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Interactive Development of RADTRAN*

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ABSTRACT

The RADTRAN computer code for transportation risk analysis, which has been under continuous development at Sandia National Laboratories since 1977, has evolved from a purely research tool into a publicly available system with a variety of applications. This expansion of the user community has substantially increased the need to make the system easier to use without decreasing its capabilities or the quality of output. A large set of modifiable RADTRAN input files has been available via TRANSNET for several years. One approach to assisting the user involves adding annotations/information to each of these files. A second approach is providing additional help in building new/modifying old input files.

Keeping the proposed information/annotation files separate from but closely coupled to the modifiable input files within the TRANSNET shell system allows the modifiable input files to remain as regular input files while providing rapid, automatic access to useful information about the analysis. In this way, the sample input files remain intact as regular RADTRAN input files and any files generated using associated on-line menus or editors may be readily converted into new input files. A single sample file is selected and used as an example to illustrate the prototype help features.

INTRODUCTION

The RADTRAN computer code for transportation risk analysis [1,2,3,4], which has been under continuous development and application at Sandia National Laboratories (SNL) since 1977 and is now available in the fourth release (RADTRAN 4), has evolved from a tool for research and internal applications into a publicly available system used by many with less than professional expertise in risk analysis. RADTRAN 4 and related codes comprise a computational system that is publicly available on TRANSNET [5], the SNL node on the Internet that provides access to the RADTRAN code system.

The expansion of the RADTRAN user community has been paralleled by increased usage of the code system on TRANSNET. The system includes a user-friendly, menu-driven, "front-end" that guides the user in the creation and editing of RADTRAN 4 input files. Since the inception of the TRANSNET system [5], SNL has maintained a telephone help capability for RADTRAN users. Users who have problems, questions, or need project-specific data are able to speak directly to a RADTRAN code developer. From this direct user interaction, two of the authors of this paper noted certain types of problems were being repeatedly encountered. Some problems could be traced to ambiguous wording in the menus or documentation or unrealistic expectations regarding capabilities and/or flexibilities of the code system, but a few problems were intrinsic to the code. For example, a user discovered that a logical error occurred when zero was entered as the population density for a route segment. The code

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was modified because this was a circumstance other users were likely to encounter (large areas of the United States have zero population density). At first, such difficulties were corrected as they arose on an ad hoc basis. Any alterations made in the code were posted on the RADTRAN revision-history bulletin board on TRANSNET. As the computational system became more complex and the user community became larger and less experienced, this approach no longer sufficed.

SNL has employed several strategies to address user needs. Workshops have been held, most recently at the International High-Level Radioactive Waste Management Conference in Las Vegas. Recognizing the value of user feedback to SNL's efforts to continue improving both the user friendliness and the technical value of the RADTRAN system, in 1994 SNL initiated a new strategy of convening formal RADTRAN user meetings. Two SNL-sponsored meetings of RADTRAN users were held in 1994. At the first of these, the scope was limited to the RADTRAN 4 code system; notices were mailed to all individuals in the United States who either had current user passwords or who had requested executable tapes of RADTRAN 4 for use with their own mainframe computers. The second meeting had a broader scope, covering both the RADTRAN system and other codes and databases available on TRANSNET. At these meetings, users were presented with an outline of planned modifications/improvements and asked for feedback and suggestions for improvement. Reports of these meetings will be available this year.

The results of these meetings were positive and constructive. The suggestions for improvements addressed everything from highly specific single-parameter comments to such broad concepts as addition of a graphical user interface (GUI) and incorporation of a geographical information system (GIS). There were several criticisms of the existing input/file/generating menus on TRANSNET. These ranged from the general to the particular. One general criticism was that several common, inadvertent key-press combinations cause the user to exit without having saved any part of the file being developed. This has been corrected on the current operating system. An example of a particular comment deals with a default dispersability category (DISP=1). It cannot be modified by the user, but the menu screens do not explain this.

While GUI development may be appropriate for the long term, the simpler matter of making it easier for a user to construct a RADTRAN input file can be implemented with available technology within the existing computational environment. Because RADTRAN requires large amounts of input data (like all risk codes) and many new users are relatively inexperienced, it seemed more reasonable to help develop the users' understanding of what is needed for suitable input than to devote resources to development of a GUI that might look like a home-computer game but not really assist the user. As long as it continues to be one of the world's most powerful tools for serious risk analysis, little purpose is served by slick packaging before basic user needs are addressed.

The current RADTRAN computational system includes a collection of approximately 15 Transportation Technology Center (TTC) file sets derived from actual risk analyses performed by SNL for the DOE. These files were placed on the system primarily to make them accessible to critics and activists opposing U.S. Department of Energy (DOE) environmental assessments (EAs) and environmental impact statements (EISs) that the analyses supported. This step was taken in response to activists' criticisms that DOE/SNL risk analyses contained "hidden assumptions" that could not be reviewed by anyone who did not have access to a mainframe computer. Placing the input files on the system thus performs a public quality assurance and review function in that it allows anyone with Internet access or a personal computer (PC) and a modem to obtain the raw input files, to run RADTRAN, and to

satisfy themselves that the results reported in the documents they support are indeed the actual RADTRAN outputs.

The current menu system also allows users to modify (edit) these files. Thus, critics are able to satisfy themselves as to the effect on the result of changing "assumptions." The latter capability was soon seen to be useful to serious analysts as well, because it can be used to modify a few parameters and thereby quickly analyze similar but not identical problems. However, as currently structured, the TTC files are "pure" input files and contain little information to help a beginning user identify the sources of the data. Little need was seen for such a user interface at first, because the source information was contained in the EAs and EISs that the input files were developed to support. However, the files soon were being used as "starting points" by persons who had no interest in the original problem but who did have a similar problem to analyze. Both the lack of explanatory information and the fact that the input files cannot be easily modified without consulting the RADTRAN 4 User Guide [4] were cited as non-user friendly features of the current system during the user feedback meetings. Therefore, a first step toward increased user friendliness is the association of background information with each TTC file.

BACKGROUND INFORMATION FOR TTC FILES

Much potentially helpful background information could be associated with each input file. For example, a user might be interested in knowing why a particular input file was generated. Other types of information the user might find helpful include general conclusions resulting from the RADTRAN run and the types of related analyses that are possible using simple modifications (with the modifications described in detail) of a particular file.

ON-LINE USER GUIDE

An on-line user guide also was recommended by some users. This would consist of making the text of the published User Guide [4] available on the TRANSNET system. This option has the drawback of not being accessible while the user is building or modifying an input file. For that reason, enhancing the file-generating menus with additional information is believed to be a more beneficial option. This option is discussed in the following section.

AVAILABLE RADTRAN INPUT FILES

Figure 1 shows the list of RADTRAN TTC file sets currently available to the TRANSNET user. One set of files (FOREIGN RESEARCH REACTOR SPENT FUEL) has been selected to illustrate the proposed user assistance. These files were developed to analyze transport of foreign research reactor spent fuel by several modes [6]. Figure 2 shows the second step in file selection with the present current RADTRAN menus. The first line on this sample screen is "Enter a Category Number -> 15."

This means that the user selected number 15 from the list in Figure 1. The screen shows the full title of the citation and gives all the files available under Category 15. The last line in the table is "Enter subcategory number you wish to use [1-6] -> 1," which means that the Highway Routes subcategory was selected. Figure 3 shows the last line of Figure 2 and then shows the titles of all the input files available for research reactor spent fuel analysis by highway (truck) mode in this file set. In the example, File Number 1 has been selected. Table I shows the sample input file, ASTRAXT. As the figure shows, it is "pure" computer input and does not contain much information helpful to an inexperienced user.

NEW HELP FILES

Figures 4 and 5 are examples of background information associated with a particular TTC file; in this example, the ASTRAXT file. It tells something about the nature of the problem that was to be solved, why it was important, and gives detailed information about specific input parameters used in the analysis. Figure 6 summarizes the results of running this particular TTC file for both the first route-segment (3.2 km) and the total route and shows the types of outputs that may be obtained from RADTRAN. Note that probability and consequences as well as risk are given.

SPREADSHEET FOR BUILDING AN INPUT FILE

Several users have commented that in its current form, the RADTRAN menu system does not contain sufficient help for a beginner who isn't familiar with the User Guide [4]. The Appendix shows some of the help statements for a prototype enhanced menu system; information is given for each line in a RADTRAN input file. This experimental system now exists as a PC-based spreadsheet. The few default values remaining in RADTRAN, such as those for atmospheric dispersion, are listed under the appropriate keywords. Emphasis has been placed on identifying which input values are required for route-specific analysis and which are not. In addition, the user is frequently reminded about the necessity of making the sizes of the various data arrays consistent. Failure to enter the proper number of values in certain arrays is a common beginner's error. Isotope data may be automatically entered from RADTRAN's internal isotope database by use of an alphanumeric identifier. The spreadsheet lists all available isotopes and their identifiers but does not display the contents of the database itself. A complete data list for each isotope used can be obtained by running a full output of RADTRAN.

-
- (1) CESIUM/STRONTIUM CAPSULES
 - (2) CONTAMINATED SOIL
 - (3) LSA WASTE
 - (4) LWR FUEL (REPOSITORY EAs)
 - (5) METALLIC SPENT FUEL
 - (6) NATIONAL ASSESSMENTS (not available)
 - (7) PLUTONIUM OXIDE
 - (8) RADIOPHARMACEUTICALS
 - (9) STATE EXAMPLES
 - (10) TRANSURANIC WASTE
 - (11) VITRIFIED WASTE
 - (12) OFFSITE FUELS - SAND88-0714
 - (13) TAIWAN SPENT FUEL - FAILED FUEL (TTC-1041)
 - (14) TAIWAN RESEARCH REACTOR SPENT FUEL (DOE/EA-0515)
 - (15) FOREIGN RESEARCH REACTOR SPENT FUEL (DOE/EA-0912)

Figure 1. First Step in Selecting a TTC File

Enter a category number -> 15

ENVIRONMENTAL ASSESSMENT OF URGENT-RELIEF ACCEPTANCE OF FOREIGN
RESEARCH REACTOR SPENT NUCLEAR FUEL DOE/EA-0912 APRIL 1994

There are six subcategories

- (1) Highway Routes
- (2) Rail Routes
- (3) Port Stops (3 port stops plus final port)
- (4) Final Port Stop only
- (5) Overseas Route
- (6) Handlers & Close-in Truck Stop

Enter subcategory number you wish to use [1-6] -> 1

Figure 2. Second File Selection Step

Enter subcategory number you wish to use [1-6] -> 1

- (1) HIGHWAY; ASTRA REACTOR, 13 ASSEMBLIES
- (2) HIGHWAY; BER2 REACTOR, 13 ASSEMBLIES
- (3) HIGHWAY; BR2 REACTOR, 36 ASSEMBLIES
- (4) HIGHWAY; BR2 REACTOR, (PARTIAL) 12 ASSEMBLIES
- (5) HIGHWAY; DR3 REACTOR, 36 ASSEMBLIES
- (6) HIGHWAY; DR3 REACTOR, (PARTIAL) 12 ASSEMBLIES
- (7) HIGHWAY; DR3 REACTOR, (PARTIAL) 18 ASSEMBLIES
- (8) HIGHWAY; FRG REACTOR, 33 ASSEMBLIES
- (9) HIGHWAY; GRR1 REACTOR, 33 ASSEMBLIES
- (10) HIGHWAY; GRR1 REACTOR, (PARTIAL) 7 ASSEMBLIES
- (11) HIGHWAY; HFR REACTOR, 33 ASSEMBLIES
- (12) HIGHWAY; HFR REACTOR, (PARTIAL) 20 ASSEMBLIES
- (13) HIGHWAY; HFR REACTOR, (PARTIAL) 24 ASSEMBLIES
- (14) HIGHWAY; HIFAR REACTOR, 26 ASSEMBLIES
- (15) HIGHWAY; HOR REACTOR, 33 ASSEMBLIES
- (16) HIGHWAY; HOR REACTOR, (PARTIAL) 20 ASSEMBLIES
- (17) HIGHWAY; R2 REACTOR, 64 ASSEMBLIES
- (18) HIGHWAY; R2 REACTOR, (PARTIAL) 58 ASSEMBLIES
- (19) HIGHWAY; SAPHIR REACTOR, 33 ASSEMBLIES
- (20) HIGHWAY; SAPHIR REACTOR, (PARTIAL) 20 ASSEMBLIES

Enter the data set you wish to use [1-20] -> 1

TTC-DEVELOPED INPUT FILE OPENED: ASTRAX

Figure 3. Third File Selection Step

Table I. Sample RADTRAN input file - ASTRAXT

```

&& FOREIGN_FUELS_TRUCK_TRANSPORT_
TITLE
FRR_EA_DRAFT_TRUCK_ASTR_GOSSLAR_10MW_13ASSEM_150DAY_CHARLESTON_NC-S
RP
FORM UNIT
DIMEN 46 6 4 10 18
PARM 1 3 2 1 0
PACKAGE LABGRP NOBLE VOLATILE ACT_OTHER RUTH
SHIPMENT LABISO
H3GAS C14GAS P32 U233 U235 U238 NP237 PU236 PU238 PU239 PU240 PU241
PU242 AM241 AM243 CM242 CM244 CF252 KR85 SR89 SR90 Y91 ZR95 NB94 NB95
MO99 TC99 RU103 RU106 TE125M TE127 TE127M TE129 TE129M I129 I131 XE133
CS134 CS137 CE141 CE144 PM147 SM151 EU152 EU154 EU155
NORMAL NMODE=1
1.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
2.000E+00 1.000E+01 0.000E+00 1.100E-02 0.000E+00 0.000E+00
0.000E+00 5.000E+01 2.000E+01 0.000E+00 0.000E+00 0.000E+00
2.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
0.000E+00
ACCIDENT SEVFRC NPOP=1 NMODE=1
6.03E-01 3.94E-01 3.00E-03 3.00E-06 5.00E-06 7.00E-06
NPOP=2 NMODE=1
6.02E-01 3.94E-01 4.00E-03 4.00E-06 3.00E-06 2.00E-06
NPOP=3 NMODE=1
6.04E-01 3.95E-01 3.80E-04 3.80E-07 2.50E-07 1.30E-07
RELEASE RFRAC
GROUP=1 0.00E+00 0.00E+00 0.00E+00 1.00E-02 1.00E-01 1.10E-01
GROUP=2 0.00E+00 0.00E+00 0.00E+00 1.00E-08 9.00E-04 9.80E-04
GROUP=3 0.00E+00 0.00E+00 0.00E+00 1.00E-08 5.00E-08 5.00E-08
GROUP=4 0.00E+00 0.00E+00 0.00E+00 1.00E-08 1.00E-06 4.20E-05
AERSOL DISP=3 0.00E+00 0.00E+00 0.00E+00 1.00E+00 1.00E+00 1.00E+00
DISP=4 0.00E+00 0.00E+00 0.00E+00 1.00E+00 1.00E+00 1.00E+00
DISP=5 0.00E+00 0.00E+00 0.00E+00 1.00E+00 1.00E+00 1.00E+00
RESP DISP=3 0.00E+00 0.00E+00 0.00E+00 1.00E+00 1.00E+00 1.00E+00
DISP=4 0.00E+00 0.00E+00 0.00E+00 5.00E-02 1.00E+00 1.00E+00
DISP=5 0.00E+00 0.00E+00 0.00E+00 5.00E-02 5.00E-02 5.00E-02
EOF
ISOTOPES -1 1 1.00 1.00 1.00 0.00 SFUEL
U235 1.34E-03 ACT_OTHER 5
U238 8.06E-05 ACT_OTHER 5
PU238 1.31E+02 ACT_OTHER 5
PU239 6.01E-01 ACT_OTHER 5
PU240 5.42E-01 ACT_OTHER 5
PU241 2.09E+02 ACT_OTHER 5
CM242 1.36E+01 ACT_OTHER 5
CM244 2.09E+00 ACT_OTHER 5

```

Table I (continued)

KR85	9.41E+02	NOBLE	3				
SR89	4.57E+04	ACT_OTHER	5				
SR90	7.90E+03	ACT_OTHER	5				
Y91	6.97E+04	VOLATILE	5				
ZR95	9.02E+04	ACT_OTHER	5				
NB95	1.67E+05	VOLATILE	5				
RU103	1.69E+04	RUTH	5				
RU106	9.49E+03	RUTH	5				
TE127	5.05E+02	ACT_OTHER	5				
TE127M	5.15E+02	ACT_OTHER	5				
TE129	3.42E+02	ACT_OTHER	5				
TE129M	5.38E+02	ACT_OTHER	5				
CS134	1.79E+04	VOLATILE	4				
CS137	7.89E+03	VOLATILE	4				
CE141	1.71E+04	ACT_OTHER	5				
CE144	1.35E+05	ACT_OTHER	5				
PM147	9.22E+03	VOLATILE	5				
EU154	5.49E+02	ACT_OTHER	5				
LINK 1	3.2	48.3	2250.7	2800.0	1.93E-07 U		2
LINK 1	15.4	48.3	2250.7	2800.0	3.16E-07 U		1
LINK 1	208.5	88.5	15.2	470.0	1.61E-07 R		1
LINK 1	67.4	88.5	296.3	780.0	1.61E-07 S		1
LINK 1	7.2	48.3	2127.0	2800.0	3.16E-07 U		1
LINK 1	1.0	88.5	8.9	470.0	1.93E-07 R		2
LINK 1	3.9	88.5	802.3	780.0	1.93E-07 S		2
LINK 1	0.0	48.3	0.0	0.0	1.93E-07 U		2
LINK 1	0.0	88.5	0.0	0.0	1.93E-07 R		2
LINK 1	3.2	88.5	511.6	780.0	1.93E-07 S		2
LINK 1	0.0	48.3	0.0	0.0	1.93E-07 U		2
LINK 1	2.9	88.5	30.0	470.0	3.85E-07 R		2
LINK 1	5.1	88.5	159.0	780.0	3.85E-07 S		2
LINK 1	0.0	48.3	0.0	0.0	3.85E-07 U		2
LINK 1	14.2	88.5	29.0	470.0	1.93E-07 R		2
LINK 1	3.5	88.5	141.6	780.0	1.93E-07 S		2
LINK 1	0.0	48.3	0.0	0.0	1.93E-07 U		2
LINK 1	4.8	88.5	0.0	0.0	1.93E-07 R		2
LINK 1	0.0	88.5	0.0	0.0	1.93E-07 S		2
LINK 1	0.0	48.3	0.0	0.0	1.93E-07 U		2
LINK 1	14.5	88.5	0.3	470.0	1.93E-07 R		2
LINK 1	0.0	88.5	0.0	0.0	1.93E-07 S		2
LINK 1	0.0	48.3	0.0	0.0	1.93E-07 U		2
PKGSIZ	SFUEL 1.77						
EOF							
EOI							

ASTRAXT: Supports DOE/EA-0912, "Environmental Assessment of Urgent-Relief Acceptance of Foreign Research Reactor Spent Nuclear Fuel," April 1994; assesses potential impacts of transportation by ship to the U.S. of spent nuclear fuel containing uranium of U.S. origin from research reactors requiring urgent relief. Alternatives include a range of possible marine ports of entry and two overland modes (truck and rail) from port to Savannah River Plant (SRP). **ASTRAXT** fuel comes from Austrian ASTRA reactor (see Directory of Nuclear Research Reactors, IAEA, 1989); transported in a Gosslar cask (13 assemblies/cask); conservatively modeled as cooled for 150 days prior to shipment; route-specific for HM-164 highway route from hazmat marine terminal at Port of Charleston, SC, to SRP.

Figure 4. Background Information—ASTRAXT

AREADA (see also **DFLEV**) - Areas (isopleths) of the downwind "footprint" of a puff of particulate matter that might be dispersed in an accident in which containment is compromised. Default values for 18 areas were used in this analysis.

DFLEV - Dilution factors (time-integrated concentrations) for **AREADA** values. Defaults are conservative; derived from Turner, 1969 (Public Health Service, Publ. No. 999-AP-26), for a small puff release at ground level, using U.S. average meteorology. To model an elevated release, for example, overwrite defaults with new values of **DFLEV** and **AREADA** from any Gaussian dispersion code set up for desired meteorology; radionuclide concentrations will be lowered.

Figure 5. Sample Annotations by Keyword—ASTRAXT

INCIDENT-FREE POPULATION DOSE (person-rem):

	CREW	OFF LINK	ON LINK	STOPS	TOTALS
LINK 1	4.75E-06	9.74E-06	3.63E-05	1.56E-05	6.65E-05
TOTAL	3.05E-04	3.42E-05	2.30E-04	1.73E-03	2.30E-03

MAXIMUM INDIVIDUAL IN-TRANSIT DOSE: 1.36E-08 rem

IMPORTANCE ANALYSIS:

Top 5 input parameters for Link 1: DISTANCE TRAVELED; NUMBER OF SHIPMENTS; PACKAGES PER SHIPMENT; DOSE RATE; K ZERO (a function of PKGSZ)

PROBABILITY AND CONSEQUENCES (50-YEAR CEDE; person-rem):

ACCIDENT

CATEGORY	PROBABILITY	CONSEQUENCES
1	3.73E-07	0.00E+00
2	2.44E-07	0.00E+00
3	2.35E-10	0.00E+00
4	2.35E-13	1.21E-01
5	1.54E-13	3.60E+03
6	8.03E-14	3.87E+03

OVERALL POPULATION RISK (person-rem):

	GROUND	INHALED	RESUSPD	CLOUDSH	TOTAL
LINK 1	8.29E-10	9.78E-12	2.66E-11	5.26E-13	8.66E-10
TOTAL	8.93E-08	1.06E-09	2.87E-09	5.67E-11	9.33E-08

TOTAL EXPOSED POPULATION: INCIDENT-FREE

LINK 1: 1.15E+04 persons
TOTAL: 1.39E+05 persons

TOTAL EXPOSED POPULATION: ACCIDENT

LINK 1: 3.04E+06 persons

Figure 6. Sample RADTRAN Output--ASTRAXT

REFERENCES

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APPENDIX

{Comment line(s) ignored by RADTRAN:						Page 1
&& FOREIGN FUELS TRUCK TRANSPORT						
TITLE FRR EA DRAFT TRUCK ASTRA GOSSLAR 10MW 13ASSEM 150DAY CHARLESTON NC-SRP						
{Enter up to 74 alphanumeric characters as a unique title for the input file						
FORM	UNIT					
{Enter UNIT for population dose, NONUNIT for health effects; {N.B., NONUNIT is currently disabled pending model update						
	{NISO	NSEV	NGROUP	NRAD	NAREAS	
DIMEN	46	6	4	10	18	
{With DIMEN the computer is given the DIMENSION of several arrays used in {RADTRAN. If the numbers are not correct, the file will not run.						
{NISO = total Number of ISOTopes in array LABISO; maximum value 65						
{NSEV = Number of accident-SEVerity categories; maximum value 20						
{NGROUP = Number of physical-chemical isotope GROUPS; maximum value 15						
{NRAD = Number of RADial distances for nondispersal accidents; maximum value 15						
{NAREAS = Number of downwind AREAS for dispersal accidents; maximum value 30						
	{IRNKC	IANA	IUOPT	ISEN	IPSQSB	
PARM	1	3	2	1	0	
{With PARM "flags" (switches) are set to indicate what option to choose {when there is a choice of PARaMeters. These flags must be set.						
{IRNKC = flag for probability-consequence plots; saves intermediate probability { and consequence values for graphical display; yes=1/no=0						
{IANA = flag for types of analyses the user wishes to perform: { incident-free (=1)/ accident (=2)/ or both (=3)						
{IUOPT = flag for building shielding options: 1=full; 2=reduced; 3=none						
{ISEN = flag for amount of output: 1=summary only; 2=standard; 3=full						
{IPSQSB = flag for dispersion option: 1=six sets of default values for Pasquill { categories A through F; 0=single look-up table with overwritable defaults						
=====						

APPENDIX (Continued)

Keyword(s)		Data Elements (at least one space follows the Keyword(s))					Page 4
NORMAL							
- NMODE=1							
	1.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	
	2.000E+00	1.000E+01	0.000E+00	1.100E-02	0.000E+00	0.000E+00	
	0.000E+00	5.000E+01	2.000E+01	0.000E+00	0.000E+00	0.000E+00	
	2.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	
	0.000E+00						
{Under the NORMAL keyword is an ordered array of 25 parameter values for EACH							
{selected transportation mode; the following variable names describe the parameters;							
{their values MUST be entered in the order given. Values for aggregate analysis ONLY							
{are starred; they cannot be skipped in a LINK analysis file (see later)- enter a value							
{of zero (0) instead.							
	{*FTZNR	{*FTZNS	{*FTZNU	{*VELR	{*VELS	{*VELU	
	{CREWNO	ADSTCW	HANDNO	STOPTIM	MINST	TIMZR	
	{FMINCL	PDST	RST	DTSTOR	PDSTOR	RSTOR	
	{PPV	{*FRSHR	{*FCTST	{*FTLFWY	{*TCNTPR	{*TCNTPS	
	{*TCNTPU						
{ 1	*FTZNR	Fraction of travel in rural zone; aggregate ONLY					
{ 2	*FTZNS	Fraction of travel in suburban zone; aggregate ONLY					
{ 3	*FTZNU	Fraction of travel in urban zone; aggregate ONLY					
{ 4	*VELR	Velocity in rural zone (km/hr); aggregate ONLY					
{ 5	*VELS	Velocity in suburban zone (km/hr); aggregate ONLY					
{ 6	*VELU	Velocity in urban zone (km/hr); aggregate ONLY					
{ 7	CREWNO	Number in crew on a shipment					
{ 8	ADSTCW	Distance from radiation source to crew					
{ 9	HANDNO	Number of handlings per shipment					
{ 10	STOPTIM	Stop time for shipment (hr/km)					
{ 11	MINST	Minimum stop time per trip (hr); divide by number of links					
{		in a LINK analysis					
{ 12	TIMZR	Distance-independent stop time per trip; only for rail mode (hr);					
{		divide by the number of links in a LINK analysis					
{ 13	FMINCL	Minimum number of rail inspections or classifications; rail mode only					
{ 14	PDST	Number of persons exposed during shipment when stopped					
{ 15	RST	Average exposure distance when stopped during shipment (m)					
{ 16	DTSTOR	Storage time per shipment by mode (hr)					
{ 17	PDSTOR	Number of persons exposed during storage					
{ 18	RSTOR	Average exposure distance during storage (m)					
{ 19	PPV	Number of persons per vehicle sharing the transport link					
{ 20	*FRSHR	Fraction of urban travel during rush hour; aggregate ONLY					
{ 21	*FCTST	Fraction of urban travel on city streets; aggregate ONLY					
{ 22	*FTLFWY	Fraction of rural and suburban travel on freeways; aggregate ONLY					
{ 23	*TCNTPR	One-way traffic count in rural zones (vehicle/hr); aggregate ONLY					
{ 24	*TCNTPS	One-way traffic count in suburban zones (vehicle/hr); aggregate ONLY					
{ 25	*TCNTPU	One-way traffic count in urban zones (vehicle/hr); aggregate ONLY					
=====							

APPENDIX (Continued)

Keyword(s)	Data Elements (at least one space follows the Keyword(s))	Page 6
{ Several types of accident-related values are entered under the ACCIDENT keyword:		
ACCIDENT		
ARATMZ		
NMODE=0	0.0001	1E-07 1E-11
{Under ARATMZ, enter three Accident RATES (accidents per km) by transportation mode, {one for each population-density zone in the order rural (NPOP=1), suburban (NPOP=2), {urban (NPOP=3); for aggregate analyses ONLY; for route-specific analyses, leave blank.		
SEVFRC		
NPOP=1		
NMODE=1	6.03E-01	3.94E-01 3.00E-03 3.00E-06 5.00E-06 7.00E-06
NPOP=2		
NMODE=1	6.02E-01	3.94E-01 4.00E-03 4.00E-06 3.00E-06 2.00E-06
NPOP=3		
NMODE=1	6.04E-01	3.95E-01 3.80E-04 3.80E-07 2.50E-07 1.30E-07
{Under SEVFRC, enter the SEVerity FRaCtion, or fraction of accidents in each severity {category; (the number of severity categories is entered as NSEV, under DIMEN), for each {population-density zone (NPOP=1,2,3) and transportation mode. This information is {required for all analyses, whether aggregate or route-specific, since route segments are {always designated as rural, suburban or urban in character. See the LINK keyword.		
{ Possible releases of radioactive material are treated under the RELEASE keyword.		
RELEASE		
RFRAC		
GROUP=1	0.00E+00	0.00E+00 0.00E+00 1.00E-02 1.00E-01 1.10E-01
GROUP=2	0.00E+00	0.00E+00 0.00E+00 1.00E-08 9.00E-04 9.80E-04
GROUP=3	0.00E+00	0.00E+00 0.00E+00 1.00E-08 5.00E-08 5.00E-08
GROUP=4	0.00E+00	0.00E+00 0.00E+00 1.00E-08 1.00E-06 4.20E-05
{Enter arrays of Release FRAction values for each physical-chemical isotope {group (GROUP=1,2, etc.); the array size must equal the number of severity {categories; if no release would occur, indicate with a zero (0). Physical- {chemical group designations are assigned to isotopes under keyword ISOTOPES.		

APPENDIX (Continued)

Keyword(s)		Data Elements (at least one space follows the Keyword(s))					Page 7	
AERSOL								
DISP=3								
	0.00E+00	0.00E+00	0.00E+00	1.00E+00	1.00E+00	1.00E+00		
DISP=4								
	0.00E+00	0.00E+00	0.00E+00	1.00E+00	1.00E+00	1.00E+00		
DISP=5								
	0.00E+00	0.00E+00	0.00E+00	1.00E+00	1.00E+00	1.00E+00		
{Dispersability category designations are assigned to isotopes under keyword ISOTOPES. {Use AERSOL to assign AERoSOL fraction (i.e., fraction of released material that is in {aerosol form) for each dispersability category that will be used ONLY if user does not {wish to accept default values. The array size must equal the number of severity categories.								
RESP								
DISP=3								
	0.00E+00	0.00E+00	0.00E+00	1.00E+00	1.00E+00	1.00E+00		
DISP=4								
	0.00E+00	0.00E+00	0.00E+00	5.00E-02	1.00E+00	1.00E+00		
DISP=5								
	0.00E+00	0.00E+00	0.00E+00	5.00E-02	5.00E-02	5.00E-02		
{Dispersability category designations are assigned to isotopes under keyword ISOTOPES. {Use RESP to assign RESPIrable fraction (i.e., fraction of released aerosol material that is {respirable) for each dispersability category that will be used ONLY if user does not {wish to accept default values. The array size must equal the number of severity categories.								
{ Dispersibility Category Default Values								
{				Aerosol		Respirable		
{	Category	Description		Fraction		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		
{	8	Liquid		1.0E+00		1		
{	9	Other		1.0E+00		1		
{	10	Gas		1.0E+00		1		
{	11	Flammable		1.0E+00		1		
{	*For loss-of-shielding analyses only,							
{	can NOT be modified.			**Also use for nonvolatile liquids.				
=====								

APPENDIX (Continued)

Keyword(s)	Data Elements (at least one space follows the Keyword(s))							Page 10
{The isotopes to be used are given in two arrays following the keyword ISOTOPES:								
	{NM	TABSPY	PKGSHP	TIPKG	FRGAMA	FRNEUT	LABMAT	
ISOTOPES	--1	1	1.00	1.00	1.00	0.00	SFUEL	
{For each type of package, enter an array of seven values in the order shown.								
{They correspond to the following:								
{NM = Number of transportation Mode; negative value = exclusive use;								
{TABSPY = Number of Shipments								
{PKGSHP = Number of PackaGes per SHiPment;								
{TIPKG = Package dose rate at 1 meter (mrem/hr);								
{FRGAMA = FRaction of package dose rate that is GAMma radiation;								
{FRNEUT = FRaction of package dose rate that is NEUTron radiation;								
{LABMAT = LABel for package of MATerial containing the isotope; maximum								
{ of 12 separate LABMATs may be described per run.								
{This array must be followed immediately by subsidiary arrays of four values each there;								
{must be one array for each isotope (tot=NISO). The four array values correspond to:								
{LIBSAV = Name of Isotope; must be in LABISO, and must be either in the								
{ internal isotope data library or have been DEFINed by the user;								
{CIPKG = Curies per package of the Isotope;								
{IPCGRP = Identifies Physical-Chemical GRoup to which the isotope is								
{ assigned (see discussion of LABGRP under PACKAGE keyword);								
{IDSP = Identifies DiSPersability category to which the isotope is								
{ assigned (see ACCIDENT keyword).								
{LIBSAV	CIPKG	IPCGRP	IDSP					
U235	1.34E-03	ACT OTHER	5					
U238	8.06E-05	ACT OTHER	5					
PU238	1.31E+02	ACT OTHER	5					
PU239	6.01E-01	ACT OTHER	5					
PU240	5.42E-01	ACT OTHER	5					
PU241	2.09E+02	ACT OTHER	5					
CM242	1.36E+01	ACT OTHER	5					
CM244	2.09E+00	ACT OTHER	5					
KR85	9.41E+02	NOBLE	3					
SR89	4.57E+04	ACT OTHER	5					
SR90	7.90E+03	ACT OTHER	5					
Y91	6.97E+04	VOLITAL	5					
ZR95	9.02E+04	ACT OTHER	5					
NB95	1.67E+05	VOLITAL	5					
RU103	1.69E+04	RUTH	5					
RU106	9.49E+03	RUTH	5					
TE127	5.05E+02	ACT OTHER	5					
TE127M	5.15E+02	ACT OTHER	5					
TE129	3.42E+02	ACT OTHER	5					
TE129M	5.38E+02	ACT OTHER	5					
CS134	1.79E+04	VOLITAL	4					
CS137	7.89E+03	VOLITAL	4					
CE141	1.71E+04	ACT OTHER	5					
CE144	1.35E+05	ACT OTHER	5					
PM147	9.22E+03	VOLITAL	5					
EU154	5.49E+02	ACT OTHER	5					
=====								

APPENDIX (Continued)

Keyword(s)		Data Elements (at least one space follows the Keyword(s))						Page 12	
{The LINK keyword is used for route-specific analyses. The keyword is entered at the beginning of each line of input, which describes each LINK in the total route.									
{ Values of the following variables are entered for each LINK (to maximum 40 LINKS):									
{LMODE=mode number for link									
{LDIST=length of link (km)									
{LSPED=vehicle speed in link (km/hr)									
{LPOPD=population density in link (persons/sqkm)									
{LVDEN=one-way vehicle density in link (vehicles/hr)									
{LARAT=accident rate on link (accidents/km)									
{LZONE=zone type for link (R=rural, S=suburban, U=urban)									
{LTYPE=link type (1=freeway, 2=nonfreeway, 3=other)									
	{LMODE	LDIST	LSPED	LPOPD	LVDEN	LARAT	LZONE	LTYPE	
LINK	1	3.2	48.3	2250.7	2800.0	1.93E-07	U	2	
LINK	1	15.4	48.3	2250.7	2800.0	3.16E-07	U	1	
LINK	1	208.5	88.5	15.2	470.0	1.61E-07	R	1	
LINK	1	67.4	88.5	296.3	780.0	1.61E-07	S	1	
LINK	1	7.2	48.3	2127.0	2800.0	3.16E-07	U	1	
LINK	1	1.0	88.5	8.9	470.0	1.93E-07	R	2	
LINK	1	3.9	88.5	802.3	780.0	1.93E-07	S	2	
LINK	1	0.0	48.3	0.0	0.0	1.93E-07	U	2	
LINK	1	0.0	88.5	0.0	0.0	1.93E-07	R	2	
LINK	1	3.2	88.5	511.6	780.0	1.93E-07	S	2	
LINK	1	0.0	48.3	0.0	0.0	1.93E-07	U	2	
LINK	1	2.9	88.5	30.0	470.0	3.85E-07	R	2	
LINK	1	5.1	88.5	159.0	780.0	3.85E-07	S	2	
LINK	1	0.0	48.3	0.0	0.0	3.85E-07	U	2	
LINK	1	14.2	88.5	29.0	470.0	1.93E-07	R	2	
LINK	1	3.5	88.5	141.6	780.0	1.93E-07	S	2	
LINK	1	0.0	48.3	0.0	0.0	1.93E-07	U	2	
LINK	1	4.8	88.5	0.0	0.0	1.93E-07	R	2	
LINK	1	0.0	88.5	0.0	0.0	1.93E-07	S	2	
LINK	1	0.0	48.3	0.0	0.0	1.93E-07	U	2	
LINK	1	14.5	88.5	0.3	470.0	1.93E-07	R	2	
LINK	1	0.0	88.5	0.0	0.0	1.93E-07	S	2	
LINK	1	0.0	48.3	0.0	0.0	1.93E-07	U	2	
{Characteristic dimension(meters) for each package of material (label in LABMAT);									
{ to maximum of 12 packages);									
	{ label	size							
PKGSIZ									
	SFUEL	1.77							
EOF									
EOI									
=====									