PERFORMANCE SPECIFICATION PROCEDURE 1
Performance Specification Verification

Note: Test each COMS that conforms to the design specifications (PSP 1b) with the data recording system to be employed during monitoring. If different data recording systems are used during the performance test and monitoring, obtain prior approval from the Administrator.

A. Equipment Preparation

1. Measure the mounting distance between the transmitter and receiver/reflector unit at the source (do not use distances from engineering drawings). Then, set up and calibrate the COMS using the measured path length according to the manufacturer's written instructions.
2. If the COMS has automatic path length adjustment, follow the manufacturer's instructions to adjust the signal output from the analyzer in order to yield results based on the emission outlet path length.
3. Set the instrument and data recording system ranges so that maximum instrument output is within the span range specified in the applicable subpart.
4. Align the instrument so that maximum system response is obtained during a zero (or upscale) check performed across the simulated monitor path length. As part of this alignment, include rotating the reflector unit (detector unit for single pass instruments) on its axis until the point of maximum instrument response is obtained.
5. Zero and span the instrument according to the manufacturer's instructions. Perform the zero alignment adjustment by balancing the response of the COMS so that the simulated zero check coincides with the actual zero check performed across the simulated monitor path length. At this time, measure the indicated upscale calibration value (must be ≥ applicable opacity standard, but ≤0.5 applicable span value).

B. Calibration Error Test

1. Insert the calibration attenuators (low, mid, and high range) in the transmissometer path at or as near the midpoint of the measurement path as feasible. If a particular instrument requires placement in the instrument housing, attach data from the manufacturer showing this procedure is acceptable. Ensure that the entire beam received by the detector passes through the attenuator and that interference from reflected light is minimized.
2. Make a total of five nonconsecutive readings for each filter.
3. Calculate the calibration error for each of the three test attenuators. If the path length is adjusted by the measurement system, subtract the "path adjusted" calibration attenuator values from the values indicated by the measurement system recorder.

C. System Response Test

1. Insert the high-range calibration attenuator in the transmissometer path five times, and determine the upscale and downscale response times.
2. Calculate the system response time.

D. Optical and Zero Alignment

Install the COMS on the affected facility according to the manufacturer's written instructions and PSP 2a. Perform either of the following optical and zero alignment procedures.

1. Preferred Procedure
   a. When the facility is not in operation, optically align the light beam of the transmissometer upon the optical surface located across the duct or stack (i.e., the retroreflector or photodetector, as applicable) according to the manufacturer's instructions; verify the alignment with the optical alignment sight.
   b. Under clear stack conditions, verify the zero alignment (step A5) 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. (*Note:* The stack should be monitored and the data output (instantaneous real-time basis) examined to determine whether fluctuations from zero opacity are occurring before a clear stack condition is assumed to exist.)
   c. 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.

2. Alternative Procedure
   a. If the facility is operating and a zero stack condition cannot practicably be obtained, use the zero alignment obtained during step A4 before installing the transmissometer on the stack.
   b. Install the system at the source and align the optics according to the manufacturer's instruction. Verify the alignment with the optical alignment sight.
   c. Verify the zero alignment and adjust, if necessary, the first time a clear stack condition is obtained after completion of the operational test period.

E. Conditioning Period

1. After completing the preliminary field adjustments, operate the COMS according to the manufacturer's instructions for an initial conditioning period of ≥168 hr while the source is operating. A successful conditioning period is as follows:
   a. Except during times of instrument zero and upscale calibration checks, the COMS measures the effluent gas opacity and produces a permanent record of the COMS output.
   b. No unscheduled maintenance, repair, or adjustment is made.
   c. Except for periods of source breakdown (record the dates and times of process shutdown), the 168-hr period is continuous. If the interruption is due to monitor failure, restart the 168-hr period when the monitor becomes operational.
2. Conduct daily zero calibration and upscale calibration checks; and, when accumulated drift exceeds the daily operating limits, make adjustments and clean the exposed optical surfaces. The data recorder must reflect these checks and adjustments.
3. At the end of the operational test period, verify that the instrument optical alignment is correct.

F. Operational Test Period

1. After completing the conditioning period, operate the system for an additional 168 hr (need not follow immediately after the 168-hr conditioning period). A successful operational test is the same as that for the conditioning period.
2. The following are permissible during the operational test period.
   a. Zero and calibration adjustments, optical surface cleaning, and optical realignment (optional) only at 24-hr intervals or at such shorter intervals if specified by the manufacturer's written instructions. (Make a record of these operations.)
   b. Automatic zero and calibration adjustments without operator intervention or initiation at any time.

G. Zero and Upscale Drift Tests

1. At the outset of the 168-hr operational test period, measure the initial simulated zero (or ≤10% opacity) and upscale opacity readings.
2. After each 24-hr interval, check the zero reading before any optional or required cleaning and adjustment (adjustments and cleaning must be performed when the accumulated zero calibration or upscale calibration drift exceeds the 24-hr drift specification of ±2% opacity).
   a. If no adjustments are made after the zero check, record the final zero reading as the initial zero reading for the next 24-hr period.
   b. If adjustments are made, record the zero value after adjustment as the initial zero value for the next 24-hr period.
   c. If the instrument has automatic zero compensation and the zero value cannot be measured before compensation is entered, then record the amount of automatic zero compensation (as opacity) for the final zero reading of each 24 hour period.
3. After the zero calibration value has been checked and any optional or required adjustments have been made, check the simulated upscale calibration value. Follow the same general rule as in step G2.
4. Determine the 24-hr zero and calibration drifts.

H. Retest

1. If the COMS fails one of the preliminary tests, repeat the performance testing for the failed specification prior to conducting the operational test period.
2. If the COMS fails to meet the specifications for the operational test period, repeat the operational test period; depending on the cause of failure, it may be necessary to repeat the design and preliminary performance tests.

PERFORMANCE SPECIFICATION PROCEDURE 1a
Installation and Measurement Location

Note: The intent is to install the COMS at a location where the opacity measurements are representative of the total emissions, generally one where the stack gases are well-mixed.

A. Measurement Location

Install the continuous opacity monitoring system (COMS) at a location that is:

1. Downstream from all particulate control equipment.
2. Where condensed water vapor is not present.
3. Free of interference from ambient light (applicable only if transmissometer is responsive to ambient light).
4. Accessible to permit routine maintenance.

B. Measurement Path

Select a measurement path that passes through a centroidal area equal to 25% of the cross section. For additional requirements or modifications, see Figures P1a-1 through P1a-5.

C. Alternative Locations and Measurement Paths

Demonstrate acceptability of alternative locations and measurement paths as follows:

1. Select a measurement location and path that meet the criteria in steps A and B. Select the alternative location and path.
2. Measure the opacities at the two locations or paths for ≥2 hr and determine the average opacity. Measurement may be measured at different times, if the process operating conditions are same.
3. Acceptability Criteria: Alternative/Reference ≤ ±0.10 or Alternative minus Reference ≤ ±2%.

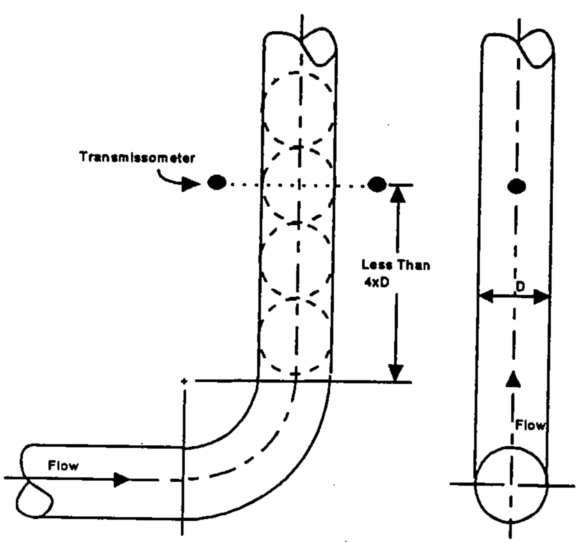

Figure P1a-1. Transmissometer location downstream of a bend in a vertical stack.

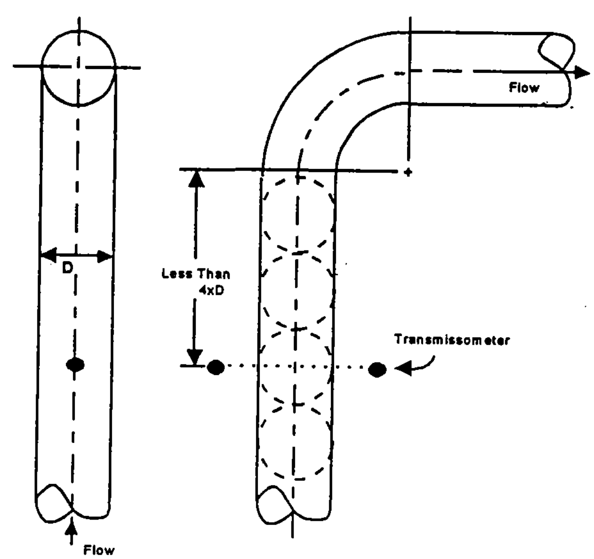

Figure P1a-2. Transmissometer location upstream of a bend in a vertical stack.

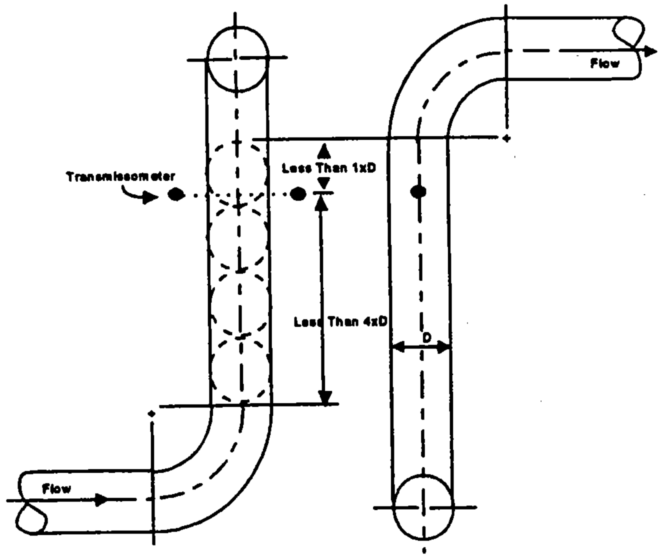

Figure P1a-3. Transmissometer location between bends in a vertical stack.

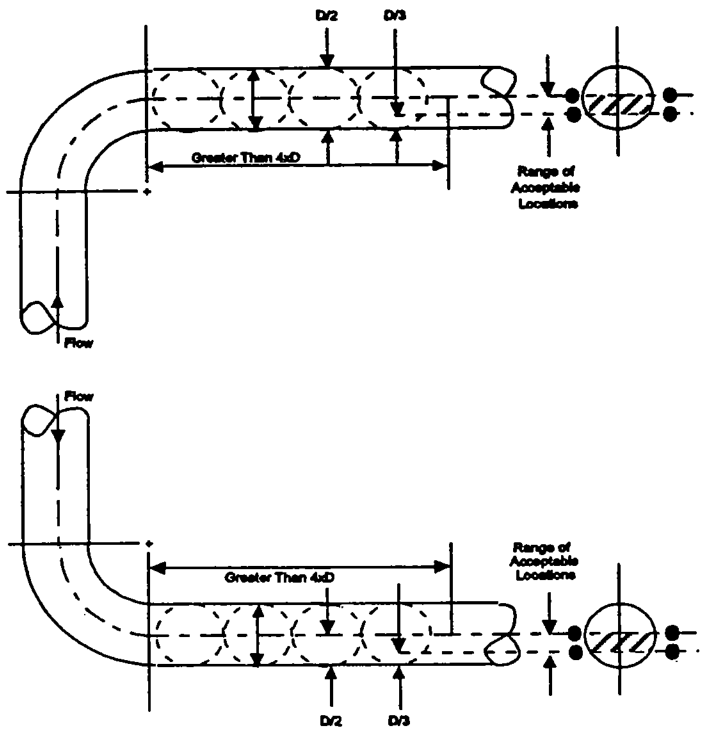

Figure P1a-4. Transmissometer location greater than four diameters downstream of a vertical bend in a horizontal stack.

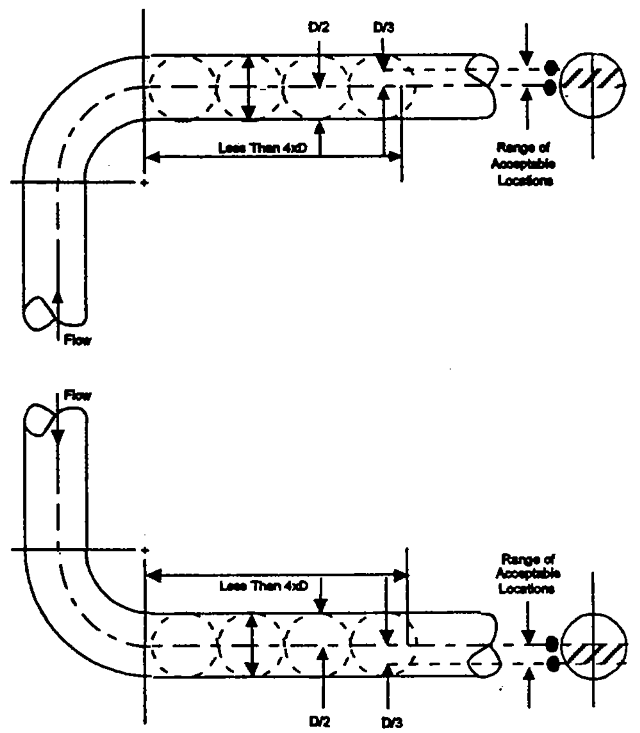

Figure P1a-5. Transmissometer location less than four diameters dow of a vertical bend in a horizontal stack.

PERFORMANCE SPECIFICATION DATA SHEET 1a
Calibration Error Determination

Client/Plant Name ______________________ Job # ____________ Date __________

Analyzer Manufacturer/Model/Serial No. ______________________________

COMS Location ____________________ Personnel ______________________

Pathlength, L_1 __________ Outlet Pathlength, L_2 __________ $OD_1 = OD_2 (L_1/L_2)$

COMS Output Pathlength Corrected? Yes ___ No ___

Calibrated Neutral Density Filter Values				
Range	Actual (1)		Path-Adjusted (2)	
	Optical Density, OD	Opacity, Op	Optical Density, OD	Opacity, Op
Low				
Mid				
High				

Run No.	Level	Cal Filter Path-Adjusted (% Op)	Instrument Reading (% Op)	Arithmetic Difference (% Op) 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, $\bar{x}$						
Confidence Coefficient, CC						
Calibration Error, $\lvert\bar{x}\rvert + \lvert CC\rvert$						

$$S_d = \sqrt{\frac{\sum_{i=1}^{n} x_i^2 - \frac{\left(\sum_{i=1}^{n} x_i\right)^2}{n}}{n-1}} \qquad CC = t_{0.975} \frac{S_d}{\sqrt{n}}$$

QA/QC Check

Completeness ____ Legibility ____ Accuracy ____ Specifications ____ Reasonableness ____

Checked by: ______________________________ ______________________________

Personnel (Signature/Date) Team Leader (Signature/Date)

PERFORMANCE SPECIFICATION PROCEDURE 1b
Design Specifications Verification

Note: This procedure will not apply to all instrument designs and will require modification in some cases; all procedural modifications are subject to the approval of the Administrator.

A. *Spectral Response*

1. Obtain detector response, lamp emissivity, and filter transmittance data from their respective manufacturers, and develop the effective spectral response curve of the transmissometer.
2. Then determine the peak and mean spectral response wavelengths, and the maximum response at any wavelength below 400 nm and above 700 nm expressed as a percentage of the peak response.

B. *Angle of View*

1. Set up the receiver as specified by the manufacturer's written instructions.
2. Draw an arc with radius of 3 m in the horizontal direction. Using a small (<3 cm) nondirectional light source, measure the receiver response at 5-cm intervals on the arc for 30 cm on either side of the detector centerline.
3. Repeat step B2 in the vertical direction.
4. For both horizontal and vertical directions, calculate the response of the receiver as a function of viewing angle (26 cm of arc, 3-m radius, equals 5°). Determine angle of view.

C. *Angle of Projection*

1. Set up the projector as specified by the manufacturer's written instructions.
2. Conduct steps B2 and B3.
3. For both the horizontal and vertical directions, calculate the response of the photoelectric detector as a function of the projection angle, and determine the angle of projection.

D. *Optical Alignment Sight*

Instruments that provide an absolute zero check while in operation and while maintaining the same optical alignment during measurement and calibration may omit this step (e.g., some "zero pipe" units).

1. Set up the instrument in the laboratory according to manufacturer's written instructions for a monitor path length of 8 m..
2. Align, zero, and span the instrument. Insert an attenuator of 10% (nominal opacity) into the instrument path length.
3. Slowly misalign the projector unit by rotating it vertically until a positive or negative shift of 2% opacity is obtained by the data recorder. Then, following the manufacturer's written instructions, check the alignment. The alignment procedure must indicate that the instrument is misaligned.
4. Repeat this test for lateral misalignment of the projector.
5. Repeat steps D2 and D4 with the receiver or retroreflector unit (i.e., lateral misalignment only).

E. *Other Design Features*

1. Access to External Optics. Access the optical surfaces exposed to the effluent stream and clean the surfaces without removing the unit from the source mounting or without disturbing the optical alignment.
2. Slotted Tube. Measure the length of the slotted portion(s). Check if slotted tube is 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.
   a. Obtain data from the manufacturer that the transmissometer minimizes light reflections (at least data from laboratory operation of the transmissometer both with and without the slotted tube in position).
   b. If the slot length is <90% of the effluent path length, provide comparative data between slotted tube and another instrument that meets the requirement according to PSP 1a, step C.

F. *Alternatives*

1. Design Specification Verification. Obtain a Manufacturer's Certificate of Conformance in lieu of doing the above.
   a. The certificate must state that the first analyzer randomly sampled from each month's production was tested according to the above procedures and satisfactorily met all requirements of section 5 of Performance Specification 1 (PS 1).

b. 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 PS 1; and was determined to be acceptable under MIL-STD-105D procedures, acceptable quality level 1.0.

c. The certificate must include the results of each test performed for the analyzer(s) sampled during the month the analyzer being installed was produced.

2. Spectral Response (Step A). Laboratory measurements of the instrument's spectral response curve may be conducted. These procedures are subject to approval of the Administrator.

PERFORMANCE SPECIFICATION DATA SHEET 1b
Response Time

Client/Plant Name ______________________________ Job # ____________ Date ________

Analyzer Manufacturer/Model/Serial No. ______________________________

COMS Location ______________________ Personnel ______________________

High Range Calibration Filter Value:

Actual Optical Density (Opacity) ________ (______)

Path-Adjusted Optical Density (Opacity) ________ (______)

Upscale Response Value (0.95 x Filter Value), %Op = ________

Downscale Response Value (0.95 x Filter Value), %Op = ________

	Run No.	Response Time (sec)
Upscale	1	________
	2	________
	3	________
	4	________
	5	________
Downscale	1	________
	2	________
	3	________
	4	________
	5	________
	Average	

QA/QC Check

Completeness ____ Legibility ____ Accuracy ____ Specifications ____ Reasonableness __

Checked by: ______________________________ ______________________________

Personnel (Signature/Date) Team Leader (Signature/Date)

PERFORMANCE SPECIFICATION PROCEDURE 1c
Calibration Attenuator

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

A. Selection

1. Based on the span value specified in the applicable subpart, select a minimum of three calibration attenuators (low, mid, and high range) using table CP1.

Table CP1. Required Calibration Attenuator Values (Nominal)

Span Value (% Opacity)	Calibrated Attenuator Optical Density (Equivalent Opacity), D_2		
	Low-Range	Mid-Range	High-Range
40	0.05 (11)	0.1 (20)	0.2 (37)
50	0.1 (20)	0.2 (37)	0.3 (50)
60	0.1 (20)	0.2 (37)	0.3 (50)
70	0.1 (20)	0.3 (50)	0.4 (60)
80	0.1 (20)	0.3 (50)	0.6 (75)
90	0.1 (20)	0.4 (60)	0.7 (80)
100	0.1 (20)	0.4 (60)	0.9 (87.5)

2. For systems with automatic path length compensation, calculate the attenuator values required to obtain a system response equivalent to the applicable values shown in table CP1.
3. 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), 0.6(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 calibration attenuators having the values given in table CP1 or having values closest to those calculated in step A2.
4. Obtain the selected attenuators along with specified time over which the attenuator values can be considered stable and any special handling and storing procedures required to enhance attenuator stability.

B. Attenuator Calibration

1. Select a calibration spectrophotometer meeting the following minimum design specifications:
   a. Wavelength range: 400-700 nm
   b. Detector angle of view: $<10°$
   c. Accuracy: $<0.5\%$ transmittance, NIST-traceable calibration.
2. Make measurements on required filters or screens at wavelength intervals of ≤ 20 nm. (As an alternative procedure, use the calibration spectrophotometer to measure the C.I.E. Daylight$_c$ luminous transmittance of the attenuators.
3. Check the attenuators several times, at different locations on the attenuator.

C. Attenuator Stability Checks

1. Check attenuator values at intervals $\leq$ stability period guaranteed by the manufacturer or ≤ 3 months, whichever is more frequent. Recheck at least every 3 months.
2. If desired, the stability checks with a high-quality laboratory transmissometer (secondary) other than the calibration spectrophotometer may be used. The same instrument must always be used for the stability checks. Determine a base value on the secondary instrument by measuring attenuators immediately following initial calibration.
3. Recalibrate the attenuator on the calibration spectrophotometer or replace it with a new attenuator if values change by $\geq \pm 2\%$ opacity.

PERFORMANCE SPECIFICATION DATA SHEET 1c
Zero and Calibration Drift

Client/Plant Name ______________________________ Job # ______________ Date ________

Analyzer Manufacturer/Model/Serial No. ______________________________

COMS Location ______________________ Personnel ______________________

Pathlength, L_1 ________ Emission Outlet Pathlength, L_2 ________ Output Pathlength Corrected? Yes ____ No ____

Upscale Calibration Value: Actual OD (Opacity) ________ (______) Path-Adjusted OD (Opacity) ________ (______

Date	Time		% Opacity												
			Zero Reading[a]		Zero Drift		Upscale Cal Reading		Upscale Drift	Cal Drift			Alignment	
	Begin	End	Initial A	Final B	C = B-A	Zero Adj?	Initial D	Final E	F = E-D	G = F-C[b]	Span Adj?	Lens Clnd?	Ckd?	Adj?
Arithmetic Mean, $\bar{x}$						Arithmetic Mean, $\bar{x}$								
Confidence Coefficient, CC						Confidence Coefficient, CC								
Zero Drift = $\lvert \bar{x} \rvert + \lvert CC \rvert$						Calibration Drift = $\lvert \bar{x} \rvert + \lvert CC \rvert$								

[a] without automatic zero compensation.
[b] If zero was adjusted manually or automatically prior to upscale check, then use C = 0.

QA/QC Check

Completeness ____ Legibility ____ Accuracy ____ Specifications ____ Reasonableness ____

Checked by: ______________________________ ______________________________

Personnel (Signature/Date) Team Leader (Signature/Date)