

ADDENDUM

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

U.S. ENVIRONMENTAL PROTECTION AGENCY  
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## **PREFACE**

This document provides updated user instructions for the AERMOD dispersion model, including modifications introduced with version 06341 and later. This addendum supplements and updates the information contained in the current AERMOD User's Guide (EPA, 2004a).

## **ACKNOWLEDGEMENTS**

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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 and updates 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. Note that portions of the current AERMOD User's Guide (EPA, 2004a) are no longer valid or applicable.

Several 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 (see Sections 1.2 and 2.2 for more details), 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-DFAULT options for modeling conversion of NO to NO<sub>2</sub>: 1) the Plume Volume Molar Ratio Method (PVMRM) (Hanrahan, 1999a and 1999b); and 2) the Ozone Limiting Method (OLM);
3. The third set of revisions, first introduced with version 06341 of AERMOD, includes the following (additional information is provided in Model Change Bulletin (MCB) #1 provided on the SCRAM AERMOD webpage):
  - 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<sub>2</sub> chemistry for NO<sub>2</sub> 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<sub>2</sub>/NO<sub>x</sub> 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 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.
4. The fourth set of revisions, first introduced with version 09292 of AERMOD, includes the following (additional information is provided in MCB#3 provided on the SCRAM AERMOD webpage):
- a. New options for varying emissions by hour-of-day and day-of-week (HRDOW and HRDOW7);
  - b. Modification of the regulatory default option (DFAULT) on the CO MODELOPT card to impose a restriction on the urban roughness length parameter to be 1 meter for regulatory default applications. Any value other than 1 meter for the urban roughness length option on the CO URBANOPT card will be treated as a non-DFAULT option;
  - c. Removal of the TOXICS option from the MODELOPT keyword. Options formerly associated with the TOXICS option are still considered non-DFAULT options within AERMOD. The area source optimizations formerly associated with the TOXICS option are now selected using the new non-DFAULT FASTAREA option on the MODELOPT keyword;
  - d. A new non-DFAULT option for optimizing runtime for POINT and VOLUME sources based on an alternative implementation of the horizontal meander algorithm has been incorporated through the FASTALL option on the MODELOPT keyword. The FASTALL option also includes the FASTAREA optimizations if area sources are included in the model inputs;
  - e. The option for specifying hourly emissions from a separate file through the HOUREMIS keyword has been enhanced to allow the use of hourly varying release heights and initial dispersion coefficients for VOLUME and AREA/AREAPOLY/AREACIRC sources;
  - f. The OPENPIT source option has been modified to allow for use of the OPENPIT source for gaseous (non-particulate) emissions and with METHOD\_2 for particulate emissions;
  - g. The non-DFAULT option of FLAT terrain can now be specified on a source-by-source basis, allowing both FLAT and ELEV terrain treatments within the same model run (see Section 4.1 of the *AERMOD Implementation Guide* regarding modeling of sources with terrain-following plumes in sloped terrain);
  - h. A non-DFAULT option for a user-specified dry deposition velocity for gaseous emissions has been added under the GASDEPVD keyword on the CO pathway;
  - i. A new SUMMFILE option has been included on the OU pathway to output the summary of high ranked values to a separate file;

- j. An option to use scientific notation for output result files has been added through the FILEFORM keyword on the OU pathway. The FILEFORM option is applicable to PLOTFILES, plot-formatted POSTFILES, MAXIFILES, RANKFILES, and SEASONHR files;
  - k. An option (WARNCHKD) has been added to the MODELOPT keyword to allow issuing of warning messages rather than fatal errors for non-sequential meteorological data files, in order to allow use of multi-year meteorological data files that may contain gaps between years of data under the DFAULT option; and
  - l. The maximum length of filenames specified in the 'aermod.inp' file has been increased to 200 (controlled by the ILEN\_FLD parameter in modules.f), and the maximum input string length to 512 (controlled by the ISTRG parameter in modules.f). Double quotes (") are also allowed as field delimiters in the 'aermod.inp' file to support filenames with embedded spaces.
5. The fifth set of revisions, first introduced with version 11059 of AERMOD, includes the following (additional information is provided in MCB#4 provided on the SCRAM AERMOD webpage):
- a. Revisions to the processing options available for 24-hour averages of PM<sub>2.5</sub> to support implementation of recommendations regarding appropriate modeling procedures for demonstrating compliance the PM<sub>2.5</sub> NAAQS;
  - b. Enhancements to support processing for the 1-hour NO<sub>2</sub> and SO<sub>2</sub> NAAQS, based on the annual distribution of daily maximum 1-hour values, averaged across the number of years processed, including three new output file options, MAXDAILY, MXDYBYR, and MAXDCONT, and revisions to the RECTABLE keyword to support user-specified ranks up the 999<sup>th</sup> highest value to support significant contribution analyses;
  - c. A new option to specify uniform or temporally-varying background concentrations, using the BACKGRND keyword on the SO pathway;
  - d. A new option to specify temporally-varying background ozone concentrations, using the O3VALUES keyword on the CO pathway;
  - e. Incorporation of the default equilibrium ratio 0.90 for NO<sub>2</sub>/NO<sub>x</sub> for the OLM option, which was previously associated only with the PVMRM option (the CO NO2EQUIL option can also be used to specify a non-default equilibrium ratio for the OLM option);
  - f. Increasing the maximum length for source IDs from 8 to 12 characters;
  - g. An option to suppress file headers for formatted output files, using the NOHEADER keyword on the OU pathway;
  - h. A modification to the urban option to address issues with the transition from the nighttime urban boundary layer to the daytime convective boundary layer (a non-DFAULT option has been included to allow users to revert to the original implementation); and

- i. Corrections to several bugs related to the PVMRM algorithm and modifications to the DEBUGOPT keyword to allow user to specify only PVMRM or deposition (DEPOS) debug output, without the MODEL debug file, which can be very large.
6. The sixth set of revisions, first introduced with version 11103 of AERMOD, includes the following (additional information is provided in MCB#5 provided on the SCRAM AERMOD webpage):
- a. Correction to a bug that resulted in all short-term values being 0.0 if only the 1st-highest rank was selected for applications involving the special processing for daily maximum values (24hr PM25, 1hr NO2 and 1hr SO2); and
  - b. Additional error handling to identify potential problems with the Fortran format specifier for hourly ozone files and hourly background files specified on the CO OZONEFIL and SO BACKGRND keywords, respectively. The hourly ozone and/or background concentrations may have been assigned values of zero (0) in previous versions of AERMOD if the user-specified Fortran format included an integer (I) format to read the concentration values. The requirements for user-specified Fortran formats with these options has been clarified in the appropriate sections below.
7. The seventh set of revisions, first introduced with version 12060 of AERMOD, includes the following (additional information is provided in MCB#7 provided on the SCRAM AERMOD webpage):
- a. Corrections to bugs associated with the MAXDCONT option for determining source contributions for the 1hr NO2, 1hr SO2 and 24hr PM25 NAAQS based on a distribution of daily maximum values for applications including a day-of-week component on the EMISFACT, O3VALUES, or BACKGRND keywords, and for applications using an hourly emission file (SO HOUREMIS keyword) for at least one source, but not all sources, in a particular run;
  - b. Corrected a bug for applications with the OLM and PVMRM options under the EVENT processing mode when only the CO OZONEVAL keyword is used to specify a background ozone value, without an hourly ozone file through the CO OZONEFIL keyword or varying ozone values through the CO O3VALUES keyword;
  - c. Replaced subroutine LTOPG for determining PG stability class based on Monin-Obukhov length and surface roughness used in the FASTAREA option with code from the CTDMPPLUS model that more closely matches the Golder (1972) figure;
  - d. Incorporated an option for users to indicate that all sources in a particular model run are to be treated as URBAN sources, by specifying 'ALL' on the SO URBANSRC keyword. The URBANSRC ALL option is only applicable for applications that include a single urban area;

- e. Included a new option for users to specify the number of years of meteorological data being processed for multi-year applications of the MAXDCONT option, using the new NUMYEARS keyword on the ME pathway. This allows users with less than 5 years of site-specific met data to specify the number of years being processed in order to minimize memory storage requirements. Consistent with previous versions, the default number of years absent the NUMYEARS option is five (5); and
  - f. Includes checks of the range of ranks specified on the OU RECTABLE keyword when the THRESH option on the MAXDCONT keyword is being used, since the analysis of contributions for MAXDCONT is limited to the range of ranks specified on the RECTABLE keyword. A fatal error message will be generated if the range of ranks specified is less than or equal to the design value rank for the specified pollutant plus 4, i.e., a fatal error will be generated if the range of ranks is less than or equal to 8 for 1-hr SO<sub>2</sub>, or less than or equal to 12 for 1-hr NO<sub>2</sub> or 24-hr PM<sub>2.5</sub>. A non-fatal warning message is also generated if the range of ranks is less than or equal to the design value rank plus 20, i.e., if the range of ranks is less than or equal to 24 for 1-hr SO<sub>2</sub>, or less than or equal to 28 for 1-hr NO<sub>2</sub> or 24-hr PM<sub>2.5</sub>.
8. The eighth set of revisions, first introduced with version 12345 of AERMOD, includes the following (additional information is provided in MCB#8 provided on the SCRAM AERMOD webpage):
- a. Adjustments to wind speeds based on the assumption that input wind speeds are vector (or resultant) mean winds (see Eq. 112 on page 79 of the AERMOD Model Formulation Document (Cimorelli, *et al.*, 2004)) have been removed. This is considered a formulation bug fix since current EPA guidance for site-specific meteorological monitoring (EPA, 2000) recommends that scalar mean wind speeds be used in steady-state Gaussian dispersion models. Furthermore, all wind speeds derived from NWS or FAA airport data represent scalar mean wind speeds. An option has also been included on the MODELOPT keyword on the CO pathway (VECTORWS) that allows users to specify that input wind speeds are vector means, in which case the previous adjustments will be included. The new VECTORWS option is not linked with the DFAULT option, but users should be able to confirm that input speeds are vector means in order to justify use of the option. However, scalar mean wind speeds, if available, should be used based on the current guidance.
  - b. Modifications to check for large negative hourly emissions ( $< -90$ ), which may be used as missing indicators. Since AERMOD allows inputs of negative emissions for use in emission credit calculations, negative values used as missing indicators in the HOUREMIS file result in negative hourly concentrations in the previous versions. Warning messages are generated and the emission rate is set to zero (0) for these cases.
  - c. Two new BETA (non-Default) options have been included to address concerns regarding model performance under low wind speed conditions. The

LOWWIND1 option increases the minimum value of sigma-v from 0.2 to 0.5 m/s and "turns off" the horizontal meander component. The LOWWIND2 option increases the minimum value of sigma-v from 0.2 to 0.3 m/s, and incorporates the meander component, with some adjustments to the algorithm, including an upper limit on the meander factor (FRAN) of 0.95. A new LOW\_WIND keyword has been added to the CO pathway that allows users to adjust the minimum sigma-v value (within a range of 0.01 to 1.0 m/s), and the minimum wind speed value (within a range from 0.01 to 1.0 m/s), with a default value of 0.2828 m/s, consistent with the default applied in previous versions based on  $\text{SQRT}(2 \cdot \text{SVmin} \cdot \text{SVmin})$  with  $\text{SVmin}=0.2$ . The new LOW\_WIND keyword also allows users to adjust the maximum value for the meander factor (FRAN) within a range of 0.50 to 1.0, inclusive, when the LOWWIND2 option is used. These new LowWind BETA options can also be used in conjunction with the new option in AERMET (v12345) to adjust the surface friction velocity ( $U^*$ ) under low-wind/stable conditions ( $\text{ADJ}_U^*$ ), based on Qian and Venkatram (2011). More details regarding these LowWind BETA options is provided in Section 2.1.10.

- d. A new LINE source type has been included that allows users to specify line-type sources based on a start-point and end-point of the line and the width of the line, as an alternative to the current AREA source type for rectangular sources. The LINE source type utilizes the same routines as the AREA source type, and will give identical results for equivalent source inputs. The LINE source type also includes an optional initial sigma-z parameter to account for initial dilution of the emissions. As with the AREA source type, the LINE source type does not include the horizontal meander component in AERMOD.
  - e. Additional range checks on hourly stack exit velocities and exit temperatures input through the SO HOUREMIS option. A fatal error is generated if the hourly exit temperature is less than 200K (about -100F), unless the hourly emissions are zero (0) for that hour. This may indicate that incorrect units for exit temperature have been used, or that the order of exit temperature and exit velocity may have been reversed in the HOUREMIS file. Also added a new warning message for exit velocities larger than 250 m/s. Comparable changes were incorporated in subroutine PPARM for inputs on the SRCPARAM keyword.
  - f. Modified the acceptable AERMET version date from 06341 to 11059. AERMOD will no longer run with met data based on version 06341 of AERMET. AERMOD will run using met data based on version 11059. However, a warning message will be generated, and users are strongly encouraged to update their meteorological data to version 12345 of AERMET due to the scope of changes included in that update.
9. The ninth set of revisions, first introduced with version 13350 of AERMOD, includes the following (additional information is provided in MCB#9 provided on the SCRAM AERMOD webpage):

- a. Incorporated new options for modeling NO<sub>2</sub>, including a Default Ambient Ratio Method (ARM) option and non-Default BETA Ambient Ratio Method - 2 (ARM2);
  - b. Incorporated options to vary background ozone (O<sub>3</sub>) data by wind sector (new CO O3SECTOR keyword) for use with the OLM and PVMRM options, and options to vary background concentrations for the pollutant being modeled by wind sector (new SO BGSECTOR keyword). Any of the existing options for specifying background data can be used with the new sector-varying options, and will continue to work as before if no sectors are defined. The applicable sector is determined by the flow vector (downwind) based on the wind direction in the surface meteorological data file;
  - c. Added new "debug" output file options for the OLM option and for the new ARM and ARM2 options for NO<sub>2</sub>. Also added a new PRIME debug option to separate the debug information associated with the PRIME downwash algorithm from the non-PRIME related information provided under the MODEL debug option. Also removed all debug information from the main 'aermod.out' file.
10. The ninth set of revisions, first introduced with version 14134 of AERMOD, includes the following (additional information is provided in MCB#10 provided on the SCRAM AERMOD webpage):
- a. Modified subroutine POLLID to allow for an additional user-specified field to disable the special processing associated with the 1-hr NO<sub>2</sub>, 1-hr SO<sub>2</sub> and 24-hr PM<sub>2.5</sub> NAAQS, which are based on a multi-year average of ranked maximum daily values (1-hr values in the case of NO<sub>2</sub> and SO<sub>2</sub> and 24-hr values in the case of PM<sub>2.5</sub>). The optional field allowed after than pollutant ID can be 'H1H', 'H2H', or 'INC' (without the single quotes), indicating that the results will be processed consistent with a deterministic standard, such as the original 3-hr and 24-hr SO<sub>2</sub> standards, which could be exceeded once per year, and consistent with PSD increments, which can also be exceeded once per year. These options are intended to provide a mechanism for modeling to demonstrate compliance with the 24-hr PM<sub>2.5</sub> increments, and also to provide a mechanism to evaluate the various NO<sub>2</sub> chemistry options incorporated in AERMOD without the requirement for modeling complete years of meteorological data.
  - b. Modified subroutine DEBOPT to include a new AREA/LINE debug option, which is output to a separate file, including an optional user-specified file name. This includes additional information regarding AREA/LINE (and OPENPIT) calculations as compared to the AREA-related debug information included under the previous DEBUG option. Also modified subroutines ACALC and PSIDE to output AREA/LINE debug information under the new AREA/LINE debug option. Debug information is no longer included in the main 'aermod.out' file.

- c. Modified subroutine MEOPEN to check for flags in the header record of the input SURFFILE indicating that MMIF-generated meteorological inputs were used, which is currently treated as non-DFAULT/BETA option, and for use of BULKRN option, which is treated as a DFAULT option. Subroutine MEOPEN also checks for measurement heights in the input PROFFILE file and issues a warning if heights exceed 999m, which could indicate that inputs were based on MMIF or other gridded meteorological data that were processed in a manner that did not include identifying information in the surface file header record (e.g., processing MMIF-generated pseudo- surface and upper air data with user-defined surface characteristics rather than the AERSURF file generate by MMIF. Subroutine MEOPEN was also modified to include checks for blank/missing upper air, surface and/or onsite station IDs in the surface file header record, and issues warning messages if the respective station IDs specified on the ME pathway in the aermod input file are not zero (0).
- d. Modified subroutine PRTSRC to include a table of SrcIDs for sources identified as urban sources under the URBANSRC keyword.
- e. Modified subroutine PRTDET to include the original GrpVal concentration from the Non-EVENT run in the header information for the DETAIL output option under EVENT processing.
- f. Modified subroutine PRTOPT to include additional information on the initial input summary page of the ‘aermod.out’ file related to the use of NO2 options, and to identify which debug options have been selected on the CO DEBUGOPT keyword.
- g. The “acceptable” AERMET version date has been modified to version 12345, and AERMOD will not run if meteorological data generated by earlier versions of AERMET are input. AERMOD will run if meteorological data from versions 12345 or 13350 are used, but a warning message will be issued and AERMET version 14134 should be used for regulatory applications of AERMOD.

## 1.2 BACKGROUND ON DEPOSITION ALGORITHMS

The deposition algorithms incorporated into AERMOD are based on the draft Argonne National Laboratory (ANL) report (Wesely et al., 2002), with modifications based on peer review. Treatment of wet deposition was revised from Wesely et al. (2002) 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 based on the ANL report were initially implemented in the AERMOD model under the non-DFAULT TOXICS option, which was selected by including the TOXICS keyword on the CO MODELOPT card. Beginning with version 09292 of AERMOD, the TOXICS option has been removed from the model. Those options in AERMOD that were formerly associated with the TOXICS option are still considered non-DFAULT options but no longer require the specification of the TOXICS option to allow their use. 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 dry deposition based on the ANL algorithms, 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 in AERMOD are the same as for the particle deposition algorithm in the ISCST3 model and are described below in Section 2.2. 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 requirements for deposition are described in Section 2.2.

Consistent with Section 7.2.7(b) of the *Guideline on Air Quality Models* (40 CFR Part 51, Appendix W), the use of “Method 1” for particle deposition in AERMOD is allowed under the regulatory DFAULT option. However, use of the “Method 1” particle deposition algorithms require quantification of the particle size distribution and should be done in coordination with the appropriate reviewing authority. Use of the “Method 2” option for particle deposition and the gas deposition algorithms (both dry and wet) are considered non-DFAULT options in AERMOD. Table 1-1 summarizes the required keywords for the various deposition options within AERMOD and whether they are allowed under the DFAULT option.



Table 1-1. Summary of Deposition Options in AERMOD

<b>Pollutant Type</b>	<b>Model Output Type</b>	<b>Required Keywords</b>	<b>Allowed under DFAULT?</b>
Gaseous	CONC w/dry depletion DDEP	CO GASDEPVD or CO GDSEASON, CO GDLANUSE, and SO GASDEPOS	No
Gaseous	CONC w/wet depletion WDEP	SO GASDEPOS	No
Gaseous	CONC w/dry & wet depletion DEPOS	CO GDSEASON, CO GDLANUSE, and SO GASDEPOS	No
Particulate ("Method 1")	CONC w/dry and/or wet depletion DEPOS DDEP WDEP	SO PARTDIAM, SO PARTDENS, and SO MASSFRAX	Yes <sup>1</sup>
Particulate ("Method 2")	CONC w/dry and/or wet depletion DEPOS DDEP WDEP	SO METHOD_2	No

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<sup>1</sup> While "Method 1" is allowed under the regulatory "DFAULT" option within AERMOD, the use of "Method 1" for particulate emissions in regulatory modeling applications should follow the guidance provided in Section 7.2.7(b) of Appendix W.

## **2.0 USER INSTRUCTIONS**

### **2.1 DISPERSION MODELING OPTIONS**

#### **2.1.1 Modification to Urban Option for Morning Transition**

The urban option within AERMOD was modified, beginning with version 11059, to address potential issues associated with the transition from the nighttime urban boundary layer to the daytime convective boundary layer. Prior to version 11059, the enhanced dispersion due to the urban heat island during nighttime stable conditions was ignored once the rural boundary layer became convective. This could result in an unrealistic drop in the mixing height for urban sources during the morning transition to a convective boundary layer, which could contribute to overly conservative concentrations for low-level sources under such conditions. This potentially anomalous behavior was observed in a few cases during the application of AERMOD for the Risk and Exposure Assessment (REA) conducted in support of the most recent review for the NO<sub>2</sub> National Ambient Air Quality Standard (NAAQS) (EPA, 2008). The potential significance of this issue for AERMOD applications in support of air quality permitting has increased with the recent promulgation of the 1-hour NO<sub>2</sub> and 1-hour SO<sub>2</sub> NAAQS.

To address this issue, AERMOD was modified to continue applying the urban boundary layer option for urban sources until the daytime (rural) convective boundary exceeds the population-dependent urban boundary layer height. This modification to the urban option within AERMOD has been evaluated using the 1985 Indianapolis SF<sub>6</sub> field study data, and shows improved model performance during daytime convective conditions compared to the original implementation of the urban option. Model-to-monitor comparisons of 1-hour NO<sub>2</sub> concentrations from the Atlanta NO<sub>2</sub> REA also exhibit improved model performance with this modification to the urban option in AERMOD. A summary of these model evaluation results is provided in Appendix E.

While the urban option has been modified under the regulatory default mode beginning with version 11059, a non-DEFAULT option to revert to the urban option as implemented prior to

### 2.1.2 MODELOPT Keyword

<b>Syntax:</b>														
CO	MODELOPT	<u>DEFAULT</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>SCIM</u>	<u>PVMRM</u>	<u>PSDCREDIT</u>	<u>FASTALL</u>
				<u>DEPOS</u>	and/or			or				or <u>OLM</u>		or
				<u>DDEP</u>		<u>ELEV</u>		<u>WARNCHKD</u>				or <u>ARM</u>		<u>FASTAREA</u>
				and/or								or <u>ARM2</u>		
				<u>WDEP</u>										
		<u>DRYDPLT</u>		<u>WETDPLT</u>		<u>NOURBTRAN</u>		<u>LOWWIND1</u>		<u>VECTORWS</u>				
		or		or				or						
		<u>NODRYDPLT</u>		<u>NOWETDPLT</u>				<u>LOWWIND2</u>						
<b>Type:</b>	Mandatory, Non-repeatable													
<b>Order:</b>	Must precede POLLUTID, HALFLIFE and DCAYCOEF													

DFAULT - Specifies that the regulatory default options will be used; note that specification of the DFAULT option will override some non-DFAULT options that may be specified in the input file, while other non-DFAULT options will cause fatal errors when DFAULT is specified (see below for details);

BETA - Non-DFAULT option that allows for draft, “Beta” test options to be used (see Section 2.1.3 for more details); currently includes the PSDCREDIT option (Section 2.5.6); options for capped and horizontal stack releases (2.1.9); the LOWWIND1 and LOWWIND2 options and the use of meteorological inputs based on the non-Default ADJ\_U\* option incorporated in version 12345 of AERMET that adjusts the surface friction velocity ( $U^*$ ) under low-wind/stable conditions (Section 2.1.10),;

CONC - Specifies that concentration values will be calculated;

<u>DEPOS</u> -	Specifies that total deposition flux values (both dry and wet) will be calculated;
<u>DDEP</u> -	Specifies that dry deposition flux values will be calculated;
<u>WDEP</u> -	Specifies that wet deposition flux values will be calculated;
<u>AREADPLT</u> -	Specifies that a non-DFAULT method for optimized plume depletion due to dry removal mechanisms will be included in calculations for area sources;
<u>FLAT</u> -	Specifies that the non-DFAULT option of assuming flat terrain will be used; Note that FLAT and ELEV may be specified in the same model run to allow specifying the non-DFAULT FLAT terrain option on a source-by-source basis; FLAT sources are identified by specifying the keyword <u>FLAT</u> in place of the source elevation field on the SO LOCATION keyword;
<u>ELEV</u> -	Specifies that the default option of assuming elevated terrain will be used; Note that FLAT and ELEV may be specified in the same model run to allow specifying the non-DFAULT FLAT terrain option on a source-by-source basis;
<u>NOSTD</u> -	Specifies that the non-DFAULT option of no stack-tip downwash will be used;
<u>NOCHKD</u> -	Specifies that the non-DFAULT option of suspending date checking will be used for non-sequential meteorological data files;
<u>WARNCHKD</u> -	Specifies that the option of issuing warning messages rather than fatal errors will be used for non-sequential meteorological data files;
<u>NOWARN</u> -	Specifies that the option of suppressing the detailed listing of warning messages in the main output file will be used (the number of warning messages is still reported, and warning messages are still included in the error file controlled by the CO ERRORFIL keyword);
<u>SCREEN</u> -	Specifies that the non-DFAULT option for running AERMOD in a screening mode will be used;
<u>SCIM</u> -	Sampled Chronological Input Model - used only with the ANNUAL average option to reduce runtime by sampling meteorology at a user-specified regular interval; SCIM sampling parameters must be specified on the ME pathway;

<u>PVMRM</u> -	Specifies that the non-DFAULT Plume Volume Molar Ratio Method (PVMRM) for NO <sub>2</sub> conversion will be used;
<u>OLM</u> -	Specifies that the non-DFAULT Ozone Limiting Method (OLM) for NO <sub>2</sub> conversion will be used;
<u>ARM</u> -	Specifies that the DFAULT Ambient Ratio Method (ARM) for NO <sub>2</sub> conversion will be used;
<u>ARM2</u> -	Specifies that the non-DFAULT BETA Ambient Ratio Method - 2 (ARM2) for NO <sub>2</sub> conversion will be used;
<u>PSDCREDIT</u> -	Specifies that the non-DFAULT BETA test option will be used to calculate the increment consumption with PSD credits using the PVMRM option;
<u>FASTALL</u> -	Non-DFAULT option to optimize model runtime through use of alternative implementation of horizontal meander for POINT and VOLUME sources; also optimizes model runtime for AREA/AREAPOLY/AREACIRC and OPENPIT sources through hybrid approach (formerly associated with TOXICS option, now controlled by FASTAREA option);
<u>FASTAREA</u> -	Non-DFAULT option to optimize model runtime through hybrid approach for AREA/AREAPOLY/AREACIRC and OPENPIT sources (formerly associated with TOXICS option);
<u>DRYDPLT</u> -	Option to incorporate dry depletion (removal) processes associated with dry deposition algorithms; this requires specification of dry deposition source parameters and additional meteorological variables; dry depletion will be used by default if dry deposition algorithms are invoked;
<u>NODRYDPLT</u> -	Option to disable dry depletion (removal) processes associated with dry deposition algorithms;
<u>WETDPLT</u> -	Option to incorporate wet depletion (removal) processes associated with wet deposition algorithms; this requires specification of wet deposition source parameters and additional meteorological variables; wet depletion will be used by default if wet deposition algorithms are invoked;
<u>NOWETDPLT</u> -	Option to disable wet depletion (removal) processes associated with wet deposition algorithms;

- NOURBTRAN - Non-DFAULT option to ignore the transition from nighttime urban boundary layer to daytime convective boundary layer (i.e., to revert to the urban option as implemented prior to version 11059);
- LOWWIND1 - Non-DFAULT BETA option to address concerns regarding model performance under low wind speed conditions. The LOWWIND1 option increases the minimum value of sigma-v from 0.2 m/s to 0.5 m/s, and “turns off” the horizontal meander component. The BETA keyword must also be specified in order to invoke the LOWWIND1 option;
- LOWWIND2 - Non-DFAULT BETA option to address concerns regarding model performance under low wind speed conditions. The LOWWIND2 option increases the minimum value of sigma-v from 0.2 m/s to 0.3 m/s, and includes some adjustments to the horizontal meander component. The BETA keyword must also be specified in order to invoke the LOWWIND2 option (note that LOWWIND1 and LOWWIND2 cannot both be invoked in the same model run);
- VECTORWS - Option to specify that input wind speeds are vector mean (or resultant) wind speeds, rather than scalar means. Under the VECTORWS option, the adjustments to wind speeds based on Equation 112 of the AERMOD Model Formulation Document (Cimorelli, *et al.*, 2004) will be applied. The VECTORWS option is not linked with the DFAULT option.

The DFAULT option has been modified beginning with version 09292 to impose a restriction on the optional urban roughness length parameter to be 1 meter for regulatory default applications.

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. Appropriate deposition parameters must be specified in order to output deposition fluxes using the DEPOS, DDEP, and/or WDEP keywords (see Sections 1.2 and 2.2 for more details).

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, unless the user specifies the NODRYDPLT and/or NOWETDPLT options. 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 use of the NODRYDPLT and/or NOWETDPLT options will result in a more conservative estimate of concentrations and/or deposition fluxes for applications involving deposition processes, but the degree of additional conservatism will vary depending on the source characteristics, meteorological conditions, receptor locations and terrain influences. However, the inclusion of particle deposition effects may increase ground-level concentrations for some sources compared to the same source modeled as a gaseous emission, due to the effect of gravitational settling on the particulate plume. The magnitude of this effect will depend on the source characteristics (elevated or low-level) and particle size distribution.

The PVMRM, OLM, and ARM2 options for modeling NO<sub>2</sub> conversion are non-DEFAULT options, and the ARM2 option is also considered as a BETA option. The ARM option is considered to be a DEFAULT option. Only one of these options for NO<sub>2</sub> conversion can be specified for a given model run, and all 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). These options have additional input requirements as described in Section 2.6.

Beginning with version 09292, the TOXICS option is no longer used in AERMOD and the FASTAREA option on the MODELOPT is now used to select the non-DEFAULT option to optimize model runtime for AREA sources (including AREA, AREAPOLY, AREACIRC and OPENPIT source types, as well as LINE sources introduced with version 12345 (see Section 2.4)). When the FASTAREA option is specified, the area source integration routine is optimized to reduce model runtime by incorporation of a three-tiered approach using the Romberg numerical integration, a 2-point Gaussian Quadrature routine for numerical integration, or a point source approximation, depending on the location of the receptor relative to the source. In the regulatory default mode the Romberg numerical integration is utilized for all receptors. Also beginning with version 09292, a non-DEFAULT option to optimize model runtime for POINT and

VOLUME sources has been included, which is selected by the FASTALL option on the MODELOPT keyword. Specification of the FASTALL option also activates the FASTAREA option if AREA sources are including in the model inputs. Both FASTALL and FASTAREA skip receptors that are more than 80 kilometers from the source.

The FASTALL option for POINT and VOLUME sources uses an alternative implementation of the horizontal meander algorithm based on an effective horizontal dispersion coefficient ( $\sigma_{yeff}$ ) that replicates the centerline concentration based on the full meander approach. Use of the effective  $\sigma_y$  allows the model runtime to be optimized by skipping receptors that are more than  $4\sigma_{yeff}$  off the plume centerline. Based on tests conducted to date, comparisons of concentrations based on the FASTALL option for POINT and VOLUME sources with concentrations based on the DFAULT option are similar to comparisons of concentrations for AREA sources using the FASTAREA option. The average ratio of FASTALL concentrations to DFAULT values is about 1.02 for high ranked values, showing a slight bias toward overprediction for the FASTALL option. However, the range of ratios for high ranked values shows both overpredictions and underpredictions relative the DFAULT option, and differences at specific receptors may be much larger.

The NOURBTRAN non-DFAULT option has been included to allow users to revert to the urban option as implemented prior to version 11059, which ignores the transition from the nighttime urban boundary layer to the daytime convective boundary layer. As with other non-DFAULT options in AERMOD, use of the NOURBTRAN option in regulatory modeling applications would require justification and approval on a case-by-case basis.

### 2.1.3 BETA Test Options

A 'BETA' test option switch is included on the CO MODELOPT keyword 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-DFAULT option, and will result in a fatal error if the DFAULT option is



also specified. Draft enhancements included in AERMOD under the BETA option, through version 13350, include:

- 1) Options for capped stacks (source type = POINTCAP) and for horizontal releases (source type = POINTHOR);
- 2) The PSDCREDIT option for PVMRM to account for NO/NO<sub>2</sub> chemistry of combined plumes in the computation of increment consumption with PSD credits;
- 3) The LOWWIND1 and LOWWIND2 options under the CO MODELOPT keyword to address concerns regarding model performance under low wind speed conditions;
- 4) The ADJ\_U\* option incorporated in version 12345 of AERMET that adjusts the surface friction velocity (U\*) under low wind/stable conditions (see AERMET User's Guide Addendum for more details regarding the ADJ\_U\* option); and
- 5) The ARM2 option incorporated in version 13350 of AERMOD to estimate the conversion of NO to NO<sub>2</sub>.

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. More details regarding the POINTCAP and POINTHOR options are provided in Section 2.1.9; more details regarding the PSDCREDIT option are provided in Section 2.5.6; more details regarding the LOWWIND1 and LOWWIND2 options in AERMOD and the ADJ\_U\* option in AERMET are provided in Section 2.1.10; and more details regarding the ARM2 option for estimating NO<sub>2</sub> conversion is provided in Section 2.6.

#### 2.1.4 Averaging Time Options

The averaging periods for AERMOD are selected using the AVERTIME keyword on the CO (Control) pathway. The syntax and type of the AVERTIME keyword are summarized below:

<b>Syntax:</b>	CO AVERTIME Time1 Time2 . . . TimeN <u>MONTH</u> <u>PERIOD</u> or <u>ANNUAL</u>
<b>Type:</b>	Mandatory, Non-repeatable

where the parameters Time1 . . . TimeN refer to the user-specified short term averaging periods of 1, 2, 3, 4, 6, 8, 12, and/or 24 hours, the secondary keyword MONTH refers to monthly averages (for calendar months), the secondary keyword PERIOD refers to the average for the entire data period, and the secondary keyword ANNUAL refers to an annual average. Any of the short term averaging periods listed above may be selected for a given run. Since the monthly averages are treated as short term averages, the user can select appropriate output options, such as the second highest values by receptor, on the OU pathway. The location of the PERIOD or ANNUAL keyword in the parameter list is not critical. The order of the short term averaging periods (including MONTH) is also not critical, although it does control the order of the averaging period result tables in the main output file. Generally, it is recommended that the short term averaging periods be input in increasing order, unless there is a clear advantage in doing otherwise.

The user may specify either the PERIOD keyword or the ANNUAL keyword, but not both. For concentration calculations, the PERIOD and ANNUAL keywords produce the same results for a single year data file. However, the ANNUAL average option applies only to complete years of data, and for multi-year data files, the ANNUAL average output is based on the average of the ANNUAL values across the years of data processed. For deposition calculations, the PERIOD keyword will provide a total deposition flux for the full period of meteorological data that is modeled, including multi-year data files, with default units of g/m<sup>2</sup>, whereas the ANNUAL keyword will provide an annualized rate of the deposition flux with default units of g/m<sup>2</sup>/yr. Use of the ANNUAL average option for meteorological data periods of less than a year will result in a fatal error. For meteorological data periods of longer than a year, if the meteorological data file does not contain complete years of data, any data remaining after the last complete year will be ignored for the ANNUAL average, and a warning message will be generated. The treatment of short term averages with multiple-year data files is comparable to

their treatment when the CO MULTYEAR option is used (see Section 2.1.5 below for a description of the MULTYEAR option).

#### 2.1.5 Performing Multiple Year Analyses with MULTYEAR Option

The MULTYEAR keyword on the CO pathway provides an option for the user to perform a multiple year analysis such as would be needed to determine the "high-sixth-high in five years" design value for determining PM-10 impacts without the need for postprocessing of multiple concentration files, and for multiple year analyses associated with the 24-hour PM2.5 NAAQS and 1-hour NO<sub>2</sub> and SO<sub>2</sub> NAAQS which are based on concentrations averaged across the number of years processed. More information regarding the 24-hour PM2.5 and 1-hour NO<sub>2</sub> and SO<sub>2</sub> NAAQS is provided in Sections 2.1.6 and 2.1.7. Since the multiple year option makes use of the model re-start capabilities described in the Section 3.2.10 of the AERMOD User's Guide (2004a), the MULTYEAR keyword is not compatible with the SAVEFILE or INITFILE keywords. The model will generate a fatal error message if the user attempts to exercise both options in a single run. The syntax and type of the MULTYEAR keyword is summarized below:

<b>Syntax:</b>	CO MULTYEAR ( <u>H6H</u> ) Savfil (Inifil)
<b>Type:</b>	Optional, Non-repeatable

where the optional H6H field, formerly used to highlight the use of the MULTYEAR option for determining the High-6<sup>th</sup>-High (H6H) 24-hour average for the "pre-1997" PM-10 NAAQS, is no longer required since the "post-1997" PM-10 NAAQS was vacated. A warning message will be generated if the H6H field is included on the MULTYEAR keyword indicating that it is not required. The Savfil parameter specifies the filename for saving the results arrays at the end of each year of processing, and the Inifil parameter specifies the filename to use for initializing the results arrays at the beginning of the current year. The Inifil parameter is optional, and should be left blank for the first year in the multi-year series of runs. The MULTYEAR option works by accumulating the high short term average results from year to year through the mechanism of the re-start save file. The model may be setup to run in a batch file with several years of meteorological data, and at the end of each year of processing, the short term average results

reflect the cumulative high values for the years that have been processed. The PERIOD average results are given for only the current year, but the model carries the highest PERIOD values from year to year and includes the cumulative highest PERIOD averages in the summary table at the end of the run.

When setting up a batch file to perform a multiple year analysis, the user would first create an input runstream file for the first year with all of the applicable modeling options, the source inventory data, the receptor locations, the meteorology options for the first year and the output file options. To obtain the PM-10 design value, be sure to include the SIXTH highest value on the OU RECTABLE card (see Section 3.7.1 of the AERMOD User's Guide (2004a)). For the CO MULTYEAR card for the first year, the user would only specify the Savfil parameter, and may use a card such as:

```
CO MULTYEAR YEAR1.SAV
```

For the subsequent years, the user could copy the input file created for Year-1, and edit the files to change the year parameters and meteorology filename on the ME pathway (and possibly in the title information), and edit the MULTYEAR cards. For the subsequent years, both the Savfil and Inifil parameters must be specified, with the Savfil for Year-1 becoming the Inifil for Year-2, and so on. The MULTYEAR cards (one for each AERMOD run) might look like this:

```
CO MULTYEAR YEAR1.SAV (First year)
CO MULTYEAR YEAR2.SAV YEAR1.SAV (Second year)
CO MULTYEAR YEAR3.SAV YEAR2.SAV (Third year)
CO MULTYEAR YEAR4.SAV YEAR3.SAV (Fourth year)
CO MULTYEAR YEAR5.SAV YEAR4.SAV (Fifth year)
```

The MULTYEAR keyword option is separate from the ability of the AERMOD model to process a multiple-year meteorological data file in a single model run. The latter capability can be used for applications of the model to long term risk assessments where the average impacts over a long time period are of concern rather than the maximum annual average determined from five individual years.

## 2.1.6 Processing for Particulate Matter (PM) NAAQS

### 2.1.6.1 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 98<sup>th</sup> percentile 24-hour average and a 3-year average of the annual mean concentration at each ambient monitor. EPA issued new draft recommendations in March 2013 (EPA, 2013) regarding appropriate modeling procedures for use in modeling demonstrations of compliance with the PM<sub>2.5</sub> NAAQS that is intended to supersede the earlier guidance issued in March 2010 (EPA, 2010a). The March 2013 draft guidance, which addresses the issue of secondary formation of PM<sub>2.5</sub> due to precursor emissions, has modified the earlier guidance regarding use of the average of the first-highest 24-hour average concentrations across the number of years modeled to represent the modeled contribution for a cumulative impact assessment and recommends using the average of the eighth-highest (98<sup>th</sup> percentile) of 24-hour concentrations to represent the modeled contribution for a cumulative impact assessment. Use of the first-highest 24-hour average is still appropriate for significant contribution determinations. Note that the use of a 3-year average for monitored design values to determine attainment of the NAAQS does not preempt the requirement in Section 8.3.1.2 of the *Guideline on Air Quality Models* (40 CFR Part 51, Appendix W) for use of 5 years of National Weather Service (NWS) data, and the 5-year average of modeled impacts serves as an unbiased estimate of the 3-year average for purposes of modeling demonstrations of compliance with the NAAQS.

Based on EPA's March 2013 draft recommendations, the 24-hour modeled contribution to the 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 (H8H) 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 24-hour concentration at each receptor for each year modeled, averages those eighth-

highest concentrations at each receptor across the number of years of meteorological 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', 'PM-2.5', 'PM2.5' or 'PM-25' 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 can be concatenated into a single multi-year file for input into the model, or the MULTYEAR option (Section 2.1.5) can be used with separate model runs for each year. There is no requirement to remove the header records between concatenated surface meteorological data files prior to running the model, and multi-year meteorological data files can also be generated by processing multi-year inputs in AERMET, the meteorological processor for AERMOD. (NOTE: While the MULTYEAR option with separate yearly meteorological data files can be used to determine the modeled design values for PM2.5, the OU MAXDCONT option (see Section 2.8.1) to determine contributions from other source groups to the cumulative modeled design value will not work with the MULTYEAR option or with separate meteorological data files for each year.) 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 are applied to the PM-2.5 NAAQS processing whenever a pollutant ID of ‘PM25’, ‘PM-2.5’ or ‘PM-25’ is specified on the CO POLLUTID keyword:

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. The FIRST (or 1ST) highest value should be requested on the RECTABLE keyword for 24-hour averages for estimating modeled PM2.5 contributions for compliance with the NAAQS. However, the model places no restriction on the ranks requested on the RECTABLE keyword since selection of ranks lower than the FIRST highest may be needed to determine whether a source or group of sources is contributing significantly to modeled violations of the NAAQS.
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 keyword on the CO pathway can be used to calculate multi-year averages for the PM-2.5 NAAQS; however, the MAXDCONT option will not work with the MULTYEAR. Multiple year analyses are best 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, based on the H1H averaged over N years, may consist of averages over a multi-year period, they are not compatible with the EVENT processor, and the high ranked values generated based on the RECTABLE keyword will not be included in the EVENTFIL. However, if the MAXIFILE option is used to output 24-hour averages exceeding a user-defined threshold, these individual exceedances 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.

#### 2.1.6.2 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 monitored 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-6<sup>th</sup>-High (H6H) value 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 above in Section 2.1.5; 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 24-hour average results of these two approaches will be equivalent. The special processing consisting of the 99<sup>th</sup> percentile 24-hour value averaged over N years for PM-10 in versions of AERMOD prior to 09292, referred to as the “Post-1997” PM-10 option, has been removed since that standard was vacated.

#### 2.1.7 Processing for 1-hour NO<sub>2</sub> and SO<sub>2</sub> NAAQS

New 1-hour NAAQS for NO<sub>2</sub> and SO<sub>2</sub> were promulgated in February 2010 and June 2010, respectively. EPA has issued guidance related to dispersion modeling in support of these 1-hour standards (EPA, 2010b; EPA, 2010c; and EPA, 2011). The form of these new 1-hour standards is similar, based on a percentile rank from the annual distribution of daily maximum 1-hour values, averaged across the number of years processed. For the 1-hour NO<sub>2</sub> standard the modeled design value is based on the 98<sup>th</sup>-percentile of the daily maximum 1-hour values, which is represented by the eighth-highest of the daily maximum 1-hour values across the year. The 1-hour SO<sub>2</sub> modeled design value is based on the 99<sup>th</sup>-percentile, or fourth-highest, of the daily maximum 1-hour values across the year. For typical multi-year modeling analysis based on 5 years of NWS meteorological data, the modeled design value is the 5-year average of the eighth-highest values daily maximum 1-hour values for NO<sub>2</sub>, or fourth-highest values for SO<sub>2</sub>.

The form of these new 1-hour standards complicates the process of determining the modeled design value as well as the analyses that may be required to determine whether a particular source or group of sources contributes significantly to any modeled violations of the standards, paired in time and space. Several enhancements have been incorporated into



AERMOD, beginning with version 11059, to facilitate the modeling analyses required to demonstrate compliance with these new standards. These enhancements are described in Section 2.8.1. The ability of the model to exercise these new options is facilitated by specifying ‘NO2’ or ‘SO2’ as the pollutant ID on the CO POLLUTID keyword, with the following restrictions. Whenever a pollutant ID of ‘NO2’ or ‘SO2’ is specified and 1-hour averages are selected, the options to calculate 1-hour NO<sub>2</sub> or SO<sub>2</sub> design values based on the distribution of daily maximum 1-hour values will be allowed, unless short-term averaging periods other than 1-hour are also specified on the AVERTIME keyword. If other short-term averages are specified, non-fatal warning messages will be generated and the options for processing 1-hour NO<sub>2</sub> or SO<sub>2</sub> design values will be disabled. In that case, the 1-hour modeled design values will be processed the same as other short-term averages, based on the overall distribution of hourly values. Also, if ANNUAL or PERIOD averages are specified on the AVERTIME keyword along with 1-hour averages, a non-fatal warning message will be generated unless the CO MULTYEAR keyword is specified, since the annual NAAQS for NO<sub>2</sub> and SO<sub>2</sub> is based on the highest PERIOD or ANNUAL average from an individual year, rather than an average across the years modeled. However, the special processing based on daily maximum 1-hour values will be still applied for the 1-hour averages in these cases since the ANNUAL or PERIOD averages may be appropriate if only 1 year of site-specific meteorological data is modeled.

#### 2.1.8 Specifying Multiple Urban Areas

The AERMOD model (beginning with the version 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:

<b>Syntax:</b>	<u>For Multiple Urban Areas:</u> CO URBANOPT UrbanID UrbPop (UrbName) (UrbRoughness)
	<u>For Single Urban Areas:</u> CO URBANOPT UrbPop (UrbName) (UrbRoughness)
<b>Type:</b>	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. Beginning with version 09292, any value for the urban roughness length other than 1.0 meter will be treated as a non-DEFAULT option. 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:

<b>Syntax:</b>	<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
	or
	SO URBANSRC ALL (to specify all sources as URBAN)
<b>Type:</b>	Optional, Repeatable
<b>Order:</b>	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 ID ranges that are to be modeled with urban effects. Source ranges are described in more detail 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. However, beginning with version 12060, users can specify that all sources are to be treated as urban sources by specifying 'ALL' on the SO URBANSRC keyword for applications with a single urban area. Since the URBANSRC ALL option is identified during the pre-SETUP phase, there are no restrictions on the order of the URBANSRC ALL keyword within the SO pathway.

#### 2.1.9 BETA Options for Capped and Horizontal Stack Releases

Draft BETA test options are included in AERMOD (beginning with the version 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 of 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 to be appropriate for sources subject to building downwash influences with the PRIME downwash algorithm for the following reason. The PRIME algorithm uses the specified stack diameter to define the initial radius of the plume for the numerical plume rise calculation, and the initial radius of the plume can significantly influence plume rise based on the PRIME algorithm. As a result, use of an effective diameter adjusted to maintain the 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, has been adapted for the PRIME numerical plume rise formulation. For capped stacks the initial radius of the plume is assumed to be 2 times the actual stack diameter to account for the interaction of the exiting plume with the cap. The initial vertical velocity of the plume is set at 0.001 m/s, and the initial lateral velocity of the plume is set at 25% of the initial exit velocity of the plume. For horizontal stacks, the initial vertical velocity of the plume is set at 0.001 m/s, and the total exit velocity of the plume is assigned to the initial lateral velocity, and the plume is assumed to be emitted in the downwind direction. Although this adaptation of the Model Clearinghouse procedure to PRIME downwash sources has not been validated by field tracer or wind tunnel data, analyses have shown that simply setting the exit velocity to 0.001 m/s without any further adjustment when downwash is applied, as suggested in Section 6.1 of the AERMOD Implementation Guide (EPA, 2009), may lead to overly conservative results (EPA, 2007).

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), and is also summarized in Appendix B of this Addendum. 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, and the model does not account for directional effects that may occur with horizontal releases. The model also does not account for stacks oriented at a non-horizontal angle relative to vertical. For PRIME downwash 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.

### 2.1.10 BETA Options for Low Wind Conditions

Draft BETA test options are included in AERMOD (beginning with the version dated 12345) for addressing concerns regarding model performance under low wind speed conditions, including the LOWWIND1 and LOWWIND2 options on the MODELOPT keyword. The LOWWIND1 BETA option increases the minimum value of sigma-v from 0.2 to 0.5 m/s and "turns off" the horizontal meander component. The LOWWIND2 BETA option increases the minimum value of sigma-v from 0.2 to 0.3 m/s, but incorporates the meander component with some adjustments. Under the LOWWIND2 option an upper limit of 0.95 is applied to the meander factor (FRAN). The LOWWIND1 and LOWWIND2 BETA options are mutually exclusive and the model will issue a fatal warning message if both options are specified.

Although the LOWWIND1 and LOWWIND2 BETA options incorporate preset values for the minimum sigma-v, and in the case of LOWWIND2 the maximum meander factor, consistent with the developmental nature and the BETA status of these options, a LOW\_WIND keyword has been added to the CO pathway that allows users to adjust the minimum sigma-v value (SVmin) for both LowWind options (within a range of 0.01 to 1.0 m/s), and the minimum wind speed value (WSmin), within a range from 0.01 to 1.0 m/s. Inclusion of the LOW\_WIND keyword is intended to facilitate further testing and evaluation of the LowWind options. Absent user-specified values on the LOW\_WIND keyword, a default value of 0.2828 m/s is used for WSmin, consistent with the default applied in previous versions of AERMOD based on  $\text{SQRT}(2 \cdot \text{SVmin} \cdot \text{SVmin})$  with  $\text{SVmin}=0.2$ . The LOW\_WIND keyword also allows users to adjust the maximum value for the meander factor (FRANmax), within a range of 0.50 to 1.0, inclusive, when the LOWWIND2 option is used. The syntax and type of the LOW\_WIND keyword are:

<b>Syntax:</b>	CO LOW_WIND SVmin (WSmin) [for LOWWIND1] CO LOW_WIND SVmin (WSmin (FRANmax)) [for LOWWIND2]
<b>Type:</b>	Optional, Non-repeatable

where SVmin is the minimum value of sigma-v, within a range of 0.01 to 1.0 m/s, WSmin is the minimum wind speed, within a range of 0.01 to 1.0 m/s, and FRANmax is the maximum meander factor under the LOWWIND2 option, within a range of 0.50 to 1.0, inclusive. The WSmin parameter on the LOW\_WIND keyword is optional for both LowWind options, and the FRANmax parameter is also optional for the LOWWIND2 option. However, a value for WSmin must also be included in order to specify a value for FRANmax.

In addition to the adjustments to SVmin and meander described above, both of the LowWind BETA options also modify the adjustment of vector mean wind speeds (based on Eq. 112, p. 79, of the AERMOD Model Formulation Document (Cimorelli, *et al.*, 2004)) to use the original values of sigma-v based on Section 4.1.6 of the AERMOD MFD, before they are adjusted based on SVmin.

In addition to the LowWind BETA options, an option has been incorporated in the AERMET meteorological processor (beginning with the version dated 12345) to address concerns regarding model performance under low wind conditions. The ADJ\_U\* option in AERMET, which adjusts the surface friction velocity (U\*) under low-wind/stable conditions based on Qian and Venkatram (2011), can be used with or without the LOWWIND1 and LOWWIND2 options. However, use of meteorological data based on the ADJ\_U\* option requires that the BETA option be specified on the MODELOPT keyword even if the BETA LowWind options are not used since the ADJ\_U\* option is also considered a non-Default option. Beginning with version 13350 of AERMET, an adjustment to U\* under the ADJ\_U\* option is also available as a BETA option for applications utilizing the Bulk Richardson Number (BULKRN) method, based on Luhar and Raynor (2009) (see also AECOM (2009)). See the AERMET Model Change Bulletin (MCB) #4 and AERMET User's Guide Addendum for additional details regarding the ADJ\_U\* option in AERMET.

As noted above, the LowWind BETA options in AERMOD and the ADJ\_U\* option in AERMET are considered to be non-Default options and are therefore subject to the alternative model provisions in Section 3.2 of Appendix W (40 CFR Part 51). Users should coordinate with the appropriate reviewing authority regarding the procedures and requirements for approval of

these BETA options for regulatory modeling applications. Appendix F provides a summary of preliminary evaluations of the LowWind BETA options in AERMOD in conjunction with the ADJ\_U\* option in AERMET.

## **2.2 DEPOSITION ALGORITHM INPUTS AND OPTIONS**

The AERMOD model includes algorithms for both dry and wet deposition of both particulate and gaseous emissions. Based on the guidance provided for application of the AERMOD model in Appendix W, and based on the history of deposition algorithms in the AERMOD and ISC models, the particle deposition algorithms with a user-specified particle size distribution (referred to below as “Method 1”) can be applied under the regulatory default option. This option is comparable to the particle deposition algorithm in the ISCST3 model (EPA, 1995a). The gas deposition algorithms and the “Method 2” option for particle deposition based on the ANL draft report (Wesely, et al, 2002) are considered to be non-DFAULT options in AERMOD, and the model will issue a fatal error message and abort processing if the DFAULT option is specified with the gas deposition or Method 2 particle deposition options. As discussed above in Section 1.2, the TOXICS option formerly associated with the options for gas deposition and Method 2 for particle deposition is no longer used in the AERMOD model. No additional option switches are required to allow use of these non-DFAULT options. Table 1-1 in Section 1.2 summarizes the required keywords and regulatory status of various deposition options within AERMOD. The remainder of this section provides a detailed description of the model input parameters associated with the deposition algorithms.

### **2.2.1 Definition of Seasons for Gas Dry Deposition**

The gas deposition algorithms in AERMOD 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 (with generally continuous snow cover)
- 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:

<b>Syntax:</b>	CO GDSEASON Jan Feb Mar ... Dec
<b>Type:</b>	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 gas deposition algorithms, unless the GASDEPVD option for user-specified dry deposition velocity on the CO pathway is used, described below in Section 2.2.5. Note that some of the seasonal categories defined above may not apply for certain regions, such as Category 4, winter with continuous snow cover, for moderate climates.

### 2.2.2 Definition of Land Use Categories for Gas Dry Deposition

The gas deposition algorithms include some gas deposition resistance terms based on five seasonal categories, defined above, and 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 direction sector through the GDLANUSE keyword on the CO pathway. The syntax and type of the GDLANUSE keyword are:

<b>Syntax:</b>	CO GDLANUSE Sec1 Sec2 Sec3 ... Sec36
<b>Type:</b>	Optional, Non-repeatable

where a numeric value from 1 to 9 is entered for each of the 36 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 gas deposition algorithms, unless the GASDEPVD option for user-specified deposition velocity is used. The first value, Sec1, corresponds with the land use category, downwind of the application site, 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), and should generally reflect conditions downwind relative to the source location. 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 (autumn/unharvested cropland) and 5 (transitional spring), for use with the gas dry deposition algorithms.

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

<b>Syntax:</b>	CO GASDEPDF React F_Seas2 F_Seas5 (Refpoll)
<b>Type:</b>	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 (O<sub>3</sub>), titanium tetrachloride (TiCl<sub>4</sub>), and divalent mercury (Hg<sup>2+</sup>), and a value of 0.1 should be input for nitrogen dioxide (NO<sub>2</sub>).

#### 2.2.4 Specifying Source Parameters for Gas Deposition (Dry and/or Wet)

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 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:

<b>Syntax:</b>	SO GASDEPOS Srcid (or Srcrng) Da Dw rcl Henry
<b>Type:</b>	Optional, Repeatable
<b>Order:</b>	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 (cm<sup>2</sup>/s), Dw is the diffusivity in water for the pollutant being modeled (cm<sup>2</sup>/s), rcl is the cuticular resistance to uptake by lipids for individual leaves (s/cm), and Henry is the Henry's Law constant (Pa m<sup>3</sup>/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 Option for Specifying the Deposition Velocity for Gas Dry Deposition

An optional keyword is available on the Control (CO) pathway to allow the user to specify the dry deposition velocity for gaseous emissions. A single dry deposition velocity can be input for a given model run, and is used for all sources of gaseous pollutants. Selection of this option will by-pass the algorithm for computing deposition velocities for gaseous pollutants, and should only be used when sufficient data to run the algorithm are not available. Results of the AERMOD model based on a user-specified deposition velocity should be used with extra caution.

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

<b>Syntax:</b>	CO GASDEPVD Uservd
<b>Type:</b>	Optional, Non-repeatable

where the parameter Uservd is the gaseous dry deposition velocity (m/s). A non-fatal warning message is generated by the model if a value of Uservd greater than 0.05 m/s (5 cm/s) is input by the user. When the GASDEPVD keyword is used, the GDSEASON, GDLANUSE, and GASDEPRF keywords for the CO pathway, and the GASDEPOS keyword for the SO pathway, are no longer applicable and cannot be used in the same model run. As a result, gas wet deposition processes (DEPOS, WDEP, and WETDPLT) cannot be simulated with the GASDEPVD option is used.

### 2.2.6 Specifying Source Parameters for Particle Deposition

The AERMOD model includes two methods for handling dry and/or wet 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  $\mu\text{m}$  or larger, or when the particle size distribution is known. The particle size distribution must be known reasonably well in order to use Method 1. Method 2 may be 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  $\mu\text{m}$  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  $\mu\text{m}$  in diameter) and the deposition velocity for the coarse mode (i.e., greater than 2.5  $\mu\text{m}$  but less than 10  $\mu\text{m}$  in diameter). As described in Sections 1.2 and 2.2, use of the Method 2 option is considered non-DEFAULT.

#### 2.2.6.1 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. These inputs are comparable to the particulate inputs used in the ISCST3 model (EPA,1995a). 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:

<b>Syntax:</b>	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
<b>Type:</b>	Optional, Repeatable
<b>Order:</b>	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 mass-mean aerodynamic particle diameter (microns) for each of the particle size categories, 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 ( $\text{g}/\text{cm}^3$ ) 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.

#### 2.2.6.2 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:

<b>Syntax:</b>	SO METHOD_2 Srcid (or Srcrng) FineMassFraction Dmm
<b>Type:</b>	Optional, Repeatable
<b>Order:</b>	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 (between 0 and 1) of particle mass emitted in the fine mode, less than 2.5 microns, and Dmm is the representative mass-mean aerodynamic 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).

#### 2.2.7 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 (see Section 3.3.6 of the AERMOD User's Guide (EPA, 2004a)) 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:

<b>Syntax:</b>	SO CONCUNIT Emifac Emilbl Conlbl
<b>Type:</b>	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:

<b>Syntax:</b>	SO DEPOUNIT Emifac Emilbl Deplbl
<b>Type:</b>	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.

### 2.2.8 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 3.2.13 of the 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. Since these files include data for each source for each hour, file sizes may become large.

### 2.2.9 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 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)). The meteorological data file for the 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 subsequent data records contain 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 ( $\text{W/m}^2$ )	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, $z_o$ (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 or gaseous emissions from open pits, such as surface coal mines and rock quarries. If particulate emissions are modeled, the user must specify the particle size information through the appropriate keywords described in Section 2.2. 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:

<b>Syntax:</b>	SO SRCPARAM Srcid Opemis Relhgt Xinit Yinit Pitvol (Angle)
<b>Type:</b>	Optional, Repeatable
<b>Order:</b>	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  $\text{g}/(\text{s}\cdot\text{m}^2)$ ,



- 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	NORTHPIT	1.15E-4	0.0	150.0	500.0	3.75E+6	30.0
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where the source ID is NORTHPIT, the emission rate is 1.15E-4 g/(s-m<sup>2</sup>), 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.

## 2.4 LINE SOURCE OPTION

Beginning with version 12345, a LINE source type has been added to the SO pathway. The LINE source option is invoked by specifying a source type of LINE on the source location (SO LOCATION) card. The LINE source type option allows users to specify line-type sources based on a start-point and end-point of the line and the width of the line, as an alternative to the current AREA source type for rectangular sources. The LINE source type utilizes the same routines as the AREA source type, and will give identical results for equivalent source inputs. The LINE source type also includes an optional initial sigma-z parameter to account for initial dilution of the emissions. As with the AREA source type, the LINE source type does not include the horizontal meander component in AERMOD. Since the LINE source type utilizes the AREA source algorithms, the runtime optimizations associated with the FASTAREA option will also apply to LINE sources if included.

The syntax, type and order for the LOCATION card for LINE sources are summarized below:

<b>Syntax:</b>	SO LOCATION Srcid LINE Xs1 Ys1 Xs2 Ys2 (Zs)
<b>Type:</b>	Mandatory, Repeatable
<b>Order:</b>	Must be the first card for each source input

where the Srcid parameter is the user-specified source ID, Xs1 and Ys1 are the x and y coordinates for the midpoint of one end of the LINE, Xs2 and Ys2 are the x and y coordinates for the midpoint of the other end of the LINE, and Zs is the optional elevation of the source above sea-level.

The syntax, type and order for the SRCPARAM card for LINE sources are summarized below:

<b>Syntax:</b>	SO SRCPARAM Srcid Lnemis Relhgt Width (Szinit)
<b>Type:</b>	Mandatory, Repeatable
<b>Order:</b>	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:

Lnemis - line source emission rate in  $\text{g}/(\text{s}\cdot\text{m}^2)$ ,

Relhgt - average release height above ground in meters (unless ELEVUNIT keyword is used to specify elevations in feet),

Width - width of the source in meters (with a minimum width of 1m),

Szinit - initial vertical dimension of the line source in meters (optional),

As noted above, the LINE source type option in AERMOD uses the same algorithms as used for the AREA source type for rectangular sources, and will give identical results for equivalent source definitions. The LINE source emission rate is in  $\text{g}/(\text{s}\cdot\text{m}^2)$  and the model assumes that emissions are uniformly distributed across the dimensions of the LINE source. As with the AREA source type, the LINE source type does not include the horizontal meander component that is incorporated for POINT and VOLUME sources. Also, as with the AREA source type, the LINE source type will estimate concentrations (and/or deposition) at receptors located within the dimensions of the source.

## 2.5 SPECIFYING BACKGROUND CONCENTRATIONS

Beginning with version 11059, users can specify uniform or temporally varying background concentrations using the BACKGRND keyword on the SO pathway, and beginning with version 13350 users can vary background concentrations by wind sector. Background concentrations can be included with any source group to estimate cumulative ambient impacts. Background concentrations can be specified using a range of options similar to those available with the EMISFACT keyword for source emissions, or on an hourly basis from a separate data file. For

applications that include sector-varying background concentrations, the sectors are defined based on the SO BGSECTOR keyword, as follows:

<b>Syntax:</b>	SO BGSECTOR StartSect1 StartSect2 . . . StartSectN, where $N \leq 6$
<b>Type:</b>	Optional, Non-Repeatable

For applications that include sector-varying background concentration the minimum sector width allowed is 30 degrees and warning messages will be issued for sector widths less than 60 degrees. **Sector-varying background concentrations will be selected based on the flow vector, i.e., the downwind direction, based on the wind direction specified in the surface meteorological data file.**

For applications that do not include sector-varying background concentrations, the syntax of the BACKGRND keyword is as follows:

<b>Syntax:</b>	SO BACKGRND BGflag BGvalue(i), i=1,n and/or SO BACKGRND <u>HOURLY</u> BGfilnam (BGformat)
<b>Type:</b>	Optional, Repeatable

where the BGflag parameter is the variable background concentration flag, BGvalue is the array of background concentration values associated with BGflag, HOURLY indicates use of an hourly background file, BGfilnam is the filename for the hourly background data, and BGformat is the optional Fortran format of the hourly background file ('free' format is used by default). The BGfilnam can be up to 200 characters in length based on the default parameters in AERMOD. Double quotes (") at the beginning and end of the filename can also be used as field delimiters to allow filenames with embedded spaces.

For applications that include sector-varying background concentrations, the syntax of the BACKGRND keyword is as follows:

<b>Syntax:</b>	SO BACKGRND SECTn BGflag BGvalue(i), i=1,n and/or SO BACKGRND SECTn <u>HOURLY</u> BGfilnam (BGformat)
<b>Type:</b>	Optional, Repeatable

where the SECTn parameter identifies the applicable sector as defined on the SO BGSECTOR keyword, and the other parameters are as defined above.

The HOURLY background file must include the year, month, day, and hour, followed by the background concentration, in that order (unless specified differently through the BGformat parameter). The year can be specified as either a 2-digit or 4-digit year. If an optional Fortran format is specified using the BGformat parameter, the year, month, day, and hour variables must be read as integers using the Fortran I format, and the background concentration must be read as a real variable, using the Fortran F, E, or D format, e.g., (4I2,F8.3). Note that background values that do not include decimal places can be read as Fx.0, where x is the length of the data field. The BGformat parameter must include the open and close parentheses as shown in the example, and may also include embedded spaces if double quotes (“”) are used to delimit the field. A warning message will be generated if the specified format does not meet these requirements, and AERMOD may also issue a fatal error message when reading the file in cases where real variables are read with an integer format, or vice versa.

If the optional BGformat parameter is missing, then the model will read the background data using a Fortran ‘free’ format, i.e., assuming that commas or spaces separate the data fields, and that the fields are in the order given above. The date sequence in the background data file must also match the date sequence in the hourly meteorological data files.

Note that the HOURLY option and an option to specify values based on the BGflag parameter can both be specified in the same model run. This allows the user to specify background concentrations on a temporally-varying basis, such as SEASHR, that can be used to substitute for missing values in an hourly background file. **NOTE: AERMOD will issue a fatal error message and abort processing if missing data are encountered in an HOURLY background file unless the user provides other temporally-varying background**

**concentrations (e.g., SEASHR, etc.) to substitute for missing data.** Background concentration units can be specified using the BACKUNIT keyword, described below. If the BACKUNIT keyword is omitted, default units of PPB are assumed for background NO<sub>2</sub> and SO<sub>2</sub>, PPM for CO, and UG/M3 for all other pollutants. Background concentrations specified in units of PPB or PPM are converted to UG/M3 based on reference temperature (25 C) and pressure (1013.25 mb).

To include background concentrations with a particular source group, the reserved “source ID” of BACKGROUND (or BACKGRND) can be included on the SRCGROUP keyword, including source group ALL. AERMOD will automatically include background concentrations in source group ALL, but the user can specify that background not be included in group ALL by including the NOBACKGROUND (or NOBACKGRND) keyword after ‘ALL’ on the SRCGROUP keyword. The contribution of background concentrations can be tracked separately by including a source group with BACKGROUND as the only “source ID.” **NOTE:** **The source of background concentrations and the method used to incorporate background concentrations in a cumulative impact assessment involves several considerations and should be documented and justified on a case-by-case basis.**

Background concentrations specified with the BACKGRND keyword are combined with source impacts on a temporally-paired basis to estimate cumulative ambient impacts. However, since modeled concentrations are not calculated for hours with calm or missing meteorological data, background concentrations are also omitted for those hours. This may result in the background contribution being lower than expected for short-term averages of 3-hours up to 24-hours for periods when the denominator used to calculate the multi-hour average is adjusted in accordance with EPA’s calms policy (see Section 8.3.4.2 of Appendix W), which is implemented within the AERMOD model. For example, if 12 hours out of a 24-hour period are calm or missing, the calms policy dictates that the 24-hour average concentration would be based on the sum of the 12 non-calm/non-missing hours divided by 18. The contribution from background concentrations would also be based on the sum of background values for the 12 non-calm/non-missing hours, divided by 18. If background was specified as uniform during that 24-hour

period, then the contribution from background would appear to be 33.3% lower than expected (i.e., 12/18).

The BGflag parameter must be specified as one of the following secondary keywords (the number in parentheses indicates the number of values required for each option):

- ANNUAL - annual background value (n=1),
- SEASON - background values vary seasonally (n=4),
- MONTH - background values vary monthly (n=12),
- HROFDY - background values vary by hour-of-day (n=24),
- WSPEED - background values vary by wind speed (n=6),
- SEASHR - background values vary by season and hour-of-day (n=96),
- HRDOW - background values vary by hour-of-day, and day-of-week [M-F, Sat, Sun] (n=72),
- HRDOW7 - background values vary by hour-of-day, and the seven days of the week [M, Tu, W, Th, F, Sat, Sun] (n=168),
- SHRDOW - background values vary by season, hour-of-day, and day-of-week [M-F, Sat, Sun] (n=288),
- SHRDOW7 - background values vary by season, hour-of-day, and the seven days of the week [M, Tu, W, Th, F, Sat, Sun] (n=672),
- MHRDOW - background values vary by month, hour-of-day, and day-of-week [M-F, Sat, Sun] (n=864), and
- MHRDOW7 - background values vary by month, hour-of-day, and the seven days of the week [M, Tu, W, Th, F, Sat, Sun] (n=2,016).

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 BACKGRND keyword may be repeated as many times as necessary to input all of the background values, and repeat values may be used for the numerical inputs, e.g., 12\*25.6 can be used to specify a value of 25.6 for 12 adjacent “cells” within the array of values.

Background concentration units can be specified on the optional BACKUNIT keyword on the SO pathway. The syntax of the BACKUNIT keyword is as follows:

<b>Syntax:</b>	SO BACKUNIT BGUnits
<b>Type:</b>	Optional, Non-repeatable

where the BGUnits parameter specifies the units as parts-per-billion (PPB), parts-per-million (PPM), or micrograms/cubic-meter (UG/M3). Units specified on the BACKUNIT keyword are applied to HOURLY and temporally-varying background values if both are included in the same model run. If the BACKUNIT keyword is omitted, default units of PPB are assumed for background NO<sub>2</sub> and SO<sub>2</sub>, PPM for CO, and UG/M3 for all other pollutants. Background concentrations specified in units of PPB or PPM are converted to UG/M3 based on reference temperature (25 C) and pressure (1013.25 mb).

## 2.6 OPTIONS FOR MODELING NO<sub>2</sub>

This section provides a description of the AERMOD inputs related to the non-Default PVMRM and OLM options for modeling the conversion of NO to NO<sub>2</sub>, and, beginning with version 13350, the Default Ambient Ratio Method (ARM) option and non-Default/Beta Ambient Ratio Method – 2 (ARM2). A technical description of the PVMRM algorithm as incorporated within AERMOD 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 ARM option is based on Tier 2 of the multi-tiered approach for modeling NO<sub>2</sub> impacts discussed in Section 5.4.2 of Appendix W (EPA, 2005). Further guidance on the

application of the ARM approach is provided in a clarification memo issued on March 1, 2011 (EPA, 2011). The ARM2 option is based on work sponsored by API (API, 2013) to develop a method to adjust the modeled NO<sub>x</sub> concentrations based on an empirical relationship between ambient NO<sub>x</sub> and ambient NO<sub>2</sub> concentrations. A key difference between the PVMRM and OLM methods as compared to the ARM and ARM2 methods is that ARM and ARM2 do not require the user to input background ozone (O<sub>3</sub>) concentrations. In addition, the ARM and ARM2 options do not require user-specified in-stack NO<sub>2</sub>/NO<sub>x</sub> ratios, as required by PVMRM and OLM; however, the default minimum ratio utilized in the ARM2 method may not be appropriate in cases where the sources being modeled are known to have relatively high in-stack NO<sub>2</sub>/NO<sub>x</sub> ratios.

The PVMRM and OLM algorithms have been implemented as non-Default options, which means that the PVMRM and OLM options cannot be used if the Default 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 2.6.6.1.

**It is important to note that the OLM, PVMRM, ARM, and ARM2 options listed above for modeling the conversion of NO to NO<sub>2</sub> are NOT applied to the background NO<sub>2</sub> concentrations input through the SO BACKGRND option (described in Section 2.5). The background NO<sub>2</sub> concentrations, if provided, will be added to the modeled NO<sub>2</sub> concentrations after the NO-NO<sub>2</sub> conversion has been calculated. For Tier 2 applications involving temporally-varying background NO<sub>2</sub> concentrations, the ARM or ARM2 option in AERMOD should be used to ensure that the ambient ratios are applied only to the modeled NO<sub>2</sub> concentrations before adding the contribution from background NO<sub>2</sub> concentrations.**

#### 2.6.1 Specifying Ozone Concentrations for PVMRM and OLM Options

The background ozone concentrations for the PVMRM and OLM options can be input as a single value through the OZONEVAL keyword on the CO pathway, as temporally-varying values through the O3VALUES keyword on the CO pathway, or as hourly values from a separate data file specified through the OZONEFIL keyword on the CO pathway. The user must specify background ozone concentrations through the OZONEVAL, O3VALUES, or OZONEFIL keyword in order to use the PVMRM or OLM options. The OZONEVAL or O3VALUES keyword may also be specified with the OZONEFIL keyword, in which case the value(s) entered on the OZONEVAL or O3VALUES keyword will be used to substitute for hours with missing ozone data in the hourly ozone data file. Beginning with version 13350 users can vary background ozone concentrations by wind sector. For applications that include sector-varying background ozone concentrations, the sectors are defined based on the CO O3SECTOR keyword, as follows:

<b>Syntax:</b>	CO O3SECTOR StartSect1 StartSect2 . . . StartSectN, where $N \leq 6$
<b>Type:</b>	Optional, Non-Repeatable

For applications that include sector-varying background concentration the minimum sector width allowed is 30 degrees and warning messages will be issued for sector widths less than 60 degrees. **Sector-varying background concentrations will be selected based on the flow vector, i.e., the downwind direction, based on the wind direction specified in the surface meteorological data file.**

The syntax of the OZONEVAL keyword is as follows:

<b>Syntax:</b>	CO OZONEVAL O3Value (O3Units) (w/o sectors)
	or
	CO OZONEVAL SECTn O3Value (O3Units) (w/ sectors)
<b>Type:</b>	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), and SECTn refers to the user-specified sector defined on the optional O3SECTOR keyword for which the O3Value inputs are applied.

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 reference temperature (25 C) and pressure (1013.25 mb).

The syntax of the O3VALUES keyword is as follows, and is similar to the EMISFACT keyword on the SO pathway for specifying temporally-varying emission rates:

<b>Syntax:</b>	CO O3VALUES O3Flag O3values(i), i=1,n	(w/o sectors)
	or	
	CO O3VALUES SECTn O3Flag O3values(i), i=1,n	(w/ sectors)
<b>Type:</b>	Optional, Repeatable	

where the SECTn parameter specifies the applicable sector as defined on the optional O3SECTOR keyword, and where the parameter O3Flag is the variable ozone concentration flag, and must be specified as one of the following secondary keywords (the number in parentheses indicates the number of values required for each option):

ANNUAL - annual ozone value (n=1); equivalent to OZONEVAL keyword in PPB,

SEASON - ozone values vary seasonally (n=4),

MONTH - ozone values vary monthly (n=12),

HROFDY - ozone values vary by hour-of-day (n=24),

WSPEED - ozone values vary by wind speed (n=6),

SEASHR - ozone values vary by season and hour-of-day (n=96),

HRDOW - ozone values vary by hour-of-day, and day-of-week [M-F, Sat, Sun] (n=72),

HRDOW7 - ozone values vary by hour-of-day, and the seven days of the week [M, Tu, W, Th, F, Sat, Sun] (n=168),

SHRDOW - ozone values vary by season, hour-of-day, and day-of-week [M-F, Sat, Sun] (n=288),

SHRDOW7 - ozone values vary by season, hour-of-day, and the seven days of the week [M, Tu, W, Th, F, Sat, Sun] (n=672),

MHRDOW - ozone values vary by month, hour-of-day, and day-of-week [M-F, Sat, Sun] (n=864), and

MHRDOW7 - ozone values vary by month, hour-of-day, and the seven days of the week [M, Tu, W, Th, F, Sat, Sun] (n=2,016).

The O3Values array is the array of ozone values, where the number of values is shown above for each O3Flag 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 O3VALUES keyword may be repeated as many times as necessary to input all of the ozone values, and repeat values may be used for the numerical inputs.

The order of inputs specified for the hour-of-day/day-of-week options (HRDOW, SHRDOW, SHRDOW7, etc.) are by hour-of-day, then season or month, if applicable, and then by day-of-week. For the HRDOW/SHRDOW/MHRDOW options, the days of the week are specified in the order of Weekdays (M-F), Saturdays, and Sundays. For the HRDOW7/SHRDOW7/ MHRDOW7 options, the days of the week are specified in the order of Mondays, Tuesdays, etc., through Sundays. Section 2.6.1 below includes an example illustrating the order of inputs for these options for the EMISFACT keyword.

Ozone concentrations specified on the O3VALUES keyword are assumed to be in units of PPB unless the OZONUNIT keyword is specified. The syntax of the OZONUNIT keyword is as follows:

<b>Syntax:</b>	CO OZONUNIT OzoneUnits
<b>Type:</b>	Optional, Non-repeatable

where the OzoneUnits parameter specifies the units as parts-per-billion (PPB), parts-per-million (PPM), or micrograms/cubic-meter (UG/M3). Units specified on the CONCUNIT keyword are only applied to ozone concentrations input through O3VALUES keyword, which assumes default units of PPB if the OZONUNIT keyword is not specified. Ozone concentrations specified in units of PPB or PPM are converted to UG/M3 based on reference temperature (25 C) and pressure (1013.25 mb).

Hourly ozone concentrations can be input through the optional OZONEFIL keyword. The syntax of the OZONEFIL keyword is as follows:

<b>Syntax:</b>	CO OZONEFIL O3FileName (O3Units) (O3Format)	(w/o sectors)
	or	
	CO OZONEFIL SECTn O3FileName (O3Units) (O3Format)	(w/ sectors)
<b>Type:</b>	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 O3Format parameter specifies the Fortran format to read the ozone data. If sector-varying ozone concentrations are being used, based on the CO O3SECTOR keyword, then the applicable sector ID needs to be specified, e.g., 'SECT1' indicates that values are specified for the first sector. The O3FileName can be up to 200 characters in length based on the default parameters in AERMOD. Double quotes (") at the beginning and end of the filename can also be used as field delimiters to allow filenames with embedded spaces.

The hourly ozone file must include the year, month, day, and hour, followed by the ozone concentration, in that order (unless specified differently through the O3Format parameter). The year can be specified as either 2-digit or 4-digit year. If an optional Fortran format is specified using the O3Format parameter, the year, month, day, and hour variables must be read as integers using the Fortran I format, and the ozone concentration must be read as a real variable, using the Fortran F, E, or D format, e.g., (4I2,F8.3). Note that ozone values that do not include decimal places can be read as Fx.0, where x is the length of the data field. However, ozone values that to

not include decimal places may be read incorrectly if the O3Format specified for reading the data includes decimal places. For example, a value of '1234' would be interpreted as '123.4' if a format of F4.1 was used. The O3Format parameter must include the open and close parentheses as shown in the example, and may also include embedded spaces if double quotes (") are used to delimit the field. A warning message will be generated if the specified format does not meet these requirements, and AERMOD may also issue a fatal error message when reading the file in cases where real variables are read with an integer format, or vice versa.

If the optional O3Format 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, and that the fields are in the order given above. 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 reference temperature (25 C) and pressure (1013.25 mb).

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 background ozone values have been specified using the OZONEVAL and/or O3VALUES keyword, then the appropriate value will be used to substitute for missing ozone data from the ozone file. If no OZONEVAL or O3VALUES keywords are used, then the model will assume full conversion of NO to NO<sub>2</sub> for hours with missing ozone data.

#### 2.6.2 Specifying the Ambient Equilibrium NO<sub>2</sub>/NO<sub>x</sub> Ratio for PVMRM and OLM

The PVMRM option for modeling conversion of NO to NO<sub>2</sub> incorporates a default NO<sub>2</sub>/NO<sub>x</sub> ambient equilibrium ratio of 0.90. Beginning with version 11059 of AERMOD, a default equilibrium ratio of 0.90 has also been incorporated in the OLM option. A NO<sub>2</sub>/NO<sub>x</sub> equilibrium ratio other than 0.90 can be specified for either the PVMRM or OLM option through the optional NO2EQUIL keyword on the CO pathway. The syntax of the NO2EQUIL keyword is as follows:

<b>Syntax:</b>	CO NO2EQUIL NO2Equil
<b>Type:</b>	Optional, Non-repeatable

where the NO2Equil parameter is the NO<sub>2</sub>/NO<sub>x</sub> equilibrium ratio and must be between 0.10 and 1.0, inclusive.

### 2.6.3 Specifying the Default In-stack NO<sub>2</sub>/NO<sub>x</sub> Ratio for PVMRM and OLM

The PVMRM and OLM options for modeling conversion of NO to NO<sub>2</sub> require that an in-stack NO<sub>2</sub>/NO<sub>x</sub> ratio be specified. Based on guidance issued June 28, 2010, regarding the 1-hour NO<sub>2</sub> NAAQS, AERMOD has been modified to require the user to specify in-stack NO<sub>2</sub>/NO<sub>x</sub> ratios for each source under the OLM and PVMRM options, i.e., AERMOD no longer assumes a default in-stack ratio of 0.10 for the OLM or PVMRM option.

The in-stack NO<sub>2</sub>/NO<sub>x</sub> 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 for specific sources if the CO NO2STACK card has been specified. The syntax of the NO2STACK keyword is as follows:

<b>Syntax:</b>	CO NO2STACK NO2Ratio
<b>Type:</b>	Optional, Non-repeatable

where the NO2Ratio parameter is the default in-stack NO<sub>2</sub>/NO<sub>x</sub> 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 OLM and PVMRM options require the user to specify an in-stack NO<sub>2</sub>/NO<sub>x</sub> ratio for each source, using either the CO NO2STACK or SO NO2RATIO cards (described in Section 2.6.4), or both.

### 2.6.4 Specifying In-stack NO<sub>2</sub>/NO<sub>x</sub> Ratios by Source for PVMRM and OLM



As noted above, the PVMRM and OLM options for modeling NO<sub>2</sub> conversion require in-stack NO<sub>2</sub>/NO<sub>x</sub> ratios to be specified for each source, i.e., AERMOD no longer assumes a default in-stack ratio of 0.10 for the OLM option. The user can specify in-stack NO<sub>2</sub>/NO<sub>x</sub> ratios through the optional NO2RATIO keyword on the SO pathway. The syntax of the NO2RATIO keyword is as follows:

<b>Syntax:</b>	SO NO2RATIO SrcID or SrcRange NO2Ratio
<b>Type:</b>	Optional, Repeatable
<b>Order:</b>	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 NO<sub>2</sub>/NO<sub>x</sub> 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 NO<sub>2</sub>/NO<sub>x</sub> ratio for each source, using either the CO NO2STACK (described in Section 2.6.3) or SO NO2RATIO cards, or both.

#### 2.6.5 Specifying Combined Plumes for OLM

The OLM option for modeling NO<sub>2</sub> conversion includes an option for specifying which sources are to be modeled as combined plumes, i.e., where the NO<sub>x</sub> within the plumes competes for the available ambient ozone. Sources which are not specified for modeling as combined plumes will be modeled as individual plumes, i.e., where all of the ambient ozone is available for

conversion of NO to NO<sub>2</sub>. 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:

<b>Syntax:</b>	SO OLMGROUP OLMGrpID SrcID's and/or SrcRange's or SO OLMGROUP <u>ALL</u>
<b>Type:</b>	Optional, Repeatable (except for OLMGROUP ALL)
<b>Order:</b>	Must follow the LOCATION card for each source input; OLMGROUP ALL must follow the LOCATION card for all sources

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 record, and if more than one input card is needed to define the sources for a particular OLM group, then additional records 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 a specific OLM group unless the same group of sources is also identified on a SRCGROUP card. Another constraint for the OLMGROUP keyword 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 option, 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.

#### 2.6.6 Specifying Ambient NO<sub>2</sub>/NO<sub>x</sub> Ratios for the ARM and ARM2 Options

The Default ARM and non-Default/BETA ARM2 options, incorporated in AERMOD beginning with version 13350, are both based on applying an ambient ratio of NO<sub>2</sub>/NO<sub>x</sub> to a modeled NO<sub>x</sub> concentration to estimate ambient NO<sub>2</sub> concentrations. The ARM option utilizes separate ambient ratios for modeling 1-hr and annual NO<sub>2</sub> impacts, whereas the ARM2 option applies an ambient ratio to the 1-hr modeled NO<sub>x</sub> concentrations based on a formula derived empirically from ambient monitored ratios of NO<sub>2</sub>/NO<sub>x</sub>. Default values based on EPA recommendations for the 1-hr and annual ambient ratios under the ARM option are 0.80 (EPA, 2011) and 0.75 (EPA, 2005), respectively. The ARM2 option includes default upper and lower limits on the ambient ratio applied to the modeled NO<sub>x</sub> concentration of 0.9 and 0.2, respectively. The default ratios for the ARM and ARM2 options can be modified using the optional ARMRATIO on the CO pathway as follows:

<b>Syntax:</b>	CO ARMRATIO ARM_1h (ARM_ann)	For ARM Option
	or CO ARMRATIO ARM2_Min ARM2_Max	For ARM2 Option
<b>Type:</b>	Optional, Non-Repeatable	

#### 2.6.7 Modeling NO<sub>2</sub> Increment Credits with PVMRM

Due to the ozone-limiting effects of the PVMRM option, the predicted concentrations of NO<sub>2</sub> are not linearly proportional to the emission rate. Therefore, the approach of modeling NO<sub>2</sub> 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 NO<sub>2</sub> 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 NO<sub>2</sub>.

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.

#### 2.6.7.1 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: SO<sub>2</sub> (3-hr, 24-hr, and annual averages), NO<sub>2</sub> (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.

#### 2.6.7.2 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 NO<sub>2</sub>, 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 NO<sub>2</sub> 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 NO<sub>2</sub> 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<sub>x</sub> conversion chemistry on specific groups of sources. The expression shown in Equation 1 above represents four model simulations: **(A+B)**, **(B)**, **(B+C)**, and **(B)** again. In this case, the two **(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 **A** and **B** groups together, then models the **B** and **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.

### 2.6.7.3 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:

<b>Syntax:</b>	SO PSDGROUP Grpid Srcid's and/or Srcrng's
<b>Type:</b>	Mandatory for PSDCREDIT option, Repeatable
<b>Order:</b>	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 used 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.

#### 2.6.7.4 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<sub>x</sub> 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 NO<sub>2</sub>. 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 2.6.6.2. The results reported under the ‘PSDINC’ source group label are based on the expression presented above in Equation 2.

## 2.7 VARIABLE EMISSION RATES

### 2.7.1 Specifying Variable Emission Factors (EMISFACT)

The AERMOD model provides the option of specifying variable emission rate factors for individual sources or for groups of sources. The syntax, type and order of the EMISFACT keyword are summarized below:

<b>Syntax:</b>	SO EMISFACT SrcID or SrcRange Qflag Qfact(i), i=1,n
<b>Type:</b>	Optional, Repeatable
<b>Order:</b>	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 (the number in parentheses indicates the number of values required for each option):

- 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),
- HRDOW - emission rates vary by hour-of-day, and day-of-week [M-F, Sat, Sun] (n=72),
- HRDOW7 - emission rates vary by hour-of-day, and the seven days of the week [M, Tu, W, Th, F, Sat, Sun] (n=168),
- 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 more recent HRDOW and MHRDOW options are presented below, with column headers to indicate the order in which values are to be input:

SO EMISFACT STK1 HRDOW	enter 24 hourly scalars for each of the "days", first for Weekdays (Monday-Friday), then for Saturdays, and finally for Sundays, e.g.,									
** Weekdays:	Hrs:	1-5	6	7-17	18	19-24				
SO EMISFACT STK1 HRDOW		5*0.3	0.5	11*1.0	0.5	6*0.3				
** Saturdays:	Hrs:	1-5	6	7-17	18	19-24				
SO EMISFACT STK1 HRDOW		5*0.3	0.5	11*1.0	0.5	6*0.3				
** Sundays:	Hrs:	1-5	6	7-17	18	19-24				
SO EMISFACT STK1 HRDOW		5*0.3	0.5	11*1.0	0.5	6*0.3				

SO EMISFACT STK1 HRDOW7	enter 24 hourly scalars for each of the "days", first for Mondays, then for Tuesdays, ..., then for Saturdays, and finally for Sundays, e.g.,									
** Mondays:	Hrs:	1-5	6	7-17	18	19-24				
SO EMISFACT STK1 HRDOW7		5*0.3	0.5	11*1.0	0.5	6*0.3				
** Tuesdays:	Hrs:	1-5	6	7-17	18	19-24				
SO EMISFACT STK1 HRDOW7		5*0.3	0.5	11*1.0	0.5	6*0.3				
.										
.										
.										
** Saturdays:	Hrs:	1-5	6	7-17	18	19-24				
SO EMISFACT STK1 HRDOW7		5*0.3	0.5	11*1.0	0.5	6*0.3				
** Sundays:	Hrs:	1-5	6	7-17	18	19-24				
SO EMISFACT STK1 HRDOW7		5*0.3	0.5	11*1.0	0.5	6*0.3				

SO EMISFACT STK1 MHRDOW	enter 24 hourly scalars for each of the twelve months, first 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, first 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	

### 2.7.2 Specifying an Hourly Emission Rate File (HOUREMIS)

The source (SO) pathway includes an option for inputting hourly emission rates for the AERMOD model, controlled by the HOUREMIS keyword. AERMOD currently allows for a single hourly emission file to be used with each model run. The syntax, type and order for this keyword are summarized below:

<b>Syntax:</b>	SO HOUREMIS Emifil Srcid's (and/or Srcrng's)
<b>Type:</b>	Optional, Repeatable
<b>Order:</b>	Must follow the LOCATION card for each source input

where the Emifil parameter specifies the filename for the hourly emission file, and Srcid or Srcrng identify the source or sources for which hourly emission rates are included. The Emifil filename can be up to 200 characters in length based on the default parameters in AERMOD. Double quotes (“”) at the beginning and end of the filename can also be used as field delimiters to allow filenames with embedded spaces. 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. The user may include more than one HOUREMIS card in a runstream file, if needed to specify additional sources, but there can be only one hourly emissions file, and therefore the filename must be the same on all HOUREMIS cards.

The format of each record of the hourly emissions file includes a pathway and keyword (SO HOUREMIS), followed by the Year, Month, Day, Hour, Source ID, and emission rate (in the appropriate units). For POINT sources, the stack gas exit temperature (K), and stack gas exit velocity (m/s) are also specified. Beginning with version 09292, the release heights and initial dispersion coefficients can also be varied on an hourly basis for AREA, AREAPOLY, AREACIRC, and VOLUME sources using the HOUREMIS option. The user selects this enhanced option by including the additional source parameters in the hourly emissions file. AERMOD determines whether hourly release heights and initial dispersion coefficients are being used based on the first HOUREMIS record for each source, and these additional parameters must

be included on all HOUREMIS records unless the emissions are missing, which is indicated by leaving the emission rate and all fields beyond the source ID blank.

The hourly emissions file is processed using the same routines used to process the runstream input file, therefore each of the parameters must be separated by at least one space, but otherwise the format is flexible. It is also not necessary to include the SO HOUREMIS on each line, as long as the parameters (Year, Month, etc.) do not begin before column 13. The data in the hourly emission file must also include the exact same dates as are included in the meteorological input files, and the source IDs must correspond to the source IDs defined on the SO LOCATION cards and be in the same order as defined in the 'aermod.inp' file.

The model will check for a date mismatch between the hourly emissions file and the meteorological data, and also for a source ID mismatch. However, it is not necessary to process the entire hourly emissions file on each model run, i.e., the correct emissions data will be read if the ME DAYRANGE or the ME STARTEND cards (see Section 3.5.4 of the AERMOD User's Guide) are used, as long as all the dates (including those that are processed and those that are skipped) match the meteorological data files.

An example of several lines from an hourly emissions file for two point sources is provided below:

SO HOUREMIS	88	8	16	1	STACK1	52.5	382.60	12.27
SO HOUREMIS	88	8	16	1	STACK2	44.3	432.33	22.17
SO HOUREMIS	88	8	16	2	STACK1	22.3	377.88	9.27
SO HOUREMIS	88	8	16	2	STACK2	42.2	437.68	19.67
SO HOUREMIS	88	8	16	3	STACK1	51.5	373.72	11.87
SO HOUREMIS	88	8	16	3	STACK2	41.3	437.28	18.77
SO HOUREMIS	88	8	16	4	STACK1	36.0	374.83	9.63
SO HOUREMIS	88	8	16	4	STACK2	43.7	437.68	18.23

The use of hourly varying release heights and initial dispersion coefficients for VOLUME and AREA sources is illustrated in the following example:

SO	HOUREMIS	88	3	1	1	VOL1	500.0	2.0	2.0	2.0
SO	HOUREMIS	88	3	1	1	AREA1	5.000	2.0	2.0	
SO	HOUREMIS	88	3	1	2	VOL1	500.0	2.0	2.0	3.0
SO	HOUREMIS	88	3	1	2	AREA1	5.000	2.0	3.0	
SO	HOUREMIS	88	3	1	3	VOL1	500.0	2.0	2.0	4.0
SO	HOUREMIS	88	3	1	3	AREA1	5.000	2.0	4.0	

For POINT sources, the model will use the stack release height and stack inside diameter defined on the SO SRCPARAM card, but will use the emission rate, exit temperature and exit velocity from the hourly emission file. As noted above regarding VOLUME and AREA sources, if the emission rate, exit temperature and exit velocity are not included for a particular hour, i.e, any or all of those fields are blank, the model will interpret emissions data for that hour as missing and will set the parameters to zero. Since the emission rate will be zero, there will be no calculations made for that hour and that source.

## 2.8 OUTPUT OPTIONS

A number of enhancements have been incorporated in AERMOD, beginning with version 11059, to more fully support the form of the new 1-hour NO<sub>2</sub> and SO<sub>2</sub> standards, as well as the 24-hour PM<sub>2.5</sub> standard. The form of these NAAQS are similar in that they are based on a ranked percentile value averaged over the number of years processed. In order to support implementation of recent guidance regarding modeling to demonstrate compliance with these NAAQS, the RECTABLE keyword had been modified to allow user-specified ranks of short-term averages (for all pollutants) up to the 999th highest value. The previous version of AERMOD was limited to the 10th-highest value and also restricted the rank for the 24-hour PM<sub>2.5</sub> NAAQS to the 8th highest value (corresponding to the 98th percentile of daily values during a year).

### 2.8.1 Output Options for 24-hour PM<sub>2.5</sub> and 1-hour NO<sub>2</sub> and SO<sub>2</sub> Standards

Beginning with version 11059, three output options have been incorporated on the OU pathway to support the 1-hour NO<sub>2</sub> and SO<sub>2</sub> standards, especially the analyses that may be required to determine a source's (or group of sources) contributions to modeled violations of the

NAAQS for comparison to the Significant Impact Level (SIL). The form of the standards, based on averages of ranked values across years, complicates this analysis, especially for the 1-hour NO<sub>2</sub> and SO<sub>2</sub> standards which are based on ranked values from the distribution of daily maximum 1-hour averages. One of the options (MAXDCONT) can also be used for the 24-hour PM<sub>2.5</sub> NAAQS.

The MAXDCONT option, applicable to 24-hour PM<sub>2.5</sub>, 1-hour NO<sub>2</sub> and 1-hour SO<sub>2</sub> standards, can be used to determine the contribution of each user-defined source group to the high ranked values for a target source group, paired in time and space. This is accomplished as an internal post-processing routine after the main model run is completed. The user can specify the range of ranks to analyze, or can specify an upper bound rank, e.g., 8th-highest for 1-hour NO<sub>2</sub> (note that “upper bound” rank implies a higher concentration, while “lower bound” rank implies a lower concentration), and a threshold value, such as the NAAQS, for the target source group. The model will process each rank within the range specified, but will stop after the first rank (in descending order of concentration) that is below the threshold.

The syntax, type and order of the optional MAXDCONT keyword are summarized below:

<b>Syntax:</b>	OU MAXDCONT GrpID UpperRank LowerRank FileName (FileUnit) or OU MAXDCONT GrpID UpperRank <u>THRESH</u> ThreshValue FileName (FileUnit)
<b>Type:</b>	Optional, Repeatable

where GrpID is the target or reference source group toward which contributions are being determined, UpperRank and LowerRank are the upper bound and lower bound ranks (where upper bound rank implies higher concentrations and lower bound rank implies lower concentrations), THRESH indicates that the lower bound rank is determined based on a lower concentration threshold, ThreshValue is the user-specified concentration threshold for GrpID impacts which serves as a lower bound on the range of ranks analyzed, FileName is the output file name, and (FileUnit) is the optional file unit. The filename can be up to 200 characters in length based on the default parameters in AERMOD. Double quotes (“) at the beginning and



end of the filename can also be used as field delimiters to allow filenames with embedded spaces. When the THRESH option is selected AERMOD will skip the contribution analysis for any receptor where the target GrpID impact is less than the threshold, and will stop processing completely after the first rank where the target GrpID values are below the threshold for all receptors. **NOTE: It is important note that the range of ranks that can be analyzed under the MAXDCONT option is limited to the range of ranks (not the individual ranks) specified on the OU RECTABLE keyword, even when the THRESH option is used in lieu of specifying a LowerRank value. AERMOD will issue a fatal error if the THRESH option is used and the range of ranks is less than or equal to 8 for the 1-hr SO<sub>2</sub> NAAQS, or less than or equal to 12 for the 1-hr NO<sub>2</sub> and 24-hr PM<sub>2.5</sub> NAAQS. Non-fatal warning messages will be generated if the THRESH option is used and the range of ranks is less than or equal to 24 for the 1-hr SO<sub>2</sub> NAAQS, or less than or equal to 28 for the 1-hr NO<sub>2</sub> and 24-hr PM<sub>2.5</sub> NAAQS.**

When the MAXDCONT option is specified, AERMOD stores all meteorological variables in memory for each hour during the initial stage of processing in order to optimize the model runtime during the post-processing stage. Any temporally-varying emissions and background concentrations, including background ozone concentrations for the OLM and PVMRM options, are also stored in memory for each hour. While optimizing runtime for the post-processing, this approach may also significantly increase the memory storage requirements of the model. In addition, since the MAXDCONT option extracts meteorological variables and other temporally-varying data stored in memory to optimize runtime, the MAXDCONT option cannot be used with the model “re-start” option using the INITFILE and SAVEFILE keywords on the CO pathway, or with the MULTYEAR option on the CO pathway.

The MAXDAILY option, introduced with version 11059, is applicable to 1-hour NO<sub>2</sub> and 1-hour SO<sub>2</sub> NAAQS and generates a file of daily maximum 1-hour concentrations for a specified source group, for each day in the data period processed. The MAXDAILY file provides an interim output that may be useful for analyzing the 1-hour NO<sub>2</sub> and SO<sub>2</sub> NAAQS. The syntax, type and order of the optional MAXDAILY keyword are summarized below:

<b>Syntax:</b>	OU MAXDAILY GrpID FileName (FileUnit)
<b>Type:</b>	Optional, Non-repeatable

where GrpID is the source group selected for daily maximum 1-hour values, FileName is the name of the MAXDAILY output file, and FileUnit is the optional file unit. The filename can be up to 200 characters in length based on the default parameters in AERMOD. Double quotes (“) at the beginning and end of the filename can also be used as field delimiters to allow filenames with embedded spaces.

Another option applicable to 1-hour NO<sub>2</sub> and 1-hour SO<sub>2</sub> NAAQS introduced with version 11059, the MXDYBYR keyword, generates a summary of daily maximum 1-hour concentrations by year for each rank specified on the RECTABLE keyword. The data periods included in the MXDYBYR file are the periods used in the MAXDCONT postprocessing option. The syntax, type and order of the optional MXDYBYR keyword are summarized below:

<b>Syntax:</b>	OU MXDYBYR GrpID FileName (FileUnit)
<b>Type:</b>	Optional, Non-repeatable

where GrpID is the source group selected for daily maximum 1-hour values summarized by year, FileName is the name of the MXDYBYR output file, and FileUnit is the optional file unit. The filename can be up to 200 characters in length based on the default parameters in AERMOD. Double quotes (“) at the beginning and end of the filename can also be used as field delimiters to allow filenames with embedded spaces.

### 2.8.2 Miscellaneous Output Options

The optional SUMMFILE keyword can be used to generate a separate formatted output file containing the summary of high ranked values included at the end of the standard ‘aermod.out’ file. The optional FILEFORM keyword can be used to specify the use of exponential notation, rather than fixed format as currently used, for results that are output to

separate result files. The optional NOHEADER keyword can be used to suppress file headers in formatted output file options. These new options are described below.

The syntax, type and order of the optional SUMMFILE keyword are summarized below:

<b>Syntax:</b>	OU SUMMFILE SummFileName
<b>Type:</b>	Optional, Non-repeatable

where the SummFileName is the name of the external file containing the summary of high ranked values. The SUMMFILE filename can be up to 200 characters in length based on the default parameters in AERMOD. Double quotes (“”) at the beginning and end of the filename can also be used as field delimiters to allow filenames with embedded spaces. In addition to the summary of high ranked values, the SUMMFILE also includes the “MODEL SETUP OPTIONS SUMMARY” page from the main ‘aermod.out’ file.

The syntax, type and order of the optional FILEFORM keyword are summarized below:

<b>Syntax:</b>	OU FILEFORM <u>EXP</u> or <u>FIX</u>
<b>Type:</b>	Optional, Non-repeatable

where the EXP parameter specifies that output results files will use exponential-formatted values, and the FIX parameter specifies that the output results files will use fixed-formatted values. The default option is to use fixed-formatted results, so use of FILEFORM = ‘FIX’ is extraneous. Note that AERMOD only examines the first three characters of the input field, so that the full terms of ‘EXPONENTIAL’ or ‘FIXED’ can also be used. The format specified on this optional keyword is applicable to PLOTFILES, plot-formatted POSTFILES, MAXIFILES, RANKFILES, and SEASONHR files, but will not affect the format of results in the standard ‘aermod.out’ file or the optional SUMMFILE. The FILEFORM optional may be useful to preserve precision in applications with relatively small impacts, especially for the purpose of post-processing hourly concentrations using the POSTFILE option. The option may also be useful for applications with relatively large impacts that may overflow the Fortran format

specifier of F13.5 used for fixed-formatted outputs. AERMOD will issue a warning message if values that exceed the range allowed for fixed-format are detected unless the FILEFORM EXP option has been selected.

The syntax, type and order of the optional NOHEADER keyword are summarized below:

<b>Syntax:</b>	OU NOHEADER FileType1 FileType2 FileType3 ... FileTypeN or OU NOHEADER <u>ALL</u>
<b>Type:</b>	Optional, Non-repeatable

where FileTypeN identifies the keywords for formatted output files for which the file headers will be suppressed, which may include the includes the following file types: POSTFILE, PLOTFILE, MAXIFILE, RANKFILE, SEASONHR, MAXDAILY, MXDYBYR, and MAXDCONT. The keyword ALL may be used to specify that header records will be suppressed for ALL applicable output file types.

## 2.9 MODEL STORAGE LIMITS

The AERMOD model has been designed using a dynamic storage allocation approach, where the model allocates data storage as needed based on the number of sources, receptors, source groups, and input requirements, up to the maximum amount of memory available on the computer being used. The AERMOD model uses dynamic arrays to allocate data storage at model runtime rather than at compile time. The AERMOD model preprocesses the model runstream input file to determine the data storage requirements for a particular model run, and then allocates the input data arrays before processing the setup data. Once the setup processing is completed, the model allocates storage for the result arrays. When allocating data storage, the AERMOD model traps for errors, e.g., not enough memory available to allocate. If the allocation is unsuccessful, then an error message is generated by the model and further processing is prevented. If the CO RUNORNOT NOT option is selected, the model will still go through all array allocations so that the user can determine if sufficient memory is available to complete the

run. Also, an estimate of the total amount of memory needed for a particular run is printed out as part of the first page of printed output.

The storage parameters that are established at model runtime are as follows:

NSRC =	Number of Sources
NREC =	Number of Receptors
NGRP =	Number of Source Groups
NOLM =	Number of OLM Groups (OLMGROUP Keyword)
NAVE =	Number of Short Term Averaging Periods
NVAL =	Number of High Values by Receptor (RECTABLE Keyword)
NTYP =	Number of Output Types (CONC currently is the only output type)
NMAX =	Number of Overall Maximum Values (MAXTABLE Keyword)
NQF =	Number of Variable Emission Rate Factors per Source
NPDMAX =	Number of Particle Diameter Categories per Source
NVMAX =	Number of Vertices for Area Sources (including AREA, AREACIRC, and AREAPOLY source types) and/or OPENPIT Sources
NSEC =	Number of Sectors for Building Downwash Parameters (set to 36 if downwash sources are included)
NURB =	Number of Urban Areas (URBANOPT Keyword)
NNET =	Number of Cartesian and/or Polar Receptor Networks
IXM =	Number of X-coord (Distance) Values per Receptor Network
IYM =	Number of Y-coord (Direction) Values per Receptor Network
NARC =	Number of Receptor Arcs Used with EVALCART Keyword
NEVE =	Number of Events for EVENT processing

The MAXDCONT option on the OU pathway introduced with version 11059 to determine source group contributions to modeled values under the 24-hr PM<sub>2.5</sub> and 1-hr SO<sub>2</sub> and NO<sub>2</sub> NAAQS can significantly increase the memory requirements of AERMOD due to the fact that all meteorological and other variables needed to perform the MAXDCONT processing are stored in memory in order to optimize model runtime. The memory requirements for the

MAXDCONT have been optimized with version 12060, and a new option on the ME pathway was also introduced with version 12060 to further reduce memory requirements for applications involving less than five (5) years of meteorological data, e.g., if one or more years of site-specific meteorological data area being used. The NUMYEARS keyword on the ME pathway allows the user to specify the number of years of data being processed for purposes of allocating array storage for the MAXDCONT option, with a default value of five (5) years being assumed if the optional NUMYEARS keyword is omitted. The syntax of the optional NUMYEARS keyword is summarized below:

<b>Syntax:</b>	ME NUMYEARS NumYrs
<b>Type:</b>	Optional, Non-repeatable

where NumYrs specifies the number of (full) years of meteorological data being processed.

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*Note: All references listed here, with the exception of AECOM (2010), Hanrahan (1999a and 1999b), Qian and Venkatram (2011), Luhar and Rayner (2009) and EPA (2008), can be found on the U.S. EPA SCRAM website at the following url: <http://www.epa.gov/ttn/scram/>*

## **APPENDIX A. ALPHABETICAL KEYWORD REFERENCE**

This appendix provides an alphabetical listing of all of the keywords used by the AERMOD model. Each keyword is identified as to the pathway for which it applies, the keyword type (either mandatory or optional, and either repeatable or non-repeatable), and with a brief description of the function of the keyword. For a more complete description of the keywords, including a list of associated parameters, refer to Section 2.0 of this Addendum, the Functional Keyword/Parameter Reference in Appendix B of this Addendum, and/or the Detailed Keyword Reference in Section 3 of the AERMOD User's Guide (EPA, 2004a).

<b>Keyword</b>	<b>Path</b>	<b>Type</b>	<b>Keyword Description</b>
AREAVERT	SO	M – R	Specifies location of vertices for an AREAPOLY source type (mandatory if AREAPOLY source is used)
ARMRATIO	CO	O – N	Option to override default minimum and maximum (equilibrium) ratios for the ARM or ARM2 options
AVERTIME	CO	M – N	Averaging time(s) to process
BACKGRND	SO	O – R	Option to specify temporally varying background concentrations
BACKUNIT	SO	O – N	Option to specify units for background concentrations
BGSECTOR	SO	O – N	Option to specify wind sectors for use in varying background concentrations of the pollutant being modeled by wind direction.
BUILDHGT	SO	O – R	Building height values for each wind sector
BUILDLEN	SO	O – R	Building projected length values for each wind sector
BUILDWID	SO	O – R	Building projected width values for each wind sector
CONCUNIT	CO	O – N	Optional conversion factors for emission input units and concentration output units
DAYRANGE	ME	O – R	Specifies days or ranges of days to process (default is to process all data)
DAYTABLE	OU	O – N	Option to provide summaries for each averaging period for each day processed.
DCAYCOEF	CO	O – N	Optional decay coefficient for exponential decay
DEBUGOPT	CO	O – N	Option to generate detailed result and meteorology files for debugging purposes
DEPOUNIT	SO	O – N	Optional conversion factors for emission input units and deposition output units
DISCCART	RE	O – R	Defines discretely placed receptors referenced to a Cartesian system
DISCPOLR	RE	O – R	Defines discretely placed receptors referenced to a polar system
ELEVUNIT	SO RE	O – N O – N	Defines input units for receptor elevations (RE path), or source elevations (SO path) (defaults to meters)
EMISFACT	SO	O – R	Optional input for variable emission rate factors
EMISUNIT	SO	O – N	Optional conversion factors for emission units and concentration units
ERRORFIL	CO	O – N	Option to generate detailed error listing file (error file is mandatory for CO RUNORNOT NOT case)
EVALCART	RE	O – R	Defines discretely placed receptor locations referenced to a Cartesian system, grouped by arc for use with the EVALFILE output option
EVALFILE	OU	O – R	Option to output file of normalized arc maxima for model evaluation studies

<b>Keyword</b>	<b>Path</b>	<b>Type</b>	<b>Keyword Description</b>
EVENTFIL	CO	O – N	Specifies whether to generate an input file for EVENT model
EVENTLOC	EV	M – R	Describes receptor location for an event
EVENTOUT	OU	M – N	Specifies level of output information provided by the EVENT model
EVENTPER	EV	M – R	Describes data and averaging period for an event
FILEFORM	OU	O – N	Specify fixed or exponential format for output results files
FINISHED	ALL	M – N	Identifies the end of inputs for a particular pathway
FLAGPOLE	CO	O – N	Specifies whether to accept receptor heights above local terrain (m) for use with flagpole receptors, and allows for a default flagpole height to be specified
GASDEPDF	CO	O – N	Option to override default parameters for gas dry deposition
GASDEPOS	SO	O – R	Specify source parameters for gas deposition algorithms
GASDEPVD	CO	O – N	Option to specify deposition velocity for gas dry deposition
GDLANUSE	CO	O – N	Specify land use categories by sector for gas dry deposition
GDSEASON	CO	O – N	Specify seasonal definitions for gas dry deposition
GRIDCART	RE	O – R	Defines a Cartesian grid receptor network
GRIDPOLR	RE	O – R	Defines a polar receptor network
HALFLIFE	CO	O – N	Optional half-life for exponential decay
HOUREMIS	SO	O – R	Option for specifying hourly emission rates in a separate file
INCLUDED	SO, RE, EV	O – R	Option to include input data from a separate file in the runstream for the SO and/or RE pathways, or for the EV pathway for EVENTS
INITFILE	CO	O – N	Option to initialize model from file of intermediate results generated by SAVEFILE option
LOCATION	SO	M – R	Identifies coordinates for particular source location
LOW_WIND	CO	O – N	Option for user-specified parameters for the LOWWIND1 and LOWWIND2 BETA options
MASSFRAX	SO	O – R	Optional input of mass fraction for each particle size category
MAXDAILY	OU	O – R	Option to output file of daily maximum 1-hour values for each day processed; only applicable for 1-hour NO <sub>2</sub> and 1-hour SO <sub>2</sub> NAAQS
MAXDCONT	OU	O – R	Option to output contributions of each source group to ranked values averaged across years for a reference source group, paired in time and space; only applicable for 24-hour PM <sub>2.5</sub> , 1-hour NO <sub>2</sub> , and 1-hour SO <sub>2</sub> NAAQS
MAXIFILE	OU	O – R	Option to list events exceeding a threshold value to file (if CO EVENTFIL option is used, these events are included in the input file generated for the EVENT model)
MAXTABLE	OU	O – R	Option to summarize the overall maximum values

<b>Keyword</b>	<b>Path</b>	<b>Type</b>	<b>Keyword Description</b>
METHOD_2	SO	O – R	Specify optional source parameters for METHOD_2 option for particle deposition
MODELOPT	CO	M – N	Job control and dispersion options
MULTYEAR	CO	O – N	Specifies that run is part of a multi-year run, e.g., for PM-10 H6H in five years
MXDYBYR	OU	O – R	Option to output file of daily maximum 1-hour values by year, for each year processed; only applicable for 1-hour NO <sub>2</sub> and 1-hour SO <sub>2</sub> NAAQS
NOHEADER	OU	O – N	Option to suppress file headers for output file options, e.g., POSTFILE, PLOTFILE, MAXDCONT, etc
NO2EQUIL	CO	O – N	Option to override default NO <sub>2</sub> /NO <sub>x</sub> equilibrium ratio for PVMRM or OLM
NO2RATIO	SO	O – R	Option to specify in-stack NO <sub>2</sub> /NO <sub>x</sub> equilibrium ratio for OLM and PVMRM options by source
NO2STACK	CO	O – N	Option to specify default in-stack NO <sub>2</sub> /NO <sub>x</sub> equilibrium ratio for OLM and PVMRM options; may be overridden by NO2RATIO
NUMYEARS	ME	O – N	Option to specify the number of years of meteorological data being processed for purposes of allocating array storage for the OU MAXDCONT option
OLMGROUP	SO	O – R	Specifies sources to combine for OLM option for merging plumes
OZONEFIL	CO	O – N	Specifies hourly ozone file for OLM and PVMRM options
OZONEVAL	CO	O – N	Specifies background value of ozone for OLM and PVMRM options
OZONUNIT	CO	O – N	Option to specify units for temporally-varying ozone concentrations for the O3VALUES keyword.
O3SECTOR	CO	O – N	Option to specify wind sectors for use in varying background ozone (O3) concentrations by wind direction for use with OLM and PVMRM options.
O3VALUES	CO	O – R	Option to specify temporally varying ozone concentrations for use with OLM and PVMRM options for estimating NO <sub>2</sub>
PARTDENS	SO	O – R	Specifies particle density by size category for particle deposition
PARTDIAM	SO	O – R	Specifies particle diameters by size category for particle deposition
PLOTFILE	OU	O – R	Option to write certain results to a storage file suitable for input to plotting routines
POLLUTID	CO	M – N	Identifies pollutant being modeled
POSTFILE	OU	O – R	Option to write results to a mass storage file for postprocessing
PROFBASE	ME	M – N	Specifies the base elevation for the potential temperature profile
PROFFILE	ME	M – N	Describes input profile meteorological data file

<b>Keyword</b>	<b>Path</b>	<b>Type</b>	<b>Keyword Description</b>
PSDGROUP	SO	O – R	Specifies source groups for PSDCREDIT option with PVMRM
RANKFILE	OU	O – R	Option to produce output file of ranked values for Q-Q plots
RECTABLE	OU	O – R	Option to output high ranked value(s) by receptor
RUNORNOT	CO	M – N	Identifies whether to run model or process setup information only
SAVEFILE	CO	O – N	Option to store intermediate results for later restart of the model after user or system interrupt
SCIMBYHR	ME	O – N	Specifies sampling parameters for the SCIM option
SEASONHR	OU	O – R	Option to output values by season and hour-of-day
SITEDATA	ME	O – N	Describes on-site meteorological station
SRCGROUP	SO	M – R	Identification of source groups
SRCPARAM	SO	M – R	Identifies source parameters for a particular source
STARTEND	ME	O – N	Specifies start and end dates to be read from input meteorological data file (default is to read entire file)
STARTING	ALL	M – N	Identifies the start of inputs for a particular pathway
SUMMFILE	OU	O – N	Option to output summary of high ranked values to separate file
SURFDATA	ME	M – N	Surface meteorological station
SURFFILE	ME	M – N	Describes input surface meteorological data file
TITLEONE	CO	M – N	First line of title for output
TITLETWO	CO	O – N	Optional second line of output title
TOXXFILE	OU	O – R	Creates output file for use with TOXX model component of TOXST
UAIRDATA	ME	M – N	Upper air meteorological station
URBANOPT	CO	O – R	Option to specify population for urban option
URBANSRC	SO	O – R	Option to specify use of urban option by source
WDROTATE	ME	O – N	Wind direction rotation adjustment
WINDCATS	ME	O – N	Upper bound of wind speed categories
XBADJ	SO	O – R	Along-flow distances from the stack to the center of the upwind face of the projected building
YBADJ	SO	O – R	Across-flow distances from the stack to the center of the upwind face of the projected building

## APPENDIX B. FUNCTIONAL KEYWORD/PARAMETER REFERENCE

This appendix provides a functional reference for the keywords and parameters used by the input runstream files for the AERMOD model. The keywords are organized by functional pathway, and within each pathway the order of the keywords is based on the function of the keyword within the preprocessor. The pathways used by the preprocessor are as follows, in the order in which they appear in the runstream file and in the tables that follow:

- CO** - for specifying overall job **C**ontrol options; and
- SO** - for specifying **S**ource location information (optional);
- RE** - for specifying **R**eceptor information; and
- ME** - for specifying **M**eteorology information and options;
- EV** - for specifying **E**vent information and options;
- OU** - for specifying **O**utput file information.

The pathways and keywords are presented in the same order as in the Detailed Keyword Reference in Section 3 of the AERMOD User's Guide (EPA, 2004a), and in the Quick Reference at the end of the manual, with the exception of new keywords that are not reflected in the original user's guide.

Two types of tables are provided for each pathway. The first table lists all of the keywords for that pathway, identifies each keyword as to its type (either mandatory or optional and either repeatable or non-repeatable), and provides a brief description of the function of the keyword. The second type of table presents the parameters for each keyword, in the order in which they should appear in the runstream file where order is important, and describes each parameter in detail.

The following convention is used for identifying the different types of input parameters. Parameters corresponding to secondary keywords which should be input "as is" are listed on the tables with all capital letters and are underlined, although none of the inputs to AERMOD are treated as case-sensitive. Other parameter names are given with an initial capital letter and are not input "as is." In all cases, the parameter names are intended to be descriptive of the input variable being represented, and they often correspond to the Fortran variable names used in the

AERMOD code. Parentheses around a parameter indicate that the parameter is optional for that keyword. The default that is taken when an optional parameter is left blank is explained in the discussion for that parameter.



TABLE B-1  
DESCRIPTION OF CONTROL PATHWAY KEYWORDS

CO Keywords	Type	Keyword Description
STARTING	M – N	Identifies the start of CONTROL pathway inputs
TITLEONE	M – N	First line of title for output
TITLETWO	O – N	Optional second line of title for output
MODELOPT	M – N	Job control and dispersion options
AVERTIME	M – N	Averaging time(s) to process
URBANOPT	O – R	Specifies parameters for urban dispersion option
POLLUTID	M – N	Identifies type of pollutant being modeled
HALFLIFE <sup>1</sup>	O – N	Optional half life used for exponential decay
DCAYCOEF <sup>1</sup>	O – N	Optional decay coefficient
GASDEPDF	O – N	Option to override default parameters for gas dry deposition
GASDEPVD	O – N	Option to specify deposition velocity for gas dry deposition
GDLANUSE	O – N	Specify land use categories by sector for gas dry deposition
GDSEASON	O – N	Specify seasonal definitions for gas dry deposition
LOW_WIND	O – N	Option for user-specified parameters for the LOWWIND1 and LOWWIND2 BETA options
NO2EQUIL	O – N	Option to override default NO <sub>2</sub> /NO <sub>x</sub> equilibrium ratio for PVMRM or OLM
NO2STACK	O – N	Option to specify default in-stack NO <sub>2</sub> /NO <sub>x</sub> equilibrium ratio for OLM and PVMRM options; may be overridden by NO2RATIO option on SO pathway
ARMRATIO	O – N	Option to override default minimum and maximum (equilibrium) ratios for the ARM or ARM2 options
O3SECTOR	O – N	Specifies optional wind sectors for use in varying background ozone (O <sub>3</sub> ) concentrations by wind direction for use with OLM and PVMRM options; can be used with the OZONEFIL, OZONEVAL, and O3VALUES options.
OZONEFIL	O – R	Specifies filename for hourly ozone file for use with OLM and PVMRM options
OZONEVAL	O – R	Specifies background value of ozone for use with OLM and PVMRM options
O3VALUES	O – R	Option to specify temporally varying ozone concentrations for use with OLM and PVMRM options for estimating NO <sub>2</sub>
OZONUNIT	O – N	Option to specify units for temporally-varying ozone concentrations for the O3VALUES keyword
FLAGPOLE	O – N	Specifies whether to accept receptor heights above local terrain (m) for use with flagpole receptors, and allows for default flagpole height to be specified
RUNORNOT	M – N	Identifies whether to run model or process setup information only

EVENTFIL <sup>2</sup>	O – N	Specifies whether to generate an input file for EVENT model
SAVEFILE <sup>3</sup>	O – N	Option to store intermediate results for restart of model after user or system interrupt
INITFILE <sup>3</sup>	O – N	Option to initialize model from intermediate results generated by SAVEFILE option
MULTYEAR <sup>3</sup>	O – N	Option to process multiple years of meteorological data (one year per run) and accumulate high short term values across years
DEBUGOPT	O – N	Option to generate detailed result and meteorology files for debugging purposes
ERRORFIL	O – N	Option to generate detailed error listing file
FINISHED	M – N	Identifies the end of CONTROL pathway inputs

Type: M – Mandatory      N – Non-Repeatable  
           O – Optional        R – Repeatable

- 1) Either HALFLIFE or DCAYCOEF may be specified. If both cards appear a warning message will be issued and the first value entered will be used in calculations. The DFAULT option assumes a half life of 4 hours for SO<sub>2</sub> modeled in urban mode.
- 2) The EVENTFIL keyword controls whether or not to generate an input file for EVENT processing. The primary difference between AERMOD "regular" processing and EVENT processing by AERMOD is in the treatment of source group contributions. The AERMOD model treats the source groups independently, whereas EVENT processing determines individual source contributions to particular events, such as the design concentrations determined from AERMOD, or user-specified events. By specifying the EVENTFIL keyword, an input runstream file will be generated that can be used directly for EVENT processing. The events included in the generated EVENT processing input file are defined by the RECTABLE and MAXIFILE keywords on the OU pathway, and are placed in the Event pathway.
- 3) The SAVEFILE and INITFILE keywords work together to implement the model's re-start capabilities. Since the MULTYEAR option utilizes the re-start features in a special way to accumulate high short term values from year to year, it cannot be used together with the SAVEFILE or INITFILE keyword in the same model run.

TABLE B-2  
DESCRIPTION OF CONTROL PATHWAY KEYWORDS AND PARAMETERS

Keyword	Parameters	
TITLEONE	Title1	
where:	Title1	First line of title for output, character string of up to 68 characters (additional characters can be included on the TITLEONE keyword, but only the first 68 characters are printed in the output files).
TITLETWO	Title2	
where:	Title2	Optional second line of title for output, character string of up to 68 characters (any additional characters are not printed)
MODELOPT	<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>SCIM</u> <u>PVMRM</u> <u>PSDCREDIT</u> <u>DEPOS</u> and/or or or <u>OLM</u> <u>DDEP</u> <u>ELEV</u> <u>WARNCHKD</u> or <u>ARM</u> and/or or <u>ARM2</u> <u>WDEP</u>  <u>FASTALL</u> <u>DRYDPLT</u> <u>WETDPLT</u> <u>NOURBTRAN</u> <u>LOWWIND1</u> <u>VECTORWS</u> or or or or <u>FASTAREA</u> <u>NODRYDPLT</u> <u>NOWETDPLT</u> <u>LOWWIND2</u>	
where:	<u>DFAULT</u>  <u>BETA</u>  <u>CONC</u> <u>DEPOS</u> <u>DDEP</u> <u>WDEP</u> <u>AREADPLT</u>  <u>FLAT</u> <u>ELEV</u>  <u>NOSTD</u> <u>NOCHKD</u>  <u>WARNCHKD</u>	<p>Specifies that regulatory default options will be used; specification of <u>DFAULT</u> option will override non-<u>DFAULT</u> options that may be specified</p> <p>Non-<u>DFAULT</u> option that allows for draft, “Beta” test options to be used; includes <u>PSDCREDIT</u> option and capped and horizontal stack releases</p> <p>Specifies that concentration values will be calculated</p> <p>Specifies that total deposition flux values will be calculated</p> <p>Specifies that dry deposition flux values will be calculated</p> <p>Specifies that wet deposition flux values will be calculated</p> <p>Specifies use of non-<u>DFAULT</u> method for optimized plume depletion due to dry removal mechanisms for area sources</p> <p>Non-<u>DFAULT</u> option of assuming flat terrain will be used</p> <p>Default option of assuming elevated terrain will be used;  <u>Note:</u> Both <u>FLAT</u> and <u>ELEV</u> may be specified in the same model run to allow specifying the non-<u>DFAULT</u> <u>FLAT</u> terrain option on a source-by-source basis (see the SO LOCATION keyword for specifying <u>FLAT</u> sources)</p> <p>Non-<u>DFAULT</u> option of no stack-tip downwash will be used</p> <p>Non-<u>DFAULT</u> option of suspending date checking will be used for non-sequential meteorological data files, also implemented when <u>SCREEN</u> option is specified</p> <p>Specifies option for issuing warning messages rather than fatal errors for non-sequential meteorological data files</p>

Keyword	Parameters	
	<u>NOWARN</u>	Option to suppress detailed listing of warning messages in the main output file will be used
	<u>SCREEN</u>	Non-DFAULT option for running AERMOD in a screening mode for AERSCREEN will be used
	<u>SCIM</u>	Non-DFAULT Sampled Chronological Input Model (SCIM) option; applies to ANNUAL averages only; SCIM sampling parameters must be specified on the ME pathway
	<u>PVMRM</u>	Non-DFAULT Plume Volume Molar Ratio Method (PVMRM) for NO <sub>2</sub> conversion will be used
	<u>OLM</u>	Non-DFAULT Ozone Limiting Method (OLM) for NO <sub>2</sub> conversion will be used
	<u>ARM</u>	DFAULT Ambient Ratio Method (ARM) for NO <sub>2</sub> conversion will be used
	<u>ARM2</u>	Non- DFAULT Ambient Ratio Method – 2 (ARM2) for NO <sub>2</sub> conversion will be used
	<u>PSDCREDIT</u>	Non-DFAULT BETA test option to calculate the increment consumption with PSD credits using the PVMRM option
	<u>FASTALL</u>	Non-DFAULT option to optimize model runtime for POINT, VOLUME and AREA sources (AREA optimizations formerly associated with TOXICS option)
	<u>FASTAREA</u>	Non-DFAULT option to optimize model runtime for AREA sources (formerly associated with TOXICS option)
	<u>DRYDPLT</u>	Option to incorporate dry depletion (removal) processes associated with dry deposition algorithms; dry depletion will be used by default if dry deposition algorithms are invoked
	<u>NODRYDPLT</u>	Option to disable dry depletion (removal) processes
	<u>WETDPLT</u>	Option to incorporate wet depletion (removal) processes associated with wet deposition algorithms; wet depletion will be used by default if wet deposition algorithms are invoked
	<u>NOWETDPLT</u>	Option to disable wet depletion (removal) processes.
	<u>NOURBTRAN</u>	Non-DFAULT option to revert to the urban option as implemented prior to version 11059 (see Section 2.1.1).
	<u>LOWWIND1</u>	Non-DFAULT BETA option to address concerns regarding model performance under low wind speed conditions (see Section 2.1.10). Cannot be used with LOWWIND2 option.
	<u>LOWWIND2</u>	Non-DFAULT BETA option to address concerns regarding model performance under low wind speed conditions (see Section 2.1.10). Cannot be used with LOWWIND1 option.
	<u>VECTORWS</u>	Option to specify that input wind speeds are vector mean (or resultant) wind speeds, rather than scalar means (see Section 2.1.2). The VECTORWS option is <u>not</u> linked with the DFAULT option.
AVERTIME	Time1 Time2 ... TimeN <u>MONTH</u> <u>PERIOD</u> or <u>ANNUAL</u>	
where:	TimeN	Nth optional averaging time (1, 2, 3, 4, 6, 8, 12, or 24-hr)

Keyword	Parameters	
	<u>MONTH</u> <u>PERIOD</u>  <u>ANNUAL</u>	<p>Option to calculate <u>MONTH</u>ly averages</p> <p>Option to calculate averages for the entire data <u>PERIOD</u>; for the <u>MULTYEAR</u> option, the summary of highest <u>PERIOD</u> averages is based on the highest <u>PERIOD</u> average across the individual years processed with <u>MULTYEAR</u></p> <p>Option to calculate <u>ANNUAL</u> averages (assumes complete years); for multi-year meteorological data files, with and without the <u>MULTYEAR</u> option, the multi-year average of the <u>ANNUAL</u> values is reported</p>
URBANOPT	<p>For multiple urban areas:  UrbanID Urbpop (Urbname) (UrbRoughness)</p> <p>For single urban area:  Urbpop (Urbname) (UrbRoughness)</p>	
where:	UrbanID UrbPop (UrbName) (UrbRoughness)	<p>Specifies the alphanumeric urban ID (up to eight characters)</p> <p>Specifies the population of the urban area</p> <p>Specifies the name of the urban area (optional)</p> <p>Specifies the urban surface roughness length, meters (optional, defaults to 1.0m; value other than 1.0m treated as non-DEFAULT)</p>
POLLUTID	Pollut ( <u>H1H</u> or <u>H2H</u> or <u>INC</u> )	
where:	Pollut	<p>Identifies type of pollutant being modeled. Any name of up to eight characters may be used, e.g., <u>SO2</u>, <u>NOX</u>, <u>CO</u>, <u>PM25</u>, <u>PM-2.5</u>, <u>PM10</u>, <u>PM-10</u>, <u>TSP</u> or <u>OTHER</u>.</p> <p><u>NOTE</u>: Some processing options are pollutant-specific, and require the user to specify the appropriate pollutant ID. For example, use of <u>PM10</u>, <u>PM-10</u>, <u>PM25</u>, <u>PM2.5</u>, <u>PM-2.5</u>, <u>PM-25</u>, <u>LEAD</u>, <u>NO2</u>, <u>SO2</u>, or <u>OTHER</u> allows for the use of the <u>MULTYEAR</u> option.</p> <p>Use of <u>PM25</u>, <u>PM2.5</u>, <u>PM-2.5</u>, or <u>PM-25</u>, triggers special processing for the PM-2.5 NAAQS, based on values averaged across the number of years processed (see Section 2.1.5.1).</p> <p>Use of <u>NO2</u> or <u>SO2</u> triggers special processing for their respective 1-hr NAAQS based on daily maximum 1-hr concentrations, averaged across the number of years modeled if the <u>CO</u> <u>AVERTIME</u> keyword includes 1-hr averages (see Section 2.1.7).</p> <p>Use of <u>NO2</u> is required in order to use the <u>OLM</u> and <u>PVMRM</u> options for simulating conversion of <u>NO</u> to <u>NO2</u>.</p> <p>Use of <u>SO2</u> also triggers the use of a 4-hour half-life for <u>SO2</u> decay for urban applications under the regulatory default option.</p>

Keyword	Parameters	
	<u>H1H</u> or <u>H2H</u> or <u>INC</u>	Use of the <u>H1H</u> or <u>H2H</u> or <u>INC</u> keyword (not case-specific) disables the special processing requirements associated the 1-hr NO2 and SO2 NAAQS and the 24-hr PM2.5 NAAQS. Specifying one of these keywords would allow for modeling PM2.5 24-hr increments which are based on the H2H value, and also allow evaluating NO2 options in AERMOD based on incomplete years of field measurements.
HALFLIFE	Haflif	
where:	Haflif	Half life used for exponential decay (s)
DCAYCOEF	Decay	
where:	Decay	Decay coefficient for exponential decay ( $s^{-1}$ ) = 0.693/HAFLIF
GASDEPDF	React F_Seas2 F_Seas5 (Refpoll)	
where:	React F_Seas2 F_Seas5 (Refpoll)	Value for pollutant reactivity factor ( $f_o$ ) Fraction (F) of maximum green LAI for seasonal category 2 Fraction (F) of maximum green LAI for seasonal category 5 Optional name of reference pollutant
GASDEPVD	Uservd	
where:	Uservd	User-specified dry deposition velocity (m/s) for gaseous pollutants
GDLANUSE	Sec1 Sec2 ... Sec36	
where:	Sec1 Sec2 . . Sec36	Land use category for winds blowing toward sector 1 (10 degrees) Land use category for winds blowing toward sector 2 (20 degrees)  Land use category for winds blowing toward sector 36 (360 degrees)
GDSEASON	Jan Feb ... Dec	
where:	Jan . . . . Dec	Seasonal category for January: 1 = Midsummer/Lush vegetation; 2 = Autumn/Unharvested cropland; 3 = Late autumn after harvest or Winter with no snow; 4 = Winter with continuous snow cover; or 5 = Transitional spring/partial green coverage/short annuals)  Seasonal category for December
LOW_WIND	SVmin (WSmin) [for LOWWIND1] SVmin (WSmin (FRANmax)) [for LOWWIND2]	
where:	SVmin (WSmin) (FRANmax)	Minimum value of sigma-v, within a range of 0.01 to 1.0 m/s Minimum value of wind speed, within a range of 0.01 to 1.0 m/s Maximum value meander factor, within a range of 0.50 to 1.0 inclusive

Keyword	Parameters	
NO2EQUIL	NO2Equil	
where:	NO2Equil	Equilibrium ratio of NO <sub>2</sub> /NO <sub>x</sub> for the PVMRM and OLM options; between 0.1 and 1.0, inclusive (default is 0.9)
NO2STACK	NO2Ratio	
where:	NO2Ratio	Default in-stack ratio of NO <sub>2</sub> /NO <sub>x</sub> for PVMRM and OLM options, which may be overridden by NO2RATIO keyword on SO pathway.  <u>NOTE:</u> Beginning with version 11059, AERMOD no longer assumes a default in-stack ratio of 0.1 for the OLM option.
ARMRATIO	ARM_1hr (ARM_Ann) For ARM Option or ARM2_Min ARM2_Max For ARM2 Option	
where:	ARM_1hr ARM_Ann ARM2_Min ARM2_Max	ARM ambient ratio for NO <sub>2</sub> /NO <sub>x</sub> applied for 1hr NO <sub>2</sub> concentrations, with a default value of 0.80 ARM ambient ratio for NO <sub>2</sub> /NO <sub>x</sub> applied for Annual NO <sub>2</sub> concentrations, with a default value of 0.75 Minimum ARM2 ambient ratio, with a default value of 0.20 Maximum ARM2 ambient ratio, with a default value of 0.90
O3SECTOR	StartSect1 StartSect2 . . . StartSectN, where N is ≤ 6	
where:	StartSect1 StartSect2 . . StartSectN	Starting direction for the first sector Starting direction for the second sector . . Starting direction for the last sector  <u>NOTE:</u> The minimum sector width allowed is 30 degrees, and warning messages will be issued for sector widths less than 60 degrees. Sector-varying O <sub>3</sub> concentrations will be selected based on the flow vector, i.e., the downwind direction based on the wind direction specified in the surface meteorological data file.
OZONEFIL	O3FileName (O3Units) (O3Format) (without O3SECTORs) or SECTn O3FileName (O3Units) (O3Format) (with O3SECTORs)	
where:	SECTn O3FileName (O3Units) (O3Format)	Applicable sector (n = 1 to 6) defined on the CO O3SECTOR keyword, if specified Filename for hourly ozone data file (YR, MN, DY, HR, O3Value) Units of ozone data (PPM, PPB, or UG/M3); default is UG/M3 Fortran format statement to read ozone file; default is FREE-format, i.e., comma or space-delimited data fields (Yr Mn Dy Hr O3Value). The O3Format parameter must include open and close parentheses, the date variables must be read as integers (Fortran I

Keyword	Parameters	
		format), and the O3Value must be read as real (Fortran F, E, or D format), e.g., '(4I2,F8.3)'. The year may be specified as a 2-digit or 4-digit year, and the data period in the OZONEFIL must match the data period in the meteorological data files.
OZONEVAL	O3Value (O3Units ) or SECTn O3Value (O3Units)	(without O3SECTORs)  (with O3SECTOR)
where:	SECTn  O3Value (O3Units)	Applicable sector (n = 1 to 6) defined on the CO O3SECTOR keyword, if specified Background ozone concentration; also used to substitute for missing data in OZONEFIL Units of ozone value (PPM, PPB, or UG/M3); default is UG/M3
O3VALUES	O3Flag O3values(i), i=1,n) or SECTn O3Flag O3values(i), i=1,n)	(without O3SECTORs)  (with O3SECTORs)
where:	SECTn  O3Flag          O3values	Applicable sector (n = 1 to 6) defined on the CO O3SECTOR keyword, if specified Background ozone values flag: <u>ANNUAL</u> for annual; <u>SEASON</u> for seasonal; <u>MONTH</u> for monthly; <u>HROFDY</u> for hour-of-day; <u>WSPEED</u> for wind speed category; <u>SEASHR</u> for season-by-hour; <u>HRDOW</u> for emission rates vary by hour-of-day, and day-of-week [M-F, Sat, Sun]; <u>HRDOW7</u> for emission rates vary by hour-of-day, and the seven days of the week [M, Tu, W, Th, F, Sat, Sun]; <u>SHRDOW</u> for season by hour-of-day by day-of-week (M-F,Sat,Sun); <u>SHRDOW7</u> for season by hour-of-day by day-of-week (M,Tu,W,Th,F,Sat,Sun); <u>MHRDOW</u> for month by hour-of-day by day-of-week (M-F,Sat,Sun); <u>MHRDOW7</u> for month by hour-of-day by day-of-week (M,Tu,W,Th,F,Sat,Sun) Array of background concentrations, for: <u>ANNUAL</u> , n=1; <u>SEASON</u> , n=4; <u>MONTH</u> , n=12; <u>HROFDY</u> , n=24; <u>WSPEED</u> , n=6; <u>SEASHR</u> , n=96; <u>HRDOW</u> , n=72; <u>HRDOW7</u> , n=168; <u>SHRDOW</u> , n=288; <u>SHRDOW7</u> , n=672; <u>MHRDOW</u> , n=864; <u>MHRDOW7</u> , n=2016  <u>NOTE:</u> Background ozone values input through the O3VALUES keyword are assumed to be in units of PPB, unless modified by the OZONUNIT keyword.
OZONUNIT	OzoneUnits	
where:	OzoneUnits	Ozone concentration units for O3VALUES, specified as <u>PPB</u> for parts-per-billion, <u>PPM</u> for parts-per-million, or <u>UG/M3</u> for micrograms/cubic-meter.
FLAGPOLE	(Flagdf)	



Keyword	Parameters	
where:	(Flagdf)	Default value for height of (flagpole) receptors above local ground, a default value of 0.0 m is used if this optional parameter is omitted
RUNORNOT	<u>RUN</u> or <u>NOT</u>	
where:	<u>RUN</u> <u>NOT</u>	Indicates to run full model calculations Indicates to process setup data and report errors, but to <u>not</u> run full model calculations
EVENTFIL	(Evfile) (Evopt)	
where:	(Evfile)  (Evopt)	Identifies the filename to be used to generate a file for input to EVENT model (Default=EVENTFIL.INP) Optional parameter to specify the level of output detail selected for the EVENT model: either <u>SOCONT</u> or <u>DETAIL</u> (default is <u>DETAIL</u> if this parameter is omitted)
SAVEFILE	(Savfil) (Dayinc) (Savfl2)	
where:	(Savfil)  (Dayinc) (Savfl2)	Specifies name of disk file to be used for storing intermediate results (default = SAVE.FIL); file is overwritten after each dump Number of days between dumps (optional: default is 1) Optional second disk filename to be used on alternate dumps - eliminates risk of system crash during the dump. If blank, file is overwritten each time.
INITFILE	(Inifil)	
where:	(Inifil)	Specifies name of disk file of intermediate results to be used for initializing run (default = SAVE.FIL)
MULTYEAR	<u>(H6H)</u> Savfil (Inifil)	
where:	<u>(H6H)</u>  Savfil  (Inifil)	Optional field formerly used to specify that High-Sixth-High is being calculated for use in PM10 processing; no longer required Specifies name of file to be used for storing results at the end of the year Optional name of file used for initializing the results arrays from previous year(s). The Inifil parameter is not used for the first year in the multi-year run.
DEBUGOPT	<u>MODEL</u> (Dbgfil) and/or <u>METEOR</u> (Dbmfil) and/or <u>PRIME</u> (Prmfil) and/or <u>DEPOS</u> and/or [ <u>AREA</u> (AreaDbFil) or <u>LINE</u> (LineDbFil)] and/or [ <u>PVMRM</u> (Dbpvfil) or <u>OLM</u> (OLMfil) or <u>ARM</u> (ARMfil) or <u>ARM2</u> (ARM2fil)]	
where:	<u>MODEL</u> (Dbgfil)  <u>METEOR</u> (Dbmfil)	Specifies that <u>MODEL</u> debugging output will be generated Optional filename for the model calculation debug file (a default filename of 'MODEL.DBG' will be used if omitted) Specifies that <u>METEOR</u> ological profile data file will be generated Optional filename for the meteorological profile data file (a default filename of 'METEOR.DBG' will be used if omitted)

Keyword	Parameters	
	<u>PRIME</u> (Prmfil)  <u>DEPOS</u>  <u>AREA</u> or <u>LINE</u> (AreaDbfil)  <u>PVMRM</u> (Dbpvfil)  <u>OLM</u> (OLMfil)  <u>ARM</u> (ARMfil)  <u>ARM2</u> (ARM2fil)	<p>Specifies that <u>PRIME</u> debugging output will be generated Optional filename for PRIME debug file (a default filename of 'PRIME.DBG' will be used if omitted)</p> <p>Specifies that <u>DEPOS</u>ition debugging output will be generated, using default filenames of 'GDEP.DAT' for gas deposition and 'PDEP.DAT' for particle deposition.</p> <p>Specifies that <u>AREA</u> or <u>LINE</u> debugging output will be generated, including debugging outputs for OPENPIT sources, if included in the modeling.</p> <p>Optional filename for AREA debug file (a default filename of 'AREA.DBG' will be used if omitted)</p> <p>Specifies that <u>PVMRM</u> debugging output will be generated Optional filename for PVMRM debug file (a default filename of 'PVMRM.DBG' will be used if omitted)</p> <p>Specifies that <u>OLM</u> debugging output will be generated Optional filename for OLM debug file (a default filename of 'OLM.DBG' will be used if omitted)</p> <p>Specifies that <u>ARM</u> debugging output will be generated Optional filename for ARM debug file (a default filename of 'ARM.DBG' will be used if omitted)</p> <p>Specifies that <u>ARM2</u> debugging output will be generated Optional filename for ARM2 debug file (a default filename of 'ARM2.DBG' will be used if omitted)</p> <p><u>Note:</u> The user can specify any of the applicable debug options for a particular model run, and the options can be specified in any order. However, the optional filenames must be specified immediately after the keyword option associated with the filename. Also note that debugging information that was written to the main 'aermod.out' file for the <u>MODEL</u> debug option prior to version 13350 is now written to the applicable debug file (either <u>MODEL</u> or <u>PRIME</u>), and beginning with version 14134 debug information for AREA/LINE/OPENPIT sources is written to the <u>AREA</u> debug file.</p>
ERRORFIL	(Errfil)	
where:	(Errfil)	Specifies name of detailed error listing file (default = ERRORS.LST)

TABLE B-3  
DESCRIPTION OF SOURCE PATHWAY KEYWORDS

SO Keywords	Type	Keyword Description
STARTING	M – N	Identifies the start of SOURCE pathway inputs
ELEVUNIT	O – N	Defines input units for source elevations (defaults to meters), must be first keyword after SO STARTING if used.
LOCATION	M – R	Identifies coordinates for particular source
SRCPARAM	M – R	Identifies source parameters for a particular source
BUILDHGT	O – R	Building height values for each wind sector
BUILDLIN	O – R	Building projected length values for each wind sector
BUILDWID	O – R	Building projected width values for each wind sector
XBADJ	O – R	Along-flow distances from the stack to the center of the upwind face of the projected building
YBADJ	O – R	Across-flow distances from the stack to the center of the upwind face of the projected building
AREAVERT	M – R	Specifies location of vertices for an AREAPOLY source type (mandatory if AREAPOLY source is used)
URBANSRC	O – R	Identifies which sources to model with urban effects
EMISFACT	O – R	Optional input for variable emission rate factors
EMISUNIT	O – N	Optional unit conversion factors for emissions, concentrations
CONCUNIT	O – N	Optional conversion factors for emissions and concentrations
DEPOUNIT	O – N	Optional conversion factors for emissions and depositions
PARTDIAM	O – R	Input variables for optional input of particle size (microns)
MASSFRAX	O – R	Optional input of mass fraction for each particle size category
PARTDENS	O – R	Optional input of particle density (g/cm <sup>3</sup> ) for each size category
METHOD_2	O – R	Optional input of parameters for METHOD_2 particle deposition
GASDEPOS	O – R	Optional input of gas deposition parameters
NO2RATIO	O – R	Option to specify in-stack NO <sub>2</sub> /NO <sub>x</sub> equilibrium ratio for OLM and PVMRM options by source
HOUREMIS	O – R	Option for specifying hourly emission rates in a separate file
BGSECTOR	O – N	Specifies optional wind sectors for use in varying background concentrations by wind direction for the pollutant being modeled, as specified on the BACKGRND keyword

<b>SO Keywords</b>	<b>Type</b>	<b>Keyword Description</b>
BACKGRND	O – R	Option to specify temporally varying background concentrations
BACKUNIT	O – N	Option to specify units for background concentrations
INCLUDED	O – R	Option to include data from a separate file in the runstream
OLMGROUP	O – R	Specifies sources to combine for OLM option to account for merging plumes
PSDGROUP <sup>1</sup>	O – R	Specifies source groups for PSDCREDIT option with PVMRM
SRCGROUP <sup>1</sup>	M – R	Identification of source groups
FINISHED	M – N	Identifies the end of SOURCE pathway inputs

- 1) The PSDGROUP or SRCGROUP keywords must be the last keyword within the SO pathway before the FINISHED keyword. The SRCGROUP keyword is mandatory, unless the PSDCREDIT option is used, which requires the PSDGROUP option instead.

TABLE B-4

## DESCRIPTION OF SOURCE PATHWAY KEYWORDS AND PARAMETERS

Keyword	Parameters	
ELEVUNIT	<u>METERS</u> or <u>FEET</u>	
where:	<u>METERS</u> <u>FEET</u>	Specifies input units for source base elevations of meters (default if ELEVUNIT is omitted) Specifies input units for source elevations of feet <u>Note:</u> This keyword applies to source base elevations only.
LOCATION	SrcID Srctyp Xs Ys (Zs) [for all Srctyp's except <u>LINE</u> ] or (FLAT) [for 'FLAT & ELEV' option] or SrcID Srctyp Xs1 Ys1 Xs2 Ys2 (Zs) [for <u>LINE</u> Srctyp] or (FLAT) [for 'FLAT & ELEV' option]	
where:	SrcID Srctyp Xs Ys Xs1, Xs2 Ys1, Ys2 (Zs) (FLAT)	Source identification code (unique alphanumeric string of up to 12 characters) Source type: <u>POINT</u> , <u>POINTCAP</u> , <u>POINTHOR</u> , <u>VOLUME</u> , <u>AREA</u> , <u>AREAPOLY</u> , <u>AREACIRC</u> , <u>OPENPIT</u> , <u>LINE</u> x-coord of source location, corner for <u>AREA</u> , <u>AREAPOLY</u> , and <u>OPENPIT</u> , center for <u>AREACIRC</u> (m) y-coord of source location, corner for <u>AREA</u> , <u>AREAPOLY</u> , and <u>OPENPIT</u> , center for <u>AREACIRC</u> (m) x-coords of midpoint for start and end of <u>LINE</u> source (m) y-coords of midpoint for start and end of <u>LINE</u> source (m) Optional z-coord of source location (elevation above mean sea level, defaults to 0.0 if omitted) Optional keyword to indicate non-DEFAULT option for identifying sources to model as FLAT terrain
SRCPARAM	SrcID Ptemis Stkhgt Stktmp Stkvel Stkdia ( <u>POINT</u> , <u>POINTCAP</u> , <u>POINTHOR</u> source) Vlemis Relhgt Syinit Szinit ( <u>VOLUME</u> source) Aremis Relhgt Xinit (Yinit) (Angle) (Szinit) ( <u>AREA</u> source) Aremis Relhgt Nverts (Szinit) ( <u>AREAPOLY</u> source) Aremis Relhgt Radius (Nverts) (Szinit) ( <u>AREACIRC</u> source) Lnemis Relhgt Width (Szinit) ( <u>LINE</u> source) Opemis Relhgt Xinit Yinit Pitvol (Angle) ( <u>OPENPIT</u> source)	
where:	SrcID __Emis __Hgt	Source identification code Source emission rate: in g/s for Ptemis and Vlemis; g/(s-m <sup>2</sup> ) for Aremis, Lnemis, and Opemis Source physical release height above ground (center of height for <u>VOLUME</u> , height above base of pit for <u>OPENPIT</u> )

Keyword	Parameters	
	Stktmp Stkvel Stkdia Syinit Szinit Xinit Yinit  Angle  Nverts  Radius Width Pitvol	Stack gas exit temperature (K) Stack gas exit velocity (m/s) Stack inside diameter (m) Initial lateral dimension of <u>VOLUME</u> source (m) Initial vertical dimension of <u>VOLUME</u> , <u>AREA</u> , <u>LINE</u> source (m) Length of side of <u>AREA</u> source in X-direction (m) Length of side of <u>AREA</u> source in Y-direction (m) (optional parameter, assumed to be equal to Xinit if omitted) Orientation angle (deg) of <u>AREA</u> or <u>OPENPIT</u> source relative to N measured positive clockwise, rotated around the source location, (Xs,Ys) (optional parameter, assumed to be 0.0 if omitted) Number of vertices used for <u>AREAPOLY</u> or <u>AREACIRC</u> source (optional for <u>AREACIRC</u> sources) Radius of circular area for <u>AREACIRC</u> source (m) Width of <u>LINE</u> source (m) Volume of <u>OPENPIT</u> source (m <sup>3</sup> )
BUILDHGT	SrcID (or SrcRange) Dsbh(i), i=1,36	
where:	SrcID SrcRange  Dsbh	Source identification code Range of sources (inclusive) for which building dimensions apply, entered as two alphanumeric strings separated by a '-' Array of direction-specific building heights (m) beginning with 10 degree flow vector and incrementing by 10 degrees clockwise
BUILDLIN	SrcID (or SrcRange) Dsbl(i), i=1,36	
where:	SrcID SrcRange Dsbl	Source identification code Range of sources (inclusive) for which building dimensions apply Array of direction-specific building lengths (m) beginning with 10 degree flow vector and incrementing by 10 degrees clockwise
BUILDWID	SrcID (or SrcRange) Dsbw(i), i=1,36	
where:	SrcID SrcRange Dsbw	Source identification code Range of sources (inclusive) for which building dimensions apply Array of direction-specific building widths (m) beginning with 10 degree flow vector and incrementing by 10 degrees clockwise
XBADJ	SrcID (or SrcRange) Xbadj(i), i=1,36	
where:	SrcID SrcRange Xbadj(i)	Source identification code Range of sources (inclusive) for which XBADJ distances apply Array of direction-specific along-wind distances beginning with 10 degree flow vector and incrementing by 10 degrees clockwise
YBADJ	SrcID (or SrcRange) Ybadj(i), i=1,36	
where:	SrcID SrcRange Ybadj(i)	Source identification code Range of sources (inclusive) for which YBADJ distances apply Array of direction-specific across-wind distances beginning with 10 degree flow vector and incrementing by 10 degrees clockwise

Keyword	Parameters	
AREAVERT	SrcID Xv(1) Yv(1) Xv(2) Yv(2) ... Xv(i) Yv(i)	
where:	SrcID Xv(1)  Yv(1)  Xv(i) Yv(i)	Source identification code X-coordinate of the first vertex of an AREAPOLY source (must be the same as the value of Xs for that source defined on the SO LOCATION card) Y-coordinate of the first vertex of an AREAPOLY source (must be the same as the value of Ys for that source defined on the SO LOCATION card) X-coordinate for the i <sup>th</sup> vertex of an AREAPOLY source Y-coordinate for the i <sup>th</sup> vertex of an AREAPOLY source
URBANSRC	<u>For multiple urban areas:</u> UrbanID SrcID's and/or SrcRng's  <u>For single urban areas:</u> SrcID's and/or SrcRng's	
where:	UrbanID SrcID SrcRange	Specifies the alphanumeric urban ID (up to eight characters) Specifies which source(s) will be modeled with urban effects Specifies a range of sources that will be modeled with urban effects
EMISFACT	SrcID (or SrcRange) Qflag Qfact(i), i=1,n	
where:	SrcID SrcRange Qflag         Qfact	Source identification code Range of sources (inclusive) for which emission rate factors apply Variable emission rate flag: <u>SEASON</u> for seasonal; <u>MONTH</u> for monthly; <u>HROFDY</u> for hour-of-day; <u>WSPEED</u> for wind speed category; <u>SEASHR</u> for season-by-hour; <u>HRDOW</u> for emission rates vary by hour-of-day, and day-of-week [M-F, Sat, Sun]; <u>HRDOW7</u> for emission rates vary by hour-of-day, and the seven days of the week [M, Tu, W, Th, F, Sat, Sun]; <u>SHRDOW</u> for season by hour-of-day by day-of-week (M-F,Sat,Sun); <u>SHRDOW7</u> for season by hour-of-day by day-of-week (M,Tu,W,Th,F,Sat,Sun); <u>MHRDOW</u> for month by hour-of-day by day-of-week (M-F,Sat,Sun); <u>MHRDOW7</u> for month by hour-of-day by day-of-week (M,Tu,W,Th,F,Sat,Sun) Array of scalar emission rate factors, for: <u>SEASON</u> , n=4; <u>MONTH</u> , n=12; <u>HROFDY</u> , n=24; <u>WSPEED</u> , n=6; <u>SEASHR</u> , n=96; <u>HRDOW</u> , n=72; <u>HRDOW7</u> , n=168; <u>SHRDOW</u> , n=288; <u>SHRDOW7</u> , n=672; <u>MHRDOW</u> , n=864; <u>MHRDOW7</u> , n=2016
EMISUNIT	Emifac Emilbl Outlbl	
where:	Emifac       Emilbl	Emission rate factor used to adjust units of output (default value is 1.0E06 for CONC for grams to micrograms; default value is 3600 for grams/sec to grams/m <sup>2</sup> /hr for deposition) Label to use for emission units (default is grams/sec)

Keyword	Parameters	
	Outlbl	Label to use for output units; applies to first output type if more than one output type is generated (default is micrograms/m**3 for concentration and grams/m**2 for deposition)
CONCUNIT	Emifac Emilbl Conlbl	
where:	Emifac	Emission rate factor used to adjust units of output (default value is 1.0E06 for concentration for grams to micrograms)
	Emilbl	Label to use for emission units (default is grams/sec)
	Conlbl	Label to use for concentrations (default is micrograms/m <sup>3</sup> )
DEPOUNIT	Emifac Emilbl Deplbl	
where:	Emifac	Emission rate factor used to adjust units of output for deposition (default value is 3600 for grams/sec to grams/m <sup>2</sup> /hr)
	Emilbl	Label to use for emission units (default is grams/sec)
	Deplbl	Label to use for deposition (default is grams/m <sup>2</sup> )
PARTDIAM	SrcID (or SrcRange) Pdiam(i), i=1,Npd	
where:	SrcID	Source identification code
	SrcRange	Range of sources (inclusive) for which size categories apply
	Pdiam	Array of particle diameters (microns)
MASSFRAX	SrcID (or SrcRange) Phi(i), i=1,Npd	
where:	SrcID	Source identification code
	SrcRange	Range of sources (inclusive) for which mass fractions apply
	Phi	Array of mass fractions for each particle size category
PARTDENS	SrcID (or SrcRange) Pdens(i), i=1,Npd	
where:	SrcID	Source identification code
	SrcRange	Range of sources (inclusive) for which particle densities apply
	Pdens	Array of particle densities (g/cm <sup>3</sup> ) for each size category
METHOD_2	SrcID (or SrcRange) FineMassFraction Dmm	
where:	SrcID	Source identification code
	FineMassFraction	Fraction (between 0 and 1) of particle mass emitted in fine mode, less than 2.5 microns
	Dmm	Representative mass mean particle diameter in microns
GASDEPOS	SrcID (or SrcRange) Da Dw rcl Henry	
where:	SrcID	Source identification code
	Da	Diffusivity in air for the pollutant being modeled (cm <sup>2</sup> /s)
	Dw	Diffusivity in water for the pollutant being modeled (cm <sup>2</sup> /s)
	rcl	Cuticular resistance to uptake by lipids for individual leaves (s/cm)
	Henry	Henry's Law constant (Pa m <sup>3</sup> /mol)
NO2RATIO	SrcID (or SrcRange) NO2Ratio	
where:	SrcID	Source identification code
	SrcRange	Source ID range for specified ratio



Keyword	Parameters	
	NO2Ratio	In-stack ratio of NO <sub>2</sub> /NO <sub>x</sub>
HOUREMIS	Emifil SrcID's SrcRange's	
where:	Emifil SrcID's SrcRange's	Specifies name of the hourly emission rate file Discrete source IDs that are included in the hourly emission file Source ID ranges that are included in the hourly emission file
BGSECTOR	StartSect1 StartSect2 . . . StartSectN, where N is ≤ 6	
where:	StartSect1 StartSect2 . . StartSectN	Starting direction for the first sector Starting direction for the second sector . . Starting direction for the last sector  <u>NOTE:</u> The minimum sector width allowed is 30 degrees, and warning messages will be issued for sector widths less than 60 degrees. Sector-varying background concentrations will be selected based on the flow vector, i.e., the downwind direction, based on the wind direction specified in the surface meteorological data file.
BACKGRND	BGflag BGvalue(i), i=1,n and/or HOURLY BGfilnam (BGformat) (without BGSECTORs)  or SECTn BGflag BGvalue(i), i=1,n and/or SECTn HOURLY BGfilnam (BGformat) (with BGSECTORs)	
where:	SECTn  BGflag  BGvalue	Applicable sector (n = 1 to 6) defined on the SO BGSECTOR keyword, if specified  Variable background concentration flag: <u>ANNUAL</u> for annual; <u>SEASON</u> for seasonal; <u>MONTH</u> for monthly; <u>HROFDY</u> for hour-of-day; <u>WSPEED</u> for wind speed category; <u>SEASHR</u> for season-by-hour; <u>HRDOW</u> for emission rates vary by hour-of-day, and day-of-week [M-F, Sat, Sun]; <u>HRDOW7</u> for emission rates vary by hour-of-day, and the seven days of the week [M, Tu, W, Th, F, Sat, Sun]; <u>SHRDOW</u> for season by hour-of-day by day-of-week (M-F,Sat,Sun); <u>SHRDOW7</u> for season by hour-of-day by day-of-week (M,Tu,W,Th,F,Sat,Sun); <u>MHRDOW</u> for month by hour-of-day by day-of-week (M-F,Sat,Sun); <u>MHRDOW7</u> for month by hour-of-day by day-of-week (M,Tu,W,Th,F,Sat,Sun) Array of background concentrations; for: <u>ANNUAL</u> , n=1; <u>SEASON</u> , n=4; <u>MONTH</u> , n=12;

Keyword	Parameters	
	<p><u>HOURLY</u></p> <p>BGfilnam (BGformat)</p>	<p><u>HROFDY</u>, n=24; <u>WSPEED</u>, n=6; <u>SEASHR</u>, n=96;  <u>HRDOW</u>, n=72; <u>HRDOW7</u>, n=168; <u>SHRDOW</u>, n=288;  <u>SHRDOW7</u>, n=672; <u>MHRDOW</u>, n=864;  <u>MHRDOW7</u>, n=2016</p> <p>Flag indicating that hourly background concentrations are specified in a separate data file; data period must match the meteorological data period being processed; no missing values are allowed in the hourly file, unless temporally-varying background concentrations are also specified through the BGflag parameter, which are used to substitute for missing hourly values.</p> <p>Filename for hourly background concentrations</p> <p>Optional Fortran format of hourly background concentration file; the default format is FREE format, i.e., comma or space-delimited data fields (Yr Mn Dy Hr BGvalue). The BGformat parameter must include open and close parentheses, the date variables must be read as integers (Fortran I format), and the BGvalue must be read as real (Fortran F, E, or D format), e.g., '(4I2,F8.3)'. The year may be specified as a 2-digit or 4-digit year, and the data period in the HOURLY background file must match the data period in the meteorological data files. The BGformat parameter cannot include any blank spaces, unless the field is enclosed by double quotes.</p> <p><u>NOTE:</u> Background concentrations specified on the BACKGRND keyword are currently assumed to be in units of PPB for NO<sub>2</sub> and SO<sub>2</sub>, PPM for CO, and UG/M3 for all other pollutants, unless otherwise specified on the SO BACKUNIT keyword.</p> <p>Background concentrations can be included with any source group, including group 'ALL', by including a "SrcID" of 'BACKGROUND' on the SRCGROUP keyword. <b>Note that background concentrations are automatically included with group ALL by default; however, background concentrations can be excluded from group ALL by including NOBACKGROUND (or NOBACKGRND) on the SRCGROUP ALL keyword.</b></p>
BACKUNIT	BGunits	
where:	BGunits	Background concentration units, specified as <u>PPB</u> for parts-per-billion, <u>PPM</u> for parts-per-million, or <u>UG/M3</u> for micrograms/cubic-meter. Background concentrations input in units of PPB or PPM are converted to micrograms/cubic-meter based on reference temperature (25 C) and pressure (1013.25 mb).
INCLUDED	Incfil	

Keyword	Parameters	
where:	SrcIncFile	Filename for the included source file, up to 200 characters in length; double quotes (“”) may be used as delimiters for the filename to allow for embedded spaces; and quotes don’t count toward the limit of 200
OLMGROUP	OLMGrpID SrcID's SrcRange's or <u>ALL</u>	
where:	OLMGrpID SrcID's SrcRange's	Group ID (Grpid = ALL specifies group including all sources) Discrete source IDs to be included in group Source ID ranges to be included in group  <u>Note:</u> Card may be repeated with same Grpid if more space is needed to specify sources
PSDGROUP	PSDGrpID SrcID's SrcRange's	
where:	PSDGrpID  SrcID's SrcRange's	PSD GrpID for PSDCREDIT option, must be one of the following: INCRCONS – increment-consuming sources, NONRBASE – non-retired baseline sources, or RETRBASE – retired (increment-expanding) baseline sources. Discrete source IDs to be included in group Source ID ranges to be included in group  <u>Note:</u> Card may be repeated with same PSDGrpID if more space is needed to specify sources
SRCGROUP	SrcGrpID SrcID's SrcRange's	
where:	SrcGrpID SrcID's  SrcRange's	Group ID (Grpid = ALL specifies group including all sources) Discrete source IDs to be included in group; a “SrcID” of ‘BACKGROUND’ (or ‘BACKGRND’) can be used to include background concentrations, based on the BACKGRND keyword. Also note that background concentrations are automatically included with group ALL; however, background concentrations can be excluded from group ALL by specifying ‘NOBACKGROUND’ on the SRCGROUP ALL keyword.  Source ID ranges to be included in group  <u>Note:</u> Card may be repeated with same Grpid if more space is needed to specify sources

TABLE B-5  
DESCRIPTION OF RECEPTOR PATHWAY KEYWORDS

RE Keywords	Type	Keyword Description
STARTING	M – N	Identifies the start of RECEPTOR pathway inputs
ELEVUNIT	O – N	Defines input units for receptor elevations (defaults to meters), must be first keyword after RE STARTING if used.
GRIDCART	O <sup>1</sup> – R	Defines a Cartesian grid receptor network
GRIDPOLR	O <sup>1</sup> – R	Defines a polar receptor network
DISCCART	O <sup>1</sup> – R	Defines the discretely placed receptor locations referenced to a Cartesian system
DISCPOLR	O <sup>1</sup> – R	Defines the discretely placed receptor locations referenced to a polar system
EVALCART	O <sup>1</sup> – R	Defines discrete Cartesian receptor locations for use with EVALFILE output option
INCLUDED	O – R	Identifies an external file containing receptor locations to be included in the inputs
FINISHED	M - N	Identifies the end of RECEPTOR pathway inputs

- 1) At least one of the following must be present: GRIDCART, GRIDPOLR, DISCCART, DISCPOLR, or EVALCART, unless the INCLUDED keyword is used to include receptor inputs from an external file. Multiple receptor networks can be specified in a single run, including both Cartesian and polar.

TABLE B-6  
DESCRIPTION OF RECEPTOR PATHWAY KEYWORDS AND PARAMETERS

Keyword	Parameters	
ELEVUNIT	<u>METERS</u> or <u>FEET</u>	
where:	<u>METERS</u> <u>FEET</u>	Specifies input units for receptor elevations of meters Specifies input units for receptor elevations of feet Note: This keyword applies to receptor elevations only.
GRIDCART	Netid <u>STA</u> <u>XYINC</u> Xinit Xnum Xdelta Yinit Ynum Ydelta or <u>XPNTS</u> Gridx1 Gridx2 Gridx3 .... GridxN, and <u>YPNTS</u> Gridy1 Gridy2 Gridy3 .... GridyN <u>ELEV</u> Row Zelev1 Zelev2 Zelev3 ... ZelevN <u>HILL</u> Row Zhill1 Zhill2 Zhill3 ... ZhillN <u>FLAG</u> Row Zflag1 Zflag2 Zflag3 ... ZflagN <u>END</u>	
where:	Netid <u>STA</u> <u>XYINC</u> Xinit Xnum Xdelta Yinit Ynum Ydelta <u>XPNTS</u>  Gridx1 GridxN <u>YPNTS</u>  Gridy1 GridyN <u>ELEV</u> Row Zelev <u>HILL</u> Row Zhill <u>FLAG</u> Row Zflag  <u>END</u>	Receptor network identification code (up to eight alphanumeric characters) Indicates <u>STA</u> of GRIDCART subpathway, repeat for each new Netid Keyword identifying grid network generated from x and y increments Starting local x-axis grid location in meters Number of x-axis receptors Spacing in meters between x-axis receptors Starting local y-axis grid location in meters Number of y-axis receptors Spacing in meters between y-axis receptors Keyword identifying grid network defined by series of x and y coordinates Value of first x-coordinate for Cartesian grid Value of 'nth' x-coordinate for Cartesian grid Keyword identifying grid network defined by series of x and y coordinates Value of first y-coordinate for Cartesian grid Value of 'nth' y-coordinate for Cartesian grid Keyword to specify that receptor elevations follow Indicates which row (y-coordinate fixed) is being input An array of receptor terrain elevations for a particular Row Keyword to specify that hill height scales follow Indicates which row (y-coordinate fixed) is being input An array of hill height scales for a particular Row Keyword to specify that flagpole receptor heights follow Indicates which row (y-coordinate fixed) is being input An array of receptor heights above local terrain elevation for a particular Row (flagpole receptors) Indicates <u>END</u> of GRIDCART subpathway, repeat for each new Netid

Keyword	Parameters	
GRIDPOLR	Netid <u>STA</u> <u>ORIG</u> Xinit Yinit, or <u>ORIG</u> Srcid <u>DIST</u> Ring1 Ring2 Ring3 ... RingN <u>DDIR</u> Dir1 Dir2 Dir3 ... DirN, or <u>GDIR</u> Dirnum Dirini Dirinc <u>ELEV</u> Dir Zelev1 Zelev2 Zelev3 ... ZelevN <u>HILL</u> Dir Zhill1 Zhill2 Zhill3 ... ZhillN <u>FLAG</u> Dir Zflag1 Zflag2 Zflag3 ... ZflagN <u>END</u>	
where:	Netid <u>STA</u> <u>ORIG</u> Xinit Yinit Srcid <u>DIST</u> Ring1 RingN <u>DDIR</u> Dir1 DirN <u>GDIR</u> Dirnum Dirini Dirinc <u>ELEV</u> Dir Zelev <u>HILL</u> Row Zhill  <u>FLAG</u> Dir Zflag  <u>END</u>	Receptor network identification code (up to eight alphanumeric characters) Indicates <u>STA</u> of GRIDPOLR subpathway, repeat for each new Netid Optional keyword to specify the origin of the polar network (assumed to be at x=0, y=0 if omitted) local x-coordinate for origin of polar network (m) local y-coordinate for origin of polar network (m) Source ID of source used as origin of polar network Keyword to specify distances for the polar network Distance to the first ring of polar coordinates (m) Distance to the 'nth' ring of polar coordinates (m) Keyword to specify discrete direction radials for the polar network First direction radial in degrees (1 to 360) The 'nth' direction radial in degrees (1 to 360) Keyword to specify generated direction radials for the polar network Number of directions used to define the polar system Starting direction of the polar system Increment (in degrees) for defining directions Keyword to specify that receptor elevations follow Indicates which direction is being input An array of receptor terrain elevations for a particular direction radial Keyword to specify that hill height scales follow Indicates which row (y-coordinate fixed) is being input An array of hill height scales for a particular Row Keyword to specify that flagpole receptor heights follow Keyword to specify that flagpole receptor heights follow Indicates which direction is being input An array of receptor heights above local terrain elevation for a particular direction (flagpole receptors) Indicates <u>END</u> of GRIDPOLR subpathway, repeat for each new Netid
DISCCART	Xcoord Ycoord (Zelev Zhill) (Zflag)	
where:	Xcoord Ycoord (Zelev)  (Zhill)	local x-coordinate for discrete receptor location (m) local y-coordinate for discrete receptor location (m) Elevation above sea level for discrete receptor location (optional), used only for <u>ELEV</u> terrain Hill height scale (optional)

Keyword	Parameters	
	(Zflag)	Receptor height (flagpole) above local terrain (optional), used only with <u>FLAGPOLE</u> keyword
DISCPOLR	Srcid Dist Direct (Zelev Zhill) (Zflag)	
where:	Srcid	Specifies source identification for which discrete polar receptor locations apply (used to define the origin for the discrete polar receptor)
	Dist	Downwind distance to receptor location (m)
	Direct	Direction to receptor location, in degrees clockwise from North
	(Zelev)	Elevation above sea level for receptor location (optional), used only for <u>ELEV</u> terrain
	(Zhill)	Hill height scale (optional)
	(Zflag)	Receptor height (flagpole) above local terrain (optional), used only with <u>FLAGPOLE</u> keyword
EVALCART	Xcoord Ycoord Zelev Zhill Zflag Arcid (Name)	
where:	Xcoord	Local x-coordinate for discrete receptor location (m)
	Ycoord	Local y-coordinate for discrete receptor location (m)
	Zelev	Elevation above sea level for discrete receptor location (optional), used only for <u>ELEV</u> terrain
	Zhill	Hill height scale (m)
	Zflag	Receptor height (flagpole) above local terrain (optional), used only with <u>FLAGPOLE</u> keyword
	Arcid	Receptor arc ID used to group receptors along an arc or other grouping (up to eight characters)
	(Name)	Optional name for receptor (up to eight characters)
INCLUDED	RecIncFile	
where:	RecIncFile	Identifies the filename for the included receptor file, up to 200 characters in length; double quotes (") may be used as delimiters for the filename to allow for embedded spaces; quotes don't count toward the limit of 200

TABLE B-7  
DESCRIPTION OF METEOROLOGY PATHWAY KEYWORDS

ME Keywords	Type	Keyword Description
STARTING	M – N	Identifies the start of METEOROLOGY pathway inputs
SURFFILE	M – N	Describes input meteorological surface data file
PROFFILE	M – N	Describes input meteorological profile data file
SURFDATA	M – N	Describes surface meteorological station
UAIRDATA	M – N	Describes upper air meteorological station
SITEDATA	O – N	Describes on-site meteorological station
PROFBASE	M – N	Specifies the base elevation for the potential temperature profile
STARTEND	O – N	Specifies start and end dates to be read from input meteorological data file (default is to read entire file)
DAYRANGE	O – R	Specifies days or ranges of days to process (default is to process all data)
SCIMBYHR	O – N	Specifies the parameters for the SCIM (Sampled Chronological Input Model) option (see CO MODELOPT)
WDROTATE	O – N	May be used to correct for alignment problems of wind direction measurements, or to convert wind direction from to flow vector
WINDCATS	O – N	Input upper bounds of wind speed categories, five values input - sixth category is assumed to have no upper bound (used for WSPEED option on the EMISFACT keyword)
FINISHED	M – N	Identifies the end of METEOROLOGY pathway inputs



TABLE B-8  
DESCRIPTION OF METEOROLOGY PATHWAY KEYWORDS AND PARAMETERS

Keyword	Parameters	
SURFFILE	Sfcfil	
where:	Sfcfil	Specify filename for surface meteorological input file <u>Note:</u> FREE format is used for all SURFFILE reads beginning with version 09292.
PROFFILE	Profil	
where:	Profil	Specify filename for profile meteorological input file <u>Note:</u> FREE format is used for all PROFFILE reads beginning with version 09292.
SURFDATA	Stanum Year (Name) (Xcoord Ycoord)	
where:	Stanum Year (Name) (Xcoord) (Ycoord)	Station number, e.g. 5-digit WBAN number for NWS station Year of data being processed (four digits) Station name (optional) x-coordinate of station location (m) (optional) y-coordinate of station location (m) (optional)
UAIRDATA	Stanum Year (Name) (Xcoord Ycoord)	
where:	Stanum Year (Name) (Xcoord) (Ycoord)	Station number, e.g. 5-digit WBAN number for NWS station Year of data being processed (four digits) Station name (optional) x-coordinate of station location (m) (optional) y-coordinate of station location (m) (optional)
SITEDATA	Stanum Year (Name) (Xcoord Ycoord)	
where:	Stanum Year (Name) (Xcoord) (Ycoord)	Station number for on-site meteorological data station Year of data being processed (four digits) Station name (optional) x-coordinate of station location (m) (optional) y-coordinate of station location (m) (optional)
PROFBASE	BaseElev (Units)	
where:	BaseElev (Units)	Base elevation (above MSL) for the potential temperature profile Units of BaseElev: <u>METERS</u> or <u>FEET</u> (default is <u>METERS</u> )
STARTEND	Strtyr Strtmn Strtdy (Strthr) Endyr Endmn Enddy (Endhr)	
where:	Strtyr Strtmn Strtdy (Strthr) Endyr	Year of first record to be read Month of first record to be read Day of first record to be read Hour of first record to be read (optional) Year of last record to be read

Keyword	Parameters	
	Endmn Enddy (Endhr)	Month of last record to be read Day of last record to be read Hour of last record to be read (optional)  <u>Note:</u> File read begins with hour 1 of the start date and ends with hour 24 of the end date if Stahr and Endhr are omitted.
DAYRANGE	Range1 Range2 Range3 ... RangeN	
where:	Range1  RangeN	First range of days to process, either as individual day (XXX) or as range (XXX-YYY); days may be input as Julian dates (XXX) or as month and day (XX/YY) The 'N-th' range of days to process
NUMYEARS	NumYrs	
where:	NumYrs	Specifies the number of years of meteorological data being processed for purposes of allocating array storage for the OU MAXDCONT option. A default value of 5 years is assumed if the optional NUMYEARS keyword is omitted.
SCIMBYHR	NRegStart NRegInt (SfcFilnam PflFilnam)	
where:	NRegStart  NRegInt (SfcFilnam)  (PflFilnam)	Specifies the first hour to be sampled with the SCIM option; required to have a value from 1 to 24 Specifies the sampling interval, in hours Optional output file name to list the surface meteorological data for the sampled hours Optional output file name to list the profile meteorological data for the sampled hours
WDROTATE	Rotang	
where:	Rotang	Specifies angle (in degrees) to rotate wind direction measurements to correct for alignment problems; value of Rotang is subtracted from WD measurements, i.e., rotation is counterclockwise
WINDCATS	Ws1 Ws2 Ws3 Ws4 Ws5	
where:	Ws1 Ws2 Ws3 Ws4 Ws5	Upper bound of first wind speed category (m/s) Upper bound of second wind speed category (m/s) Upper bound of third wind speed category (m/s) Upper bound of fourth wind speed category (m/s) Upper bound of fifth wind speed category (m/s) (sixth category is assumed to have no upper bound)

TABLE B-9  
DESCRIPTION OF EVENT PATHWAY KEYWORDS

<b>EV Keywords</b>	<b>Type</b>	<b>Keyword Description</b>
STARTING	M – N	Identifies the start of EVENT pathway inputs
EVENTPER	M – R	Describes data and averaging period for an event
EVENTLOC	M – R	Describes receptor location for an event
INCLUDED	O – R	Identifies an external file containing EVENT data to be included in the inputs
FINISHED	M – N	Identifies the end of EVENT pathway inputs

TABLE B-10  
DESCRIPTION OF EVENT PATHWAY KEYWORDS AND PARAMETERS

Keyword	Parameters	
EVENTPER	Evname Aveper Grpid Date Conc	
where:	Name	Specify name of event to be processed (e.g. H002H24ALL), (up to ten alphanumeric characters)
	Grpid	Specify source group ID for event
	Aveper	Specify averaging period for event
	Date	Specify data period for event (ending YYMMDDHH for averaging period)
	Conc	Specifies the concentration value generated during the initial non-EVENT processing
EVENTLOC	Evname <u>XR=</u> Xr <u>YR=</u> Yr (Zelev Zhill) (Zflag) or <u>RNG=</u> Rng <u>DIR=</u> Dir (Zelev Zhill) (Zflag)	
where:	Evname	Specify name of event to be processed (e.g. H002H24ALL), (up to ten alphanumeric characters)
	<u>XR=</u>	X-coordinate for event (discrete Cartesian receptor)
	<u>YR=</u>	Y-coordinate for event (discrete Cartesian receptor)
	<u>RNG=</u>	Distance range for event (discrete polar receptor)
	<u>DIR=</u>	Radial direction for event (discrete polar receptor)
	(Zelev)	Terrain elevation for event (optional)
	(Zhill)	Hill height scale (optional)
	(Zflag)	Receptor height above ground for event (optional)
INCLUDED	EventIncFile	
where:	EventIncFile	Identifies the filename for the included EVENT file, up to 200 characters in length; double quotes (") may be used as delimiters for the filename to allow for embedded spaces; and quotes don't count toward the limit of 200

Note: EVENT locations can be input as either discrete Cartesian receptors (XR=, YR=) or as discrete polar receptors (RNG=, DIR=). Events that are specified in the file generated by the AERMOD model (CO EVENTFIL card) are always given as discrete Cartesian coordinates. Discrete polar receptors are assumed to be relative to an origin of (0,0).

TABLE B-11  
DESCRIPTION OF OUTPUT PATHWAY KEYWORDS

OU Keywords	Type	Keyword Description
STARTING	M – N	Identifies the start of OUTPUT pathway inputs
RECTABLE	O – R	Option to specify value(s) by receptor for output
MAXTABLE	O – R	Option to summarize the overall maximum values
DAYTABLE	O – N	Option to print summaries for each averaging period for each day processed.
MAXIFILE	O – R	Option to list events exceeding a threshold value to file (if CO EVENTFIL option is used, these events are included in the input file generated for the EVENT model).
POSTFILE <sup>1</sup>	O – R	Option to write results to a mass storage file for postprocessing.
PLOTFILE <sup>1</sup>	O – R	Option to write certain results to a storage file suitable for input to plotting routines
TOXXFILE	O – R	Option to write results to a storage file suitable for input to the TOXX model component of TOXST or the RISK
RANKFILE	O – R	Option to output file of ranked values for Q-Q plots (must be used with the MAXTABLE keyword)
EVALFILE	O – R	Option to output file of normalized arc maxima from EVALCART receptors for model evaluation studies
SEASONHR	O – R	Option to output results by season and hour-of-day
MAXDAILY	O – R	Option to output file of daily maximum 1-hour values for each day processed; only applicable for 1-hour NO <sub>2</sub> and 1-hour SO <sub>2</sub> NAAQS
MXDYBYR	O – R	Option to output file of daily maximum 1-hour values by year, for each year processed; only applicable for 1-hour NO <sub>2</sub> and 1-hour SO <sub>2</sub> NAAQS
MAXDCONT	O – R	Option to output contributions of each source group to ranked values averaged across years for a reference source group, paired in time and space; only applicable for 24-hour PM <sub>2.5</sub> , 1-hour NO <sub>2</sub> , and 1-hour SO <sub>2</sub> NAAQS
SUMMFILE	O – N	Option to output summary of high ranked values to separate file
FILEFORM	O – N	Specify fixed or exponential format for output results files
NOHEADER	O – N	Option to suppress file headers for output file options, e.g., POSTFILE, PLOTFILE, MAXDCONT, etc.
EVENTOUT	M – N	Specifies the level of output information provided for EVENT Processing [EVENT Only]
FINISHED	M – N	Identifies the end of OUTPUT pathway inputs

- 1) POSTFILE is used to output concurrent concentration values for particular source groups and averaging times across the receptor network suitable for postprocessing. PLOTFILE is used to output specific design values, such as second high concentrations, across the receptor network, suitable for plotting concentration contours.

TABLE B-12  
DESCRIPTION OF OUTPUT PATHWAY KEYWORDS AND PARAMETERS

Keyword	Parameters	
RECTABLE	Aveper <u>FIRST</u> <u>SECOND</u> ... <u>SIXTH</u> ... <u>TENTH</u> and/or Aveper <u>1ST</u> <u>2ND</u> ... <u>6TH</u> ... <u>10TH</u> and/or Aveper <u>1</u> <u>2</u> ... <u>6</u> ... <u>10</u> ... <u>N</u> ... <u>999</u>	
where:	Aveper <u>FIRST</u> <u>SECOND</u> <u>SIXTH</u> <u>1ST</u> <u>2ND</u> <u>6TH</u> <u>N</u>	<p>Averaging period to summarize with high values (keyword <u>ALLAVE</u> specifies all short-term averaging periods)</p> <p>Select summaries of <u>FIRST</u> highest values by receptor</p> <p>Select summaries of <u>SECOND</u> highest values by receptor</p> <p>Select summaries of <u>SIXTH</u> highest values by receptor</p> <p>Select summaries of <u>1ST</u> highest values by receptor</p> <p>Select summaries of <u>2ND</u> highest values by receptor</p> <p>Select summaries of <u>6TH</u> highest values by receptor</p> <p>Select summaries of <u>N</u>-th highest values by receptor (up to <u>999</u>-th highest values)</p> <p><u>Note:</u></p> <p>If two parameters are input separated by a dash (e.g. <u>FIRST-THIRD</u> or <u>4-12</u>), then summaries of all high ranked values within that range (inclusive) are provided.</p> <p>If the CO EVENTFIL keyword is exercised, then the events generated by the RECTABLE keyword are included in the input file for EVENT model.</p> <p>The range of ranks specified on the RECTABLE keyword (but not the individual ranks specified) also determines the range of ranks that may be considered with the MAXDCONT option.</p>
MAXTABLE	Aveper Maxnum	
where:	Aveper Maxnum	<p>Averaging period to summarize with overall maximum values (keyword <u>ALLAVE</u> specifies all averaging periods)</p> <p>Specifies number of overall maximum values to summarize</p>
DAYTABLE	Avper1 Avper2 Avper3 ...	
where:	Avper1	<p>Averaging period, e.g., <u>24</u> for 24-hr averages, to summarize with values by receptor for each day of data processed (keyword <u>ALLAVE</u> for first parameter specifies all averaging periods)</p>
MAXIFILE	Aveper GrpID Thresh Filnam (Funit)	
where:	Aveper	<p>Specifies averaging period for list of values equal to or exceeding a threshold value</p>

Keyword	Parameters	
	GrpID Thresh Filnam Funit	Specifies source group to be output to file Threshold value (e.g. NAAQS) for list of exceedances Name of disk file to store maximum values Optional parameter to specify the file unit  <u>Note:</u>  If the CO EVENTFIL keyword is exercised, then the events generated by the MAXIFILE keyword are included in the input file for EVENT processing.
POSTFILE	Aveper GrpID Format Filnam (Funit)	
where:	Aveper  GrpID Format  Filnam Funit	Specifies averaging period to be output to file, e.g., <u>24</u> for 24-hr averages, <u>PERIOD</u> for period averages Specifies source group to be output to file Specifies format of file, either <u>UNFORM</u> for unformatted files or <u>PLOT</u> for formatted files for plotting Specifies filename for output file Optional parameter to specify the file unit
PLOTFILE	Aveper GrpID Hivalu Filnam (Funit) (Short Term values) Aveper GrpID Filnam (Funit) (PERIOD or ANNUAL averages)	
where:	Aveper  GrpID Hivalu  Filnam Funit	Specifies averaging period to be output to file, e.g., <u>24</u> for 24-hr averages, <u>PERIOD</u> for period averages, etc. Specifies source group to be output to file Specifies rank to be included in high value summary (e.g. <u>FIRST</u> , <u>SECOND</u> , <u>1ST</u> , <u>2ND</u> , etc.) to be output to file (the rank must be included on the RECTABLE card) Specifies filename for output file Optional parameter to specify the file unit
TOXXFILE	Aveper Cutoff Filnam (Funit)	
where:	Aveper  Cutoff  Filnam Funit	Specifies averaging period to be output to file, e.g., <u>1</u> for 1-hr averages. Specifies cutoff (threshold) value in g/m <sup>3</sup> for outputting results for AERMOD model Specifies filename for output file Optional parameter to specify the file unit
RANKFILE	Aveper Hinum Filnam (Funit)	
where:	Aveper  Hinum Filnam Funit	Specifies averaging period to be output to file, e.g., <u>24</u> for 24-hr averages Specifies the number of high values to be ranked Specifies filename for output file Optional parameter to specify the file unit
EVALFILE	SrcID Filnam (Funit)	





Keyword	Parameters	
		the range of ranks that may be considered with the MAXDCONT option, even with the <u>THRESH</u> option.
SUMMFILE	SummFileName	
where:	SummFileName	Specifies filename of output summary file
FILEFORM	<u>EXP</u> or <u>FIX</u>	
where:	<u>EXP</u> <u>FIX</u>	Specifies that the output results files will use EXponential-formatted values Specifies that the output results files will use FIXed-formatted values (fixed-formatted values will be used if FILEFORM is omitted)
NOHEADER	FileType1 FileType2 FileType3 . . . FileTypeN or <u>ALL</u>	
where:	FileTypeN  <u>ALL</u>	Specifies the output file type(s) for which header records will be suppressed; includes the following file types:  POSTFILE, PLOTFILE, MAXIFILE, RANKFILE, SEASONHR, MAXDAILY, MXDYBYR, and MAXDCONT  Specifies that header records will be suppressed for <u>ALL</u> applicable output file types
EVENTOUT	<u>SOCONT</u> or <u>DETAIL</u> [EVENT Only]	
where:	<u>SOCONT</u> <u>DETAIL</u>	Provide source contribution information only in the event output Include hourly concentrations for each source and hourly meteorological data in the event output

## APPENDIX C. LIST OF ERROR/WARNING MESSAGES

This appendix provides a list of error, warning and informational messages used in the current version of the AERMOD model. Three types of messages can be produced by the model during processing of model inputs and during model calculations. These are described below:

- **Fatal Errors** that will halt any further processing, except to identify additional error conditions (type E);
- **Warnings** that do not halt processing but indicate possible errors or suspect conditions (type W); and
- **Informational** messages that may be of interest to the user but have no direct bearing on the validity of the results (type I).

A more detailed explanation of the error handling and reporting procedures used in AERMOD is provided in Appendix C of the AERMOD User's Guide (EPA, 2004a). The three message types are identified with the letters E (errors), W (warnings), and I (informational messages). The 3-digit message numbers are generally grouped into categories corresponding to the different stages of the processing, although these distinctions may not always be obvious. These categories are:

100 - 199	Input Runstream Image Structure Processing
200 - 299	Parameter Setup Processing
300 - 399	Data and Quality Assurance Processing
400 - 499	Run Time Message Processing
500 - 599	Input/Output Message Processing

The list provided below includes the message number, the main message text, and the “hint” field that may include additional details regarding the message. **Note that the listing of messages in the AERMOD User's Guide (EPA, 2004a) is not up-to-date. Several additional messages have been added to AERMOD since that time, and the numbering of some messages may have changed.**

<b>Message Number</b>	<b>Error/Warning Message</b>	<b>Hint (not updated)</b>
100	Invalid Pathway Specified. The Troubled Pathway is	
105	Invalid Keyword Specified. The Troubled Keyword is	
109	Too many fields specified on runstream image; MAX=	
110	Keyword is Not Valid for This Pathway. Keyword is	
111	LOW_WIND Keyword specified without LOWWIND Options	
112	User-specified minimum Sigma-V on LOW_WIND Keyword	
113	User-specified minimum WindSpeed on LOW_WIND Keywd	
114	User-specified maximum FRAN on the LOW_WIND Keywrđ	
115	STARTING or FINISHED Out of Sequence: Pathway =	
116	Vector Wind Speeds specified on MODELOPT Keyword	
120	Pathway is Out of Sequence: Pathway =	
121	LowWind1 Beta Option specified on MODELOPT Keyword	
122	LowWind2 Beta Option specified on MODELOPT Keyword	
125	Missing FINISHED-Runstream File Incomplete: ISTAT=	
130	Missing Mandatory Keyword. The Missing Keyword is	
131	Minimum sigmav value (SVmin) for LowWind1 Beta Opt	
132	Minimum sigmav value (SVmin) for LowWind2 Beta Opt	
133	Maximum FRAN value (FRANmax) for LowWind2 Beta Opt	
135	Nonrepeatable Keyword or Recursed INCLUDED: Keywrđ	
136	Conflicting Beta Option - LowWind1 and LowWind2	
140	Invalid Order of Keyword. The Troubled Keyword is	
141	Conflicting Options for NO2 conversion specified:	
142	Following Keyword Invalid Without PVMRM or OLM:	
143	Following Keyword Invalid Without PVMRM Option:	
144	Following Keyword Invalid Without OLM Option:	
145	Following Keyword Invalid Without ARM or ARM2:	
146	PSDGROUP Keyword Specified without PSDCREDIT Opt.	
147	Following Option is Invalid with PSDCREDIT Option:	
148	Both OZONEVAL and O3VALUES keywords are specified	
149	Conflicting options specified on MODELOPT keyword:	
150	Conflicting Options: MULTYEAR Option with	
151	Non-DEFAULT NoUrbTran option selected on MODELOPT	

<b>Message Number</b>	<b>Error/Warning Message</b>	<b>Hint (not updated)</b>
152	ELEVUNIT card must be first for this Pathway:	
153	Conflicting Opts: MAXDCONT with Re-Start or MULTYR	
154	Conflicting options: SCIM cannot be used with	
155	Conflicting Decay Keyword. Inputs Ignored for	
156	Option ignored - not valid with SCIM. Option =	
157	Wet SCIM Not Supported - Wet SCIM Inputs Ignored	
158	EMISUNIT Keyword Used With More Than 1 Output Type	
159	EMISUNIT Keyword Used With the Following Keyword:	
160	Duplicate ORIG Secondary Keyword for GRIDPOLR:	
161	MAXDCONT option already defined for source group:	
162	Option only applies to 1-hr NO2 or 1-hr SO2 NAAQS:	
163	Option only applies to 24h PM25, 1h NO2 or 1h SO2:	
164	NOHEADER selected for non-specified output option:	
165	Inconsistent temporally-varying BACKGRND options:	
166	BGSECTOR/O3SECTOR option invalid w/o BG/O3 Inputs:	
167	Inconsistent temporally-varying O3VALUES options:	
168	Hourly BACKGRND already specified for this sector:	
170	Invalid Secondary Keyword for Receptor Grid:	
171	Sector ID specified without Sector-varying Option:	
175	Missing Secondary Keyword END for Receptor Grid:	
180	Conflicting Secondary Keyword for Receptor Grid:	
181	BULKRN Delta-T & SolarRad option for SBL was used	
182	MMIF-generated meteorological inputs were used	
183	Non-DEFAULT option for MMIF-generated data without	
184	PROFILE heights > 999m; inputs could be from MMIF	
185	Either No Sources or No Receptors are specified!!!	
186	THRESH_1MIN 1-min ASOS wind speed threshold used	
187	ADJ_U* Beta Option for Low Winds used in AERMET	
188	Non-Default ADJ_U* Option used in AERMET without	
189	No Keywords for OU Path and No PERIOD/ANNUAL Aves.	
190	Incompatible Option Used With SAVEFILE or INITFILE	
191	PM25, 1h NO2 or SO2 w/o MAXIFILE incompatible with	

<b>Message Number</b>	<b>Error/Warning Message</b>	<b>Hint (not updated)</b>
192	FASTALL option also implies use of FASTAREA option	
193	Units keyword specified without appropriate option	
194	DEBUGOPT input option is invalid or not applicable	
195	Incompatible Keyword used with GASDEPVD option	
196	Gas deposition algorithms are non-DFAULT options	
197	METHOD_2 for particulates is a non-DFAULT option	
198	TOXICS Option obsolete; see Users Guide Addendum	
199	Non-DFAULT BETA Option Required for	
200	Missing Parameter(s). No Options Specified For	
201	Not Enough Parameters Specified For the Keyword of	
202	Too Many Parameters Specified For the Keyword of	
203	Invalid Parameter Specified. Troubled Parameter:	
204	Regulatory DFAULT Conflicts with Non-DFAULT Option	
205	No Option Parameter Setting. Forced by Default to	
206	Regulatory DFAULT Overrides Non-DFAULT Option For	
207	No Parameters Specified. Default Values Will Used.	
208	Illegal Numerical Field Encountered in	
209	Negative Value Appears For Non-negative Variable.	
211	Duplicate Averaging Period Specified for Keyword	
212	END Encountered Without (X,Y) Points Properly Set	
213	ELEV Input Inconsistent With Option: Input Ignored	
214	ELEV Input Inconsistent With Option: Defaults Used	
215	FLAG Input Inconsistent With Option: Input Ignored	
216	FLAG Input Inconsistent With Option: Defaults Used	
217	More Than One Delimiter In A Field for Keyword	
218	Number of (X,Y) Points Does Not Match Number of	
219	Urban ID field is too long (>8); first 12 char:	
220	Missing Origin (Use Default = 0,0) In GRIDPOLR	
221	Missing Dist or Direction Setting In Polar Network	
222	O3SECTOR or BGSECTOR Value is out of order:	
223	Missing Distance or Degree Field in	
224	SrcID specified on SRCGROUP keyword not defined:	

<b>Message Number</b>	<b>Error/Warning Message</b>	<b>Hint (not updated)</b>
225	SrcID specified on OLMGROUP keyword not defined:	
226	SrcID specified on PSDGROUP keyword not defined:	
227	O3SECTOR or BGSECTOR Width is out of range:	
228	Default(s) Used for Missing Parameters on Keyword	
229	Too Many Parameters - Inputs Ignored on Keyword	
230	Source ID field is too long (>12); first 12 chars:	
231	Too Many Numerical Values Specified for	
232	OLMGroup ID field is too long (>8); first 12 char:	
233	Building Dimensions Specified for Non-POINT Source	
234	Too Many Sectors Input for	
235	Num of SRCGRPs exceeds limit for EVT name; Set=999	
236	Not Enough BUILDHGTs Specified for SourceID	
237	Not Enough BUILDWIDs Specified for SourceID	
238	Not Enough BACKGRND Concentration Values Specified	
239	Not Enough QFACTs Specified for SourceID	
240	Inconsistent Number of Particle Categories for	
241	Not Enough BUILDLENs Specified for SourceID	
242	No Particle Cat. or Gas Depos. Specified for SRCID	
243	Wet depos (DEPOS, WDEP, WETDPLT) incompatible with	
244	Source parameters are missing or incomplete for	
245	SrcGroup ID field is too long (>8); first 12 char:	
246	Not Enough XBADJs Specified for SourceID	
247	Not Enough YBADJs Specified for SourceID	
248	Either BGVALs or BGFILE missing for this sector:	
249	Source elevation is missing (-9999.0); SRCID =	
250	Duplicate XPNT/DIST or YPNT/DIR Specified for GRID	
252	Duplicate Receptor Network ID Specified. NETID =	
253	PSDGROUP ID field is too long (>8); first 12 char:	
256	EVALFILE Option Used Without EVALCART Receptors	
259	Receptor elevation is missing (-9999.0); IREC =	
260	Number of EMISFACT/O3VALUES/BACKGRND values > max:	
261	Not Enough O3VALUES Ozone Concentrations Specified	

<b>Message Number</b>	<b>Error/Warning Message</b>	<b>Hint (not updated)</b>
262	First Vertex Does Not Match LOCATION for AREAPOLY	
264	Too Many Vertices Specified for AREAPOLY Source	
265	Not Enough Vertices Specified for AREAPOLY Source	
266	Invalid shape defined (area=0) for AREAPOLY source	
271	O3FILE w/o O3VALs; full conv for hrs with miss O3	
272	Upper bound rank > Lower bound rank for MAXDCONT:	
273	Range of ranks for MAXDCONT THRESH Opt is limited:	
276	Special proc for 1h-NO2/SO2 24hPM25 NAAQS disabled	
277	Specified option not applicable for this pollutant	
279	Multiple URBANOPT/URBANSRC inputs not allowed for:	
280	Number of Output Types Specified Exceeds Max:NTYP=	
282	Following SRCID Included in Multiple OLMGROUPs:	
283	OZONEVAL, O3VALUES or OZONEFIL Keyword Needed for	
284	Invalid POLLUTID Specified for PVMRM/OLM; Must Use	
285	BACKGROUND and BACKGRND are invalid as Source IDs	
286	Following SRCID Included in Multiple PSDGROUPs:	
287	PSDGROUP ID Must be INCRCONS, RETRBASE or NONRBASE	
288	Use of "*" for repeated values not meaningful for	
289	Source defined as both particulate and gaseous	
290	This array limit exceeded; possible coding error:	
291	Filename specified is too long. Maximum length =	
292	Potential problem with Fortran format specifier:	
293	User-specified met data format not used; use FREE	
294	PERIOD and ANNUAL averages are both selected for	
295	Invalid Averaging Period Specified for SCREEN Mode	
296	Averaging Period .NE. 1-Hr for TOXXFILE Option	
297	Aver. Period must be .LE. 24 for EVENT Processing	
298	Results reported for source group ALL include	
299	SRCGROUP ALL is missing, but is NOT required for	
300	Specified SRCID Has Not Been Defined Yet: KEYWORD=	
301	Urban Area ID Has Not Been Defined. URBID =	
302	Following SRCID Included in Multiple Urban Areas:	



<b>Message Number</b>	<b>Error/Warning Message</b>	<b>Hint (not updated)</b>
303	Urban ID has already been defined. URBID =	
305	Stack height > or = EPA formula height for SRCID:	
310	Attempt to Define Duplicate LOCATION Card for SRC:	
313	Attempt to Define Duplicate EVENTPER card for	
315	Attempt to Define Duplicate SRCPARAM Card for SRC:	
317	Specified SRCID not included in any PSD/SRCGROUP:	
318	No Sources Defined for Urban Area. URBID =	
319	No Sources Included in Specified Source Group:	
320	Input Parameter May Be Out-of-Range for Parameter	
321	BACKGROUND concs are NOT included in any SRCGROUP!	
322	Release Height Exceeds Effective Depth for OPENPIT	
323	BACKGRND included w/o BACKGRND keyword for SrcGrp:	
324	Release Height Exceeds 3000 Meters for SRCID:	
325	Negative Exit Velocity (Set=1.0E-5) for SRCID:	
330	Mass Fraction Parameters Do Not Sum to 1. for Src	
332	Mass Fraction Parameter Out-of-Range for Source	
334	Particle Density Out-of-Range for Source	
335	Particle Diameter Out-of-Range for Source	
336	NO2RATIO Missing or Invalid for OLM/PVMRM - SrcID:	
338	Neg Emis Rate Cannot be Used with OLM/PVMRM. Src:	
340	Possible Error in PROFBASE Input: Value is < 0	
341	Emissions in HOUREMIS file < -90; set to 0.0 for	
342	Src ID Mismatch in Hourly Emissions File for ID =	
344	Missing HOUREMIS fields; EmisRate set = 0. KURDAT=	
345	Problem processing the HOUREMIS file. KURDAT =	
346	Too many fields for HOUREMIS file. KURDAT =	
350	Julian Day Out Of Range at	
352	The "H6H" field is no longer required for MULTYEAR	
353	Urban Roughness Length (m) May Be Out-of-Range:	
360	2-Digit Year Specified: Valid for Range 1950-2049	
361	Multiyear PERIOD/ANNUAL values for NO2/SO2 require	
362	Multiyear 1h NO2/SO2 processing not applicable for	

<b>Message Number</b>	<b>Error/Warning Message</b>	<b>Hint (not updated)</b>
363	Multiyr 24h/Ann PM25 processing not applicable for	
365	Year Input is Greater Than 2147	
370	Invalid Date: 2/29 In a Non-leap Year.	
380	This Input Variable is Out-of-Range:	
381	Latitude in Surface File Is Not Valid:	
382	Error Decoding Latitude:	
384	Not enough fields specified for HOUREMIS; KURDAT =	
386	PARTDIAM and METHOD_2 specified for same SRCID:	
387	METHOD_2 option already specified for this SRCID:	
390	Aspect ratio (L/W) of LINE source greater than 100	
391	Aspect ratio (L/W) of AREA source greater than 100	
392	Aspect ratio (L/W) of OPENPIT is greater than 10	
394	Met data may be from outdated version of AERMET:	
395	Met. Data Error; Incompatible Version of AERMET:	
396	Met data from outdated version of AERMET, version:	
397	SCREEN option used without use of SCREEN Met Data	
398	SCREEN met used without specifying SCREEN option	
399	EXP format specified with no applicable file types	
400	Output values exceed format limit; use OU FILEFORM	
405	Value of PHEE Exceeds 1.0 on KURDAT =	
406	Number of Vertices Exceeds Max (NVMAX) for SRCID:	
409	Error Allocating Storage for Setup/Result Arrays!	
410	Wind Direction Out-of-Range. KURDAT =	
413	Number of Threshold Events > 999999 for Ave Period	
415	MAXDCONT THRESH not reached within range of ranks	
420	Wind Speed Out-of-Range. KURDAT =	
430	Ambient Temperature Data Out-of-Range. KURDAT =	
432	Friction Velocity Out-of-Range. KURDAT =	
435	Surface Roughness Length Out-of-Range. KURDAT =	
438	Convective Velocity Data Out-of-Range. KURDAT =	
439	Monin-Obukhov Length Out-of-Range. KURDAT =	
440	Calm Hour Identified in Meteorology Data File at	

<b>Message Number</b>	<b>Error/Warning Message</b>	<b>Hint (not updated)</b>
441	Vert Pot Temp Grad abv ZI set to min .005, KURDAT=	
442	Vert Pot Temp Grad abv ZI exceeds 0.1 K/m, KURDAT=	
450	Record Out of Sequence in Meteorological File at:	
452	Missing hourly BACKGRND w/o BGSUB, KURDAT/Sector =	
453	BGSUB for missing hourly BACKGRND, KURDAT/Sector =	
454	Date/time Mismatch: BACKGRND File, KURDAT/Sector =	
455	Date/time Mismatch: Hourly Emission File, KURDAT =	
456	Date/time Mismatch on Surface & Profile. KURDAT =	
457	Date/time Mismatch: OZONEFIL File, KURDAT/Sector =	
458	O3SUB for missing hourly O3 value, KURDAT/Sector =	
459	No Hrly O3 & No Sub; Use Full Conversion, KURDAT =	
460	Missing Hour Identified in Meteor. Data File at	
465	Number of Profile Levels Exceeds Max: MXPLVL =	
470	Mixing Height Value is < or = 0.0. KURDAT =	
474	WS RefHt invalid (<0.001); Not msg or clm: KURDAT=	
475	WS reference height is higher than 100m. KURDAT =	
480	Less than 1yr for MULTYEAR, MAXDCONT or ANNUAL Ave	
481	Data Remaining After End of Year. Number of Hours=	
482	Too many years modeled for 24h-PM25 1h-NO2 1h-SO2:	
483	User Start Date is Earlier Than Start of Met File	
484	Restart Date < STARTEND date or start of Met File	
485	MULTYR DataGap; Restart Date < STARTEND or MetFile	
486	MULTYR Date Overlap; STARTEND Date < Restart Date	
487	MULTYR Date Overlap; MetFile Start < Restart Date	
488	First met HR.ne.1; ST results may not be valid	
489	First met HR.ne.1; EV results may not be valid for	
490	Problem reading SURFFILE date for EVENTS; MNDYHR =	
491	MAXDCONT option requires 1st Hr of met data = 01;	
492	SURFDATA YR .NE. 1st YR of file, adj to match file	
493	SURFDATA YR must match 1st YR of file for DAYRANGE	
495	Surface met file does not include enough variables	
496	Total precipitation in SURFFILE is zero (0.0) with	

<b>Message Number</b>	<b>Error/Warning Message</b>	<b>Hint (not updated)</b>
497	Possible code ERROR!!! EVENT mismatch for EVENTID:	
498	Possible code ERROR! MAXDCONT mismatch GRP/RNK/REC	
499	PRIME plume rise error; check stack parameters for	
500	Fatal Error Occurs Opening the Data File of	
501	Dup Filename! Fatal Error Opening the Data File of	
510	Fatal Error Occurs During Reading of the File of	
520	Fatal Error Occurs During Writing to the File of	
530	CAUTION! Met Station ID Mismatch with SURFFILE for	
531	CAUTION! Met Station ID Missing from SURFFILE for	
540	No RECTABLE/MAXTABLE/DAYTABLE for Average Period	
550	File Unit/Name Conflict for the Output Option:	
555	File Unit/Name conflict across options: GRP# AVE	
560	User Specified File Unit .LE. 30 for OU Keyword:	
565	Possible Conflict With Dynamically Allocated FUNIT	
570	Problem Reading Temporary Event File for Event:	
580	End of File Reached Trying to Read the File of	
585	Output data file for INITFILE option was not found	
590	The INITFILE filename matches a SAVEFILE filename	
592	MAXIFILE includes data past start of MULTYEAR run	
593	POSTFILE includes data past start of MULTYEAR run	

## **APPENDIX D**

### **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

## APPENDIX E. EVALUATION OF MODIFIED URBAN OPTION

The urban option in AERMOD was modified, beginning with version 11059, to address potential issues associated with the transition from the nighttime urban boundary layer to the daytime convective boundary layer. Prior to version 11059, the enhanced dispersion associated with the urban nighttime heat island effect was ignored once the boundary layer turned convective. This could result in an unrealistic drop in the mixed layer height during early morning hours for urban applications, which could contribute to unrealistically high concentrations for low-level plumes. This effect was observed in the application of AERMOD for the Risk and Exposure Assessment (REA) in support of the NO<sub>2</sub> NAAQS review in association with mobile source emissions (EPA, 2008). Beginning with version 11059 the urban option in AERMOD continues application of the urban boundary layer approach for urban sources until the daytime convective mixing height exceeds the urban nighttime mixing height, based on the user-specified population (Cimorelli, *et al.*, 2004). This revision to AERMOD will generally reduce concentrations during the early morning transition to convective conditions for low-level urban sources, but may increase daytime concentrations for elevated urban sources.

The modified implementation of the urban option was evaluated using data from the 1985 Indianapolis SF<sub>6</sub> urban field study (Perry, et al, 2005), and model-to-monitor comparisons at four ambient monitors for 2002 from the Atlanta NO<sub>2</sub> REA (EPA, 2008). The Indianapolis study involved an elevated buoyant release and the Atlanta REA study involved mostly low-level mobile source emissions. Results from the Indianapolis study are presented in the form of Q-Q plots of ranked 1-hour modeled vs. observed concentrations, unpaired in time and space. Figure E-1 shows model performance for all stabilities and Figure E-2 shows model performance for convective conditions only. The revised urban option does not affect results under stable conditions. Results from the Atlanta NO<sub>2</sub> REA are also presented in the form of Q-Q plots of 1-hour ranked modeled vs. observed concentrations, unpaired in time, for each of the four ambient NO<sub>2</sub> monitors, shown in Figures E-3 through E-6. Both of these evaluations show improved model performance with the modified urban option in AERMOD.

### INDIANAPOLIS SF6 1-HR Q-Q PLOT (CONC) - All Stabilities

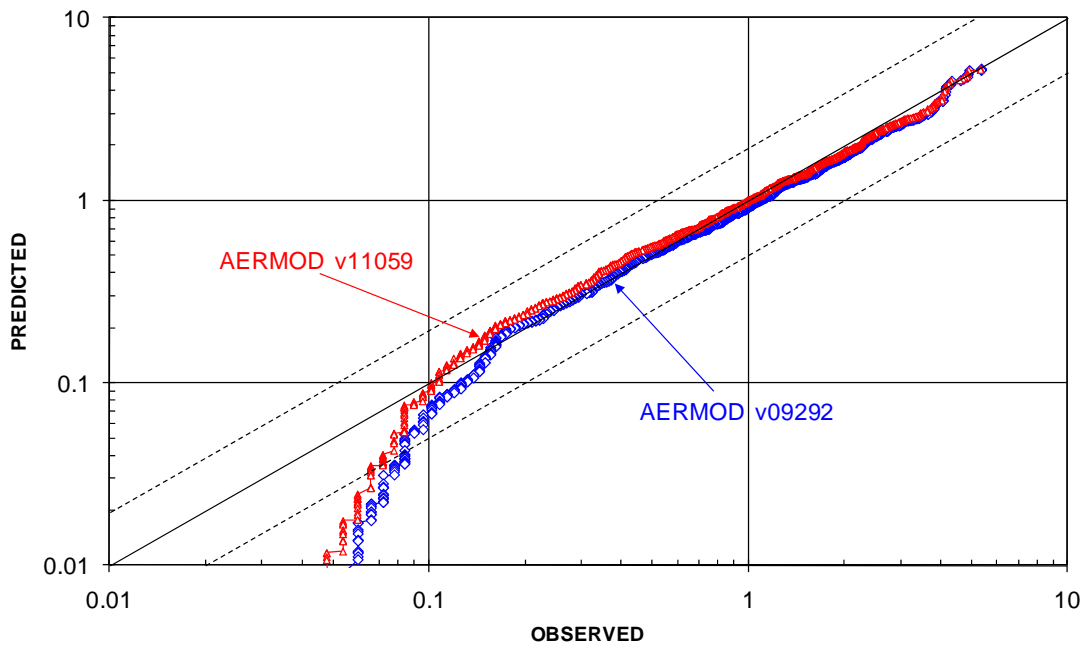


Figure E-1. 1-hour Q-Q Plot for Indianapolis SF<sub>6</sub> Study for All Stabilities

### INDIANAPOLIS SF6 1-HR Q-Q CBL (CONC) - Convective Conditions

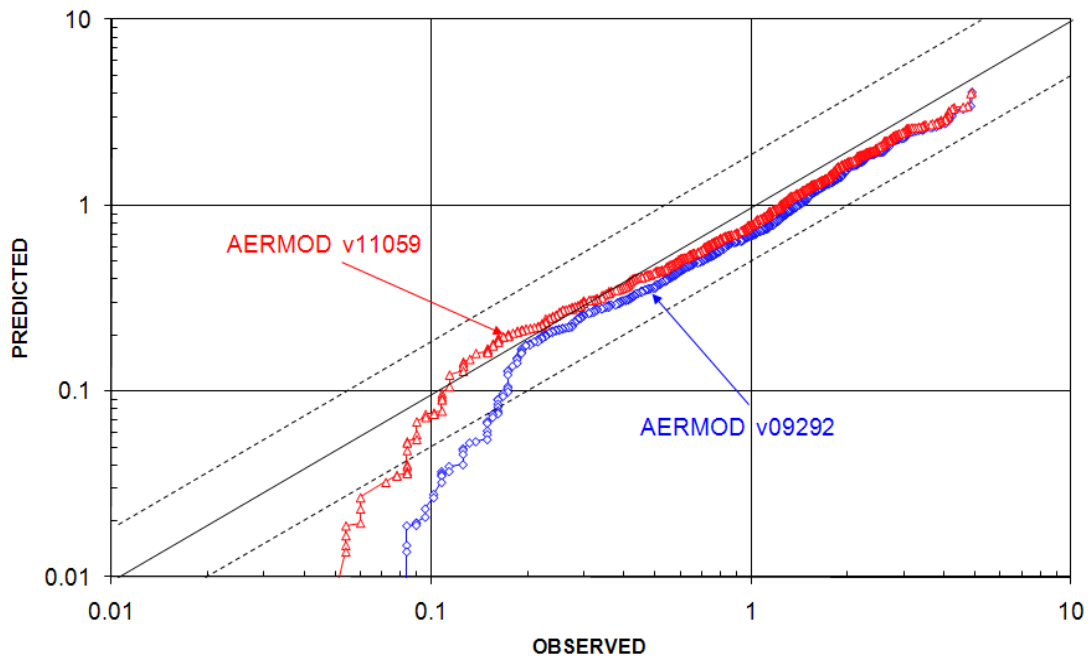


Figure E-2. 1-hour Q-Q Plot for Indianapolis SF<sub>6</sub> Study for Convective Conditions



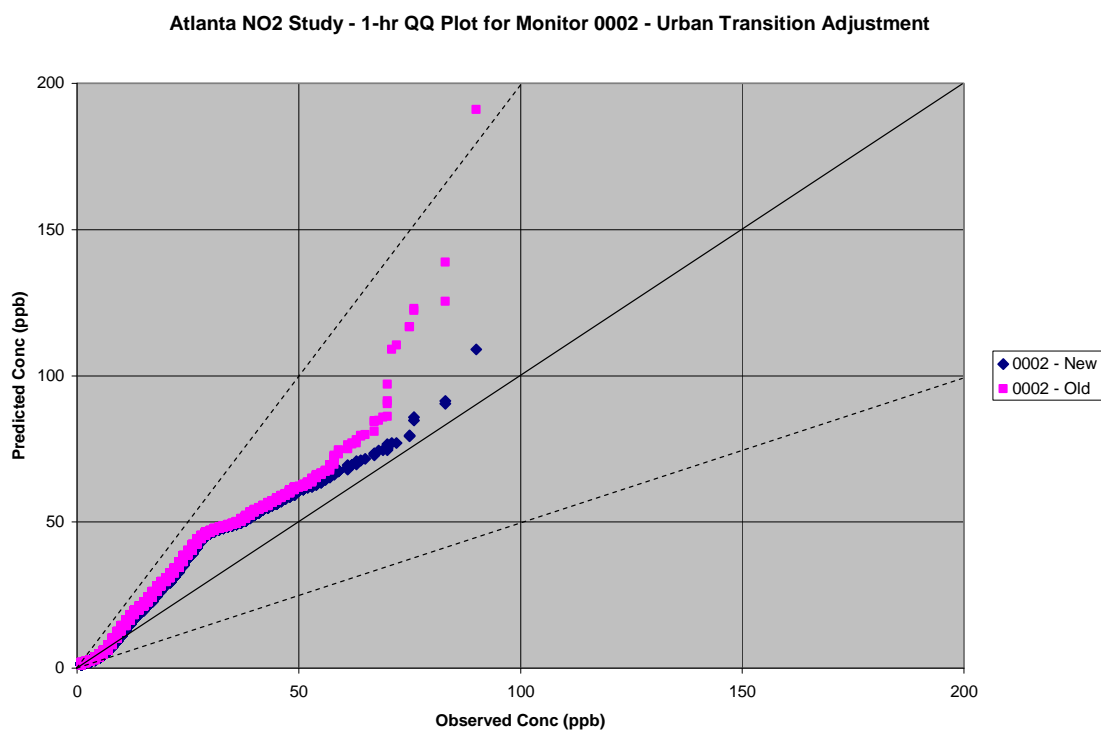


Figure E-3. 1-hour Q-Q Plot for Atlanta NO<sub>2</sub> Study for Monitor 0002

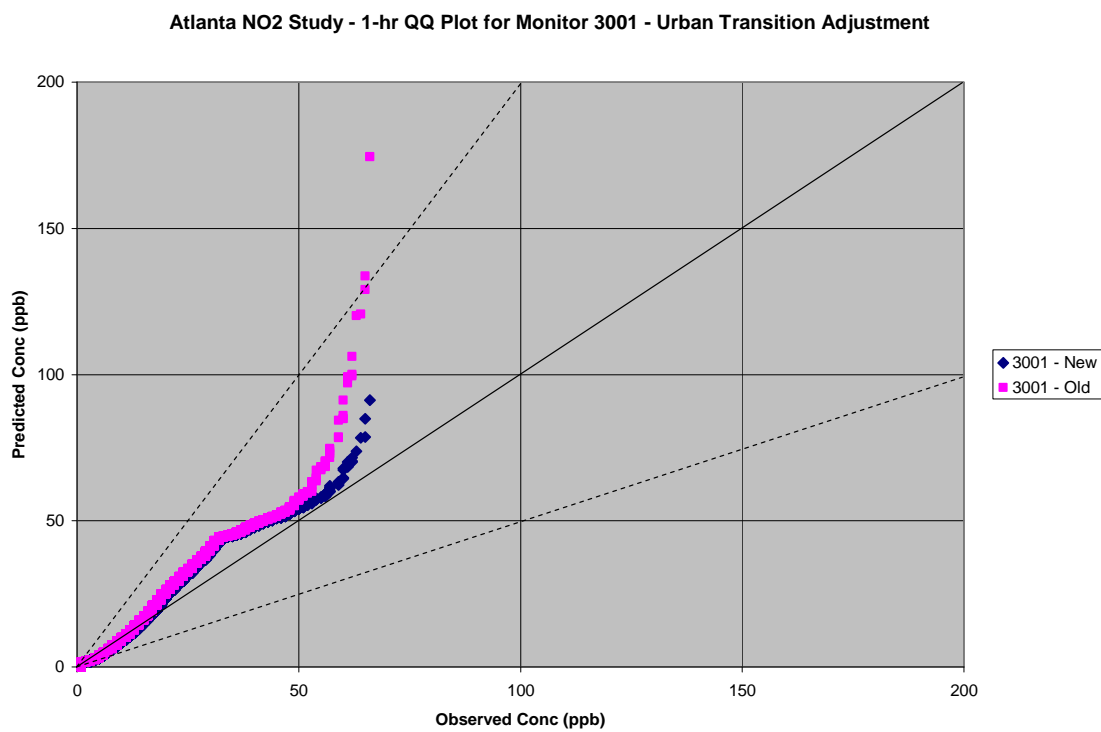


Figure E-4. 1-hour Q-Q Plot for Atlanta NO<sub>2</sub> Study for Monitor 3001

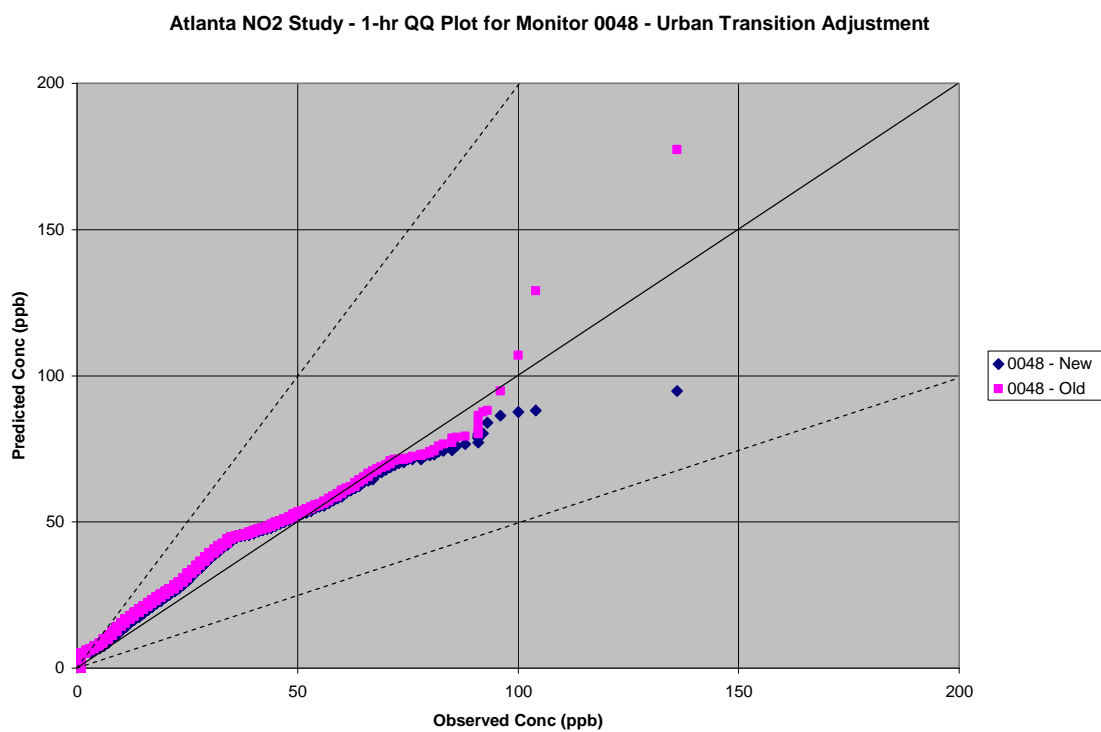


Figure E-5. 1-hour Q-Q Plot for Atlanta NO<sub>2</sub> Study for Monitor 0048

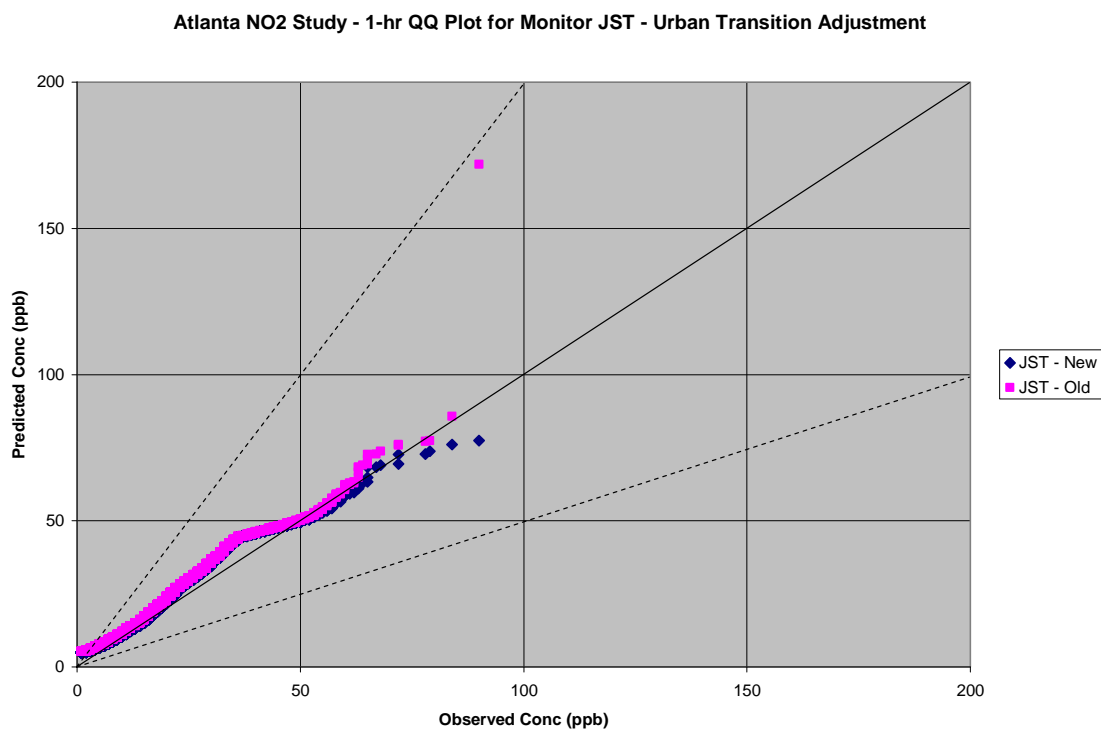


Figure E-6. 1-hour Q-Q Plot for Atlanta NO<sub>2</sub> Study for Monitor JST

## APPENDIX F. EVALUATION OF LOW WIND BETA OPTIONS

Beginning with version 12345, AERMOD includes non-default BETA options to address concerns regarding model performance under low wind speed conditions. This includes the LOWWIND1 and LOWWIND2 BETA options on the MODELOPT keyword in AERMOD, and the ADJ\_U\* option included in Stage 3 of the AERMET meteorological processor, beginning with version 12345. Preliminary evaluation results for these BETA options in AERMOD are presented below, based on field studies conducted in 1974 by the Air Resources Laboratory of the National Oceanic and Atmospheric Administration (NOAA) to investigate diffusion under low wind speed conditions at Idaho Falls (NOAA, 1974) and Oak Ridge (NOAA, 1976). These two field studies were used in the API-sponsored evaluations of AERMOD conducted by AECOM (AECOM, 2009), that were subsequently submitted as part of APIs public comments on EPA's 10<sup>th</sup> Conference on Air Quality Models held in March 2012. **Note: The preliminary evaluation results presented below have not been updated based on revisions to AERMET and AERMOD dated 13350. Updated results will be provided when available.**

The preliminary evaluation results presented here were based in part on the information included in the AECOM's 2009 report and data files subsequently provided by AECOM. However, some adjustments were made based on an independent assessment of the surface roughness for each of the study locations, an adjustment to the effective tracer release height at Idaho Falls from 1.5 to 3m based on information provided on page 24 of the NOAA Technical Memorandum for Idaho Falls (NOAA, 1974), and adjustments to the wind measurement heights for Oak Ridge based on the discussion in Section 2.2 and information provided in Table 1 of the NOAA Technical Memorandum for Oak Ridge (NOAA, 1976). The AECOM evaluation for Oak Ridge used a 2m wind measurement height, whereas page 8 of the NOAA report for Oak Ridge indicated that the wind measurements were "accomplished by laser anemometry" due to the fact that wind speeds were "below the threshold of standard cup anemometers". Footnotes in Table 1 also confirm that wind speeds were "measured by laser anemometers" for all tests, except for Test 11 where the wind speed was measured at the 30.5m level on one of meteorological towers included in the study. Given the fact that the transmitters and receivers for the laser anemometer were located on the hills on either side of the valley where the tracer was released, at elevations between 50 to 100 feet higher than the elevation at the release point (based on Figure 2b of the NOAA report), a 2m wind measurement height may not be appropriate. However, the NOAA report does not indicate an "effective" measurement height above ground for the wind speeds measured by the laser anemometers. Another aspect of the use of laser anemometry that complicates the determination of an appropriate measurement height is the fact that the "measured" wind speeds may represent more of a volume average than a point measurement. Based on these considerations, the preliminary evaluation results presented here were based on an "effective" wind measurement height of 10m, and the winds were also assumed to represent vector mean wind speeds.

A series of figures is provided below for each site, starting with the Idaho Falls study followed by the Oak Ridge study. For each site a series of Q-Q plots, paired plots and residual plots are shown starting with the No ADJ\_U\*/No LowWind Option case, followed by ADJ\_U\*/No\_LowWind Option; ADJ\_U\*/LowWind1; and ADJ\_U\*/LowWind2.

