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Toxic Gas Accident Analysis Code User's Manual

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ABSTRACT

One of the offsite hazards which could threaten the safety of a nuclear power plant is nearby transportation accidents involving releases of toxic gases or volatile liquids. Significant releases of such materials could endanger the plant through incapacitation of control room personnel. An interactive computer program has been developed to aid in the evaluation of control room habitability for these accidents. The first part of the program can be used to study the time history of toxic material concentrations in the control room under varying external conditions, all of which can be specified by the user. The second part estimates the annual probability of operator incapacitation at a particular plant due to nearby accidents on roads or rail lines, or at storage sites. A data base manager is provided so that all data (site and route layouts, plant characteristics, meteorological data, and chemical data) can be entered and maintained in a convenient format. The program was developed for use on CDC computers using the NOS timesharing system.

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INTRODUCTION

Offsite hazards which could threaten the safe operation or safe shutdown of a plant are considered as part of the safety analysis for a nuclear power plant. One of the hazards arising from the transport of hazardous materials in the vicinity of a plant is a transportation accident involving toxic gases (or volatile liquids).[1] The release to the atmosphere of a significant quantity of a toxic material could endanger the plant through incapacitation of the control room operators.

A computer program, TOXRISK, has been developed to aid in the evaluation of nuclear power plant control room habitability in the event of a nearby toxic material release. The program uses a model which is consistent with the approach described in NRC Regulatory Guide 1.78.[2] Release of the gas is treated as an initial puff followed by a continuous plume. The relative proportions of these as well as the plume release rate are supplied by the user. Transport of the gas is modeled as a Gaussian distribution and occurs through the action of a constant velocity, constant direction wind. Dispersion or diffusion of the gas during transport is described by modified Pasquill-Gifford dispersion coefficients.[3,4] Great flexibility is afforded the user in specifying the release description, meteorological conditions, relative geometry of the accident and plant, and the plant ventilation system characteristics.

Two types of simulation can be performed: multiple case (parametric) studies, and probabilistic analyses. Both make use of relevant data from a computer data base. When the program begins execution, a menu is presented and the user chooses between the Data Base Manager, the Multiple Case program, and the Probabilistic Study program. These are described in later chapters. Throughout the program, flow control is menu-driven and self-explanatory.

The Data Base Manager provides a convenient means of storing, retrieving, and modifying blocks of data needed for the analysis programs. Each block of data is identified by a unique name and an analyst can easily build a library of data to suit a particular application of the TOXRISK program. As an aid to the user, the program is supplied with a skeleton data base, including weather data for 29 cities.[6]

An analyst can use the Multiple Case program to perform parametric studies with full control over all aspects of the physical system. Within each run, a single parameter can assume a number of discrete values, assigned either directly by the user or encompassing a range. For each set of conditions, the Multiple Case program calculates resultant gas concentrations inside the control room and presents a summary of information that describes the event. An optional time history profile of inside and outside concentrations can also be produced.

The Probabilistic Study program provides a means for estimating the annual probability of operator incapacitation due to toxic gas accidents on surrounding transportation routes[5] and storage sites. The potential accident locations are specified as a set of discrete locations. For each potential accident location, the program uses shipping frequency and accident rate data to determine the probability of an accident. An accident severity distribution of up to five classes is used to describe the magnitude of the release; the description and probability of each release class, given an accident, is supplied by the user. For each potential accident location, the program makes use of local wind direction, wind speed, and stability class frequency distributions to calculate the total probability of operator incapacitation from all potential sources of a particular chemical. Conditional probabilities of incapacitation for each value of wind direction, wind speed, stability class, and release class are also presented.

Despite the power and flexibility of the Probabilistic Study program, it is very easy to use. All numerical data are stored in the data base. The user need only specify the names of previously created data blocks. User control is completely menu driven. Examples of interactive terminal sessions are shown in Appendix B.

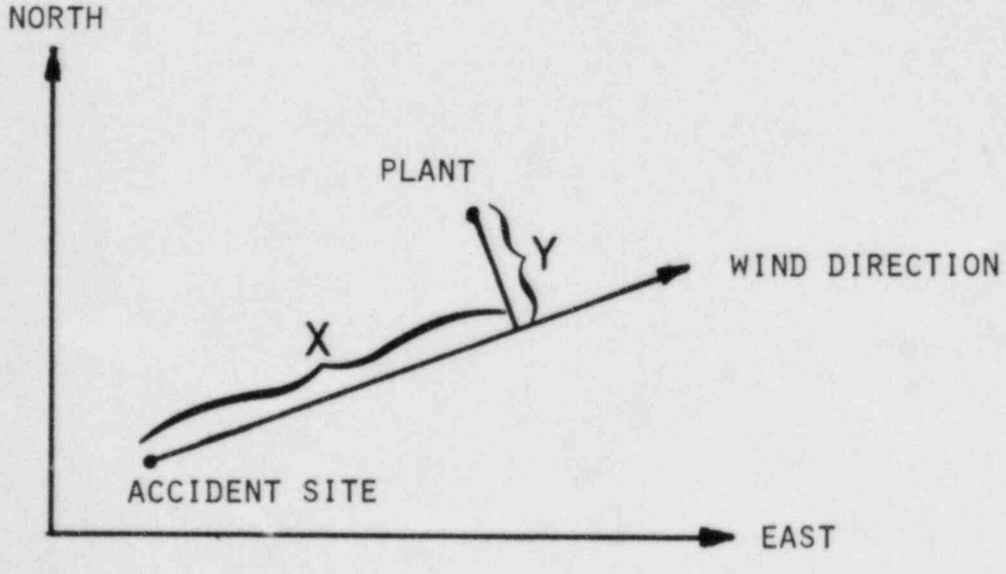
GENERAL MODEL DESCRIPTION

In both the Multiple Case program and the Probabilistic Study program, the same model is used to describe the transport of a toxic gas from a release location into the reactor control room.[2,3,4,5]

A conventional Cartesian grid is used to represent the locations of possible accidents and the plant, with the Y-axis pointing north. The unit of length is meters. The size of the accidental release is described by the total spill quantity (kg), which is subdivided into a puff or flashing fraction and a plume fraction. If in liquid form, some of this spill quantity may immediately flash to vapor. (1 - flashing fraction = plume fraction.) The remaining material is released at a constant rate for the plume duration time. Both the puff and plume describe the initial release in terms of the density (kg/meter^3) of the chemical in gaseous form at ambient conditions.

For tank cars of a pressurized liquid in which part of the material flashes to vapor upon rupture of the tank, the mass released in the puff is proportional to the flashing fraction. The remainder, which does not flash to vapor, is a supercooled liquid and will boil off over some period of time. For chlorine, the flashing fraction ranges from about 17 percent at 20°C (70°F) to about 35 percent at 70°C (160°F). These fractions are based on the idealized adiabatic decompression of the pressurized liquid.[3] It is possible to specify instantaneous vaporization of the entire spill quantity by setting the plume fraction to zero. If this is done, the plume release rate is ignored.

A wind-oriented geometry is used within the code for calculating the gas concentrations due to the puff and plume at a point outside of the control room air inlet.



where

X is the along-wind distance
Y is the cross-wind distance

All releases are assumed to occur on the ground ($Z = 0$). There is no provision in the current model for bouyancy effects.

The puff and plume of released gas are transported by a homogeneous, constant wind field. A Gaussian distribution is used to model the concentration of the toxic material in space (X, Y, Z) along with modified Pasquill-Gifford dispersion coefficients.[3,4]

The wind field is described in the manner commonly used for wind rose environmental assessment, but opposite of conventional meteorology. Wind direction refers to the direction that flow is <u>towards</u>. Wind speed is given in units of m/s and the seven Pasqu ll stability classes are compressed into three: unstable, neutral, and stable. Dispersion coefficients are calculated using an exponential formulation.

The Gaussian puff has an initial dispersion that is characterized[2] by σ_0:

$$\sigma_o(M) = \left[\left(\frac{1}{2\pi^3} \right)^{1/2} \frac{M}{\rho} \right]^{1/3}$$

where M is the mass released and ρ is the gas density at ambient conditions.

The formulation for a neutrally buoyant Gaussian puff is given in terms of a unit concentration ($C = 1$ corresponds to a 100 percent concentration).

$$C(X,Y,Z) = \lambda_o \exp \left\{ - \frac{1}{2} \left[\frac{(X-Ut)^2 + Y^2}{\sigma_o^2 + \sigma_Y^2} + \frac{Z^2}{\sigma_o^2 + \sigma_Z^2} \right] \right\}$$

where $$\lambda_o = \left\{ 1 + \frac{\sigma_Z^2}{\sigma_o^2} \right\}^{-1/2} \left\{ 1 + \frac{\sigma_X^2}{\sigma_o^2} \right\}^{-1}$$

The distances X, Y, Z are measured from the release point in the wind oriented coordinate system. The time, t, is measured from the start of the release and U is the wind speed.[2] The wind direction is assumed constant during and after an accident and is in the X direction. The puff's dispersion in the X direction is taken to be the same as in the Y direction, $\sigma_X = \sigma_Y$.

The dispersion parameters σ_Y and σ_Z are defined by[5]

$$\sigma_Y = C_Y(Ut)^{\beta_Y}$$

$$\sigma_Z = C_Z(Ut)^{\beta_Z} \quad .$$

The parameters C_Y, C_Z, β_Y, and β_Z for the three stability categories are summarized below:[3,4]

DISPERSION PARAMETERS

	C_Y	β_Y	C_Z	β_Z
Unstable	0.28	0.90	0.11	1.0
Neutral	0.15	0.90	0.30	0.70
Stable	0.085	0.90	0.30	0.60

Notice that dispersion coefficients (σ_Y, σ_Z) used for the puff are a function of distance from the release. Dispersion coefficients for plumes are calculated at the alongwind distance as described below and they remain constant with distance.

The dispersion parameters supplied with the program were chosen to represent Pasquill stability classes A-B-C, D, and E-F. On each entrance to the Multiple Case program or Probabilistic Study program, the user is given an opportunity to edit these parameters. Any changes made by the user remain in effect until the end of the terminal session unless subsequent changes are made to the dispersion parameters.

The concentration outside the control room is the sum of the independently calculated puff and plume concentrations. The outside concentration due to the plume in the along-wind coordinate system is given by:

$$C(X,Y,Z) = \frac{Q}{\pi U \sigma_Y \sigma_Z \rho} \exp\left(- \frac{Y^2}{2\sigma_Y{}^2} - \frac{Z^2}{2\sigma_Z{}^2} \right)$$

where Q is the plume release rate (kg/hr).[3,4] The other variables are as defined for the puff. Again, C = 1 corresponds to a 100 percent concentration. The along-wind distance X enters the equation in the σ_Y and σ_Z dispersion coefficients. These dispersion coefficients are constant in time for the plume. The plume appears at the plant at time t = X/U and disappears at time t = X/U + plume duration. The outside concentration due to the plume remains constant over this interval.

The control room ventilation system draws in contaminated air, which leads to the exposure of the operators. The concentration inside the control room, C_I, can be expressed by means of a differential equation involving the outside concentration C_o and the ventilation system air exchange rate R:[1]

$$\frac{dC_I}{dt} = R(C_o - C_I)$$

where R is in units of control-room-volumes/time-unit.

The control room ventilation rate is modeled in three parts: normal, isolated and exhaust rates. The isolated rate is actually the infiltration rate for the overall system, usually in the range of 1 to 10 percent of the normal rate. The exhaust rate is specified separately from the normal rate, so the effect of faster clearing of a contaminated room can be studied. For each accident sequence studied, the outside air intake is closed upon detection of the toxic chemical in the intake (concentration above the alarm level), it remains closed while the cloud passes the plant, and it reopens when the outside concentration falls below the alarm level. These changes in the ventilation rate cannot occur instantly and both a closing and an opening time must be specified. Ventilation rate during the opening and closing period is calculated using linear interpolation.

Air intake for the control room is presently taken from one inlet which can be located at a selected height above the ground (Z).

NUMERICAL SOLUTION TECHNIQUE

Numerical integration of the differential equation by a Runge-Kutta method yields values for both inside concentration and exposure dose as functions of time.

The functions R and C_O in the ventilation system equation are implemented as FORTRAN subprograms that return appropriate function values. The routine for C_O calculates and adds the puff and plume concentrations. The program for R performs linear interpolation if the dampers are in the process of opening or closing.

A constraint equation is used to test for the occurrence of a certain condition during the numerical integration. In the Multiple Case program, it is used to determine when the inside concentration reaches a maximum. In the Probabilistic Study program, it signals the end of an integration when one of the incapacitation criteria is reached inside the control room.

In order to determine the exact times when the outside concentration rises to and falls back to the alarm detector level, the numerical root-finder subroutine ZEROIN is used. These times are used to control the closing and opening of the air intake dampers for isolatable control rooms. In cases where the release is all plume, the root-finder is not used. Time bounds are then calculated directly from the wind speed and along-wind distance.

Numerical integration to simulate the control room ventilation system is performed by a modified version of the math library routine RKF that makes use of a constraint equation and uses a fourth-fifth order solution method. It solves the coupled set of first order differential equations

$$D_I' = C_I$$

$$C_I' = R(t) \times (C_O(t) - C_I)$$

where R is the ventilation rate and C_O is the concentration at the air inlet. Both are expressed as functions of time, which makes a closed form analytical solution impractical. D_I represents the exposure dose, the integral of the inside concentration C_I.

DATA BASE MANAGER

The data needed for TOXRISK have been divided into 10 categories that are referenced by names specified in the program. Each of the categories can contain one or more record blocks that are referenced by names provided by the user. The data base file was designed to reside on a random access mass storage device so that any record block could be read, written, or rewritten directly, without regard to file position.

The Data Base Manager provides the user with the capability of adding, modifying or purging information on the data base file through interactive commands.

The user will see two forms of the same menu during a session with the Data Base Manager. The listing in Figure 1 will be seen when the manager program is entered from the top level menu. The level number shown in a menu listing indicates the level below the initial or main menu. An "EXIT" returns control to the next higher level menu. The brief form in Figure 2 is displayed after a menu item is completed. The letters listed in the menus are the only valid responses in selecting a menu item, i.e., "N," not "NAMES" is expected for "Names of Blocks in a Category." The following sections describe each of the above functions.

<u>Terminal Listings</u>

C. All categories:
The names of the 10 categories are displayed.

D. Entire directory:
Each category name and all the block names in that category are displayed.

N. Names of the blocks in a category:
The user is asked for the name of the category. Then the names of the blocks in that category are displayed.

B. Contents of a selected block:
The user is asked for a category name and then a block name in that category. The data in that block are listed.

Note: For some lists, it has been anticipated that the list will exceed the screen size. In these cases, the first 23 lines are listed and then the message ENTER *CR* TO CONTINUE LISTING will appear. Hit the carriage return key to see the rest of the listing.

```
DATA MANAGEMENT MENU   (LEVEL 2)

    THE OPTIONS FOR TERMINAL LISTINGS ARE:

C  - ALL CATEGORIES
D  - ENTIRE DIRECTORY
N  - NAMES OF BLOCKS IN A CATEGORY
B  - CONTENTS OF A SELECTED BLOCK

    THE OPTIONS FOR CHANGING THE DATA BASE ARE:

A  - ADD A BLOCK
M  - MODIFY A BLOCK
MA - MODIFY AND ADD A BLOCK
P  - PURGE A BLOCK
O  - TO SEE OFF-LINE LISTINGS MENU
E  - EXIT TO LEVEL 1(MAIN DRIVER)
```

Figure 1. Data Base Manager Complete Menu

```
ENTER MENU ITEM DESIRED.      E,EXIT
C,CATEGORIES  D,DIRECTORY  N,NAMES OF BLOCKS B,BLOCK CONTENTS
A,ADD A BLOCK  M,MODIFY    MA,MODIFY/ADD       P,PURGE
O,OFF-LINE MENU
```

Figure 2. Data Base Manager Abbrev[illegible]ed Menu

Changing the Data Base

All the menu items in this section require the user to enter a category name and a block name. If a new block name is requested, the user must enter a name that does not appear in the block name list of the category requested. The same block name may be used in more than one category but the block contents in each would be appropriately different. If the program does not specifically request a new block name, the user must enter the name of an existing block in that category (see section entitled Rules and Restrictions for Name Entries).

A. Add a block:
The user enters the category name and the new block name. The user is then asked to enter each item of data required for a block in that category. The data block is then added to the list of existing blocks in the category (see Notes on Adding a Block).

M. Modify a block:
The content of the block is displayed in menu form after the user enters the category name and block name. The user then selects the item of data to be changed and enters the new value. The modified data block replaces the old data block in the data base.

MA. Modify and add a block:
After the category name and the name of an existing block in that category are entered, a new block name is requested. The user then modifies the block as in M, above. The previously existing block remains unchanged in the data base. The modified block with the new name is added to the list of existing blocks in the category (see Notes on Adding a Block).

P. Purge a block:
A block is purged by internally flagging a block name so that the block is not copied to the revised data base at the end of the session. The user enters the category name and block name. For the duration of the current session the word "BLANK" replaces the block name to be purged in that particular category's block name list. The user is not allowed to use the purged block name again in the current session.

Off-Line Listings Menu

OFF-LINE LISTING MENU. LEVEL 3.

1. RETURN TO LEVEL 1(MAIN DRIVER).
2. RETURN TO LEVEL 2(DATA MANAGEMENT).
3. LIST ALL BLOCKS IN A CATEGORY.
4. LIST ENTIRE DATA SET.

The menu Items 3 and 4 for off-line listings are self-explanatory. The information is written to local file TAPE8 which is later routed to a printer. Item 1 will cause an exit from the Data Manager and display the top level menu. Item 2 causes a return to the Data Manager menu.

Rules and Restrictions for Name Entries

1. Category name--Valid entries are: one of the ten category names or the word EXIT: The 10 categories are: PLANT, CHEMICAL, VENTSYS, DETECTOR, WINDROSE, WINDSPST, SHIPFREQ, ACCRATE, RELEASE, and ACCLOCN. Entering EXIT causes a return to the Data Manager menu. A carriage return is an invalid response.

2. Block name--Valid entries are names appearing in the block name list for the category requested. Leading blanks are not suppressed; i.e., "ZION" is not the same as " ZION". If the name "BLANK" appears in the list, it cannot be referenced.

3. New Block name--The first 10 characters entered are stored as the new block name with the following restrictions:

a. The name cannot already exist in the block name list of the category. The one exception is ACCLOCN (see Special Handling of ACCLOCN, below).

b. The name must have at least one nonblank character.

c. The name cannot be the word "BLANK" or the word "EXIT".

d. The name cannot be the same as a block name (in the requested category) that has been purged in the current session.

e. A carriage return will cause a list of the block names in a category to be displayed.

Notes on Adding a Block

The user should be aware that once data entry is begun for a block there is no exit until all data are entered.

The size of the data base is not a normal concern of the user. The size of the subindex for the categories is limited by dimensions in the program, which have arbitrarily been set to allow 150 blocks in each category. When adding a block, a check is made so that the number of blocks will not exceed the maximum.

Special Handling of ACCLOCN

For the ACCLOCN category, the block length varies depending on the number of nodes needed to describe the accident route. The most useful modification to these blocks is adding or deleting nodes, but the mass storage routines do not allow replacing a block with a block larger than the existing one. To get around this, the program allows the user to name a new block the same as an existing one for the ACCLOCN category in the Modify/Add mode (MA). The modified block replaces the existing block and the old block is purged.

MULTIPLE CASE STUDIES

The Multiple Case Studies program performs single parameter variation studies, with all other variables or parameters fixed and specified by the user. Characteristics of the reactor site, the plant, and the chemical under consideration are retrieved from the data base upon entering the Multiple Case program. The user is requested to supply the names of four previously created data blocks; CHEMICAL, DETECTOR, PLANT, VENTSYS. To see a list of the names of existing data blocks in a category, hit carriage return when a block name is requested. Typing EXIT will return control to the top level menu.

In the CHEMICAL category, density is used for the atmospheric dispersion calculations but the incapacitation level is not used by the Multiple Case program. DETECTOR characteristics are used to control the closing and opening of the air intake dampers. The alarm level is the level of outside concentration that triggers isolation of the control room. Threshold level is not presently used by the program. The Multiple Case program uses only the intake stack height from the PLANT data block. Ventilation system characteristics for a specific type of control room are retrieved from the VENTSYS data block and used in the differential equation governing air exchange.

All of the information obtained from the data base remains fixed until the Multiple Case program is exited. The user must specify a new set of data blocks on each subsequent entrance to the Multiple Case program from the top level menu.

The Multiple Case program is designed for the automated performance of one-dimensional parametric studies. The user can specify a set of values to be used for one of the following 10 parameters; ACCIDENT X, ACCIDENT Y, PLANT X, PLANT Y, PLUME FRACTION, RELEASE RATE, SPILL QUANTITY, WIND SPEED, WIND DIRECTION, and STABILITY CLASS. Except for STABILITY CLASS, this set can have up to 99 elements and the elements can be specified either explicitly or else implicitly as a range of evenly spaced values. STABILITY CLASS has only three possible values.

Upon completion of all requested cases, the user is given a chance to supply a new set of varying quantity values for the same or a different parameter. The user is then given an opportunity to edit the previously specified fixed parameter values (i.e., the other nine parameters). The previously defined values of each parameter are presented one at a time and the user can enter a new value or else hit carriage return if no change is desired. All input is checked for validity to avoid failure in performance of the numerical calculations. Preliminary testing indicates that extremely large spill quantities may be specified (10 million kg) and the plume duration can be up to 300 hours. This testing with extreme ranges of values has been done to assure numerical stability, and in no way implies that the models themselves are valid or applicable for these extreme values.[3]

It is important that the user not attempt to abort the program's execution, because any pending changes to the data base will be lost along with the terminal session log file. Many opportunities are given for exiting the Multiple Case program. All of these return control to the top level menu where the user can enter the Data Base Manager or the probabilistic risk assessment program. Typing E in response to a yes/no question will return control to the top level menu. On exit from the top level menu, control goes to a cleanup routine which rewrites the data base file if any changes have been made. Control is then returned to the TOXEXEC procedure file which replaces the data base permanent file and routes the output files to the printer.

The following describes each of the 10 input parameters:

ACCIDENT X, ACCIDENT Y: position of the release in a Cartesian system with X-axis pointing east. Unit of length is meters.

PLANT X, PLANT Y: position of the control room in the same coordinate system.

PLUME FRACTION: portion of the total spill mass that is not immediately flashed to vapor. The plume release rate is assumed constant until the entire spill has vaporized. Values must be within the inclusive range (0-1).

RELEASE RATE: rate of vaporization for the plume fraction of the release, in kg/hour. The duration of plume release in hours is spill quantity x plume fraction/release rate.

SPILL QUANTITY: total mass in kg of released material that makes up the puff and plume.

WIND SPEED: velocity of the spatially homogeneous wind field in m/sec.

WIND DIRECTION: direction that the wind blows towards. This choice was made in order to be consistent with other consequence analyses. A northerly wind blows in the positive Y-axis direction. Direction can be specified as one of 16 compass points (N, NNE, etc.). For finer resolution of off-axis dispersion, wind direction can be made the varying quantity and the program will perform calculations for an arbitrary (<100) number of cases between any two wind directions. When the wind direction for a specific case does not coincide with one of the 16 compass points, it is printed out as a wind heading in degrees clockwise from north.

STABILITY CLASS: characterization of the atmospheric turbulence. A condensed set of the traditional Pasquill-Gifford stability classes is used: unstable, neutral, and stable.

PROBABILISTIC STUDIES

An estimate of the probability of control room operator incapacitation due to nearby accidental releases of a particular toxic gas can be easily obtained for a specific reactor site. The road or transport network surrounding a reactor site is modelled as a set of discrete accident location nodes which is stored as a block in the data base. Each accident node is described by its location in Cartesian coordinates, the type of corridor (i.e., four lane divided highway, local rail, barge etc.), and its associated length. Separate data base blocks are used to store values of shipping frequencies and accident rates for each of the route types. By multiplying appropriate numerical values from the three data blocks we obtain the expected yearly incidence of accidents at each location node:

$$\text{km} \times \frac{\text{shipments}}{\text{year}} \times \frac{\text{accidents}}{\text{shipment-km}} = \frac{\text{accidents}}{\text{year}} .$$

Provision is made for the description of a five class accident severity distribution for each corridor type. Each class of release severity is described by its relative probability of occurrence, spill quantity, plume fraction, and plume release rate. Many different release description blocks can be stored in the data base, each contains a description of five release classes for each of the eight route types.

Meteorological data for a site is stored in two types of data base blocks: <u>wind rose</u>, and <u>wind speed stability-class</u> joint frequency distribution.

Characteristics of a released chemical are stored in a CHEMICAL block that includes the chemical's density, incapacitation mechanism (concentration or dose), and its incapacitating level. The risk from only one chemical at a time can be studied with this program.

Three data blocks describe the reactor control room: PLANT, VENTSYS, and DETECTOR. Plant location is described in the conventional Cartesian grid where Z is the air inlet stack height. Provision is made for modeling the ventilation of control rooms with automatic chemical detection systems that isolate the room when the alarm level is reached at the control room air inlet. A threshold value is stored in the data base but it is not presently used.

Three air exchange rates are stored in units of control-room-volumes hour: normal operation, isolation, and exhaust. For a plant without an automatic isolation system, these values would all be equal. Changes in the ventilation rate cannot occur instantaneously; therefore, closing and opening durations must be specified. Ventilation rates during the periods are calculated by linear interpolation. The rate of change of the ventilation rate is limited to a maximum of 0.25 volumes/hour/second.

The detector characteristics control the operation of the ventilation system. When the outside concentration reaches alarm level and the detection response time has elapsed, the ventilation rate changes from the open rate to the isolated rate. The room remains isolated until the outside concentration falls below the alarm level. The ventilation rate then changes to the exhaust level. Numerical integration stops when the inside concentration drops below the alarm level.

Probabilistic Study Implementation

Each accident node contributes independently to the overall risk of operator incapacitation. For a postulated accident at each node, releases of five severity classes are considered. All combinations of 8 wind speeds, 48 wind directions (interpolated from the 16 sector wind rose), and 3 stability classes are also considered. For each set of conditions that result in operator incapacitation, the incremental contribution to overall risk $\Delta\rho$ is given by

$\Delta\rho$ = node length (km)

x shipping frequency (shipments/year)

x accident rate (accidents/shipment-km)

x probability of this release class given an accident

x probability of this wind speed

x probability of this wind direction

x probability of this stability class.

By optimizing the order in which the calculations are performed, it is practical to perform probabilistic studies interactively at a terminal instead of waiting for a batch job. Systematic variation is performed for five release severity classes, eight wind speeds, three stability classes, and 12 wind angles for each accident node. This yields 1,440 possible combinations; yet for most cases it is only necessary to perform one-tenth of these calculations. The controlling loops are structured so that an early exit is taken if further variation of the parameters will not lead to operator incapacitation.

The innermost loop performs variation of wind angle. The wind is initially blown straight from the accident to the plant and succeeding loops increment the off-axis angle in 7.5° steps. When a particular wind angle does not yield operator incapacitation, then no further increase in the wind angle will produce incapacitation and these cases are skipped. This savings is most apparent under stable meteorological conditions when dispersion is small.

Another early exit can produce even greater savings in cases where the plant's air inlet is at ground level. If no incapacitation occurs when the wind blows straight from accident to plant and "stable" conditions prevail, then no further variation of wind direction or stability class will yield incapacitation and consideration of 35 cases is eliminated.

Various shortcuts have been introduced in the numerical solution for the Probabilistic Study Program without affecting the underlying model. The numerical integration can be speeded up considerably since we are only interested in knowing whether or not incapacitation has occurred for a given set of conditions, and not in detailed concentration profiles.

For chemicals that have an incapacitation threshold that is concentration dependent, there is no need to integrate a second equation for the exposure dose. This means that risk assessment for dose-dependent incapacitation will be approximately 30 percent more expensive than concentration-dependent incapacitation if the two levels are comparable; i.e., the incidence of incapacitation is equal.

The constraint equation in the numerical integrator is used here to signal the occurrence of incapacitation. A considerable savings is achieved through stopping the numerical integration at this point.

Since we are only interested in quantitative results with a yes/no answer and not in detailed concentration profiles, the error tolerance requirements on the numerical integrator were relaxed in order to achieve faster execution. This change produced small errors (~5 percent) in the final results and this error was always in the conservative direction. Execution time was decreased by roughly 20 percent.

Conditional probabilities are accumulated for each value of release severity class, wind speed, wind direction, and stability class. Whenever a set of conditions is found to cause incapacitation, the probability of those condition's simultaneous occurrence is added to the appropriate index in each of four arrays representing the four parameters. Upon completion of the Probabilistic Study Program, each conditional probability array distributes the total probability of incapacitation among the possible condition states of its parameter.

An analyst can use the conditional probabilities to determine the sensitivity of operator safety to changes in release severity, wind speed, wind direction, and stability class while employing realistic values for the relative distribution of these parameters. The relative distribution of conditional probabilities can be used in lieu of parametric studies if careful attention is given to the choice of accident location nodes, shipping frequencies, and accident rates.

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APPENDIX A

Directions for Using the TOXRISK Program on the Sandia National Laboratories Computer System

The TOXRISK program has been installed in preliminary form for test and evaluation on a CDC CYBER 170/855 running under the NOS 2 operating system. This is Sandia's open timesharing system, and it can be accessed by telephone at 300 or 1200 baud. The program is written in FORTRAN 5 and it makes extensive use of CDC's random access "mass storage files," which are not described in the FORTRAN 77 language standard. The program requires no modification to run under the NOS 1 operating system and it is likely that only minor changes would be required to install the program on a NOS/BE system. Substantial effort would be required for conversion of the program to a non-CDC computer due to the strong dependance of the Data Base Manager on the CDC mass storage file system.

A skeleton data base has been prepared that includes wind rose and wind speed stability-class joint distributions similar to those used in the Reactor Safety Study.[6] This data base has been assembled in order to provide a starting point for users.

In order to use TOXRISK, each user must first store a copy of the skeleton data base as one of his/her permanent files. The following control statements accomplish this:

```
GET,TOXDATA/UN=DCHANIN
SAVE,TOXDATA
```

These statements need only be executed once. The user is then free to modify the data base file with the Data Base Manager in TOXRISK and these changes will not affect other users.

There are two means by which data base information can be exchanged among users. The simplest approach is to GET a copy of another user's file and then SAVE it in the manner described above. If it is necessary to merge data from several sources into one data base file, then the utility programs INPF and ESTD must be used. INPF creates a card image file that contains the data base information in an eye-readable format. ESTD performs the inverse operation of creating a data base file from a card image file. Data from several card image files can be manipulated with a text editor and merged into one eye-readable file. This file can then be used as the input for ESTD in order to create a single random access data base file. The two utility programs are described further in Appendix F.

Execution of the TOXRISK program is controlled by the procedure file TOXEXEC. Enter the two following control statements each time you want to run the program in order to get the latest version of the procedure file:

```
GET,TOXEXEC/UN=DCHANIN
TOXEXEC
```

By default, TOXEXEC uses a data base permanent file named TOXDATA in the user's permanent file space. If this file is not found, an error message is printed. Another data base file name can be specified as the argument to TOXEXEC (i.e., "TOXEXEC,TXDATA1"). This alternate data base file must have been created by the TOXRISK program.

If changes are made to the data base during the terminal session, this procedure file will automatically replace the original data file with the updated version.

A complete log of the terminal session is written to local file TAPE7 and any requested off-line listings of the data base are written to TAPE8. The procedure file TOXEXEC automatically prints these files at the central site and the listings are delivered to the user's output box. Users at other sites can arrange to have this output mailed. Each user's copy of TOXEXEC can be tailored to meet their individual needs and the ROUTE control statements can be removed if automatic printing of these files is not desired.

A microfiche listing of an output file can be obtained by entering the following control statement after the terminal session. An optional eye-readable title up to 66 characters long can be appended to the statement after the period (.).

```
COMQ,TAPE7,DAT. OPTIONAL TITLE UP TO 66 CHARS or
COMQ,TAPE8,DAT. OPTIONAL TITLE UP TO 66 CHARS
```

Files to be listed on microfiche must include carriage control characters; TAPE7 and TAPE8 have carriage control. The microfiche will be delivered to the user's output box and mailing can be arranged.

If a fatal error occurs during the session, a dump file is automatically sent to the program authors for examination and debugging. Detection of any program error during execution inhibits updating of the data base file in order to preserve its integrity.

-----**WARNING**-----

Please do not abort the program from the terminal. To get out of the program, enter EXIT or E at an appropriate time. A terminal abort (control-T) will destroy the TAPE7 session log, prevent any pending data base modification, and "lock up" your terminal so that central site operator intervention is required.

A complete compiler output listing of the program and the initial data base are listed on microfiche in a pocket in Appendix G. The meteorological data for a number of reactor sites are included.[6,7]

APPENDIX B

Sample Terminal Sessions

Data Base Manager Program

All of the options of the Data Base Manager Program are illustrated in the following Figures B-1 through B-5.

```
? d

 PLANT            CHEMICAL         VENTSYS          DETECTOR
 ___________      ___________      ___________      ___________
    IND PT           CHLORINE         TYPE B           CL SLOW
    DIABLO                            TYPE C           CL FAST
    ZION
    YANKEE ME
    DAVIS BESS
    ORIGIN
    TEST

                  WINDROSE                                   WINDSPST
    ___________________________________________      ___________________________
    DIABLO        ALLENS CR        ARKANSAS          ALBUQUERQU     APALACHICO
    BAILLY S      BEAVER VA        BELLEFONT         BISMARCK       BOSTON
    BIG ROCK      BLACK FOX        BRAIDWOOD         BROWNSVILL     CAPE HATTE
    BROWNS FE     BRUNSWICK        BYRON 1           CARIBOU        CHARLESTON
    CALLAWAY      CALVERT C        CATAWBA 1         CHICAGO        COLUMBIA
    CHEROKEE      CLINTON          COMMANCHE         DODGE CITY     EL PASO
    COOK DC       COOPER S         CRYSTAL R         ELY NEVAD      FORT WORTH
    DAVIS-BE      DIABLO CA        DRESDEN 2         FRESNO         GREAT FALL
    DUANE ARN     FARLEY 1         FERMI 2           LAKE CHARL     MADISON
    FITZPATRI     FORKED RI        BASE              MEDFORD        MIAMI
ENTER *CR* TO CONTINUE LISTING.?
                                                     MILWAUKEE      MOLINE
                                                     NEW YORK       OMAHA
                                                     PHOENIX        SANTA MARI
                                                     SEATTLE        WASHINGTON
                                                     BASE

 SHIPFREQ         ACCRATE          RELEASE          ACCLOCN
 ___________      ___________      ___________      ___________
    BASE             BASE             BASE             BASE
    TEST             TEST                              TEST
 LIST COMPLETE.
```

Figure B-1. Terminal Listing of Directory

```
? b
    FOR BLOCK CONTENTS, ENTER THE CATEGORY OF THE BLOCK
? chemical
    ENTER THE NAME OF THE BLOCK IN CHEMICAL   *CR* TO SEE BLOCK LIST.
? chlorine


  CONTENTS OF CHLORINE   IN CHEMICAL

  THE DENSITY OF THE CHEMICAL(G/M**3) = 3170.
  TYPE OF INCAPACITATION = CONC      INCAP. LEVEL(PPM)  =  10.0

  LIST COMPLETE.

 ENTER MENU ITEM DESIRED.         E,EXIT
 C,CATEGORIES     D,DIRECTORY     N,NAMES OF BLOCKS      B,BLOCK CONTENTS
 A,ADD A BLOCK    M,MODIFY        MA,MODIFY/ADD          P,PURGE
 O,OFF-LINE MENU
```

Figure B-2. Block Content

```
? a
    FOR BLOCK ADDITION, ENTER THE CATEGORY OF THE BLOCK
? ventsys
    ENTER THE NEW NAME (10 CHARACTERS MAX) OF THE BLOCK IN VENTSYS
  TO BE ADDED. *CR*  TO SEE BLOCK LIST.
? type a
  ENTER THREE EXCHANGE RATES(VOLUMES/HOUR)
  RATE FOR OPEN
? 1.
  RATE FOR ISOLATED
? .015
  RATE FOR EXHAUST
? 1.
  ENTER TWO DAMPER TIMES(SECONDS)
  CLOSING DAMPER TIME
? 10
  OPENING DAMPER TIME
? 10.

  THE THREE EXCHANGE RATES(VOLUMES/HOUR) ARE
   OPEN = 1.000       ISOLATED = .1500E-01  EXHAUST = 1.000
  THE TWO DAMPER TIMES(SECONDS)
   CLOSING = 10.00        OPENING = 10.00

  TYPE A     HAS BEEN ADDED.

 ENTER MENU ITEM DESIRED.          E,EXIT
 C,CATEGORIES     D,DIRECTORY      N,NAMES OF BLOCKS      B,BLOCK CONTENTS
 A,ADD A BLOCK    M,MODIFY         MA,MODIFY/ADD          P,PURGE
 O,OFF-LINE MENU
```

Figure B-3. Add a Block

```
? m
    ENTER THE CATEGORY OF THE BLOCK TO BE MODIFIED.
? windrose
   ENTER THE NAME OF THE BLOCK IN WINDROSE   TO BE MODIFIED.
  *CR* TO SEE BLOCK LIST.
? base

  WINDROSE
   N       NNE     NE      ENE     E       ESE     SE      SSE
   .0624   .0624   .0624   .0624   .0624   .0624   .0624   .0624
   S       SSW     SW      WSW     W       WNW     NW      NNW
   .0624   .0624   .0624   .0624   .0644   .0624   .0624   .0624
  THE TOTAL PROBABILITY IS  1.0000


  ENTER THE DIRECTION OF THE PROBABILITY TO BE CHANGED.
  ENTER "ALL" TO CHANGE ALL VALUES.
  ENTER "EXIT" IF NO MORE CHANGES.
? ese
  ENTER THE PROBABILITY FOR ESE
? .0644

  THE SUM OF THE PROBABILITIES IS  1.0020-OUT OF RANGE.

  WINDROSE
   N       NNE     NE      ENE     E       ESE     SE      SSE
   .0624   .0624   .0624   .0624   .0624   .0644   .0624   .0624
   S       SSW     SW      WSW     W       WNW     NW      NNW
   .0624   .0624   .0624   .0624   .0644   .0624   .0624   .0624
  THE TOTAL PROBABILITY IS  1.0020


  ENTER 1 TO CHANGE THE ENTRIES,
        2 TO HAVE THE ENTRIES SCALED BY THE SUM(IF NON-ZERO).
? 2

  THE SCALE FACTOR USED WAS       .99798

  WINDROSE
   N       NNE     NE      ENE     E       ESE     SE      SSE
   .0622   .0622   .0622   .0622   .0622   .0643   .0622   .0622
   S       SSW     SW      WSW     W       WNW     NW      NNW
   .0622   .0622   .0622   .0622   .0642   .0622   .0622   .0622
  THE TOTAL PROBABILITY IS  1.0000


  ENTER THE DIRECTION OF THE PROBABILITY TO BE CHANGED.
  ENTER "ALL" TO CHANGE ALL VALUES.
  ENTER "EXIT" IF NO MORE CHANGES.
? exit
  BASE       HAS BEEN MODIFIED.
```

Figure B-4. Modify a Block

```
? ma
     ENTER THE CATEGORY FOR MODIFICATION AND ADDITION.
? accloen
   ENTER THE NAME OF THE BLOCK IN ACCLOCN    TO BE MODIFIED.
 *CR* TO SEE BLOCK LIST.
?
BASE       TEST
   ENTER THE NAME OF THE BLOCK IN ACCLOCN    TO BE MODIFIED.
 *CR* TO SEE BLOCK LIST.
? base
   ENTER THE NEW NAME  OF THE MODIFIED BLOCK IN ACCLOCN    TO BE ADDED.
 FOR THIS CATEGORY ONLY, THE NEW BLOCK NAME CAN BE THE SAME AS THE OLD.
? base
 THERE ARE   4 NODES IN BASE       NOW.
  ENTER THE NUMBER OF NODES THE MODIFIED BLOCK WILL HAVE.
 NOTE,ADDING AND DELETING OF NODES IS NOT ALLOWED IN THE SAME PASS.
? 6

 NODE NO.    LOCATION(X,Y)        NODE LENGTH        TYPE
               (METERS)              (KM)
     1      500.00        0.00       1.00           4 LANE INTERSTATE
     2        0.00    -1000.00       1.00           4 LANE DIVIDED
     3    -1500.00        0.00       1.00           2 LANE UNDIVIDED
     4        0.00     2000.00       1.00           INTERSECTION
 ADDITION OF   2 NODES REQUESTED.

 FOR NODE   5, ENTER THE NODE TYPE NUMBER. *CR* TO SEE TYPE LIST.
?
   1. 4 LANE INTERSTATE
   2. 4 LANE DIVIDED
   3. 2 LANE UNDIVIDED
   4. INTERSECTION
   5. MAIN LINE RAIL
   6. LOCAL RAIL
   7. BARGE
   8. STORAGE SITE

 FOR NODE   5, ENTER THE NODE TYPE NUMBER. *CR* TO SEE TYPE LIST.
? 3
 ENTER THE LOCATION(METERS) OF NODE   5, X ON THE FIRST LINE,  Y ON THE NEXT .
? -1500
? 500
 ENTER THE LENGTH(KM) OF NODE.
? .5

 FOR NODE   6, ENTER THE NODE TYPE NUMBER. *CR* TO SEE TYPE LIST.
? 3
 ENTER THE LOCATION(METERS) OF NODE   6, X ON THE FIRST LINE,  Y ON THE NEXT .
? -1500
? 1000
 ENTER THE LENGTH(KM) OF NODE.
? .5

 NODE NO.    LOCATION(X,Y)        NODE LENGTH        TYPE
               (METERS)              (KM)
     1      500.00        0.00       1.00           4 LANE INTERSTATE
     2        0.00    -1000.00       1.00           4 LANE DIVIDED
     3    -1500.00        0.00       1.00           2 LANE UNDIVIDED
     4        0.00     2000.00       1.00           INTERSECTION
     5    -1500.00      500.00        .50           2 LANE UNDIVIDED
     6    -1500.00     1000.00        .50           2 LANE UNDIVIDED

 ENTER "NODE" TO CHANGE AN EXISTING NODE.
 ENTER "ALL" TO CHANGE ALL VALUES.
 ENTER "EXIT" IF NO MORE CHANGES.
? exit
 BASE       HAS BEEN MODIFIED, THEN ADDED AS BASE
```

Figure B-5. Modify and Add

APPENDIX B (Continued)

Sample Terminal Sessions

Multiple Case Program

A typical use of the Multiple Case Program is illustrated in the following Figures B-6 through B-10.

```
/toxexec
USER'S OWN VERSION OF TOXRISK ATTACHED

  RANDOM ACCESS FILE IS OPEN.

  LEVEL ONE MENU
     E - EXIT
     D - DATA BASE MANAGER
     M - MULTIPLE CASE
     P - PROBABILISTIC STUDY

  ENTER LEVEL ONE MENU LETTER.
? m
 ENTER Y IF YOU WANT TO CHANGE THE DISPERSION COEFFICIENTS
? y

 HIT CARRIAGE RETURN TO LEAVE PRESENT VALUE

 UNSTABLE CONDITIONS: SIGMA Y FIRST COEFFICIENT;    .2800
? .25

 UNSTABLE CONDITIONS:SIGMA Y SECOND COEFFICIENT;    .9000
?

 UNSTABLE CONDITIONS: SIGMA Z FIRST COEFFICIENT;    .1100
? .1

 UNSTABLE CONDITIONS:SIGMA Z SECOND COEFFICIENT;   1.0000
?

 NEUTRAL  CONDITIONS: SIGMA Y FIRST COEFFICIENT;    .1500
?

 NEUTRAL  CONDITIONS:SIGMA Y SECOND COEFFICIENT;    .9000
?

 NEUTRAL  CONDITIONS: SIGMA Z FIRST COEFFICIENT;    .3000
?

 NEUTRAL  CONDITIONS:SIGMA Z SECOND COEFFICIENT;    .8000
?

 STABLE   CONDITIONS: SIGMA Y FIRST COEFFICIENT;    .0850
?

 STABLE   CONDITIONS:SIGMA Y SECOND COEFFICIENT;    .9000
?

 STABLE   CONDITIONS: SIGMA Z FIRST COEFFICIENT;    .3000
?

 STABLE   CONDITIONS:SIGMA Z SECOND COEFFICIENT;    .6000
?

 WELCOME TO THE INTERACTIVE TOXIC GAS CODE.
 TYPING E OR EXIT IN RESPONSE TO A YES/NO QUESTION
 WILL RETURN YOU TO THE TOP LEVEL MENU

 ABORTING THE PROGRAM LOCKS UP THE INTERACTIVE JOB


 TO SEE BLOCK LIST, ENTER CARRIAGE RETURN

 ENTER NAME OF CHEMICAL BLOCK OR "EXIT"
```

Figure B-6. Editing of Dispersion Coefficients

```
 WELCOME TO THE INTERACTIVE TOXIC GAS CODE.
 TYPING E OR EXIT IN RESPONSE TO A YES/NO QUESTION
 WILL RETURN YOU TO THE TOP LEVEL MENU

 ABORTING THE PROGRAM LOCKS UP THE INTERACTIVE JOB


 TO SEE BLOCK LIST, ENTER CARRIAGE RETURN

 ENTER NAME OF CHEMICAL BLOCK OR "EXIT"
? chlorine

  THE DENSITY OF THE CHEMICAL(G/M**3) = 3170.
  TYPE OF INCAPACITATION = CONC       INCAP. LEVEL(PPM)  =  10.0

 ENTER NAME OF DETECTOR BLOCK OR "EXIT"
? cl fast

  RESPONSE TIME(SECONDS) FOR THIS CHEMICAL = 5.000
  THRESHOLD LEVEL(PPM) =  .100          ALARM LEVEL(PPM) =  1.00

 ENTER NAME OF PLANT BLOCK OR "EXIT"
? origin

   LOCATION OF PLANT X=0.         Y=0.
   HEIGHT OF STACK =0.
   SIZE OF THE BUILDING L=0.         W=0.         H=0.
   NUMBER OF INLETS  0.0
   DISTANCE BETWEEN INLETS =    0.00

 ENTER NAME OF VENTSYS BLOCK OR "EXIT"
? type b

  THE THREE EXCHANGE RATES(VOLUMES/HOUR) ARE
   OPEN = 1.000       ISOLATED = .6000E-01  EXHAUST = 1.000
  THE TWO DAMPER TIMES(SECONDS)
   CLOSING = 10.00         OPENING = 10.00

 ENTER A ONE LINE CASE TITLE
? sample problem for documentation, rail car accident large puff
 CASE #  1, ENTER THE INDEX OF THE VARYING QUANTITY
```

Figure B-7. Retrieving Four Blocks From the Data Base

```
 ENTER A ONE LINE CASE TITLE
? sample problem for documentation, rail car accident large puff
 CASE #  1, ENTER THE INDEX OF THE VARYING QUANTITY

 0-EXIT
 1-ACCIDENT X
 2-ACCIDENT Y
 3-PLANT X
 4-PLANT Y
 5-PLUME FRACTION
 6-RELEASE RATE
 7-SPILL QUANTITY
 8-WIND SPEED
 9-WIND DIRECTION
 10-STABILITY CLASS
? 4
 ENTER THE NUMBER OF SUBCASES TO BE RUN (0-EXIT)
? 2
 FOR SUBCASE #     1
 ENTER PLANT Y POSITION (M)
? 1000
 FOR SUBCASE #     2
 ENTER PLANT Y POSITION (M)
? 2000
 ENTER ACCIDENT SITE X POSITION (M)
? 0
 ENTER ACCIDENT SITE Y POSITION (M)
? 0
 ENTER PLANT X POSITION (M)
? 0
 ENTER FRACTION IN PLUME (0-1)
? 0
 ENTER PLUME RELEASE RATE (KG/HOUR)
? 0
 ENTER TOTAL SPILL QUANTITY (KG)
? 80000
 ENTER WIND SPEED (M/S)
? 1
 ENTER WIND DIRECTION (N-NNW)
? n
 ENTER STABILITY CLASS (1-3)
? 3
 ENTER TYPE OF OUTPUT DESIRED: S-SUMMARY, P-PROFILE, E-EXIT
? s
```

Figure B-8. Setting Values for the 10 Input Parameters

```
 ENTER TYPE OF OUTPUT DESIRED: S-SUMMARY, P-PROFILE, E-EXIT
? s


 SUBCASE #  1        PLANT Y POSITION (M)          =  1000.
   % IN PLUME   PLUME RATE    TOT QUANT   WIND SPEED    WIND DIR.   STAB CLASS
      0.0000    0.             8.00E+04    1.00E+00         N               3.

 ALONG-WIND DISTANCE=   1000.0 M          CROSS-WIND DISTANCE=               0.0 M
 MAX. OUTSIDE CONC.= 65789.0 PPM          OUTSIDE CONC. DUE TO PLUME=     0.0 PPM
 PLUME START TIME=  16.7 MINUTES          PLUME END TIME=               16.7 MINUTES
                                                     TIME FROM START OF RELEASE
 OUTSIDE CONC. RISES TO THRESHOLD LEVEL (1.0E-01 PPM)   13.3 MINUTES
 OUTSIDE CONC. RISES TO ALARM LEVEL     (1.0E+00 PPM)   13.6 MINUTES (ALARM ON)
 OUTSIDE CONC. FALLS BACK TO ALARM LEVEL                20.8 MINUTES
 OUTSIDE CONC. FALLS BACK TO THRESHOLD LEVEL            21.3 MINUTES

 TIME FROM ALARM            1 MINUTE      2 MINUTES      5 MINUTES
 OUTSIDE CONC. (PPM)           792.9        24329.8         3319.5
  INSIDE CONC. (PPM)              .2            8.5          122.4
 EXPOSURE DOSE (PPM-S)      1.88E+00       1.50E+02       1.42E+04

 MAXIMUM INSIDE CONC. IS    123.36 PPM AT      6.0 MINUTES AFTER INITIAL ALARM
 INSIDE CONC. DECREASES BACK TO ALARM LEVEL   296.4 MINUTES AFTER INITIAL ALARM
 TOTAL EXPOSURE DOSE IS 4.7E+05 PPM-S

 SUBCASE #  2        PLANT Y POSITION (M)          =  2000.
   % IN PLUME   PLUME RATE    TOT QUANT   WIND SPEED    WIND DIR.   STAB CLASS
      0.0000    0.             8.00E+04    1.00E+00         N               3.

 ALONG-WIND DISTANCE=   2000.0 M          CROSS-WIND DISTANCE=               0.0 M
 MAX. OUTSIDE CONC.= 15229.1 PPM          OUTSIDE CONC. DUE TO PLUME=     0.0 PPM
 PLUME START TIME=  33.3 MINUTES          PLUME END TIME=               33.3 MINUTES
                                                     TIME FROM START OF RELEASE
 OUTSIDE CONC. RISES TO THRESHOLD LEVEL (1.0E-01 PPM)   27.6 MINUTES
 OUTSIDE CONC. RISES TO ALARM LEVEL     (1.0E+00 PPM)   28.1 MINUTES (ALARM ON)
 OUTSIDE CONC. FALLS BACK TO ALARM LEVEL                40.1 MINUTES
 OUTSIDE CONC. FALLS BACK TO THRESHOLD LEVEL            41.1 MINUTES

 TIME FROM ALARM            1 MINUTE      2 MINUTES      5 MINUTES
 OUTSIDE CONC. (PPM)            43.8          655.0        15229.1
  INSIDE CONC. (PPM)              .0             .3           22.9
 EXPOSURE DOSE (PPM-S)      6.26E-01       6.23E+00       1.33E+03

 MAXIMUM INSIDE CONC. IS     51.05 PPM AT     10.2 MINUTES AFTER INITIAL ALARM
 INSIDE CONC. DECREASES BACK TO ALARM LEVEL   248.0 MINUTES AFTER INITIAL ALARM
 TOTAL EXPOSURE DOSE IS 2.0E+05 PPM-S

 DO YOU WANT TO CHANGE THE VARYING QUANTITY SET? (PLANT Y    )
? n

 DO YOU WANT TO CHANGE THE FIXED QUANTITIES?
? n
 ENTER A ONE LINE CASE TITLE
? profile
 CASE #  2, ENTER THE INDEX OF THE VARYING QUANTITY
```

Figure B-9. Multiple Case Summary Output

ENTER TYPE OF OUTPUT DESIRED: S-SUMMARY, P-PROFILE, E-EXIT
? p

SUBCASE # 1 PLANT Y POSITION (M) = 1000.

TIME FROM START OF RELEASE (MIN.)	OUTSIDE CONC. (PPM)	INSIDE CONC. (PPM)	EXPOSURE DOSE (PPM-S)	VENT. RATE (VOLUMES/HR.)
13.6	1.02	.00	8.29E-03	1.00
14.0	23.04	.01	1.76E-01	.06
14.4	281.93	.05	7.62E-01	.06
14.8	1994.26	.42	5.11E+00	.06
15.2	8666.81	2.30	3.25E+01	.06
15.6	24420.14	8.59	1.51E+02	.06
16.0	46791.90	22.77	5.09E+02	.06
16.4	63608.65	45.26	1.31E+03	.06
16.8	63698.01	71.32	2.71E+03	.06
17.2	48589.13	94.09	4.71E+03	.06
17.6	29087.58	109.54	7.17E+03	.06
18.0	14034.03	117.90	9.91E+03	.06
18.4	5588.26	121.58	1.28E+04	.06
18.8	1875.90	122.91	1.57E+04	.06
19.2	541.04	123.29	1.87E+04	.06
19.6	136.37	123.36	2.16E+04	.06
19.6	123.36	123.36	2.18E+04	.06

MAXIMUM INSIDE CONCENTRATION HAS BEEN REACHED

20.0	30.50	123.34	2.46E+04	.06
20.4	6.14	123.30	2.76E+04	.06
20.8	1.12	123.25	3.05E+04	.06
21.2	.19	122.95	3.35E+04	1.00
21.6	.03	122.13	3.64E+04	1.00
22.0	.00	121.32	3.93E+04	1.00
30.0	0.00	106.18	9.39E+04	1.00
40.0	0.00	89.88	1.53E+05	1.00
50.0	0.00	76.08	2.02E+05	1.00
60.0	0.00	64.40	2.44E+05	1.00
70.0	0.00	54.51	2.80E+05	1.00
80.0	0.00	46.14	3.10E+05	1.00
90.0	0.00	39.06	3.35E+05	1.00
100.0	0.00	33.06	3.57E+05	1.00
110.0	0.00	27.99	3.75E+05	1.00
120.0	0.00	23.69	3.91E+05	1.00
130.0	0.00	20.05	4.04E+05	1.00
140.0	0.00	16.98	4.15E+05	1.00
150.0	0.00	14.37	4.24E+05	1.00
160.0	0.00	12.16	4.32E+05	1.00
170.0	0.00	10.30	4.39E+05	1.00
180.0	0.00	8.72	4.45E+05	1.00
190.0	0.00	7.38	4.50E+05	1.00
200.0	0.00	6.24	4.54E+05	1.00
210.0	0.00	5.29	4.57E+05	1.00
220.0	0.00	4.47	4.60E+05	1.00
230.0	0.00	3.79	4.62E+05	1.00
240.0	0.00	3.21	4.65E+05	1.00
250.0	0.00	2.71	4.66E+05	1.00
260.0	0.00	2.30	4.68E+05	1.00
270.0	0.00	1.94	4.69E+05	1.00
280.0	0.00	1.65	4.70E+05	1.00
290.0	0.00	1.39	4.71E+05	1.00
300.0	0.00	1.18	4.72E+05	1.00
310.0	0.00	1.00	4.72E+05	1.00

Figure B-10. Multiple Case Profile Output

Appendix B (Continued)

Sample Terminal Sessions

Probabilistic Study Program

A typical use of the Probabilistic Study Program is illustrated in the following Figures B-11 through B-15.

```
 ENTER NAME OF WINDROSE BLOCK OR "EXIT"
? dresden 2

  WINDROSE
   N        NNE      NE       ENE      E        ESE      SE       SSE
   .0883    .0898    .0963    .0665    .1011    .0852    .0802    .0561
   S        SSW      SW       WSW      W        WNW      NW       NNW
   .0494    .0306    .0388    .0333    .0356    .0335    .0601    .0552
  THE TOTAL PROBABILITY IS  1.0000

 ENTER NAME OF WINDSPST BLOCK OR "EXIT"
? chicago

 WIND SPEED(M/S)        UNSTABLE        NEUTRAL          STABLE
      0 - 1                .0038           .0076           .0154
      1 - 2                .0054           .0065           .0197
      2 - 3                .0197           .0463           .0768
      3 - 4                .0323           .0708           .0793
      4 - 5                .0408           .0818           .0470
      5 - 6                .0306           .1056           .0285
      6 - 7                .0053           .1147           .0001
      GT  7                .0058           .1557           .0002
  THE TOTAL PROBABILITY IS   .9997
```

Figure B-11. Retrieving the Meteorological Blocks From the Data Base

```
 ENTER NAME OF SHIPFREQ BLOCK OR "EXIT"
? base

  THE NUMBER OF SHIPMENTS PER YEAR FOR 4 LANE INTERSTATE IS  1000.00
  THE NUMBER OF SHIPMENTS PER YEAR FOR 4 LANE DIVIDED    IS  1000.00
  THE NUMBER OF SHIPMENTS PER YEAR FOR 2 LANE UNDIVIDED  IS  1000.00
  THE NUMBER OF SHIPMENTS PER YEAR FOR INTERSECTION      IS  1000.00
  THE NUMBER OF SHIPMENTS PER YEAR FOR MAIN LINE RAIL    IS  1000.00
  THE NUMBER OF SHIPMENTS PER YEAR FOR LOCAL RAIL        IS  1000.00
  THE NUMBER OF SHIPMENTS PER YEAR FOR BARGE             IS  1000.00

 ENTER NAME OF ACCRATE BLOCK OR "EXIT"
? base

  THE # OF ACC. PER SHIPMENT-KM FOR 4 LANE INTERSTATE IS   1.000E-06
  THE # OF ACC. PER SHIPMENT-KM FOR 4 LANE DIVIDED    IS   1.000E-06
  THE # OF ACC. PER SHIPMENT-KM FOR 2 LANE UNDIVIDED  IS   1.000E-06
  THE # OF ACC. PER SHIPMENT-KM FOR INTERSECTION      IS   1.000E-06
  THE # OF ACC. PER SHIPMENT-KM FOR MAIN LINE RAIL    IS   1.000E-06
  THE # OF ACC. PER SHIPMENT-KM FOR LOCAL RAIL        IS   1.000E-06
  THE # OF ACC. PER SHIPMENT-KM FOR BARGE             IS   1.000E-06
  THE NUMBER OF ACCIDENTS PER YEAR  STORAGE SITE      IS   1.000E+03
```

Figure B-12. Shipping Frequency and Accident Rate Data Blocks

```
ENTER NAME OF RELEASE BLOCK OR "EXIT"
? base
```

CORRIDOR TYPE 1   4 LANE INTERSTATE

RELEASE CLASS	A	B	C	D	E
RELEASE PROB.	.0100	.0400	.2500	.3000	.4000
SPILL QUAN. (KG)	8.00E+04	4.00E+04	1.00E+04	2.00E+03	0.
PLUME FRACTION	0.0000	.2500	.7500	1.0000	0.0000
PLUME RELEASE (KG/HOUR)	0.	4.00E+03	2.50E+03	5.00E+02	0.

CORRIDOR TYPE 2   4 LANE DIVIDED

RELEASE CLASS	A	B	C	D	E
RELEASE PROB.	.0100	.0400	.2500	.3000	.4000
SPILL QUAN. (KG)	8.00E+04	4.00E+04	1.00E+04	2.00E+03	0.
PLUME FRACTION	0.0000	.2500	.7500	1.0000	0.0000
PLUME RELEASE (KG/HOUR)	0.	4.00E+03	2.50E+03	5.00E+02	0.

CORRIDOR TYPE 3   2 LANE UNDIVIDED

RELEASE CLASS	A	B	C	D	E
RELEASE PROB.	.0100	.0400	.2500	.3000	.4000
SPILL QUAN. (KG)	8.00E+04	4.00E+04	1.00E+04	2.00E+03	0.
PLUME FRACTION	0.0000	.2500	.7500	1.0000	0.0000
PLUME RELEASE (KG/HOUR)	0.	4.00E+03	2.50E+03	5.00E+02	0.

CORRIDOR TYPE 4   INTERSECTION

RELEASE CLASS	A	B	C	D	E
RELEASE PROB.	.0100	.0400	.2500	.3000	.4000
SPILL QUAN. (KG)	8.00E+04	4.00E+04	1.00E+04	2.00E+03	0.
PLUME FRACTION	0.0000	.2500	.7500	1.0000	0.0000
PLUME RELEASE (KG/HOUR)	0.	4.00E+03	2.50E+03	5.00E+02	0.

CORRIDOR TYPE 5   MAIN LINE RAIL

RELEASE CLASS	A	B	C	D	E
RELEASE PROB.	.0100	.0400	.2500	.3000	.4000

Figure B-13. Release Description Data Block

ENTER NAME OF ACCLOCN BLOCK OR "EXIT"
? test

NODE NO.	LOCATION(X,Y) (METERS)		NODE LENGTH (KM)	TYPE
1	4500.00	-1500.00	.50	2 LANE UNDIVIDED
2	4000.00	-1500.00	.50	2 LANE UNDIVIDED
3	3500.00	-1500.00	.50	2 LANE UNDIVIDED
4	3000.00	-1500.00	.50	2 LANE UNDIVIDED
5	2500.00	-1500.00	.50	2 LANE UNDIVIDED
6	2000.00	-1500.00	.50	2 LANE UNDIVIDED
7	1500.00	-1500.00	.50	2 LANE UNDIVIDED
8	1000.00	-1500.00	.50	2 LANE UNDIVIDED
9	500.00	-1500.00	.50	2 LANE UNDIVIDED
10	0.00	-1500.00	.50	2 LANE UNDIVIDED
11	-500.00	-1500.00	.50	2 LANE UNDIVIDED
12	-1000.00	-1500.00	.50	2 LANE UNDIVIDED
13	-1500.00	-1500.00	.50	2 LANE UNDIVIDED
14	-2000.00	-1500.00	.50	2 LANE UNDIVIDED
15	-2500.00	-1500.00	.50	2 LANE UNDIVIDED
16	-3000.00	-1500.00	.50	2 LANE UNDIVIDED
17	-3500.00	-1500.00	.50	2 LANE UNDIVIDED
18	-2000.00	4000.00	.50	LOCAL RAIL
19	-2000.00	3500.00	.50	LOCAL RAIL
20	-2000.00	3000.00	.50	LOCAL RAIL
21	-2000.00	2500.00	.50	LOCAL RAIL
22	-2000.00	2000.00	.50	LOCAL RAIL
23	-2000.00	1500.00	.50	LOCAL RAIL
24	-2000.00	1000.00	.50	LOCAL RAIL
25	-2000.00	500.00	.50	LOCAL RAIL
26	-2000.00	0.00	.50	LOCAL RAIL
27	-2000.00	-500.00	.50	LOCAL RAIL
28	-2000.00	-1000.00	.50	LOCAL RAIL
29	-2000.00	-1500.00	.50	LOCAL RAIL
30	-2000.00	-2000.00	.50	LOCAL RAIL
31	-2000.00	-2500.00	.50	LOCAL RAIL
32	-2000.00	-3000.00	.50	LOCAL RAIL
33	-2000.00	-3500.00	.50	LOCAL RAIL
34	-2000.00	-4000.00	.50	LOCAL RAIL

Figure B-14. Accident Location Data Block

WIND SPEED	P OF WIND SPEED	P OF IO
1	.0268	1.59E-07
2	.0316	8.49E-08
3	.1428	1.62E-07
4	.1824	7.94E-08
5	.1696	3.73E-08
6	.1647	1.79E-08
7	.1201	1.30E-08
8	.1617	0.

STABILITY CLASS	P OF STABILITY CLASS	P OF IO
UNSTABLE	.1437	0.
NEUTRAL	.5890	6.41E-09
STABLE	.2670	5.47E-07

WIND DIRECTION	P OF WIND DIRECTION	P OF IO
N	.0883	9.32E-08
NNE	.0898	1.09E-07
NE	.0963	7.03E-08
ENE	.0665	6.03E-08
E	.1011	3.54E-08
ESE	.0852	4.78E-08
SE	.0802	2.76E-08
SSE	.0561	6.26E-09
S	.0494	0.
SSW	.0306	0.
SW	.0388	0.
WSW	.0333	0.
W	.0356	0.
WNW	.0335	1.06E-08
NW	.0601	2.35E-08
NNW	.0552	7.01E-08

RELEASE CLASS	P OF RELEASE CLASS	P OF IO
1	.0100	3.14E-07
2	.0400	2.13E-07
3	.2500	2.63E-08
4	.3000	0.
5	.4000	0.

```
 TOTAL PROBABILITY OF OPERATOR INCAPACITATION IS  5.54E-07 PER YEAR


  LEVEL ONE MENU
     E - EXIT
     D - DATA BASE MANAGER
     M - MULTIPLE CASE
     P - PROBABILISTIC STUDY

  ENTER LEVEL ONE MENU LETTER.
? e
OERROR SUMMARY
     ERROR     TIMES
      0115     2572
REVERT. NORMAL EXIT, DATABASE IS UNCHANGED
/
```

Figure B-15. Probabilistic Study Results

APPENDIX C

Data Base Manager Subroutines

ABORT: Forces the program to terminate abnormally
Calling routine: CLEANUP
External references: None

ACCLED: Modifies a block in the ACCLOCN Category
Calling routine: MDADBK, MODFBK
External references: READI, READR, SCREEN
Entry point in ACCLOC

ACCLOC: Creates a block to add to the ACCLOCN Category
Calling routine: ADDBLK
External references: READI, READR, SCREEN

ACCLPR: Prints a block from the ACCLOCN Category
Calling routine: OFLIST, TERLIS
External references: None
Entry point in ACCLOC

ACCRAT: Creates a block to add to the ACCRATE Category
Calling routine: ADDBLK
External references: READI, READR

ACCRED: Modifies a block in the ACCRATE Category
Calling routine: MDADBK, MODFBK
External references: READI, READR
Entry point in ACCRAT

ACCRPR: Prints a block from the ACCRATE Category
Calling routine: OFLIST, TERLIS
External references: None
Entry point in ACCRAT

ADDBLK: Adds a newly created block to the data base
Calling routine: MENU
External references: ACCLOC, ACCRAT, CHEMCHR, DETCHAR, PLATIN, RELDES, SHIPFR, VENRATE WDROSE, WDSPST.

CHEMCHR: Creates a block to add to the CHEMICAL Category
Calling routine: ADDBLK
External references: READI, READR

CHEMED: Modifies a block in the CHEMICAL Category
Calling routine: MDADBK, MODFBK
External references: READI, READR
Entry point in CHEMCHR

CHEMPR: Prints a block from the CHEMICAL Category
Calling routine: OFLIST, TERLIS
External referrences: None
Entry Point in CHEMCHR

CLEANUP: Writes a revised data base
Calling routine: TOXDR
External references: ABORT, GETBLK

DETCED: Modifies a block in the DETECTOR Category
Calling routine: MDADBK, MODFBK
External references: READI, READR
Entry Point in DETCHAR

DETCHAR: Creates a block to be added to the DETECTOR Category
Calling routine: ADDBLK
External references: READI, READR

DETCPR: Prints a block from the DETECTOR Category
Calling routine: OFLIST, TERLIS
External references: None
Entry Point in DETCHAR

ERRMS: Prints an error message if the data base file cannot be opened
Calling routine: RECOVR (system error trap)
External references: None

GETBLK: Returns the requested block's content and its length
Calling routine: ADDBLK, CLEANUP, MDADBK, MODRBK, OFLIST, TERLIS
External references: None

MDADBK: Adds a modified block to the data base
Calling routine: MENU
External references: ACCLED, ACCRED, CHEMED, DETCED, GETBLK, PLATED, READI, RELDED, SHIPED, VENRED, WDRSED, WDSPED
Entry point in ADDBLK

MENU: Main driver for the Data Base Manager
Calling routine: TOXDR
External references: ADDBLK, MDADBK, MODFBK OFLIST, PURGBK, READI, TERLIS.

MODFBK: Replaces a block in the data base with the modified block
Calling routine: MENU
External references: ACCLED, ACCRED, CHEMED, DETCED, GETBLK, PLATED, READI, RELDED, SHIPED, VENRED, WDRSED, WDSPED.
Entry point in ADDBLK

OFLIST: Writes requested information to a file to be routed to a printer
Calling routine: MENU
External references: ACCLPR, ACCRPR, CHEMPR, DETCPR, GETBLK, PLATPR, RELDPR, SHPFPR, VENRPR, WDRSPR, WDSPPR

PLATED: Modifies a block in the PLANT Category
Calling routine: MDADBK, MODFBK
External references: READI, READR
Entry point in PLATIN

PLATIN: Creates a block to be added to the PLANT Category
Calling routine: ADDBLK
External references: READI, READR

PLATPR: Prints a block from the PLANT Category
Calling routine: OFLIST, TERLIS
External references: None
Entry point in PLATIN

PURGBK: Flags a block to be omitted in the revised data base
Calling routine: MENU
External references: None

READI: Reads an integer response for the interactive commands
Calling routine: ACCLED, ACCLOC, ACCRAT, ACCRED CHEMCHR, CHEMED, DETCED, DETCHAR, PLATED, PLATIN, RELDED, RELDES, SHIPED, SHIPFR, VENRATE, VENRED, WDROSE, WDRSED, WDSPED, WDSPST
External references: None

READR: Reads a real response for the interactive commands
Calling routine: Same as for READI
External references: None
Entry point in READI

RELDED: Modifies a block in the RELEASE Category
Calling routine: MDADBK, MODFBK
External references: READI, READR

RELDES: Creates a block to add to the RELEASE Category
Calling routine: ADDBLK
External references: READI, READR

RELDPR: Prints a block from the RELEASE Category
Calling routine: OFLIST, TERLIS
External references: None

SCREEN: Interrupts the terminal listing when the screen is full
Calling routine: ACCLED, ACCLOC, TERLIS
External references: None

SHIPED: Modifies a block in the SHIPFREQ Category
Calling routine: MDADBK, MODFBK
External references: READI, READR
Entry point in SHIPFR

SHIPFR: Creates a block to be added to the SHIPFREQ Category
Calling routine: ADDBLK
External references: READI, READR

SHPFPR: Prints a block from the SHIPFREQ Category
Calling routine: OFLIST, TERLIS
External references: None
Entry point in SHIPFR

TERMNAT: Closes files if an abnormal termination occurs
Calling routine: TOXDR
External references: RECOVR

TERLIS: Writes the requested information on terminal screen
Calling routine: MENU
External references: ACCLPR, ACCRPR, CHEMPR, DETCPR, GETBLK, PLATPR, RELDPR, SCREEN, SHPFPR, VENRPR, WDRSPR, WDSPPR

VENRATE: Creates a block to be added to the VENTSYS Category
Calling routine: ADDBLK
External references: READI, READR

VENRED: Modifies a block in the VENTSYS Category
Calling routine: MDADBK, MODFBK
External references: READI, READR
Entry point in VENRATE

VENRPR: Prints a block from the VENTSYS Category
Calling routine: OFLIST, TERLIS
External references: None
Entry point in VENRATE

WDROSE: Creates a block to be added to the WINDROSE Category
Calling routine: ADDBLK
External references: READI, READR

WDRSED: Modifies a block in the WINDROSE Category
Calling routine: MDADBK, MODFBK
External references: READI, READR
Entry point in WDROSE

WDRSPR: Prints a block from the WINDROSE Category
Calling routine: OFLIST, TERLIS
External references: None
Entry point in WDROSE

WDSPED: Modifies a block in the WINDSPST Category
Calling routine: MDADBK, MODFBK
External references: READI, READR

WDSPPR: Prints a block from the WINDSPST Category
Calling routine: OFLIST, TERLIS
External references: None
Entry point in WDSPST

WDSPST: Creates a block to be added to the WINDSPST Category
Calling routine: ADDBLK
External references: READI, READR

APPENDIX D

Multiple Case Studies Subroutines

COUTEND-- Determines when outside concentration reaches a specified level
Calling routine: ZEROIN
External references: FCOUT

FCOUT-- Calculates outside concentration due to puff and plume
Calling routine: RKFTS
External references: None

FINDMAX-- Constraint equation to find maximum inside concentration
Calling routine: RKFTS
External references: FCOUT, FROV

FROV-- Calculates control room ventilation rate
Calling routine: FINDMAX, VENTSYS
External references: None

GETDAT-- Interrogates user for a specific value
Calling routine: GETFIXD, GETVARY, MULT
External references: None

GETDAT1-- Interrogates user for a specific value allowing editing
Calling routine: GETFIXD
External references: None

GETDBMS-- Fetches four blocks of data from the data base
Calling routine: MULT
External references: CHEMPR, DETCPR, GETBLK, LISTBLK, PLATPR, VENRPR

GETVARY-- Gets a set of values for the varying quantity
Calling routine: MULT
External references: GETDAT

LTSTBLK-- Prints a list of blocks in a given category
Calling routine: GETDBMS
External references: None

MULT-- Main driver for the Multiple Case program
Calling routine: MAIN
External references: GETDAT, GETDBMS, GETFIXD, GETVARY, QVARY, SMOG

QVARY-- Interrogates user for the varying quantity index and the number of subcases
Calling routine: MULT
External References: None

RKFTS-- Runge-Kutta-Fehlberg differential equation solver with a constraint equation
Calling routine: SMOG
External references: FINDMAX, VENTSYS

SMOG-- Control numerical calculations for a set of conditions
Calling routine: MULT
External references: FCOUT, FROV, RKFTS, ZEROIN

VENTSYS-- Ventilation system differential equations
Calling routine: RKFTS
External references: FCOUT, FRCV

ZEROIN-- Numerical root-finder that locates damper closing and opening times
Calling routine: SMOG
External references: COUTEND

APPENDIX E

Probabilistic Studies Subroutines

COUTENP-- Determines when outside concentration reaches a specified level
Calling routine: ZEROIN
External references: FCOUTP, FROV

FCOUTP-- Calculates outside concentration due to puff and plume
Calling routine: RKFTS
External references: None

FROV-- Calculates control room ventilation rate
Calling routine: TOXSTOP, VENTCON, VENTSYS
External references: None

GETDPMS-- Fetches four blocks of data from the data base
Calling routine: PROB
External references: CHEMPR, DETCPR, GETBLK, LISTBLK, PLATPR, VENRPR

GTDBMSP-- Fetches six blocks of data from the data base
Calling routine: PROB
External references: ACCLPR, ACCRPR, GETBLK, LISTBLK, RELDPR, SHPFPR, WDRSPR, WDSPFR

LISTBLK-- Prints a list of blocks in a given category
Calling routine: GETDPMS, GTBMSP
External references: None

PROB-- Main driver for probabilistic studies
Calling routine: MAIN
External references: GETDBMS, GTDBMSP, SMOGP

TOXSTOP-- Constraint equation for incapacitation threshold
Calling routine: RKFTS
External references: None

VENTCON-- Ventilation system differential equation (first order)
Calling routine: RKFTS
External references: FCOUTP, FROV

VENTDOS-- Ventilation system differential equation (second order)
Calling routine: RKFTS
External references: FCOUTP, FROV

ZEROIN-- Numerical root-finder that locates damper closing and opening times
Calling routine: SMOGP
External references: COUTENP

APPENDIX F

Data File Programs

1. Establish Data Base

The code ESTD reads a card image input file from TAPE1 and establishes the random access file (TAPE2) in a form acceptable to the Data Base Manager routine.

The general form of the input file is:

Card 1	Format (2A10)	Category Name Block Name
Cards 2-n		
	(values required as defined by the category named on Card 1)	
3		
.		
.		
.		
.		
.		
n		

This group of cards is repeated for each block being entered into the data base.

The last card must be "END" starting in column 1. In fact, the input file may consist only of the word END and the data base would be established with all categories. The blocks of data could then be added with the Data Base Manager.

Once Card 1 is read with the category name and block name, the format of the remaining card(s) in that card group is determined by category name.

PLANT Location and physical dimensions of a plant	Block Length - 8 Words (1 Card)	
	X - Y -	Location of the plant (meters)
Format (8F10.0)	STHT -	Height of the plant stack (meters)
	XLEN - WID - HEGT -	The length, width and height of the building (meters)

	INLT -	The number of air inlets in the building
	XINL -	Distance between the inlets (meters)
CHEMICAL Description of a chemical Format (F10.0, A10, F10.0)	Block Length - 3 words (1 Card)	
	DEN -	Density of the chemical (g/m^3)
	WORD -	Either "CONC" or "DOSE" for the means of incapacitation
	XLEV -	The level of incapacitation for CONC, the level in PPM. For Dose, the level in PPM/sec
VENTSYS Description of the ventilation systems of a plant Format (5F10.0)	Block Length - 5 words (1 Card)	
	OPNR -	Open exchange rate (vol/hr)
	XISR -	Isolated exchange rate (vol/hr)
	EXHR -	Exhaust exchange rate of a plant (vol/hr)
	TCLOS -	Closing damper time (seconds)
	TOPEN -	Opening damper time (seconds)
DETECTOR Detection responses for a chemical Format (3F10.0)	Block Length - 3 words (1 Card)	
	REST -	Response time for this chemical (seconds)
	THRLEV -	Threshold level - PPM
	ALALEV -	Alarm level - PPM

SHIPFREQ Shipping frequencies for each type of shipping node Format (7F10.0)	Block Length - 7 words (1 Card) $FREQ_i$ - Number of shipments/year for the first 7 node types. Node types are: 1. Four lane interstate 2. Four lane divided 3. Two lane undivided 4. Intersection 5. Main line rail 6. Local rail 7. Barge 8. Storage site

WINDROSE Wind direction distribution Format (8F10.0)	Block Length - 16 words (2 Cards) PROB - Probability of wind blowing into the 16 directions, N, NNE, etc

WINDSPST Wind Speed Stability-Class distribution Format (8F10.0)	Block Length - 24 words (3 Cards) $PROB_i$ - Probability for wind speed (8 ranges) and atmospheric stability class (3 classes) $PROB_1$ - Is for wind speed range 0-1 m/s and for stability class - Unstable $PROB_2$ - Is for wind speed range 0-1 m/s and for stability class - Neutral . . . $PROB_{24}$ - Is for wind speed greater than 7 m/s and for stability class--stable

ACCRATE Accident rate for each type of shipping node. Format (8F10.0)	Block Length - 8 words (1 Card)	
	$RATE_i$ -	Number of accidents per km for node types 1-7
	$RATE_8$ -	Number of accidents per year for type 8 (storage site)

RELEASE Description of 5 accident release severity classes, A-E (A is the largest release, E the smallest) Format (5F10.0)	Block Length - 160 words (32 Cards)	
	The following information for each of the 5 classes	
	$PROB_i$ -	Probability of release occurring in $class_i$
	$SPILL_i$ -	Spill quantity for $class_i$
	$RATE_i$ -	Plume rate for $class_i$
	$FRAC_i$ -	Plume fraction for $class_i$ where i = 1,5
	The above card group is repeated (in order 1-8) for each of the node types.	

ACCLOCN Route description	Block length is Variable	
Format (F10.0)	NON -	Number of nodes
Format (4F10.0)	TYP -	Node type (1-8)
	X Y	Location of the node on the route in meters
	XLEN -	Length of the node
	(XLEN for type 8 is always 1).	

2. Data Base File to Card Deck

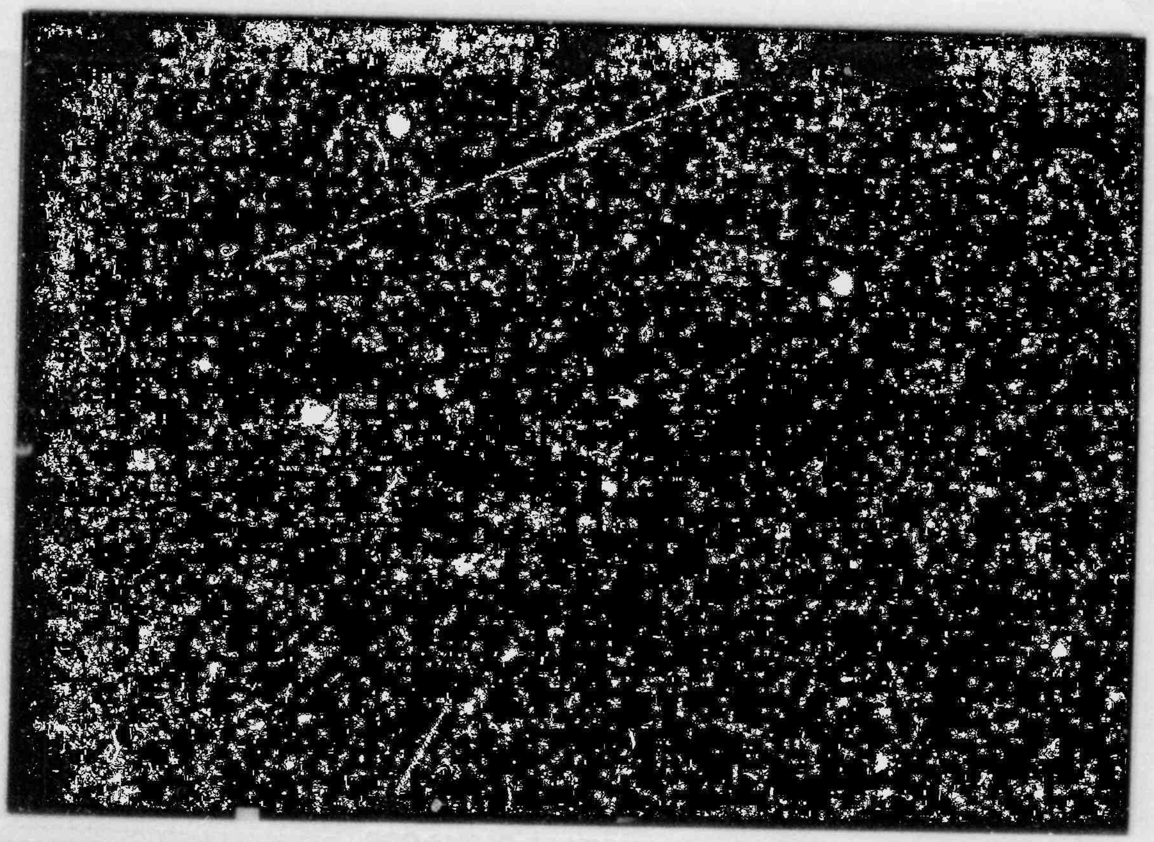
The program PNDATA reads the data base file from TAPE2 and writes a file (TAPE9) in card image format. This file may be used to make a card deck or used as input to the ESTD program.

APPENDIX G

Program Listings

The microfiche below contains listings of:

1. Procedure file.
2. Compiler output listing of TOXRISK and subroutines.
3. Compiler output listings of the data base conversion programs ESTD and PNDATA.
4. Initial data base in card image format.



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13. ABSTRACT (200 words or less)

One of the offsite hazards which could threaten the safety of a nuclear power plant is nearby transportation accidents involving releases of toxic gases or volatile liquids. Significant releases of such materials could endanger the plant through incapacitation of control room personnel. An interactive computer program has been developed to aid in the evaluation of control room habitability for these accidents. The first part of the program can be used to study the time history of toxic material concentrations in the control room under varying external conditions, all of which can be specified by the user. The second part estimates the annual probability of operator incapacitation at a particular plant due to nearby accidents on roads or rail lines, or at storage sites. A data base manager is provided so that all data (site and route layouts, plant characteristics, meteorological data, and chemical data) can be entered and maintained in a convenient format. The program was developed for use on CDC computers using the NOS time-sharing system.

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