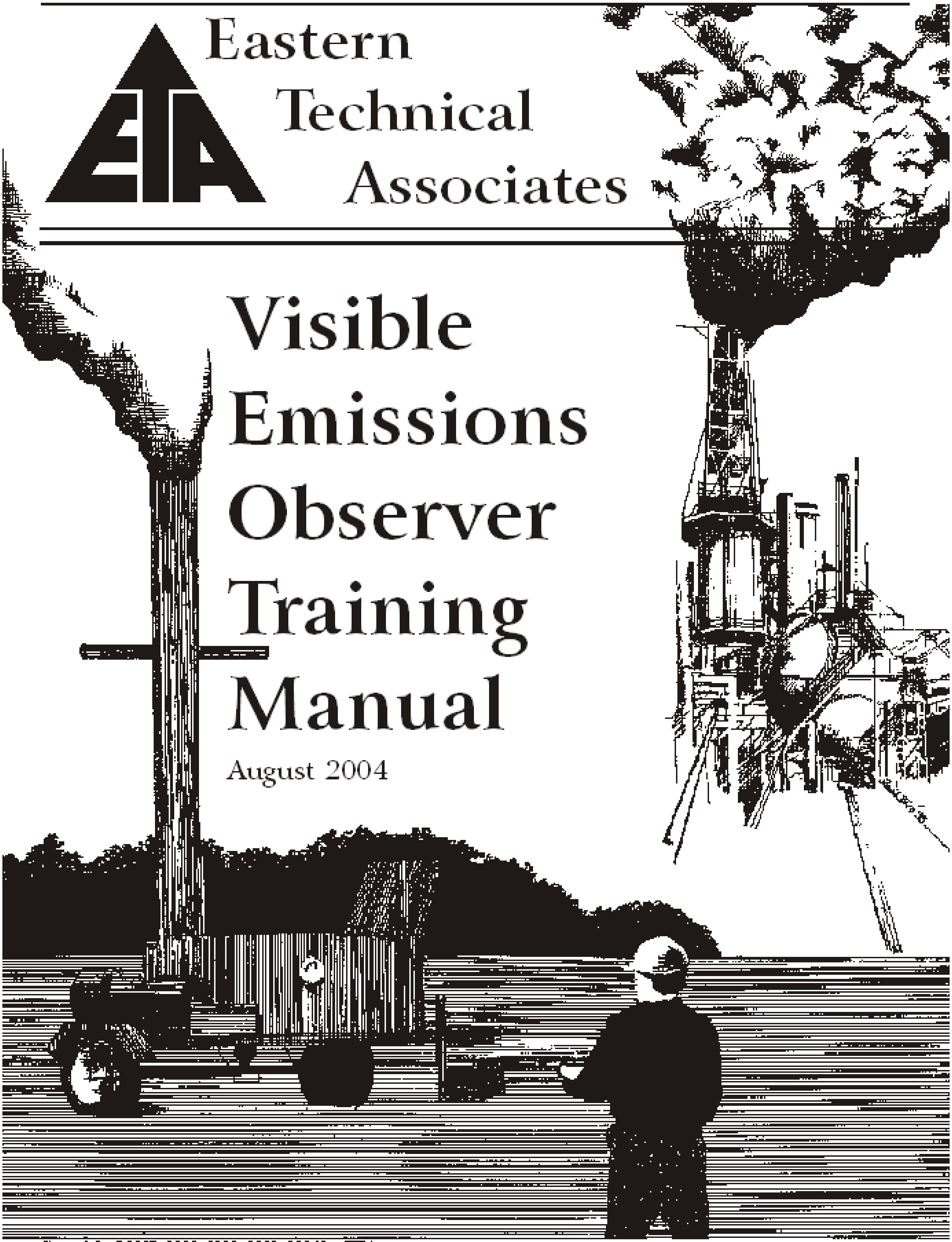
Eastern Technical Associates

Visible Emissions Observer Training Manual

August 2004



Welcome Smoke School Trainee

Over the next few days you will be trained in one of the oldest yet most commonly used source measurement techniques — smoke reading. There are more persons reading smoke today than at any time in the 100 plus year history of the method. We have prepared this manual to assist you in your training, certification, and, most importantly, field observations. It is impossible to give proper credit to all of the people who contributed to, developed, and supported the technology that contributed to the manual. The list would probably be longer than the manual. We have only been working in the field since 1970 and stand in the footprints of the innovators who preceded us. Much of the material in this manual comes from the contributions of the many visible emissions instructors we have been privileged to know, EPA documents, and the contributions of our staff over the last 25 years.

The purpose of the manual is to give you a ready, readable reference for topics addressed in the classroom portion of our training and for future reference when you are certified and performing measurements in the field. Unfortunately, we could not cover all of the possible situations you may encounter in the field. However, 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 who 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 wish you early success!

Thomas Rose
Tom Rose
President

Michael W. Lunsford
Mike Lunsford
Director of Training

For the most current information on opacity and related topics, please visit our website at **www.eta-is-opacity.com**.

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Chapter I

INTRODUCTION

Section 111 of the Clean Air Act requires the EPA 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. Standards of Performance for New and Modified Stationary Sources (NSPS) standards can be found in 40 CFR Part 60. Emission Standards for Hazardous Air Pollutants (NESHAP) standards are contained in 40 CFR Part 61 and 62. 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 United States Environmental Protection Agency shifting the emissions monitoring burden to Industry. From an opacity stand point, the companies are required to measure and report their own compliance with permit conditions and standards. Regulatory agencies did, however, 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. SIP permits in some cases may differ from the federal opacity standards in terms of the opacity limits, the measurement method or test procedure, or 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). Some 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 $27,500

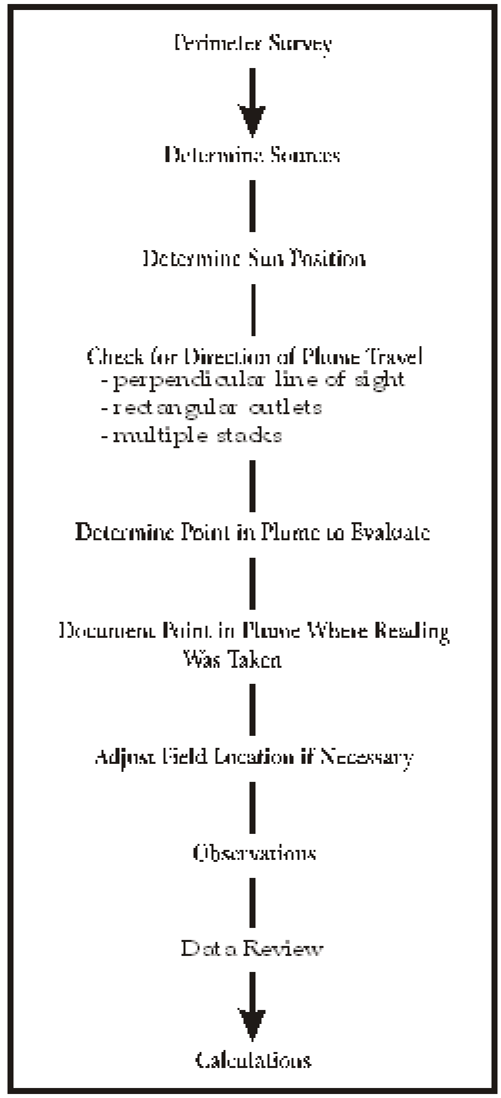
Regulated sources may be subject to stiff penalties for failure to comply with federal and/or state emissions standards, including opacity standards. Civil and administrative penalties of up to $27,500 per day per violation can be assessed under the Clean Air Act (CAA). States and local agencies are 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 well 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 VE Observation 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 which must be carefully adhered to during the observation are highlighted. Method 9 and Method 22 are reprinted in full in Chapters 10 and 11 respectively. We have included a VE Observation Form in Chapter IV and in the back 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 current information on opacity at our website www.eta-is-opacity.com .

Another source of internet information is www.epa.gov.



Ch. 1- Fig. 1: Inspection Flow Chart

Notes:

Chapter II

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 population increases. 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 (or 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, in violation of a city ordinance, emitted offensive odors and smoke, and was a nuisance.

RINGELMANN

The opacity evaluation system we use today evolved from a concept developed by Maximillian Ringelmann in the late 1800's. 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. 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 1900's 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." Similarly, in 1907 the Supreme Court of Indiana declared that dense, black smoke was 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, New York statute. The statute prohibited smoke from 5:00 a.m. to 7:30 a.m., presumably to protect commuters, and allowed dense smoke for only 5 minutes in every consecutive 4 hour period.

Throughout the early 1900's legislatures and municipalities wrestled with the problem of air pollution. In 1916,2 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, Pennsylvania 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 1950's and 1960's 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

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 Administrator of the EPA 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 had failed to adequately demonstrate the achievability of the new standards. The court ruled for the 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 responses to these issues, EPA undertook field trials needed to establish observer error, observation protocols, and equipment guidelines.

METHOD 9 PROMULGATION

The Environmental Protection Agency (EPA) published the EPA 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 (notably 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 1970's and 1980's, 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 their knowledge and documented an opacity violation on the chimney. Lawyers for Western Alfalfa argued that an inspection done on its premises without their consent violated the Fourth Amendment's protection from unreasonable search. In their decision, the Supreme Court held that the inspector sighted what anyone in the city could see, the smoke. Furthermore, that the inspector may operate within or without the premises and still be considered within the "open fields" exception to the Fourth Amendment. In another ruling, the courts refused to enforce a violation that regulatory agents had excessively delayed notification of the facility. The court sited 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 defense. This decision is commonly referred to as "speedy notification".

THE DONNER HANNA CASE

The differences between Federal Reference Methods (FRMs) and SIPs were highlighted in the landmark case of Donner Hanna Coke Corporation v. Costle. The coke oven battery was being regulated by the EPA under rules in the SIP. It was being regulated under a time aggregation rule patterned after Allegheny County Regulation. Emissions from the battery were timed with a stopwatch in accordance with historical precedents in New York and Pennsylvania. However, there was no legally adopted state measurement method. According to the 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 SIP methods. Although these methods were used extensively by the states and the EPA, they 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 make it 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 Messrs. Lee and Rose (then an EPA employee) developed the modern white smoke vaporization system. Mr. Lee continued to modify and improve smoke generators while Mr. Rose developed training methods. In 1975 Mr. Rose developed the laminar flow elbow used to conduct smoke schools in high wind. He also wrote the Quality Assurance Manual for Smoke School Operation. In 1979 Mr. Lee and Mr. Rose formed ETA, bringing the combined expertise in equipment and training together. Mr. Lee retired in 1999. Today ETA is the leading provider of Visible Emissions Training worldwide.

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 during the case of U.S. v. Kaiser Steel Corp.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 6 minute average (as required by Method 9), they totaled more than a half million dollars. Interestingly enough, the 1990 Clean Air Act amendments included provisions for the use of "credible evidence," specifically in response to the Kaiser Steel case.

TODAY

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 recently promulgated two rules that are already having a considerable impact on opacity. The first is the Compliance Assurance Monitoring (CAM) rule which requires certain facilities to certify their compliance with standards. Opacity measurements are an effective, relatively simple method used to check compliance. Secondly, 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).

Notes:

Chapter III

OPACITY MEASUREMENT PRINCIPLES

The relationships between light transmittance, plume opacity, and Ringelmann number, are presented in ch 3-fig 1.

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

Ch. 3- Fig. 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 simpler terms we say:

> ***OPACITY IS THE OBSCURING POWER OF AN EMISSION EXPRESSED IN 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 as follows:

$$\text{Percent opacity} = (1 - I/I_o) \times 100$$

VARIABLES INFLUENCING OPACITY OBSERVATIONS

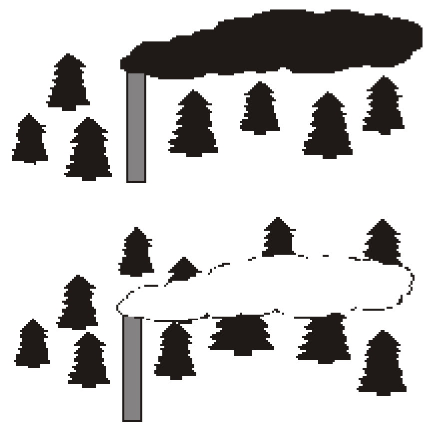
Method 9 warns:

> *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 pathlength, 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 (0.4 to 0.7um) have the greatest scattering effect and cause the highest opacity. Note that these particles are in the respirable range and are designated as PM10 particles. 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 plume 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.

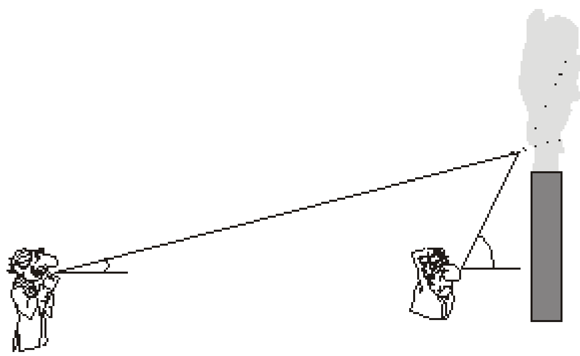


Ch. 3- Fig. 2: Plume Contrast

The line of sight pathlength through the plume is of particular concern.

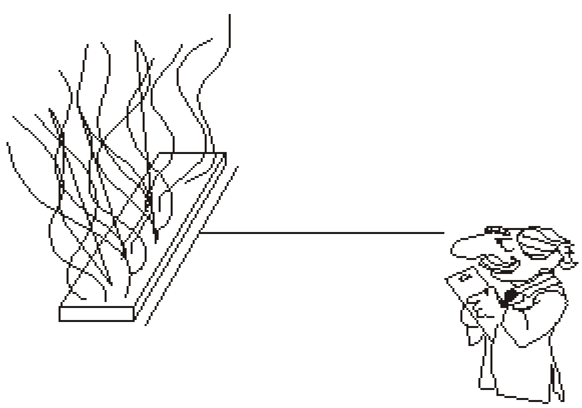
Method 9 states:

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



Ch. 3- Fig. 3: Perpendicular Line of Vision

...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.



Ch.3- Fig.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 5). 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 Chapter VII). As the angle increases the error increases. To avoid this problem you should stand at least 3 stack distances away from a vertically rising 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 3 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.

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 percent of black plumes and 99 percent 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 no 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 ninety-five percent of the white plumes were read within 5%. This means that you are likely to over read about once in twenty 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.

OTHER VISIBLE EMISSIONS METHODS

METHOD 22

Since its introduction in 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 is the stated goal. This is frequently the case with fugitive emissions sources or sources with toxic emissions. Method 22 differs from the 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.

METHODS 203 A, B, & C

Many SIP rules predate the 1974 promulgation of Method 9. Method 9 states that opacity shall be determined as an average of 24 consecutive observations recorded at 15-second intervals (6-minute average). There are times when the SIP rule might be at odds with the 6-minute averaging technique specified in Method 9. EPA recognized this problem when it stated the following in the preamble:

> *Many state and local air pollution control agencies use different approaches in enforcing opacity standards other than the 6-minute averaging period specified in this revision to Method 9. EPA recognizes that certain types of opacity violations that are intermittent in nature require a different approach in applying the opacity standards than this revision to Method 9.*

As a result, EPA is proposing methods 203A, 203B, and 203C, which can support SIP rules when the data reduction techniques differ from Method 9. For example, method 203A (Time-Averaged Regulations) provides for averaging times other than 6 minutes.

Method 203B (Time-Exception Regulations) utilizes a technique known as "time aggregation." When using this method you 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 (the time exception).

Method 203C (Instantaneous-Limitation Regulations) is used on sources that have a specified limitation or “cap” which may never be exceeded. The method allows for 5 or 15 second observation intervals with a 1 minute averaging time.

Proposed Method 203 is for continuous opacity monitors or transmissometers. As of this date, it has not completed the promulgation process. Method 203 is also linked with EPA Performance Specification 1 which describes transmissometer requirements.

Notes:

COMPARISON OF METHODS 9 & 22

METHOD 9		METHOD 22
Any NSPS or SIP sources with an opacity standard.	APPLICABILITY	NSPS and SIP fugitive and specified flare sources with a "no visible emission" standard. No opacity level can be specified.
The method determines the value of opacity measured.	MEASUREMENT	The method determines the time duration of a visible emission but not the opacity.
You must demonstrate the ability to measure plumes in the field every six months.	CERTIFICATION	You are not required to participate in field certification.
In some states you are required to attend a lecture program.	LECTURE	You must be able to demonstrate knowledge. A lecture is advised but reading material is acceptable.
No distance is specified, but you must have a clear view of the emissions.	DISTANCE FROM SOURCE	From 15 feet to 0.25 mile.
You view the emission from a position that minimizes the line of sight through the plume to minimize positive bias.	VIEWING ANGLE	You simply observe the emission.
The sun is implied as the light source and it is required to be at your back.	LIGHT SOURCE	Light sources other than the sun are acceptable, but must be documented. The light must be greater than 100 lux, but it is not required to be at your back.
Momentary observation every 15 seconds for a period determined by the standard. Each observation is recorded.	VIEWING TIMES	Continuous viewing with observer rest breaks every 15 to 20 minutes. You time the emissions with a stopwatch and record the duration of emissions.

Chapter IV

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, color; for identification purposes. (**)

Height of Emission Point - stack or emission point height, from files or engineering drawings. The height may 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. (*)

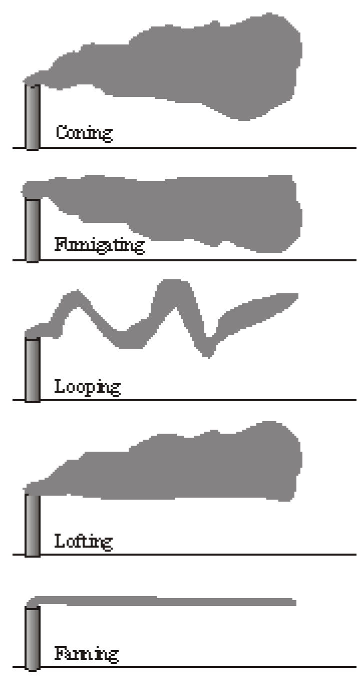
Direction to Emission Point (Degrees) - direction to emission point; use compass. Reference to True North or Magnetic North.

Vertical Angle to Observation Point - vertical angle from you to the observation point (i.e., point in plume at which 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 at which 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 at which 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.).



Ch.4-Fig.1: Plume Types

Emission Color - gray, brown, white, etc..

Water Droplet Plume - If present, specify:

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

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. (*)

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 + or - 5 MPH.(*)

Wind Direction - direction wind is from; use compass; 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; use local U.S. Weather Bureau only if nearby.

Source Layout Sketch - an overhead view which 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 when pen's shadow crosses your position.

Longitude, Latitude, Declination - observer longitude, latitude and declination. May 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 may 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.

FAILURE TO PROPERLY DOCUMENT OBSERVATIONS IS THE MAJOR CAUSE OF FAILED LITIGATION

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

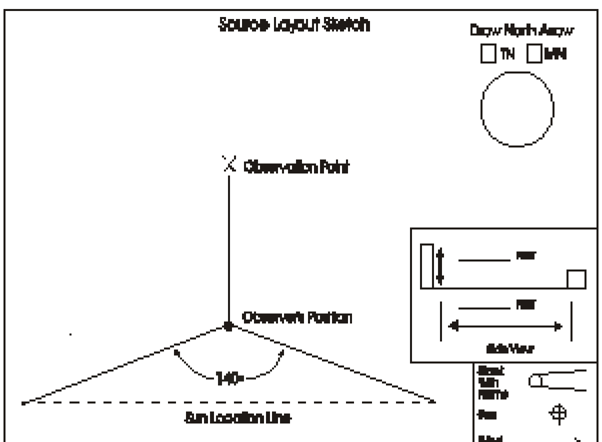
Emission Color Start End | Water Droplet Plume Attached ☐ Detached ☐ None ☐

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



Longitude | Latitude | Declination

Additional Information

VEOF1.1

Notes

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

Specifications Sheet- VE Example

Facility Information:

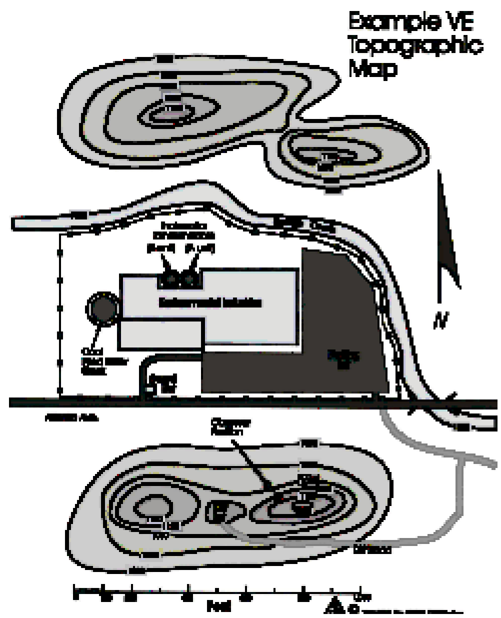
> **Name: Environmental Industries**
> **Address: 2412 Atlantic Ave., Raleigh, NC 27604**
> **Regulatory Method: Method 9 (6 minute average)**

Permit Compliance Limit:

> **The source shall not emit into the atmosphere emissions that, on evaluation, create a six (6) minute average data sequence equal to, or grater than twenty percent (20%) opacity.**

Emission Point Information:

Process Equipment- Incinerator
Operation Mode- 85% of Maximum Capacity
Control Equipment- Electrostatic Precipitator
Operating Mode- Spark Rate of 149/minute
Stack Heigh= 150 ft
Observation Angle- Geometry
Direction- Topographic Map
Latitude= 35.78 degrees N
Longitude= 78.65 degrees W
Compass Declination= 6 degrees W



Meteorological Information:

> **Wind Speed: 7-10 MPH**
> **Skies: Refer to Slide**
> **Temperature/Relative Humidity: Sling Psychrometer**

Sun Location- US Naval Observatory Website:

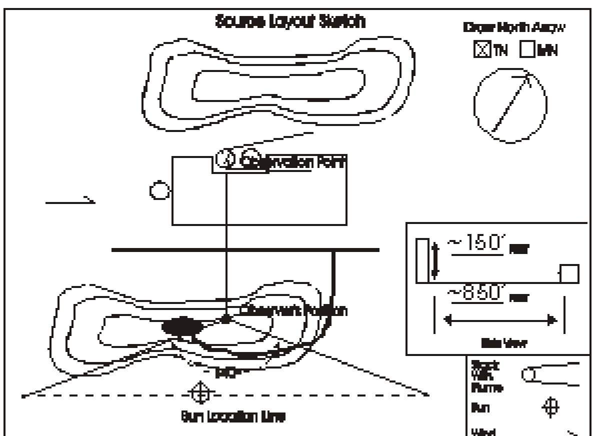
Actual Standard Time (PM)	1:00	1:30	2:00	2:30	3:00
Azimuth- Degrees from True North	176	189	202	214	224
Altitude- Degrees off Horizon	57	56	55	52	48

EXAMPLE COMPLETED VISIBLE EMISSION OBSERVATION FORM

Form Number	E	I	0	0	1	Page 1	Of 1
Continued on VEO Form Number							

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

Field	Entry
Company Name	Environmental Industries
Facility Name	Same
Street Address	2412 Atlantic Ave
City	Raleigh
State	NC
Zip	27604
Process	Incinerator
Unit #	B
Operating Mode	85% MAX
Control Equipment	Electrostatic Precipitator
Operating Mode	149/min
Describe Emission Point	Westmost of two shorter stacks, white w/ red stripes
Height of Emiss. Pt.	Start ~150′ End same
Height of Emiss. Pt. Rel. to Observer	Start ~30′ End same
Distance to Emiss. Pt.	Start ~850′ End same
Direction to Emiss. Pt. (Degrees)	Start 335° End same
Vertical Angle to Obs. Pt.	Start 2° End same
Direction to Obs. Pt. (Degrees)	Start 335° End same
Distance and Direction to Observation Point from Emission Point	Start Approx the same End same
Describe Emissions	Start coning End same
Emission Color	Start white End same
Water Droplet Plume	Attached ☐ Detached ☐ None ☒
Describe Plume Background	Start Trees on hill End same
Background Color	Start green End same
Sky Conditions	Start clear End same
Wind Speed	Start 7-10 mph End same
Wind Direction	Start west End same
Ambient Temp.	Start 74° End same
Wet Bulb Temp.	64°
RH Percent	58%

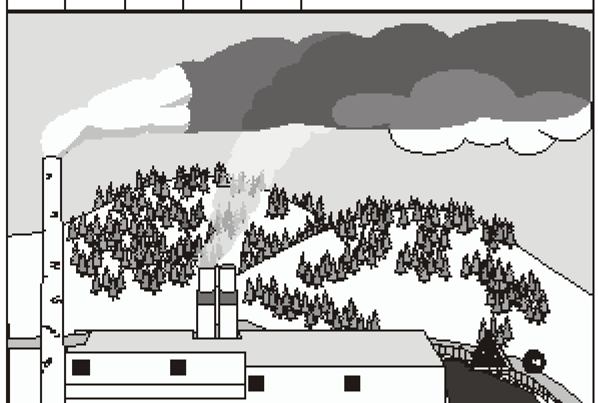


Longitude	Latitude	Declination
78.65° W	35.78° N	6° W

Additional Information: No interference from other emissions

Observation Date	Time Zone	Start Time	End Time
6/15/04	EDT	1445	1455

Min \ Sec	0	15	30	45	Comments
1	15	15	10	5	
2	15	20	25	25	
3	30	40	35	35	
4	40	30	35	35	Ave. = 32.5%
5	15	25	25	40	
6	40	40	30	35	
7	35	40	30	35	
8	30	30	20	15	
9	10	15	5	10	
10	10	10	10	5	
11					
12					
13					
14					
15					



Min \ Sec	0	15	30	45	Comments
26					
27					
28					
29					
30					

Field	Entry
Observer's Name (Print)	I. C. Smoke
Observer's Signature	I. C. Smoke
Date	6/15/04
Organization	Sigworth Environmental
Certified by	ETA
Date	6/3/04

VEOF1.1

Chapter V

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 optional, 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 black ballpoint pens (medium point), several large rubber bands, and a sufficient number of VE Observation Forms to document any expected and unexpected observations. Black ballpoint pens are used so that completed forms can be copied and remain legible over several reproduction generations. 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 Chapter IV.

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 1 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.

Checklist

Clipboard
Ballpoint pens
VE forms
Rubber bands
Timers (2)
Compass
Topographic map
Rangefinder
Clinometer

Sling psychrometer
    Water

Camera
    Film
    Tripod
    Telephoto lens
    Macro lens

Video camera
    Tape
    Batteries
    Tripod

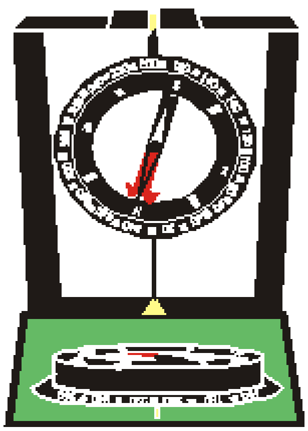
Ch.5-Fig.1: Observer's Checklist

TOPOGRAPHIC MAPS

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 rangerfinders. 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˚. 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 the reading, you should consider investing in a compass that allows you to adjust the declination.



Ch.5-Fig.2: Compass

GLOBAL POSITIONING SYSTEMS (GPS)

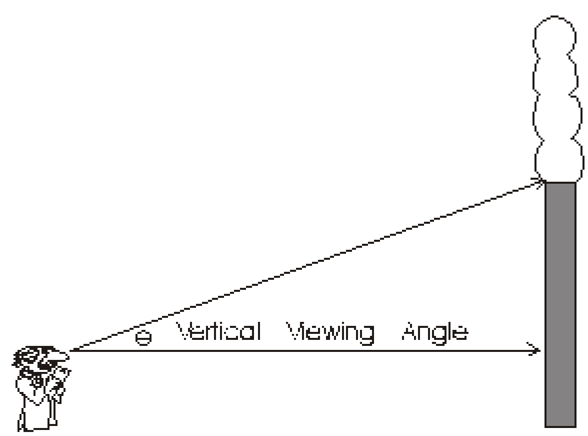
Defining your exact position within 10 meters in terms of latitude and longitude is valuable information for an observer. It helps in determining proper sun position. A GPS is a hand held unit that works by receiving signals from satellites orbiting the Earth. A GPS unit can be purchased for less than $200.

RANGE FINDER

If a topographic map of the area is not available, you will need a range finder. Even with a map, a range finder is very useful in field work. The two types in general use are the split-image and the stadiometric rangerfinders. However, laser units are also becoming widely available. The split-image type uses the technique of superimposing one image over another to determine the distance. The most useful models for most opacity work have a maximum range of about 1000 yards. To use the stadiometric range finder, you must know the height or width of an object at the same distance as the object of interest. Stadiometric range finders are lighter and more compact than split-image rangerfinders. Split image rangerfinders, although inherently more accurate, are more likely to become uncalibrated when bumped during transport. The accuracy of either type of range finder should be checked on receipt and periodically thereafter with targets at known distances of approximately 500 meters and 1000 meters. An acceptable range finder must be accurate to within 10 percent of the measurement distance.

ABNEY LEVEL OR CLINOMETER

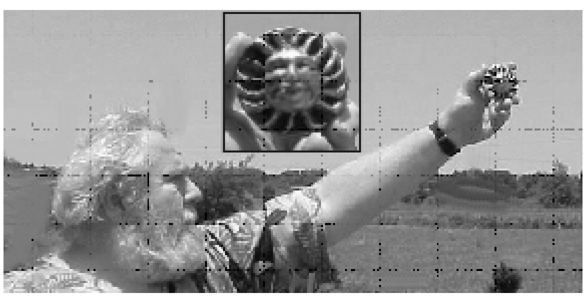
You will need a clinometric device for determining the vertical viewing angle (see figure 10a). For visible emissions observation purposes, it should be accurate within 2˚. Many suitable devices are available in a wide range of prices, including Abney levels, pendulum clinometers, and sextants. Abney levels use a bubble in a curved tube to determine the angle with an accuracy of 1-2˚. 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˚. Then check it at 45˚ by placing it on a 45˚ 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˚ 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.



Ch.5-Fig.3: Vertical Viewing Angle

SUNDOG

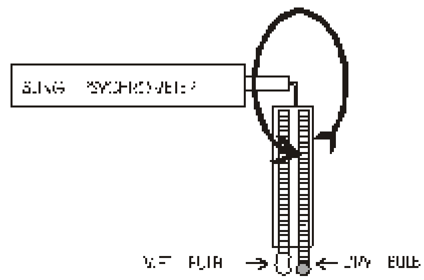
Field confirmation of a correct position of the observer in relation to the sun and observation point in the plume is almost impossible without the right equipment. Prior to observations, the observer can run computer simulations of the SOS or Sun Observer Source angle to assure that the SOS is at least 110 degrees (the 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 the three points...the sun, the observers position, and the 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.



Ch.5-Fig.4- Sundog

SLING PSYCHROMETER

If there is a potential for the formation of a condensed water droplet "steam" plume, you will need a sling psychrometer (see figure 11) 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 surroundingthe bulb. Thermometer accuracy should be checked by placing the bulbs in a deionized ice water bath at 0˚C. Electronic models that use newly developed solid state sensors are also available and do not have to be slung. Electronic models are simpler to use but require tedious periodic calibration using standard salt solutions. The manufacturer's calibration procedures should be explicitly followed.



Ch.5-Fig.5: Sling Psychrometer

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 as 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.

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. Photographs document the specific stack that is under observation but do not document the exact opacity. Photographs may be useful to document field conditions, observer position, background, and sun location (by shadows). Select a 35-mm camera with through-the-lens light metering, a "macro" lens or a 250 to 350-mm telephoto lens, and a 6-diopter closeup lens (for photographing the photo logbook). A photo logbook is necessary for proper photographic documentation. Use only fresh color negative film with an ASA of approximately 100. You can get first generation slides or prints from the negatives. The first photograph is of the log identifying the time, date, and source. Log each photograph when you take it. The last photograph is of the completed log. Instruct the processor not to cut the film or print roll so that you can refer to the photo log at the end of the roll to identify each photograph.

Because of the wider tonal range of video, it does a better job of reproducing the actual appearance of the plume than photography. In terms of resolution, video is poorer than film. The most practical video systems for opacity work are the new digital video camera.

Avoid regular VHS or 8mm camcorders because of the limited resolution and poor quality copies. Digital Cameras can be very useful in documenting the appearance and location of emissions. The ease in 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 own staff to ensure that 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 in a convenient package.

For further information regarding **Visible Emissions Observer Support Products**, please contact our office or visit our website at www.eta-is-opacity.com.

Notes:

Chapter VI

FIELD OPERATIONS

PRE-OBSERVATION PROCEDURES

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 notifications 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 rates.
9. Identify unique problems and conditions that may 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 may 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. Observation may not be required if the source has a variance or is exempt from the 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 VII). This determination may 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

accordingly 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

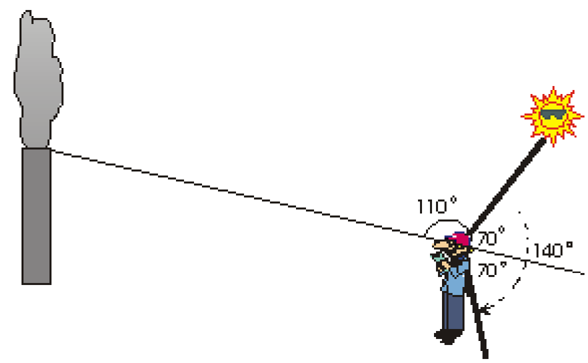
First, determine the sources of visible emissions at the facility and identify the specific source that you are going to observe. Before making your observations you need to determine the correct viewing position for the source being monitored. You will need to select backgrounds, determine the wind 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 may 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° sector to his back.

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° (see figure 12). This will place the sun in the required cone-shaped 140° 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.



Ch.6-Fig.1: Determining Proper Sun Position

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 which might be different from that at your office location. Position the sun in a 140 degree sector to your back when facing the source. You may 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."

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:

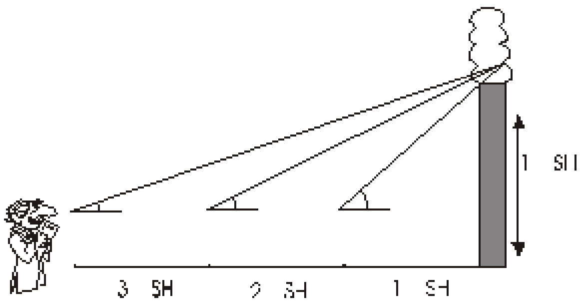
- You are observing a tall stack
- The sun is high overhead
- You are observing the plume high in the sky

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

CHECK FOR DIRECTION OF PLUME TRAVEL

Method 9 states:

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



Ch.6-Fig.2: 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 13). The intent is to keep within +/-18° 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 (refer to Chapter III). 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° of perpendicular to the plume line of travel. The reason for standing approximately perpendicular to the plume when making the VE determination 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°, final opacity values must be corrected using the method in Chapter VII (Slant Angle Correction).

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 (commonly referred to as *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° sector to your back). Observations should be made after the point of water evaporation, in full accordance with Method 9.

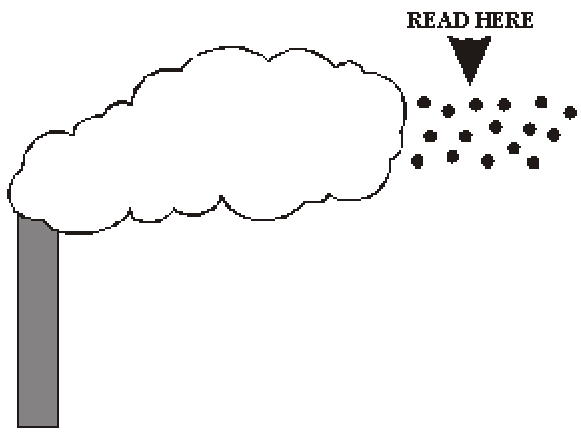
If there is a *steam plume*, sections 2.3.1 and 2.3.2 explain how to implement the rule.

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 may hang on to particulate matter and if the particulate is hygroscopic, the water could hang on at lower humidities. 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.

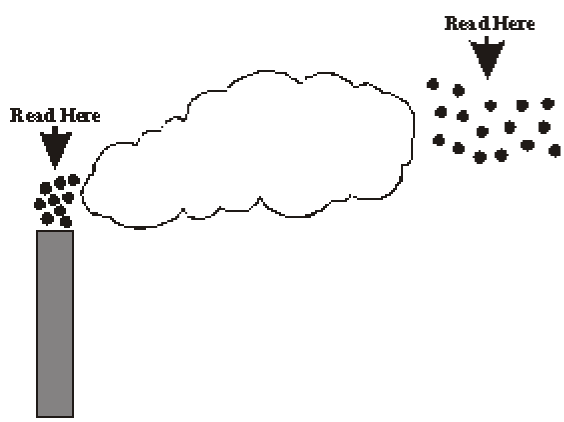


Ch.6-Fig.3: Attached Steam Plume

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.



Ch.6-Fig.4: 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 it 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 in. 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 can be sure that you will be challenged later on this issue if there is no reason to suspect 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 may 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 percent opacity intervals unless the permit or regulation specifies otherwise. Continue on 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 may 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 the observation. 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- hand section 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.

Chapter VII

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.

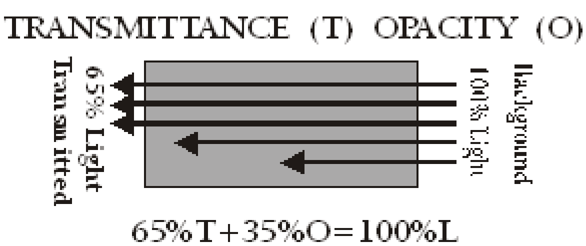
T = % Light Transmitted
O = % Light Obscured
L = 100% Total Light

% 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?



Ch.7-Fig.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 figure 17). 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 such as ETA's OpaciCalc for Windows. 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.

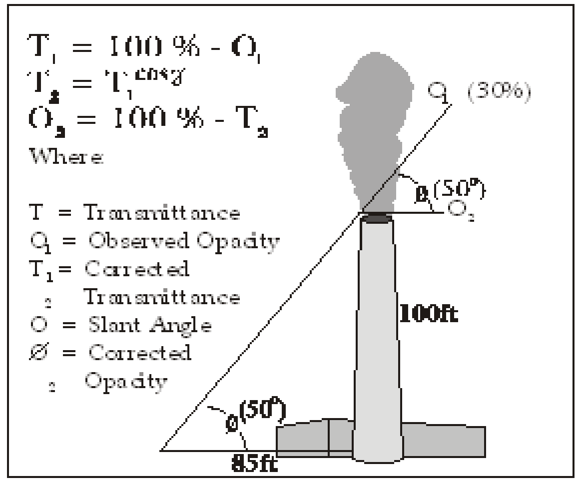
Federal standards and SIP opacity regulations sometimes contain averaging times other than 6 minutes. **EPA's policy is that if the SIP regulation does not clearly specify an averaging time or other data-reduction technique, the 6-minute average calculations should be used.** EPA is currently in the 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
Min / Sec	0	15	30	45	Comments
	15	15	75	10	
2	16	15	15	15	
3	45	80	70	10	
4	15	15	10	35	
5	35	16	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	6	6	10	15	

Ch.7-Fig.2: 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 table 2). The usual guidance to eliminate this problem is to observe the plume from a distance of at least 3 stack heights from the source. At 3 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 and, consequently, observed opacity increases 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 may 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.



Ch.7-Fig.3: Corrected Optics for Slant Angles

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 18). The observed opacity is 30%. What is the true opacity?

Ch.7-Fig.4: Slant Angle Correction

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) is 50O.

4. Determine the cosine of the slant angle.
   Cosine of 50O = 0.643

5. Calculate corrected transmittance (T2).
   $T1^{COSi}$ = T2
   $0.70^{COS\ 50}$ = T2
   0.700.643 = T2
   0.795 or 80% = T2

6. Calculate corrected opacity (O2).
   100% - T2 = O2
   100% - 80% = O2
   20% = O2

EASTERN TECHNICAL ASSOCIATES

SLANT ANGLE CORRECTION TABLE

SLANT ANGLE	MEASURED OPACITY (%) 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	18.8	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	92.6	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	34.6	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	10.6	14.4	17.9	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	2.9	5.7	8.7	12.0	14.9	18.1	21.4	24.9	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	77.8	99.0

CORRECTED OPACITY (%)

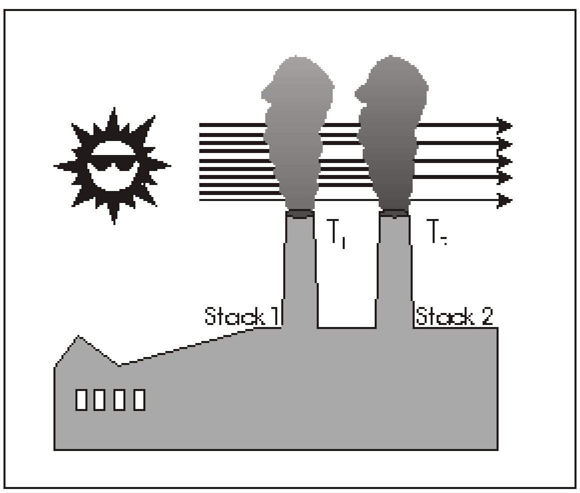
TWO PLUMES PROCEDURE (COMBINED OPACITY)

Sometimes it is necessary to combine the opacities of two separate emissions (e.g. bag house stubstacks, 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:

Two stacks from different boilers are side by side (see figure 19). Under the bubble concept the combined opacity is utilized from this source. Viewing conditions (i.e. sun angle) do not allow the plumes to be viewed together. The opacity of each stack was determined, one is 10% and the opacity of the other is 30%. What is the combined opacity?



Ch.7-Fig.5: Two Plumes Procedure

1. The opacity (O1) of stack 1 is 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 is 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 - the ambient temperature.
Wet bulb temperature - the temperature indicated by a "wet bulb" thermometer (thermometer with its bulb covered by a moistened wick and exposed to a moving air stream); represented by the curved axis on the left side of the chart (saturation temperature).
Moisture content - percentage moisture content of the stack gas; represented by the vertical axis. This information is available from source test data.

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. The point on the psychrometric chart where the plotted values intersect is called the ambient state point. 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 plume condense?

Solution:

Refer to the Steam Plume Modeling Chart example on the following page. Plot ambient wet bulb and dry 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); therefore, a water vapor plume will be visible.

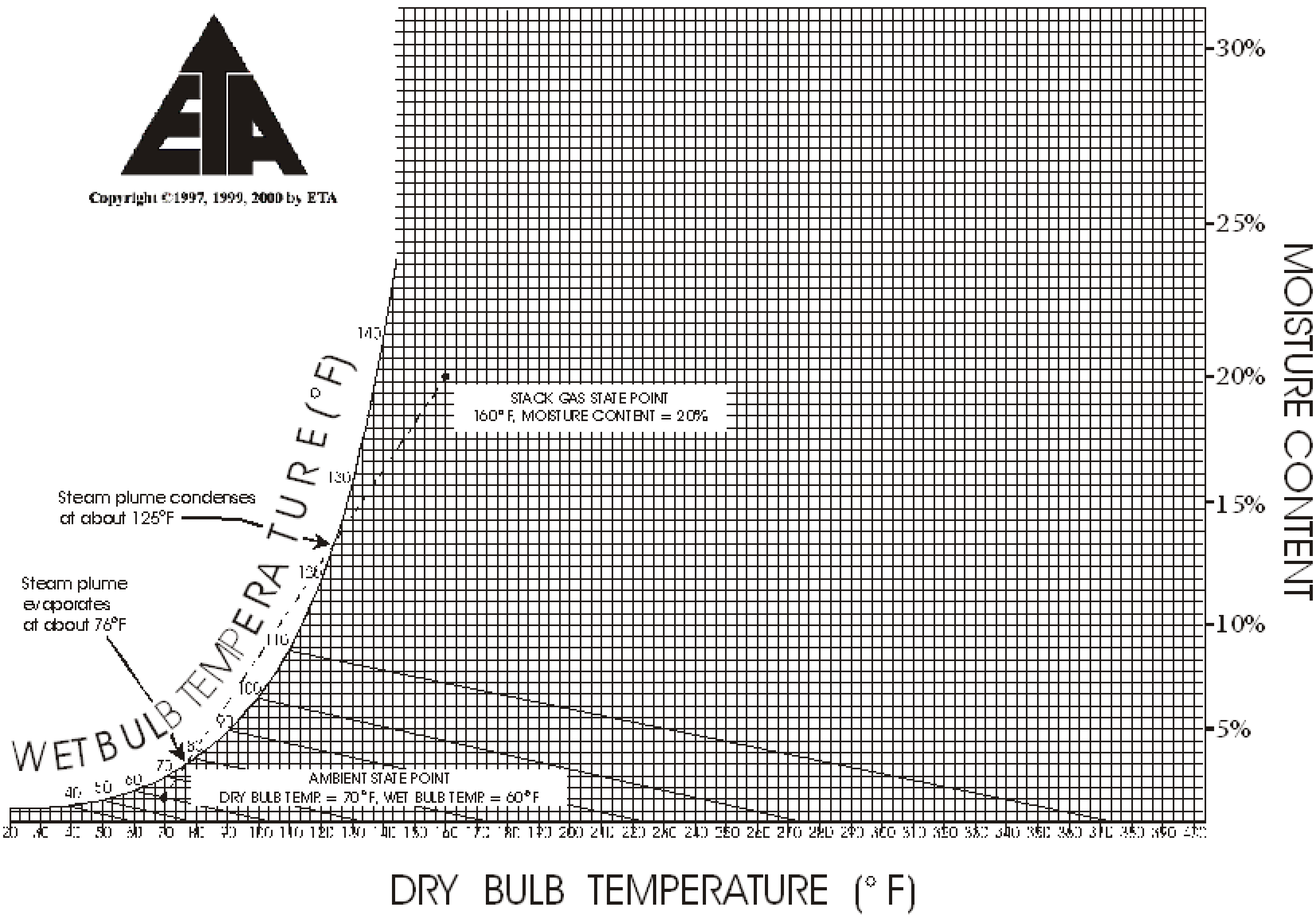
Note:

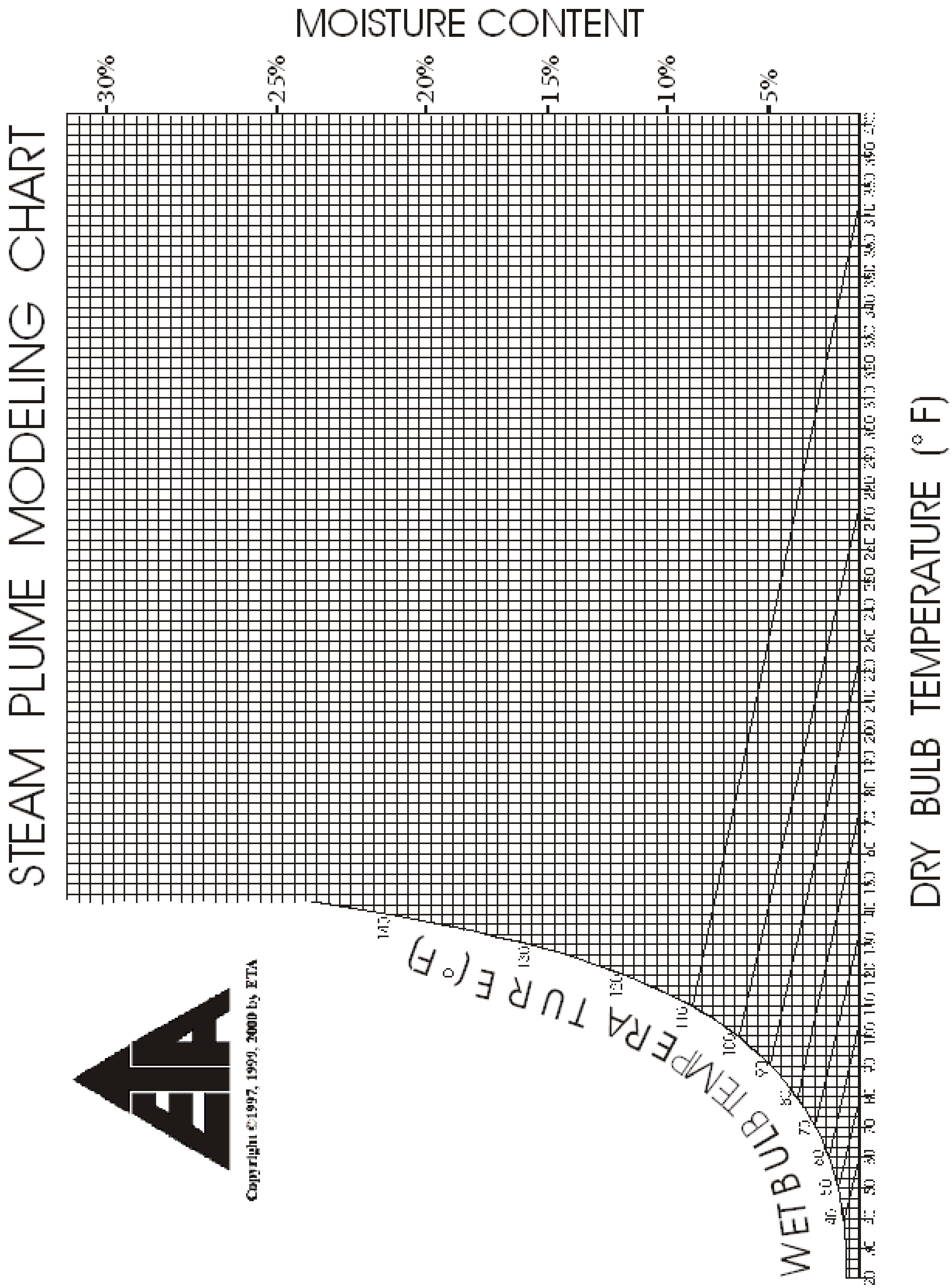
The following steam plume modeling charts are based on conditions at sea level (i.e. 29.92 in. Hg). Barometric pressure varies with elevation. As a result, barometric pressure is routinely corrected for altitude. If the barometric pressure is less than 29.5 inches Hg, an equation must be used to calculate the final moisture content (MC). For further 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 website at **www.eta-is-opacity.com.**

This modeling approach is based on ideal gases in plumes not containing hygroscopic particles or salts. Condensed water vapor plumes containing hygroscopic particles, acids, or salts can form above the normal dew point. For more information on condensed water vapor plumes, please visit our website at **www.eta-is-opacity.com.**

Notes:

STEAM PLUME MODELING CHART




STEAM PLUME MODELING CHART
MOISTURE CONTENT
30%
25%
20%
15%
10%
5%
DRY BULB TEMPERATURE (° F)
WET BULB TEMPERATURE (° F)
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Chapter VIII

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 DATE

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 6 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:

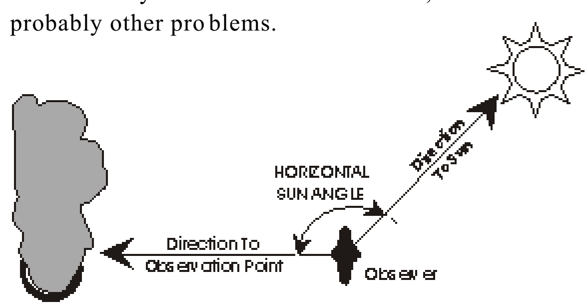
> Name of the plant
>
> Facility and emission point location
>
> Type facility
>
> Observer's name and affiliation
>
> Date and time of observation
>
> Estimated distance to the emission point
>
> Approximate wind direction
>
> Estimated wind speed
>
> Description of the sky conditions (presence and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

If any of these items are missing, it may be pointed out in a deposition, or 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. The source layout sketch. 2. The direction to source section. 3. The observation date and observation period start stop times.

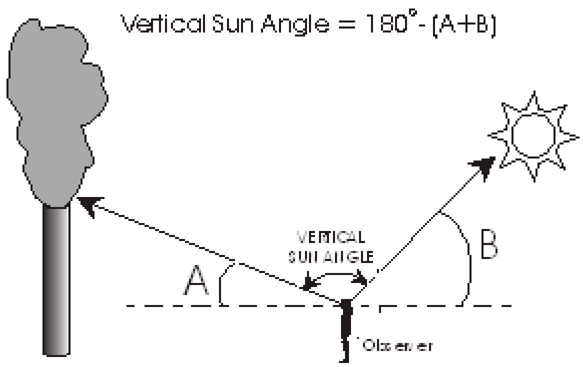
Areas 2 and 3 can be used to determine if the sun location marked on the source layout sketch is correct. Look at the north arrow's relationship to the source and determine whether there are any discrepancies when compared to emission point "Direction from Observer" line on the VEO form. If the data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



Ch.8-Fig.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 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 or the US Naval Observatory ICE program may be utilized to get the sun location.



Ch.8-Fig.2: Vertical Sun angle (side view)

Lastly 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 co-mingle with the plume being evaluated and create a positive bias in the observations. 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 may 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? 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 (over 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 Chapter VII (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 over a shorter time frame.
- 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 may 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 difficulties.

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

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

Chapter IX

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 observaions highly reccommends an intensive 1- or 2-day classroom session. Although classroom training is not required , it is highly recommended because the lecture sessions increase the observer's knowledge and confidence in field operations, reduces the time needed to certify, trains the smoke reader in documentation techniques that will help their obsevations 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 opacities from 0 to 100 % opacity. 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. You should bring the following items to the field session:

Two medium, black, ballpoint pens
Clipboard
Two rubber bands

Optional items include:

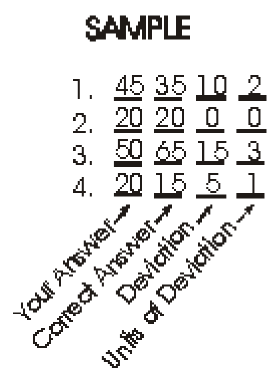
A folding chair
Non- alcoholic beverage or snack
Golf umbrella
Sunscreen
Hat

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 practice form. This form is used for practice prior to certification runs. First, the field instructor will demonstrate the standard plume opacities: 25 percent, 50 percent, and 75 percent. 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 percent. The field instructor will then announce the correct answers to the four practice plumes. Write down the correct answers beside the estimates and compare the answers (see figure 22). This procedure will be followed for both the black and white smoke. Only after a significant segment of the group is successful will actual certification testing begin.



Ch.9-Fig.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 percent increments to 25 random black plumes and 25 random white plumes. Your error can not exceed 15 percent opacity on any one reading. Your average error can not exceed 7.5 percent opacity for each category.

TESTING FORM

After the practice session, a two-part form will be handed out. An example of this form is given at the end of this chapter. Fill in the name section 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, then circle no. If you are wearing sunglasses circle yes, and fill in the type, and/or color of lens such as Polaroid, Photo gray, etc.

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 shown again.

THE FIELD TEST

Field Instructors will announce when the plume should be read, and when the paper should be marked. The following procedure will be used during the test:

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

"Reading Number 1"

Look up and make your determination of the opacity. Approximately 3 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 number is announced.

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

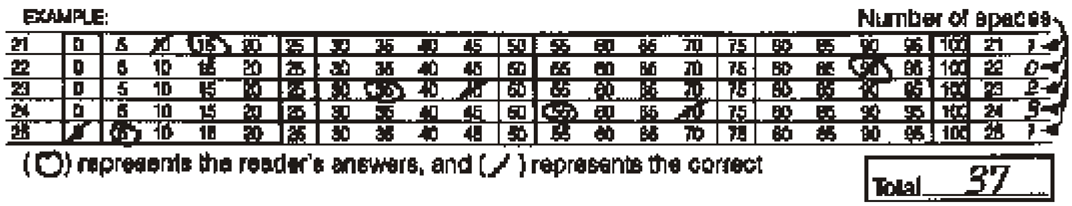
If the wind makes the plume unreadable, yell "SCRATCH" or “REPEAT” loud enough for the field instructor to hear. The instructor will then repeat that reading at the same opacity. The goal is to present you with the best possible test.

On occasion, the field instructor will interrupt the reading with the word "scratch." The paper should not be marked; 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 a run (i.e., 50 plumes).

At the conclusion of the test, make sure your form is filled out entirely. 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 figure 23). Marking your yellow copy expedites grading and assists in further training when needed.

Notes:



Ch.9-Fig.2: Determining Error

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 exampleif the 25 had been circled and the operator announced 30, the error would be one space:

A 20 and a 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:

1. NO ERROR OF 4 OR GREATER ANYWHERE ON THE PAGE

2. TOTAL ERROR ON EACH SET OF 37 OR LESS

The white and black smoke can each have a total error of up to 37 increments. 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 graders verify that you have passed the test. After all the papers have been graded, the names of those who have passed the test will be announced. Once you have completed the certification process, a certificate will be sent to the address on the registration form within 2 to 3 weeks.

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 6 months, at which time you must repeat the qualification procedure to retain certification. This is a requirement of Method 9.

Chapter X

METHOD 9

Method 9 - Visual Determination of the Opacity of Emissions from Stationary Sources

INTRODUCTION

Many stationary sources discharge visible emissions into the atmosphere; 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 may be controllable and some of which may not be controllable in the field. Variables which 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 which may 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 which 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) which involve a total of 769 sets of 25 readings each are 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 power 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.

The positive observational error associated with an average of twenty-five 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 back. Consistent with maintaining the above requirement, the observer shall, as much as possible, make his observations from a position such that his 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 observations with his 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 Plume. 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.

2.4 Recording Observations. Opacity observations shall be recorded to the nearest 5 percent 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 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

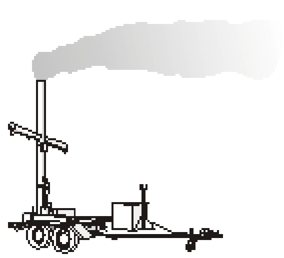
3.1 Certification Requirements. To receive certification as a qualified observer, a candidate must be tested and demonstrate the ability to assign opacity readings in 5 percent increments to 25 different black plumes and 25 different white plumes, with an error not to exceed 15 percent opacity on any one reading and average error not to exceed 7.5 percent 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 which meets the requirements of Section 3.3.
The certification shall be valid for a period of 6 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 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 to 100 percent 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 percent 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 6 months, whichever occurs first.

3.3.1 Calibration. The smoke meter is calibrated after allowing a minimum of 30 minutes warm-up by alternately producing simulated opacity of 0 percent and 100 percent. When stable response at 0 percent or 100 percent is noted, the smoke meter is adjusted to produce an output of 0 percent or 100 percent, as appropriate. This calibration shall be repeated until stable 0 percent and 100 percent readings are produced without adjustment. Simulated 0 percent and 100 percent 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.

Technical Note:
ETA generators are built and tested to assure that all of the requirements of Table 9.1 are met.



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 span drift	+/-1% opacity, 30 minutes
Response time	5 seconds

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 percent 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 may be calculated from:

$$é = 2 \tan^{-1} (d/2L),$$

where
é = 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 may be calculated from:

$$é = 2 \tan^{-1} (d/2L),$$

where
é = 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 percent in the smoke meter pathlength. Filters calibrated within +/-2 percent 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 percent 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 over a 1-hour period. The drift is measured by checking the zero and span at the end of this period.

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

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3. Condon. E.U., and Odishaw, H., Handbook of Physics, McGraw-Hill Co., New York, NY, 1958, Table 3.1, p. 6-52.

Notes:

Chapter XI

METHOD 22

Method 22--Visual Determination of Fugitive Emissions From Material Processing Sources

(Method 22 added by 47 FR 34142, August 6, 1982)

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. As 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 revised 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, October 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. Record also the estimated wind speed, wind direction, and sky condition. 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 is feasible. 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 observations begin. Use one stopwatch to monitor the duration of the observation period; 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 completed, 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; stop the watch when the emission stops. 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., the emission time.

5.4.1 Observation Period. Choose an observation period of sufficient length 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 6 minutes in any hour, then observations may (optional) be stopped after an emission time of 6 minutes is exceeded. Similarly, when the regulation is expressed as an emission frequency and the regulation prohibits emissions for greater than 10 percent of the time in any hour, then observations may (optional) be terminated after 6 minutes of emissions are observed since 6 minutes is 10 percent of an hour. In any case, the observation period shall not be less than 6 minutes in duration. In some cases, the process operation may be intermittent or cyclic. In such cases, it may 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 to 20 minutes without taking a rest break. For sources requiring observation periods of greater than 20 minutes, the observer shall take a break of not less than 5 minutes and not more than 10 minutes after every 15 to 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) may prevent a clear view of the affected facility. This may particularly be a problem during periods of high wind. If the view of the potential emission points 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 form.

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 the observation period began and ended, as well as the clock time 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.

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 further 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. Guidelines for Evaluation of Visible Emissions. EPA-340/1-75-007, April 1975.

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 Wohlschlegel, 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.

ETA recommends the following for further 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.

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U.S. Environmental Protection Agency. Guidelines for Evaluation of Visible Emissions. EPA-340/1-75-007, April 1975.

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.

FUGITIVE OR SMOKE EMISSION INSPECTION OUTDOOR LOCATION

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

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

OBSERVATIONS	Clock Time	Observation Period Duration, min:sec	Accumulated Emission Time, min:sec
Begin Observation	______	______	______
	______	______	______
	______	______	______
	______	______	______
	______	______	______
	______	______	______
	______	______	______
	______	______	______
	______	______	______
End Observation	______		

FUGITIVE OR SMOKE EMISSION INSPECTION
INDOOR 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 and sun, indicate potential emission points and/or actual emission points.

OBSERVATIONS	Clock Time	Observation Period Duration, min:sec	Accumulated Emission Time, min:sec
Begin Observation	________		
	________	________	________
	________	________	________
	________	________	________
	________	________	________
	________	________	________
	________	________	________
	________	________	________
	________	________	________
		________	________
End Observation	________		

EPA
VISIBLE EMISSION OBSERVATION FORM 1

Form Number | Page ___ Of ___

Continued on VEO Form Number

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

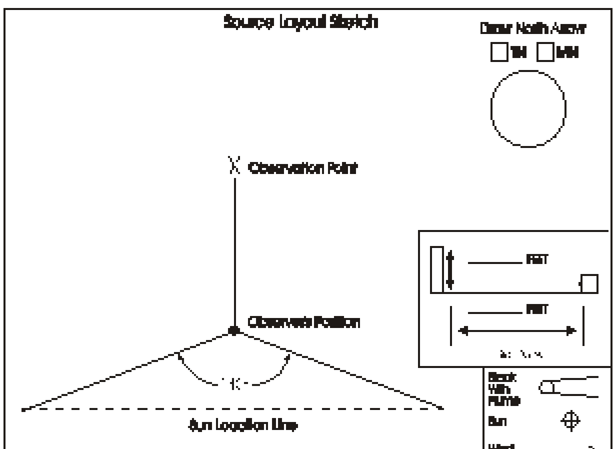
Emission Color Start End | Water Droplet Plume Attached ☐ Detached ☐ None ☐

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



Longitude | Latitude | Declination

Additional Information

Observation Date	Time Zone	Start Time	End Time

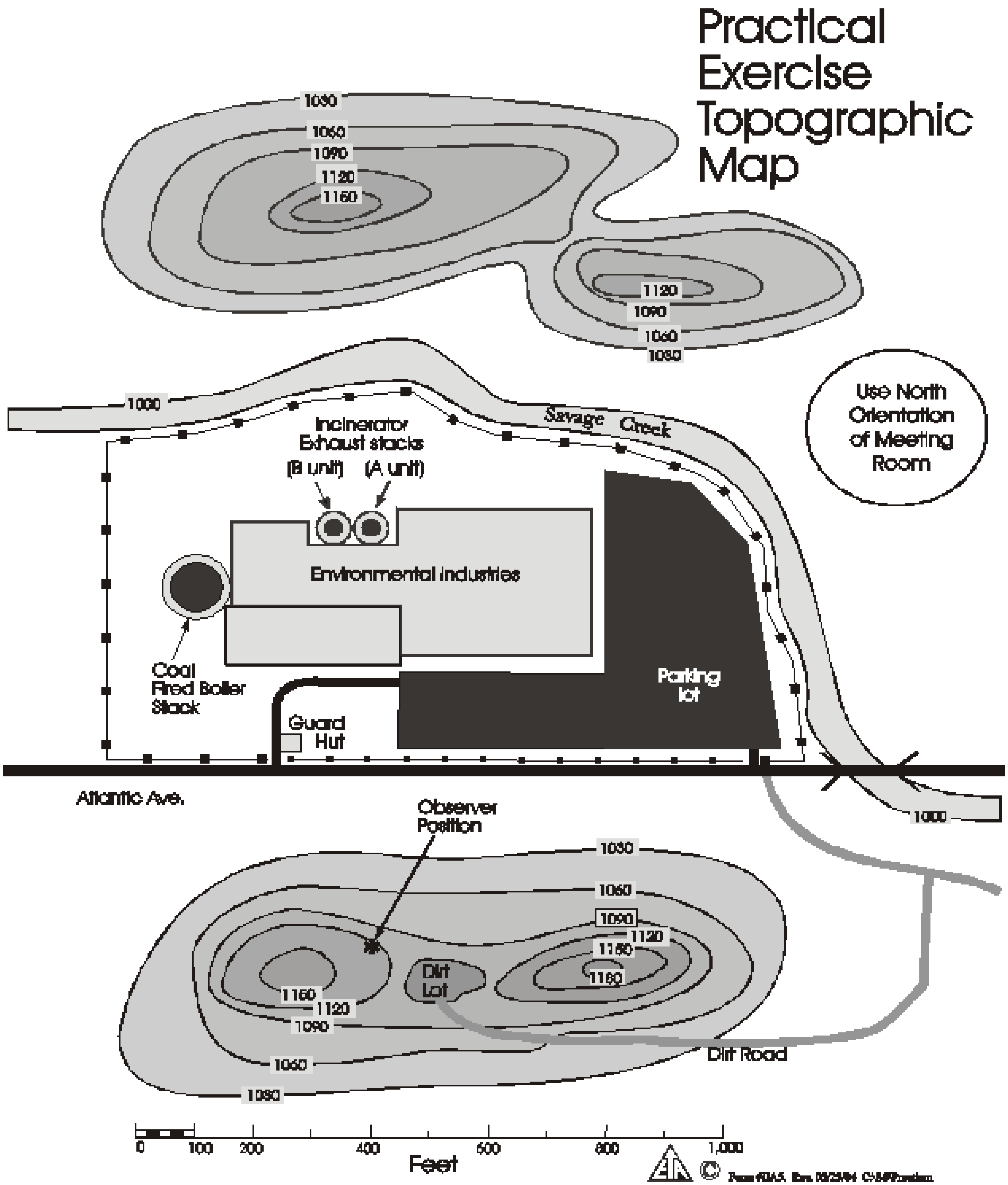
Sec / Min	0	15	30	45	Comments
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					
17					
18					
19					
20					
21					
22					
23					
24					
25					
26					
27					
28					
29					
30					

Observer's Name (Print)

Observer's Signature | Date

Organization

Certified By | Date


Practical Exercise Topographic Map
1030
1060
1090
1120
1160
1120
1090
1060
1030
1000
Savage Creek
Use North Orientation of Meeting Room
Incinerator Exhaust stacks
(B unit)
(A unit)
Environmental Industries
Coal Fired Boiler Stack
Parking lot
Guard Hut
Atlantic Ave.
1000
Observer Position
1030
1060
1090
1120
1160
1160
Dirt Lot
1160
1120
1090
1060
1030
Dirt Road
0
100
200
400
600
800
1,000
Feet

Specifications Sheet Practical Exercise

Facility Information:

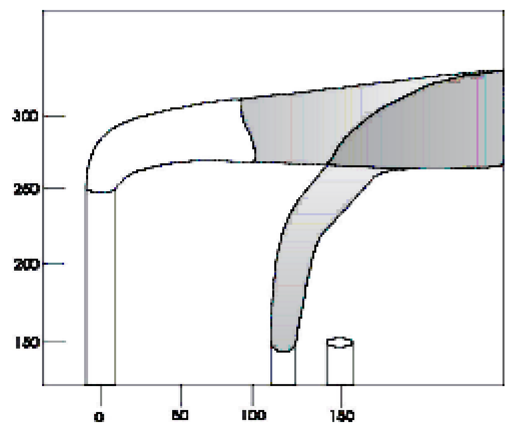
Name: Environmental Industries
Address: 2412 Atlantic Ave., Raleigh, NC 27604
Regulatory Method: Method 9 (6 minute average)

Permit Compliance Limit:

The source shall not emit into the atmosphere emissions that, on evaluation, create a six (6) minute average data sequence equal to, or grater than twenty percent (20%) opacity.

Emission Point Information:

Process Equipment- Coal Fired Water Tube Boiler
Operation Mode- 85% of Maximum Capacity
Control Equipment- Electrostatic Precipitator
Operating Mode- Spark Rate of 149/minute
Stack Heigh= 250 ft
Observation Angle- Abney Level
Direction- Compass
Latitude= 35.78 degrees N
Longitude= 78.65 degrees W
Compass Declination= 6 degrees W



Meteorological Information:

Wind Speed: 7-10 MPH
Skies: Refer to Slide
Temperature/Relative Humidity: Sling Psychrometer

Sun Location- US Naval Observatory Website:

Actual Standard Time (PM)	1:00	1:30	2:00	2:30	3:00
Azimuth- Degrees from True North	176	189	202	214	224
Altitude- Degrees off Horizon	57	56	55	52	48

Visible Emissions Observations:

VEO Form Number: EI001
Opacity: The following opacities were observed during the ten (10) minute observation. Your start time is when you begin entering opacities. Enter data on the VEO form. Min. 1 {15,15,10,5} Min. 2 {15, 20, 25, 25} Min. 3 {30,40,35,35} Min. 4 {40,30,35,35} Min. 5 {15,25,25,40} Min. 6 {40,40,30,35} Min. 7 {35,40,30,35} Min. 8 {30,30,20,15} Min. 9 {10,15,5,10} Min. 10 {10,10,10,5}

Please complete (include sketch of the area) and **sign your VEO form** including your actual organization name.

Notes

EASTERN TECHNICAL ASSOCIATES

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 assists clients with mass/opacity variance requests when mass is in compliance and opacity is not.

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