Designation: D 3195 – 90 (Reapproved 1998)ε1

Standard Practice for Rotameter Calibration[1]

This standard is issued under the fixed designation D 3195; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

ε[1] NOTE—Paragraph X1.5 was corrected editorially in October 1998.

1. Scope

1.1 This practice covers the calibration of variable-area flowmeters (rotameters) used to determine air sample volumes at or close to ambient conditions of pressure and temperature, in the analysis of atmospheres for pollutant content.

1.2 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*

D 1071 Test Methods for Volumetric Measurement of Gaseous Fuel Samples[2]

D 1356 Terminology Relating to Sampling and Analysis of Atmospheres[3]

D 3631 Test Methods for Measuring Surface Atmospheric Pressure[3]

E 1 Specification for ASTM Thermometers[4]

E 337 Test Method for Measuring Humidity with a Psychrometer (the Measurement of Wet- and Dry-Bulb Temperatures)[3]

3. Terminology

3.1 *Definitions:*

3.1.1 For definitions of terms used in this practice, refer to Terminology D 1356.

3.1.2 *standard conditions* are taken as 25°C and 101.3 kPa (760 mm Hg) at existing ambient humidity. This conforms to most of the ASTM methods for atmospheric sampling and analysis that involve volumetric corrections. Absolute temperature scales are to be used when substituting values into the formulae used in this procedure.

4. Summary of Practice

4.1 Two alternative methods of performing the required volume determinations for rotameter calibration are described:

4.1.1 Using the water-sealed rotating drum meter (wet test meter). See Section 7.

4.1.2 Using the volumetric gasometer (bell prover). See Section 8.

5. Significance and Use

5.1 Choice of method depends primarily on which equipment is available. Higher accuracy is possible with the gasometer. The accuracies of the methods of atmospheric analysis, for which the calibration procedure is intended, do not warrant the very highest possible accuracy in flow measurement.

6. Apparatus

6.1 *Wet Test Meter, or Volumetric Gasometer*, with water seal and equipped with a water manometer on the inlet.

6.2 *Counter Balance Weights*, for gasometer.

6.3 *Mercury Barometer*—See Test Methods D 3631.

6.4 *Psychrometer*, (if room air is used for calibration gas). See Test Method E 337.

6.5 *Thermometer*, to measure ambient temperature. See Specification E 1.

6.6 *Stopwatch*.

6.7 *Air Supply*, either a cylinder of compressed air or a diaphragm type pump of adequate capacity and a ballast volume or restrictor to eliminate pulsations.

6.8 *Needle Valve*.

7. Procedure Using Wet Test Meter

7.1 Unless it was already calibrated within the previous 3 months, calibrate the wet test meter by Test Methods D 1071. The method described in Section 19 is recommended for highest accuracy.

7.2 Set up the apparatus as shown in Fig. 1, making connections as short as possible and large enough inside diameter to avoid any appreciable pressure drops.

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[1] This practice is under the jurisdiction of ASTM Committee D22 on Sampling and Analysis of Atmospheres and is the direct responsibility of Subcommittee D22.01 on Quality Control.

Current edition approved Dec. 28, 1990. Published February 1991. Originally published as D 3195 – 73. Last previous edition D 3195 – 73 (1985)ε[1].

[2] *Annual Book of ASTM Standards*, Vol 05.05.

[3] *Annual Book of ASTM Standards*, Vol 11.03.

[4] *Annual Book of ASTM Standards*, Vol 14.03.

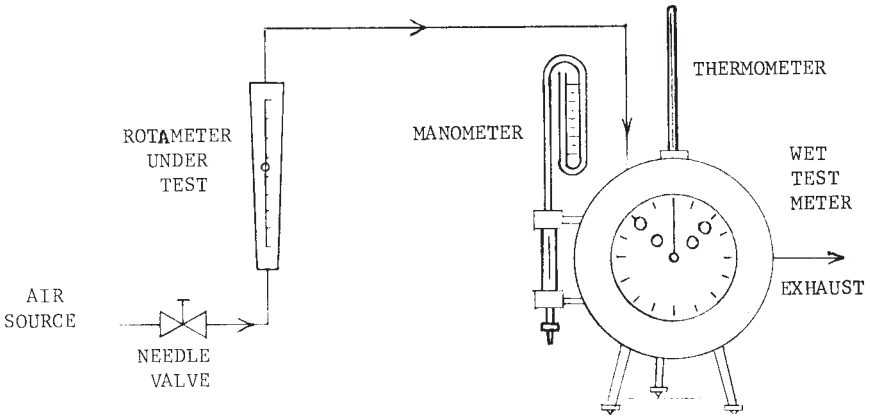

FIG. 1 Calibration Assembly Using Wet Test Meter

7.3 Before and after the complete calibration run, record room temperature, barometric pressure in accordance with Test Methods D 3631, and relative humidity (when room air is used for calibrating gas) in accordance with Test Method E 337. Use average values for subsequent calculations.

7.4 Start air flowing through the rotameter and wet test meter. Adjust the flow to the desired rate with the needle valve. Take a pair of timed readings on the wet test meter, under steady flow, for each of five or more uniformly spaced points on the rotameter scale, going from low values to high values. Repeat, going from high to low. Note the manometer reading and meter water temperature for each meter reading.

8. Procedure Using Gasometer

8.1 Unless it was already calibrated within the previous six months, in the same location, calibrate the gasometer by Test Methods D 1071.

8.2 Set up the apparatus as shown in Fig. 2, making connections as short as possible and large enough inside diameter to avoid any appreciable pressure drops.

8.3 Before and after the complete calibration run, record the room temperature, barometric pressure, and relative humidity (when room air is used for calibrating gas). Use average values for subsequent calculations.

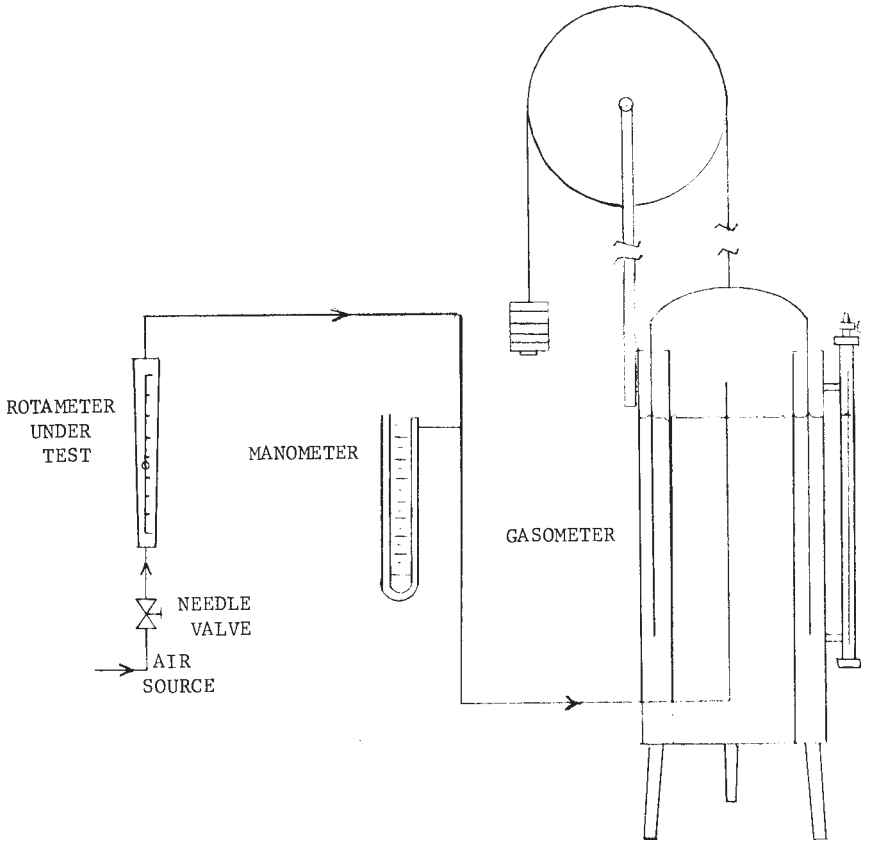

FIG. 2 Calibration Assembly Using Gasometer

8.4 Start air flowing through the rotameter and into the gasometer. Adjust the flow to the desired value with the needle valve.

8.5 Adjust eight counterbalance weights on the gasometer as required to maintain no greater than 2 in. of water backpressure when operating.

8.6 Take a pair of timed readings on the gasometer scale, under steady flow, for each of five or more uniformly spaced points on the rotameter scale going from low values to high values. Repeat, going from high to low.

9. Calculations

9.1 Convert all temperature and pressure readings to absolute units, as follows:

$$°F + 460 = °R \quad (1)$$

$$°C + 273 = K$$

$$\text{in. of water} \times 0.249 = \text{kPa}$$

$$\text{in. of water} \times 0.0737 = \text{in. Hg}$$

$$\text{in. of water} \times 1.87 = \text{mm Hg}$$

9.2 Calculate the indicated flow readings for all recorded rotameter points by dividing the indicated delta volumes by the time.

9.3 Using the following equation, convert these indicated flow readings to actual flows that would be indicated by the rotameter if it were calibrated for air at the standard conditions stated in 5.2:

$$Q_1 = Q(P_m - D)T_a/P_mT_m \sqrt{T_a/T_s} \quad (2)$$

where: (see Appendix)

Q_1 = flow rate rotameter should indicate,
Q = flow rate indicated by wet test meter or gasometer,
T_s = standard temperature (298 K or 537°R),
T_m = meter temperature (water temperature for wet test meter; room temperature for gasometer),
T_a = room temperature,
P_m = gas pressure during calibration (inlet pressure for wet test meter; barometric pressure for gasometer) (kPa, in water, mm Hg), and
D = vapor pressure of water in the calibrating gas (kPa, in water, mm Hg).

9.4 Prepare the calibration curve by best fit to all points. It should be labeled "... at 25°C and 101.3 kPa (760 mm Hg)."

10. Keywords

10.1 calibration; flowmeter; rotameter

APPENDIX

(Nonmandatory Information)

X1. DERIVATION OF FLOWMETER EQUATION

X1.1 The equation is based on the premise that the calibrated rotameter should read air flow correctly at standard conditions, as defined. Therefore, in order to prepare the calibration curve it is first necessary to convert the wet test meter or gasometer readings to the values that would be indicated by the rotameter if it had been calibrated under standard conditions. This can be done logically in several steps. First, the indicated values are corrected for the water vapor added by the wet test meter or gasometer, assuming saturation, by operating with the factor:

$$P_m - D/P_m \quad (X1.1)$$

where:

P_m = gas pressure during calibration (inlet pressure for wet test meter; barometric pressure for gasometer), and
D = vapor pressure of water at 100 % R.H. and temperature T_m, minus the vapor pressure of water in the calibrating gas.

X1.2 Next, the volume measured in the wet test meter or gasometer is corrected to what it was in the rotameter. This factor is:

$$T_a/T_m \quad (X1.2)$$

where:

T_a = room temperature, and
T_m = meter temperature (water temperature for wet test meter; room temperature for gasometer).

X1.3 This is what the rotameter should read but if it were calibrated with air at standard temperature and used to measure air at this different temperature, the viscosity effect would cause a slightly different reading. Since viscosity is proportional to the square root of absolute temperature (independent of pressure up to 10 atmospheres), the indicated flow would differ from actual flow by the factor:

$$\sqrt{T_a/T_s} \quad (X1.3)$$

where:

T_s = standard temperature (298 K or 537°R)

X1.4 Putting these elements all together gives us the equation indicated in the body of the method.

X1.5 Subsequent use of the rotameter normally involves taking the indicated flow off the curve and correcting it to standard conditions. The factor for this correction is:

$$T_sP_r/T_aP_s \sqrt{T_s/T_a} \quad (X1.4)$$

where:

P_r = rotameter pressure, and
P_s = standard pressure (760 mm Hg or 101.3 kPa)

NOTE X1.1—In many cases, P_r is, or can be assumed to be, the same as barometric pressure. However, when any question exists, and for highest accuracy, a water manometer should be used, just downstream of the rotameter.