State of California
AIR RESOURCES BOARD

METHOD 2A

Direct Measurement of Gas Volume Through Pipes and Small Ducts

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METHOD 2A

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1 Applicability and Principle

1.1 Applicability

This method applies to the measurement of gas flow rates in pipes and small ducts, either in-line or at exhaust positions, within the temperature range of 0 to 50^{o}C.

1.2 Principle

A gas volume meter is used to measure gas volume directly. Temperature and pressure measurements are made to correct the volume to standard conditions.

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 Apparatus

Specifications for the apparatus are given below. Any other apparatus that has been demonstrated (subject to approval of the Executive Officer) to be capable of meeting the specifications will be considered acceptable.

2.1 Gas Volume Meter

A positive displacement meter, turbine meter, or other direct volume measuring device capable of measuring volume to within 2 percent. The meter shall be equipped with a temperature gauge (± percent of the minimum absolute temperature) and a pressure gauge (± 2.5 mm Hg). The manufacturer's recommended capacity of the meter shall be sufficient for the expected maximum and minimum flow rates at the sampling conditions. Temperature, pressure, corrosive characteristics, and pipe size are factors necessary to consider in choosing a suitable gas meter.

2.2 Barometer

A mercury, aneroid, or other barometer capable of measuring atmospheric pressure to within 2.5 mm Hg. In many cases, the barometric reading may be contained from a nearby national weather service station, in which case the station value (which is the absolute barometric pressure) shall be requested, and an adjustment for elevation differences between the weather station and the sampling point shall be applied at a rate of minus 2.5 mm Hg per 30 meter elevation increase, or vice-versa for elevation decrease.

2.3 Stopwatch

Capable of measurement to within 1 second.

3 Procedure

3.1 Installation

As there are numerous types of pipes and small ducts that may be subject to volume measurement, it would be difficult to describe all possible installation schemes. In general, flange fittings should be used for all connections wherever possible. Gaskets or other seal materials should be used to assure leak-tight connections. The volume meter should be located so as to avoid severe vibrations and other factors that may affect the meter calibration.

3.2 Leak Test

3.2.1

A volume meter installed at a location under positive pressure may be leak-checked at the meter connections by using a liquid leak detector solution containing a surfactant. Apply a small amount of the solution to the connections. If a leak exists, bubbles will form, and the leak must be corrected.

3.2.2

A volume meter installed at a location under negative pressure is very difficult to test for leaks without blocking flow at the inlet of the line and watching for meter movement. If this procedure is not possible, visually check all connections and assure tight seals.

3.3 Volume Measurement

3.3.1

For sources with continuous, steady emission flow rates, record the initial meter volume reading, meter temperature(s), meter pressure, and start the stopwatch. Throughout the test period, record the meter temperature(s) and pressure so that average values can be determined. At the end of the test, stop the timer and record the elapsed time, the final volume reading, meter temperature(s), and pressure. Record the barometric pressure at the beginning and end of the test run. Record the data on a table similar to Figure 2A-1.

3.3.2

For sources with noncontinuous non-steady emission flow rates, use the procedure in 3.3.1 with the addition of the following: Record all the meter parameters and the start and stop times corresponding to each process cyclical or noncontinuous event.

4 Calibration

4.1 Volume Meter

4.1.1

The volume meter is calibrated against a standard reference meter prior to its initial use in the field. The reference meter is a spirometer or liquid displacement meter with a capacity consistent with that of the test meter.

4.1.2

Alternatively, a calibrated, standard pitot may be used as the reference meter in conjunction with a wind tunnel assembly. Attach the test meter to the wind tunnel so that the total flow passes through the test meter. For each calibration run, conduct a 4-point traverse along one stack diameter at a position at least eight diameters of straight tunnel downstream and two diameters upstream of any bend, inlet, or air mover. Determine the traverse point locations as specified in Method 1. Calculate the reference volume using the velocity values following the procedure in Method 2, the wind tunnel cross-sectional area, and the run time.

4.1.3

Set up the test meter in a configuration similar to that used in the field installation (i.e., in relation to the flow moving device). Connect the temperature and pressure gauges as they are to be used in the field. Connect the reference meter at the inlet of the flow line, if appropriate for the meter, and begin gas flow through the system to condition the meters. During this conditioning operation, check the system for leaks.

4.1.4

The calibration shall be run over at least three different flow rates. The calibration flow rates shall be about 0.3, 0.6, and 0.9 times the test meter's rated maximum flow rate.

4.1.5

For each calibration run, the data to be collected include: reference meter initial and final volume readings, the test meter initial and final volume reading, meter average temperature and pressure, barometric pressure, and run time. Repeat the runs at each flow rate at least three times.

4.1.6

Calculate the test meter calibration coefficient, Y_m for each run as follows:

$$Y_m = \frac{(V_{rf} - V_{ri})\,(t_r + 273)\,P_b}{(V_{mf} - V_{mi})\,(t_m + 273)\,(P_b + P_g)} \qquad \text{Eq. 2A-1}$$

Where:

Y_m = Test volume meter calibration coefficient, dimensionless.
V_r = Reference meter volume reading, m^3.

V_m	=	Test meter volume reading, m^3.
t_r	=	Reference meter average temperature, ^oC.
t_m	=	Test meter average temperature, ^oC.
P_b	=	Barometric pressure, mm Hg.
P_g	=	Test meter average static pressure, mm Hg.
f	=	Final reading for run.
I	=	Initial reading for run.

4.1.7

Compare the three Y_m values at each of the flow rates tested and determine the maximum and minimum values. The difference between the maximum and minimum values at each flow rate should be no greater than 0.030. Extra runs may be required to complete this requirement. If this specification cannot be met in six successive runs, the test meter is not suitable for use. In addition, the meter coefficients should be between 0.95 and 1.05. If these specifications are met at all the flow rates, average all the Y_m values from runs meeting the specifications to obtain an average meter calibration coefficient, Y_m.

4.1.8

The procedure above shall be performed at least once for each volume meter. Thereafter, an abbreviated calibration check shall be completed following each field test. The calibration of the volume meter shall be checked by performing three calibration runs at a single, intermediate flow rate (based on the previous field test) with the meter pressure set at the average value encountered in the field test. Calculate the average value of the calibration factor. If the calibration has changed by more than 5 percent, recalibrate the meter over the full range of flow as described above.

NOTE: If the volume meter calibration coefficient values obtained before and after a test series differ by more than 5 percent, the test series shall either be voided, or calculations for the test series shall be performed using whichever meter coefficient value (i.e., before or after) gives the greater value of pollutant emission rate.

4.2 Temperature Gauge

After each test series, check the temperature gauge at ambient temperature. Use an American Society for Testing and Materials (ASTM) mercury-in-glass reference thermometer, or equivalent, as a reference. If the gauge being checked agrees within 2 percent (absolute temperature) of the reference, the temperature data collected in the field shall be considered valid. Otherwise, the test data shall be considered invalid or adjustment of the test results shall be made, subject to the approval of the Executive Officer.

4.3 Barometer

Calibrate the barometer used against a mercury barometer prior to the field test.

5 Calculations

Carry out the calculations, retaining at least one extra decimal figure beyond that of the acquired data. Round off figures after the final calculations.

5.1 Nomenclature

P_b	=	Barometric pressure, mm Hg.
P_g	=	Average static pressure in volume meter, mm Hg.
Q_s	=	Gas flow rate, m^3/min, standard conditions.
T_m	=	Average absolute meter temperature, ^oK.
V_m	=	Meter volume reading, m^3.
Y_m	=	Average meter calibration coefficient, dimensionless.
f	=	Final reading for test period.
i	=	Initial reading for test period.
s	=	Standard conditions, 20^oC and 760 mm Hg.
θ	=	Elapsed test period time, min.

5.2 Volume

$$V_{ms} = 0.3853\, Y_m\,(V_{mf} - V_{mi})\,\frac{(P_b + P_g)}{T_m} \qquad \text{Eq. 2A-2}$$

Gas Flow Rate

$$Q_s = \frac{V_{ms}}{q} \qquad \text{Eq. 2A-3}$$

6. Bibliography

6.1 EPA Method 2A, Direct Measurement of Gas Volume through Pipes and Small Ducts, CFR40, Part 60, Appendix A

Plant	
Date	Run Number
Sample Location	
Barometric Pressure, mm Hg	Start Finish
Operators	
Meter Number	Meter Calibration Coefficient
	Last Date Calibrated

Time	Volume	Static Pressure	Temperature		
Run/Clock	Meter Reading	mm Hg	°C	°K	
Average					

Figure 2A-1. Volume Flow Rate Measurement Data.