

HIGH-VOLUME AIR SAMPLER CALIBRATION WORKSHEET

Site Location: _____
 Date: _____ Barometric Pressure, P_2 mm Hg (or kPa) _____
 Calibrated By: _____ Temperature, T_2 (K) _____
 Sampler No. _____ Serial No. _____
 Transfer std. type: _____ Serial No. _____

$P_{std} = 760$ mm Hg (or 101 kPa)

Optional: Average barometric pressure: $P_a =$ _____
 Seasonal average temperature: $T_a =$ _____

No.	Pressure drop of gas or of water	$\sqrt{\frac{P_2}{P_a} \left(\frac{298}{T_2} \right)}$	Q_{std} (from office certification) std m ³ /min	Sampler flow rate indication (arbitrary)	(Y)	
					For specific pressure and temperature cor- rections (see Table 1)	For incorporation of average pressure and seasonal average tem- perature (see Table 1)
1					<input type="checkbox"/> 1 or $\sqrt{\frac{P_2}{P_a} \left(\frac{298}{T_2} \right)}$ or $\sqrt{\frac{P_2}{P_a} \left(\frac{298}{T_2} \right)}$	<input type="checkbox"/> 1 or $\sqrt{\frac{P_2}{P_a} \left(\frac{T_a}{T_2} \right)}$ or $\sqrt{\frac{P_2}{P_a} \left(\frac{T_a}{T_2} \right)}$
2						
3						
4						
5						
6						

LEAST SQUARES CALCULATIONS

Linear regression of Y on X: $Y = mX + b$; Y = appropriate expression from Table 1; $X = Q_{std}$

Slope (m) = _____ Intercept (b) = _____ Correlation Coeff. (r) = _____

To determine subsequent flow rate during use: $X = \frac{1}{m} (Y-b)$; $Q_{std} = \frac{1}{m} [\text{Appropriate expression from Table 2}] - b$

Figure 5. Example of high-volume air sampler calibration worksheet.

[47 FR 54912, Dec. 6, 1982; 48 FR 17355, Apr. 22, 1983]

APPENDIX C TO PART 50—MEASUREMENT PRINCIPLE AND CALIBRATION PROCEDURE FOR THE MEASUREMENT OF CARBON MONOXIDE IN THE ATMOSPHERE (NON-DISPERSIVE INFRARED PHOTOMETRY)

MEASUREMENT PRINCIPLE

1. Measurements are based on the absorption of infrared radiation by carbon monoxide (CO) in a non-dispersive photometer. Infrared energy from a source is passed

through a cell containing the gas sample to be analyzed, and the quantitative absorption of energy by CO in the sample cell is measured by a suitable detector. The photometer is sensitized to CO by employing CO gas in either the detector or in a filter cell in the optical path, thereby limiting the measured absorption to one or more of the characteristic wavelengths at which CO strongly absorbs. Optical filters or other means may

also be used to limit sensitivity of the photometer to a narrow band of interest. Various schemes may be used to provide a suitable zero reference for the photometer. The measured absorption is converted to an electrical output signal, which is related to the concentration of CO in the measurement cell.

2. An analyzer based on this principle will be considered a reference method only if it has been designated as a reference method in accordance with part 53 of this chapter.

3. Sampling considerations.

The use of a particle filter on the sample inlet line of an NDIR CO analyzer is optional and left to the discretion of the user or the manufacturer. Use of filter should depend on the analyzer's susceptibility to interference, malfunction, or damage due to particles.

CALIBRATION PROCEDURE

1. *Principle.* Either of two methods may be used for dynamic multipoint calibration of CO analyzers:

(1) One method uses a single certified standard cylinder of CO, diluted as necessary with zero air, to obtain the various calibration concentrations needed.

(2) The other method uses individual certified standard cylinders of CO for each concentration needed. Additional information on calibration may be found in Section 2.0.9 of Reference 1.

2. *Apparatus.* The major components and typical configurations of the calibration systems for the two calibration methods are shown in Figures 1 and 2.

2.1 Flow controller(s). Device capable of adjusting and regulating flow rates. Flow rates for the dilution method (Figure 1) must be regulated to $\pm 1\%$.

2.2 Flow meter(s). Calibrated flow meter capable of measuring and monitoring flow rates. Flow rates for the dilution method (Figure 1) must be measured with an accuracy of $\pm 2\%$ of the measured value.

2.3 Pressure regulator(s) for standard CO cylinder(s). Regulator must have nonreactive diaphragm and internal parts and a suitable delivery pressure.

2.4 Mixing chamber. A chamber designed to provide thorough mixing of CO and diluent air for the dilution method.

2.5 Output manifold. The output manifold should be of sufficient diameter to insure an insignificant pressure drop at the analyzer connection. The system must have a vent designed to insure atmospheric pressure at the manifold and to prevent ambient air from entering the manifold.

3. *Reagents.*

3.1 CO concentration standard(s). Cylinder(s) of CO in air containing appropriate concentrations(s) of CO suitable for the selected operating range of the analyzer under calibration; CO standards for the dilution method may be contained in a nitrogen ma-

trix if the zero air dilution ratio is not less than 100:1. The assay of the cylinder(s) must be traceable either to a National Bureau of Standards (NBS) CO in air Standard Reference Material (SRM) or to an NBS/EPA-approved commercially available Certified Reference Material (CRM). CRM's are described in Reference 2, and a list of CRM sources is available from the address shown for Reference 2. A recommended protocol for certifying CO gas cylinders against either a CO SRM or a CRM is given in Reference 1. CO gas cylinders should be recertified on a regular basis as determined by the local quality control program.

3.2 Dilution gas (zero air). Air, free of contaminants which will cause a detectable response on the CO analyzer. The zero air should contain <0.1 ppm CO. A procedure for generating zero air is given in Reference 1.

4. *Procedure Using Dynamic Dilution Method.*

4.1 Assemble a dynamic calibration system such as the one shown in Figure 1. All calibration gases including zero air must be introduced into the sample inlet of the analyzer system. For specific operating instructions refer to the manufacturer's manual.

4.2 Insure that all flowmeters are properly calibrated, under the conditions of use, if appropriate, against an authoritative standard such as a soap-bubble meter or wet-test meter. All volumetric flowrates should be corrected to 25 °C and 760 mm Hg (101 kPa). A discussion on calibration of flowmeters is given in Reference 1.

4.3 Select the operating range of the CO analyzer to be calibrated.

4.4 Connect the signal output of the CO analyzer to the input of the strip chart recorder or other data collection device. All adjustments to the analyzer should be based on the appropriate strip chart or data device readings. References to analyzer responses in the procedure given below refer to recorder or data device responses.

4.5 Adjust the calibration system to deliver zero air to the output manifold. The total air flow must exceed the total demand of the analyzer(s) connected to the output manifold to insure that no ambient air is pulled into the manifold vent. Allow the analyzer to sample zero air until a stable response is obtained. After the response has stabilized, adjust the analyzer zero control. Offsetting the analyzer zero adjustments to +5 percent of scale is recommended to facilitate observing negative zero drift. Record the stable zero air response as Z_{CO} .

4.6 Adjust the zero air flow and the CO flow from the standard CO cylinder to provide a diluted CO concentration of approximately 80 percent of the upper range limit (URL) of the operating range of the analyzer. The total air flow must exceed the total demand of the analyzer(s) connected to the output manifold to insure that no ambient air is

pulled into the manifold vent. The exact CO concentration is calculated from:

$$[\text{CO}]_{\text{OUT}} = \frac{[\text{CO}]_{\text{STD}} \times F_{\text{CO}}}{F_{\text{D}} + F_{\text{CO}}} \quad (1)$$

where:

$[\text{CO}]_{\text{OUT}}$ = diluted CO concentration at the output manifold, ppm;

$[\text{CO}]_{\text{STD}}$ = concentration of the undiluted CO standard, ppm;

F_{CO} = flow rate of the CO standard corrected to 25 °C and 760 mm Hg, (101 kPa), L/min; and

F_{D} = flow rate of the dilution air corrected to 25 °C and 760 mm Hg, (101 kPa), L/min.

Sample this CO concentration until a stable response is obtained. Adjust the analyzer span control to obtain a recorder response as indicated below:

Recorder response (percent scale) =

$$\frac{[\text{CO}]_{\text{OUT}}}{\text{URL}} \times 100 + Z_{\text{CO}} \quad (2)$$

where:

URL = nominal upper range limit of the analyzer's operating range, and

Z_{CO} = analyzer response to zero air, % scale.

If substantial adjustment of the analyzer span control is required, it may be necessary to recheck the zero and span adjustments by repeating Steps 4.5 and 4.6. Record the CO concentration and the analyzer's response. 4.7 Generate several additional concentrations (at least three evenly spaced points across the remaining scale are suggested to

verify linearity) by decreasing F_{CO} or increasing F_{D} . Be sure the total flow exceeds the analyzer's total flow demand. For each concentration generated, calculate the exact CO concentration using Equation (1). Record the concentration and the analyzer's response for each concentration. Plot the analyzer responses versus the corresponding CO concentrations and draw or calculate the calibration curve.

5. *Procedure Using Multiple Cylinder Method.* Use the procedure for the dynamic dilution method with the following changes:

5.1 Use a multi-cylinder system such as the typical one shown in Figure 2.

5.2 The flowmeter need not be accurately calibrated, provided the flow in the output manifold exceeds the analyzer's flow demand.

5.3 The various CO calibration concentrations required in Steps 4.6 and 4.7 are obtained without dilution by selecting the appropriate certified standard cylinder.

REFERENCES

1. Quality Assurance Handbook for Air Pollution Measurement Systems, Volume II—Ambient Air Specific Methods, EPA-600/4-77-027a, U.S. Environmental Protection Agency, Environmental Monitoring Systems Laboratory, Research Triangle Park, NC 27711, 1977.
2. A procedure for Establishing Traceability of Gas Mixtures to Certain National Bureau of Standards Standard Reference Materials. EPA-600/7-81-010, U.S. Environmental Protection Agency, Environmental Monitoring Systems Laboratory (MD-77), Research Triangle Park, NC 27711, January 1981.

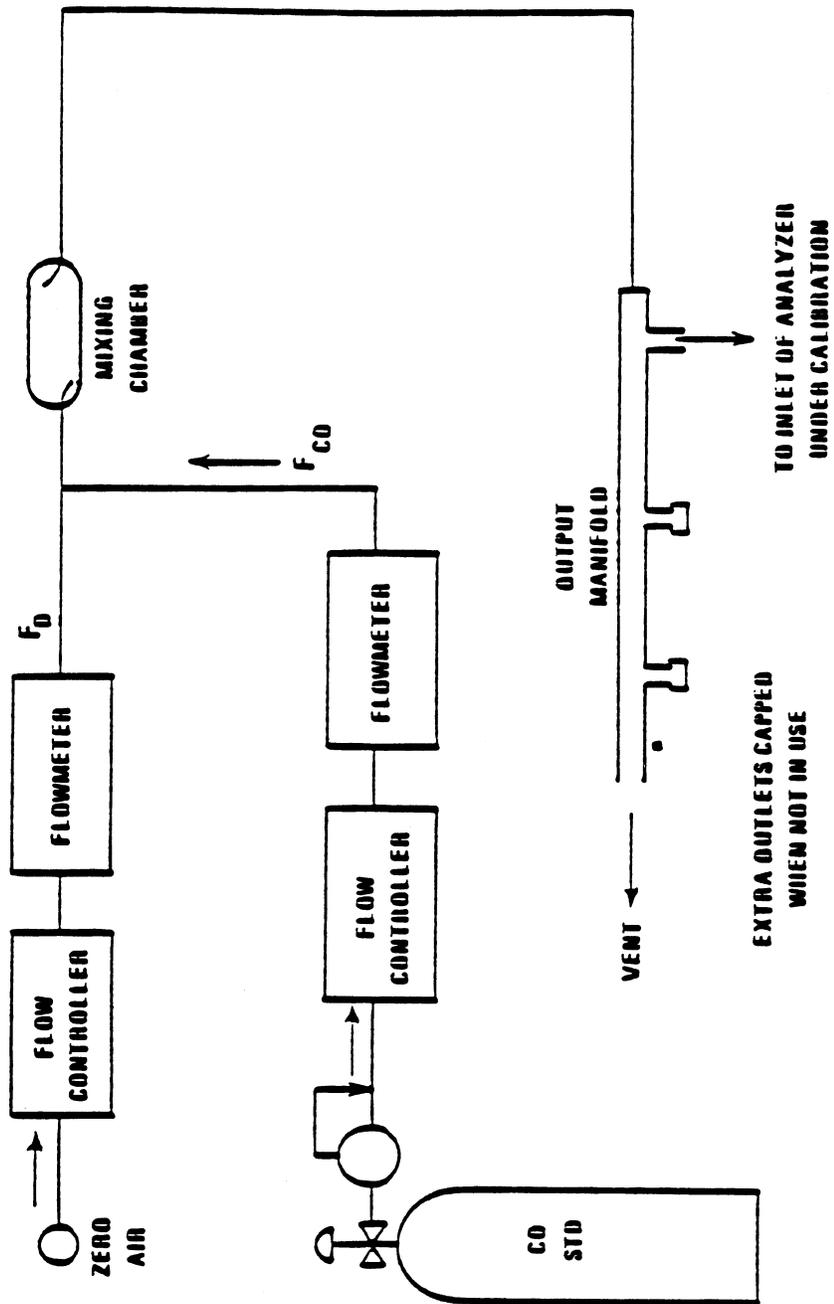


Figure 1. Dilution method for calibration of CO analyzers.

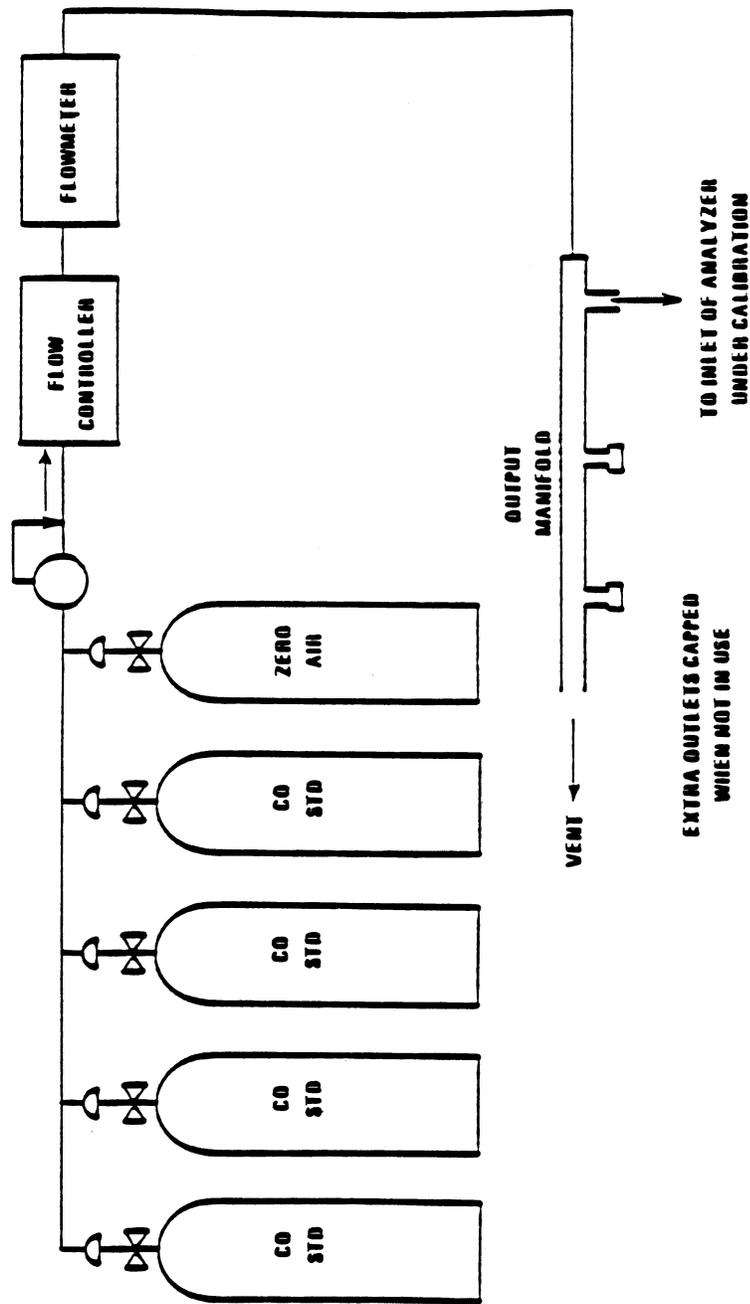


Figure 2. Multiple cylinder method for calibration of CO analyzers.

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