Abridged User's Guide for RAM

          The document contained in this file is an abridged version of the
most recent version of the RAM User's Guide. This document
has been placed on the SCRAM website to facilitate the immediate
use of the RAM model without having to wait for delivery of the
complete user's guide. Although some portions of the User's Guide
have been omitted to keep the file size to a reasonable size,
nothing was omitted that is needed by the user to run the model.
Nevertheless, the user is strongly encouraged to obtain the
complete user's guide from NTIS. The NTIS document number and
ordering information can be found on the SCRAM website on the
User's Guide page under NTIS Availability.

USER'S GUIDE FOR RAM --

SECOND EDITION

(ABRIDGED)

by

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PREFACE TO THE ABRIDGED VERSION

This abridged version of the most recent RAM User's Guide has been created for users of the Support Center for Regulatory Air Models Bulletin Board System (SCRAM BBS). It is stored in Word Perfect format on the SCRAM BBS in the Regulatory Models Section under Documentation. The availability of this and other model user's guides on the SCRAM BBS will facilitate the immediate user of models which have been downloaded from the SCRAM BBS, without having to wait for delivery of the complete user's guide.

Although some portions of the User's Guide have been omitted to save space, nothing was omitted that is needed by the user to run the model. Nevertheless, the user is strongly encouraged to obtain the complete user's guide from NTIS. NTIS Document Numbers for model user's guides can be found on the SCRAM BBS in the Models/Documents Section under News.

Note that the actual page numbers in your copy of the document may differ from those indicated in the Table of Contents, depending on the kind of printer (as well as the available type font) that is used to print your copy of this document.

The abridged version of the RAM user's guide was composed by Computer Sciences Corporation, Research Triangle Park, North Carolina, for the SCRAM BBS.

ACKNOWLEDGMENTS

EXECUTIVE SUMMARY

The RAM algorithm is a Gaussian-plume dispersion model that calculates short-term pollutant concentrations from multiple point and/or area sources at a user-specified receptor grid in level or gently rolling terrain. Pollutants considered are relatively non-reactive, such as sulfur dioxide and suspended particulates. Both urban and rural situations can be simulated. In the rural mode, those proposed by Briggs based on the work of Pooler-McElroy are used. Plume rise is calculated following the methods of Briggs and both buoyancy rise and momentum rise are included. For point sources, concentrations are determined using distance crosswind and distance upwind from the receptor to each source. For area sources, the narrow plume simplification of Gifford and Hanna is used with the modification that the area sources are not at ground level, but have an effective height.

Inputs to the model are a set of options selected by the user, source parameters, meteorological data, and receptor information. Using the hourly meteorology, concentrations are calculated for receptor locations either specified by the user or generated by the program. Emissions and source parameters for point or area sources are required inputs. The meteorological data baase, and hence the simulation, can vary from one hour to one year. Concentrations for 5 averaging periods can be computed. For long-term runs such as a year, a high-five tabulation can be obtained to determine the highest and second highest concentrations at each receptor for each of five averaging periods. Receptors can be specified by the user or they can be generated by the program. If they are input by the user, receptor name as well as coordinates may be provided on input.

For model execution, the user specifies parameters and options needed for the application. Required parameters are type of pollutant, number of sources, averaging period(s), power-law wind-profile exponents, and whether the urban or rural mode is to be used. Options are included for the treatment of stack-tip downwash, gradual plume rise, and buoyancy-induced dispersion. The user also specifies types of sources and those that are significant, receptor configuration, characteristics of emission sources, and meteorological inputs. Whether the run is part of a segmented run, outputs desired, and use of the default feature are also specified by the user. The default feature sets parameters and options for regulatory application; final plume rise and momentum plume rise are used as are buoyancy-induced dispersion and stack-tip downwash. Calm wind conditions are treated following the "Calms Processor (CALMPRO) User's Guide" (U. S. EPA, 1984).

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Both point and area sources are considered by the model. Their particulars can be included in the run stream or they can be read from disk or tape files. Source coordinates and parameters must be given, as well as emission rates. A total of 250 point sources and 100 area sources are permitted. Of these, up to 25 point sources and 10 area sources can be labeled significant to obtain their contribution at a receptor separately.

As with the data on emissions, the meteorology can be read as part of the input stream, from a file processed by the program RAMMET, or from a file having the format of RAMMET. Surface parameters and mixing height must be present for each simulation hour; the meteorological file is of a variable length from one hour to one year.

Receptors can be specified by the user or they can be generated by the model. If they are input by the user, receptor name as well as coordinates may be provided. If generated by the program, the user selects whether a polar coordinate grid of 180 receptors (36 radials by 5 distances) or a honeycomb receptor configuration is desired. Also, when significant sources are specified, the model selects two receptors downwind of each source where maxima are likely to occur. A total of 180 receptors are permitted.

On output, the model produces printed and disk or tape files. The printed output lists the options and source information including a ranking according to source height; those selected by the user as significant are properly identified. Receptors are next listed with their appropriate coordinates. This is followed by the meteorological parameters as input by the user. Model-calculated concentrations are tabulated by receptor. Various other output files can be obtained.

SECTION 1

INTRODUCTION

The RAM system is based on the Gaussian-plume equation which assumes steady state; it includes dispersion algorithms for both urban and rural situations. The algorithm can be used for short-term (one hour to one day) determination of urban air quality resulting from pollutants released from multiple point and area sources.

The algorithm was first described by Novak and Turner (1976). It is applicable to locations with level or gently rolling terrain where a single wind vector for each hour is a reasonable approximation of the flow over the source area considered. A single mixing height and a single stability class for each hour are assumed representative of the area. The use of RAM is restricted to relatively non-reactive pollutants and is usually applied to sulfur dioxide and total suspended particulates.

Emission information required of point sources consists of source coordinates, emission rate, physical height, stack diameter, stack gas exit velocity, and stack gas temperature. Emission information required of area source squares consists of south-west corner coordinates, source side length, total area emission rate, and effective area source height. Output consists of calculated air pollutant concentrations at each receptor for hourly averaging times and a longer averaging time specified by the user. Contributions to the concentration in the two categories -- point sources and area sources -- are also given on output. The contributions to the concentration from specific point and area sources can be obtained at the option of the user.

Computations are performed hour by hour as if the atmosphere had achieved steady-state condition. Therefore, errors will occur where there is a gradual buildup (or decrease) in concentrations from hour to hour, such as under light wind conditions. Also, with light wind conditions, the definition of wind direction is likely to be inaccurate; variations in the wind flow from location to location in the area are quite probable.

Briggs' plume-rise equations are used to estimate effective height of point sources. Concentrations from the point sources are determined using distance crosswind and distance upwind from the receptor to each source.

Considerable time is saved in calculating concentrations from area

sources by using a narrow plume simplification which considers sources at various distances on a line directly upwind from the receptor to be representative in the crosswind direction of the sources at those distances affecting the receptor. Area source sizes are used as given in the emission inventory in lieu of creating an inventory of uniform elements.

Options are available to allow the use of four different types of receptor locations:

- those with coordinates input by the user,
- those with coordinates determined by RAM and are downwind of significant point and area sources where maxima are likely to occur,
- those with coordinates determined by RAM to give good area coverage of a specific portion of the region, and
- those with coordinates determined by RAM to radially circle a designated point; radial distances are supplied by the user.

Options are also available to limit the output produced.

Urban planners may use RAM to determine the effects of new source locations and control strategies upon short-term air quality. If the input meteorological parameter values can be forecast with sufficient accuracy, control agency officials may use RAM to predict ambient air quality levels, primarily over the 24-hour averaging time, to locate mobile air sampling units, and to assist with emission reduction tactics. Diurnal and day-to-day emission variations must be considered in the source inventory input to the model, especially for control tactics. For most of these uses, the optional feature to assist in locating concentration maxima should be used. Computations are organized so that execution of the program is rapid, thus real-time computations are feasible.

This document is divided into three parts, each directed to a different reader: managers, dispersion meteorologists, and computer specialists. The first three sections are aimed at managers and project directors who wish to evaluate the applicability of the model to their needs. Sections 4, 5, 6, 7, and 10 are directed to dispersion meteorologists or engineers who are required to become familiar with details of the model. Finally, Sections 8 through 11 are directed toward persons responsible for implementing and executing the program.

SECTION 2

DATA-REQUIREMENTS CHECKLIST

Model Options

RAM requires data on options, sources, meteorology, and receptors. The user must indicate which of the following options are to be used.

- stack-tip downwash
- gradual plume rise
- buoyancy-induced dispersion
- input of point and area sources
- emissions from a previous run of RAM
- meteorological data on card-image records
- input of hourly point and area source emissions
- specification of significant point and area sources
- input of receptors by specifying coordinates
- option for RAM to generate receptors downwind of significant point and area sources
- option for RAM to generate a honeycomb array of receptors
- input of radial distances to generate a polar coordinate receptor array.

The following are options to omit certain outputs. A number of these options should be used or the program will generate large quantities of printed information.

- point source list
- area source list and map
- emissions with height table
- resultant meteorological data summary for the averaging period
- all hourly output (point, area, summaries)
- hourly point contribution
- meteorological data on hourly point contributions
- plume height and distance to final rise on hourly point contributions
- hourly area contributions
- meteorological data on hourly area contributions
- hourly summary
- meteorological data on hourly summary
- all averaging period output
- point averaging period contributions
- area averaging period contributions
- averaging period summary
- average concentrations and high-five table.

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The following options can also affect the amount of output.

- use of a default option
- use of parts of segmented runs
- output of partial concentrations to disk or tape
- output of hourly concentrations to disk or tape
- output of averaging period concentrations to a file
- output of averaging period concentrations to card-image records.

Meteorological Data

The meteorological data required for the model are:

- power-law wind profile exponents for each stability class
- anemometer height
- stability class at the hour of measurement
- wind speed
- air temperature
- wind direction
- mixing height.

Source Emissions Data

The information required of the emissions sources is:

- coordinates of the point source
- emission rate for sulfur dioxide
- emission rate for suspended particulates
- physical stack height
- stack gas temperature
- stack exit diameter
- stack gas exit velocity
- coordinates of SW corner of area source
- side length of area source.

The user may also specify up to 25 point sources and up to 10 area sources as being significant (i.e., sources for which additional information is output).

Receptor Data

The user may also choose to input the coordinates of the receptors (up to 180) or enter one to five radial distances, in which case, RAM will generate 36 receptors for each distance entered. If the user specifies

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the array boundaries, RAM can also generate its own honeycomb array of receptors. Additionally, RAM can generate receptors downwind of significant point or area sources if the significant source option is used.

SECTION 3

FEATURES AND LIMITATIONS

USES

RAM is primarily a short-term (one hour to one day) urban or rural algorithm used to estimate air quality from point and area sources.

Effects of either control strategies or tactics for specific short-term periods may be examined by users. The expected effect of a proposed source or sources can also be determined. The spatial variation in air quality throughout the urban/rural area, or in a portion of the area, for specific periods can be evaluated readily.

In a forecast or predictive mode such as over a 24-hour period, the algorithm can assist in locating mobile or portable air samplers and can assist with emission reduction tactics. Successful use of RAM in the forecast mode is contingent on the validity of the algorithm assumptions and the ability to accurately forecast both the input meteorological parameter values and the input emission parameter values.

The model has the following added features:

- urban dispersion coefficients recommended by Briggs -- see Figure 7 and Table 8 of Gifford (1976),
- wind-profile exponents for urban and rural situations,
- optional treatment of calm conditions following methods developed by the EPA (1984),
- stack-tip downwash using the algorithm of Briggs (1974),
- momentum-plume rise to treat momentum-dominated plumes as suggested by Briggs (1969),
- buoyancy-induced dispersion following the method of Pasquill (1976), and a
- default option, primarily for regulatory application of the model.

These features were added to satisfy the requirements outlined in "Guideline on Air Quality Models (Revised)" (EPA, 1986). The default option is designed as a convenience for the user to help avoid inadvertent errors in setting the appropriate switches for regulatory use. The reader is cautioned to refer to the current regulatory guidance contained in the "Guideline on Air Quality Models".

Urban and Rural Modes

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The urban dispersion parameter values are those recommended by Briggs and included in Figure 7 and Table 8 of Gifford (1976). They have been coded in a subroutine which yields dispersion coefficients as functions of atmospheric stability and downwind distance. Separate urban and rural default wind-profile exponents are used in the model. These exponents are used by the model when the user exercises the default option or when they have not been provided on input. The rural exponents correspond to a surface roughness of about 0.1 meters; the urban exponents result from a roughness of about 1 meter (plus urban heat release influences). For a more detailed discussion of wind profiles, the reader is referred to Irwin (1979).

ALGORITHM ASSUMPTIONS

Gaussian Plumes

Calculations of concentrations from point sources are made for emissions diluted according to the mean wind speed, assuming that the time-averaged plumes over 1-hour periods have Gaussian (normal) distributions perpendicular to the plume centerline in the horizontal and vertical.

Narrow Plume Simplification

Calculations of concentrations from area sources are made by considering that area sources at various distances on a line directly upwind from the receptor are representative of the sources at those distances that affect the receptor. This assumption is best fulfilled by gradual rather than abrupt changes in area emission rates from adjacent area sources. The narrow plume simplification is considered in more detail in the next section.

Meteorological Conditions Representative of the Region

The meteorological input for each hour consists of a value for each of the five parameters: wind direction, wind speed, temperature, stability class, and mixing height, all of which should be representative of the entire region containing the sources and receptors. Mixing height is required only if the atmospheric stability is neutral or unstable.

Steady-state

Calculations are made as if the atmosphere had reached a steady state. Concentrations for a given hour are calculated independently of conditions for the previous hour(s).

Concentration, Sum of Contributions

The total concentration for a given hour for a particular receptor is the sum of the estimated contributions from each source.

Vertical Stability

Except for stable layers aloft, which inhibit vertical dispersion, the atmosphere is treated as a single layer in the vertical with the same rate of vertical dispersion throughout the
layer. Complete eddy reflection is assumed both from the ground and from the stable layer aloft given by the mixing layer.

Mixing Height

If vertical temperature soundings are available from a representative location, they should be used with hourly surface temperatures to estimate hourly mixing heights for periods with neutral or unstable stratification. If National Weather Service hourly data are used in the model, two values of mixing height per day are required. These are the maximum and minimum mixing heights as defined by Holzworth (1972). The preprocessor program RAMMET provides a crude interpolation to obtain hourly mixing heights; however, this interpolation does not consider hourly surface temperatures.

Wind Speeds and Directions

Wind speeds and directions should be hourly averages (National Weather Service hourly observations are not really hourly averages, but are averages of a few minutes at the time of the observation, usually 5 to 10 minutes prior to the hour). Input winds should be representative of the entire region. In addition to input winds, the user is required to give the anemometer height.

The increase of wind speed with height is included, based upon a power-law wind profile. The exponent is dependent upon the stability classification and surface roughness. (See Irwin, 1979.) For any given hour, winds at various heights above ground are likely to deviate considerably from this climatological mean profile. If user-defined exponents are not supplied, default exponents are used by the model.

There is no inclusion of directional shear with height. This means that the direction of flow is assumed to be the same at all levels over the region. The taller the effective height of the emission, the larger the expected error in the direction of plume transport. Although the effects of surface friction are such that wind direction usually veers (turns

clockwise) with height, the thermal effects (in response to the horizontal temperature gradient in the region) may cause increased veering or can overcome the effect of friction and cause backing (turning counterclockwise with height).

National Weather Service observations report wind to the nearest 10E. In order to avoid unrealistic results that would occur from having the wind come from exactly the same direction hour after hour, the program RAMMET, which processes the meteorological data, uses random numbers from 0 to 9 to add from -4E to +5E to the reported wind direction. The purpose of this is to prevent an extreme overestimate of concentration at a point downwind of a source during a period of steady wind when sequential observations show the same direction. Rather than allow the plume centerline to remain in exactly the same position for several hours, the alteration allows for some variation of the plume centerline within the 10E sector. Although this can in no way simulate the actual sequence of hourly events (wind direction to 1E accuracy cannot be obtained from wind direction reported to the nearest 10E), such alterations can be expected to result in concentrations over a period of record to be more representative than those obtained using winds to only the 10E increments reported. (Sensitivity tests of this alteration for single sources have indicated that, where a few hours of unstable conditions are critical to producing high concentrations, the resulting concentrations are extremely sensitive to the exact sequence of random numbers used, such as two wind directions 1E apart versus two wind directions 9E apart. Differences of 24-hour concentrations from a single source by 40 to 50 percent have appeared in the sensitivity tests due to the alteration.) It is, therefore, important to use accurate wind information as input to RAM.

Dispersion Parameter Values

The dispersion parameter values representative for urban areas are those recommended by Briggs and included in Figure 7 and Table 8 of Gifford (1976).

The dispersion parameter values representative for open countryside are the Pasquill-Gifford curves (Pasquill, 1961; Gifford, 1960) which appear in the Workbook of Atmospheric Dispersion Estimates (Turner, 1970). The subroutines used to determine the open countryside parameter values are the same as in the UNAMAP programs MPTER and PTPLU (Pierce and Turner, 1980; Pierce et al., 1982; Chico and Catalano, 1986).

Plume Rise

Plume rise from point sources is calculated using the methods of Briggs

(1969, 1971, 1972, 1974, 1975). Although the plume rise from point sources is usually dominated by buoyancy, plume rise due to momentum is also taken into account. Merging of nearby buoyant plumes is not considered. Stack-tip downwash is considered, but building downwash is not.

The variation of effective height of emission from area sources as a function of wind speed is thought to be an important factor in properly simulating dispersion in urban areas. Since this effect is seldom considered in the compilation of urban area emission inventories, it is difficult to have the appropriate parameters to estimate this effect; however, it can be approximated in RAM. The methodology used is explained in Section 5.

Emission Inventories

For similar meteorological conditions, the contribution to the concentration at a receptor from a source is directly proportional to the emission rate from that source. It is imperative, therefore, to have emissions expressed accurately. Many air pollutant sources vary emissions with time, such as by hour of the day or weekdays versus weekends, and attempts should be made to include these variations. For facilities with detailed emission inventories, hourly emissions can be determined external to RAM and entered via a separate file. Hourly exit velocities are calculated within RAM in proportion to annual exit velocities as hourly emissions are to annual emissions.

Removal or Chemical Reactions

Transformations of a pollutant primarily as a function of time resulting in loss of that pollutant throughout the entire depth of each plume can be approximated by RAM. This is accomplished by an exponential decrease with travel time from the source. The input parameter is the time expected to lose 50% (half-life) of the emitted pollutant. RAM does not have the capability to change this parameter value during a given run. If the loss to be simulated takes place through the whole plume without dependence upon concentration, then the exponential loss may provide a reasonable simulator if the loss rate is realistic. However, if the loss mechanism is selective, such as impaction with features on the ground, reactions with materials on the ground, or dependence on the concentration in a given small parcel of air (requiring consideration of contributions from all sources to this parcel), the loss mechanism built into RAM will not be adequate.

Topographic Influences

RAM is designed for application over level or gently rolling terrain where the assumption of a flat plane used in the algorithm is reasonable. Dispersion parameters for the urban algorithms are representative of surface roughness over urban areas ($z_o \simeq 1m$). Dispersion parameters for the rural algorithms are representative of surface roughness over rural areas ($z_o \simeq 0.1$ m). The algorithms in RAM have no topographical influences incorporated, and some difficulties might be expected in attempting to use the model in terrain situations. Under unstable conditions, plumes may tend to rise over terrain obstructions; under stable conditions, leveled-off plumes may remain at nearly the same mean sea level height, but may be expected to alter the plume path in response to the terrain features, resulting in a different wind direction locally than that specified for the region.

Fumigation

Fumigation is a transient phenomenon that eliminates the inversion layer containing a stable plume from below, causing mixing of pollutants downward and resulting in uniform concentrations with height beneath the original plume centerline. This phenomenon is not included in the calculations made by RAM. Conditions specified for each hour are calculated as if a steady state had been achieved.

Default Option

A default option is a feature of the model which facilitates compliance with regulatory requirements. For either rural or urban situations, exercising this option overrides other user-input selections and results in the following:

- final plume rise is used (gradual or transitional plume rise is not used for plume height, but it is used to calculate the magnitude of the buoyancy-induced dispersion),
- buoyancy-induced dispersion is used,
- stack-tip downwash is considered,
- default urban or rural wind-profile exponents are used as given in Table 1,
- default vertical potential temperature gradients for stable conditions are used,
- a decay half-life of four hours for SO_2 in urban mode is used, otherwise no decay,
- momentum-plume rise is calculated, and
- calms are treated according to methods developed by the EPA (1984). These are discussed next.

Optional Treatment of Calm Conditions

When the default option is exercised, calm conditions are handled according to methods developed by EPA. A calm hour is indicated in the preprocessed meteorological data as an hour with a wind speed of 1.0 m/sec and a wind direction the same as the previous hour. When a calm is detected in the meteorological data, the concentrations at all receptors are set to zero. When calculating a multiple-hour average concentration, the sum of the hourly concentrations is divided by the number of hours less the number of calm hours, provided that the divisor used in calculating the average is never permitted to be less than 75 percent of the averaging time being considered. This results in the following:

- 3-hour averages are always determined by dividing the sum of the hourly contributions by 3 (i.e., no change from prior methods);
- 8-hour averages are calculated by dividing the sum of the hourly contributions by the number of non-calm hours or 6, whichever is greater;
- 24-hour averages are determined by dividing the sum of the hourly contributions by the number of non-calm hours or 18, whichever is greater; and
- period of record averages are calculated by dividing the sum of all the hourly contributions by the number of non-calm hours during the period of record.

This calms procedure is not available in RAM outside of the default option. If not using the default, calms are treated as 1.0 m/s winds.

Summary

The closer the situation to be simulated agrees with the assumptions stated above, the greater the expectation of reasonable results. The narrow plume simplification is most reasonable for situations where there are no great variations in area emission rates for adjacent area sources.

The higher the effective height of a point source, the greater is the chance for poor results since actual directional shear in the atmosphere, not included in the algorithm, will cause plumes to move in directions different from the direction input to the model. Also, the higher the source height, the greater is the potential for encountering layers in the atmosphere having dispersion characteristics different from those being used. As stated above, it is necessary to properly consider variations in emissions.

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Reliable meteorological inputs are also necessary. The light wind situation is most likely to violate assumptions, since variations in the flow over the region are likely to occur, and the slower transport may cause buildup of pollutants from hour to hour. Unfortunately, these are the conditions that are likely to be associated with maximum 3-hour and 24-hour concentrations in urban areas. These light wind situations do not conform to the assumptions of Gaussian steady-state models. The calms processing segment in RAM takes into account these deficiencies by calculating averages for periods longer than three hours in such a way that persistent light wind conditions do not cause a gross overestimate of concentrations at a given receptor.

RAM is not appropriate for making concentration estimates for topographic complications. The greater the departure from relatively flat terrain conditions, the greater the departure from the assumptions of the algorithm.

RAM is most applicable for pollutants that are quite stable chemically and physically. A general loss of pollutant with time can be accounted for by the algorithm. Selective removal or reaction at the plume-ground interface or dependence upon concentration levels may not be well handled by RAM.

SECTION 4

BASIS FOR RAM

The basis for RAM is also discussed in Novak and Turner (1976). The user may select use of either urban or rural parameters. The urban dispersion parameters F_y and F_z are those suggested by Briggs and reported by Gifford (1976). The urban F's are functions of distance between source and receptor and of atmospheric stability class where the class is specified by open country conditions.

The dispersion parameters for rural conditions are those of Pasquill-Gifford (Pasquill, 1961; Gifford, 1960), as used in the UNAMAP programs PTPLU, CRSTER, and MPTER. These values are equivalent to the dispersion parameter values given in Figures 3-2 and 3-3 of the Workbook of Atmospheric Dispersion Estimates (Turner, 1970).

DILUTION BY THE WIND

Emissions from continuous sources are assumed to be stretched along the direction of the wind by the speed of the wind. Thus the stronger the wind, the greater the dilution of the emitted plume. To approximate the increase in wind speeds with height from point of measurement to stack top, a power-law increase with height is used. The exponent used is a function of stability.

DISPERSION RESULTS IN GAUSSIAN-DISTRIBUTED CROSS SECTIONS

The time-averaged concentration distributions through a dispersed plume resulting from a continuous emission from a point source or an area element are considered to be Gaussian in both the horizontal and vertical directions. Modification of the vertical distribution by eddy reflection at the ground or at a stable layer aloft is considered. This eddy reflection is calculated by a "folding back" of the portion of the distribution that would extend beyond the barrier if it were absent. This is equivalent to a virtual-image source beneath the ground (or above the stable layer).

STEADY-STATE CONDITIONS

Concentration estimates are made for each simulated hourly period using the mean meteorological conditions for that hour as if a steady-state condition had been achieved. Steady-state Gaussian plume equations are used for point sources, and the integrations of these equations are used

for area sources.

SECTION 5

TECHNICAL DESCRIPTION

CONCENTRATION SUM OF INDIVIDUAL CONTRIBUTIONS

The total concentration of a pollutant at a receptor is taken as the sum of the individual concentration estimates from each point and area source affecting that receptor, that is, concentrations are additive. Concentration estimates for averaging time longer than one hour are determined by linearly averaging the hourly concentrations during the period.

WIND SPEED

In RAM the input wind speed data must include the height above ground of the measurements, and may include the exponents for the wind profile. If no exponents are given in the input, the values in Table 1 are used. The wind speed at the physical stack height h is calculated from:

$$u(h) = u \ (h/h_a)^p \tag{1}$$

where u is the input wind speed for this hour, h is the height of wind measurement, and the exponent p, for the wind profile, is a function of stability. If u(h) is determined to be less than 1 m/s, it is set equal to 1 m/s.

TABLE 1. EXPONENTS FOR WIND PROFILES

Stability class	URBAN (RAM) exponent	RURAL (RAMR) exponent
A	0.15	0.07
B	0.15	0.07
C	0.20	0.10
D	0.25	0.15
E	0.30	0.35
F	0.30	0.55

PLUME RISE FOR POINT SOURCES

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The use of the methods of Briggs to estimate plume rise and effective height of emission are discussed below.

First, actual or estimated wind speed at stack top, u(h), is assumed to be available.

Stack Downwash

To consider stack downwash, the physical stack height is modified following Briggs (1973, p. 4). The h' is found from

$$h' = h + 2\{[v_s/u(h)] - 1.5\}d \text{ for } v_s < 1.5\ u(h), \tag{2}$$

$$h' = h \text{ for } v_s \geq 1.5\ u\ (h),$$

where h is physical stack height (meters), v_s is stack gas velocity (meters per second), and d is inside stack-top diameter (meters). This h' is used throughout the remainder of the plume height computation. If stack downwash is not considered, h'= h in the following equations.

Buoyancy Flux

For most plume rise situations, the values of the Briggs buoyancy flux parameter, F (m^4/s^3) is needed. The following equation is equivalent to Briggs' (1975, p. 63) Eq. 12:

$$F = (g\ v_s\ d^2\ )T)/(4\ T_s), \tag{3}$$

where g is the acceleration of gravity, 9.806 m/s^2,)T = T_s - T, T_s is stack gas temperature (Kelvin), and T is ambient air temperature (Kelvin) at stack top.

Unstable or Neutral: Crossover Between Momentum and Buoyancy

For cases with stack gas temperature greater than or equal to ambient air temperature, it must be determined whether the plume rise is dominated by momentum or buoyancy. The crossover temperature difference)T)$_c$ is determined for 1) F less than 55 or 2) F greater than or equal to 55. If the difference between stack gas temperature and ambient air temperature,)T, exceeds or equals the)T)$_c$, plume rise is assumed to be buoyancy dominated; if the difference is less than)T)$_c$ plume rise is assumed to be momentum dominated (see below).

The crossover temperature difference is found by setting Briggs' (1969, p. 59) Eq. 5.2 equal to the combination of Briggs (1971, p. 1031) Eqs.

6 and 7 and solving for ΔT. For F less than 55,

$$(\Delta T)_c = 0.0297 \ v_s^{\ 1/3} \ T_s/d^{2/3}. \tag{4}$$

For F equal to or greater than 55,

$$(\Delta T)_c = 0.00575 \ v_s^{2/3} \ T_s/d^{1/3} \tag{5}$$

Unstable or Neutral: Buoyancy Rise

For situations where ΔT exceeds or is equal to $(\Delta T)_c$ as determined above, buoyancy is assumed to dominate. The distance to final rise x_f (in kilometers) is determined from the equivalent of Briggs' (1971, p. 1031) Eq. 7, and the distance to final rise is assumed to be 3.5x*, where x* is the distance at which atmospheric turbulence begins to dominant entrainment. For F less than 55,

$$x_f = 0.049 \ F^{5/8}. \tag{6}$$

For F equal to or greater than 55,

$$x_f = 0.119 \ F^{2/5}. \tag{7}$$

The plume height, H (in meters), is determined from the equivalent of the combination of Briggs' (1971, p. 1031) Eqs. 6 and 7. For F less than 55,

$$H = h' + 21.425 \ F^{3/4}/u(h). \tag{8}$$

For F equal to or greater than 55,

$$H = h' + 38.71 \ F^{3/5}/u(h). \tag{9}$$

Unstable or Neutral: Momentum Rise

For situations where the stack gas temperature is less than the ambient air temperature, it is assumed that the plume rise is dominated by momentum. Also if ΔT is less than $(\Delta T)_c$ from Eq. 4 or 5, it is assumed that the plume rise is dominated by momentum. The plume height is calculated from Briggs' (1969, p. 59) Eq. 5.2:

$$H = h' + 3 \ d \ v_s/u(h). \tag{10}$$

Briggs (1969) suggests that this equation is most applicable when v_s/u is

greater than 4. Since momentum rise occurs quite close to the point of release, the distance to final rise is set equal to zero.

Stability Parameter

For stable situations, the stability parameter s is calculated from the equation (Briggs, 1971, p. 1031):

$$s = g(\Delta\theta/\Delta z)/T \qquad (11)$$

where θ is potential temperature. As an approximation, for stability class E (or 5), $\Delta\theta/\Delta z$ is taken as 0.02 K/m, and for stability class F (or 6), $\Delta\theta/\Delta z$ is taken as 0.035 K/m.

Stable: Crossover Between Momentum and Buoyancy

For cases with stack gas temperature greater than or equal to ambient air temperature, it must be determined whether the plume rise is dominated by momentum or buoyancy. The crossover temperature difference $(\Delta T)_c$ is found by setting Briggs' (1975, p.96) Eq. 59 equal to Briggs' (1969, p. 59) Eq. 4.28, and solving for ΔT. The result is

$$(\Delta T)_c = 0.019582 \ v_s \ T \ s^{1/2}. \qquad (12)$$

if the difference between stack gas temperature and ambient air temperature (ΔT) exceeds or equals $(\Delta T)_c$, the plume rise is assumed to be buoyancy dominated; if ΔT is less than $(\Delta T)_c$, the plume rise is assumed to be momentum dominated.

Stable: Buoyancy Rise

For situations where ΔT is greater than or equal to $(\Delta T)_c$, buoyancy is assumed to dominate. The distance to final rise (in kilometers) is determined by the equivalent of a combination of Briggs' (1975, p. 96) Eqs. 48 and 59:

$$x_f = 0.0020715 \ u(h) \ s^{-1/2}. \qquad (13)$$

The plume height is determined by the equivalent of Briggs' (1975, p. 96) Eq. 59:

$$H = h' + 2.6\{F/[u(h) \ s]\}^{1/3}. \qquad (14)$$

The stable buoyancy rise for calm conditions (Briggs, 1975, pp. 81-82)

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is also evaluated:

$$H = h' + 4 \ F^{1/4} \ s^{-3/8} \tag{15}$$

The lower of the two values obtained from Eqs. 14 and 15 is taken as the final effective height.

Stable: Momentum Rise

When the stack gas temperature is less than the ambient air temperature, it is assumed that the plume rise is dominated by momentum. If)T is less than ()T)$_c$ as determined by Eq. 12, it is also assumed that the plume rise is dominated by momentum. The plume height is calculated from Briggs' (1969, p. 59) Eq. 4.28:

$$H = h' + 1.5\{(v_s^2 \ d^2 \ T)/[4 \ T_s \ u(h)]\}^{1/3} \ s^{-1/6}. \tag{16}$$

The equation for unstable or neutral momentum rise (10) is also evaluated. The lower result of these two equations is used as the resulting plume height.

All Conditions: Distance Less than Distance to Final Rise (Gradual Rise)

Where gradual rise is to be estimated for unstable, neutral, or stable conditions, if the distance upwind from receptor to source x (in kilometers), is less than the distance to final rise, the equivalent of Briggs' (1971, p. 1030) Eq. 2 is used to determine height:

$$H = h' + (160 \ F^{1/3} \ x^{2/3})/u(h). \tag{17}$$

This height is used only for buoyancy-dominated conditions; should it exceed the final rise for the appropriate condition, the final rise is substituted instead.

General

In working through the receptors to determine concentrations for a given hour, the first time a source is found to lie upwind of a receptor, the following quantities are determined and stored for that source: u(h), h', F, H, and x_f. These quantities are then used each time this source is encountered during this hour without recalculation. Only if the upwind receptor-source distance is less than x_f is the effective plume height determined for each occurrence by the last equation mentioned.

BUOYANCY-INDUCED DISPERSION FOR POINT SOURCES

For strongly buoyant plumes, entrainment as the plume ascends through the ambient air contributes to both vertical and horizontal spread. Pasquill (1976) suggests that this induced dispersion, F_{zo}, can be approximated by the plume rise divided by 3.5.

$$F_{zo} = \Delta h/3.5 \tag{18}$$

where Δh is either the gradual plume rise as calculated by Eq. 5 for distances less than the distance to final rise, or the final rise for distances greater than that distance. The effective dispersion can then be determined by adding variances:

$$F_{ze} = (F_{zo}^2 + F_z^2)^{1/2}, \tag{19}$$

where F_{ze} is the effective dispersion, and F_z is the dispersion due to ambient turbulence levels. At the distance of final rise and beyond, the induced dispersion is constant, based on the height of final rise. At distances closer to the source, gradual-plume rise is used to determine the induced dispersion.

Since in the initial growth phases of release, the plume is nearly symmetrical about its centerline, buoyancy-induced dispersion in the horizontal direction, F_{yo}, equal to that in the vertical direction, is used,

$$F_{yo} = \Delta h/3.5 \tag{20}$$

To yield an effective lateral dispersion value, F_{ye}, this expression is combined with that for dispersion due to ambient turbulence:

$$F_{ye} = (F_{yo}^2 + F_y^2)^{1/2}. \tag{21}$$

EFFLUENT RISE FOR AREA SOURCES

RAM can include in effective height with wind speed for area sources. The input area source height, H_A, is assumed to be the average physical height of the area source plus the effluent rise with a wind speed of 5 m/s. The user specifies the fraction, f, of the input height that represents the physical height, h_p. This fraction is the same for all area sources in the inventory.

$$h_p = f \, H_A \tag{22}$$

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The difference is the effluent rise for a wind speed of 5 m/s

$$\Delta H\ (u = 5) = H_A - h_p \qquad\qquad (23)$$

If f = 1, there is no rise and the input height is the effective height for all wind speeds. For any wind speed, u, the rise is assumed to be inversely proportional to wind speed and is determined from:

$$\Delta H\ (u) = 5(H_A - h_p)\ /\ u \qquad\qquad (24)$$

and the effective height is:

$$H_e\ (u) = h_p + \Delta H(u). \qquad\qquad (25)$$

CONCENTRATION FORMULAS

Concentrations from Point Sources

The upwind distance x of the point source from the receptor and the crosswind distance, y, of the point source from the receptor are calculated as part of estimates for each source-receptor pair for each simulated hour. Both dispersion parameter values F_y and F_z are determined as functions of this upwind distance x and stability class.

The terms below are used in the equations that follow.

$$g_1 = \exp\ (-0.5 y^2 / F_y^2)$$

$$g_2 = \exp\ [-0.5(z - H)^2 / F_z^2] + \exp\ [-0.5(z + H)^2 / F_z^2]$$

$$g_3 = \sum_{N=-4}^{4} \{\exp\ [-0.5(z - H + 2NL)^2 / F_z^2] +$$
$$\exp\ [-0.5(z + H + 2NL)^2 / F_z^2]\}$$

(This infinite series converges rapidly and evaluation with N varying from -4 to +4 is usually sufficient.) where

   H = effective height of emissions, meters

   L = mixing height, the top of the unstable layer, meters

   y = crosswind distance, meters

   z = receptor height above ground, meters

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F_y = standard deviation of plume concentration distribution in the horizontal, meters

F_z = standard deviation of plume concentration distribution in the vertical, meters

One of three equations is used to estimate concentrations under various conditions of stability and mixing height. The equation

$$P_p = Qg_1g_2 \ / \ (2BF_yF_zu) \qquad\qquad (26)$$

is used for stable conditions or for unlimited mixing where,

P_p = ground-level concentration from a single point source, g/m^3, and

Q = point source emission rate, g/sec.

In this equation, eddy reflection at the ground is assumed. For unstable or neutral conditions where vertical dispersion is great enough that uniform mixing is assured ($F_z \geq 1.6L$) beneath an elevated inversion, the following equation is used.

$$P_p = Qg_1 \ / \ F_yLu(2B)^{1/2} \qquad\qquad (27)$$

(If H or z is above the mixing height, $P_p = 0$.)

For unstable or neutral conditions where uniform mixing is not assured ($F_z < 1.6L$), the following equation is used.

$$P_p = Qg_1g_3 \ / \ (2BF_yF_zu) \qquad\qquad (28)$$

This equation incorporates multiple eddy reflections from the ground and the base of the stable layer aloft.

Concentrations from Area Sources

The total concentration at a receptor from the two-dimensional area source distribution is calculated using the narrow plume simplification discussed by Gifford and Hanna (1971). This simplification is assumed because the upwind zone of influence affecting a receptor (an upwind oriented point source plume) is normally quite narrow in comparison with the characteristic length scale for appreciable changes in the magnitude of the area-source emission rate itself. Under these circumstances the two-dimensional integral that expresses the total area-source contribution to concentration at a receptor can be replaced approximately

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by a one-dimensional integral. This integral involves only:

- knowledge of the distribution of the area-source emission rates along the line in the direction of the upwind azimuth from the receptor location,

- the meteorologically dependent function that specifies the crosswind-integrated concentration in the Gaussian plume from a point source.

In using this area source technique, Gifford and Hanna assumed area-source emissions at ground level, allowing integration upwind to be accomplished analytically. In RAM the area sources are allowed to have an effective height, requiring the integration to be accomplished numerically. Internal tables of integrations for one to three effective area source heights are calculated at the beginning of each simulated hour using the specific meteorological conditions for that hour. The total concentration from all area sources is determined by performing the integration piecewise over each source in the upwind direction from the receptor until the farthest boundary of the source region is reached.

SECTION 6

VERIFICATION RUN

A sample input data set and the resulting output are distributed with the model code for verification purposes. A detailed discussion of that data set can be found in Section 6 of the complete "User's Guide for RAM" which is available from NTIS.

SECTION 7

USES OF RAM

RAM simulates pollutants from point and area sources in urban or rural settings over periods of one hour to one year. The meteorological data can be entered on cards, with one card for each simulated hour, or on magnetic media by using option 8. General emission information can also be on the input stream or from disk or tape files using option 9 or 10.

Point and area sources are specified by options 5 and 6. The locations of receptors may be specified by the user (option 14).

The use of options 15 and 16 to locate additional receptors downwind of significant point and area sources assists in determining locations of maximum concentration. Since the resultant wind vector for the averaging period selected is used to determine the direction of these receptors from the sources, averaging times that contain significant wind shifts may result in misleading averages. The user should note that when options 15 and 16 are used to locate receptors downwind from significant sources, the locations for these receptors will shift for each averaging period, dependent upon the resultant meteorological conditions for each period. Therefore, receptors with the same numbers will be at different locations for different averaging times.

If the user desires to cover a specific area so that pollutant patterns are discerned, option 17 can be used to place additional receptors. The pattern used is such that adjacent receptors are equidistant; this is referred to as a honeycomb pattern. The distance between receptors is selected by the user as are the boundaries of the area covered. If the boundaries are entered as zeros, the boundaries are set to coincide with the boundaries of the area source map array. Since the honeycomb receptors are set for each averaging time, they may be different from one averaging time to another. The model can be executed for an hour without receptors downwind of significant sources in order to obtain a list of receptors for good area coverage. Their coordinates can then be input for a longer period run where it is desired to have receptors in fixed positions.

It should be noted that concentration gradients may be very steep, especially those due to point source plumes. Therefore, the addition of more receptors will result in a more complex concentration pattern and some hot spots. The user, when searching for maximum concentrations, must decide on receptor spacing commensurate with resources, analysis

time, and the purpose of the project before including additional receptors.

For the typical run, hourly output would be desired, so option 24 should be set for hourly output. If option 24 is not set, no hourly output is printed. The use of option 40 to write partial concentrations onto a disk file should be used only if additional computer analysis is intended using the individual contributions of sources upon particular receptors. Computer programs to perform this analysis must be written by the individual user to suit his or her purpose.

Option 30 is checked only if option 24 is used to obtain hourly summaries. The use of option 30 will print a summary page for each hour. This summary provides the total concentration for each receptor, the contribution to the concentration from all point sources, the contribution to the concentration from all area sources, the contribution from all the significant point sources combined, and the contribution from all the significant area sources. Information that will be obtained by using option 24, but not option 30, are the contributions to the concentrations at each of the receptors from each of the significant sources. The maximum of 10 significant area sources results in an additional page of output per simulated hour. The maximum of 25 significant point sources results in three additional pages of output per simulated hour (one page for every 10 significant point sources or fraction thereof). Unless the concentration contributions are specifically needed for analysis of contributions from particular sources, option 30 should be zero to reduce the quantity of output.

Option 8 would be set to one to enter meteorological data as part of the run stream rather than reading an external file using unit 11. Options 9 and 10 are set to one to enter hourly emissions. If the contribution at a receptor from particular sources is of interest, and if these particular sources are not high enough to be included in the significant source list from RAM, options 11 and 12 may be used to specify the sources of interest. If option 11 or 12 is used to obtain concentration contributions for the averaging time, it is desirable to leave option 30 off to obtain hourly output.

Option 41 or 42 would not usually be employed unless concentrations at each receptor are required for further analysis or are to be used with graphics software to produce concentration isopleth maps.

SECTION 8

COMPUTER ASPECTS OF THE MODEL

STRUCTURE OF RAM

RAM consists of three sections: preprocessing subroutines, main logic, and output subroutines.

Inputs for the model are assumed to be from disk files; outputs either go to disk or printer. Options and program control are read from FORTRAN unit 5; processing is then controlled through specifications in this file. If so specified in the control file, meteorology and emissions can be obtained from units 11, 15, and 16, respectively. The program uses two temporary files for intermediate work, but they are not temporary in the JCL sense, i.e., they are not deleted at the end of the job step and should be deleted by the user when they are no longer needed. As the program calculates concentrations, they are averaged and written to units 1, 10, 12, and 13. Tabular output is written to unit 6 which is usually the default for printed files.

Preprocessing subroutines are used to initialize variables and are called to determine dispersion parameter values as functions of stability class and source-receptor distance. The data produced are coefficients and exponents for the various ranges of effective height of emission and are used to determine maximum Pu/Q (relative concentration normalized for wind speed) for point sources and distance to maximum concentration for point and area sources as functions of stability class and effective height of emission.

Other subroutines process the emission data. Their principal task is to set up the area source map array. The area source map array provides correspondence between locations (referred to by coordinates) and area source number. Other tasks, such as ranking sources according to set criteria, are also accomplished.

RAM expects hourly meteorological input data, including mixing height and stability class. This and other values can be entered in the input stream or from a preprocessed file. The auxiliary program RAMMET can process raw meteorological data into the needed format using hourly surface data and mixing heights from the National Climatic Data Center. Input consists of one year of surface data (one observation per hour) and one maximum and one minimum mixing height per day. RAMMET determines hourly stability and performs interpolations to estimate hourly mixing

heights. The output data are organized to produce a single record for each day.

The output subroutines are OUTPUT and OUTAV. OUTPUT provides hourly concentrations in micrograms per cubic meter, including the contributions from significant point sources along with a summary table. OUTAV provides the same information for the averaging period.

PROGRAM MODULES

After initialization, the flow is governed by three loops: calendar days, averaging time, and hours. A minimum of one hour and a maximum of 8,784 hours can be processed by the model. A brief description of the main program and subroutines follows.

MAIN -   The main program determines Pu/Q maxima and distance to the point of maximum for point sources as functions of stability class and effective height of emissions. Coefficients and exponents relating these two parameters to effective height of emission are determined for various stability and effective height range combinations. These coefficients and exponents, as well as ones for determining the distance of the maximum concentration downwind from the edge of an area source, are calculated for use in the emissions module which processes emission inventory information for later use. An important aspect of this is the construction of the area source map array which allows a correspondence between any location in the area source region and the number of the area source at that location. All source coordinates in units convenient to the user (user units) are converted to internal units. An internal unit is a length such that any area source side length used in a given run can be expressed as an integer multiple of an internal unit. The internal unit is generally equal to the length of the side of the smallest area in the emission inventory. The user must determine the internal unit length and specify it in user units. Both point and area sources are ranked according to expected impact at ground level. The 25 point sources and the 10 area sources with the greatest expected ground-level impact are listed. Also, the total emissions from various physical heights for both point and area sources are listed. This helps the user in determining area source heights and the number to be used.

BRIEF DESCRIPTION OF SUBROUTINES

The subroutine and function descriptions that follow are called by RAM to perform specific tasks.

ANGARC - This function determines the appropriate arctan of the east resultant wind component over the north resultant wind component with the resulting angle between 0E and 360E

JMHREC - This subroutine and entry point GREC called by RAM determine receptor locations downwind of significant sources based upon the resultant meteorological conditions for the averaging period, usually 3 or 24 hours. Plume rise and effective height of emission are calculated. The distance of the maximum concentration is determined as a function of the stability and the effective height of emission in order to locate the position of a receptor. Two receptors are generated for each significant point source, one at the expected distance of maximum concentration and one at twice this distance. One receptor is generated for each significant area source at the expected distance of maximum concentration.

JMHHON - This subroutine called by RAM generates additional receptors within a specified area in order to give adequate coverage of that area with the minimum number of receptors. Receptors are placed equidistant from nearby receptors, resulting in a honeycomb array. The distance between receptors is an input to the main program. Proposed honeycomb receptors located closer than half this distance to any other receptor are not included.

PT -   This subroutine calculates concentrations from point sources. Subroutines RCON and SYZ (ENTRY point in SYSZ) are called to complete the computations.

RCON -   This subroutine called by PT calculates P/Q, the relative concentrations from point sources. This subroutine calls SYZ.

SYZ -   This subroutine called by RCON calculates the standard deviation of the concentration in the y- and z- directions. It employs the Briggs urban dispersion parameters for urban conditions, and the Pasquill-Gifford parameters for rural conditions.

JMH54 -   This subroutine called by RAM generates tables of Pu/q_A (relative concentration normalized for wind speed) from area sources that extend from a receptor to various upwind distances. A table is

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produced for each area source height. One to three heights can be used. This subroutine calls subroutine JMHCZ.

JMHCZ - This subroutine called by JMH54 calculates concentrations from infinite crosswind line sources at a distance x upwind from a receptor. To obtain the vertical dispersion parameter value F_z, subroutine SIGZ is called.

SIGZ - This subroutine called by JMHCZ determines the value of the vertical dispersion parameter F_z for a given upwind distance of a receptor to the source. The parameter values for urban areas are those put into equation form by Briggs. The parameter values for rural areas are from Pasquill-Gifford.

JMHARE - This subroutine performs the integration along the line upwind from the receptor to obtain the effect of all area sources along the line. This is accomplished by finding the nearest and farthest distance of each source along the path and calling subroutine JMHPOL for each distance.

JMHPOL - This subroutine called by JMHARE interpolates for a given distance from the values in the tables generated by subroutine JMH54. This yields the effect of an area source at the given height extending upwind to this distance.

RANK - This subroutine arranges concentrations of various averaging times into tables of the highest five concentrations for each receptor for each averaging time (high-five tables).

OUTPT - This subroutine produces output concentrations in micrograms per cubic meter for each hour for significant sources and for the summaries.

OUTAV - This subroutine called by RAM gives concentrations for the averaging period. Contributions and/or summary information are also generated by OUTAV.

PROCESSOR PROGRAM RAMMET

If option 8 specifies that meteorological data should be expected from a file, a peripheral program RAMMET can be used to generate the file. RAMMET processes meteorological data for one year. The data input consists of hourly meteorological records in the standard card format 144 of the National Climatic Data Center and twice-a-day estimates of mixing height (minimum and maximum). Hourly stability class is determined using

the objective method of Turner (1964) based on Pasquill's technique (Pasquill, 1961). Shifts by only one stability class are allowed for adjacent hours. Hourly mixing height is interpolated from the twice-a-day estimates. Hourly meteorological data of wind direction, wind speed, temperature, stability class, and mixing height are written into a file with one record per day for the entire year. Random numbers can be read from a file or generated by the computer used.

SECTION 9

INPUT DATA PREPARATION

In this section, the general input data requirements are listed. There
are 18 record types in the input stream. Each record type consists of
one or more records.

Table 2 describes the input data; in some cases an explanation follows
the entry.

TABLE 2. RECORD INPUT SEQUENCE FOR RAM
44444444444444444444444444444444444444Ü4444444444444444444444444444444444
4

Record type and variable Units	Column	Format	Variable description

44444444444444444444444444444444444444444444444444Ü44444444444444444444
4

Record type 1

| LINE1 --- | 1-80 | 20A4 | 80-character title |

Record type 2

| LINE2 --- | 1-80 | 20A4 | 80-character title |

Record type 3

| LINE3 --- | 1-80 | 20A4 | 80-character title |

RECORDS 1 - 3. Each card image has up to 80 alphanumeric characters.
The input title appears on all output and can suit the user. Normal use
has been to identify the user and run date on card-image 1, the location
and date of the emissions data on card-image 2, and the location and
dates of both surface and upper-air meteorological data on card-image 3.

RAM-RECORD TYPE 4 - 14 variables

Record type 4

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```
IDATE(1)            ---         FF*         2-digit year
                                ---

IDATE(2)            ---         FF          Starting Julian day      ---

IHSTRT              ---         FF          Starting hour
    ---
```

*FF is free format.

```
4444444444444444444444444444444444444444444444444444444444444444444
4
Record type
and variable       Column      Format     Variable description
  Units
4444444444444444444444444444444444444444444444444444444444444444444
4
```

Record type and variable Units	Column	Format	Variable description
NPER	---	FF	Number of averaging periods ---
NAVG	---	FF	Number of hours in an --- averaging period (com- monly 24)
IPOL ---	---	FF	Pollutant indicator
			3, sulfur dioxide 4, suspended particulate
MUOR ---	---	FF	Model indicator
			1, urban mode 2, rural mode
NSIGP	---	FF	Number of point sources --- from which concentration contributions are desired (maximum=25)
NSIGA	---	FF	Number of area sources --- from which concentration contributions are desired (maximum=10)
NAVS ---	---	FF	Additional averaging time for high-five table. Usu- ally 2, 4, 6, or 12.
CONONE ---	---	FF	Multiplier to convert user units to kilometers.

Example multipliers are: 3.048 x 10^{-4} for feet to kilometers; 1.609347

for miles to kilometers; 1.0 x 10^{-3} for meters to kilometers.

UNITS	---	FF	Number of user units per smallest area source side length. Should equal 1 if no area sources. (internal units)
Z	---	FF	Receptor height
m			

```
4444444444444444444444444444444U44444444444444444444444444444444444444
4
Record type
and variable       Column      Format      Variable description
  Units
4444444444444444444444444444444U44444444444444444444444444444444444444
4

  HAFL             ---         FF          Pollutant half-life
  sec
```

An entry of zero in HAFL will cause RAM to skip pollutant loss calculations.

RAM-RECORD TYPE 5 - The values are for 50 different options; 1 is used to employ the option and a zero indicates non-use.

Record type 5

```
  IOPT(1)          1           I1          No stack downwash
  ---

  IOPT(2)          2           I1          No gradual plume rise
  ---

  IOPT(3)          3           I1          Use buoyancy induced
  ---

                                             dispersion

  IOPT(4)          4           I1          Not used
                                           ---

  IOPT(5)          5           I1          Input point sources
  ---

  IOPT(6)          6           I1          Input area sources
  ---

  IOPT(7)          7           I1          Use  emissions from previous
  ---

                                             run.  Data accessed from
                                             Unit 9.

  IOPT(8)          8           I1          Meteorology  data in input
  ---
```

			stream. Otherwise, input from Unit 11.
IOPT(9)	9	I1	Read hourly point source ---
			emissions (Unit 15)
IOPT(10)	10	I1	Read hourly area source --- emissions (Unit 16)
IOPT(11)	11	I1	Specify significant point ---
			sources

Option 11 will allow the examination of the individual contributions to each receptor from each of the specified sources. Both point and area sources may be specified. (See IOPT(12).)

4444444444444444444444444444444U4444444444444444444444444444444444444444
4

Record type
and variable   Column   Format   Variable description
  Units
4444444444444444444444444444444U4444444444444444444444444444444444444444
4

  IOPT(12)   12   I1   Specify significant area
  ---
                                                sources

  IOPT(13)   13   I1   Not used

  IOPT(14)   14   I1   Enter receptors by   ---
                                                specifying coordinates

  IOPT(15)   15   I1   RAM generates receptors ---
                                                downwind of significant
                                                point sources

  IOPT(16)   16   I1   RAM generates receptors
  ---
                                                downwind of significant
                                                area sources

  IOPT(17)   17   I1   RAM generates honeycomb
  ---
                                                array of receptors to
                                                cover specified area

RAM generates a honeycomb array of receptors, placed equidistant in
staggered rows over a specified area. This insures good area coverage.
Candidate receptor positions are checked against other receptors (either
input or generated by other options of the program) and if the distance
between the proposed receptor is less than one-half the normal distance
between honeycomb receptors, then the candidate receptor is not added to
the list. The boundaries of the area to be covered by these receptors
are specified by the user.

  IOPT(18)   18   I1   Input radial distances
  ---
                                                to generate polar
                                                coordinate receptor array.

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36 receptors for each
                                              distance.

   IOPT(19)   19   I1   Not used

Printed output is controlled by the options that follow. Options 20
through 36 are all options to omit output. In the program default, most
of these options to omit output are used since some of the options can
generate large amounts of printed output.

4444444444444444444444444444444444444444444444444444444444444444444444
4
Record type
and variable   Column   Format   Variable description
  Units
4444444444444444444444444444444444444444444444444444444444444444444444
4

  IOPT(20)   20   I1   Omit point source list ---

  IOPT(21)   21   I1   Omit   area   source list and
  ---
                                              map

  IOPT(22)   22   I1   Omit emissions with height
  ---
                                              table

  IOPT(23)   23   I1   Omit resultant meteorology
  ---
                                              data summary for averaging
                                              period

  IOPT(24)   24   I1   Omit all hourly output ---
                                              (point, area, summaries)

  IOPT(25)   25   I1   Omit hourly point contribu-
  ---
                                              tions

  IOPT(26)   26   I1   Omit meteorology data on
  ---
                                              hourly point contribu-
                                              tions

  IOPT(27)   27   I1   Omit plume height and
  ---
                                              distance to final rise
                                              on hourly point contribution

  IOPT(28)   28   I1   Omit hourly area
  ---
                                              contributions

  IOPT(29)   29   I1   Omit   meteorology data on

43

```
---                                           hourly area contributions

IOPT(30)           30          I1        Omit hourly summary
---

IOPT(31)           31          I1        Omit  meteorological data on
---
                                              hourly summary

IOPT(32)           32          I1        Omit  all averaging period
---
                                              output

IOPT(33)           33          I1        Omit  point averaging period
---
                                              contributions
```

```
44444444444444444444444444444444444444444444444444444444444444444444
4
```
Record type
and variable   Column   Format   Variable description
  Units
```
44444444444444444444444444444444444444444444444444444444444444444444
4
```

Record type and variable	Column	Format	Variable description	Units
IOPT(34)	34	I1	Omit area averaging period contributions	---
IOPT(35)	35	I1	Omit averaging period summary	---
IOPT(36)	36	I1	Omit average concentrations and highest five concentrations table	---
IOPT(37)	37	I1	Not used	---

The remaining options control the flow of the program and the amount of
output. This is especially so for Option 40, in which a large file can
be generated by employing this option.

IOPT(38)	38	I1	Set default option for regulatory application	---

Option 38 sets a series of options and parameters when the model is to
be used for regulatory application.

IOPT(39)	39	I1	Part of segmented run	---
IOPT(40)	40	I1	Write partial concentrations to disk or tape (Unit 10)	---

The user will need to write the software to process this output.
Although it is unlikely that Options 39 and 40 will be employed on the
same run, it is possible to do so. However, the second and subsequent

segments will not skip over previously generated partial concentration files. Therefore, unless Unit 10 accesses a different file on each segment, any previously generated partial concentration files will be overwritten.

```
44444444444444444444444444444444444444444444444444444444444444444444
4
```

Record type
and variable   Column   Format   Variable description
  Units

```
44444444444444444444444444444444444444444444444444444444444444444444
4
```

  IOPT(41)   41   I1   Write hourly concentrations
  ---

                                              to disk or tape (Unit 12)

  IOPT(42)   42   I1   Write averaging-period   ---
                                              concentration to disk
                                              or tape (Unit 13)

The output files generated by Options 41 and 42 are useful only when the
receptors are set for the run and not varying from one averaging period
to another. Therefore, these options can be used with Options 14 and 18,
but a program termination will occur in trying to use Option 41 or 42 in
combination with any of Options 15, 16, or 17.

IOPT(43)   43   I1   Write averaging-period   ---
                                              concentrations in card-
                                              image format (80 bytes)
                                              to Unit 1.

IOPT(44)   44   I1   Not used this version

IOPT(45)   45   I1   Not used this version

IOPT(46)   46   I1   Not used this version

IOPT(47)   47   I1   Not used this version

IOPT(48)   48   I1   Not used this version

IOPT(49)   49   I1   Not used this version

```
IOPT(50)                50              I1          Not used this version
   ---
```

RAM-RECORD TYPE 6 - 2 variables, 1 to 7 values. Selection of the default
option (Option 38) causes wind exponents to be set to the default values
for the appropriate urban or rural cases. This record is still required
to input the anemometer height; all other data on the record will be
ignored when Option 38 is set.

Record type 6

```
   HANE             ---         FF          Anemometer height          m

   PL(I)            ---         FF          Wind speed power law       ---
                                              exponents
```

444444444444444444444444444444444U44444444444444444444444444444444444444444444
4
Record type
and variable   Column   Format   Variable description
  Units
444444444444444444444444444444444U44444444444444444444444444444444444444444444
4

RAM-RECORD TYPE 7 - 9 variables, 8 values (one of these records for each
point source). This is used if Option 5 = 1 (the user inputs point
sources) and Option 7 = 0 (no emissions are entered from a previous run).

Record type 7

  PNAME(I,NPT)   1-12   3A4   12-character point source
  ---

                                                    identification

  SOURCE(1,NPT)   13-20   F8.2   East coordinate of point
  ---

                                                    source (user units)

  SOURCE(2,NPT)   21-28   F8.2   North coordinate of point
  ---

                                                    source (user units)

  SOURCE(3,NPT)   29-36   F8.2   Sulfur dioxide emission
  g/sec

                                                    rate

Emission rates for pollutants other than sulfur dioxide and particulates
may be substituted. If substitutions are made, changes in data
statements are necessary in order to have the proper pollutant names on
the printed output.

  SOURCE(4,NPT)   37-44   F8.2   Particulate emission rate
  g/sec

  SOURCE(5,NPT)   45-52   F8.2   Physical stack height
  m

  SOURCE(6,NPT)   53-60   F8.2   Stack gas temperature
  K

  SOURCE(7,NPT)   61-68   F8.2   Stack inside diameter

m

```
 SOURCE(8,NPT)     69-76      F8.2        Stack gas exit velocity
m/sec
```

To indicate the end of point source records, the word "ENDP" is placed in record columns 1 to 4.

RAM-RECORD TYPE 8 - 7 variables, 6 values (one of these records is required for each area source). This is used if Option 6 = 1 (the user inputs area sources) and Option 7 = 0 (no emissions input from previous run).

44444444444444444444444444444444④444444444444444444444444444444444444444
4
Record type
and variable   Column   Format   Variable description   Units
44444444444444444444444444444444④444444444444444444444444444444444444444
4

 Record type 8

  ANAME(J,NAS)   1-12   3A4   12-character area source   ---

identification

  ASORC(1,NAS)   13-22   F10.2   East coordinate of SW   ---

                                                                        corner
of area source
                                                                        (user
units)

  ASORC(2,NAS)   23-32   F10.2   North coordinate of SW   ---

                                              corner of area source
                                              (user units)

  ASORC(5,NAS)   33-42   F10.2   Side length of area source   ---

                                              (user units)

Note that ASORC(5,NAS) - side length, is read out of order to conform
with the existing order of IPP emissions data.

  ASORC(3,NAS)   43-52   F10.2   Sulfur dioxide emission   g/sec

                                              rate for entire area

  ASORC(4,NAS)   53-62   F10.2   Particulate emission rate   g/sec

                                                                        for
entire area

Particulate Emission Rate for entire area is a total rate for the entire
area. It is later transformed into gm/sec^{-1}m^{-2}. As with point sources,

emission rates for other pollutants may be substituted for sulfur dioxide and particulates, with appropriate name changes made in the data statements to modify titles on the printouts.

ASORC(6,NAS)   63-72   F10.2   Area source height   m

Although only one pollutant can be considered for a given run of RAM, both of the entered emission rates are listed in the output. One of the emission rates may be left off and will appear as zeros in the output.

Area sources can vary in size, but certain requirements must be met. There must be a definable internal unit such that the side length of all other area sources is an integer multiple of the side length of this internal unit. For example, if an emission inventory consists of area source squares having side lengths of 1, 2.5, 5, and 10 km, the internal unit must be chosen to equal 0.5 km. It is better to conduct emission inventories so that area source squares have side lengths that are multiples of the side lengths of the smallest area source
444444444444444444444444444444444444U4444444444444444444444444444444444444444444
4
Record type
and variable   Column   Format   Variable description
  Units
444444444444444444444444444444444444U4444444444444444444444444444444444444444444
4

squares. Also, if a grid is constructed of unlt squares, squares having side length of one internal unit, the boundaries of all area sources must coincide with lines ln that grid; there can be no overlap of one area source over another. Although these statements may seem restrictive, the area source entries to RAM are quite versatile. Concentrations from area sources are calculated by performing computations for each area source encountered in proceeding from a receptor in the upwind direction until the upwind boundary of the area source is encountered. If there are large areas (larger than the unit square) of zero emissions within the rectangle that includes all area sources (area source region), it is desirable to define these as area sources with zero emissions in squares as large as possible. This will result in considerable savings in computer processing time.

If the height of emission is the effective height of the area source at a wind speed of 5 m/sec, and if the physical height of the source is a set fraction of this value, which is the same for all area sources, it will be possible to consider the variation of effective height of area sources with wind speed in RAM. Otherwise, the fraction will be 1.0 and

it will be assumed that the input height of emission is the effective height for all wind speeds.

RAM-RECORD TYPE 9 - 2 variables. This record is required only if Option 11 is used (i.e., the user will specify significant point sources).

Record type 9

  INPT   1-3   I3   Number of user-specified
                         ---

                                           significant sources

The maximum number of user-specified significant point sources is 25 - this number must be non-zero.

  MPS(I)   4-78   I3   INPT point source numbers
                       ---

                                            the
user wants considered
                                   significant (max = 25)

There will be as many sources in this list as indicated in INPT.

RAM-RECORD TYPE 10 - 4 variables - 4 values. Information for area sources. This record is required only if Option 6 is employed (user will input area sources).

```
44444444444444444444444444444444U44444444444444444444444444444444444444
4
```

Record type
and variable   Column   Format   Variable description
  Units
```
44444444444444444444444444444444U44444444444444444444444444444444444444
4
```

Record type 10

  FH   ---   FF   Fraction of area source
  ---

                                                      height which is physical
                                                      height

    XLIM   ---   FF   Distance limit on inte- ---
                                                      gration for area source
                                                      (user units)

The distance XLIM should be equal to or exceed the greatest possible
distance from a receptor (including receptors generated by RAM) to the
farthest corner of the area source region for this run, but cannot exceed
116 kilometers.

  NHTS   ---   FF   Integer number of heights
  ---

                                                      to be used for area
                                                      sources (min=1, max=3)

  HINT   ---   FF   Height(s) for area source
  m

                                                      integrations. Same
                                                      number as NHTS.

RAM-RECORD TYPE 11 - 1 variable - 1 or 2 values. This record is required
only if record type 10 is used.

Record type 11

  BPH   ---   FF   Breakpoint heights between
  m

                                                      area source heights

These values are to be used as boundaries between the specified area
source heights used for calculations. If only one area source height is

to be used, only one BPH value is entered; it should be greater than any area source height of the area source data. If NHTS is 2, the single value for BPH should be between the two HINT values. If NHTS is 3 and the three HINT values are, for example, 15, 25, and 35; the two values for BPH might be 20 and 30.

RAM-RECORD TYPE 12 - 2 variables - 1 to 11 values. This record is required only if Option 12 is used (i.e., user specifies significant area sources).

```
44444444444444444444444444444444U44444444444444444444444444444444444444
4
```
Record type
and variable   Column   Format   Variable description
  Units
```
44444444444444444444444444444444U44444444444444444444444444444444444444
4
```

Record type 12

  INAS   1-3   I3   Number of user-specified
  ---

                                            significant area sources
                                            (max=10)

  MAS   4-33   I3   INAS   area source numbers
   ---

                                            the user wants to
                                            consider significant

RAM-RECORD TYPE 13 - 4 variables. Used if Option 8 = 0 (meteorological
data will be input on Unit 11).

Record type 13

  ISFCD   ---   FF   Surface Met. Station

                                            Identifier

ISFCD is a 5-digit identification of the meteorological tape to be used.
For tapes generated by the National Climatic Data Center, this will
normally be the surface station number.

  ISFCYR   ---   FF   Year of surface meteoro-
                                            logy data

  IMXD   ---   FF   Upper-air Station   ---
                                            Identifier

  IMXYR   ---   FF   Year of mixing height ---
                                            data (2 digits)

4444444444444444444444444444444444444444444444444444444444444444444444
4

Record type
and variable   Column   Format   Variable description
  Units
4444444444444444444444444444444444444444444444444444444444444444444444
4

RAM-RECORD TYPE 14 - 3 variables - 7 values. This record is used with
Option 18 (input of polar coordinates) if the user chooses to input
receptor positions according to a radial distance from a coordinate
source.

Record type 14

  RADIL(I)   ---   FF   One to five radial dis- ---
                                             tances (user units)

RADIL(I) is one to five radial distances (with the remaining distances
entered as zeros) centered on any location. Each radial distance
generates 36 receptors at each radial distance at azimuths of 10 to 360
degrees.

  CENTX   ---   FF   East coordinate about   ---
                                             which radials are
                                             centered (user units)

  CENTY   ---   FF   North coordinate about   ---
                                             which radials are cen-
                                             tered (user units)

RAM-RECORD TYPE 15 - 3 variables. If Option 14 (user specifies receptor
coordinates) is used, there will be one record for each receptor that the
user specifies.

 Record type 15

  RNAME(I)   1-8   2A4   8-digit alphanumeric   ---
                                             station identification

  RREC   9-18   F10.3   East coordinate of   ---
                                             receptor (user units)

  SREC   19-28   F10.3   North coordinate of
                                             receptor (user units) ---

57

Both coordinates of receptors should be positive. Receptors may be either inside or outside the area source region. A record with "ENDR" in columns 1 - 4 signals that the receptor list has been completed.

4444444444444444444444444444444U4444444444444444444444444444444444444444
4
Record type
and variable   Column   Format   Variable description
  Units
4444444444444444444444444444444U4444444444444444444444444444444444444444
4

RAM-RECORD TYPE 16 - 5 variables - 5 values. This record is needed only
if Option 17 is used to generate additional receptors for area coverage.

Record type 16

    GRDSPU   ---   FF   Grid spacing between   ---
                                                honeycomb receptors
                                                (user units)

    HRMIN   ---   FF   Minimum east coordinate ---
                                                (user units)

    HRMAX   ---   FF   Maximum east coordinate ---
                                                (user units)

    HSMIN   ---   FF   Minimum north coordinate

                                                (user units)

    HSMAX   ---   FF   Maximum north coordinate

                                                (user units)

If HRMIN, HRMAX, HSMIN, HSMAX are entered as zero, the boundaries
considered for these receptors will be the same as those of the area
source region. However, if no area sources are input and if honeycomb
receptors are to be generated, this record must have boundaries included
to provide the bounds for receptor generation.

RAM-RECORD TYPE 17 - 2 variables. This record is needed only if Option
39 is used (i.e., this run is part of a segmented run).

Record type 17

    IDAY   ---   FF   Number of days previously
    ---
                                                processed

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LDRUN   ---   FF   Last day to be processed ---

                                         in this run

44444444444444444444444444444444U444444444444444444444444444444444444
4

Record type
and variable   Column   Format   Variable description   Units
44444444444444444444444444444444U444444444444444444444444444444444444
4

RAM-RECORD TYPE 18 - 8 variables - 8 values. Meteorology.
Used if Option 8 = 0.

Record type 18

Variable	Column	Format	Variable description	Units
JYR	---	FF	Year of meteorology data (2 digits)	---
DAY1	---	FF	Julian day of meteorology data	---
JHR	---	FF	Hour of meteorology data	---
IKST	---	FF	Stability class for this hour	---
QU	---	FF	Wind speed for this hour	m/sec
QTEMP	---	FF	Ambient air temperature for this hour	K
QTHETA	---	FF	Wind direction for this hour (degrees azimuth from which winds blows)	deg
QHL	---	FF	Mixing height for this hour	m

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Emissions Data

In the emissions file either point sources, area sources, or both may be included. When both types are included, the user still has the option to select one or both source types. Any rectangular coordinate system is allowed provided that the positive quadrant is used, that is, all coordinate values are positive and a single coordinate system is used for both point and area sources. The scale of the coordinate system is arbitrary. An option is also available in which the user can specify radial coordinates of receptors by specifying up to five radial distances.

To account for variability in emission rates with time in order to simulate emissions most accurately, it is possible to enter new emission rates for each of the sources for each simulated hour using Option 9 and/or Option 10. In order to employ this option, emissions for each source must have been determined and written on two tape or disk files (one for point sources and one for area sources) with one record for each hour that is to be simulated. The emission information from RAM is still required and must be a "normal" emission rate in order that the exit velocity of the source can be scaled up or down in proportion to the hourly emission rate. Also, all permanent information about sources such as coordinates, physical stack height, and diameter are furnished on record type 8.

Meteorological Data and RAMMET

As noted previously, meteorological data for RAM can be furnished in either of two ways: 1) records containing the meteorological data for each simulated hour (one record per hour), or 2) magnetic disk or tape output from program RAMMET.

Meteorological data output from RAMMET may be used as input to RAM. RAMMET requires one year of hourly surface observations and one year plus two days of daily maximum and minimum mixing height data. The hourly surface data normally on magnetic tape in card image format, CARD DECK 144, can be obtained from the National Climatic Center in Asheville, NC.

All required surface data for each hour must be included on the tape; therefore, all data flagged as missing by RAMMET must be accounted for, determined, and included in the data set before proceeding. The data used from the surface observation tape for each hour are: year, month, day, hour, cloud ceiling code, wind direction, wind speed, temperature, and opaque cloud cover.

The mixing height data is expected in card image format for RAMMET, one card per day containing the minimum and maximum mixing height for that day.

When using meteorological data from RAMMET, there are greater restrictions on certain input parameters than there are when meteorological data from cards are used. Using RAMMET data, one averaging time must be used, and it must be evenly divisible into 24. The start hour must be 1. Periods must be sequential in the time series. The starting day may be any day included in the file. The file will be positioned to the correct start day.

One averaging time must be used when using meteorological data with the run stream, but it can be any integer value from 1 to 24. The start hour can be any hour from 1 to 24. Day and hour values must be entered correctly and must be in sequence within each period. Data from period to period needs to be in sequence; for example, calculations for two 2-hour periods can be done first: day 181, hour 24, followed by day 182, hour 1.

SECTION 10

EXECUTION OF THE MODEL AND SAMPLE TEST

RAM produces an error-free compile on IBM MVS and DEC VAX/VMS computers with comparable output results.

Job Control Language (JCL) for model execution on an IBM system under MVS would be as follows:

```
//JOBID
//JOB (PROJ,ACCT,OTHER),TIME=1
//RAMP      EXEC PGM=RAM,TIME=(,20)
//STEBLIB   DD DSN=USERID.MODELS.LOAD,DISP=SHR
//FT06F001 DD SYSOUT=A
//FT05F001 DD * (Input records)
```

Sample Test

The example given in Chapter 10 of the original User's Guide (available from NTIS) uses one year of meteorological data processed by RAMMET, and uses the default option for regulatory application in the urban mode. When the default option is exercised, the following features apply:

-               urban dispersion parameters are used,

-               final plume rise is used,

-               buoyancy-induced dispersion is accounted for,

-               urban-profile exponents of .15, .15, .20, .25, .30, and .30 are used,

-               stack-tip downwash is calculated,

-               calms are processed according to regulatory guidance,

-               options 7, 8, 11, 12, 15, 16, and 39 through 43 are set to zero, and

-               output options 23 through 35 are set to 1.

SECTION 11

ERROR MESSAGES AND REMEDIAL ACTION

RAM can generate up to 22 error messages, some of which cause program termination. Table 3 lists each message along with error description and suggested corrective action.

TABLE 3. ERROR MESSAGES AND CORRECTIVE ACTION

444444444444444444444444444444444444444444444444444444444444444444444444444
4

MESSAGE: NSIGP (THE NUMBER OF SIGNIFICANT POINT SOURCES) WAS FOUND
                TO EXCEED THE LIMIT (25). USER TRIED TO INPUT x SOURCES.
                ******** EXECUTION TERMINATED ********

DESCRIPTION: The maximum number of significant point sources allowed by
                the program is 25.

ACTION: Modify the value input in record type 9 to be 25

_____

MESSAGE: NSIGA (THE NUMBER OF SIGNIFICANT AREA SOURCES) WAS FOUND
                TO EXCEED THE LIMIT (10). USER TRIED TO INPUT x SOURCES.

                ******** EXECUTION TERMINATED *******

DESCRIPTION: The maximum number of significant area sources allowed by
                the program is 10.

A   C   T   I   O   N   :
        Modify the input value to be 10.

_____

MESSAGE: USER TRIED TO INPUT MORE THAN x POINT SOURCES. THIS GOES
                BEYOND THE CURRENT PROGRAM DIMENSIONS.

DESCRIPTION: The maximum number of point sources is 250.

ACTION: Reduce the number of point sources to comply with the
                maximum of 250.

_____

MESSAGE: USER TRIED TO INPUT MORE THAN x AREA SOURCES. THIS GOES
                BEYOND THE CURRENT PROGRAM DIMENSIONS.

DESCRIPTION: The maximum number of area sources is 100.

ACTION: Reduce the number of area sources to comply with the
                maximum of 100.

_____

MESSAGE: DIMENSIONS TOO SMALL TO HOLD ARRAY x BY y.

DESCRIPTION: The internal dimensions of the area source array are
                (25,25) for internal units.

ACTION: Recompile with dimensions larger than (25,25).

_____

MESSAGE: AREA SOURCES, UNITS OR SIDE LENGTHS SPECIFIED INCORRECTLY
                ERROR ON EAST MAXIMUM BOUNDARY.

DESCRIPTION: The area source east boundary extends beyond the east
                boundary of the modeling region.

ACTION: Reduce the area source size, increase the size of the
                modeling region, or recompile the program with larger
                dimensions.

_____

MESSAGE: AREA SOURCES, UNITS OR SIDE LENGTHS SPECIFIED INCORRECTLY
                ERROR ON NORTH MAXIMUM BOUNDARY.

DESCRIPTION: The area source north boundary extends beyond the north
                boundary of the modeling region.

ACTION: Reduce the area source size, increase the size of the
                modeling region, or recompile the program with larger
                dimensions.

_____

MESSAGE: SOURCE, x, IS ALREADY LOCATED AT POSITION (,x,). CHECK
                SOURCE x.

DESCRIPTION: Two sources are collocated.

ACTION: Verify the input stream and separate or combine the

66

collocated sources.

MESSAGE: AREA ARRAY IS TOO WIDE FOR PAGE SIZE, THEREFORE WILL NOT
                 BE PRINTED.

DESCRIPTION: The area source array cannot be printed due to its size.

ACTION: If a printout is needed, reduce the size of the area
                 source region.

MESSAGE: ***ERROR---USER TRIED TO SPECIFY, x, SIGNIFICANT SOURCES
                 BUT IS ONLY ALLOWING, y, TOTAL SIGNIFICANT SOURCES IN THIS
                 RUN. RUN TERMINATED-CHECK INPUT DATA.

DESCRIPTION: The number of significant sources exceeds the total
                 significant sources specified.

ACTION: Verify consistency of significant sources in the input
                 stream.

MESSAGE: (MPS) THE INPUT SIGNIFICANT SOURCE NUMBER WAS FOUND TO
                 EQUAL ZERO - USER CHECK INPUT DATA.

DESCRIPTION: The number of significant sources exceeds the total
                 significant sources specified.

ACTION: Verify consistency of significant sources in the input
                 stream.

MESSAGE: THE INPUT LIMIT OF MAXIMUM DISTANCE FOR AREA INTEGRATION,
                 x, CONVERTS TO y KM WHICH EXCEEDS STORAGE LIMITATIONS. UP
                 TO 116 KM DISTANCES ARE ALLOWED.

DESCRIPTION: The maximum distance for area source integration was
                 exceeded.

ACTION: Modify the limit such that the distance does not exceed
                 116 km.

MESSAGE: ERROR IN SPECIFYING SIGNIFICANT POINT SOURCES.

DESCRIPTION: The significant point sources were not input properly.

ACTION: Verify the input stream and correct as needed.

_____

MESSAGE: DISAGREEMENT OF IDENTIFIERS- SURFACE DATA FROM CARD: STATION = x, YEAR = x. FROM MET FILE: STATION = y, YEAR = y. MIXING HEIGHT DATA FROM CARD: STATION = x, YEAR = x. FROM MET FILE: STATION = y, YEAR = y.

DESCRIPTION: Header information in the meteorological file is not in agreement with that specified in the input stream.

ACTION: Modify the input stream or replace the meteorological data set to effect a match.

_____

MESSAGE: ****USER EITHER TRIED TO INPUT MORE THAN 180 RECEPTORS OR ENDR WAS NOT PLACED AFTER THE LAST RECEPTOR CARD.

        ********EXECUTION TERMINATED*******

DESCRIPTION: The maximum number of user-specified receptors is 180, and a record with ENDR in columns 1-4 is required to signify the end of receptor input.

ACTION: Modify the input as needed.

_____

MESSAGE: NO RECEPTORS HAVE BEEN CHOSEN.

DESCRIPTION: Either user-input or program-generated receptors are required. Neither type was specified.

ACTION: Correct the input stream to specify receptors.

_____

MESSAGE: DAYS DO NOT MATCH, IDAY = x, IDAYS = Y.

DESCRIPTION: If the run is part of a segmented run, the starting day must match the day in the prior run.

ACTION: Modify the input stream to effect a match.

_____

MESSAGE: RUN TERMINATED. CAN NOT WRITE FILES (OPTIONS 41 OR 42)
                WHEN HAVING RAM GENERATE RECEPTORS FOR EACH AVERAGING
                PERIOD, (OPTIONS 15,16,17).

DESCRIPTION: Options 41 or 42 are not compatible with options 15, 16,
                17.

ACTION: Modify the input stream to ensure compatibility.

_____

MESSAGE: DATE ON MET TAPE, x, DOES NOT MATCH INTERNAL DATE, y.

DESCRIPTION: The Julian date calculated by RAM does not match the date
                in the input meteorological tape.

ACTION: Verify the proper data sequence in the input meteorology.

_____

MESSAGE: HOUR, x, IS NOT PERMITTED. HOURS MUST BE DEFINED BETWEEN
                1 AND 24.

DESCRIPTION: The hour specified is other than 1-24.

ACTION: Modify the input to conform to the hour stipulation
                required by RAM.

_____

MESSAGE: DATE BEING PROCESSED IS = x.   DATE OF HOURLY POINT
                EMISSION RECORD IS y. ***PLEASE CHECK EMISSION RECORDS.

DESCRIPTION: In the point emission record in process, the date does not
                match the internal date calculated by RAM.

ACTION: Verify data sequence in the hourly area source emission
                file.
4444444444444444444444444444444444444444444444444444444444444444444444444
4

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