

**SO₂ NAAQS Designations Modeling
Technical Assistance Document**

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Executive Summary

This document is one of two technical assistance documents being provided by the EPA to assist state, local, and tribal air agencies in the characterization of ambient air quality in areas with significant sulfur dioxide (SO₂) emission sources either through ambient monitoring or dispersion modeling as outlined in the expected data requirements rule. The primary purpose of this SO₂ national ambient air quality standard (NAAQS) Designations Modeling Technical Assistance Document (TAD) is to provide recommendations on how an air agency might appropriately and sufficiently model ambient air in proximity to an SO₂ emission source to establish air quality data for comparison to the SO₂ NAAQS for the purposes of designations. This TAD provides recommendations on several aspects of dispersion modeling in this context including the use of temporally varying actual emissions, source characterization, meteorological data, model selection, and background concentrations. Recommendations discussed in this TAD supersede the guidance set forth in the March 24, 2011 memorandum, “Area Designations for the 2011 Revised Primary Sulfur Dioxide National Ambient Air Quality Standards” (U.S. EPA, 2011a).

This TAD does not impose binding and enforceable requirements or obligations on any person, and is not final agency action. It is intended to provide recommendations for others to consider as they develop information to be used in future separate final actions, such as area designations and other NAAQS implementation actions. The TAD is subject to change and does not represent the culmination of any agency proceeding or a final interpretation by the EPA of any pre-existing statutory or regulatory requirements.

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1. Introduction

1.1 Background

The traditional NAAQS implementation process begins with the area designations process described in section 107 of the Clean Air Act (CAA), which generally relies on air quality concentrations to be characterized by ambient monitoring data collected by the air agency to identify areas that are exceeding the relevant standard. The preamble to the final SO₂ NAAQS noted that although the current SO₂ ambient monitoring network included 400+ monitors nationwide, the scope of the network had certain limitations, and approximately two-thirds of the monitors are not located to characterize maximum concentration source-oriented impacts. It was observed that some areas without monitoring likely have concentrations violating the NAAQS. To address these potential public health impacts, the SO₂ NAAQS preamble and subsequent draft guidance issued in September 2011 recommended that air agencies submit substantive attainment demonstration state implementation plans (SIPs) based on air quality modeling by June 2013 [under Clean Air Act section 110(a)(1)] that would show how areas expected to be designated unclassifiable and have sources emitting over 100 tons of SO₂ per year would attain and maintain the NAAQS in the future.

A number of stakeholders expressed concern with this suggested implementation approach, particularly with the number of sources to be modeled (more than 1680 sources had emissions exceeding 100 tons in 2008), and the recommended SIP submission date for areas *without* monitoring being before the SIP due date for violating areas *with* monitoring data. In response, EPA Assistant Administrator Gina McCarthy sent letters to state Environmental Commissioners on April 12, 2012, indicating that the EPA wanted to further consult with stakeholders regarding how to best implement this standard and protect public health in an effective manner. The letters also stated that the agency would not expect air agencies to submit attainment demonstrations by June 2013 for areas not designated as “nonattainment” based on ambient monitoring data. The EPA developed a white paper on possible implementation approaches and proceeded to convene three stakeholder meetings in May- June 2012 with environmental group representatives; state, local, and tribal air agency representatives; and industry representatives. On July 27, 2012, the EPA also announced that it was extending the deadline for SO₂ NAAQS area designations by an additional year, to June 3, 2013, based on the unavailability of data.

1.2 Purpose

This SO₂ Designations Modeling TAD is one of two TADs being provided by the EPA to assist state, local, and tribal air agencies in the characterization of ambient air quality in areas proximate to or impacted by significant SO₂ emission sources¹. The EPA issued an SO₂ Strategy Paper in February 2013 describing the agency’s plan for addressing public health concerns in areas outside the initial areas intended for nonattainment designation in June 2013. The SO₂

¹ For historical use of modeling in SO₂ designations see 75 FR 35551-35552.

Strategy Paper recognized the need to further characterize current air quality across the country to address important public health impacts caused by exposure to ambient SO₂ concentrations, with an understanding that there are limitations in the current SO₂ ambient monitoring network. The paper described the EPA's plans to develop a future data requirements rule which would require states to characterize air quality in areas around and impacted by the nation's larger SO₂ emission sources (including areas in which maximum one-hour emissions levels are not adequately characterized by the current ambient monitoring network). Under this intended approach, state, local, and tribal air agencies would be able to characterize ambient air quality conditions either through the use of additional ambient monitoring or through dispersion modeling. The planned data requirements rule would provide criteria for identifying the sources for which air quality should be characterized. It would also provide a schedule defining when states would need to decide whether to conduct monitoring or modeling for key sources, and when the resultant findings would need to be submitted to the EPA for use in the designations process.

In a future rule (2014), the EPA will establish requirements for characterizing SO₂ air quality in priority areas, focusing on areas with sources that have emissions higher than a threshold amount. The EPA expects to establish these thresholds taking population into account. States will have the flexibility to characterize air quality using modeling of actual emissions or using appropriately sited existing and new monitors. These data would be used in two future rounds of designations in 2017 (based on modeling) and 2020 (based on new monitoring).

This TAD presents recommendations on how an air agency might appropriately and sufficiently model ambient air in proximity to or impacted by an SO₂ emission source to assess compliance with the SO₂ NAAQS for designations purposes. The primary objective of the modeling would be to determine whether an area currently meets the SO₂ NAAQS, and thereby indicate the designation process for the area. This TAD presents recommended steps to characterize current air quality based on actual emissions for the most recent years for a source of interest, and for any nearby sources, which may influence the air quality of the area. The TAD also presents recommendations on proper use of modeling inputs, such as emissions, meteorological data, and background concentrations.

Many sections of this TAD are consistent with the EPA's *Guideline on Air Quality Models* (U.S. EPA, 2005), or Appendix W to 40 CFR part 51, and other relevant modeling guidance issued to characterize projected future air quality based on allowable emissions to support attainment planning and permitting programs. However, an important difference between attainment planning and permitting guidance that this TAD reflects is that this TAD describes how to characterize "current" air quality based on actual emissions data from recent years for the purposes of designations. Users of this TAD should consult with the appropriate EPA Regional Modeling Contact² to discuss any specific questions they may have.

This TAD is primarily for use by air agencies to assess likely areas of attainment and nonattainment with the 1-hour SO₂ NAAQS. We recognize that other stakeholders may wish to

² List of Regional Modeling Contacts by EPA Regional Office is available from SCRAM website at: http://www.epa.gov/ttn/scram/guidance_cont_regions.htm

use modeling to assess ambient SO₂ air quality, and this TAD provides the EPA's expectations for modeling for those other stakeholders as well.³ We also note that states—or other parties—may wish to assess SO₂ compliance on a schedule that is quicker than what we included in our strategy paper or than the EPA may propose in the data requirements rule, and that credible modeling information submitted that indicates potential violations of the NAAQS would need to be evaluated by states and, potentially, the EPA.

2. Guidance on Air Quality Models

The starting point for this TAD is the EPA's *Guideline on Air Quality Models*, also published as Appendix W of 40 CFR part 51. Appendix W is the primary source of information on the regulatory application of air quality models for SIP revisions for existing sources and for New Source Review (NSR) and Prevention of Significant Deterioration (PSD) programs. Air quality modeling in support of this designations process would need to employ air quality dispersion models⁴ that properly address the source-oriented nature of SO₂ and, thus, should rely upon the principles and techniques in Appendix W when applicable.

The *Guideline on Air Quality Models* was originally published in April 1978 and was incorporated by reference in the regulations for the Prevention of Significant Deterioration of Air Quality, Title 40, Code of Federal Regulations (CFR) sections 51.166 and 52.21 in June 1978 [43 FR 26382-26388]. These Guidelines were subsequently codified as Appendix W to 40 CFR 51 on August 12, 1996, at 61 FR 41838. The purpose of Appendix W guidelines is to promote consistency in the use of modeling within the air quality management process. The EPA periodically revises these guidelines to address new model developments and new or expanded regulatory requirements.

However, this TAD addresses a different context than the usual regulatory context addressed in Appendix W (NSR, PSD, and SIP). This TAD addresses modeling analyses that the EPA expects to be conducted pursuant to its planned data requirements rule, in which modeling is an optional approach for developing information to determine whether an area with a relatively large source or set of sources is violating the SO₂ air quality standard. Since the purpose here pertains to designations, this guidance supports analyses of existing air quality rather than analyses of emission limits necessary to provide for attainment. Consequently, the guidance in this TAD differs in selected respects from the guidance published in Appendix W. These differences include:

- Use of the most recent 3 years of actual emissions (designations) vs. maximum allowable emissions (other regulatory applications)

³ Please note that this guidance supersedes the EPA's March 2011 air quality modeling guidance, intended for the designations process, which recommended the use of allowable emissions only to characterize air quality.

⁴ Dispersion modeling uses mathematical formulations to characterize the atmospheric processes that disperse a pollutant emitted by a source. Based on emissions and meteorological inputs, a dispersion model can be used to predict concentrations at selected downwind receptor locations.

- Use of 3 years of meteorological data (designations) vs. one to five years (other regulatory applications)
- Use of actual stack height for designations using actual emissions vs. Good Engineering Practice (GEP) stack height for other regulatory applications (NSR, PSD, and SIP)

Clarifications and interpretations of modeling procedures become official EPA guidance through several courses of action: 1) the procedures are published as regulations or guidelines; 2) the procedures are formally transmitted as guidance to Regional Office managers; 3) the procedures are formally transmitted as guidance to Regional Modeling Contacts as a result of a Regional consensus on technical issues; or 4) the procedures are a result of decisions by the EPA's Model Clearinghouse that effectively establish national precedent. Formally located in the Air Quality Modeling Group (AQMG) of EPA's Office of Air Quality Planning and Standards (OAQPS), the Model Clearinghouse is the single EPA focal point for the review of criteria pollutant modeling techniques for specific regulatory applications. Model Clearinghouse and related clarification memoranda involving decisions with respect to interpretation of modeling guidance are available at the Support Center for Regulatory Atmospheric Modeling (SCRAM) website.⁵

Recently issued EPA guidance of relevance for consideration in modeling for designations includes:

- "Applicability of Appendix W Modeling Guidance for the 1-hour SO₂ NAAQS" August 23, 2010 -- confirming that Appendix W guidance is applicable for NSR/PSD permit modeling for the new SO₂ NAAQS (U.S. EPA, 2010a).
- "Additional Clarification Regarding Application of Appendix W Modeling Guidance for the 1-hour NO₂ National Ambient Air Quality Standard" March 1, 2011 -- (U.S. EPA, 2011a) provides additional guidance regarding NO₂ permit modeling and is also relevant to SO₂.

Questions about the interpretation of modeling techniques and procedures unanswered by the original guidance documents should be directed towards the appropriate EPA Regional Modeling Contact.

3. Model Selection

Preferred air quality models for use in regulatory applications are addressed in Appendix A of the EPA's *Guideline on Air Quality Models*. If a model is to be used for a particular application, the user should follow the guidance on the preferred model for that application. These models may be used without an area specific formal demonstration of applicability as long as they are used as indicated in each model summary of Appendix A. Further recommendations for the

⁵ The Support Center for Regulatory Atmospheric Modeling (SCRAM) website is available at: <http://www.epa.gov/ttn/scram/>.

application of these models to specific source problems are found in subsequent sections of Appendix W. In 2005, the American Meteorological Society/Environmental Protection Agency Regulatory Model (AERMOD) was promulgated as the EPA's preferred near-field dispersion modeling for a wide range of regulatory applications in all types of terrain based on extensive developmental and performance evaluation.

For area designations under the 1-hour SO₂ primary NAAQS, AERMOD should be used unless use of an alternative model can be justified (Section 3.2, Appendix W), such as the Buoyant Line and Point Source Dispersion Model (BLP). As outlined in the August 23, 2010 clarification memo, "Applicability of Appendix W Modeling Guidance for the 1-hour SO₂ National Ambient Air Quality Standard" (U.S. EPA, 2010a), AERMOD is the preferred model for single source modeling to address the 1-hour SO₂ NAAQS as part of the NSR/PSD permit programs. AERMOD is appropriate to inform this designations process because SO₂ concentrations result from direct emissions from combustion sources so that concentrations are highest relatively close to sources and are much lower at greater distances due to dispersion. Given the source-oriented nature of this pollutant (see, e.g., 75 FR at 35570), dispersion models are appropriate air quality modeling tools to predict the near-field concentrations of this pollutant.

The AERMOD modeling system includes the following components:

- AERMOD: the dispersion model (U.S. EPA, 2004a; U.S. EPA, 2012a)
- AERMAP: the terrain processor for AERMOD (U.S. EPA, 2004b)
- AERMET: the meteorological data processor for AERMOD (U.S. EPA, 2004c; U.S. EPA 2012b)

Other components that may be used, depending on the application, are:

- BPIPPRIME: the building input processor (U.S. EPA, 2004d)
- AERMINUTE: a 1-minute ASOS winds pre-processor to AERMET (U.S. EPA, 2011c)
- AERSURFACE: the surface characteristics processor for AERMET (U.S. EPA, 2008)
- AERSCREEN: a recently released screening version of AERMOD (U.S. EPA, 2011d; U.S. EPA, 2011e)

Before running AERMOD, the user should become familiar with the user's guides associated with the modeling components listed above and the AERMOD Implementation Guide (AIG) (U.S. EPA, 2009). The AIG lists several recommendations for applications of AERMOD which would be applicable for designations modeling.

4. Modeling Domain

Selection of the modeling domain is important in terms of how many sources⁶ to explicitly model and what kind of receptor network to create. Two questions may arise in model domain selection:

1. Where to center the modeling domain?, and
2. How large should the modeling domain be? (i.e., in terms of the number of sources to model and size of the receptor network in order to account for the areas of impact).

The locations of potential modeling domains would be determined based on a case-by-case basis as described in this section, depending on the number and locations of sources that meet or exceed the EPA determined emissions threshold, to be established in the future data requirements rule.

4.1 Determining Sources to Model

The determination of modeling domains and number of sources to consider for modeling should begin with analyzing the spatial distributions of sources that meet or exceed the emissions threshold established in the expected data requirements rule. The modeling domains could be centered over these sources. Some of these sources may be relatively isolated from each other and, in some cases, they may be within a few kilometers of each other such that they can be modeled together. In many cases, there may also be sources that are below the anticipated EPA thresholds within the potential modeling domains of the large sources. If there are sufficient numbers of these types of sources near the large sources, then these areas may wish to consider a monitoring strategy rather than conducting modeling of all the sources. An example of this type of situation would be a large source located in an urban area that is surrounded by numerous smaller sources. In addition, some situations may be more conducive to monitoring rather than modeling, such as non-point type sources (*i.e.*, ports), sources in complex terrain, or clusters of small sources (see 75 FR 35562).

Determining specific sources (those sources that are below the emissions threshold) to explicitly model is a multi-step process. The goal of determining other sources to model is to determine those sources that could cause or contribute to a NAAQS violation. Sound technical justification, best professional judgment, and consultation with the appropriate EPA Regional Modeling Contact should be used to determine which sources to model and which to represent via background concentrations. When considering other sources to include in the modeling, Appendix W states in Section 8.2.3.b that all sources expected to cause a significant concentration gradient in the vicinity of the source of interest should be explicitly modeled and that the number of such sources is expected to be small except in unusual cases. Other sources in the area, *i.e.* those not causing significant concentration gradients in the vicinity of the source of

⁶ Throughout Section 4, source refers to the facility as a whole, not individual units within a facility.

interest, should be included in the modeling via monitored background concentrations as described later in Section 8 of this TAD. The number of sources to explicitly model should generally be small. The March 1, 2011 NO₂ memorandum (U.S. EPA, 2011b) also offers recommendations for determining nearby sources, and those recommendations are relevant for SO₂ as well. The NO₂ memo recommends the following:

1. Analyze contour plots of the source which clearly depict the impact area of the source, preferably overlaid on a map that identifies key geographic features that may influence the dispersion patterns. The concentration contour plot also serves to visually depict the concentration gradients associated with the source's impact.
2. Controlling meteorological conditions for the source's impact should be identified as clearly as possible. Use of the MAXDAILY or MXDYBYR AERMOD output options can help identify the appropriate time periods to be used to calculate controlling design values.
3. A wind rose of the meteorological station used in the modeling can help to analyze flow patterns.

For application under the anticipated data requirements rule, in these three steps, for designation purposes "source" refers to those sources that would exceed the future EPA determined emissions threshold and contour plots should present the modeled design values. Overlaying other sources' locations on the contour plots can aid in determining the possibility of a significant concentration gradient around those sources. The March 1, 2011 NO₂ memorandum also offers guidance on the determination of significant concentration gradients and distance from the source. The memo discusses that concentration gradients associated with a particular source will be generally largest between the source and the distance to the maximum ground level concentrations from the source. Beyond that distance, gradients tend to be smaller and more spatially uniform. The memo also offers a general guideline that the distance between a source and its maximum ground level concentration is generally 10 times the stack height in flat terrain. However, the potential influence of terrain can impact the location and magnitudes of significant concentration gradients. The use of significant concentration gradients can help inform the decision on the size of the modeling domain and sources to consider for modeling. For more details on the significant concentration gradient, refer to the March 1, 2011 NO₂ memorandum.

For those sources that are questionable for inclusion in the modeling, the use of screening modeling via AERSCREEN may aid in the decision process. While AERSCREEN does not output a design value, but a maximum hourly concentration, it can serve as a conservative estimate to compare against the NAAQS and Significant Impact Level (SIL)⁷. If a source exceeds the EPA interim SIL or a state-selected impact criterion, it should be evaluated with refined modeling. If the maximum 1-hour concentration output from AERSCREEN violates the NAAQS, it does not necessarily mean that the screened source is in nonattainment, but that the source should be evaluated using refined dispersion modeling. For small isolated sources, screening may be useful on a source by source basis. However, for a cluster of small sources,

⁷ The 3 ppb interim SIL for the new 1-hour SO₂ NAAQS was provided by the EPA for states to consider using for the PSD program in the August 23, 2010 memorandum "Guidance Concerning the Implementation of the 1-hour SO₂ NAAQS for the Prevention of Significant Deterioration Program."

their cumulative impact should also be assessed. Individual sources may not be significant by themselves, but together they could cause or significantly contribute to a NAAQS violation.

4.2 Receptor Grid

The model receptor grid is unique to the particular situation and depends on the size of the modeling domain, the number of modeled sources, and complexity of the terrain. Receptors should be placed in areas that are considered ambient air (i.e., where the public generally has access) and placed out to a distance such that areas of violation can be detected from the model output to help determine the size of any nonattainment areas. Receptor placement should be of sufficient density to provide resolution needed to detect significant gradients in the concentrations, with receptors placed closer together near the source to detect local gradients and placed farther apart away from the source. In addition, the user should place receptors at key locations such as around facility fence lines (which define the ambient air boundary for a particular source) or monitor locations (for comparison to monitored concentrations for model evaluation purposes). The receptor network should cover the modeling domain and in general follow the recommendations of Section 7.2.2 of Appendix W.

If modeling indicates elevated levels of SO₂ (near or above the standard) near the edge of the receptor grid, expanding the grid or conducting an additional modeling run centered on the area of concern should be considered. As noted above, terrain complexity should also be considered when setting up the receptor grid. If complex terrain is included in the model calculations, AERMOD requires that receptor elevations be included in the model inputs for proper model execution. In those cases, the AERMAP terrain processor (U.S. EPA, 2004b) should be used to generate the receptor elevations and hill heights. Beginning with version 09040, AERMAP can process either Digitized Elevation Model (DEM) or National Elevation Data (NED) data files. The AIG recommends the use of NED data since they are more up to date than DEM data, which are no longer updated (Section 4.3 of the AIG).

5. Emissions Inputs

In the expected data requirements rule, the EPA expects to provide an option to base SO₂ designations on modeling of actual emissions data. This provision would reflect a view that designations are intended to address current actual air quality (i.e., modeling simulates a monitor), and, thus, are unlike attainment plan modeling, which must provide assurances that attainment will occur. For the purposes of designations, modeling can be used as a surrogate to ambient monitoring to characterize air quality for the designations process. The EPA recommends modeling the most recent 3 years of actual emissions. These data will generally best represent the emissions that would cause the impacts monitored in a 3-year monitoring data set under most circumstances.

In some cases, air agencies may wish to conduct modeling using allowable or PTE emissions⁸. For areas that show attainment based on current actual emissions, the EPA anticipates developing guidance for periodic review to judge whether emissions have increased to levels that might be causing NAAQS violations. In contrast, an area that is found to attain based on allowable emissions would need no such further periodic review with the exception of normal NSR or PSD applications. In addition, sources that implement emission controls during the relevant 3-year period and that become subject to an emission limit requiring that control may wish to demonstrate that limit assures attainment, even though the 3-year average emission level would be estimated to yield NAAQS violations. The EPA anticipates issuing further guidance on this subject in conjunction with its data requirements rule. Recognizing that allowable or actual emissions may be used, this section offers guidance on the use of both types of emissions.

5.1 Years to Model

For the purposes of modeling to characterize air quality for use in SO₂ designations, the EPA recommends using the most recent 3 years of actual emissions data and concurrent meteorological data (see Section 7) to allow the modeling to simulate what a monitor would observe. It also remains acceptable to use allowable emissions instead of actuals for designations purposes because allowable emissions would provide a more conservative estimate. When using allowable emissions, the most recent permitted or PTE rate should be used. When using actual emissions, each year would be modeled with its actual emissions and concurrent meteorology.

5.2 Actual Emissions

When using the “actual emissions” approach, rather than a more conservative approach based on allowable emissions, it is necessary to provide as accurate a representation as possible of the actual emissions history of the source of the relevant time period. Clearly, continuous emissions monitoring system (CEMS) data will provide acceptable historical emissions information when it is available. CEMS data are available for many electric generating units, and certain other types of sources. In the absence of CEMS data, the simplest approach for characterizing “actual emissions” is to use total annual emissions and assign a uniform emission rate for the entire year (i.e. the total annual emissions divided by 8,760 hours or 8,784 for leap years or the actual number of hours of operation). However, this approach usually is not the most accurate representation of actual emissions for sources that experience emissions rate variability throughout the year.

Representing this variability accurately is important given the short term nature of the SO₂ NAAQS. AERMOD has several options for emissions to temporally vary within a model simulation. This can be done via hourly varying emissions (AERMOD keyword HOUREMIS) or through the use of variable emission factors (AERMOD keyword EMISFACT). This section will

⁸ Throughout the rest of the TAD, allowable will be synonymous with PTE and permitted emissions.

discuss possible methodologies to calculate temporally varying emissions and how to apply them in AERMOD. When choosing a method, the most detailed available throughput, operating schedule and emissions information should be used. The approaches discussed in this section are recommended for use if representative temporally varying emissions or temporal profiles are not readily available. Sources should consult with the appropriate reviewing authority regarding the applicability of existing representative temporally varying emissions or temporal profiles in the designations modeling.

5.2.1 Hourly Varying Emissions

Hourly varying emissions data may be input into AERMOD using the HOUREMIS keyword in the source pathway of the AERMOD control file (AERMOD.INP). See Section 3.3.9 of the AERMOD User's Guide for the input format of hourly emissions. Currently, one file containing all the hourly emissions for all hourly varying sources is allowed per AERMOD run. For example, if there are ten hourly varying sources in an AERMOD run, the hourly emissions file contains hourly emissions for all ten sources.

Note that these hourly emissions override the emission rates entered on the SRCPARAM line of the AERMOD input file. For proper model execution, the hourly emissions file should contain all the hours that are contained in the input meteorological files and each hour should have an entry for each hourly varying source. If this is not the case, then AERMOD will abort execution. If an emissions source does not have emissions for a particular hour, then an emission rate of zero should be entered. One important item to remember regarding emissions in AERMOD (hourly or use of AERMOD emissions factors), is that the emissions are listed for the hour ending and are for hours 1-24, Local Standard Time. For example, for emissions occurring between midnight and 1:00 AM LST, the emissions would be assigned to 1:00 AM in the hourly emissions file. For more details about the syntax and use of hourly emissions, see Section 3.3.9 of the AERMOD User's Guide and Section 2.6.2 of the AERMOD User's Guide Addendum.

5.2.2 Non-hourly Variable Emissions Rates

In addition to hourly varying emissions, AERMOD also allows emissions to vary with time using variable emission rate factors⁹. For the purposes of SO₂ designations, these can be used to characterize the temporal variation of emissions if there is not enough information to determine hourly emissions. The emission rate factors are described in Table 1 below. Refer to Section 3.3.5 of the AERMOD User's Guide and Section 2.6.1 of the AERMOD User's Guide Addendum for more information about the rate factors. Note, for the seasonal rate factors, winter refers to December, January, and February; spring refers to March, April, and May; summer refers to June, July, and August; fall refers to September, October, and November.

⁹ AERMOD emission rate factors vary the emission input rate. These are not to be confused with emissions factors used to estimate emissions, such as the AP-42 factors.

When using the variable emissions rate factors, the input emission rate (SRCPARAM keyword emissions rate) is multiplied by the emission rate factors to yield an emission rate for the specific hour being processed in AERMOD. For example, suppose an emission rate of 5 g/s is entered on the SRCPARAM line and seasonal factors are used. Suppose further that the winter emission rate for all hours is 2.5 g/s, the spring rate is 3.5 g/s, the summer rate is 5 g/s and the fall rate is 1 g/s. The emission rate factors that would be entered on the EMISFACT line would be in order: 0.5, 0.7, 1.0, and 0.2 for winter, spring, summer, and fall respectively. In this case, the multiplication of the appropriate seasonal factor by the emission rate (5 g/s) on the SRCPARAM line results in the four seasonal rates of 2.5 g/s, 3.5 g/s, 5 g/s and 1 g/s.

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1 **Table 1. AERMOD emission rate factors and descriptions.**

Factor	Description (number of factors)	Order of rate factors in AERMOD
SEASON	Emissions vary seasonally (4)	Winter, Spring, Summer, Fall
SEASHR	Emissions vary by season and hour-of-day (96)	Hours 1-24 for Winter, hours 1-24 for Spring, hours 1-24 for Summer, hours 1-24 for fall
SHRDOW	Emissions vary by season, hour of day and day of week type (weekday (Mon-Fri), Saturday, or Sunday) (288)	Hours 1-24 for winter weekday, hours 1-24 for spring weekday, hours 1-24 for summer weekday, hours 1-24 for fall weekday, hours 1-24 for winter Saturday...hours 1-24 for fall Saturday, hours 1-24 for winter Sunday...hours 1-24 for fall Sunday
SHRDOW7	Emissions vary by season, hour of day and day of week (Mon., Tues. Wed., Thur., Fri., Sat., and Sunday) (672)	Hours 1-24 for winter Monday, hours 1-24 for spring Monday, hours 1-24 for summer Monday, hours 1-24 for fall Monday, hours 1-24 for winter Tuesday...hours 1-24 for fall Tuesday,... hours 1-24 for winter Sunday, hours 1-24 for spring Sunday, hours 1-24 for summer Sunday, hours 1-24 for fall Sunday
MONTH	Emissions vary monthly (12)	January, February, March, April, May, June, July, August, September, October, November, December
MHRDOW	Emissions vary by month, hour of day and day of week type (weekday, Saturday, or Sunday) (864)	Hours 1-24 for January weekday, hours 1-24 for February weekday... hours 1-24 for December weekday, hours 1-24 for January Saturday...hours 1-24 for December Saturday, hours -14 for January Sunday...hours 1-24 for December Sunday
MHRDOW7	Emissions vary by month, hour of day and day of week (Mon., Tues. Wed., Thur., Fri., Sat., and Sunday) (2,016)	Hours 1-24 for January Monday, hours 1-24 for February Monday... hours 1-24 for December Monday, hours 1-24 for January Tuesday...hours 1-24 for December Tuesday...hours -14 for January Sunday...hours 1-24 for December Sunday
HROFDY	Emissions vary by hour-of-day (24)	Hours 1-24
HRDOW	Emissions vary by hour of day and day of week type (weekday (Mon-Fri), Saturday, or Sunday) (72)	Hours 1-24 for weekday, hours 1-24 for Saturday, hours 1-24 for Sunday.
HRDOW7	Emissions vary by hour of day and day of week (Mon., Tues. Wed., Thur., Fri., Sat., and Sunday) (168)	Hours 1-24 for Monday, hours 1-24 for Tuesday, hours 1-24 for Wednesday, hours 1-24 for Thursday, hours 1-24 for Friday, hours 1-24 for Saturday, hours 1-24 for Sunday
WSPEED	Emissions vary by wind speed (6)	Speed 1, speed 2, speed 3, speed 4, speed 5, speed 6. Wind speeds may be defined with ME WINDCATS keyword. Default categories are 1.54, 3.09, 5.14, 8.23, and 10.8 m/s

Table 2 explains scenarios to determine which emission rate factors would fit a particular source’s temporal profile. Note that seasonal profiles should only be used if a source’s climatological seasonal/monthly assignment matches the default AERMOD seasons. If they do not, then monthly variations should be used. This could be applicable in areas where March is more of a winter scenario than spring, for example. If more refined emissions are known, such as weekly or daily emissions, then the emissions would have to be input as hourly emissions since there are no rate factors for those scenarios.

Table 2. Emission rate factors scenarios.

Factor	Conditions for use
SEASON	Emissions are known to vary seasonally only; Variation by day of week or hour unknown or unvarying
SEASHR	Emissions are known to vary seasonally and by hour of day; Variation by day of week unknown or unvarying.
SHRDOW	Emissions are known to vary seasonally, by hour of day and day of week (weekday, Saturday and Sunday; Variation by specific weekdays (Monday, Tuesday, etc.) unknown or unvarying.
SHRDOW7	Emissions are known to vary seasonally, by hour of day and day of week (Monday, Tuesday, Wednesday, Thursday, Friday, Saturday and Sunday
MONTH	Emissions are known to vary monthly only; Variation by day of week or hour unknown or unvarying.
MHRDOW	Emissions vary by month, hour of day and day of week type (weekday, Saturday, or Sunday). MHRDOW could be used as a substitute for monthly hour of day variation (analogous to SEASHR). Assume all days the same hourly profiles.
MHRDOW7	Emissions vary by month, hour of day and day of week (Mon., Tues. Wed., Thur., Fri., Sat., and Sunday).
HROFDY	Emissions vary by hour-of-day (24) only; No seasonal, monthly, or day of week variation known or unvarying.
HRDOW	Emissions vary by hour of day and day of week type only (weekday (Mon-Fri), Saturday, or Sunday); Variation by season or month, or specific weekdays unknown or unvarying.
HRDOW7	Emissions vary by hour of day and day of week (Mon., Tues. Wed., Thur., Fri., Sat., and Sunday); Variation by season or month unknown or unvarying.
WSPEED	Emissions vary by wind speed only.

5.2.3 Calculating Temporally Varying Emissions

In the absence of readily available temporally varying emissions or a predefined methodology, varying emissions should be calculated using the most detailed available information such as production logs, fuel usage information, operating schedules, etc. Given the short-term nature of

the SO₂ standard, it is important to characterize peak emissions that may occur due to production, changes in sulfur content of fuels, or operating schedules. Several possible approaches are discussed here. When calculating temporally varying emissions, it is important that the input emissions are mass conservative, i.e. the sum of the modeled hourly emissions sum to the annual emissions. This is discussed in more detail in Section 5.2.6.

5.2.3.1 Use of AP-42 Emissions Factors

If an emission source does not have hourly emissions readily available, it may be possible to calculate hourly emissions or temporally varying emissions for the emissions factors listed in the AERMOD User's Guide and addendum. One way to calculate temporally varying emissions would be to use emission factors such as the AP-42 emissions factors¹⁰ with throughput or production rates. These factors could be applied to calculate emissions ranging from hourly, to daily, monthly, or annual emissions. The June 28, 2010 memorandum, "Applicability of Appendix W Modeling Guidance for the 1-hour NO₂ National Ambient Air Quality Standard," (U.S., EPA, 2010b) has an example of using AP-42 factors to calculate an emission rate.

5.2.3.2 Ratio Method

If reliable emissions factors are not available to calculate emissions, an approximation of seasonal, monthly, etc. emissions can be made using ratios of annual production rates to seasonal, monthly, etc. production rates or even operating schedules. An example would be a facility that has a coal fired boiler, knows the monthly usage of coal in tons, and has a record of annual SO₂ emissions in tons, but does not have a record of the sulfur content of each month's coal. The ratio of monthly coal consumption to annual consumption can be calculated and applied to the annual SO₂ emissions to yield SO₂ tons/month.

5.2.3.3 Other Methods

While the use of AP-42 factors or a simple ratio method can be used to calculate temporally varying emissions, if temporally varying emissions are already available from another method, it may be possible to use such emissions and format as AERMOD emission rate factors or hourly varying emissions. An example would be to use emissions processed through the Sparse Matrix Operator Kernel Emissions model (SMOKE),¹¹ the emissions processor for the Community Multi-scale Air Quality model (CMAQ). If a modeled source's emissions have been processed in SMOKE for other modeling applications and the temporal profile is considered representative of the current conditions, it may be possible to import the temporally allocated emissions into AERMOD via the AERMOD emissions factors. A memorandum discussing an example use of

¹⁰ <http://www.epa.gov/ttn/chief/ap42/index.html>

¹¹ <http://www.smoke-model.org/index.cfm>

temporal factors can be found in the April 29, 2002 memorandum “Temporal Allocation of Annual Emissions Using EMCH Temporal Profiles,” (U.S. EPA, 2002). Again, any input emissions to AERMOD are input as hour-ending. If the input emissions are hour-beginning, the hour should be adjusted to hour-ending.

5.2.3.4 Calculating AERMOD Emission Rate Factors

When calculating temporally varying emissions, the process can be broken down into a series of steps of refining the emissions from a coarse level to the finest level of hourly emissions:

1. The coarsest level of emissions is annual, seasonal, or monthly.
2. These emissions are then spread over the operational days of the same temporal period of the emissions (annual, seasonal, or monthly).
3. Emissions from step 2 are assigned to the operational hours of each day in the time period.

In general, these steps can be represented by the general equation:

$$E = SO_2 \times DF \times HF \quad (1)$$

Where E represents temporally allocated SO₂ emissions per hour (tons, lbs, kg, etc.), SO₂ represents the annual, seasonal, or monthly SO₂ emissions (step 1) in the same units as E, DF is the daily allocation factor (step 2), and HF is the hourly allocation factor (step 3). The SO₂ emissions represented by SO₂ in Equation 1 could be emissions calculated using the methodologies discussed in Sections 5.2.3.1 through 5.2.3.3. The use of annual, seasonal, or monthly SO₂ emissions will depend on which AERMOD emissions factor is used to represent a source’s emissions. Emissions input to AERMOD should then be converted to g/s. Note, for area sources (AREA, AREACIRC, and AREAPOLY) and line (LINE) sources, emissions should then be divided by the area of the source in square meters to have the correct input units of g/s/m².

The daily allocation factor, DF, distributes the SO₂ emissions (SO₂ in equation 1) among the operational days of the year, season, or month. The sum of the daily factors should sum to one for the year, a particular season, or particular month. If a source does not have a predefined daily factor, the daily factor may be calculated as:

$$DF = \frac{E_{daytype}}{SO_2} \times \left(\frac{1}{Opdays_{daytype}} \right) \quad (2a)$$

Or, in the absence of more information, for operational days,

$$DF = \frac{1}{Opdays_{total}} \quad (2b)$$

Where SO₂ is defined as in Equation 1, $E_{\text{day type}}$ are the total day type emissions summed over the same time span as the SO₂ emissions, $\text{Opdays}_{\text{day type}}$ would be the corresponding number of operational days for that day type, and $\text{Opdays}_{\text{total}}$ are the operational days across all day types for the time span covered by the SO₂ emissions. For days with no emissions, the daily factor would be zero.

The available information would determine whether equation 2a or 2b is used. For example, suppose a source's emissions are represented by the AERMOD MHRDOW emissions factor. For a given month, there is enough available information such that each day type's (weekday, Saturday, or Sunday) total emissions are known for a month. Equation 2a could then be used to calculate the daily factor for the month. However, if only the total operational days for the month are known, then Equation 2b would be used and each operational day type would be assigned the same daily factor.

Note that if AERMOD emission factors are used, $\text{Opdays}_{\text{day type}}$ and $\text{Opdays}_{\text{total}}$ assumes that all occurrences of a given day type for a time period (season, month, or annual) have the same operational status throughout the time period. For example, for a MHRDOW emission factor, the use of $\text{Opdays}_{\text{day type}}$ or $\text{Opdays}_{\text{total}}$ assumes that all weekdays have the same status (either all are operational or all non-operational), all Saturdays have the same status and all Sundays have the same status. Equations 2a and 2b will not conserve the mass of emissions if a source has an irregular schedule of operations such as shutdowns for holidays or other non-scheduled shutdowns. More information about irregular schedules can be found in Section 5.2.3.5.

The hourly factor, HF distributes the daily emissions among the operational hours of the day and the sum of the non-zero hourly factors should sum to one for each day. If a source does not have a predefined hourly profile, the hourly factor can be calculated as:

$$HF = \frac{E_{\text{hour,daytype}}}{E_{\text{daytype}}} \quad (3a)$$

Or in the absence of more information for operational hours,

$$HF = \frac{1}{\text{Hours}_{op}} \quad (3b)$$

Where HF is the hourly factor, $E_{\text{hour,day type}}$ are the total hourly emissions for a given hour for a given day type across all occurrences for a given day type, $E_{\text{day type}}$ is defined as for Equation 2a, and Hours_{op} are the number of operational hours per day for a given day type. Note, when using Equation 3b, the HF for non-operational hours would be zero. As with the daily factor equations, the available information would determine which equation to use for the hourly factor. Using the example presented above, suppose an emission source's emissions are again represented by the MHRDOW emission factor. In addition to knowing the emissions for each day type, the hourly emissions for each day type are known. Then equation 3a can be used to calculate the hourly factor, HF. However, if that information is not known, then the emissions would be distributed

uniformly across operational hours of the day using Equation 3b. Example calculations for Equations 1 through 3 are shown in Appendix A.

Example daily and hourly factors are shown in Appendix B for each of the AERMOD emissions factors for illustrative purposes only to show the format of the AERMOD emissions factors. Sources may have their own temporal profiles that can be fitted to Equation 1. An example would be an hourly emissions profile that starts out as zero in the morning, peaks around mid-day, and then tails off back to zero near the end of the day.

For cases where a pre-applied temporal profile has been applied as discussed in Section 5.2.3.3, the emissions should be translated to an AERMOD emission rate factor.

5.2.3.5 Use of Hourly Emissions vs. Emissions Factors

In some situations, the choice between using hourly emissions (HOUREMIS) and using the emissions factors (EMISFACT) can be difficult. If input emissions vary hourly then the HOUREMIS input is the most logical to use. There may be situations where the emission rate factors would appear to be the initial input method but it may actually be necessary to translate those emissions to hourly emissions. These situations may occur because:

1. The facility may have had an irregular operating schedule due to holidays or shutdowns (unplanned or planned).
2. Emissions parameters such as exit velocity, exit temperature, release height, initial vertical dispersion, or initial horizontal dispersion vary with the emissions levels.
3. The most detailed available information about emissions or throughput are not characterized well by the AERMOD emission rate factors.

An example of the first situation would be that SO₂ emissions have been calculated based on a monthly, day of week, and hourly variation (MHRDOW7 emissions rate factor). The MHRDOW7 emission rate factor assumes that all given hours and days of a particular day type do not vary within a month, i.e. all 8:00 AM hours for Mondays in July would have the same emission rate. However, suppose that the facility does not operate on Independence Day, July 4, and the 4th falls on a Monday for a given year. In this situation, all other Mondays in July would receive the same emissions but the Monday of the 4th would receive zero emissions. The emissions for the operational Mondays could be calculated using Equations 1-3, with $Opdays_{day\ type}$ or $Opdays_{total}$ being the number of operating days without the presumptions described in Section 5.2.3.4. The 4th would be assigned zero emissions and the other Mondays would receive identical non-zero emissions based on Equation 1. Another example would be if a facility was shut down due to natural causes, i.e. storms or earthquakes or other causes (malfunction, economic reasons, etc.). An example application of situation #1 can be found in Appendix A.

For situation #2, emissions parameters may vary as the emissions vary. In some cases, exit temperatures or exit velocities change with emission levels. While the emissions rates can be calculated using Equation 1, it would be necessary to format and input those emissions to hourly emissions to account for the change in emissions parameters as emissions change.

Finally, there may also be situations where the AERMOD emission rate factors do not characterize the emissions when calculating emissions from non-hourly throughput. These would be cases where the most detailed throughput is weekly or daily and there is enough variation week to week or day to day such that the most detailed emission rate factor, MHRDOW7 would not work. In these types of situations, it may be necessary to use the hourly emissions input method.

There is one item to note regarding the use of AERMOD emissions factors. As explained in Section 5.1.2, the emission rate factors are multiplied by the emission rate supplied on the SRCPARAM to calculate emissions used for a particular hour in the AERMOD run. Equation 1 yields an emission rate, i.e. g/s that would be applied to a particular hour. To input the calculated temporally varying emissions, it may be easier to enter an emission rate of 1 g/s for point and volume sources, or 1 g/s/m² for area or line sources on the SRCPARAM line, and use the calculated emission rates as the AERMOD emissions factors. This avoids a question of what emission rate to enter on the SRCPARAM line and calculating the ratios of the temporally varying emissions to the reference emission rate. Using the simple example in Section 5.1.2 for seasonal rate factors, an emission rate of 1 g/s can be entered on the SRCPARAM line and the actual seasonal rates of 2.5 g/s, 3.5 g/s, 5 g/s and 1 g/s can be entered with the EMISFACT line(s). For an area type or line source, an emission rate of 1 g/s/m² can be entered on the SRCPARAM line and the actual emission rates in g/s/m² can be entered with the AERMOD emissions factors. The method of inputting the emissions is entirely at the user's discretion.

5.2.4 Intermittent Emissions

As discussed in the March 1, 2011 NO₂ clarification memorandum (U.S. EPA, 2011b), the EPA issued recommendations regarding the use of intermittent emissions (emergency generators, startup/shutdown) in modeling allowable emissions for PSD, NSR, or SIP modeling. In that memorandum, the EPA states that the most appropriate data to use for comparison to the 1-hour NO₂ NAAQS would be based on emissions scenarios that are continuous enough or frequent enough to contribute significantly to the annual distribution of maximum daily 1-hour concentrations. Guidance was developed for the treatment of intermittent emissions because the modeling used for PSD, NSR, or SIPs assume continuous operation at allowable emission. The memo states that assumed continuous operation of intermittent type sources would effectively impose an additional level of stringency beyond that intended by the NAAQS, and it would be inappropriate to implement the standard in such a manner, and compliance demonstrations should be based on emissions scenarios that are continuous enough or frequent enough to contribute significantly to the annual distribution of maximum daily 1-hour concentrations. For more details, refer to the March 1, 2011 NO₂ memo (U.S. EPA, 2011b). Notwithstanding that discussion for PSD, NSR, or SIP modeling, the EPA recommends the inclusion of emissions from intermittent sources when modeling for the purposes of characterizing actual ambient air quality as a surrogate for monitoring, as described in this document. Thus, when using temporally varying actual emissions, efforts should be made to include emissions from intermittent sources and to represent the actual hours during which these emissions occurred. Emissions from intermittent sources should be included in modeling performed to characterize

actual emissions impacts because such emissions would be reflected in ambient monitoring concentrations if a monitor were present in the area of interest.

5.2.5 Mass Conservation of Emissions

It is important that the temporally varying input emissions are mass conservative, i.e. the sum of the modeled hourly emissions is equal to the annual emissions. The daily factors and hourly factors shown in Equations 2a-b and 3a-c account for this conservation. For example, a source has an annual emissions total of 10 tons of SO₂. The winter emissions are 3 tons, spring emissions are 2 tons, summer emissions are 4 tons and fall emissions are 1 ton. Since all days and hours are considered operational, DF can be calculated by Equation 2b and HF by Equation 3b. The resulting seasonal varying emissions are shown in Table 3. Note, seasonal emissions are converted from tons to pounds during calculations.

Table 3. AERMOD SEASON emissions.

Season	Seasonal emissions (tons)	Number of operational days	DF (1/days)	Number of operational hours	HF (1/hours)	Emissions (lb/hr)	Emissions (g/s)
Winter	3	90	0.01111	24	0.041667	2.7777	0.35
Spring	2	92	0.01087	24	0.041667	1.81159	0.23
Summer	4	92	0.01087	24	0.041667	3.6232	0.46
Fall	1	91	0.01099	24	0.041667	0.9158	0.12

The resulting AERMOD factors are shown in Figure 1, assuming an input emission rate of 1 g/s.

Figure 1. SEASON AERMOD emissions factors.

<p>** Winter, Spring, Summer, Fall</p> <p>SO EMISFACT SOURCE1 SEASON 0.35 0.23 0.46 0.12</p>
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After applying the appropriate emission rate factor to each modeled hour, i.e. applying the winter emissions rate to winter hours, etc. and summing across the entire year, the resulting emissions are 10 tons and these emissions factors conserve the total mass.

5.3 Allowable Emissions

As noted in the beginning of Section 5, most cases will involve the use of actual emissions. States may find that use of allowable or PTE emissions is simpler and may show that an area would attain the standard with those conservative assumptions. (Note, if the modeling based on allowable emissions does not show attainment, then use of actual emissions should be conducted.) An air agency may choose to follow this type of approach if a conservative analysis of this type would still indicate attainment in the area of interest.

Because of the short-term nature of the SO₂ NAAQS, the maximum short-term or hourly emission rate could be input into AERMOD for each modeled hour. As stated in the August 23, 2010 memo (U.S. EPA, 2010a),

“Since short-term SO₂ standards (≤ 24 hours) have been in existence for decades, existing SO₂ emission inventories used to support modeling for compliance with the 3-hour and 24-hour SO₂ standards should serve as a useful starting point, and may be adequate in many cases for use in assessing compliance with the new 1-hour SO₂ standard since issues identified in Table 8-2 of Appendix W related to short-term vs. long-term emission estimates may have already been addressed.”

For those cases using maximum allowable emissions, the existing SO₂ inventories used for permitting or SIP planning demonstrations should contain the necessary emissions information for designations-related modeling. If short-term emissions are not readily available, they may be calculated using the methodology shown in Table 8-1 of Appendix W. For an example calculation of short term emissions, see the June 28, 2010 memorandum “Applicability of Appendix W Modeling Guidance for the 1-hour NO₂ National Ambient Air Quality Standard” (U.S., EPA, 2010b). Although the example is for NO₂, the calculation methodology would be the same for SO₂.

Regarding the use of allowable emissions and modeling of intermittent emissions sources, such as emergency generators and startup/shutdown emissions, recommendations in the March 1, 2011 memo, “Additional Clarification Regarding Application of Appendix W Modeling Guidance for the 1-hour NO₂ National Ambient Air Quality Standard,” should be followed for SO₂ as well. As previously stated in Section 5.2.5 of this TAD, the EPA believes the most appropriate data to use for comparison to the 1-hour SO₂ NAAQS are based on emissions scenarios that are continuous enough or frequent enough to contribute significantly to the annual distribution of maximum daily 1-hour concentrations. Although the referenced guidance in this memo is for NO₂ permit modeling, the common 1-hour averaging time and form of both the NO₂ and SO₂ standards makes this modeling guidance applicable to the 1-hour SO₂ NAAQS and, thus, applicable to SO₂ modeling in support of designations. For more details, refer to the March 1, 2011 NO₂ memo (U.S. EPA, 2011b). If any questions arise regarding preparation of emissions inputs for dispersion modeling including intermittent emissions from sources, then users should consult the appropriate EPA Regional Modeling Contact.

6. Source Characterization

This section provides guidance on source characterization to develop appropriate inputs for dispersion modeling with the AERMOD modeling system. Section 6.1 discusses the use of actual stack heights, Section 6.2 provides details on source configuration and source types, and Section 6.3 provides details on urban/rural determination of the sources.

6.1 Stack Heights

For the purposes of modeling with actual emissions to characterize air quality for use in a future SO₂ designations process, actual stack heights should be used rather than GEP stack height. The EPA recommends the use of actual stack heights so that the modeling analysis can most closely represent the actual ambient air quality conditions as influenced by the source. As previously stated, the purpose of the modeling is to act as a surrogate for monitoring. If a monitor were located in the area around the source, the concentrations detected at the monitor would be reflective of the effect of emissions from the actual stack heights of influencing sources.

If modeling with allowable emissions as discussed in Section 5.3, however, GEP stack heights should be input into the model since those emissions limits were set with GEP heights.

For both actual and GEP stack heights, if building downwash is being considered, the BPIPPRIME program (U.S. EPA, 2004d) should be used to input building parameters for AERMOD.

6.2 Source Configurations and Source Types

An accurate characterization of the modeled facilities is critical for refined dispersion modeling, including accurate stack parameters and physical plant layout. Accurate stack parameters should be determined for the emissions being modeled. Stack parameters (exit temperature, diameter, and exit velocity) should reflect the emissions used, allowable or actual. Accurate locations (i.e. latitude and longitude or Universal Transverse Mercator (UTM) coordinates and datum)¹² of the modeled emission sources are also important, as this can affect the impact of an emission source on receptors, determination of stack base elevation, and relative location to any nearby building structures. Not only are accurate stack locations needed, but accurate information for any nearby buildings is important. This information would include location and orientation relative to stacks and building size parameters (height, and corner coordinates of tiers) as these parameters are input into BPIPPRIME to calculate building parameters for AERMOD. If stack locations and or building information are not accurate, downwash will not be accurately accounted for in AERMOD.

¹² Latitudes and longitudes to four decimal places position a stack within 30 feet of its actual location and five decimal places place a stack within 3 feet of its actual location. Users should use the greatest precision available.

Emission source type characterization within the modeling environment is also important. As stated in the AERMOD User's Guide and addendum, emissions sources can be characterized as several different source types: POINT sources, capped stacks (POINTCAP), horizontal stacks (POINTHOR), VOLUME sources, OPENPIT sources, rectangular AREA sources, circular area sources (AREACIRC), and irregularly shaped area sources (AREAPOLY). Note that POINTCAP and POINTHOR are not part of the regulatory default option in AERMOD because the user must invoke the BETA option in the model options keyword MODELOPT while not including the "DFAULT" modeling option for these options to work properly. While most sources can be characterized as POINT sources, some sources, such as fugitive releases or nonpoint sources (emissions from ports, airports, or smaller point sources with no accurate locations) may be best characterized as VOLUME or AREA type sources. If questions arise about proper source characterization or typing, users should consult the appropriate EPA Regional Modeling Contact.

6.3 Urban/rural Determination

For any dispersion modeling exercise, the "urban" or "rural" determination of a source is important in determining the boundary layer characteristics that affect the model's prediction of downwind concentrations. In addition, for SO₂ modeling, the urban/rural determination is important because AERMOD invokes a 4-hour half life¹³ for urban SO₂ sources (See Section 7.2.6 of Appendix W) due to SO₂ removal by conversion to H₂SO₄ (catalytic and photochemical) and adsorption onto particular matter (Turner, 1964). This would only be done for urban sources when the POLLUTID keyword in AERMOD is set to "SO2" and the MODELOPT keyword includes the DFAULT option. Rural sources within the same AERMOD run would not be affected. If the DFAULT option is not included with the MODELOPT keyword, the 4-hour half life would not be used and the user would specify the 4-hour half life using the HALFLIFE or DCAYCOEFF keywords in order to account for the chemical transformation. See Section 3.2.6 of the AERMOD User's Guide (U.S. EPA, 2004a) for more details about these keywords. If the user invokes the HALFLIFE or DCAYCOEFF option, then any rural sources included in the modeling would need to be run in separate AERMOD runs so that they are not subject to the 4-hour half life. Note that if the DFAULT option is used, the rural sources would not need to be in a separate run from the urban sources. Determining whether a source is urban or rural can be done using the methodology outlined in Section 7.2.3 of Appendix W and recommendations outlined in Sections 5.1 through 5.3 in the AIG (U.S. EPA, 2009). In summary, there are two methods of urban/rural classification described in Section 7.2.3 of Appendix W.

The first method of urban determination is a land use method (Appendix W, Section 7.2.3c). In the land use method, the user analyzes the land use within a 3 km radius of the source using the meteorological land use scheme described by Auer (1978). Using this methodology, a source is considered urban if the land use types, I1 (heavy industrial), I2 (light-moderate industrial), C1 (commercial), R2 (common residential), and R3 (compact residential) are 50 percent or more of the area within the 3 km radius circle. Otherwise, the source is considered a rural source. The

¹³ Over a 4-hour period, SO₂ concentrations decrease by half from the initial value.

second method uses population density and is described in Section 7.2.3d of Appendix W. As with the land use method, a circle of 3 km radius is used. If the population density within the circle is greater than 750 people/km², then the source is considered urban. Otherwise, the source is modeled as a rural source. Of the two methods, the land use method is considered more definitive (Section 7.2.3e, Appendix W).

Caution should be exercised with either classification method. As stated in Section 5.1 of the AIG (U.S. EPA, 2009), when using the land use method, a source may be in an urban area but located close enough to a body of water or other non-urban land use category to result in an erroneous rural classification for the source. The AIG in Section 5.1 cautions users against using the land use scheme on a source by source basis, but advises considering the potential for urban heat island influences across the full modeling domain. When using the population density method, Section 7.2.3e of Appendix W states, “Population density should be used with caution and should not be applied to highly industrialized areas where the population density may be low and thus a rural classification would be indicated, but the area is sufficiently built-up so that the urban land use criteria would be satisfied...” With either method, Section 7.2.3(f) of Appendix W recommends modeling all sources within an urban complex as urban, even if some sources within the complex would be considered rural using either the land use or population density method.

Another consideration that may need attention by the user and is discussed in Section 5.1 of the AIG relates to tall stacks located within or adjacent to small to moderate size urban areas. In such cases, the stack height or effective plume height for very buoyant sources may extend above the urban boundary layer height. The application of the urban option in AERMOD for these types of sources may artificially limit the plume height. The use of the urban option may not be appropriate for these sources, since the actual plume is likely to be transported over the urban boundary layer. Section 5.1 of the AIG gives details on determining if a tall stack should be modeled as urban or rural, based on comparing the stack or effective plume height to the urban boundary layer height. The 100 m stack illustrated in Figure 3b, may be such an example as the urban boundary layer height for this stack would be 189 m (based on a population of 100,000) and equation 104 of the AERMOD formulation document (Cimorelli, et al., 2004). This equation is:

$$z_{iuc} = z_{iuo} \left(\frac{P}{P_o} \right)^{1/4} \quad (4)$$

Where z_{iuo} is a reference height of 400 m corresponding to a reference population P_o of 2,000,000 people.

Given that the stack is a buoyant release, the plume may extend above the urban boundary layer and may be best characterized as a rural source, even if it were near an urban complex. Exclusion of these elevated sources from application of the urban option would need to be justified on a case-by-case basis in consultation with the appropriate EPA Regional Modeling Contact.

AERMOD requires the input of urban population when utilizing the urban option. Population can be entered to one or two significant digits (i.e., an urban population of 1,674,365 can be entered as 1,700,000). Users can enter multiple urban areas and populations using the URBANOPT keyword in the runstream file (U.S. EPA, 2004a). If multiple urban areas are entered, AERMOD requires that each urban source be associated with a particular urban area or AERMOD model calculations will abort. Urban populations can be determined by using a method described in Section 5.2 of the AIG (U.S. EPA, 2009).

7. Meteorological Data

Section 7 gives guidance on the selection of meteorological data for input into AERMOD. Much of the guidance from Section 8.3 of Appendix W is applicable to designations modeling and is summarized here. This section discusses representativeness of the data and sources of data.

7.1 Years of Data

As discussed in Section 5.1, the most recent 3 years of meteorological data should be used in the designations modeling to allow the modeling to simulate a monitor. This use of 3 years of data for designations differs from the usual meteorological data requirements in other regulatory applications (NSR, PSD, or SIP) of dispersion modeling, which require at least one year of site-specific data or five years of representative NWS data, not necessarily from the most recent years. For designations modeling using site specific data, more than 1 year of data would be needed to allow the modeling to simulate a monitor.

7.2 Surface Characteristics and Representativeness

The selection of meteorological data that are input into a dispersion model should be considered carefully. The selection of data should be based on spatial and climatological (temporal) representativeness (Appendix W, Section 8.3). The representativeness of the data is based on: 1) the proximity of the meteorological monitoring site to the area under consideration, 2) the complexity of terrain, 3) the exposure of the meteorological site, and 4) the period of time during which data are collected. Sources of meteorological data are: National Weather Service (NWS) stations, site-specific or onsite data, and other sources such as universities, Federal Aviation Administration (FAA), military stations, and others. Appendix W addresses spatial representativeness issues in Sections 8.3.a and 8.3.c.

Spatial representativeness of the meteorological data can be adversely affected by large distances between the source and receptors of interest and the complex topographic characteristics of the area (Appendix W, Section 8.3.a and 8.3.c). If the modeling domain is large enough such that conditions vary drastically across the domain, then the selection of a single station to represent the domain should be carefully considered. Also, care should be taken when selecting a station if

the area has complex terrain. While a source and meteorological station may be in close proximity, there may be complex terrain between them such that conditions at the meteorological station may not be representative of the source. An example would be a source located on the windward side of a mountain chain with a meteorological station a few kilometers away on the leeward side of the mountain. Spatial representativeness for off-site data should also be assessed by comparing the surface characteristics (albedo, Bowen ratio, and surface roughness) of the meteorological monitoring site and the analysis area. When processing meteorological data in AERMET (U.S. EPA, 2004c), the surface characteristics of the meteorological site should be used [Section 8.3.c of Appendix W and the AERSURFACE User's Guide (U.S. EPA 2008)]. Spatial representativeness should also be addressed for each meteorological variable separately. For example, temperature data from a meteorological station several kilometers from the analysis area may be considered adequately representative, while it may be necessary to collect wind data near the plume height (Section 8.3.c of Appendix W).

Surface characteristics can be calculated in several ways. For details see Section 3.1.2 of the AIG (U.S. EPA, 2009). The EPA has developed a tool, AERSURFACE (U.S. EPA, 2008) to aid in the determination of surface characteristics. The current version of AERSURFACE uses 1992 National Land Cover Data. Note that the use of AERSURFACE is not a regulatory component of AERMOD, but the methodology outlined in Section 3.1.2 of the AIG should be followed unless an alternative method can be justified.

7.3 Meteorological Inputs

For the purpose of the modeling for designations, the most recent 3 years of NWS data or site-specific data should be used. This is recommended because the modeling is being conducted as a surrogate for ambient monitoring, and area designations are commonly established based on the 3-year design value of the area.

7.3.1 NWS Data

NWS data are available from the National Climatic Data Center (NCDC) in many formats, with the most common one in recent years being the Integrated Surface Hourly data (ISH). Most available formats can be processed by AERMET. As stated in Section 7.2, when using data from an NWS station alone or in conjunction with site-specific data, the data should be spatially and temporally representative of conditions at the modeled sources. A clarification memorandum released March 8, 2013 (U.S. EPA, 2013), offers guidance on the use of NWS data, including the use of the AERMINUTE (U.S. EPA, 2011b) pre-processor and a minimum wind speed threshold in modeling.

7.3.2 *Site-specific Data*

The use of site-specific meteorological data is the best way to achieve spatial representativeness. AERMET can process a variety of formats and variables for site-specific data. The use of site-specific data for regulatory applications is discussed in detail in Section 8.3.3 of Appendix W. Due to the range of data that can be collected onsite and the range of formats of data input to AERMET, the user should consult Appendix W, the AERMET User's Guide and addendum (U.S. EPA, 2004c, U.S. EPA, 2012b), and Meteorological Monitoring Guidance for Regulatory Modeling Applications (U.S. EPA, 2000). Also, when processing site-specific data for an urban application, Section 3.3 of the AERMOD Implementation Guide offers recommendations for data processing. In summary, the guide recommends that site-specific turbulence measurements should not be used when applying AERMOD's urban option, in order to avoid double counting the effects of enhanced turbulence due to the urban heat island.

7.3.3 *Upper Air Data*

AERMET needs full upper air soundings to calculate the convective mixing height. For AERMOD applications in the U.S., the early morning sounding, usually the 1200 UTC (Universal Time Coordinate) sounding, is typically used for this purpose. Upper air soundings can be obtained from the Radiosonde Data of North America CD for the period 1946-1997. Upper air soundings for 1994 through the present are also available for free download from the Radiosonde Database Access website. Users should choose all levels or mandatory and significant pressure levels¹⁴ when selecting upper air data. Selecting mandatory levels only would not be adequate for input into AERMET as the use of just mandatory levels would not provide an adequate characterization of the potential temperature profile.

8. Background Concentrations

The inclusion of ambient monitored background concentrations in the model results is important in determining the cumulative impact of the target source and other contributing nearby sources impacts. The modeled contribution to the cumulative analysis should follow the form of the standard and be calculated as described in Section 2.6.1.2 of the August 23, 2010 clarification memo on "Applicability of Appendix W Modeling Guidance for the 1-hour SO₂ National Ambient Air Quality Standard." This memo suggested a "first tier" approach to including a uniform monitored background contribution based on adding the overall highest hourly background SO₂ concentration from a representative monitor to the modeled design value. We recognize that this approach could be overly conservative in many cases and may also be prone to reflecting source-oriented impacts, increasing the potential for double-counting of modeled

¹⁴ By international convention, mandatory levels are in millibars: 1,000, 850, 700, 500, 400, 300, 200, 150, 100, 50, 30, 20, 10, 7.5, 3, 2, and 1. Significant levels may vary depending on the meteorological conditions at the upper-air station.

and monitored contributions. Therefore, as discussed in EPA's March 1, 2011 memo, "Additional Clarification Regarding Application of Appendix W Modeling Guidance for the 1-hour NO₂ Ambient Air Quality Standard," we recommend a less conservative "first tier" approach for a uniform monitored background concentration based on the monitored design values for the latest 3-year period, regardless of the years of meteorological data used in the modeling. Adjustments to this approach may be considered in consultation with the appropriate EPA Regional Modeling Contact with adequate justification and documentation of how the background concentration was calculated.

Section 8.2.2 of Appendix W gives guidance on background concentrations for isolated single sources and is also applicable for multi-source areas. One option is, as described in Section 8.2.2.b:

"Use air quality data in the vicinity of the source to determine the background concentration for the averaging times of concern. Determine the mean background concentration at each monitor by excluding concentrations when the source in question is impacting the monitor... For shorter time periods, the meteorological conditions accompanying concentrations of concern should be identified. Concentrations for meteorological conditions of concern, at monitors, not impacted by the source in question, should be averaged for separate averaging time to determine the average background value. Monitoring sites inside a 90° degree sector downwind of the source may be used to determine the area of impact."

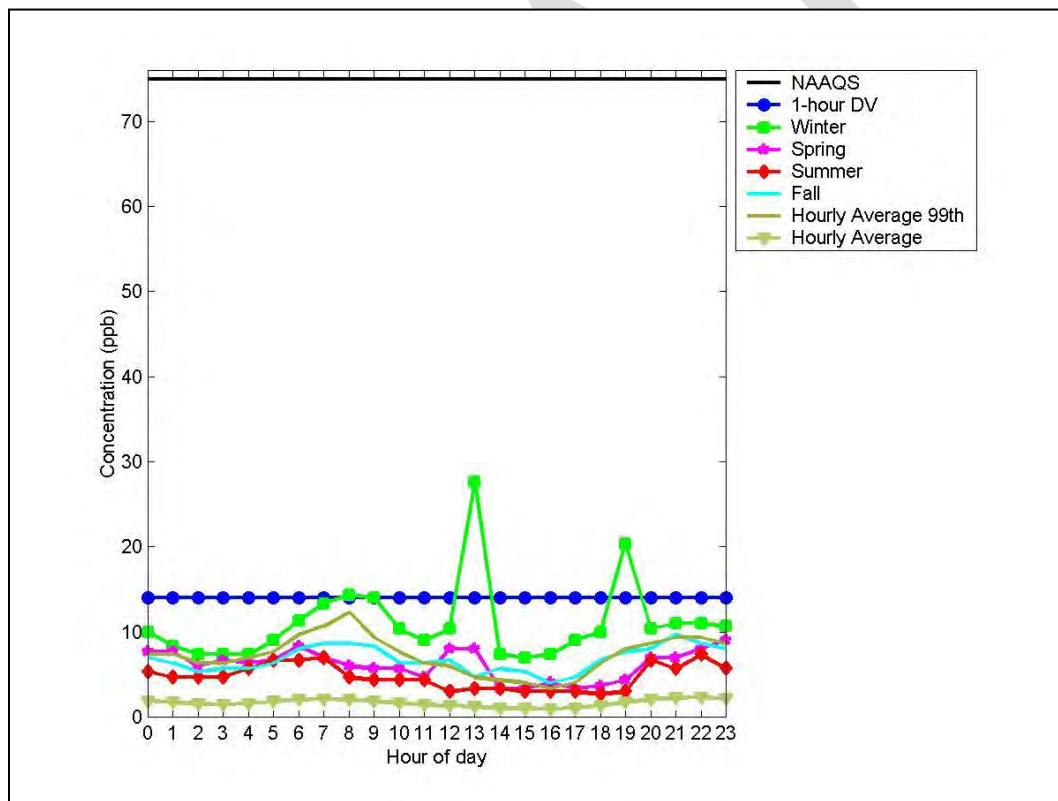
When no monitors are located in the vicinity of the sources being modeled, a "regional site" (i.e., one that is located away from the area of interest but is impacted by similar natural and distant man-made sources) may be used to determine background (Section 8.2.2.c, Appendix W). In multi-source areas, background includes two components, nearby sources and other sources (Section 8.2.3 of Appendix W). Nearby sources are those sources that are expected to cause a significant concentration gradient in the vicinity of the source or sources under consideration, and should be explicitly modeled as discussed in Section 4.1. Identification of nearby sources calls for professional judgment and consultation with the appropriate EPA Regional Modeling Contact. For other sources, such as natural sources, minor sources and distant major sources, the methodology of Section 8.2.2 should be used.

The EPA's March 1, 2011 memo, "Additional Clarification Regarding Application of Appendix W Modeling Guidance for the 1-hour NO₂ Ambient Air Quality Standard," describes an appropriate methodology of calculating temporally varying background monitored concentrations by hour of day and season (excluding periods when the source in question is expected to impact the monitored concentration). The methodology for NO₂ is to use the 98th percentile concentration for each hour of the day by season and average across 3 years. This same methodology is applicable to SO₂ designations modeling based on use of the 99th percentile by hour of day and season for background concentration excluding periods when the dominant source(s) are influencing the monitored concentration. Recent updates included in AERMOD allow for the inclusion of temporally varying background concentrations in the design value calculation in combination with modeling results. This TAD also concurs with the guidance in

the March 1, 2011 memo regarding the application of hour-by-hour background with modeled concentrations, in that the general recommendation is not use hour-by-hour pairing but average values as described in this section. Hour-by-hour pairing is not recommended because this approach would assume that the hourly monitored background concentration is spatially uniform for the hour and that monitored values are representative of background levels at each receptor for each receptor (U.S. EPA, 2011b).

An illustrative example is shown in Figure 2. Shown are the NAAQS standard concentration, the monitor's 3-year average design value, and 3-year averages of the 99th percentile concentrations by season and hour of day. To calculate the 99th percentile concentration for a season and hour of day combination, the second highest concentration for that combination should be selected. Also shown are 3-year averages of the 99th percentile concentration by hour of day (across all seasons), and the average concentration by hour of day across the 3 years¹⁵. In this example, the winter background concentrations show a distinct diurnal variability, with less for each of the other seasons.

Figure 2. SO₂ monitored concentrations for various averaging times.



¹⁵Modelers should use the 1st-highest value for more detailed pairings, such as month by hour-of-day or season by hour-of-day and day-of-week.

The conventions regarding reporting time differ between ambient air quality monitoring, where the observation time is based on the hour-beginning convention, and meteorological monitoring, where the observation is based on the hour-ending time. Thus, ambient monitoring data reported for hour 00 should be paired with meteorological data for hour 01, etc. This is important when incorporating time-varying background concentrations in the AERMOD calculations, which AERMOD allows.

9. Running AERMOD and Implications for Design Value Calculations

Recent enhancements to AERMOD include options to aid in the calculation of design values for comparison with the SO₂ NAAQS. These enhancements include:

- The output of daily maximum 1-hour concentrations by receptor for each day in the modeled period for a specified source group. This is the MAXDAILY output option in AERMOD. Depending on the number of receptors and number of years modeled in the AERMOD run, this file can become quite large.
- The output, for each rank specified on the RECTABLE output keyword, of daily maximum 1-hour concentrations by receptor for each year for a specified source group. This is the MXDYBYR output option.
- The MAXDCONT option, which shows the contribution of each source group to the high ranked values for a specified target source group, paired in time and space. The user can specify a range of ranks to analyze, or specify an upper bound rank, e.g., 4th highest, and a lower 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, specified by the user. A warning message will be generated if the threshold is not reached within the range of ranks analyzed (based on the range of ranks specified on the RECTABLE keyword). This option may be needed to aid in determining which sources to include in a nonattainment area.

For more information regarding these options, consult Section 2.8 of the AERMOD User's Guide addendum (U.S. EPA, 2012a).

Ideally, all explicitly modeled sources, receptors, and background should be modeled in one AERMOD run for all modeled years. In this case, the use of the one of the above output options can be used in AERMOD to calculate design values for comparison to the NAAQS and determine the area's attainment status and/or inform attainment/nonattainment boundaries. The use of these options in AERMOD allows AERMOD to internally calculate concentration metrics that can be used to calculate design values and therefore lessen the need for large output files, i.e. hourly POSTFILES.

However, there may be situations where a single AERMOD run with all explicitly modeled sources is not preferred or is not reasonable. One example that is applicable to designations

modeling, is each emissions year may need to be modeled separately when using AERMOD emissions factors. Other situations often arise due to runtime or storage space considerations during the AERMOD modeling. Sometimes separate AERMOD runs are done for each facility or group of facilities, or by year, or the receptor network is divided into separate sub-networks. In some types of these situations, the MAXDAILY, MXDYBYR, or MAXDCONT output option may not be an option for design value calculations, especially if all sources are not included in a single run. If the user wishes to utilize one of the three output options, then care should be taken in developing the model inputs to ensure accurate design value calculations.

Situations that would effectively preclude the use of the MAXDAILY, MXDYBYR, and MAXDCONT option to calculate meaningful AERMOD design value calculations include the following examples:

- Separate AERMOD runs for each source or groups of sources.
- Separate AERMOD runs for each source and each modeled year.

In the two situations listed above, the MAXDAILY, MXDYBYR, or, MAXDCONT option would not be useful as the different AERMOD runs do not include a total concentration with contributions from all facilities. In these situations, the use of hourly POSTFILES, which can be quite large, and external post-processing would be needed to calculate design values.

Situations that may use the MAXDAILY, MXDYBYR, or, MAXDCONT option but may necessitate some external post-processing afterwards to calculate a design value include:

- The receptor network is divided into sections and an AERMOD run, with all sources and years, is made for each network. After the AERMOD runs are complete, the MAXDAILY, MXDYBYR, or, MAXDCONT results for each network can be post-processed into the larger network for comparison against the NAAQS.
- All sources and receptors are modeled in an AERMOD run for each year. In this case, the MAXDAILY, MXDYBYR, or, MAXDCONT results can be post-processed to calculate the appropriate NAAQS design values.
- Two facilities are modeled with 3 years of NWS data. All facilities are modeled with all receptors for each year individually, resulting in three AERMOD runs. MAXDAILY, MXDYBYR, or, MAXDCONT output can be used and post-processed to generate the necessary design value concentrations.
- The receptor network is divided and each year is modeled separately for each sub-network with all sources. For each sub-network, both facilities are modeled for each year separately, resulting in twelve AERMOD runs. MAXDAILY, MXDYBYR, or, MAXDCONT output can be used and post-processed to generate the necessary design value concentrations.

10. Documentation

It is expected that the forthcoming data requirements rule would provide that the state would submit a modeling and analysis protocol that details the methodology and model inputs before commencement of the modeling exercise. This information should support the states' modeling decisions, and provide a basis for the EPA's evaluation of those decisions. The protocol should include the following:

- Characterization of the modeled area,
- An emissions analysis of the area under consideration for designations, and
- Methodology for preparing air quality and meteorology inputs including choice of meteorological data and representativeness of the data.

Additionally, the documentation should include:

- Summary and analysis of modeling results,
- Provision of modeling data inputs and outputs in electronic form, and
- In cases of variable emissions, summary of the emissions used.

A meeting with the appropriate EPA Regional Modeling Contact and other technical and planning staff to discuss the modeling and analysis protocol is recommended before submitting the protocol and beginning any refined modeling.

11. Summary

In summary, we emphasize the following key points of this SO₂ modeling guidance:

- States should submit a modeling and analysis protocol that details the methodology and model inputs before commencement of the modeling exercise. This information should support the states' recommended designations, and provide a basis for the EPA's evaluation of the recommendations.
- AERMOD is the EPA's preferred near-field dispersion model for regulatory applications and is applicable for SO₂ designations modeling consistent with EPA's *Guideline on Air Quality Models*, also published as Appendix W of 40 CFR Part 51.
- Modeling can be done with the most recent 3 years of temporally varying actual emissions or, in some cases, the current allowable emissions (if attainment can be shown). Modeling for the purposes of characterizing current SO₂ air quality (such as for the purposes of area designations) should be conducted with the following inputs:
 - the most recent 3 years of temporally varying actual emissions; or, as an alternative, the most recent allowable emissions if attainment can be shown with allowable emissions.

- the most recent 3 years of representative NWS meteorological data or site specific meteorology.
- actual stack height information, not GEP stack height when using actual emissions
- GEP stack height when using allowable emissions
- background concentrations characterized according to the:
 - “First tier” approach, based on monitored design values added to modeled design values; or
 - Temporally varying approach, based on the 99th percentile monitored concentrations by hour of day and season added to modeled design values.

At any time during the designations process when there are questions regarding modeling or interpretation of this guidance, the appropriate EPA Regional Modeling Contact should be consulted.

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Appendix A: Example Calculations of Temporally Allocated Emissions

A.1 Example Daily and Hourly Factor Calculations

The SO₂ modeling TAD introduced the formulation of temporally allocated emissions. This appendix presents example calculations of equations 1 through 3, including the use of equations 2a and 2b and 3a and 3b. The example presented here is for illustrative purposes only.

Scenario:

Calculate temporally allocated emissions for the SHRDOW AERMOD emission rate factor. Shown are values for a single stack (source ID STACK) for winter that is not operational on Saturdays.

Emissions and operational days:

- Winter emissions: 220 tons (77 days)
- Winter weekday emissions: 180 tons (64 days)
- Winter Saturday emissions: 0 tons (0 days)
- Winter Sunday emissions: 40 tons (13 days)

Daily factors, DF calculated using Equation 2a.

- Winter weekday DF = $(180/220) \times (1/64) = 0.0128$
- Winter Saturday DF = $(0/220) \times (1/13) = 0$
- Winter Sunday DF = $(40/220) \times (1/13) = 0.014$

Daily factors, DF, calculated using Equation 2b.

- Winter DF for weekdays and Sundays = $1/77 = 0.0128$
- Winter DF for Saturdays = 0

Hourly factors, HF calculated using Equation 3a for weekdays and Sundays are shown in Tables A-1 and A-2 respectively. Hourly factors for Saturdays are zero.

Table A-1. Weekday hourly factors

Hour	Total weekday emissions (tons) (E_{weekday})	Total hourly emissions (tons) ($E_{\text{hour, weekday}}$)	HF ($E_{\text{hour, weekday}}/E_{\text{weekday}}$)
1	180	8	0.0444
2		8	0.0444
3		8	0.0444
4		8	0.0444
5		8	0.0444
6		8	0.0444
7		8	0.0444
8		7	0.0389
9		7	0.0389
10		7	0.0389
11		7	0.0389
12		8	0.0444
13		8	0.0444
14		8	0.0444
15		7	0.0389
16		7	0.0389
17		7	0.0389
18		7	0.0389
19		7	0.0389
20		7	0.0389
21		7	0.0389
22		7	0.0389
23		8	0.0389
24		8	0.0444

Table A-2. Sunday hourly factors

Hour	Total weekday emissions (tons) (E_{weekday})	Total hourly emissions (tons) ($E_{\text{hour,weekday}}$)	HF ($E_{\text{hour,weekday}}/E_{\text{weekday}}$)
1	40	1.6	0.04
2		1.6	0.04
3		1.6	0.04
4		1.6	0.04
5		1.6	0.04
6		1.6	0.04
7		1.6	0.04
8		1.6	0.04
9		1.6	0.04
10		1.7	0.0425
11		1.7	0.0425
12		1.7	0.0425
13		1.7	0.0425
14		1.6	0.04
15		1.6	0.04
16		1.6	0.04
17		1.7	0.0425
18		1.7	0.0425
19		1.7	0.0425
20		1.7	0.0425
21		1.7	0.0425
22		1.7	0.0425
23		1.7	0.0425
24		1.7	0.0425

Hourly factors calculated using Equation 3b (assuming 24 operational hours).

- HF for weekdays and Sundays = $1/24 = 0.0417$
- HF for Saturdays = 0

Hourly allocated emissions using combinations of Equations 2a, 2b, 3a, and 3b and converting from tons/hour to g/s are shown in Tables A-3 (weekdays) and A-4 (Sundays). Figures A-1 through A-3 are examples of the input format for AERMOD for winter.

Table A-3. Weekday allocated emissions based on the use Equations 2a, 2b, 3a, and 3b.

Hour	Seasonal SO ₂ (tons)	DF		HF		Allocated emissions (g/s)		
		2a	2b	3a	3b	2a+3a	2a+3b	2b+3b
1	220	0.0128	0.0128	0.0444	0.0417	31.5	29.6	29.6
2	220	0.0128	0.0128	0.0444	0.0417	31.5	29.6	29.6
3	220	0.0128	0.0128	0.0444	0.0417	31.5	29.6	29.6
4	220	0.0128	0.0128	0.0444	0.0417	31.5	29.6	29.6
5	220	0.0128	0.0128	0.0444	0.0417	31.5	29.6	29.6
6	220	0.0128	0.0128	0.0444	0.0417	31.5	29.6	29.6
7	220	0.0128	0.0128	0.0444	0.0417	31.5	29.6	29.6
8	220	0.0128	0.0128	0.0389	0.0417	27.6	29.6	29.6
9	220	0.0128	0.0128	0.0389	0.0417	27.6	29.6	29.6
10	220	0.0128	0.0128	0.0389	0.0417	27.6	29.6	29.6
11	220	0.0128	0.0128	0.0389	0.0417	27.6	29.6	29.6
12	220	0.0128	0.0128	0.0444	0.0417	31.5	29.6	29.6
13	220	0.0128	0.0128	0.0444	0.0417	31.5	29.6	29.6
14	220	0.0128	0.0128	0.0444	0.0417	31.5	29.6	29.6
15	220	0.0128	0.0128	0.0389	0.0417	27.6	29.6	29.6
16	220	0.0128	0.0128	0.0389	0.0417	27.6	29.6	29.6
17	220	0.0128	0.0128	0.0389	0.0417	27.6	29.6	29.6
18	220	0.0128	0.0128	0.0389	0.0417	27.6	29.6	29.6
19	220	0.0128	0.0128	0.0389	0.0417	27.6	29.6	29.6
20	220	0.0128	0.0128	0.0389	0.0417	27.6	29.6	29.6
21	220	0.0128	0.0128	0.0389	0.0417	27.6	29.6	29.6
22	220	0.0128	0.0128	0.0389	0.0417	27.6	29.6	29.6
23	220	0.0128	0.0128	0.0389	0.0417	27.6	29.6	29.6
24	220	0.0128	0.0128	0.0444	0.0417	31.5	29.6	29.6

Table A-4. Sunday allocated emissions based on the use Equations 2a, 2b, 3a, and 3b.

Hour	Seasonal SO ₂ (tons)	DF		HF		Allocated emissions (g/s)		
		2a	2b	3a	3b	2a+3a	2a+3b	2b+3b
1	220	0.014	0.0128	0.04	0.0417	31.0	32.4	29.6
2	220	0.014	0.0128	0.04	0.0417	31.0	32.4	29.6
3	220	0.014	0.0128	0.04	0.0417	31.0	32.4	29.6
4	220	0.014	0.0128	0.04	0.0417	31.0	32.4	29.6
5	220	0.014	0.0128	0.04	0.0417	31.0	32.4	29.6
6	220	0.014	0.0128	0.04	0.0417	31.0	32.4	29.6
7	220	0.014	0.0128	0.04	0.0417	31.0	32.4	29.6
8	220	0.014	0.0128	0.04	0.0417	31.0	32.4	29.6
9	220	0.014	0.0128	0.04	0.0417	31.0	32.4	29.6
10	220	0.014	0.0128	0.0425	0.0417	33.0	32.4	29.6
11	220	0.014	0.0128	0.0425	0.0417	33.0	32.4	29.6
12	220	0.014	0.0128	0.0425	0.0417	33.0	32.4	29.6
13	220	0.014	0.0128	0.0425	0.0417	33.0	32.4	29.6
14	220	0.014	0.0128	0.04	0.0417	31.0	32.4	29.6
15	220	0.014	0.0128	0.04	0.0417	31.0	32.4	29.6
16	220	0.014	0.0128	0.04	0.0417	31.0	32.4	29.6
17	220	0.014	0.0128	0.0425	0.0417	33.0	32.4	29.6
18	220	0.014	0.0128	0.0425	0.0417	33.0	32.4	29.6
19	220	0.014	0.0128	0.0425	0.0417	33.0	32.4	29.6
20	220	0.014	0.0128	0.0425	0.0417	33.0	32.4	29.6
21	220	0.014	0.0128	0.0425	0.0417	33.0	32.4	29.6
22	220	0.014	0.0128	0.0425	0.0417	33.0	32.4	29.6
23	220	0.014	0.0128	0.0425	0.0417	33.0	32.4	29.6
24	220	0.014	0.0128	0.0425	0.0417	33.0	32.4	29.6

Figure A-1. Example format of AERMOD inputs for winter using Equations 2a and 3a.

**Winter weekdays SO EMISFACT STACK SHR DOW 7*31.5 4*27.6 3*31.5 9*27.6 31.5
**Winter Saturdays SO EMISFACT STACK SHR DOW 24*0.0
** Winter Sundays SO EMISFACT STACK SHR DOW 9*31.0 4*33.0 3*31.0 8*33.0

Figure A-2. Example format of AERMOD inputs for winter using Equations 2b and 3b.

**Winter weekdays SO EMISFACT STACK SHR DOW 24*29.6
**Winter Saturdays SO EMISFACT STACK SHR DOW 24*0.0
** Winter Sundays SO EMISFACT STACK SHR DOW 24*32.4

Figure A-3. Example format of AERMOD inputs for winter using Equations 2a and 3b.

**Winter weekdays SO EMISFACT STACK SHR DOW 24*29.6
**Winter Saturdays SO EMISFACT STACK SHR DOW 24*0.0
** Winter Sundays SO EMISFACT STACK SHR DOW 24*29.6

A.2 Example Calculations for Irregular Operating Schedule

Scenario:

Assume a boiler operates on the following schedule for 2011:

- Continuous weekday operation
- No operation on Saturdays or Sundays
- The boiler also does not operate on the following days
 - May 30 (Monday)
 - July 4 (Monday)
 - September 5 (Monday)
 - November 24 and 25 (Thursday & Friday)
 - December 23 and 24 (Thursday & Friday)

Monthly emissions have been calculated based on monthly fuel usage and emissions factors. The daily factor can be calculated for the operational weekdays using Equation 2b, and the hourly factor can be calculated from Equation 3b.

Table A-5. Allocated hourly emissions.

Month	Monthly emissions (tons)	Number of operational weekdays	DF	HF	Hourly emissions (tons/hour)	Hourly emissions (g/s)
January	10	21	0.0476	0.0417	0.0198	5.0
February	9	20	0.05	0.0417	0.0188	4.7
March	10	23	0.0435	0.0417	0.0181	4.6
April	11	21	0.0476	0.0417	0.0218	5.5
May	13	21	0.0476	0.0417	0.0258	6.5
June	12	22	0.0455	0.0417	0.0247	5.7
July	10	20	0.05	0.0417	0.0209	5.2
August	13	23	0.0435	0.0417	0.0236	5.9
September	12	21	0.0476	0.0417	0.0238	6.0
October	13	21	0.0476	0.0417	0.0258	6.5
November	10	20	0.05	0.0417	0.0209	5.2
December	10	21	0.0476	0.0417	0.0198	5.0

The hourly emissions in Table A-5 are applied to the operational hours for the year. Because the stack is not operational on the holidays listed above, the MHRDOW rate factor or MHRDOW7 rate factor is not applicable because not all occurrences of a given day are operational. Using May as an example, not all Mondays are operating on the same schedule because the stack is not operational on May 30. Therefore, the emissions calculated in Table A-5 can be input as hourly emissions, instead of using AERMOD emissions factors. Figures A-4 and A-5 presents partial examples of different days of an hourly file.

Appendix B: Example Emissions Allocations and AERMOD Input Formats

This Appendix provides illustrative examples of calculating and inputting emission rate factors for a boiler that has annual emissions of 6708 tons. The examples use Equations 2b and 3b for the daily and hourly factor calculations. For these examples, the input emission rate on the SRCPARAM line is 1 g/s. Thus, the emission rate factors are the actual temporally allocated emissions in g/s. Daily factors are for non-leap years. The input formats shown in the Appendix are for illustrative purposes only and to give examples of the order of the factors. Emissions are rounded to the nearest g/s for display purposes only. While the order of the factors is important, the exact formatting is the user's choice.

SEASON

Known information: seasonal emissions

Unknown information: No day to day or hourly variation. Assume all days and hours are operational.

- Emissions (tons)
 - Winter: 2093
 - Spring: 1803
 - Summer: 1930
 - Fall: 882
- $DF = 1/\text{number of operational days each season}$ (1/90 for winter, 1/92 for spring and summer, 1/91 for fall). Note for leap years, winter would 1/91.
- $HF = 1/\text{number of operational hours per day}$ (1/24)

Figure B-1. SEASON emission rate factors.

**	winter, spring, summer, fall
SO EMISFACT BOILER SEASON	244.0 206.0 220.0 102.0

SEASHR

Known information: seasonal emissions, operating schedule of 8:00 AM to 8:00 PM LST.

Unknown information: No day to day variation. Assume all days are operational.

- DF = 1/number of operational days each season (1/90 for winter, 1/92 for spring and summer, 1/91 for fall)
- HF = 1/number of operational hours per day for operational hours (1/12)
- HF=0 for hour beginning at 1:00 AM to hour ending 8:00 AM and hour beginning 9:00 PM to hour ending midnight. Start non-zero emissions at 9:00 AM LST and end at 9:00 PM LST (2100 LST).

Figure B-2. SEASHR emission rate factors.

**hours 1-8 are 0, 9-20 are non-zero, 21-24 are 0			
**Winter			
** hours	1-8	9-20	21-24
SO EMISFACT BOILER SEASHR	8*0.0	12*488.0	4*0.0
**Spring			
** hours	1-8	9-20	21-24
SO EMISFACT BOILER SEASHR	8*0.0	12*412.0	4*0.0
**Summer			
** hours	1-8	9-20	21-24
SO EMISFACT BOILER SEASHR	8*0.0	12*441.0	4*0.0
**Fall			
** hours	1-8	9-20	21-24
SO EMISFACT BOILER SEASHR	8*0.0	12*204.0	4*0.0

SHRDOW

Known information: seasonal emissions, weekday operation and operating schedule of 8:00 AM to 8:00 PM LST. Facility is non-operational on weekends.

Unknown information: No 7-day variation. Assume all weekdays are operational and with same schedule and weekends are non-operational (zero emissions).

- DF = 1/number of operational days each season (1/65 for winter, spring and fall, 1/66 for summer)
- HF = 1/number of operational hours per day for operational hours (1/12)
- HF=0 for 1:00 AM t to 8:00 AM and 9:00 PM to midnight

Figure B-3. SHRDOW emission rate factors.

** weekdays: hours 1-8 are 0, 9-20 are non-zero, 21-24 are 0				
** Winter				
** hours	1-8	9-20	21-24	
SO EMISFACT BOILER SHRDOW	8*0.0	12*676.0	4*0.0	
** Spring				
** hours	1-8	9-20	21-24	
SO EMISFACT BOILER SHRDOW	8*0.0	12*583.0	4*0.0	
** Summer				
** hours	1-8	9-20	21-24	
SO EMISFACT BOILER SHRDOW	8*0.0	12*614.0	4*0.0	
** Fall				
** hours	1-8	9-20	21-24	
SO EMISFACT BOILER SHRDOW	8*0.0	12*285.0	4*0.0	
**Saturdays, all hours are 0 emissions				
**	Winter	Spring	Summer	Fall
SO EMISFACT BOILER SHRDOW	24*0.0	24*0.0	24*0.0	24*0.0
**Sundays, all hours are 0 emissions				
**	Winter	Spring	Summer	Fall
SO EMISFACT BOILER SHRDOW	24*0.0	24*0.0	24*0.0	24*0.0

SHRDOW7

Known information: seasonal emissions, weekday operation and operating schedule varies for different weekdays. Facility is non-operational on weekends.

Unknown information: No week-to-week variation. Assume all weeks each season are the same.

Facility schedule:

- Open Mondays and Fridays, 10:00 AM to 9:00 PM (hour ending 11:00 AM – 9:00 PM)
- Open Tuesdays-Thursdays 8:00 AM to 9:00 PM (hour ending 9:00 AM – 9:00 PM)
- Closed Saturdays and Sundays
- $DF = 1/\text{number of operational days each season}$ (1/65 for winter, spring and fall, 1/66 for summer)
- $HF = 1/\text{number of operational hours per day for operational hours}$
 - 1/10 for Mondays and Fridays
 - 1/12 for all other weekdays
- $HF=0$ for non-operational hours

Figure B-4. SHRDOW7 emission rate factors.

** Mondays: hours 1-10 are 0, 11-20 are non-zero, 21-24 are 0						
**						
		Winter			Spring	
** hours	1-10	11-20	21-24	1-10	11-20	21-24
SO EMISFACT BOILER SHRDOW7	10*0.0	10*811.0	4*0.0	10*0.0	10*699.0	4*0.0
**						
		Summer			Fall	
** hours	1-10	11-20	21-24	1-10	11-20	21-24
SO EMISFACT BOILER SHRDOW7	10*0.0	10*737.0	4*0.0	10*0.0	10*342.0	4*0.0
**Tuesdays: hours 1-8 are 0, 9-20 are nonzero, 21-24 are 0						
**						
		Winter			Spring	
** hours	1-8	11-20	21-24	1-8	11-20	21-24
SO EMISFACT BOILER SHRDOW7	8*0.0	12*676.0	4*0.0	8*0.0	12*583.4.0	4*0.0
**						
		Summer			Fall	
** hours	1-8	11-20	21-24	1-8	11-20	21-24
SO EMISFACT BOILER SHRDOW7	8*0.0	12*614.0	4*0.0	8*0.0	12*285.0	4*0.0
**Wednesdays: hours 1-8 are 0, 9-20 are nonzero, 21-24 are 0						
**						
		Winter			Spring	
** hours	1-8	11-20	21-24	1-8	11-20	21-24
SO EMISFACT BOILER SHRDOW7	8*0.0	12*676.0	4*0.0	8*0.0	12*583.4.0	4*0.0
**						
		Summer			Fall	
** hours	1-8	11-20	21-24	1-8	11-20	21-24
SO EMISFACT BOILER SHRDOW7	8*0.0	12*614.0	4*0.0	8*0.0	12*285.0	4*0.0
**Thursdays: hours 1-8 are 0, 9-20 are nonzero, 21-24 are 0						
**						
		Winter			Spring	
** hours	1-8	11-20	21-24	1-8	11-20	21-24
SO EMISFACT BOILER SHRDOW7	8*0.0	12*676.0	4*0.0	8*0.0	12*583.4.0	4*0.0
**						
		Summer			Fall	
** hours	1-8	11-20	21-24	1-8	11-20	21-24
SO EMISFACT BOILER SHRDOW7	8*0.0	12*614.0	4*0.0	8*0.0	12*285.0	4*0.0
**Fridays: hours 1-8 are 0, 9-20 are nonzero, 21-24 are 0						
**						
		Winter			Spring	
** hours	1-8	11-20	21-24	1-8	11-20	21-24
SO EMISFACT BOILER SHRDOW7	8*0.0	12*676.0	4*0.0	8*0.0	12*583.4.0	4*0.0
**						
		Summer			Fall	
** hours	1-8	11-20	21-24	1-8	11-20	21-24
SO EMISFACT BOILER SHRDOW7	8*0.0	12*614.0	4*0.0	8*0.0	12*285.0	4*0.0
**Saturdays, all hours are 0 emissions						
**						
SO EMISFACT BOILER SHRDOW7	Winter	Spring	Summer	Fall		
	24*0.0	24*0.0	24*0.0	24*0.0		
**Sundays, all hours are 0 emissions						
**						
SO EMISFACT BOILER SHRDOW7	Winter	Spring	Summer	Fall		
	24*0.0	24*0.0	24*0.0	24*0.0		

MONTH

Known information: monthly emissions

Unknown information: No day to day or hourly variation. Assume all days and hours are operational.

- Monthly emissions (tons)
 - January: 635
 - February: 569
 - March: 738
 - April: 606
 - May: 459
 - June: 612
 - July: 634
 - August: 683
 - September: 474
 - October: 0
 - November: 408
 - December: 889
- $DF = 1/\text{number of operational days each month (1/number of days in month)}$
- $HF = 1/\text{number of operational hours per day for operational hours (1/24)}$

Figure B-5. MONTH emission rate factors.

** Monthly emissions factors

**	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
SO EMISFACT BOILER MONTH	215.0	213.0	250.0	212.0	155.0	214.0	215.0	231.0	166.0	0.0	143.0	301.0

MHRDOW

Known information: monthly emissions, weekday operation and operating schedule of 8:00 AM to 8:00 PM LST. Facility is non-operational on weekends.

Unknown information: No 7-day variation. Assume all weekdays are operational and with same schedule and weekends are non-operational (zero emissions).

- DF = 1/number of operational days each month (1/number of days in month)
- HF = 1/number of operational hours per day for operational hours (1/12)
- HF=0 for 1:00 AM t to 8:00 AM and 9:00 PM to midnight

Figure B-6. MHRDOW emission rate factors.

** hours 1-24 for weekdays									
** all hours for October are 0									
** hours 1-8 are 0, 9-20 are non-zero, 21-24 are 0									
**	Jan			Feb			Mar		
** hours	1-8	11-20	21-24	1-8	11-20	21-24	1-8	11-20	21-24
SO EMISFACT BOILER MHRDOW	8*0.0	12*606.0	4*0.0	8*0.0	12*597.0	4*0.0	8*0.0	12*705.0	4*0.0
**	Apr			May			Jun		
** hours	1-8	11-20	21-24	1-8	11-20	21-24	1-8	11-20	21-24
SO EMISFACT BOILER MHRDOW	8*0.0	12*578.0	4*0.0	8*0.0	12*459.0	4*0.0	8*0.0	12*585.0	4*0.0
**	Jul			Aug			Sep		
** hours	1-8	11-20	21-24	1-8	11-20	21-24	1-8	11-20	21-24
SO EMISFACT BOILER MHRDOW	8*0.0	12*579.0	4*0.0	8*0.0	12*683.0	4*0.0	8*0.0	12*453.0	4*0.0
**	Oct	Nov		Dec					
** hours	1-24	1-8	11-20	21-24	1-8	11-20	21-24		
SO EMISFACT BOILER MHRDOW	24*0.0	8*0.0	12*408.0	4*0.0	8*0.0	12*812.0	4*0.0		
** hours 1-24 for Saturdays									
** all hours 0									
**	Jan	Feb	Mar	Apr	May	Jun			
SO EMISFACT BOILER MHRDOW	24*0.0	24*0.0	24*0.0	24*0.0	24*0.0	24*0.0			
**	Jul	Aug	Sep	Oct	Nov	Dec			
SO EMISFACT BOILER MHRDOW	24*0.0	24*0.0	24*0.0	24*0.0	24*0.0	24*0.0			
** hours 1-24 for Sundays									
** all hours 0									
**	Jan	Feb	Mar	Apr	May	Jun			
SO EMISFACT BOILER MHRDOW	24*0.0	24*0.0	24*0.0	24*0.0	24*0.0	24*0.0			
**	Jul	Aug	Sep	Oct	Nov	Dec			
SO EMISFACT BOILER MHRDOW	24*0.0	24*0.0	24*0.0	24*0.0	24*0.0	24*0.0			

MHRDOW7

Known information: monthly emissions, weekday operation and operating schedule varies for different weekdays. Facility is non-operational on weekends.

Unknown information: No week-to-week variation. Assume all weeks each season are the same.

Facility schedule:

- Open Mondays and Fridays, 10:00 AM to 9:00 PM (hour ending 11:00 AM – 9:00 PM)
- Open Tuesdays-Thursdays 8:00 AM to 9:00 PM (hour ending 9:00 AM – 9:00 PM)
- Closed Saturdays and Sundays
- $DF = 1/\text{number of operational days each month (1/\# weekdays each month)}$
- $HF = 1/\text{number of operational hours per day for operational hours}$
 - 1/10 for Mondays and Fridays
 - 1/12 for all other weekdays
- $HF=0$ for non-operational hours

Figure B-7. MHRDOW7 emission rate factors.

**hours for Mondays												
** hours 1-10 are 0, 11-20 are non-zero, 21-24 are 0												
**	Jan			Feb			Mar			Apr		
** hours	1-10	11-20	21-24	1-10	11-20	21-24	1-10	11-20	21-24	1-10	11-20	21-24
SO EMISFACT BOILER MHRDOW7	10*0.0	12*727.0	4*0.0	10*0.0	12*716.0	4*0.0	10*0.0	12*845.0	4*0.0	10*0.0	12*694.0	4*0.0
**	May			Jun			Jul			Aug		
** hours	1-10	11-20	21-24	1-10	11-20	21-24	1-10	11-20	21-24	1-10	11-20	21-24
SO EMISFACT BOILER MHRDOW7	10*0.0	12*551.0	4*0.0	10*0.0	12*701.0	4*0.0	10*0.0	12*695.0	4*0.0	10*0.0	12*820.0	4*0.0
**	Sep			Oct			Nov			Dec		
** hours	1-10	11-20	21-24	1-24	1-10	11-20	21-24	1-10	11-20	21-24		
SO EMISFACT BOILER MHRDOW7	10*0.0	12*543.0	4*0.0	24*0.0	10*0.0	12*716.0	4*0.0	10*0.0	12*845.0	4*0.0		
**hours for Tuesdays												
**hours 1-8 are 0 9-20 are non-zero, 21-24 are 0												
**	Jan			Feb			Mar			Apr		
** hours	1-8	11-20	21-24	1-8	11-20	21-24	1-8	11-20	21-24	1-8	11-20	21-24
SO EMISFACT BOILER MHRDOW7	8*0.0	12*606.0	4*0.0	8*0.0	12*597.0	4*0.0	8*0.0	12*705.0	4*0.0	8*0.0	12*578.0	4*0.0
**	May			Jun			Jul			Aug		
** hours	1-8	11-20	21-24	1-8	11-20	21-24	1-8	11-20	21-24	1-8	11-20	21-24
SO EMISFACT BOILER MHRDOW7	8*0.0	12*459.0	4*0.0	8*0.0	12*585.0	4*0.0	8*0.0	12*579.0	4*0.0	8*0.0	12*683.0	4*0.0
**	Sep			Oct			Nov			Dec		
** hours	1-8	11-20	21-24	1-24	1-8	11-20	21-24	1-8	11-20	21-24		
SO EMISFACT BOILER MHRDOW7	8*0.0	12*453.0	4*0.0	24*0.0	8*0.0	12*408.0	4*0.0	8*0.0	12*812.0	4*0.0		
**hours for Wednesdays												
**hours 1-8 are 0 9-20 are non-zero, 21-24 are 0												
**	Jan			Feb			Mar			Apr		
** hours	1-8	11-20	21-24	1-8	11-20	21-24	1-8	11-20	21-24	1-8	11-20	21-24
SO EMISFACT BOILER MHRDOW7	8*0.0	12*606.0	4*0.0	8*0.0	12*597.0	4*0.0	8*0.0	12*705.0	4*0.0	8*0.0	12*578.0	4*0.0
**	May			Jun			Jul			Aug		
** hours	1-8	11-20	21-24	1-8	11-20	21-24	1-8	11-20	21-24	1-8	11-20	21-24
SO EMISFACT BOILER MHRDOW7	8*0.0	12*459.0	4*0.0	8*0.0	12*585.0	4*0.0	8*0.0	12*579.0	4*0.0	8*0.0	12*683.0	4*0.0
**	Sep			Oct			Nov			Dec		
** hours	1-8	11-20	21-24	1-24	1-8	11-20	21-24	1-8	11-20	21-24		
SO EMISFACT BOILER MHRDOW7	8*0.0	12*453.0	4*0.0	24*0.0	8*0.0	12*408.0	4*0.0	8*0.0	12*812.0	4*0.0		
**hours for Thursdays												
**hours 1-8 are 0 9-20 are non-zero, 21-24 are 0												
**	Jan			Feb			Mar			Apr		
** hours	1-8	11-20	21-24	1-8	11-20	21-24	1-8	11-20	21-24	1-8	11-20	21-24
SO EMISFACT BOILER MHRDOW7	8*0.0	12*606.0	4*0.0	8*0.0	12*597.0	4*0.0	8*0.0	12*705.0	4*0.0	8*0.0	12*578.0	4*0.0
**	May			Jun			Jul			Aug		
** hours	1-8	11-20	21-24	1-8	11-20	21-24	1-8	11-20	21-24	1-8	11-20	21-24
SO EMISFACT BOILER MHRDOW7	8*0.0	12*459.0	4*0.0	8*0.0	12*585.0	4*0.0	8*0.0	12*579.0	4*0.0	8*0.0	12*683.0	4*0.0
**	Sep			Oct			Nov			Dec		
** hours	1-8	11-20	21-24	1-24	1-8	11-20	21-24	1-8	11-20	21-24		
SO EMISFACT BOILER MHRDOW7	8*0.0	12*453.0	4*0.0	24*0.0	8*0.0	12*408.0	4*0.0	8*0.0	12*812.0	4*0.0		
**hours for Fridays												
**hours 1-8 are 0 9-20 are non-zero, 21-24 are 0												
**	Jan			Feb			Mar			Apr		
** hours	1-8	11-20	21-24	1-8	11-20	21-24	1-8	11-20	21-24	1-8	11-20	21-24
SO EMISFACT BOILER MHRDOW7	8*0.0	12*606.0	4*0.0	8*0.0	12*597.0	4*0.0	8*0.0	12*705.0	4*0.0	8*0.0	12*578.0	4*0.0
**	May			Jun			Jul			Aug		
** hours	1-8	11-20	21-24	1-8	11-20	21-24	1-8	11-20	21-24	1-8	11-20	21-24
SO EMISFACT BOILER MHRDOW7	8*0.0	12*459.0	4*0.0	8*0.0	12*585.0	4*0.0	8*0.0	12*579.0	4*0.0	8*0.0	12*683.0	4*0.0
**	Sep			Oct			Nov			Dec		
** hours	1-8	11-20	21-24	1-24	1-8	11-20	21-24	1-8	11-20	21-24		
SO EMISFACT BOILER MHRDOW7	8*0.0	12*453.0	4*0.0	24*0.0	8*0.0	12*408.0	4*0.0	8*0.0	12*812.0	4*0.0		
** hours 1-24 for Saturdays												
** all hours 0												
**	Jan	Feb	Mar	Apr	May	Jun						
SO EMISFACT BOILER MHRDOW7	24*0.0	24*0.0	24*0.0	24*0.0	24*0.0	24*0.0						
**	Jul	Aug	Sep	Oct	Nov	Dec						
SO EMISFACT BOILER MHRDOW7	24*0.0	24*0.0	24*0.0	24*0.0	24*0.0	24*0.0						
** hours 1-24 for Sundays												
** all hours 0												
**	Jan	Feb	Mar	Apr	May	Jun						
SO EMISFACT BOILER MHRDOW7	24*0.0	24*0.0	24*0.0	24*0.0	24*0.0	24*0.0						
**	Jul	Aug	Sep	Oct	Nov	Dec						
SO EMISFACT BOILER MHRDOW7	24*0.0	24*0.0	24*0.0	24*0.0	24*0.0	24*0.0						

HROFDY

Known information: annual emissions (6708 tons), operating schedule of 8:00 AM to 8:00 PM LST.

Unknown information: No seasonal, monthly, or within week variation. Assume all days are operational.

- $DF = 1/\text{number of operational days each year (365)}$
- $HF = 1/\text{number of operational hours per day for operational hours (1/12)}$
- $HF=0$ for 1:00 AM t to 8:00 AM and 9:00 PM to midnight

Figure B-8. HROFDY emission rate factors.

** hours 1-8 are 0, 9-20 are non-zero, 21-24 are 0			
**	1-8	9-20	21-24
SO EMISFACT BOILER HROFDY	8*0.0	12*386.0	4*0.0

HRDOW

Known information: annual emissions, weekday operation and operating schedule of 8:00 AM to 8:00 PM LST. Facility is non-operational on weekends.

Unknown information: No seasonal, monthly, 7-day variation. Assume all weekdays are operational and with same schedule and weekends are non-operational (zero emissions).

- $DF = 1/\text{number of operational days each year (M-F, 261 days)}$
- $HF = 1/\text{number of operational hours per day for operational hours (1/12)}$
- $HF=0$ for 1:00 AM t to 8:00 AM and 9:00 PM to midnight

Figure B-9. HRDOW emission rate factors.

** hours 1-24 for weekdays			
** hours 1-8 are 0, 9-20 are non-zero, 21-24 are 0			
**	1-8	9-20	21-24
SO EMISFACT BOILER HRDOW	8*0.0	12*540.0	4*0.0
** hours 1-24 for Saturdays, all hours 0			
SO EMISFACT BOILER HRDOW	24*0.0		
** hours 1-24 for Sundays, all hours 0			
SO EMISFACT BOILER HRDOW	24*0.0		

HRDOW7

Known information: annual emissions, weekday operation and operating schedule varies for different weekdays. Facility is non-operational on weekends.

Unknown information: No seasonal, monthly, or week-to-week. Assume all weekdays are operational and with same schedule and weekends are non-operational (zero emissions).

Facility schedule:

- Open Mondays and Fridays, 10:00 AM to 9:00 PM (hour ending 11:00 AM – 9:00 PM)
- Open Tuesdays-Thursdays 8:00 AM to 9:00 PM (hour ending 9:00 AM – 9:00 PM)
- Closed Saturdays and Sundays
- $DF = 1/\text{number of operational days each month (1/\# weekdays, 1/261)}$
- $HF = 1/\text{number of operational hours per day for operational hours}$
 - 1/10 for Mondays and Fridays
 - 1/12 for all other weekdays
- $HF=0$ for non-operational hours

Figure B-10. HRDOW7 emission rate factors.

```
** hours 1-24 for Mondays
** hours 1-10 are 0, 11-20 are non-zero, 21-24 are 0
**           1-10  11-20  21-24
SO EMISFACT BOILER HRDOW 10*0.0 10*648.0 4*0.0
** hours 1-24 for Tuesdays
** hours 1-8 are 0, 9-20 are non-zero, 21-24 are 0
**           1-8   9-20   21-24
SO EMISFACT BOILER HRDOW 8*0.0 12*540.0 4*0.0
** hours 1-24 for Wednesdays
** hours 1-8 are 0, 9-20 are non-zero, 21-24 are 0
**           1-8   9-20   21-24
SO EMISFACT BOILER HRDOW 8*0.0 12*540.0 4*0.0
** hours 1-24 for Thursdays
** hours 1-8 are 0, 9-20 are non-zero, 21-24 are 0
**           1-8   9-20   21-24
SO EMISFACT BOILER HRDOW 8*0.0 12*540.0 4*0.0
** hours 1-24 for Fridays
** hours 1-10 are 0, 11-20 are non-zero, 21-24 are 0
**           1-8   9-20   21-24
SO EMISFACT BOILER HRDOW 10*0.0 10*648.0 4*0.0
** hours 1-24 for Saturdays, all hours 0
SO EMISFACT BOILER HRDOW 24*0.0
** hours 1-24 for Sundays, all hours 0
SO EMISFACT BOILER HRDOW 24*0.0
```

Appendix C: Example Facility with Hourly Emissions and Emissions Factors

This appendix shows how a mix of hourly emissions and AERMOD emission rate factors can be used to represent emissions for a hypothetical facility.

Scenario:

The facility has three coal fired boilers with hourly emissions for 2009-2011 and a fourth coal fired boiler without hourly emission records. Table C-1 shows the annual emissions for 2009-2011 for the four boilers and Table C-2 shows the stack parameters that will be used in the AERMOD modeling.

Table C-1. Annual boiler and facility emissions.

Unit	2009 SO ₂ (tpy)	2010 SO ₂ (tpy)	2011 SO ₂ (tpy)
BOILER1	1551	1608	1448
BOILER2	1535	1616	1441
BOILER3	1531	1728	1430
BOILER4	1583	1748	1481
Facility total	6200	6700	5800

Table C-2. Boiler stack parameters.

Unit	Stack ht (m)	Stack temperature (K)	Exit velocity (m/s)	Stack diameter (m)
BOILER1	210	435	33	6
BOILER2	210	425	30	6
BOILER3	210	415	32	6
BOILER4	210	445	35	6

Figures C-1 through C-3 show sample lines from the input hourly emissions file for boilers 1-3 for 2009, 2010, and 2011 respectively. Shown are the first 3 hours of the year and the last hour of the year. Hourly exit velocities and temperature are unknown so the values from Table C-2 are used.

Figure C-1. Example hourly emissions file for 2009.

SO HOUREMIS	9	1	1	1	BOILER1	2.175739E+01	435.00000	33.00000
SO HOUREMIS	9	1	1	1	BOILER2	1.837727E+01	425.00000	30.00000
SO HOUREMIS	9	1	1	1	BOILER3	5.599931E+01	415.00000	32.00000
SO HOUREMIS	9	1	1	2	BOILER1	2.188530E+01	435.00000	33.00000
SO HOUREMIS	9	1	1	2	BOILER2	6.090245E+00	425.00000	30.00000
SO HOUREMIS	9	1	1	2	BOILER3	5.583214E+01	415.00000	32.00000
SO HOUREMIS	9	1	1	3	BOILER1	2.231842E+01	435.00000	33.00000
SO HOUREMIS	9	1	1	3	BOILER2	0.000000E+00	425.00000	30.00000
SO HOUREMIS	9	1	1	3	BOILER3	5.641850E+01	415.00000	32.00000
.								
.								
.								
SO HOUREMIS	9	12	31	24	BOILER1	3.788546E+01	435.00000	33.00000
SO HOUREMIS	9	12	31	24	BOILER2	0.000000E+00	425.00000	30.00000
SO HOUREMIS	9	12	31	24	BOILER3	3.405196E+01	415.00000	32.00000

Figure C-2. Example hourly emissions file for 2010.

SO HOUREMIS	10	1	1	1	BOILER1	3.833381E+01	435.00000	33.00000
SO HOUREMIS	10	1	1	1	BOILER2	0.000000E+00	425.00000	30.00000
SO HOUREMIS	10	1	1	1	BOILER3	2.352908E+01	415.00000	32.00000
SO HOUREMIS	10	1	1	2	BOILER1	3.805702E+01	435.00000	33.00000
SO HOUREMIS	10	1	1	2	BOILER2	0.000000E+00	425.00000	30.00000
SO HOUREMIS	10	1	1	2	BOILER3	2.393857E+01	415.00000	32.00000
SO HOUREMIS	10	1	1	3	BOILER1	3.864851E+01	435.00000	33.00000
SO HOUREMIS	10	1	1	3	BOILER2	0.000000E+00	425.00000	30.00000
SO HOUREMIS	10	1	1	3	BOILER3	2.398912E+01	415.00000	32.00000
.								
.								
.								
SO HOUREMIS	10	12	31	24	BOILER1	3.808483E+01	435.00000	33.00000
SO HOUREMIS	10	12	31	24	BOILER2	3.592617E+01	425.00000	30.00000
SO HOUREMIS	10	12	31	24	BOILER3	3.326324E+01	415.00000	32.00000

Figure C-3. Example hourly emissions file for 2011.

SO HOUREMIS	11	1	1	1	BOILER1	3.771253E+01	435.00000	33.00000
SO HOUREMIS	11	1	1	1	BOILER2	3.038794E+01	425.00000	30.00000
SO HOUREMIS	11	1	1	1	BOILER3	3.030849E+01	415.00000	32.00000
SO HOUREMIS	11	1	1	2	BOILER1	2.977126E+01	435.00000	33.00000
SO HOUREMIS	11	1	1	2	BOILER2	3.087726E+01	425.00000	30.00000
SO HOUREMIS	11	1	1	2	BOILER3	2.532202E+01	415.00000	32.00000
SO HOUREMIS	11	1	1	3	BOILER1	2.788588E+01	435.00000	33.00000
SO HOUREMIS	11	1	1	3	BOILER2	3.135648E+01	425.00000	30.00000
SO HOUREMIS	11	1	1	3	BOILER3	2.639272E+01	415.00000	32.00000
.								
.								
.								
SO HOUREMIS	11	12	31	24	BOILER1	3.149773E+01	435.00000	33.00000
SO HOUREMIS	11	12	31	24	BOILER2	2.263458E+01	425.00000	30.00000
SO HOUREMIS	11	12	31	24	BOILER3	3.221026E+01	415.00000	32.00000

As previously stated, hourly emissions are not known for Boiler 4. However, monthly coal usage records are available. The AP-42 emissions factor for Boiler 4 is $35S$ (bituminous, sub-bituminous coal) where S is the sulfur content of the coal in percent. For this example, assumed sulfur content is 1 percent for all months. The resulting SO_2 emissions are in pounds. The next step is to determine what is the best available AERMOD emission rate factor to represent the emissions. The operational schedule (hours per day, days of week) is not known, so for this scenario, it is assumed that the boiler operates continuously. Therefore, the MONTH emissions factor appears to be the most refined factor to use. Using equation 1 in the TAD, the calculated monthly SO_2 emissions input to AERMOD are shown in Table C-3 along with monthly coal usage, monthly SO_2 emissions, number of operational days per month, the day allocation factor DF, number of operational hours per day and hourly allocation factor. Since the boiler is assumed to operate continuously, the daily factor for each month is based on the number of days per month and the hourly factor is based on 24 hours.

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Table C-3. Monthly coal usage and estimated SO₂ emissions.

Year	Month	Coal (tons)	SO ₂ (lb)	Days	hours	DF	HF	Input SO ₂ (g/s)
2009	Jan	8206	287208	31	24	0.03226	0.04167	48.63894
	Feb	7884	275943	28	24	0.03571	0.04167	51.73817
	Mar	7622	266758	31	24	0.03226	0.04167	45.17562
	Apr	8160	285588	30	24	0.03333	0.04167	49.97663
	May	1187	41551	31	24	0.03226	0.04167	7.03674
	Jun	8075	282625	30	24	0.03333	0.04167	49.45813
	Jul	8843	309501	31	24	0.03226	0.04167	52.41427
	Aug	8377	293185	31	24	0.03226	0.04167	49.65112
	Sep	8509	297823	30	24	0.03333	0.04167	52.11786
	Oct	9092	318232	31	24	0.03226	0.04167	53.89280
	Nov	6652	232805	30	24	0.03333	0.04167	40.73985
	Dec	7834	274207	31	24	0.03226	0.04167	46.43717
2010	Jan	8087	283043	31	24	0.03226	0.04167	47.93359
	Feb	7587	265528	28	24	0.03571	0.04167	49.78536
	Mar	8508	297779	31	24	0.03226	0.04167	50.42911
	Apr	8970	313942	30	24	0.03333	0.04167	54.93850
	May	8762	306676	31	24	0.03226	0.04167	51.93576
	Jun	8580	300306	30	24	0.03333	0.04167	52.55233
	Jul	10137	354801	31	24	0.03226	0.04167	60.08592
	Aug	7492	262224	31	24	0.03226	0.04167	44.40778
	Sep	8110	283856	30	24	0.03333	0.04167	49.67368
	Oct	8455	295908	31	24	0.03226	0.04167	50.11231
	Nov	5926	207413	30	24	0.03333	0.04167	36.29646
	Dec	9259	324062	31	24	0.03226	0.04167	54.88024
2011	Jan	8249	288711	31	24	0.03226	0.04167	48.89341
	Feb	6667	233340	28	24	0.03571	0.04167	43.75025
	Mar	7146	250105	31	24	0.03226	0.04167	42.35549
	Apr	6798	237932	30	24	0.03333	0.04167	41.63707
	May	6187	216548	31	24	0.03226	0.04167	36.67252
	Jun	7130	249538	30	24	0.03333	0.04167	43.66813
	Jul	8329	291502	31	24	0.03226	0.04167	49.36605
	Aug	8200	287002	31	24	0.03226	0.04167	48.60410
	Sep	5781	202330	30	24	0.03333	0.04167	35.40698
	Oct	6553	229372	31	24	0.03226	0.04167	38.84436
	Nov	6734	235702	30	24	0.03333	0.04167	41.24692
	Dec	6869	240420	31	24	0.03226	0.04167	40.71537

Figures C-4 through C-6 show the syntax of the monthly emissions factors in AERMOD. For these examples, the input emission rate for BOILER4 is 1.0 g/s on the SRCPARAM line (see Figure C-7).

Figure C-4. Syntax of BOILER4 monthly emissions for 2009.

```
** January-June
SO EMISFACT BOILER4 MONTH 4.863894E+01 5.173817E+01 4.517562E+01 4.997663E+01 7.036744E+00 4.945813E+01
** July-December
SO EMISFACT BOILER4 MONTH 5.241427E+01 4.965112E+01 5.211786E+01 5.389280E+01 4.073985E+01 4.643717E+01
```

Figure C-5. Syntax of BOILER4 monthly emissions for 2010.

```
** January-June
SO EMISFACT BOILER4 MONTH 4.793359E+01 4.978536E+01 5.042911E+01 5.493850E+01 5.193576E+01 5.255233E+01
** July-December
SO EMISFACT BOILER4 MONTH 6.008592E+01 4.440778E+01 4.967368E+01 5.011231E+01 3.629646E+01 5.488024E+01
```

Figure C-6. Syntax of BOILER4 monthly emissions for 2011.

```
** January-June
SO EMISFACT BOILER4 MONTH 4.889341E+01 4.375025E+01 4.235549E+01 4.163707E+01 3.667252E+01 4.366813E+01
** July-December
SO EMISFACT BOILER4 MONTH 4.936605E+01 4.860410E+01 3.540698E+01 3.884436E+01 4.124692E+01 4.071537E+01
```

Figure C-7 shows the source (SO) pathway of an AERMOD input file for 2009. The hourly emissions file shown in Figure C-1 is named hourly_emis_09.dat. In this example, only one source group is named, ALL. Source groups will vary case by case. Figures C-8 and C-9 show the source pathway of an AERMOD input for 2010 and 2011, respectively.

Figure C-7. Source pathway of AERMOD input file for 2009.

```
SO STARTING
** locations
SO LOCATION BOILER1 POINT 0.00 0.00 149.64
SO LOCATION BOILER2 POINT 37.00 -45.00 149.11
SO LOCATION BOILER3 POINT 90.00 -122.00 148.43
SO LOCATION BOILER4 POINT 90.00 -122.00 148.43

** parameters
SO SRCPARAM BOILER1 1.0 210.00000 435.00000 33.00000 6.00000
SO SRCPARAM BOILER2 1.0 210.00000 425.00000 30.00000 6.00000
SO SRCPARAM BOILER3 1.0 210.00000 415.00000 32.00000 6.00000
SO SRCPARAM BOILER4 1.0 210.00000 445.00000 35.00000 6.00000

** define sources with hourly emissions and identify hourly emissions file for 2009
SO HOUREMIS hourly_emis_09.dat BOILER1-BOILER3

** BOILER4 monthly emissions for 2009
** January-June
SO EMISFACT BOILER4 MONTH 4.863894E+01 5.173817E+01 4.517562E+01 4.997663E+01 7.036744E+00 4.945813E+01
** July-December
SO EMISFACT BOILER4 MONTH 5.241427E+01 4.965112E+01 5.211786E+01 5.389280E+01 4.073985E+01 4.643717E+01

SO SRCGROUP ALL
SO FINISHED
```


Figure C-8. Source pathway of AERMOD input file for 2010.

```
SO STARTING
** locations
SO LOCATION BOILER1 POINT    0.00    0.00 149.64
SO LOCATION BOILER2 POINT    37.00   -45.00 149.11
SO LOCATION BOILER3 POINT    90.00  -122.00 148.43
SO LOCATION BOILER4 POINT    90.00  -122.00 148.43

** parameters
SO SRCPARAM BOILER1 1.0 210.00000 435.00000 33.00000 6.00000
SO SRCPARAM BOILER2 1.0 210.00000 425.00000 30.00000 6.00000
SO SRCPARAM BOILER3 1.0 210.00000 415.00000 32.00000 6.00000
SO SRCPARAM BOILER4 1.0 210.00000 445.00000 35.00000 6.00000

** define sources with hourly emissions and identify hourly emissions file for 2010
SO HOUREMIS hourly_emis_10.dat BOILER1-BOILER3

** BOILER4 monthly emissions for 2010
** January-June
SO EMISFACT BOILER4 MONTH 4.793359E+01 4.978536E+01 5.042911E+01 5.493850E+01 5.193576E+01 5.255233E+01
** July-December
SO EMISFACT BOILER4 MONTH 6.008592E+01 4.440778E+01 4.967368E+01 5.011231E+01 3.629646E+01 5.488024E+01

SO SRCGROUP ALL
SO FINISHED
```

Figure C-9. Source pathway of AERMOD input file for 2011.

```
SO STARTING
** locations
SO LOCATION BOILER1 POINT    0.00    0.00 149.64
SO LOCATION BOILER2 POINT    37.00   -45.00 149.11
SO LOCATION BOILER3 POINT    90.00  -122.00 148.43
SO LOCATION BOILER4 POINT    90.00  -122.00 148.43

** parameters
SO SRCPARAM BOILER1 1.0 210.00000 435.00000 33.00000 6.00000
SO SRCPARAM BOILER2 1.0 210.00000 425.00000 30.00000 6.00000
SO SRCPARAM BOILER3 1.0 210.00000 415.00000 32.00000 6.00000
SO SRCPARAM BOILER4 1.0 210.00000 445.00000 35.00000 6.00000

** define sources with hourly emissions and identify hourly emissions file for 2011
SO HOUREMIS hourly_emis_11.dat BOILER1-BOILER3

** BOILER4 monthly emissions for 2010
** January-June
SO EMISFACT BOILER4 MONTH 4.889341E+01 4.375025E+01 4.235549E+01 4.163707E+01 3.667252E+01 4.366813E+01
** July-December
SO EMISFACT BOILER4 MONTH 4.936605E+01 4.860410E+01 3.540698E+01 3.884436E+01 4.124692E+01 4.071537E+01

SO SRCGROUP ALL
SO FINISHED
```