I. History, Theory, And Methods for Evaluating Visible Emissions

History of the Method

Edward I, the demise of William Wallace (of Braveheart fame), was the first to enforce an "opacity" law in 1307, executing a black smith for the use of coal. Laws are a little less Draconian today, but not much from a business's prospective. A business can be fined to death, even though you will not personally be executed. However, jail is a real possibility for the owner and/or owners' responsible party. We live in a litigious society, and as an Opacity Evaluator you will become a trained witness in this narrow field.

The Equivalent Opacity Method has contributed greatly to the clean environment we enjoy today and is the most effective and reasonable tool for continued improvement. The method first began with purely economic incentives and can be traced to the work of Maximilian Ringelmann. Mr. Ringelmann was a boiler engineer who developed a series
of charts with increasing intensity of black cross-hatched lines. Through comparison of the emissions to the charts, the combustion efficiency of the unit could be tuned. The Ringelmann Number provided important positive feedback on the efficiency of the boiler, during an age which lacked the instrumentation available today.

By the beginning of the Twentieth Century the Ringelmann Number had begun to be relied upon for Air Emissions compliance purposes by the Bureau of Mines and several state programs. Some of these laws may remain on the books, so it is important to realize how these methods relate and that the data can be transposed, though with some loss of accuracy. The Ringelmann Number lacks the accuracy of the Equivalent Opacity Method, which is now the preferred method in most, if not all, jurisdictions.

Equivalent Opacity (40 CFR 60 Appendix A, Reference Method 9) was developed in the mid Twentieth Century as a means of more accurately determining and regulating emissions. It has now largely, if not completely, replaced the Ringelmann Number as an enforcement tool. Much of the Method can be attributed to the California Air Resources Board, including the development of the first smoke generator.

The Equivalent Opacity Method has been adopted into law and is the compliance audit "method of choice" for many facilities affected by Title V because of its qualitative nature. Studies were undertaken to determine the potential errors under the best conditions. It was determined that the Black Smoke could be read with a positive error of less than 7.5% 100% of the time and with less than 5% positive error, 99% of the time. White Smoke could be read with a positive error of less than 7.5%, 99% of the time, and 5%, 95% of the time. Although there is a slight positive error, it was very repeatable, and the statistical bias and accuracy of each reader can be determined by reference to the six-month certification records.

A legally defensible Certification of Compliance requires a reputable and current certification, complete documentation of any atmospheric or observer conditions which might bias the readings, and adherence to the key requirements of the Method. Regulatory requirements specific to your facility may require or allow a variance from the Method.

Opacity Theory

Opacity is the ability of an emission to obscure, expressed as a percent. Literally the reduction in visibility of an object or background as viewed through the diameter of a plume. (Look at the Background, not the smoke.)

Accuracy of the Method -Tested and True, legally referenced.

The first reaction to many being trained for the first time in a qualitative procedure is to be concerned about the accuracy, repeatability and possible bias of an individual observer. The accuracy of the method, with correct training and application of the training, has been proven in repeated empirical studies and tested legally.

Part of the technical and legal test of the method relates to correct observation procedures, and for any legal proceeding, the documentation's completeness, reliability, and ability to be referenced outside a potentially biased source. The reasons behind the technical basis for the accuracy will be discussed throughout this review, but particularly in this section and in Section III. Some important legal information is included in Section V.

Technical Basis:

I = the Incident Light leaving the plume along the same path
Io = the Incident Light impinging upon the emission plume
Opacity= (1- I/Io) x 100 = the amount of light obscured by the emission

Comparison of Methods

% Transmission	% Opacity	Ringelmann Number
0	100	5
20	80	4
40	60	3
60	40	2
80	20	1
100	0	0

Light Obscuring Mechanics

Reflection - Mirror
Refraction - Breaks the light into a different direction. (Fracture)
Absorption - Re-emission in non-visible wavelength. (Like a sponge - absorbs and takes away the visible light.)

The light from an object is obscured by means of reflection, refraction, and absorption. How these mechanics are affected by the process, environmental, and observational variable s is important to realize in determining the best observational plan and position. Real world constraints may mean compromising the ideal in order to accomplish the reading. It is important that the significant factors which may affect the opacity be fully documented.

Distance also obscures your vision, and it is our recommendation that the observer be between 15' and 1/4 mile. Closer and the observer is standing in the emission. A farther distance obscures the observer's vision. Exceptions may be necessary, but the observer should be 15' to 1/4 mile.

Variables that Influence the Accuracy of Opacity Measurements

The Game Plan: 140, Contrast-Angles-Perpendicular, WV, Haze-Interval-Knight-Eyes

The purpose of the VE training and certification program is to refine and calibrate the eye to read opacity within a scale of 5 percent increments. The human eye is a unique instrument, capable of this degree of accuracy, of discerning light in a narrow electromagnetic band and discerning the wavelength (color).

Several factors influence the accuracy of a given observation/opacity reading. A defensible certification of compliance requires the reader to understand and document these factors. The Visual Emissions Observations (VEO) form requires the observer to note and describe the conditions of reading that are necessary to substantiate the validity of observations. **Without understanding and documenting these factors, it is possible that the readings would be invalidated/or impeached in a court review.**

Significant Affects*: need to be documented or corrected for in the field

Emission Characteristics*: Comments, Attachments, or Note as Proprietary

Particle Size (0.4 to 0.7 microns), Particle Density, Particle Refractive Index, Chemical Properties.

The Emission Characteristics have a significant effect on the emissions. Particles in the 0.4 to 0.7-micron range will scatter light more effectively than those in other ranges. For many processes this may not be a controllable factor as emissions below 1 micron are increasingly difficult to remove. Upstream agglomeration process may assist, but in many cases, these are not practical solutions.

Other factors shown to exert a significant affect are the emission's density and refractive index. Chemical properties affect the color and may also cause a secondary plume formation, which will be discussed later. If possible, it is good to be aware of and document these properties.

Sun Angle*: Required to be right, the sun angle overrides all other criteria, biases against the source. Block F

The importance. Of the sun angle is two-fold. First and most obvious is the eye-fatigue associated with staring into the glare of the sun. This could result in significantly lower or higher readings. More important to the accuracy of the method, however, are the physics of light scattering. Small particles tend to scatter light in the forward direction, at small angles with reference to the direction of the sun's rays. Thus, the plume will appear much more opaque, if it is not viewed with the sun behind the observer's back. The most accurate readings are taken when the sun is within a 140-degree sector behind the observer. The Azimuth must be greater than 110 degrees above the forward horizon (toward the direction of observation) or 70 degrees above the horizon from the back of the observer. There is no recognized mechanism for compensating for the errors which would occur if this is done incorrectly.

Example: 25k: fine thrown out because of wrong sun angle.

Avoid 11 am to 1 pm in most US time zones. If justified, not having the sun at Azimuth at noon time is usually accepted, for compliance demonstration, it is not likely enforceable.

Wind Direction*: Recommended/document. Block F/E correctly reconciled

It is important to read through the plume diameter of approximately the size of the stack exit. It the plume is blown toward or away from the observer it is likely to be read through a longer path-length than if readings are taken with the wind blowing perpendicular to the line of sight. The longer the path length through the plume the greater the apparent opacity.

Mathematically the error involved in making non-perpendicular observation, with actual emissions of 20% at 45 degrees, will result in a predicted observed emission of 27% (or a 35% error). It is difficult, if not impossible, to with reasonable accuracy, correct for non-perpendicular observations. Ideally the observer should relocate to a better position and even if in the middle of observation, the wind shifts, the observer should shift positions and note this on the VEO form. For enforcement purposes, if a suitable position cannot be found, the observer should note the conditions and discontinue reading until viewing conditions improve.

Unlike the slant angle, the angle at which the emissions are blown by wind off perpendicular cannot be accurately determined and due to variable winds, may not be consistent. For daily audits, "waiting until the conditions improve" may be problematic. The audit must be done. Since the observation will be biased against the source in the unadjusted format it therefore should be accepted as "the emissions are not worse than". Most state programs find this to be a reasonable declaration and will accept results of tests conducted in a manner or under conditions which would bias against the source, if the results indicate the source is meeting the requirements.

If the source is not meeting the requirements under conditions of reading which bias against the source, but you believe this to be related only to the adverse reading condition, and not an actual occurrence, it will be necessary to wait for a more suitable condition, and/or thoroughly document the conditions (process and reading) and note the reason you believe the source to be still in compliance. The environmental coordinator at your site and the site legal counsel may need to know the details of the situation and provide direction as to the appropriate actions in this situation.

Slant Angle*: Document, correct data if needed. Block C

As the observer moves closer to the base of the stack, the angle of sight through the plume and resultant Path Length increases, causing the observed opacity to increase, even though the cross-plume opacity is constant. The effect is predictable when the geometry is examined. Looking at the effect with geometry, it can be seen that at 3 stack height (18 degrees slant angle) that the observed path length increases by only 5% and the potential error at 20% opacity is insignificant within the variation of the method. However, at one stack height the effect approaches the margin of error at 20% opacity.

A slant angle chart which provides correction factor based on the geometric calculations is included on page **47.**

An observer must balance the ability to be within visual range and at the same time meet these criteria. Distance also obscures your vision.

Background*: An example of a bad background is white paper on white paper. Block E

Maximum accuracy is reported when the plume is read against a contrasting background. The reader should choose the background of maximum color contrast with the plume. i.e... a green tree is considered best for a light (white) colored plume and a blue sky for a black plume. However, many observers find a contrasting object, such as a building or tree, improves the accuracy and repeatability of their readings.

LIGHT-Gee-WHITE, green Black and Blue
Observers line of sight should not include more than one plume.

Condition	Contrast	Apparent Density
Cloudy Sky	Lower	Lower
Cle r	Higher	Higher
Haze	Lower	Lower
Good Visibility	Higher	Higher
White Smoke & White Clouds	Lower	Lower
Black Smoke & Dark Clouds	Lower	Lower

Viewing Point*: Document- Block D

Method 9 procedures expressly require that the observation point be that of the maximum opacity. Since the plume dissipates as it travels away from the point of emission, this would normally be as close to the point of emission as possible. There are exceptions when uncombined water or secondary particulate formation can occur. Observations must be made where uncombined water is not present, since water condensate can form highly opaque plumes and water emissions are not a regulated air emission.

Page 16 (2.3) provides some information as to appropriate observations under these conditions. It is important to note that without documentation specifically noting the viewing point, any observation would be unrepeatable and without basis. Always report the viewing location.

Time Interval Between Readings*: Document any deviation from the standard. Block H

Staring at a steady state plume continuously while making 15-second internal reading causes eye fatigue, which can lead to reduced visual acuity. To prevent this the observer should only glance up at the plume momentarily and then make the determination (recall in your mind the calibration points, compare, and decide) of the plume opacity at regular 15-second intervals. This does have a double meaning... it applies in the field when conducting tests and when you certify. Staring at the plume when you try to certify will cause more difficulty, not less in accomplishing the certification.

The method requires a 15-second internal. If the observer is tired or distracted to the point of not being able to maintain this interval during the reading, observation should be terminated until conditions are more favorable. Any deviation from the 15-second interval must be noted and explained on the VEO form.

When reading for long periods - take a break if you lose concentration.

Atmospheric Haze*: Document, or preferably DON'T. Block E

Haze, natural or manmade, reduces the contrast between the emission plume and the background. A reduced contrast leads to a reduced opacity, as observed. If the visibility is at least three (3) miles, hazy conditions should not significantly affect the opacity reading. However, if the visibility is less than three (3) miles, readings be delayed. It is not possible to account for the effect of haze as the result would bias in favor of the source. Most regulatory authorities would not consider the results acceptable, but if daily readings are required and a more suitable condition cannot be attained, note the condition and conduct the readings at www.weather.com or the nearest airport. In addition, the observer's judgement should be used to determine the visibility.

Wind Speed* Atmospheric Stability: Block E

A strong wind or unstable atmospheric conditions can cause the plume to rapidly dissipate. Although this will bias in favor of the source, under most circumstances this is not a concern, if the plume can be read close to the stack exit and the plume remains reasonably intact. If the plume shears off at the stack or condensate/secondary particulate formation are a concern, the readings would not be possible. A camera would be helpful in documenting the plume situation at the time of such readings.

Either a wind meter, the Beaufort Wind Scale (page 35) or local (plant, site or public one in the vicinity) should be used at reference. Some states forbid reading above 35 mph because of assumed conditions of haze. Others recommend against it. As a training company we recommend assuring your safety first.

Night Viewing:

Night viewing is not viable with this training. We provide a separate program. DON'T read at night without certifications to do so. Although this is possible with the appropriate training, Night Observations are beyond the scope of Method 9 and this training.

Corrective Lens/Eyesight/Eye' Fatigue: Document. Block G

Corrective lens are accepted under the method. Poor uncorrected eyesight and other eye problems are the reason some do not certify. Six-month certifications are required under Method 9. We also recommend at least annual eye exams by an Optometrist or Ophthalmologist and use of the same corrective lens as when certifying, although this is not required by the Method.

Under the Method eye fatigue is a concern, as this may reduce visual acuity. There is no method for determining the effect, and this might vary. Therefore, it would be better to read at the beginning of a shift, rather than at the end.

The method requires that you note if you are wearing sunglasses during the certification process and if so, you should wear the same sunglasses during reading. Lens which change shade with the intensity of the light must not be used in Tennessee, although are allowed in other states.

Use of Camera:

Block C (documents emission point)
A camera or photo of emissions has not been determined by the courts to necessarily reflect the specific level of opacity. It is considered Secondary evidence which will support the testimony regarding geometry and plume characteristics/location/flow. Those not involved in enforcement would rarely require this additional documentation, and the concern of revealing proprietary information does exist. A telephoto lens should not be used.

Site survey:
A perimeter survey and if possible, a complete review of the site plan should be conducted prior to the emissions reading. For those unfamiliar with a facility it is important to correctly identify the sources to be read and confirm that multiple source interactions will not affect the readings. Attention to adverse environmental conditions and a post survey should also be done after completion of reading to further assure the readings were not inadvertently affected by other sources. Any concerns should be noted.

Opacity Reading Methods

Time Exception:

- Average Numbers, irrespective of time
- Time Averaging (Reference Method 9)
- Stopwatch Procedure: Method 22, Some State Methods

II. Sources of Visible Emissions

The specifics of your permit will define the applicable sources and monitoring requirements. An emission does not necessarily mean a permit violation as, in many cases, start-up, shutdowns and periods of specific malfunction may be excluded. Any allegation of violation must include a review of all of these applicable factors.

Combustion

The three T's and oxygen: Drunk T, T, T, Ohhhh (A Cop)

Combustion is affected by time (mass flow through the process to high), temperature (insufficient), turbulence (inadequate mixing), and the amount of oxygen (starved for oxygen). With modem instrumentation technology and 02 sensing, this is rarely a long-term problem. However, these are the parameters you can adjust to improve the situation or use as a means of trouble-shooting a problem.

- Most common and correctable
- Non-combustion Sources

<u>Includes but is not limited to:</u>

Process Losses:

Fumes, Dust, Mists, Gases, Vapors, Grinding, Melting, Cooking, Material Handling, Reaction Processes, Drying, & Calcining

Fugitive:

Roads, blasting. Roof monitors, demolitions, farming, open burning.

Sources

Condensed Water Vapor:

exempt, read the plume where condensation is not present

Attached v. detached, see page **45**

Read ..... before or after billowy white appearance, as it will collapse back in the atmosphere quickly (relative to humidity conditions) whereas a white emission will dissipate as it travels downwind. You must know the underlying process.

Temperature and humidity conditions along with source conditions can be utilized to verify the conditions under which a steam plume will form. When reading these plumes the weather conditions must be recorded in order to defend the observations and should always be recorded.

Condensable and Secondary Plume Formation

Page 45 provides some specific examples.
In some case the emission may form into a particulate after discharge into the atmosphere. Method 9 requires that the most dense part of the plume be read (with an exception for water droplets). Therefore, care must be made to determine opacity at the correct location in the plume. Knowledge of the process, chemical and physical characteristic of the plume are important in verification of these conditions.

Other Factors Affecting Plume Opacity

- Control Hardware: type, maintenance, and operation
- Operation - review and note
- Raw Materials, a constantly changing process
- Circumvention (This is included to emphasize that the regulators do & people should be trained accordingly.)
- Water Vapor Plumes - excluded, more detail page **44-45.**

Atmospheric Conditions:

Coming up next, Strong winds dilute, plume toward you increases

Miscellaneous Factors:

The Game Plan: 140, CAP, WV, Hike

III. Air Pollution Meteorology

Basic Plume Behavior: (Block D Emissions) Page 46

Coning	Lofting	Looping
Fanning	Fumigation	Mushrooming - Biases reading high (don't read)

Effect of:

- Wind Speed and Direction (use of wind gauge, Beaufort wind scale)
- Humidity/Temperature (use of sling psychrometer/chart)
- High Humidity >70% is often associated with atmospheric turbulence. (Avoid reading if possible)
- Sky Conditions, Cloud Cover (Page 35)
- Atmospheric Haze
- Sky Contrast

Use supporting information from the local weather station, but always be aware and responsible to document what you see and reconcile any differences. Document that readings were possible and the possibility of any variance.

IV. Field Operations

When reading minimum equipment is needed: Watch (15 second timer(s)), forms, and pen/pencil.

Useful Equipment: Camera, Compass, Inclinometer, Wind meter, sling psychrometer. Complete background, history of the source and location of the Emissions.

How to fill out the Form: Tab, the most important document to reference in this Manual

A. Company Identification
B. Process & Control Device
C. Emission Point Identification
D. Describe Emissions
E. Observation Conditions
F. Source Layout
G. Additional Information
H. Data Set
I. Observer Data
J. Form Interrelation

Today - Certification Form: Procedure for today

V. Legal Concepts

Industry Needs to know

"Opacity readings account for more than 90 percent of Agency Enforcement Actions." EPA-600/ 4-83-011.

Specifics of your Permit Requirements

Specific Permit Variances Exemptions:

Process upset condition, start-up, shutdown, etc. Property Rights Exist - regulators have the Authority but must get a search warrant (bad mistake). If provided/granted access they have the right to bring what they see to court. Rights to Confidential Information remain, those who have nothing to hide are innocent, but how you present and the detail of documentation matters. Entry without the Waiver: EPA employees are specifically instructed not to sign such waivers.

Testing

Confidential Information can remain confidential with whom you and the agency certified is significant. Whistle Blower Laws protect you: never lie, or cover up a problem, deal with it and do right.

Regulatory Agencies Need to Know

Legal History	Legal Precedents	Right of Entry	Hold Harmless Agreements
Free & Open Field Concepts	Evidence & Source Information Disclosure	Case Preparation	Case Law Review

VI. Testing Procedures

Time to calibrate the eyes and train the observer in each of you.

Time and Location.

Information required on the Form. Fill it out completely.

Circle the Opacity you choose for each point.
To change and answer and change again? Make an X over the wrong answer you wish to change and then circle the correct answer. It is not uncommon to want to change an answer, or several, when the opacity changes from high to low or vice versa. This is alright, but your first impression is usually your best. Once you turn in the top copy there are no more changes.

When to read and when not to look. When you hear "READ," glance, review mentally, decide. As long as you hear "REEEEAAAAAAD" you can glance again but look away as soon as the word ends. The machine may have drifted off the point, but at least the operator may have ceased documentation with which to compare your reading. You would not likely certify, and from our consideration the basis of the certification could be questioned. It may take a while to sync with our operator, ...but your attentiveness will result in a more rapid certification.

Definition
Obscuring Power as expressed in a percent (not how much smoke). LOOK AT THE BACKGROUND.

The Game Plan: 140, CAP, WV, Hike.

These are your readings ...... that is what you sign not your neighbor's, not anyone else.

To grade your papers, you will keep the yellow copy. Make a slash over the correct answer as we call each answer. Then count the number of spaces to the answer you selected, 0,1,2,3...........if any answer is 4 (20% opacity) or more off you have failed. Tally the deviations and divide by 5 to determine your variation in percent opacity. A tally of 37 or less for the black and 37 or less for white results in a variation of less than 7.5% on each respectively and meets the Method 9 Criteria for Certification.

Before issuing your certification card we will recheck your results for grading errors. If you did not meet the Method 9 Criteria for Certification, we will not issue a certification. Our terms and conditions are reflected on our website.

Sunglasses: best none, grey or green otherwise those wonderful glasses which change tint are not recommended or non-standard (all those cool) colors are also not recommended under the method. I would consider them worthy for throwing out any data. And you must wear them when doing readings or not. Certify how you read, read how you certify.

The current Method 9 as published in the Federal Register, Volume 39, No. 219 on November 12, 1974. The original current method can be found at www.epa.gov/ttn/emc/promgate.html website.

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 controlled 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[1] 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), 95 percent of the sets 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 considered when determining possible violations of applicable opacity standards.

1 For a set, positive error equals the average opacity determined by observer's 25 observations - average opacity determined from transmissometer's 25 recordings.

Method 9

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 3 60.11 (b) and 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 ° 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, facility type, observer's name and affiliation, and the date on a field data sheet (Figure 9-1). 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 Observation

Opacity observations shall be recorded to the nearest S percent at 15-second intervals on an observational record sheet. (See Figure 9-2 for an example-) 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 av raging 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. (See Figure 9-1for an example.)

3 Qualification 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 o 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 a one (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.

Method9

Table 9-1 Smoke Meter Design & Performance Specifications

Parameter	Specification
A. Light Source	Incandescent lamp operated at nominal rated voltage
B. Spectral Response of Photocell	Photopic (daylight spectral response of the human eye - reference 4.3)
C. Angle of View	15° maximum total angle
D. Angle of Projection	15° maximum total angle
E. Calibration	+/- 3% opacity, maximum
F. Zero and Span Drift	+/- 1 % opacity, 30 minutes
G. Response Time	+/- 5 seconds

3.3.1 Calibration

The smoke meter is calibrated after allowing a minimum of 30 minutes warmup by alternately producing simulated opacity of o percent and 100 percent. When stable response at o percent or 100 percent is noted, the smoke meter is adjusted to produce an output of o percent or 100 percent, as appropriate. This calibration shall be repeated until stable o percent and 100 percent opacity values maybe produced by alternately switching the power to the light source on and off while the smoke generator is not producing smoke.

3.3.2 Smoke Meter Evaluation

'The smoke meter design and performance are to be evaluated as follows.

3.3.2.1 Light Source

Verify from manufacturer's data and from voltage measurements made at the lamp, as installed, that the lamp is operated within +5 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 in (b) of Table 9. 1.

3.3.2.3 Angle of View

Check construction geometry to ensure that the total angle of view of the smoke plume, as seen by the photocell, does not exceed 15°. The total angle of view may be calculated from: o<=2 tan (d/2L), where= 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. The total angle of projection may be calculated from: = 2 tam (d/ZL), where o<= total angle of projection; d = the sum of -1 the length of the lamp filament + the diameter of the limiting aperture. and o<L = Ap 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 Section 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 anyone 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 o percent and 100 percent opacity values and observing the time required to reach stable response. Opacity values of o 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.

4 Bibliography

4.1 Air Pollution Control District Rules and Regulations, Los Angeles County Air Pollution Control District, Regulation IV, Prohibitions, Rule 50.

4.2 Weisburd, Melvin I., Field Operations and Enforcement Manual for Air, U.S. Environmental Protection Agency, Research Triangle Park, NC, APTD-1100, August 1972, pp. 4-1-4.36.

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

Problems and Errors

Common Procedural Problems

- Not reading perpendicular to the plume
- Reading the plume at the wrong time
- Reading with the wrong sun angle
- Staring at the plume

Common Procedural Errors

- Not filling in all form information
- Mistakes calculating the total deviation
- Miscounting the deviation
- Skipping a line (two. marks on one line)
- Forgetting the signature

Figure 9- 1

Company ______________

Location ______________

Text Number ______________

Date ______________

Type Facility ______________

Control Device ______________

Hours of Observation ______________

0b server ______________

Observer Certification Date ______________

Observer Affiliation ______________

Point of Emissions ______________

Height of Discharge Plant ______________

	Initial			Final
Clock Time				
Observer Locations Distance to Discharge				
Direction from Discharge				
Height of Observation Point				
Background Description				
Weather Conditions Wind Direction				
Wind Speed				
Ambient Temperature				
Sky Conditions (clear, overcast, % clouds, etc.)				
Plume Description Color				
Distance Visible				
Other Information				

We recommend using the Percent cloud cover to never confuse the issue by indicating partly cloudy, which not a metrologically correct term.

Set Number	**Time**		**Opacity**	
	Start	**End**	**Sum**	**Average**

Readings ranged from ________ to % opacity.

Summary of Average Opacity

The source was / was not in compliance with____ at the time evaluation was made.

Table 2. Comparison of Methods 9 & 22

	Method 9	Method 22
Applicability	Any NSPS and SIP sources with an opacity standard. such as 20 percent.	NSPS and SIP fugitive and specified flare sources with a "no visible emission" standard. No opacity level can be specified.
Measurement	The method determines the value of the opacity measured.	The method determines the existence of a plume but not the opacity.
Certification	Observer must demonstrate the ability to measure plumes in the field every six months.	Observer is not required to participate in field · certification.
Lecture	Observer is not required to attend a lecture program.	Observer must be able to demonstrate knowledge. A lecture is advised, but reading material is acceptable.
Distance From Source	No distance is specified, but the observer must have a clear view of the emissions.	From 15 feet to 0.25 mile.
Viewing Angle	Observer views the plume from a position that minimizes the line of sight through the plume to minimize positive bias.	Observer simply observes the plume.
Light Source	The sun is implied as the light source and it is required to be at the observer's back.	Light sources other than the sun are acceptable but must be documented. The light must be at least 100 lux, but it is not required to be at the observer's back.
Viewing Times	Momentary observation every 15 seconds for a period determined by the standard. Each observation is recorded.	Continuous viewing with observer rest breaks every 15 to 20 minutes. The observer times the emissions with a stopwatch and records the duration of emissions.

Visual Determination of Fugitive Emissions from Material Sources & Smoke Emissions from Flares Note:

This method is not inclusive with request to observer certification. Some material is incorporated by reference from Method 9.

1.0 Scope & Application

This method is applicable for the determination of the frequency of fugitive emissions from stationary sources, only as specified in an applicable subpart of the regulations. This method also is applicable for the determination of the frequency of visible smoke emissions from flares.

2.0 Summary of Method

2.1 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 This method is used also to determine visible smoke emissions from flares used for combustion of waste process materials.

2.3 This method determines the amount of time that 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 visible emissions occur and does not require the determination of opacity levels, observer certification according to the procedures of Method 9 is not required. However, it is necessary that the observer is knowledgeable with respect to the general procedures for determining the presence of visible emissions. At a minimum, the observer must be trained and knowledgeable regarding the effects of background contrast, ambient lighting, observer position relative to lighting, wind, and the presence of uncombined water (condensing water vapor) on the visibility of emissions. This training is to be obtained from written materials found in References 1 and 2 or from the lecture portion of the Method 9 certification course.

3.0 Definitions

3.1 Emission Frequency

means the percentage of time that emissions are visible during the observation period.

3.1 Emission Time

means the accumulated amount of time that emissions are visible during the observation period.

Fugitive Emissions

means emissions generated by an affected facility which is not collected by a capture system and is released to the atmosphere. This includes 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; or (4) are emitted directly from process equipment.

3.4 Observation Period

means the accumulated time period during which observations are conducted, not to be less than the period specified in the applicable regulation.

3 Smoke Emissions

means a 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.

4.0 Interferences

4.1 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 shall be terminated, and the observer shall clearly note this fact on the data form.

5.0 Safety

5.1 Disclaimer

This method may involve hazardous materials, operations, and equipment. This test method may not address all of the safety problems associated with its use. It is the responsibility of the user of this test method to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to performing this test method.

6.0 Equipment

6.1 Stopwatches (Two)

Accumulative type with unit divisions of at least 0.5 seconds.

6.2 Light Meter

Light meter capable of measuring illuminance in the 50 to 200 lux range, required for indoor observations only.

7.0 Reagents & Supplies (Reserved)

8.0 Sample Collection, Preservation, Storage & Transfer (Reserved)

9.0 Quality Control (Reserved)

10.0 Calibration & Standardization (Reserved)

11.0 Analytical Procedure

11.1 Selection of Observation Location

Survey the affected facility, or the 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 least4.6 m (15 feet), but not more than 400 m (0.25 miles), from the emission source is recommended. For outdoor locations, select a position where the sunlight is not shining directly in the observer's eyes.

11.2 Field Records

11.2.1 Outdoor Location

Record the following information on the field data sheet (Figure 22-1): 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.

11.2.2 Indoor Location

Record the following information on the field data sheet (Figure 22-2): 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 the observer location relative to the source. Indicate the potential and actual fugitive emission points on the sketch.

11.3 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.

11.4 Observations

11.4.1 Procedure

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 (see Section 11-4-3), stop the stopwatch when a break begins and restart the stopwatch without resetting it 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 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.)

11.4.1 Observation Period

Choose an observation period of sufficient length to meet the requirements for determining compliance with the emission standard in the applicable subpart of the regulations. 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 emission are observed for 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.

5.1 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.

11.5 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.

12.0 Data Analysis & 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 the actual observation period is less than the required period, and multiply this quotient by 100.

13.0 Method Performance (Reserved)

14.0 Pollution Prevention (Reserved)

15.0 Waste Management (Reserved)

16.0 References

1. Missan, R, and A 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-

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-650/4-74-005L November 1975.

17.0 Tables, Diagrams, Flowcharts, & Validation Data

Figure 22 - 1 Fugitive Smoke *Emission Inspection* Outdoor Location

Company ______________________ Observer ______________________

Location ______________________ Affiliation ______________________

Company Rep. ______________________ Date ______________________

Sky Conditions ______________________ Wind Direction ______________________

Precipitation ______________________ Wind Speed ______________________

Industry ______________________ Process Unit ______________________

Sketch process unit: include 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			

Figure 22 - 2 Fugitive Smoke Emission Inspection Indoor Location

Company ______________ Location_____________ Company Rep.___________	Observer ______________ Affiliation____________ Date _____________
Industry_____________	Process Unit _____________

Light type (fluorescent, incandescent, natural)_______________________________________

Light location (overhead, behind observer, etc.)_______________________________________

Illuminance (lux or foot-candles)_______________________________________

Sketch process unit: include 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			

Federal Reference Method 9 - Visual Determination of the Opacity of Emissions from Stationary Sources (Federal Register 39 39879, November 12, 1974) requires the recording of certain specific information in the field documentation of a visible emissions observation. The required information includes the name of the plant, the emission, description of the sky conditions, the plume background, in addition to a minimum of 24 opacity observations.

Field experience gained from past use of Method 9 in determining compliance of sources subject to opacity standards has demonstrated a need for additional documentation when making visible emissions (VE) observations. The attached Visible Emission Observation Form was developed to assist in the collection of information required by Method 9 and suggested additional information. The form was developed after a review of the opacity of forms in use in EPA Regional Offices and State and local air quality control agencies. The form includes not only the data required by Method 9, but also more descriptive information on observation conditions.

The Visible Emission Observation Form as designed is a three-part form. The top copy (original) goes to the agency files, the second copy is for VE observer's file, and it is intended that the third copy be given to the appropriate facility personnel immediately following the on-site field observation if this is the agency policy or procedure. The forms are numbered serially with a 5-digit number, and each copy of the three-part form is imprinted with the same number. The form should be completed on-site and signed by the observer. It is recommended that waterproof black ink always be used with these forms.

The Visible Emission Observation Form (see Figure 1) can be functionally divided into 10 major sections, with each section documenting one or two aspects of the opacity determination. An "additional information" section is included for notation of relevant information not covered elsewhere on the form. Spaces for temporal change entries (e.g. "start" "end" and the "comments" section of the data set) are used to record new information when the observation conditions change during the observation period.

The following guidelines discuss the major sections and each data element found on the VE Observation Form. This includes a short explanation of each section's purpose, an explanation of each data element, a description of the type of information being sought, and in some cases, examples of appropriate entries. Discussions are keyed to Figure 1 (p 39) by corresponding capital letters, and starred items indicated that the information is required by Method 9.

Separate companion forms including a company notification record and sheets for data reduction calculations are being prepared to accompany the VE Observation Form. To tie all these forms together, all companion forms will include a space for recording the S digit number(s) of the VE Observation Form(s) to which the relate. Each companion form will be accompanied by a set of instructions, which like the instructions which follow, will address each data element on the form and will include example of appropriate entries.

2.2 Method 203A- Visual Determination of Opacity of Emissions from Stationary Sources for Time-Averaged Regulations

Method 203A is virtually identical to EPA's Method 9 of 40 CFR part 60 appendix A, except for the data-reduction procedures, which provide for averaging times other than.6 minutes. Readings are taken every 15 seconds and averaged over a time period specified in the applicable regulation ranging from 2 minutes to 6 minutes. The certification procedures for this method are identical to those provided in Method 9.

2.3 Method 203B - Visual Determination of Opacity of Emissions from Stationary Sources for Time-Exception Regulations

A time exception regulation means any regulation that allows predefined periods of opacity above the otherwise applicable opacity limit (e.g., to allow an excess of 20 percent opacity for 3 minutes in 1 hour). The certification procedures for this method are identical to those provided in Method 9.

You must record opacity observations to the nearest 5 percent at 15-second intervals on an observational record sheet. Each observation recorded represents the average opacity of emissions for a 15-second period. The overall length of time for which observations are recorded must be appropriate to the applicable regulation.

Data Reduction for Time-Exception Regulations - For a time exception regulation, reduce opacity observations as follows: count the number of observations above the applicable standard and multiply that number by 0.25 to determine the minutes of omissions above the target opacity.

2.4 Method 203C - Visual Determination of Opacity of Emissions from Stationary Sources for Instantaneous Limitation Regulations

Method 203C is virtually identical to EPA's Method 9 of 40 CFR Part 60, Appendix A, except for 5-second reading intervals and the data-reduction procedures.

Make opacity observations at the point of greatest opacity in that portion of the plume where condensed water vapor is not present. Do not look continuously at the plume; instead, observe the plume momentarily at 5-second intervals. The overall time for which recordings are made must be of a length appropriate to the applicable regulation for which opacity is being measured.

Data Reduction for Instantaneous Limitation Regulations. For an instantaneous limitation regulation, a 1-minute averaging time used. You must divide the observations recorded on the record sheet into sets of consecutive observations. A set is composed of the consecutive observations made in 1 minute. Sets need not be consecutive in time, and in no case must two sets overlap. You must reduce opacity observations by dividing the sum of all observations recorded in a set by the number of observations recorded in each set. Reduce opacity observations by averaging 12 consecutive observations recorded at 5-second intervals. Divide the observations recorded on the record sheet into sets of 12 consecutive observations. For each set of 12 observations, calculate the average by summing the opacity of the 12 observations and dividing this sum by 12.

3.0 VEO Form Completion, By Section

VEOFI is divided into 12 sections. The following sections describe the correct procedure for completing each section. Included in the instructions, will be a discussion of each data blank purpose. This will assist the observer in completing the form in cases where the information or conditions are ambiguous. The information that is required by Method 9 is indicated with an asterisk (*I. The EPA anticipates that most State and Local Agencies will provide similar guidelines and requirements for Methods 203A, B, and C. In addition to the VEO Form, other companion forms may accompany the VEO Form (e.g. company notification records, date reduction sheets, etc.). These sheets should all have the 5-digit VEO Form Number from the VEO Form.

3.1 Observation Method

This visible emission observation form may be used with EPA Reference Method 9, Method 203A or Method 203B.

3.1.1 Method Used

Circle the method which is specified by the SIP, permit, or operating procedures. The method used will determine which data recording form will be completed. For example, Method 203A, 203B, or Method 9. If the specified method is 203C remember to use Visible Emission Form 2.

A. Company Identification

Provides information that uniquely identifies the company and permits the observer to locate or contact the company.

@ <u>CompanyName</u>
Street Address

City	State	Zi
Phone-Key Contact	Source ID Number	

Company Name*: Include the facility's complete name. For positive identification of the facility, the parent company name, division, or subsidiary name should be included.

Street Address*: Indicate the street address of the facility (not the mailing address or the home office address) so that the exact physical location of the source is known. If necessary, the mailing address or home office address may be listed elsewhere.

Phone (Key Contact) *: List the phone number for the appropriate contact person at the facility such as the plant manager or environmental officer.

Source ID Number*: This space is provided for the use of agency personnel and may be used to enter the number the agency uses to identify that particular source, such as the State file number, Compliance Data System number, or National Emission Data System number.

B. Equipment and Operating Mode: Process & Control Device Type

Include a several word descriptions of the process and control device, with an indication of the current capacity or operating mode of the equipment. This may be the batch-type, the production rate, or some other indication of the operational load of the equipment. An addendum attachment of production record or an appendix in the report including additional information) may be beneficial.

In enforcement / regulatory situations this may include information available only by facility operators/ owners/officials. EPA personnel asking a plant official for information requires the approval of OMB, an active case investigation, or a prominent disclaimer that the official is under no obligation to answer. (Note to operators - DON'T. Any information released should be through official channels with proper notation as to the proprietary nature of the data. Utilize the approved channels within your organization to release information.) Since the facility may consider their production rate information as proprietary, the inspector shall specifically inform them that they have the right to request this information be submitted subject to the confidential business information provisions of 40 CFR 2, Subpart B

Instructions

This Section is needed in Enforcement Actions and New Source Performance Testing. Additional information may be required, and most likely will be required for New Source Performance Testing to prove the Equipment is operating to within 90% production capacity and to document the control equipment conditions under which the Process achieved compliance. The Method requires the process be recorded in the documentation, but often this requirement is met by Describing the Source in the blank labeled Source ID Number such that the person in the field familiar with the operation identifies the correct source (#1 Boiler, etc.) For Title V Compliance Monitoring purposes this section may not be required, if 1) the process was adequately described in section A, and 2) the production rate and control equipment operating conditions are being recorded for the Title V Report compilation by another means.

Process Description: * Enter a description which clearly identifies the process equipment and type of facility that emits the plume of emission to be read. The description should be brief, but should include as much information as possible, Such as:

Coal-Fired Blr-Unit #4 / Power Plant	#2 Oil-Fired Bir/ Chemical Plant
Primary Crusher at Rock Quarry	Fiberglass Curing Oven
BOF #1 / Steel Mill	Reverb Furnace / Copper Smelter

Operating Mode: Depending on the type of process this could be a quantification of the production rate or a description of the portion of the batch-type process for which the emission opacity is being read. It may be an explanation of the condition as start-up, upset, or shut down. It may be a statement of the percent of the capacity (90% Capacity) or a tonnage per hour being produced. For a steel Furnace the readings being made should include the exact part of the process cycle for which the observations are being made, such as "charging", Tapping, etc. This information must be obtained from Plant personnel if you are a regulator or consultant.

Control Equipment: Specify the Type(S) of control equipment being used in the system after the process equipment in session, (shaker baghouse, scrubber, hot-side Electrostatic precipitator)

Operating Mode: Indicate the manner in which the control equipment is being operated at the time of the opacity observations. For a bag house this would be pressure drop, for a scrubber you would include pressure drop scrub and flow rate, and potentially also the pH (measure of acidity level). For an ESP this might include operating fields, the voltage/charge and additive moisture flow if using a wet ESP) If the equipment is in automatic, manual or bypass mode may also be relevant. In all likely hood this will be obtained from a plant official, but for Title V reporting purposes this information is not required on the Method 9 form if the information is being communicated to the compliance reporting separately.

C. Emission Point Identification

Contains information uniquely identifying the emission point and its spatial relationship with the observer's position. It is recommended that distances and heights in this section be noted in consistent units.

@ Describe Emission Point

Height Above Ground Level	Height Relative to Observer
Distance from Observer	Direction from Observer

Start End

* **Denotes this is required in Method 9**

Describe Emission Point*: Describe the type and physical characteristics of the emission point. The description must be specific enough so that the emission outlet can be distinguished from all others at the source. The description of the type of emission point should address whether it is (1) a specifically designed outlet such as stacks, vents, and roof monitors (having confined emissions) or (2) an emission source having unconfined emissions such as storage piles, chemical tanks, and non-duct& material handling operations. Description of the physical characteristics of the emission point should include the appearance (such as color, texture, etc.) and geometry (size, shape, etc.) of the stack or other outlet, and its location in relation to other recognizable facility and marks.

Any special identification codes the agency or source uses to identify a particular stack or outlet should be noted along with the description; the source of the code should also be recorded. A special identification code should not be used alone to describe the emission point, since they are sometimes incorrect and also require a secondary reference. The observer must be certain of the origin of the emissions that were being read. A description of the emission point coupled with the identification of the process equipment and control equipment should accomplish that purpose.

Height Above Ground Level*: Indicate the height of the stack or other emission outlet from its foundation base. This information is usually available from agency files. engineering drawings, or computer printouts (such as NEDS printouts). The information also may be obtained by using a combination of a rangefinder and an Abney level or clinometer. The height may also be estimated.

Height Relative to Observer*: Indicate an estimate of the height of the stack outlet (or of any other type of emission outlet) above the position of the observer. This measurement indicates the observer's position in relation to the stack base (i.e., higher or lower than the base) and is necessary if slant angle calculations are performed.

Distance from Observer*: Record the distance from the point of observation to the emission outlet. This measurement may be made by using a rangefinder. A map may also be used to estimate the distance. This measurement must be reasonably accurate when the observer is close to the stack (within 3 stack heights). This is because it may be used in conjunction with the outlet height relative to the observer to determine the slant angle at which the observations were made (see Figure 2). A precise determination of the slant angle becomes important in calculating the positive bias inherent in opacity readings made when the observer is within three stack heights of the stack.

Direction from Observer: Specify the Direction from the observer to the Observation Location. Be Careful to correctly answer the data-field as the question is posed, as newer forms may request the direction to the Observer from the observation location. It is recommended in the 1980's literature that this is to be done to the 8 POINT compass direction (N, NE. E.....etc.) however the newer forms require this to be provided to the degree and often require a second measurement to confirm the direction. When using a compass hold the compass flat and point it to the direction of the observation point (this is not always at the emission point). The needle will point toward magnetic north. Now rotate the compass to the observation direction to read the direction to the observation point, or if measuring from the observation point (in some case observation point and emission point are the same) you will read the direction to the observer's position. A map may also be used to make this determination, the VEO-APP.com utilizes the GPS coordinates of the observation location and the GPS coordinates of the source to determine this direction. It should be noted that the Method requires only an estimate of the direction, so an 8-point evaluation based upon plant north (information and directions you are familiar with) is adequate to meet the requirements of the Method. The additional detail of a compass direction to the degree is required for enforcement actions because this information is used to verify the sun is in the 140-degree sector behind the observer.

D. Emission Description

Includes information that definitely establishes what was observed while making the visible emissions determination. **Note:** items called for in this section may change a number of times during the observation period. It is recommended that these changes be noted in the comment space beside the appropriate opacity readings and reference to this be made in the corresponding space in this section.

@ Describe Emission

Start		End	
Emission Color		If Water Droplet Plume	
Start	End	Attached □	Detached **D**
Point in The Plume at Which Opacity Was Determined			
Start		End	

Describe Emissions*: Include the physical characteristics and behavior of the plume (not addressed elsewhere on the form) and the distance it is visible. Physical descriptions may include such things as texture, gradation, and contents, examples are "lacy," "fluffy," "copious," "mushrooming," "spreading over horizon," and "detached non-water vapor condensables." The standard plume terminology illustrated in Figure 4 may be used to describe plume behavior. The behavior is generally used to determine the atmospheric stability on the day of the opacity observations.

Emission Color*: Note the color of the emissions. The plume color can sometimes be useful in determining the composition of the emissions and also serves to document the total contrast between the plume and its background as seen by the opacity observer. For emissions that change color a number of times during the observation period (such as those from a basic oxygen furnace), the color changes should be noted in the comments space next to the opacity readings themselves.

If Water Droplets Plume*: This box is only completed if visible water droplets are present. Check "attached" if condensation of the moisture contained in the plume occurs within the stack, and the water droplet plume is visible at the stack exit. Check "detached" if condensation occurs some distance downwind from the stack exit and the water droplet plume and the stack appear to be unconnected.

Plumes containing condensed water vapor ("water droplet plumes" or "steam plumes") are usually very white and billowy, and then wispy at the point of dissipation, where the opacity decreases rapidly from a high value (usually 100%) to zero if there is no residual opacity contributed by contaminate in the plume. Water vapor collapses upon itself as it evaporates back in the atmosphere, more quickly in low humidity conditions.

To document the presence or absence of condensed water vapor in the plume, two points must be addressed. First, is sufficient moisture present (condensed or uncondensed) in the effluent to produce water droplets at in-stack or ambient conditions? Second, if enough moisture is present, are the in-stack and ambient conditions such that they will condense either before exiting the stack or after exiting (when it meets with the ambient air)? The first question can be answered by examining the process type and/or the treatment of the effluent gas after the process. Some common sources of moisture in the plume are:

- Water produced by combustion of fuels
- Water from dryers
- Water introduced by wet scrubbers
- Water introduced for gas cooling prior to an electrostatic precipitator or other control device
- Water used to control the temperature of chemical reactions

If water is present in the plume, data from a sling psychrometer, which measures relative humidity, in combination with the moisture content and temperature of the effluent gas can be used to predict whether the formation of a steam plume is probable.

Point in the Plume at Which Opacity was Determined*: Describe as accurately as possible the physical location in the plume such as the distance from the emission point where the observations were made. This is necessary to establish that nothing interfered with the observer's clear view of the contaminant plume itself, such as condensed water vapor. It is also important in the case of secondary plume formation. Therefore, the observer must specify 1) if the readings were made prior to water droplet plume formation or after water droplet plume dissipation and 2) the distance from the emission point and/or water droplet plume. Descriptions such as "4 feet above outlet" and "So feet downstream from outlet," "10 feet after steam dissipation" are appropriate. On page 45 there are examples of the correct location for making opacity readings in various steam' plume and secondary plume situations.

E. Observation Conditions

Covers the background and ambient weather conditions that occur during the observation period and could effect observed opacity.

@ Describe Plume Backgrounds

Start	End
Background Color	Sky Conditions
Start End	Attached Detached
Wind Speed	Wind Direction
Start	End
Ambient Temp	Wet Bulb Temp RH%
Start End	

Describe Plume Background*: Describe the background that the plume is obscuring and against which the opacity is being read. When describing the background, include characteristics such as texture. Examples of background descriptions are "structure behind roof monitor," "stand of pine trees," "edge of jagged stony bill side," "clear blue sky," "stack scaffolding," and "building obscured by haze."

Background Color*: Describe the background color including the shade of the color (e.g., new leaf green, conifer green, dark brick red, sky blue, and light gray stone). In general, the background chosen to read against should contrast with the color of the plume.

Sky Conditions*: Indicate the percent cloud cover of the sky. This information can be indicated by using straight percentages (e.g., 10% overcast, 100% overcast) or by description, as shown:

Term	Amount of Cloud Cover
Clear	<10%
Scattered	10%to50%
Broken	50%to90%
Overcast	>90%

Wind Speed*: Record the wind speed. It is recommended that it be measured or estimated to +5 miles per hour. The wind speed may be measured using a band-held anemometer (if available), or it can be estimated by using the Beaufort Scale of Wind Speed Equivalents

Wind Direction*: Indicate the direction from which the wind is blowing. It is suggested that the direction should be estimated to eight points of the compass. This can be accomplished by observing which way the plume is blowing. If this is not possible, the wind direction may be determined by observing a blowing flag or by noting the direction a few blades of grass or handful of dust are blown when tossed into the air. Keep in mind that the wind direction
at the observation point may be different from that at the emission point; the wind direction at the emission point is the one of interest.

Ambient Temperature*: The outdoor temperature at the plant site is measured by a thermometer (in degrees Fahrenheit or centigrade). Be certain to note which temperature scale is used. The ambient temperature is used in conjunction with the wet bulb temperature when there are indications of a condensing water droplet plume.

Wet Bulb Temperature*: Record the wet bulb temperature from the sling psychrometer. This is done when there is possibility of a condensing water droplet plume.

Relative Humidity Chart*: Enter the relative humidity measured by using a sling psychrometer in conjunction with a psychrometric chart. This information is used to determine if water vapor in the plume will condense to form a steam plume.

F. *Observer Position & Source Layout*

Clearly identifies the observer's position in relation to the emission point, plant landmarks, topographic features* sun position, and wind direction.

Source Layout Sketch*: This sketch should be drawn as a rough plan view and should include as many landmarks as possible. At the very least, the sketch should locate the relative positions of the observed outlet and associated buildings in such way that they will not be confused with others at a later reading. The exact landmarks will depend on the specific source, but they might include the items below. To assist in subsequent analysis of the reading conditions, sketch in the plume (indicate the direction of wind travel). The wind direction also must be indicated in the previous section.

Other stacks	Mills	Roads	Fences	Building
Stockpiles	Rail heads	Tree Lines	Background for readings	Interfering Plumes From Other Sources

Draw North Arrow*: To determine the direction of north, point the line of sight in the source layout sketch in the direction of the actual emission point, place the compass next to the circle and draw an arrow in the circle parallel to the compass needle (which points north). A map may also be used to the determine direction to north.

Sun's Location*: It is important to verify this parameter before making any opacity readings. The sun's location should be within the 140° sector indicated in the layout sketch; this confirms that the sun is within the 140 degrees sector to the observer's back.

To draw the sun's location, point the line of sight in the source layout sketch in the direction of the actual emission point, move a pen upright along the "sun location line' until the shadow of the pen falls across the observer's position. Then draw the sun at the point where the pen touches the "sun location line."

G. Additional Information

Includes conditions and/or deviations of a factual nature that have bearing on the opacity observations and that cannot be addressed elsewhere on the form.

Additional Information: Note conditions or deviations of a factual nature that cannot be addressed elsewhere on the form such as in the comments section of the data set. These must be purely factual in nature and specific to the particular source. Examples of information that may be included in this section are:

- Description of unusual stack configuration (to show multiple stacks or stack in relation to roofline); attach drawing, if necessary.
- References to attachments
- Observed or reported changes to the emissions or process during observation that are not noted in the comments area of the form.
- Additional source identification information

H. Data Set

Opacity readings for the observation period, organized by minute and second. This section also includes the actual date and start and end times for the observation period and space to each minute of readings for noting relevant comments.

Observation Date*: Enter the date on which the opacity observations were made.

Start Time, End Time*: Indicate the times at the beginning and the end of the actual observation period. The times may be expressed in 12-hour or 24-hour time (i.e., 8:35 am or 08:35); however, 24-hour time tends to be less confusing.

Data Set*: Spaces are provided on one form for entering an opacity reading every 15 seconds for up to a 30-minute observation period. If observations continue beyond 30-minutes, a second form (and third, etc.) should be used to record additional readings. The readings should be in percent opacity and made to the nearest 5 percent. The readings are entered from left to right for each numbered minute, beginning at the upper left corner of the left-hand column, labeled row "MIN 1" (minute 1) and column "SEC o" (o seconds). The next readings are entered consecutively in the spaces labeled MIN 1, SEC 15; MIN 1, SEC 30; MIN, SEC 45; MIN 2, SEC o; MIN 2, SEC 15; etc.

If for any reason, a reading is not made for a particular 15-second period, a dash (-) should be placed in the space showing that the space is not just an oversight. The comment section beside that reading should be used for an explanation of why the reading was missed.

Comments: Spaces for comments are provided next to the date for each minute of opacity readings. These are intended to provide space to note changing observation conditions and/or reasons for missed readings in direct conjunction with the readings themselves. Items to be noted include:

- Changes in ambient conditions from the time of the start of readings
- Changes in plume color, behavior, or other characteristics
- Presence of interfering plumes from other sources
- Changes in observer position and indication that a new form is initiated
- Conditions that might interfere with readings or cause them to be biased high or low
- Unusual process conditions
- Reasons for missed readings

Comment: Other forms require essentially the same information but may be formatted for six minutes or 1 hour.

I. Observer Data

Information required to validate the opacity data.

©

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

Observer's Name*: Print observer's entire name

Observer's Signature: Self-explanatory

Date*: Enter the date on which the form was signed and provide the date of the current certification.

Organization*: Provide the name of the agency or company that employs the observer.

Certified By: Identify the agency, company, or other organization that conducted the "smoke school" or VE training and certification course where the observer obtained his/her current certification.

J. Forms Interrelation

Provides space for recording another VE Observation Form number so that forms concerning the san1e observation can be interrelated.

Continued on VEO Form Numbers

Continued on VEO Form Number: Fill in the 5-digit number of the VE Observation Form, if any, where the observations from the form in use are continued. Each form of a series that has a form coming after it will have the number of the next noted in this section.

*** Required by Reference Method 9, other items recommended.**

Water Vapor Plume

The emission of water vapor from a stack is not currently a regulated emission but may cause much public concern because of the association with a point source. If water vapor is in the stack in a sufficient quantity that the saturation dew point is reached when the water is discharged into the colder atmosphere, then visibility will be obscured by the condensed water (a vapor cloud will be formed). This is a naturally occurring process as benign as the clouds created in the atmosphere by natural processes (such as vapor rising from a warm lake on a cool day creating a bank of fog 1). The factor that affects the condensation is the presence of moisture in sufficient quantity to condense in the current ambient conditions. (See Psychometric Chart).

In some cases, design methods can be used to eliminate the water vapor plume. In other situations, the visible condensation may only occur rarely. From a regulatory viewpoint these plumes are considered to have the potential to mask visible emissions problems, as the condensation (water emissions not being regulated) must be excluded from the observation. When documenting a visible emission reading at the densest point of the plume, other than at the source outlet, and when there is a potential for water vapor condensation to obscure the visibility, it is important to document the ambient conditions to show that the water vapor plume would be attached or detached, or not present.

Four important aspects of water vapor plumes are covered herein in detail:

A	Water Vapor Plume	Formation
B.	Water Vapor Plume	Identification
C.	Water Vapor Plume	Reading VEs when present
D.	Water Vapor Plume	Occurrence - prediction of

A. *Formation*

Water vapor is present in the effluent gas stream from many processes, including cooling, drying, combustion, and wet scrubbing. Often it is not present in a sufficient quantity to ever condense in the atmosphere, but at times (such as the cooling towers from a nuclear reactor), the quantity of water is sufficient at all times to condense.

Condensation occurs when the water vapor contained in the effluent gas is exposed to cooler an1bient air, and the water vapor cools to below its dew point. The water vapor condenses (the air is no longer capable of hold this much moisture) into a mist and becomes visible. This mist re-vaporizes and disappears as the plume is diluted with ambient air.

The initial condensation may begin to occur within the stack (attached plume, see figure) or may begin to occur some distance from the emission point (detached plume).

B. *Identification*

For sources with primarily white smoke the identification of water presence can likely only be confirmed by documentation of the stack conditions, apart from a great degree of field experience. Look at sources, car emissions, diesel truck emissions, and known water vapor plumes (Arkansas Nuclear 1).

Water vapor plumes are characterized by their whiteness in bright sunlight and the wispiness of the plume. Wispiness is how the plume behaves as a cloud, dissipating and re-vaporizing into the atmosphere as it moves from the source. The re-vaporization time will vary dependent upon the ambient and source conditions. Re-vaporization tends to be very quick in dry hot conditions, less in dry cold conditions (but the tendency for vapor to condense at all is enhanced by the lower ambient temperature), and slowest under humid cold conditions (although humidity tends to be less as the temperature cools). The amount of ambient air required for dilution of the plume and re-vaporization of the mist increases as the ambient temperature decreases, the ambient relative humidity increases, and the amount of moisture in the effluent stream from the source increases.

C. *Reading*

If there is some source of water vapor in the effluent, in order for the observation of visible emissions to be defended as equal to or greater than that observed the relative humidity should be less than 60%. However, under any relative humidity condition the statement can be made that the observation was less than or equal to, as the presence of water vapor would potentially cause (by confusion with the emission) an overstatement of the actual emissions. Avoid the condition if possible. A record MUST be made of the ambient conditions prevailing during any visible emission reading. When reading visible emissions in the presence of a water vapor plume, the source and ambient conditions will combine into one of two possible situations: Attached Plume and Detached Plume. A detached plume is a less common condition, but under this circumstance normal observation can continue.

As the name implies under this circumstance, water vapor condenses and becomes visible at some distance from the point source. Essentially the gas coming from the source is at a speed, temperature, and moisture content such that this interval exists at the current ambient conditions. In this instance the opacity of the plume can be determined in the interval between the stack and the point where the vapor begins to condense and become visible. Ambient conditions may change causing the plume to become attached. If during reading, make notation and change or cease as the situation dictates.

An attached plume is more common. In some circumstances there may be water droplets, or condensation already occurring within the stack. Under this circumstance the point of observation for opacity must be at the point where the plume has completely dissipated. In practice this can be a problem as changing ambient and wind conditions and the inherent wispiness makes determination of this point a fluid (continuing) decision. If a slight residual plume is obscured by the water vapor plume, the only method of determining compliance may be a source test other than visible emission observation.

Remember, however the observation is to be made at the densest point in the plume, and in certain processes this may occur after re-vaporization. Make preliminary observations to determine if this will be required.

D. *Occurrence Determination* - The *Psychrometric Chart*

The psychrometric chart is used in visible emissions for predicting the occurrence of visible water vapor plumes.

The psychrometric chart is a graphical representation of the properties of air and water vapor mixtures. Each point on the chart represents one unique combination of these (5) five properties:

I. Dry Bulb Temperature: the actual temperature. This is represented by the lower axis of the chart (page 45).

II. Saturation or Wet Bulb Temperature: the temperature indicated by a wet thermometer (a thermometer covered with a wet wick and exposed to a moving air stream..... be certain to us plain water DI if available). The saturation temperature is represented by the curved axis on the left side of the chart.

III. Relative Humidity: The ratio of the partial pressure of the water vapor to the vapor pressure of water temperature at the same temperature. Relative Humidity values are represented by the curved lines originating in the lower left portion of the chart, with the curved line along the left side representing the relative humidity of 100 percent (the saturation point, see item 11.)

IV. Absolute Humidity aka Humidity Ratio: The mass of water vapor present per unit mass of dry air, expressed as grains per pound or pound per pound. The absolute humidity is represented by the vertical axis.

V. Specific Volume: The volume per unit mass of air, expressed as cubic feet per pound. The specific volume is represented by the lower right to upper left diagonal lines.

Atmospheric pressure does affect the relationship represented by the charts and has resulted in the publication of charts for sea level (29.92 in Hg) and 5000 feet (24.89 in Hg). The chart herein published is at 29.92 in of Hg and should be suitable in most applications. For a more accurate determination the actual value can be determined between sea level and 5000 feet by interpolation. Above 5000 feet will require additional reference material not included in this reference.

By plotting two of the properties on the chart the remaining three can be determined, without extensive calculation. For instance the wet bulb and dry bulb temperature, as determined in the field, of the ambient air can be used to plot one point on the chart, from which the values of relative humidity, humidity ratio, and specific volume of the ambient air can be determined.

In order to predict the occurrence of visible water vapor not only must the ambient conditions surrounding the plume be determined, but also the source conditions of the effluent gas contained in the plume or more commonly the stack conditions. Plot both the ambient and stack condition points on the psychrometric chart. With two properties known at each state the properties of the plume as it moves from one state (within the stack) to the other state (ambient conditions) can be draw", as a line connecting these two points. If during the transition from one point to the other the line passes through the saturation area of the psychrometric chart then the moisture will condense beginning at that point and when the line returns to below the saturation point of the curve the moisture will re-vaporize back into the atmosphere. Under this scenario there will be a detached plume.

Any point where this line is to the left of 100% relative humidity (the saturation point), the water vapor will condense into a visible mist, but it can be seen for most ambient conditions a mist will not normally exist. Therefore, the visible mist will re-vaporize and dissipate.

Normally the stack properties which are available are the dry bulb temperature and moisture content (MC expressed as a fraction) expressed as percent from a prior source test or from engineering estimates, or plant records provided by the source. This data may be used as an estimate for the purpose of determining the occurrence of a visible water vapor plume. Moisture content cannot be plotted directly on the psychrometric chart, but must be converted to absolute humidity (AH) as follows:

AH = (4354 X MC) / (1 - MC)

The absolute humidity and dry bulb temperature can then be used to plot the state point for the source condition.

See Example:

Given:
The dry bulb temperature and wet bulb temperature on a given morning were 80 degrees F and 70 degrees F with a Barometric pressure of 29.92 in of Hg. The Effluent Stack temperature was 135 degrees F with a moisture content of 16.33 %.

Find:
1) Will there be a visible water vapor plume? Will it be attached or detached?

2) The burner is replaced increasing the stack temperature to 160 degrees F, other conditions remaining the same. Will there be a visible water vapor plume? Will it be attached or detached?

3) Heat Recovery is added to the stack, and the stack exit temperature is now 100 degrees F. The dry bulb temperature being 80 degrees F and the wet bulb temperature being 70 degrees F will there be a visible water vapor plume? Will it be attached or detached?

4) Under each of these scenarios describe how you would expect the plume to be evaluated.

4.1

4.2

4.3

Solution:
1) Plot the ambient condition point at the intersection of the So degrees F dry bulb temperature and the 70 degrees F wet bulb temperature (page 43 top chart)

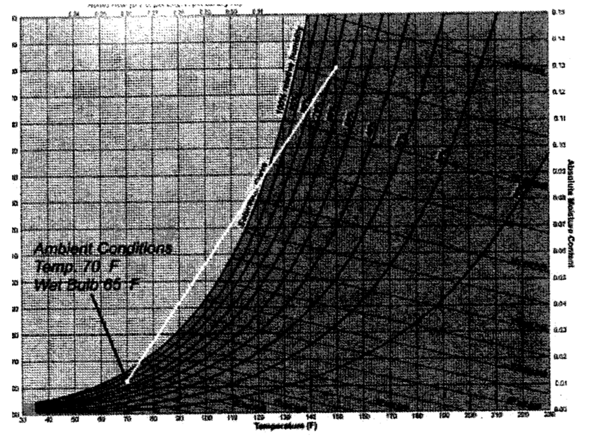
2) Calculate the Absolute Humidity

AH= 4354, XMC / (1-MC) which@ 16.33 = 4354 x .1633 / (1-.1633) = 849.76 #/#

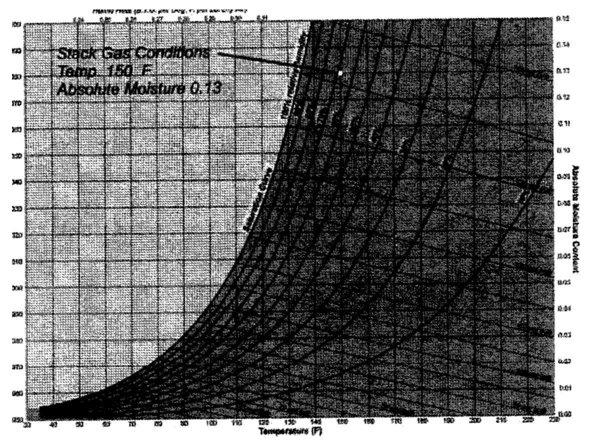
3) Plot the stack condition at 850- and 135-degrees F (Middle chart page 43)

4) Connect the points. If the Stack Conditions cross into the Saturation area (shaded gray on page 43), the water is in the liquid (condensed water vapor plume) state and will form a visible water vapor plume. If it stays to the right of the saturation area there will not be a visible water vapor plume.

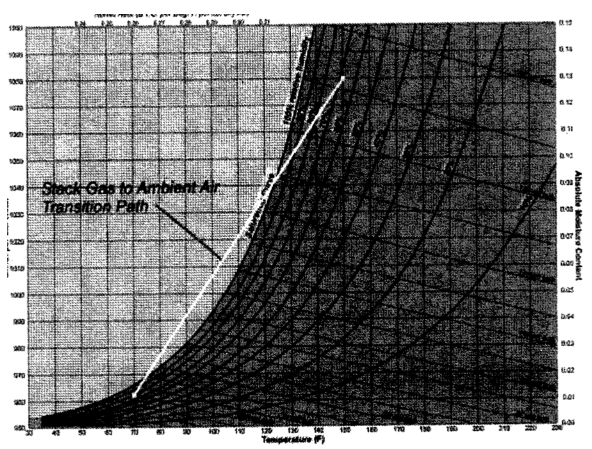
Footnotes:
1) McCabe and Smith, Unit Operations, Section 22 pp 747.BBB



Plot the Ambient Condition



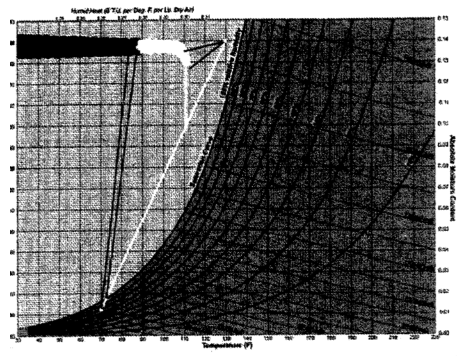
Plot the Stack Condition

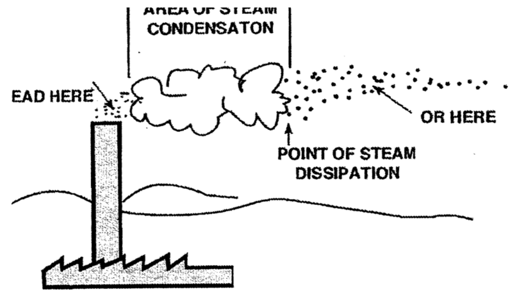


Draw a line between the two

Along the saturation temperature line locate the wet bulb temperature and follow the wet bulb line to the dry bulb temperature. Next plot the stack conditions and then connect. If the line crosses into the area of saturation water vapor will condense, if not then the stack is so hot that the water will evaporate into the atmosphere as it achieves equilibrium with the ambient condition before it condenses.

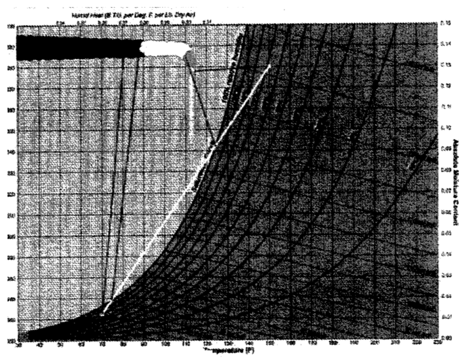
Attached Steam Plume

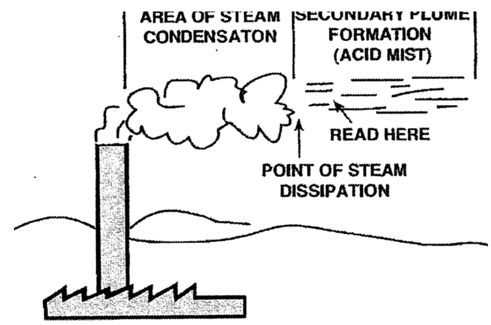




Detached Steam Plume

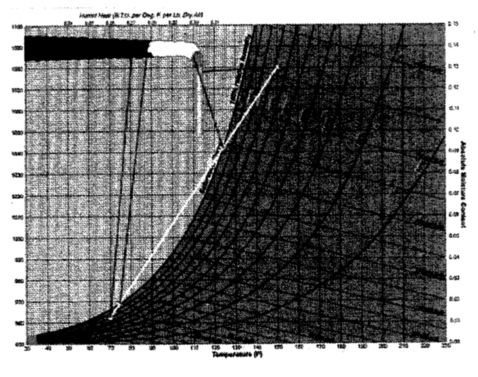
In some cases, it may be necessary to make readings at the point of steam dissipation if the plume is more opaque at that point.





Secondary Plume

Plume from a sulfuric acid plant with detached steam plume. Plume is clear at stack exit. Secondary acid mist is formed in area of steam condensation.



No Water Vapor Plume

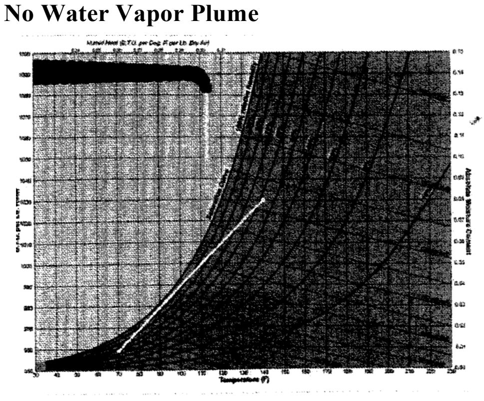


Figure 5: Location for reading opacity under various conditions

Plume Behavior Descriptors

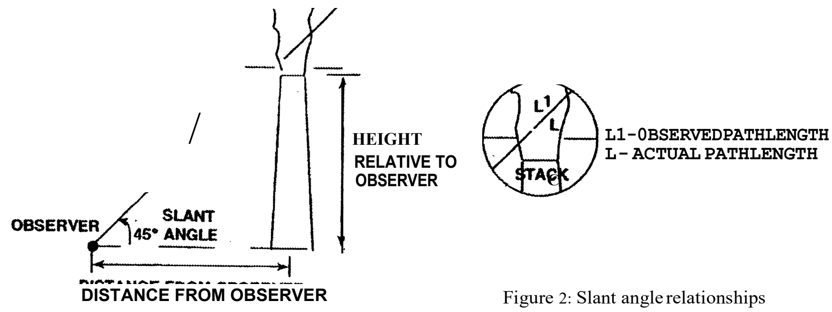


Figure 2: Slant angle relationships
VEO (figure 2)-00/01

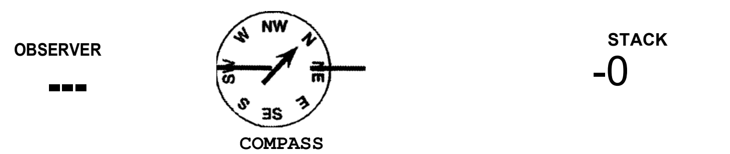


Figure 3: Direction of observation point from observer is
VEO (figure 3)-

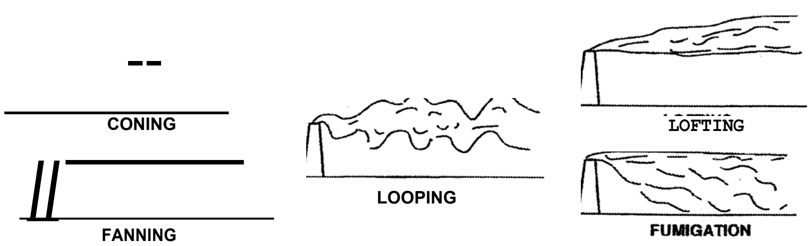


Figure 4: Recommended plume behavior descriptors
VEO (figure 4)-03/02

Comments / Feedback

1= *Greatly Disagree* **2=** *Disagree* **3=** *Neutral* **4=** *Agree* **5=** *Greatly Agree*

1. The instructor was adequately prepared.

   1 2 3 4 5

2. Did you Feel the lecture maintained a relaxed and professional atmosphere?

   1 2 3 4 5

3. Do you feel the lecture provided you with a complete understanding of observation techniques and documentation requirements?

   1 2 3 4 5

4. The instructor was knowledgeable and was able to effectively convey the information needed.

   1 2 3 4 5

5. The instructor was able to answer my questions adequately.

   1 2 3 4 5

6. The handouts and videos used were useful in helping me understand the method.

   1 2 3 4 5

7. Field training requirements were covered adequately.

   1 2 3 4 5

8. If any, what changes or recommendations for the lecture would you make? (optional)

9. Comments or Questions?