KENTUCKY METHOD 150(F-1)
VISUAL DETERMINATION OF INTERMITTENT
OPACITY EMISSIONS FROM STATIONARY SOURCES

Kentucky Method 150(F-1) is a method for reading visible emissions from stationary sources, and differs in its application from Method 9 in terms of data reduction. Kentucky Method 150(F-1) allows for an averaging time of three minutes (twelve readings) in order to allow for reading the opacity of intermittent emissions.

Many stationary sources discharge visible emissions into the atmosphere. This method involves the determination of emission 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 emission opacity. The appearance of an emission 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 emission appearance include: Angle of the observer with respect to the emission; angle of the observer with respect to the sun; and angle of the observer with respect to an emission with a large length to width ratio. The method includes specific criteria applicable to these variables.

Other variables which may not be controllable in the field are luminescence and color contrast between the emission and the background against which the emission is viewed. These variables exert an influence upon the appearance of an emission as viewed by an observer, and can affect the ability of the observer to accurately assign opacity values to the observed emission. Studies of the theory of emission opacity and field studies have demonstrated that an emission 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 an emission, 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 an emission is viewed under such contrasting conditions. Under conditions presenting a less contrasting background, the apparent opacity of an emission 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 an emission 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.

1. PRINCIPLE AND APPLICABILITY

1.1 PRINCIPLE

The opacity of emissions from stationary sources of visible emissions 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 of visible emissions for an intermittent emission regulation.

1.3 DEFINITIONS

"Intermittent emission regulation" means any regulation which utilizes a 3-minute averaging time (the average of twelve consecutive observations taken at 15-second intervals) to determine the opacity of visible emissions.

"Intermittent emission" means a visible emission of particulate matter which persists for three minutes or less, the opacity of which is measured in accordance with this test method.

"Continuous emission" means a visible emission of particulate matter which persists for more than three minutes, the opacity of which is measured in accordance with Reference Method 9.

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 observer should have a clear view of the source and the potential emission with the sun or other light source oriented in the 140° sector to his back. A position at least 15 feet from the source, but permitting a clear, unobstructed view of the source, is recommended. To the extent feasible, the line of sight should be approximately perpendicular to the flow of potential fugitive emissions, and also to the longer axis of the potential fugitive emissions. When possible, the observer's line of sight should not include more than one emission at a time when multiple emissions are involved. If multiple emissions cannot be observed separately, the observer should attempt to make his observations with his line of sight perpendicular to the longer axis of such multiple emissions.

2.2 FIELD RECORDS

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

2.3 OBSERVATIONS

Readings of opacity should be made for the point(s) of highest opacity within the visible fugitive emission in that portion of the emission where condensed water vapor is not present. The highest opacity usually occurs immediately above or immediately downwind of the source, so observers should concentrate on the area(s) close to the source. The observer shall not look continuously at the emission, but instead shall observe the emission momentarily at 15-second intervals.

2.4 RECORDING OBSERVATIONS

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

2.5 DATA REDUCTION

2.5.1 Intermittent Emission Regulation

An intermittent emission regulation provides for averaging over a period of 3 minutes for which opacity observations shall be reduced to an average of twelve observations recorded at 15-second intervals. Divide the observations recorded on the record sheet into sets of twelve. A set is composed of any twelve consecutive observations. The first observation must be preceded immediately by an observation of zero. The twelve observations must either contain an observation of zero or be followed immediately by an observation of zero. Sets need not be consecutive in time and in no case shall any set of observations overlap with any other set, whether taken for intermittent or continuous emissions. For each set of observations, calculate the appropriate average by summing the opacity of the observations and dividing the sum by twelve.

3. QUALIFICATIONS AND TESTING

3.1 CERTIFICATION REQUIREMENTS

To receive certification as a qualified observer, a candidate must be tested and demonstrate the ability to assign opacity readings in 5 percent increments to 25 different black plumes and 25 different white plumes, with an error not to exceed 15 percent opacity on any one reading and an average error not to exceed 7.5 percent opacity in each category. Candidates shall be tested according to the procedures described in paragraph 3.2. Smoke generators used pursuant to paragraph 3.2 shall be equipped with a smoke meter which meets the requirements of paragraph 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 paragraph 3.2 shall be equipped with a smoke meter installed to measure opacity across the diameter of the smoke generator stack. The smoke meter output shall display in-stack opacity based upon a pathlength equal to the stack exit diameter, on a full 0 to 100 percent chart recorder scale. The smoke meter optical design and performance shall meet the specifications shown in Table 2. The smoke meter shall be calibrated as prescribed in paragraph

3.3.1 prior to the conduct of each smoke reading test. At the completion of each test, the zero and span drift shall be checked and if the drift exceeds ±1 percent opacity, the condition shall be corrected prior to conducting any subsequent test runs. The smoke meter shall be demonstrated, at the time of installation, to meet the specifications listed in Table 2. 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.

TABLE 2. -- SMOKE METER DESIGN AND 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 4.1).
c.	Angle of view	15° maximum total angle.
d.	Angle of projection	15° maximum total angle.
e.	Calibration error	± 3 percent opacity, maximum.
f.	Zero and span drift	± 1 percent opacity, 30 minutes.
g.	Response time	$\leq$ 5 seconds.

3.3.1 Calibration

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

3.3.2 Smoke Meter Evaluation

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

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

3.3.2.2 Spectral Response of Photocell. Verify from manufacturer's data that the photocell has a photopic response; i.e., the spectral sensitivity of the cell shall closely approximate the standard spectral-luminosity curve for photopic vision which is referenced in (b) of Table 2.

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: $\Theta = 2 \tan^{-1} d/2L$, where Θ = total angle of view; d = the sum of the photocell diameter + the diameter of the limiting aperture; and L = 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: $\Theta = 2 \tan^{-1} d/2L$, where Θ = total angle of projection; d = the sum of the length of the lamp filament + the diameter of the limiting aperture; and L = the distance from the lamp to the limiting aperture.

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

3.3.2.6 Zero and Span Drift. Determine the zero and span drift by calibrating and operating the smoke generator in a normal manner over a 1-hour period. The drift is measured by checking the zero and span at the end of this period.

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

4. REFERENCES

4.1 Federal Register, Volume 39, No. 219, November 12, 1974. Method 9 - Visual Determination of the Opacity of Emissions from Stationary Sources (Appendix A).

4.2 Technical Assistance Document: Quality Assurance Guideline for Visible Emission Training Programs, Office of Air, Noise, and Radiation, EPA-600/S4-83-011, May 1982.

4.3 Quality Assurance Handbook for Air Pollution Measurement Systems: Volume III, Stationary Source Specific Methods, Section 3.12, Method 9, Visible Determination of the Opacity of Emissions from Stationary Sources, Environmental Monitoring Systems Laboratory, EPA-600/4-77-027(b), February 1984.