Air Dispersion Modeling Guidelines

For Oklahoma Air Quality Permits

Prepared by the Engineering Section of the Permitting Unit
Air Quality Division
Oklahoma Department of Environmental Quality

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1. Introduction

This is a guidance document on air dispersion modeling developed by the Air Quality Division (AQD) of the Oklahoma Department of Environmental Quality. The guidance provides assistance to applicants in demonstrating compliance with modeling requirements. These requirements protect the public's health, general welfare, physical property, and the natural environment.

Air dispersion modeling analyses may be required with an Air Quality permit application under Oklahoma Administrative Code (OAC) 252, Chapter 100, Subchapters 8, 31, and 42. This guidance clarifies existing practices, aids the modeler in developing an acceptable analysis, and assists AQD personnel in expediting the review process.

This document relies on modeling guidance contained in the EPA Guideline On Air Quality Models as codified in 40 CFR Part 51, Appendix W, as well as guidance issued by the EPA Office of Air Quality Planning and Standards (OAQPS) and EPA Region VI.

The remainder of Sections 1 and 2 address general modeling concepts. Sections 3 and 4 address specific issues in modeling toxic air contaminates (TAC), per OAC 252:100-42, and modeling compliance with the National Ambient Air Quality Standards (NAAQS) and Increment consumption for Title V/Part 70, New Source Review (NSR), and Prevention of Significant Deterioration (PSD) permit applications. Appendix A contains a table of point source model input data (emissions) requirements for PSD and NSR compliance demonstrations. Appendix B provides a derivation for flare modeling guidance. Appendix C contains a checklist for modeling protocol submission. Appendix D contains a checklist for final modeling data submittal.

1.1 What is Air Dispersion Modeling

Air dispersion modeling is a method of predicting the ambient impact of one or more stationary sources of air pollutants. The algorithms used in the models are based both on the known physics of atmospheric processes and on empirical data. The results of an analysis are used by AQD staff to determine if a new or existing source of air pollutants can comply with state and federal maximum ambient concentration limits. The models are used to predict the highest concentrations expected from a source. For that reason, the models are designed to be conservative, i.e., over-predict ambient impacts. Because the models may over-predict the impact in an analysis, a modeled prediction alone does not mean that there will be a condition of air pollution. This prediction is a flag indicating potential air quality violations. AQD staff may require that the source perform more complex modeling or change physical or operational parameters of the source to reduce ambient impacts. If modeling continues to predict a violation, the AQD may require the source to conduct monitoring.

1.2 State and Federal Regulations Requiring Modeling

Various state and federal regulations require modeling. The Oklahoma Administrative Code, Title 252, Chapter 100 (OAC 252:100) codifies air regulations for the AQD. OAC 252:100-8 regulates major sources. Both the federal PSD and NSR construction permit programs and the federal Title V/Part 70 permit program are incorporated in Subchapter 8. These programs require modeling to demonstrate compliance with and to protect the NAAQS and Increment.

OAC 252:100-31 regulates emissions of sulfur (S) compounds from stationary sources in Oklahoma. This subchapter also limits the ambient concentrations of hydrogen sulfide (H_2S) from new and exiting sources and sulfur dioxide (SO_2) from existing sources and new petroleum and natural gas process facility with equipment subject OAC 252:100-31-26(a)(1).

OAC 252:100-42 regulates emissions and impacts of TAC and Areas of Concern (AOC). This subchapter provides the methodology for developing and promulgating Maximum Acceptable Ambient Concentrations (MAAC) for individual TAC. TAC and associated MAAC are listed in Appendix O of OAC 252:100. After an AOC has been designated modeling may be required as part of the compliance strategy for the AOC.

1.3 Levels of Modeling

1.3.1 Screen Modeling

Screening modeling analyses provide conservative estimates of source impacts with a minimum of input. For the EPA model, SCREEN3, worst-case meteorological conditions with respect to Pasquill Gifford stability classes are used to evaluate maximum ground level concentrations. Screening programs are generally limited in their ability to evaluate terrain impacts and downwash effects from multiple buildings. However, for relatively simple sources, such as a single source with little to no elevated terrain and few downwash structures, these models will provide conservative estimates of downwind concentrations.

1.3.2 Refined Modeling

Refined modeling requires more detailed and precise input data and utilizes more complex models in order to provide more accurate estimates of ground level concentrations. Refined modeling may be required if the screening analysis results indicate that predicted concentrations from the evaluated sources could exceed a standard or a guideline. Refined modeling may also be requested if it is determined that a screening analysis will not adequately address the modeling scenario. It is usually the applicant’s responsibility to perform refined modeling.

1.4 Acceptable Models

In general, Oklahoma defers to the *Guideline on Air Quality Models*, 40 CFR Part 51, Appendix W on the issue of acceptable models. This document provides guidance on appropriate model applications. The document is updated as EPA approves new models. However, Oklahoma reserves the option to evaluate the use of unapproved models on a case-by-case basis. Depending on circumstance, this evaluation may require concurrence by EPA Region VI and/or public review. The following models may be used as is appropriate.

1.4.1 SCREEN3

SCREEN3 is the primary single-source screening model available from EPA. The model may be used for point, area, volume, and flare sources. EPA is currently working on a beta version of the code for AERSCREEN which will be released as soon as possible. AERSCREEN is the screening model for AERMOD and will replace use of SCREEN3. The model will produce estimates of regulatory design concentrations without the need for meteorological data and is designed to produce concentrations that are equal to or greater than the estimates produced by AERMOD with a fully developed set of meteorological and terrain data.

1.4.2 AERMOD

As of December 9, 2006, the AERMOD modeling system, a steady-state plume dispersion model for assessment of pollutant concentrations from a variety of sources, has become the primary model used for refined modeling. AERMOD incorporates air dispersion based on planetary boundary layer turbulence structure and scaling concepts, including treatment of both surface and elevated sources, and both simple and complex terrain. There are two input data processors of the regulatory AERMOD modeling system: AERMET, a meteorological data preprocessor that incorporates planetary boundary layer turbulence structure and scaling concepts, and AERMAP, a terrain data preprocessor that incorporates complex terrain using USGS Digital Elevation Data. The model code and supporting documents are not static but evolve to accommodate the best available science. Be sure to check the EPA SCRAM website often for updates.

1.4.3 CALPUFF

CALPUFF is a multi-layer, multi-species non-steady-state puff dispersion model. The CALPUFF model should be used for long-range impacts (greater than 50 km), visibility (light extinction), and acid deposition in Class I areas. CALPUFF modeling is generally required for PSD source impacts on Class I areas.

1.4.4 Scheffe Tables

The Scheffe Tables are a screening method for predicting ozone impacts from VOC dominated sources. Richard Scheffe developed the Scheffe Tables through use of the Reactive Plume Model (RPM). The AQD will determine whether or not use of the Scheffe Tables is appropriate on a case-by-case basis. Since promulgation of the 8-hour standard use of the Scheffe Tables has become questionable. Until EPA publishes guidelines for compliance for individual sources, use of Sheffe Tables or inclusion in modeling conducted for the Early Action Compact will be used to demonstrate compliance with the standard.

1.5 Modeling Protocol

A modeling protocol is preferred prior to performing any refined modeling analysis. A modeling protocol is requested for PSD and NSR applications. For PSD/NSR applications, the AQD requests that the protocol be available for review prior to pre-application meetings. The applicant should allow one to two weeks for review. If the applicant proposes to use an unapproved model, four to six weeks should be allowed for examination. Upon review, the applicant will receive written notification of acceptance of the modeling approach as well as guidance on any outstanding issues. However, the applicant should be aware that an approved modeling protocol does not necessarily limit the extent of the modeling that will be required to demonstrate compliance with the applicable standards. A general outline for a complete modeling protocol is available in Appendix C. The outline identifies the expected format and content of the submission.

2. Modeling Analysis

2.1 Source Type

2.1.1 Point Source

This is the most common type of source to be modeled. Emissions from point sources are released to the atmosphere through well-defined stacks, chimneys, or vents. Point sources are usually buoyant and have an upward velocity. The following stack parameters are needed to model point sources: emissions, inside diameter, height above ground level, velocity or flow rate, and temperature. Other parameters relating to neighboring structures (height, width, length, and location with respect to the stack) may also be needed to include effects from building downwash.

2.1.2 Area Source

The area source algorithms are used to model low level or ground level releases with no plume rise (e.g., storage piles, slag dumps, and lagoons). The area source may be used to specify a rectangular-shaped area source with arbitrary orientation, an irregularly-shaped polygon of up to 20 sides, a circular-shaped area source (modeled as an equal-area polygon of up to 20 sides).

Area sources use an emission rate per unit area instead of total emissions. Emissions for area sources should be the annual average emissions. The total emissions are divided by the total area in square meters. Detailed guidance for area sources is contained in the *User's Guide for the AMS/EPA Regulatory Model - AERMOD* (EPA-454/B-03-001, 9/2004).

Caution: A 10:1 aspect ratio of length to width must be maintained when developing rectangular areas sources. If this ratio is to be exceeded, the area should be subdivided accordingly to achieve the target aspect ratio.

Note: AERMOD has not implemented plume meander for area sources. Please refer to the EPA *AERMOD Implementation Guide* (EPA, September 27, 2005) for guidance concerning this issue.

2.1.3 Fugitive Sources

Fugitive dust usually refers to dust put into the air by the wind blowing over roads, fields, or piles. Reentrained dust is put into the air by vehicles traveling over dirt roads or dusty areas. Fugitive emissions include emissions that are not captured and vented through a stack but that are vented to the atmosphere through general building vents. These types of fugitive sources can be modeled as line, area, or volume sources. Fugitive sources modeled as "area" sources must have a significant degree of mechanically generated turbulence (e.g., sand and gravel operations, haul roads).

2.1.4 Volume Source

The Volume source algorithms are used to model releases from a variety of industrial sources, such as building roof monitors, multiple vents, and conveyor belts. The following parameters are needed to characterize volume sources: emission rate, release height (h_e), and initial horizontal (σ_{Yo}) and vertical dimensions (σ_{Zo}).

The release height is the center of the volume above ground. Determination of the initial horizontal and vertical dimensions (initial sigmas) are based on the geometry and location of the source. The actual height, width, and depth of the release are used to calculate the initial horizontal and vertical dispersion parameters. Guidance for developing the initial sigmas is contained in Table 3-1 of the *User's Guide for the AMS/EPA Regulatory Model - AERMOD* (EPA-454/B-03-001, 9/2004) and is reproduced below.

The base of the volume source must be square. If the source is not square, model the source as a series of adjacent volume sources. For relatively uniform sources, determine the "Equivalent Square" by taking the square root of the area of the length and width of the volume base.

Table 3-1. Summary of Suggested Procedures for Estimating Initial Lateral Dimensions and Initial Vertical Dimensions for Volume and Line Sources

Type of Source	**Procedure for Obtaining Initial Dimension**
Initial Lateral Dimension (σ_{Yo})	
Single Volume Source	σ_{Yo} = length of side divided by 4.3
Line Source Represented by Adjacent Volume Sources	σ_{Yo} = length of side divided by 2.15
Line Source Represented by Separated Volume Sources	σ_{Yo} = center to center distance divided by 2.15
Initial Vertical Dimension (σ_{Zo})	
Surface-based Source (h_e~0)	σ_{Zo} = vertical dimension of source divided by 2.15
Elevated Source (h_e>0) on or adjacent to a Building	σ_{Zo} = building height divided by 2.15
Elevated Source (h_e>0) not on or adjacent to a building	σ_{Zo} = vertical dimension of source divided by 4.3

2.1.5 Road Emissions

The AQD may require fugitive dust from road emissions to be modeled. If modeling is required, the emissions may be modeled as a volume source.

2.1.5.1 Guidance

The following is some guidance concerning modeling of road emissions.

- Do not include road emissions in permit modeling analyses for short-term averaging periods - periods less than annual.
- Do not include road emissions in permit modeling analyses for an annual averaging period if they will not be generated in association with the transport, storage, or transfer of materials (raw, intermediate, and waste), including sand, gravel, caliche, or other road-base aggregates at the facility.

Volume Source Characterization: Follow the eight steps described in the following paragraphs:

Step 1: Determine the adjusted width of the road. The adjusted width is the actual width of the road plus 6 meters. The additional width represents turbulence caused by the vehicle as it moves along the road. This width will represent a side of the base of the volume.

Step 2: Determine the number of volume sources, N. Divide the length of the road by the adjusted width. The result is the maximum number of volume sources that could be used to represent the road.

Step 3: Determine the height of the volume. The height will be equal to twice the height of the vehicle generating the emissions; rounded to the nearest meter.

Step 4: Determine the initial horizontal sigma for each volume.

- If the road is represented by a single volume, divide the adjusted width by 4.3.
- If the road is represented by adjacent volumes, divide the adjusted width by 2.15.
- If the road is represented by alternating volumes, divide twice the adjusted width, measured from the center point of the first volume to the center point of the next represented volume, by 2.15. Start with the volume nearest to the property line. This representation is often used for long roads.

Step 5: Determine the initial vertical sigma. Divide the height of the volume determined in Step 3 by 2.15.

Step 6: Determine the release point. Divide the height of the volume by two. This point is in the center of the volume.

Step 7: Determine the emission rate for each volume used to calculate the initial horizontal sigma in Step 4. Divide the total emission rate equally among the individual volumes used to represent the road, unless there is a known spatial variation in emissions.

Step 8: Determine the UTM coordinate for the release points. The release point location is in the center of each of the base of the volume. This location must be at least one meter from the nearest receptor. (TNRCC 1999)

2.1.6 Open Pits

The open pit source option is used to model particulate emissions from open pits, such as surface coal mines and rock quarries. The open pit source option uses an effective area for modeling pit emissions, based on meteorological conditions, and then utilizes the numerical integration area source algorithm to model the impact of emissions from the effective area sources. The AERMOD model accepts rectangular pits with an optional rotation angle specified relative to a north-south orientation. The rotation angle is specified relative to the vertex used to define the source location (e.g., the southwest corner). Open pit sources have no plume rise. The parameters needed are the open pit emission rate, the average release height, the lengths of the sides of the open pit, the volume of the open pit, and the orientation angle in degrees from the north. Please note the following:

- As with the area source, an emission rate per unit area is used.
- The release height parameter cannot exceed the effective depth of the pit, which is calculated by the model based on the length, width and volume of the pit.
- A release height of 0.0 indicates emissions that are released from the base of the pit.

- The length-to-width aspect ratio for open pit should be less than 10 to 1.
- Unlike the area source, the open pit cannot be subdivided. Characterize irregularly shaped pit areas by a rectangular shape of equal area.

2.1.7 Pseudo-Point Sources

Fugitive sources and non-standard stacks (stacks or vents with rain caps, and stacks or vents that release emissions horizontally) may be modeled as pseudo-point sources. Nonstandard point sources may have buoyancy or momentum and the modeling parameters used should provide representative impacts. Please refer to the EPA *AERMOD Implementation Guide* (EPA, September 27, 2005) for guidance concerning this issue. Tilted stacks can take into account the vertical velocity of the plume using trigonometric factors where appropriate.

2.1.8 Flares

Flares are handled similarly to point sources; however, the heat release is used to calculate plume rise and effective stack diameter. For screening purposes, the flare option in SCREEN3 is acceptable. A flare option is not available in ISC3. Therefore, in refined modeling, it is necessary to compute equivalent emission parameters to account for the buoyancy of the plume. There are several assumptions made in the SCREEN3 flare option, which form the basis of the equivalent parameter approach. The following parameters are assumed in SCREEN3:

An ambient temperature of 293 K,
55% of the heat lost due to radiation,
a plume rise calculated from the top of the flame, assuming that the flame is bent 45 degrees from the vertical,
an effective stack exit velocity of 20 meters per second, and
an effective stack exit temperature of 1,273 K.

The stack height and inside diameter are adjusted to account for the flame height and the buoyancy of the plume by the following equations:

$$H_{equiv} = H_{actual} + 0.00128 Q_c^{0.478} \qquad \text{(Eq. 1)}$$

$$D_{equiv} = 1.754 x 10^{-4} \sqrt{Q_c} \qquad \text{(Eq. 2)}$$

Where:

H_{equiv}	= equivalent height of the flare, m
H_{actual}	= actual height of the stack from the ground, m
Q_c	= flared gas heat release, Btu/hr
D_{equiv}	= equivalent diameter of the flare, m

The derivation for the equations is available in Appendix B. The selection of effective stack parameters could influence the building downwash estimates. Therefore, if building downwash is of a concern then more realistic stack parameters should be evaluated. For this circumstance, please seek individual guidance from AQD.

2.1.9 Building Vents and Open Doors

Vents with a vertical discharge and no impediment to flow may be modeled as point sources. Horizontal vents or stacks with rain caps should be modeled as pseudo-point sources. Open doors may be modeled as pseudo-point sources with a stack height of two thirds (⅔) the total height of the opening. The stack height may be adjusted based on the release height within the building. Please seek specific guidance from the AQD.

2.2 Screening Procedures

2.2.1 Emission Rate

The maximum short-term emission rate should be used to demonstrate compliance with all short term averaging rates. Model emission input data for point sources has been defined by EPA in 40 CFR Part 51, Appendix W, Tables 8-1 and 8-2 and is reproduced in Appendix A.

Note: For equipment that may run under a variety of conditions that affect emission rates and dispersion modeling estimates, a series of screening analyses should be run to determine the worst-case impact. For example, turbines should be evaluated at varying loads and temperatures to determine the worst-case scenarios.

2.2.2 Terrain

If the terrain within five kilometers of the stack rises to more than 20% of the shortest, non-fugitive, on-site stack being modeled, then the terrain feature elevations should be included for the receptor grid. It is preferred that terrain be included in all refined modeling.

2.2.3 GEP Stack Height

Good Engineering Practice (GEP) stack height is the minimum stack height needed to prevent the stack exhaust plume from being entrained in the wake of nearby obstructions. If a proposed stack is below the GEP height, then the plume entrainment must be taken into account by modifying certain dispersion parameters used in air dispersion models. However, if the stack height equals or exceeds the calculated GEP stack height, then the stack height is considered the GEP stack height. Plume entrainment within the wake of nearby obstructions is unlikely and need not be considered when modeling stacks at the GEP stack height. The GEP stack height limitation set forth in OAC 252:100-8-1.5 applies in all cases.

2.2.4 Building Downwash

When one or more structures interrupt the wind flow, an area of turbulence called building downwash is created. Pollutants emitted from a fairly low level (e.g., a roof, vent or short stack) can be caught in this turbulence, affecting their dispersion. Modeling that includes calculations for building downwash gives a more accurate representation of pollutant impact than does modeling that omits consideration of downwash affects.

A building is any physical obstruction to airflow at the modeled facility. A structure is a building or group of buildings determined to be important in downwash considerations. The dominant downwash structure is the structure that renders the highest GEP recommended stack height. If a stack is at GEP or higher, then downwash is not a factor. GEP stack height is calculated according to the following equation.

$$H = h + 1.5L$$

where: H = Recommended stack height.
h = The distance from the highest point on a tier or building to ground level.
L = The lesser of the height or projected width for a particular tier or structure.

SCREEN3 calculates the maximum projected width as the greatest crosswind distance between two points in a building or structure. There are methods of determining the downwash structures and in fact the dominant downwash structure; however, if multiple downwash structures exist, the BPIP-Prime program should be used in conjunction with AERMOD.

2.2.5 Rural/Urban Classification

Dispersing plumes encounter more turbulence in urban areas than in rural areas, due to building wakes as well as the somewhat warmer temperatures in urban areas. For any given set of meteorological conditions, the urban plume dispersion coefficients should be larger than the rural plume dispersion coefficients. The higher coefficients cause an urban plume to spread more rapidly than a rural plume, and hence the maximum ground-level concentration of an urban plume occurs closer to the emission source than it does for a rural plume. (Beychok 1994)

All models allow for the selection of urban or rural dispersion coefficients. Determination of the applicability of urban or rural dispersion is based on land use or population density. The land use method is preferred.

2.2.5.1 Land Use

Circumscribe a 3 km radius circle about the source. If Auer land use types I1, I2, C1, R2, and R3 account for 50 percent or more of the area, select the urban option. Otherwise, use the rural option.

Auer Land Use Categories I1, I2, C1, & R2 (Auer 1978)

Type	Use and Structure	Vegetation
I1	Heavy Industrial	Grass and tree growth extremely rare; <5% vegetation
	Major chemical, steel and fabrication industries; generally 3-5 story buildings, flat roofs	
I2	Light-moderate industrial	Very limited grass, trees almost totally absent; <5% vegetation
	Rail yards, truck depots, warehouses, industrial parks, minor fabrications; generally 1-3 story buildings, flat roofs	
C1	Commercial	Limited grass and trees; <15% vegetation
	Office and apartment buildings, hotels;>10 story heights, flat roofs	
R2	Compact Residential	Limited lawn sizes and shade trees; <30% vegetation
	Single, some multiple, family dwelling with close spacing; generally <2 story, pitched roof structures; garages (via alley), no driveways	

2.2.5.2 Population Density

Compute the average population density per square kilometer within the area as defined above. If the density is greater than 750 people/km use the urban option. Otherwise, use the rural option.

2.3 Refined Analysis

2.3.1 Emission Rate

The maximum short-term emission rate should be used to demonstrate compliance with all short term averaging rates. Model emission input data for point sources has been defined by EPA in 40 CFR Part 51, Appendix W, Tables 8-1 and 8-2 and is reproduced in Appendix A.

Note: For equipment that may run under a variety of conditions that may affect emission rates and dispersion modeling estimates, a series of screening analyses should be run to determine the worst-case impact. For example, turbines should be evaluated at varying loads and temperatures to determine the worst-case impact scenario.

2.3.2 Terrain

Terrain data should be included in all refined modeling analyses. The applicant may request that they be allowed to assume flat terrain particularly for areas in western Oklahoma or in small modeling domains (less than 1 km). However, a justification for the use of flat terrain should be made before modeling is submitted.

Terrain data are available from United States Geological Survey (USGS) as Digital Elevation Modeling (DEM) data. These data are generally available in two resolutions: 1-degree DEM maps and 7.5-minute maps (referred to as quadrangles). The 7.5-minute quadrangles are freely available in the new Spatial Data Transfer Standard (SDTS) format and will need to be converted to the DEM format. The 7.5-minute DEM data are the preferred source for elevation data. Oklahoma will only accept 1 degree DEM data for use with coarse grids with receptor spacing of 1 km and greater, without a specific demonstration or determination that another resolution is more appropriate.

The 7.5-minute DEM are based on Universal Transverse Mercator (UTM) coordinates and use a 30 meter spacing. Interpolation will be required to translate the data to receptor grids. Choose the highest elevation within a representative area for grid spacing greater than 60 meters. For grid spacing less than 60 meters choose the highest of the nearest 4 terrain points. These methods are intended to give conservative results for modeling.

Oklahoma has three UTM zones (zones 13, 14, and 15). If the modeling domain crosses a UTM zone, source and receptor coordinates will need to be translated to a common zone. The UTM coordinates on the DEM data may not be consistent with those on paper maps. Though most maps and DEM data in Oklahoma are based on the 1927 North American Datum (NAD27), the applicant must check for consistency. Therefore, the datum on which source coordinates and elevation data are based on must be reported in the application. In some areas multiple DEM data may be available for download from USGS, only level 2 DEM files may be used.

The Army Corps of Engineers has developed a conversion program, which will translate data to a common zone and will also convert from one datum to another. The program is called Corpscon and may be obtained from the AQD.

Note: Digital elevation data obtained originally in the SDTS format may be used if obtained from the USGS after June 1, 2001. All earlier data in the SDTS format contains a positional error that may impact modeling.

2.3.3 Met Data

It is currently acceptable in Oklahoma to perform modeling based on SCRAM data from 1986 through 1991. The closest National Weather Service (NWS) monitoring site with both surface and upper air data may be used for input regardless of whether that site is located in Oklahoma. Data from Amarillo, Texas may be used when modeling in the Oklahoma Panhandle; and data from Shreveport/Longview may be used for southeast Oklahoma (including, but not limited to, Choctaw and McCurtain Counties). Approval of AQD should be obtained prior to use of met data outside of Oklahoma.

Met data for northeast and east-central Oklahoma may be Tulsa surface data coupled with Oklahoma City/Norman upper air data. Modeling in the western ⅔ of Oklahoma may use Oklahoma City/Norman data.

Caution: The NWS moved the upper air monitoring site from Oklahoma City to Norman in 1989, causing a three-week gap in met data. 1989 may be excluded from all situations where Oklahoma City data is appropriate. In 1993, Norman was given its own NWS designation, which their office stated as "72357" but which has also been stated as "03948." Met data for Norman should be used in place of Oklahoma City (Station No. 13967) for all subsequent years.

The heights of the anemometers in Tulsa and Oklahoma City were changed in 1992 from a height of 23 feet (7.01 m) in Tulsa and 20 feet (6.10 m) in Oklahoma City to 10 meters. The anemometer height must be accurate for the time period in question; Therefore, the applicant must report the anemometer height used and must verify the height to be used for any out-of-state NWS stations.

2.3.3.1 Selection of Surface Characteristics for Met Data Processing

When using AERMET to prepare the meteorological data for AERMOD, you must input three surface characteristics: Albedo, Bowen Ratio, and Surface Roughness. AQD has approved use of NWS data for use with AERMOD, using the surface characteristics shown in the tables below for the met data sets as indicated. The NWS met data and surface characteristics shown below are considered representative for all modeling conducted in Oklahoma. For these met data sets and surface characteristics, there is only one defined sector. The surface characteristics in the tables below were developed from the values in Tables 4-1 through 4-3 of the *User's Guide for the AERMOD Meteorological Preprocessor (AERMET)* (EPA-454/B-03-002, November 2004). For facilities wanting to use different surface characteristics and or met data, site-specific surface analysis, sensitivity analysis, and/or meteorological data will be required.

Albedo Values

Met Data Set	Land Use[1]	Winter[2]	Spring	Summer	Autumn
Oklahoma City	C/G	0.40	0.16	0.19	0.19
Tulsa	D/C	0.35	0.13	0.16	0.15
Amarillo	DS/C	0.38	0.22	0.24	0.23
Longview/Shreveport	D	0.31	0.12	0.12	0.12

C - Cultivated Land; G - Grassland; D - Deciduous Forest; DS - Desert Shrubland.
[1] - Based on average value for the land uses shown, except where indicated.
[2] - Based on average values for winter and autumn, due intermittent snowfall in Oklahoma.

Bowen Ratio Values (Based on Average Moisture Conditions)

Met Data Set	Land Use[1]	Winter[2]	Spring	Summer	Autumn
Oklahoma City	C/G	1.18	0.35	0.65	0.85
Tulsa	D/C	1.18	0.50	0.40	0.85
Amarillo	DS[3]/C	1.55	0.65	1.00	1.35
Longview/Shreveport	D	1.25	0.70	0.30	1.00

C - Cultivated Land; G - Grassland; D - Deciduous Forest; DS - Desert Shrubland.
[1] - Based on average value for the land uses shown, except where indicated.
[2] - Based on average values for winter and autumn, due intermittent snowfall in Oklahoma.
[3] - Based on wet desert shrub land values.

Surface Roughness Values

Met Data Set	Land Use[1]	Winter	Spring	Summer	Autumn
Oklahoma City	C[2]/G	0.02	0.13	0.08	0.01
Tulsa	D/C[2]	0.27	0.60	0.68	0.41
Amarillo	DS/C[2]	0.09	0.25	0.18	0.16
Longview/Shreveport	D	0.50	1.00	1.30	0.80

C - Cultivated Land; G - Grassland; D - Deciduous Forest; DS - Desert Shrubland.
[1] - Based on average value for the land uses shown, except where indicated.
[2] - The cultivated values were shifted due to the growing seasons in Oklahoma.

AQD is currently working on developing more recent met data sets using Oklahoma Mesonet data. Hopefully, these met data sets will be available in the future for modeling conducted in Oklahoma. The Oklahoma Mesonet is a world-class network of environmental monitoring stations designed and implemented by scientists at the University of Oklahoma and at Oklahoma State University.

2.3.4 Nearby Sources

Existing nearby sources are required to be included in PSD and NSR NAAQS and Increment analyses. The AQD has historically allowed the use of the “20-D rule” to narrow the list of sources to only those that have the potential to significantly impact the modeling domain. The “20-D Rule” states that when a nearby source’s emissions (TPY) are less than 20 times the distance (in kilometers) from the nearby source and the source in question, that source may be designated a background source and not be modeled. Stated differently, any minor source (100 TPY or less), which is 5 km or more from the source in question, may be preemptively excluded.

However, the AQD will now only exclude those sources that have emissions less than 10-D. Upon request, the AQD will provide the applicant with a list of sources within a defined radius from the source in question. The list will include stack parameters as reported annually in emission inventories and potential emissions. If required, actual emissions for use in more refined increment consumption modeling will be provided at a later date. All sources and emissions provided to the applicant by AQD should be included in the modeling analysis. For large inventories, the AQD may request that the applicant provide some assistance in obtaining potential and actual emissions for some of the sources to be modeled. This may require the applicant to review permits and permit applications for the sources. Permits may be available from the AQD electronically. The applicant should submit with the application a final list of sources included in the modeling analysis.

2.3.5 Background Monitoring

Background concentrations must be added to PSD and NSR NAAQS analyses. If the modeled impacts from the facility are less than the monitoring de minims levels ambient monitoring data from the appropriate monitoring sites should be obtained and used by the applicant. However, if the monitoring de minimis levels are exceeded, then the applicant should provide justification for use of existing monitoring based on the guidance provided in the *Ambient Monitoring Guidelines for Prevention of Significant Deterioration (PSD)* (EPA-450/4-87-007, May 1987). If the facility is unable to meet the guidelines provided, pre-construction ambient monitoring to determine the background concentrations may be required. Post construction ambient monitoring may also be required or used to show compliance with the NAAQS.

2.3.6 GEP Stack Height

The Good Engineering Practice (GEP) stack height limitation of OAC 252:100-8-1.5 applies in all cases. The Building Parameter Input Program Plume Rise Model Enhancements (BPIP-PRIME) should be used for AERMOD.

2.3.7 Receptor Grids

100 meter spacing is usually sufficient for most purposes except preliminary coarse-grid modeling. While Cartesian Grids are preferred, polar grids will be acceptable so long as the receptor distances do not exceed grid spacing requirements. Before a final receptor grid formation may be established, concentrations modeled on an initial coarse grid should be evaluated. Areas of maximum concentration should be established and a fine grid (100 meter spacing and 50 meter spacing with downwash) should be used uniformly throughout those areas and extending to 1 kilometer beyond the areas of maximum concentration. It is the applicants responsibility to demonstrate that the grid is sufficiently compact to identify the maximum concentration for each averaging period. For modeling in which a significant impact radius is defined, a fine grid (100 meter spacing) should extend out to 3 kilometers from the source or 1 kilometer beyond the significant impact radius, whichever is greater.

2.3.8 NO_2 Modeling

Section 5.2.4 of Appendix W, 40 CFR Part 51, implements a Tiered screening approach to obtain annual average estimates of NO_2 from point sources for PSD and NSR analyses. Use of Tier I (conversion of all NO_X to NO_2) and Tier II (Use of the ambient ratio method (ARM)) of this multi-tiered approach are approved by AQD for all NO_2 modeling. Use of a Tier III analysis by an applicant should be approved by AQD prior to modeling submittal and may require EPA approval.

2.3.9 PM_{10} Modeling Guidance

The determination of PM_{10} design values is briefly discussed Appendix W, 40 CFR Part 51 and is explained in the *PM_{10} SIP Development Guideline* (EPA-450/2-86-001, 1986). Until incorporation of the new PM_{10} and $PM_{10\text{-}2.5}$ $PM_{2.5}$ standards, the modeled design concentration for the PM_{10} 24-hour NAAQS is the highest sixth high (H6H) concentration over a 5-year period at any receptor. The MULTYEAR keyword in the control (CO) pathway in the AERMOD model can be used to obtain the H6H concentration in 5 years. The modeled design concentration for the PM_{10} annual NAAQS is the 5-year average of the highest annual average concentrations.

2.3.10 Ozone Modeling Guidance-Sheffe Tables

Previously, under guidance from EPA, AQD has conservatively required the use of the Scheffe tables to evaluate ozone impacts from PSD sources with VOC emissions greater than 100 tons per year. The Scheffe tables are a tabular result of photochemical modeling conducted with the Reactive Plume Model, and VOC speciation assumptions for both rural and urban areas. The tables are used as a conservative screening analysis.

Since promulgation of the 8-hour standard use of the Scheffe Tables has become questionable. The AQD will determine whether or not use of the Scheffe Tables is appropriate on a case-by-case basis. Until EPA publishes guidelines for compliance for individual sources, use of Sheffe Tables or inclusion in modeling conducted for the Early Action Compact will be used to demonstrate compliance with the standard. However, an applicant may be required to conduct more extensive modeling using models such as the Reactive Plume Model (RPM) or Urban Airshed Model (UAM), which are acceptable for determining ozone impacts.

2.3.11 Deposition

The *Addendum to the User's Guide For The AMS/EPA Regulatory Model – AERMOD* **(**October 2004) explains the deposition algorithms and specifies the source parameters for use of deposition. All additional data used for an air dispersion analysis that incorporates deposition should be provided to and approved by AQD.

The wet deposition option should not be used for regulatory modeling analysis. Wet deposition is not a guideline feature of AERMOD. Per EPA guidance, dry gas deposition is not usually required for PM_{10} evaluations because of negligible settling velocities. However, AQD reserves the right to request a dry deposition evaluation for any PM emissions, but most specifically for TAC.

3. State Required Modeling

3.1 TAC Modeling

The AQD as part of the compliance strategy for an AOC may require owners or operators of applicable stationary sources within an AOC to perform ambient air modeling for the TAC of concern to demonstrate compliance with the applicable MAAC established per OAC 252:100-42. All applications of air quality modeling shall be based on the applicable models, databases, and other requirements specified in Appendix W of 40 CFR Part 51. Modification or substitution of approved models will be considered on a case-by-case basis. Owners or operators of facilities located in an AOC shall not be required to demonstrate compliance with the TAC MAAC within the boundaries of their facilities.

3.2 SO_2 Modeling

Subchapter 31 controls emissions of sulfur compounds from stationary sources. Per OAC 252:100-31-7(a) emissions of SO_2 from any existing facility or any new petroleum and natural gas process facility with equipment subject to OAC 252:100-31-26(a)(1) shall not impact existing ambient air concentrations of SO_2 at any given point by more than:

	Concentrations	
Averaging periods	**$\mu g/m^3$**	**ppmv**
5-minute	1,300	0.50
1-hour	1,200	0.46
3-hour	650	0.25
24-hour	130	0.05
Annual	80	0.03

Per OAC 252:100-31-7(b) emissions of hydrogen sulfide (H_2S)from any new or existing source shall not result in a 24-hour average ambient air concentration H_2S at any given point of 0.2 ppmv or greater.

Facilities with emissions of SO_2 and/or H_2S are required to show compliance with the ambient standards using EPA approved atmospheric dispersion models. Facilities must demonstrate compliance with the ambient air standards taking into account emissions from all the sources at the facility. Per OAC 252:100-31(c) the ambient standards do not apply to ambient air concentrations or impacts occurring on the property from which such emission occurs, providing such property, from the emission point to the point of any such concentration, is controlled by the person responsible for such emission.

3.3 TV (Major Source/Modification) Modeling

Criteria pollutant modeling to demonstrate NAAQS and Increment compliance may be required of any new major source or modification to an existing major source with a net increase of 100 TPY of a single criteria pollutant. NAAQS modeling should be conducted by evaluating the total source impact with an appropriate monitored background concentration added. Concurrence from the AQD should be obtained on which monitor will provide adequate background concentrations. Increment modeling should be conducted by evaluating the total source impact of increment consuming sources. Temporary sources of emissions are not required to be included in the modeling analyses as long as they do not impact a Class I area or an area where an applicable increment is known to be violated.

Note: If modeling demonstrates that the source will exceed PSD monitoring thresholds, post-construction monitoring though not specifically required under the Title V/Part 70 regulations may be required under the general authorizations of the DEQ. This decision will be made on a case-by-case basis and will depend on the extent of the impact area as well as the extent to which the NAAQS or Increment are threatened by the source.

4. PSD Modeling

A checklist for PSD modeling submittals is available in Appendix D.

4.1 Significant Impact Analysis

A significant impact analysis is the first level of modeling performed in a PSD evaluation. For each applicable pollutant, the analysis must include all stack emissions and quantifiable fugitive emissions resulting from the proposed source. For a proposed modification, the determination includes contemporaneous emissions increases and decreases, with emissions decreases input as negative emissions in the model. The EPA allows for the exclusion of temporary emissions such as those associated with construction. The applicant is required to compare results to the modeling significance levels as defined in 40 CFR Part 51.165(b)(2). If the highest modeled concentration over five years of meteorological data is less than or equal to the modeling significance levels, then the demonstration is complete. Per EPA guidance, the source is not considered to cause or contribute to an exceedance of the NAAQS or consume increment if the modeled impact is at or below the modeling significance level. If the highest modeled concentration is greater than the modeling significance levels, the applicant is required to perform additional refined modeling or reduce the impact to below the significance levels. If the modeled impacts remain above the modeling significance levels, a radius of impact (ROI) is defined. The ROI extends from the center of the proposed facility to the farthest receptor that shows an impact at or above the significance levels.

4.2 Increment Analysis

The AQD maintains a record of county/area baseline dates; however, a database of increment consumers is not available. Upon request, the AQD will provide the applicant with a list of sources within the ROI plus fifty kilometers. The list will include stack parameters as reported annually in emission inventories and potential emissions. Increment consuming sources should be indicated in the list. A Tiered approach is taken towards increment consuming sources. For Tier 1, the increment consuming sources should be modeled using their potential emissions. If the modeling results indicate a violation of the increment, then the applicant should request the maximum actual emissions for those sources. For short term increments, if no hourly data exists for that source then potential emissions should be used. For Tier II actual emissions may be used to show compliance with the Increment. When there are a large number of increment consuming sources, the AQD may request assistance from the applicant in determining actual emissions. The applicant should always submit with the application a final list of sources included in the modeling analysis.

If the proposed site is within 50 kilometers of another state, the applicant must obtain a list of sources to be evaluated from that state. If the ROI extends into another state, the applicant must confirm whether a baseline has been set in that region or not. If a baseline date has been set, the applicant must follow the guidance provided by that state for the evaluation of increment consumption within that state.

The following excerpt is taken directly from the Draft *New Source Review Workshop Manual Prevention of Significant Deterioration and Nonattainment Area Permitting* (EPA, October 1990).

> "For a PSD increment analysis, an estimate of the amount of increment consumed by existing point sources generally is based on increases in actual emissions occurring since the minor source baseline date. The exception, of course, is for major stationary sources whose actual emissions have increased (as a result of construction) before the minor source baseline date but on or after the major source baseline date. For any increment-consuming (or increment-expanding) emissions unit, the actual ***emissions limit***, ***operating level***, and ***operating factor*** may all be determined from source records and other information (e.g., state emission files), when available, reflecting actual source operation. For the annual averaging period, the change in the actual ***emissions rate*** should be calculated as the difference between:
>
> - *the current average actual* ***emissions rate***, and
> - *the average actual* ***emissions rate*** *as of the minor source baseline date (or major source baseline date for major stationary sources).*
>
> In each case, the average rate is calculated as the average over the previous 2-year period (unless the permitting agency determines that a different time period is more representative of normal source operation). For each short-term averaging period (24 hours and less), the change in the actual ***emissions rate*** for the particular averaging period is calculated as the difference between:
>
> - *the current maximum actual* ***emissions rate****, and*
> - *the maximum actual* ***emissions rate*** *as of the minor source baseline date (or major source baseline date for applicable major stationary sources undergoing consturction before the minor source baseline date).*
>
> In each case, the maximum rate is the highest occurrence for that averaging period during the previous 2 years of operation."

If an exceedance of the increment is identified and the applicant has a significant impact on that receptor, the situation must be rectified. The AQD cannot issue a permit that violates the increment.

4.3 NAAQS Analysis

Upon request, the AQD will provide the applicant with a list of sources within the ROI plus fifty kilometers. The list will include stack parameters as reported annually in emission inventories and potential emissions. All sources and emissions provided to the applicant by AQD should be included in the modeling analysis. For large inventories, the AQD may request that the applicant provide some assistance in obtaining potential emissions for some of the sources to be modeled. This may require the applicant to review permits and permit applications for the sources. Permits may be available from the AQD electronically. The applicant should submit with the application a final list of sources included in the modeling analysis.

If the proposed site is within 50 kilometers of another state, the applicant must obtain a list of sources to be evaluated from that state. If the radius of impact extends into another state, the applicant must follow the guidance provided by that state for the evaluation of the NAAQS within that state.

4.4 Visibility Analyses

Visibility impact analyses are required for the area around the affected source and may be required for any Class I areas near the affected source. The current EPA guidance document *Workbook for Plume Visual Impact Screening and Analysis (Revised)* (EPA 454/R-92-023, October 1992) describes how to evaluate plume visual impacts including use of the visual impact screening model (VISCREEN). VISCREEN can be applied in two successive screening modes without the need for extensive input. If screening calculations using VISCREEN demonstrate that during the worst case meteorological conditions a plume is imperceptible then it will not cause an adverse impact on visibility. To determine if a plume is perceptible, the impacts are compared to the screening criteria. If impacts exceed the screening criteria, further analysis may be required. The screening criteria are a change in relative sensitivity (ΔE) value of 2.0 and a green absolute contrast value of 0.05.

4.4.1 Class II Area Impact Analysis

VISCREEN should be used to address the visibility impacts of a source or modification within a Class II area. There are three levels of visibility analyses the first level is using the emissions and the default parameters defined by the program. The second level is where the user selects certain variables to get a more realistic view of the predicted impacts. The third level is a comprehensive analysis using PLUVUE.

Since VISCREEN was developed to over predict impacts and EPA’s guidance was developed mainly for Class I areas, AQD was concerned that the low screening levels would cause applicants to be required to perform Level 3 analyses for Class II areas. In an effort to prevent potentially time consuming efforts which would not lead to a real improvement in air quality, AQD has determined that the Class II screening levels should be approximately twice the Class I screening levels. Therefore, when comparing visibility impacts in a Class II area the following screening levels should be used: a ΔE value of 4.0 and a green absolute contrast value of 0.1. If a Level 1 and Level 2 analysis exceeds these levels a comprehensive analysis should be performed.

There are some sensitive areas located in Class II areas. If your facility is located within 40 km of one of these sensitive areas, the boundaries of the sensitive area should be used in the visibility analysis. The sensitive areas include but are not limited to the following areas:

Sensitive Area	Nearest Town
Tall Grass Prairie Preserve	Pearson, OK
Great Salt Plains State Park	Jet, OK
Lake Optima Wildlife Refuge	Hardesty, OK
Rita Blanca National Grassland	Felt, OK
Black Kettle National Grassland	Strong City, OK
Arbuckle's Lake Recreational Area	Sulfur, OK
Tishomingo Wildlife Refuge	Tishomingo, OK
Deep Fork Wildlife Refuge	Okmulgee, OK
Ouachita National Forest	Big Cedar, OK
McCurtain County Wildlife Refuge	Hochatown, OK
Little River Wildlife Refuge	Idabel, OK

Notes: When using VISCREEN and there are no sensitive receptors located within 40 km of the facility; The distance from the source to the observer and the distance from the source to the closest Class I area boundary should be set equal to each other and can arbitrarily be set to 1 km; and The distance from the source to farthest Class I area boundary may be arbitrarily established as 10 km. NO_2 emissions can be estimated using the ambient ratio method.

4.4.2 Class I Area Impact Analysis

Sources seeking PSD permits in the state of Oklahoma may be required to perform an impact analysis on a Class I area. Contact information for the federal land managers (FLM) for a Class I area may be obtained from the AQD. There is one Class I area in the state of Oklahoma: The Wichita Mountain Wildlife Preserve managed by the U.S. Fish and Wildlife Service (FWS). Two Class I areas are located in the state of Arkansas (these areas may require evaluations from sources locating in eastern Oklahoma): The Caney Creek Wilderness Preserve and The Upper Buffalo Wilderness Preserve managed by the Forest Service (FS). Another Class I area is located in the state of Missouri (this area may require evaluations from sources locating in northeastern Oklahoma): The Hercules-Glade Wilderness Preserve managed by the FS. Visibility analyses for Class I areas located more than 50 km from a facility must be performed using CALPUFF.

The National Parks Service (NPS) - Air Resources Division, FWS - Air Quality Branch and FS - Air Quality Program have produced a guidance document entitled *Federal Land Managers' Air Quality Related Values Workgroup (Flag) Phase I Report* (December 2000). The guidance set forth in this document is followed in PSD review for Class I area impacts. This document may be obtained electronically from the AQD or the participating agencies.

Appendix A

Point Source Model Input Data For NAAQS Compliance in PSD Demonstrations

40 CFR Part 51, Appendix W, Table 8-2

Averaging Time	Emission Limit X (#/MMBTU)[1]	Operating Level X (MMBTU/hr)[1]	Operating factor (e.g., hr/yr, hr/day)
Proposed Major New or Modified Source			
Annual & Quarterly	Maximum allowable emission limit or federally enforceable permit limit.	Design capacity or federally enforceable permit condition.	Continuous operation (i.e., 8,760 hours).[2]
Short term (≤ 24 hours)	Maximum allowable emission limit or federally enforceable permit limit.	Design capacity or federally enforceable permit condition.[3]	Continuous operation (i.e., all hours of each time period under consideration) (for all hours of the meteorological data base).[2]
Nearby Source(s)[4, 6]			
Annual & Quarterly	Maximum allowable emission limit or federally enforceable permit limit.[5]	Actual or design capacity (whichever is greater), or federally enforceable permit condition.	Actual operating factor averaged over the most recent 2 years.[7, 8]
Short term (≤ 24 hours)	Maximum allowable emission limit or federally enforceable permit limit.[5]	Actual or design capacity (whichever is greater), or federally enforceable permit condition.[3]	Continuous operation (i.e., all hours of each time period under consideration) (for all hours of the meteorological data base).[2]
Other Source(s)[6, 9]			
Annual & Quarterly	Maximum allowable emission limit or federally enforceable permit limit.[5]	Annual level when actually operating, averaged over the most recent 2 years.[7]	Actual operating factor averaged over the most recent 2 years.[7, 8]
Short term (≤ 24 hours)	Maximum allowable emission limit or federally enforceable permit limit.[5]	Annual level when actually operating, averaged over the most recent 2 years.[7]	Continuous operation (i.e., all hours of each time period under consideration) (for all hours of the meteorological data base).[2]

[1] Terminology applicable to fuel burning sources; analogous terminology (e.g., #/throughput) may be used for other types of sources.

[2] If operation does not occur for all hours of the time period of consideration (e.g., 3 or 24 hours) and the source operation is constrained by a federally enforceable permit condition, an appropriate adjustment to the modeled emission rate may be made (e.g.,

if operation is only 8:00 a.m. to 4:00 p.m. each day, only these hours will be modeled with emissions from the source.) Modeled emissions should not be averaged across non-operating time periods.

[3] Operating levels such as 50 percent and 75 percent of capacity should be modeled to determine the load causing the highest concentration.

[4] Includes existing facility to which modification is proposed if the emissions from the existing facility will not be affected by the modification. Otherwise use the same parameters as for major modification.

[5] See paragraph 9.2.3(c)

[6] See paragraph 9.2.3(d)

[7] Unless it is determined that this period is not representative.

[8] For those permitted sources not yet in operation or that have not established an appropriate factor, continuous operation (i.e., 8,760 hours) should be used.

[9] Generally, the ambient impacts from non-nearby background sources can be represented by air quality data unless adequate data does not exist.

Appendix B

Flare Calculation Derivation

An American Petroleum Institute (API) publication (API 1969) provides a correlation for flame length as a function of the flared gas heat release. This equation was republished and modified for a flame tilted at a 45° angle from the vertical in Fundamentals of Stack Gas Dispersion (Beychok 1994). The resulting equation provides the vertical height of a flare stack flame.

$$H_{fv} = 0.00128 Q_c^{0.478} \quad \text{(Eq. 1)}$$

Where: H_{fv} = flare stack flame vertical height vector, m
Q_c = flared gas heat release, Btu/hr

The equivalent height is then found by summing the height of the flare with the vertical height vector of the flame.

$$H_{equiv} = H_{actual} + 0.00128 Q_c^{0.478} \quad \text{(Eq. 2)}$$

Where: H_{equiv} = The equivalent height of the flare, m
H_{actual} = The actual height of the stack from the ground, m

The total plume rise is derived from the initial vertical velocity momentum and the initial buoyancy momentum. The buoyancy momentum is essentially a measure of the sensible heat emissions from the stack. However, the ISCST3 program does not allow the user to directly input the heat release. The flux parameter is instead calculated from the temperature differential between the stack and ambient air. This is a problem for a flare analysis because the heat release is diminished due to radiant heat losses. Therefore, an equivalent diameter is chosen, which when combined with the temperature assumption will force the program to calculate a buoyancy flux that accounts for the radiant heat loss. This equivalent diameter is back calculated from the Briggs' buoyancy flux parameter, which is derived from the sensible heat emissions.

The Briggs' buoyancy flux parameter may be expressed by the following equivalent expressions, with the reasonable assumption that combusted stack gas has essentially the same molecular weight and specific heat as ambient air.

$$F = \frac{g v_s r^2 (T_s - T_a)}{T_s} \quad \text{(Eq. 3)}$$

and

$$F = \frac{gQ}{(\pi c_{pa} T_a \rho_a)} \quad \text{(Eq. 4)}$$

Where: $g = 9.807$ m/sec^2
v_s = stack exit velocity, m/sec
r = stack exit radius, m

Q = stack sensible heat emission, cal/sec
cp_a= specific heat of ambient air, cal/(g-°C)
ρ_a = ambient air density, g/m^3
T_a = ambient air temperature, K
T_s = stack gas temperature, K
F = buoyancy flux parameter, m^4/sec^3

Since g and π are constants and since cp_a, T_a, and ρ_a are essentially constants, it may be inferred that the buoyancy flux parameter is a measure of the sensible heat emissions from the stack. So, assuming an average annual temperature of 68°F or 20°C, the equation 4 may be restated as follows:

$$F = \left(3.68x10^{-5}\right)\left(Q \text{ in cal/sec}\right) \qquad \text{(Eq. 5)}$$

and

$$F = \left(2.58x10^{-6}\right)\left(Q \text{ in Btu/hr}\right) \qquad \text{(Eq. 6)}$$

where: F = buoyancy flux parameter, m^4/sec^3

Because 55% of the heat is assumed to be lost due to radiation, equation 6 is adjusted specifically for flares.

$$F = \left(1.161x10^{-6}\right)\left(Q_c \text{ in Btu/hr}\right) \qquad \text{(Eq. 7)}$$

The equivalent diameter may now be found as a function of Q by setting equal equations 7 and 3 and solving for the radius (r).

$$D_{equiv} = 1.754x10^{-4}\sqrt{Q_c} \qquad \text{(Eq. 8)}$$

where: D_{equiv} = the equivalent diameter of the flare, m

The above guidance is consistent with guidance issued by the Ohio EPA. It differs from EPA Region V and Louisiana DEQ guidance with the inclusion of the stack height adjustment; however, this adjustment is made within the SCREEN3 flare option and is appropriate for the ISC3 point source option. It differs from Texas guidance with the inclusion of the stack height adjustment and an ambient temperature assumption. Texas guidance is based on an ambient temperature of 35°C. The guidance above assumes an average annual temperature of 20°C. Because the ambient temperature is important in both the heat release calculation and the equivalent diameter calculation, care should be exercised in modeling specific events. Rather than using the standard guidance above, specific events should be modeled with equivalent parameters based on the actual ambient conditions.

Appendix C

Modeling Protocol Submission Outline

1. **Project Overview**
    - **1.1.** Discussion of Plant Processes
    - **1.2.** References to Regulatory Applicability
2. **Emission Sources**
    - **2.1.** Source Description
    - **2.2.** Location of Emissions
    - **2.3.** Pollutants
3. **Impact Assessment Tools and Techniques**
    - **3.1.** Description of Models to Be Used
        - **3.1.1.** Version
        - **3.1.2.** Circumstance of use, i.e., SCREEN3 for initial toxic MAAC screening
    - **3.2.** Discussion on Use of Ratio method
    - **3.3.** Discussion on Merging Stacks
    - **3.4.** For PSD Analysis
        - **3.4.1.** Discussion on Use of Sheffe Tables
        - **3.4.2.** Discussion on Use of "20 D Rule"
        - **3.4.3.** Discussion on Use of Visibility Screening Tools for Class I Areas
4. **Area Maps and Facility Plot Plans (if available)**
    - **4.1.** Clearly Marked Scale
    - **4.2.** Property Lines
    - **4.3.** Fence Lines
    - **4.4.** Downwash Structures
    - **4.5.** True-north Arrow
    - **4.6.** UTM Coordinates for Vertical and Horizontal Borders
    - **4.7.** Reference UTM Coordinates and Locations of All Emission Points
    - **4.8.** Identification of Sensitive Receptors and Nearest Residents (Area Map Only)
    - **4.9.** For NAAQS Analysis Identification of Any State/Local/On-site Ambient Air Monitoring Sites Used for Background Concentrations
    - **4.10.** For PSD Applications, identification of PSD Class I areas within 300 km (186.4 miles) or within 10D of emissions.
    - **4.11.** Provide an Accompanying List of Structures with UTM Locations, Heights, and Model Labels or ID Numbers
5. **Modeling Emission Inventory**
    - **5.1.** On-Site Sources
        - **5.1.1.** Assumptions
        - **5.1.2.** Table of Source Input Data (if available)
    - **5.2.** Discussion of Methodology for Obtaining Off-property Modeling Parameters
6. **Air Quality Monitoring Data For NAAQS Compliance**
    - **6.1.** Discussion on the Issue of Pre-construction Monitoring
    - **6.2.** Proposed Monitoring Sites
    - **6.3.** Discussion on How Concentrations will be Adjusted for Background Sources Specifically Modeled.
7. **Land Use**

Appendix C

7.1. Auer Land-use Analysis
7.2. Copy of USGS map (if used in analysis)

8. Receptor Grid
8.1. Discussion on Grid Type
8.2. Discussion on Receptor Placement
8.3. Diagram of Each Grid Type w/Labels

9. Meteorological Data
9.1. Surface Station
9.2. Upper-air Station
9.3. Period of Record

10. Discussion on Method of Evaluation Additional Impacts Analysis (PSD)

11. Class I Area Impacts Analysis (PSD)
11.1. Discussion of Method of Analysis
11.2. AQRV of concern

Appendix D

Final Submission Outline

12. Project Overview
- **12.1.** Discussion of Plant Processes
- **12.2.** References to Regulatory Applicability

13. Emission Sources
- **13.1.** Source Description
- **13.2.** Location of Emissions
- **13.3.** Table of Emissions by Source and Pollutants

14. Impact Assessment Tools and Techniques
- **14.1.** Description of Models Used
  - **14.1.1.** Version
  - **14.1.2.** Circumstance of use, i.e., SCREEN3 for initial toxic MAAC screening
- **14.2.** Discussion on Use of Ratio method
- **14.3.** Discussion on Collocating Sources
- **14.4.** For PSD Analysis
  - **14.4.1.** Discussion on Use of Sheffe Tables
  - **14.4.2.** Discussion on Use of "20 D Rule"
  - **14.4.3.** Discussion on Use of Visibility Screening Tools for Class I Areas

15. Area Maps and Facility Plot Plans
- **15.1.** Clearly Marked Scale
- **15.2.** Property Lines
- **15.3.** Fence Lines
- **15.4.** Downwash Structures
- **15.5.** True-north Arrow
- **15.6.** UTM Coordinates for Vertical and Horizontal Borders
- **15.7.** Reference UTM Coordinates and Locations of All Emission Points
- **15.8.** Identification of Sensitive Receptors and Nearest Residents (Area Map Only)
- **15.9.** Identification of Any State/Local/On-site Ambient Air Monitoring Sites Used for Background Concentrations
- **15.10.** For PSD Applications, Identification of PSD Class I Areas Within 100 km (62 miles)
- **15.11.** Provide an Accompanying List of Structures with UTM Locations, Heights, and Model Labels or ID Numbers

16. Air Quality Monitoring Data
- **16.1.** Discussion on the Issue of Pre-construction Monitoring
- **16.2.** Summary Information for Monitoring Sites
  - **16.2.1.** Year of Observation
  - **16.2.2.** Location
  - **16.2.3.** First, Second, and Fourth High Concentrations
  - **16.2.4.** Annual Arithmetic Mean Concentration
- **16.3.** Discussion on How Concentrations will be Adjusted for Background Sources Specifically Modeled.

17. Modeling Emission Inventory
- **17.1.** On-Site Sources

Appendix D

17.1.1. Assumptions
17.1.2. Table of Source Input Data
17.2. Background Sources for NAAQS and Increment Modeling
17.2.1. Discussion of Methodology for Obtaining Off-property Modeling Parameters
17.2.2. "20 D Rule" Table
17.2.2.1. All Sources Within 50 km
17.2.2.2. UTM Coordinates
17.2.2.3. Distance from Significant Impact Radius
17.2.2.4. Total Emissions
17.2.3. Table of Source Modeling Parameters

18. Land Use
18.1. Auer Land-use Analysis
18.2. Copy of USGS map (if used in analysis)

19. Receptor Grid
19.1. Terrain
19.1.1. Discussion on Terrain for Individual Receptors
19.1.2. For PSD Applications Attach Contour Plots
19.2. Design
19.2.1. Discussion on Grid Type
19.2.2. Diagram of Each Grid Type w/Labels

20. Meteorological Data
20.1. Surface Station
20.2. Upper-air Station
20.3. Period of Record

21. Modeling Results
21.1. Summary Table for Each Pollutant
21.1.1. Listing Standard, (NAAQS, Increment, or MAAC)
21.1.2. Listing Monitored Background Concentrations
21.2. For Each Standard, Receptor Grid Plots w/Appropriate Concentration
21.3. For PSD Applications, Area Plot w/Concentration Contour Plot

22. Additional Impacts Analysis (PSD)
22.1. Discussion on Method of Evaluation
22.2. Evaluation Results on Growth, Soils and Vegetation

23. Class I Area Impacts Analysis (PSD)
23.1. Discussion of Method of Analysis
23.2. Results of Analysis on effect on AQRV

24. Attached Disks of All Model Input and Output files

References

American Petroleum Institute (API). 1969. Guide for pressure relief and depressurizing systems. API RP 521, First Edition.

Auer, A. H. 1978. Correlation of Land Use and Cover with Meteorological Anomalies, Journal of Applied Meteorology, 17:636-643.

Beychok, Milton R. 1994. Fundamentals of Stack Gas Dispersion. 3rd ed. Irvine, California: Milton Beychok

Davies, M. J. E., and D. M. Leahey. 1984. Observation of Plume Rise from Sour Gas Flares. Atmospheric Environment Volume 18, No. 5: 917-922.

Koerber, Michael, Regional Meteorologist, EPA Region V. Letter to Regions I-IV, VI-X, 28 July 1986.

Louisiana Department of Environmental Quality (LDEQ). 1999. Air Quality Modeling Procedures. Baton Rouge, Louisiana: LDEQ

Ohio Environmental Protection Agency (Ohio EPA). Air Dispersion Modeling Guidance, Engineering Guide No. 69. Columbus, Ohio: Ohio EPA.

Scheffe, Richard D. 1988. VOC/NO_X Point Source Screening Tables, draft.

Texas Natural Resource Conservation Commission (TNRCC). 1999. Air Quality Modeling Guidelines. Austin, Texas: TNRCC.

United States Environmental Protection Agency (EPA). 1990. Draft New Source Review Workshop Manual. Research Triangle Park, North Carolina: EPA

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