90E+01
				XE133	0.00E+00	1.40E+01
				TL201	0.00E+00	2.00E+01

BUILDING SHIELDING OPTION= 2
((1=TOTAL SHIELDING, 2=PARTIAL SHIELDING, 3=NO SHIELDING)

RPD= 6.000E+00
((RATIO OF PEDESTRIAN DENSITY ((PEDESTRIAN/KM SQ OF SIDEWALK)
TO POPULATION DENSITY ((PEOPLE/KM SQ IN URBAN AREAS)

RR = 1.000E+00
((TRANSMISSION FACTOR FOR RURAL AREAS)

RS = 8.700E-01
((TRANSMISSION FACTOR FOR SUBURBAN AREAS)

RU = 1.800E-02
((TRANSMISSION FACTOR FOR URBAN AREAS)

MULTIPLE TYPE A PACKAGES - DEDICATED TRUCK, PACKED ARRAY

DNORML INPUT

NO		TRUCK
1	FRACTION OF TRAVEL IN RURAL POPULATION ZONE	6.400E-01
2	FRACTION OF TRAVEL IN SUBURBAN POPULATION ZONE	3.400E-01
3	FRACTION OF TRAVEL IN URBAN POPULATION ZONE	2.000E-02
4	VELOCITY IN RURAL POPULATION ZONE ((KILOMETERS/HOUR)	8.849E+01
5	VELOCITY IN SUBURBAN POP.. ZONE ((KILOMETERS/HOUR)	4.025E+01
6	VELOCITY IN URBAN POPULATION ZONE (KILOMETERS/HOUR)	2.416E+01
7	NUMBER OF CREWMEN	2.000E+00
8	DISTANCE FROM SOURCE TO CREW ((METERS)	6.760E+00
9	NUMBER OF HANDLINGS	0.000E+00
10	STOP TIME PER KM ((HR/KM)	1.100E-02
11	MINIMUM STOP TIME PER TRIP ((HR)	0.000E+00
12	ZERO STOP TIME PER TRIP ((HR)	0.000E+00
13	MINIMUM NUMBER OF RAIL CLASSIFICATIONS/INSPECTIONS	0.000E+00
14	PERSONS EXPOSED WHILE STOPPED	5.000E+01
15	AVERAGE EXPOSURE DISTANCE WHILE STOPPED ((METERS)	2.000E+01
16	STORAGE TIME PER SHIPMENT ((HR)	0.000E+00
17	NUMBER OF EXPOSED PERSONS DURING STORAGE	1.000E+02
18	AVERAGE EXPOSURE DISTANCE WHILE IN STORAGE ((METERS)	1.000E+02
19	NUMBER OF PEOPLE PER VEHICLE ON LINK	2.000E+00
20	FRACTION OF URBAN TRAVEL DURING RUSH HOUR TRAFFIC	8.000E-02
21	FRACTION OF URBAN TRAVEL ON CITY STREETS	5.000E-02
22	FRACTION OF RURAL-SUBURBAN TRAVEL ON FREEWAYS	8.500E-01
23	*TRAFFIC COUNT PASSING A SPECIFIC POINT-RURAL ZONE	4.700E+02
24	*TRAFFIC COUNT PASSING A SPECIFIC POINT-SUBURBAN ZONE	7.800E+02
25	*TRAFFIC COUNT PASSING A SPECIFIC POINT-URBAN ZONE	2.800E+03

*((ONE WAY VEHICLES/HR)

MULTIPLE TYPE A PACKAGES - DEDICATED TRUCK, PACKED ARRAY

ISOTOPE RELATED DATA

NUCLIDE	CURIES PER PKG	RELEASE GROUP	RESUSP FACTOR	LUNG TYPE	DISPERS. CATEGORY	1YR INHAL LUNG	REM/CI MARROW
H3WTR							
H3WTR	6.30E-02	A	1.00E+00	2	9	6.00E+01	6.00E+01
C14ORG							
C14ORG	3.00E-03	A	5.56E+00	2	9	2.10E+03	2.10E+03
P32							
P32	9.40E-02	A	1.17E+00	1	9	1.60E+05	1.10E+04
S35							
S35	2.10E-01	A	1.88E+00	1	9	0.00E+00	0.00E+00
CA45							
CA45	3.00E-03	A	2.40E+00	1	9	0.00E+00	0.00E+00
CR51							
CR51	1.71E-01	A	1.32E+00	1	9	0.00E+00	0.00E+00
GA67							
GA67	2.40E-02	A	1.04E+00	1	9	0.00E+00	0.00E+00
MO99							
MO99	5.53E+00	B	1.03E+00	1	9	2.70E+04	1.80E+02
I125							
I125	1.00E-03	A	1.64E+00	1	9	6.80E+02	1.60E+02
I131							
I131	1.70E-02	A	1.10E+00	1	9	4.00E+03	2.30E+02
XE133							
XE133	3.59E-01	A	1.00E+00	1	10	0.00E+00	0.00E+00
TL201							
TL201	1.50E-02	A	1.04E+00	1	9	0.00E+00	0.00E+00

MULTIPLE TYPE A PACKAGES - DEDICATED TRUCK, PACKED ARRAY

NUCLIDE	HALF LIFE	GAMMA ENERGY	CLOUD FACTOR	TRANSFER CROPS	TRANSFER SOIL	DEPOS SPEED
H3WTR						
H3WTR	4.51E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
C14ORG						
C14ORG	2.09E+06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.00E-02
P32						
P32	1.43E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.00E-02
S35						
S35	8.74E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.00E-02
CA45						
CA45	1.63E+02	4.35E-08	2.59E-11	0.00E+00	0.00E+00	1.00E-02
CR51						
CR51	2.77E+01	3.26E-02	5.01E-03	0.00E+00	0.00E+00	1.00E-02
GA67						
GA67	3.26E+00	1.58E-01	2.34E-02	0.00E+00	0.00E+00	1.00E-02
MO99						
MO99	2.75E+00	2.76E-01	2.53E-02	0.00E+00	0.00E+00	1.00E-02
I125						
I125	6.01E+01	4.20E-02	1.77E-03	0.00E+00	0.00E+00	1.00E-02
I131						
I131	8.04E+00	3.80E-01	6.05E-02	0.00E+00	0.00E+00	1.00E-02
XE133						
XE133	5.25E+00	4.60E-02	5.58E-03	0.00E+00	0.00E+00	0.00E+00
TL201						
TL201	3.04E+00	9.32E-02	1.39E-02	0.00E+00	0.00E+00	1.00E-02

MULTIPLE TYPE A PACKAGES - DEDICATED TRUCK, PACKED ARRAY

ISOTOPE RELATED DATA

NUCLIDE	50-YR EFFECTIVE REM/CI	
	INHALE	INGEST
H3WTR		
H3WTR	6.30E+01	6.30E+01
C14ORG		
C14ORG	2.10E+03	2.10E+03
P32		
P32	2.20E+04	7.70E+03
S35		
S35	4.10E+03	6.50E+02
CA45		
CA45	9.50E+03	3.00E+03
CR51		
CR51	4.50E+02	1.30E+02
GA67		
GA67	5.90E+02	7.20E+02
MO99		
MO99	4.50E+03	4.40E+03
I125		
I125	2.30E+04	3.80E+04
I131		
I131	3.10E+04	5.30E+04
XE133		
XE133	0.00E+00	0.00E+00
TL201		
TL201	2.60E+02	2.90E+02

MULTIPLE TYPE A PACKAGES - DEDICATED TRUCK, PACKED ARRAY

RELEASE RELATED DATA

ACCIDENT RATES (PER KM)

MODE	RURAL	SUBURBAN	URBAN
TRUCK	1.40ZE-07	2.681E-06	1.599E-05

RELEASE FRACTIONS

GROUP	SEVER: 1	SEVER: 2	SEVER: 3	SEVER: 4	SEVER: 5	SEVER: 6	SEVER: 7
1	0.00E+00	1.00E-02	1.00E-01	1.00E-01	1.00E+00	1.00E+00	1.00E+00
2	0.00E+00	0.00E+00	1.00E-02	1.00E-01	1.00E+00	1.00E+00	1.00E+00

GROUP	SEVER: 8
1	1.00E+00
2	1.00E+00

ACCIDENT SEVERITY FRACTIONS
FOR TRUCK

ZONE	SEVER: 1	SEVER: 2	SEVER: 3	SEVER: 4	SEVER: 5	SEVER: 6	SEVER: 7
1	4.62E-01	3.02E-01	1.76E-01	4.03E-02	1.18E-02	6.47E-03	5.71E-04
2	4.35E-01	2.85E-01	2.21E-01	5.06E-02	6.64E-03	1.74E-03	6.72E-05
3	5.83E-01	3.82E-01	2.78E-02	6.36E-03	7.42E-04	1.46E-04	1.13E-05

ZONE	SEVER: 8
1	1.13E-04
2	5.93E-06
3	9.94E-07

MULTIPLE TYPE A PACKAGES - DEDICATED TRUCK, PACKED ARRAY

AEROSOLIZED FRACTION OF RELEASED MATERIAL

DISP CAT	SEVER: 1	SEVER: 2	SEVER: 3	SEVER: 4	SEVER: 5	SEVER: 6	SEVER: 7
1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
2	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
3	1.00E-02	1.00E-02	1.00E-02	1.00E-02	1.00E-02	1.00E-02	1.00E-02
4	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02
5	1.00E-01	1.00E-01	1.00E-01	1.00E-01	1.00E-01	1.00E-01	1.00E-01
6	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
7	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
8	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
9	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
10	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
11	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00

DISP CAT	SEVER: 8
1	0.00E+00
2	1.00E+00
3	1.00E-02
4	5.00E-02
5	1.00E-01
6	1.00E+00
7	1.00E+00
8	1.00E+00
9	1.00E+00
10	1.00E+00
11	1.00E+00

MULTIPLE TYPE A PACKAGES - DEDICATED TRUCK, PACKED ARRAY

FRACTION OF AEROSOLS BELOW 10 MICRONS AED

DISP CAT	SEVER: 1	SEVER: 2	SEVER: 3	SEVER: 4	SEVER: 5	SEVER: 6	SEVER: 7
1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
2	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02
3	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02
4	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02
5	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02
6	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02
7	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
8	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
9	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
10	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
11	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00

DISP CAT	SEVER: 8
1	0.00E+00
2	5.00E-02
3	5.00E-02
4	5.00E-02
5	5.00E-02
6	5.00E-02
7	1.00E+00
8	1.00E+00
9	1.00E+00
10	1.00E+00
11	1.00E+00

MULTIPLE TYPE A PACKAGES - DEDICATED TRUCK, PACKED ARRAY

COST RELATED DATA

EMERGENCY RESPONSE COST

	SEVER: 1	SEVER: 2	SEVER: 3	SEVER: 4	SEVER: 5	SEVER: 6	SEVER: 7
1	2.00E+01	4.00E+02	5.00E+02	6.00E+02	1.50E+03	1.70E+03	2.10E+03

	SEVER: 8
1	2.50E+03

ON-SCENE COSTS
(RF=RELEASE FRACTION)

RF=0.	0.<RF<=.01	.01<RF<=0.1	.1<RF<=1.
250.	2400.	2400.	5000.

MULTIPLE TYPE A PACKAGES - DEDICATED TRUCK, PACKED ARRAY

HEALTH RELATED DATA

EARLY FATALITY PROBABILITIES

DOSE(REM)	LUNG-1	LUNG-2	LUNG-3	MARROW
100000.000	1.000E+00	1.000E+00	1.000E+00	1.000E+00
80000.000	1.000E+00	8.500E-01	8.000E-01	1.000E+00
70000.000	1.000E+00	8.000E-01	5.000E-01	1.000E+00
40000.000	1.000E+00	7.000E-01	0.000E+00	1.000E+00
30000.000	1.000E+00	5.000E-01	0.000E+00	1.000E+00
25000.000	1.000E+00	2.000E-01	0.000E+00	1.000E+00
20000.000	1.000E+00	8.000E-02	0.000E+00	1.000E+00
10000.000	6.000E-01	0.000E+00	0.000E+00	1.000E+00
8000.000	1.000E-01	0.000E+00	0.000E+00	1.000E+00
6000.000	6.000E-02	0.000E+00	0.000E+00	1.000E+00
4000.000	3.000E-02	0.000E+00	0.000E+00	1.000E+00
3000.000	0.000E+00	0.000E+00	0.000E+00	1.000E+00
2000.000	0.000E+00	0.000E+00	0.000E+00	1.000E+00
1000.000	0.000E+00	0.000E+00	0.000E+00	1.000E+00
800.000	0.000E+00	0.000E+00	0.000E+00	9.960E-01
700.000	0.000E+00	0.000E+00	0.000E+00	9.000E-01
600.000	0.000E+00	0.000E+00	0.000E+00	4.000E-01
500.000	0.000E+00	0.000E+00	0.000E+00	5.000E-02
400.000	0.000E+00	0.000E+00	0.000E+00	0.000E+00
300.000	0.000E+00	0.000E+00	0.000E+00	0.000E+00
100.000	0.000E+00	0.000E+00	0.000E+00	0.000E+00
75.000	0.000E+00	0.000E+00	0.000E+00	0.000E+00
50.000	0.000E+00	0.000E+00	0.000E+00	0.000E+00
30.000	0.000E+00	0.000E+00	0.000E+00	0.000E+00
15.000	0.000E+00	0.000E+00	0.000E+00	0.000E+00
5.000	0.000E+00	0.000E+00	0.000E+00	0.000E+00
1.000	0.000E+00	0.000E+00	0.000E+00	0.000E+00
0.100	0.000E+00	0.000E+00	0.000E+00	0.000E+00
0.010	0.000E+00	0.000E+00	0.000E+00	0.000E+00
0.010	0.000E+00	0.000E+00	0.000E+00	0.000E+00

MULTIPLE TYPE A PACKAGES - DEDICATED TRUCK, PACKED ARRAY

DISPERSAL ACCIDENT INPUT

AREADA (M SQ)	DILUTION FACTOR*
4.590E+02	3.420E-03
1.530E+03	1.720E-03
3.940E+03	8.580E-04
1.250E+04	3.420E-04
3.040E+04	1.720E-04
6.850E+04	8.580E-05
1.760E+05	3.420E-05
4.450E+05	1.720E-05
8.590E+05	8.580E-06
2.550E+06	3.420E-06
4.450E+06	1.720E-06
1.030E+07	8.580E-07
2.160E+07	3.420E-07
5.520E+07	1.720E-07
1.770E+08	8.580E-08
4.390E+08	5.420E-08
8.120E+08	4.300E-08
1.350E+09	3.420E-08

* DILUTION FACTOR UNITS ARE ((CI-SEC/M**3/(CI-RELEASED)

NON-DISPERSAL ACCIDENT INPUT

RADIST((M)		
RURAL	SUBURBAN	URBAN
3.050E+00	3.050E+00	3.050E+00
6.100E+00	6.100E+00	6.100E+00
9.100E+00	9.100E+00	9.100E+00
1.220E+01	1.220E+01	1.220E+01
1.520E+01	1.520E+01	1.520E+01
3.050E+01	3.050E+01	3.050E+01
6.100E+01	6.100E+01	6.100E+01
9.140E+01	9.140E+01	9.140E+01
1.524E+02	1.524E+02	1.524E+02
3.050E+02	3.050E+02	3.050E+02

BUILDING DOSE FACTOR	= 8.600E-03
FRACTION OF LAND UNDER CULTIVATION	= 5.000E-01
CONTAMINATION CLEAN UP LEVEL ((UCI/M**2))	= 2.000E-01
BREATHING RATE ((M**3/SEC))	= 3.300E-04

MULTIPLE TYPE A PACKAGES - DEDICATED TRUCK, PACKED ARRAY

REGULATORY CHECKS

THE SHIPMENT OF H3WTR BY MODE 1 IS DESIGNATED AS EXCLUSIVE USE
BUT IS NOT REQUIRED TO BE SO DESIGNATED BY REGULATIONS

THE SHIPMENT OF C14ORG BY MODE 1 IS DESIGNATED AS EXCLUSIVE USE
BUT IS NOT REQUIRED TO BE SO DESIGNATED BY REGULATIONS

THE SHIPMENT OF P32 BY MODE 1 IS DESIGNATED AS EXCLUSIVE USE
BUT IS NOT REQUIRED TO BE SO DESIGNATED BY REGULATIONS

THE SHIPMENT OF S35 BY MODE 1 IS DESIGNATED AS EXCLUSIVE USE
BUT IS NOT REQUIRED TO BE SO DESIGNATED BY REGULATIONS

FOR THE SHIPMENT OF CA45 BY MODE 1
THE DOSE RATE AT 2 METERS COULD EXCEED 10 MR/HR
PPS*TI HAS BEEN RESET TO EQUAL 11.97

FOR THE SHIPMENT OF CA45 BY MODE 1
THE DOSE RATE IN THE CREW COMPARTMENT COULD EXCEED 2 MREM/HR
THE DOSE RATE HAS BEEN RESET FROM 14.31 TO 2 FOR CREW CALCULATIONS

THE SHIPMENT OF CR51 BY MODE 1 IS DESIGNATED AS EXCLUSIVE USE
BUT IS NOT REQUIRED TO BE SO DESIGNATED BY REGULATIONS

THE SHIPMENT OF GA67 BY MODE 1 IS DESIGNATED AS EXCLUSIVE USE
BUT IS NOT REQUIRED TO BE SO DESIGNATED BY REGULATIONS

THE SHIPMENT OF MO99 BY MODE 1 IS DESIGNATED AS EXCLUSIVE USE
BUT IS NOT REQUIRED TO BE SO DESIGNATED BY REGULATIONS

THE SHIPMENT OF I125 BY MODE 1 IS DESIGNATED AS EXCLUSIVE USE
BUT IS NOT REQUIRED TO BE SO DESIGNATED BY REGULATIONS

THE SHIPMENT OF I131 BY MODE 1 IS DESIGNATED AS EXCLUSIVE USE
BUT IS NOT REQUIRED TO BE SO DESIGNATED BY REGULATIONS

THE SHIPMENT OF XE133 BY MODE 1 IS DESIGNATED AS EXCLUSIVE USE
BUT IS NOT REQUIRED TO BE SO DESIGNATED BY REGULATIONS

THE SHIPMENT OF TL201 BY MODE 1 IS DESIGNATED AS EXCLUSIVE USE
BUT IS NOT REQUIRED TO BE SO DESIGNATED BY REGULATIONS

MULTIPLE TYPE A PACKAGES - DEDICATED TRUCK, PACKED ARRAY

MODE TRUCK

1-YEAR LUNG DOSE - INHALATION PATHWAY
BDF = 1 (REM)

AREA #	SEVER: 1	SEVER: 2	SEVER: 3	SEVER: 4	SEVER: 5	SEVER: 6	SEVER: 7
1	0.00E+00	1.38E-03	6.44E-02	5.19E-01	5.19E+00	5.19E+00	5.19E+00
2	0.00E+00	6.93E-04	3.23E-02	2.61E-01	2.61E+00	2.61E+00	2.61E+00
3	0.00E+00	3.37E-04	1.57E-02	1.27E-01	1.27E+00	1.27E+00	1.27E+00
4	0.00E+00	1.30E-04	6.07E-03	4.90E-02	4.90E-01	4.90E-01	4.90E-01
5	0.00E+00	6.25E-05	2.91E-03	2.35E-02	2.35E-01	2.35E-01	2.35E-01
6	0.00E+00	2.98E-05	1.39E-03	1.12E-02	1.12E-01	1.12E-01	1.12E-01
7	0.00E+00	1.13E-05	5.27E-04	4.25E-03	4.25E-02	4.25E-02	4.25E-02
8	0.00E+00	5.35E-06	2.49E-04	2.01E-03	2.01E-02	2.01E-02	2.01E-02
9	0.00E+00	2.49E-06	1.16E-04	9.36E-04	9.36E-03	9.36E-03	9.36E-03
10	0.00E+00	9.41E-07	4.36E-05	3.54E-04	3.54E-03	3.54E-03	3.54E-03
11	0.00E+00	4.29E-07	2.00E-05	1.61E-04	1.61E-03	1.61E-03	1.61E-03
12	0.00E+00	2.03E-07	9.48E-06	7.65E-05	7.65E-04	7.65E-04	7.65E-04
13	0.00E+00	7.52E-08	3.50E-06	2.83E-05	2.83E-04	2.83E-04	2.83E-04
14	0.00E+00	3.54E-08	1.65E-06	1.33E-05	1.33E-04	1.33E-04	1.33E-04
15	0.00E+00	1.62E-08	7.54E-07	6.09E-06	6.09E-05	6.09E-05	6.09E-05
16	0.00E+00	8.65E-09	4.03E-07	3.25E-06	3.25E-05	3.25E-05	3.25E-05
17	0.00E+00	5.28E-09	2.46E-07	1.98E-06	1.98E-05	1.98E-05	1.98E-05
18	0.00E+00	3.45E-09	1.61E-07	1.30E-06	1.30E-05	1.30E-05	1.30E-05

AREA #	SEVER: 8
1	5.19E+00
2	2.61E+00
3	1.27E+00
4	4.90E-01
5	2.35E-01
6	1.12E-01
7	4.25E-02
8	2.01E-02
9	9.36E-03
10	3.54E-03
11	1.61E-03
12	7.65E-04
13	2.83E-04
14	1.33E-04
15	6.09E-05
16	3.25E-05
17	1.98E-05
18	1.30E-05

MULTIPLE TYPE A PACKAGES - DEDICATED TRUCK, PACKED ARRAY

1-YEAR MARROW DOSE - INHALATION PATHWAY
BDF = 1 (REM)

AREA #	SEVER: 1	SEVER: 2	SEVER: 3	SEVER: 4	SEVER: 5	SEVER: 6	SEVER: 7
1	0.00E+00	9.52E-05	1.29E-03	4.32E-03	4.32E-02	4.32E-02	4.32E-02
2	0.00E+00	4.78E-05	6.47E-04	2.17E-03	2.17E-02	2.17E-02	2.17E-02
3	0.00E+00	2.32E-05	3.15E-04	1.05E-03	1.05E-02	1.05E-02	1.05E-02
4	0.00E+00	8.99E-06	1.22E-04	4.08E-04	4.08E-03	4.08E-03	4.08E-03
5	0.00E+00	4.31E-06	5.84E-05	1.96E-04	1.96E-03	1.96E-03	1.96E-03
6	0.00E+00	2.05E-06	2.78E-05	9.32E-05	9.32E-04	9.32E-04	9.32E-04
7	0.00E+00	7.80E-07	1.06E-05	3.54E-05	3.54E-04	3.54E-04	3.54E-04
8	0.00E+00	3.69E-07	5.00E-06	1.68E-05	1.68E-04	1.68E-04	1.68E-04
9	0.00E+00	1.72E-07	2.33E-06	7.79E-06	7.79E-05	7.79E-05	7.79E-05
10	0.00E+00	6.49E-08	8.79E-07	2.94E-06	2.94E-05	2.94E-05	2.94E-05
11	0.00E+00	2.96E-08	4.01E-07	1.34E-06	1.34E-05	1.34E-05	1.34E-05
12	0.00E+00	1.41E-08	1.90E-07	6.37E-07	6.37E-06	6.37E-06	6.37E-06
13	0.00E+00	5.20E-09	7.03E-08	2.35E-07	2.35E-06	2.35E-06	2.35E-06
14	0.00E+00	2.45E-09	3.31E-08	1.11E-07	1.11E-06	1.11E-06	1.11E-06
15	0.00E+00	1.12E-09	1.52E-08	5.07E-08	5.07E-07	5.07E-07	5.07E-07
16	0.00E+00	5.99E-10	8.10E-09	2.71E-08	2.71E-07	2.71E-07	2.71E-07
17	0.00E+00	3.66E-10	4.95E-09	1.65E-08	1.65E-07	1.65E-07	1.65E-07
18	0.00E+00	2.40E-10	3.24E-09	1.08E-08	1.08E-07	1.08E-07	1.08E-07

AREA #	SEVER: 8
1	4.32E-02
2	2.17E-02
3	1.05E-02
4	4.08E-03
5	1.96E-03
6	9.32E-04
7	3.54E-04
8	1.68E-04
9	7.79E-05
10	2.94E-05
11	1.34E-05
12	6.37E-06
13	2.35E-06
14	1.11E-06
15	5.07E-07
16	2.71E-07
17	1.65E-07
18	1.08E-07

MULTIPLE TYPE A PACKAGES - DEDICATED TRUCK, PACKED ARRAY

MODE TRUCK

GROUND SURFACE CONTAMINATION TABLE ((MICRO CI/M**2)
BEFORE CLEANUP

AREA #	SEVER: 1	SEVER: 2	SEVER: 3	SEVER: 4	SEVER: 5	SEVER: 6	SEVER: 7
1	0.00E+00	1.25E+00	6.92E+01	5.80E+02	5.80E+03	5.80E+03	5.80E+03
2	0.00E+00	6.26E-01	3.47E+01	2.91E+02	2.91E+03	2.91E+03	2.91E+03
3	0.00E+00	3.04E-01	1.69E+01	1.41E+02	1.41E+03	1.41E+03	1.41E+03
4	0.00E+00	1.18E-01	6.53E+00	5.47E+01	5.47E+02	5.47E+02	5.47E+02
5	0.00E+00	5.64E-02	3.13E+00	2.62E+01	2.62E+02	2.62E+02	2.62E+02
6	0.00E+00	2.69E-02	1.49E+00	1.25E+01	1.25E+02	1.25E+02	1.25E+02
7	0.00E+00	1.02E-02	5.67E-01	4.75E+00	4.75E+01	4.75E+01	4.75E+01
8	0.00E+00	4.83E-03	2.68E-01	2.25E+00	2.25E+01	2.25E+01	2.25E+01
9	0.00E+00	2.25E-03	1.25E-01	1.05E+00	1.05E+01	1.05E+01	1.05E+01
10	0.00E+00	8.49E-04	4.71E-02	3.95E-01	3.95E+00	3.95E+00	3.95E+00
11	0.00E+00	3.87E-04	2.15E-02	1.80E-01	1.80E+00	1.80E+00	1.80E+00
12	0.00E+00	1.84E-04	1.02E-02	8.54E-02	8.54E-01	8.54E-01	8.54E-01
13	0.00E+00	6.78E-05	3.77E-03	3.16E-02	3.16E-01	3.16E-01	3.16E-01
14	0.00E+00	3.20E-05	1.78E-03	1.49E-02	1.49E-01	1.49E-01	1.49E-01
15	0.00E+00	1.46E-05	8.11E-04	6.80E-03	6.80E-02	6.80E-02	6.80E-02
16	0.00E+00	7.80E-06	4.33E-04	3.63E-03	3.63E-02	3.63E-02	3.63E-02
17	0.00E+00	4.76E-06	2.64E-04	2.21E-03	2.21E-02	2.21E-02	2.21E-02
18	0.00E+00	3.11E-06	1.73E-04	1.45E-03	1.45E-02	1.45E-02	1.45E-02

AREA #	SEVER: 8
1	5.80E+03
2	2.91E+03
3	1.41E+03
4	5.47E+02
5	2.62E+02
6	1.25E+02
7	4.75E+01
8	2.25E+01
9	1.05E+01
10	3.95E+00
11	1.80E+00
12	8.54E-01
13	3.16E-01
14	1.49E-01
15	6.80E-02
16	3.63E-02
17	2.21E-02
18	1.45E-02

MULTIPLE TYPE A PACKAGES - DEDICATED TRUCK, PACKED ARRAY

INCIDENT-FREE SUMMARY
******** **** *******

INCIDENT-FREE POPULATION EXPOSURE IN PERSON-REM

	PASSENGR	CREW	HANDLERS	OFF LINK	ON LINK	STOPS	STORAGE	TOTALS
LINK 1								
H3WTR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
C14ORG	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
P32	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
S35	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CA45	0.00E+00	1.26E-01	0.00E+00	4.21E-02	1.32E-01	8.03E-01	0.00E+00	1.10E+00
CR51	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
GA67	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MO99	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
I125	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
I131	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
XE133	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
TL201	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
TOTALS:	0.00E+00	1.26E-01	0.00E+00	4.21E-02	1.32E-01	8.03E-01	0.00E+00	1.10E+00

MAXIMUM INDIVIDUAL IN-TRANSIT DOSE

LINK 1 2.50E-06 REM

MULTIPLE TYPE A PACKAGES - DEDICATED TRUCK, PACKED ARRAY

INCIDENT-FREE IMPORTANCE ANALYSIS SUMMARY FOR LINK 1
****

INDEX	DESCRIPTION OF PARAMETER	IMPORTANCE
1	DISTANCE TRAVELED	1.103E-02
2	NUMBER OF SHIPMENTS	1.103E-02
3	PACKAGES PER SHIPMENT	9.770E-03
4	DOSE RATE ((TRANSPORT INDEX)	9.770E-03
5	K ZERO	9.770E-03
6	STOP TIME	8.032E-03
7	PERSONS EXPOSED WHILE STOPPED	8.032E-03
8	FRACTION OF TRAVEL - SUBURBAN	1.903E-03
9	NUMBER OF PEOPLE PER VEHICLE	1.317E-03
10	NUMBER OF CREW MEMBERS	1.261E-03
11	TRAFFIC COUNT - SUBURBAN	8.630E-04
12	FRACTION OF TRAVEL - RURAL	8.292E-04
13	FRACTION OF RUSH HOUR TRAVEL	4.166E-04
14	POPULATION DENSITY - SUBURBAN	3.950E-04
15	SUBURBAN SHIELDING FACTOR ((RS)	3.720E-04
16	TRAFFIC COUNT - RURAL	2.711E-04
17	FRACTION OF TRAVEL - URBAN	2.664E-04
18	TRAFFIC COUNT - URBAN	1.827E-04
19	FRACTION OF TRAVEL ON CITY STREETS	1.376E-04
20	RATIO OF PEDESTRIAN DENSITY ((RPD)	4.117E-05
21	POPULATION DENSITY - URBAN	2.049E-05
22	POPULATION DENSITY - RURAL	5.424E-06
23	RURAL SHIELDING FACTOR ((RR)	5.271E-06
24	URBAN SHIELDING FACTOR ((RU)	2.487E-06
25	HANDLER EXPOSURE DISTANCE	0.000E+00
26	NUMBER OF PERSONS EXPOSED DURING STORAGE	0.000E+00
27	NUMBER OF FLIGHT ATTENDANTS	0.000E+00
28	PERSONS EXPOSED PER HANDLING	0.000E+00
29	EXPOSURE TIME FOR HANDLERS	0.000E+00
30	DISTANCE FROM SOURCE TO CREW	0.000E+00
31	STORAGE EXPOSURE DISTANCE	0.000E+00
32	NUMBER OF HANDLINGS	0.000E+00
33	STORAGE TIME PER SHIPMENT	0.000E+00
34	VELOCITY - URBAN	-3.265E-04
35	VELOCITY - SUBURBAN	-1.987E-03
36	VELOCITY - RURAL	-2.002E-03
37	FRACTION OF TRAVEL ON FREEWAYS	-3.958E-03
38	EXPOSURE DISTANCE WHILE STOPPED	-1.606E-02

THE IMPORTANCE VALUE ESTIMATES THE PERSON-REM INFLUENCE
OF A ONE PERCENT INCREASE IN THE PARAMETER

MULTIPLE TYPE A PACKAGES - DEDICATED TRUCK, PACKED ARRAY

ACCIDENT SUMMARY
******** *******

NUMBER OF EXPECTED ACCIDENTS -- MODE TRUCK

CATEGORY	RURAL	SUBURB	URBAN
1	7.86E-05	7.51E-04	3.53E-04
2	5.14E-05	4.92E-04	2.32E-04
3	2.99E-05	3.82E-04	1.68E-05
4	6.85E-06	8.74E-05	3.85E-06
5	2.01E-06	1.15E-05	4.50E-07
6	1.10E-06	3.01E-06	8.85E-08
7	9.71E-08	1.16E-07	6.85E-09
8	1.92E-08	1.02E-08	6.02E-10

EARLY FATALITY CONSEQUENCES -- MODE TRUCK

CATEGORY	RURAL	SUBURB	URBAN
1	0.00E+00	0.00E+00	0.00E+00
2	0.00E+00	0.00E+00	0.00E+00
3	0.00E+00	0.00E+00	0.00E+00
4	0.00E+00	0.00E+00	0.00E+00
5	0.00E+00	0.00E+00	0.00E+00
6	0.00E+00	0.00E+00	0.00E+00
7	0.00E+00	0.00E+00	0.00E+00
8	0.00E+00	0.00E+00	0.00E+00

ECONOMIC CONSEQUENCES -- MODE TRUCK

CATEGORY	RURAL	SUBURB	URBAN
1	2.70E+02	2.70E+02	2.70E+02
2	1.17E+04	1.35E+04	7.51E+04
3	6.40E+05	9.27E+05	1.29E+07
4	3.32E+06	6.10E+06	1.37E+08
5	1.02E+08	1.34E+08	1.67E+09
6	1.02E+08	1.34E+08	1.67E+09
7	1.02E+08	1.34E+08	1.67E+09
8	1.02E+08	1.34E+08	1.67E+09

MULTIPLE TYPE A PACKAGES - DEDICATED TRUCK, PACKED ARRAY

RADIOLOGICAL CONSEQUENCES -- MODE TRUCK
50 YEAR POPULATION DOSE IN PERSON REM

CATEGORY	RURAL	SUBURB	URBAN
1	0.00E+00	0.00E+00	0.00E+00
2	8.33E-05	9.99E-03	3.24E-02
3	2.38E-03	2.85E-01	9.27E-01
4	1.66E-02	1.98E+00	6.44E+00
5	1.63E-01	1.96E+01	6.35E+01
6	1.63E-01	1.96E+01	6.35E+01
7	1.63E-01	1.96E+01	6.35E+01
8	1.63E-01	1.96E+01	6.35E+01

MULTIPLE TYPE A PACKAGES - DEDICATED TRUCK, PACKED ARRAY

EXPECTED VALUES OF POPULATION RISK IN PERSON REM

	GROUND	INHALED	RESUSPD	CLOUDSH	*INGESTION	TOTAL
H3WTR						
H3WTR	0.00E+00	6.91E-08	0.00E+00	0.00E+00	0.00E+00	6.91E-08
C14ORG						
C14ORG	0.00E+00	2.55E-08	1.17E-07	0.00E+00	0.00E+00	1.42E-07
P32						
P32	0.00E+00	2.24E-05	3.84E-06	0.00E+00	0.00E+00	2.62E-05
S35						
S35	0.00E+00	2.33E-06	2.05E-06	0.00E+00	0.00E+00	4.37E-06
CA45						
CA45	1.51E-13	3.85E-08	5.41E-08	3.18E-19	0.00E+00	9.26E-08
CR51						
CR51	9.40E-06	8.32E-07	2.67E-07	2.81E-08	0.00E+00	1.05E-05
GA67						
GA67	5.48E-07	2.11E-07	8.48E-09	2.53E-08	0.00E+00	7.92E-07
MO99						
MO99	1.85E-04	3.76E-04	1.28E-05	6.41E-06	0.00E+00	5.80E-04
I125						
I125	7.17E-07	1.12E-06	7.20E-07	2.61E-10	0.00E+00	2.56E-06
I131						
I131	8.06E-06	2.07E-05	2.03E-06	1.22E-07	0.00E+00	3.09E-05
XE133						
XE133	0.00E+00	0.00E+00	0.00E+00	2.11E-07	0.00E+00	2.11E-07
TL201						
TL201	3.44E-07	1.05E-07	3.97E-09	1.71E-08	0.00E+00	4.71E-07
TOTALS:	2.04E-04	4.24E-04	2.19E-05	6.81E-06	0.00E+00	6.56E-04

* NOTE THAT INGESTION RISK IS A SOCIETAL RISK;
THE USER MAY WISH TO TREAT THIS VALUE SEPARATELY.

MULTIPLE TYPE A PACKAGES - DEDICATED TRUCK, PACKED ARRAY

EXPECTED RISK VALUES - OTHER

LINK	ECON $$	EARLY FATALITY
1	4.90E+03	0.00E+00
TOTAL	4.90E+03	0.00E+00

EOI
END OF RUN

5.4 Output File 4

Page 1 — The cover page is the same as for Output Files 1., 2., and 3.

Page 2 — Note the following important differences in the echo check page:

1. The TITLE line reads MULTIPLE TYPE A PACKAGES - DEDICATED TRUCK, PACKED ARRAY. This indicates that an exclusive-use (dedicated) truck shipment containing Type A packages arranged in a certain geometry is being analyzed. This example was taken from a study performed by SNL for the U.S. Department of Transportation (Finley et al., 1988). The array geometry was used in that study to calculate the shipment-level effective dose rate used in this example. The package contents and numbers, travel distance, and fractions of travel were also taken directly from the study.

2. For this analysis the DIMEN values are 12 isotopes, eight accident-severity categories, two physical-chemical groups, 10 radial areas, and 18 downwind dispersion areas. The isotope number is taken from Finley et al. (1988). The eight-category accident-severity scheme from NUREG-0170 was also used by Finley et al. (1988). All of the isotopes were separated into two physical-chemical groups: Group A and Group B.

3. The PARM flags are unchanged.

4. Two physical-chemical group labels, A and B, are used in this analysis to designate isotope types.

5. The isotope labels are assigned as shown.

6. The DNORML array values for which user-defined (i.e., nondefault) values are entered are shown after the keyword NORMAL. In addition to entering values for fractions of travel, for this problem the user must enter the average distance of the crew from the source, the number of handlings, and the storage distance.

7. User-defined values for ECONF, ONSCST, and EMRCST have been entered to illustrate the use of the economic model. The values are taken from Madsen et al. (1986).

8. The release fractions are shown after the keyword RFRAC for each group. Those for Group A (Group 1) represent release fractions for a generic Type A package (NRC, 1977); and those for Group B (Group 2) represent release fractions for a somewhat less dispersible material. The latter is applied only to molybdenum-99 (MO99) packages because the isotope is bound to an ion-exchange resin.

9. Because one of the isotopes, TL201, is not in the internal isotope data library, the DEFINE function is used to enter the following in the order indicated: name, half-life, photon energy, cloud-dose factor, effective dose equivalent for inhalation, effective dose equivalent for ingestion, food transfer factor, soil transfer factor, deposition velocity, acute pulmonary dose-response curve designator, 1-yr inhalation dose to lung/Ci inhaled, and 1-yr inhalation dose to marrow/Ci inhaled.

10. After the first EOF, 12 distinct material arrays, one for each package type in the shipment, have been entered under the keyword ISOTOPES. As noted previously, each package contains only one isotope, so there is only one isotope line below the material line in each array. Note that in this example, the material names are the same as the isotope names. That is not required; each material could have been given a name different from its constituent isotope. (See the analogous sections in Output Files 1 through 3.) The first array indicates that there are seven Type A packages, each containing .063 Ci of tritiated water (H3WTR). The second array indicates that there are three Type A packages, each containing .003 Ci of carbon-14 in organic form (C140RG), and so forth. A shipment-level effective dose rate is used to calculate incident-free risks, so for the sake of simplicity, the single calcium-45 package (CA45) is assigned the entire dose rate calculated for the shipment (25.4 mrem/hr). All other packages are assigned dose rates of zero; i.e., they are used in the accident risk but not the incident-free dose calculations as intended. Note that there are 30 packages, each containing 5.53 Ci each of molybdenum-99, which is the only isotope in the shipment in physical-chemical group B. Note also for packages of xenon-133 (XE133) the gaseous state of the isotope is accounted for in the internal data library, where xenon-133 is assigned a deposition velocity of 0.0 m/sec, as shown on page 7 of the output.

11. As in Output File 1, the package size is entered in meters for each package type after the keyword PKGSIZ. However, since the shipment-level effective dose rate has been assigned to a single calcium-45 (CA45) package, this package is also assigned the length dimension of the semi-trailer in which the shipment is being transported (12.2 m). All other packages were assigned their actual average size of 0.61 m. These package-size values are unimportant, however, because the terms containing the size parameters for these packages also contain the package-specific dose rates, which were set to zero. Thus in the incident-free dose calculations all but the CA45 term, which is acting as a placeholder for the entire shipment, is reduced to zero.

12. Because this is a non-LINK analysis, the total distance in kilometers is entered after the keyword DISTKM.

Pages 3 through 18 These pages contain tables of input data and most are similar to those in Output Files 1 through 3. Note that all packages in the shipment and their contents are listed in tabular form on page 4. Note also the extensive regulatory-check messages (page 15). A message is printed for each package or material informing the user whether that package type is or is not required to be shipped by exclusive-use carrier. This check is always performed, and the user is always informed when a package type is not required by regulation to be shipped in an exclusive-use shipment, even though the user has designated the shipment as exclusive-use. Messages associated with CA 45, which was assigned the entire dose rate calculated for the shipment (25.4 mrem/hr at 1 m, neglecting self-shielding), indicate that the dose rate should be reduced to meet regulatory standards if the hypothetical shipment modeled here would actually be performed. The calculation proceeded using the maximum permitted dose rate.

Page 19 Incident-Free Summary. On this page the incident-free doses are given. Although each package is listed, this is a shipment-level analysis and the effective dose rate of the entire shipment was assigned to CA45. Thus the shipment values appear in the CA45 row and zero values appear in all other rows.

Page 20 Incident-Free Importance Analysis Summary. The importance values for the parameters used in the incident-free analysis are provided here.

Pages 21 through 24 Accident Risk Summary. The probabilities of expected accidents and economic consequences tabulated on page 21 are shipment-level values. The consequences tabulated on pages 21 through 22 are also shipment values that represent summations over all packages, but the risk values given on page 23 are broken down by package and by isotope. In this analysis, each package contains a material consisting of only one isotope, so the distinction between the levels is not apparent. The last page of the output shows estimated early fatalities and economic risks for the shipment.

6.0 REFERENCES

CFR (U.S. Code of Federal Regulations), Title 10, "Energy," Nuclear Regulator Commission, U.S. Government Printing Office, Washington, DC, 1989.

CFR (U.S. Code of Federal Regulations), Title 49, "Transportation," U.S. Government Printing Office, Washington, DC, 1982.

Cashwell, J. W., 1989. "TRANSNET--Access to Transportation Models and Databases," SAND89-0982C, Sandia National Laboratories, Albuquerque, NM.

Cashwell, J. W., K. S. Neuhauser, P. C. Reardon, and G. W. McNair, 1986. "Transportation Impacts of the Commercial Radioactive Waste Management Program," SAND85-2715, Sandia National Laboratories, Albuquerque, NM.

DOE (U.S. Department of Energy), 1988a. External Dose-Rate Conversion Factors for Calculation of Dose to the Public, DOE/EH-0070, U.S. Department of Energy, Washington, DC.

DOE (U.S. Department of Energy), 1988b. Internal Dose Conversion Factors for Calculation of Dose to the Public, DOE/EH-0071, U.S. Department of Energy, Washington, DC.

Dunning, D. D., 1983. Estimates of Internal Dose Equivalent from Inhalation and Ingestion of Selected Radionuclides, WIPP/DOE-176, Department of Energy, Washington, DC.

EPA (U.S. Environmental Protection Agency), 1977. "Proposed Guidance on Dose Limits for Persons Exposed to Transuranic Elements in the General Environment," EPA 520/4-77-016, U.S. Environmental Protection Agency, Washington, DC.

Finley, N. C., D. C. Aldrich, S. L. Daniel, D. M. Ericson, C. Henning-Sachs, P. C. Kaestner, N. R. Ortiz, D. D. Sheldon, J. M. Taylor, and S. F. Herreid, 1980. "Transportation of Radionuclides in Urban Environs: Draft Environmental Assessment," NUREG/CR-0743, SAND79-0369, Sandia National Laboratories, Albuquerque, NM.

Finley, N. C., J. D. McClure, and P. C. Reardon, 1988. "An Analysis of the Risks and Consequences of Accidents Involving Shipments of Multiple Type A Radioactive Material Packages," SAND88-1915, Sandia National Laboratories, Albuquerque, NM.

ICRP (International Commission on Radiological Protection), 1983. Radionuclide Transformations, Energy and Intensity of Emissions, Publication 38, Annals of the ICRP, Vols. 11-13, Oxford, England: Pergamon Press.

ICRP (International Commission on Radiological Protection), 1981. Limits for Intakes of Radionuclides by Workers, Publication 30, Part 3, Annals of the ICRP, Vol. 6(2/3), Oxford, England: Pergamon Press.

ICRP (International Commission on Radiological Protection), 1975. Task Group Report on Reference Man, Publication 23, Oxford, England: Pergamon Press.

Kanipe, F. L., and K. S. Neuhauser, in preparation (c). "RADTRAN 4: Volume 4, Programmer's Manual," Sandia National Laboratories, Albuquerque, NM.

Madsen, M. M., E. L. Wilmot, and J. M. Taylor, 1983. "RADTRAN II User Guide," SAND-2681, Sandia National Laboratories, Albuquerque, NM.

Madsen, M. M., J. M. Taylor, R. O. Ostmeyer, and P. C. Reardon, 1986. "RADTRAN III," SAND84-0036, Sandia National Laboratories, Albuquerque, NM.

Magurno, B. A., 1983. "ENDF-102, Data Formats and Procedures for the Evaluated Nuclear Data File, ENDF/B-V," BNL-NCS-50496, Brookhaven National Laboratory, Brookhaven, NY.

McFarlane, R. E., D. W. Muir, and R. M. Boicourt, 1982. "The NJOY Nuclear Data Processing System, Vol. I: User's Manual," LA-9303-M, Los Alamos National Laboratory, Los Alamos, NM.

NRC (U.S. Nuclear Regulatory Commission), 1977. "Final Environmental Statement on the Transportation of Radioactive Material by Air and Other Modes," NUREG-0170, U.S. Nuclear Regulatory Commission, Washington, DC.

Neuhauser, K. S., and F. L. Kanipe, in preparation (a). "RADTRAN 4: Volume 1, Executive Summary, "Sandia National Laboratories, Albuquerque, NM.

Neuhauser, K. S., and F. L. Kanipe, in preparation (b). "RADTRAN 4: Volume 2, Technical Manual," Sandia National Laboratories, Albuquerque, NM.

Neuhauser, K. S., J. W. Cashwell, P. C. Reardon, and G. W. McNair, 1984. "A Preliminary Cost and Risk Analysis for Transporting Spent Fuel and High-Level Wastes to Candidate Repository Sites," SAND84-1795, Sandia National Laboratories, Albuquerque, NM.

O'Dell, R. D., F. W. Brinkley, and D. R. Marr, 1982. "User's Manual for ONEDANT: A Code Package for One-Dimensional, Diffusion-Accelerated, Neutral-Particle Transport," LA-9184-M, Los Alamos National Laboratory, Los Alamos, NM

Ostmeyer, R. M., 1986a. An Approach to Estimating Food Ingestion Exposures for Nuclear Waste Transportation Accidents, SAND85-1722, Sandia National Laboratories, Albuquerque, NM.

Ostmeyer, R. M., 1986b. A Revised Rail-Stop Exposure Model for Incident-Free Transport of Nuclear Waste, SAND85-2149, Sandia National Laboratories, Albuquerque, NM.

Parks, C. V., B. L. Broadhead, O. W. Hermann, J. S. Tang, S. N. Cramer, J. C. Gauthey, B. L. Kirk, and R. W. Roussin, 1988. "Assessment of Shielding Analysis Methods, Codes, and Data for Spent Fuel Transport/ Storage Applications," ORNL/CSD/TM-246, Oak Ridge National Laboratories, Oak Ridge, TN.

Shleien, B., and M. Terpilak, 1987. Health Physics and Radiological Health Handbook, Nucleon Lectern Associates, Inc., Olney, MD.

Taylor J. M., and S. L. Daniel, 1982. "RADTRAN II: A Revised Computer Code to Analyze Transportation of Radioactive Material," SAND80-1943, Sandia National Laboratories, Albuquerque, NM.

Taylor, J. M., and S. L. Daniel, 1977. "RADTRAN: A Computer Code to Analyze Transportation of Radioactive Material," SAND76-0243, Sandia National Laboratories, Albuquerque, NM.

U.S. Bureau of the Census, 1988. County and City Data Book, 1988, Washington, DC: U.S. Government Printing Office.

Wilmot, E. L., M. M. Madsen, J. W. Cashwell, and D. S. Joy, 1983. "A Preliminary Analysis of the Cost and Risk of Transporting Nuclear Waste to Potential Candidate Commercial Repository Sites," SAND83-0867, Sandia National Laboratories, Albuquerque, NM.

APPENDIX A

SUBROUTINE GLOSSARY

APPENDIX A
SUBROUTINE GLOSSARY

Table A-1 lists all subroutines in the code. The left column in Table A-1 contains the subroutines in alphabetical order; the right column contains corresponding definitions.

Table A-1

Subroutines in RADTRAN 4

Subroutine	Definition
ACC	Calculates nondispersal (IACC=1) or dispersal (IACC=2) accidents.
ARRAY	Reads N values into the A floating-point array.
BANNER	Prints banner page heading.
BESSL	Computes a modified Bessel function of order zero.
CENTER	Centers characters in a string.
CONVRT	Converts the TEST variable into a real number if appropriate; otherwise, sets the results to 4HWORD.
COST	Computes the economic impact by population-density zone and accident-severity category; checks for the route-controlled shipment.
CPBYTE	Converts the TEST variable into individual characters and places the result into the JVY array.
EARLY	Computes the expected number of early fatalities and early morbidities.
ECON	Calculates the economic impacts from dispersal-accident cleanup.
EFFIT	Determines early fatality probabilities using the lookup table.
FINDI	Performs integration using Bessel function calls.
GOTOER	Prints GOTO error message and stops the program.

Table A-1

Subroutines in RADTRAN 4 ((Continued)

Subroutine	Definition
IARRAY	Reads N values into the IA integer array..
INITLZ	Initializes variable arrays by setting all values to zero..
MDT	Calculates the concentration of material in radioactive dispersion cloud after the cloud has been depleted by deposition..
NEWPAG	Prints a form feed and prints the date,, time,, page number,, and title at the top of each printout page..
NEXT	Reads input lines and in the TEST variable,, returns the position of the next field;; prints the input echo of each line..
NORLINK	Called by the NORML subroutine to compute off- and on-link incident-free doses by link for truck,, van,, and rail modes.. Package exposure rates are checked against regulatory limits.. An exclusive-use check is also made for the shipment..
NORML	Calculates incident-free doses to all population subgroups from all transportation modes.. Package exposure rates are checked against regulatory limits.. An exclusive-use check is also made for the shipment..
PASQ	Called if Pasquill stability categories are used;; loads the areas and concentrations into the AREADA and DFLEV arrays..
PRCHRD	Prints input tables and variables..
PRCONS	Prints consequence tables..
PRISTP	Prints table for isotope-related data..
PRNORD	Prints the DNORML array for incident-free input data..
PROUTA	Prints the incident-free summary table..
PROUTB	For the UNIT option,, prints the expected value of population risk in person-rem;; for NONUNIT,, prints the expected numbers of latent cancer fatalities and genetic effects..

Table A-1

Subroutines in RADTRAN 4 ((Continued)

Subroutine	Definition
PROUTC	For the NON-LINK option., prints tables of size NSEV-by-NPOP; for the LINK., prints tables of size NSEV-by-NLNK..
PROUTD	Prints tables of NNN-by-NSEV., where the NNN dimension is determined by the array being printed..
PRRELD	Prints values of variables for accident-related input data..
PRSEGD	Called only for the LINK option; prints values of variables for each link and each mode..
PRSEND	Prints importance analysis summary..
PSIXIN	Returns values of PSI(x) equals derivative of log gamma ((x)..
QUAD1	Thirty-second-order Gaussian quandrature..
QUAD2	Performs integration for the on-link dose for travel in the same direction..
RADIN4	Calls routines to print the input data for extended output., calls routines to set and initialize variables; incident-free and accident calculations are summed; calls print routines for incident-free and accident tables..
RDDAT	Reads in default data from separate data files..
RDINFR	Reads data through the use of keyword identifiers..
SCAN	Scans the input line; determines the location of the next field item; and places it into the TEST variable..
SCRIPT	Called by the BANNER subroutine to print large letters..
SENSTV	Derivatives of incident-free transport parameters for sensitivity analysis by population subgroup and mode..
SENSUM:	Represents the summation of derivatives calculated in SENSTV..
SETISO	Sets isotope-specific variables..

Table A-1

Subroutines in RADTRAN 4 ((Concluded)

Subroutine	Definition
SETMAT	Sets material-specific variables..
SETMOD	Sets mode-specific variables..
SETVAL	Sets distance traveled., package size., and size-dependent package coefficient..
SHIELD	Sets rural., suburban., and urban shielding depending on the user-selected IUOPT shielding option..
SHIFTC	Right-justifies character string..
SHIFTL	Left-justifies character string..
TRANS	Returns exp(Ur)•B(r)..
WIRNK	Writes probability and consequence data to file 6 for importance analysis summary or plotting..
XERR	Prints error message and stops the run..

APPENDIX B

VARIABLE GLOSSARY AND VARIABLES GROUPED IN COMMON BLOCKS

APPENDIX B
VARIABLE GLOSSARY AND VARIABLES GROUPED IN COMMON BLOCKS

B.1 Variable Glossary

Table B-1 lists the important variables in the RADTRAN 4 code. The first column in Table B-1 contains the variable names in alphabetical order. The second column contains the type of number, such as an integer, real, logical, or character. The third column contains the unit of measure. Unitless is given if the variable has no unit of measure. The fourth column contains the definition and description of the variable. Table B-2 groups the variables in common blocks. Variables included in Tables B-1 and B-2 are important to theoretical applications. Variables not included serve as holders of intermediate mathematical values during calculations.

Table B-1

Important Variables in RADTRAN 4

Variable	Type	Units/ (Unitless)	Description
ALT20	Real	m^2	Represents the area involving decontamination factors between 1 and 20.
A20T40	Real	m^2	Represents the area involving decontamination factors between 20 and 40.
ACCGE	Real	genetic effects	Represents the genetic effects per accident for each accident-severity category and population-density zone.
ACCLCF	Real	LCFs	Represents latent cancer fatalities (LCFs) per accident by accident-severity category and population-density zone.
ACCPYR	Real	accidents	Represents the expected number of accidents by accident-severity category and population-density zone.
ACCRAT	Real	accidents/ km	Represents accident rates.
ADSTCW	Real	m	Represents the average distance from the radiation source to the crew.
AERSOL	Real	(unitless)	Represents the fraction of isotope that is released from a package in aerosol form.
AGT40	Real	m^2	Represents the area involving decontamination factors greater than 40.

Table B-1

Important Variables in RADTRAN 4 (Continued)

Variable	Type	Units/ (Unitless)	Description
AM241	Real	*	Represents the array of properties of americium-241.
AM243	Real	*	Represents the array of properties of americium-243.
APITI	Real	m^2	Represents the area with decontamination factors between 0.1 and 1.
ARATMZ	Real	accidents/ km	Represents the overall accident rate for each mode in each population-density zone.
AREADA	Real	m^2	Represents dispersal accident isopleth areas.
ASIZE	Real	m^2	Represents the size of each AREADA.
ATERM	Real	mrem/hr	Represents the dose rate multiplied by the number of packages per shipment (TI • PPS).
BDF	Real	(unitless)	Represents the building dose factor (BDF), which is a measure of air filtration by heating/cooling/ventilation systems.
BRATE	Real	m^3/min	Represents the breathing rate of persons exposed to aerosol releases.
BTERM	Real	mrem/hr	Represents the Transport Index (TI) multiplied by package per shipment and total number of shipments (TI • PPS • SPY).

*Common Block P contains data arrays for all isotopes in the internal data library. Each array contains 11 parameters: half-life (days) (ICRP, 1983); photon energy (MeV/disintegration) (ICRP, 1983); cloudshine dose factor (rem-m^3/Ci-sec) (DOE, 1988a); 50-yr committed effective dose equivalent for inhalation (rem/Ci) (Dunning, 1983; DOE, 1988b); 50-yr committed effective dose equivalent for ingestion (rem/Ci) (Dunning, 1983; DOE, 1988b); food transfer factor; soil transfer factor; deposition velocity of aerosol particles (m/sec); lung type for early effects calculations (ICRP, 1983); 1-yr lung dose for inhalation (rem/Ci) (Dunning, 1983); 1-yr marrow dose for inhalation (rem/Ci) (Dunning, 1983).

Table B-1

Important Variables in RADTRAN 4 (Continued)

Variable	Type	Units/ (Unitless)	Description
C14GAS	Real	*	Represents the array of properties of carbon-14 dioxide gas.
C14ORG	Real	*	Represents the array of properties of carbon-14 in organic form.
CA45	Real	*	Represents the array of properties of calcium-45.
CAYZER	Real	m^2	Represents the Transport Index (TI)-to-dose rate conversion factor.
CDF	Real	rem-m^2/ Ci-sec	Represents the cloudshine dose factor.
CE141	Real	*	Represents the array of properties of cerium-141.
CE144	Real	*	Represents the array of properties of cerium-144 [photon energy includes the short half-life daughter praseodymium-144].
CF252	Real	*	Represents the array of properties of californium-252.
CH1	Real	hr/m	Represents the exposure factor for general freight railcrew (.16).
CH2	Real	hr/m	Represents the exposure factor for dedicated railcrew (.01).
CHIVAL	Real	Ci-sec/ m^3/Ci released	Represents atmospheric dilution factors for each annular zone.
CI	Real	Ci	Represents the amount of radioactivity per package of an isotope.
CIPKG	Real	Ci	Represents the radioactivity level for each isotope per package.

*Common Block P.

Table B-1

Important Variables in RADTRAN 4 (Continued)

Variable	Type	Units/ (Unitless)	Description
CLDGE	Real	genetic effects	Represents genetic effects from cloudshine for each accident-severity category and population-density zone.
CLDLCF	Real	LCFs	Represents latent cancer fatalities (LCFs) from cloudshine for each accident-severity category.
CLDOSF	Real	rem-m^2/ Ci-sec	Represents the cloudshine dose factor for each isotope.
CM242	Real	*	Represents the array of properties of curium-242.
CM244	Real	*	Represents the array of properties of curium-244.
CO58	Real	*	Represents the array of properties of cobalt-58.
CO60	Real	*	Represents the array of properties of cobalt-60.
COEF	Real	(unitless)	Represents coefficients for gamma and neutron calculations.
CONTUF	Logical	(unitless)	Represents the byte flag.
CR51	Real	*	Represents the array of properties of chromium-51.
CREWNO	Real	persons	Represents the number of crew persons of a shipment.
CS134	Real	*	Represents the array of properties of cesium-134.
CS137	Real	*	Represents the array of properties of cesium-137 [photon energy includes the short half-life daughter barium-137m].

*Common Block P.

Table B-1

Important Variables in RADTRAN 4 (Continued)

Variable	Type	Units/ (Unitless)	Description
CULVL	Real	$\mu Ci/m^2$	Represents the clean-up level.
D4	Real	person-rem	Represents the dose to handlers.
DECON	Real	(unitless)	Represents the ratio of deposited curies to clean-up criterion (CULVL) for each accident-severity category, isodose area, and isotope.
DELTIM	Real	hr	Represents exposure times (before cleanup) of dispersed material deposited on the ground.
DEPVEL	Real	m/sec	Represents the deposition velocity for aerosol particles.
DFLEV	Real	Ci-sec/ m^3/Ci released	Represents time-integrated concentrations of radionuclides in an annular area normalized to the initial released inventory.
DIHD	Real	m	Represents the average exposure distance from the radiation source to handlers.
DIST	Logical	(unitless)	Set to TRUE if the keyword DISTKM is used; otherwise, set to FALSE.
DISTKM	Real	km	Represents the distance traveled per trip for each model.
DLIM	Real	m^2	Represents the maximum allowable size of an isopleth; used in the MDT subroutine (2E+09).
DNHGE	Real	genetic effects	Represents genetic effects from inhalation exposure by accident-severity category and population-density zone.
DNHLCF	Real	LCFs	Represents latent cancer fatalities (LCFs) from inhalation exposure by accident-severity category.

Table B-1

Important Variables in RADTRAN 4 (Continued)

Variable	Type	Units/ (Unitless)	Description
DNORML	Real	(various units)	Represents the array holding 25 variables pertaining to the incident-free dose calculation.
DOSDST	Real	rem	Represents the dose-vs.-distance relationship for nondispersal accidents.
DOSE2	Real	person-rem	Represents the crew dose by population-density zone for sensitivity analysis.
DOSE5	Real	person-rem	Represents the off-link dose by employed variables for the importance analysis summary.
DOSE6	Real	person-rem	Represents the on-link dose by employed variable for the importance analysis summary.
DOSEN	Real	person-rem	Represents the dose to 10 exposed groups for the incident-free dose calculation.
DOSMAX	Real	rem	Represents the maximum incident-free individual dose for each link.
DPKG	Real	m	Represents the package dimension.
DSTRVL	Real	km	Represents the distance traveled per shipment.
DTHD	Real	hr	Represents the average exposure time for handlers.
DTOT	Real	person-rem or LCFs	Represents the UNIT option, a 50-yr population dose commitment; for the NONUNIT option, latent cancer fatalities (LCFs).
DTST	Real	hr/km	Represents the stop time per unit distance traveled.
DTSTOR	Real	hr	Represents the storage time per shipment.

Table B-1

Important Variables in RADTRAN 4 (Continued)

Variable	Type	Units/ (Unitless)	Description
DUMMY	Real	(unitless)	Represents the storage for isotopes defined with the DEFINE keyword.
DZ	Real	m	Represents the source-to-receptor distance (x) used in the maximum individual dose calculation; equal to 30 m.
EARLYD	Real	rem	Represents the early effects calculation of the inhalation dose to five specific organs by accident-severity category.
EARLYL	Real	rem	Represents the early-category fatalities calculation of the inhalation dose by lung type for each accident-severity category.
ECNMPT	Real	U.S. dollars	Represents the economic impact for each accident-severity category and population-density zone.
ECNPYR	Real	U.S. dollars	Represents the expected economic impact for each accident-severity category and population-density zone.
ECONF	Real	(unitless)	Represents economic factor to account for inflation.
EFFSIZ	Real	m	Represents the effective package size to compute the package coefficient if the actual package size is greater than or equal to 4 m.
EFPYR	Real	(unitless)	Represents the total expected early fatalities for each accident-severity category and population-density zone.
EMPYR	Real	(unitless)	Represents the total expected early morbidities for each accident-severity category and population-density zone.
EMRCST	Real	U.S. dollars	Represents the emergency clean-up cost.
EMTRSH	Real	rem	Represents thresholds for early morbidities for five organ types.

Table B-1

Important Variables in RADTRAN 4 (Continued)

Variable	Type	Units/ (Unitless)	Description
EPS	Real	(unitless)	Represents the tolerance level used in the MDT subroutine (.001).
EU152	Real	*	Represents the array of properties of europium-152.
EU154	Real	*	Represents the array of properties of europium-154.
EU155	Real	*	Represents the array of properties of europium-155.
EVAL1	Real	U.S. dollars	Represents economic option 1 (see the RADTRAN 4 Technical Manual [Neuhauser and Kanipe, in preparation [b]]).
EVAL2	Real	U.S. dollars	Represents the economic option 2 (see the RADTRAN 4 Technical Manual [Neuhauser and Kanipe, in preparation [b]]).
EVAL3	Real	U.S. dollars	Represents the economic option 3 (see the RADTRAN 4 Technical Manual [Neuhauser and Kanipe, in preparation [b]]).
EXPEO	Real	persons	Represents the expected number of persons in each annular area.
EXPLCF	Real	LCFs	Represents expected latent cancer fatalities (LCFs) by the impact to five specific organs.
FCTST	Real	(unitless)	Represents the fraction of urban travel on city streets.
FDTRAN	Real	(unitless)	Represents the food transfer factor for ingestion pathway for each isotope.
FE55	Real	*	Represents the array of properties of iron-55.

*Common Block P.

Table B-1

Important Variables in RADTRAN 4 (Continued)

Variable	Type	Units/ (Unitless)	Description
FE59	Real	*	Represents the array of properties of iron-59.
FG	Real	(unitless)	Represents the fraction of gamma radiation from material.
FKMPS	Real	km	Represents the array of distances traveled per shipment for each isotope.
FMINCL	Real	(unitless)	Represents the minimum number of rail inspections and classifications (rail mode only).
FMU	Real	m^{-1}	Represents the linear attenuation coefficient of 1-MeV gamma radiation in the air; used in maximum individual dose.
FN	Real	(unitless)	Represents the fraction of neutron radiation from material.
FNOATT	Real	persons	Represents the number of flight attendants on commercial passenger flights.
FRCZON	Real	(unitless)	Represents the fraction of travel in each population-density zone.
FRGAMA	Real	(unitless)	Represents the fraction of dose rate attributed to gamma radiation for each material.
FRNEUT	Real	(unitless)	Represents the fraction of dose rate attributed to neutron radiation for each material.
FRSHR	Real	(unitless)	Represents the fraction of urban travel during rush-hour traffic.
FTLFWY	Real	(unitless)	Represents the fraction of rural and suburban travel on freeways.
FTZNR	Real	(unitless)	Represents the fraction of travel in rural zones.

*Common Block P.

Table B-1

Important Variables in RADTRAN 4 ((Continued)

Variable	Type	Units/ (Unitless)	Description
FTZNS	Real	(unitless)	Represents the fraction of travel in suburban zones.
FTZNU	Real	(unitless)	Represents the fraction of travel in urban zones.
GA67	Real	*	Represents the array of properties of gallium-67.
GAM	Real	(unitless)	Represents the Euler's constant that is equal to 0.5772156649; used in the Bessel function calculation in the BESSL subroutine.
GEPYR	Real	genetic effects	Represents expected genetic effects for each accident-severity category and population-density zone.
GNDSGE	Real	genetic effects	Represents genetic effects per million person-rem from groundshine.
GRDGE	Real	genetic effects	Represents genetic effects from groundshine for each accident-severity category and population-density zone.
GRDLCF	Real	LCFs	Represents latent cancer fatalities (LCFs) from groundshine for each accident-severity category and population-density zone.
H3GAS	Real	*	Represents the array of properties of tritium gas.
H3WTR	Real	*	Represents the array of properties of tritiated water.
HANDNO	Real	(unitless)	Represents the number of handlings of a package during shipment.
HLIFE	Real	days	Represents the half-life for radioactive decay of an isotope.

*Common Block P.

Table B-1

Important Variables in RADTRAN 4 (Continued)

Variable	Type	Units/ (Unitless)	Description
I125	Real	*	Represents the array of properties of iodine-125.
I129	Real	*	Represents the array of properties of iodine-129.
I131	Real	*	Represents the array of properties of iodine-131.
IACC	Integer	(unitless)	Represents the flag for dispersal-type accidents (1 = no; 2 = yes).
IANA	Integer	(unitless)	Represents the incident-free or accident analysis flag.
ICARD	Character	(unitless)	Holds last input line.
ICARDI	Character	(unitless)	Holds individual characters from the TEST and ICARD variables for comparison with expected characters.
ICOUNT	Integer	(unitless)	Represents the total number of isotopes in an analysis.
IDISP	Integer	(unitless)	Represents dispersibility category for each isotope.
IDSP	Integer	(unitless)	Represents the dispersion category of an isotope.
IEXCLU	Integer	(unitless)	Switches designating exclusive-use or nonexclusive-use for each mode (1 = yes).
IGRP	Integer	(unitless)	Represents the pointer to the current physical-chemical group.
IKW1	Character	(unitless)	Represents the first-level keywords.
IKW2	Character	(unitless)	Represents the second-level keywords under PACKAGE.
IKW3	Character	(unitless)	Represents the second-level keywords under SHIPMENT.

*Common Block P.

Table B-1

Important Variables in RADTRAN 4 (Continued)

Variable	Type	Units/ (Unitless)	Description
IKW4	Character	(unitless)	Represents the second-level keywords under NORMAL.
IKW5	Character	(unitless)	Represents the second-level keywords under ACCIDENT.
IKW6	Character	(unitless)	Represents the second-level keywords under MATERIAL.
IKW7	Character	(unitless)	Represents the second-level keywords under RELEASE.
IKW8	Character	(unitless)	Represents the second-level keywords under OTHER.
INCFRE	Real	person-rem	Represents incident-free doses for each material in each link.
INGGE	Real	genetic effects	Represents genetic effects from ingestion for each accident-severity category in rural zones.
INGLCF	Real	LCFs	Represents latent cancer fatalities (LCFs) from ingestion for each accident-severity category in rural zones.
INGVAL	Real	rem/Ci	Represents the number of rems per curie ingested for each isotope.
IPOGRP	Integer	(unitless)	Represents the index of physical-chemical group for each isotope.
IPOINT	Integer	(unitless)	Represents the pointer to current input character.
IPRAM	Integer	(unitless)	Represents the index for the PRMNDS array (21).
IPSQSB	Integer	(unitless)	Represents the flag for Pasquill category treatment of dispersion (1 = yes).
IRNKC	Integer	(unitless)	Represents the flag for placing data in file 6 (1 = yes).

Table B-1

Important Variables in RADTRAN 4 (Continued)

Variable	Type	Units/ (Unitless)	Description
ISEN	Integer	(unitless)	Represents the flag designating full printout and importance analysis calculations.
ISO	Integer	(unitless)	Indexes the number of isotopes as determined by the input order.
ISONAM	Character	(unitless)	Represents the array of isotope names in the internal library plus the names defined with the DEFINE keyword (125 names).
ISOSAV	Integer	(unitless)	Represents isotope indices for each isotope in each material.
ITRAIN	Integer	(unitless)	Represents the flag to select railcrew exposure factor.
IUOPT	Integer	(unitless)	Represents the flag designating a desired shielding model.
KBYTE	Integer	(unitless)	Represents the maximum length of an input word or number (10 characters).
KI	Integer	(unitless)	Represents pointers to print the importance analysis summary in rank order (38 pointers).
KLOCK	Character	(unitless)	Represents the current time retrieved from system call.
KR852	Real	*	Represents the array of properties of krypton-85.
LABDOS	Character	(unitless)	Represents labels for DNORML entries.
LABEF	Character	(unitless)	Represents labels for early-fatality input tables.
LABGRP	Character	(unitless)	Represents labels for user-designated physical-chemical groups of isotopes.

*Common Block P.

Table B-1

Important Variables in RADTRAN 4 (Continued)

Variable	Type	Units/ (Unitless)	Description
LABISO	Character	(unitless)	Represents labels for isotopes.
LABMAT	Character	(unitless)	Represents labels for user-selected material names.
LABMOD	Character	(unitless)	Represents labels for the 10 transportation modes.
LABORG	Character	(unitless)	Represents labels for eight organ types.
LABPOP	Character	(unitless)	Represents labels of population-density zones (rural, suburban, urban).
LARAT	Real	accident/ km	Represents the accident rate for each link.
LBTRSH	Character	(unitless)	Represents labels for dose thresholds.
LCFPYR	Real	LCFs	Represents expected latent cancer fatalities (LCFs) for each accident-severity category and population-density zone.
LDESCR	Character	(unitless)	Describes variables for sensitivity output.
LDIST	Real	km	Represents the distance traveled for each link.
LIB	Integer	(unitless)	Represents the internal index of each isotope in the data library.
LIBSAV	Integer	(unitless)	Represents the array index for internal and DEFINE keyword data for all isotopes in an analysis.
LISTLH	Integer	(unitless)	Represents the index for expected risk values (12).
LMODE	Integer	(unitless)	Represents the mode for each link.
LNGTAB	Integer	(unitless)	Represents the table of acute pulmonary response curves.
LNGTYP	Integer	(unitless)	Represents the current lung type.

Table B-1

Important Variables in RADTRAN 4 (Continued)

Variable	Type	Units/ (Unitless)	Description
LPOPD	Real	people/ km^2	Represents the population density for each link.
LSPED	Real	km/hr	Represents the speed of shipment for each link.
LTYPE	Integer	(unitless)	Represents the road type for each link (1 = freeway; 2 = nonfreeway; 3 = not applicable).
LVDEN	Real	vehicles/hr	Represents the vehicle density for each link; measured in one-way traffic passing a point per hour.
LZONE	Integer	(unitless)	Represents the population zone for each link (1 = rural; 2 = suburban; and 3 = urban).
MAT	Integer	(unitless)	Represents the index number of material as determined by the input order.
MATSAV	Integer	(unitless)	Represents material indices for each material in each mode.
MAXARS	Integer	(unitless)	Represents the maximum number of areas in AREADA calculation (30 areas).
MAXDSP	Integer	(unitless)	Represents the maximum number of dispersion categories (11 dispersion categories).
MAXGRP	Integer	(unitless)	Represents the maximum number of physical-chemical groups (15 groups).
MAXISO	Integer	(unitless)	Represents the maximum number of isotopes (65 isotopes).
MAXMAT	Integer	(unitless)	Represents the maximum number of materials (12 materials).
MAXMOD	Integer	(unitless)	Represents the maximum number of transportation modes (10 modes).
MAXNDL	Integer	(unitless)	Represents the maximum number of entries in the DNORML array (25 entries).

Table B-1

Important Variables in RADTRAN 4 (Continued)

Variable	Type	Units/ (Unitless)	Description
MAXRAD	Integer	(unitless)	Represents the maximum number of radial distances (15 distances).
MAXSEV	Integer	(unitless)	Represents the maximum number of accident-severity categories (20 accident-severity categories).
MAXTYP	Integer	(unitless)	Represents the maximum number of values entered in PKGCDM (15 values).
MCOUNT	Integer	(unitless)	Represents the total number of materials in an analysis.
MN54	Real	*	Represents the array of properties of manganese-54.
MO99	Real	*	Represents the array of properties of molybdenum-99 [photon energy includes the daughter technetium-99m].
MODE	Integer	(unitless)	Represents the current mode number.
MODSAV	Integer	(unitless)	Represents modes used in analysis.
MTAL	Integer	(unitless)	Represents the number of iterations allowed to find the tolerance level in the MDT subroutine (100 iterations).
NA	Integer	(unitless)	Represents the number of Pasquill isopleth areas for a dispersal accident (18 isopleth areas).
NAREAS	Integer	(unitless)	Represents the number of annular isodose areas used in the analysis of dispersal accidents.
NAVINT	Integer	(unitless)	Represents the number of isopleth areas used to find CHIVAL for each isotope.
NB94	Real	*	Represents the array of properties of niobium-94.

*Common Block P.

Table B-1

Important Variables in RADTRAN 4 (Continued)

Variable	Type	Units/ (Unitless)	Description
NB95	Real	*	Represents the array of properties of niobium-95.
NC	Integer	(unitless)	Represents the number of Pasquill stability categories (six categories)
NCS	Integer	(unitless)	Represents the maximum length of an input line (80 characters).
NDLAB	Integer	(unitless)	Represents the number of parameters in incident-free transportation model (25 parameters).
NDOSE	Integer	(unitless)	Represents the number of incident-free dose categories (10 dose categories).
NDOSP1	Integer	(unitless)	Represents the total columns for incident-free dose categories (11 columns).
NDERV	Integer	(unitless)	Represents the number of variables printed in the importance analysis summary (38 variables).
NE	Integer	(unitless)	Represents the number of columns in the PROBEF array (four columns).
NGROUP	Integer	(unitless)	Represents the number of physical-chemical groups.
NIS	Integer	(unitless)	Represents the total number of isotopes for each material.
NISOTP	Integer	(unitless)	Represents the number of defined isotopes (60 plus the number defined with the DEFINE keyword to a maximum of 125 isotopes).
NKW1	Integer	(unitless)	Represents the number of keywords in IKW1.
NKW2	Integer	(unitless)	Represents the number of keywords in IKW2.
NKW3	Integer	(unitless)	Represents the number of keywords in IKW3.
NKW4	Integer	(unitless)	Represents the number of keywords in IKW4.

*Common Block P.

FICHE # 3

Table B-1

Important Variables in RADTRAN 4 (Continued)

Variable	Type	Units/ (Unitless)	Description
NKW5	Integer	(unitless)	Represents the number of keywords in IKW5.
NKW6	Integer	(unitless)	Represents the number of keywords in IKW6.
NKW7	Integer	(unitless)	Represents the number of keywords in IKW7.
NKW8	Integer	(unitless)	Represents the number of keywords in IKW8.
NLEG	Integer	(unitless)	Represents the number of modes or number of links.
NLNK	Integer	(unitless)	Represents the number of links.
NMAT	Integer	(unitless)	Represents the total number of materials in each mode.
NMODE	Integer	(unitless)	Represents the number of modes used in the analysis.
NORG	Integer	(unitless)	Represents the total number of organ types (eight organic types).
NP237	Real	*	Represents the array of properties of neptunium-237.
NPKG	Integer	(unitless)	Represents the total number of packages.
NPOP	Integer	(unitless)	Represents the number of population-density zones (3).
NPOP1	Integer	(unitless)	Represents the number of population-density zones plus one pedestrian zone (4).
NPRAM	Integer	(unitless)	Represents the number of variables used in the importance analysis summary (38 variables).
NPRP	Integer	(unitless)	Represents the number of properties for library isotopes (11 properties).
NRAD	Integer	(unitless)	Represents the number of radial distances for nondispersal accidents.

*Common Block P.

Table B-1

Important Variables in RADTRAN 4 (Continued)

Variable	Type	Units/ (Unitless)	Description
NREMLV	Integer	(unitless)	Represents the number of dose levels used in the look-up table for early fatalities (30 dose levels).
NRFLAG	Logical	(unitless)	Set to true when a delimiter is encountered.
NSEV	Integer	(unitless)	Represents the number of accident-severity categories.
NTHRS	Integer	(unitless)	Represents the number of early morbidity thresholds (five thresholds).
NVY	Character	(unitless)	Holds numerical characteristics 0 through 9 for comparison with ICARDI.
ONSCST	Real	U.S. dollars	Represents on-scene clean-up costs for each accident-severity category and dispersibility category.
P32	Real	*	Represents the array of properties of phosphorus-32.
PCKG	Logical	(unitless)	Set to TRUE if the PKGSIZ keyword is used; otherwise, set to FALSE.
PDST	Real	persons	Represents the number of persons exposed during storage.
PDSTOR	Real	persons	Represents the number of persons exposed during storage.
PDTOT	Real	person-rem or LCFs	Represents for the UNIT option, total 50-yr population dose commitment; for the NONUNIT option, latent cancer fatalities (LCFs) by accident-severity category and population-density zone.
PECMPT	Real	U.S. dollars	Represents the economic impact over all accident-severity categories for each population-density zone.

*Common Block P.

Table B-1

Important Variables in RADTRAN 4 (Continued)

Variable	Type	Units/ (Unitless)	Description
PHTE	Real	MeV/disintegration	Represents the photon energy of an isotope.
PHTENG	Real	MeV/disintegration	Represents the photon energy value for each isotope.
PKGCDM	Real	m	Represents the characteristic dimension of a given type of package.
PKGCOE	Real	m^2	Represents the conversion factor for point-source dose rate from dose rate at 1 m for each material.
PKGSHP	Real	(unitless)	Represents the number of packages per shipment for each mode and material.
PKGSIZ	Real	m	Represents the characteristic package dimension for each material.
PKGSZ1	Real	m	Represents the threshold dimension for packages handled by forklifts.
PKGSZ2	Real	m	Represents the threshold dimension for packages handled by cranes.
PM147	Real	*	Represents the array of properties of promethium-147.
POPDEN	Real	person/km^2	Represents population densities of zones.
POPDR	Real	person/km^2	Represents the rural population density.
POPDS	Real	person/km^2	Represents the suburban population density.
POPDU	Real	person/km^2	Represents the urban population density.
POPDUP	Real	POPDU • 0.1 • RPD	Represents the pedestrian population density.

*Common Block P.

Table B-1

Important Variables in RADTRAN 4 (Continued)

Variable	Type	Units/ (Unitless)	Description
PPH	Real	persons	Represents the number of exposed persons per handling.
PPS	Real	(unitless)	Represents the number of packages of a material per shipment.
PPV	Real	persons	Represents the number of persons per vehicle sharing the transport link.
PRMNDS	Real	(unitless)	Represents the partial derivative of normal dose concerning DNORML parameters.
PROBEF	Real	(unitless)	Represents the array of the probability of early fatality from an exposure to marrow or lung.
PSAREA	Real	m	Represents areas used in Pasquill dispersion calculation.
PSPROB	Real	(unitless)	Represents the probability of occurrence of each of six Pasquill stability categories.
PSQLCT	Real	Ci-sec/ m^3-Ci released	Represents integrated air-concentration values for Pasquill stability categories.
PSUMEF	Real	(unitless)	Represents the sum of early fatalities for each accident-severity category and population-density zone.
PSUMEM	Real	(unitless)	Represents the sum of early morbidities for each accident-severity category and population-density zone.
PU236	Real	*	Represents the array of properties of plutonium-236.
PU238	Real	*	Represents the array of properties of plutonium-238.
PU239	Real	*	Represents the array of properties of plutonium-239.

*Common Block P.

Table B-1

Important Variables in RADTRAN 4 (Continued)

Variable	Type	Units/ (Unitless)	Description
PU240	Real	*	Represents the array of properties of plutonium-240.
PU241	Real	*	Represents the array of properties of plutonium-241.
PU242	Real	*	Represents the array of properties of plutonium-242.
Q6	Real	0.5 rem-m^2/hr-Ci-MeV	Represents the constant used in dose-rate formula.
RADIST	Real	m	Represents radial distances defining exposure annuli for the nondispersal accident model.
RDF	Real	(unitless)	Represents the resuspension dose factor.
RDFGE	Real	(unitless)	Represents genetic effects from resuspension exposure.
RDFLCF	Real	(unitless)	Represents latent cancer fatalities from resuspension exposure.
REMLEV	Real	rem	Represents dose levels for the look-up table for early fatalities.
RESP	Real	(unitless)	Represents respirable fractions of an isotope in aerosol form.
RFRAC	Real	(unitless)	Represents the package release fraction for each physical-chemical group and accident-severity category.
RPCVAL	Real	rem/Ci	Represents the conversion factors for each isotope for eight organ types.
RPD	Real	(unitless)	Represents the ratio of pedestrian density to overall population density.
RR	Real	(unitless)	Represents the shielding effectiveness factor for rural areas.

*Common Block P.

Table B-1

Important Variables in RADTRAN 4 (Continued)

Variable	Type	Units/ (Unitless)	Description
RS	Real	(unitless)	Represents the shielding effectiveness factor for suburban areas.
RSPEC	Logical	(unitless)	Represents true if LINKS if used; otherwise false.
RSPHLF	Real	days	Represents the resuspension half-time (time for half of the material to re-deposit [365 days]).
RST	Real	m	Represents the average exposure distance during shipment stops.
RSTOR	Real	m	Represents the average exposure distance while shipment is stored.
RU	Real	(unitless)	Represents the shielding effectiveness factor for urban areas.
RU103	Real	*	Represents the array of properties of ruthenium-103 (photon energy includes the short half-life daughter rhodium-103m).
RU106	Real	*	Represents the array of properties of ruthenium-106 (photon energy includes the short half-life daughter rhodium-106).
RVELR	Real	sec/m	Represents the reciprocal of rural velocity.
RVELS	Real	sec/m	Represents the reciprocal of suburban velocity.
RVELU	Real	sec/m	Represents the reciprocal of urban velocity.
S35	Real	*	Represents the array of properties of sulfur-35.
SB125	Real	*	Represents the array of properties of antimony-125.
SENPRM	Real	(unitless)	Represents derivatives (38) for importance analysis summary for each link.

*Common Block P.

Table B-1

Important Variables in RADTRAN 4 (Continued)

Variable	Type	Units/ (Unitless)	Description
SEVFRC	Real	(unitless)	Represents the fraction of accidents that are of a particular accident-severity category.
SLTRAN	Real	(unitless)	Represents the soil transfer factor for ingestion pathway for each isotope.
SM151	Real	*	Represents the array of properties of samarium-151.
SPY	Real	(unitless)	Represents the number of shipments by a mode.
SR89	Real	*	Represents the array of properties of strontium-89.
SR90	Real	*	Represents the array of properties of strontium-90.
STERM	Real	mrem-m^2/ hr	Represents the product of BTERM and TI (Transport Index)-to-dose-rate factor (TI • PPS • SPY • CAYZER).
STPMIN	Real	hr	Represents the minimum stop time per shipment.
SUMEF	Real	fatalities	Represents total early fatalities by the impact to all organs for each accident-severity category and population-density zone.
SUMEM	Real	morbidities	Represents total early morbidities by the impact to all organs for each accident-severity category and population-density zone.
TABHLF	Real	days	Represents the half-life for radioactive decay of each isotope.
TABRDF	Real	(unitless)	Represents resuspension dose factors for each isotope.
TABSPY	Real	(unitless)	Represents the number of shipments for each mode.

*Common Block P.

Table B-1

Important Variables in RADTRAN 4 (Continued)

Variable	Type	Units/ (Unitless)	Description
TBAR	Real	days	Represents the time required for radioactive decay to reduce the contamination level to the criterion level.
TBDIHD	Real	m	Represents exposure distances from intermediate and large packages to handlers.
TBDTHD	Real	hr	Represents exposure times from intermediate and large packages to handlers.
TBPPH	Real	persons	Represents the number of persons exposed per handling of intermediate and large packages.
TC99	Real	*	Represents the array of properties of technetium-99.
TCLEVL	Real	Ci/m^2	Represents the total contamination level over all isotopes for each accident-severity category.
TCNTPR	Real	vehicles/ hr	Represents the one-way traffic count in rural zones.
TCNTPS	Real	vehicles/ hr	Represents the one-way traffic count in suburban zones.
TCNTPU	Real	vehicles/ hr	Represents the one-way traffic count in urban zones.
TDCONF	Real	(unitless)	Represents the total decontamination factor of all isotopes for each accident-severity category.
TDSDST	Real	rem	Represents the total dose vs distance for each value of RADIST.
TE125M	Real	*	Represents the array of properties of tellurium-125M.

*Common Block P.

Table B-1

Important Variables in RADTRAN 4 (Continued)

Variable	Type	Units/ (Unitless)	Description
TE127	Real	*	Represents the array of properties of tellurium-127.
TE127M	Real	*	Represents the array of properties of tellurium-127M.
TE129	Real	*	Represents the array of properties of tellurium-129.
TE129M	Real	*	Represents the array of properties of tellurium-129M.
TEST	Character	(unitless)	Holds the last input word.
TI	Real	mrem/hr	Represents the dose rate; equals dose in mrem/hr at 1 m.
TIMZR	Real	hr	Represents the zero stop time per trip (rail mode only).
TIPKG	Real	mrem/hr	Represents the dose rate at 1 m for each package of a given material by each mode.
TITLE	Character	(unitless)	Title of the data set entered by the user.
TOL	Real	(unitless)	Represents the tolerance level for comparing equivalence of numbers (1E-5).
TS1	Real	day	Represents the lesser of 50 yr or the time required to reduce the contamination level to the criterion level.
TS2	Real	day	Represents the lesser of 10 days or the time required to reduce the contamination level to the criterion level.
TS3	Real	day	Represents the lesser of adjusted clean-up the time or the time required to reduce the contamination level.
TS4	Real	day	Represents the time required to raze and rebuild a large area.

*Common Block P.

Table B-1

Important Variables in RADTRAN 4 (Continued)

Variable	Type	Units/ (Unitless)	Description
TSUMRS	Real	(see VSUMRS)	Represents intermediate sums of the accident output.
TWOPI	Real	(unitless)	Represents 6.2831853071796.
U233	Real	*	Represents the array of properties of uranium-233.
U235	Real	*	Represents the array of properties of uranium-235.
U238	Real	*	Represents the array of properties of uranium-238.
URSKF	Logical	(unitless)	Set to TRUE for effective dose output; set to FALSE for individual organ doses.
VALINK	Real	fatalities, morbidities, and U.S. dollars	Represents shipment-specific values for early fatalities, early morbidities, and economic costs.
VELDEP	Real	m/sec	Represents the deposition velocity of particles in aerosol form for each isotope.
VELM	Real	m/sec	Represents the reciprocal of the average velocity for a mode.
VELR		sec/m	Represents the rural velocity.
VELS	Real	sec/m	Represents the suburban velocity.
VELU	Real	sec/m	Represents the urban velocity.
VSUMRS	Real	person-rem or LCFs and genetic effects	Represents for the non-LINK option, the array of accident output for each isotope; for the LINK option, the array of accident output for each link.

*Common Block P.

Table B-1

Important Variables in RADTRAN 4 (Concluded)

Variable	Type	Units/ (Unitless)	Description
VV	Real	km/hr	Represents the velocity used in maximum individual dose calculation (24 km/hr).
WBLCF	Real	LCF/person-rem	Represents latent cancer fatalities (LCFs) per million person-rem effective dose.
WORDS	Character	(unitless)	Represents characters used as delimiters for the RADTRAN input.
WS	Real	3 m	Represents the sidewalk width used in early effects calculation; equal to 3 m.
XE133	Real	*	Represents the array of properties of xenon-133.
XFARM	Real	(unitless)	Represents the fraction of rural land under cultivation.
Y91	Real	*	Represents the array of properties of yttrium-91.
ZN65	Real	*	Represents the array of properties of zinc-65.
ZR95	Real	*	Represents the array of properties of zirconium-95.

*Common Block P.

Table B-2

Variables in Common Blocks

COMMON BLOCK - ACD
Values used to compute accident dose

ACCGE
ACCLCF
ACCPYR
ACCRAT
AERSOL
ARATMZ
AREADA
ASIZE
BDF
CIPKG
CULVL
DELTIM
DFLEV
DNHGE
DNHLCF
DOSDST
ECNMPT
ECONF
EFPYR
EMPYR
EMRCST
EXPEO
FRCZON
GEPYR
GNDSGE
IACC
IDISP
IPCGRP
LCFPYR
LNGTAB
NAREAS
NTHRS
ONSCST
PHTENG
RADIST
RDFGE
RDFLCF
RESP
RFRAC
RPCVAL
SEVFRC
SUMEF
SUMEM
TABHLF
TABRDF
WBLCF
XFARM

COMMON BLOCK - ACD2
Additional values used to compute
accident dose and economic impact

AGT40
AP1T1
A1T20
A20T40
BRATE
CHIVAL
CLDGE
CLDLCF
CLDOSF
DECON
DTOT
EARLYD
EARLYL
ECNPYR
EMTRSH
INGGE
INGVAL
IPSQSB
IRNKC
NAVINT
NPOP1
PDTOT
PECMPT
PSAREA
PSPROB
PSQLCTPSUMEF
PSUMEM
SLTRAN
TBAR
TCLEVL

Table B-2

Variables in Common Blocks (Continued)

COMMON BLOCK - ACD2 (Concluded)
Additional values used to compute accident dose and economic impact

EVAL1	TDCONF
EVAL2	TDSDST
EVAL3	TS1
EXPLCF	TS2
FDTRAN	TS3
GRDGE	TS4
GRDLCF	URSKF
INGLCF	VELDEP

COMMON BLOCK - CARD
Variable used when reading the input deck

CONTUF	NCS
IPOINT	NRFLAG
KBYTE	

COMMON BLOCK - CCARD
Character variables used when reading the input deck

ICARD	NVY
ICARDI	TEST

COMMON BLOCK - CMDT
Variables used in subroutine MDT, which calculates concentration of material in cloud after depletion

DLIM	MTAL
EPS	

COMMON BLOCK - CON
Mathematical constants

DZ	Q6
FMU	TOL
GAM	TWOPI
NDREV	VV
NC	WS
PI	

Table B-2

Variables in Common Blocks (Continued)

COMMON BLOCK - HEADER
Character arrays printed at the top of each page of output

CDATE	TITLE
KLOCK	

COMMON BLOCK - IKW
Character strings containing input keywords

IKW1	IKW5
IKW2	IKW6
IKW3	IKW7
IKW4	IKW8

COMMON BLOCK - LABELS
Arrays used to store character strings that are read in or used to label output tables

LABDOS	LABMOD
LABEF	LABORG
LABGRP	LABPOPLBTRSH
LABISO	LDESCR
LABMAT	WORDS

COMMON BLOCK - LVAR
Link variables, used only when LINKS option is used

LARAT	LTYPE
LDIST	LVDEN
LMODE	LZONE
LPOPD	NLNK
LSPED	RSPEC

COMMON BLOCK - MAIN
Main common block containing many of the most commonly used parameters

DIST	NGROUP
DISTKM	NIS
FKMPS	NMAT
IANA	NMODE

Table B-2

Variables in Common Blocks (Continued)

COMMON BLOCK - MAIN (Concluded)
Main common block containing many of the most commonly used parameters

ICOUNT	NORG
IEXCLU	NPKG
IPRAM	NPOP
ISEN	NRAD
ISO	NSEV
IUOPT	PCKG
LIB	PKGSHP
LIBSAV	POPDEN
LISTLH	RPD
MAT	RR
MATSAV	RS
MCOUNT	RU
MODE	TABSPY

COMMON BLOCK - MAXSZ
Maximum permitted array sizes

MAXARS	MAXNLD
MAXDSP	MAXRAD
MAXGRP	MAXSEV
MAXISO	MAXTYP
MAXMAT	NPRAM
MAXMOD	RSPHLF

COMMON BLOCK - NIKW
Integer variables containing the lengths of the IKW arrays

NKW1	NKW5
NKW2	NKW6
NKW3	NKW7
NKW4	NKW8

COMMON BLOCK - NORML
Values used to compute incident-free doses

CH1	KI
CH2	MODSAV
COEF	NDLAB
DNORML	NDOSE

Table B-2

Variables in Common Blocks (Continued)

COMMON BLOCK - NORML (Concluded)
Values used to compute incident-free doses

DOSEN	NDOSP1
DOSMAX	NLEG
DPKG	PKGCDM
EFFSIZ	PKGCOE
FNOATT	PKGSZ2
FRGAMA	PKGSIZ
FRNEUT	PKGSZ1
INCFRE	SENPRM
ITRAIN	TIPKG

COMMON BLOCK - NSEN
Variables used in incident-free dose calculations and sensitivity analysis

ATERM	RVELR
BTERM	RVELS
D4	RVELU
PRMNDS	STERM

COMMON BLOCK - O
Character array of isotope names

ISONAM

COMMON BLOCK - P
Arrays of isotope properties

AM241	NISOTP
AM243	NP237
C14GAS	NPRP
C14ORG	P32
CA45	PM147
CE141	PU236
CF252	PU238
CM242	PU239
CM244	PU240
CO58	PU241
CO60	PU242
CR51	RU103
CS134	RU106
CS137	S35

Table B-2

Variables in Common Blocks (Continued)

COMMON BLOCK - P (Concluded)
Arrays of isotope properties

DUMMY	SB125
EU152	SM151
EU154	SR89
EU155	SR90
FE55	TC99
FE59	TE125M
GA67	TE127
H3GAS	TE127M
H3WTR	TE129
I125	TE129M
I129	U233
I131	U235
KR85	U238
MN54	XE133
MO99	Y91
NB94	ZN65
NB95	ZR95

COMMON BLOCK - PROB
Values used to determine the
probabilities of early fatality

NE	PROBEF
NREMLV	REMLEV

COMMON BLOCK - SENDOS
Dose values used for sensitivity analysis

DOSE2	DOSE6
DOSE5	

COMMON BLOCK - SET
Variables with values that are
set in subroutine SETVAL

ADSTCW	PDST
CAYZER	PDSTOR
CDF	PHTE
CI	POPDR
CREWNO	POPDS

Table B-2

Variables in Common Blocks (Concluded)

COMMON BLOCK - SET (Concluded)
Variables with values that are
set in subroutine SETVAL

DEPVEL	POPDU
DSTRVL	POPDUP
DTHD	PPH
DTST	PPS
DTSTOR	PPV
FCTST	RDF
FG	RST
FMINCL	RSTOR
FN	SPY
FRSHR	STPMIN
FTLFWY	TCNTPR
FTNZR	TCNTPS
FTNZS	TCNTPU
FTNZU	TI
HANDNO	TIMZR
HLIFE	VELM
IDSP	VELR
IGRP	VELS
LNGTYP	VELU

COMMON BLOCK - TALLY
Summations used in analysis

TSUMRS	VSUMRS
VALINK	

COMMON BLOCK - TBD
Values used to calculate handler dose

TBDIHD	TBPPH
TBDTHD	

REFERENCES

DOE (U.S. Department of Energy), 1988a. External Dose-Rate Conversion Factors for Calculation of Dose to the Public, DOE/EH-0070, U.S. Department of Energy, Washington, DC.

DOE (U.S. Department of Energy), 1988b. Internal Dose Conversion Factors for Calculation of Dose to the Public, DOE/EH-0071, U.S. Department of Energy, Washington, DC.

Dunning, D. D., 1983. Estimates of Internal Dose Equivalent from Inhalation and Ingestion of Selected Radionuclides, DOE/WIPP-176, Department of Energy, Washington, DC.

ICRP (International Commission on Radiological Protection), 1983. Radionuclide Transformations, Energy and Intensity of Emissions, Publication 38, Annals of the ICRP, Vols. 11-13, Oxford, England: Pergamon Press.

Neuhauser, K. S., and F. L. Kanipe, in preparation (a). "RADTRAN 4: Volume 1, Executive Summary, "Sandia National Laboratories, Albuquerque, NM.

Neuhauser, K. S., and F. L. Kanipe, in preparation (b). "RADTRAN 4: Volume 2, Technical Manual," Sandia National Laboratories, Albuquerque, NM.

APPENDIX C

PROBABILITY AND CONSEQUENCE DATA

APPENDIX C
PROBABILITY AND CONSEQUENCE DATA

Probability and consequence data are written to output file FILE6.DAT by subroutine WTRNK when IRNKC = 1. These data are used for probability-consequence plotting and accident sensitivity analyses. FILE6.DAT is intended to preserve the numerous intermediate probability and consequence calculations that are performed in RADTRAN 4 prior to the generation of the final products and summations which are the actual risk values.

FILE6.DAT is intended to provide the user with the direct results of the intermediate calculations performed in RADTRAN 4. An additional feature is implemented by the subroutine PAIRS, which reads consequence and probability data from FILE6.DAT using keywords within the file to locate the data. The probabilities are link and mode specific, and the consequence types (population dose [or latent cancer fatalities and genetic consequences] and economic consequences) are dispersion-cloud-specific. This means that for each link and mode analyzed, up to six separate dispersion clouds and associated sets of consequence values may be computed for each consequence type. Corresponding probability arrays also are constructed. Each probability value is multiplied by the appropriate Pasquill probability, if Pasquill dispersion clouds are used. If Pasquill dispersion clouds are not used, then a single set of dispersion data is used, and all values in the probability arrays are multiplied by 1.0.

For each mode and link in a given analysis, the accident rates by population-density zone and accident-severity category are written to the file. The total number of expected accidents for all shipments is written for each mode and link. A record is written for each isotope that is in each material for each mode and link in the analysis containing estimates of either dose or latent cancer fatalities and genetic effects. Note that the expected numbers of accidents in each population-density zone and accident-severity category are contained in a matrix at the mode and link level, whereas dose and health-effects estimates are calculated at the isotope-level and are given for each population density (if non-LINK), accident severity, and Pasquill category (if IPSQSB = 1) for each mode and link.

Because no mathematical manipulations are performed on the data written to FILE6.DAT, the total number of expected accidents and the total dose or number of latent cancer fatalities, etc., are not directly available from the file. These summations must be performed externally if the user wishes to obtain these values.

As a result of the internal architecture of RADTRAN 4, three sets of numbers are written to FILE6.DAT for each link when LINK is used, but since each link can have only one assigned character (rural, suburban, or urban), two of the three sets of numbers will have all zero values.

The order in which the values are written in the record is shown in the subroutine below.

```
      SUBROUTINE WTRNK (LEG,IPASQ,COST,EOF)
C     THIS ROUTINE WRITES CONSEQUENCE DATA TO FILE6 FOR USE IN
C     PLOTTING.
C     LEG   = LINK NUMBER IF ROUTE-SPECIFIC OR ITH MODE IF NOT
C             ROUTE-SPECIFIC
C     IPASQ = PASQUILL CLOUD (1 TO 6) -- SHOULD BE 1 IF PASQUILL
C             NOT USED
C     COST  = SET TRUE IF PRINTING ECONOMIC EMPACT DATA, FALSE
C             OTHERWISE
C     EOF   = SET TRUE IF A RUN IS COMPLETE, OTHERWISE FALSE

      COMMON/ACD/RADIST(15,3),DOSDST(15,20,3),CIPKG(65),DELTIM(3),
     * EXPEO(29,4),RFRAC(15,20),SUMEF(20,3),SUMEM(20,3),ASIZE(30),
     * ACCLCF(20,3),ACCGE(20,3),SEVFRC(10,20,3),FRCZON(3),
     * ARAMTZ(10,3),ACCRAT(20,3),ACCPYR(20,3),EFPYR(20,3),
     * EMPYR(20,3),LCFPYR(20,3),GEPYR(20,3),ECNMPT(20,3),
     * PHTENG(65),IDISP(65),EMRCST(20),ONSCST(12,4),CULVL,BDF,
     * XFARM,WBLCF,GNDSGE,IACC,NTHRS,NAREAS,DFLEV(30),AREADA(30),
     * IPCGRP(65),TABRDF(65),TABHLF(65),RESP(11,20),AERSOL(11,20),
     * LNGTAB(65), RPCVAL(65,8), DNHLCF(20,3), DNHGE(20,3),
     * RDFLCF(20,3), RDFGE(20,3)
      REAL LCFPYR

      COMMON/ACD2/GRDLCF(20,3),GRDGE(20,3),AP1T1(20),
     * A1T20(20),A20T40(20),AGT40(20),
     * ECNPYR(20,3),EMTRSH(5),EXPLCF(5),CHIVAL(30,65),
     * BRATE,VELDEP(65),IRNKC,NPOP1,IPSQSB,PSAREA(18),PSQLCT(18,6),
     * PSPROB(6),CLDLCF(20,3),CLDGE(20,3),CLDOSF(65),
     * TS1(4),TS2(4),TS3(3),TS4,TBAR(4),EVAL1(3),EVAL2(3),EVAL3(3),
     * FDTRAN(65),SLTRAN(65),INGVAL(65,8),
     * EARLYL(30,20,3),EARLYD(30,20,5),TDSDST(15,20,3),
     * TDCONF(30,20),TCLEVL(30,20),DECON(30,20,65),NAVINT(65),
     * DTOT(20,3),PDTOT(20,3),PSUMEF(20,3),PSUMEM(20,3),
     * INGLCF(20),INGGE(20),PECMPT(20,3),URSKF
      REAL INGVAL,INGLCF,INGGE
      LOGICAL URSKF


      COMMON/MAIN/TABSPY(10),FKMPS(65,10),ISOSAV(12,65),
     * MATSAV(10,12),PKGSHP(10,12),NMAT(10),NIS(12),NSEV,NPOP,
     * DISTKM(10),MODE,NORG,IUOPT,NRAD,IANA,IPRAM,ISEN,
     * IEXCLU(10),MAT,ISO,LIB,NMODE,MCOUNT,RPD,RR,RS,RU,
     * LISTLH,POPDEN(4),NGROUP,ICOUNT,LIBSAV(65),DIST,PCKG
      LOGICAL DIST,PCKG

      COMMON/SET/VELR,VELS,VELU,VELM,TCNTPR,TCNTPS,TCNTPU,
     * FTZNR,FTZNS,FTZNU,FRSHR,FCTST,POPDR,POPDS,POPDU,PPV,
     * FTLFWY,DSTRVL,CAYZER,TI,PPS,SPY,ADSTCW,CREWNO,HANDNO,
     * DTSTOR,PDSTOR,RSTOR,DIHD,DTHD,PPH,DTST,PDST,RST,CI,PHTE,
     * LNGTYP,RDF,HLIFE,POPDUP,STPMIN,CDF,DEPVEL,TIMZR,FMINCL,
     * IGRP,IDSP,FG,FN
```

```
      COMMON/LABELS/LABSEN(38),LDESCR(38),LABISO(65),
     * LABDOS(25,2),LABORG(8),LABPOP(3),LABMOD(10),LABEF(4),
     * WORDS(6),LBTRSH(5),LABGRP(15),LABMAT(12)

      CHARACTER LABSEN*10,LDESCR*40,LABISO*10,LABDOS*30,
     * LABORG*10,LABPOP*10,LABMOD*10,LABEF*10,WORDS*1,
     * LBTRSH*10,LABGRP*10,LABMAT*10

      LOGICAL COST, EOF
      INTEGER LEG0, IPASQ0
      SAVE LEG0, IPASQ0
      DATA LEG0 / 0 /, IPASQ0 / 0 /

      IF (.NOT.EOF) THEN

         IF (LEG0 .EQ. 0) WRITE (6,'(I5)') NSEV

         IF (LEG.NE.LEG0) THEN
C .....MODE AND/OR LINK DEPENDENT INFORMATION
            LEG0 = LEG
            IPASQ0 = 0
            WRITE (6,'(''       LEG'')')
            WRITE (6,10) LEG, LABMOD(MODE), MODE
            WRITE (6,'('' ACCIDENT RATE'')')
            WRITE (6,60) ((ACCRAT(J,K),K=1,NPOP),J=1,NSEV)
            WRITE (6,
     *       '('' EXPECTED NUMBER OF ACCIDENTS (PROBABILITY)'')')
            WRITE (6,60) ((ACCPYR(J,K),K=1,NPOP),J=1,NSEV)
         ENDIF

         IF (IPASQ.NE.IPASQ0) THEN
C .....PASQUILL PROBABILTIY
            IPASQ0 = IPASQ
            WRITE (6,'('' PASQUILL CATEGORY AND PROBABILITY'')')
            WRITE (6,20) IPASQ, PSPROB(IPASQ)
         ENDIF

         IF (.NOT.COST) THEN
C .....ISOTOPE DEPENDENT INFORMATION
            WRITE (6,'('' ISOTOPE'')')
            WRITE (6,80) ISO, IDISP(ISO), CI*PPS, HLIFE
            WRITE (6,70) LABISO(LIB), LABGRP(IPCGRP(ISO)),
*           LABMAT(MAT)
            WRITE (6,'('' LCF (NON-UNIT) OR PERSON-REM '',
*           '' (UNIT) CONSEQUENCE DATA'')')
            WRITE (6,60) ((ACCLCF(J,K),K=1,NPOP),J=1,NSEV)
            WRITE (6,'('' GE CONSEQUENCE DATA'')')
            WRITE (6,60) ((ACCGE(J,K),K=1,NPOP),J=1,NSEV)
         ELSE
            WRITE (6,'('' ECONOMIC IMPACT DATA'')')
            WRITE (6,60) ((ECNMPT(J,K),K=1,NPOP),J=1,NSEV)
         ENDIF
```

```
      ELSE
C.....END OF A RUN
         WRITE (6, '(''        EOF'')')
         LEG0 = 0
         IPASQ0 = 0
      ENDIF
      RETURN
C
   10 FORMAT (1X,I5,1X,A10,1X,I5)
   20 FORMAT (1X,I5,1PE10.2)
   60 FORMAT (8(1PE10.2))
   70 FORMAT (1X,A10,1X,A10,1X,A10)
   80 FORMAT (1X,2I5, 2(1PE10.2))
      END
```

where

ACCRAT = accident rate
ACCPYR = expected number of accidents
ACCLCF = number of latent cancer fatalities if NONUNIT; dose in person-rem if UNIT
ACCGE = number of genetic effects (NONUNIT only)
CI = number of curies of isotope
COST = LOGICAL true if economic impact printed; false otherwise
EOF = "end of file" used to denote end of data input for a discrete subset of data
HLIFE = half-life of isotope
IDISP = dispersability category
IPASQ0 = previous Pasquill cloud number; initialized to zero
IPASQ = Pasquill cloud number (1 to 6); should be 1 if Pasquill not used in analysis
IPCGRP = physical-chemical group number
ISO = isotope number according to input order
LABGRP = physical-chemical group label
LABISO = isotope label
LABMAT = material label
LABMOD = mode label
LEG0 = previous link number; initialized to zero
LEG = link number
LIB = isotope number in internal data library
MAT = material number
MODE = mode number
NPOP = population-density zone
NSEV = accident-severity category
PPS = number of packages per shipment
PSPROB = frequency of Pasquill stability category.

For each consequence type, the consequences are sorted and printed in decreasing order (highest first) and the corresponding probability array is

re-ordered accordingly. When the consequences are printed, zero-probability consequences are omitted. The probabilities associated with each non-zero consequence are summed and printed at the same time that the consequences are printed. The resulting ordered pairs can be used for producing consequences-vs-probability plots in which the probability associated with each consequence represents the probability of the corresponding consequence being equal to or greater than the given value.

FILE10.DAT contains either doses (person-rem) or latent cancer fatalities and associated probabilities. FILE11.DAT contains genetic consequences and associated probabilities. FILE12.DAT contains economic consequences and probabilities. If the original output was requested in terms of dose rather than health effects, then doses will be written in FILE10.DAT as indicated, but all consequence values in FILE11.DAT will be zero and should be neglected. If FILE6.DAT contains more than one data set (indicated by the key word EOF after each data set), then each data set in FILE10.DAT, FILE11.DAT, and FILE12.DAT will be separated by the word EOF. If there is only one data set, then no EOF is printed and all values in these files will be numeric.

APPENDIX D

RADTRAN 4 ERROR MESSAGES

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RADTRAN 4 ERROR MESSAGES

The following is a listing of error messages for RADTRAN 4. This listing does not include device error messages that the user may receive from the system on which RADTRAN 4 is installed. Device error messages are system-specific, and RADTRAN may be installed on a variety of systems. Many of the RADTRAN 4 error messages are self-explanatory, but explanations are provided below to assist the user. Error messages appear in the main output file. In general, the remainder of the output file will not be printed because calculation was terminated. With a few exceptions, which are noted below, recovery from RADTRAN errors consists of correcting value(s) in the input file.

The first 7 error messages listed are are Array Index Errors. Array Index Errors are usually typographical errors in which an improper index value is assigned to a parameter. Index values are always integers. To illustrate, consider the Index Array Error for IDSP, which addresses the dispersability category index of physical-chemical groups. There are 11 possible dispersability categories--i.e., IDSP may equal any integer from 1 to 11. If, when building an input file, the user mistakenly enters a dispersability category value of 13 for a physical-chemical group, then the input file will not run and the Array Index Error message will appear in the truncated output. Note that the error-detection logic detects illegitimate index values but is incapable of detecting whether the assignment of a legitimate dispersability category is scientifically correct. This is the task of the user.

ERROR MESSAGE LISTING IN ALPHABETICAL ORDER

ARRAY INDEX ERROR, IDSP = n MAXDSP = m

where

n = value entered as a dispersability category
m = maximum value for a dispersability category.

This error message indicates that the user has incorrectly entered a value for the IDSP index of a parameter that is greater than the maximum allowed value. The user must edit the input file to change the parameter index to an acceptable value.

ARRAY INDEX ERROR, IGRP = n NGROUP = m

where

n = value entered as a physical-chemical group designator
m = number of physical-chemical groups designated.

This error message indicates that the user has incorrectly entered a value for the IGRP index of a parameter that is greater than the value

entered under keyword DIMEN. The user must edit the input file to change the parameter to an acceptable value.

ARRAY INDEX ERROR, ISO = n NISO = m

where

n = value entered as an isotope designator
m = maximum value for an isotope designator.

This error message indicates that the user has incorrectly entered a value for the ISO index of a parameter that is greater than the value entered under keyword DIMEN. The user must edit the input file to change the parameter to an acceptable value.

ARRAY INDEX ERROR, MODE ENTERED IS n. MODES MUST BE BETWEEN 1 AND m

where

n = mode number entered (must be an integer)
m = maximum number of modes.

This error message indicates that the user has incorrectly entered a value for MODE n that is less than 1 or is greater than the maximum allowed value. The user must edit the input file to change the parameter to an acceptable value.

ARRAY INDEX ERROR, NO = n NORG = M

where

n = value entered as an organ designator
m = maximum value for an organ designator.

This error message indicates that the user has incorrectly entered a value for the NO index of a parameter that is greater than the maximum allowed value. The user must edit the input file to change the parameter to an acceptable value.

ARRAY INDEX ERROR, NP = n NPOP = m

where

n = value entered as a population density designator
m = maximum value for a population density designator.

This error message indicates that the user has incorrectly entered a value for the NP index of a parameter that is greater than the maximum allowed value. The user must edit the input file to change the parameter to an acceptable value.

ARRAY INDEX ERROR, NS = n NSEV = n

where

n = value entered as a severity category designator
m = number of severity categories designated.

This error message indicates that the user has incorrectly entered a value for the NS index of a parameter that is greater than the maximum allowed value. The user must edit the input file to change the parameter to an acceptable value.

CONVERGENCE FAILED IN SUBROUTINE BESSL

The user should never receive this message during authorized use of RADTRAN because the input parameters for the BESSL routine are not user-definable. If this message should appear, contact the code developer, SNL.

DISP OR NIM ARE NOT APPROPRIATE KEYWORDS WITH RFRAC

This error message indicates that the user has tried to use DISP (or NIM) as a keyword subordinate to RFRAC; GROUP is the appropriate keyword under RFRAC. The keyword NIM is an acronym for the number of the index of the material; in RADTRAN 4, the user also has available the newer keyword, DISP, which is synonymous with NIM and is derived from the more self-explanatory term dispersability category. DISP (or NIM) is used to identify a set of AERSOL and RESP values.

ERROR IN FILE6

If an error is encountered reading FILE6.DAT, then this error message is printed in FILE10.DAT, FILE11.DAT, and FILE12.DAT.

ERROR IN PROBABILITIES FOR PASQUILL CATEGORIES x SUM = y

where

x = set of six values representing the frequencies of occurrence of the six Pasquill stability categories [x_1 x_2 x_3 x_4 x_5 x_6]
y = sum of the Pasquill probabilities.

This error message indicates that the sum of the probabilities of occurrence of the six Pasquill atmospheric stability categories is not equal to one. The sum of the probabilities of these categories must be adjusted to equal 1.0 before the code can run.

ERROR ON DATA INPUT --
SUM OF FRACTIONAL TRAVEL VALUES FOR MODE n IS NOT EQUAL TO 1.0
RURAL = x SUBURBAN = y URBAN = z

where

n = mode number
x = rural fraction of travel
y = suburban fraction of travel
z = urban fraction of travel.

This error message can only appear when RADTRAN is used in non-LINKS applications. The message indicates that the sum of the fractions of travel in rural, suburban, and urban population-density zones entered by the user do not sum to 1.0. The values must be adjusted by the user so that x + y + z = 1.0 before the code will run.

ERROR - POPULATION DENSITY CANNOT BE ZERO.

For non-LINKS runs, the user must enter a new, non-zero value for population density under keyword POPDEN. Note that this does not apply to LINKS, in which the user can assign zero population density to individual route segments.

ERROR TOLERANCE NOT MET IN QUAD1

This message only appears if the limits of integration exceed the abilities of the QUAD1 subroutine. Since the user does not control these values, this message should not appear during authorized use. If it should appear, contact the code developer (Sandia National Laboratories).

EXPECTED A NUMERIC VALUE, FOUND: s

where

s = character string read in from input.

This message appears if the user enters a character string instead of a numeric value where the latter is required.

FINDI FAILED ON BSKIN CALL

This message indicates that the user has input a value for u (linear absorption coefficient), which is used in the gamma and neutron dose calculations, of less than zero. The coefficient must have a positive value.

FRACTIONS OF GAMMA AND NEUTRON FOR MATERIALS CANNOT BE CHANGED.
MATERIAL s HAS FRACTION OF GAMMA = n AND FRACTION OF NEUTRON = m

where

s = material name
n = gamma fraction
m = neutron fraction.

Once the fractions of the package dose rate at 1 meter from the package that are represented by gamma and neutron radiations, respectively, are defined for a package, these fractions must be used consistently throughout the input file. If they are not, then this error message is displayed and the user must check the input file for consistency.

FRACTIONS OF GAMMA AND NEUTRON MUST SUM TO 1.0
FOR MATERIAL s THE FRACTION OF GAMMA IS n AND THE FRACTION OF NEUTRON IS m

where

s = material
n = gamma fraction
m = neutron fraction.

The sum of the fractions of the package dose rate at 1 meter from the package that are gamma and neutron radiations, respectively, must be 1.0. The user must adjust the values so that n + m = 1.0 before the code will run.

GOTO ERROR AT s

where

s = name of subroutine which had an error in a GOTO statement.

This message should not appear during authorized use of RADTRAN. It indicates a programming error with a computed GOTO statement. Should this message appear, contact the code developer (Sandia National Laboratories).

GROUP OR NPTYPE ARE NOT APPROPRIATE KEYWORDS WITH AERSOL OR RESP

DISP is the appropriate keyword for AERSOL and RESP. GROUP (or NPTYPE) is used as a subordinate keyword for RFRAC. The keyword NPTYPE stands for number of package type; the keyword GROUP stands for physical-chemical group.

INVALID IACC VALUE IN EARLY

The IACC value is a flag used to indicate that a material contains dispersable (IACC = 2) or nondispersable (IACC = 1) isotopes. The user should never receive this message during authorized use of RADTRAN because IACC is only set to 1 or 2. If this message should appear, contact the code developer (Sandia National Laboratories).

ISOTOPE NAMED s NOT IN DATA SET

where

s = isotope listed under keyword ISOTOPES (not in internal data).

Isotope s has not been defined. The user must define it using the DEFINE keyword.

ISOTOPE s WAS ASSIGNED A DISTANCE FOR MODE n THAT IS DIFFERENT FROM DISTANCES ASSIGNED TO OTHER ISOTOPES IN THAT MODE

where

s = isotope name
n = mode number.

This message appears if the keyword FKMPS is used incorrectly. All isotopes transported on the same vehicle by the same mode must go the same distance.

ISOTOPE s WAS ASSIGNED A PHYSICAL/CHEMICAL GROUP TYPE WITH A PACKAGE SIZE THAT IS DIFFERENT FROM OTHER ISOTOPES IN MATERIAL t

where

s = isotope name
t = material name.

This message appears if the keyword PKGCDM is used incorrectly. All isotopes in the same material are in the same package; therefore, different isotopes within the package cannot be associated with different package dimensions.

ISOTOPE s NOT LISTED

where

s = isotope listed under keyword ISOTOPES (not listed under LABISO).

This message appears if an isotope name used under keyword ISOTOPES was not entered under keyword LABISO.

IUOPT SHOULD BE 1, 2, OR 3. IUOPT = i

where

i = number entered by user as IUOPT.

This message means that, after the keyword PARM, the user has entered a value for IUOPT that is not 1, 2, or 3.

MATERIAL s HAS ALREADY BEEN ASSIGNED TO MODE n

where

s = material name
n = mode number.

This message means that the user has tried to assign a material to mode n twice.

s IS NOT LISTED ABOVE

where

s = physical-chemical group name (not listed under LABGRP).

This message means that the user has attempted to used a physical-chemical group name not listed under the keyword LABGRP.

THE RECIPROCAL VELOCITY IS ZERO IN SETMOD

This message appears if all velocities are zero or if all fractions of travel are zero.

THE EXCLUSIVE USE DESIGNATOR FOR MODE n HAS ALREADY BEEN SET, CANNOT CHANGE IT.

where

n = mode number.

This message indicates that the user has made multiple entries of the keyword ISOTOPES with the same mode number but different exclusive-use designators. The use designation of a mode cannot change within a single run of RADTRAN.

THE NUMBER OF SHIPMENTS HAS ALREADY BEEN SET TO x FOR MODE n

where

x = number of shipments
n = mode number.

This message indicates that the user has made multiple entries of the keyword ISOTOPES with the same mode but different numbers of shipments. The number of shipments per mode of a material cannot change within a single run of RADTRAN.

TOO MANY MATERIALS, MAX IS n

where

n = maximum number of materials allowed.

This message indicates that a new material name was entered that increased the number of materials to more than the maximum allowed. The user must delete at least one material.

UNKNOWN IDENTIFIER DETECTED ON INPUT s

where

s = character string read in from input.

The message appears when a character string that is not a keyword has been used in a keyword location. This message can result from either a spelling error or improper location of the character string.

WHEN USING LINKS; EITHER USE ONLY ONE "ISOTOPES" LINE WHICH WILL DEFINE ALL MODES, OR WRITE AN "ISOTOPES" LINE FOR EACH MODE USED.

This message appears when a LINKS line was entered indicating a mode not defined with ISOTOPES. Note that a single ISOTOPES line may be used for multiple modes to permit earlier input files to run.

TOO MANY ISOTOPES IN THE MATERIALS, MAXIMUM ALLOWED IS 65

This message appears when the user has included more than 65 isotopes in a material description. All materials must be modeled as consisting of no more than 65 significant isotopes.

YOU ARE ATTEMPTING TO DIMENSION AN ARRAY LARGER THAN THE AVAILABLE STORAGE

IDENTIFIER	VALUE	MAXIMUM
NISO	n1	m1
NSEV	n2	m2
NGROUP	n3	m3
NRAD	n4	m4
NAREAS	n5	m5

This message indicates that the user has entered at least one value after the keyword DIMEN that exceeds the maximum allowable value. To assist the user to correct the error, the values entered by the user and the maximum allowable values are shown in the error message.

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