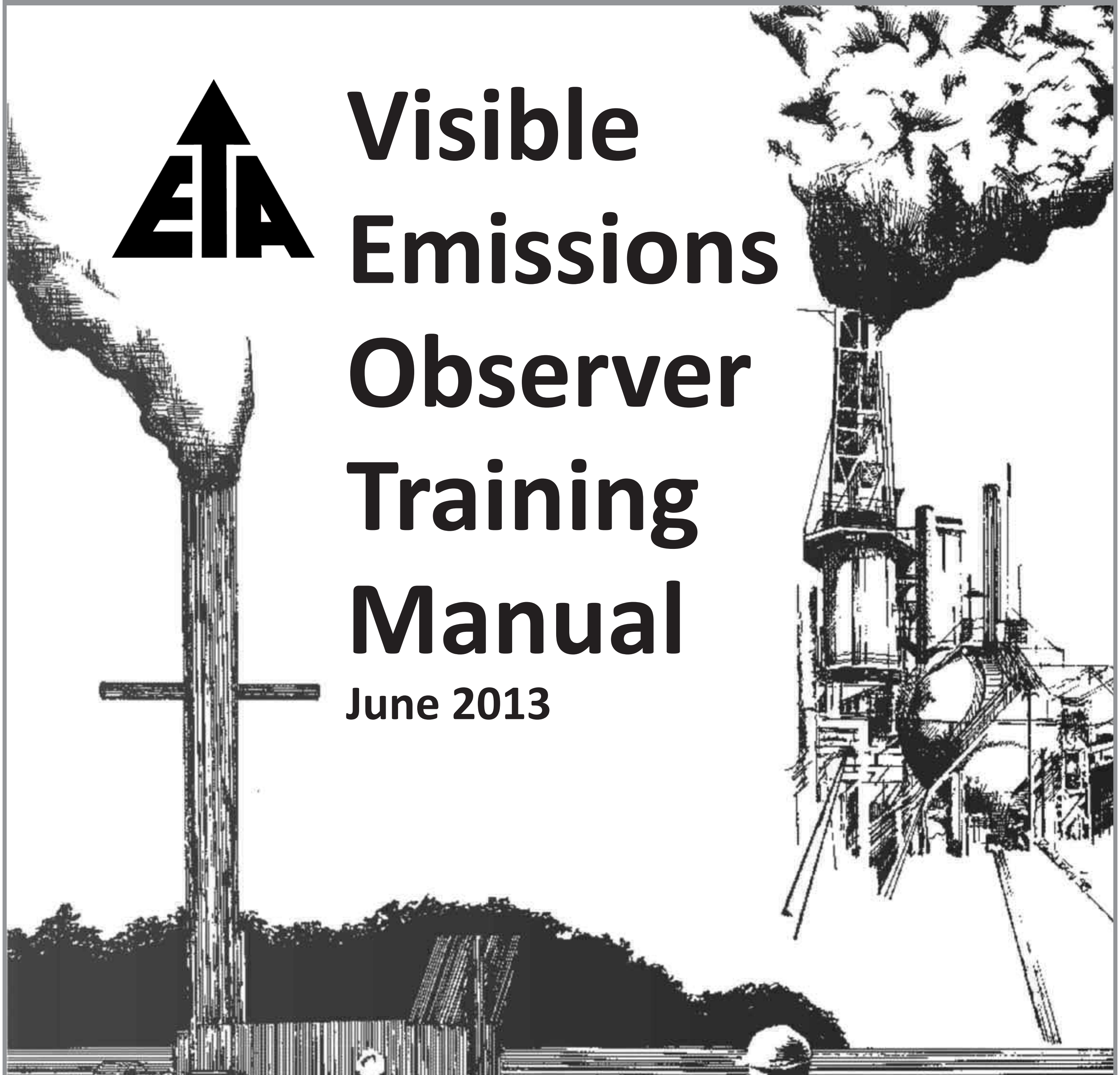
Eastern Technical Associates

Visible Emissions Observer Training Manual

June 2013



Welcome Visible Emissions Observer Trainee:

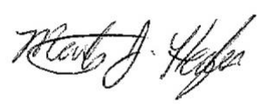
During the next few days you will be trained in one of the oldest and most common source measurement techniques – visible emissions observations. There are more people measuring visible emissions today than at any time in the 100-plus-year history of emissions observations. We have prepared this manual to assist you in your training, certification, and most important, field observations. It is impossible to give proper credit to all who developed and supported the technology that contributed to this manual. The list would probably be longer than the manual itself. We have been working in this field since 1970 and stand in the footprints of many innovators. Much of the material in this manual comes from the contributions of the many visible emissions instructors we have been privileged to work with as well as U.S. EPA documents and the contributions of our staff for more than 30 years.

The purpose of this manual is to give you a hands-on, readable reference for the topics addressed in the classroom portion of our training. It should also be useful as a reference document in the future when you are a certified observer performing measurements in the field. Unfortunately, we cannot cover all of the possible situations you might encounter, but the guidance in this document combined with the training you receive in ETA's classroom and field programs should enable you to make valid observations for more than 90% of the sources you observe. If we do not have the answers, we can usually direct you to someone that does.

We hope you enjoy your experience at Smoke School and look forward to seeing you in the future. We will not wish you good luck because luck has nothing to do with certification, so we will simply wish you early success!

General Manager

Jody Monk



Director of Training

Marty Hughes

For the most up-to-date information regarding ETA's training schedule, opacity, related topics, forms, and links, please visit either www.smokeschool.com.

Eastern Technical Associates, Inc.
Visible Emissions Observer
Training Manual

Prepared by:
ETA Staff

Eastern Technical Associates, Inc.
P.O. Box 1009
Garner, NC 27529
(919) 878-3188

Cover by David Terry
Edited by John Ashley
Design and graphics by Steve Allen

Table of Contents

CHAPTER 1

Introduction

Section 111 of the Clean Air Act requires the U.S. Environmental Protection Agency to promulgate emission standards for pollutants that significantly affect air quality. The federal opacity standards for various industries are found in the Codified Federal Registry (CFR). Standards of Performance for New and Modified Stationary Sources (NSPS) can be found in 40 CFR Part 60. Emission standards for Hazardous Air Pollutants (NESHAP) are contained in 40 CFR Part 61 and 63. Title V of the 1990 Clean Air Act Amendments further defined the process by which facilities are permitted. Title V and Part 64 also establish the need for Compliance Assurance Monitoring (CAM).

CAM was a change in direction by the EPA, shifting the emissions monitoring burden to industry. From an opacity standpoint companies are required to measure and report their own compliance with permit conditions and standards. However, regulatory agencies do retain the ability to enforce standards and permit conditions.

These standards require the use of Reference Method 9 or Reference Method 22 (contained in Appendix A of Part 60) for the determination by trained observers of the level or frequency of visible emissions. In addition to the plume observation procedures, Method 9 contains data reduction and reporting procedures as well as procedures and specifications for training and certifying qualified visible emissions (VE) observers.

Permits issued under State Implementation Plans (SIPs) typically include several types of opacity regulations. In some cases SIP permits may differ from the federal opacity standards in terms of the opacity limits, the measurement method or test procedure, and the data evaluation technique. For example, some SIP opacity rules limit visible emissions to a specified number of minutes per hour or other time period (time exemption). Some limit opacity to a certain level averaged over a specified number of minutes (time averaged). Others set opacity limits where no single reading can exceed the standard (instantaneous or "cap").

Regardless of the exact format of the SIP opacity regulations, nearly all use the procedures in Method 9 for conducting VE field observations and for training and certifying VE observers. The procedures contain specific instructions on proper observation techniques, data gathering, required spatial relationships, and documentation requirements. The validity of the VE determinations used for compliance or noncompliance demonstration purposes depends to a great extent on how well the field observations are documented on the VE Observation Form. This manual will stress the type and extent of documentation needed to satisfy Method 9 requirements.

In addition to the plume observation procedures, Method 9 contains data reduction and reporting procedures as well as procedures and specifications for training and certifying qualified visible emissions (VE) observers.

Federal and State Opacity Standards are Independently Enforceable and Serve as a Primary Compliance Surveillance Tool

Federal opacity standards and most SIP opacity regulations are independently enforceable, i.e., a source may be cited for an opacity violation even when it is in compliance with the particulate mass standard. Thus, visible emissions observations serve as a primary compliance surveillance tool for enforcement of emissions control standards. Method 9, Section 2 states that the procedures contained in the Method shall be performed by observers qualified in accordance with the certification requirements contained in Section 3. In addition, many federal and SIP regulations and construction and operating permits also require owners/operators of affected facilities to assess and report opacity data during the initial compliance tests and at specified intervals over the long term.

A NSPS or SIP Opacity Violation Can Result in a Fine of $10,000 to $37,500

Regulated sources may be subject to stiff penalties for failure to comply with federal, state, or local opacity standards. Civil and administrative penalties of up to $37,500 per day per violation can be assessed under the Clean Air Act (CAA). State and local agencies are encouraged under Title V of the CAA to have program authority to levy fines up to $10,000 per day per violation. Therefore, visible emissions determinations for compliance demonstration or enforcement purposes must be made accurately and must be sufficiently documented to withstand rigorous examination in potential enforcement proceedings, administrative or legal hearings, or eventual court litigation.

Procedural errors or omissions on the visible emissions evaluation forms or data sheets can invalidate the data or otherwise provide a basis for questioning the evaluation. Only by carefully following the procedures set forth in Method 9 and by paying close attention to proper completion of the VEO form can you be assured of acceptance of the evaluation data for compliance or enforcement purposes.

The purpose of this classroom manual is to provide background information and a step-by-step guide for VE observers who have recently completed the VE training and certification tests to conduct VE observations in accordance with the published opacity methods. The basic steps of a well-planned and properly performed VE inspection are illustrated in the inspection flow chart (see Figure 1). This manual is organized to follow the flow chart. Sections of the reference method that must be carefully adhered to during the observation are highlighted. Method 9 and Method 22 are reprinted in full in Chapters 4 and 11. We have included a VE Observation Form in the Appendix of the manual which may be copied or modified for field use.

It should be noted that much of the information presented in this manual has been derived from a number of previously published technical guides, manuals, and reports on Method 9 and related opacity methods. You can obtain the most up-to-date information on opacity from our Web site: www.smokeschool.com. Another source of internet information is http://www.epa.gov/ttn/emc/methods/method9.html

Inspection Flow Chart

Perimeter Survey
↓
Determine Sources
↓
Determine Sun Position
↓
Check for Direction of Plume Travel
- perpendicular line of sight
- rectangular outlets
- multiple stacks

↓
Determine Point in Plume to Evaluate
↓
Document Point in Plume Where Reading Was Taken
↓
Adjust Field Location if Necessary
↓
Observations
↓
Data Review
↓
Calculations

Chapter 1 Figure 1: Inspection Flow Chart

Notes

CHAPTER 2

History of Opacity

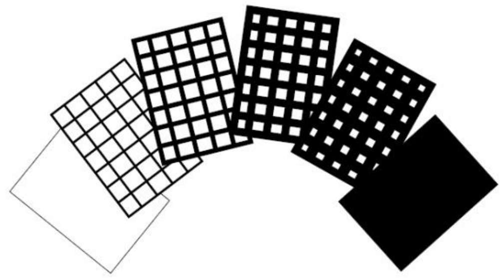
The history of air pollution regulation dates back as far as the 13th century. In 1273, Edward I (Longshanks) of England prohibited the burning of sea coal in London. The smoke produced by its combustion was considered detrimental to human health. In 1307, a local blacksmith was convicted, condemned, and executed for this offense.

The adverse effects of air pollution increased with subsequent industrial development and urban populations. Most early U.S. and English case law concerning air pollution fell under a part of the law commonly referred to as nuisance law. In the absence of specific regulations or laws against air pollutants, someone wanting to stop pollution (e.g. smoke from factories) had to bring a tort (injury) case against the offender. Smoke was not generally considered a nuisance. Each case had to stand on its own merit and prove that the smoke in question was a nuisance.

Eventually communities passed regulations that sought to control air pollution. Court records from the late 19th and early 20th centuries contain many examples of city and state prosecutions of smoke ordinance violations. One of the earliest U.S. cases to uphold a municipal smoke control ordinance was the case of City of New Orleans v. Lambert[1]. The case involved another blacksmith shop that emitted offensive smoke and odors as was deemed a nuisance.

Ringelmann

The opacity evaluation system we use today evolved from a concept developed by Maximillian Ringelmann in the late 1800s. Ringelmann, an engineer working in France, developed a method to quantify emissions according to the visual density of the observed smoke. Ringelmann realized that the amount of dense black smoke from coal-fired boilers was determined by combustion efficiency. Darker smoke meant poorer efficiency. Ringelmann developed a series of charts with graduated black grids on white backgrounds.



Chapter 2 Figure 1: Ringelmann cards

When he placed the charts approximately 100 feet away, the grids appeared as shades of grey. Ringelmann was able to quantify emissions by comparing the shade of the smoke with the corresponding shade on his charts. By applying this information and adjusting the fuel/air ratio of a furnace, he could increase efficiency and decrease smoke. The Ringelmann Chart was adopted and promoted by the U.S. Bureau of Mines in the early 1900s in its efforts to improve coal combustion practices. It has since been used extensively to assess and control emissions.

Early Legal Refinement

Meanwhile cases involving air pollution continued to enter the courts. In the case of Glucose Refining Company v. City of Chicago[2], a Chicago court upheld the view that "... the emission of dense smoke in populous communities is a public nuisance." In 1907, the Supreme Court of Indiana declared dense, black smoke to be a public nuisance in the case of Bowers v. City of Indianapolis[3]. In 1908, the use of a color scale to evaluate smoke was upheld in the case of Cincinnati v. Burkhardt[4]. Shortly thereafter, in 1910, the use of the Ringelmann scale was upheld in a Rochester, N.Y., statute. The statute prohibited smoke from 5 a.m. to 7:30 a.m., presumably to protect commuters and allowed dense smoke for only five minutes in every consecutive four-hour period.

Throughout the early 1900s legislatures and municipalities wrestled with the problem of air pollution. In 1916, the breakthrough case of

Northwestern Laundry v. Des Moines[5] was filed in U.S. District Court in Iowa. This case, brought against the city smoke inspectors and smoke abatement board, sought to enjoin or block the enforcement of a Des Moines regulation that stated dense smoke in sections of the city was a public nuisance. The court dismissed the case and supported the state's authority to regulate air pollution considered injurious to the common welfare.

By 1920, many municipalities had incorporated the Ringelmann scale into their health and safety regulations in an attempt to control smoke as a nuisance. To prove a violation of these nuisance codes it was necessary to prove that the smoke was dense and created a nuisance. After a number of air pollution-related deaths in Donora, P.A., in 1948, the Surgeon General declared smoke was not only a nuisance, but a health hazard as well. This set the stage for federal enforcement of air pollution regulations.

Equivalent Opacity

In the 1950s and 1960s, Los Angeles added two major refinements to the evaluation of visible emissions. The first refinement involved the concept of "equivalent opacity". Initially, the Ringelmann method had been developed for the evaluation of black smoke. However, observers using equivalent opacity were able to use the Ringelmann method on other colors of smoke. For example, white emissions could be equivalent to a Ringelmann number in their ability to obscure the view of a background. In some states equivalent opacity was still measured in Ringelmann numbers whereas in other states the 0-100% scale was used.

In addition, Los Angeles developed a formal training and certification program for visible emissions. Regulatory personnel were trained and certified using a smoke generator equipped with an opacity meter. As a result, regulatory agencies ensured that certified inspectors did not have to carry and use Ringelmann cards.

In 1968, the Federal Air Pollution Control Office published AP-30, a joint industry/government study of the relative accuracy of visible emissions observations and transmissometers. The study also addressed the influence of sun position on visible emissions observations. Visible emissions observers must account for sun position in order to get reproducible results with opacity measurements.

Portland Cement Association v. Ruckelshaus

In 1973, Portland Cement Association petitioned the District of Columbia District Court to review the promulgation of new standards for the cement kiln industry. In particular, the U.S. Environmental Protection Agency Administrator published a proposed regulation setting the standards of performance to 10% opacity. The Portland Cement Association challenged the new codes on the grounds that the economic costs of implementing the needed changes unfairly discriminated against the cement industry. The Portland Cement Association also charged that the EPA failed to adequately demonstrate the achievability of the new standards. The court ruled for Portland Cement Association by setting cement kiln opacity limits to 20%. The court's decision also questioned the tight time schedules for proposing standards laid out in the Clean Air Act. In response to these issues, EPA undertook field trials needed to establish observer error, observation protocols, and equipment guidelines.

Method 9 Promulgation

EPA published Method 9 procedures for New Source Performance Standards (NSPS) in 1974. The agency subsequently stopped using Ringelmann numbers unless required by State Implementation Plans (SIPs). Current NSPS procedures are based solely on opacity. Although some state regulations (California) still specify the use of the Ringelmann system for black and grey emissions, the national trend is to read all emissions in percent opacity. In response to court actions in the 1970s and '80s, Eastern Technical

Associates (ETA) conducted extensive field studies for EPA and demonstrated that visible emissions can be accurately assessed by properly trained and certified observers.

Western Alfalfa v. Air Pollution Variance Board of Colorado

A Colorado state health inspector entered the Western Alfalfa Corporation facility without its knowledge and documented an opacity violation. Western Alfalfa argued that an inspection on its premises without consent violated the company's Fourth Amendment protections from an unreasonable search. In its decision, the Supreme Court held that the inspector sighted what anyone in the city could see – smoke. Furthermore, the inspector may operate inside or outside the premises and still be considered within the "open fields" exception to the Fourth Amendment. In a separate ruling, the court refused to enforce a violation in which regulatory agents had excessively delayed notifying the facility. The court cited a necessity to immediately inform the facility management of documentation that indicated a violation. The court reasoned that sources must have the opportunity to reconstruct operating conditions as a defense. This decision is referred to as "speedy notification".

The Donner Hanna Case

The differences between Federal Reference Methods (FRMs) and State Implementation Plans (SIPs) were highlighted in the landmark case of Donner Hanna Coke Corporation v. Costle. The company's coke oven battery was being regulated by the EPA according to a time aggregation rule in which emissions from the battery were timed with a stopwatch. Regulators altered Method 9 in accordance with a New York SIP for monitoring coke batteries. However, this technique had not been legally adopted as an official measurement method. According to NSPS, in the absence of a legally adopted state measurement method, the method of measurement must be Federal Reference Method 9. EPA inspectors were denied entry into the facility because they intended to use the stopwatch technique rather than Method 9. The court upheld the company position and denied entry to EPA inspectors. The regulatory community was shocked by the court's decision and was forced to reconcile the fact that there were differences in FRMs and SIPs. Although this technique was used extensively by several states and the EPA, it had not been officially promulgated within these agencies. To use a method that is different from the one on the books, it must go through the necessary steps in order to become valid.

Creation of ETA

In 1970, Willie S. Lee, President of Environmental Industries, developed and began to manufacture the first reliable smoke generators meeting EPA specifications. In 1974, Willie Lee and Tom Rose (then an EPA employee) developed the modern white smoke vaporization system. Willie Lee continued to modify and improve smoke generators while Tom Rose developed training methods. In 1975, Tom Rose developed the laminar flow elbow used to conduct smoke schools in high wind and also wrote the Quality Assurance Manual for Smoke School Operation. In 1979, Willie Lee and Tom Rose formed ETA, bringing the combined expertise in equipment and training together. Willie Lee retired in 1999. Tom Rose passed away in October, 2011. Today ETA continues to be the leading provider of Visible Emissions Training in the world.

In recent years regulatory agencies and environmental organizations have begun to see the value in certification for other methods of opacity monitoring. To fulfill this need, ETA, in addition to certifying opacity observers, now provides the testing program in the Source Evaluation Society for qualification of emissions testers conducting manual and instrumental measurements of industrial sources.

Method 22 Promulgation

The EPA adopted Method 22 in 1982. It has also become an important tool in the evaluation of visible emissions. Unlike Method 9, Method 22 is a technique that only addresses the amount of time that any visible emissions occur. No certification is required. However, an understanding of the appropriate observation techniques is essential for correct use of the method. You can gain this knowledge by attending a smoke school lecture such as those presented by ETA. Many current regulations imply that the observation technique should be Method 22. For example, when a rule states that visible emissions are not acceptable and does not specify a particular method, you should use Method 22.

The Kaiser Steel Case

The method of measurement used when evaluating visible emissions has been an issue throughout the history of air pollution litigation. This issue resurfaced in 1984 in the case of U.S. v. Kaiser Steel Corporation 7. The Department of Justice was prosecuting Kaiser Steel for California SIP violations involving cast house emissions from a steel plant. Also at issue was the use of testimony in place of actual evidence. The attempt to use expert opinions to determine noncompliance rather than actual observations was the beginning of the "credible evidence" debate. The judge eventually ruled that the expert testimony was not compelling and declared that fines would only be imposed when there was sufficient evidence Kaiser had indeed violated the law. Although fines were only assessed for violations of the six-minute average (as required by Method 9), they totaled more than half a million dollars. Interestingly, the 1990 Clean Air Act Amendments included provisions for the use of "credible evidence" specifically in response to the Kaiser Steel case.

P.M. 10 and P.M. 2.5

Opacity measurement remains the mainstay of federal, state, and local air pollution control efforts. More visible emissions observers certify now than ever before. The emphasis on opacity is sure to continue with the increased interest in fugitive emissions and the evident relationship of opacity to PM 10 (particles of 10 microns in diameter or smaller) and PM 2.5 (particles of 2.5 microns in diameter or smaller) emissions. These smaller particles tend to scatter more light and obscure the view more than larger particles. As a result, emissions that contain large numbers of these smaller particles tend to exhibit high opacity values. PM 10 and PM 2.5 particles are particularly dangerous because they can easily enter the lungs and cause permanent damage to the respiratory system.

Furthermore, the EPA promulgated two rules that are already having a considerable impact on opacity. The first is the Compliance Assurance Monitoring (CAM) rule that requires certain facilities to certify their compliance with standards. Opacity measurements are an effective and relatively simple method used to check compliance. Second, the "Credible Evidence Rule" allows for the use of information other than reference test methods to prove or disprove violations. According to the rule, a single measured parameter (e.g. opacity) can be used to demonstrate compliance or trigger an enforcement action.

Footnotes:

1. City of New Orleans v. Lambert, 14 La. Ann. 247 (1859).
2. Glucose Refining Company v. City of Chicago, 138 Fed. 209. 215 (1905).
3. Bowers v. City of Indianapolis, 162 Ind. 105. 81 N.E. 1097 at 1098. 13 Ann. Cas. 1198 (1907).
4. Cincinnati v. Burkhardt, 30 Ohio Cir. Ct. Rep. 350 Ann. Cas. 1918 B. 174 (1908).
5. Northwestern Laundry v. Des Moines, 239 U.S. 486, 36 S. Ct. 206, 60 L. Ed. 396 (1916).
6. Donner Hanna Coke Corporation v. Costle, 464 F. Supp. 1295 (D.N.Y. 1979).
7. U.S. v. Kaiser Steel Corp., No. CV-82-2623 IH (C.D. Cal. Jan. 17, 1984).
8. Air Pollution Variance Board of Colorado v. Western Alfalfa Corporation, No. 73-690, May 20, 1974 (U.S. Supreme Court).
9. Portland Cement Association v. Ruckelshaus, 72-1073, 1975 (DC Circuit Court).

CHAPTER 3

Opacity Measurement Principles

The relationships between light transmittance, plume opacity, and Ringelmann number are presented in Chapter 3-Figure 1 below:

Comparison of Ringelmann Number, Plume Opacity, and Light Transmittance

RINGELMANN	OPACITY	TRANSMITTANCE
0	0%	100%
1	**20%**	**80%**
2	40%	60%
3	**60%**	**40%**
4	80%	20%
5	**100%**	**0%**

Chapter 3 Figure 1: Comparison Chart

A literal definition of plume opacity is the degree to which the transmission of light is reduced or the degree to which visibility of a background as viewed through the diameter of a plume is reduced. In more simple terms we say:

Opacity is the obscuring power of an emission expressed as a percent

In terms of physical optics, opacity is dependent upon transmittance (I/Io) through the plume, where Io is the incident light flux and I is the light flux leaving the plume along the same light path. Percent opacity is defined:

Percent opacity = (1-I/Io) X 100

Variables Influencing Opacity Observations

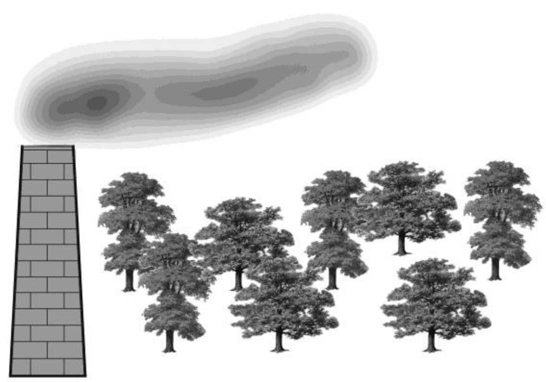
Method 9 warns:

> *The appearance of a plume as viewed by an observer depends upon a number of variables, some of which may be controllable and some of which may not be controllable in the field.*

The factors that influence plume opacity readings include: particle density; particle refractive index; particle size distribution; particle color; plume background; line of sight path length; distance and relative elevation to stack exit; sun angle; and lighting conditions.

Particle size is particularly significant. Particles decrease light transmission by both scattering and direct absorption. Particles with diameters approximately equal to the wavelength of visible light have the greatest scattering effect and cause the highest opacity. For a given mass emission rate smaller particles will cause a higher opacity effect than larger particles.

Luminous contrast and color contrast are variables that might be controllable in the field. The contrast between the plume and the background can affect the appearance of the plume and, as a result, affect your ability to accurately assign opacity values. A plume is most visible and has the greatest apparent opacity when viewed against a contrasting background. On the other hand, as the contrast between a plume and its background decreases, the apparent opacity decreases. The latter situation greatly increases the likelihood of a negative bias (i.e., you will underestimate the true opacity of the plume). When faced with a situation where there is a choice of backgrounds, you should always choose the one providing the greatest contrast because it will permit the most accurate opacity reading.



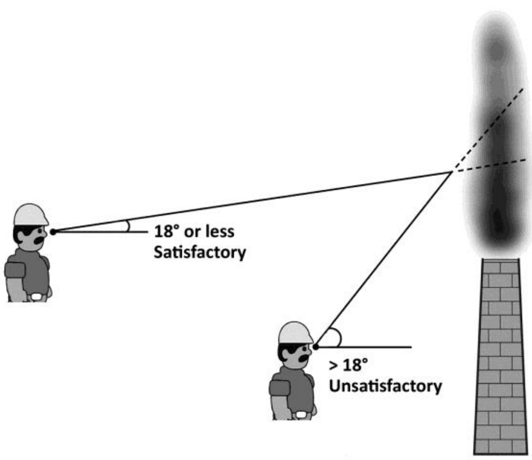
Chapter 3 Figure 2: Plume Contrast- Black

Chapter 3 Figure 2: Plume Contrast - White

The line of sight path length through the plume is of particular concern.

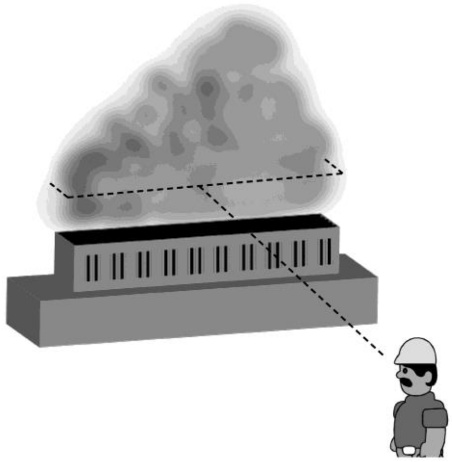
Method 9 states:

> *... the observer shall, as much as possible, make his/her observations from a position such that his/her line of vision is approximately perpendicular to the plume direction ...*



Chapter 3 Figure 3: Perpendicular line of sight

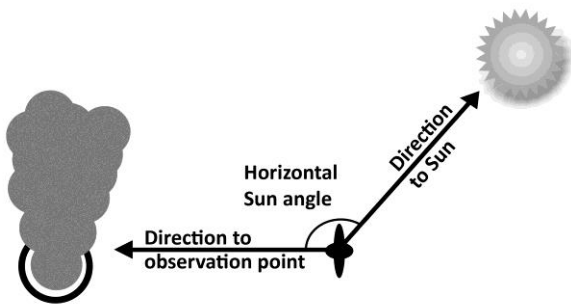
> *... and when observing opacity of emissions from rectangular outlets (e.g. roof monitors, open baghouses, non-circular stacks), approximately perpendicular to the longer axis of the outlet.*



Chapter 3 Figure 4: Viewing rectangular outlets

As you move closer to a stack with a vertically rising emission, the viewing (slant) angle formed by your line of sight increases (see Figure 3). This causes the observed opacity to increase because you read through more emissions. If your line of sight is greater than +/- 18 degrees from the perpendicular, a positive error greater than 1% occurs (see Slant Angle Correction in Appendix). As the angle increases the error increases. To avoid this problem you should stand at least three stack heights distance away from a vertical plume. The three-stack-heights relationship is applicable only if you and the base of the stack are in the same horizontal plane. If you are on a higher plane than the base of the stack, then the minimum distance for proper viewing can be reduced to less than three stack heights. Conversely, if your plane is lower than that of the stack base, then the minimum suggested distance will be greater than the three stack heights.

Notes



Chapter 3-Figure 5: Determining Proper Sun Position – Horizontal Sun Angle

Sun Angle

Method 9 states:

The qualified observer shall stand at a distance sufficient to provide a clear view of the emissions with the sun oriented in the 140-degree sector to his/her back.

The horizontal and vertical sun angle from the observer to the observation point is a critical consideration. If the position of the sun at the time of the observation is not within 140 degrees horizontally and vertically of the observer's back, the opacity readings will have a positive bias. This observation error invalidates opacity readings. Sun angle and position must be carefully addressed on the VEO form.

Measurement Uncertainty

All measurement systems have an associated level of uncertainty and Method 9 is no exception. The EPA determined the uncertainty level for Method 9 with numerous field trials at two confidence intervals for white and black smoke. The uncertainty associated with Method 9 is described by the EPA in terms of positive error as follows:

1) *For black plumes (133 sets at a smoke generator) 100 percent of the sets were read with a positive error of less than 7.5 percent opacity; 99 percent were read with a positive error of less than 5 percent opacity.*
2) *For white plumes (170 sets at a smoke generator, 168 sets at a coal-fired plant, 298 sets at a sulfuric acid plant), 99 percent of the sets were read with a positive error of less than 7.5 percent opacity; 95 percent were read with a positive error of less than 5 percent opacity.*

This means that 100% of black plumes and 99% of white plumes do not have an uncertainty greater than 7.5%. There is only a one percent chance that you will exceed this level on a white plume and zero percent chance that an observer will exceed this level of uncertainty on a black plume. This means that with two observations, there is little chance of an uncertainty of 7.5%. Negative biases due to observation conditions reduce the observational uncertainty.

Ninety-nine percent of the black plumes and 95% of white plumes were read within 5%. This means that you are likely to over read about one in 20 readings. Again, negative biases due to observation conditions reduce the observational uncertainty.

From this analysis, clearly the way to reduce the level of uncertainty is to increase the number of observations in either averaging time or in number of averages. Both techniques improve the accuracy of the method.

Notes

CHAPTER 4

U.S. EPA Method 9

Method 9: Visual Determination of the Opacity of Emissions from Stationary Sources.

Introduction

Many stationary sources discharge visible emissions into the atmosphere and these emissions are usually in the shape of a plume. This method involves the determination of plume opacity by qualified observers. The method includes procedures for the training and certification of observers and procedures to be used in the field for determination of plume opacity. The appearance of a plume as viewed by an observer depends upon a number of variables, some of which might be controllable and some of which might not be controllable in the field. Variables that can be controlled to an extent to which they no longer exert a significant influence upon plume appearance include: angle of the observer with respect to the plume; angle of the observer with respect to the sun; point of observation of attached and detached steam plume; and angle of the observer with respect to a plume emitted from a rectangular stack with a large length to width ratio. The method includes specific criteria applicable to these variables.

Other variables that might not be controllable in the field are luminescence and color contrast between the plume and the background against which the plume is viewed. These variables exert an influence upon the appearance of a plume as viewed by an observer and can affect the ability of the observer to accurately assign opacity values to the observed plume. Studies of the theory of plume opacity and field studies have demonstrated that a plume is most visible and presents the greatest apparent opacity when viewed against a contrasting background. It follows from this, and is confirmed by field trials, that the opacity of a plume viewed under conditions where a contrasting background is present can be assigned with the greatest degree of accuracy. However, the potential for a positive error is also the greatest when a plume is viewed under such contrasting conditions. Under conditions presenting a less contrasting background, the apparent opacity of a plume is less and approaches zero as the color and luminescence contrast decrease toward zero. As a result, significant negative bias and negative errors can be made when a plume is viewed under less contrasting conditions. A negative bias decreases rather than increases the possibility that a plant operator will be cited for a violation of opacity standards due to observer error.

Studies have been undertaken to determine the magnitude of positive errors that can be made by qualified observers while reading plumes under contrasting conditions and using the procedures set forth in this method. The results of these studies (field trials) that involve a total of 769 sets of 25 readings each are as follows:
1. For black plumes (133 sets at a smoke generator), 100% of the sets were read with a positive error of less than 7.5% opacity; 99% were read with a positive error of less than 5% opacity.
2. For white plumes (170 sets at a smoke generator, 168 sets at a coal-fired power plant, 298 sets at a sulfuric acid plant), 99% of the sets were read with a positive error of less than 7.5% opacity; 95% were read with a positive error of less than 5% opacity.

The positive observational error associated with an average of 25 readings is therefore established. The accuracy of the method must be taken into account when determining possible violations of applicable opacity standards.

1. Principle and Applicability

1.1 Principle. The opacity of emissions from stationary sources is determined visually by a qualified observer.

1.2 Applicability. This method is applicable for the determination of the opacity of emissions from stationary sources pursuant to 60.11(b) and for qualifying observers for visually determining opacity of emissions.

2. Procedures

The observer qualified in accordance with Section 3 of this method shall use the following procedures for visually determining the opacity of emissions:

2.1 Position. The qualified observer shall stand at a distance sufficient to provide a clear view of the emissions with the sun oriented in the 140-degree sector to his/her back. Consistent with maintaining the above requirement, the observer shall, as much as possible, make his/her observations from a position such that his/her line of vision is approximately perpendicular to the plume direction, and when observing opacity of emissions from rectangular outlets (e.g., roof monitors, open baghouses, noncircular stacks), approximately perpendicular to the longer axis of the outlet. The observer's line of sight should not include more than one plume at a time when multiple stacks are involved and in any case the observer should make his/her observations with his/her line of sight perpendicular to the longer axis of such a set of multiple stacks (e.g., stub stacks on baghouses).

2.2 Field Records. The observer shall record the name of the plant, emission location, type facility, observer's name and affiliation, a sketch of the observer's position relative to the source, and the date on a field data sheet. The time, estimated distance to the emission location, approximate wind direction, estimated wind speed, description of the sky condition (presence and color of clouds), and plume background are recorded on a field data sheet at the time opacity readings are initiated and completed.

2.3 Observations. Opacity observations shall be made at the point of greatest opacity in that portion of the plume where condensed water vapor is not present. The observer shall not look continuously at the plume but instead shall observe the plume momentarily at 15-second intervals.

2.3.1 Attached Steam Plumes. When condensed water vapor is present within the plume as it emerges from the emission outlet, opacity observations shall be made beyond the point in the plume at which condensed water vapor is no longer visible. The observer shall record the approximate distance from the emission outlet to the point in the plume at which the observations are made.

2.3.2 Detached Steam Plumes. When water vapor in the plume condenses and becomes visible at a distinct distance from the emission outlet, the opacity of emissions should be evaluated at the emission outlet prior to the condensation of water vapor and the formation of the steam plume or beyond the point in the plume at which condensed water vapor is no longer visible. In either circumstance, observations shall be made at the point of greatest opacity.

2.4 Recording Observations. Opacity observations shall be recorded to the nearest 5% at 15-second intervals on an observational record sheet. A minimum of 24 observations shall be recorded. Each momentary observation recorded shall be deemed to represent the average opacity of emissions for a 15-second period.

2.5 Data Reduction. Opacity shall be determined as an average of 24 consecutive observations recorded at 15-second intervals. Divide the observations recorded on the record sheet into sets of 24 consecutive observations. A set is composed of any 24 consecutive observations. Sets need not to be consecutive in time and in no case shall two sets overlap. For each set of 24 observations, calculate the average by summing the opacity of the 24 observations and dividing this sum by 24. If an applicable standard specifies an averaging time requiring more than 24 observations, calculate the average for all observations made during the specified time period. Record the average opacity on a record sheet.

3. Qualifications and Testing

3.1 Certification Requirements. To receive certification as a qualified observer, a candidate must be tested and demonstrate the ability to assign opacity readings in 5% increments to 25

different black plumes and 25 different white plumes with an error not to exceed 15% opacity on any one reading and an average error not to exceed 7.5% opacity in each category. Candidates shall be tested according to the procedures described in Section 3.2. Smoke generators used pursuant to Section 3.2 shall be equipped with a smoke meter that meets the requirements of Section 3.3.
The certification shall be valid for a period of six months at which time the qualification procedure must be repeated by any observer in order to retain certification.

3.2 Certification Procedure. The certification test consists of showing the candidate a complete run of 50 plumes – 25 black plumes and 25 white plumes – generated by a smoke generator. Plumes within each set of 25 black and 25 white runs shall be presented in random order. The candidate assigns an opacity value to each plume and records his/her observation on a suitable form. At the completion of each run of 50 readings, the score of the candidate is determined. If a candidate fails to qualify, the complete run of 50 readings must be repeated in any retest. The smoke test may be administered as part of a smoke school or training program and may be preceded by training or familiarization runs of the smoke generator during which candidates are shown black and white plumes of known opacity.

3.3 Smoke Generator Specifications. Any smoke generator used for the purposes of Section 3.2 shall be equipped with a smoke meter installed to measure opacity across the diameter of the smoke generator stack. The smoke meter output shall display in-stack opacity based upon a pathlength equal to the stack exit diameter on a full 0-100% chart recorder scale. The smoke meter optical design and performance shall meet the specifications shown in Table 9-1. The smoke meter shall be calibrated as prescribed in Section 3.3.1 prior to the conduct of each smoke reading test. At the completion of each test, the zero and span drift shall be checked and if the drift exceeds +/- 1% opacity, the condition shall be corrected prior to conducting any subsequent test runs. The smoke meter shall be demonstrated, at the time of installation, to meet the specifications listed in Table 9-1. This demonstration shall be repeated following any subsequent repair or replacement of the photocell or associated electronic circuitry including the chart recorder or output meter, or every six months, whichever occurs first.

Smoke Meter Design and Performance Specifications: Table 9-1 from Method 9

PARAMETER	SPECIFICATION
Light source	Incandescent lamp operated at nominal rated voltage
Spectral response of photocell	Photopic (daylight spectral response of the human eye)
Angle of view	15 degrees maximum total angle
Angle of projection	15 degrees maximum total angle
Calibration error	+/- 3% opacity, maximum
Zero and drift span	+/- 1% opacity, 30 minutes
Response time	5 seconds

Chapter 4 Table 1: Table 9-1 from Method 9

3.3.1 Calibration. The smoke meter is calibrated after allowing a minimum of 30 minutes warm-up by alternately producing simulated opacities of 0% and 100%. When stable response at 0% or 100% is noted, the smoke meter is adjusted to produce an output of 0% or 100% as appropriate. This calibration shall be repeated until stable 0% and 100% readings are produced without adjustment. Simulated 0% and 100% opacity values may be produced by alternately switching the power to the light source on and off while the smoke generator is not producing smoke.

3.3.2 Smoke Meter Evaluation. The smoke meter design and performance are to be evaluated as follows:

3.3.2.1 Light Source. Verify from manufacturer's data and from voltage measurements made at the lamp, as installed, that the lamp is operated within +/- 5% of the nominal rated voltage.

3.3.2.2 Spectral Response of Photocell. Verify from manufacturer's data that the photocell has a photopic response, i.e., the spectral sensitivity of the cell shall closely approximate the standard spectral-luminosity curve for photopic vision which is referenced in (b) of Table 9-1.

3.3.2.3 Angle of View. Check the construction geometry to ensure that the total angle of view of the smoke plume, as seen by the photocell, does not exceed 15 degrees. The total angle of view can be calculated from:

è = 2 tan-1 (d/2L), where:
è = total angle of view;
d = the sum of the photocell diameter + the diameter of the limiting aperture; and
L = the distance from the photocell to the limiting aperture.

The limiting aperture is the point in the path between the photocell and the smoke plume where the angle of view is most restricted. In smoke generator smoke meters this is normally an orifice plate.

3.3.2.4 Angle of Projection. Check construction geometry to ensure that the total angle of projection of the lamp on the smoke plume does not exceed 15 degrees. The total angle of projection can be calculated from:

è = 2 tan-1 (d/2L), where:
è = total angle of projection;
d = the sum of the length of the lamp filament + the diameter of the limiting aperture; and
L = the distance from the lamp to the limiting aperture.

3.3.2.5 Calibration Error. Using neutral-density filters of known opacity, check the error between the actual response and the theoretical linear response of the smoke meter. This check is accomplished by first calibrating the smoke meter according to 3.3.1 and then inserting a series of three neutral-density filters of nominal opacity of 20, 50, and 75% into the smoke meter pathlength. Filters calibrated within +/- 2% shall be used. Care should be taken when inserting the filters to prevent stray light from affecting the meter. Make a total of five nonconsecutive readings for each filter. The maximum error on any one reading shall be 3% opacity.

3.3.2.6 Zero and Span Drift. Determine the zero and span drift by calibrating and operating the smoke generator in a normal manner for a one-hour period. The drift is measured by checking the zero and span at the end of the period.

3.3.2.7 Response Time. Determine the response time by producing a series of five simulated 0% and 100% opacity values and observing the time required to reach stable response. Opacity values of 0% and 100% can be simulated by alternately switching the power to the light source off and on while the smoke generator is not operating.

4. Bibliography

1. Air Pollution Control District Rules and Regulations, Los Angeles County Air Pollution Control District, Regulation IV, Prohibitions, Rule 50.
2. Weisburd, Melvin I., Field Operations and Enforcement Manual for Air, U.S. Environmental Protection Agency, Research Triangle Park, N.C., APTD-1100, August 1972, pp. 4.1-4.36.
3. Condon, E.U., and Odishaw, H., Handbook of Physics, McGraw-Hill Co., New York, N.Y., 1958, Table 3.1, p. 6-52.

CHAPTER 5

U.S. EPA Method 9 Procedures

Pre-Observation Guidelines

The following procedures are not required by Method 9 but are recommended in order to provide consistent data collection, documentation, and verification of emissions viewing conditions. Regulatory observers in particular should ensure that all Agency guidelines and procedures for VE observations are rigorously followed. Not all procedures are needed for every observation.

Before making on-site VE determinations, the observer should provide prior notification when applicable, establish an observation protocol, and check for availability of supplies and properly maintained equipment.

The observer should be thoroughly familiar with the source facility, operation, emissions, and applicable regulations. In preparation for the on-site visit, regulatory observers should review the Agency's information (in the official source file) on the source in question. In addition, the observer should:

1. Determine the pertinent people to be contacted.
2. Become familiar with the processes and operations at the facility and identify those facilities to be observed.
3. Review the permit conditions, requirements, and recent applications.
4. Determine applicable emission regulations.
5. Identify all operating air pollution control equipment, emission points, and types and quantities of emissions.
6. Review history of previous inspections, source test results, and complaints.
7. Check the file to become familiar with (or review) plant layout and possible observation sites.
8. Determine normal production and operation rules.
9. Identify unique problems and conditions that might be encountered (e.g., steam plume).
10. Discuss with attorney if case development is expected.
11. Obtain a copy of the facility map with labeled emission points, profile drawings, and photographs if available. A facility map is very helpful during inspection and should be a required item for every Agency source file. The map makes it easier for the observer to identify point sources and activities, and it may be used to mark any emission points that have been added or modified.
12. If an operating permit exists, obtain a copy because it might contain the VE limits for each point source and any special operating requirements.
13. Determine the status of the source with respect to any variance or exemption from the Agency's rules and regulations.
14. Review facility terminology.
15. Use references such as facility maps and previous inspection reports to determine if the viewing position is restricted because of buildings or natural barriers. If the viewing position requires observations to be taken at a particular time of day (morning or evening) because of sun angle, consider this when planning the inspection.
16. Determine the possibility of water vapor in the plume condensing (see Chapter 7). This determination might prevent a wasted trip to the facility on days when a persistent water droplet plume is anticipated because of adverse ambient conditions.
17. Check to see if safety training is required to enter the facility and determine what safety equipment is needed (if any) prior to the observation.
18. Be sure to follow Agency and/or facility safety protocol.
19. During your observations you must focus on the observation point. As a result, it is very important that you choose an observation position that minimizes exposure to safety hazards.
20. You may occasionally obtain proprietary or confidential business data during the course of a VE investigation. It is essential that this information be handled properly according to your Agency's policies.

Note: If the observer is not familiar with the type of facility or operation, he/she should consult available reference material and inspection manuals on the source category.

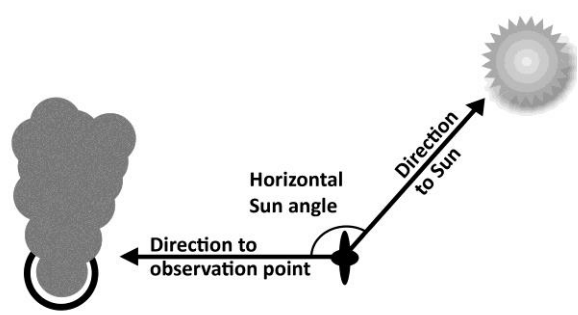
Plan the Observation

First, determine the sources of visible emissions at the facility and identify the specific source you are going to observe. Before making your observations, you need to determine the correct viewing position for the source being monitored. You will need to select backgrounds, determine the wind direction, and establish proper sun position. Record the source identification on the field data sheet. Next, identify any potential interferences near the source, for example, other visible emissions plumes from nearby sources, fugitive dusts from work activities in the line of sight, or obstructing buildings. Finally, identify any other sources that are unlisted but visible. If you do not consider each of these items, the observation might be invalidated in subsequent legal actions.

Determine Sun Position

Method 9 states:

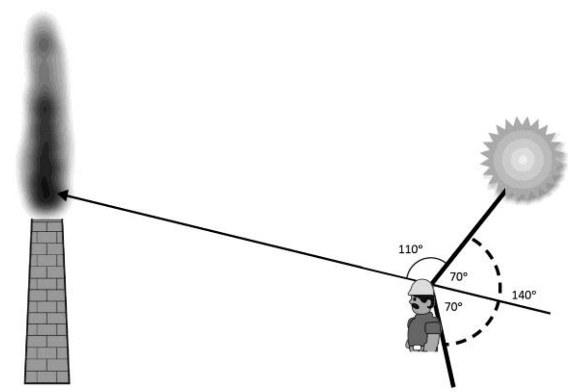
The qualified observer shall stand at a distance sufficient to provide a clear view of the emissions with the sun oriented in the 140-degree sector to his/her back.



Chapter 5 Figure 1: Determining Proper Sun Position – Horizontal Sun Angle

This means that a line from the sun to the observer and a line from the observer to the observation point in the plume must form an angle of at least 110 degrees (see Chapter 5-Figure 1). This will place the sun in the required cone-shaped 140-degree sector. The purpose of this rule is to prevent forward scattering of light transmitted in the plume. Forward scattering enhances the plume visibility and creates a positive bias in measurement results. In fact, every viewing requirement of the method is designed to prevent positive bias.

Use a compass to determine the position of the sun relative to north. If you are using true north as a reference, remember to correct the compass for the magnetic declination at the site that might be different from the declination at your office location. Position the sun in a 140-degree sector to your back when facing the source. You can quickly check the horizontal sun position by using the sun location line on the VEO form. Determine the sun location by pointing the line of sight on the Source Layout Sketch in the direction of the actual observation point. Move your pen horizontally along the sun location line until the shadow of the pen crosses the observer's position. When the shadow covers the observer's position, mark the sun on the sun location line.



Chapter 5 Figure 2: Determining Proper Sun Position – Vertical Sun Angle

Now you must determine whether the vertical location of the sun is acceptable. You can validate that the sun angle is correct with a Sundog or similar device. Vertical sun location is particularly important under one or more of the following conditions:

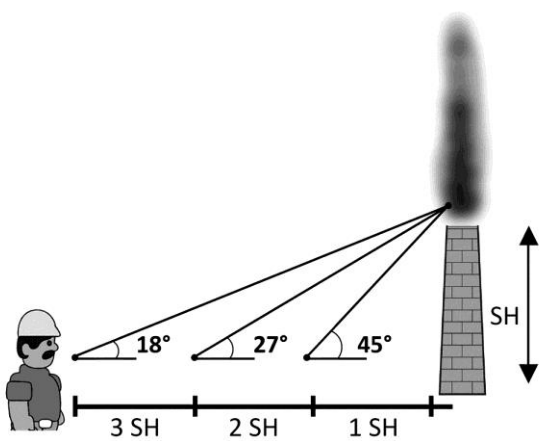
1. You are observing a tall stack.
2. The sun is high overhead.
3. You are observing the plume high in the sky.

Remember that the combined vertical angle from the observation point to the observer to the sun must be at least 110 degrees. Computer programs are available for sun position determination. Please refer to Chapter 9 for further information regarding sun position.

Check for Direction of Plume Travel

Method 9 states:

[The VE observer should] ... make his/her observations from a position such that his/her line of vision is approximately perpendicular to the plume direction.]



Chapter 5 Figure 3: Correct line of sight

When observing the plume, you should be at least three effective stack heights away from a vertically rising plume (see Figure above). The intent is to keep within +/- 18 degrees of perpendicular to the plume. The three-stack-heights relationship is applicable only if you are in the same horizontal plane as the base of the stack. If the plume is horizontal, make sure that your line of sight is approximately perpendicular to the plume at the point of observation. The line of sight should be within 18 degrees of perpendicular to the plume line of travel. The reason for standing approximately perpendicular to the plume when making VE determinations is to use the shortest line of sight pathlength through the plume, which will result in the most accurate estimate of plume opacity. If the angle exceeds 18 degrees, final opacity values must be corrected using the Slant Angle Correction Table in the Appendix of this manual.

Determine Point in Plume to Evaluate

Method 9 provides excellent guidance on the selection of the spot in the plume to observe. This guidance is presented in several sections and unless the method is read in its entirety, the information can be confusing. The following extractions from Method 9 address what to consider in selecting the point in the plume for the observation.

Method 9 states:

2.3 Observations

Opacity observations shall be made at the point of greatest opacity in that portion of the plume where condensed water vapor is not present.

This is the first and most significant criterion. It has two elements that must be adhered to:

1. You must read opacity at the densest portion of the plume.
2. There cannot be any condensed water vapor at the point of observation.

If there is no condensed water vapor (steam) present in the plume, you can read at the densest part of the plume. Sometimes condensed material appears to be attached to fine particles. The condensed water vapor (steam) does not dissipate sharply as it does in many sources. Instead, a large amount of water is retained on particles, giving the appearance of steam beyond the point of actual steam dissipation.

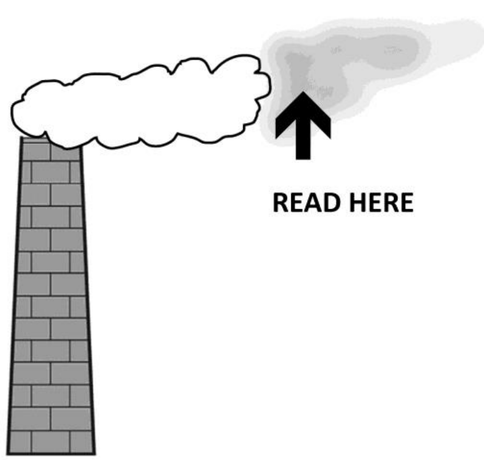
If this is the case, you should observe the plume with the sun in the background to clearly identify the point of water evaporation. After this point has been established, return to the appropriate observer's position (i.e., with the sun in the 140-degree sector to your back). Observations should be made after the point of water evaporation in full accordance with Method 9.

Method 9 states:

2.3.1 Attached Steam Plumes

When condensed water vapor is present within the plume as it emerges from the emission outlet, opacity observations shall be made beyond the point in the plume at which condensed water vapor is no longer visible. The observer shall record the approximate distance from the emission outlet to the point in the plume at which the observations are made.

You must be sure that the condensed water aerosol is not enhancing the opacity of the particulate matter in the plume. If the relative humidity is high, water might hang on to particulate matter and if the particulate is hygroscopic, the water could hang on at lower levels of humidity. Neither is acceptable for a valid observation. You can observe the plume from the other side, looking into the sun to determine where there is a real break point in the steam plume. Do not look into the sun when observing for record.

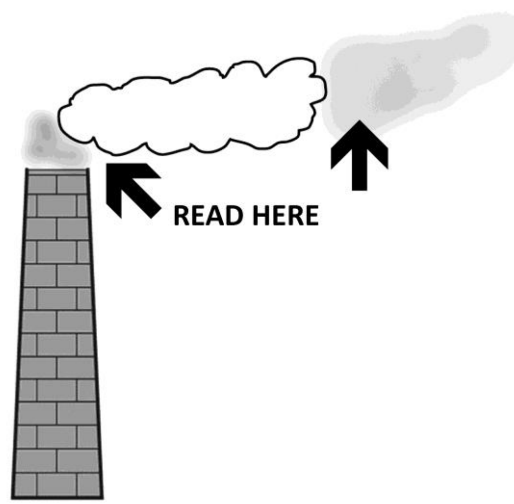


Chapter 5 Figure 4: Attached steam plume

Method 9 states:

2.3.2 Detached Steam Plumes

When water vapor in the plume condenses and becomes visible at a distinct distance from the emission outlet, the opacity of emissions should be evaluated at the emission outlet prior to the condensation of water vapor and the formation of the steam plume.



Chapter 5 Figure 5: Detached steam plume

Note: The word shall has been changed to should in this subsection. If the steam plume is detached you have two choices:

1. Read before the steam forms.
2. Read after is evaporates.

It is easy to choose between these options if you remember that **observations shall be made at the point of greatest opacity** is the primary rule. If the plume is denser before the steam plume forms, read there. If the plume is denser after the steam plume evaporates, read there, unless there are specific directives to the contrary.

Certain complex plumes with **high condensable loadings or secondary reactive products** could present problems in determining where to read the plume and how to interpret the results. This is where your homework comes into play. Permits or emissions test data should provide information concerning the material being emitted.

Other cases that require caution are those in which condensed hydrocarbons are the principle component of the visible plume. Some opacity regulations might not be applicable to sources with condensing hydrocarbon plumes if the intent of the emissions standard was only to control primary particulate emissions detected by the emissions control system. An example is the case of blue haze plumes from asphalt concrete batch plants, which have been determined to be exempt from the NSPS opacity requirement.

Document the Point in the Plume Where the Reading was Taken

You must document on the data sheet the point in the plume selected for the opacity reading. This location should be documented in terms of distance and direction from the stack and in relative terms to any condensed water or steam break. You may be challenged later on this issue if you fail to indicate that the plume has a high moisture content or condensable emissions.

Adjust Field Location if Necessary

After picking the point in the plume to observe, recheck that you are in the correct position relative to the sun and that point. If you are not, move. Recheck each of the same factors at the new field position and move again if necessary. Do not start observations until all the factors conform to the requirements of Method 9. It might be necessary to return at a different time or date in order to attain acceptable observation conditions.

Observations

Compared to the preliminary activities, observing the emissions is easy. You will complete the top, far left section of the form first. Be sure to fill in the observation date in the appropriate space on the form and enter the start time when you make the first observation. Use the 24-hour clock to avoid confusion with a.m. and p.m. and indicate the time zone. For example, 10:30 a.m. Eastern Daylight Time should be recorded as 1030 EDT; 2:30 p.m. Eastern Daylight Time should be recorded as 1430 EDT.

Method 9 states:

The observer shall not look continuously at the plume, but instead shall observe the plume at 15-second intervals.

Watch your timer and only observe the plume momentarily at the 0-, 15-, 30-, and 45-second intervals. It takes only a few seconds to record your observation on the form. Record your observations in 5% opacity increments unless the permit or regulation specifies otherwise. Continue until the required number of observations have been made. Method 9 usually requires at least 24 observations for a complete data set. Good measurement practice is to take more than the bare minimum required, and it might be necessary to take more than one data set to defend the observations against litigation in some courts.

There is a comment section for each minute of observations. Use these comment sections to document events that effect the validity of the observation, such as interferences or reasons for missing readings. Document changes in your position or plume color. When you conclude your observation session, record the stop time in the appropriate section.

Fill in the section on observer and affiliation. Remember to record any important or relevant information not covered by the form in the Additional Information section. Sign and date the form. Enter the requested information concerning your last certification.

Data Review

Field Data Check

Before you leave the field, look over the form carefully. Start at the bottom right and work your way up, following the form backwards. Make sure that each section is either filled out correctly or left blank on purpose. All entries should be legible. Remember, this is the first-generation copy and all subsequent copies will be of lower print quality. The visible emissions observation form can be introduced as evidence in enforcement litigation under the principle of "past recollection recorded". This means that you made entries on the form while they were fresh in your mind. A five-minute review at this time can save hours later.

Complete the Form

As soon as possible gather the missing information and complete the form. Do not sign the form until you have completed all entries you intend to complete.

Method 9 states:

… the time, estimated distance to the emission location, approximate wind direction, estimated wind speed, description of the sky condition (presence and color of clouds), and plume background are recorded on a field data sheet at the time opacity readings are initiated and completed.

Any additional entries made after you sign the form must be dated and initialed. Failure to document changes properly makes the observations subject to challenge. Even the mark out might have to be explained in a deposition or in court.

Notes

CHAPTER 6

Calculations

Opacity/Transmittance Relationship

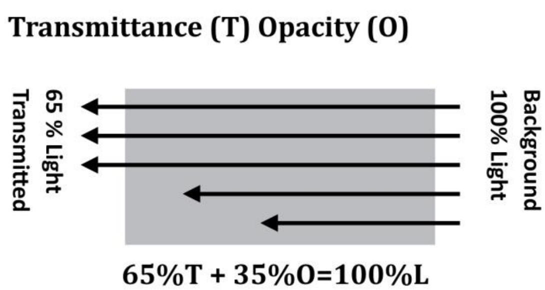
Opacity is related to the transmittance of light through a plume. The amount of light transmitted (T) through a plume, plus the amount of light obscured (O) by a plume, equals the total amount of light (L) from the background.

T = % Light Transmitted
O = % Light Obscured
L = % Total Light

% Light Transmitted (T) + % Light Obscured (O) = 100% Total Light (L)

T + O = L

For example, the opacity of a plume is 35%. What is the transmittance?



Chapter 6 Figure 1: O-T Relationships

T + O = L
T + 35% = 100%
T = 100% - 35%
T = 65%

Method 9 Data Reduction

Method 9 states:

Opacity shall be determined as an average of 24 consecutive observations …

Divide the observations recorded on the record sheet into sets of 24 consecutive observations. A set is composed of any 24 consecutive observations. Sets need not be consecutive in time and no two sets shall overlap.

This means that you can select any set of 24 sequential values to construct your final average (see Ch 6-Fig 2: 6-minute average). The best practice is to construct a screening average (rolling average) of each possible average in the data set and then select the data combinations that you want to calculate. In an hour of observations with no data gaps there are 217 potential averages.

Computer programs are available for this calculation. If you are simply determining noncompliance, you can often scan the data to pick out a data set that appears to violate the standard and calculate the average.

The set does not have to start at the beginning of a minute. It can start at any point in the observation data. Often this is the difference between compliance and noncompliance.

Method 9 states:

For each set of 24 observations, calculate the average by summing the opacity of the 24 observations and dividing this sum by 24.

A simple mean is calculated for each data set and each mean is compared to the standard. If any correction is made for pathlength, it must be made before calculating the average.

Method 9 states:

If any applicable standard specifies an averaging time requiring more than 24 observations, calculate the average for all observations made during the specified time period.

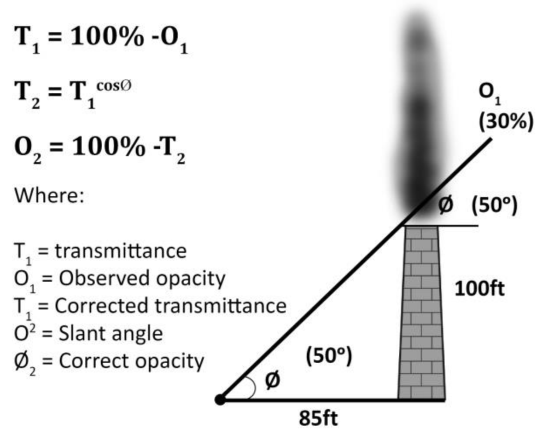
Federal standards and State Implementation Plan (SIP) opacity regulations sometimes contain averaging times other than six minutes. **EPA's policy is that if the SIP regulation does not clearly specify an averaging time or other data-reduction technique, the 6-minute average calculations should be used.** EPA is currently in the process of providing additional methods to cover alternative averaging times.

Observation Date		Time Zone		Start Time	End Time
02-21-94		EST		14:32	15:02
Sec / Min	0	15	30	45	Comments
1	15	15	75	10	
2	15	15	15	15	
3	45	80	70	10	
4	15	15	10	35	
5	35	15	30	25	
6	10	65	15	20	
7	25	45	70	90	
8	45	35	30	30	
9	25	15	60	30	
10	15	10	90	45	
11	40	10	5	5	6 minute average = 36.7 %
12	5	5	10	15	
13	10	15	80	35	
14	5	5	10	15	

Chapter 6 Figure 2: 6-minute average

Slant Angle Correction

Ideally, you should be situated so that your line of sight crosses only one plume diameter. An observation will be positively biased if it is made through a longer visual pathlength than is appropriate (see Ch. 6-Figure 3: Corrected Optics for Slant Angles). The usual guidance to eliminate this problem is to observe the plume from a distance of at least three stack heights from the source. At three stack heights, the line of sight is approximately perpendicular to the plume (about 18 degrees) resulting in minimal error (i.e., 1% positive bias). However, in some cases readings must be taken relatively close to the stack. As you move closer to the base of the stack your visual pathlength increases, which causes observed opacities to increase even though the actual cross-plume opacity remains constant. If observations are performed with a slant angle greater than +/- 18 degrees, the **individual** data values must be mathematically adjusted to account for the increased opacity values due to the added visual pathlength. The actual opacity can be calculated from the observed opacity if the slant angle is known or if the height of the stack and the distance from the observer to the base of the stack are known. The individual data values can be mathematically adjusted in the final report to account for the increased visual pathlength. You should **NOT** attempt to mentally adjust the readings during an observation or alter the values recorded on your observation form to account for slant angle.



Chapter 6 Figure 3: Corrected Optics for Slant Angle

For example:

You are standing approximately 85 feet from a 100-foot stack with a 50-degree vertical angle to the observation point (see Figure above). The observed opacity is 30%. What is the true opacity?

1. The observed opacity (O1) is 30%.
2. Calculate transmittance (T1).

100% - O1 = T1
100% - 30% = T1
70% or 0.70 = T1

3. The slant angle (i) = 50 degrees.
4. Determine the cosine of the slant angle (Cosine of 50 degrees = 0.643).
5. Calculate corrected transmittance (T2).

$T1^{COSi} = T2$
$0.70^{COS\ 50} = T2$
(0.70)(0.643) = T2
0.795 or 80% = T2

6. Calculate corrected opacity (02).

100% - T2 = O2
100% - 80% = O2
20% = O2

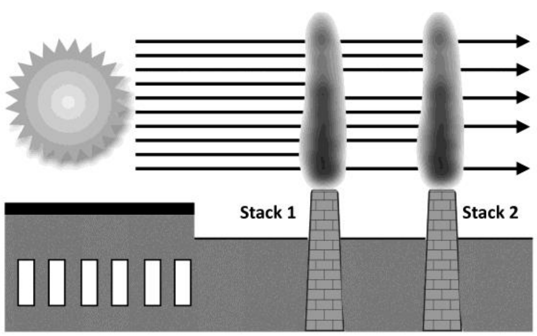
See Slant Angle Correction Table in Appendix.

Two Plumes Procedure (Combined Opacity)

Sometimes it is necessary to combine the opacities of two separate emissions (e.g., baghouse stub stacks, multiple fugitive emissions, etc.). Under these circumstances, you must utilize the combined effect of the source.

O1 = Opacity of Stack 1
T1 = Transmittance of Stack 1
O2 = Opacity of Stack 2
T2 = Transmittance of Stack 2
TC = Combined Transmittance
OC = Combined Opacity

For example:



Chapter 6 Figure 4: Two Plumes Procedure

Two stacks from different boilers are side by side (see Figure above). Under the bubble concept the combined opacity is utilized from this source. Viewing conditions (e.i., sun angle) do not allow the plumes to be viewed together. The opacity of the first stack was determined to be 10% and the second 30%. What is the combined opacity?

1. The opacity (O1) of Stack 1 = 10%.
2. Calculate the transmittance (T1) of Stack 1:

100% - O1 = T1
100% - 10% = T1
90% or 0.90 = T1

3. The opacity (O2) of Stack 2 = 30%
4. Calculate the transmittance (T2) of Stack 2:

100% - O2 = T2
100% - 30% = T2
70% or 0.70 = T2

5. Calculate the combined transmittance (TC):

T1 x T2 = TC
0.90 x 0.70 = TC
0.63 or 63% = TC

6. Calculate the combined opacity (OC):

100% - TC = OC
100% - 63% = OC
37% = OC

Condensed Water Vapor Plume Evaluation

The psychrometric chart can be used to predict or confirm the formation of a visible water vapor (steam) plume. The psychrometric chart is a graphical representation of three atmospheric conditions:

Dry bulb temperature = ambient temperature.
Wet bulb temperature = temperature indicated by a "wet bulb" thermometer (thermometer with its bulb covered by a moistened wick and exposed to a moving air stream). This is represented by the curved axis on the left side of the chart (saturation temperature).
Moisture content = percentage moisture content of the stack gas. This is represented by the vertical axis. This information is available from a source data test.

By using a sling psychrometer to measure the wet and dry bulb temperatures, you can determine the "ambient state point". This point is determined by plotting the wet and dry bulb temperatures on the psychrometric chart where the plotted values intersect. This describes the current condition of the ambient air. Similarly, you can determine the "stack gas state point" by plotting the dry bulb temperature and moisture content of the stack emission. The point on the psychrometric chart where the plotted values intersect is called the stack gas state point.

To predict or confirm the potential presence of a water vapor plume, both the ambient air conditions and the stack gas conditions must be known or calculated, and the state conditions must be located on the psychrometric chart. The change of the exhaust gas from the stack state conditions to the ambient air state conditions will be accompanied by a visible water vapor plume if any portion of the line connecting the two points on the chart (dilution line) is located to the left of the 100% relative humidity line (saturation line). The visible water vapor plume results from the condensation of water present in the exhaust stream. It is relatively simple to determine the state point for the ambient air conditions. The wet bulb and dry bulb temperatures, which determine a unique state point, can be measured with a sling psychrometer and plotted on the psychrometric chart. To determine the state point for the stack gas conditions, you must obtain the moisture content and dry bulb temperature data for the stack gas.

For example:

Ambient conditions:
Dry bulb temperature = 70˚ F
Wet bulb temperature = 60˚ F
Barometric pressure = 29.92 in. Hg
Effluent gas conditions:
Dry bulb temperature = 160˚ F
Moisture content = 20%

Will a water vapor plume condense?

Solution:

Refer to the Steam Plume Modeling Chart in the Appendix. Plot ambient dry and wet bulb temperatures. Plot stack gas moisture content and stack gas dry bulb temperature. Connect the ambient state point and stack gas state point with a straight line. The line crosses the 100% relative humidity line (saturation line) and therefore a water vapor plume will be visible.

Note: The following steam plume modeling charts are based on conditions at sea level (i.e., 29.92 in Hg). Barometric pressure varies with elevation. As a result, barometric pressure is routinely corrected for altitude. If the barometric pressure is less than 29.5 inches Hg, an equation must be used to calculate the final moisture content (MC). For additional information, please refer to Section 3.12.6 of the Quality Assurance Handbook for Air Pollution Measurement Systems: Volume III. Stationary Source Specific Methods, Addition Section 3.12 or refer to our Web site: www.smokeschool.com.

See Steam Plume Modeling Charts in Appendix.

Notes

CHAPTER 7

Documentation

Method 9 has specific requirements for recording field conditions and source information during visible emissions observations. These requirements are specified in paragraph 2.2 (Field Records) of Method 9. It is vital that you use an observation form that includes all of the required information. The following are brief descriptions of the type of information that needs to be entered on the form:

** Represents information to be recorded when readings are initiated and completed.*

*** Represents information required by Method 9 to be documented.*

** **Company Name –** full company name, parent company or division information, if necessary.

** **Facility Name –** name of facility, if applicable.

** **Street Address –** street (not mailing) address or physical location of facility where VE observation is being made.

** **Process, Unit #, Operating Mode –** brief description of process equipment, unit # if applicable, and operating rate, % capacity utilization and/or mode (e.g., charging, tapping).

Control Equipment, Operating Mode – specify control device type(s) and % utilization, control efficiency.

** **Describe Emission Point –** stack or emission point location, geometry, diameter, or color for identification purposes.

Height of Emission Point – stack or emission point height from files or engineering drawings. The height can also be estimated or obtained by using combination of a range finder and an Abney level or clinometer.

Height of Emission Point Relative to Observer – indicate stack or emission point height relative to your position (above your position +, below your position -).

* **Distance to Emission Point –** distance to emission point +/- 10%. To determine, use range finder or map, triangulate distance, or pace off.

Direction to Emission Point (Degrees) – direction to emission point. Use compass and reference to true north or magnetic north.

Vertical Angle to Observation Point – vertical angle from you to the observation point (i.e., point in plume where opacity was determined). This angle can be measured using an Abney level or clinometer.

Direction to Observation Point (Degrees) – direction to observation point (i.e., point in plume where opacity was determined and read). Use compass.

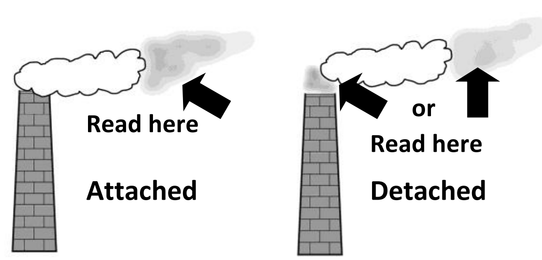
Distance and Direction to Observation Point from Emission Point – indicate the approximate distance and direction to the observation point (i.e. point in plume where opacity is determined and read) from the emission point (e.g. stack outlet).

Describe Emissions – describe plume behavior and/or other physical characteristics (e.g. looping, fumigating, secondary particle formation, etc.). See **Chapter 7 – Figure 2**.

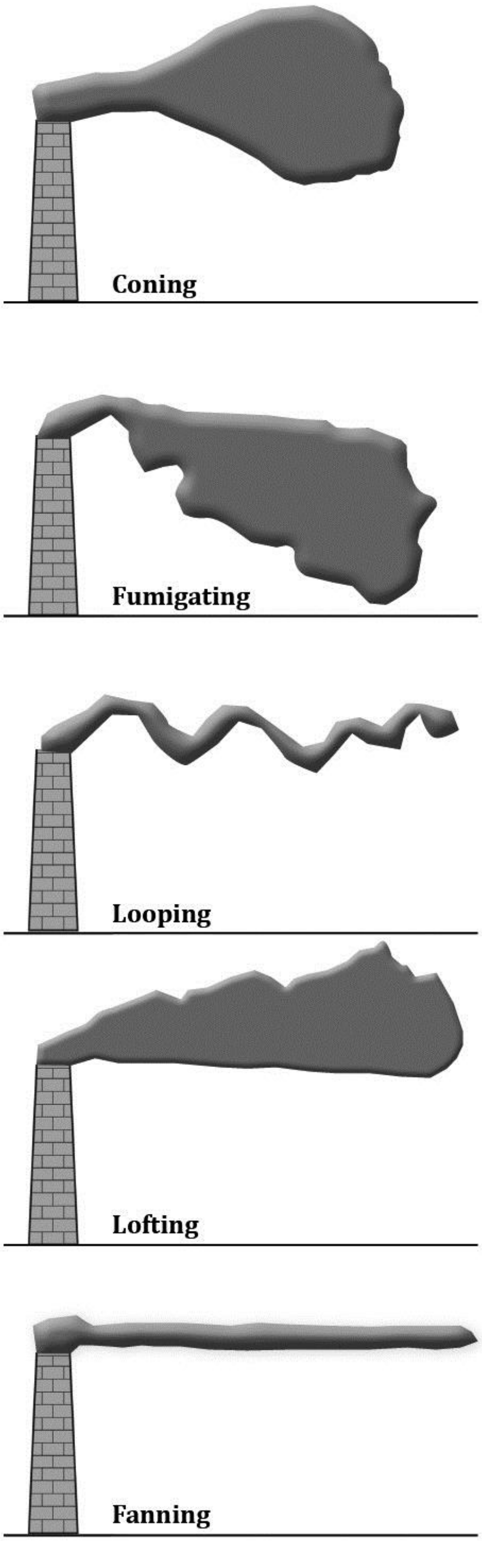
Emission Color – gray, brown, white, etc.

Water Droplet Plume – If present, specify:

Attached – forms prior to exiting stack
Detached – forms after exiting stack



Chapter 7 Figure 1: Attached and detached plumes



Chapter 7 Figure 2: Plume Types

*** Describe Plume Background –** object(s) plume is read against.

Background Color – blue, white, green, etc.

*** Sky Conditions –** indicate cloud cover by percentage or description (e.g. clear, scattered, broken, overcast) and color of clouds.

SKY CONDITION	% CLOUD COVER
Clear	<10%
Scattered	10% to 50%
Broken	50% to 90%
Overcast	>90%

*** Wind Speed –** use Beaufort wind scale or hand-held anemometer. Be accurate to +/- 5 MPH.

*** Wind Direction –** direction wind is from. Use compass and be accurate to eight points.

Ambient Temperature – in degrees F or degrees C.

Wet Bulb Temperature – the wet bulb temperature from the sling psychrometer.

RH% - relative humidity. Use sling psychrometer and local U.S. Weather Bureau only if nearby.

**** Source Layout Sketch –** an overhead view that should include wind direction, associated stacks, roads and other landmarks to fully identify location of emission point and your position.

Draw North Arrow – point line of sight in direction of emission point, place compass beside circle, and draw in arrow parallel to compass needle.

Sun Location Line – point line of sight in direction of emission point, place pen upright on sun location line, and mark location of sun where the pen's shadow crosses your position.

Longitude, Latitude, Declination – observer longitude, latitude, and declination. Can be obtained from a map or GPS.

Additional Information – factual implications, deviations, alterations, and/or problems not addressed elsewhere. Refer to additional pages if used.

Form Number, Page of, Continued on VEO Form Number – you can identify form as desired.

**** Observation Date –** date observations conducted.

Time Zone – for example, Eastern Standard Time (EST) or Central Daylight Time (CDT).

*** Start Time/End Time –** beginning and ending times of observation period (e.g. 1635 or 4:35 p.m.)

Data Set – percent opacity to nearest 5%. Enter from left to right starting in left column.

Comments – identify and/or explain any anomalies in the data set.

**** Observer's Name (print) –** print your name in full.

Observer's Signature, Date – sign and date.

**** Organization –** your employer.

Certified By, Date – organization providing certification and date of most recent certification.

Notes

EPA
VISIBLE EMISSION OBSERVATION FORM 1

Method Used (Circle One)
Method 9   203A   203B   Other: ____________

Company Name		
Facility Name		
Street Address		
City	State	Zip

Process	Unit #	Operating Mode
Control Equipment		Operating Mode

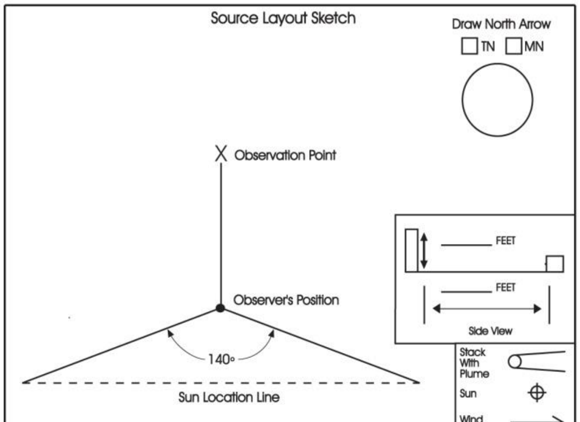
Describe Emission Point	
Height of Emiss. Pt. Start End	Height of Emiss. Pt. Rel. to Observer Start End
Distance to Emiss. Pt. Start End	Direction to Emiss. Pt. (Degrees) Start End

Vertical Angle to Obs. Pt. Start End	Direction to Obs. Pt. (Degrees) Start End
Distance and Direction to Observation Point from Emission Point Start	End

Describe Emissions Start	End
Emission Color Start End	Water Droplet Plume Attached ☐ Detached ☐ None ☐

Describe Plume Background Start	End	
Background Color Start End	Sky Conditions Start End	
Wind Speed Start End	Wind Direction Start End	
Ambient Temp. Start End	Wet Bulb Temp.	RH Percent

Source Layout Sketch



Longitude	Latitude	Declination

Additional Information

Notes

Form Number						Page	Of
Continued on VEO Form Number							

Observation Date	Time Zone	Start Time	End Time

Sec / Min	0	15	30	45	Comments
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					
17					
18					
19					
20					
21					
22					
23					
24					
25					
26					
27					
28					
29					
30					

Observer's Name (Print)	
Observer's Signature	Date
Organization	
Certified By	Date

Notes

SPECIFICATION SHEET – PRACTICAL EXERCISE

Facility Information:

Eastern Power, Smith Lake Facility
5600 South Atlantic Road
City, State, Zip Code

Permit Compliance Limit:

Eastern Power, Smith Lake Facility, coal-fired boiler unit A, shall not emit into the atmosphere emissions that, on evaluation, create a 6-minute average data sequence equal to or greater than 20% opacity.

Emission Source Information:

Process: Coal-Fired Boiler
Operating Mode: 75% of Maximum Capacity
Control Equipment: Wet Scrubber
Operating Mode: Automatic
Stack Height: Worksheet
Angle to Observation Point: Worksheet / Abney level
Direction: Compass
Latitude and Longitude: GPS Coordinates of Location
Compass Declination: Determined by Location

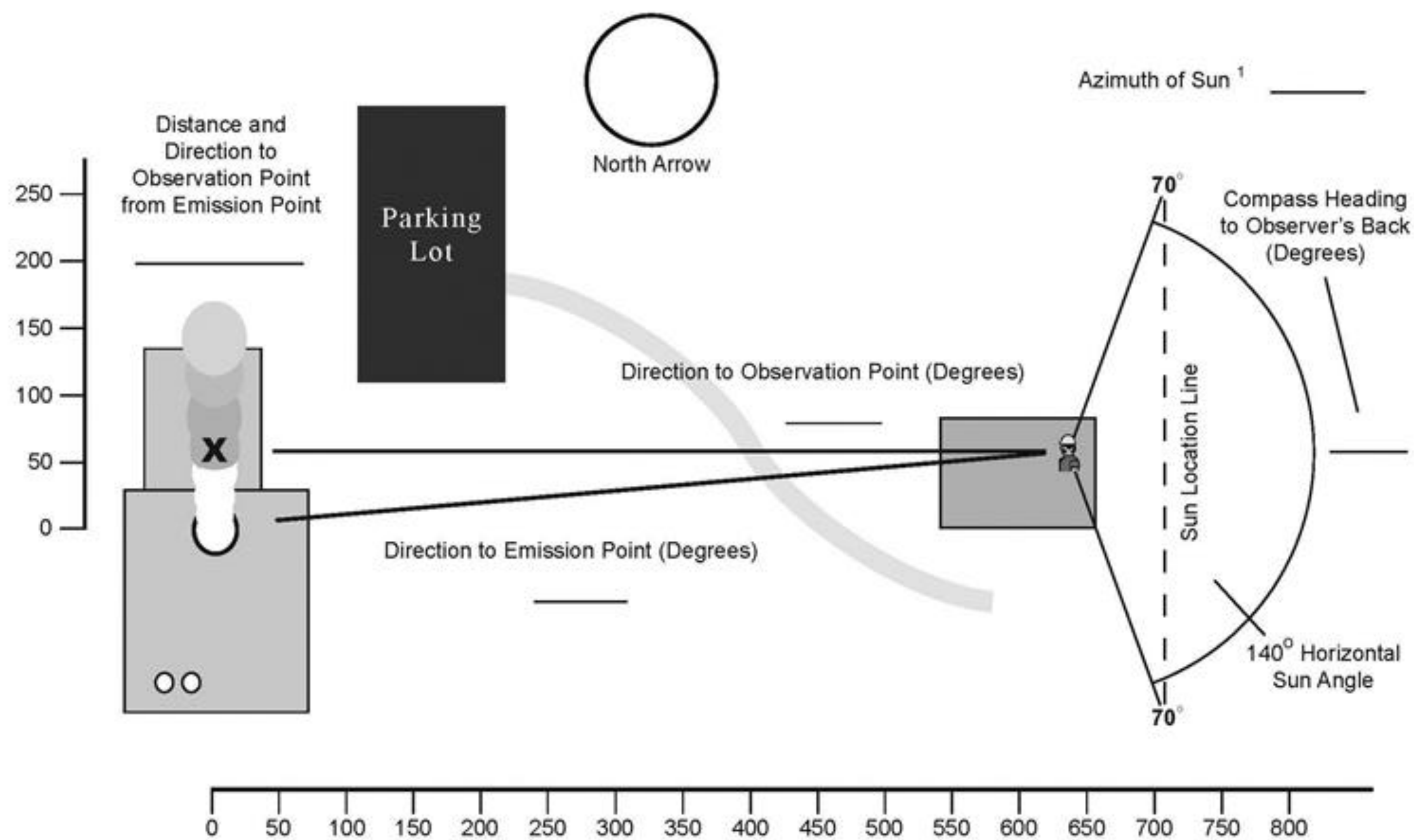
Weather Information:

Wind Speed: 10-12 mph
Wind Direction: Determined with Compass
Sky Conditions: Worksheet
Temperature / Relative Humidity: Sling Psychrometer

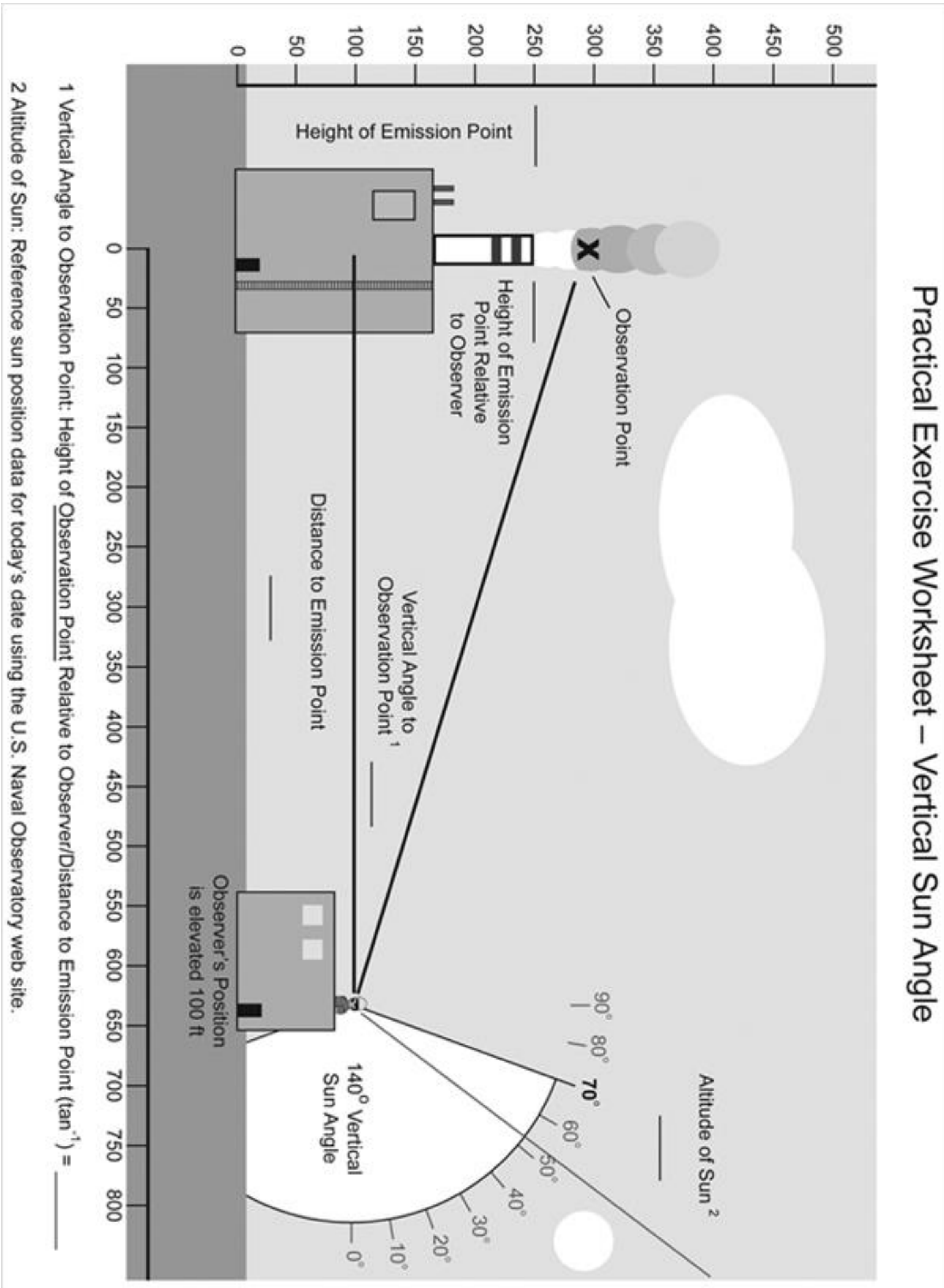
Visible Emissions Observations:

VEO Form Number: EP00A
Opacity: The following opacity readings were taken during a 10-minute observation. Your start time is when you begin taking readings. The end time is when you finish your last reading.
Minute 1: (5, 5, 5, 5); **Minute 2:** (5, 0, 5, 10); **Minute 3:** (5, 10, 10, 5);
Minute 4: (10, 10, 15, 15); **Minute 5:** (15, 20, 20, 20); **Minute 6:** (20, 25, 35, 30);
Minute 7: (25, 25, 20, 15); **Minute 8:** (20, 15, 10, 10); **Minute 9:** (10, 15, 5, 5);
Minute 10: (10, 5, 10, 5).

Practical Exercise Worksheet – Horizontal Sun Angle



1 Azimuth of Sun: Reference sun position data for today's date using the U.S. Naval Observatory web site. The azimuth of the sun should always be within +/- 70 degrees of the compass heading to the observer's back.


Practical Exercise Worksheet – Vertical Sun Angle
0
50
100
150
200
250
300
350
400
450
500
Height of Emission Point
Observation Point
Height of Emission Point Relative to Observer
Vertical Angle to Observation Point 1
Distance to Emission Point
Observer's Position is elevated 100 ft
Altitude of Sun 2
90°
80°
70°
60°
50°
40°
30°
20°
10°
0°
140° Vertical Sun Angle
0
50
100
150
200
250
300
350
400
450
500
550
600
650
700
750
800
1 Vertical Angle to Observation Point: Height of Observation Point Relative to Observer/Distance to Emission Point (tan-1) = ____
2 Altitude of Sun: Reference sun position data for today's date using the U.S. Naval Observatory web site.

CHAPTER 8

Equipment

Method 9 does not contain any special requirements or specifications for equipment or supplies. However, certain equipment is necessary to conduct a valid observation that will withstand the rigors of litigation. Experience gained from litigation has shown that accurate, high-quality equipment is essential for valid observations. As a result, we recommend you use the best equipment available to you in order to collect the highest quality data possible. Other equipment, though option, can make the collection of high-quality data easier. This section gives specifications, criteria, or the design features for the recommended basic VE equipment as well as optional equipment that can simplify data collection. It is imperative that you follow the manufacturer's specific calibration and maintenance procedures to properly maintain and use your equipment. In court you must be able to provide accurate data concerning observation conditions and geometric measurements relative to your position.

Clipboard and Accessories

You should have a clipboard, several ballpoint pens, large rubber bands, and a sufficient number of VE Observation Forms to document any expected or unexpected observations. Ballpoint pens are used so that completed forms can be copied and remain legible despite numerous reproductions. Rubber bands hold the data form flat on the clipboard under windy conditions and hold other papers and blank forms on the back of the clipboard. Use observation forms that meet EPA Method 9 requirements. A sample form that has been extensively field tested is provided in the appendix.

Timer

During a VE observation, it is necessary to time the 15-second intervals between opacity readings. Use a watch or dedicated timer. The best practice is to attach two dedicated timers to your clipboard. Liquid crystal display timers are preferred because of their accuracy and readability. Use one timer to determine the start and stop times of the observation and the other timer to provide a continuous display of time to the nearest second. Most stick-on timers run from one to 60 seconds repeatedly. A timer with a beeper that sounds every 15 seconds is recommended for use in some industrial locations, enabling you to pay attention to your surroundings and your safety.

Observer's Checklist
Clipboard
Ballpoint pens
VE Forms
Rubber bands
Timers (2)
Compass/ GPS
Topographic Map
Rangefinder
Clinometer
Sling Psychrometer and water
Camera (tripod, telephoto lens, macro lens)
Video camera (batteries, tripod)

Chapter 8 Figure 1: Observer's Checklist

Topographic Maps

The United States Geological Survey (USGS) 7.5-minute topological maps are a practical necessity for serious opacity work. From these maps you can determine your exact location, true north, distances, access roads, latitude, longitude, magnetic declination, relative ground height, and background features. You also can use these maps to calibrate rangefinders. If you are planning an inspection, photocopy the section of the map that shows the facility on the back of your observation form. Laminate the full-sized map for field use and to allow temporary marking with dry erasable pens.

Compass

A compass is needed to determine the direction to the emission point, the observation point, and to determine the wind direction at the source. Select a compass that you can read to the nearest 2 degrees. The compass should be jewel-mounted and liquid-filled to dampen the needle's movement. Map-reading compasses are excellent for this purpose. If you wish to take the magnetic declination for your area into account when you take readings, you should consider investing in a compass that allows you to adjust the declination.

Global Positioning Systems (GPS)

GPS units can be purchased for less than $50.

Defining your exact position within 10 meters in terms of latitude and longitude is valuable information for an observer. It helps in determining proper sun position. A GPS is a hand-held unit that works by receiving signals from satellites orbiting the earth. A GPS unit can be purchased for less than $50.

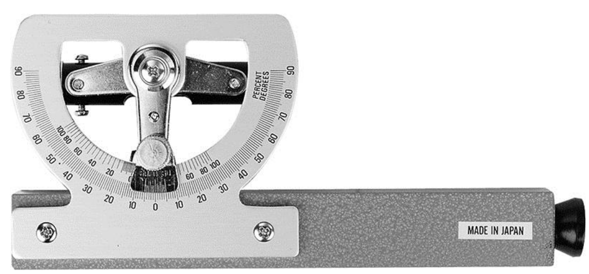
Rangefinder

If a topographic map of the area is not available, you will need a rangefinder. Even with a map, a rangefinder is very useful in field work. The two types in general use are the split-image and the stadiometric rangefinders. However, laser units are also widely available. The split-image type uses the technique of superimposing one image over another to determine the distance. The most useful models for opacity work have a maximum range of about 1000 yards. To use the stadiometric rangefinder, you must know the height or width of an object at the same distance as the object of interest.

Rangefinders should be accurate to within 10% of the measurement distance.

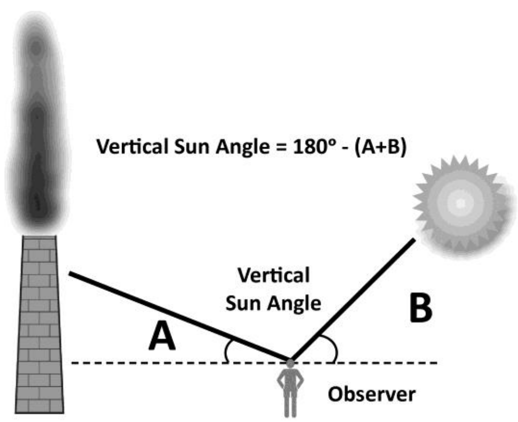
Stadiometric rangefinders are lighter and more compact than split-image rangefinders. Split-image rangefinders, although inherently more accurate, are more likely to become uncalibrated when bumped during transport. The accuracy of either type of rangefinder should be checked on receipt and periodically thereafter with targets at known distances of approximately 500 meters and 1000 meters. An acceptable rangefinder must be accurate to within 10% of the measurement distance.

Abney Level or Clinometer



Abney levels are accurate to within 1-2 degrees.

You will need a clinometric device for determining the vertical viewing angle (see Chapter 9-Figure 2). For visible emissions observation purposes, it should be accurate to within 2 degrees. Many suitable devices are available in a wide range of prices, including Abney levels, pendulum clinometers, and sextants. Abney levels use a bubble in a curved tube to determine the angle with an accuracy of 1-2 degrees. The accuracy can be tested by placing the level flat on a table that has been previously leveled with a reference level. It should read 0 degrees. Then check it at 45 degrees by placing it on a 45-degree inclined plane constructed with the plane as the hypotenuse of a right triangle with equal base and height. The pendulum clinometer is the cheapest and has an accuracy of about 2 degrees when used properly. It consists of a protractor and a plum bob. Some compasses include a pendulum-type clinometer. A sextant is very accurate if you know the position of the horizon, but it is very expensive. You should **NEVER** look directly at the sun through a clinometric device.



Chapter 8 Figure 2: **Abney levels are used to determine vertical viewing angle.**

Sundog

Field confirmation of a correct position of the

observer in relation to the sun and observation point in the plume is almost impossible without the right equipment. Prior to observations, the observer can run computer simulations of the Sun Observer Source (SOS) angle to assure that the SOS is at least 110 degrees (EPA requirement). A Sundog is an observational tool that allows the observer to confirm an acceptable sun angle in the field. The observer rotates the device until it is on a plane with three points (sun, observer's position, source). Once the device is held in the plane, the observer looks toward the source through a slit and notes the position of a projected dot from the sun on a surface within the Sundog. If the dot is projected on the green surface, the sun angle is acceptable. Otherwise it is not. Proper use of a Sundog prevents observations from being voided after the fact.

Binoculars

Binoculars are helpful for identifying stacks, searching the area for emissions, interferences, and helping to characterize the behavior and composition of the plume. Binoculars are designated by two numbers such a 7 x 35. The first number is the magnification and the second is the field of view. Select binoculars with a magnification of at least 8 or 10 (8 x 50 and 10 x 50 are standard designations). The binoculars should have color-corrected coated lenses and a rectilinear field of view. Check the color correction by viewing a black and white pattern such as a Ringelmann card at a distance greater than 50 feet. You should see only black and white; no color rings or bands should be evident. Test for rectilinear field of view by viewing a brick wall at a distance greater than 50 feet. There should be no pin cushion or barrel distortion of the brick pattern. Plume observations for compliance purposes should not be made through binoculars unless you are certified with binoculars.

Sling Psychrometer

If there is a potential for the formation of a condensed water droplet (steam) plume, you will need a sling psychrometer to determine the temperature and relative humidity of the ambient air. The sling psychrometer consists of two thermometers, accurate to +/- 0.5° C, mounted on a sturdy assembly with a swivel attachment to a chain, strap, or handle. One thermometer has a cotton wick tube surrounding the bulb. Thermometer accuracy should be checked by placing the bulbs in a deionized ice water bath at 0˚ C. Electronic models are simpler to use but require tedious periodic calibration using standard salt solutions. The manufacturer's calibration procedures should be explicitly followed.

Sling psychrometers are used to determine the temperature and relative humidity.

Photo/Video Documentation

Use a camera to document the presence of emissions before, during, and after the actual opacity determination and to document the presence or lack of interferences. Digital images can document the specific stack that is under observation but do not document the exact opacity. Digital images can be useful to document field conditions, observer position, background, and sun location (by shadows).

Digital cameras can be very useful in documenting the appearance and location of emissions. The ease with which digital images can be manipulated does, however, limit their usefulness for opacity evaluation. When taking still pictures and shooting video, a tripod will improve the quality of the image.

Equipment Selection

We recommend you use the best equipment available to you to collect the highest quality data possible. ETA has developed Visible Emissions Observer Field Test Kits for our staff to ensure observations are properly documented. These kits are available for purchase by the public. All items in the kits are commercially available. We have simply organized them into a convenient package.

For more information regarding visible emissions support products, please contact our office or visit us online at www.smokeschool.com/products.

Digital Camera Certification

- A certified digital still camera is allowed to capture a set of images of a plume against a contrasting background.
- Each image is then analyzed with software that determines plume opacity by comparing a user-defined portion of the plume where opacity is being measured with a background image of the same source. The difference between the images provides contrasting values and therefore the basis for determining opacity.
- Analysis software is used to average opacities from the series of digital images taken of the plume during a fixed period of time.

Learn more at www.smokeschool.com

CHAPTER 9

Quality Assurance Audit

If the form is used as proof of compliance or violation in a permit application or agency enforcement action, a third party should review the document and data reduction in detail. The following sections describe the elements of a minimal audit.

After each item on the form is checked, you should compare related data items for consistency. For example, check if:

> The wind direction arrow in the sketch agrees with the wind direction recorded in the text section of the form.
>
> The final signature date is consistent with the observation date.
>
> The time of day is consistent with the sun position.

Observer Certification Must Be Within 6 Months of Observation

Compare the date of observation at the top of the form with the date of the certification at the bottom of the form. The observation date must be within six months of your certification date.

Required Documentation Must Be Supplied

Method 9 has specific requirements for recording information regarding the emission point, observation point, and the field conditions at the time of the observation. Check to see whether the following information is provided on the VE Observation form:

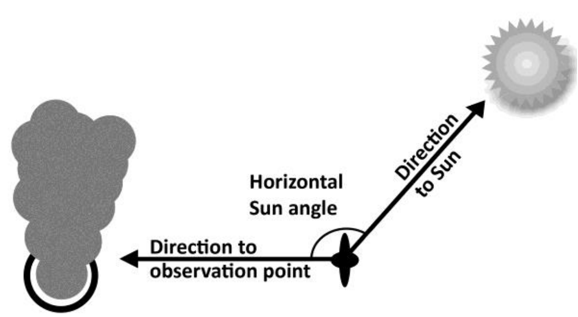
- Name of the facility
- Facility and emission point location
- Type facility
- Observer's name and affiliation
- Date and time of observation
- Estimated distance to the emission point
- Approximate wind direction
- Estimated wind speed
- Description of the sky conditions (presence and color of clouds)
- Plume background
- Sketch of sun, source, observer position
- Distance from the emission outlet to the point in the plume where observations are made
- 24 observations (unless other criteria exist)

If any of these items are missing, it might be pointed out in a deposition, in a motion before the court, or to the judge when you are on the witness stand.

Sun Angle Requirements Must Be Met

Three areas on the VEO form can be used to indicate horizontal sun angle: 1. Source layout sketch; 2. The direction to the source section; and 3. The observation date and observation period start/stop times.

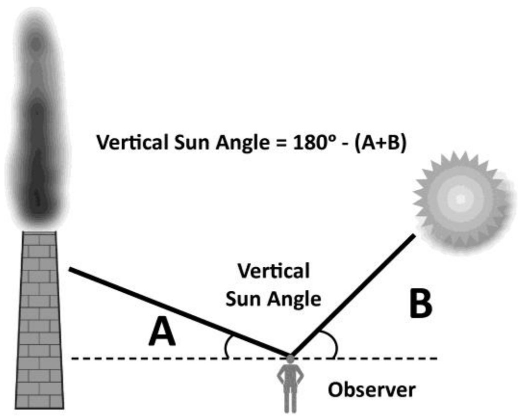
Areas 2 and 3 can be used to determine if the sun location marked on the source layout sketch is correct. Look at the north arrow's relationship to the source and determine whether there are any discrepancies when compared to the emission point "direction from observer" line on the VEO form. If the data is contradictory about direction of source, there are probably other problems.



Chapter 9 Figure 1: Horizontal Sun Angle (top view).

Check the time of day to see if the data are reasonable. For example, if the time of the observation is noon and the observer's sketch shows the sun over the left shoulder, the observer must be southeast of the source. Sketching the relative positions on polar graph paper is a useful technique to establish that the observations were performed and documented correctly.

The vertical sun angle problem is part of the sun angle problem. The line from the height of the sun in the sky to the observer and the line from the observer up to the emission point should be at least 110 degrees. To audit for vertical sun angle, it is necessary to note the time of day, year, and location of the facility in terms of latitude and longitude. Given this information, solar tables and local declination can be found at the Naval Observatory Web site: www.aa.usno.navy.mil.



Chapter 9 Figure 2: Vertical sun angle (side view)

Last, the total sun angle should be checked using solid trigonometry or a computer program.

Line of Sight Should Be Perpendicular to Direction of Plume Travel

Check to ensure that the plume was observed along a line of sight perpendicular to the long axis of the vent if the vent is not circular. This is important when observing fugitive emissions. Sources such as storage piles, dusty roads, roof monitors, and ships' holds are difficult to observe properly because of this requirement. In many cases you must reach a compromise between the axis of the source and the axis of the plume. If a reading is not made from a position nearly perpendicular to the plume, you should look at the final opacity and determine whether correcting the data for pathlength will still give the same final result in terms of compliance status.

Proper Observational Intervals Must Be Observed

Were observations made at 15-second intervals or in compliance with the applicable regulations?

Data Gaps Must Be Explained

Were a minimum number of observations made with no data gaps? If data gaps exist on the form, are they explained? If an average was calculated with a data gap, what value was assigned to the data gap? What is the reason for selecting the value?

Interferences Must Be Checked and Noted on Form

Check for possible interferences. Obstacles in the line of sight or other emissions in front of or behind the plume being monitored create interferences that must be avoided or noted on the data form. Review the sketch for other vents, stacks, or sources of fugitive emissions that might cross the line of sight or comingle with the plume being evaluated and create a positive bias in the observation. The sketch should indicate the backgrounds and their relative distances. If mountains or other distant objects are used as a reading background, check if haze is indicated in the background section. This might create a negative bias in the opacity readings. Also, note in the comments section beside the observation whether interferences were reported. Finally, check the additional information section and the data section for comments regarding haze or other interferences.

Steam Plumes Noted and Proper Procedures Followed

Were the emissions observed at a point where there was no condensed water vapor? If the form indicates the presence of a steam plume, pay special attention to the point in the plume where the observation was made. Check the ambient temperature and relative humidity, if available. If the temperature is low or if the relative humidity is high (more than 70%), consider the possibility of a steam plume that does not evaporate easily. If the data is available, model the steam plume using the technique in the Appendix (Condensed Water Vapor Plume Evaluation).

When you use this method you must recognize that:

- The charts were developed from steam tables to represent the conditions in an ideal closed system and the atmosphere is not an ideal closed system.
- The tables do not consider the presence of particulate matter or condensation nuclei.
- The temperature of the emissions gases is an average of at least a one-hour emissions test and does not necessarily represent the conditions at time of observation.
- The moisture content entered into the calculation is an average of at least one hour and might not be representative of the plume conditions during a shorter period of time.
- The chart does not recognize that the plume might not be uniform in moisture concentration and that some portions of the plume might be at supersaturation.
- The tables do not consider the presence of hygroscopic particulate matter that could attract and hold onto water by lowering its vapor pressure.

The chart is best used by constructing a line with an error band that recognizes the associated error in measurement of each of the input parameters. It should be assumed that no water plume forms only if the error band does not approach the dew point.

Data Reduction and Reporting Must Be Performed in Accordance with the Regulation

Are the calculations in compliance with the regulation? Does the regulation require averaging over a time period other than 6 minutes? Does it require time aggregation? Is the math correct? Was the highest average determined? Is there data showing noncompliance in excess of the regulation in terms of opacity and time?

Opacity Readings Must Be Representative of Actual Conditions

Verify that no interferences or extenuating circumstances existed during the observation that would make the opacity values not representative of actual conditions or otherwise invalidate the observation.

Depending upon the potential use of the form, it might be wise to have an additional third party audit the form. After completing the second audit, compare the results of the two independent audits and resolve any outstanding differences.

The National Bureau of Standards Handbook 91 on Experimental Statistics states:

> *A certified or reported value whose accuracy is entirely unknown is worthless.*

Notes

____

____

____

____

____

____

CHAPTER 10

Field Training and Certification

The field training and certification program is conducted after the completion of a classroom session. The classroom session is designed to introduce the trainee to the fundamentals of opacity measurement with specific emphasis on essential aspects of Method 9. Section 3.12.1.2.2 of the Quality Assurance Handbook for visible emissions observations highly recommends an intensive 1- to 2-day classroom session. Although classroom training is not required in some states, it is highly recommended because the lecture sessions increase the observer's knowledge and confidence in field operations, reduces the time needed to certify, and trains the smoke reader in documentation techniques that will help his/her observations withstand litigation. It also provides a forum for information exchange. After the classroom session, a Field Training and Certification Program is held outdoors using a smoke generator that is capable of presenting black and white plumes with opacity from 0-100%. The smoke generation system contains a calibrated instrument to measure and record the opacities of the plumes that are presented.

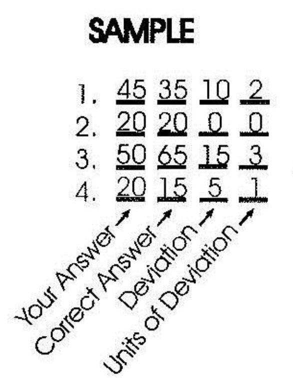
Because this session is conducted outdoors, it is important to wear clothing appropriate for the weather conditions. Ballpoint pens, clipboards, rubber bands, and all test materials will be provided by ETA. Optional items include: folding chair, food/drink, umbrella, sunscreen, and a hat.

The field certification process consists of five elements:

- **Demonstration of standards**
- **Practice plumes**
- **Testing for black and white**
- **Grading**
- **Retest if necessary**

Practice Plumes

On the first day of field certification, you will be issued a green practice form. This form is used for practice prior to certification runs. First, the field instructor will demonstrate the standard plume opacities: 25%, 50%, and 75%. This demonstration will help orient you with the scale used in the testing program. Four practice plumes will then be generated. You estimate the opacity of each plume, basing the estimate on the given standards. The estimate of opacity should be expressed in increments of 5%. The field instructor will then announce the correct answers to the four practice plumes. Put a slash mark through the correct answers and compare to the opacities you circled (see Figure 1 below). This procedure will be followed for the black and white smoke. Only after a significant segment of the group is successful will actual certification testing begin.



Chapter 10 Figure 1: Practice Plumes

Testing Requirements

To certify as a qualified observer, you must be tested and demonstrate the ability to accurately assign opacity readings in 5% increments to 25 random black plumes and 25 random white plumes. Your error cannot exceed 15% opacity on any one reading. Your average error cannot exceed 7.5% opacity for each category.

Testing Form

After the practice session, switch over to the two-part white test form. An example of this form is found in the Appendix of this manual.

Fill in the form as follows:

1. Last name, First name, MI.

2. Affiliation is the name of your employer.

3. The field instructor will announce the run number for each run.

4. Fill in the city in the course location blank.

5. Fill in the correct date.

6. If you are not wearing sunglasses, circle "No". If you are wearing sunglasses, circle "Yes" and fill in the type and/or color of lens.

7. Sky conditions, wind speed, and direction will be given by the field instructor.

8. Estimate the distance and direction to the stack.

9. The affirmation must be signed before the paper is handed in, acknowledging that the readings are your own.

10. The field instructor will announce whether the smoke will be black or white.

Circle the appropriate color on the form. When all of these steps have been completed, you are ready to take the test. The test consists of a set of 25 black plumes and a set of 25 white plumes. The plumes are generated at random levels of opacity within each test set. Prior to the test, the standards are given again.

The Field Test

ETA field instructors will announce when the plume should be read and when papers should be marked. The following procedure will be used during the test:

Prior to each reading do not observe the plume but instead look at the ground or your paper. The field instructor will announce:

"Reading Number 1"

At this time, look up at the plume and make your determination of opacity. Approximately three seconds will be allowed.

The field instructor will then announce:

"Mark"

At the word "Mark", immediately look away from the plume and mark your paper. Simply circle the answer that best matches the observation. Do not look back at the plume until the next reading is announced.

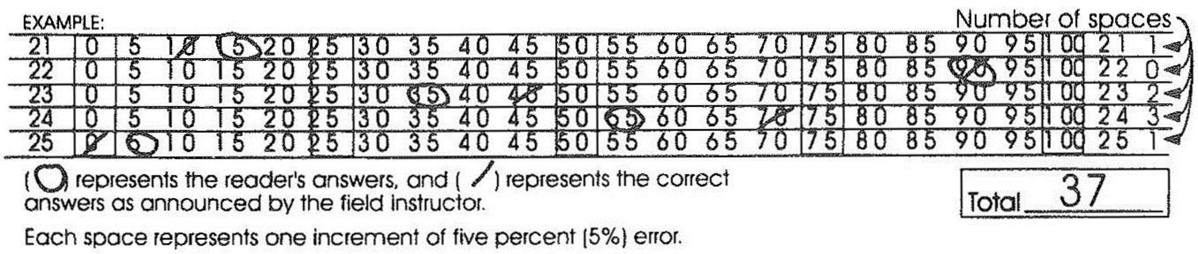
This process continues for the entire first set. Check your paper for missing observations or observations on the wrong line. If you need to change an answer, cross it out and circle the new answer.

If the wind makes the plume unreadable, yell "Scratch" or "Repeat" loud enough for the field instructor to hear. The instructor will then repeat that reading at the same opacity. The goal is to present you with the best possible test.

On occasion, the field instructor will interrupt the reading with the word "Scratch". The paper should not be marked because the reading will be repeated. It will be repeated at the same opacity value unless you are informed otherwise.

After 25 plumes of one color smoke, the process will be repeated for the other color. Completion of both sets constitutes one run (50 plumes).

At the conclusion of the test, make sure your form is filled out completely. The white copies of the certification test form will be collected. After all forms are collected, the field instructor will announce the correct answers. Mark the yellow copy with a slash through the value announced by the field instructor (see Chapter 10-Figure 2: Determining Error). Marking your yellow copy



Chapter 10 Figure 2: Determining Error

expedites grading and assists in further training when needed.

After all 50 values are announced, compare each of your answers to the correct answer. For each value count the number of spaces between the two answers. Remember it does not matter whether the value was higher or lower than the correct answer, just count the number of spaces.

For example, if you circled 25 and the correct answer was 30, the error would be one space. A 20 and 30 would be an error of two. A 20 and a 35 would be an error of three. A 20 and a 40 would be an error of four.

Record the error on the right-hand side of the paper. When you finish marking errors, you can determine whether you passed. The two criteria are:

- No error of four units of deviation or greater on any one of the 50 readings.
- No more than 37 units of deviation on each set of 25 white and 25 black plumes (7.5% average error).

The white and black smoke can each have a total error of up to 37 increments (units of deviation). If your paper meets both criteria, the yellow sheet should be passed to the graders and they will grade the original for record.

DO NOT leave the field site until the instructors verify that you have passed the test. After all the papers have been graded, the names of those who have passed will be announced. Once you have completed the certification process, certificates will be issued.

Staring at the Plume

The most common error in smoke observation is staring at the plume. Staring at the plume typically results in fatigued vision and makes accurate observations nearly impossible. The second most common error in certification is reading the plume at the wrong time. To prevent both of these problems, listen carefully to the field instructor and follow the given instructions. Furthermore, you should never try to anticipate the opacity of the next reading.

Certification Period

The certification shall be valid for a period of SIX MONTHS at which time you must repeat the qualification procedure to retain certification. This is a requirement of Method 9.

CHAPTER 11

Method 22

Background

Since its introduction in 47 FR 34142, Aug. 6, 1982, Method 22 has been used with increasing frequency. It is used in conjunction with emissions standards or work practices in which no visible emissions are the stated goal. This is frequently the case with fugitive emissions sources or sources with toxic emissions. Method 22 differs from Method 9 in that it is qualitative rather than quantitative and does not require field certification. Method 22 indicates only the presence or absence of emissions rather than the opacity value. Thus, many of the provisions of Method 9 that enhance the accuracy of opacity measurement are not necessary in Method 22 determinations. Method 22 does not require that the sun be the light source or that you stand with the sun at your back. In fact, for reading asbestos emissions regulated under NESHAP Subpart M, you are directed to look toward the light source to improve your ability to see the emissions. Under Method 22, the duration of the emissions is accurately measured using a stopwatch. Table 1 compares major features of Method 9 and Method 22.

Method 22

1. Introduction

This method involves the visual determination of fugitive emissions, i.e., emissions not emitted directly from a process stack or duct. Fugitive emissions include emissions that (1) escape capture by process equipment exhaust hoods; (2) are emitted during material transfer; (3) are emitted from buildings housing material processing or handling equipment; and (4) are emitted directly from process equipment. This method is also used to determine visible smoke emissions from flares used for combustion of waste process materials.

This method determines the amount of time that any visible emissions occur during the observation period, i.e., the accumulated emission time. This method does not require that the opacity of emissions be determined. Since this procedure requires only the determination of whether a visible emission occurs and does not require the determination of opacity levels, observer certification according to the procedures of Method 9 are not required. However, it is necessary that the observer is educated on the general procedures for determining the presence of visible emissions. At a minimum, the observer must be trained and knowledgeable regarding the effects on the visibility of emissions caused by background contrast, ambient lighting, observer position relative to lighting, wind, and the presence of uncombined water (condensing water vapor). This training is to be obtained from written materials found in References 7.1 and 7.2 or from the lecture portion of the Method 9 certification course.

(1. amended by 48 FR 48335, October 18, 1983)

2. Applicability and Principle

2.1 Applicability. This method applies to the determination of the frequency of fugitive emissions from stationary sources (located indoors or outdoors) when specified as the test method for determining compliance with new source performance standards.

This method also is applicable for the determination of the frequency of visible smoke emissions from flares.

(2.1 amended by 48 FR 48335, October 18, 1983)

2.2 Principle. Fugitive emissions produced during material processing, handling, and transfer operations or smoke emissions from flares are visually determined by an observer without the aid of instruments.

(2.2 amended by 48 FR 48335, October 18, 1983)

3. Definitions

3.1 Emission Frequency. Percentage of time that emissions are visible during the observation period.

3.2 Emission Time. Accumulated amount of time that emissions are visible during the observation period.

3.3 Fugitive Emissions. Pollutant generated by an affected facility which is not collected by a capture system and is released to the atmosphere.

(3.4 and 3.5 revised by 48 FR 48335,Oct. 18, 1983)

3.4 Smoke Emissions. Pollutant generated by combustion in a flare and occurring immediately downstream of the flame. Smoke occurring within the flame, but not downstream of the flame, is not considered a smoke emission.

3.5 Observation Period. Accumulated time period during which observations are conducted, not to be less than the period specified in the applicable regulation.

4. Equipment

4.1 Stopwatches. Accumulative type with unit divisions of at least 0.5 seconds; two required.

4.2 Light Meter. Light meter capable of measuring illuminance in the 50- to 200-lux range; required for indoor observations only.

5. Procedure

5.1 Position. Survey the affected facility or building or structure housing the process to be observed and determine the locations of potential emissions. If the affected facility is located inside a building, determine an observation location that is consistent with the requirements of the applicable regulation (i.e., outside observation of emissions escaping the building/structure or inside observation of emissions directly emitted from the affected facility process unit). Then select a position that enables a clear view of the potential emission point(s) of the affected facility or of the building or structure housing the affected facility, as appropriate for the applicable subpart. A position at least 15 feet, but not more than 0.25 miles, from the emission source is recommended. For outdoor locations, select a position where the sun is not directly in the observer's eyes.

5.2 Field Records

5.2.1 Outdoor Location. Record the following information on the field data sheet: company name, industry, process unit, observer's name, observer's affiliation, and date. Also record the estimated wind speed, wind direction, and sky conditions. Sketch the process unit being observed and note the observer location relative to the source and the sun. Indicate the potential and actual emission points on the sketch.

5.2.2 Indoor Location. Record the following information on the field data sheet: company name, industry, process unit, observer's name, observer's affiliation, and date. Record as appropriate the type, location, and intensity of lighting on the data sheet. Sketch the process unit being observed and note observer location relative to the source. Indicate the potential and actual fugitive emission points on the sketch.

5.3 Indoor Lighting Requirements. For indoor locations, use a light meter to measure the level of illumination at a location as close to the emission source(s) as possible. An illumination of greater than 100 lux (10 foot candles) is considered necessary for proper application of this method.

5.4 Observations. Record the clock time when the observations begin. Use one stopwatch to monitor the duration of the observation period and start this stopwatch when the observation period begins. If the observation period is divided into two or more segments by process shutdowns or observer rest breaks, stop the stopwatch when a break begins and restart it without resetting when the break ends. Stop the stopwatch at the end of the observation period. The accumulated time indicated by this stopwatch is the duration of the observation period. When the observation period is complete, record the clock time.

During the observation period continuously watch the emission source. Upon observing an emission (condensed water vapor is not considered an emission), start the second accumulative stopwatch and stop the watch when the emission ends. Continue this procedure for the entire observation period. The accumulated elapsed time on this stopwatch is the total time emissions were visible during the observation period (i.e., true emission time).

5.4.1 Observation Period. Choose an observation period of sufficient duration to meet the requirements for determining compliance with the emission regulation in the applicable subpart. When the length of the observation period is specifically stated in the applicable subpart, it may not be necessary to observe the source for this entire period if the emission time required to indicate noncompliance (based on the specified observation period) is observed in a shorter time period. In other words, if the regulation prohibits emissions for more than six minutes in any hour, then observations can (optional) be stopped after an emission time of six minutes has been exceeded. Similarly, when the regulation is expressed as an emission frequency and the regulation prohibits emissions for greater than 10% of the time in any hour, then observations can (optional) be terminated after six minutes of emissions are observed since six minutes is 10% of an hour. In any case, the observation period shall not be less than six minutes in duration. In some cases, the process operation might be intermittent or cyclic. In such cases, it might be convenient for the observation period to coincide with the length of the process cycle.

5.4.2 Observer Rest Breaks. Do not observe emissions continuously for a period of more than 15-20 minutes without taking a rest break. For sources requiring observation periods of more than 20 minutes, the observer shall take a break of not less than five minutes and not more than 10 minutes after every 15-20 minutes of observation. If continuous observations are desired for extended time periods, two observers can alternate between making observations and taking breaks.

5.4.3 Visual Interference. Occasionally fugitive emissions from sources other than the affected facility (e.g., road dust) can prevent a clear view of the affected facility. This can particularly be a problem during periods of high wind. If the view of the potential emission point is obscured to such a degree that the observer questions the validity of continuing observations, then the observations are terminated and the observer clearly notes this fact on the data sheet.

5.5 Recording Observations. Record the accumulated time of the observation period on the data sheet as the observation period duration. Record the accumulated time emissions were observed on the data sheet as the emission time. Record the clock time when the observation period began and ended as well as the clock time when any observer breaks began and ended.

6. Calculations

If the applicable subpart requires that the emission rate be expressed as an emission frequency (in percent), determine this value as follows: Divide the accumulated emission time (in seconds) by the duration of the observation period (in seconds) or by any minimum observation period required in the applicable subpart if the actual observation period is less than the required period and multiply this quotient by 100. **Method 22 forms can be found in the Appendix of this manual.**

7. References

7.1 Missan, Robert and Arnold Stein. Guidelines for Evaluation of Visible Emissions Certification. Field Procedures, Legal Aspects, and Background Material. EPA Publication No. EPA-340/1-75-007. April 1975.

ETA recommends the following for additional reading on visible emissions topics:

Conner, W.D., and N. White. Comparative Study of Plume Opacity Measurement Methods. Environmental Sciences Research Laboratory, U.S. Environmental Protection Agency. EPA-600/2-80-001. January 1980.

U.S. Environmental Protection Agency. APTI Course 439 Visible Emissions Evaluation. Student Manual. EPA-450/3-78-106. 1978.

U.S. Environmental Protection Agency. Evaluation and Collaborative Study of Method for Visual Determination of Opacity of Emissions from Stationary Sources. EPA-650/4-75-009.

U.S. Environmental Protection Agency. Quality Assurance Handbook for Air Pollution Measurement Systems: Volume III. Stationary Source Specific Methods. Addition Section 3.12. EPA-600/4-77-027b. February 1984.

7.2 Wohlschlegal, P. and D.E. Wagoner. Guideline for Development of a Quality Assurance Program: Volume IX – Visual Determination of Opacity Emissions From Stationary Sources. EPA Publication No. EPA-850/4-74-005-1. November 1975.

Notes

CHAPTER 12

Title 40 CFR Subparts

Many facilities are affected by the subparts in 40 CFR parts 60, 61 and 63 regarding visible emissions monitoring and compliance requirements. For example Subpart OOO – Standards of Performance for Nonmetallic Mineral Processing Plants has specific compliance criteria, exemptions and observer procedural requirements for performing visible emissions observations. For example:

Subpart OOO Compliance Criteria

(3) When determining compliance with the fugitive emissions standard for any affected facility described under section 60.672(b) of this subpart, the duration of the Method 9 observations may be reduced from 3 hours (thirty 6 minute averages) to 1 hour (ten 6-minute averages) only if the following conditions apply:

(i) There are no individual readings greater than 10 percent opacity; and

(ii) There are no more than 3 readings of 10 percent for the 1 hour period.

Subpart OOO Observer Procedures

(i) The observer must maintain a minimum distance of 15 feet between them and the emission source.
(ii) The observer shall, when possible select a position that minimizes interference from other fugitive emissions sources. (e.g. road dust)
(iii) For affected facilities using wet dust suppression for particulate matter control, a visible water mist may be present. When a water mist is present, the observation of emissions is to be made at a point in the plume where the mist is no longer visible.

Subpart XXXXXX

National Emissions Standards for Hazardous Air Pollutants Area Source Standards for Nine Metal Fabrication and Finishing Source Categories is another good example of a subpart that is contains specific visible emissions monitoring requirements. The visible emissions monitoring requirements per source in this subpart establishes the frequencies of the visible emissions observations based on their actual visual emissions performance.

Please keep in mind that this section is for reference use only and is not comprehensive of all the Title 40 CFR Subparts that contain visible emissions monitoring and compliance requirements. Therefore it is important as an owner or operator of a facility to become familiarized and understand the subparts that affect your facility.

Additional Methods

EPA ALT 082

Air permits from regulatory agencies often require measurementsof opacity from air pollution sources in the outdoor ambient environment. Opacity has been visually measured by certified smoke evaluators in accordance with USEPA Method 9 for many years.

EPA Alternate 082 was approved on February 15, 2012, as a broadly applicable test method for determining opacity measurements in the outdoor ambient environment. This test method is referred to as the Digital Camera Opacity Technique (DCOT) and utilizes ASTM D7520-09 in lieu of USEPA Method 9 for demonstrating compliance with Federal opacity regulations under any subpart to 40 CFR Part 60, 61 and 63 regulating ducted emissions sources that fall within ASTM D7520-09 method's scope.

ASTM D7520-09 Test Method Summary

The test method describes the procedures to determine the opacity of a plume in the outdoor ambient environment using digital imagery and associated software and hardware. The opacity of emissions is determined by the application of a Digital Camera Opacity Technique (DCOT) system that consists of a Digital Still Camera, Analysis Software, and the Output Function's content to obtain and interpret digital images to determine and report plume opacity ranging from 0-100% opacity.

A Digital Camera is used to capture a set of digital images of a plume against a contrasting background. Each image is analyzed with software that determines plume opacity by comparing a user defined portion of the plume image where opacity is being measured in comparison to the background providing the contrasting values. The Analysis Software is used to average the opacities from the series of digital images taken of the plume over a fixed period of time. The software is also used to archive the image set utilized for each opacity determination including the portion of each image selected by the operator.

The DCOT operator must follow the exact procedures for EPA Method 9 "Visual Emission Evaluation Procedure", therefore, they must be knowledgeable about observing plumes to determine their opacity in accordance with "Principles of Visual Emissions Measurements" and Procedures to Evaluate those Emissions Using Digital Camera Optical Technique (DCOT). Certification of DCOT systems and DCOT operators must follow the certification requirements prescribed for EPA ALT 082.

ASTM D7520-09 is available at:

www.ASTM.org

EPA ALT 082 Approval Letter with outlined limitations can be found at:

www.epa.gov/ttn/emc/approalt/ALT082.pdf

Methods 203 A, B and C

Many state and local air pollution control agencies use different approaches in enforcing opacity standards other than the 6 minute averaging period utilized in USEPA Method 9. The EPA recognizes that certain types of opacity violations that are intermittent in nature require a different approach in applying the opacity standards than to Method 9. Therefore Method 203 A, B, and C were promulgated as test methods suitable for State Implementation Plans (SIP) and are applicable to the determination of the opacity of emissions from sources. Listed are the descriptions of the Test Methods 203 A, B and C and how to apply their different data reduction mechanisms.

203 A – Visual Determination of Emissions from Stationary Sources for Time-Averaged Regulations

A time averaged regulation is any regulation that requires averaging visible emission data to determine the opacity of visible emissions over a specific time period. Method 203 A is almost identical to EPA Method 9 except for the data reduction mechanism, which provide for averaging times other than 6 minutes. Example: 3 minute avenging time.

203 B – Visual Determination of Emissions from Stationary Sources for Time-Exception Regulation

A time-exception regulation means any regulation that allows predefine periods of opacity observations above an otherwise applicable opacity limit. (Example: allowing exceedances of 20 percent opacity for up to 3 minutes in 1 hour.) Method 203 B is almost identical to EPA Method 9 except for the data reduction mechanism that applies to time-exception regulations.

When using this method count the number of observations above the applicable standard. This number is multiplied by 0.25 to determine the minutes of emissions above the target opacity. Compare the number of minutes of violations with the number of minutes allowable in the standard.

203 C – Visual Determination of Opacity of Emissions from Stationary Sources for Instantaneous
Limitation Regulations

An Instantaneous Limitation is an opacity limit which is never to be exceeded. Method 203 C is almost identical to Method 9, except for 5-second reading intervals are recorded and the data reduction mechanism which has been modified for instantaneous limitation regulations.

When using this method reduce opacity observations by averaging 12 consecutive observations at 5-second intervals equivalent to a 1 minute average. Method 203 C needs a specific data form. Visit http://www.epa.gov/ttn/emc/methods/FieldDataFormsM203ABC.pdf To download a Method 203 C data form.

Notes

Appendix

EASTERN TECHNICAL ASSOCIATES

NAME

AFFILIATION | RUN #

COURSE LOCATION | DATE / /

SUNGLASSES YES NO TYPE: | SKY | WIND (SPEED) (DIRECTION)

I HEREBY ACKNOWLEDGE THAT THE READINGS BELOW ARE MY OWN. ______________________________ (SIGNATURE)

READING NUMBER WHITE BLACK DISTANCE & DIRECTION TO STACK______________________________ ERROR

01	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	01	
02	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	02	
03	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	03	
04	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	04	
05	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	05	
06	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	06	
07	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	07	
08	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	08	
09	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	09	
10	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	10	
11	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	11	
12	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	12	
13	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	13	
14	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	14	
15	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	15	
16	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	16	
17	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	17	
18	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	18	
19	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	19	
20	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	20	
21	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	21	
22	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	22	
23	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	23	
24	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	24	
25	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	25	

WHITE BLACK DISTANCE & DIRECTION TO STACK______________________________ TOTAL ________

26	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	26	
27	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	27	
28	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	28	
29	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	29	
30	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	30	
31	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	31	
32	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	32	
33	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	33	
34	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	34	
35	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	35	
36	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	36	
37	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	37	
38	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	38	
39	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	39	
40	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	40	
41	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	41	
42	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	42	
43	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	43	
44	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	44	
45	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	45	
46	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	46	
47	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	47	
48	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	48	
49	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	49	
50	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	50	

BLACK: TOTAL __________ x .2= __________ | WHITE: TOTAL __________ x .2= __________ | TOTAL __________

EPA
VISIBLE EMISSION OBSERVATION FORM 1

Method Used (Circle One)			
Method 9	203A	203B	Other: ____________

Company Name		
Facility Name		
Street Address		
City	State	Zip

Process	Unit #	Operating Mode
Control Equipment		Operating Mode

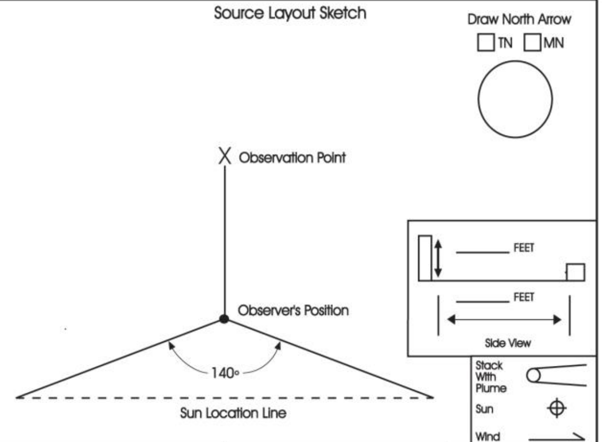
Describe Emission Point	
Height of Emiss. Pt. Start End	Height of Emiss. Pt. Rel. to Observer Start End
Distance to Emiss. Pt. Start End	Direction to Emiss. Pt. (Degrees) Start End

Vertical Angle to Obs. Pt. Start End	Direction to Obs. Pt. (Degrees) Start End
Distance and Direction to Observation Point from Emission Point Start	End

Describe Emissions Start	End
Emission Color Start End	Water Droplet Plume Attached ☐ Detached ☐ None ☐

Describe Plume Background Start	End	
Background Color Start End	Sky Conditions Start End	
Wind Speed Start End	Wind Direction Start End	
Ambient Temp. Start End	Wet Bulb Temp.	RH Percent

Source Layout Sketch



Longitude	Latitude	Declination

Additional Information

VEOF1.1

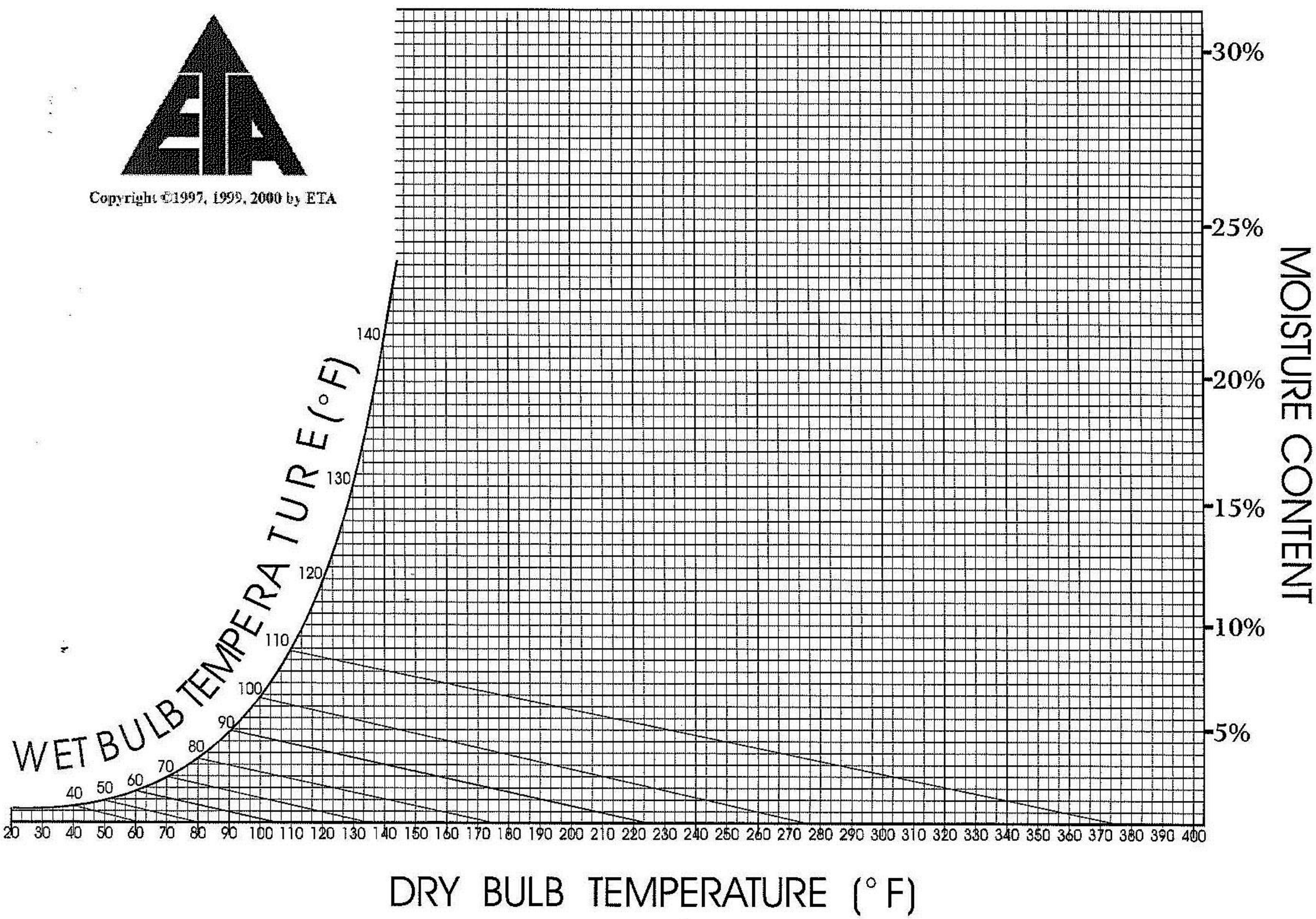
Form Number	Page	Of
Continued on VEO Form Number		

Observation Date	Time Zone	Start Time	End Time

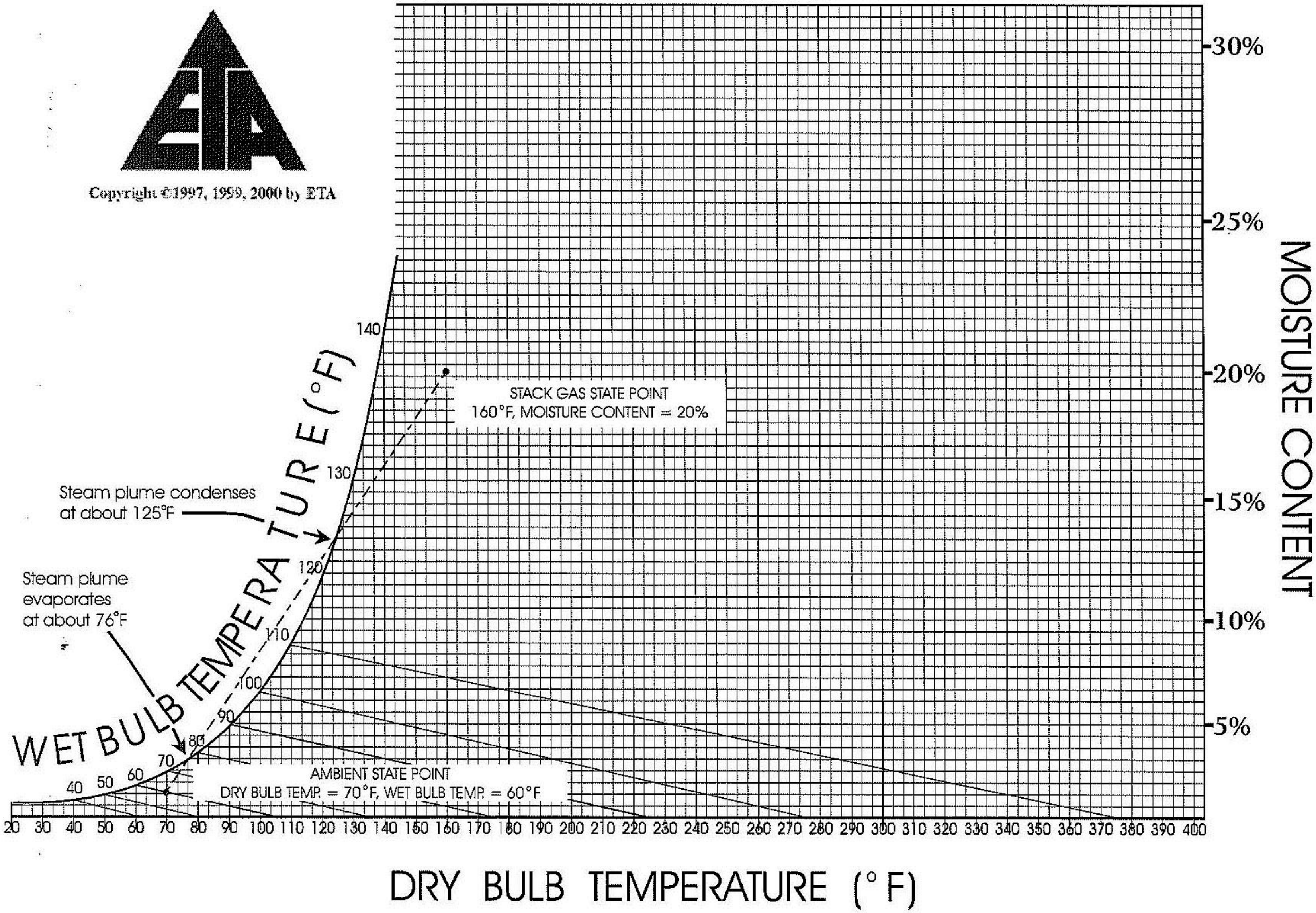
Min \ Sec	0	15	30	45	Comments
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					
17					
18					
19					
20					
21					
22					
23					
24					
25					
26					
27					
28					
29					
30					

Observer's Name (Print)	
Observer's Signature	Date
Organization	
Certified By	Date

STEAM PLUME MODELING CHART



STEAM PLUME MODELING CHART



EASTERN TECHNICAL ASSOCIATES
SLANT ANGLE CORRECTION TABLE

SLANT	MEASURED OPACITY (%)																			
ANGLE	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
19	4.7	9.4	14.2	19.0	23.8	28.6	33.4	38.2	43.1	48.0	52.9	57.9	62.9	67.9	73.0	78.1	83.3	88.6	94.1	100.0
20	4.7	9.4	14.2	18.9	23.7	28.5	33.3	38.1	43.0	47.9	52.8	57.7	62.7	67.7	72.8	78.0	83.2	88.5	94.0	100.0
21	4.7	9.4	14.1	18.9	23.6	28.3	33.1	37.9	42.8	47.6	52.5	57.5	62.5	67.5	72.6	77.7	83.0	88.3	93.9	100.0
22	4.6	9.3	14.0	18.8	23.4	28.2	32.9	37.7	42.6	47.4	52.3	57.2	62.2	67.3	72.3	77.5	82.8	88.2	93.8	100.0
23	4.6	9.2	13.9	18.7	23.3	28.0	32.7	37.5	42.3	47.2	52.1	57.0	62.0	67.0	72.1	77.3	82.6	88.0	93.7	100.0
24	4.6	9.2	13.8	18.6	23.1	27.8	32.5	37.3	42.1	46.9	51.8	56.7	61.7	66.7	71.8	77.0	82.3	87.8	93.5	100.0
25	4.5	9.1	13.7	18.4	23.0	27.6	32.3	37.1	41.8	46.6	51.5	56.4	61.4	66.4	71.5	76.7	82.1	87.6	93.4	100.0
26	4.5	9.0	13.6	18.3	22.8	27.4	32.1	36.8	41.6	46.4	51.2	56.1	61.1	66.1	71.2	76.5	81.8	87.4	93.2	100.0
27	4.5	9.0	13.5	18.2	22.6	27.2	31.9	36.6	41.3	46.1	50.9	55.8	60.8	65.8	70.9	76.2	81.6	87.1	93.1	100.0
28	4.4	8.9	13.4	18.0	22.4	27.0	31.6	36.3	41.0	45.8	50.6	55.5	60.4	65.5	70.6	75.9	81.3	86.9	92.9	100.0
29	4.4	8.8	13.3	17.9	22.2	26.8	31.4	36.0	40.7	45.5	50.3	55.1	60.1	65.1	70.3	75.5	81.0	86.7	92.7	100.0
30	4.3	8.7	13.1	17.7	22.1	26.6	31.1	35.7	40.4	45.1	49.9	54.8	59.7	64.7	69.9	75.2	80.7	86.4	92.5	100.0
31	4.3	8.6	13.0	17.6	21.9	26.3	30.9	35.5	40.1	44.8	49.6	54.4	59.3	64.4	69.5	74.8	80.3	86.1	92.3	100.0
32	4.3	8.5	12.9	17.4	21.6	26.1	30.6	35.2	39.8	44.4	49.2	54.0	58.9	64.0	69.1	74.5	80.0	85.8	92.1	100.0
33	4.2	8.5	12.7	17.2	21.4	25.9	30.3	34.8	39.4	44.1	48.8	53.6	58.5	63.6	68.7	74.1	79.6	85.5	91.9	100.0
34	4.2	8.4	12.6	17.1	21.2	25.6	30.0	34.5	39.1	43.7	48.4	53.2	58.1	63.1	68.3	73.7	79.3	85.2	91.7	100.0
35	4.1	8.3	12.5	16.9	21.0	25.3	29.7	34.2	38.7	43.3	48.0	52.8	57.7	62.7	67.9	73.2	78.9	84.8	91.4	100.0
36	4.1	8.2	12.3	16.7	20.8	25.1	29.4	33.9	38.3	42.9	47.6	52.4	57.2	62.2	67.4	72.8	78.5	84.5	91.1	99.9
37	4.0	8.1	12.2	16.5	20.5	24.8	29.1	33.5	38.0	42.5	47.2	51.9	56.8	61.8	66.9	72.3	78.0	84.1	90.9	99.9
38	4.0	8.0	12.0	16.3	20.3	24.5	28.8	33.1	37.6	42.1	46.7	51.4	56.3	61.3	66.5	71.9	77.6	83.7	90.6	99.9
39	3.9	7.9	11.9	16.1	20.0	24.2	28.5	32.8	37.2	41.6	46.2	50.9	55.8	60.8	66.0	71.4	77.1	83.3	90.3	99.9
40	3.9	7.8	11.7	15.9	19.8	23.9	28.1	32.4	36.7	41.2	45.8	50.4	55.3	60.2	65.4	70.9	76.6	82.9	89.9	99.9
41	3.8	7.6	11.5	15.7	19.5	23.6	27.8	32.0	36.3	40.7	45.3	49.9	54.7	59.7	64.9	70.3	76.1	82.4	89.6	99.9
42	3.7	7.5	11.4	15.5	19.2	23.3	27.4	31.6	35.9	40.3	44.8	49.4	54.2	59.1	64.3	69.8	75.6	81.9	89.2	99.9
43	3.7	7.4	11.2	15.3	19.0	23.0	27.0	31.2	35.4	39.8	44.2	48.8	53.6	58.5	63.7	69.2	75.0	81.4	88.8	99.9
44	3.6	7.3	11.0	15.1	18.7	22.6	26.6	30.8	35.0	39.3	43.7	48.3	53.0	57.9	63.1	68.6	74.5	80.9	88.4	99.9
45	3.6	7.2	10.9	14.8	18.4	22.3	26.3	30.3	34.5	38.7	43.1	47.7	52.4	57.3	62.5	68.0	73.9	80.4	88.0	99.9
46	3.5	7.1	10.7	14.6	18.1	21.9	25.9	29.9	34.0	38.2	42.6	47.1	51.8	56.7	61.8	67.3	73.2	79.8	87.5	99.8
47	3.4	6.9	10.5	14.4	17.8	21.6	25.5	29.4	33.5	37.7	42.0	46.5	51.1	56.0	61.1	66.6	72.6	79.2	87.0	99.8
48	3.4	6.8	10.3	14.1	17.5	21.2	25.0	29.0	33.0	37.1	41.4	45.8	50.5	55.3	60.5	65.9	71.9	78.6	86.5	99.8
49	3.3	6.7	10.1	13.9	17.2	20.9	24.6	28.5	32.4	36.5	40.8	45.2	49.8	54.6	59.7	65.2	71.2	77.9	86.0	99.8
50	3.2	6.5	9.9	13.6	16.9	20.5	24.2	28.0	31.9	36.0	40.1	44.5	49.1	53.9	59.0	64.5	70.5	77.2	85.4	99.7
51	3.2	6.4	9.7	13.4	16.6	20.1	23.7	27.5	31.4	35.4	39.5	43.8	48.3	53.1	58.2	63.7	69.7	76.5	84.8	99.7
52	3.1	6.3	9.5	13.1	16.2	19.7	23.3	27.0	30.8	34.7	38.8	43.1	47.6	52.3	57.4	62.9	68.9	75.8	84.2	99.7
53	3.0	6.1	9.3	12.8	15.9	19.3	22.8	26.5	30.2	34.1	38.2	42.4	46.8	51.5	56.6	62.0	68.1	75.0	83.5	99.6
54	3.0	6.0	9.1	12.6	15.6	18.9	22.4	25.9	29.6	33.5	37.5	41.6	46.0	50.7	55.7	61.2	67.2	74.2	82.8	99.6
55	2.9	5.9	8.9	12.3	15.2	18.5	21.9	25.4	29.0	32.8	36.7	40.9	45.2	49.9	54.8	60.3	66.3	73.3	82.1	99.5
56	2.8	5.7	8.7	12.0	14.9	18.1	21.4	24.8	28.4	32.1	36.0	40.1	44.4	49.0	53.9	59.3	65.4	72.4	81.3	99.4
57	2.8	5.6	8.5	11.7	14.5	17.7	20.9	24.3	27.8	31.4	35.3	39.3	43.5	48.1	53.0	58.4	64.4	71.5	80.4	99.3
58	2.7	5.4	8.3	11.4	14.1	17.2	20.4	23.7	27.2	30.7	34.5	38.5	42.7	47.2	52.0	57.4	63.4	70.5	79.6	99.2
59	2.6	5.3	8.0	11.2	13.8	16.8	19.9	23.1	26.5	30.0	33.7	37.6	41.8	46.2	51.0	56.3	62.4	69.5	78.6	99.1
60	2.5	5.1	7.8	10.9	13.4	16.3	19.4	22.5	25.8	29.3	32.9	36.8	40.8	45.2	50.0	55.3	61.3	68.4	77.6	99.0

CORRECTED OPACITY (%)

FUGITIVE OR SMOKE EMISSION INSPECTION

OUTDOOR LOCATION

Company	Observer
Location	Affiliation
Company Rep.	Date
Sky conditions	Wind Direction
Precipitation	Wind Speed
Industry	Process Unit

Sketch process unit: indicate observer position relative to source; indicate potential emission points and/or actual emission points.

Observations	**Clock time**	**Observation period duration, min: sec**	**Accumulated emission time min: sec**
Begin			
End observation			

FUGITIVE OR SMOKE EMISSION INSPECTION

INDOOR LOCATION

Company	Observer
Location	Affiliation
Company Rep.	Date
Industry	Process Unit

Light type (Fluorescent, incandescent, natural)

Light location (overhead, behind observer, etc.)

Illuminance (lux of footcandles)

Sketch process unit: Indicate observer position relative to source; indicate potential emission points and/or actual emission points

Observations	**Clock time**	**Observation period duration, min: sec**	**Accumulated emission time min: sec**
Begin			
End observation			

Eastern Technical Associates, Inc.

OPACITY SERVICES

Eastern Technical Associates (ETA) is internationally recognized as the prime source of opacity services.

ETA provides year-round visible emissions training and certification programs throughout the U.S. for private industry as well as government agencies.

ETA provides opacity consultation services including:

- Visible emissions observations
- Visible emissions observation form audits
- Mitigation of opacity problems

ETA performs special studies to help industries and regulatory agencies understand the problems for a specific source. These studies include:

- Fugitive emissions
- Problem sources
- Condensation plumes
- Reactive plumes

ETA provides litigation support for both industrial clients and governmental agencies. These services include:

- Technical review of Notices of Violation
- Negotiation
- Expert witness testimony
- Technical exhibit preparation