State of California
Air Resources Board

METHOD 10

Determination of Carbon Monoxide Emissions from Stationary Sources

Adopted: June 29, 1983
Amended: _______________

Note: this document consists of the text of the proposed amendment to Method 10. Proposed deletions are noted by graphic screen and proposed additions are noted by underline.

Method 10 - Determination of Carbon Monoxide Emissions from Stationary Sources

1. PRINCIPLE AND APPLICABILITY

1.1 Principle. An integrated or continuous gas sample is extracted from a sampling point and analyzed for carbon monoxide (CO) content using a Luft-type nondispersive infrared analyzer (NDIR) or equivalent.

1.2 Applicability. This method is applicable for the determination of carbon monoxide emissions from stationary sources only when specified by the test procedures for determining compliance with new source performance standards. The test procedure will indicate whether a continuous or an integrated sample is to be used.

Any modification of this method beyond those expressly permitted shall be considered a major modification subject to the approval of the Executive Officer. The term Executive Officer as used in this document shall mean the Executive Officer of the Air Resources Board (ARB), or his or her authorized representative.

2. RANGE AND SENSITIVITY

2.1 Range. 0 to 1000 ppm.

2.2 Sensitivity. Minimum detectable concentration is 20 ppm for a 0- to 1,000ppm span.

3. INTERFERENCES

Any substance having a strong absorption of infrared energy will interfere to some extent. For example, discrimination ratios for water (H_2O) and carbon dioxide (CO_2) are 3.5 percent H_2O per 7 ppm CO and 10 percent CO_2 per 10 ppm CO, respectively, for devices measuring in the 1500- to 3000-ppm range. For devices measuring in the 0- to 100-ppm range, interference ratios can be as high as 3.5 percent H_2O per 25 ppm CO and 10 percent CO_2 per 50 ppm CO. The use of silica gel and ascarite traps will alleviate the major interference problems. The measured gas volume must be corrected if these traps are used.

4. PRECISION AND ACCURACY

4.1 Precision. The precision of most NDIR analyzers is approximately 2 percent of span.

4.2 Accuracy. The accuracy of most NDIR analyzers is approximately 5 percent of span after calibration.

5. APPARATUS

Note: Mention of trade names or specific products does not constitute endorsement.

5.1 Continuous Sample (Figure 10-1).

5.1.1 Probe. Stainless steel or sheathed borosilicate (Pyrex) or quartz glass, equipped with a filter to remove particulate matter.

5.1.2 Air-Cooled Condenser or Equivalent. To remove any excess moisture.

5.1.3 Sample Line. Line shall be made of Teflon, and if necessary, insulated and capable of being heated to a minimum of 120^{o} C. If condensation is not a problem, sample line does not have to be heated. Alternatively, sample line made from other material (equivalent or better) may be used subject to the approval of the Control Agency’s Authorized RepresentativeExecutive Officer.

5.2 Integrated Sample (Figure 10-2).

5.2.1 Probe. Stainless steel or sheathed borosilicate or quartz glass, equipped with a filter to remove particulate matter. Same as in Section 5.1.1.

5.2.2 Air-Cooled Condenser or Equivalent. To remove any excess moisture. Same as in Section 5.1.2.

5.2.3 Valve. Needle valve, or equivalent, to adjust flow rate.

5.2.4 Pump. Leak-free diaphragm type, or equivalent, to transport gas.

5.2.5 Rate Meter. Rotameter, or equivalent, to measure a flow range from 0 to 1.0 liter per minute (0 to 0.035 cfm).

5.2.6 Flexible Bag. Tedlar, or equivalent, with a capacity of 60 to 90 liters (2 to 3 ft^{3}). Leak-test the bag in the laboratory before using by evacuating bag with a pump followed by a dry gas meter. When evacuation is complete, there should be no flow through the meter.

5.2.7 Pitot Tube. Type S, or equivalent, attached to the probe so that the sampling rate can be regulated proportional to the stack gas velocity when velocity is varying with time or a sample traverse is conducted.

5.2.8 Sample Line. See Section 5.1.3

5.3 Analysis (Figure 10-3).

5.3.1 Carbon Monoxide Analyzer. Nondispersive infrared spectrometer, or equivalent. This instrument should be demonstrated, preferably by the manufacturer, to meet or exceed manufacturer's specifications and those described in this method or ARB Method 100.

5.3.2 Drying Tube. To contain approximately 200 g of silica gel. Acceptable alternatives would be to inclulde the refrigeration system specified under ARB Method 100 (Section 2.1.4) or other types of dessicants (equivalent or better), subject to the approval of the Control Agency’s Authorized RepresentativeExecutive Officer.

5.3.3 Calibration Gas. Refer to Section 6.1.

5.3.4 Filter. As recommended by NDIR manufacturer.

5.3.5 CO_2 Removal Tube. To contain approximately 500 g of ascarite. Alternatively, other methods of CO_2 interference elimination (equivalent or better) may be used, subject to the approval of the Control Agency's Authorized RepresentativeExecutive Officer. Acceptable methods would be an analyzer with a filter or electronic signal conditioning to correct CO_2 interference.

5.3.6 Ice Water Bath. For ascarite and silica gel tubes, if used.

5.3.7 Valve. Needle valve, or equivalent, to adjust flow rate.

5.3.8 Rate Meter. Rotameter, or equivalent, to measure gas flow rate of 0 to 1.0 liter/min (0 to 0.035 cfm) through NDIR.

5.3.9 Recorder (Optional). To provide permanent record of NDIR readings.

6. REAGENTS

6.1 Calibration Gases.

Zero Gas: Pure air or nitrogen with less than 1 ppm of CO.

Span Gas: The calibration gas shall be approximately 70-80 percent of the analyzer range but not more than 150 percent of the applicable source performance standard unless exceeded by the source. The expected maximum concentration to be measured should be not more than 90 percent of the analyzer range. The calibration gas shall be traceable to the National Bureau of Standards primary standards gas blend. Known concentrations of CO in nitrogen (N_2) for instrument span and two additional concentrations corresponding to approximately 60 percent and 30 percent span. The span concentration shall not exceed 1.5 times the applicable source performance standard. The calibration gases shall be certified by the manufacturer to be within ±2 percent of the specified concentration.

6.1 Calibration Gases. Known concentration of CO in nitrogen (N_2) for instrument span, prepurified grade of N_2 for zero, and two additional concentrations corresponding approximately to 60 percent and 30 percent of span. The span concentration shall not exceed 1.5 times the applicable source performance standard. The calibration gases shall be certified by the manufacturer to be within 2 percent of the specified concentration.

6.2 Silica Gel. Indicating type, 6- to 16-mesh, dried at 175 ^{o}C (350347 ^{o}F) for 2 hours.

6.3 Ascarite. Commercially available.

7. PROCEDURE

7.1 Sampling.

7.1.1 Continuous Sampling. Set up the equipment as shown in Figure 10-1 making sure all connections are leak free. Place the probe in the stack at a sampling point, and probepurge the sampling line. Connect the analyzer, and begin drawing sample into the analyzer. Allow 5 minutes for the system to stabilize, then record the analyzer reading as required by the test procedure. (See paragraphsSections 7.2 and 8). CO_2 content of the gas may be determined by using the ARB Method 3 integrated sampling procedure, or by weighing the ascarite CO_2 removal tube and computing CO_2 concentration from the gas volume sampled and the weight gain of the tube.

7.1.2 Integrated Sampling. Evacuate the flexible bag. Set up the equipment as shown in Figure 10-2 with the bag disconnected. Place the probe in the stack, and purge the sampling line. Connect the bag, making sure that all connections are leak free. Sample at a rate proportional to the stack velocity. CO_2 content of the gas may be determined by using the ARB Method 3 integrated sample procedures, or by weighing the ascarite CO_2 removal tube and computing CO_2 concentration from the gas volume sampled and the weight gain of the tube.

7.2 CO Analysis. Assemble the apparatus as shown in Figure 10-3, calibrate the instrument, and perform other required operations as described in paragraphSection 8. Purge analyzer with N_2 prior to introduction of each sample. Direct the sample stream through the instrument for the test period, recording the readings. Check the zero and the span again after the test to assure that any drift or malfunction is detected. Record the sample data on Table 10-1.

8. CALIBRATION

Assemble the apparatus according to Figure 10-3. Generally an instrument requires a warm-up period before stability is obtained. Follow the manufacturer's instructions for specific procedure. Allow a minimum time of 1 hour for warmup. During this time check the sample conditioning apparatus, i.e., filter, condenser, drying tube, and CO_2 removal tube, to ensure that each component is in good operating condition. Zero and calibrate the instrument according to the manufacturer's procedures using, respectively, ~~nitrogen~~ N_2 and the calibration gases.

9. CALCULATION--CONCENTRATION OF CARBON MONOXIDE

Calculate the concentration of carbon monoxide in the stack using Equation 10-1.

$$C_{CO(stack)} = C_{CO(NDIR)} (1 - F_{CO2}) \qquad \text{Equation 10-1}$$

where:

$C_{CO(stack)}$ = Concentration of CO in stack, ppm by volume, dry basis.

$C_{CO(NDIR)}$ = Concentration of CO measured by NDIR analyzer, ppm by volume, dry basis.

F_{CO2} = Volume fraction of CO_2 in sample, i.e., percent CO_2 from Orsat analysis divided by 100.

= 0 if CO_2 interference is eliminated by means other than CO_2 physical removal.

10. ALTERNATIVE PROCEDURE - INTERFERENCE TRAP

The sample conditioning system described in EPA Method 10A, Sections 2.1.2 and 4.2, may be used as an alternative to the silica gel and ascarite traps.

ADDENDA

A. Performance Specifications for NDIR Carbon Monoxide Analyzers.

TABLE A-1. Performance Specifications for NDIR CO Analyzers

Range (minimum)	0-1000 ppm
Output (minimum)	0-10 mV
Minimum detectable sensitivity	20 ppm
Rise time, 90 percent (maximum)	30 seconds
Fall time, 90 percent (maximum	30 seconds
Zero drift (maximum)	10% in 8 hours
Span drift (maximum)	10% in 8 hours
Precision (maximum)	±2% of full scale
Noise (maximum)	±1% of full scale
Linearity (maximum deviation)	2% of full scale
Interference rejection ratio	CO_2 - 1000 to 1; H_2O - 500 to 1

B. Definitions of Performance Specifications.

Range - The minimum and maximum measurement limits.

Output - Electrical signal which is proportional to the measurement; intended for connection to readout or data processing devices. Usually expressed as millivolts or milliamps full scale at a given impedance.

Full Scale - The maximum measuring limit for a given range.

Minimum Detectable Sensitivity - The smallest amount of input concentration that can be detected as the concentration approaches zero.

Accuracy - The degree of agreement between a measured value and the true value; usually expressed as ± percent of full scale.

Time to 90 Percent Response - The time interval from a step change in the input concentration at the instrument inlet to a reading of 90 percent of the ultimate recorded concentration.

Rise Time (90 Percent) - The interval between initial response time and time to 90 percent response after a step increase in the inlet concentration.

Fall Time (90 Percent) - The interval between initial response time and time to 90 percent response after a step decrease in the inlet concentration.

Zero Drift - The change in instrument output over a stated time period, usually 24 hours, of unadjusted continuous operation when the input concentration is zero; usually expressed as percent full scale.

Span Drift - The change in instrument output over a stated time period, usually 24 hours, of unadjusted continuous operation when the input concentration is a stated upscale value; usually expressed as percent full scale.

Precision - The degree of agreement between repeated measurements of the same concentration, expressed as the average deviation of the single results from the mean.

Noise - Spontaneous deviations from a mean output not caused by input concentration changes.

Linearity - The maximum deviation between an actual instrument reading and the reading predicted by a straight line drawn between upper and lower calibration points.

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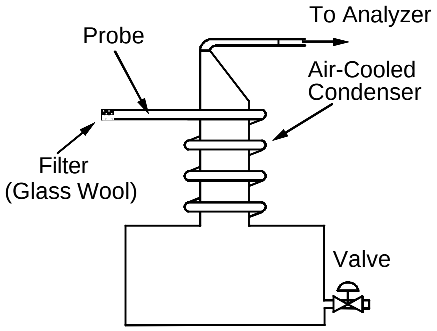

Figure 10-1. Continuous Sampling Train.

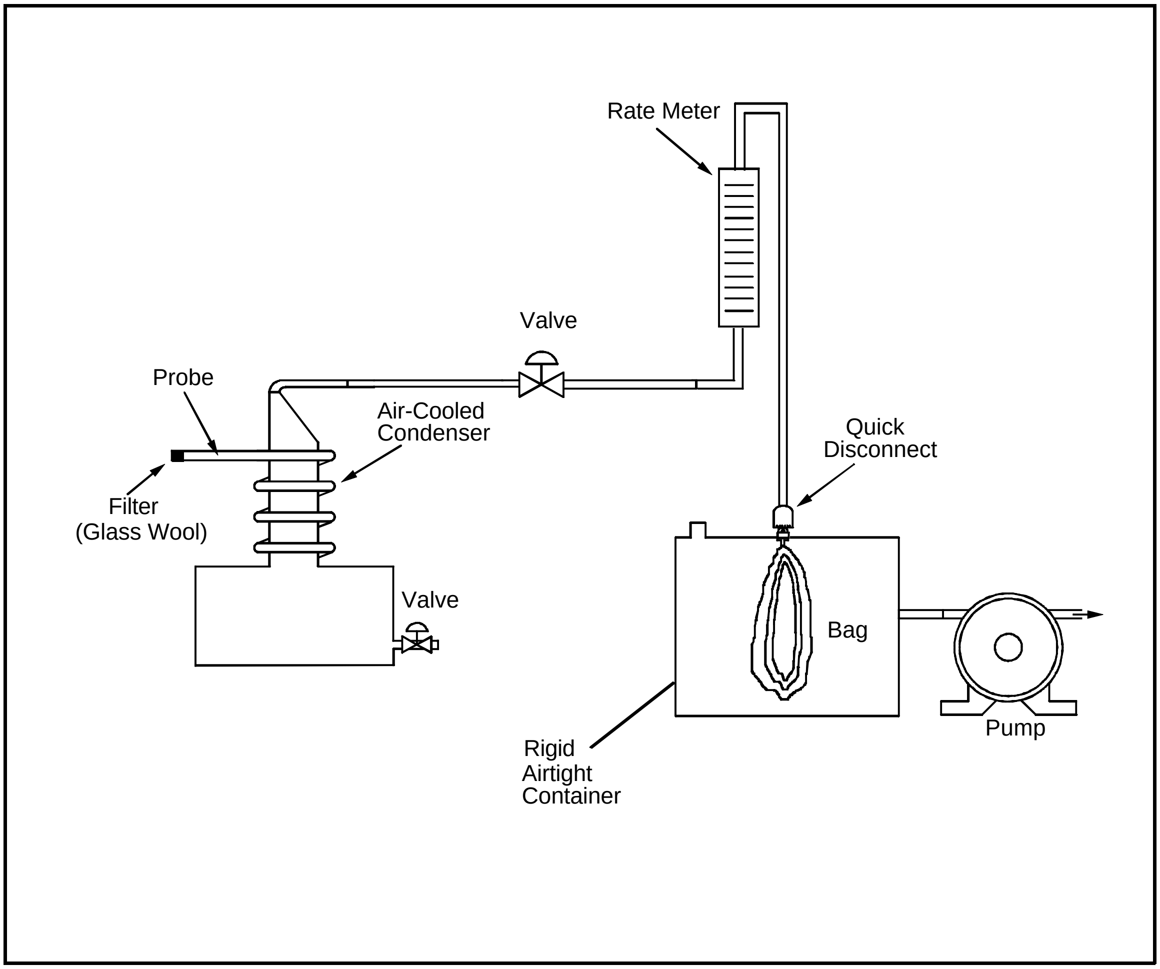

Figure 10-2. Integrated Gas Sampling Train.

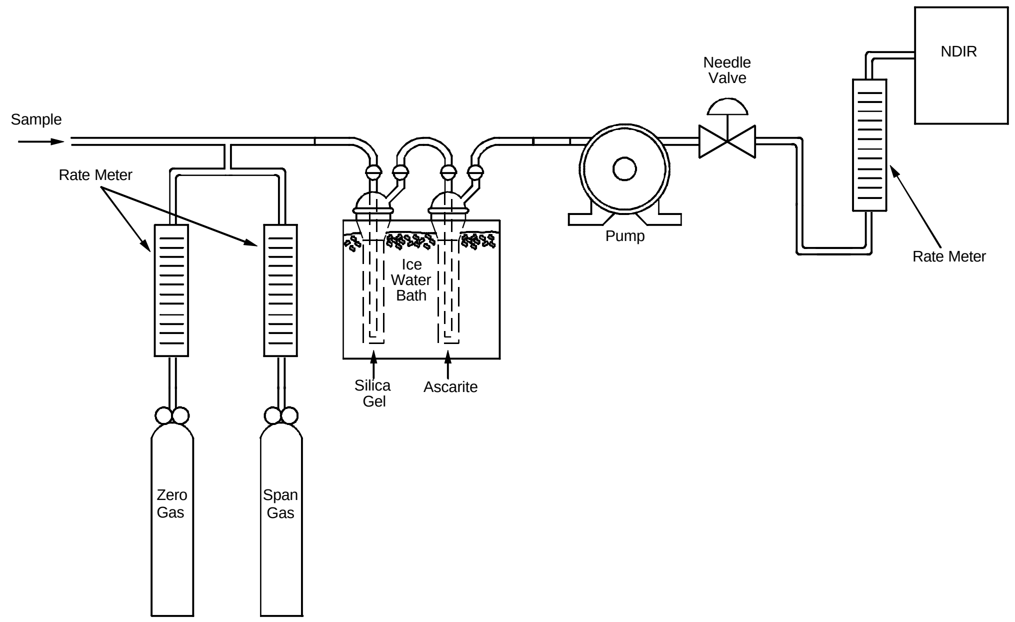

Figure 10-3. Analytical Equipment.

TABLE 10-1 - FIELD DATA

Location: Date:

Test: Operator:

Clock Time	Rotameter Reading liters/min (cfm)	Comments