

ADDENDUM

**USER'S GUIDE FOR THE
AMS/EPA REGULATORY MODEL - AERMOD
(EPA-454/B-03-001, September 2004)**

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1.0 INTRODUCTION

1.1 OVERVIEW OF AERMOD REVISIONS

This document provides user instructions for revisions to the AERMOD dispersion model. The discussion provided here supplements the information contained in the current AERMOD User's Guide (EPA, 2004a), and it is assumed that the reader is already familiar with the contents of that document.

Three sets of AERMOD revisions are included in this Addendum:

1. The first set of revisions, first introduced with version 03273 of AERMOD, includes dry and wet deposition algorithms for both particulate and gaseous emissions, and the OPENPIT source option, originally incorporated in the ISCST3 model (EPA, 1995a), for modeling particulate emissions from open pit (below grade) sources, such as surface coal mines and rock quarries;
2. The second set of revisions, first introduced with version 04300 of AERMOD, includes two non-default options for modeling conversion of NO_x to NO_2 : 1) the Plume Volume Molar Ratio Method (PVMRM) (Hanrahan, 1999a and 1999b); and 2) the Ozone Limiting Method (OLM); and
3. The third set of revisions, first introduced with version 06341 of AERMOD, includes the following:
 - a. A new "BETA" option on the CO MODELOPT card to allow for new features to be added to AERMOD that are still in BETA-test status;
 - b. A BETA option for incorporating NO/ NO_2 chemistry for NO_2 increment consumption calculations with PSD credits using the PVMRM option;
 - c. BETA options for capped and horizontal stack releases;
 - d. An option to specify an initial default in-stack NO_2/NO_x ratio for the PVMRM and OLM options;
 - e. New options for varying emissions by month, hour-of-day, and day-of-week (MHRDOW and MHRDOW7);
 - f. An option to allow multiple urban areas to be defined in a single model run;
 - g. Updated processing to support modeling demonstrations for the National Ambient Air Quality Standards (NAAQS) for PM, including the 24-hour average design value for primary PM-2.5 impacts; and

- h. Use of dynamic array allocation for AREAPOLY sources to allocate array limits for the maximum number of vertices at model runtime, replacing the previous fixed array limit of 20 vertices.

1.2 BACKGROUND ON DEPOSITION ALGORITHMS

The deposition algorithms are based on the draft Argonne National Laboratory (ANL) report (Wesely, et. al., 2002), with modifications based on peer review. Treatment of wet deposition is revised based on recommendations by peer review panel members (Walcek, et al., 2001). A full technical description of the deposition algorithms implemented in AERMOD is provided in an EPA report (EPA, 2003).

The deposition algorithms have been implemented in the AERMOD model under the non-default TOXICS option, which is selected by including the TOXICS keyword on the CO MODELOPT card (see Section 2.1.1). The other changes to the AERMOD model inputs associated with the deposition algorithms are limited to the CO (control) pathway and the SO (source) pathway. For gaseous deposition, the user must define the seasonal categories based on the ANL report for each of the calendar months, and must also define the land use category and three pollutant-specific physical parameters that are provided in the appendices of the ANL report. An optional keyword is also provided to override default values for three parameters used in the gas deposition algorithm. The input requirements for Method 1 particle deposition are the same as for the non-TOXICS particle deposition algorithm in the ISCST3 model and are described below. For Method 2 particle deposition, the user must define the fraction of the particle mass in the fine particle category (less than 2.5 microns) and a representative mass mean diameter for the particles, which are also provided for selected pollutants in Appendix B of the ANL report. The keywords used to define these inputs and the meteorological data format are described in Section 2.2.

2.0 USER INSTRUCTIONS

2.1 DISPERSION MODELING OPTIONS

2.1.1 MODELOPT Keyword

The dispersion options are controlled by the MODELOPT keyword on the CO pathway. The syntax, type, and order of the MODELOPT keyword are summarized below:

Syntax:	
CO <u>MODELOPT</u> <u>DFAULT</u> <u>BETA</u> <u>CONC</u> <u>AREADPLT</u> <u>FLAT</u> <u>NOSTD</u> <u>NOCHKD</u> <u>NOWARN</u> <u>SCREEN</u> <u>TOXICS</u> <u>SCIM</u> <u>PVMRM</u> <u>PSDCREDIT</u>	
	<u>DEPOS</u> <u>DDEP</u> and/or <u>WDEP</u>
Type:	Mandatory, Non-repeatable
Order:	Must precede <u>POLLUTID</u> , <u>HALFLIFE</u> and <u>DCAYCOEF</u>

where:

- BETA - Non-default option that allows for draft, “Beta” test options to be used; currently includes the PSDCREDIT option and options for capped and horizontal stack releases (see further explanation in Section 2.1.2);
- DEPOS - Specifies that total deposition flux values (both dry and wet) will be calculated (non-default TOXICS option must be specified);
- DDEP - Specifies that dry deposition flux values will be calculated (non-default TOXICS option must be specified);
- WDEP - Specifies that wet deposition flux values will be calculated (non-default TOXICS option must be specified);
- AREADPLT - Specifies that an optimized method for plume depletion due to dry removal mechanisms will be included in calculations for area sources (non-default TOXICS option must be specified);
- PVMRM - Specifies that the non-default Plume Volume Molar Ratio Method (PVMRM) for NO₂ conversion will be used;
- OLM - Specifies that the non-default Ozone Limiting Method (OLM) for NO₂ conversion will be used; and

PSDCREDIT - Specifies that the BETA test option will be used to calculate the increment consumption with PSD credits using the PVMRM option.

The other keywords on the MODELOPT card are described in the AERMOD user's guide (EPA, 2004a).

The user may select any or all of the output types (CONC, DEPOS, DDEP and/or WDEP) to be generated in a single model run. The order of these secondary keywords on the MODELOPT card has no effect on the order of results in the output files - the outputs will always be listed in the order of CONC, DEPOS, DDEP, and WDEP.

Beginning with version 04300, the dry and/or wet removal (depletion) mechanisms (the DRYDPLT and WETDPLT options in earlier versions of AERMOD) will automatically be included in the calculated concentrations or deposition flux values if the dry and/or wet deposition processes are considered. Note that dry and wet removal effects on calculated concentration values can be included even if deposition flux values are not being calculated. However, the additional data requirements for dry and wet deposition, described in Section 2.2, must be met in order for dry and wet removal to be included in the concentration calculations.

The PVMRM and OLM options for modeling NO₂ conversion are non-default options, and only one of these options can be specified for a given model run. Both options require that the pollutant ID be specified as 'NO2' on the CO POLLUTID card (see Section 3.2.5 of the AERMOD User's Guide).

2.1.2 BETA Test Options

A new 'BETA' test option has been added to the CO MODELOPT card to identify and allow for new features to be added to the model that are still in a draft BETA-test status. The BETA option is a non-DEFAULT option, and will be overridden if the DEFAULT option is specified. Two draft enhancements are included in version 06341 of AERMOD under the BETA option:

- 1) Options for capped stacks (source type = POINTCAP) and for horizontal releases (source type = POINTHOR); and
- 2) The PSDCREDIT option for PVMRM to account for NO/NO₂ chemistry of combined plumes in the computation of increment consumption with PSD credits.

Inclusion of these draft BETA-test options does not imply any endorsement of their use for regulatory or non-regulatory applications of the model. In addition, the designation of BETA-test to these draft enhancements does not imply that these options have completed rigorous internal (Alpha) testing prior to being included in a public release of the model.

2.1.3 Processing for Particulate Matter (PM) NAAQS

2.1.3.1 Processing for Fine Particulate Matter (PM-2.5)

A NAAQS for fine particulate matter, with aerodynamic particle diameters of 2.5 microns or less (PM-2.5), was promulgated in 1997, and the 24-hour standard was revised in December 2006. For attainment demonstrations, the PM-2.5 standard is based on a 3-year average of the 98th percentile 24-hour average and a 3-year average of the annual mean at each ambient monitor. For purposes of modeling demonstrations of compliance with the NAAQS, the eighth-highest value is an unbiased surrogate for the 98th percentile 24-hour average concentration at a particular receptor over a one-year period. Since the *Guideline on Air Quality Models* (40 CFR Part 51, Appendix W) prescribes the use of a 5-year data set for off-site National Weather Service (NWS) meteorological data or at least one year of site-specific data, a policy was established to utilize all available meteorological data (both single and multiple years of data) as an unbiased estimate of the 3-year averages for purposes of modeling demonstrations of compliance with the NAAQS.

Based on this policy, the 24-hour design value for purposes of modeling demonstrations of compliance with the PM-2.5 NAAQS is based on the highest of the eighth-highest (H8H) concentrations at each receptor, if one year of site-specific meteorological data is input to the model, or the highest of the multi-year average of the eighth-highest concentrations at each

receptor, if more than one year of meteorological data is input to the model. In other words, the model calculates the eighth-highest concentration at each receptor for each year modeled, averages those eighth-highest concentrations across the number of years of data, and then selects the highest, across all receptors, of the N-year averaged eighth-highest values.

Similar to the 24-hour averages, an unbiased estimate of the 3-year average annual mean is simply the annual mean, if only one year of site-specific meteorological data is input to the model, or the multi-year average of the annual means if multiple years of meteorological data are used. The annual design value for PM-2.5 is then based on the highest annual average across the receptor domain for single-year meteorological data input, or the highest of the multi-year averaged annual means across the receptor domain for multi-year meteorological data input.

The special processing of the 24-hour and annual averages for the PM-2.5 NAAQS is triggered by specifying a pollutant ID of 'PM25' or 'PM-2.5' on the CO POLLUTID card. In this case, the model will compute the 24-hour and annual average design values as described in the previous paragraphs. In order for the PM-2.5 processing to work correctly for multiple year periods, the yearly meteorological data files must be concatenated into single multi-year files for input into the model. There is no requirement to remove the header records between concatenated surface meteorological data files prior to running the model. Processing the average of the individual annual mean values across multiple years for PM-2.5 also requires use of the ANNUAL average option on the AVERTIME keyword, rather than PERIOD average. The PERIOD option computes a single multi-year average concentration for each receptor, which may give slightly different results than the multi-year average of individual ANNUAL mean concentrations due to differences in the number of calms and/or missing data from year to year.

In order to comply with these processing requirements, the following restrictions which are applied to the PM-2.5 NAAQS processing whenever a pollutant ID of 'PM25' or 'PM-2.5' is specified:

1. The averaging periods on the AVERTIME keyword are limited to the 24-hour and ANNUAL averages. Use of the PERIOD average or use of a short-term average other than 24-hour will result in a fatal error message being generated.

2. Only the EIGHTH (or 8TH) highest value may be requested on the RECTABLE keyword for 24-hour averages. Specifying another high value on the RECTABLE card will result in a fatal error message being generated.
3. The model will only process meteorological data for periods of record that span complete years, although the meteorological data period does not need to follow calendar years (i.e., the data period does not need to start on January 1, hour 1). If the period of record spans less than one complete year of data, a fatal error message will be generated and the model run will be unsuccessful. If additional meteorological data remains after the end of the last complete year of data, the remaining data will be ignored, and a non-fatal warning message will be generated specifying the number of hours ignored.
4. The MULTYEAR card on the CO pathway cannot be used to calculate multi-year averages for the PM-2.5 NAAQS. Multiple year analyses must be accomplished by including the multiple years of meteorology in a single data file.
5. Since the 24-hour average design values for PM-2.5 analyses may consist of averages over a multi-year period, they are incompatible with the EVENT processor. If the MAXIFILE option is used to output 24-hour average threshold violations, these may be used with the EVENT processor. Therefore, if the EVENTFIL option is used without the MAXIFILE option for PM-2.5 analyses, a non-fatal warning message will be generated, and the EVENTFIL option will be ignored.

2.1.3.2 Processing for Particulate Matter of 10 Microns or Less (PM-10)

The 24-hour NAAQS for particulate matter with aerodynamic particle diameters of 10 microns or less (PM-10) is in the form of an expected exceedance value, which cannot be exceeded more than once per year on average over a three year period for purposes of attainment demonstrations. Modeling demonstrations of compliance with the PM-10 NAAQS are based on the High-N+1-High value over N years, or in the case of five years of NWS meteorological data, the High-6th-High (H6H) over five years. In the AERMOD model, the H6H 24-hour average over five years can be modeled in one of two ways: 1) running five individual years and combining the results using the CO MULTYEAR option, as described in Section 3.2.12 of the AERMOD User's Guide; or 2) using a single five-year meteorological data file and specifying the SIXTH (or 6TH) highest value on the OU RECTABLE card. If applied properly, the results of these two approaches will be equivalent. The special processing consisting of the 99th percentile 24-hour value averaged over N years for PM-10 in previous

versions of AERMOD, referred to as the “Post-1997” PM-10 option, has been removed since that standard was vacated.

2.1.4 Specifying Multiple Urban Areas

The AERMOD model (dated 06341) includes the option to specify multiple urban areas within the same model run. This option may be applicable for large domains that encompass more than one identifiable urban area where the separation is large enough to warrant separate treatment of the urban boundary layer effects. Use of the option for multiple urban areas eliminates the need for post-processing for such applications. The multiple urban areas are defined using multiple CO URBANOPT cards. The syntax of the modified URBANOPT keyword is as follows:

Syntax:	<u>For Multiple Urban Areas:</u> CO URBANOPT UrbanID UrbPop (UrbName) (UrbRoughness)
	<u>For Single Urban Areas:</u> CO URBANOPT UrbPop (UrbName) (UrbRoughness)
Type:	Optional, Repeatable for multiple urban areas

where the UrbanID parameter is the alphanumeric urban ID defined by the user (up to eight characters) when multiple urban areas are defined, the UrbPop parameter specifies the population of the urban area, the optional UrbName parameter may be used to identify the name of the urban area, and the optional UrbRoughness parameter may be used to specify the urban surface roughness length. Note the UrbName must be specified if the user wants to specify the urban roughness length. A default value of 1.0 meter will be used for the urban roughness length if the UrbRoughness parameter is omitted. Caution should be used when specifying a non-default urban roughness length, and use of a non-default value should be clearly documented and justified. Note that the syntax of the URBANOPT keyword for single urban areas has not changed from the previous version of AERMOD, so that existing input files will not require modification.

The syntax of the URBANSRC keyword on the SO pathway has also been modified to allow for the option of specifying multiple urban areas. The syntax of the modified URBANSRC keyword is as follows:

Syntax:	<u>For Multiple Urban Areas:</u> SO URBANSRC UrbanID SrcID's and/or SrcRng's <u>For Single Urban Areas:</u> SO URBANSRC SrcID's and/or SrcRng's
Type:	Optional, Repeatable
Order:	Must follow the LOCATION card for each source input

where the UrbanID parameter is the alphanumeric urban ID (up to eight characters) defined by the user on the CO URBANOPT keyword when multiple urban areas are defined, and the SrcID's and SrcRng's are the individual source IDs and/or source ranges that are to be modeled with urban effects. Source ranges are described in more detail in the description in Section 3.3.3 of the AERMOD User's Guide (EPA, 2004a). As with the URBANOPT keyword, the syntax of the URBANSRC keyword for applications with single urban areas has not changed from the previous version of AERMOD, so that existing input files will not require modification.

2.1.5 BETA Options for Capped and Horizontal Stack Releases

Draft BETA test options are included in AERMOD (dated 06341) for modeling releases from capped and horizontal stacks. For sources that are not subject to building downwash influences, the plume rise for these capped and horizontal stacks is simulated based on an EPA Model Clearinghouse Memorandum, dated July 9, 1993, included in Appendix A of this Addendum. The Model Clearinghouse procedure for these sources entails setting the exit velocity very low (0.001 m/s) to account for suppression of vertical momentum for the plume, and using an effective stack diameter that maintains the actual flow rate of the plume. Maintaining the flow rate will also serve to maintain the buoyancy of the plume in order to provide a more realistic estimate of plume rise. The Model Clearinghouse procedure also addresses the issue of stack-tip downwash for these cases.

The Model Clearinghouse procedure is not considered appropriate for sources subject to building downwash influences with the PRIME downwash algorithm for the following reason. The PRIME algorithm uses the stack diameter to define the initial radius of the plume for the numerical plume rise calculation; use of an effective diameter adjusted to maintain flow rate is not appropriate and could produce unrealistic results. For PRIME downwash sources modeled using the BETA options for capped and horizontal releases, the basic premise of the Model Clearinghouse procedure, i.e. that the vertical momentum is suppressed while the buoyancy of the plume is conserved, have been adapted for the PRIME numerical plume rise formulation.

The user selects the BETA options for capped and/or horizontal releases by specifying one of the new source types on the SO LOCATION card: POINTCAP for capped stacks, and POINTHOR for horizontal releases. For each of these options, the user specifies the actual stack parameters [release height (m), exit temperature (K), exit velocity (m/s), and stack diameter (m)] using the SO SRCPARAM card as if the release were a non-capped vertical point source. The syntax of the SO LOCATION and SRCPARAM keywords is described in Sections 3.3.1 and 3.3.2, respectively, of the AERMOD User's Guide (EPA, 2004a). The AERMOD model performs the necessary adjustments internally to account for plume rise and stack-tip downwash. For horizontal releases, the model currently assumes that the release is oriented with the wind direction. For PRIME-downwashed sources, the user-specified exit velocity for horizontal releases is treated initially as horizontal momentum in the downwind direction.

More details regarding the BETA options for capped and horizontal releases will be provided later, as warranted based on further testing and evaluation.

2.2 DEPOSITION ALGORITHM INPUTS AND OPTIONS

2.2.1 Definition of Seasons for Gas Dry Deposition

The new deposition algorithms include land use characteristics and some gas deposition resistance terms based on five seasonal categories, defined in Table 2 of the ANL report as:

- Seasonal Category 1: Midsummer with lush vegetation
- Seasonal Category 2: Autumn with unharvested cropland
- Seasonal Category 3: Late autumn after frost and harvest, or winter with no snow
- Seasonal Category 4: Winter with snow on ground
- Seasonal Category 5: Transitional spring with partial green coverage or short annuals

The user correlates these seasonal definitions to calendar months through the GDSEASON keyword on the CO pathway. The syntax and type of the GDSEASON keyword are:

Syntax:	CO GDSEASON Jan Feb Mar ... Dec
Type:	Optional, Non-repeatable

where a numeric value from 1 to 5 is entered for each of the twelve calendar months to associate it with the seasonal definitions given above. This keyword is optional for the model, but mandatory when applying the new gas deposition algorithms. Some of the seasonal categories defined above may not apply for certain regions, such as Category 4 for southern latitudes.

2.2.2 Definition of Land Use Categories for Gas Dry Deposition

The new deposition algorithms include some gas deposition resistance terms based on five seasonal categories, defined above, and on nine land use categories as follows (from Table 1 of the ANL report):

<u>Land Use Category</u>	<u>Description</u>
1	Urban land, no vegetation
2	Agricultural land
3	Rangeland
4	Forest
5	Suburban areas, grassy
6	Suburban areas, forested
7	Bodies of water
8	Barren land, mostly desert
9	Non-forested wetlands

The user defines the land use categories by wind direction through the GDLANUSE keyword on the CO pathway. The syntax and type of the GDLANUSE keyword are:

Syntax:	CO GDLANUSE Sec1 Sec2 Sec3 ... Sec36
Type:	Optional, Non-repeatable

where a numeric value from 1 to 9 is entered for each of the 36 wind direction sectors (every 10 degrees) to associate it with the land use definitions given above. This keyword is optional for the model, but mandatory when applying the new gas deposition algorithms. The first value, Sec1, corresponds with the land use category for winds blowing toward 10 degrees, plus or minus 5 degrees. The downwind sectors are defined in clockwise order, with Sec36 corresponding to winds blowing toward 360 degrees (North). The user can specify "repeat values" by entering a field such as "36*3" as a parameter for the GDLANUSE keyword. The model will interpret this as "36 separate entries, each with a value of 3." Since the model must identify this as a single parameter field, there must not be any spaces between the repeat-value and the value to be repeated.

2.2.3 Option for Overriding Default Parameters for Gas Dry Deposition

An optional keyword is available on the Control (CO) pathway to allow the user to override the default values of the reactivity factor (f_o), and the fraction (F) of maximum green leaf area index (LAI) for seasonal categories 2 and 5, for use with the gas dry deposition algorithms.

The syntax and type of the GASDEPDF keyword are summarized below:

Syntax:	CO GASDEPDF React F_Seas2 F_Seas5 (Refpoll)
Type:	Optional, Non-repeatable

where the parameter React is the value for pollutant reactivity factor (f_o), and F_Seas2 and F_Seas5 are the fractions (F) of maximum green LAI for seasonal categories 2 and 5, respectively. The parameter Refpoll is the optional name of the pollutant. If the optional

GASDEPDF keyword is omitted, then the default value of 0 is used for React, and default values of 0.5 and 0.25 are used for F_Seas2 and F_Seas5, respectively. A value of F=1.0 is used for seasonal categories 1, 3, and 4. A reactivity factor value of 1 should be input for ozone (O₃), titanium tetrachloride (TiCl₄), and divalent mercury (Hg²⁺), and a value of 0.1 should be input for nitrogen dioxide (NO₂).

2.2.4 Specifying Source Parameters for Gas Deposition

The input of source parameters for dry and wet deposition of gaseous pollutants is controlled by the GASDEPOS keyword on the SO pathway. The gas dry deposition variables may be input for a single source, or may be applied to a range of sources.

The syntax, type, and order for the GASDEPOS keyword are summarized below:

Syntax:	SO GASDEPOS Srcid (or Srcrng) Da Dw rcl Henry
Type:	Optional, Repeatable
Order:	Must follow the LOCATION card for each source input

where the Srcid or Srcrng identify the source or sources for which the inputs apply, the parameter Da is the diffusivity in air for the pollutant being modeled (cm²/s), Dw is the diffusivity in water for the pollutant being modeled (cm²/s), rcl is the cuticular resistance to uptake by lipids for individual leaves (s/cm), and Henry is the Henry's Law constant (Pa m³/mol). Values of the physical parameters for several common pollutants may be found in the appendices to the ANL report (Wesely, et. al, 2002).

2.2.5 Specifying Source Parameters for Particle Deposition

The AERMOD model includes two methods for handling dry deposition of particulate emissions. Method 1 is used when a significant fraction (greater than about 10 percent) of the total particulate mass has a diameter of 10 μm or larger. The particle size distribution must be known reasonably well in order to use Method 1. Method 2 is used when the particle size distribution is not well known and when a small fraction (less than 10 percent of the mass) is in

particles with a diameter of 10 μm or larger. The deposition velocity for Method 2 is calculated as the weighted average of the deposition velocity for particles in the fine mode (i.e., less than 2.5 μm in diameter) and the deposition velocity for the coarse mode (i.e., greater than 2.5 μm but less than 10 μm in diameter).

2.2.5.1 Specifying Particle Inputs for Method 1

The input of source variables for particle deposition using Method 1 is controlled by three keywords on the SO pathway, PARTDIAM, MASSFRAX, and PARTDENS. The particle variables may be input for a single source, or may be applied to a range of sources.

The syntax, type and order for these three keywords are summarized below:

Syntax:	SO PARTDIAM Srcid (or Srcrng) Pdiam(i),i=1,Npd SO MASSFRAX Srcid (or Srcrng) Phi(i),i=1,Npd SO PARTDENS Srcid (or Srcrng) Pdens(i),i=1,Npd
Type:	Optional, Repeatable
Order:	Must follow the LOCATION card for each source input

where the Srcid or Srcrng identify the source or sources for which the inputs apply, and where the Pdiam array consists of the particle diameter (microns) for each of the particle size categories (up to a maximum of 20 set by the NPDMAX PARAMETER in the computer code), the Phi array is the corresponding mass fractions (between 0 and 1) for each of the categories, and the Pdens array is the corresponding particle density (g/cm^3) for each of the categories.

The number of particle size categories for a particular source is Npd. The user does not explicitly tell the model the number of categories being input, but if continuation cards are used to specify particle size variables, all inputs of a keyword for a particular source or source range must be contiguous, and the number of categories must agree for each of the three keywords input for a particular source. As many continuation cards as needed may be used to define the inputs for a particular keyword. The model checks the inputs to ensure that the mass fractions sum to 1.0 (within 2 percent) for each source input, and issues a warning message if that range is

exceeded. The model also ensures that mass fractions for each particle size category are within the proper range (between 0 and 1), and issues fatal error messages for any value exceeded that range.

2.2.5.2 Specifying Particle Inputs for Method 2

The Method 2 particle information is input through the METHOD_2 keyword on the SO pathway. The syntax, type, and order for the METHOD_2 keyword are summarized below:

Syntax:	SO METHOD_2 Srcid (or Srcrng) FineMassFraction Dmm
Type:	Optional, Repeatable
Order:	Must follow the LOCATION card for each source input

where the Srcid or Srcrng identify the source or sources for which the inputs apply, the parameter FineMassFraction is the fraction of particle mass emitted in the fine mode, less than 2.5 microns, and Dmm is the representative mass mean particle diameter in microns. Estimated values of fine particle fractions and mass mean diameters for various pollutants are provided in Appendix B of the ANL report (Wesely, et al, 2002).

2.2.6 Specifying Emission and Output Units

Since the AERMOD model allows for both concentration and deposition to be output in the same model run, the EMISUNIT keyword cannot be used to specify emission unit factors if more than one output type is being generated. The AERMOD model therefore allows for concentration and deposition units to be specified separately through the CONCUNIT and DEPOUNIT keywords, respectively. The syntax and type of the CONCUNIT keyword are summarized below:

Syntax:	SO CONCUNIT Emifac Emilbl Conlbl
Type:	Optional, Non-repeatable

where the parameter Emifac is the factor to convert emission rate input units to the desired output units, Emilbl is the label for the emission input units (up to 40 characters), and Conlbl is the output unit label (up to 40 characters) for concentration calculations. The syntax and type of the DEPOUNIT keyword are summarized below:

Syntax:	SO DEPOUNIT Emifac Emilbl Deplbl
Type:	Optional, Non-repeatable

where the parameter Emifac is the factor to convert emission rate input units to the desired output units, Emilbl is the label for the emission input units (up to 40 characters), and Deplbl is the output unit label (up to 40 characters) for deposition calculations.

2.2.7 Deposition Velocity and Resistance Outputs

In order to facilitate review and testing of the deposition algorithms in the AERMOD model, the model includes an option to output the main resistance terms and deposition velocities for gaseous and particle sources. These optional outputs are generated if the user specifies the ‘CO DEBUGOPT MODEL’ option described in Section 3.2.12 of the current AERMOD User’s Guide (EPA, 2004a). The gas deposition data are written to a file called GDEP.DAT, which includes the values of R_a , R_b , R_c , and V_{dg} (see Wesely, et al, 2002, for definitions) for each source and for each hour modeled. A header record is included to identify the columns. The particle deposition data are written to a file called PDEP.DAT, which includes the values of R_a , R_p , V_g , and V_d for each source and for each hour modeled. The particle outputs are labeled as being based on either Method 1 or Method 2. For Method 1, results are output for each particle size category. The filename and file units for these data files are hardcoded in the model, and the files are overwritten each time the model is executed.

2.2.8 Meteorological Data for Deposition Algorithms

The AERMET meteorological processor was modified (beginning with the version dated 04300) to output additional meteorological parameters needed for the deposition algorithms in

AERMOD. The additional variables include the precipitation code, precipitation rate, relative humidity, surface pressure, and cloud cover. These additional variables are automatically included after the standard variables for each hour, and do not require any additional user input. The precipitation data needed for wet deposition calculations in AERMOD can be obtained from the SAMSON, HUSWO or ISHD (TD-3505) formats currently supported by AERMET (EPA, 2004b). The meteorological data file for the new deposition algorithms is read as a free format file, i.e., each field on a record is separated from adjacent fields by a comma or by one or more spaces.

The input meteorological data file consists of a header record that includes the latitude and longitude, surface station ID (e.g., WBAN number), upper air station ID, the on-site station ID, and the AERMET version date (see Section D.1 of the AERMOD model user's guide (EPA, 2004a)). Each subsequent record contains the following variables in the order listed:

<u>Variable Description</u>	<u>Format</u>
Year	Integer
Month	Integer
Day of Month	Integer
Julian Day (Day of Year)	Integer
Hour of Day	Integer
Heat Flux (W/m^2)	Real
Surface Friction Velocity, u_* (m/s)	Real
Convective Velocity Scale, w_* (m/s)	Real
Lapse Rate Above Mixing Height (K/m)	Real
Convective Mixing Height (m)	Real
Mechanical Mixing Height (m)	Real
Monin-Obukhov Length, L (m)	Real
Surface Roughness Length, z_0 (m)	Real
Bowen Ratio	Real
Albedo	Real
Reference Wind Speed (m/s)	Real
Reference Wind Direction (degrees)	Real
Reference Height for Wind (m)	Real
Ambient Temperature (K)	Real
Reference Height for Temperature (m)	Real
Precipitation Code (0-45)	Integer
Precipitation Amount (mm)	Real
Relative Humidity (%)	Real
Surface Pressure (mb)	Real
Cloud Cover (tenths)	Integer

2.3 OPEN PIT SOURCE OPTION

The open pit source option is invoked by specifying a source type of OPENPIT on the source location (SO LOCATION) card. The OPENPIT source algorithm can be used to model particulate emissions from open pits, such as surface coal mines and rock quarries. The OPENPIT algorithm uses an effective area for modeling pit emissions, based on meteorological conditions, and then utilizes the numerical integration area source algorithm to model the impact of emissions from the effective area sources. A complete technical description of the OPENPIT source algorithm is provided in the ISC3 Model User's Guide - Volume II (EPA, 1995b).

The AERMOD model accepts rectangular pits with an optional rotation angle specified relative to a north-south orientation. The rotation angle is specified relative to the vertex used to define the source location on the SO LOCATION card (e.g., the southwest corner). The syntax, type and order for the SRCPARAM card for OPENPIT sources are summarized below:

Syntax:	SO SRCPARAM Srcid Opemis Relhgt Xinit Yinit Pitvol (Angle)
Type:	Optional, Repeatable
Order:	Must follow the LOCATION card for each source input

where the Srcid parameter is the same source ID that was entered on the LOCATION card for a particular source, and the other parameters are as follows:

Opemis - open pit emission rate in g/(s-m²),

Relhgt - average release height above the base of the pit in meters,

Xinit - length of X side of the open pit (in the east-west direction if Angle is 0 degrees) in meters,

Yinit - length of Y side of the open pit (in the north-south direction if Angle is 0 degrees) in meters,

Pitvol - volume of open pit in cubic meters, and

Angle - orientation angle for the rectangular open pit in degrees from North, measured positive in the clockwise direction (optional).

The same emission rate is used for both concentration and deposition calculations in the AERMOD model. It should also be noted that the emission rate for the open pit source is an emission rate per unit area, which is different from the point and volume source emission rates, which are total emissions for the source. The Relhgt parameter cannot exceed the effective depth of the pit, which is calculated by the model based on the length, width and volume of the pit. A Relhgt of 0.0 indicates emissions that are released from the base of the pit.

If the optional Angle parameter is input, and the value does not equal 0.0, then the model will rotate the open pit clockwise around the vertex defined on the SO LOCATION card for this source. The relationship between the Xinit, Yinit, and Angle parameters and the source location, (Xs,Ys), for a rotated pit is the same as for rectangular area sources. The Xinit dimension is measured from the side of the area that is counterclockwise along the perimeter from the vertex defined by (Xs,Ys), while the Yinit dimension is measured from the side of the open pit that is clockwise along the perimeter from (Xs,Ys). Unlike the area source inputs, the Yinit parameter is not optional for open pit sources. The Angle parameter is measured as the orientation relative to North of the side that is clockwise from (Xs,Ys), i.e. the side with length Yinit. The Angle parameter may be positive (for clockwise rotation) or negative (for counterclockwise rotation), and a warning message is generated if the absolute value of Angle is greater than 180 degrees. The selection of the vertex to use for the source location is not critical, as long as the relationship described above for the Xinit, Yinit, and Angle parameters is maintained.

The aspect ratio (i.e., length/width) of open pit sources should be less than 10 to 1. However, since the pit algorithm generates an effective area for modeling emissions from the pit, and the size, shape and location of the effective area is a function of wind direction, an open pit cannot be subdivided into a series of smaller sources. Aspect ratios of greater than 10 to 1 will be flagged by a warning message in the output file, and processing will continue. Since open pit sources cannot be subdivided, the user should characterize irregularly-shaped pit areas by a rectangular shape of equal area. Receptors should not be located within the boundaries of the

pit; concentration and/or deposition at such receptors will be set to zero. Such receptors will be identified during model setup and will be flagged in the summary of inputs.

An example of a valid SRCPARAM input card for an open pit source is given below:

```
SO SRCPARAM NORTHFIT 1.15E-4 0.0 150.0 500.0 3.75E+6 30.0
```

where the source ID is NORTHFIT, the emission rate is 1.15E-4 g/(s-m²), the release height is 0.0 m, the X-dimension is 150.0 m, the Y-dimension is 500.0 m, the pit volume is 3.75E+6 cubic meters (corresponding to an effective pit depth of about 50 meters) and the orientation angle is 30.0 degrees clockwise from North.

Since the OPENPIT algorithm is applicable for particulate emissions, the particle categories for an open pit source must be defined using the PARTDIAM, MASSFRAX, and PARTDENS keywords on the SO pathway.

2.4 PVMRM AND OLM OPTIONS FOR MODELING NO₂

This section provides a description of the inputs related to the non-default PVMRM and OLM options for modeling the conversion of NO_x to NO₂. A technical description of the PVMRM and OLM algorithms is provided in an Addendum to the AERMOD Model Formulation Document (Cimorelli, *et al.*, 2004). Background on the original development of the PVMRM option is provided by Hanrahan (1999a and 1999b).

The PVMRM and OLM algorithms have been implemented as non-default options, which means that the PVMRM and OLM options will be overridden if the DFAULT keyword is included on the CO MODELOPT card. As described in Section 2.1.1, a BETA-test draft model option, PSDCREDIT, has been added for use when an application is for increment consumption with PSD credits using PVMRM. The special source grouping required for the PSDCREDIT option is described below in Section 2.4.6.1.

2.4.1 Specifying Ozone Concentrations for PVMRM and OLM Options

The background ozone concentrations can be input as a single value through the OZONEVAL keyword on the CO pathway, or may be input as hourly values through a separate data file specified through the OZONEFIL keyword on the CO pathway. The user must specify either the OZONEVAL or OZONEFIL keywords, or both, in order to use the PVMRM or OLM options. If both keywords are entered, then the value entered on the OZONEVAL keyword will be used to substitute for hours with missing ozone data in the ozone data file.

The syntax of the OZONEVAL keyword is as follows:

Syntax:	CO OZONEVAL O3Value (O3Units)
Type:	Optional, Non-repeatable

where the O3Value parameter is the background ozone concentration in the units specified by the optional O3Units parameter (PPM, PPB, or UG/M3). If the optional O3Units parameter is missing, then the model will assume units of micrograms/cubic-meter (UG/M3) for the background ozone values. If units of PPM or PPB are used, then the model will convert the concentrations to micrograms/cubic-meter based on the reference ambient temperature and the base elevation specified on the ME PROFBASE card. The OZONEVAL keyword word is optional and non-repeatable.

The syntax of the OZONEFIL keyword is as follows:

Syntax:	CO OZONEFIL O3FileName (O3Units) (Format)
Type:	Optional, Non-repeatable

where the O3FileName parameter is the filename for the hourly ozone concentration file, the optional O3Units parameter specifies the units of the ozone data (PPM, PPB, or UG/M3, with UG/M3 as the default), and the optional Format parameter specifies the Fortran FORMAT to read the ozone data. If the optional Format parameter is missing, then the model will read the ozone data using a Fortran free format, i.e., assuming that commas or spaces separate the data

fields. The contents of the ozone data file must include the year (2-digits), month, day, hour and ozone value in that order (unless specified differently through the Format parameter). The date sequence in the ozone data file must match the date sequence in the hourly meteorological data files. As with the OZONEVAL keyword, if units of PPM or PPB are used, then the model will convert the concentrations to micrograms/cubic-meter based on the reference ambient temperature and the base elevation specified on the ME PROFBASE card.

Values of ozone concentrations in the ozone data file that are less than zero or greater than or equal to 900.0 will be regarded as missing. If a background ozone value has been specified using the OZONEVAL keyword, then that value will be used to substitute for missing ozone data from the ozone file. If no OZONEVAL keyword is used, then the model will assume full conversion for hours with missing ozone data.

2.4.2 Specifying the Ambient Equilibrium NO₂/NO_x Ratio for PVMRM

The PVMRM option for modeling conversion of NO to NO₂ incorporates a default NO₂/NO_x ambient equilibrium ratio of 0.90. A NO₂/NO_x equilibrium ratio other than 0.90 can be specified through the optional NO2EQUIL keyword on the CO pathway. The syntax of the NO2EQUIL keyword is as follows:

Syntax:	CO NO2EQUIL NO2Equil
Type:	Optional, Non-repeatable

where the NO2Equil parameter is the NO₂/NO_x equilibrium ratio and must be between 0.10 and 1.0, inclusive.

2.4.3 Specifying the Default In-stack NO₂/NO_x Ratio for PVMRM and OLM

The PVMRM and OLM options for modeling conversion of NO to NO₂ require that an in-stack NO₂/NO_x ratio be specified. A default value of 0.10 for the in-stack NO₂/NO_x ratio will

be used for OLM for all sources unless a user-specified value is provided. However, the PVMRM option requires that the user specify the in-stack NO₂/NO_x ratio for each source.

The in-stack NO₂/NO_x ratio can be specified for the PVMRM or OLM options by using either the CO NO2STACK card to specify a default value to be used for all sources, or by using the SO NO2RATIO card to specify a value on a source-by-source basis. The SO NO2RATIO card can also be used to override the default value if the CO NO2STACK card has been specified. The syntax of the NO2STACK keyword is as follows:

Syntax:	CO NO2STACK NO2Ratio
Type:	Optional, Non-repeatable

where the NO2Ratio parameter is the default in-stack NO₂/NO_x ratio that will be used, unless overridden on a source-by-source basis by the SO NO2RATIO card (described below). The value of NO2Ratio must be between 0.0 and 1.0, inclusive. Users should note that while CO NO2STACK is an optional keyword, the PVMRM option requires the user to specify an in-stack NO₂/NO_x ratio for each source, using either the CO NO2STACK or SO NO2RATIO cards (described in Section 2.4.4), or both.

2.4.4 Specifying In-stack NO₂/NO_x Ratios by Source for PVMRM and OLM

The PVMRM and OLM options for modeling NO₂ conversion assume a default in-stack NO₂/NO_x ratio of 0.10 (or 10 percent). The user can specify in-stack NO₂/NO_x ratios through the optional NO2RATIO keyword on the SO pathway. The syntax of the NO2RATIO keyword is as follows:

Syntax:	SO NO2RATIO SrcID or SrcRange NO2Ratio
Type:	Optional, Repeatable
Order:	Must follow the LOCATION card for each source input

where the SrcID or SrcRange identify the source or sources for which the inputs apply, and where the NO2Ratio parameter specifies the in-stack ratio. In this way, the user can specify a single in-stack NO₂/NO_x ratio for a group of stacks. For example, the following input:

SO NO2RATIO STACK1-STACK10 0.15

will apply the in-stack ratio of 0.15 to sources with IDs falling within the range STACK1 to STACK10. Any value specified on the SO NO2RATIO card will override the default ratio, if any, specified on the CO NO2STACK card. Users should note that while SO NO2RATIO is an optional keyword, the PVMRM option requires the user to specify an in-stack NO₂/NO_x ratio for each source, using either the CO NO2STACK (described in Section 2.4.3) or SO NO2RATIO cards, or both.

2.4.5 Specifying Combined Plumes for OLM

The OLM option for modeling NO₂ conversion includes an option for specifying which sources are to be modeled as combined plumes. Sources which are not specified for modeling as combined plumes will be modeled as individual plumes. The selection of individual or combined plume option for OLM is specified through the OLMGROUP keyword on the SO pathway. The syntax of the OLMGROUP card is as follows:

Syntax:	SO OLMGROUP OLMGrpID SrcID's and/or SrcRange's
Type:	Optional, Repeatable
Order:	Must follow the LOCATION card for each source input

where OLMGrpID identifies a group to be treated as a combined plume with OLM, and the SrcID's and/or SrcRange's identify the sources to be included in the OLM group. As with the SO SRCGROUP card, individual source IDs and source ranges may be used on the same card, and if more than one input card is needed to define the sources for a particular OLM group, then additional cards may be input by repeating the pathway, keyword and OLM group ID. A user

can also specify an OLMGrpID of ALL, which means that OLM will be applied on a combined plume basis to all sources. However, unlike the SO SRCGROUP card, the results will not be output for an OLM group unless the same group of sources is also identified on a SRCGROUP card. Another constraint is that a source cannot be included in more than one OLM group. If a source is not selected for an OLMGROUP card, then OLM will be applied to that source as an individual plume. Other than the similarity in syntax, there is no connection in the model between the groups defined on the OLMGROUP card and groups defined on the SRCGROUP card. The OLMGROUP card relates to how the results are processed within the model for the OLM model, and the SRCGROUP card simply controls how source impacts are grouped in the model outputs.

If the user identifies one or more groups of sources to apply OLM on a combined plume basis using the OLMGROUP card, the model will still need to calculate the concentration for individual plumes within the OLM group in order for the model to sum the results for the sources listed on the SRCGROUP card(s). The individual source concentrations are calculated by applying the ratio of the combined concentration for the OLM group with and without OLM to each source within the OLM group.

2.4.6 Modeling NO₂ Increment Credits with PVMRM

Due to the ozone-limiting effects of the PVMRM option, the predicted concentrations of NO₂ are not linearly proportional to the emission rate. Therefore, the approach of modeling NO₂ increment consumption with PSD credits through the use of a negative emission rate for credit sources cannot be used with the PVMRM option. However, the draft PSDCREDIT option allows modeling PSD increment credits for NO₂ when the PVMRM option is specified. The PSDCREDIT option is currently implemented as a BETA-test option, and requires that the PVMRM and BETA options be specified. The PSDCREDIT option utilizes a new PSDGROUP keyword, described below, to identify which sources consume or expand increment. This option is not valid if the OLM option is specified, and no comparable option is available for modeling increment credits with the OLM option. The user should check with the appropriate reviewing authority for further guidance on modeling increment credits for NO₂.

A general discussion of concepts related to modeling increment consumption is provided below, followed by a description of inputs required to use the BETA-test PSDCREDIT option for PVMRM.

2.4.6.1 Increment Consuming and Baseline Sources

Increment is the maximum allowable increase in concentration of a pollutant above a baseline concentration for an area defined under the Prevention of Significant Deterioration (PSD) regulations. The PSD baseline area can be an entire State or a subregion of a State such as a county or group of counties. Increment standards exist for three pollutants: SO₂ (3-hr, 24-hr, and annual averages), NO₂ (annual average), and PM-10 (24-hr and annual average). Increment consumption is the additional air quality impact above a baseline concentration.

The baseline concentration is the ambient concentration of the pollutant that existed in the area at the time of the submittal of the first complete permit application by any source in that area subject to PSD regulations. A baseline source is any source that existed prior to that first application and the baseline date is the date of the PSD application. This baseline date is referred to as the minor source baseline date in PSD regulations. By definition, baseline sources do not consume increment. However, any baseline source that retires from service after the baseline date expands the increment available to new sources. Therefore, a PSD modeling analysis performed for a new source may need to account for this increment expansion. Such an analysis may therefore involve identification of three groups of sources: 1) increment-consuming sources; 2) retired (increment-expanding) baseline sources; and 3) existing, non-retired, baseline sources.

2.4.6.2 Calculating Increment Consumption under the PSDCREDIT Option

Calculating increment consumption under the PSDCREDIT option in AERMOD is not a simple arithmetic exercise involving the three groups of sources defined above. Since the amount of ozone available in the atmosphere limits the conversion of NO to NO₂, interactions of plumes from the existing and retired baseline sources with those from the increment consuming

sources must be considered as part of the calculation of net increment consumption. Without the PSDCREDIT option, properly accounting for the potential interaction of plumes among the different source categories would require post-processing of results from multiple model runs. Internal “post”-processing algorithms have been incorporated in AERMOD under the PSDCREDIT option to account for the apportioning of the three groups of sources to properly calculate increment consumption from a single model run.

Define the following three source groupings for the discussion that follows:

A = increment-consuming sources;

B = non-retired baseline sources; and

C = retired baseline, increment-expanding sources.

The calculation of the amount of increment consumption by the **A** sources cannot simply be estimated by modeling the **A** sources alone because of the possible interaction of those plumes with the plumes from **B** sources. The PVMRM algorithm is designed to account for such plume interactions and calculate the total NO to NO₂ conversion in the combined plumes based on the amount of ozone available. Therefore, the total increment consumption by the **A** sources is given by the difference between (1) the total future impact of increment consuming sources and non-retired baseline sources (**A+B**) and (2) the total current impact (**B**), which can be expressed as **(A+B) – (B)**. Here **(A+B)** represents the value that would be compared against the National Ambient Air Quality Standard (NAAQS) for NO₂ during PSD review of the **A** sources.

In a case where some of the baseline sources have been retired from service (**C** sources), the PSD regulations allow the consideration of increment expansion when assessing compliance with the PSD increment. However, the amount of increment expansion cannot be estimated by simply modeling the **C** sources alone because of the possible interaction of those plumes with the plumes from **B** sources. Therefore, the total increment expansion, i.e., PSD credit, is calculated as the difference between (1) the total impact prior to the retirement of **C** sources, i.e. **(B+C)**, and (2) the total impact from existing (non-retired) baseline sources (**B**), which can be expressed as **(B+C) – (B)**.

Finally, the net increment consumption is given by the difference between total increment consumption and the total increment expansion, or

$$[(\mathbf{A}+\mathbf{B}) - (\mathbf{B})] - [(\mathbf{B}+\mathbf{C}) - (\mathbf{B})] \quad (1)$$

Note that in the absence of any increment expansion, the net increment consumption is equal to the total increment consumption $[(\mathbf{A}+\mathbf{B}) - (\mathbf{B})]$, as described above.

These expressions of net increment consumption and expansion cannot be interpreted as algebraic equations. Instead, the terms within parentheses represent the results of separate model runs that account for the combined effects of NO_x conversion chemistry on specific groups of sources. The expression shown in Equation 1 above represents four model simulations: $(\mathbf{A}+\mathbf{B})$, (\mathbf{B}) , $(\mathbf{B}+\mathbf{C})$, and (\mathbf{B}) again. In this case, the two (\mathbf{B}) terms do cancel each other and we are left with

$$[(\mathbf{A}+\mathbf{B})] - [(\mathbf{B}+\mathbf{C})] \quad (2)$$

The expression presented in Equation 2 summarizes how the net increment consumption calculation is performed under the PSDCREDIT option. Under this option, AERMOD first models the \mathbf{A} and \mathbf{B} groups together, then models the \mathbf{B} and \mathbf{C} groups together, and finally computes the difference to obtain the desired result, i.e., the value to compare to the PSD increment standard. In order for AERMOD to perform the special processing associated with this option, the user must define which sources belong to each of the groupings defined above. The next section describes how this is accomplished.

2.4.6.3 Specifying Source Groups under the PSDCREDIT Option

The PSDCREDIT option introduces limitations on grouping sources in order to calculate increment consumption as described in the previous section. A new keyword, PSDGROUP, is used to group the sources to correctly calculate the increment consumption. The syntax, type, and order are similar to the regular SRCGROUP keyword and are summarized below:

Syntax:	SO PSDGROUP Grpid Srcid's and/or Srcrng's
Type:	Mandatory for PSDCREDIT option, Repeatable
Order:	Must follow the last keyword in the SO pathway before FINISHED

If the PSDCREDIT model option is specified, the PSDGROUP keyword must be used. The SRCGROUP keyword cannot be used under the PSDCREDIT option since results from other groupings beyond these three do not have any meaning when the PSDCREDIT option is invoked and sources are allocated to the calculation of increment consumption. Special source groups for outputting model results are defined within AERMOD for the PSDCREDIT option, as described in the next section.

Only the following special PSD group ID's can be used. Failure to use these group ID's will result in a fatal error message during setup processing by AERMOD. The group ID's are:

INCRCONS – increment-consuming sources (group **A** above); these can be new sources or modifications to existing sources;

NONRBASE – existing, non-retired baseline sources (group **B** above); and

RETRBASE – retired (increment-expanding or PSD credit) baseline sources (group **C** above).

It is important to note that the source emission inputs for sources included in the RETRBASE PSD group must be entered as positive numbers, unlike other types of PSD credit modeling where negative emissions are input to simulate the impact of the credit sources on the increment calculation. The increment-expanding contribution from RETRBASE sources is accounted for within the AERMOD model under the PSDCREDIT option.

The group ID's can appear in any order, but these are the only three that can be specified. If there are no retired baseline sources (i.e., no baseline sources are retired), the keyword RETRBASE can be omitted. Likewise, if there are no non-retired baseline sources (i.e., all baseline sources have been retired), the NONRBASE keyword can be omitted. The special group ID 'ALL' that can be use with the SRCGROUP keyword cannot be used with the PSDGROUP keyword. As with the SRCGROUP keyword for non-PSDCREDIT applications, the group ID's are repeatable and they must be the last keyword before FINISHED on the SO pathway when the PSDCREDIT option is specified.

Source ranges, which are described in more detail in Section 3.3.3 of the AERMOD User's Guide (EPA, 2004a), are input as two source IDs separated by a dash, e.g., STACK1-STACK10. Individual source IDs and source ranges may be used on the same card. If more than one input card is needed to define the sources for a particular group, then additional cards may be input, repeating the pathway, keyword and group ID. A source can appear in only one of these source groups, and must be assigned to one of the groups.

The requirements for specifying sources and source groups under the PSDCREDIT option are summarized below:

- The SRCGROUP keyword cannot be used with the PSDCREDIT option;
- Special PSD group ID's must be used with the PSDGROUP keyword;
- The group ID ALL is not allowed when the PSDCREDIT option is specified;
- A source must appear in one, and only one, of the PSDGROUPs; and
- Emission rates for increment-expanding (RETRBASE) sources must be entered as positive values.

2.4.6.4 Model Outputs under the PSDCREDIT Option

Unlike the regular SRCGROUP keyword, the PSDGROUP keyword does not define how the source impacts are grouped for model output. As described in the previous sections, the PSDGROUP keyword defines the different categories of sources needed in order to properly account for NO_x conversion chemistry under the PVMRM option.

The model outputs under the PSDCREDIT option in AERMOD are based on demonstrating compliance with the air quality standards, i.e., the NAAQS and PSD increment for NO₂. As a result, AERMOD uses hardcoded “SRCGROUP” names of ‘NAAQS’ and ‘PSDINC’ to label these two types of outputs. The results output under the ‘NAAQS’ source group label are based on the calculation of (A+B) as described above in Section 2.4.6.2. The results reported under the ‘PSDINC’ source group label are based on the expression presented above in Equation 2.

2.5 VARIABLE EMISSION RATES

The AERMOD model provides the option of specifying variable emission rate factors for individual sources or for groups of sources. Two new options have been added to the SO EMISFACT keyword to allow the user to vary emissions by month, hour-of-day, and day-of-week. The syntax, type and order of the EMISFACT keyword are summarized below:

Syntax:	SO EMISFACT SrcID or SrcRange Qflag Qfact(i), i=1,n
Type:	Optional, Repeatable
Order:	Must follow the LOCATION card for each source input

where the SrcID parameter is the same source ID that was entered on the LOCATION card for a particular source. The user also has the option of using the SrcRange parameter for specifying a range of sources for which the emission rate factors apply, instead of identifying a single source. This is accomplished by two source ID character strings separated by a dash, e.g., STACK1-STACK10. The use of the SrcRange parameter is explained in more detail in the description of the BUILDHGT keyword (see Section 3.3.3 of the AERMOD User’s Guide).

The parameter Qflag is the variable emission rate flag, and must be specified as one of the following secondary keywords:

- SEASON - emission rates vary seasonally (n=4),
- MONTH - emission rates vary monthly (n=12),

- HROFDY - emission rates vary by hour-of-day (n=24),
- WSPEED - emission rates vary by wind speed (n=6),
- SEASHR - emission rates vary by season and hour-of-day (n=96),
- SHRDOW - emission rates vary by season, hour-of-day, and day-of-week [M-F, Sat, Sun] (n=288),
- SHRDOW7 - emission rates vary by season, hour-of-day, and the seven days of the week [M, Tu, W, Th, F, Sat, Sun] (n=672),
- MHRDOW - emission rates vary by month, hour-of-day, and day-of-week [M-F, Sat, Sun] (n=864), and
- MHRDOW7 - emission rates vary by month, hour-of-day, and the seven days of the week [M, Tu, W, Th, F, Sat, Sun] (n=2,016).

The Qfact array is the array of factors, where the number of factors is shown above for each Qflag option. The seasons are defined in the following order: Winter (Dec., Jan., Feb.), Spring (Mar., Apr., May), Summer (Jun., Jul., Aug.), and Fall (Sep., Oct., Nov.). The wind speed categories used with the WSPEED option may be defined using the ME WINDCATS keyword. If the WINDCATS keyword is not used, the default wind speed categories are defined by the upper bound of the first five categories as follows (the sixth category is assumed to have no upper bound): 1.54, 3.09, 5.14, 8.23, and 10.8 m/s. The EMISFACT card may be repeated as many times as necessary to input all of the factors, and repeat values may be used for the numerical inputs. Examples for the new MHRDOW options are presented below, with column headers to indicate the order in which values are to be input:

```

SO EMISFACT STK1 MHRDOW enter 24 hourly scalars for each of the twelve months,
                           frst for Weekdays (Monday-Friday), then for Saturdays,
                           and finally for Sundays, e.g.,
** Weekdays              JAN    FEB    MAR    APR    MAY    JUN    . . .  NOV    DEC
SO EMISFACT STK1 MHRDOW 24*1.0 24*0.8 24*0.6 24*0.8 24*1.0 24*0.8      24*0.6 24*0.8
** Saturdays:
SO EMISFACT STK1 MHRDOW 24*1.0 24*0.8 24*0.6 24*0.8 24*1.0 24*0.8      24*0.6 24*0.8
** Sundays:
SO EMISFACT STK1 MHRDOW 24*1.0 24*0.8 24*0.6 24*0.8 24*1.0 24*0.8      24*0.6 24*0.8

SO EMISFACT STK1 MHRDOW7 enter 24 hourly scalars for each of the twelve months,
                           frst for Mondays, then for Tuesdays, ..., then for Saturdays,
                           and finally for Sundays, e.g.,
** Mondays                JAN    FEB    MAR    APR    MAY    JUN    . . .  NOV    DEC
SO EMISFACT STK1 MHRDOW7 24*1.0 24*0.8 24*0.6 24*0.8 24*1.0 24*0.8      24*0.6 24*0.8
** Tuesdays              JAN    FEB    MAR    APR    MAY    JUN    . . .  NOV    DEC
SO EMISFACT STK1 MHRDOW7 24*1.0 24*0.8 24*0.6 24*0.8 24*1.0 24*0.8      24*0.6 24*0.8
.
.
.
** Saturdays:
SO EMISFACT STK1 MHRDOW7 24*1.0 24*0.8 24*0.6 24*0.8 24*1.0 24*0.8      24*0.6 24*0.8
** Sundays:
SO EMISFACT STK1 MHRDOW7 24*1.0 24*0.8 24*0.6 24*0.8 24*1.0 24*0.8      24*0.6 24*0.8

```

2.6 ALLOCATABLE ARRAYS FOR AREAPOLY SOURCES

The AERMOD model has been modified to use dynamically allocatable arrays for AREAPOLY sources, described in Section 3.3.2.3 of the AERMOD User’s Guide (EPA, 2004a), in order to allocate array limits for the maximum number of vertices at model runtime, replacing the previous fixed array limit of 20 vertices. As with other dynamically allocated arrays in AERMOD, the array storage is only limited by the amount of memory available for model execution. A simplified approach is taken for AREAPOLY sources that differs slightly from other dynamically set array limits in that the model sets a reliable upper bound on the array size based on preprocessing the AERMOD input file, rather than an exact limit based on the actual maximum number of vertices required. The approach is based on first counting the total number of vertices specified for all AREAPOLY sources combined, and assuming that all but one of the AREAPOLY sources utilizes the minimum number of vertices of three (3). The number of remaining vertices is used to set the upper bound for array storage.

Since the AREACIRC option for circular area sources, described in Section 3.3.2.3 of the AERMOD User's Guide (EPA, 2004a), uses the same data arrays as the AREAPOLY source, the array limit determined for AREAPOLY sources will also apply for AREACIRC sources if both source types are used in the same model run. However, the maximum number of vertices allowed for AREACIRC sources will always be at least 50, regardless of whether AREAPOLY sources are included in the same model run.

3.0 REFERENCES

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Note: All references listed here, with the exception of Hanrahan (1999a and 1999b), can be found on the U.S. EPA SCRAM website at the following url: <http://www.epa.gov/scram001/>

APPENDIX A

**EPA Model Clearinghouse Memorandum
Dated July 9, 1993**

July 9, 1993

MEMORANDUM

SUBJECT: Proposal for Calculating Plume Rise for Stacks with Horizontal Releases or Rain Caps for Cookson Pigment, Newark, New Jersey

FROM: Joseph A. Tikvart, Chief
Source Receptor Analysis Branch, TSD (MD-14)

TO: Ken Eng, Chief
Air Compliance Branch, Region II

In response to your request, the Model Clearinghouse has reviewed your proposal for treating horizontal and capped stacks at Cookson Pigment so that the model (SCREEN or ISC2) will properly treat plume rise from the Cookson Pigment stacks. We concur in principle with the approach, with some relatively minor changes.

First, the analysis provided by New Jersey Department of Environmental Protection is technically correct. We suggest, however, that the exit velocity for horizontal and capped stacks be set to a lower figure than 0.1 m/s. A 0.1 m/s exit velocity may still result in significant momentum plume rise being calculated, even though these kinds of sources should have zero momentum rise. We therefore suggest setting the stack exit velocity to a lower value, such as .001.

For horizontal stacks that are not capped, we suggest turning stack tip downwash off, whether there are buildings or not. Stack tip downwash calculations are inappropriate for horizontal stacks.

For vertical stacks that are capped, turn stack tip downwash off and reduce the stack height by three times the actual stack diameter. The cap will probably force stack tip downwash most of the time. The maximum amount of the stack tip downwash (as calculated in ISC2) is three times the stack diameter. Reducing the stack height by this amount, while turning off the stack tip downwash option, causes the maximum stack tip downwash effect. The resulting concentrations may err slightly on the high side. For stacks with small diameters, such as those at Cookson Pigment, the error should be quite small. Note, however, that this approach may not be valid for large diameter stacks (say, several meters).

cc: A. Colecchia
D. Wilson