RADTRAN/RADCAT USER GUIDE

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WELCOME TO RADTRAN/RADCAT

RADTRAN is a program and code for calculating the risks of transporting radioactive materials. The first versions of the program, RADTRAN I and II, were developed for NUREG-0170 (USNRC, 1977), the first environmental impact statement on transportation of radioactive materials. RADTRAN and its associated software have undergone a number of improvements and advances consistent with improvements in computer technology.

DOWNLOADING AND CHECKING FOR THE LATEST VERSION

You can download the RADCAT/RADTRAN package from http://www.evolutionnext.com/radcat.

- On the web page, click on click here and fill out the application.
- When you are approved, you will be notified by email.
- When you are approved, you can click on Download Radcat. You will be asked for your username. Your username is the email address you listed in the application.
- When you sign in, you will be advised that you **may** want to download the Java Runtime Environment**.** Actually you **must** download the Java Runtime Environment if it is not already on your computer. To do this, go to http://www.java.com ; scroll to the green box at the upper right of the screen, and click on the yellow bar labeled "Get It Now."
- Download the Windows online installation. (You may want to download and read the instructions, but it isn't absolutely necessary.)
- Install the Java Runtime Environment (JRE) on your PC. If you are on a network, you may get a message indicating that you can't install. If this happens, you will need help from your network administrator to install it, or to give you access through a firewall. If you have a firewall (like ZoneAlarm) on the computer you are using, turn it off before installing the JRE.
- Once JRE is installed, you can go back to Download Radcat on the Main Menu and download RADCAT. You will be asked to integrate it to the desktop environment, which is suggested. When you launch RADCAT (the application), you may get a notice that says there is no certificate of authenticity; launch the application anyway. The process for applying for the certificate may not be complete.
- Once you have installed JRE, you can launch RADCAT either from JRE or from the RADCAT icon. If you want to download the latest version, go back to http://www.evolutionnext.com/radcat , click on Download Radcat, click on Launch the Application, and the latest version will be downloaded. You may get a notice that says there is no certificate of authenticity; launch the application anyway. The process for applying for the certificate may not be complete.

When you download RADCAT, you will be prompted to save the icon on your desktop. A Java Web Start icon can also be placed on your desktop. RADCAT/RADTRAN can be opened at any time from the desktop icon.

IMPORTANT: Because of minor changes within the formatting and the addition of features it is suggested that RADCAT 1.0 be opened using Java Web Start and this will automatically update your version of RADCAT. You will still be notified via email of any major changes or additions to RADCAT.

RUNNING RADTRAN WITH RADCAT

You can run an existing input file with RADCAT, by following these steps:

1. Open RADCAT.
2. In RADCAT, choose the file you want to run, either by using the **File** pull-down menu or by clicking on the **Open** icon. Your directory will appear and you can choose the file you wish to run. When you have selected a file, the title of the file will appear in the **Title** space.
3. Click on the **Run RADTRAN** icon (the icon showing a computer monitor). The output file will appear and can be saved to your computer.

SAVING AN INPUT FILE

You may save an input file at any time by clicking on the **Save** icon (the floppy disk). The **Save As** window will open and you can save the file in the normal Windows manner. Be sure to give your input file a ".in5" file extension (e.g. *filename*.in5).

GENERATING AN INPUT FILE WITH RADCAT

If you do not wish to use RADCAT 1.0 to create a RADTRAN 5 file, you may use the reference sheet provided in Appendix A of this user guide to assist you in creating a text input file.

NEW

When the **New** icon is selected the **Mode Selection** dialog box appears. An example of the **Mode Selection** dialog box can be seen in Figure 1. You must select a transportation **mode** (highway, rail, or barge) before a new file can be created. A file cannot be created with more than one mode. You may select a mode from the pull-down menu.

If a current file is already open selecting the **New** icon will just open another Java window with the same parameters as the prior file. This will not reset any of prior files information to the default values. Also there will be additional inputs placed into the **Radioisotopes** and **Vehicle** tabs that must be addressed.

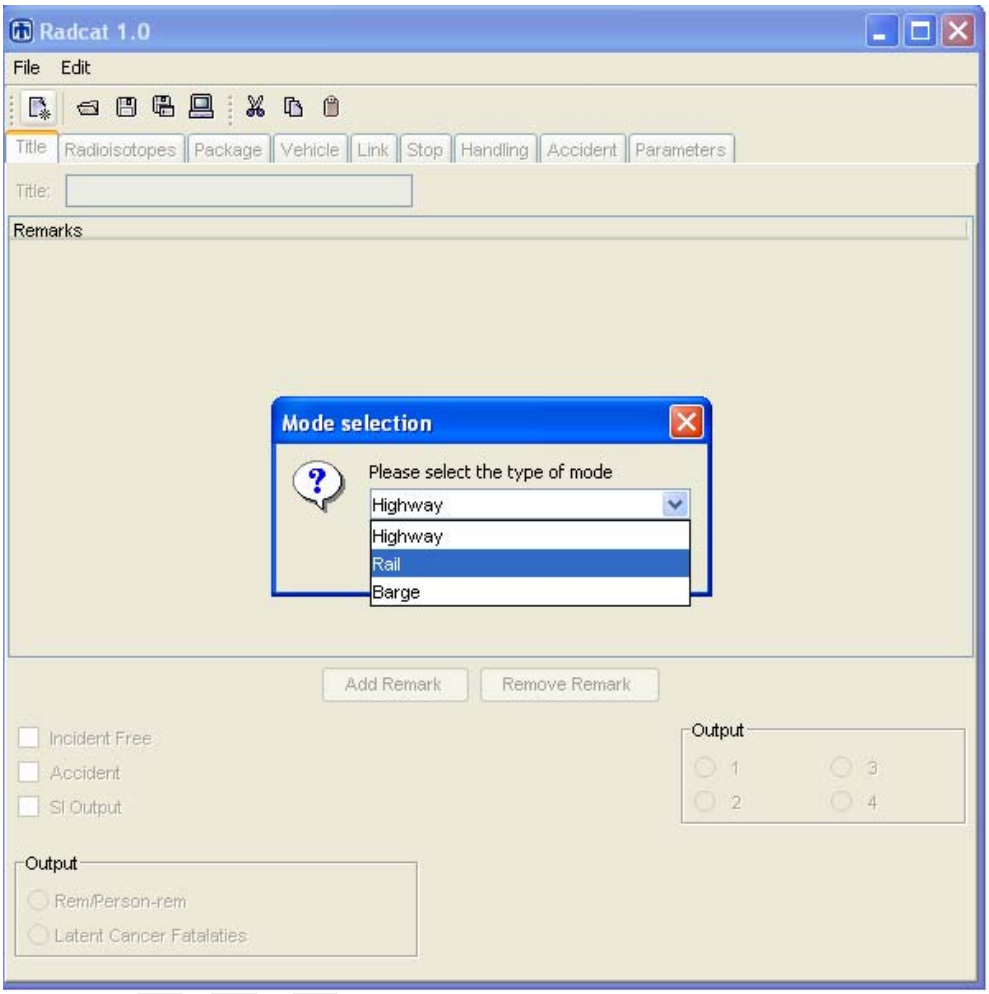


Figure 1: Mode Selection

TITLE

The **Title** box says, e.g. “My Truck” (depending on the mode chosen). You may delete this and type a name for your file in the **Title** box. Your file must have a title. After you type in the title, hit ENTER, otherwise the title will revert. The **Title** box can be seen in Figure 2.

REMARKS

The **Remarks** screen is for you to annotate your file; e.g., give a brief description of the problem, the sources of your input parameters, etc. When you click on **Add Remark** a line appears in the remarks screen. The word “REMARK” is on this line. You can delete it and enter your own remark (up to 80 characters per line. Click on **Add Remark** to append additional remarks. **Remarks** can be seen in Figure 2.

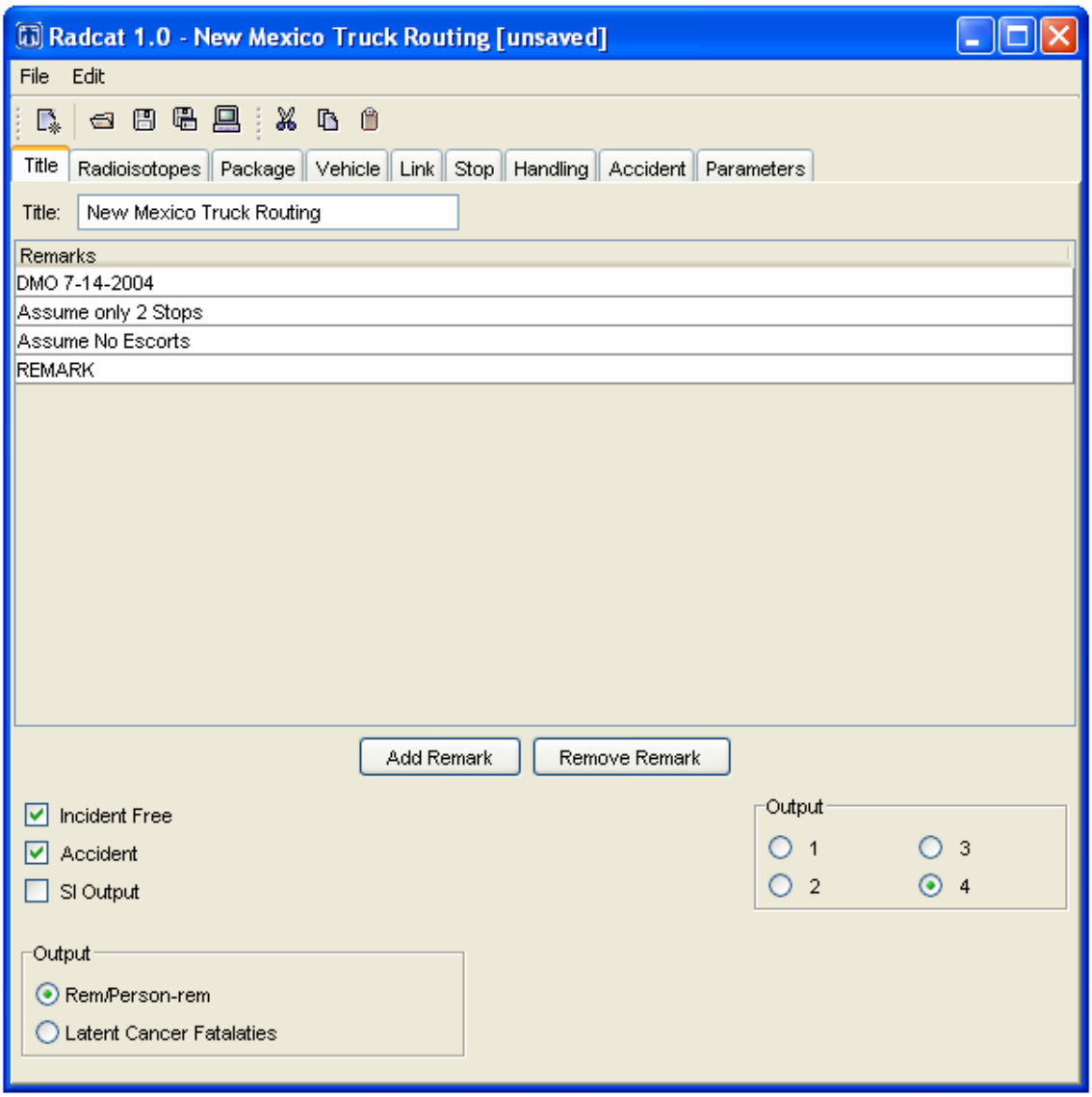


Figure 2: Title Tab

CHOOSING YOUR ANALYSIS

Checking the **Incident Free** box will result in analysis of routine, incident-free transportation only. Checking the **Accident** box will result in analysis of transportation accidents only. Checking both the **Incident Free** and **Accident** boxes results in full analysis of both routine, incident-free transportation and transportation accidents. Checking the **SI Output** will cause your output results to be in Standard International (SI) units. These options can be seen in Figure 2.

OUTPUT

Output may be either as individual and collective doses or as latent cancer fatalities. The individual dose and collective dose outputs may be in historical units – rem and person-rem, as appropriate – or Standard International (SI) units – sievert (Sv) and person-sievert (person-Sv).

Some useful conversion factors are:

1 Sv = 100 rem
1 millisievert (mSv) = 100 mrem
1 gray (Gy) = 100 rad
(rem)*(5 x 10^{-4}) = latent cancer fatality probability (LCF) for the public
(rem)*(4 x 10^{-4}) = occupational latent cancer fatality probability (LCF)
1 becquerel (Bq) = one disintegration per second, the units of Bq are sec^{-1}
1 curie (Ci) = 3.7 x 10^{10} Bq

OUTPUT LEVEL

Four options are available for controlling output size:

1. Short output form. The input echo, incident-free, and accident and non-radiological risk tables printed. Size of output file is approximately 10 pages.
2. Output for #1 plus input tables, early effects values, ground contamination tables, intermediate tables and total expected population dose tables. Size of output file is approximately 24 pages.
3. Output for #2 plus consequence tables. Size of output file is approximately 27 pages.
4. Full output. Output for #3 plus sensitivity analysis. Size of output file is approximately 32 pages.

These options can be seen in Figure 2.

PACKAGE

If you are making a new input file or adding or deleting a package in an existing file, open the **Package** tab. If you are editing an existing file without adding or deleting a package, the order in which you open the tabs doesn't make any difference. This can be seen in Figure 3.

NAME

Give your package a name in the left-hand column. You can delete "SFUEL" and substitute any name that you like. If you wish to transport more than one package, click the **Add Package** bar and add as many packages as you wish. You will be adding packages to vehicles in a later tab. Ensure that the name you choose contains no spaces. This can be seen in Figure 3.

List all the packages that you will want for this run on this tab. You cannot add packages on other tabs, nor can you delete them from other tabs.

LONG DIMENSION

Enter the maximum dimension of the package, e.g. length of a cylinder if larger than the diameter, in meters. This is the "critical dimension" in RADTRAN.

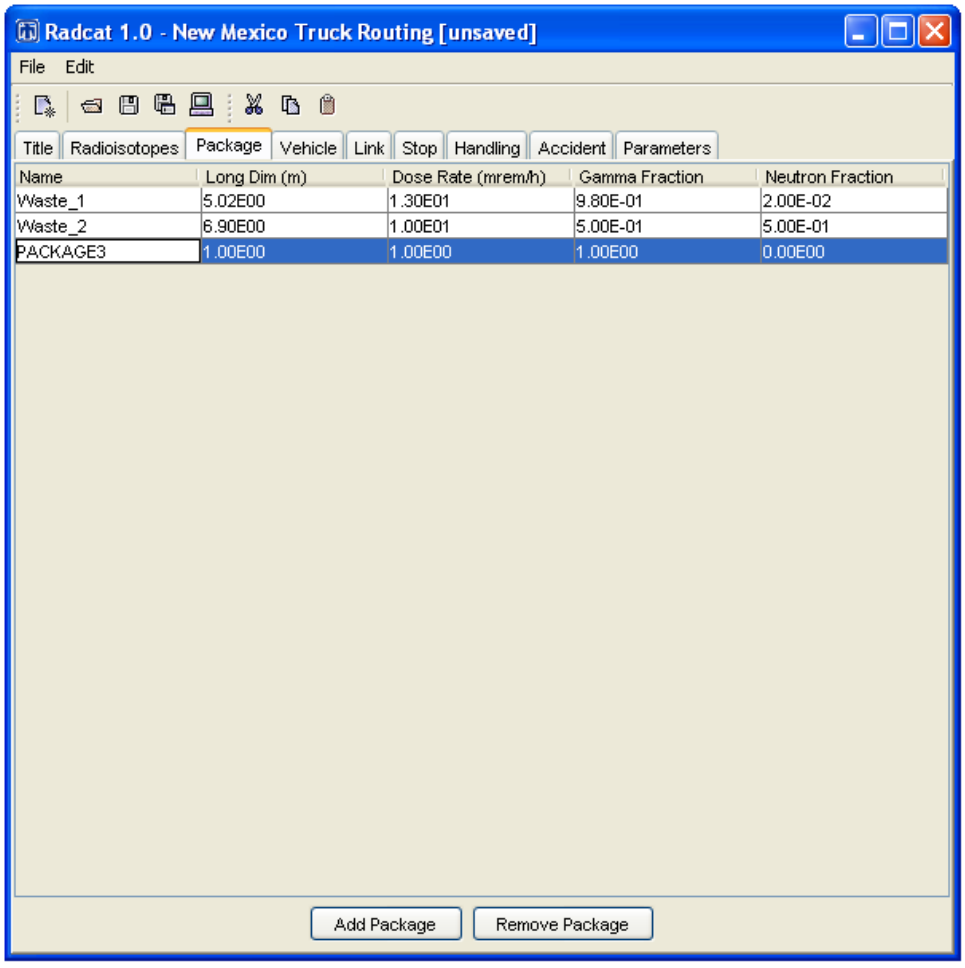


Figure 3: Package Tab

DOSE RATE

Enter the external dose rate, at one meter from the package surface, in units of mrem/hr. Note that the regulations of 10 CFR Part 71 specify that the external dose rate *at two meters* from the package surface should not exceed 10 mrem/hour. This is equivalent to 14 mrem/hr at one meter from the package surface for a "critical dimension" of about 5 m. If the actual dose rate is not known, and one assumes that the shipper is abiding by regulations, one may use the regulatory maximum, 14 mrem/hr, as the external dose rate, recognizing that this value is conservative. This can be seen in Figure 3.

RADTRAN has a flag on the **Parameter** tab, "Imposed regulatory limit on vehicle external dose," that imposes a regulatory constraint on the shipment. Selecting **YES** will cause RADTRAN to internally adjust the dose rate so that the external dose rate at two meters does not exceed 10 mrem/hr, and thus may be modeling a different dose rate than the one you entered. If you want to lift this regulatory constraint, select **NO**.

Remember that RADTRAN models the external dose rate as a source at the center of the package. The distance between the source and the receptor must take this into account.

GAMMA AND NEUTRON FRACTIONS

When you enter a value into either of these cells, RADCAT will automatically adjust the other cell so that the two add up to one. This can be seen in Figure 3.

RADIOISOTOPES

(NOTE: The title of this screen should really be “radionuclides”. We have retained “radioisotopes” for RADTRAN historical reasons.)

If you are making a new input file, or adding or deleting a vehicle in an existing file, open the **Radioisotopes** tab next after the **Package** tab. If you are editing an existing file without adding or deleting a package, the order in which you open the tabs doesn’t make any difference. This can be seen in Figure 4.

At the upper left of the **Radioisotopes** screen is a pull-down menu of the packages you have created. Select the package whose inventory you wish to specify.

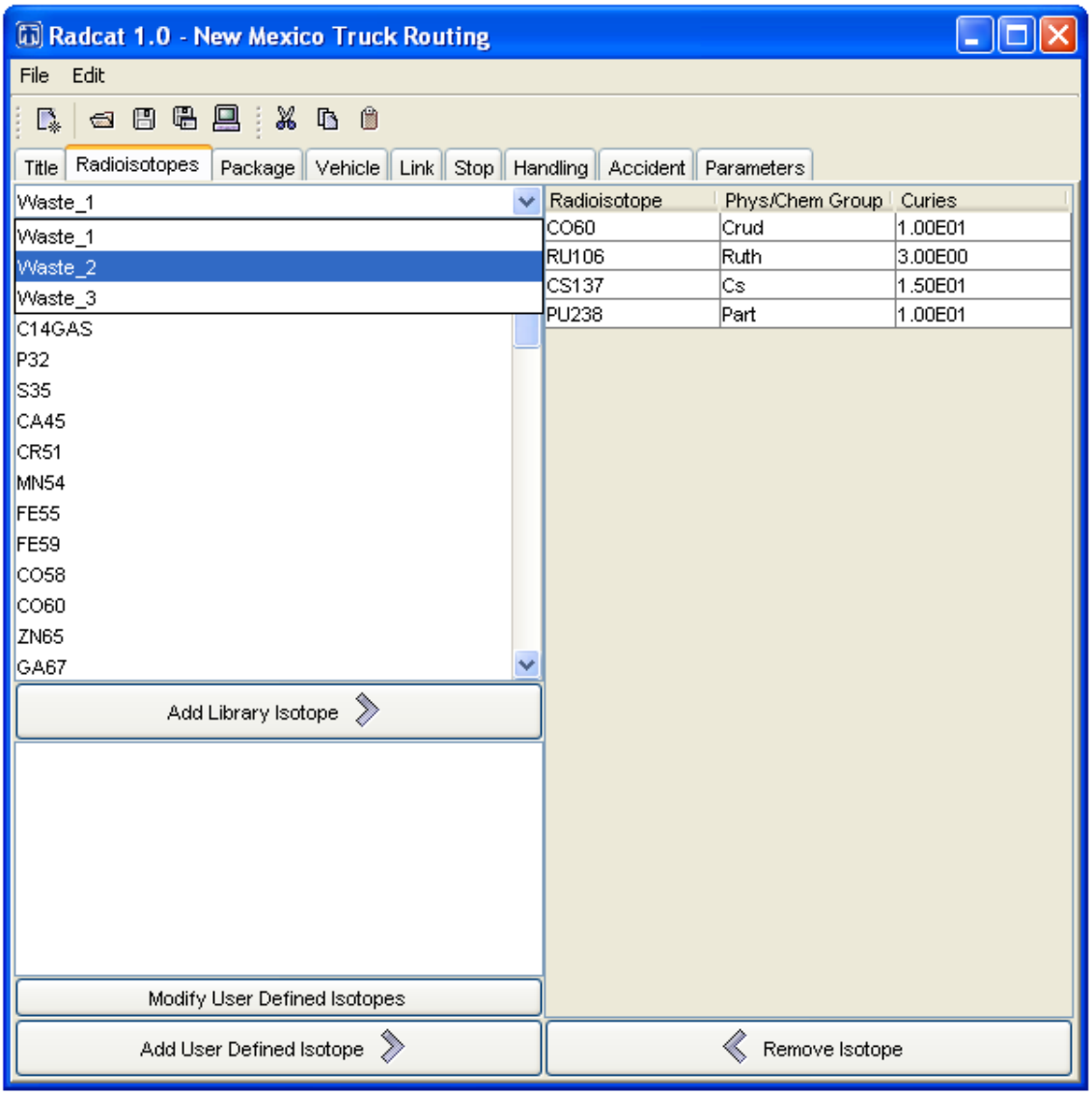


Figure 4: Radioisotope Tab with Package pull-down menu

ADDING RADIOISOTOPES FROM THE INTERNAL LIBRARY

The window just below the package pull-down menu lists all of the radionuclides in the internal RADTRAN library. Radionuclides may be added to your package by clicking on the **Add Library Isotope** arrow. The radioisotope name will then appear on the right-hand screen. Name the **Physical/Chemical Group** to which the radionuclide belongs. You may use any name you like, but the name can have no more than eight alpha-numeric characters. Remember that the release behavior in the event of an accident depends on the physical/chemical group (gas, particle, volatile substance, etc.). RADTRAN will accept up to 15 different physical chemical groups. Once you have added your first radionuclide, the **Physical/Chemical Group** entry will become a pull-down menu, so that you can select existing physical/chemical groups for other entries. Physical/chemical groups must be entered at this screen; they cannot be entered on any other screen. This can be seen in Figure 5.

Enter the number of curies of the radionuclide in the **Curies** column.

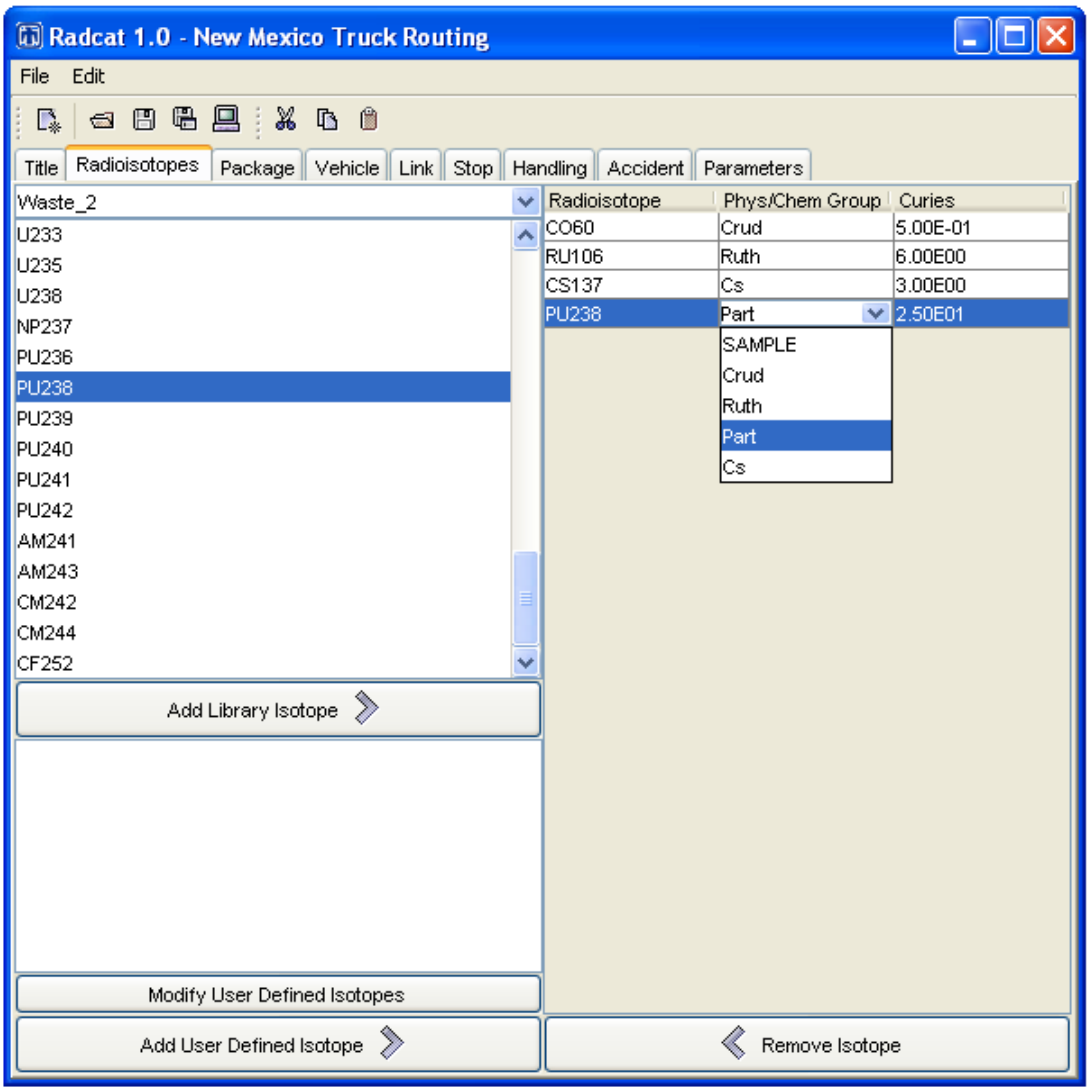


Figure 5: Radioisotopes Tab with Physical/Chemical Group pull-down menu

ADDING RADIOISOTOPES THAT ARE NOT IN THE INTERNAL LIBRARY: USER-DEFINED RADIOISOTOPES

If the radionuclide you wish to add is not in the internal library, it may be added to your package. To do this, first click on the **Modify User Defined Isotopes** bar. The **User Defined Isotopes** screen will open. In this screen, click on the **Add User Defined Isotope** bar. You may then enter the name of the radionuclide in the left-hand cell (in place of ISOTOPE2), and it may be up to eight characters long. Ensure that there are no spaces in your radionuclide name. This can be seen in Figure 6.

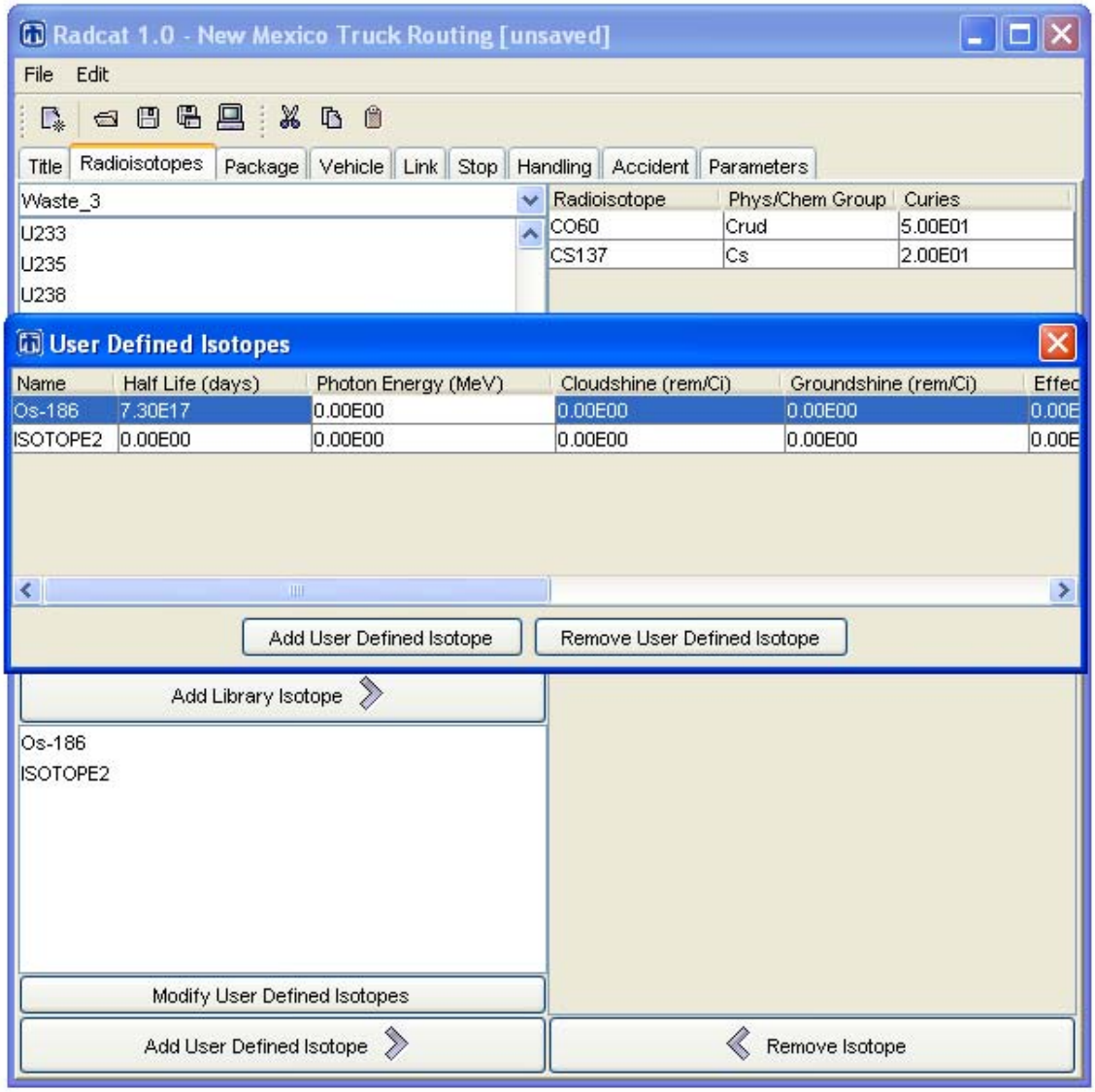


Figure 6; Radioisotopes Tab with User Defined Isotopes window

You may then enter values for **Half Life, Photon Energy,** and dose conversion factors for **Cloudshine, Groundshine, Inhalation Dose, Gonad Inhalation Dose, Lung Inhalation Dose, and Marrow Inhalation Dose. YOU MUST ENTER A VALUE LARGER THAN ZERO FOR THE HALF LIFE OF EVERY USER-DEFINED RADIONUCLIDE.** RADTRAN will not run if there is a radionuclide with a half-life of zero or with a negative half life.

If you fail to enter a value for the **Cloudshine** dose conversion factor, the **Groundshine** dose conversion factor, and/or the **Inhalation** dose conversion factor, RADTRAN will run but will report zero for the appropriate doses. If you fail to enter values for the **Gonad, Lung,** and/or **Marrow Inhalation** dose conversion factors, there will be no effect on cloudshine, groundshine, inhalation, or resuspension collective doses, but specific gonad inhalation, etc., doses will not be reported.
It is important to note that the **Inhalation** dose is entered as the **Effective Dose** in the **User Defined Isotope** window.

When you have added a user-defined radionuclide, the name of that radionuclide appears on the lower part of the **Radioisotope** tab. Using the **Add User Defined Isotope** arrow under that screen, you add the user-defined radionuclide to your package, and indicate the physical/chemical group and number of curies as before.

IMPORTANT NOTE

Inhalation, resuspension, groundshine, and cloudshine doses are calculated for all radionuclides: both those in the internal library and those that are user-defined. Ingestion doses are calculated by RADTRAN 5 only for radionuclides in the internal library.

VEHICLE

If you are making a new input file or adding or deleting a vehicle in an existing file, open the **Vehicle** tab next after the **Radioisotope** tab. If you are editing an existing file without adding or deleting a package, the order in which you open the tabs doesn't make any difference. This can be seen in Figure 7.

VEHICLE NAME

Give your vehicle a name in the left-hand column. You can delete what is there and substitute any name that you like. If you wish to analyze more than one vehicle, click the **Add Vehicle** bar and add as many vehicles as you wish. Ensure that there are no spaces in your vehicle name. This can be seen in Figure 7. Add packages to vehicles as follows:

1. Click on the vehicle you want to add the package to.
2. Then click on the package you want to add, and enter the number of these packages that you want to put on the vehicle.

You can put different packages on a vehicle. When you click on the vehicle, the number of each of the packages on that vehicle shows up in the **Number of Packages** column. If a package is not on a particular vehicle, the **Number of Packages** column will show a zero. This can be seen in Figure 7.

List all the vehicles that you will want for this run on this tab. You cannot add vehicles on other tabs, nor can you delete them from other tabs.

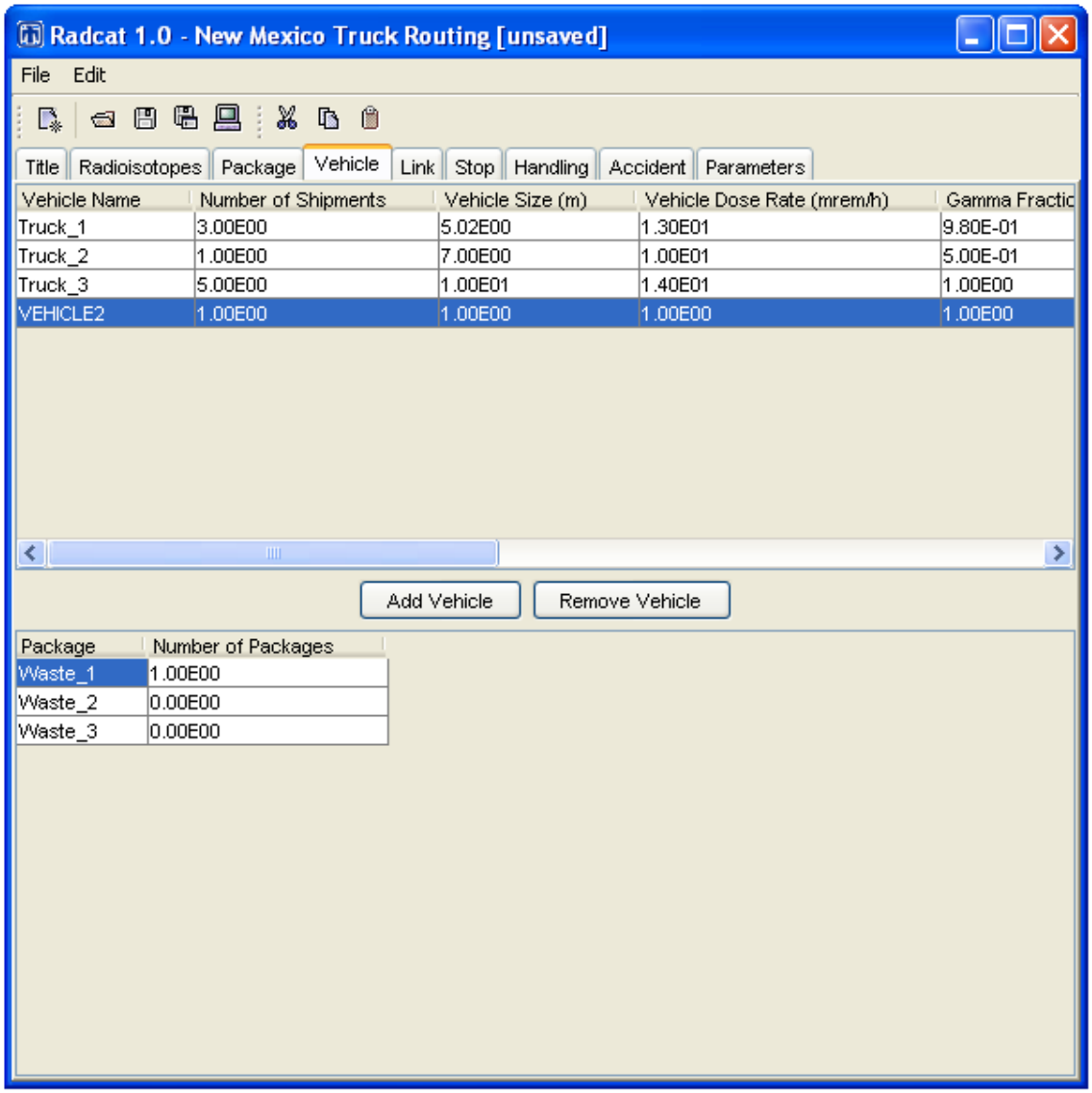


Figure 7: Vehicle Tab

NUMBER OF SHIPMENTS

Enter the number of shipments. This can be seen in Figure 7.

VEHICLE SIZE

Enter the maximum dimension of the cargo section of the vehicle, or of the part of the vehicle holding the packages, in meters. This is the “critical dimension” of the vehicle in RADTRAN. This can be seen in Figure 7.

VEHICLE DOSE RATE

Enter the external dose rate, at one meter from the edge of the cargo-carrying part of the vehicle, in units of mrem/hr. Note that the regulations of 10 CFR Part 71 specify that the external dose rate *at two meters* from this edge should not exceed 10 mrem/hour. This is equivalent to 14 mrem/hr at one meter for a "critical dimension" of approximately 5 m. If the actual dose rate is not known, and one assumes that the shipper is abiding by regulations, one may use the regulatory maximum, 14 mrem/hr, as the external dose rate, recognizing that this value is conservative. This can be seen in Figure 7.

RADTRAN has a flag on the **Parameter** tab, "Imposed regulatory limit on vehicle external dose," that imposes a regulatory constraint on the shipment. Selecting **YES** will cause RADTRAN to internally adjust the dose rate so that the external dose rate at two meters does not exceed 10 mrem/hr, and thus may not use the dose rate you entered into the calculations. If you want to lift this regulatory constraint, select **NO**.

Remember that RADTRAN models the external dose rate as a source at the center of the package. The distance between the source and the receptor must take this into account.

GAMMA AND NEUTRON FRACTIONS

When you enter a value into either of these cells, RADCAT will automatically adjust the other cell so that the two add up to one. This can be seen in Figure 7.

CREW SIZE

Enter the number of crew members traveling on the vehicle. This can be seen in Figure 8.

CREW DISTANCE

Enter the **Distance** in meters from the crew to the nearest surface of the cargo. This distance is usually between 3 and 7 meters for large trucks. This can be seen in Figure 8.

On a train the dose to the crew on the moving train is not calculated by RADTRAN. "Crew" dose for rail shipments is the dose sustained by railyard workers at stops along the route.

A barge usually has a crew of 10. Enter the average distance of the crew from the cargo.

CREW SHIELDING FACTOR

Enter a factor between 0 and 1 for crew shielding. This factor is the fraction of ionizing radiation to which the crew is exposed (the inverse of the shielding fraction), so that 1 = no shielding, and 0 = 100% shielding. This can be seen in Figure 8.

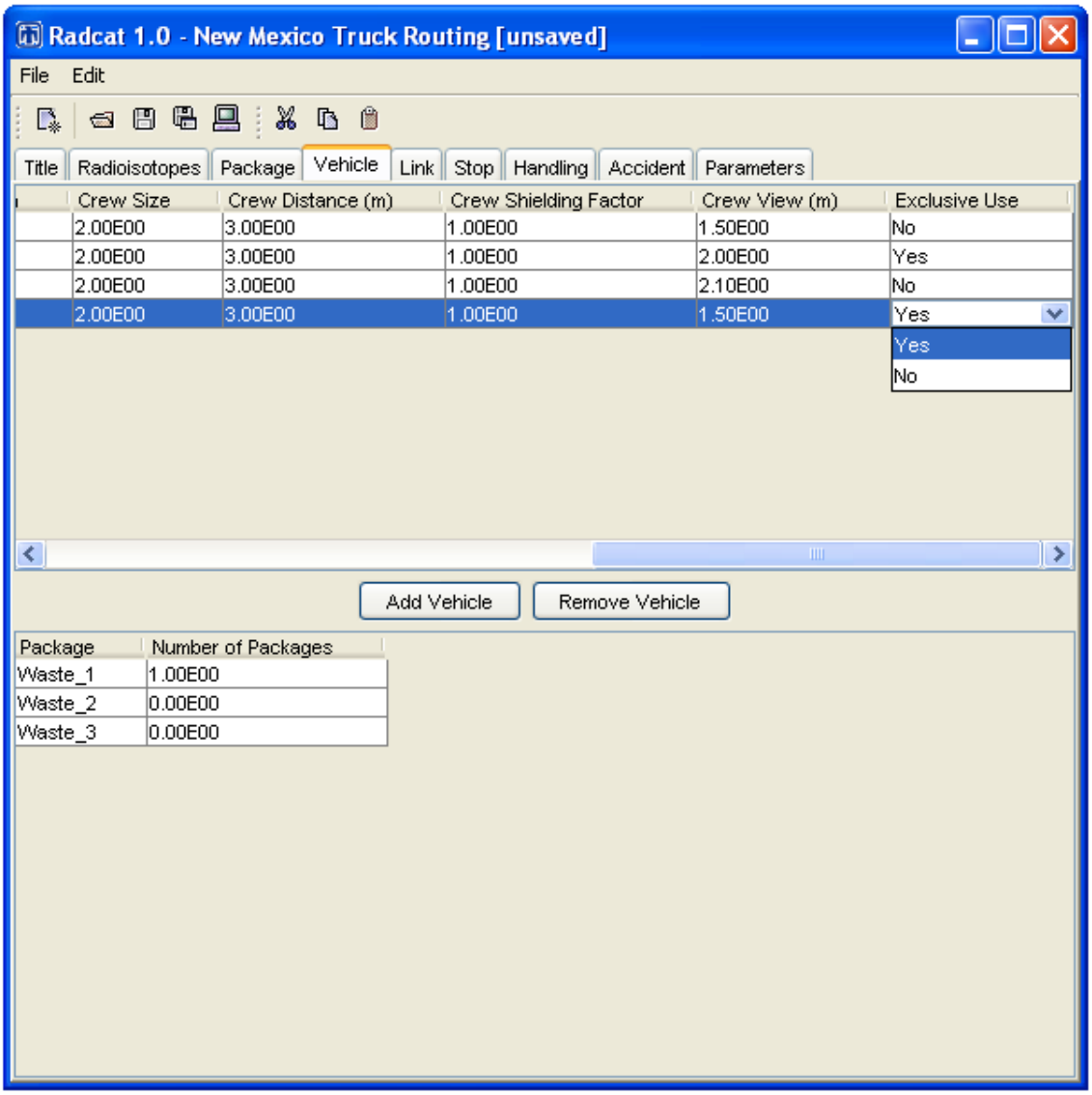


Figure 8: Vehicle Tab Continued

CREW VIEW

The **Crew View** is the largest dimension, in meters, of the cargo that faces toward the crew. This is usually the diameter of a cylindrical cask or the diagonal end dimension of a rectangular container or array. This can be seen in Figure 8.

EXCLUSIVE USE

A pull-down menu allows you to indicate whether the vehicle is exclusive use or not. This can be seen in Figure 8.

LINK

If you are making a new input file or adding or deleting a vehicle in an existing file, open the **Link** tab next after the **Vehicle** tab. If you are editing an existing file without adding or deleting a package, the order in which you open the tabs doesn't make any difference. This can be seen in Figure 9.

NOTE: The parameter values in this screen can be provided by a routing code or a geographic information system (GIS). The routing code WebTRAGIS is available from Oak Ridge National Laboratory at http://apps.ntp.doe.gov/tragis/tragis.htm.

LINK NAME

Give each route segment (**Link**) a name in the left-hand column. You can delete what is there and substitute any name that you like. Links do not need to be consecutive. Ensure that there are no spaces in your link names. You may divide the entire route into a rural link, which includes all rural segments, a suburban link, which includes all suburban segments, and an urban link, which includes all urban segments. The designation of rural, suburban, or urban is defined by the resident population density along the route (see **Population Density**). This can be seen in Figure 9.

VEHICLE

Available vehicle names are on a pull-down menu in the **Vehicle** column. Note that vehicle names cannot be added or deleted at this screen. This can be seen in Figure 9.

LENGTH

Enter the length of the route segment – the link – in kilometers, as obtained from a routing code like WebTRAGIS or from a GIS system or from a map. This can be seen in Figure 9.

A useful conversion factor is 1 km = 0.6217 mile.

SPEED

Enter the average speed of each vehicle on each link, in km/hr. This can be seen in Figure 9. Based on speed limits, we have used the following, very conservative values in RADTRAN in the past:

Trucks on freeways, primary U. S. highways, or limited-access highways: 88 km/hr (55 mph)
Trucks on two-lane rural roads: 72 km/hr (45 mph)
Trucks on urban or suburban two-lane roads: 40 km/hr (25 mph)
Trucks on city streets: 24 km/hr (15 mph)
Trucks in rush-hour traffic: one-half the non-rush hour speed on the particular road type
Trains on rural route segments: 64 km/hr (40 mph)
Trains on suburban route segments: 40 km/hr
Trains on urban route segments: 24 km/hr

POPULATION DENSITY

Enter the population density in persons/km^2, as obtained from WebTRAGIS , the City/County data book, or some other GIS system or source. This can be seen in Figure 9. This population density is usually provided for a band one-half mile (800 meters) on either side of the route. Rural, suburban, and urban population densities are classified by WebTRAGIS according to the following scheme:

rural: 0 to 139 persons/mi^2 (0 to 55 persons/km^2)
suburban: 139 to 3326 persons/mi^2 (55 to 1300 persons/km^2)
urban: more than 3326 persons/mi^2 (1300 persons/km^2)

The historic RADTRAN classifications are:

rural: 0 to 66 persons/km^2
suburban: 67 to 1670 persons/km^2)
urban: more than 1670 persons/km^2)

National averages are approximately

rural: 6 persons/km^2
suburban: 720 persons/km^2
urban: 3800 persons/km^2

Population density and vehicle speed are important parameters in determining the *off-link incident-free dose* from radioactive materials transportation. Population density is important in determining *accident dose risk.*

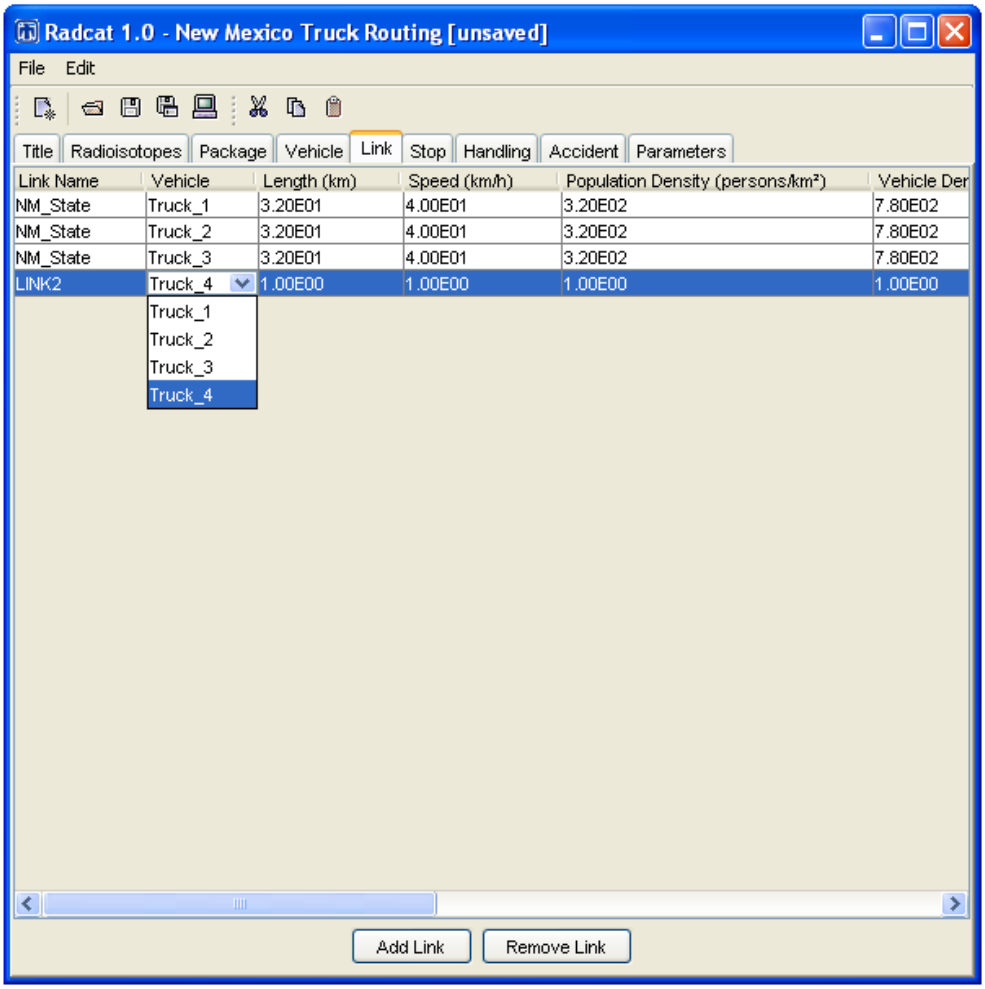


Figure 9: Link Tab

VEHICLE DENSITY

Enter the vehicle density – the vehicles that share the route with the radioactive cargo – in vehicles per hour. This can be seen in Figure 10. National average vehicle densities that have been used in RADTRAN are:

Truck
rural: 460 vehicles/hr
suburban: 780 vehicles/hr
urban: 2800 vehicles/hr
During rush hour the vehicle density may be assumed to double.

Rail
rural: 1vehicle/hr
suburban: 5 vehicles/hr
urban: 5 vehicles/hr

More accurate vehicle densities can usually be obtained from state traffic counts.

PERSONS PER VEHICLE (VEHICLE OCCUPANCY)

Enter the average persons per vehicle for the route. This can be seen in Figure 10. For highway transportation, this is usually 1.5 or 2 persons per vehicle. For rail, since most rail transportation is freight, the number is usually 3 (the train crew). If passenger trains share the route, the average vehicle occupancy can be estimated.

Vehicle density and vehicle occupancy are important parameters in determining the *on-link incident-free dose* from transportation of radioactive materials.

ACCIDENT RATE

Enter the accident rate for each route segment in accidents per vehicle-km. This can be seen in Figure 10. Accident rate is usually reported by state and type of road or rail. Useful references for accident rates are:

Saricks, C.L. and Tompkins, M.M. 1999. State-Level Accident Rates of Surface Freight Transportation: A Reexamination. ANL/ESD/TM-150. Argonne, Illinois: Argonne National Laboratory.

The Bureau of Transportation Statistics web site: http://www.bts.gov

ZONE

A pull-down menu allows you to designate each link as rural, suburban, or urban. These designations must be applied because they modify certain RADTRAN calculations. This can be seen in Figure 10.

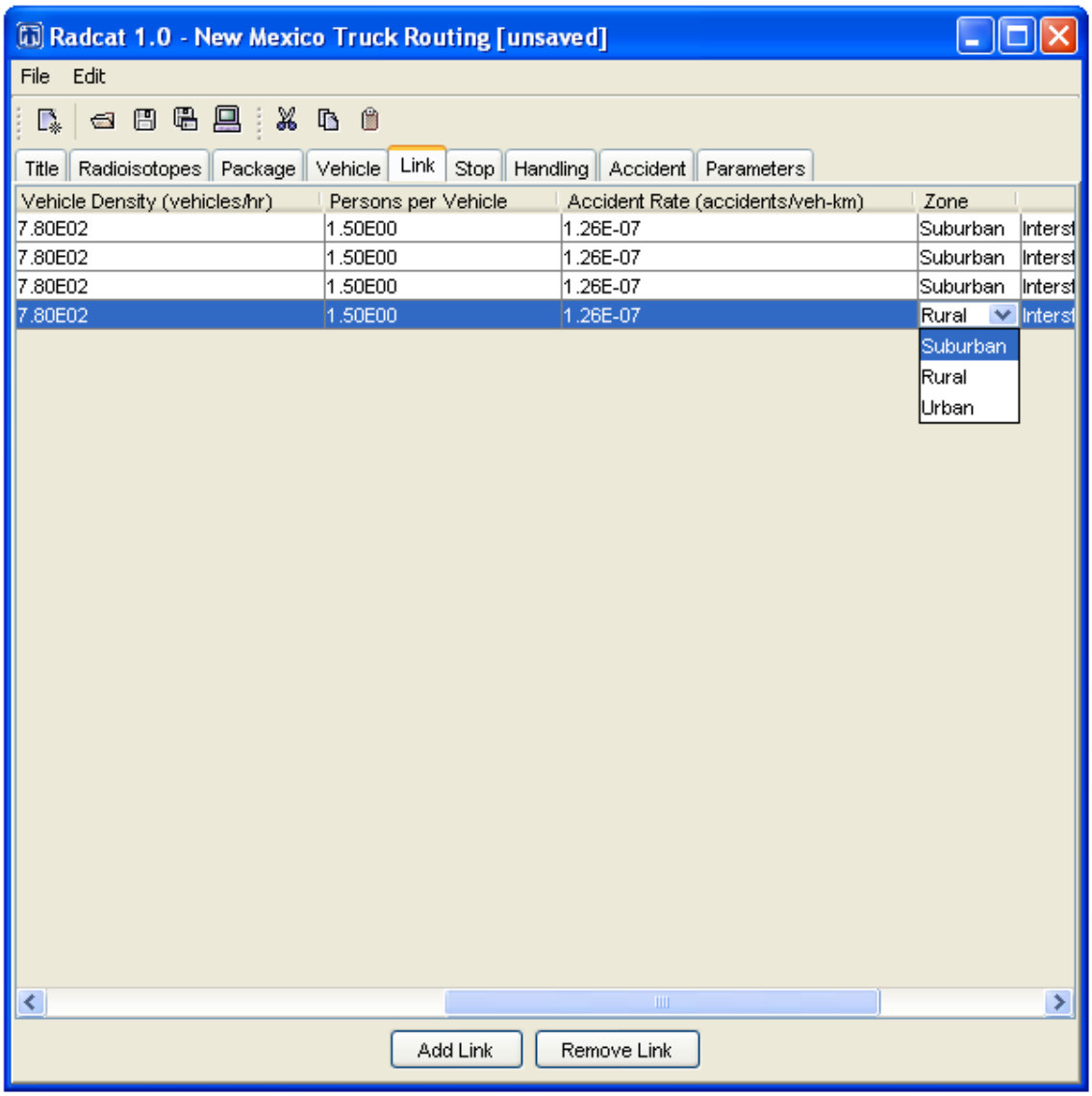


Figure 10: Link Tab Continued

TYPE

A pull-down menu allows you to designate the road type as interstate or U. S. primary, secondary road, or "other," which includes rail and barge. RADTRAN uses this designation. This can be seen in Figure 11.

FARM FRACTION

A fraction of land on rural route segments can be designated as farmland, and is then used in RADTRAN to calculate ingestion dose in the event of an accident. Farmland fractions should be set to zero on suburban or urban route segments. This can be seen in Figure 11.

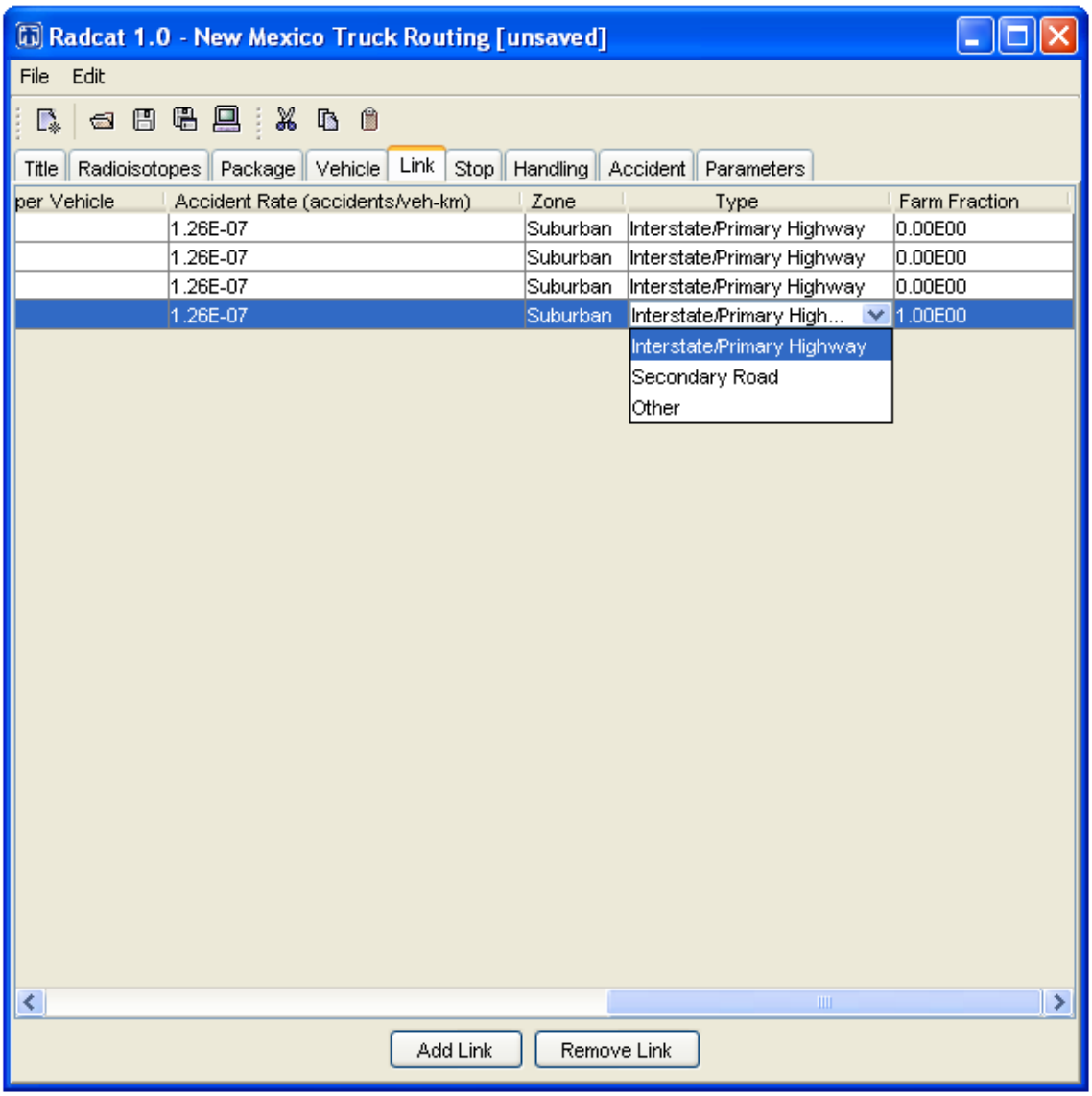


Figure 11: Link Tab with Type and Farm Fraction Cells

STOPS

If you are making a new input file or adding or deleting a vehicle in an existing file, open the **Stop** tab next after the **Link** tab. If you are editing an existing file without adding or deleting a package, the order in which you open the tabs doesn't make any difference. Figure 12 shows the **Stop** tab.

NAME

Give each **Stop** a **Name** in the left-hand column. You can delete what is there and substitute any name that you like. Ensure that there are no spaces in your stop names. You may aggregate all stops of a particular type (e.g., inspection stops, refueling stops) and just enter the total time for those stops. Different types of populations (e.g., other people at a refueling stop, residents near the stop) may be structured as different stops. This can be seen in Figure 12.

VEHICLE

Available vehicle names are on a pull-down menu in the **Vehicle** column. This can be seen in Figure 12. Note that vehicle names cannot be added or deleted at this tab.

MIN DISTANCE

Enter the shortest distance from the radioactive cargo to the receptor(s) whose dose from incident-free transportation you are calculating. This can be seen in Figure 12. The **Min(imum)** and **Max(imum) Distance** define the area around the radioactive cargo in which there are receptors at that particular stop.

MAX DISTANCE

Enter the longest distance from the radioactive cargo to the receptor(s) whose dose from incident-free transportation you are calculating. This can be seen in Figure 12. The **Min(imum)** and **Max(imum) Distance** define the area around the radioactive cargo in which there are receptors at that particular stop. The **Min(imum)** and **Max(imum) Distance** may be the same or may be different(see **People or People/km^2** below). The **Min(imum) Distance** can never be larger than the **Max(imum) Distance.**

PEOPLE OR PEOPLE/KM^2

This parameter defines the number of radiation receptors at each particular stop. If the **Min(imum)** and **Max(imum) Distance** are the same, enter the total number of people at that distance from the radioactive cargo; e.g., if there are 20 people all at 10 meters from the cargo, then enter 10 m for both **Min(imum) Distance** and **Max(imum) Distance**, and enter 20 for **People Or People/Km^2.** On the other hand, if the **Min(imum)** and **Max(imum) Distance** are different, the receptor population must be entered as a population density: persons/km^2, and this population density must be calculated off-line. For example, if there are 20 people around the cargo in an annular ring with a shortest distance to the cargo of 1 m. and a longest distance of 10 m., the population density in this annular ring may be calculated as follows:

Inner radius = 1 m.
Outer radius = 10 m.
Area of annulus = $\pi^*[(10)^2 - (1)^2] = 99\pi = 311 m^2 = 3.11 \times 10^{-4}$ km^2
Population density in the annulus = $20/(3.11 \times 10^{-4}) = 6.43 \times 10^4$ people/ km^2

Enter 1m for **Min(imum) Distance,** 10 m. for **Max(imum) Distance**, and enter 6.43×10^4 for **People Or People/Km^2**.

RADTRAN reads total population when the **Min(imum)** and **Max(imum) Distance** are the same, and reads population density when the **Min(imum)** and **Max(imum) Distance** are different. This can be seen in Figure 12.

SHIELDING FACTOR

The fraction of ionizing radiation to which the receptors are exposed; that is, the inverse of the amount of shielding, so that 1 = no shielding and 0 = 100% shielding. Enter a number between 0 and 1 for the shielding factor for each stop. This can be seen in Figure 12.

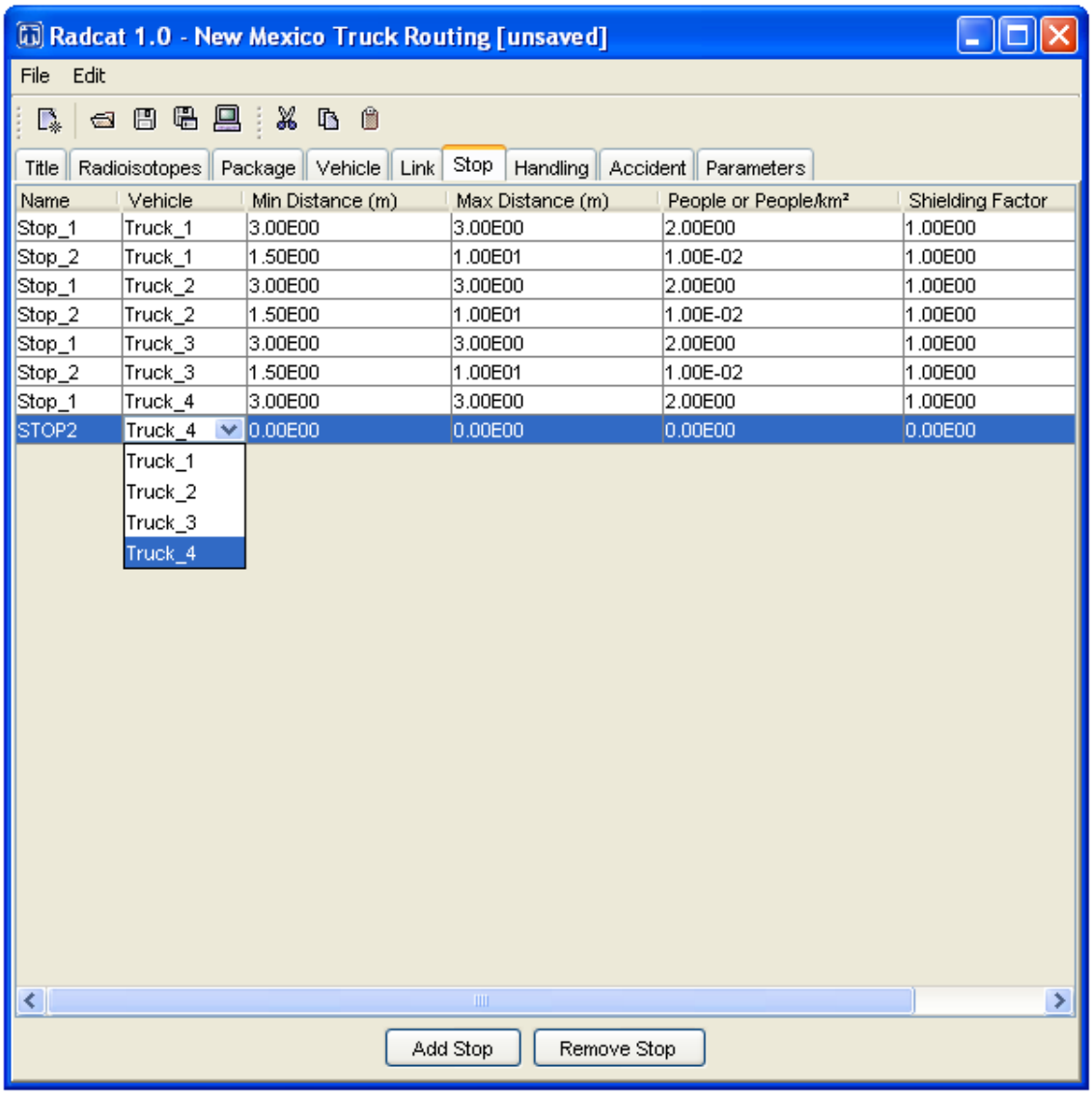


Figure 12: Stop Tab

Time

Enter the total time in hours for each type of stop. This is seen in Figure 13.

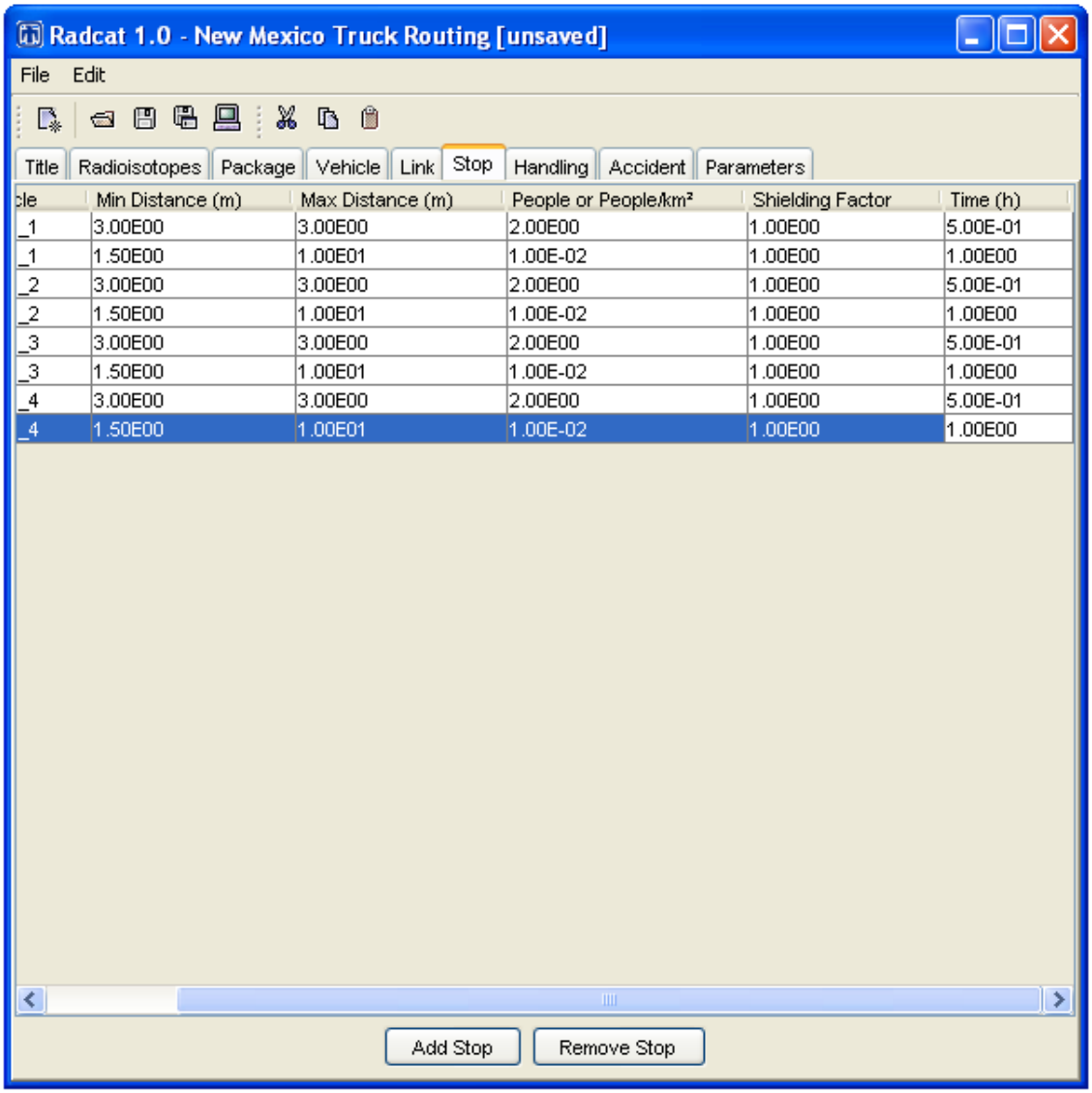


Figure 13: Stop Tab Continued

HANDLING

Handling refers to sustaining a potential dose from the cargo packages during storage, loading, and unloading, and similar activities. Doses to handlers may also be calculated using the **Stop tab** and parameters.

If you are making a new input file or adding or deleting a vehicle in an existing file, open the **Handling** tab after the **Vehicle** tab. If you are editing an existing file without adding or deleting a package, the order in which you open the screens doesn't make any difference. This can be seen in Figure 14.

NAME

Give each group of **Handlers** a **Name** in the left-hand column. Ensure that there are no spaces in your handler names. This can be seen in Figure 14.

VEHICLE

Available vehicle names are on a pull-down menu in the **Vehicle** column. This can be seen in Figure 14. Note that vehicle names cannot be added or deleted at this tab.

NUMBER OF HANDLERS

Enter the number of people in each group of handlers. This can be seen in Figure 14.

DISTANCE

Enter the average distance from the radioactive cargo to the handler group whose dose from incident-free transportation you are calculating. This can be seen in Figure 14.

TIME

Enter the total time in hours that each group of handlers is handling the cargo. This can be seen in Figure 14.

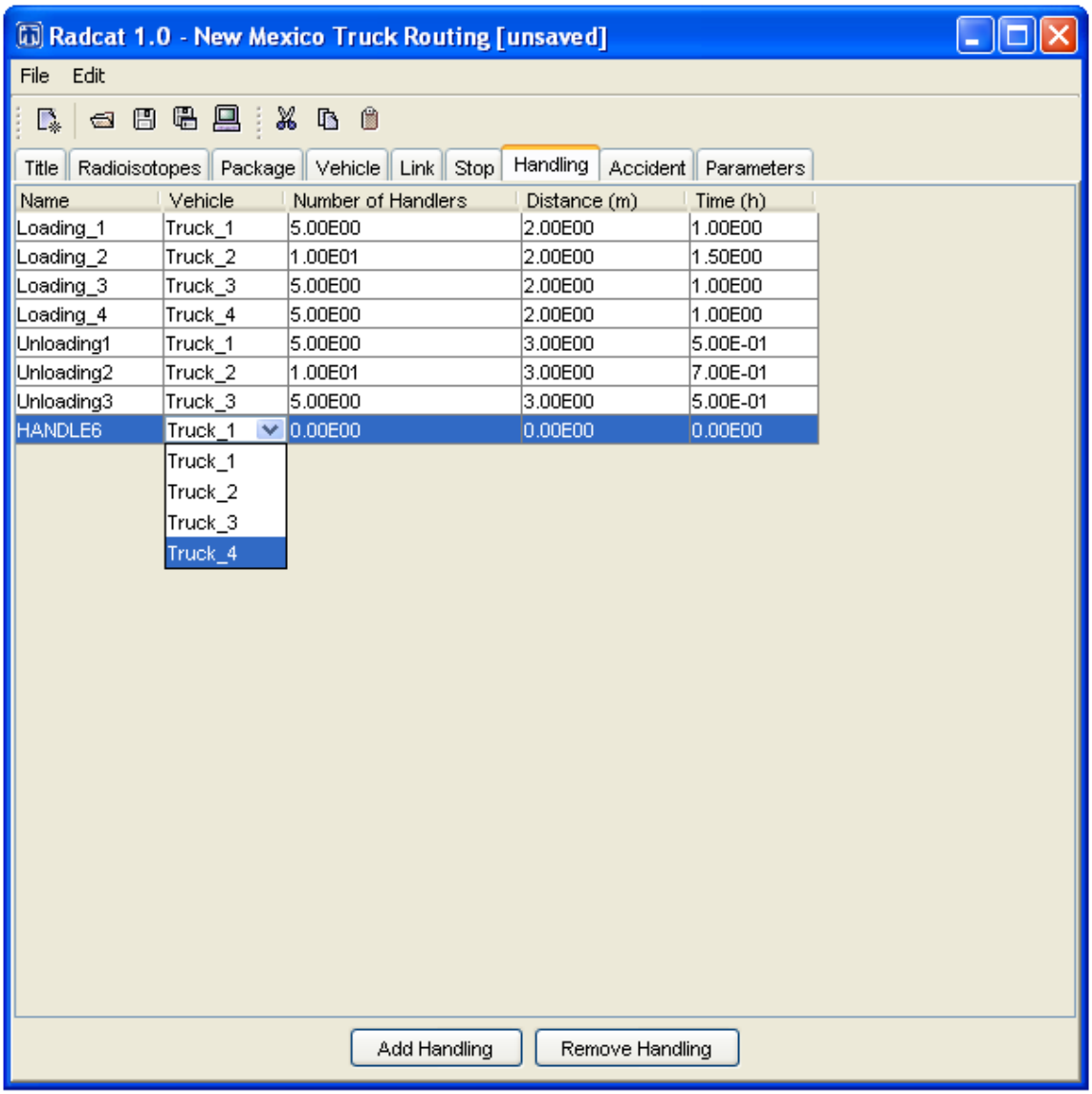


Figure 14: Handling Tab

ACCIDENT

The accident analysis requires that you have entered a radionuclide inventory at the **Radioisotopes** tab, and accident rates and population densities at the **Link** tab. RADTRAN won't crash if you have failed to do this, but all your output will be zero.

When the **Accident** screen is opened, seven screens appear:

Probability
Deposition Velocity
Release
Aerosol
Respirable
Isopleth P
Pasquill/Dispersion

CONDITIONAL PROBABILITIES (SEVERITY FRACTIONS)

Probability is the conditional probability of an accident of a particular severity, given that an accident happens. Severity of an accident – how damaging the accident is – is a function of the transportation mode. This can be seen in Figure 15. A pull-down menu at the top of this screen allows selection of the mode (rail, highway, etc.)

PROBABILITY FRACTION AND INDEX

The **Probability Fraction** is the conditional probability of an accident of a particular severity (other discussions of RADTRAN have called it the "severity fraction"). The **Index** is a numbering system for **Probability Fractions** and simply enumerates them. Note that the **Index** begins with zero. The zeroth **Probability Fraction** is usually more than 90%, because it is the fraction of accidents that do not result in any emission or leakage of radioactive material. This can be seen in Figure 15. **Probability Fractions** may be obtained from studies of accidents like the following references:

Sprung, J.L., et al.. 2000, "Reexamination of Spent Fuel Shipment Risk Estimates," NUREG/CR-6672, Washington, D.C.: U.S. Nuclear Regulatory Commission. Chapter 7, pp. 7-73 to 7-76.

DOE (U.S. Department of Energy), 2002, "Final Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada," DOE/EIS-0250F, Washington, D.C.: U.S. Department of Energy, Office of Civilian Radioactive Waste Management. Appendix J.

Probability Fractions should add to 1.0, though this is sometimes difficult to see with very small probability fractions. RADCAT does not force addition to 1.0. Enter the **Probability Fractions** in the right-hand column. This can be seen in Figure 15.

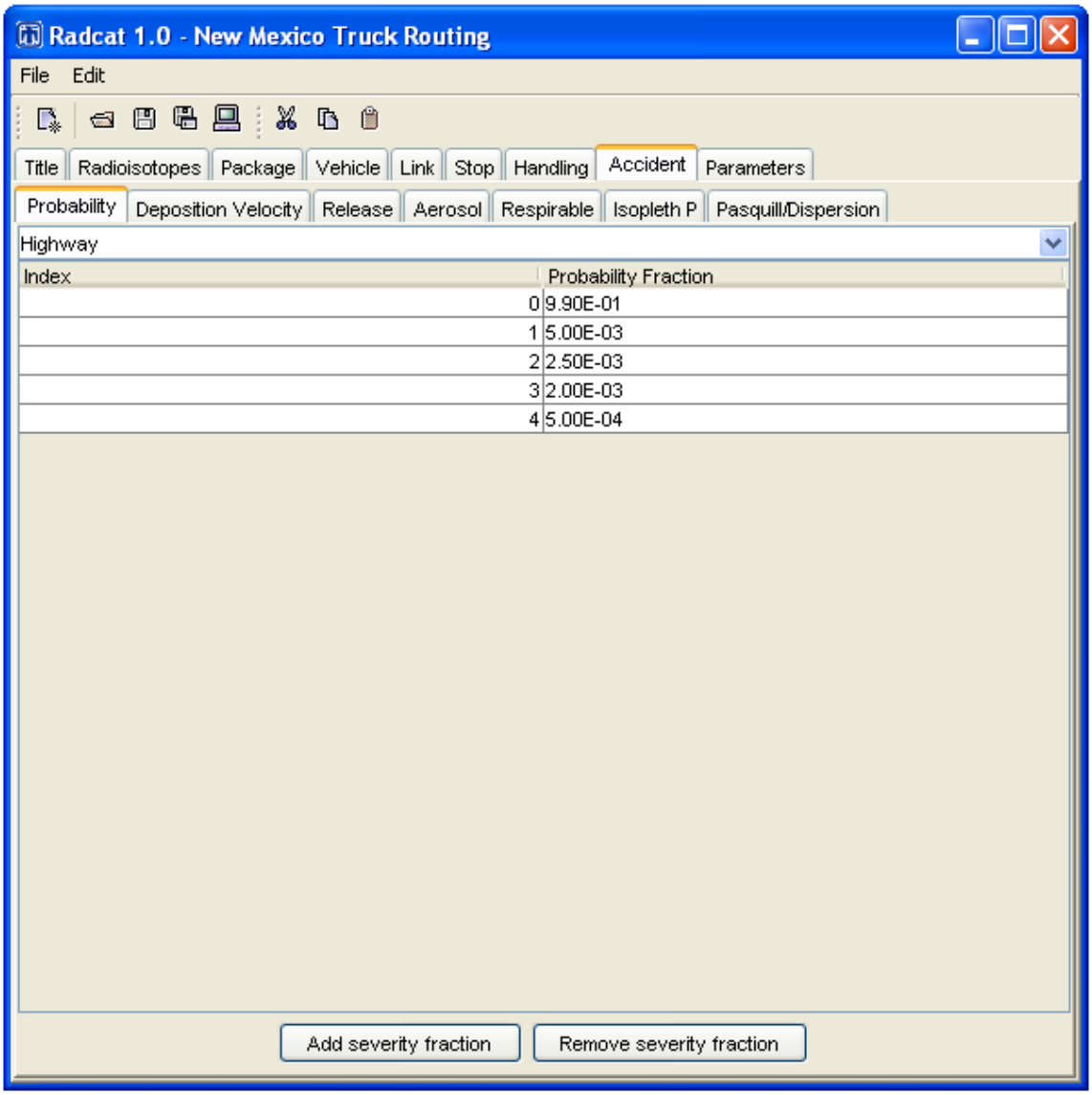


Figure 15: Accident/Probability Tab

DEPOSITION VELOCITY

Deposition Velocity depends on the physical behavior of radionuclides that are emitted into the environment as particles. The **Group** column on the left has a pull-down menu of the physical chemical groups entered at the **Radioisotope** tab. Enter a **Deposition Velocity** in meters/sec for each **Group.** Gases have a **Deposition Velocity** = 0. Small particles often have a **Deposition Velocity** = 0.01 m/sec. **Groups** may not be added or deleted at this screen. This can be seen in Figure 16.

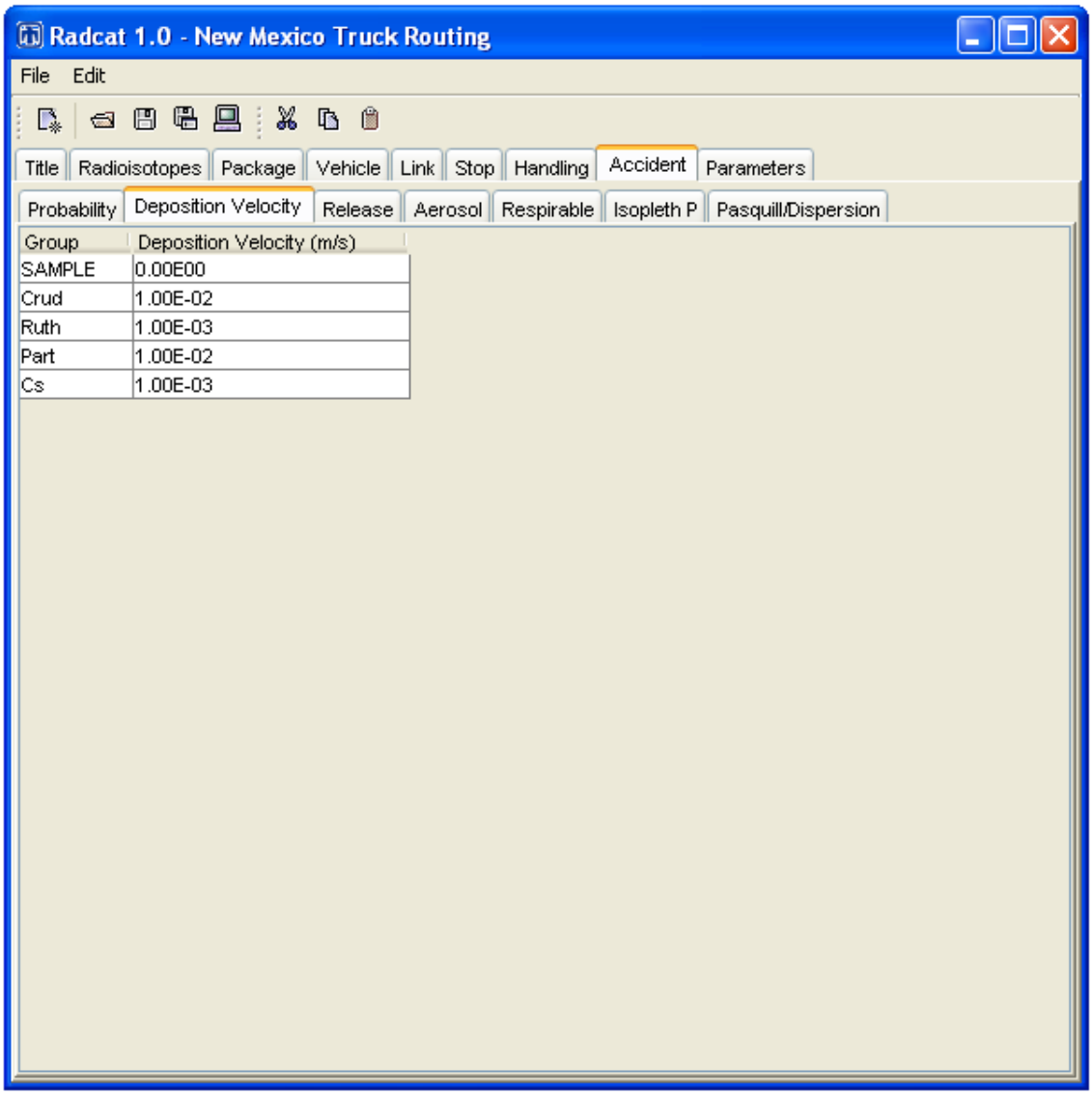


Figure 16: Accident/Deposition Velocity Tab

RELEASE FRACTION

Release Fraction, the fraction of each radionuclide that could be released in an accident, depends on the physical behavior of the radionuclides and on the severity of the accident. The pull-down menu at the top allows selection of the physical/chemical **Group. Groups** may not be added or deleted at this tab. Select a physical/chemical **Group** from the pull-down menu. This can be seen in Figure 17.

The left-hand column shows the **Index** number for each **Probability Fraction.** Enter a **Release Fraction** for each **Index** and each **Group. Indices** may not be added or deleted at this screen.

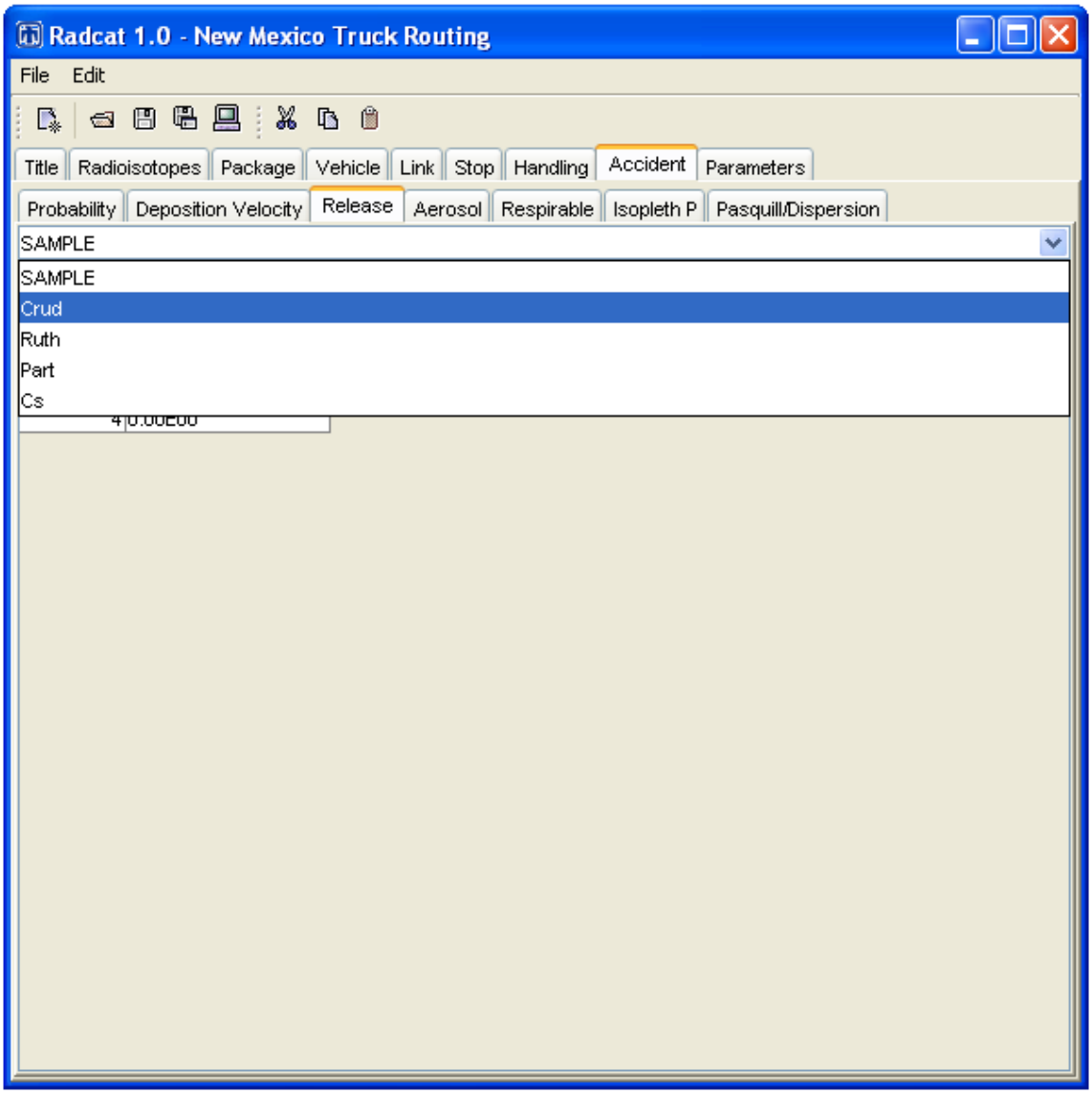


Figure 17: Accident/Release Tab

AEROSOL FRACTION

The **Aerosol Fraction,** the fraction of each **Release Fraction** that would be aerosolized in an accident, depends on the physical behavior of the radionuclides and on the severity of the accident. The pull-down menu at the top allows selection of the physical/chemical **Group. Groups** may not be added or deleted at this tab. Select a physical/chemical **Group** from the pull-down menu. This can be seen in Figure 18.

The left-hand column shows the **Index** number for each **Probability Fraction.** Enter an **Aerosol Fraction** for each **Index** and each **Group.** In most accidents, only very fine particles are released, so that often the **Aerosol Fraction** = 1. **Indices** may not be added or deleted at this screen.

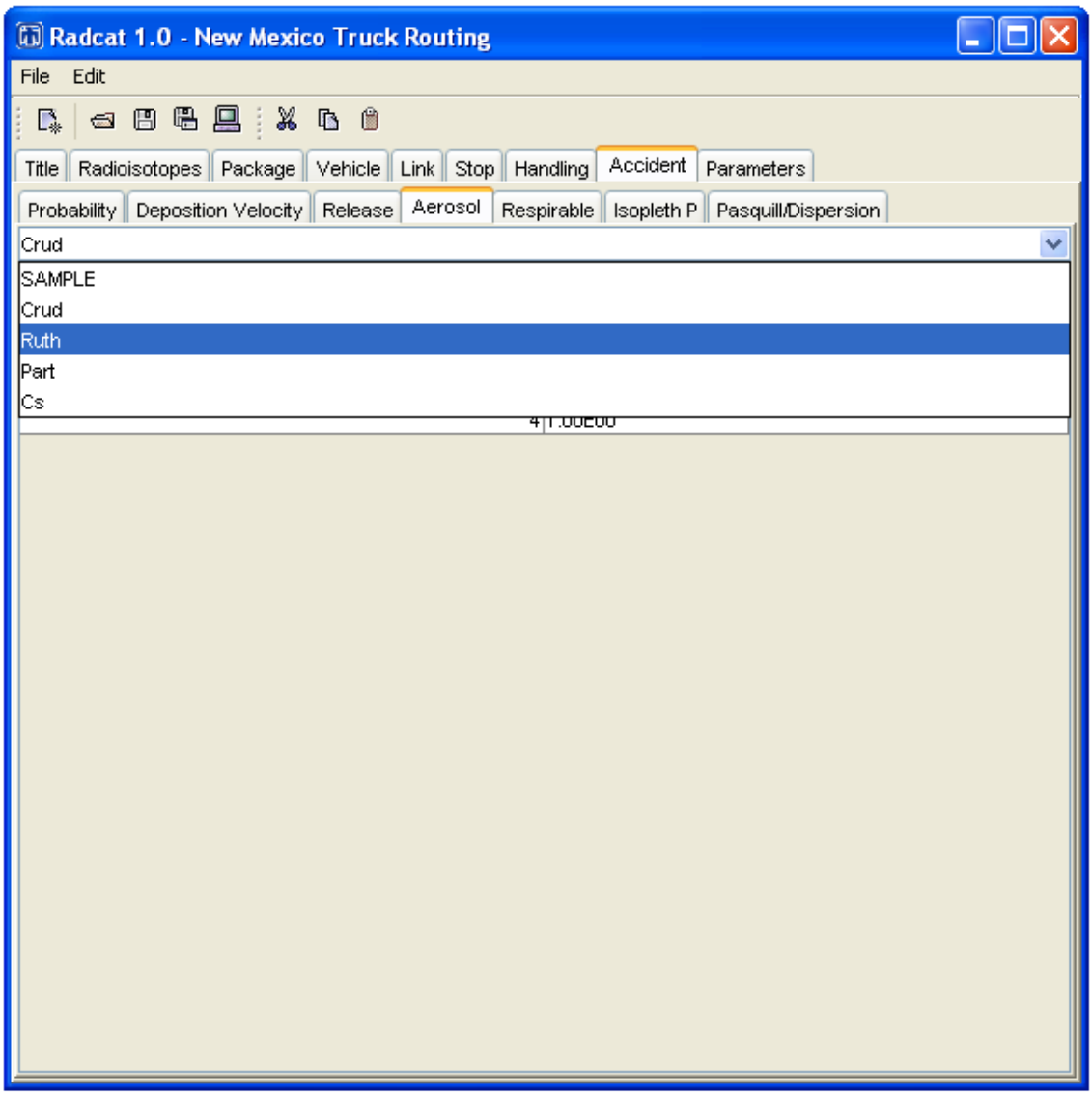


Figure 18: Accident/Aerosol Tab

RESPIRABLE FRACTION

The **Respirable Fraction,** the fraction of each **Aerosol Fraction** that consists of particles or droplets less than 10 microns in diameter, depends on the physical behavior of the radionuclides and on the severity of the accident. The pull-down menu at the top allows selection of the physical/chemical **Group.** **Groups** may not be added or deleted at this tab. Select a physical/chemical **Group** from the pull-down menu. This can be seen in Figure 19.

The left-hand column shows the **Index** number for each **Probability Fraction.** Enter a **Respirable Fraction** for each **Index** and each **Group.** The **Respirable Fraction** is usually between 0.05 and 0.1. **Indices** may not be added or deleted at this screen.

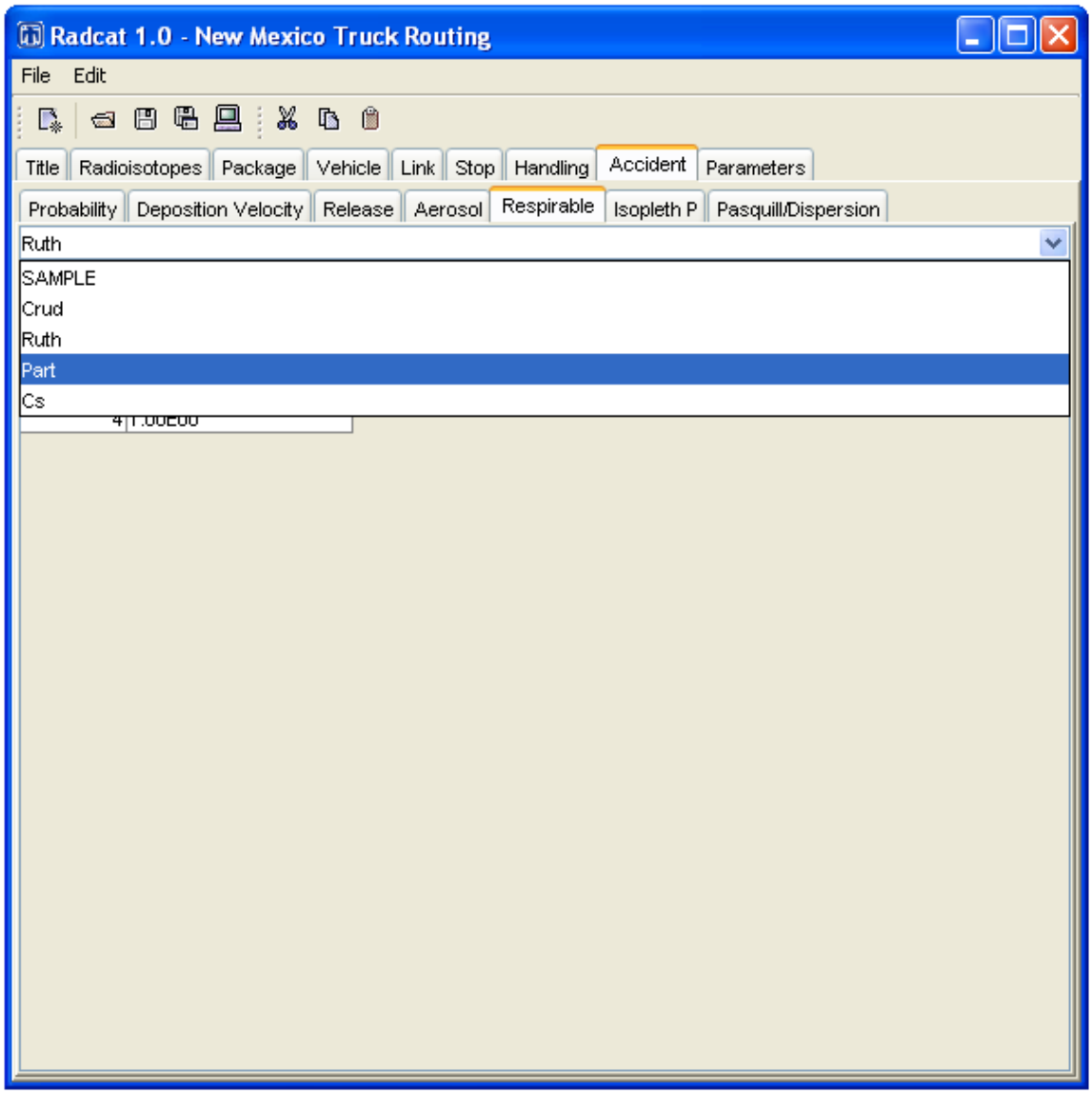


Figure 19: Accident/Respirable Tab

PASQUILL/DISPERSION

Open the **Pasquill/Dispersion** tab before you open the **Isopleth P** tab. Choosing **Dispersion** selects a set of **Isopleth Areas**, maximum **Centerline Distances** for each area, and corresponding **Time Integrated Concentrations** (dilution, or Chi/Q, factors) based on U. S. national average meteorology and wind speed. This can be seen in Figure 20. The number of areas may be added to or withdrawn using the bars at the bottom of the screen. **Isopleth Areas**, maximum **Centerline Distances** for each area, and corresponding **Time Integrated Concentrations** may be calculated externally using any Gaussian dispersion program, and can be entered manually into the table on this screen.

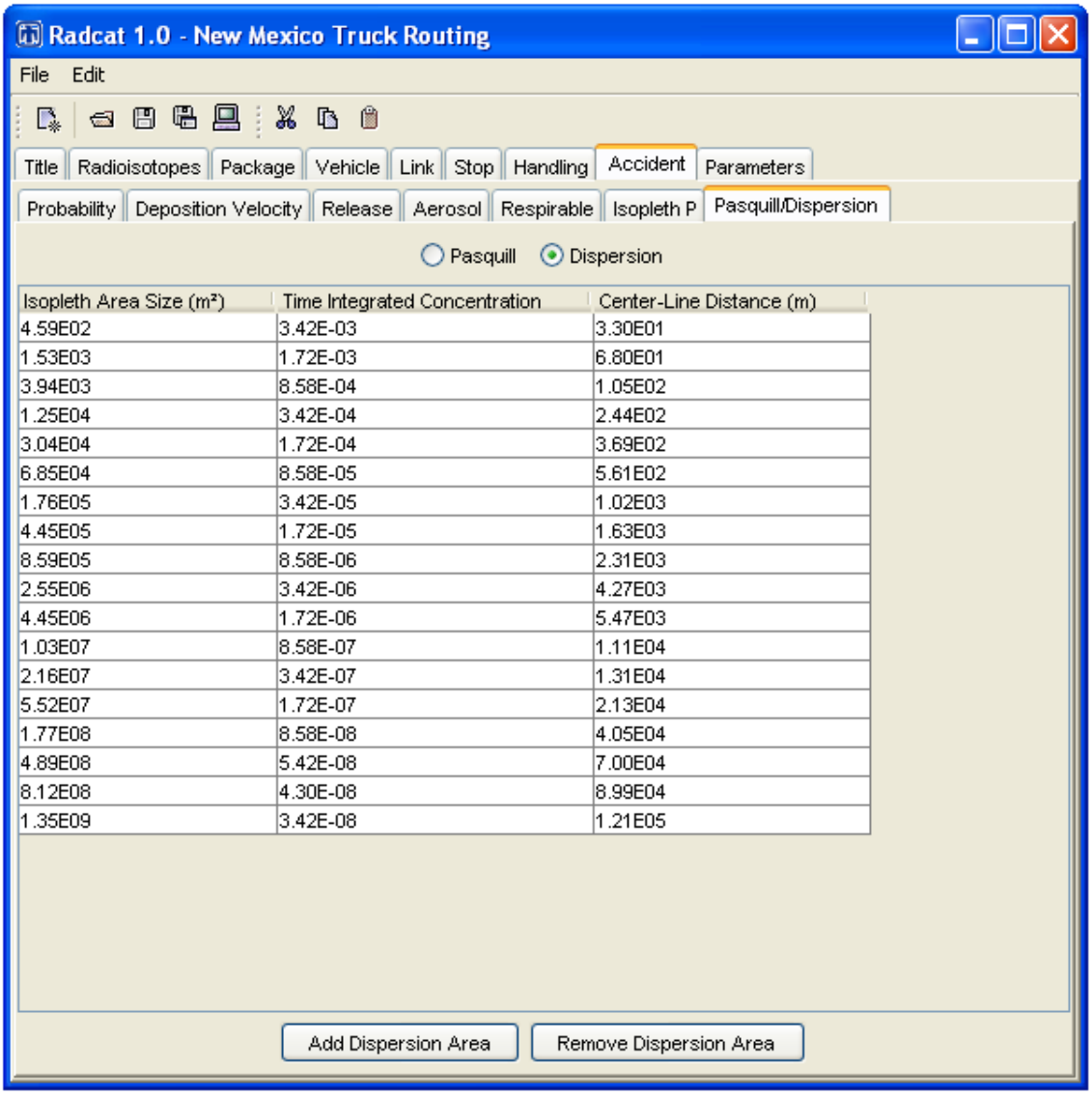


Figure 20: Accident/Pasquill/Dispersion Tab with Dispersion option

Choosing **Pasquill** opens a screen listing the six Pasquill **Stability Classes** in the left-hand **Stability Class** column and allowing the user to enter the **Fraction** of occurrence of each **Stability Class** in the **Fraction** column; these fractions must sum to 1.0. This can be seen in Figure 21. Note that in this option, wind speeds are constant for each **Stability Class,** as shown in the table below:

Stability Class	**Wind Speed (m/sec)**
A	1
B	2
C	3
D	4
E	2.5
F/G	1

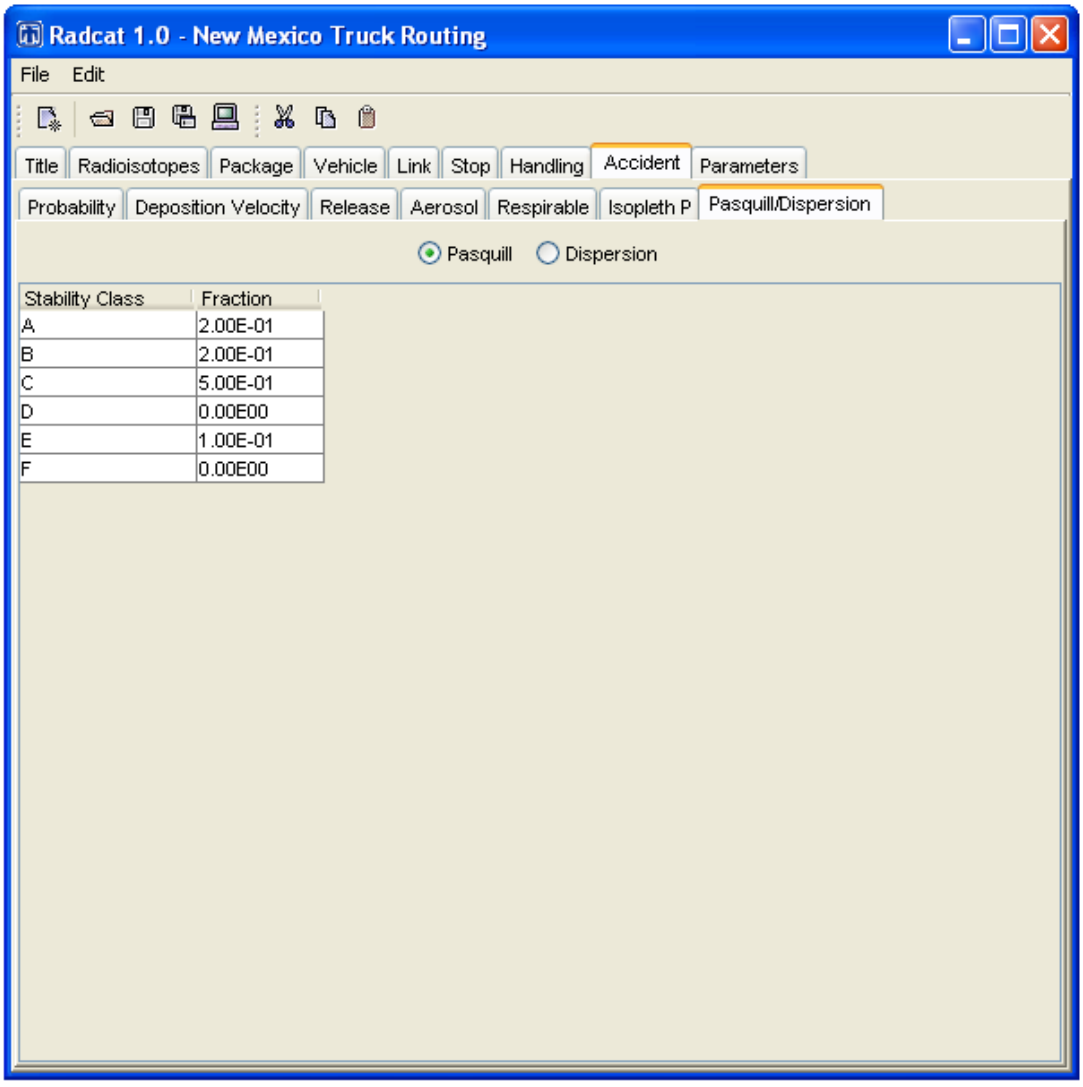


Figure 21: Accident/Pasquill/Dispersion Tab with Pasquill option

ISOPLETH P

Open the **Pasquill/Dispersion** tab before you open the **Isopleth P** tab. **Isopleth P** allows you to enter a different population density for each isopleth area. Be sure to enter the same number in all three columns (rural, suburban, and urban). This is a bug in RADCAT that is being fixed. This can be seen in Figure 22. **Isopleth P** may only be used with the **Dispersion** option on the **Pasquill/Dispersion** screen. Note that isopleth areas may not be added to or withdrawn at this screen.

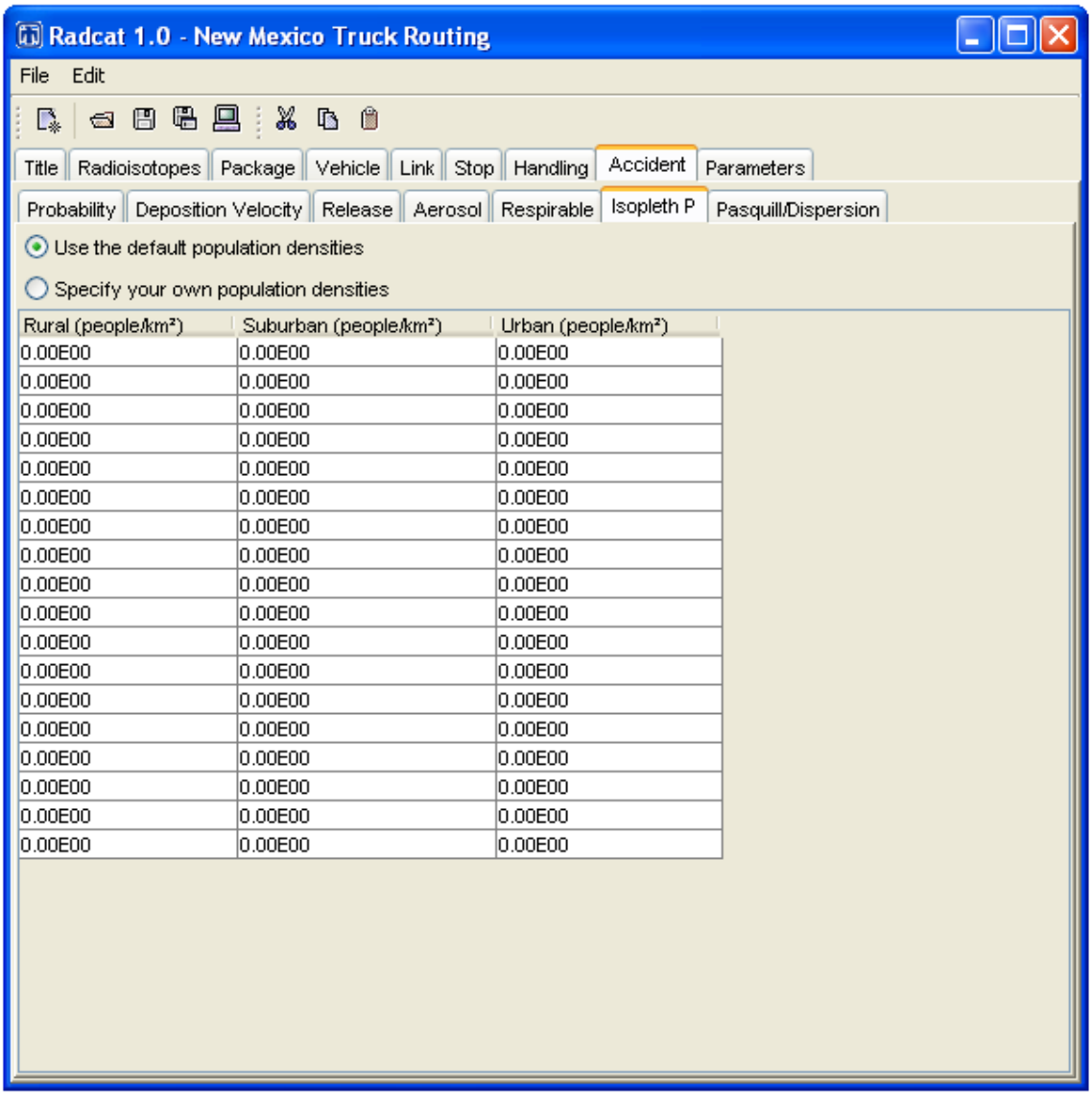


Figure 22: Accident/Isopleth P Tab

PARAMETERS

This screen lists values that have historically been used in RADTRAN for a variety of parameters. Any of these values can be overwritten by the user.

Shielding factor for residences

Enter a factor between 0 and 1 for rural, suburban, and urban residence shielding, respectively. This factor is the fraction of ionizing radiation to which rural residents are exposed to in their homes or other buildings in this zone. The inverse of the shielding fraction is used, so that 1 = no shielding, and 0 = 100% shielding. This can be seen in Figure 23. The STANDARD value is 1.0 (i.e., no shielding) for rural buildings, 0.87 for suburban buildings, and 0.018 for urban buildings.

Fraction of outside air in urban buildings

This is the fraction of aerosol particles in outside air entrained in building ventilation systems (i.e, the fraction of particles of an external aerosol that remain in aerosol form after passing through a ventilation system). This is the fraction of aerosolized particles, from a potential accidental release of RAM, that people in urban structures are exposed to, and which is used to calculate the inhalation and resuspension dose to that population. The STANDARD value of 0.05 represents a conservative average across a series of building types, including residential, office, and industrial structures (Engelmann, 1990). This value is about five times higher than the value for high-rise buildings with air-conditioning systems used by Finley et al., (1980) for New York City, which has been used in RADTRAN in the past. This can be seen in Figure 23.

Fraction of population outside buildings

The STANDARD value is 0.9 and represents the fraction of the total population that is outside the buildings in rural, suburban, and urban zones. This can be seen in Figure 23.

Fraction of population inside buildings

The STANDARD value is 0.1 and represents the fraction of the total population that is inside the buildings in rural, suburban, and urban zones. This can be seen in Figure 23.

Ratio of pedestrians/km^2 to residential population/km^2

This ratio is used to calculate the density of unshielded persons on sidewalks and elsewhere in urban areas by indexing it to the population density of the surrounding area. This ratio can also serve as the ratio of non-resident (e.g., tourist) urban population to resident urban population, since the U. S. Census includes only resident population. The STANDARD value is 6.0, which is based on empirical data from New York City (Finley et al., 1980).

Minimum small package dimension for handling

This parameter specifies the first Package Size Threshold. In RADTRAN, This parameter determines the calculation of handler dose. If a package is designated as “small,” i.e., smaller than the STANDARD threshold, the dose to the handler is calculated as originating in a uniform source. If package dimensions exceed the threshold, handler dose is calculated as directly proportional to exposure time and inversely proportional to the square of the distance from package to handler. The STANDARD value is 0.5 (Javitz, 1985). This can be seen in Figure 23.

Number of flight attendants for passenger air

This parameter is applied to passenger-air mode only and specifies the number of flight attendants. The STANDARD value is 4 (NRC 1977). This can be seen in Figure 23.

Minimum number of rail classification stops

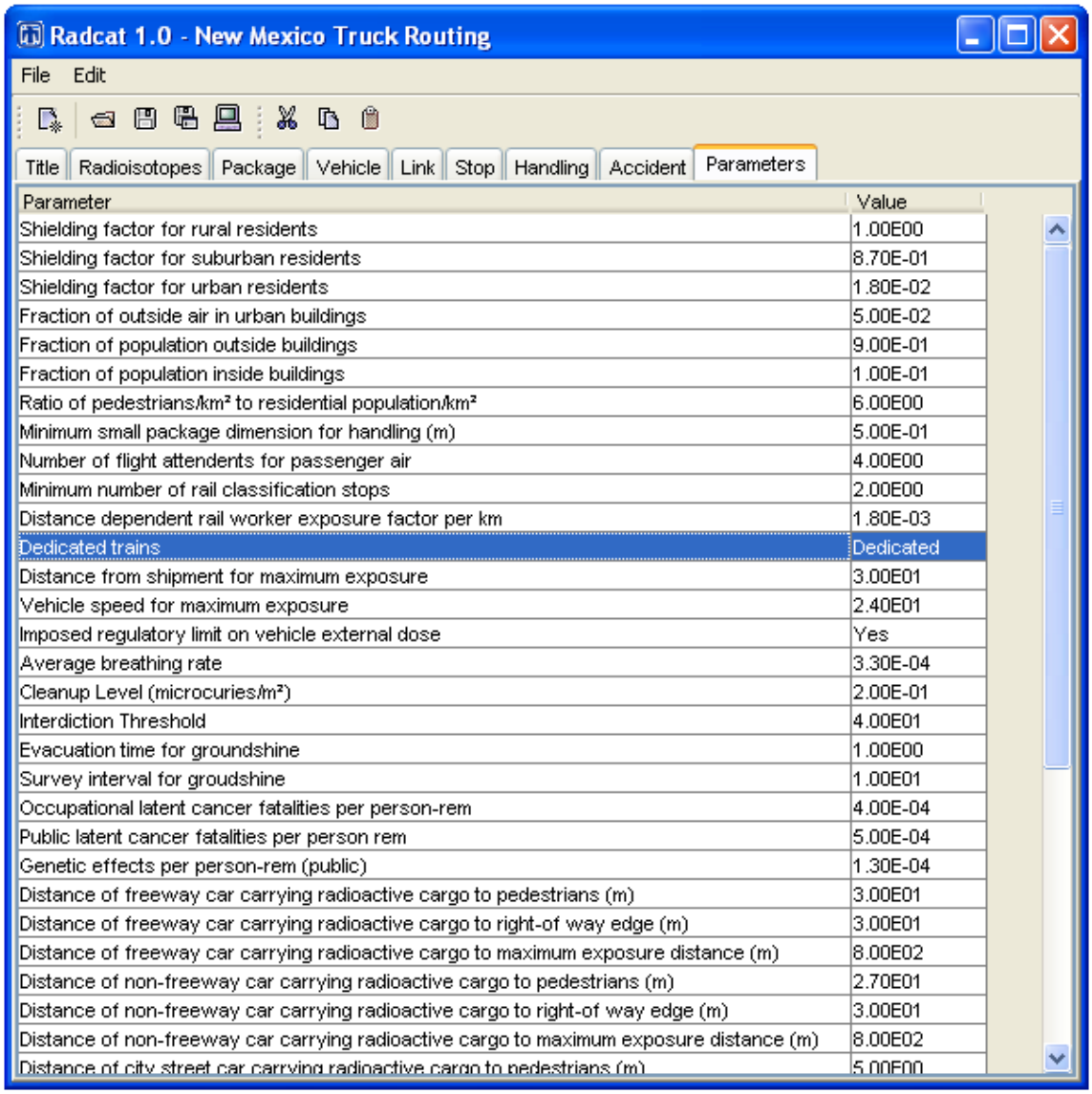
This applies to rail mode only and specifies the minimum number of railcar classifications per trip. The STANDARD value is 2 since there are at least two inspections per trip – one at the beginning and one at the end of each trip (Wooden 1986). When the origin of a rail shipment is very different from its destination, it may be useful to change the value to 1. The collective dose to railyard workers at a 30-hour classification stop has been integrated into RADTRAN, and is multiplied by this number to give the dose to these workers at classification stops. The dose is the weighted sum of the doses for all close-proximity railyard worker groups, and are calculated primarily with a line-source model, though a point-source model is used when appropriate. For general freight, dose is calculated with the modifying factors b_1 through b_7, which have units of personhr/km and are derived from Wooden (1987) as described in Appendix B of the RADTRAN 5 Technical Manual (Neuhauser, et al, 2000). This can be seen in Figure 23.

Distance dependant rail worker exposure factor per km

This parameter applies to rail mode only. It is used to calculate the component of rail-worker dose that depends on distance traveled (e.g., exposure related to stops between the shipment origin and destination). The STANDARD value of 0.0018 inspections/km is taken from Ostmeyer (1986). The 30-hour collective railyard worker dose is multiplied by this number and by the total shipment distance in kilometers to give the in-transit railyard worker dose.

Dedicated Trains

This is only used for rail mode. It denotes whether the shipment is by general freight or key trains (**NO**) or by dedicated rail (**YES**). The STANDARD setting is **NO**. This can be seen in Figure 23. The main difference between the two options is the exposures of rail workers in rail yards. For dedicated rail, worker dose is calculated with factors b_8 through b_{11} of Appendix B of the RADTRAN 5 Technical Manual (Neuhauser, et al, 2000).



Parameter	Value
Shielding factor for rural residents	1.00E00
Shielding factor for suburban residents	8.70E-01
Shielding factor for urban residents	1.80E-02
Fraction of outside air in urban buildings	5.00E-02
Fraction of population outside buildings	9.00E-01
Fraction of population inside buildings	1.00E-01
Ratio of pedestrians/km² to residential population/km²	6.00E00
Minimum small package dimension for handling (m)	5.00E-01
Number of flight attendents for passenger air	4.00E00
Minimum number of rail classification stops	2.00E00
Distance dependent rail worker exposure factor per km	1.80E-03
Dedicated trains	Dedicated
Distance from shipment for maximum exposure	3.00E01
Vehicle speed for maximum exposure	2.40E01
Imposed regulatory limit on vehicle external dose	Yes
Average breathing rate	3.30E-04
Cleanup Level (microcuries/m²)	2.00E-01
Interdiction Threshold	4.00E01
Evacuation time for groundshine	1.00E00
Survey interval for groudshine	1.00E01
Occupational latent cancer fatalities per person-rem	4.00E-04
Public latent cancer fatalities per person rem	5.00E-04
Genetic effects per person-rem (public)	1.30E-04
Distance of freeway car carrying radioactive cargo to pedestrians (m)	3.00E01
Distance of freeway car carrying radioactive cargo to right-of way edge (m)	3.00E01
Distance of freeway car carrying radioactive cargo to maximum exposure distance (m)	8.00E02
Distance of non-freeway car carrying radioactive cargo to pedestrians (m)	2.70E01
Distance of non-freeway car carrying radioactive cargo to right-of way edge (m)	3.00E01
Distance of non-freeway car carrying radioactive cargo to maximum exposure distance (m)	8.00E02
Distance of city street car carrying radioactive cargo to pedestrians (m)	5.00E00

Figure 23: Parameters Tab

Distance from shipment for maximum exposure

This parameter is used to calculate the maximum individual “in-transit” off-link dose to a member of the public. It represents the minimum perpendicular distance, in meters, from the shipment centerline to an individual standing beside the route right-of-way while a shipment passes. The STANDARD value is 30.0 meters (NRC, 1977). This can be seen in Figure 23.

Vehicle speed for maximum exposure

This parameter is used to calculate the maximum individual “in-transit” dose. It represents the minimum velocity, in km/hr, of a shipment. The STANDARD value is 24.0 km/hr (15mph) (NRC, 1977). This can be seen in Figure 23.

Imposed regulatory limit on vehicle external dose

The STANDARD setting is "**YES"** which causes a series of regulatory checks to be performed. If any circumstances are identified that violate the regulatory requirements (e.g., package dose rate exceeds regulatory maximum), then the appropriate parameter values are reset to the regulatory maximum and the calculation continues. A message informing the analyst is printed in the output. The analyst may adjust the setting to "**NO**" which will bypass the regulatory check subroutine, and ensure that the package dose rate and package critical dimension used in RADTRAN calculations are those that the analyst has INPUT. This can be seen in Figure 23.

Average breathing rate

This parameter represents breathing rate and is used for calculation of inhalation doses. The STANDARD is 3.30E-04 m^3/sec. This breathing rate is taken from the Reference Man (70-kg adult male at light work derived from Shleien 1992; Table 12.6). The value in the cited table has been converted from liters per hour to m^3/sec. This can be seen in Figure 23.

Cleanup Level

This parameter is the desired concentration, in microcuries/m^2, to which a contaminated surface should be cleaned. The parameter is the sum of deposited activity over all radionuclides of a multi-radionuclide material. The STANDARD value is the EPA guidance of 0.2 uCi/m^2 (EPA, 1977). This can be seen in Figure 23.

Interdiction Threshold

This parameter specifies the threshold value for interdiction of contaminated land. The STANDARD value is 40, i.e., a value 40 times greater than the **Cleanup Level**, and it was taken from NUREG-0170 (NRC, 1977). This can be seen in Figure 23.

Evacuation time for groundshine

This parameter specifies evacuation time in days following a dispersal accident. The STANDARD value is 1.0 day (24 hours). Mills et al. (1995) analyzed 66 verified hazmat accidents in which evacuations were carried out and found that the mean evacuation time was approximately one hour. This can be seen in Figure 23.

Survey interval for groundshine

This parameter is used to specify the time (in days) required to survey contaminated land following a dispersal accident. The STANDARD value is 10 days (NRC, 1977). This can be seen in Figure 23.

Occupational latent cancer fatalities per person-REM

This parameter specifies the occupational Latent Cancer Fatality (LCF) conversion factor; units are LCFs per REM. The STANDARD value for workers is 4.0E-04 LCF/REM. This value is consistent with the recommendations of BEIR V (NRC/NAS, 1990) and ICRP 60 (ICRP, 1991). The dose-response relationship is assumed to be a linear with no threshold in order to agree with current regulations. This can be seen in Figure 23.

Public latent cancer fatalities per person-REM

This parameter specifies the Latent Cancer Fatality (LCF) conversion factor for non-occupational public exposure; units are LCFs per REM. The STANDARD value for the public is 5.0E-04 LCF/REM. This value is consistent with the recommendations of BEIR V (NRC/NAS, 1990) and ICRP 60 (ICRP, 1991). The dose-response relationship is assumed to be a linear with no threshold in order to agree with current regulations. This can be seen in Figure 23.

Genetic effects per person-REM (public)

This parameter specifies the Genetic Effects Conversion Factor (GECF). The STANDARD value is 1.0E-04 genetic effects/REM. This value is consistent with the recommendations of BEIR V (NRC/NAS, 1990) and ICRP 60 (ICRP, 1991). This can be seen in Figure 24.

Distance of freeway vehicle carrying radioactive cargo to pedestrians

The STANDARD value is 30 meters and is taken from NUREG-0170(NRC, 1977). This parameter is the minimum pedestrian-walkway width, for instances in which does to pedestrians beside the link is calculated. This parameter is the minimum perpendicular distance over which the off-link dose calculation will be integrated. This can be seen in Figure 24. A freeway is any limited-access divided highway.

Distance of freeway vehicle carrying radioactive cargo to right-of-way edge

The STANDARD value is 30 meters and is taken from NUREG-0170 (NRC, 1977). This parameter is the maximum pedestrian-walkway width. This parameter is set equal to **Distance of freeway car carrying radioactive cargo to pedestrians**. This means that the sidewalk width is zero and thus there is no sidewalk available. This can be seen in Figure 24. A freeway is any limited-access divided highway.

Distance of freeway vehicle carrying radioactive cargo to maximum exposure distance

The STANDARD value is 800 meters and is taken from NUREG-0170 (NRC, 1977). This parameter is the maximum perpendicular distane over which the off-link dose calculations will be integrated. This can be seen in Figure 24. A freeway is any limited-access divided highway.

Distance of non-freeway vehicle carrying radioactive cargo to pedestrians

The STANDARD value is 27 meters and is taken from NUREG-0170(NRC, 1977). This parameter is the minimum pedestrian-walkway width, for instances in which doses to pedestrians beside the link is calculated. This parameter is the minimum perpendicular distance over which the off-link dose calculation will be integrated. This can be seen in Figure 24. A non-freeway is any non-limited-access highway that is not a city street.

Distance of non-freeway vehicle carrying radioactive cargo to right-of-way edge

The STANDARD value is 30 meters and is taken from NUREG-0170 (NRC, 1977). This parameter is the maximum pedestrian-walkway width. This parameter is set 3 meters greater than to **Distance of non-freeway vehicle carrying radioactive cargo to pedestrians**. This means that the sidewalk width is 3 meters and will thus allow for an off-link dose to be calculated to unshielded persons (pedestrians, bicyclists, ect.) where they may reasonably be expected to be found. This can be seen in Figure 24. A non-freeway is any non-limited-access highway that is not a city street.

Distance of non-freeway vehicle carrying radioactive cargo to maximum exposure distance

The STANDARD value is 800 meters and is taken from NUREG-0170 (NRC, 1977). This parameter is the maximum perpendicular distance over which the off-link dose calculations will be integrated. This can be seen in Figure 24. A non-freeway is any non-limited-access highway that is not a city street.

Distance of city street vehicle carrying radioactive cargo to pedestrians

The STANDARD value is 5 meters and is taken from NUREG-0170(NRC, 1977). This parameter is the minimum pedestrian-walkway width, for instances in which does to pedestrians beside the link is calculated. This parameter is the minimum perpendicular distance over which the off-link dose calculation will be integrated. This can be seen in Figure 24. A city street is any city street.

Distance of city street vehicle carrying radioactive cargo to right-of-way edge

The STANDARD value is 8 meters and is taken from NUREG-0170 (NRC, 1977). This parameter is the maximum pedestrian-walkway width. This parameter is set 3 meters greater than to **Distance of city street car carrying radioactive cargo to pedestrians**. This means that the sidewalk width is 3 meters and will thus allow for an off-link dose to be calculated to unshielded persons (pedestrians, bicyclists, ect.) where they may reasonably be expected to be found. This can be seen in Figure 24. A city street is any city street.

Distance of city street vehicle carrying radioactive cargo to maximum exposure distance

The STANDARD value is 800 meters and is taken from NUREG-0170 (NRC, 1977). This parameter is the maximum perpendicular distane over which the off-link dose calculations will be integrated. This can be seen in Figure 24. A city street is any city street.

Distance of rail car carrying radioactive cargo to pedestrians

The STANDARD value is 30 meters and is taken from NUREG-0170(NRC, 1977). This parameter is the minimum perpendicular distance over which the off-link dose calculation will be integrated. This parameter is the minimum pedestrian-walkway width, for instances in which does to pedestrians beside the link is calculated. This can be seen in Figure 24. A rail route is any rail right-of-way in the U.S.

Distance of rail car carrying radioactive cargo to right-of-way edge

The STANDARD value is 30 meters and is taken from NUREG-0170 (NRC, 1977). This parameter is the maximum pedestrian-walkway width. This parameter is set equal to **Distance of rail car carrying radioactive cargo to pedestrians**. This means that the sidewalk width is zero and thus there is no sidewalk available. This can be seen in Figure 24. A route is any rail right-of-way in the U.S.

Distance of rail car carrying radioactive cargo to maximum exposure distance

The STANDARD value is 800 meters and is taken from NUREG-0170 (NRC, 1977). This parameter is the maximum perpendicular distance over which the off-link dose calculations will be integrated. This can be seen in Figure 24. A rail route is any rail right-of-way in the U.S.

Distance of waterway barge carrying radioactive cargo to pedestrians

The STANDARD value is 200 meters and is taken from NUREG-0170(NRC, 1977). This parameter is the minimum pedestrian-walkway width, for instances in which does to pedestrians beside the link is calculated. This parameter is the minimum perpendicular distance over which the off-link dose calculation will be integrated. This can be seen in Figure 24.

Distance of waterway barge carrying radioactive cargo to right-of-way edge

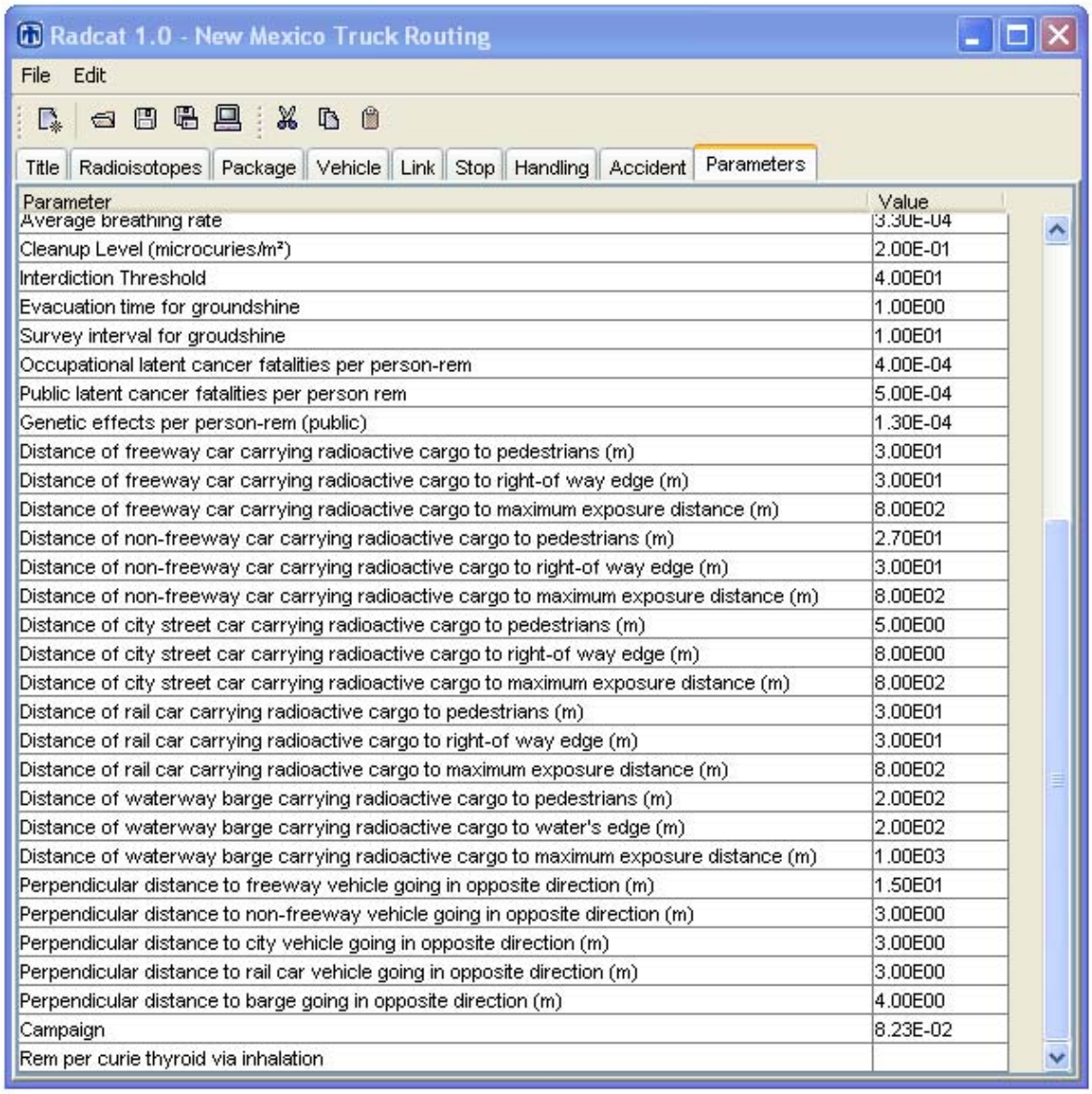
The STANDARD value is 200 meters and is taken from NUREG-0170 (NRC, 1977). This parameter is the maximum pedestrian-walkway width. This parameter is set equal to **Distance of waterway barge carrying radioactive cargo to pedestrians**. This means that the sidewalk width is zero and thus there is no sidewalk available. This can be seen in Figure 24.

Distance of waterway barge carrying radioactive cargo to maximum exposure distance

The STANDARD value is 1000 meters and is taken from NUREG-0170 (NRC, 1977). This parameter is the maximum perpendicular distance over which the off-link dose calculations will be integrated. This can be seen in Figure 24.

Perpendicular distance to freeway vehicle going in the opposite direction

The STANDARD value is 15 meters and is taken from Madsen et al. (1986 p. 36-37). This can be seen in Figure 24. This parameter specifies the perpendicular distance (i.e. a distance measured along a ling at right angles to the line of travel of the RAM shipment) between the RAM shipment and other traffic lanes, in meters. This is an average perpendicular distance between the shipment centerline and the centerline of oncoming traffic lanes. This value is based on a minimal Interstate configuration of four lanes with an average lane width of 5 meters, in the most typical traffic configuration. The latter refers to the RAM shipment being in the outside lane, oncoming traffic in the corresponding outside lane, and passing vehicles in the inner lanes. A freeway is any limited-access divided highway.



Parameter	Value
Average breathing rate	3.3UE-04
Cleanup Level (microcuries/m²)	2.00E-01
Interdiction Threshold	4.00E01
Evacuation time for groundshine	1.00E00
Survey interval for groudshine	1.00E01
Occupational latent cancer fatalities per person-rem	4.00E-04
Public latent cancer fatalities per person rem	5.00E-04
Genetic effects per person-rem (public)	1.30E-04
Distance of freeway car carrying radioactive cargo to pedestrians (m)	3.00E01
Distance of freeway car carrying radioactive cargo to right-of way edge (m)	3.00E01
Distance of freeway car carrying radioactive cargo to maximum exposure distance (m)	8.00E02
Distance of non-freeway car carrying radioactive cargo to pedestrians (m)	2.70E01
Distance of non-freeway car carrying radioactive cargo to right-of way edge (m)	3.00E01
Distance of non-freeway car carrying radioactive cargo to maximum exposure distance (m)	8.00E02
Distance of city street car carrying radioactive cargo to pedestrians (m)	5.00E00
Distance of city street car carrying radioactive cargo to right-of way edge (m)	8.00E00
Distance of city street car carrying radioactive cargo to maximum exposure distance (m)	8.00E02
Distance of rail car carrying radioactive cargo to pedestrians (m)	3.00E01
Distance of rail car carrying radioactive cargo to right-of way edge (m)	3.00E01
Distance of rail car carrying radioactive cargo to maximum exposure distance (m)	8.00E02
Distance of waterway barge carrying radioactive cargo to pedestrians (m)	2.00E02
Distance of waterway barge carrying radioactive cargo to water's edge (m)	2.00E02
Distance of waterway barge carrying radioactive cargo to maximum exposure distance (m)	1.00E03
Perpendicular distance to freeway vehicle going in opposite direction (m)	1.50E01
Perpendicular distance to non-freeway vehicle going in opposite direction (m)	3.00E00
Perpendicular distance to city vehicle going in opposite direction (m)	3.00E00
Perpendicular distance to rail car vehicle going in opposite direction (m)	3.00E00
Perpendicular distance to barge going in opposite direction (m)	4.00E00
Campaign	8.23E-02
Rem per curie thyroid via inhalation	

Figure 24: Parameters Tab Continued

Perpendicular distance to non-freeway vehicle going in the opposite direction

The STANDARD value is 3 meters and is taken from Madsen et al. (1986 p. 36-37). This can be seen in Figure 24. This parameter specifies the perpendicular distance (i.e. a distance measured along a line at right angles to the line of travel of the RAM shipment) between the RAM shipment and other traffic lanes, in meters. This is an average perpendicular distance between the shipment centerline and the centerline of oncoming traffic lanes. This value is based on a minimal road configuration of two lanes with an average lane width of 3 meters, in the most typical traffic configuration. A non-freeway is any non-limited-access highway that is not a city street.

Perpendicular distance to city vehicle going in the opposite direction

The STANDARD value is 3 meters and is taken from Madsen et al. (1986 p. 36-37). This can be seen in Figure 24. This parameter specifies the perpendicular distance (i.e. a distance measured along a line at right angles to the line of travel of the RAM shipment) between the RAM shipment and other traffic lanes, in meters. This is an average perpendicular distance between the shipment centerline and the centerline of oncoming traffic lanes. This value is based on a minimal road configuration of two lanes with an average lane width of 3 meters, in the most typical traffic configuration. A city street is any city street.

Perpendicular distance to rail car vehicle going in the opposite direction

The STANDARD value is 3 meters and is taken from Madsen et al. (1986 p. 36-37). This can be seen in Figure 24. This parameter specifies the perpendicular distance (i.e. a distance measured along a line at right angles to the line of travel of the RAM shipment) between the RAM shipment and other traffic lanes, in meters. This is an average perpendicular distance between the shipment centerline and the centerline of oncoming traffic lanes. This value is based on a minimum clearance between passing trains on double rail segments. A rail route is any rail right-of-way in the U.S.

Perpendicular distance to barge going in the same direction

The STANDARD value is 4 meters and is taken from Madsen et al. (1986). This can be seen in Figure 24. This parameter specifies the perpendicular distance (i.e. a distance measured along a line at right angles to the line of travel of the RAM shipment) between the RAM shipment and other traffic lanes, in meters. This is an average perpendicular distance between the shipment centerline and the centerline of adjacent passing vehicles. This value is based on the median value for all Interstate and secondary-road lane widths.

Campaign

This parameter specifies the duration of the shipping campaign in years. The STANDARD value is 0.0833 years. This is an average month in an average year or $1/12^{th}$ of a year. This value calculates the total number of off-link persons exposed, using the Census Bureau algorithm for the average length of residence in the U.S. This result may be used to perform external calculations of the average off-link individual dose for the entire campaign. This can be seen in Figure 24.

REM per curie thyroid via inhalation

This parameter is used to specify one-year Committed Effective Dose Equivalent (CEDE) in REM per Curie to the thyroid from inhalation of radionuclides of iodine for estimation of early-mortality risk. Radioiodine mainly travels to and irradiates a single organ, the thyroid. In previous releases the 50-year CEDE was used to approximate the one-year dose. One-year committed doses to the thyroid have been calculated directly from RADTRAN 5. This new parameter was not included in the internal radionuclide database, since it would have meant adding a new column containing zeros for all radionuclides but radioiodines. The information has been included in parameter instead. The STANDARD values are 1.27E+06 for Iodine-131, 5.77E+06 for Iodine-129, and 9.25E+05 for Iodine-125. This can be seen in Figure 24.

SAVING, RUNNING RADTRAN, EXITING

The input file can be saved with either the **Save** or the **Save As** icon. Make sure you save your input as a "**.in5**" file. This can be seen in Figure 25. The file may be run in RADTRAN by clicking on the **Run RADTRAN** icon (the computer icon). You will be prompted to save the file before you run it. If the file has already been saved, the prompt will not appear.

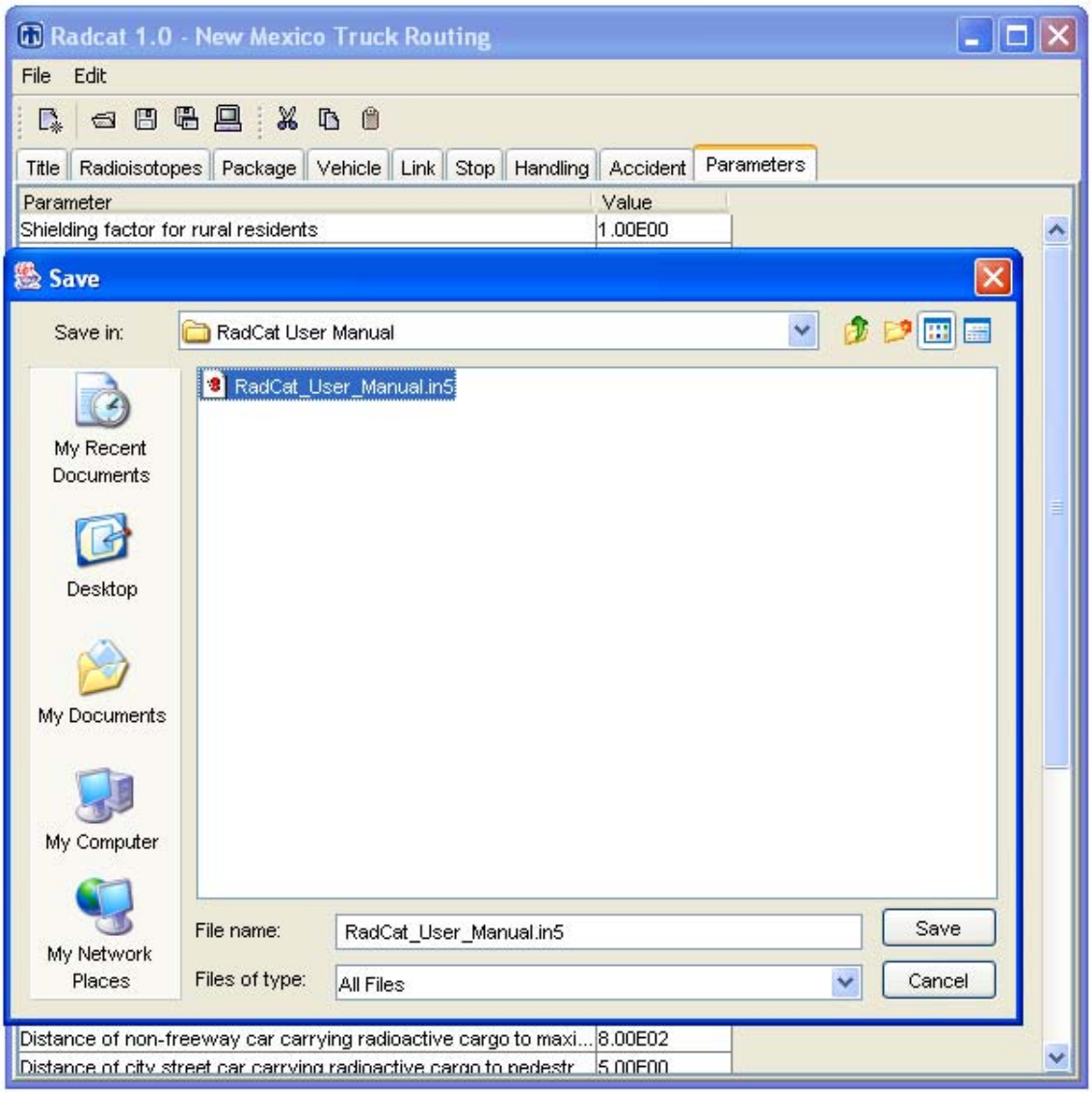


Figure 25: Saving a RADCAT 1.0 input file

When RADTRAN is run, the output appears immediately on the screen, and may be printed and/or saved. This output file can be saved as a text file (output.txt), an excel file (output.xls), or a word document (output.doc). It can be saved to any folder on your computer or LAN. Consult the RADTRAN 5.0 User's Manual for help interpreting the output file.

Exit from RADTRAN/RADCAT by clicking on the "x" in the upper right-hand corner.

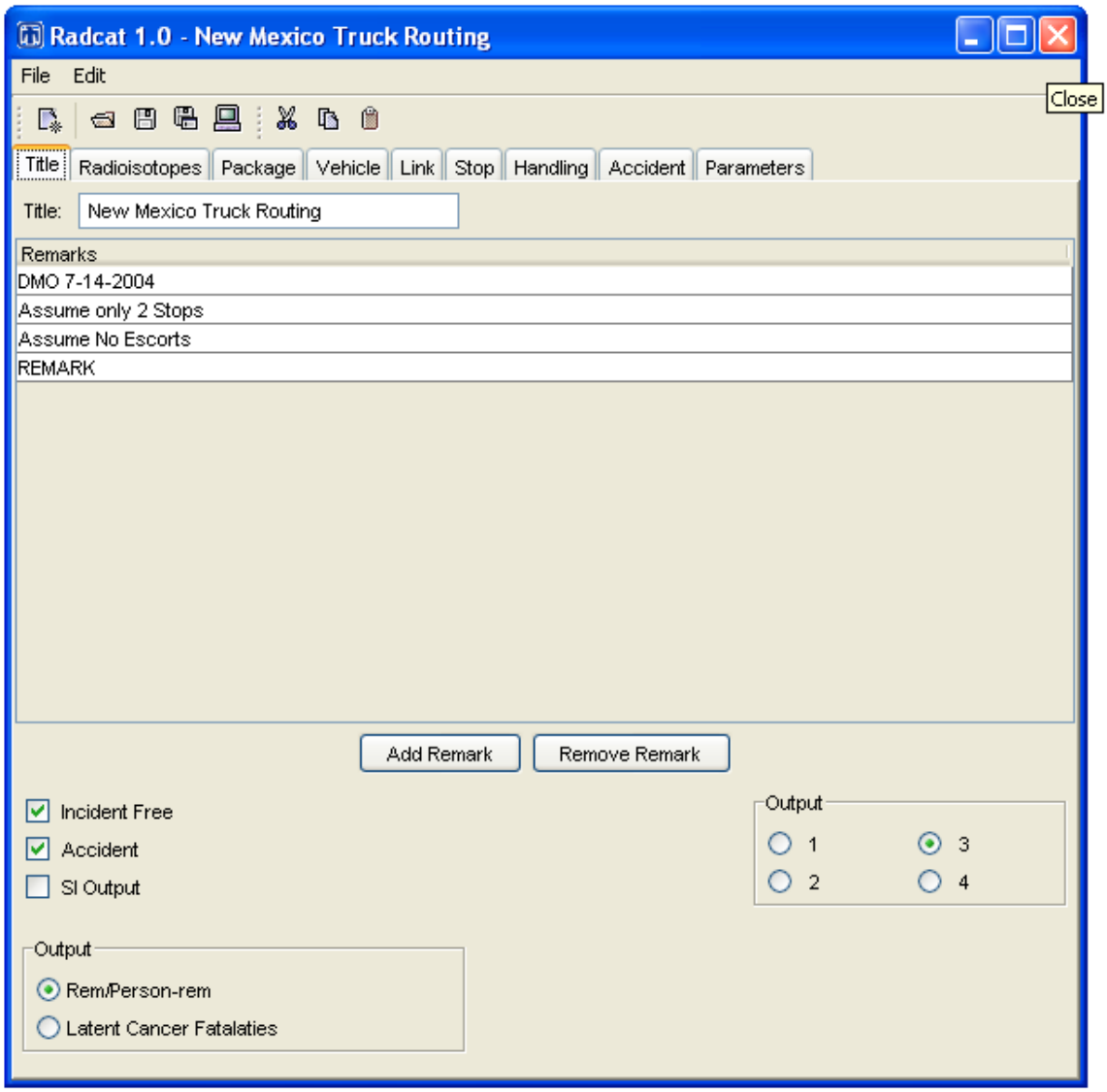


Figure 26: Closing RADTRAN/RADCAT

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APPENDIX A: RADTRAN 5 REFERENCE SHEET

CREATING RADTRAN 5 FILES WITH A TEXT EDITOR

Key:
[Brackets] indicate an optional statement
{Braces} indicate a required value
ALL CAPS indicates a keyword that must be entered

TITLE **{alphanumeric title}**
INPUT **{STANDARD or ZERO}**
FORM **{UNIT for population dose or NONUNIT for health effects}**
DIMEN **{# of severity categories} {# of nondispersal accident radii} {# of dispersal areas}**
PARM **{0 no plotting/1 plotting} {1 incident free/2 accident/3 both} {1/2/3/4 level of output} {0 User-supplied time-integrated concentration isopleths and areas/1 Pasquill stability fractions}**
SEVERITY
NPOP=**{1 rural/2 suburban/3 urban}**
NMODE=**{transport mode (see Mode Chart in Figure 1)}**
{Severity Fraction 1} {Severity Fraction 2} {Severity Fraction 3...}
[NPOP=...]
RELEASE
GROUP=**{group name}**
RFRAC
{Release Fraction 1} {Release Fraction 2} {Release Fraction 3...}
AERSOL
{Aerosol Fraction 1} {Aerosol Fraction 2} {Aerosol Fraction 3...}
RESP
{Respirable Fraction 1} {Respirable Fraction 2} {Respirable Fraction 3...}
LOS
{Loss of Shielding Fraction 1} {Loss of Shielding Fraction 2...}
DEPVEL
Deposition Velocity of Group (m/s)
[GROUP=...]
[ISOPLETHP]
{Population density of isopleth 1} {Population density of isopleth 2...}
[AREADA]
{Area of Isopleth 1 (m^2)} {Area of Isopleth 2...}
[DFLEV]
{Dilution Factor for Isopleth 1} {Dilution Factor for Isopleth 2...}
[CLINE]
{Center-Line Distance for Isopleth 1 (m)} {Center-Line Distance for Isopleth 2...}
[PSPROB]
{Pasquill Category A Fraction} {Pasquill Category B Fraction...}
[DEFINE] **{Radionuclide Name}**
{Half-life (days)} {Photon Energy (MeV/disintegration)} {Cloudshine dose factor (rem-m^3/Ci-second)} {Groundshine dose factor (rem-m^3/μCi-day)} {50-yr committed effective dose equivalent for inhalation (rem/Ci inhaled)} {50-yr committed effective gonad dose for inhalation (rem/Ci inhaled)} {1-yr lung dose for inhalation (rem/Ci inhaled)} {1-yr marrow dose for inhalation (rem/Ci inhaled)}
{Name for COMIDA Ingestion Data (or NONE)}
[DEFINE] **{Radionuclide Name...}**
PACKAGE **{alphanumeric identifier} {dose rate at 1m (mrem/hr)} {gamma fraction} {neutron fraction} {package dimension (m)}**
{Radionuclide Name} {Package Inventory (Ci)} {Group Name}
[**{Radionuclide Name} {Package Inventory (Ci)} {Group Name...}**]
END

VEHICLE **{minus sign if shipment is exclusive} {transportation mode number (see mode chart)} {identifier} {dose rate at one meter from vehicle (mrem/hr)} {gamma fraction} {neutron fraction} {vehicle length (m)} {number of shipments} {number of crew members} {distance of crew from package (m)} {crew shielding factor} {crew view dimension (m)} {package identifier} {number of packages per shipment}**
[**{package identifier} {number of packages per shipment...}**]
[FLAGS]
{see Flag Chart in Figure 2}
[MODSTD]
{see MODSTD Standard Values List}
EOF
LINK **{link identifier} {vehicle name} {segment length (km)} {velocity (kph)} {vehicle occupancy} {population density (persons/km^2)} {vehicle density} {accident rate (acc/km)} {R rural/S suburban/U urban} {1 interstate/2 non-interstate/3 other} {farm fraction}**
[LINK] **{link identifier...}**
STOP **{stop identifier} {vehicle name} {population density (annular) or number of persons (radial)} {minimum annular radius} {maximum annular radius (or same as minimum for radial)} {shielding fraction} {stop time (hr)}**
[STOP] **{stop identifier...}**
HANDLING **{handling identifier} {vehicle name} {number of handlers} {average handler distance} {handling time per package (hr)}**
[HANDLING] **{handling identifier...}**
EOF
EOI

Mode	Mode Number	Conveyance Types Associated with Mode
HIGHWAY	1	Any truck; usually a tractor-trailer(also called a “semi” or a combination truck)
RAILWAY	2	One or more railcars in a single train
WATERWAY_A	3	Any vessel; usually barge
WATERWAY_B	4	Any vessel; usually ocean-going ship (>3000 gross tons)
CARGO_AIR	5	Any plane carrying only cargo
PASNGR_AIR	6	Any plane carrying passengers & cargo
HIGHWAY_A	7	Any truck; usually small truck or passenger van
HIGHWAY_B	8	Any truck; usually cargo van/delivery truck as secondary vehicle with tractor-trailer as primary mode
HIGHWAY_C	9	Any truck, usually cargo van/delivery truck as secondary vehicle with rail as primary mode
HIGHWAY_D	10	Any truck; usually cargo van/delivery truck as secondary vehicle with cargo air as primary mode

Figure 1: Mode Chart

Flag Name	Flag Description	STANDARD Value
IACC	Setting this flag to 2 directs the code to work through all exposure pathways associated with atmospheric dispersal of package contents during an accident. The alternative value of IACC = 1, denotes non-dispersal and is used to examine particular scenarios such as loss-of-shielding or accidents involving non-dispersible package contents	2
ITRAIN	This flag, used only for rail mode, denotes whether shipment is by general freight (ITRAIN = 1) or by dedicated rail (ITRAIN = 2).	1
IUOPT	This flag is used to select a building shielding option. For the STANDARD value, persons in buildings are exposed at reduced rates and the reduction in dose rate is a function of the shielding factors RR, RS, and RU. Setting the IUOPT flag to 1 is equivalent to full shielding (everyone indoors is fully shielded and receives no dose). Setting the IUOPT flag to 3 is equivalent to no shielding (being indoors provides no protection and is the same as being outdoors).	2
REGCHECK	Setting this flag to 1 causes a series of regulatory checks to be performed. If any circumstances are identified that violate the regulatory requirements, then the appropriate parameter values are reset to the regulatory maximum and the calculation continues. The analyst may set REGCHECK = 0, which bypasses the regulatory-check subroutine.	1

Figure 2 – Flag Chart

MODSTD STANDARD VALUES LIST

MODSTD Name	Description	STANDARD Value
BDF	This is the Building Dose Factor. This factor describes the entrainment of aerosol particles in ventilation systems (i.e., the fraction of particles of an external aerosol that remain in aerosol form after passing through a ventilation system). The BDF is used to modify inhalation doses to persons in urban structures. The STANDARD value of 0.05 represents a conservative average across a series of building types, including residential, office, and industrial structures (Engelmann, 1990). This value is about five times higher than the value for high-rise buildings with air-conditioning systems used by Finley et al., (1980) for New York City, which has been used in RADTRAN in the past.	0.05
BRATE	This factor represents breathing rate and is used for calculation of inhalation doses. The breathing rate (BRATE = 3.30E-04 m^3/sec) of the Reference Man (70-kg adult male at light work) derived from Shleien 1992; Table 12.6) has been used as the STANDARD value. The value in the cited table has been converted from liters per hour to m^3/sec.	3.30E-04
CULVL	This factor describes Clean-Up Level, which is the required level to which contaminated surfaces must be cleaned up. The STANDARD value is the EPA guideline of 0.2 mCi/m^2 (EPA, 1977). This value applies to the sum of deposited activity over all radionuclides of a multi-radionuclide material. Although never officially adopted by the EPA or superseded by another standard, this value has become a *de facto* standard (Chanin and Murfin, 1996). This is a controversial issue at present, and analysts who can justify use of more realistic values are urged to do so.	0.2
EVACUATION	This parameter specifies evacuation time in days following a dispersal accident, where this includes time to respond to the accident and carry out a course of action. The STANDARD value is 24 h (1 day). Mills et al. (1995) analyzed 66 verified hazmat accidents in which evacuations were carried out and found that the mean evacuation time was approximately 1 hour. Even when response time is added, a 24-hour (1-day) value for this variable is conservative. [For non-dispersal accident evacuation, see TIMENDE.]	1.0

MODSTD Name	Description	STANDARD Value
GECON	This parameter specifies the Genetic Effects Conversion Factor. The STANDARD value is 1.0E-04 genetic effects/rem. This value is consistent with the recommendations of BEIR V (NRC/NAS, 1990) and ICRP 60 (ICRP, 1991). Estimates based on the only genetic effects (untoward pregnancy outcome and F_1 mortality) to have been documented in the atomic-bomb survivors have extremely high statistical and model uncertainties. Animal data, which is more reliable, consistently yield lower estimates. As noted in BEIR V, the recommended value is "probably …too high rather than too low" (NRC/NAS, 1990, p. 77).	1.00E-04
INTERDICT	This parameter specifies the threshold value for interdiction of contaminated land. The STANDARD value is 40, i.e., a value 40 times greater than CULVL, and it was taken from NUREG-0170 (NRC, 1977).	40
LCFCON	This parameter specifies the Latent Cancer Fatality (LCF) Conversion Factors; units are LCFs per rem. The STANDARD values are 5.0E-04 LCF/rem for the general public and 4.0E-04 LCF/rem for workers. They have been adjusted for low-dose and low-dose-rate decrease in effects with a DDRRF (Dose and Dose Rate Reduction Factor) of 2. These values are consistent with the recommendations of BEIR V (NRC/NAS, 1990) and ICRP 60 (ICRP, 1991). The dose-response relationship is assumed to be linear with no threshold in order to agree with current regulations. However, the majority of available data indicate that the actual dose-response relationship at very low doses is likely to be considerably less and, as noted in BEIR V, is not incompatible with zero (NRC/NAS, 1990, p. 181). Thus, cancer risk estimates obtained from RADTRAN 5 will be generally conservative.	5.0E-04 for the public 4.04E-04 for workers
LOS	The parameter is used to analyze loss-of-shielding accidents. It represents the fractional degradation of package shielding for each severity category in the analysis. Values may be any number between zero and 1.0.	
NE	This parameter is the neutron emission factor; it may be used to model neutron emissions following a loss-of-shielding accident. For commonly encountered radionuclides that spontaneously emit neutrons (curium-242, curium-244, and californium-242), the NE values are already available in the radionuclide library. All other radionuclides have no assigned NE factor. The NE keyword is applied only when the analyst wishes to assign a new value to an existing radionuclide or to a new material. The analyst must enter NE followed by the radionuclide name in standard format (or exactly as entered under keyword DEFINE) and the emission factor value in neutrons/s-Ci. The analyst must repeat the process (i.e., type NE followed by radionuclide name and NE factor value) for each radionuclide desired.	

MODSTD Name	Description	STANDARD Value
RADIST	This parameter is used to specify an array of Radial Distances, which are used to define annular areas for dose-calculation purposes when the IACC Flag is set to 1.	
RPCTHYROID	This parameter is used to specify 1-year CEDE (rem per curie) to the thyroid from inhalation of radionuclides of iodine for estimation of early-mortality risk. Radioiodine mainly travels to and irradiates a single organ, the thyroid. In previous releases of RADTRAN, however, the 50-year CEDE was used to approximate the 1-year dose. One-year committed doses to the thyroid have been calculated directly for RADTRAN 5. This new parameter was not included in the internal radionuclide database, since it would have meant adding a new column containing zeros for all radionuclides but the radioiodines. The information has been included under the PRCTHYROID keyword instead. The STANDARD values are 1.27E+06 for iodine-131, 5.77E+06 for iodine-129, and 9.25E+05 for iodine-125.	1.27E+06 for I-131 5.77E+06 for I-129 9.25E+05 for I-125
SURVEY	This parameter is used to specify the time (in days) required to survey contaminated land following a dispersal accident. The amount of deposited material removed by radioactive decay is calculated beginning with time of initial deposition. The longer a deposited material remains on the ground, the more is removed by decay and spread by forces such as wind and rain. The actual elapsed time between accident occurrence and completion of a survey is impossible to determine in advance, but is likely to be prolonged because of governmental and regulatory complexities. The STANDARD value is set to an unrealistically brief, but radiologically conservative, 10 days (NRC, 1977).	10
TIMENDE	This parameter specifies the time, in days, required to effect evacuation following a non-dispersal accident. Three values are entered, one for each population-density zone (rural, suburban, and urban, in that order). TIMENDE represents the time required to move potentially exposed members of the public to safe distances beyond the areas specified by the RADIST keyword. The three STANDARD values are 0.67, 0.67, and 0.42 hours (Mills et al., 1995) [for dispersal accident evacuation, see EVACUATION]	0.67 for rural 0.67 for suburban 0.42 for urban
UBF	This parameter is the Urban Building Fraction; it describes either the fraction of the population that is indoors or the fraction of the area that is occupied by buildings, depending on the type of population model being used. The STANDARD value of 0.52 is for the latter model, and is taken from Finley et al. (1980). The value is most accurate for large cities such as New York and is somewhat conservative for smaller cities.	0.52

MODSTD Name	Description	STANDARD Value
USWF	This parameter is the Urban Sidewalk Fraction; it specifies the fraction of the population that is out of doors or the fraction of the population that occupies sidewalks, depending on the type of population model being used. The STANDARD pre-assigned value of 0.1 is for the latter model, and is taken from Finley et al. (1980). As with the UBF, this value is suitable for large cities and is conservative for smaller cities.	0.1
ADJACENT	See DISTON	
CAMPAIGN	This keyword specifies the duration of the shipping campaign in years. The value calculated with CAMPAIGN is the total number of off-link persons exposed. This result may be used to perform external calculations of annual off-link dose. Annual dose values may be compared with total dose in multi-year shipping campaigns and are useful for assessing regulatory compliance with standards based on annual doses. The STANDARD value is 0.0833 years. This is an average month in an average year, or $1/12^{th}$ of a year.	0.0833
DDRWEF	This keyword applies to rail mode only and specifies the Distance Dependent Rail Worker Exposure Factor. This factor is used to calculate the component of rail-worker dose that depends on distance traveled (e.g., exposure related to engine changes, crew shift-changes, etc., while en route). The STANDARD value of 0.0018 inspections/km is taken from Ostmeyer (1986).	0.0018

MODSTD Name	Description	STANDARD Value
DISTOFF	This keyword specifies a set of three distances, in meters, used in off-link dose calculations for highway, rail, and barge modes. The three distances are: (1) the minimum perpendicular distance over which the off-link dose calculation will be integrated; (2) the minimum pedestrian-walkway width, for instances in which dose to pedestrians beside the link is calculated (see RPD for discussion of pedestrian density); and (3) the maximum perpendicular distance over which the off-link dose calculation will be integrated. DISTOFF must be followed one or more keywords that specify values for various link types. The STANDARD values, which are supplied for each link type, are from NUREG-0170 (NRC, 1977). The link types and values for each are:	
	FREEWAY Any limited-access divided highway. [30, 30, 800]	30, 30, 800
	SECONDARY Any non-limited-access highway that is not a city street (27, 30, 800)	27, 30, 800
	STREET Any city street. [5, 8, 800]	5,8,800
	RAIL Any rail right-of-way in the U.S. [30, 30, 800]	30, 30, 800
	WATER Any vessel. [200,200,800]	200, 200, 1000
	Note: that the values are the same for FREEWAY and RAIL. Setting the first two values equal to each other is equivalent to a sidewalk width of zero and means there are no sidewalks or similar close-in areas where unshielded persons (pedestrians, bicyclists, etc.) may reasonably be expected to be found. For STREET, the sidewalk is modeled as being 3 m wide (Finley et al. 1980). The values for WATER conservatively model a narrow navigable waterway (e.g., Houston Ship Channel) and are taken from NUREG-0170 (NRC, 1977). The WATER values are the ones most likely to require modification by the analyst since other bodies of water that might be modeled have ship-to-shore distances that greatly exceed 200 m and even 800 m.	

MODSTD Name	Description	STANDARD Value
DISTON	This keyword specifies a perpendicular distance (i.e., a distance measured along a line at right angles to the line of travel of the RAM shipment) between the RAM shipment and other traffic lanes, in meters. For three link types, DISTON represents the *average* perpendicular distance between the shipment *centerline* and the *centerline* of oncoming traffic lanes(s). In the passing-vehicle case, DISTON represents the distance between the shipment *centerline* and the *centerline* of adjacent passing vehicles (HIGHWAY mode only). DISTON must be followed by a second keyword that specifies the link type. The STANDARD values in parentheses in the following list are taken from Madsen et al. (1986, p. 36-37).	
	FREEWAY Any limited-access, divided highway [15.0 m];	15
	SECONDARY Any non-limited access highway [3 m];STREET Any city street [3 m];	3 for secondary roads 3 for city streets
	RAIL Any rail right-of-way [3 m].	3
	An additional parameter for highway mode only is ADJACENT It represents the minimum perpendicular distance between shipment centerline and centerline of adjacent passing vehicles [4 m].	4
	Note: The FREEWAY value is based on the Madsen et al. (1986) model of a minimal Interstate configuration of 4 lanes with an average lane width of 5 m, in the most typical traffic configuration. The latter refers to the RAM shipment being in the outside lane, oncoming traffic in the corresponding outside lane, and passing vehicles in the inner lanes. The SECONDARY and STREET values are smaller because these roadways are modeled as being only 2 lanes wide with an average lane width of 3 m. The RAIL value is based on the minimum clearance between passing trains on double rail segments. The ADJACENT value represents the median value for all Interstate and secondary-road lane widths.	

MODSTD Name	Description	STANDARD Value
FMINCL	This keyword is applied to rail mode only and specifies the minimum number of railcar classifications or inspections per one-way trip. The STANDARD value is 2 since there are always at least two inspections per one-way trip - one at the beginning and one at the end of each trip (Wooden, 1986).	2
FNOATT	This parameter is applied to passenger-air mode only and specifies the Number of Flight Attendants. The STANDARD value is 4 (NRC, 1977).	4
FREEWAY	See DISTOFF and DISTON	
MITDDIST	This parameter is used to calculate the maximum individual "in-transit" dose to a member of the public; it represents the minimum perpendicular distance, in meters, from the shipment centerline to an individual standing beside the road or railroad while a shipment passes. The STANDARD value is 30.0 m (NRC, 1977).	30
MITDVEL	This parameter is used to calculate the maximum individual "in-transit" dose; it represents the minimum velocity, in km/hr, of a shipment. The STANDARD value is 24.0 km/hr (15 mph) (NRC, 1977).	24
RAIL	See DISTOFF and DISTON	

MODSTD Name	Description	STANDARD Value
RPD	This parameter is the Ratio of Pedestrian Density. It is used to calculate the density of unshielded persons on sidewalks and elsewhere in urban areas when the IUOPT Flag is not equal to 3 by indexing it to the population density of the surrounding area. RPD is also used in the calculation of accident consequences. The STANDARD is 6.0, which is based on empirical data from New York City (Finley, 1980). It means that the pedestrian density is six times the residential population density. This figure is likely to be conservative for most other urban areas, but similar data are seldom collected in other cities.	6.0
RR	This parameter specifies the Rural Shielding Factor. The STANDARD value is 1.0 (i.e., no shielding). Although even wood-frame construction provides some shielding, the Rural Shielding Factor is set to 1.0 to conservatively account for the fact that rural economies involve a relatively large fraction of outdoor employment (farming, ranching, etc.). RR is used in incident-free dose and in dose-risk calculation for non-dispersal accidents.	1.0
RS	This parameter specifies the Suburban Shielding Factor. The STANDARD value is 0.87, which represents a residential structure of wood-frame construction (Taylor and Daniel, 1982, p.12). RS is used in incident-free dose and in dose-risk calculations for non-dispersal accidents.	0.87
RU	This parameter specifies the Urban Shielding Factor. The STANDARD value is 0.018, which represents an urban commercial building constructed of concrete block (Taylor and Daniel, 1982, p.12). RU is used in incident-free dose and in dose-risk calculations for non-dispersal accidents.	0.018

MODSTD Name	Description	STANDARD Value
SECONDARY	See DISTOFF and DISTON	
SMALLPKG	This parameter specifies the first Package Size Threshold. 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. If a package is designated as "small" then an empirical algorithm for handling dose is used; if package dimensions exceed the threshold then another method is used. The STANDARD value for SMALLPKG is 0.5 m (Javitz, 1985). Although it is highly unlikely that this value will need to be altered, the analyst has the option to do so.	0.5
STREET	See DISTOFF and DISTON	