ENVIRONMENTAL PROTECTION AGENCY

40 CFR Part 60

[FRL 1276-4]

Standards of Performance for New Stationary Sources; Continuous Monitoring Performance Specifications

AGENCY: Environmental Protection Agency (EPA).
ACTION: Proposed Revisions.

SUMMARY: On October 6, 1975 (40 FR 46250), the EPA promulgated revisions to 40 CFR Part 60, Standards of Performance for New Stationary Sources, to establish specific requirements pertaining to continuous emission monitoring. An appendix to the regulation contained Performance Specifications 1 through 3, which detailed the continuous monitoring instrument performance and equipment specifications, installation requirements, and test and data computation procedures for evaluating the acceptability of continuous monitoring systems. Since the promulgation of these performance specifications, the need for a number of changes which would clarify the specification test procedures, equipment specifications, and monitoring system installation requirements has become apparent. The purpose of the revisions is to incorporate these changes into Performance Specifications 1 through 3.

The proposed revisions would apply to all monitoring systems currently subject to performance specifications 1. 2, or 3, including sources subject to Appendix P to 40 CFR Part 51.

DATES: Comments must be received on or before December 10, 1979. ADDRESSES: *Comments.* Comments should be submitted (in duplicate if possible) to the Central Docket Section (A-130), Attn: Docket No. OAQPS-79-4, U.S. Environmental Protection Agency, 401 M Street, S.W., Washington, D.C. 20460.

Docket, Docket No. OAQPS-79-4, containing material relevant to this rulemaking, is located in the U.S. Environmental Protection Agency, Central Docket Section, Room 2903B. 401 M Street. S.W., Washington, D.C. The docket may be inspected between 8 A.M. and 4 P.M. on weekdays, and a reasonable fee may be charged for copying.

FOR FURTHER INFORMATION CONTACT: Don R. Goodwin, Director, Emission Standards and Engineering Division (MD-13), Environmental Protection Agency, Research Triangle Park. North Carolina 27711. telephone number (919) 541-5271.

SUPPLEMENTARY INFORMATION: Changes common to all three of the performance specifications are the clarification of the procedures and equipment specifications. especially the requirement for installing the continuous monitoring sample interface and of the calculation procedure for relative accuracy. Specific changes to the specifications are as follows:

Performance Specification

1. The optical design specification for mean and peak spectral responses and for the angle of view and projection have been changed from "500 to 600 nm" range to "515 to 585 nm" range and from "5°" to "3°", respectively.

2. The following equipment specifications have been added:

a. Optical alignment sight indicator for readily checking alignment,

b. For instruments having automatic compensation for dirt accumulation on exposed optical surfaces, a compensation indicator at the control panel so that the permissible maximum 4 percent compensation can be determined.

c. Easy access to exposed optical surfaces for cleaning and maintenance.

d. A system for checking zero and upscale calibration (previously required in paragraph 60.13).

e. For systems with slotted tubes, a slotted portion greater than 90 percent of effluent pathlength (shorter slots are permitted if shown to be equivalent).

f. An equipment specification for the monitoring system data recorder resolution of <5 percent of full scale.

3. A procedure for determining the acceptability of the optical alignment sight has been specified; the optical alignment sight must be capable of indicating that the instrument is misaligned when an error of ±2 percent opacity is caused by misalignment of the instrument at a pathlength of 8 meters.

4. Procedures for calibrating the attenuators used during instrument calibrations have been added; these procedures require the use of a laboratory spectrophotometer operating in the 400-700 nm range with a detector angle view of <10 degrees and an accuracy of 1 percent.

5. The following changes have been made to the procedures for the operational test period:

a. The requirement for an analog strip chart recorder during the performance tests has been deleted; all data are collected on the monitoring system data recorder.

b. Adjustment of the zero and span at 24-hour intervals during the drift tests is optional; adjustments are required only when the accumulated drift exceeds the 24-hour drift specification.

c. The amount of automatic zero compensation for dirt accumulation must be determined during the 24-hour zero check so that the actual zero drift can be quantified. The automatic zero compensation system must be operated during the performance test.

d. The requirement for offsetting the data recorder zero during the operational test period has been deleted.

e. Off the stack "zero alignment" of the instrument prior to installation is permitted.

Performance Specification 2

1. "Continuous monitoring system" has been redefined to include the diluent monitor, if applicable. The change requires that the relative accuracy of the system be determined in terms of the emission standard, e.g., mass per unit calorific value for fossil-fuel fired steam generators.

2. The applicability of the test procedures excludes single-pass. in-situ continuous monitoring systems. The procedures for determining the acceptability of these systems are evaluated on a case-by-case basis.

3. For extractive systems with diluent monitors, the pollutant and diluent monitors are required to use the same sample interface.

4. The procedure for determining the acceptability of the calibration gases has been revised, and the 20 percent (with 95 percent confidence interval) criterion has been changed to 5 percent of mean value with no single value being over 10 percent from the mean.

5. For low concentrations, a 10 percent of the applicable standard limitation for the relative accuracy has been added.

6. An equipment specification for the system data recorder requiring that the chart scale be readable to within <0.50 percent of full-scale has been added.

7. Instead of spanning the instrument at 90 percent of full-scale. a mid-level span is required.

8. The response time test procedure has been revised and the difference limitation between the up-scale and down-scale time has been deleted.

9. The relative accuracy test procedure has been revised to allow different tests (e.g., pollutant, diluent, moisture) during a 1-hour period to be correlated.

10. A low-level drift may be substituted for the zero drift test.

Performance Specification 3

1. The applicability of the test procedures has been limited to those monitors that introduce calibration gases directly into the analyzer and are used as diluent monitors. Alternative procedures for other types of monitors are evaluated on a case-by-case basis.

2. Other changes were made to be consistent with the revisions under Performance Specification 2.

The proposed revised performance specifications would apply to all sources subject to Performance Specifications 1, 2, or 3. These include sources subject to standards of performance that have already been promulgated and sources subject to Appendix P to 40 CFR Part 51. Since the purpose of these revisions is to clarify the performance specifications which were promulgated on October 6, 1975, not to establish more stringent requirements, it is reasonable to conclude that most continuous monitoring instruments which met and can continue to meet the October 6, 1975, specifications can also meet the revised specifications.

Under Executive Order 12044, the Environmental Protection Agency is required to judge whether a regulation is "significant" and therefore subject to the procedural requirements of the Order or whether it may follow other specialized development procedures. EPA labels these other regulations "specialized". I have reviewed this regulation and determined that it is a specialized regulation not subject to the procedural requirements of Executive Order 12044.

Dated: October 1, 1979.
Douglas M. Costle,
Administrator.

It is proposed to revise Appendix B, Part 60 of Chapter I, Title 40 of the Code of Federal Regulations as follows:

Appendix B – Performance Specifications

Performance Specification 1 – Specifications and Test Procedures For Opacity Continuous Monitoring Systems in Stationary Sources

1. Applicability and Principle

1.1 Applicability. This Specification contains instrument design, performance, and installation requirements, and test and data computation procedures for evaluating the acceptability of continuous monitoring systems for opacity. Certain design requirements and test procedures established in the Specification may not be applicable to all instrument designs; equivalent systems and test procedures may be used with prior approval by the Administrator.

1.2 Principle. The opacity of particulate matter in stack emissions is continuously monitored by a measurement system based upon the principle of transmissometry. Light having specific spectral characteristics is projected from a lamp through the effluent in the stack or duct and the intensity of the projected light is measured by a sensor. The projected light is attenuated due to absorption and scatter by the particulate matter in the effluent; the percentage of visible light attenuated is defined as the opacity of the emission. Transparent stack emissions that do not attenuate light will have a transmittance of 100 percent or an opacity of zero percent. Opaque stack emissions that attenuate all of the visible light will have a transmittance of zero percent or an opacity of 100 percent.

This specification establishes specific design criteria for the transmissometer system. Any opacity continuous monitoring system that is expected to meet this specification is first checked to verify that the design specifications are met. Then, the opacity continuous monitoring system is calibrated, installed, and operated for a specified length of time. During this specified time period, the system is evaluated to determine conformance with the established performance specifications.

2. Definitions

2.1 Continuous Monitoring System, The total equipment required for the determination of opacity. The system consists of the following major subsystems:

2.1.1 Sample Interface. That portion of the system that protects the analyzer from the effects of the stack effluent and aids in keeping the optical surfaces-clean.

2.1.2 Analyzer. That portion of the system that senses the pollutant and generates a signal output that is a function of the opacity.

2.1.3 Data Recorder. That portion of the system that processes the analyzer output and provides a permanent record of the output signal in terms of opacity. The data recorder may include automatic data reduction capabilities.

2.2 Transmissometer. That portion of the system that includes the sample interface and the analyzer.

2.3 Transmittance. The fraction of incident light that is transmitted through an optical medium.

2.4 Opacity. The fraction of incident light that is attenuated by an optical medium. Opacity (Op) and transmittance (Tr) are related by: $Op=1-Tr$.

2.5 Optical Density. A logarithmic measure of the amount of incident light attenuated. Optical density (D) is related to the transmittance and opacity as follows:

$$D=-\log_{10} Tr=-\log_{10}(1-Op).$$

2.6 Peak Spectral Response. The wavelength of maximum sensitivity of the transmissometer.

2.7 Mean Spectral Response. The wavelength which bisects the total area under the effective spectral response curve of the transmissometer.

2.8 Angle of View. The angle that contains all of the radiation detected by the photodetector assembly of the analyzer at a level greater than 2.5 percent of the peak detector response.

2.9 Angle of Projection. The angle that contains all of the radiation projected from the lamp assembly of the analyzer at a level of greater than 2.5 percent of the peak illuminace.

2.10 . Span Value. The opacity value at which the continuous monitoring system is set to produce the maximum data display output as specified in the applicable subpart.

2.11 Upscale Calibration Value. The opacity value at which a calibration check of the monitoring system is performed by simulating an upscale opacity condition as viewed by the receiver.

2.12 Calibration Error. The difference between the opacity values indicated by the continuous monitoring system and the known values of a series of calibration attenuators (filters or screens).

2.13 Zero Drift. The difference in continuous monitoring system output readings before and after a stated period of normal continuous operation during which no unscheduled maintenance, repair, or adjustment took place and when thy opacity (simulated) at the time of the measurements was zero.

2.14 Calibration Drift. The difference in the continuous monitoring system output readings before and after a stated period of normal continuous operation during which no unscheduled maintenance, repair, or adjustment took place and when the opacity (simulated) at the time of the measurements was the same known upscale calibration value.

2.15 Response Time. The amount of time it takes the continuous monitoring system to display on the data recorder 95 percent of a step change in opacity.

2.16 Conditioning Period, A period of time (168 hours minimum) during which the continuous monitoring system is operated without unscheduled maintenance, repair, or adjustment prior to initiation of the operational test period.

2.17 Operational Test Period. A period of time (168 hours) during which the continuous monitoring system is expected to operate within the established performance specifications without any unscheduled maintenance, repair, or adjustment.

2.18 Pathlength. The depth of effluent in the light beam between the receiver and the transmitter of a single-pass transmissometer. or the depth of effluent between the transceiver and reflector of a double-pass transmissometer. Two pathlengths are referenced by this Specification as follows:

2.18.1 Monitor Pathlength. The pathlength at the installed location of the continuous monitoring system.

2.18.2 Emission Outlet Pathlength. The pathlength at the location where emissions are released to the atmosphere.

3, Apparatus

3.1 Continuous Monitoring System. Use any continuous monitoring system for opacity which is expected to meet the design specifications in Section 5 and the performance specifications in Section 7. The data recorder may be an analog strip chart recorder type or other suitable device with an input signal range compatible with the analyzer output.

3.2 Calibration Attenuators. Use optical filters with neutral spectral characteristics or screens known to produce specified optical densities to visible light. The attenuators must be of sufficient size to attenuate the entire light beam of the transmissometer. Select and calibrate a minimum of three attenuators according to the procedures in Sections 8.1.2. and 8.1.3.

3.3 Upscale Calibration Value Attenuator. Use an optical filter with neutral spectral characteristics, a screen, or other device that produces an opacity value (corrected for pathlength, if necessary) that is greater than the sum of the applicable opacity standard and one-fourth of the difference between the opacity standard and the instrument span value, but less than the sum of the opacity standard and one-half of the difference between the opacity standard and the instrument span value.

3.4 Calibration Spectrophotometer. To calibrate the calibration attenuators use a laboratory spectrophotometer meeting the following minimum design specification:

Parameter	Specification
Wavelength range……..	400-700 nm
Detector angle of view..	$\leq 10^{o}$
Accuracy……………..	≤ 0.5 pct. Transmittance

4. Installation Specifications

Install the continuous monitoring system where the opacity measurements are representative of the total emissions from the affected facility. Use a measurement path that represents the average opacity over the cross section. Those requirements can be met as follows:

4.1 Measurement Location. Select a measurement location that is (a)downstream from all particulate control equipment; (b) where condensed water vapor is not present: (c) accessible in order to permit routine maintenance; and (d) free of interference from ambient light (applicable only if transmissometer is responsive to ambient light).

4.2 Measurement Path. Select a measurement path that passes through the centroid of the cross section. Additional requirements or modifications must be met for certain locations as follows:

4.2.1 If the location is in a straight vertical section of stack or duct and is less than 4 equivalent diameters-downstream or 1 equivalent diameter upstream from a bend, use a path that is in the plane defined by the bend.

4.2.2 If the location is in a vertical section of stack or duct and is less than 4 diameters downstream and 1 diameter upstream from a bend. use a path in the plane defined by the bend upstream of the transmissometer.

4.2.3 If the location is in a horizontal section of duct and is at least 4 diameters downstream from a vertical bend, use a path in the horizontal plane that is one-third the distance up the vertical axis from the bottom of the duct.

4.2.4 If the location is in a horizontal section of duct and is less than 4 diameters downstream from a vertical bend, use a path in the horizontal plane that is two-thirds the distance up the vertical axis from the bottom of the duct for upward flow in the vertical section, and one-third the distance up the vertical axis from the bottom of the duct for downward flow.

4.3 Alternate Locations and Measurement Paths. Other locations and measurement paths may be selected by demonstrating to the Administrator that the average opacity measured at the alternate location or path is equivalent (± 10 percent) to the opacity as measured at a location meeting the criteria of Sections 4.1 and 4.2, To conduct this demonstration, measure the opacities at the two locations or paths for a minimum period of two hours. The opacities of the two locations or paths may be measured at different times, but must be measured at the same process operating conditions.

5. Design Specifications

Continuous monitoring systems for opacity must comply with the following design specifications:

5.1 Optics.

5.1.1 Spectral Response. The peak and mean spectral responses will occur between 515 nm and 585 nm. The response at any wavelength below 400 nm or above 700 nm will be less than 10 percent of the peak spectral response.

5.1.2 Angle of View. The total angle of view will be no greater than 4 degrees.

5.1.3 Angle of Projection. The total angle of projection will be no greater than 4 degrees.

5.2 Optical Alignment sight. Each analyzer will provide some method for visually determining that the instrument is optically aligned. The system provided will be capable of indicating that the unit is misaligned when an error of ± 2 percent opacity occurs due to misalignment at a monitor pathlength of eight (8) meters.

5.3 Simulated Zero and Upscale Calibration System. Each analyzer will include a system for simulating a zero opacity and an upscale opacity value for the purpose of performing periodic checks of the transmissometer calibration while on an operating stack or duct. This calibration system will provide, as a minimum, a system check of the analyzer internal optics and all electronic circuitry including the lamp. and photodetector assembly,

5.4 Access to External Optics. Each analyzer will provide a means of access to the optical surfaces exposed to the effluent stream in order to permit the surfaces to be cleaned without requiring removal of the unit from the source mounting or without requiring optical realignment of the unit.

5.5 Automatic Zero Compensation Indicator. If the monitoring system has a feature which provides automatic zero compensation for dirt accumulation on exposed optical surfaces, the system will also provide some means of indicating that a compensation of 4 ±0.5 percent opacity has been exceeded; this indicator shall be at a location accessible to the operator (e.g.. the data output terminal). During the operational test period, the system must provide some means for determining the actual amount of zero compensation at the specified 24-hour intervals so that the actual 24-hour zero drift can be determined (see Section 8.4.1).

5.6 Slotted Tube. For transmissometers that use slotted tubes, the length of the slotted portion(s) must be equal to or greater than 90 percent of the monitor pathlength, and the slotted tube must be of sufficient size and orientation so as not to interfere with the free flow of effluent through the entire optical volume of the transmissometer photodetector. The manufacturer must also show that the transmissometer uses appropriate methods to minimize light reflections; as a minimum, this demonstration shall consist of laboratory operation of the transmissometer both with and without the slotted tube in position. Should the operator desire to use a slotted tube design with a slotted portion equal to less than 90 percent of the monitor pathlength, the operator must demonstrate to the Administrator that acceptable results can be obtained. As a minimum demonstration, the effluent opacity shall be measured using both the slotted tube instrument and another instrument meeting the requirement of this specification but not of the slotted tube design. The measurements must be made at the same location and at the same process operating conditions for a minimum period of two hours with each instrument. The shorter slotted tube may be used if the average opacity measured is equivalent (± 10 percent) to the opacity measured by the non-slotted tube design.

6. Optical Design Specifications Verification Procedure.

These procedures will not be applicable to all designs and will require modification in some cases; all modifications are subject to the approval of the Administrator.

Test each analyzer for conformance with the design specifications of Sections 5.1 and 5.2 or obtain a certificate of conformance from the analyzer manufacturer as follows:

B.1 Spectral Response. Obtain detector response. lamp emissivity and filter transmittance data for the components used in the measurement system from their respective manufacturers.

6.2 Angle of View. Set up the receiver as specified by the manufacturer's written instructions. Draw an are with radius of 3 meters in the horizontal direction. Using a small (less than 3 centimeters) non-directional light source, measure the receiver response at 4-centimeter intervals on the are for 24 centimeters on either side of the detector centerline. Repeat the test in the vertical direction.

6.3 Angle of Projection. Set up the projector as specified by the manufacturer's written instructions. Draw an are with radius of 3 meters in the horizontal direction. Using a small (less than 3 centimeters) photoelectric light detector. measure the light intensity at 4-centimeter intervals on the are for 24 centimeters on either side of the light source centerline of projection. Repeat the test in the vertical direction.

6.4 Optical Alignment Sight. In the laboratory set up the instrument as specified by the manufacturers written instructions for a monitor pathlength of 8 meters. Assure that the instrument has been properly aligned and that a proper zero and span have been obtained. Insert an attenuator of 10 percent (nominal) opacity into the instrument pathlength. Slowly misalign the projector unit until a positive or negative shift of two percent opacity is obtained by the data recorder. Then, following the manufacturer's written instructions, check the alignment and assure that the alignment procedure does in fact indicate that the instrument is misaligned. Realign the instrument and follow the same procedure for checking misalignment of the receiver or retroreflector unit.

6.5 Manufacturer’s Certificate of Conformance (Alternative to above). Obtain from the manufacturer a certificate of conformance which certifies that the first analyzer randomly sampled from each month's production was tested according to Sections 6.1 through 6.3 and satisfactorily met all requirements of Section 5 of this Specification. If any of the requirements were not met, the certificate must state that the entire month's analyzer production was resampled according to the military standard 105D sampling procedure (MIL-STD-105D) inspection level II; was retested for each of the applicable requirements under Section 5 of this Specification; and was determined to be acceptable under MIL-STD-105D procedures, acceptable quality level 1.0. The certificate of conformance must include the results of each test performed for the analyzer(s) sampled during the month the analyzer being installed was produced.

7. Performance Specifications

The opacity continuous monitoring system performance specifications are listed in Table 1-1.

Table 1-1.– *Performance specifications*

Parameter	*Specifications*
1. Calibration error [a] …………	*≤3 pct opacity.*
2. Response time………………	*≤10 seconds.*
3. Conditioning period [b] ……	*≥ 168 hours.*
4. Operational test period [b] ..	*≥ 168 hours.*
5. Zero drift (24-hour) [a] …….	*≤ 2 pct opacity.*
6. Calibration drift (24-hour) [a] ..	*≤ 2 pct opacity.*
7. Data recorder resolution……	*≤ 0.50 pct of full scale span value*

[a] Expressed as sum of absolute mean and the 95 percent confidence interval.

[b] During the conditioning and operational test periods, the continuous monitoring system shall not require any corrective maintenance, repair, replacement, or adjustment other than that clearly specified as routine and required *in* the operation and maintenance manuals.

8. Performance Specification Verification Procedure

Test each continuous monitoring system that conforms to the design specifications (Section 5) using the following procedures to determine conformance with the performance specifications of Section 7.

8.1 Preliminary Adjustments and Tests. Prior to installation of the system on the stack, perform these steps or tests at the affected facility or in the manufacturer's laboratory.

8.1,1 Equipment Preparation. Set up and calibrate the monitoring system for the monitor pathlength to be used in the installation as specified by the manufacturer's written instructions. If the monitoring system has automatic pathlength adjustment, follow the manufacturer's instructions to adjust the signal output from the analyzer to equivalent values based on the emission outlet pathlength. Set the span at the value specified in the applicable subpart. At this time perform the zero alignment by balancing the response of the continuous monitoring system so that the simulated zero check coincides with the actual zero check performed across the simulated monitor pathlength. Then, assure that the upscale calibration value is within the required opacity range (Section 3,3).

8.1.2 Calibrated Attenuator Selection. Based on the span value specified in the applicable subpart, select a minimum of three calibrated attenuators (low, mid, and high range) using Table 1-2. If the system is operating with automatic pathlength compensation, calculates the attenuator values required to obtain a system response equivalent to the applicable values shown in Table 1-2; use equation 1-1 for the conversion. A series of filters with nominal optical density (opacity) values of 0.1(20), 0.2(37), 0.3(50), 0.4(60), 0.5(68), 0.8(75), 0.7(80), 0.8(84), 0.9(88), and 1.0(90) are commercially available. Within this limitation of filter availability, select the calibrated attenuators having the values given in Table 1-2 or having values closest to those calculated by Equation 1-1.

Table *1-2.-Required Calibrated Attenuator Values (Nominal)*

Span value (percent opacity)	Calibrated attenuator optical density (equivalent opacity in parenthesis)		
	Low-range D_2	Mid-range	High-range
50	0.1 (20)	0.2 (37)	0.3 (50)
60	.1 (20)	.2 (37)	.3 (50)
70	.1 (20)	.3 (50)	.4 (60)
80	.1 (20)	.3 (50)	.6 (75)
90	.1 (20)	.4 (50)	.7 (80)
100	.1 (20)	.4 (50)	.9 (87 ½)

$$D_1 = D_2 (L_1)/L_2) \qquad \text{Equation 1-1}$$

Where:

D_1 = Nominal optical density value of required mid, low, or high range calibration attenuators.

D_2 = Desired attenuator optical density output value from Table 1-2 at the span required by the applicable subpart.

L_1= Monitor pathlength.

L_2 = Emission outlet pathlength.

8.1.3 Attenuator Calibration. Calibrate the required filters or screens using a laboratory spectrophotometer meeting the specifications of Section 3.4 to measure the transmittance in the 400 to 700 nm wavelength range; make measurements at wavelength intervals of 20 nm or less. As an alternate procedure use an instrument meeting the specifications of Section 3.4 to measure the C.I.E. Daylight, Luminous Transmittance of the attenuators. During the calibration procedure assure that a minimum of 75 percent of the total area of the attenuator is checked. The attenuator manufacturer must specify the period of time over which the attenuator values can be considered stable, as well as any special handling and storing procedures required to enhance attenuator stability. To assure stability, attenuator values must be rechecked at intervals less than or equal to the period of stability guaranteed by the manufacturer, However, values must be rechecked at least every 3 months. If desired, the stability checks may be performed on an instrument other than that initially used for the attenuator calibration (Section 3.4). However, if a different instrument is used, the instrument shall be a high quality laboratory transmissometer or spectrophotometer and the same instrument shall always be used for the stability checks. If a secondary instrument is to be used for stability checks, the value of the calibrated attenuator shall be measured on this secondary instrument immediately following calibration and prior to being used. If over a period time an attenuator value changes by more than ±2 percent opacity, it shall be recalibrated or replaced by a new attenuator.

If this procedure is conducted by the filter or screen manufacturer or independent laboratory, obtain a statement certifying the values and that the specified procedure, or equivalent, was used.

8.1.4 Calibration Error Test. Insert the calibrated attenuators (low, mid, and high range) in the transmissometer path at or as near to the midpoint as feasible. The attenuator must be placed in the measurement path at a point where the effluent will be measured; i.e., do not place the calibrated attenuator in the instrument housing. While inserting the attenuator, assure that the entire projected beam will pass through the attenuator and that the attenuator is inserted in a manner which minimizes interference from reflected light. Make a total of five nonconsecutive readings for each filter. Record the monitoring system output readings in percent opacity (see example Figure 1-1).

8.1.5 System Response Test. Insert, the high-range calibrated attenuator in the transmissometer path five times and record the time required for the system to respond to 95 percent of final zero and high-range filter values (see example Figure 1-2).

8.2 Preliminary Field Adjustments. Install the continuous monitoring system on the affected facility according to the manufacturer’s written instructions and perform the following preliminary adjustments;

8.2.1- Optical and Zero Alignment. When the facility is not in operation, conduct the optical alignment by aligning the light beam from the transmissometer upon the optical surface located across the duct or stack (i.e., the retroreflector or photodetector, as applicable) in accordance with the manufacturer's instructions. Under clear stack conditions, verify the zero alignment (performed in Section 8.1.1) by assuring that the monitoring system response for the simulated zero check coincides with the actual zero measured by the transmissometer across the clear stack. Adjust the zero alignment, if necessary. Then, after the affected facility has been started up and the effluent stream reaches normal operating temperature, recheck the optical alignment. If the optical alignment has shifted realign the optics.

8,2.2 Optical and Zero Alignment (Alternative Procedure). If the facility is already on line and a zero stack condition cannot practicably be obtained, use the zero alignment obtained during the preliminary adjustments (Section 8.1.1) prior to installation of the transmissometer on the stack. After completing all the preliminary adjustments and tests required in Section 8.1, install the system at the source and align the optics, i.e., align the light beam from the transmissometer upon the optical surface located across the duct or stack in accordance with the manufacturer's instruction. The zero alignment conducted in this manner shall be verified and adjusted, if necessary, the first time the facility is not in operation after the operational test period has been completed.

8.3 Conditioning Period. After completing the preliminary field adjustments (Section 8.2), operate the system according to the manufacturer's instructions for an initial conditioning period of not less than 168 hours while the source is operating. Except during times of instrument zero and upscale calibration checks, the continuous monitoring system will analyze the effluent gas for opacity and produce a permanent record of the continuous monitoring system output. During this conditioning period there shall be no unscheduled maintenance, repair, or adjustment. Conduct daily zero calibration and upscale calibration checks, and, when accumulated drift exceeds the daily operating limits, make adjustments and/or clean the exposed optical surfaces. The data recorder shall reflect these checks and adjustments. At the end of the operational test period, verify that the instrument optical alignment is correct. If the conditioning period is interrupted because of source breakdown (record the dates and times of process shutdown), continue the 168-hour period following resumption of source operation. If the conditioning period is interrupted because of monitor failure, restart the 168-hour conditioning period when the monitor becomes operational.

8.4 Operational Test Period. After completing the conditioning period operate the system for an additional 168-hour period. It is not necessary that the 168-hour operational test period immediately follow the 168-hour conditioning period. Except during times of instrument zero and upscale calibration checks, the continuous monitoring system will analyze the effluent gas for opacity and will produce a permanent record of the continuous monitoring system output. During this period, there will be no unscheduled maintenance, repair, or adjustment. Zero and calibration adjustments, optical surface cleaning, and optical realignment may be performed (optional) only at 24-hour intervals or at such shorter intervals as the manufacturer's written instructions specify. Automatic zero and calibration adjustments made by the monitoring system without operator intervention or initiation are followable at any time. If the operational test period is interrupted because of source breakdown, continue the 168-hour period following resumption of source operation. If the test period is interrupted because of monitor failure, restart the 168-hour period when the monitor becomes operational. During the operational test period, perform the following test procedures:

8.4.1 Zero Drift Test. At the outset of the 168-hour operational test period, record the initial simulated zero and upscale opacity readings (see example Figure 1-3). After each 24-hour interval check and record the final zero reading before any optional or required cleaning and adjustment. Zero and upscale calibration adjustments, optical surface cleaning, and optical realignment may be performed only at 24-hour intervals (or at such shorter intervals as the manufacturer’s written instructions specify) but are optional. However, adjustments and/or cleaning must be performed when the accumulated zero calibration or upscale calibration drift exceeds the 24-hour drift specifications (±2 percent opacity). If no adjustments are made after the zero check the final zero reading is recorded as the initial reading for the next 24-hour period. If adjustments are made, the zero value after adjustment is recorded as the initial zero value for the next 24-hour period. If the instrument has an automatic zero compensation feature for dirt accumulation on exposed lens, and the zero value cannot be measured before compensation is entered then record the amount of automatic zero compensation for the final zero reading of each 24-hour period. (List the indicated zero values of the monitoring system in parenthesis.)

8.4.2 Upscale Drift Test. At each 24-hour interval, after the zero calibration value has been checked and any optional or required adjustments have been made, check and record the simulated upscale calibration value. If no further adjustments are made to the calibration system at this time, the final upscale calibration value is recorded as the initial upscale value for the next 24-hour period. If an instrument span adjustment is made, the upscale value after adjustment is recorded as the initial upscale for the next 24-hour period.

During the operational test period record all adjustments, realignments and lens cleanings.

9. Calculation, Data Analysis, and Reporting

9.1 Arithmetic Mean, Calculate the mean of a set of data as follows:

$$\bar{x} = \frac{1}{n}\sum_{i=1}^{n} x_i \qquad \text{Equation 2-1}$$

Where.

$\bar{x}$ = mean value.

n = number of data points.

$\sum x_i$ = algebraic sum of the individual measurements. x,

9.2 Confidence Interval. Calculate the 95 percent confidence interval (two-sided) as follows:

$$C.I._{95} = \frac{t_{.975}}{n\sqrt{n-1}}\sqrt{n(\sum x_i^2) - (\sum x_i)^2}$$

Equation 2-2

Where:

C.I.$_{95}$ = 95 percent confidence interval estimate of the average mean value, $t_{.975} = t_{(1-a/2)}$.

Table 1-3-'.975 *Values*

n	$t_{.975}$	n	$t_{.975}$	n	$t_{.975}$
2	12.706	7	2.447	12	2.201
3	4.303	8	2.385	13	2.179
4	3.182	9	2.306	14	2.160
5	2.776	10	2.262	15	2.145
6	2.571	11	2.228	16	2.131

The values in this table are already corrected for n-1 degrees of Freedom. Use n equal to the number of data points.

9.3 Conversion of Opacity Values from Monitor Pathlength to Emission Outlet Pathlength. When the monitor pathlength is different than the emission outlet pathlength, use either of the following equations to convert from one basis to the other (this conversion may be automatically calculated by the monitoring system):

$\log(1-Op_2)=(L_2/L_1)\ \text{Log}\ (1-Op_1)$ Equation 1-4

$D_2=(L_2,/L_1)\ D_1$ Equation 1-5

Where:

Op_1 = opacity of the effluent based upon L_1

Op_2 = opacity of the effluent based upon L_2

L_1 = monitor pathlength

L_2 = emission outlet pathlength

D_1 = optical density of the effluent based upon L_1

D_2. = optical density of the effluent based upon L_2

9.4 Spectral Response. Using the spectral data obtained in Section 8.1, develop the effective spectral response curve of the transmissometer. Then determine and report the peak spectral response wavelength, the mean spectral response wavelength, and the maximum response at any wavelength below 400 nm and above 700 nm expressed as a percentage of the peak response.

9.5 Angle of View. For the horizontal and vertical directions, using the data obtained in Section 6.2. calculate the response of the receiver as a function of viewing angle (21 centimeters of arc with a radius of 3 meters equal 4 degrees), report relative angle of view curves, and determine and report the angle of view.

9.6 Angle of Projection. For the horizontal and vertical directions, using the data obtained in Section 6.3. calculate the response of the photoelectric detector as a function of projection angle, report relative angle of projection curves, and determine and report the angle of projection.

9.7 Calibration Error. See Figure 1-1. If the pathlength is not adjusted by the measurement system. subtract the actual calibrated attenuator value from the value indicated by the measurement system recorder for each of the 15 readings obtained pursuant to Section 8.1.4. If the pathlength is adjusted by the measurement system subtract the "path adjusted" calibrated attenuator values from the values indicated by the measurement system recorder the "path adjusted" calibrated attenuator values are calculated using equation 1-4 or 1-5). Calculate the arithmetic mean difference and the 95 percent confidence interval of the five tests at each attenuator value using Equations 1-2 and 1-3. Calculate the sum of the absolute value of the mean difference and the 95 percent confidence interval for each of the three test attenuators; report these three values as the calibration error.

9.8 Zero and Upscale Calibration Drifts. Using the data obtained in Sections 8.4.1 and 8.4.2 calculate the zero and upscale calibration drifts. Then calculate the arithmetic means and the 95 percent confidence intervals using Equations 1-2 and 1-3. Calculate the sum of the absolute value of the mean and the 95 percent confidence interval and report these values as the 24-hour zero drift and the 24-hour calibration drift.

9.9 Response Time. Using the data collected in Section 8.1.5, calculate the mean time of the 10 upscale and downscale tests and report this value as the system response time.

9.10 Reporting. Report the following (summarize in tabular form where appropriate).

9.10.1 General Information.

a. Instrument Manufacturer.

b. Instrument Model Number.

c. Instrument Serial Number.

d. Person(s) responsible for operational and conditioning test periods and affiliation.

e. Facility being monitored.

f. Schematic of monitoring system measurement path location.

g. Monitor pathlength, meters.

h. Emission outlet pathlength, meters.

i. System span value, percent opacity.

j. Upscale calibration value. Percent opacity.

k. Calibrated Attenuator values (low, mid, and high range), percent opacity.

9.10.2 Design Specification Test Results

a. Peak spectral response, nm.

b. Mean spectral response, nm.

c. Response above 700 nm, percent of peak.,

d. Response below 400 nm, percent of peak.

e. Total angle of view, degrees.

f. Total angle of projection, degrees.

9.10.3 Operational Test Period Results.

a. Calibration error, high-range, percent opacity.

b. Calibration error, mid-range, percent opacity.

c. Calibration error, low-range, percent opacity.

d. Response time, seconds.

e. 24-hour zero drift, percent opacity.

f. 24-hour calibration drift, percent opacity.

g. Lens cleaning, clock time.

h. Optical alignment adjustment,. clock time.

9.10.4 Statements. Provide a statement that the conditioning and operational test periods were completed according to the requirements of Sections 8.3 and 8.4. In this statement, include the time periods during which the conditioning and operational test periods were conducted.

9.10.5 Appendix. Provide the data tabulations and calculations for the above tabulated results.

9.11 Retest. If the continuous monitoring system operates within the specified performance parameters of Table 1-1, the operational test period will be successfully concluded. If the continuous monitoring system fails to meet any of the specified performance parameters, repeat the operational test period with a system that meets the design specifications and is expected to meet the performance specifications,

10. Bibliography.

10.1 "Experimental Statistics," Department of Commerce. National Bureau of Standards Handbook 91, 1963, pp. 3-31, paragraphs 3-3.1.4.

10.2 "Performance Specifications for Stationary-Source Monitoring-Systems for Gases and Visible Emissions." Environmental Protection Agency, Research Triangle Park, N. C., EPA-650/2-74-013, January 1974.

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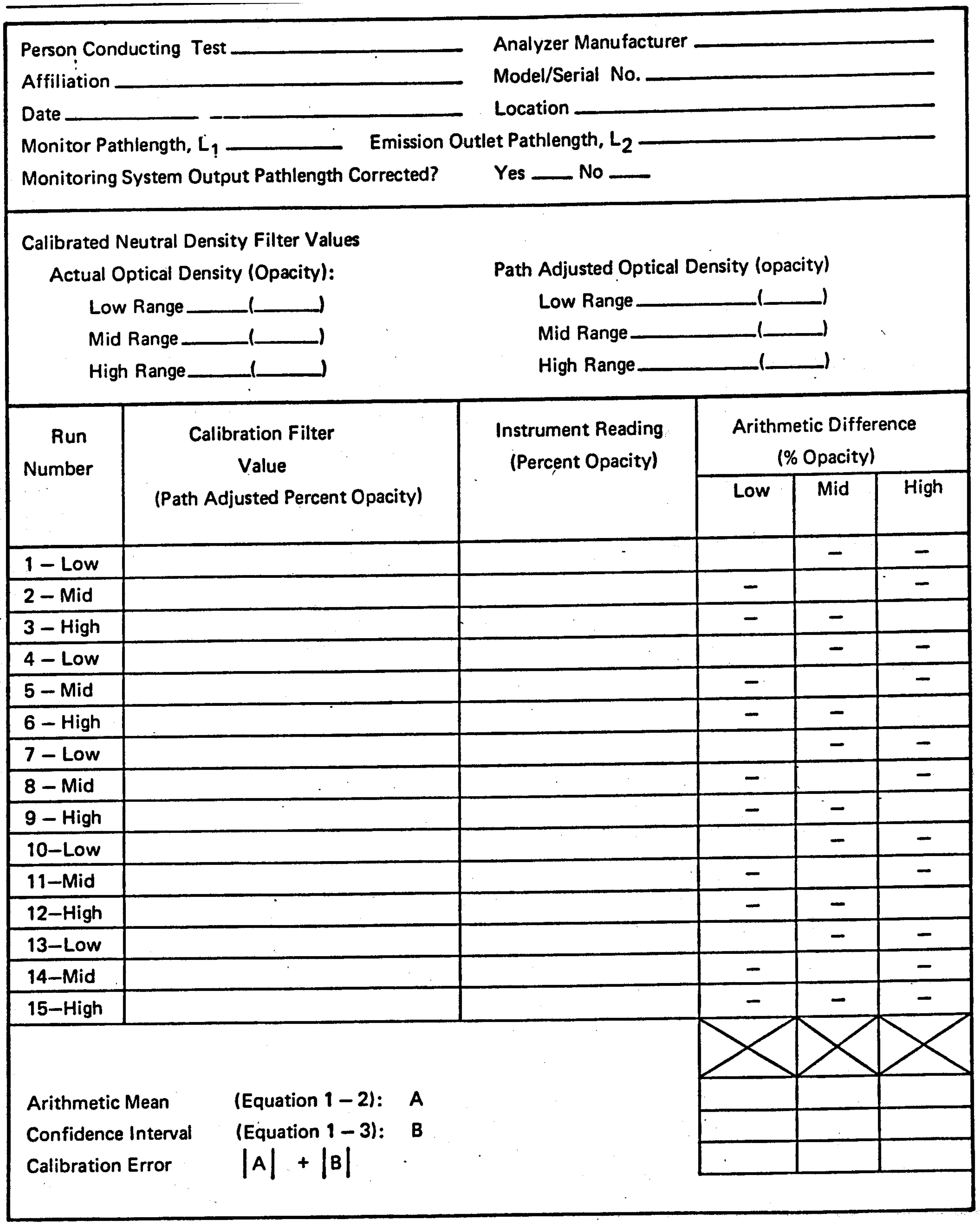


Person Conducting Test ______________ Analyzer Manufacturer ______________
Affiliation ______________ Model/Serial No. ______________
Date ______ ______________ Location ______________
Monitor Pathlength, L_1 ________ Emission Outlet Pathlength, L_2 ______________
Monitoring System Output Pathlength Corrected? Yes ____ No ____

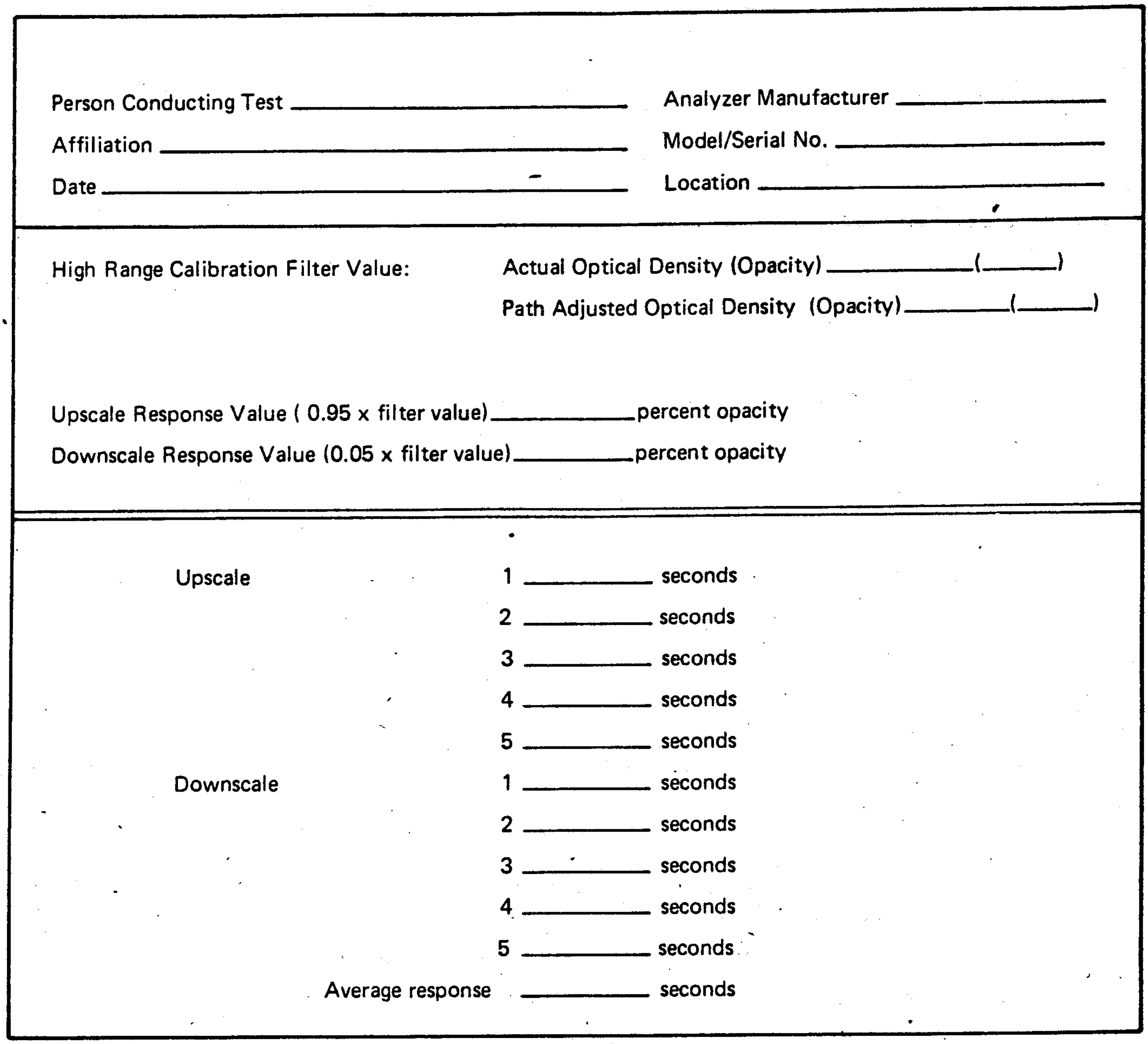
Calibrated Neutral Density Filter Values

Actual Optical Density (Opacity):
Low Range ______(______)
Mid Range ______(______)
High Range ______(______)

Path Adjusted Optical Density (opacity)
Low Range ______(______)
Mid Range ______(______)
High Range ______(______)

Run Number	Calibration Filter Value (Path Adjusted Percent Opacity)	Instrument Reading (Percent Opacity)	Arithmetic Difference (% Opacity)		
			Low	Mid	High
1 – Low				–	–
2 – Mid			–		–
3 – High			–	–	
4 – Low				–	–
5 – Mid			–		–
6 – High			–	–	
7 – Low				–	–
8 – Mid			–		–
9 – High			–	–	
10–Low				–	–
11–Mid			–		–
12–High			–	–	
13–Low				–	–
14–Mid			–		–
15–High			–	–	–
			☒	☒	☒
Arithmetic Mean	(Equation 1 – 2): A				
Confidence Interval	(Equation 1 – 3): B				
Calibration Error	|A| + |B|				

Figure 1 – 1. Calibration error determination



Person Conducting Test ____________________ Analyzer Manufacturer ____________

Affiliation ____________________ Model/Serial No. ____________

Date ____________________ Location ____________

High Range Calibration Filter Value: Actual Optical Density (Opacity) ________(______)

Path Adjusted Optical Density (Opacity) ________(______)

Upscale Response Value (0.95 x filter value) ________ percent opacity

Downscale Response Value (0.05 x filter value) ________ percent opacity

Upscale	1	________	seconds
	2	________	seconds
	3	________	seconds
	4	________	seconds
	5	________	seconds
Downscale	1	________	seconds
	2	________	seconds
	3	________	seconds
	4	________	seconds
	5	________	seconds
Average response		________	seconds

Figure 1-2. Response Time Determination

Person Conducting Test ____________ Analyzer Manufacturer ____________
Affiliation ____________ Model/ Serial No. ____________
Date ____________ Location ____________

Monitor Pathlength, L_1 ____________ Emission Outlet Pathlength, L_2 ____________
Monitoring System Output Pathlength Corrected: ? Yes ______ No ______
Upscale Calibration Value : Actual Optical Density (Opacity) ____________(______)
Path Adjusted Optical Density (Opacity) ____________(______)

Date	Time		Percent Opacity									lens cleaned?	Align–ment	
			Zero Reading*		Zero Drift	zero adjusted?	Upscale Calibration Reading		Upscale Drift	Cali–bration Drift	span adjusted?		checked?	adjusted?
	Begin	End	Initial A	Final B	C = B–A		Initial D	Final E	F = E–D	G = F–C**				

Arithmetic Mean (Eq. 1–2) ☐ ☐
Confidence Interval (Eq. 1–3) ☐ ☐
Zero Drift ☐ Calibration Drift ☐

*without automatic zero compensation
**if zero was adjusted (manually or automatically) prior to upscale check, then use c = 0.

Figure 1 -3. Zero Calibration Drift Determination

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Performance Specification 2 – Specifications and Test Procedures for SO_2 and NO_x Continuous Monitoring Systems in Stationary Sources

1. Applicability and Principle

1.1 Applicability. This Specification contains (a) installation requirements, (b) instrument performance and equipment specifications, and (c) test procedures and data reduction procedures for evaluating the acceptability of SO, and NO, continuous monitoring systems, which may include, for certain stationary sources, diluent monitors. The test procedures in item (c), above, are not applicable to single-pass, in-situ continuous monitoring systems; these systems will be evaluated on a case-by-case basis upon written request to the Administrator and alternative test procedures will be issued separately.

1.2 Principle. Any SO_2 or NO_x continuous monitoring system that is expected to meet this Specification is installed, calibrated, and operated for a specified length of time. During this specified time period, the continuous monitoring system is evaluated to determine conformance with the Specification.

2. Definitions

2.1 Continuous Monitoring System.

The total equipment required for the determination of a gas concentration or a gas emission rate. The system consists of the following major sub-systems:

2.1.1 Sample Interface. That portion of a system that is used for one or more of the following: sample acquisition, sample transportation, sample conditioning, or protection of the monitor from the effects of the stack effluent.

2.1.2. Pollutant Analyzer. That portion of the system that senses the pollutant gas and generates an output that is proportional to the gas concentration.

2.1.3, Diluent Analyzer (if applicable). That portion of the system that senses the diluent gas (e.g., CO, or 0,). and generates an output that is .proportional to the gas concentration. 2.1.4 Data Recorder. That portion of the monitoring system that provides a permanent record of the analyzer output. The data recorder may include automatic data reduction capabilities.

2.2 Types of Monitors. Continuous monitors are categorized as "extractive" or "in-situ," which are further categorized as "point," "multipoint," "limited-path," and "path" type monitors or as "single-pass" or "double-pass" type monitors.

2.2.1 Extractive Monitor. One that withdraws a gas sample from the stack -and transports the sample to the analyzer.

2.2.2 In-situ Monitor. One that senses the gas concentration in the stack environment and does not extract a sample for analysis.

2.2.3 Point Monitor. One that measures the gas concentration either at a single point or along a path which is less than 10 percent of the length of a specified measurement line.

2.2.4 Multipoint Monitor. One that measures the gas concentration at 2 or more points.

2.2.5 Limited-Path Monitor. One that measures the gas concentration along a path, which is 10 to 90 percent of the length of a specified measurement line.

2.2.6 Path Monitor. One that measures the gas concentration along a path, which is greater than 90 percent of the length of a specified measurement line.

2.2.7 Single-Pass Monitor. One that has the transmitter and the detector on opposite sides of the stack or duct.

2.2.8 Double-Pass Monitor. One that has the transmitter and the detector on the same side of the stack or duct.

2.3 Span Value. The upper limit of a gas concentration measurement range which is specified for affected source categories in the applicable subpart of the regulations.

2.4 Calibration Gases. A known concentration of a gas in an appropriate diluent gas.

2.5 Calibration Gas Cells or Filters. A device which, when inserted between the transmitter and detector of the analyzer, produces the desired output level on the data recorder.

2.S Relative Accuracy. The degree of correctness including analytical variations of the gas concentration or emission rate determined by the continuous monitoring system, relative to the value determined by the reference method(s).

2.7 Calibration Error. The difference between the gas concentration indicated by the continuous monitoring system and the known concentration of the calibration gas, gas cell, or filter.

2.8 Zero Drift. The difference in the continuous monitoring system output readings before and after a stated period of operation during which no unscheduled maintenance, repair, or adjustment took place and when the pollutant concentration at the time of the measurements was zero (i.e., zero gas, or zero gas cell or filter).

2.9 Calibration Drift. The difference in the continuous monitoring system output readings before and after a stated period of operation during which no unscheduled maintenance, repair or adjustment took place and when the pollutant concentration at the time of the measurements was a high-level value (i.e., calibration gas, gas cell or filter).

2.10 Response Time. The amount of time it takes the continuous monitoring system to display on the data recorder 95 percent of a step change in pollutant concentration.

2.11 Conditioning Period. A minimum period of time over which the continuous monitoring system is expected to operate with no unscheduled maintenance, repair, or adjustments prior to initiation of the operational test period.

2.12 Operational Test Period. A minimum period of time over which the continuous monitoring system is expected to operate within the established performance specifications with no unscheduled maintenance, repair or adjustment.

3. Installation Specifications

Install the continuous monitoring system at a location where the pollutant concentration measurements are representative of the total emissions from the affected facility and are representative of the concentration over the cross section. Both requirements can be met as follows:

3.1 Measurement Location. Select an accessible measurement location in the stack or ductwork that is at least 2 equivalent diameters downstream from the nearest control device or other point at which a change in the pollutant concentration may occur and at least 0.5 equivalent diameters upstream from the effluent exhaust. Individual subparts of the regulations may contain additional requirements. For example, for steam generating facilities, the location must be downstream of the air preheater.

3.2 Measurement Points or Paths. There are two alternatives. The tester may choose either (a) to conduct the stratification check procedure given in Section 3.3 to select the point, points, or path of average gas concentration, or (b) to use the options listed below without a stratification check.

Note.– For the purpose of this section, the "centroidal area" is defined as a concentric area that is geometrically similar to the stack cross section and is no greater than 1 percent of the stack cross-sectional area.

3.2.1 SO_2 and NO_x Path Monitoring Systems. The tester may 'choose to centrally locate the sample interface (path) of the monitoring system on a measurement line that passes through the "centroidal area" of the cross section.

3.2.2 SO_2 and NO_x Multipoint Monitoring Systems. The tester may choose to space 3 measurement points along a measurement line that passes through the "centroidal area" of the stack cross section, at distances of 16.7, 50.0, and 83.3 percent of the way across it (see Figure 2-1).

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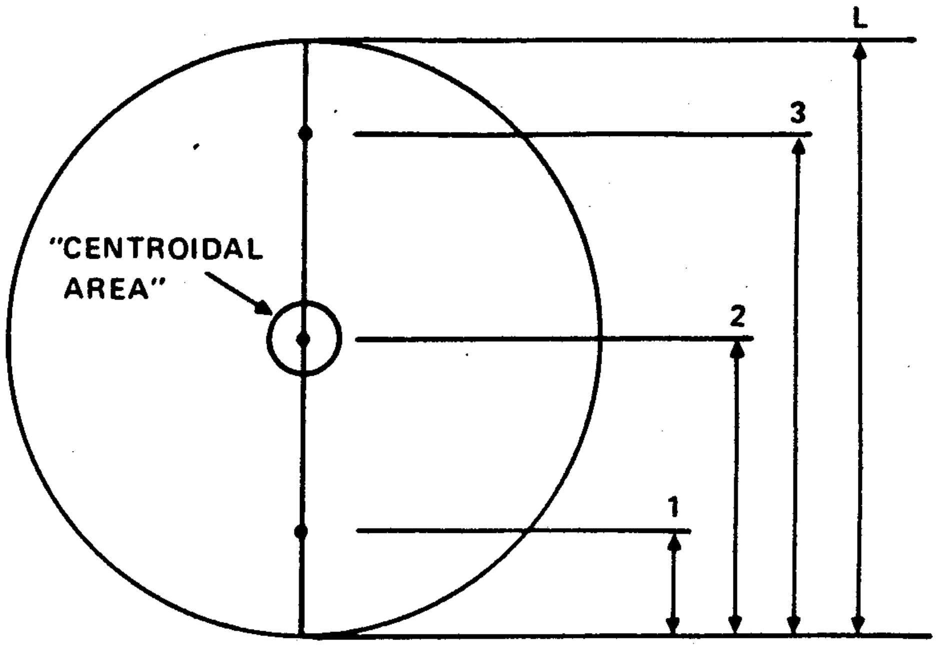

POINT NO.	DISTANCE (% OF L)
1	16.7
2	50.0
3	83.3

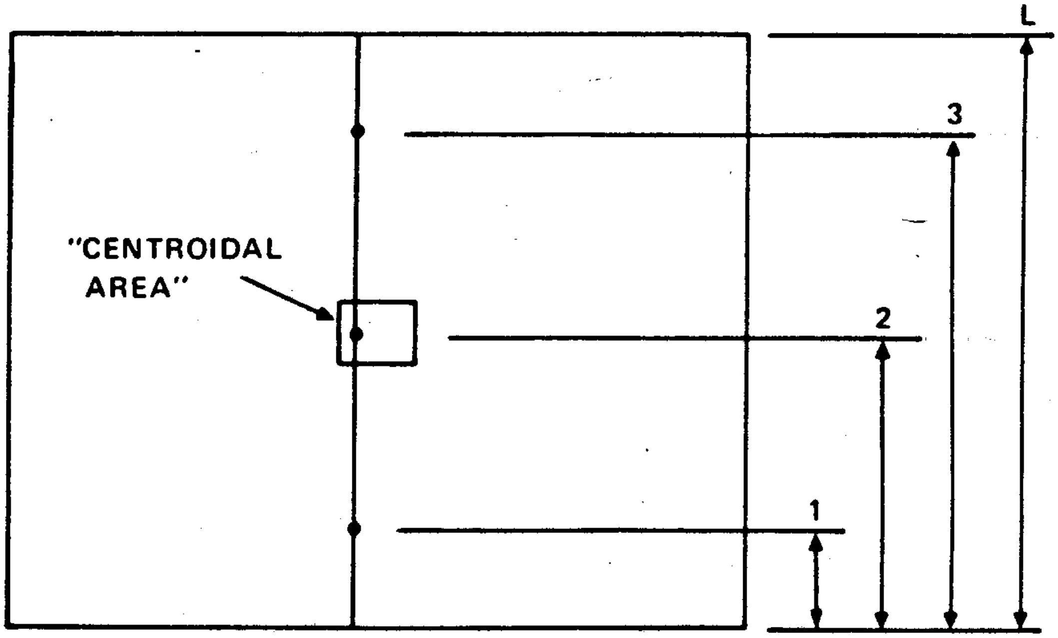

Figure 2-1. Location of an example measurement line (L) and measurement points.

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The following sampling strategies, or equivalent. for measuring the concentrations at the 3 points are acceptable: (a) The use of a 3-probe or a 3-hole single probe arrangement, provided that the sampling rate in each of the 3 probes or holes is maintained within 10 percent of their average rate (This option requires a procedure, subject to the approval of the Administrator. to demonstrate that the proper sampling rate is maintained); or (b) the use of a traversing probe arrangement, provided that a measurement at each point is made at least once every 15 minutes and all 3 points are traversed and sampled for equal lengths of time within 15 minutes.

3.2.3 SO_2 Single-Point and Limited-Path Monitoring Systems. Provided that (a) no "dissimilar" gas streams (i.e., having greater than 10 percent difference in pollutant concentration from the average) are combined upstream of the measurement location, and (b) for steam generating facilities, a CO_2 or 0_2 continuous monitor is installed in addition to the SO_2 monitor, according to the guidelines given in Section 3.1 or 3.2 of Performance Specification 3, the tester may choose to monitor SO_2 at a single point or over a limited path. Locate the point in or centrally locate the limited path over the "centroidal area." Any other location within the inner 50 percent of the stack cross-sectional area that has been demonstrated (see Section 3.4) to have a concentration within 5 percent of the concentration at a point within the "centroidal area" may be used.

3.2.4 NO, Single-Point and Limited-Path Monitoring Systems. For NO_x monitors, the tester may choose the single-point or limited-path option described in Section 3.2.3 only in coal-burning steam generators (does not include oil and gas-fired units) and nitric acid plants, which have no dissimilar gas streams combining upstream of the measurement location.

3.3 Stratification Check Procedure. Unless specifically approved in Section 3.2., conduct a stratification check and select the measurement point, points, or path as follows:

3.3.1 Locate 9 sample points, as shown in Figure *2-2*, a or b. The tester may choose to use more than 9 points, provided that the sample points are located in a similar fashion as in Figure 2-2,

3.3.2 Measure at least twice the pollutant and, if applicable (as in the case of steam generators), CO_2 or 0_2 concentrations at each of the sample points. Moisture need not be determined for this step, The following methods are acceptable for the measurements: (a) Reference Methods 3 (grab-sample), 6 or 7 of this part; (b) appropriate instrumental methods which give relative responses to the pollutant (i.e., the methods need not be absolutely correct), subject to the approval of the Administrator. or (c) alternative methods subject to the approval of the Administrator, Express all measurements, if applicable, in the units of the applicable standard.

3.3,3 Calculate the mean value and select a point, points, limited-path, or path which gives an equivalent value to the mean. The point or points must be within, and the limited-path or path must pass through, the inner 50 percent of the stack cross-sectional area. All other locations must be approved by the Administrator.

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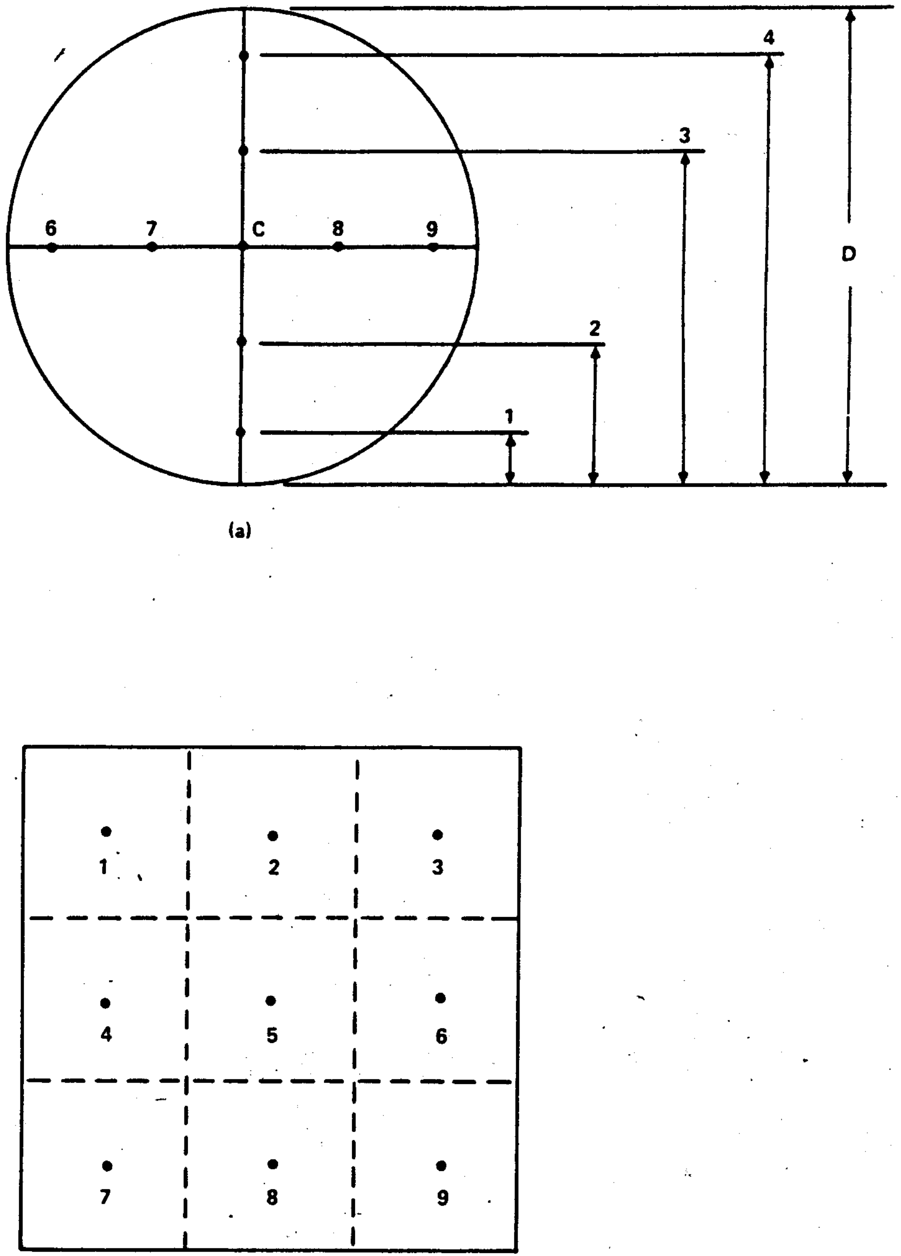
POINT NO.	DISTANCE (% OF D)
1, 9	10.0
2, 8	30.0
C	50.0
3, 7	70.0
4, 6	90.0



(b)

Figure 2-2. Location of 9 sampling points for stratification check.

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3.4 Acceptability of Single Point or Limited Path Alternative Location. Any of the applicable measurement methods mentioned in Section 3.3.2, above, may be used. Measure the pollutant and, if applicable, CO_2 or O_2 concentrations at both the centroidal area and the alternative locations. Moisture need not be measured for this test. Collect a 21-minute integrated sample or 3 grab-samples. either at evenly spaced (7 ± 2 min.) intervals over 21 minutes or all within 3 minutes, at each location. Run the comparative tests either concurrently or within 10 minutes of each other. Average the results of the 3 grab-samples.

Repeat the measurements until a minimum of 3 paired measurements spanning a minimum of 1 hour of process operation are obtained. Determine the average pollutant concentrations at the centroidal area and the alternative locations. If applicable, convert the data in terms of the standard for each paired set before taking the average. The alternative sampling location is acceptable if each alternative location value is within ± 10 percent of the corresponding centroidal area value and if the average at the alternative location is within 5 percent of the average of the centroidal area.

4. Performance and Equipment Specifications

The continuous monitoring system performance and equipment specifications are listed in Table 2-1. To be considered acceptable, the continuous monitoring system must demonstrate compliance with these specifications using the test procedures of Section 6.

5. Apparatus

5.1 Continuous Monitoring System. Use any continuous monitoring system of SO_2 or NO_x which is expected to meet the specifications in Table 2-1. For sources which are required to convert the pollutant concentrations to other emission units using diluent gas measurements, the diluent gas continuous monitor, as described in Performance Specification 3 of this Appendix, is considered part of the continuous monitoring system. The data recorder may be an analog strip chart recorder type or other suitable device with an input signal range compatible with the analyzer output.

5.2 Calibration Gases. For continuous monitoring systems that allow the introduction of calibration gases to the analyzer, the calibration gases may be SO_2 in air or N_2, NO in N_2, and NO_x in air or N_2. Two or more calibration gases may be combined in the same gas cylinder, except do not combine the NO and air. For NO_x monitoring systems that oxidize NO to NO_2, the calibration gases must be in the form of NO. Use three calibration gas mixtures as specified below:

5.2.1 High-Level Gas. A gas concentration that is equivalent to 80 to 90 percent of the span value.

Table *2-1.-Continuous Monitoring System Performance and Equipment Specifications*

Parameter	Specification
1. Conditioning period[a] .	≥168 hours.
2. Operational test period [a].	≥168 hours
3. Calibration error [b].	≤ 5 pct of each mid-level and high-level calibration value.
4. Response time	≤15 minutes (5 minutes for 3-point traversing probe arrangement).
5. Zero drift (2-hour) [bc]	≤ 2 pct of span value.
6. Zero drift (24-hour) [bc]	≤ 2 pct of span value.
7. Calibration drift (2-hour) [b].	≤ 2 pct of span value.
8. Calibration drift (24-hour) [b].	≤ 2.5 pct of span value.
9. Relative accuracy[b].	≤ 20 pct of the mean value of reference method(s) test data in terms of emission standard or 10 percent of the applicable standard, whichever is greater.
10. Calibration gas cells or filters,	Must provide a check of all analyzer internal minors and lenses and all electronic circuitry including the radiation source and detector assembly which are normally used in sampling and analysis
11. Data recorder chart resolution.	Chart scales must be readable to within ≤0.50 pct of full-scale.
12. Extractive systems with diluent monitors	Must use the same sample interface to sample both the pollutant and diluent gases. Place in series (diluent after pollutant analyzer) or use a "T."

[a] During the conditioning and operational test periods, the continuous monitoring system shall not require any corrective maintenance. repair, replacement or adjustment other than that clearly specified as routine and required in the operation and maintenance manuals.

[b] Expressed as the sum of the absolute mean value plus the 95 percent confidence interval of a series of tests divided by a reference value.

[c] A low-level (5-15 percent of span value) drift test may be substituted for the Zero Drift tests.

5.2.2 Mid-Level Gas. A gas concentration that is equivalent to 45 to 55 percent of the span value.

5.2.3 Zero Gas. A gas concentration of less than 0.25 percent of the span value. Ambient air may be used for the zero gas.

5.3 Calibration Gas Cells or Filters. For continuous monitoring systems which use calibration gas cells or filters, use three certified calibration gas cells or filters as specified below:

5.3.1 High-Level Gas Cell or Filter. One that produces an output equivalent to 80 to 90 percent of the span value.

5.3.2 Mid-Level Gas Cell or Filter. One that produces an output equivalent to 45 to 55 percent of the span value.

5.3.3 Zero Gas Cell or Filter. One that produces an output equivalent to zero. Alternatively, an analyzer may produce a zero value check by mechanical means, such as a movable mirror.

5.4 Calibration Gas – Gas Cell or Filter Combination. Combinations of the above may be used.

6. Performance Specification Test Procedures.

6.1 Pretest Preparation.

6.1.1 Calibration Gas Certification. The tester may select one of the following alternatives: (a) The tester may use calibration gases prepared ’ according to the protocol defined in Citation 10.5, i.e. These gases may be used as received without reference method analysis (obtain a statement from the gas cylinder supplier certifying that the calibration gases have been prepared according to the protocol); or (b) the tester may use calibration gases not prepared according to the protocol. In case (b), he must perform triplicate analyses of each calibration gas (mid-level and high-level, only) within 2 weeks prior to the operational test period using the appropriate reference methods. Acceptable procedures are described in Citations 10.6 and 10.7. Record the results on a data sheet (example is shown in Figure 2-3). Each of the individual analytical results must be within 10 percent (or 15 ppm, whichever is greater) of the average; otherwise, discard the entire set and repeat the triplicate analyses. If the average of the triplicate reference method test results is within 5 percent of the calibration gas manufacturer's tag value, use the tag value; otherwise, conduct at least 3 additional reference method test analyses until the results of 6 individual runs (the 3 original plus 3 additional) agree within 10 percent or 15 ppm, whichever is greater, of the average. Then use this average for the cylinder value.

Figure 2-3. Analysis of Calibration Gases[a].

Date________(Must be within 2 weeks prior to the operational test period)

Reference Method Used______________

Sample Run	Mid-level[b] ppm	High-level[c] ppm
1		
2		
3		
Average		
Maximum % Deviation[d]		

[a] Not necessary if the protocol in Citation 10.5 is used to prepare the gas cylinders.

[b] Average must be 45 to 55 percent of span value.

[c] Average must be 80 to 90 percent of span value.

[d] Must be ≤ ± 10 percent of applicable average or 15 ppm, whichever is greater.

6.1.2 Calibration Gas Cell or Filter Certification, Obtain (a) a statement from the manufacturer certifying that the calibration gas cells or filters (zero, mid-level, and high-level) will produce the stated instrument responses for the continuous monitoring system, and (b) a description of the test procedure and equipment used to calibrate the cells or filters. At a minimum, the manufacturer must have calibrated the gas cells or filters against a simulated source of known concentration.

6.2 Conditioning Period. Prepare the monitoring system for operation according to the manufacturer's written instructions. At the outset of the conditioning period, zero and span the system. Use the mid-level calibration gas (or gas cell or filter) to set the span at 50 percent of recorder full-scale. If necessary to determine negative zero drift. offset the scale by 10 percent. (Do not forget to account for this when using the calibration curve.) If a zero offset is not possible or is impractical, a low-level drift may be substituted for the zero drift, by using a low-level (5 to 15 percent of span value) calibration gas (or gas cell or filter). This low-level calibration gas (or gas cell or filter) need not be certified. Operate the continuous monitoring system for an initial 168-hour period in the manner specified by the manufacturer. Except during times of instrument zero, calibration checks, and system backpurges, the continuous monitoring system shall collect and condition the effluent gas sample (if applicable), analyze the sample for the appropriate gas constituents, and produce a permanent record of the system output. Conduct daily zero and mid-level calibration checks and, when drift exceeds the daily operating limits, make adjustments. The data recorder shall reflect these checks and adjustments. Keep a record of any instrument failure during this time. If the conditioning period is interrupted because of source breakdown (record the dates and times of process shutdown), continue the 168-hour period following resumption of source operation. If the conditioning period is interrupted because of monitor failure, restart the 168-hour conditioning period when the monitor becomes functional.

6.3 Operational Test Period. Operate the continuous monitoring system for an additional 168-hour period. The continuous monitoring system shall monitor the effluent, except during periods when the system calibration and response time are checked or during system backpurges; however, the system shall produce a permanent record of all operations. Record any system failure during this time on the data recorder output sheet.

It is not necessary that the 168-hour operational test period immediately follow the 168-hour conditioning period. During the operational test period, perform the following test procedures:

6.3.1 Calibration Error Determination. Make a total of 15 nonconsecutive zero, mid-level, and .high-level measurements (e.g., zero, mid- level, zero, high-level, mid-range, etc.).

This will result in a set of 5 each of zero, mid-level, and high-level measurements. Convert the data output to concentration units, if necessary, and record the results on a data sheet (example is shown in Figure 2-4). Calculate the differences between the reference calibration gas concentrations and the measurement system reading. Then calculate the mean, confidence interval, and calibration errors separately for the mid-level and high-level concentrations using Equations 2-1, 2-2, and 2-3. In Equation 2-3, use each respective calibration gas concentration for R.V.

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Figure 2-4. Calibration Error Determination

Run no.	Calibration gas concentration[a] ppm	Measurement system reading ppm	Arithmetic differences ppm	
	A	B	A-B	
			Mid	High
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
Arithmetic Mean (Eq. 2-1) =				
Confidence Interval (Eq. 2-2) =				
Calibration Error (Eq. 2-3)[b] =				

[a] Calibration Data from Section 6.1.1 or 6.1.2

Mid-level: C = _______ppm

High-level: D = _______ppm

[b] Use C or D as R.V. in Eq. 2-3

Figure 2-5. Response Time

Date________________________ High-level = ___________ppm

Test Run	Upscale min.	Downscale min.
1		
2		
3		
Average	A =	B =

System Response Time (slower of A and B) = ________ min.

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6.3.2 Response Time Test Procedure, At a minimum, each response time test shall provide a check of the entire sample transport line (if applicable), any sample conditioning equipment (if applicable), the pollutant analyzer, and the data recorder. For in-situ systems, perform the response time check by introducing the calibration gases at the sample interface (if applicable), or by introducing the calibration gas cells or filters at an appropriate location in the pollutant analyzer. For extractive monitors, introduce the calibration gas at the sample probe inlet in the stack or at the point of connection between the rigid sample probe and the sample transport line. If an extractive analyzer is used to monitor the effluent from more than one source, perform the response time test for each sample interface.

To begin the response time test, introduce zero gas (or zero cell or filter) into the continuous monitor. When the system output has stabilized, switch to monitor the stack effluent and wait until a "stable value" has been reached. Record the upscale response time. Then, introduce the high-level calibration gas (or gas cell or filter). Once the system has stabilized at the high-level concentration, switch to monitor the stack effluent and wait until a "stable value" is reached. Record the downscale response time. A "stable value" is equivalent to a change of less than 1 percent of span value for 30 seconds or 5 percent of measured average concentration for 2 minutes. Repeat the entire procedure three times. Record the results of each test on a data sheet (example is shown in Figure 2-5). Determine the means of the upscale and downscale response times using Equation 2-1. Report the slower time as the system response time.

6.3.3 Field Test for Zero Drift and Calibration Drift. Perform the zero and calibration drift tests for each pollutant analyzer and data recorder in the continuous monitoring system.

6.3.3.1 Two-hour Drift. Introduce consecutively zero gas (or zero cell or filter) and high-level calibration gas (or gas cell or filter) at 2-hour intervals until 15 sets (before and after) of data are obtained. Do not make any zero or calibration adjustments during this time unless otherwise prescribed by the manufacturer. Determine and record the amount that the output had drifted from the recorder zero and high-level value on a data sheet (example is shown in Figure 2-6). The 2-hour periods over which the measurements are conducted need not be consecutive, but must not overlap. Calculate the zero and calibration drifts for each set. Then calculate the mean, confidence interval, and zero and calibration drifts (2-hour) using Equations 2-1, 2-2, and 2-3. In Equation 2-3, use the span value for R.V.

6.3.3.2 Twenty-Four Hour Drift. In addition to the 2-hour drift tests, perform a series of seven 24-hour drift tests as follows: At the beginning of each 24-hour period, calibrate the monitor, using mid-level value. Then introduce the high-level calibration gas (or gas cell or filter) to obtain the initial reference value. At the end of the 24-hour period, introduce consecutively zero gas (or gas cell or filter) and high-level calibration gas (or gas cell or filter); do not make any adjustments at this time. Determine and record the amount of drift from the recorder zero and high-level value on a data sheet (example is shown in Figure 2-7). Calculate the zero and calibration drifts for each set. Then calculate the mean, confidence interval, and zero and calibration drifts (24-hour) using Equations 2-1, 2-2, and 2-3. In Equation 2-3, use the span value for R.V.

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Data set no.	Date	Time Begin	Time End	Zero Rdg Init. A	Zero Rdg Fin. B	Zero drift C=B-A	Hi-level Rdg Init. D	Hi-level Rdg Fin. E	Span drift F=E-D	Calib. drift G=F-C
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										
13										
14										
15										
Arithmetic Mean (Eq. 2-1)										
Confidence Interval (Eq. 2-2)										
Zero Drift[a]								Calibration drift[a]		

[a] Use Equation 2-3, with span value for R. V.

Figure 2-6. Zero and Calibration Drift (2 hour)

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Data set no.	Date	Time Begin	Time End	Zero Rdg Init. A	Zero Rdg Fin. B	Zero drift C=B-A	Hi-level Rdg Init. D	Hi-level Rdg Fin. E	Span drift F=E-D	Calib. drift G=F-C
1										
2										
3										
4										
5										
6										
7										
Arithmetic Mean (Eq. 2-1)										
Confidence Interval (Eq. 2-2)										
Zero drift								Calibration drift[a]		

[a] Use Equation 2-3, with the span value for R. V.

Figure 2-7. Zero and Calibration Drift (24-hour)

Note.– Automatic zero and calibration adjustments made by the monitoring system without operator intervention or initiation are allowable at any time. Manual adjustments. however, are allowable only at 24-hour intervals, unless a shorter time is specified by the manufacturer

6.4 System Relative Accuracy. Unless otherwise specified in an applicable subpart of the regulations, the reference methods for SO_2, NO_x, diluent (0_2, or CO_2), and moisture are Reference Methods 6, 7, 3, and 4, respectively. Moisture may be determined along with SO_2, using Method 6. See Citation 10.8. Reference Method 4 is necessary only if moisture content is needed to enable comparison between the Reference Method and monitor values. Perform the accuracy test using the following guidelines:

6.4.1 Location of Pollutant Reference Method Sample Points. The following specifies the location of the Reference Method sample points which are on the same cross-sectional plane as the monitor's. However, any cross-sectional plane within 2 equivalent diameter of straight runs may be used, by using the projected image of the monitor on the selected plane in the following criteria.

6.4.1.1 For point monitors, locate the Reference Method sample point no further than 30 cm (or 5 percent of the equivalent diameter of the cross section, whichever is less) from the pollutant monitor sample point.

6.4.1.2 For multipoint monitors, locate each Reference Method sample traverse point no further than 30 cm (or 5 percent of the equivalent diameter of the cross section, whichever is less) from each corresponding pollutant monitor sample point.

6.4,1.3 For limited-path and path monitors, locate 3 sample points on a line parallel to the monitor path and no further than 30 cm (or 5 percent of the equivalent diameter of the cross section, whichever is less) from the centerline of the monitor path. The three points of the Reference Method shall correspond to points in the monitor path at 16.7, 50.0, and 83.3 percent of the effective length of the monitor path.

6.4.2 Location of Diluent and Moisture Reference Method Sample Points.

6.4.2.1 For sources which require diluent monitors in addition to pollutant monitors, locate each of the sample points for the diluent Reference Method measurements within 3 cm of the corresponding pollutant Reference Method sample point as defined in Sections 6.4,1.1, 6.4,1.2, or 6.4.1.3. In addition, locate each pair of diluent and pollutant Reference Method sample points no further than 30 cm (or 5 percent of the equivalent diameter of the cross section, whichever is less) from *both* the diluent and pollutant continuous monitor sample points or paths.

6.4.2.2 If it is necessary to convert pollutant and/or diluent monitor concentrations to a dry basis for comparison with the Reference data, locate each moisture Reference Method sample point within 3 cm of the corresponding pollutant or diluent Reference Method sample point as defined in Sections 6.4.1.1, 6.4.1.2, 6.4.1.3, or 6.4.2.1.

6.4.3 Number of Reference Method Tests.

6.4.3.1 For NO_x monitors, make a minimum of 27 NO_x Reference Method measurements, divided into 9 sets.

6.4.3.2 For SO_2 monitors, make a minimum of 9 SO_2 Reference Method tests.

6.4.3.3 For diluent monitors, perform one diluent Reference Method test for each SO_2 and/or NO_x Reference Method test(s).

6.4.3.4 For moisture determinations, perform one moisture Reference Method test for each or each set of pollutant(s) and diluent (if applicable) Reference Method tests.

Note.– The tester may choose to perform more than 9 sets of NO_x measurements or more than 9 SO_2 reference method diluent, or moisture tests, If this option is chosen, the tester may, at his discretion, reject up to 3 of the set or test results, so long as the total number of set or test results used to determine the relative accuracy is greater than or equal to 9. Report all data including rejected data.

6.4.4 Sampling Strategy for Reference Method Tests. Schedule the Reference Method tests so that they will not be in progress when zero drift, calibration drift, and response time data are being taken. Within any 1-hour period, conduct the following tests: (a) one set, consisting of 3 individual measurements, of NO_x and/or one SO_2; (b) one diluent, if applicable; and (c) one moisture (if needed). Whenever two or more reference tests (pollutant, diluent, and moisture) are conducted, the tester may choose to run all these reference tests within a 1-hour period. However, it is recommended that the tests be run concurrently or consecutively within a 4-minute interval if two reference tests employ grab sampling techniques. Also whenever an integrated reference test is run together with grab sample reference tests, it is recommended that the integrated sample be started one-sixth the test period before the first grab sample is collected.

In order to properly correlate the continuous monitoring system and Reference Method data, mark the beginning and end of each Reference Method test period (including the exact time of day) on the pollutant and diluent (if applicable) chart recordings. Use one of the following strategies for the Reference Method tests:

8.4.4.1 Single Point Monitors. For single point sampling, the tester may: (a) take a 21-minute integrated sample (e.g. Method 6, Method 4, or the integrated bag sample technique of Method 3); (b) take 3 grab samples (e.g. Method 7 or the grab sample technique of Method 3), equally spaced at 7-minute (±2 min) intervals (or one-third the test period); or (c) take 3 grab samples over a 3-minute test period.

6.4.4.2 Multipoint or Path Monitors. For multipoint sampling, the tester may either: (a) make a 21-minute integrated sample traverse, sampling for 7 minutes (± 2 min) (or one-third the test period) at each point; or (b) take grab samples at each traverse point, scheduling the grab samples to that they are an equal interval (7 ± 2 minutes) of time apart (or one-third the test period).

Note.– If the number of sample points is greater than 3, make appropriate adjustments to the individual sampling time intervals. At times NSPS performance test data may be used as part of the data base of the continuous monitoring relative accuracy tests. In these cases, other test periods as specified in the applicable subparts of the regulations may be used.

6.4.5 Correlation of Reference Method and Continuous Monitoring System Data. Correlate the continuous monitoring system data with the Reference Method test data, as to the time and duration of the Reference Method tests. To accomplish this, first determine from the continuous monitoring system chart recordings, the integrated average pollutant and diluent (if applicable) concentration(s) for each Reference Method test period. Be sure to consider system response time. Then, compare each integrated average concentration against the corresponding average concentration obtained by the Reference Method; use the following guidelines to make these comparisons:

6.4.5.1 If the Reference Method is an integrated sampling technique (e.g., Method 6), make a direct comparison of the Reference Method results and the continuous monitoring system integrated average concentration.

6.4.5.2 If the Reference Method is a grab-sampling technique (e.g., Method 7), first average the results from all grab-samples taken during the test period, and then compare this average value against the integrated value obtained from the continuous monitoring system chart recording.

6.5 Data Summary for Relative Accuracy Tests. Summarize the results an a data sheet; example is shown in figure 2-8. Calculate the arithmetic differences between the reference method and the continuous monitoring output sets. Then calculate the mean, confidence interval, and system relative accuracy, using Equation 2-l, 2-2, and 2-3. In Equation 2-3, use the average of the reference method test results for R.V.

7. Equations

7.1 Arithmetic Mean. Calculate the mean of a data set as follows:

$$\overline{x} = \frac{1}{n}\sum_{i=1}^{n} x_i \qquad \texttt{Equation } \mathit{1\text{-}2}$$

Where:
x = arithmetic mean.
n = number of data points.
$\sum x_i$ = algebraic sum of the individual values, x_i.

When the mean of the differences of pairs of data is calculated, be sure to correct the data for moisture.

7.2 Confidence Interval. Calculate the 95 percent confidence interval (two-sided) as follows:

$$CI_{.95} = \frac{t_{.975}}{n\sqrt{n-1}}\sqrt{n\sum x_i^2 - \left(\sum x_i\right)^2} \qquad \text{Equation 1-3}$$

Where:
C.I.$_{95}$ = 95 percent confidence interval-estimate of mean value.

(see Table 2-2)

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Table *2-2 - t = Values*

n^a	^{t}.975	n^a	^{t}.975	n^a	^{t}.975
2	12.706	7	2.447	12	2.201
3	4.303	8	2.365	13	2.179
4	3.182	9	2.306	14	2.160
5	2.776	10	2.262	15	2.145
6	2.571	11	2.228	16	2.131

[a] The values in this table are already corrected (or n-1 degrees of freedom. Use *n* equal to the number of individual values.

Run no.	Date and time	SO_2			NO_x[b]			CO_2 or O_2[a]		SO_2[a]			NO_x[a]		
		RM	M	Diff	RM	M	Diff	RM	M	RM	M	Diff	RM	M	Diff
		ppm[d]			ppm[d]			%[d]	%[d]	mass/GCV			mass/GCV		
1															
2															
3															
4															
5															
6															
7															
8															
9															
10															
11															
12															
Average															
Confidence Interval															
Accuracy[c]															

[a] For steam generators [b] Average of 3 samples [c] Use average of reference method test results for R.V.

[d] Make sure that RM and M data are on a consistent basis, either wet or dry

Figure 2-8. Relative accuracy determination

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7.3 Relative Accuracy. Calculate the relative accuracy of a set of data as follows:

$$R.A. = \frac{|\overline{x}| + |C.I._{95}|}{R.V.} x100 \quad \text{Equation 2-3}$$

Where: R.A. = relative accuracy

$|\overline{x}|$ = absolute value of the arithmetic mean (from Equation 2-1).

$|C.I._{95}|$ = absolute value of the 95 percentconfidence interval (from Equation 2-2).

R.V. = reference value, as defined in Section 6.3.1, 6.3.3.1, 6.3.3.2, and 6.5.

8. Reporting

At a minimum (check with regional offices for additional requirements, if any) summarize the following results in tabular form: calibration error for mid-level and high-level concentrations, the slower of the upscale and downscale response times. the 2-hour and 24-hour zero and calibration drifts, and the system relative accuracy, In addition, provide, for the conditioning and operational test periods. a statement to the effect that the continuous monitoring system operated continuously for a minimum of 168 hours each. except during times of instrument zero, calibration checks, system backpurges, and source breakdown, and that no corrective maintenance, repair, replacement, or adjustment other than that clearly specified as routine and required in the operation and maintenance manuals were made. Also include the manufacturer's certification statement (if applicable) for the calibration gas, gas cells, or filters. Include all data sheets and calculations and charts (data outputs), which are necessary to substantiate that the system met the performance specifications.

9. Retest

If the continuous monitoring system operates within the specified performance parameters of Table 2-1, the operational test period will be successfully concluded. If the continuous monitoring system fails to meet any of the specifications, repeat that portion of the testing which is related to the failed specification.

10. Bibliography

10.1 "Monitoring Instrumentation for the Measurement of Sulfur Dioxide in Stationary Source Emissions," Environmental Protection Agency, Research Triangle Park, N.C., February 1973.

10.2 "Instrumentation for the Determination of Nitrogen Oxides Content of Stationary Source Emissions, "Environmental Protection Agency, Research Triangle Park, N.C., Volume 1, APTD-0847, October 1971; Volume 2, APTD-0942, January 1972.

10.3 "Experimental Statistics, "Department of Commerce, Handbook 91. 1963, pp. 3-31, paragraphs 3-3.1.4.

10.4 "Performance Specifications for Stationary-Source Monitoring Systems for Gases and Visible Emissions," Environmental Protection Agency, Research Triangle Park, N.C., EPA-650/ 2-74-013, January 1974.

10.5 Traceability Protocol for Establishing True Concentrations of Gases Used for Calibration and Audits of Continuous Source Emission Monitors (Protocol No. 1). June 15, 1978. Environmental Monitoring and Support Laboratory, Office of Research and Development, U.S. EPA, Research Triangle Park, N.C. 27711.

10.6 Westlin, P. R. and J. W. Brown. Methods for Collecting and Analyzing Gas Cylinder samples. Emission Measurement Branch, Emission Standards and Engineering Division, Office of Air Quality Planning and Standards, U.S. EPA, Research Triangle Park, N.C., July 1978.

10.7 Curtis, Foston. A Method for Analyzing NO_x Cylinder Gases – Specific Ion Electrode Procedure. Emission Measurement Branch, Emission Standards and Engineering Division. Office of Air Quality and Standards, U.S. EPA, Research Triangle Park, N.C., October 1978.

10.8 StanIey, Jon and P. R. Westlin. An Alternative Method for Stack Gas Moisture Determination. Emission Measurement Branch, Emission Standards and Engineering Division, Office of Air Quality Planning and Standards, U.S. EPA, Research Triangle Park, N.C., August 1978.

Performance Specification 3 – Specifications and Test Procedures for CO_2 and 0_2 Continuous Monitors in Stationary Sources

1. Applicability and Principle

1.1 Applicability. This Specification contains (a) installation requirements, (b) instrument performance and equipment specifications, and (c) test procedures and data reduction procedures for evaluating the acceptability of continuous CO_2 and O_2 monitors that are used as diluent monitors. The test procedures are primarily designed for systems that introduce calibration gases directly into the analyzer; other types of monitors (e.g., single-pass monitors, as described in Section 2.2.7 of Performance Specification 2 of this Appendix) will be evaluated on a case-by-case basis upon written request to the Administrator, and alternative procedures will be issued separately,

1.2 Principle. Any CO_2 or O_2 continuous monitor, which is expected to meet this Specification, is operated for a specified length of time. During this specified time period, the continuous monitor is evaluated to determine conformance with the Specification.

2. Definitions

The definitions are the same as those listed in Section 2 of Performance Specification 2.

3. Installation Specifications

3.1 Measurement Location and. Measurement Points or Paths. Select and install the continuous monitor at the same sampling location used for the pollutant monitor(s). Locate the measurement points or paths as shown in Figure 3 – 1 or 3-2.

3.2 Alternative Measurement Location and Measurement Points or Paths. The diluent monitor may be installed at a different location from that of the pollutant monitor, provided that the diluent gas concentrations at both locations differ by no more than 5 percent from that of the pollutant monitor location for CO_2 or the quantity, 20.9-percent O_2, for O_2. See Section 3.4 of Performance Specification 2 for the demonstration procedure.

4. Continuous Monitor Performance and Equipment Specifications

The continuous monitor performance and equipment specifications are listed in Table 3-1. To be considered acceptable, the continuous monitor must demonstrate compliance with these specifications, using the test procedures in Section 6.

5. Apparatus

5.1 CO_2, or O_2 Continuous Monitor. Use any continuous monitor, which is expected to meet this Specification. The data recorder may either be an analog strip-chart recorder or other suitable device having an input voltage range compatible with the analyzer output.

5.2 Calibration Gases. Diluent gases shall be air or N_2 for CO_2 mixtures, and shall-be N_2 for O_2 mixtures. Use three calibration gases as specified below:

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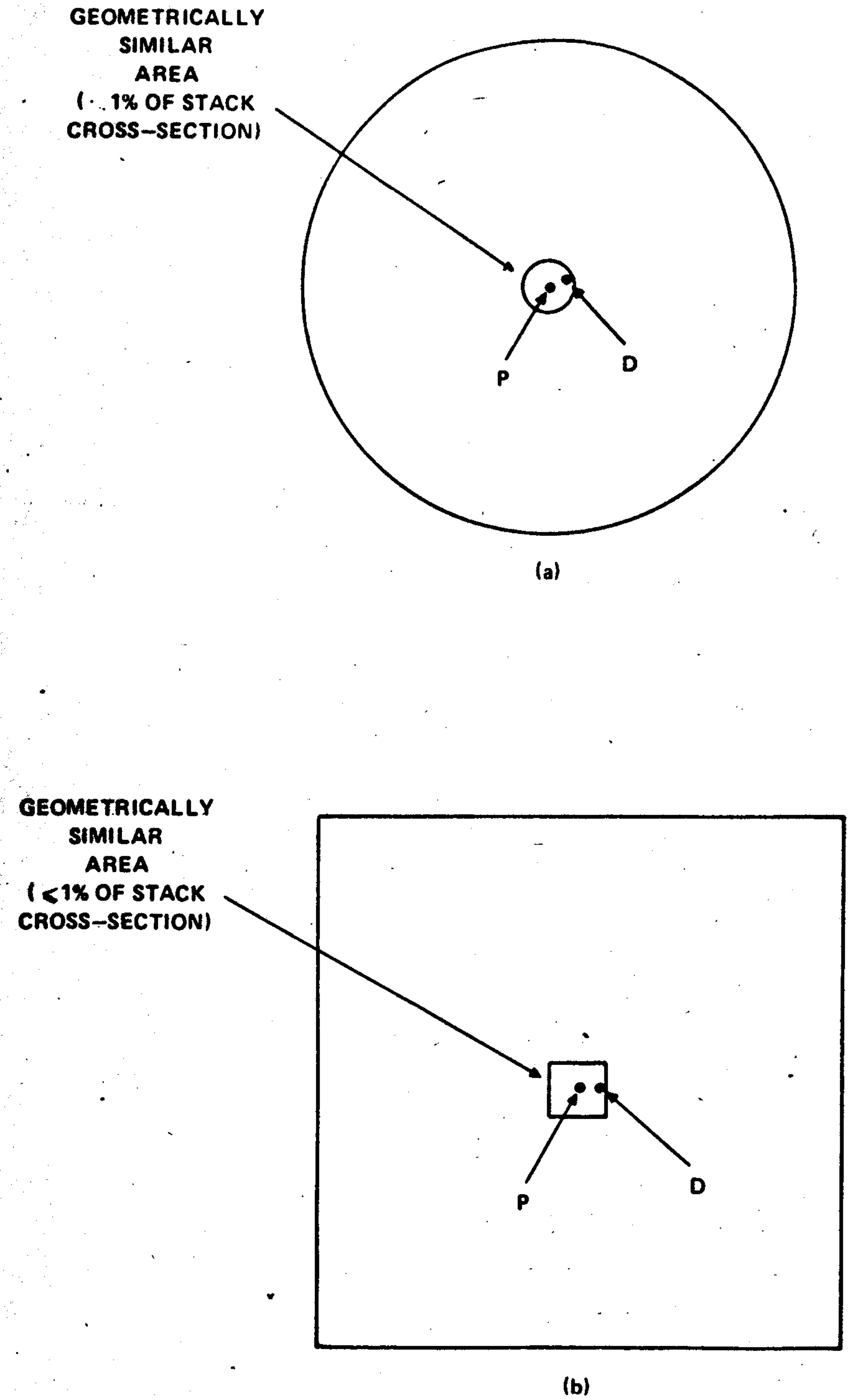

Figure 3-1. Relative locations of pollutant (P) and diluent {D) measurement points in (a) circular and (b) rectangular ducts. P is located at the centroid of the geometrically similar area. Note: The geometrically similar area need not be concentric.

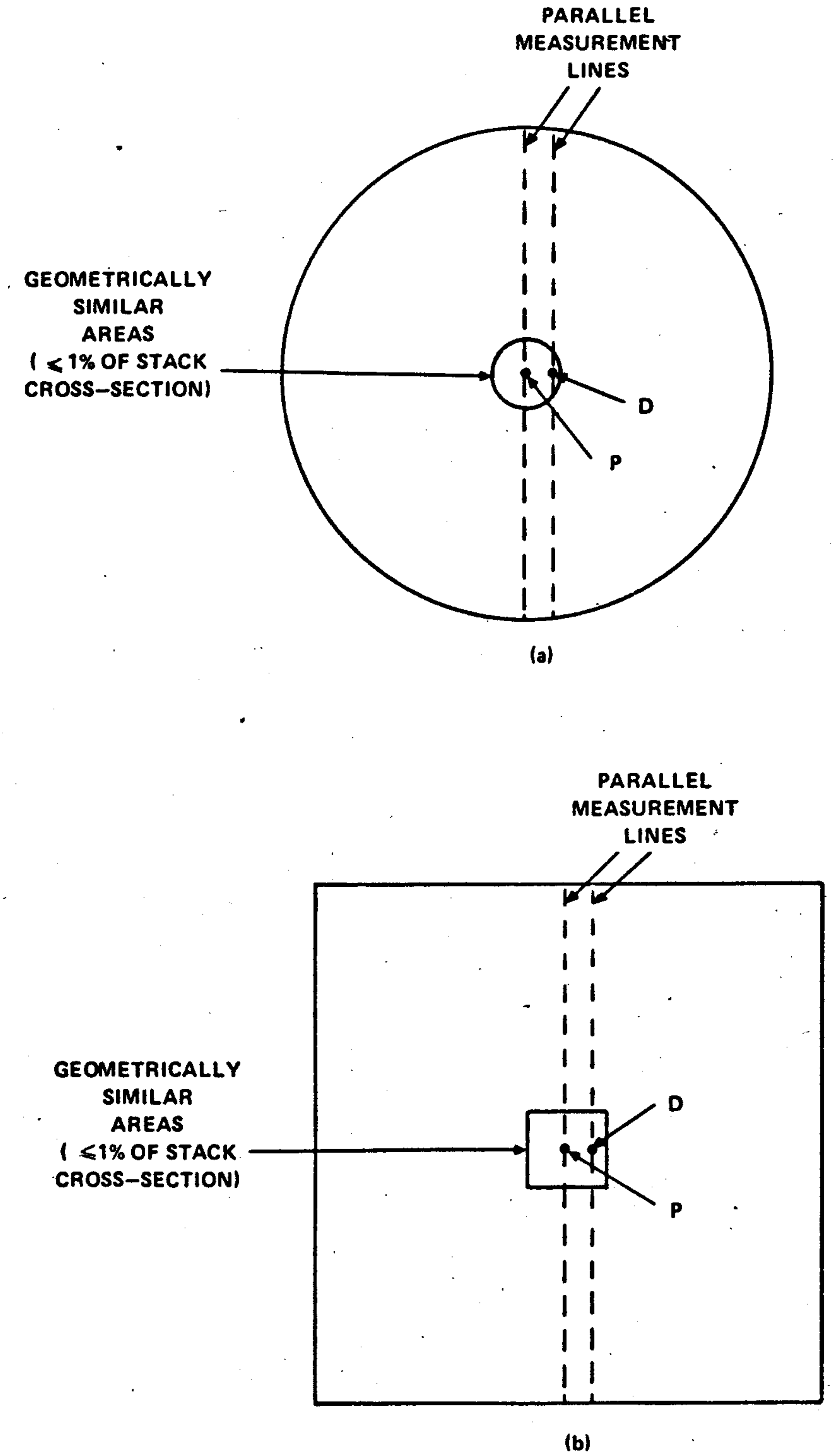

Figure 3-2. Relative locations of pollutant (P) and diluent (D) measurement paths for (a) circular and (b) rectangular ducts. P is located at the centroid of both the geometrically similar areas and the pollutant monitor path cross-sectional areas. D is located at the centroid of the diluent monitor path cross-sectional area.

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Table *3-1.-Performance and Equipment Specifications*

Parameter	Specification
1. Conditioning period[a].	>= 168 hours.
2. Operational test period [a].	>= 168 hours.
3. Calibration error[b]	<= 5 pct. Of each (mid-range and high-range. Only) calibration gas value.
4. Response time	<= 15 minutes.
5. Zero drift (2-hour)[b,c]	<= 0.4 pct. CO_2 or O_2
6. Zero drift (24-hour)[b,c]	<= 10.5 pct. CO_2, or O_2.
7. Calibration drift (2-hour) [b].	<= 0.4 pct. CO_2, or O_2.
8. Calibration drift (24-hour) [b].	<= 0.5 pct. CO_2, or O_2.
9. Data recorder chart resolution.	Chart scales must be readable to within <=0.50 pct. of full-scale.
10. Extractive monitors	Must use the same interface as the pollutant monitor. Place in a series (diluent after pollutant analyzer) or use a “T.”

[a] During the conditioning and operational test periods, the continuous monitor shall not require any corrective maintenance, repair, replacement, or adjustment other than that dearly specified as routine and required in the operation and maintenance manuals.

[b] Expressed as the sum of the absolute mean value plus the 95 percent confidence interval of a series at tests.

[c] A low-level (5-15 percent of span value) drift tests may be substituted for the zero drift tests.

5.2.1 High-Level Gas. A CO_2, or O_2 concentration of 20.0 to 22.5 percent. For O_2 analyzers, ambient air (20.9 percent O_2) may be used as the high-range calibration gas; lower high-level O_2, concentration may be used, subject to the approval of the Administrator.

5.2.2 Mid-Level Gas. A CO_2 or O_2 concentration of 11.0 to 14.0 percent; for O_2 analyzers, concentrations in the operational range may be used.

5.2.3 Zero Gas. A CO_2, or O_2 concentration of less than 0.05 percent. For CO_2 monitors, ambient air [0.03 percent CO_2) may be used as the zero gas.

6. Performance Specification Test Procedures.

6.1 Calibration Gas Certification. Follow the procedure as outlined in Section 6.1.2 of Performance Specification 2, except use 0.5 percent CO_2 or O_2 instead of the 15 ppm. Figure 3-3 is provided as an example data sheet.

6.2 Conditioning Period. Follow the same procedure outlined in Section 6.2 of Performance Specification 2.

6.3 Operational Test Period. Follow the same procedures outlined in Section 6.3 of Performance Specification 2, to evaluate the calibration error, response time, and the 2-hour and 24-hour zero and calibration drifts. See example data sheets (Figures 3-4 through 3-7).

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Figure 3-3. Analysis of Calibration Gases [a]

Date_____________ (Must be within 2 weeks prior to the operational test period)

Reference Method Used____________________

Sample run	Mid-range[c] ppm	High-range[d] ppm
1		
2		
3		
Average		
Maximum % deviation[e]		

[a] Not necessary if the protocol in Citation 10.5 of Performance Specification 2 is used to prepare the gas cylinders.

[c] Average must be 11.0 to 14.0 percent; for O_2, see Section 5.2.2.

[d] Average must be 20.0 to 22.5 percent; for O_2, see Section 5.2.1.

[e] Must be $\leq \pm$ 10 percent of applicable average or 0.5 percent, whichever is greater.

Figure 3-4. Calibration Error Determination

Run No.	Calibration Gas Concentration[a] ppm	Measurement System Reading ppm	Arithmetic Differences ppm	
	A	B	A-B	
			Mid	High
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
Arithmetic Mean (Eq. 2-1)[b] =				
Confidence Interval (Eq. 2-2)[b] =				
Calibration Error (Eq. 2-3)[b,c] =				

[a] Calibration Data from Section 6.1

Mid-level: C = _____ ppm

High-level: D = _____ ppm

[b] See Performance Specification 2

[c] Use C or D as R. V.

Figure 3-5. Response Time

Date ____________________ High-Range = __________ ppm

Test Run	Upscale min	Downscale min
1		
2		
3		
Average	A =	B =

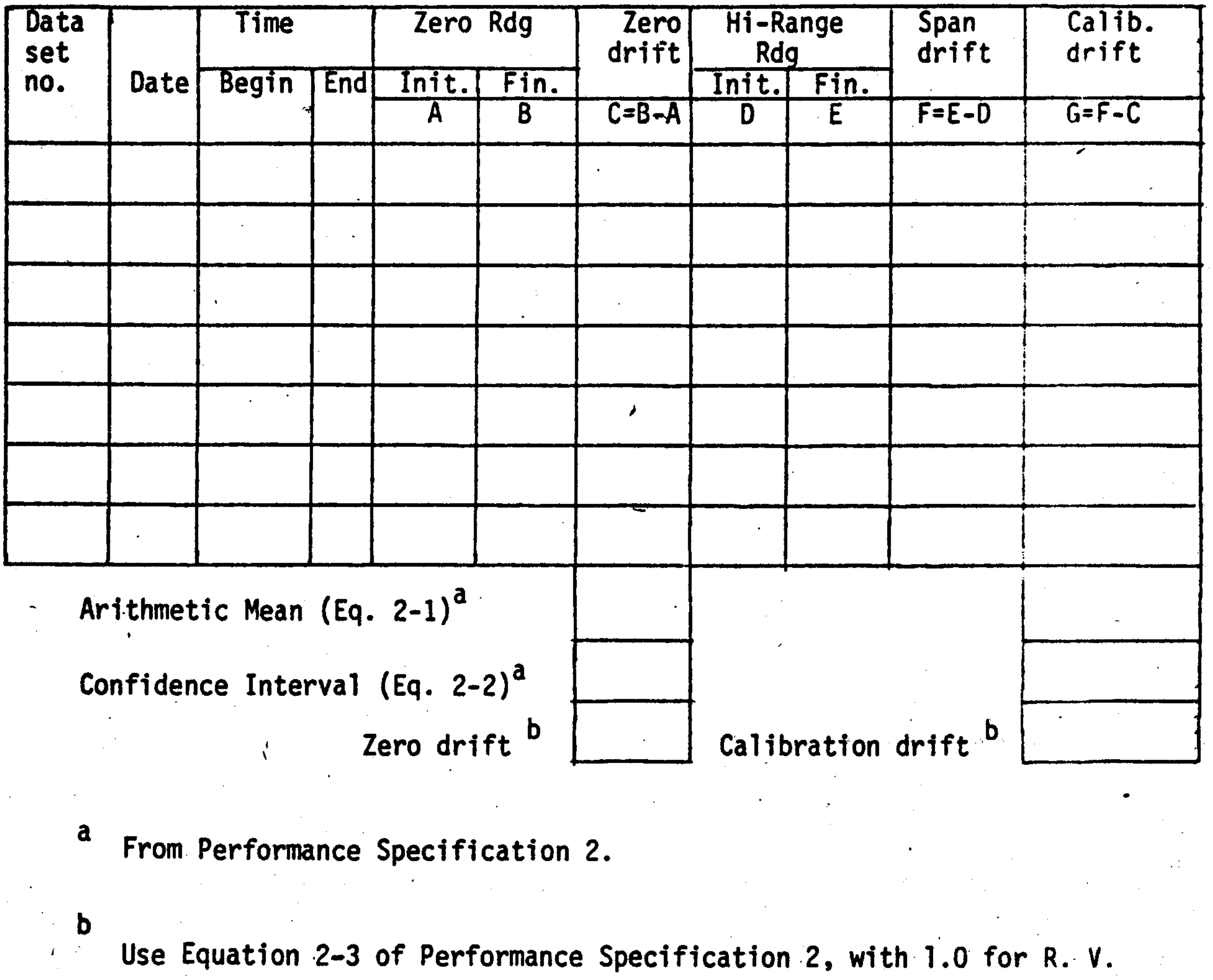
System Response Time (slower of A and B) = ________ min.

Data set no	Date	Time		Zero Rd.		Zero drift	Hi-Range Rdg.		Span drift	Calib. drift
		Begin	End	Init.	Fin.		Init.	Fin.		
				A	B	C=B-A	D	E	F=E-D	G=F-C
Arithmetic Mean (Eq. 2-1)[a]										
Confidence Interval (Eq. 2-2)[a]										
					Zero drift[b]		Calibration drift[b]			

[a] From Performance Specification 2.

[b] Use Equation 2-3 of Performance Specification 2 and 1.0 for R. V.

Figure 3-6. Zero and Calibration Drift (2 hour)



Data set no.	Date	Time		Zero Rdg		Zero drift	Hi-Range Rdg		Span drift	Calib. drift
		Begin	End	Init.	Fin.		Init.	Fin.		
				A	B	C=B-A	D	E	F=E-D	G=F-C
Arithmetic Mean (Eq. 2-1)[a]										
Confidence Interval (Eq. 2-2)[a]										
Zero drift [b]									Calibration drift [b]	

[a] From Performance Specification 2.

[b] Use Equation 2-3 of Performance Specification 2, with 1.0 for R. V.

Figure 3-7. Zero and Calibration Drift (24-hour)

6.4 System Relative Accuracy. (Note: The relative accuracy is not determined separately for the diluent monitor, but is determined for the pollutant-diluent system.) Unless otherwise specified in an applicable subpart of the regulations. the Reference Methods for the diluent concentration determination shall be Reference Method 3 for CO_2 or 0_2. For this test,Fyrite analyses may be used for CO_2 and 0_2 determinations. Perform the measurements using the guidelines below (an example data sheet is shown in Figure 2-8 of Performance Specification 2):

6.4.1 Location of Reference Method 3 Sampling Points. Locate the diluent Reference Method sampling points according to the guidelines given in Section 6.4.2.1 of Performance Specification 2.

6.4.2 Number of Reference Method Tests. Perform one Reference Method 3 test according to the guideline in Performance Specification 2.

6.4.3 Sampling Strategy for Reference Method Tests. Use the basic Reference Method sampling strategy outlined in Section 6.4.4 (and related sub-sections) of Performance Specification 2.

6.4.4 Correlation of Reference Method and Continuous Monitor Data. Use the guidelines given in Section 6.4.5 of Performance Specification 2.

7. Equations, Reporting, Retest, and Bibliography. The procedure and citations are the same as in Sections 7 through 10 of Performance Specification 2.

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