

SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT

CHAPTER III

CALIBRATIONS

OFFICE OF OPERATIONS
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CHAPTER III

CALIBRATIONS

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1. Purpose

Properly calibrated equipment (measuring instruments) is of fundamental importance to the acquisition of reliable data. The most carefully performed test will yield invalid results if the instruments used in obtaining the supporting data are out of calibration. This chapter delineates the calibration methods and standard acceptance limits and schedules (see Table III-1 and III-2) that should be followed to ensure that fully functional calibrated equipment is available to source testing personnel.

Each calibration must have a record that includes:

1. Instrument identification number
2. Date
3. Operator's signature
4. Calibration technique
5. Description of reference standard used
6. Calibration curves, correction factor, etc.
7. Comments

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2. Pitot Tubes

2.1 Specifications

2.1.1 S-Type Pitot Tube

The S-type Pitot tube (Figure III-1) must be made of metal tubing (e.g. stainless steel). The recommended external tubing diameter (dimension D Figure III-2) is between 0.48 and 0.95 cm (3/16 and 3/8 in.). There must be an equal distance from the base of each leg of the Pitot tube to its face-opening plane (dimensions PA and PB Figure III-2); the recommended distance is between 1.05 and 1.50 times the external tubing diameter. The face opening of the Pitot tube preferably should be aligned as shown in Figure III-2; however, slight misalignment of the openings are permissible (see Figure III-3).

Each Pitot tube must be permanently marked with an identification number; one leg of the tube should be marked A and the other B.

Pitot tubes that conform to the configuration and dimensions shown in Figures III-2 and III-3 may be assigned a Pitot tube coefficient of 0.84. A visual check of these dimensions must be made prior to each use. Actual measurements must be made and recorded semiannually.

Alternatively, a Pitot tube coefficient may be determined by wind tunnel testing annually. When configuration and dimensions of the Pitot tube does not meet those shown in Figures III-2 and III-3, it must be repaired, replaced, or tested in the wind tunnel to determine a new Pitot tube coefficient.

2.1.2 Standard Pitot Tube

In some instances a standard Pitot tube may be used instead of a S-type. The standard Pitot tube should have a known coefficient obtained either from the National Bureau of Standards (NBS), Route 70 S. Quince Orchard Road, Gaithersburg, Maryland, or a standard Pitot tube designed according to the criteria illustrated in Figure III-4 should be used.

Pitot tubes designed according to these specifications will have a baseline coefficient of 0.99 ± 0.01 . Inspect the standard Pitot tube for any damage upon receipt. Also inspect and leak check before and after each test.

2.2 S-Type Calibration Test Procedure

2.2.1 Equipment

2.2.1.1 Wind Tunnel Setup

The flowing gas stream must be confined to a duct of definite cross sectional area, either circular or rectangular. For circular cross sections, the minimum duct diameter is 30.5 cm (12 in.); for rectangular cross sections, the width (shorter side) must be at least 25.4 cm (10 in.). The cross sectional area of the calibration duct must be constant over a distance of 10 or more duct diameters (See Figure III-5).

To determine the number of duct diameters for a rectangular cross section, use the equivalent diameter calculated from the following equation:

$$D = \frac{2LW}{(L + W)}$$

where:

D = Equivalent diameter
L = Length
W = Width

To ensure the presence of stable, fully developed flow patterns at the calibration site, or "test section", the entry port must be located at least eight diameters downstream and two diameters upstream from the nearest disturbances.

The flow system should generate test-section velocities covering the velocity range from 180 to 915 m/min (600 to 3000 ft/min) and calibration data must be taken at three regular velocity intervals over this range. These velocities must be constant with time to guarantee steady flow during calibration. Note that S-type Pitot tube coefficients obtained by single-velocity calibration at 915 m/min (3000 ft/min) will generally be valid to within ± 3 percent for the measurement of velocities above 305 m/min (1000 ft/min) and to within ± 5 to 6 percent for the measurement of velocities between 180 and 305 m/min (600 and 1000 ft/min).

2.2.1.2 Manometer

A manometer must be mounted near the calibration site and be leveled and zeroed before each

calibration. Plastic tubing may be used for connecting the manometer with the Pitot tubes and for switching tubes.

2.2.2 Procedure

The yearly calibration of a S-type Pitot tube may be performed using either the measurement technique described in Section 2.1.1 or the wind tunnel method described in this section. S-type Pitot tubes with detachable heads must be calibrated yearly on each head by either the measurement technique described in Section 2.1.1 or by the wind tunnel method described in this section.

This procedure is a general one and must not be used without first referring to the special considerations presented in Section 2.4. To obtain calibration data from the A and the S-type Pitot tube, perform the following steps:

1. Assure that the manometer is properly filled and the oil is free from contamination and of the proper density. Inspect and leak check all Pitot tube lines; repair or replace if necessary.
2. Level and zero the manometer. Turn on the fan and allow the flow to stabilize. Seal the entry port.
3. Measure the Pitot tube configuration for conformance to the specifications. Position the standard Pitot tube at the calibration point near the center of the duct and align the tube its tip points directly into the flow. Avoid yaw and pitch angles. See Figures III-6 and III-7 for magnitude and characteristics of measurement errors in C_p . Make sure the entry port surrounding the tube is properly sealed.

4. Read ΔP_{std} and record its value in a data table similar to the one shown in Figure III-8. Remove the standard Pitot tube from the duct and disconnect it from the manometer.
5. Connect the S-type Pitot tube to the manometer. Check the manometer level and zero. Insert and align the S-type Pitot tube so its A side impact opening is at the same point as was the standard Pitot tube and is pointed directly into the flow. Make sure that the entry port surrounding the tube is properly sealed.
6. Read ΔP_s and enter its value in the data table. Remove the S-type Pitot tube from the duct and disconnect it from the manometer.
7. Repeat steps 3 through 6 above until three pairs of ΔP readings have been obtained.
8. Repeat steps 3 through 7 above for the B side of the S-type Pitot tube.
9. Obtain 6 pairs (sets) of ΔP readings at three regular velocity intervals over the range mentioned in Section 2.2.1.1.
10. If the wind tunnel is larger than 24 inches in diameter and meets the design criteria of Section 2.1.1.1, both the standard Pitot tube and S-type Pitot tube may be used simultaneously. Two entry ports, one each for the standard and S-type Pitot tubes, shall be cut in the test section. The standard Pitot entry port shall be located slightly downstream of the S-type entry port so that the standard S-type impact

openings will lie in the same cross sectional plane during calibration. Also, the impact opening of the S-type shall be placed 1/3 diameter from the entry port and the standard Pitot impact opening placed 1/3 diameter from the distant wall. To facilitate alignment of the Pitot tubes during calibration, it is advisable that the test section be constructed of plexiglas or some other transparent material (see Figure III-5).

2.3 Calculations

For each of the three pairs of $\blacktriangle P$ readings, (three from side A and three from side B obtained in Section 2.2.2 above), calculate the value of the S-type Pitot tube coefficient $C_p(s)$, for each set of measurements, using the equation:

$$C_p(s) = C_p(std) \sqrt{\frac{\Delta P(std)}{\Delta P_s}}$$

where:

$C_p(s)$ = S-type Pitot tube coefficient (individual reading)

$C_p(std)$ = Standard Pitot tube coefficient (Use 0.99 if coefficient is unknown and tube is designed according to the guidelines in Figure 3-4.)

$\blacktriangle P_{std}$ = Velocity head measured by the standard Pitot tube, cm (in.) H_2O

ΔP_s = Velocity head measured by the S-type Pitot tube, cm (in.) H₂O

For both the A and B sides of the Pitot tube calculate σ , calculate average deviation from the mean, using the equations:

$$\sigma (A) = \frac{\sum_{1}^3 [C_p(s) - C_p(A)]}{3}$$

$$\sigma (B) = \frac{\sum_{1}^3 [C_p(s) - C_p(B)]}{3}$$

where:

$\sigma (A), \sigma (B)$ = Average deviation from mean of A and B side, respectively

$C_p(s)$ = S-type Pitot tube coefficient of each pair (set) of ΔP readings for the corresponding A or B side

$\bar{C}_p(A)$ = Average Pitot tube coefficient for the corresponding A or B side

Recalibrate the S-type Pitot tube assembly if the absolute value of σ (A) or σ (B) is not ≤ 0.01 . Use the S-type Pitot tube only if the absolute value of the difference between \bar{C}_p (A) and \bar{C}_p (B) is ≤ 0.01 .

Repeat the above described procedures for the other velocity ranges. One measurement should be made at a velocity between 120-180 m/min (400-600 ft/min) and two other measurements made at velocities between 300-1220 m/min (1000-4000 ft/min). Calculate the average deviation of \bar{C}_p for sides A and B at these three velocities. If this average deviation is < 0.02 , use the mean \bar{C}_p . If it is $> .02$, then plot C_p vs. velocity and use appropriate \bar{C}_p for the velocity encountered during testing. Alternatively, the arithmetic average of the A and B side coefficient values may be used irrespective of which side faces the flow.

2.4 Special Considerations

2.4.1 Selection of Calibration Point

2.4.1.1 When calibrating an S-type Pitot tube with other components (nozzle, thermocouple, sample probe), select a calibration point at or near the center of the duct and follow the procedures outlined in Sections 2.2.2 and 2.4 above. S-type Pitot tube coefficients obtained i.e. \bar{C}_p (side A) and \bar{C}_p (side B)] will be valid if the assembly is free

from aerodynamic interference effects (see Figures III-9 and III-10).

2.4.1.2 Inserting a probe sheath into a small duct may cause significant cross sectional area blockage and yield incorrect coefficient values. To minimize blockage, the calibration point may be a few inches off center. The actual blockage will be negligible when the theoretical blockage, determined by a projected area model of the probe sheath, is 2 percent or less of the duct cross sectional area for assemblies without external sheaths (Figure III-11 a) and 3 percent or less for assemblies with external sheaths (Figure III-11 b).

2.4.1.3 For probe assemblies in which the Pitot-nozzle separation distance fails to meet the separation distance illustrated in Figure III-9, the value of $C_p(s)$ depends on the amount of free space between the tube and the nozzle, and therefore instances, separate calibrations should be performed with each of the commonly used nozzle sizes in place.

Note that it is not necessary to draw an isokinetic sample during calibration.

2.4.1.4 For a probe assembly constructed so that its Pitot tube is always used in the same orientation, only one side of the Pitot tube need be calibrated (the side facing the flow). The Pitot tube still must meet the alignment

specifications of Figure III-2 or III-3 and must have an average deviation value of 0.01 or less (see Calculations, Section 2.3).

2.5 Traceability and Acceptance Standards of Source Testing Instruments

See Table III-1.

2.6 Frequency of Calibration of Source Testing Instruments

See Table III-2.

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3. Differential Pressure Gauges

With the exception of manometers, differential pressure gauges (e.g. magnehelic gauges) are calibrated before being put into service (initially), semiannually and bimonthly. They are tested for leakage and accuracy. All test and calibration data are recorded on the forms shown in Figures III-12 and III-13 and maintained in files. Calibrated differential pressure gauges are assigned a permanent identification number indicated on it along with the date of calibration, the correction factor, and the name of the calibrating technician.

3.1 Initial and Semiannual Calibration

3.1.1 Leak Check

Both pressure and vacuum leak checks must be performed. Place the differential pressure gauge in the system shown in Figure III-14. Apply a pressure of 254 mm (10 in.) H₂O for the pressure leak test and a vacuum of 254 mm (10 in.) H₂O for the vacuum leak test. If the pressure or vacuum in the system decreases by more than 25.4 mm (1.0 in.) H₂O in five minutes remove the gauge from service.

If the gauge is to be subjected to pressure differences in excess of 254 mm (10 in.) H₂O, perform the leak checks at those levels.

3.1.2 Point Leak Check

Both pressure and vacuum checks must be performed. Place the differential pressure gauge in the system shown in Figure III-15 for the point pressure leak test. Apply pressure to the system that is 90 percent of the full scale range. If the pressure decreases by more than five percent of full scale in five minutes, remove the gauge from service.

For the vacuum leak test place the differential pressure gauge in the system shown in Figure III-15B. Perform the test as described above but apply vacuum instead of pressure.

3.1.3 Calibration Set Up and Procedure

Place the differential pressure gauge in the system shown in Figure III-15A. Apply pressures to this gauge of exactly 20, 40, 60, 80, and 100 percent of the full scale range. Read and record the standard gauge pressure at each point allowing the gauge fluids to come to equilibrium before taking any readings. If the reading on the differential pressure gauge being tested deviates by more than ± 5 percent from the pressure indicated on the standard, remove the gauge from service and repair or replace it.

Repeat the above procedure two more times covering the same range. At 50 percent of full scale check the differential pressure gauge under vacuum. Figure III-15B shows the system configuration. If the reading on this gauge being tested deviates by more than ± 5 percent from the vacuum indicated on the standard, remove the gauge from service and repair or replace it.

When all the data are accumulated, perform the calculations necessary to complete the data sheet and determine the

correction factor. Section 3.3 lists the formulas used in these calculations.

3.2 Bimonthly Calibrations

The bimonthly calibration shall be done in the same manner as the initial and semiannual calibration discussed in Section 3.1 except only 20, 60, and 80 percent of full scale are checked and no correction factor is calculated.

3.3 Calculations

3.3.1 Mean

$$\bar{x} = \frac{\sum_{i=1}^n x_i}{n}$$

where:

x_i = Percent deviation at each point

n = Number of pressure checks (3) at each point

3.3.2 Standard Deviation

$$\sigma = \sqrt{\frac{\sum_{i=1}^n (x_i - \bar{x})^2}{n}}$$

3.3.3 Ninety-five Percent Confidence Interval

$$95 \text{ percent C.I.} = \frac{4.303 \sigma}{\sqrt{n}}$$

3.3.4 Correction Factor

$$C.F. = \sum_{i=1}^k \left[\frac{\bar{n}H_2'}{H_i} \right]_i$$

where:

$\bar{n}H_2'$ = Average of all standard gauge
readings at a point

H_i = Average pressure reading on the differential
pressure gauge being tested

k = Number of points checked

3.4 Traceability and Acceptable Standards of Source Testing Instruments

See Table III-1.

3.5 Frequency of Calibration of Source Testing Instruments

See Table III-2.

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4. Stack Temperature Sensor Calibration-Except Thermocouple-Potentiometer

Each temperature sensor must be permanently marked with an identification number. Calibration shall be performed initially and annually at multiple three- points as described in Section 4.1, and extrapolated over the range of temperatures anticipated during actual sampling. A non-multiple three-point check must be performed monthly thereafter.

4.1 Calibration Test Procedure

The three calibration temperature points selected for this procedure can easily be achieved and precisely monitored. Use a mercury-in-glass ASTM thermometer as a standard. Calibration systems using other constant temperature calibration devices that span the range of use may be used if they can be calibrated with a reference mercury-in-glass ASTM thermometer.

For all three calibration points, an ASTM reference thermometer is placed next to the sensor(s) (without touching them) or a constant temperature calibration device can be used. Attain thermal equilibrium. Simultaneously record temperature and the stack temperature sensor(s) three times at one minute intervals. Record the data on a form (see Figure III-16).

4.1.1 Ice Point

Form a slush from crushed ice and water (preferably deionized, distilled) in an insulated vessel (e.g. Dewar

flask). Taking care not to touch the sides of the flask, insert the stack temperature sensor and reference thermometer into the slush to a depth of at least 50 mm (2 in.). Wait one minute or longer to achieve the thermal equilibrium and record temperatures. Obtain three readings taken at one minute intervals.

4.1.2 Boiling Point of Water

Fill a large Pyrex beaker with water to a depth of 100 mm (4 in.). Place several boiling chips in the water and bring the water to a full boil using a hot plate. Insert the stack temperature sensor(s) and reference thermometer in the boiling water to depth of at least 50 mm (2 in.), taking care not to touch the sides or bottom of the beaker. Attain thermal equilibrium. Obtain three readings at one minute intervals.

4.1.3 Third Point

For the third calibration point, a constant temperature should be selected depending on the full span of the temperature sensor. A liquid cooking oil that has a boiling point in the 203o-235oC (400o-450oF) or a muffle furnace may be used. Repeat the procedure as in Section 4.1.2.

4.2 Calculations

If the absolute temperature values of the reference thermometer being calibrated and the stack temperature sensors agree within 1.5 percent at each of the three calibration points, no correction is needed. Otherwise, plot the data on linear graph paper and draw the best fit line for the points or calculate the linear equation using the method of least squares. For the portion of the plot or equation that agrees within 1.5 percent of the absolute reference temperature, no correction is

necessary. For all other portions that do not agree within 1.5 percent, use the plot or equation to correct the data.

If the stack temperature sensor is to be used at temperatures higher than the reference thermometers will record, the stack temperature sensor may be calibrated against a thermocouple that is NBS traceable and previously calibrated following the procedure in Section 5.

4.3 Traceability and Acceptance Standards of Source Testing Instruments

See Table III-1.

4.4 Frequency of Calibration of Source Testing Instruments

See Table III-2.

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5. Stack Temperature Sensor-Thermocouple-Potentiometer System

This calibration is performed on a combination of thermocouple, lead wire, and potentiometer, all marked with an identification label. For field measurement always use the same combination. (Components must not be mixed.) Calibration must be performed initially and semiannually at multiple three points as described in Section 5.1 and extrapolated over the range of temperatures anticipated during actual sampling. A non-multiple three-point check must be performed bimonthly thereafter.

5.1 Calibration Test Procedure

Calibrations must be performed for at least three temperatures: the ice point, the boiling point of water, and a constant temperature in the 315-370°C (600-700°F) range. The last temperature may be attained by using a metal with a known melting point within the desired range, a muffle furnace in conjunction with an NBS traceable reference thermocouple-potentiometer, or calibration systems using other constant temperature calibration devices that span the range of use if they can be calibrated with a reference mercury-in-glass ASTM thermometer. Follow the calibration procedure described in Section 4.1 and record all data on a form similar to that shown in Figure III-16.

5.2 Calculations

If the absolute temperature measured with the stack temperature sensor being calibrated and the reference thermometer agree within 1.5 percent of the three calibration points, no correction is needed. If not, correct the temperature readings as described in Section 4.2.

5.3 Traceability and Acceptance Standards of Source Testing Instruments

See Table III-1.

5.4 Frequency of Calibration of Source Testing Instruments

See Table III-2.

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6. Barometer

The field barometer is adjusted initially and semiannually to within 2.54 mm (0.1 in.) Hg of the atmospheric pressure as indicated by a mercury-in-glass barometer or by the value reported by a nearby National Weather Service station corrected for elevation. The correction for elevation difference between the weather service station and sampling point should be applied at a rate of 2.5 mm (0.1 in.) Hg/30 m (100 ft.).

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7. Field Dry Gas Test Meter

The field dry gas test meter is calibrated before its initial use and semiannually thereafter. Its calibration is checked bimonthly. It is calibrated against a reference (secondary standard) wet test meter or reference dry gas test meter. The reference meter must be calibrated before its initial use, annually, and semiannually against an NBS traceable reference orifice, NBC Traceable Laminar Flow Element, NBS traceable bell prover or equivalent. The field dry gas meter to be calibrated and used as a reference (secondary) meter should be of high quality and have an appropriately sized capacity, e.g. 3 l/rev. (0.1 ft³/rev.).

7.1 Initial and Annual Calibration of a Reference Dry Gas Meter

7.1.1 Calibration Test Procedure Using an NBS Traceable Orifice or NBS Laminar Flow Element

Set up the equipment as shown in Figure III-17a. The pressure drop across the system should be minimized and not exceed 100 mm H₂O (4 in. H₂O) at a flow rate of 30 liter/min (1 cfm). This can be accomplished by using large diameter tubing connections and straight pipe fittings. Leak check the system at 100 mm (4in.) H₂O vacuum for 2 minutes. If a noticeable drop in vacuum occurs, correct the leak and rerun the check until no leaks occur.

Make triplicate runs at each of the flow rates and at no less than four different flow rates. Reach equilibrium before recording a flow rate. The flow rate should be approximately (\pm 10 percent) 5.0, 15.0, 20.0, and 30 liter/min, (0.2, 0.5, 0.75, and 1.0 cfm). Collect the data on a form similar to the one in Figure III-18.

7.1.2 Calculations

Calculate the orifice meter gas volume V_o , for each run using the flow rate Q , and the run time, θ . Calculate the reference dry gas meter coefficient (correction factor), Y_{rm} , for each run. Equations are as follows:

1. Orifice Meter Flow Rate

$$V_o = Q \cdot \theta$$

where:

V_o = Orifice meter volume, liters (ft^3) at 9°K ,
760 mm Hg. (520°R , 29.92 in. Hg.)

Q = Orifice meter flow rate, liters/min
(ft^3/min) at 289°K , 760 mm Hg. (520°R , 29.92
in. Hg.)

θ = Run time, min

2. Coefficient (Correction Factor)

$$Y_{rm} = \frac{V_o(T_{rm} + T_{std})P_{bar}}{V_{rm}(T_o + T_{std})(P_{bar} - P_{rm})}$$

where:

Y_{rm} = Reference dry gas meter coefficient
(correction factor), dimensionless

V_{rm} = Reference dry gas meter recorded volume,
liters (ft^3)

T_{rm} = Average reference dry gas meter temperature,
 $^\circ\text{C}$ ($^\circ\text{F}$), or temperature to which meter is
compensated

T_{std} = 273°C (460°F)

P_{bar} = Barometric pressure, mm Hg (in.Hg.), in. Hg.
= in. $\text{H}_2\text{O}/13.6$

T_o = Ambient temperature, $^\circ\text{C}$ ($^\circ\text{F}$)

P_{rm} = Average reference dry gas meter vacuum, mm
Hg (in. Hg.), in. Hg. = in. $\text{H}_2\text{O}/13.6$

Compare the three Y_{rm} values at each of the flow rates and determine the maximum and minimum values. The difference between the maximum and minimum values at each flow rate should be no greater than 0.010. Extra sets of triplicate runs may be made in order to meet this requirement. In addition, the meter coefficients must be between 0.95 and 1.05. If these

specifications cannot be met in three sets of successive triplicate runs the meter must not be used as a calibration standard. If these specifications are met, average the three Y_{rm} values at each flow rate resulting in four average meter coefficients, Y_{rm} .

Average the four Y_{rm} values to obtain an average coefficient (correction factor), Y_{rm} . The reference meter must not be used if the ratio Y_{rm}/Y_{rm} is not between 0.98 and 1.02. Show the calculated results on a form similar to the one in Figure III-19.

Whenever the reference dry gas meter is used, its flow rate will be multiplied by the Y_{rm} value to obtain a calibrated flow rate.

7.1.3 Calibration Test Procedure Using a Bell Prover

Use the setup recommended by the manufacturer of the bell prover. Make triplicate runs at each flow rate as described in Section 7.1.1. Meter must be accurate to within ± 2 percent of the bell prover.

7.2 Semiannual Calibration of a Reference Dry Gas Meter

Recalibrate the reference dry gas meter against the reference orifice, laminar flow element or bell prover semiannually. As an alternative to full (as described in Section 7.1) recalibration, a two-point calibration check may be made. This requirement is satisfactory provided the reference dry gas meter is kept in a laboratory, or if transported, is cared for

as a laboratory instrument. Abuse of the reference meter may change the calibration and will require more frequent recalibrations. Follow the procedure and equipment arrangement for a full calibration but run the meter at only two flow rates. The flow rates should be within ± 10 percent of 5 and 15 l/min (0.2 and 0.5 cfm). Calculate the meter coefficients for these two points and compare the values with the Y_{rm} value obtained in Section 7.1. If the two coefficients are within ± 1.5 percent at the same flow rates, the meter need not be recalibrated until the next date for a recalibration check.

7.3 Initial and Annual Calibration of a Reference Wet Test Meter

7.3.1 Calibration Test Procedure

Use any of the following methods at the flow rates indicated in Section 7.1.1:

1. Certification from the manufacturer that the wet test meter is within + 1 percent of true value at the wet test meter discharge, so that only a leak check of the system is then required.
2. Calibration by any primary air or liquid displacement method that displaces at least one complete revolution of the wet test meter.
3. Comparison against a smaller wet test meter that has previously been calibrated against a primary air or liquid displacement method, as described in Section 3.5.2 of "Quality Assurance handbook for Air Pollution Measurement Systems", Volume III, U.S. EPA-600/4-77-0276.

4. Comparison against a dry gas meter that has previously been calibrated against a primary air or liquid displacement method.

7.4 Semiannual Calibration of a Reference Wet Test Meter

7.4.1 Calibration Test Procedure

Use any of the methods in Section 7.3.1 at the flow rate indicated in Section 7.2.

7.5 Initial and Semiannual Calibration of a Field Dry Gas Test Meter

7.5.1 Calibration Test Procedure

Place the field dry gas test meter in the system shown in Figure III-17b. This field meter should be of the same high quality as the secondary standard and have an appropriate sized capacity, e.g. 3 liter/rev. (0.1 ft³/rev.). The pressure drop across the system should be minimized and not exceed 100 mm H₂O (4 in. H₂O) at a flow rate of 30 liter/min (1 cfm). This can be accomplished by using large diameter tubing connections and straight pipe fittings.

Leak check the system at 100 mm (4 in.) H₂O vacuum for 2 minutes. If a noticeable drop in vacuum occurs, correct the leak and rerun the check until no leaks occur.

Make triplicate runs at each of the flow rates and at no less than four different flow rates. The flow rates should be approximately (± 10 percent) 5.0, 15.0, 20.0, and 30 liter/min, (0.2,

0.5, 0.75, and 1.0 cfm). Collect the data on the form shown in Figure III-20.

7.5.2 Calculations

Calculate the field dry gas test meter coefficient (correction factor) Y_{fm} for each run using the following equation:

$$Y_{fm} = \frac{Y_{rm} Q_{rm} \left[\frac{T_{ref}}{T_{std} + \bar{T}_{rm}} \right] \left[\frac{P_{bar} + \bar{P}_{rm}}{29.92} \right]}{Q_{fm} \left[\frac{T_{ref}}{T_{std} + \bar{T}_{fm}} \right] \left[\frac{P_{bar} + \bar{P}_{fm}}{29.92} \right]}$$

where:

Y_{rm} = see Section 7.2.2

Q_{rm} = Reference dry gas meter flow rate, liter/min (ft³/min)

Q_{fm} = Field dry gas test meter flow rate, min (ft³/min)

T_{ref} = 289°K (520°F)

T_{std} = 273°K (46°F)

P_{bar} = Barometric pressure, mm Hg. (in. Hg.)

P_{rm} = Average reference dry gas meter pressure, mm Hg. (in. Hg.), in. Hg. = in. H₂O/13.6

P_{fm} = Field dry gas test meter average pressure, mm Hg. (in. Hg.), in. Hg. = in. H₂O/13.6

T_{rm} = Average reference dry gas meter temperature, °C (°F), temperature to which meter is compensated

T_{fm} = Average field dry gas meter temperature, °C (°F), or temperature to which meter is compensated

The value for $T_{ref}/(T_{std} + T_{rm})$ and $T_{ref}/(T_{std} + T_{fm})$ is 1 when using a temperature compensated dry gas meter. When the pump in Figure III-17b is located between the reference and field test meters, a vacuum gauge is used for each of the inlet and outlet of the reference dry gas test meter. The average vacuum is subtracted from the barometric pressure.

Compare the three Y_{fm} values at each of the flow rates and determine the maximum and minimum values. The difference between the maximum and minimum values at each flow rate would be no greater than 0.010. Extra sets of triplicate runs may be made in order to meet this requirement. In addition Y_{fm} values must be between 0.95 and 1.05. If these specifications cannot be met in three sets of successive triplicate runs, the field meter must not be used. If these specifications are met, average the three Y_{fm} values at each flow rate resulting in four average meter coefficients, Y_{fm} .

Average the four Y_{fm} values to obtain an average coefficient (correction factor), Y_{fm} . The field meter must not be used if the ratio Y_{fm}/Y_{fm} is not between 0.98 and 1.02. Show the calculated results on a form similar to the one in Figure III-21. The Y_{fm}

value will be multiplied by the measured field dry gas test meter flow rate to obtain its calibrated value.

7.6 Bimonthly Check of a Field Dry Gas Test Meter

The field dry gas test meter is checked against the reference dry test meter using the procedures of Section 7.3, except only two flow rates are used. The flow rates should within ± 10 percent be 15.0 and 20.0 l/min (0.5 cfm and 0.75 cfm). The meter calibration is considered valid if the meter coefficient = Y_{fm} calculated for the check agrees within ± 2 percent of that obtained during the previous semiannual calibration. If not, recalibrate the test meter following Section 7.3.

7.7 Traceability and Acceptance Standards of Source Testing Instruments

See Table III-1.

7.8 Frequency of Calibration of Source Testing Instruments

See Table III-1.

CHAPTER III

CALIBRATIONS

8. Turbine Meter

8.1 Semiannual Calibration Test Procedure

Calibrate the turbine meter using the same procedures in Section 7.5 with the following exceptions:

1. The turbine meter replaces the field dry gas test meter.
2. An NBS traceable reference orifice appropriate to the flow rate is used or a total volume displacement device is used as the secondary standard.
3. The meter is calibrated at 20, 40, 60, 80 percent of it's rated capacity. Obtain three runs. If the difference in flow rates between the turbine and secondary standard deviates by 2 percent or less at each flow rate, no correction is needed. Otherwise, plot the data on linear graph paper and draw the best fit line for the points or calculate the linear equation using the method of least squares. For the portion of the plot or equation that agrees within 2.0 percent of the absolute reference flow rate, no correction is necessary. For all other portions that do not agree within 2.0 percent, use the plot or equation to correct the data.

8.2 Annual Calibration Procedure

The turbine meter is calibrated against the secondary standard using the same calibration and acceptance procedures in Section 8.1, except run at flow rates of 10, 20, 30, 40, 50, 60, 70, 80, 90, and 100 percent.

CHAPTER III

CALIBRATIONS

9. Dry Gas Meter Orifice

Before its initial use in the field, and annually thereafter, the dry gas meter orifice must be calibrated according to the following procedure. This calibration can be performed during the calibration of the field dry gas test meter in Section 7.

Connect the orifice to the outlet of a calibrated reference (secondary) standard dry gas meter or a wet test meter. Refer to Figure III-22. The meter should have a capacity of 30 liter/rev. (1 ft³/rev.). A spirometer of 400 liters (14 ft³) or more capacity, or equivalent, may be used for this calibration, although a meter is usually more practical.

The meter should be periodically calibrated with a spirometer or a liquid positive displacement device to ensure the accuracy of the meter. Spirometers or meters of other sizes may be used, provided that the specified accuracies of the procedure are maintained.

Run the metering system pump for about 15 minutes with the orifice manometer indicating a median reading expected in field use to allow the pump to warm up. At a minimum of four orifice manometer settings pass an exact quantity of gas through the meter.

Select orifice settings that will give the flow rates listed in Figure III-23. Use a minimum volume of 140 liters (5 ft³) at all orifice settings. Note the inlet temperature of the dry gas meter, the outlet temperature of the dry gas meter, and orifice manometer readings. The measured $-H$ is acceptable if the four values obtained differ by no more than 3.9 mm H₂O (0.15 in. H₂O) from the average. Record all the data on a form similar to Figure III-23 and calculate

the orifice calibration factor ΔH_0 , at each orifice setting as shown in Figure III-23.

$$\Delta H_0 = (1186) \frac{\Delta H (T_{rm} + T_{std}) O^2}{P_{bar} (Y_{rm})^2 (A)^2 (V_m)^2}$$

where:

$$1186 = \frac{760 \text{ mm Hg}}{289 \text{ K}} (21.24 \text{ l})^2 \text{ or } 0.0324$$

$$= \frac{29.92 \text{ in. Hg}}{520^\circ\text{R}} (0.75 \text{ cfm})^2$$

ΔH = Pressure differential across the orifice meter, mm (in.) H_2O
at 20.0 l/min (0.75 scfm), 289°K (520°R) 760 mm (29.92 in.)Hg

T_{rm} = Average reference dry gas meter temperature, °C (°F)

T_{std} = 273°C (460°F)

O = Total sample time, min.

P_{bar} = Barometric pressure, mm Hg (in. Hg)

Y_m = Reference dry gas meter calibration factor, dimensionless,
obtained from Section 7.1.

A = 1, if meter is not temperature compensated

$$= \frac{(T_{rm} + T_{std})}{\text{Compensated temp.}}, \text{ if temperature compensated}$$

V_m = Volume of gas sample as measured by dry gas reference meter,
l (dcf)

CHAPTER III

CALIBRATIONS

10. Probe Nozzle

Probe nozzles should be calibrated before use in the field. Using a micrometer, measure the inside diameter of the nozzle to the nearest 0.025 mm (0.001 in.). Measure the diameter at three different locations and average the readings. The difference between the high and low numbers should not exceed 0.1 mm (0.004 in.). When nozzles become nicked, dented, or corroded, they should be reshaped, sharpened, and recalibrated before use. Each nozzle should be permanently and uniquely identified. Figure III-24 is an example of a nozzle calibration data form.

Chapter III text pages end at "Chapter III - 34"
and pagination resumes with tables and figures at "III - 51"

TABLE III-1
TRACEABILITY AND ACCEPTABLE STANDARDS OF SOURCE TESTING INSTRUMENTS

| Equipment | Traceability | Acceptable Standard |
|--|--|--|
| S-type Pitot Tube (Conical), (CFR40- 60-App. A, Meth. 2) | NBS Traceable or STD Pitot with Correction Factor of 0.99 ± 0.01 | ≤ 0.02 or Calibration Curve |
| Differential Pressure Gauge | Magnehelic Gauge, Inclined Manometer, Liquid in U-Tube Manometer | ± 5 percent of the Reading |
| Liquid in Glass Thermometer or Temperature Sensor | ASTM (NBS Traceable) Mercury in Glass Thermometer or Equivalent | ± 1.5 percent |
| Thermocouple- Potentiometer | ASTM (NBS Traceable) Mercury in Glass Thermometer or Equivalent | ± 1.5 percent |
| Aneroid Barometer | NBS Traceable Mercury Barometer | 2.54 mm Hg (0.1 in. Hg) |
| (Reference Standard) Dry Gas Meter | NBS Traceable Orifice Gauge or Bell Prover | ± 2 percent |
| Field Dry Gas Test Meter | (Reference Standard) Dry Gas Meter | ± 2 percent |
| Turbine Meter | NBS Traceable Orifice Gauge or Equivalent | ± 2 percent |
| Dry Gas Meter Orifice | Proper Construction | 3.8 mm H ₂ O (0.15 in. H ₂ O) |

TABLE III-2

FREQUENCY OF CALIBRATION OF SOURCE TESTING INSTRUMENTS

| Equipment | Frequency | Procedure |
|---|--------------------------------|---|
| S-Type Pitot Tube | Annual Calibrations (optional) | Measure the configuration multiple (3) points calibration or wind tunnel. |
| | Seminannual | Measure the Configuration. |
| | Reshape Pitot Tube | Measure the configuration and conduct multiple (3) point calibration if dimensions do not conform to Figures III-2 and III-3. |
| Standard Pitot Tube | Semiannual | Measure the configuration |
| Differential Pressure Gauge (Magnehelic) | Semiannual Calibration | Point leak check and triplicate runs over 5 points. |
| | Bimonthly Calibration | Point leak check and 1 run over 3 points. |
| Differential Pressure Gauge (Monometer) | Semiannual | Clean and replace fluid. |
| Liquid in Glass Thermometer or Temperature Sensor | Annual Calibration | Triplicate runs at each of 3 temperatures. |
| | Monthly Calibration | 1 run at each of 3 temperatures. |
| Thermocouple-Potentiometer | Semiannual Calibration | Triplicate runs at each of 3 temperatures. |
| | Bimonthly Calibration | 1 run at each of 3 temperatures. |
| Aneroid Barometer | Semiannually | Single point calibration 2.54 mm Hg. (0.10 Hg barometer). |

TABLE III-2 CONT.

| Equipment | Frequency | Procedure |
|---|--|---|
| (Reference Standard) Dry Gas Meter or Wet Meter | Annual Calibration | Triplicate runs at each of 4 flow rates (0.25-1.0 cfm). |
| | Semiannual Calibration | 2 point check. |
| Field Dry Gas Test Meter (use Secondary STD) | Semiannual Calibration | Triplicate runs at 4 flow rates (0.25-1.0 cfm). |
| | Bimonthly Calibration | 2 flow rates check. |
| | Check against dry gas meter orifice before and after every test. | |
| Turbine Meter | Semiannual Calibration | Triplicate runs at 4 flow rates. |
| | Annual Calibration | Triplicate runs at 10 flow rates. |
| Dry Gas Meter Orifice | Annual Calibration | H@ multiple (4) points calibration. |
| | Check against field dry gas meter before and after every test. | |

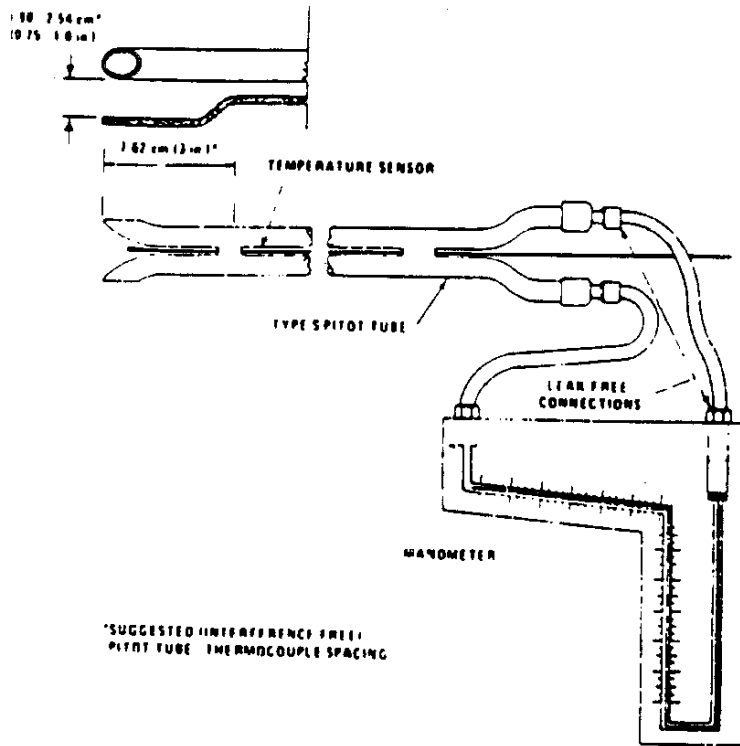
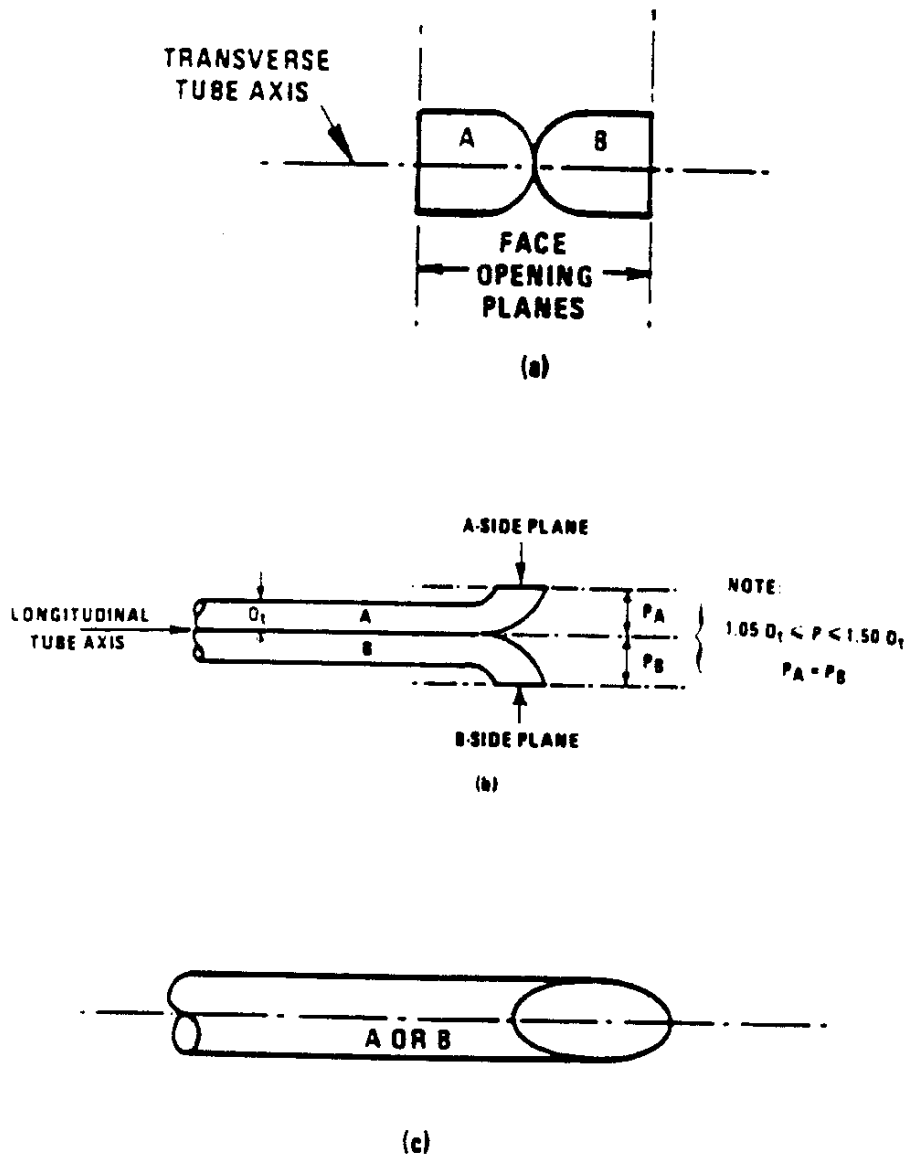
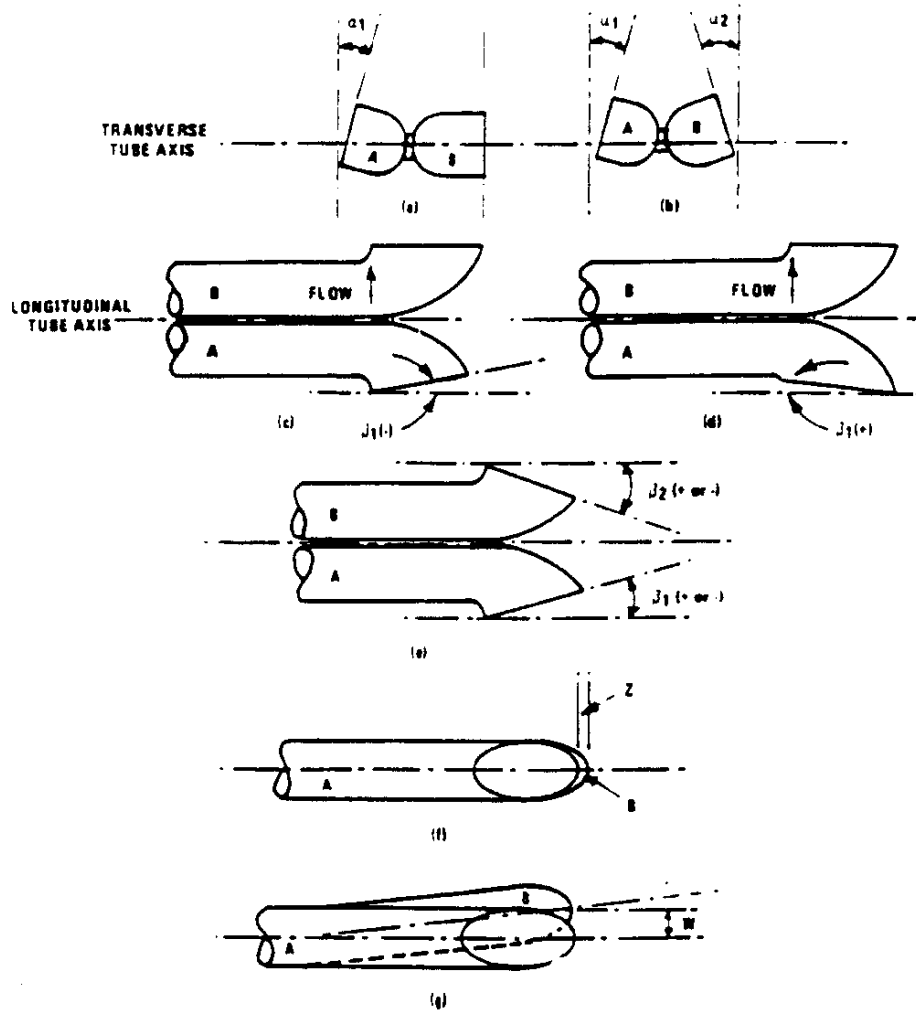


Figure III-1
Type S-Pitot tube Manometer Assembly



Properly constructed Type S pitot tube, shown in: (a) end view; face opening planes perpendicular to transverse axis; (b) top view; face opening planes parallel to longitudinal axis; (c) side view; both legs of equal length and centerlines coincident, when viewed from both sides. Baseline coefficient values of 0.84 may be assigned to pitot tubes constructed this way.

Figure III-2
 Proper Pitot Tube Configuration



Types of face-opening misalignment that can result from field use or improper construction of Type S pitot tubes. These will not affect the baseline value of $C_p(s)$ so long as α_1 and $\alpha_2 \leq 10^\circ$, β_1 and $\beta_2 \leq 5^\circ$, $z \leq 0.32$ cm (1/8 in.) and $w \leq 0.08$ cm (1/32 in.) (citation 11 in Section 6).

Figure III-3
Improper Pitot Tube Configuration

1. The tip is of hemispherical ellipsoidal, or conical design.
2. There is a minimum of six diameters straight run (based upon D_1 , the external diameter of the tube) between the tip and static pressure holes.
3. There is a minimum of eight diameters straight run between the static pressure holes and the centerline of the external tube, following the 90° bend.
4. The static pressure holes are of equal size (approximately $0.1 D$), equally spaced in a piezometer ring configuration.
5. It has a 90° bend, with curved or mitered junction. Repair, replace or return to the manufacturer any standard pitot tube which does not meet the above criteria.

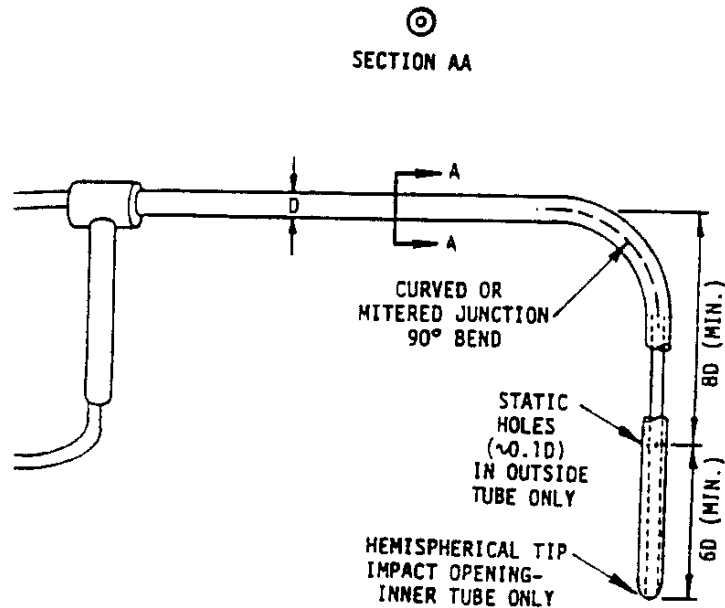


Figure III-4
Standard Pitot Tube Specification

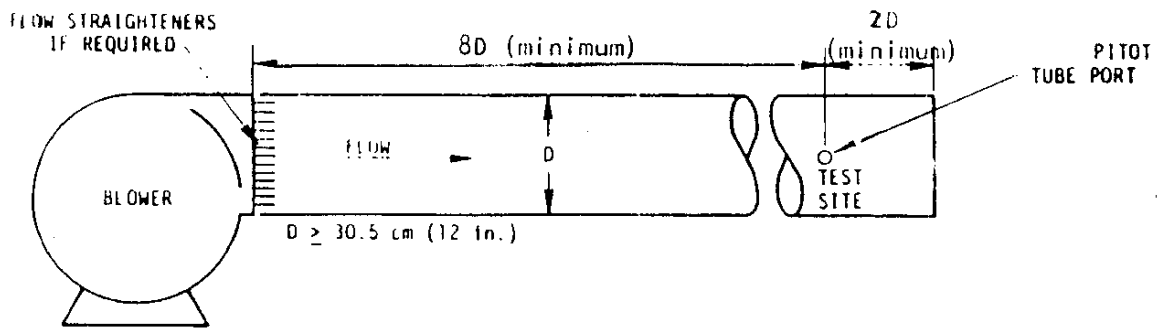


Figure III-5
Pitot Tube Calibration System

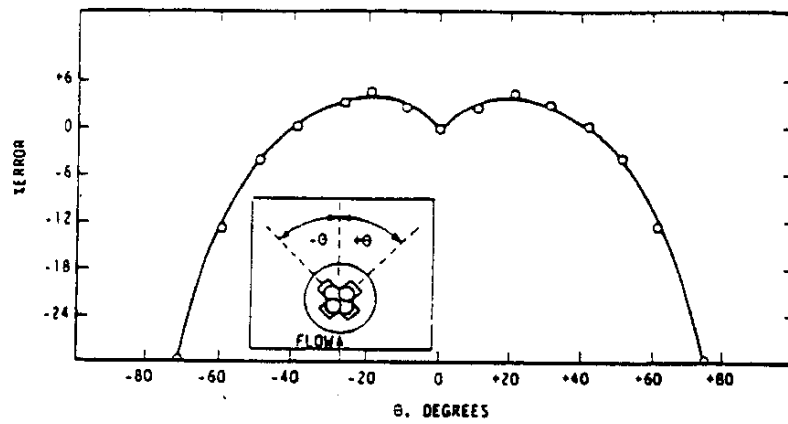


Figure III-6
 Example of error in measured stack gas velocity as a function
 of tube misalignment along its roll axis (yaw).

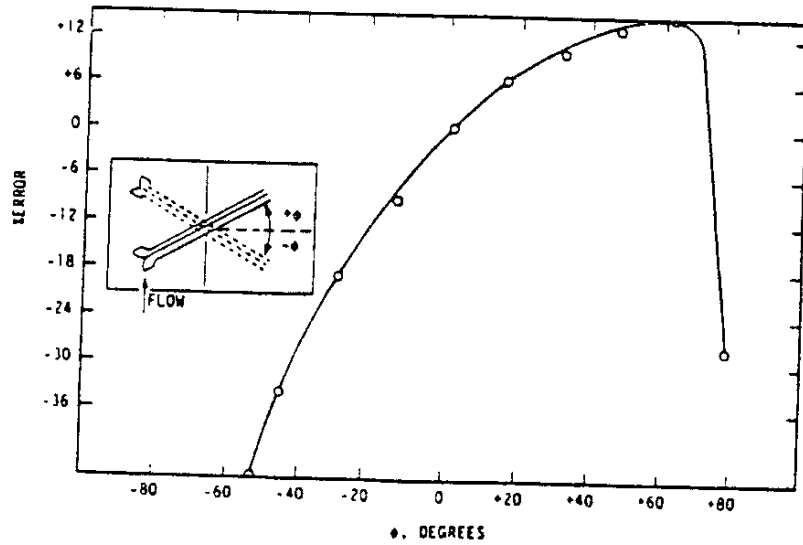


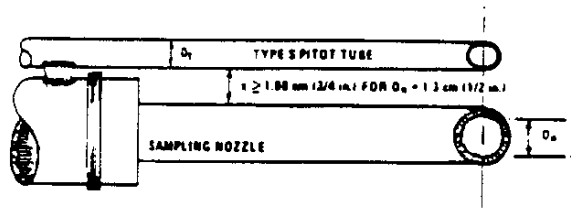
Figure III-7
 Example of error in measured stack gas velocity as a
 function of tube misalignment along its pitch axis.

DATA SHEET FOR CALIBRATION OF PITOT TUBES

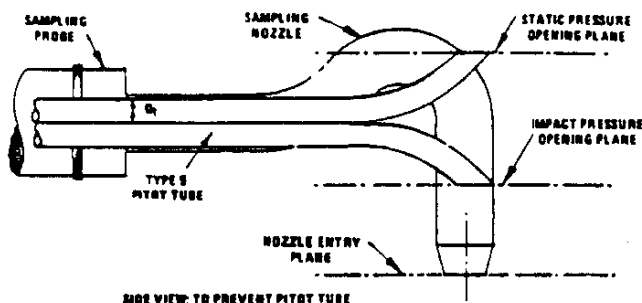
| RUN# | DATE | BY | S-Type Pitot Tube I.D. | Geo. Config. OK/NO | Side A/B | Std. (Ref.) Pitot Tube I.D. | Cal. Man. I.D. | Min. Leak Ck. | | S-Type ΔP (S) | Std. (Ref.) ΔP (Std) | C_p | $C_p - \bar{C}_p$ | Remarks | |
|------|------|----|------------------------------|--------------------------|-------------|-----------------------------------|-------------------|---------------|---|--------------------------|------------------------------------|-------|-------------------|---------|--|
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$$\alpha(A \text{ or } B) = \frac{\sum_{i=1}^3 [C_p - \bar{C}_p(A \text{ or } B)]}{3}$$

Figure III-8
 Example Data Sheet for Calibration of Pitot Tubes



A. BOTTOM VIEW SHOWING MINIMUM PITOT NOZZLE SEPARATION.

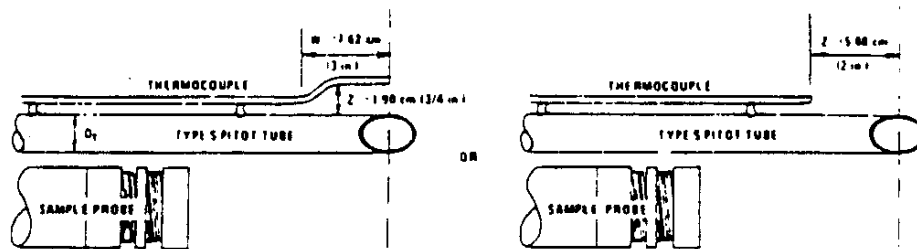


NOTE: TO PREVENT PITOT TUBE FROM INTERFERING WITH GAS FLOW STREAMLINES APPROACHING THE NOZZLE, THE IMPACT PRESSURE OPENING PLANE OF THE PITOT TUBE SHALL BE EVEN WITH OR ABOVE THE NOZZLE ENTRY PLANE.

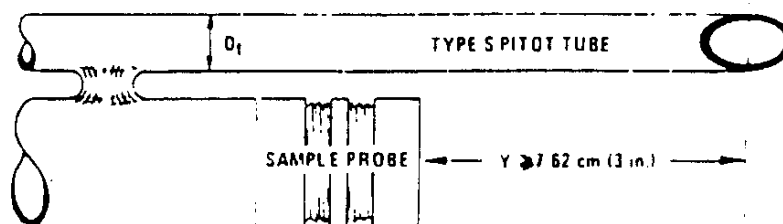
III-9

Proper Pitot Tube and Probe Configuration and Spacing

III-62

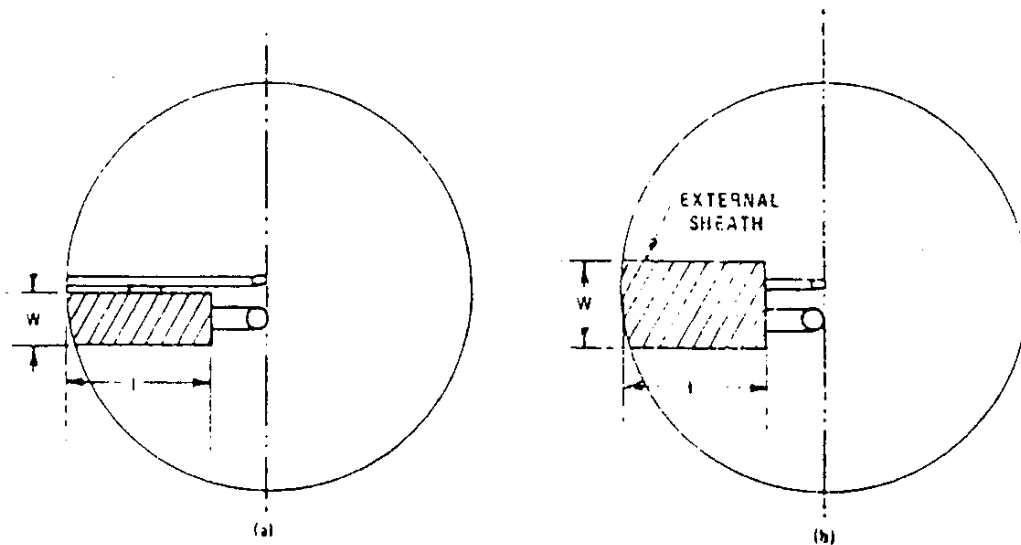


Proper thermocouple placement to prevent interference
 D_1 between 0.48 and 0.95 cm (3/16 and 3/8 in.)



Minimum pitot sample probe separation needed to prevent interference
 D_1 between 0.48 and 0.95 cm (3/16 and 3/8 in.)

Figure III-10
 Proper Thermocouple, Pitot Tube and Probe Placement



ESTIMATED
SHEATH
BLOCKAGE
(%) = $\left[\frac{l \times w}{\text{DUCT AREA}} \right] \times 100$

Figure III-11
Projected Area Models for Typical Pitot Tube Assemblies

DATA SHEET FOR MAGNETIC GAUGE
(>10 " H₂O) CALIBRATION WITH U-TUBE MANOMETER

Magnetic Gauge I.D.# _____
 Reference Gauge I.D.# _____

Date _____
 Calibrated by _____
 Calibration for:
 Semiannual _____
 Bimonthly _____
 Other _____

Full Scale of Magnetic Gauge _____ "H₂O

| System Leak Test (Pass-Fail) P or F: | | "H ₂ O Press. | | "H ₂ O Vac. | | | |
|--|---|--------------------------|---|------------------------|------------------------------------|--|-----------|
| Leak Test 90% P.S. (Pass-Fail) P or F: | | "H ₂ O Press. | | "H ₂ O Vac. | | | |
| Full Scale I | Magm. H ₁ in. H ₂ O | Refer. Column | | Sum | Differ. $\Delta H = H_1 - H_2'$ | Devic. 100% $\frac{\Delta H}{H_2'}$ I | Remarks** |
| | | L | R | $H_2 = L + R$ | | | |
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* 1.0 for H₂O and Oil Manometer
 13.55 for Hg Manometer

**Average Deviation .95% CI, Correction Factor (0.95 < F < 1.0) Precision (< +3%)

Figure III-12
 Example Data Sheet for Differential Pressure Gauge
 Calibration (English Units)

DATA SHEET FOR MAGNETIC GAGE
 (<10" H₂O) CALIBRATION WITH INCLINED MANOMETER

Magnetic Gauge I.D.# _____

Date _____

Reference Gauge I.D.# _____

Calibrated by _____

Calibration for:
 Semiannual _____

Bimonthly _____

Other _____

Full Scale of Magnetic Gauge _____ "H₂O

| System Leak Test (Pass-Fail) P or F: | | | 10" H ₂ O Press. | 10" H ₂ O Vac. | | |
|---|--|--|--------------------------------|--|--------------------------------------|-----------|
| Leak Test ~90% F.S. (Pass-Fail) P or F: | | | " H ₂ O Press. | " H ₂ O Vac. | | |
| Full Scale % ∇ | Magne. H ₁ in. H ₂ O | Standard H ₂ in. H ₂ O | $H_2^1 - H_2 \times$ P* | Differ. H = H ₂ - H ₁ | Deviation $100(H/H_2^1)$ % | Remarks** |
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* 1.0 in. for H₂O and Oil Manometer. 13.55 in. for Hg. Manometer
 ** Average Deviation, 95% CI. Correction Factor (0.95 F 1.05). Precision
 (± 3%)

Figure III-13
 Example Data Sheet for Differential Pressure Gauge
 Calibration (English Units)

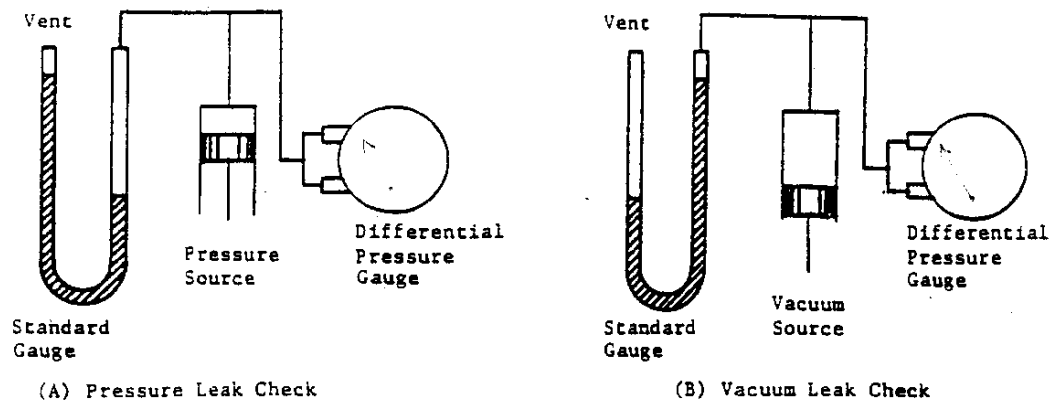
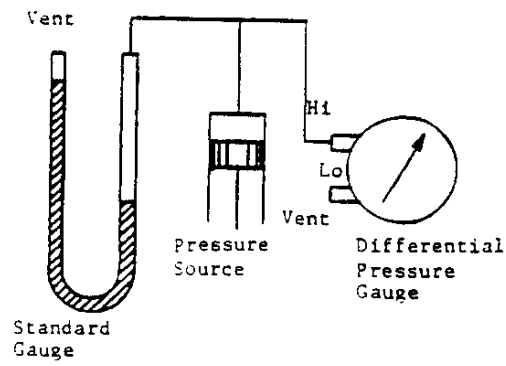
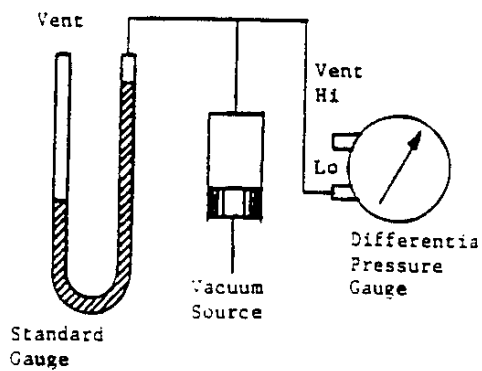


Figure III-14
 Differential Pressure Gauge Leak Check



(A) Pressure Point Test and Calibration



(B) Vacuum Point Test and Calibration

Figure III-15
 Differential Pressure Gauge Point Leak Check and Calibration Test

Calibration Data Form
Thermocouple-Potentiometer

Calibration
Semiannual _____
Bimonthly _____
Other _____
Date _____
Cal. By _____

Field Meter STQC# _____
Field Meter S/H _____
Ref. Indication S/H _____
Ref. Indication STQC# _____
Lead Wire STQC# _____

Temperature Source _____

| CH # | I. O. Number | | Temperature (°F) | | | | | | Average Temp., °F | | Δ°F C = B - A' | |
|-------|--------------|--------------|------------------|--------|---------|------------------|--------|---------|-------------------|-----------------------|-------------------|---|
| | Ref. Therm. | Temp. Sensor | Ref. Therm. (A) | | | Temp. Sensor (B) | | | A | Corrected Ref. | | B |
| | | | O Time | I Time | Average | O Time | I Time | Average | | A' = (A) (Corr Fctr.) | | |
| CH #1 | | | | | | | | | | | | |
| CH #2 | | | | | | | | | | | | |
| CH #1 | | | | | | | | | | | | |
| CH #2 | | | | | | | | | | | | |
| CH #1 | | | | | | | | | | | | |
| CH #2 | | | | | | | | | | | | |
| CH #1 | | | | | | | | | | | | |
| CH #2 | | | | | | | | | | | | |
| CH #1 | | | | | | | | | | | | |
| CH #2 | | | | | | | | | | | | |
| CH #1 | | | | | | | | | | | | |
| CH #2 | | | | | | | | | | | | |
| CH #1 | | | | | | | | | | | | |
| CH #2 | | | | | | | | | | | | |
| CH #1 | | | | | | | | | | | | |
| CH #2 | | | | | | | | | | | | |
| CH #1 | | | | | | | | | | | | |
| CH #2 | | | | | | | | | | | | |
| CH #1 | | | | | | | | | | | | |
| CH #2 | | | | | | | | | | | | |

Figure III-16
Calibration Data Form

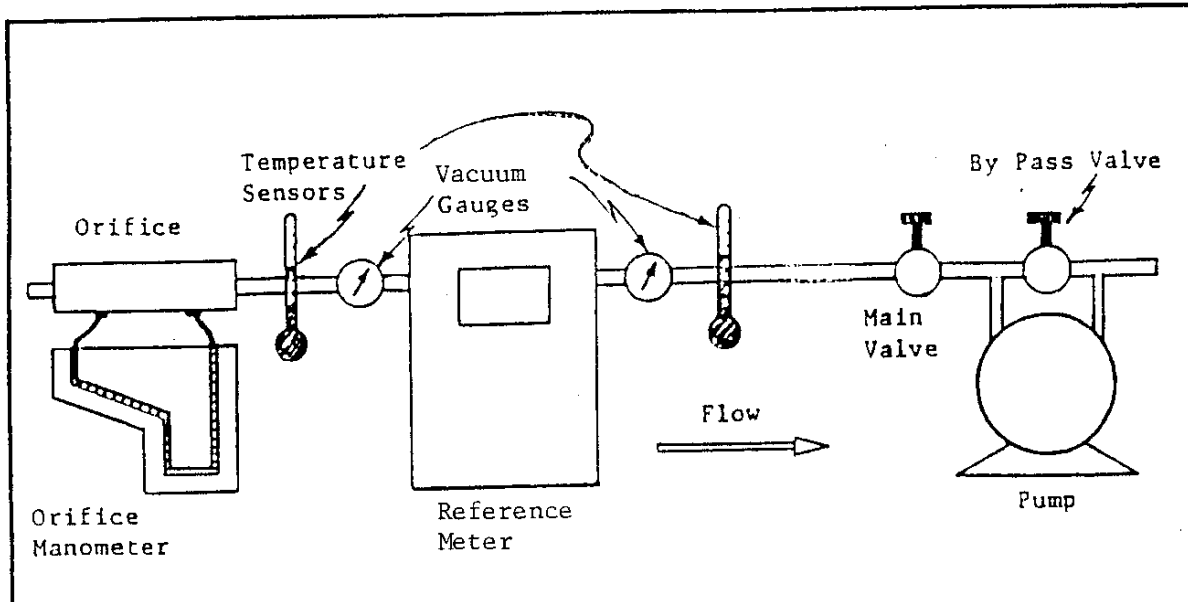


Figure III-17(a)
Reference Meter Calibration Setup

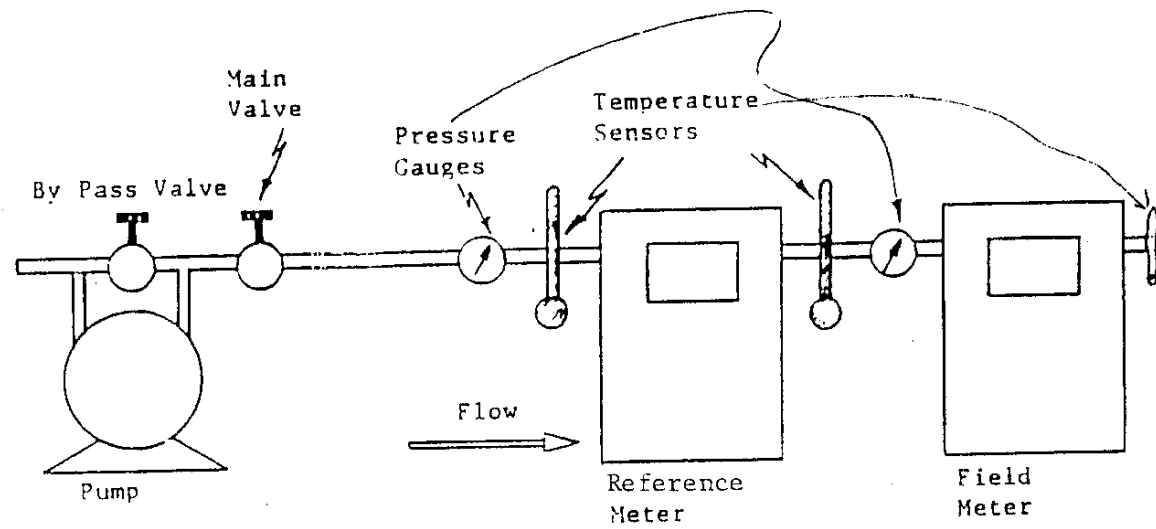


Figure III-17(b)
Field Dry Gas Test Meter Calibration Setup

SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT
DATA SHEET FOR REFERENCE DRY GAS METER CALIBRATION

ORIFICE IDENTIFICATION (S/N) _____
 DRY GAS METER IDENTIFICATION (S/N) _____
 DRY GAS METER IDENTIFICATION (STQC) _____
 BAROMETRIC PRESSURE (P_{bar}) _____
 AMBIENT TEMPERATURE _____
 LEAK CHECK _____

DATE: _____
 CALIB. BY: _____
 CALIBRATION FOR:
 ANNUAL _____
 SEMIANNUAL _____
 OTHER _____

| Approx CFM Project | Total CF | Orif. ΔP in H ₂ O | ORIFICE | | | | | REFERENCE DRY GAS METER | | | | | | | | | | |
|-----------------------|----------|---------------------------------|----------------------|--------------------------------|------------------|----------------------|-------------------------|-------------------------|----------------------|---|----------------------|----------------------|-------------------------|---------------------|--|--|--|--|
| | | | Temp. (°F) In/Out | Man. ΔP in H ₂ O | Flow Rate CFM | Time Min: Sec. | Elapse Time: Min. | Flow Rate CFM | Temp. (°F) In/Out | Vac. (in H ₂ O) In/Out | Meter Read. CF | Time Min: Sec. | Elapse Time: Min. | Flow Rate CFM | | | | |
| | | | Start | / | / | | | | | | | | | | | | | |
| | | | End | / | / | | | | | | | | | | | | | |
| | | | Avg. or Total | / | / | | | | | | | | | | | | | |
| | | | Start | / | / | | | | | | | | | | | | | |
| | | | End | / | / | | | | | | | | | | | | | |
| | | | Avg. or Total | / | / | | | | | | | | | | | | | |
| | | | Start | / | / | | | | | | | | | | | | | |
| | | | End | / | / | | | | | | | | | | | | | |
| | | | Avg. or Total | / | / | | | | | | | | | | | | | |
| | | | Start | / | / | | | | | | | | | | | | | |
| | | | End | / | / | | | | | | | | | | | | | |
| | | | Avg. or Total | / | / | | | | | | | | | | | | | |

Figure III-18
Data Sheet for Reference Dry Gas Meter Calibration

**SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT
REFERENCE DRY GAS METER COEFFICIENT CALCULATIONS**

BAROMETRIC PRESSURE

(P_{bar}) in. Hg _____ Set # _____ Date _____ STQC # _____ Calibration For: Annual _____
 AMBIENT TEMPERATURE _____ F Page # _____ Cal. by _____ I.D. # _____ Semiannual _____
 Other _____

| Flow Rate CFM | Run # | Reference Meter | | | Orifice | | | \bar{V}_{rm} (Max.) - \bar{V}_{rm} (Min) (≤ 0.010)* | Avg. Coeff. (\bar{V}_{rm}) | Avg. \bar{V}_{rm} Coeff. (\bar{V}_{rm}) | Avg. $\bar{V}_{rm}/\bar{V}_{rm}$ (± 0.02) |
|------------------|-------|--|--|-----------------------|--------------------------------|--------------------|---------------------------------------|--|--------------------------------------|--|---|
| | | Avg. Temp. T_{rm} ($^{\circ}F$) | Avg. Vac. ΔP (in. H ₂ O) | Flow Rate V_{rm} | Temp. T_o ($^{\circ}F$) | Flow Rate V_o | Coeff. V_{rm} (± 0.05)* | | | | |
| | 1 | | | | | | | | | | |
| | 2 | | | | | | | | | | |
| | 3 | | | | | | | | | | |
| | 1 | | | | | | | | | | |
| | 2 | | | | | | | | | | |
| | 3 | | | | | | | | | | |
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| | 3 | | | | | | | | | | |
| | 1 | | | | | | | | | | |
| | 2 | | | | | | | | | | |
| | 3 | | | | | | | | | | |

*CRITERIA MUST BE SATISFIED BEFORE CALCULATING \bar{V}_{rm} AND \bar{V}_{rm}

Figure III-19
Reference Dry Gas Meter Coefficient Calculations

SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT
DATA SHEET FOR FIELD DRY GAS TEST METER CALIBRATION

REFERENCE IDENTIFICATION (S/N) _____
 DRY GAS METER IDENTIFICATION (S/N) _____
 DRY GAS METER IDENTIFICATION (STQC) _____
 BAROMETRIC PRESSURE (P_{bar}) _____
 AMBIENT TEMPERATURE _____

DATE: _____
 CALIB. BY: _____
 CALIBRATION FOR:
 SEMIANNUAL _____
 BIMONTHLY _____
 OTHER _____

| Total CF | | REFERENCE DRY GAS METER | | | | | | FIELD DRY GAS TEST METER | | | | | |
|---------------------|---------------|-------------------------|---|--|----------------|-------------------|---------------|--------------------------|----------------------------|----------------|----------------|-------------------|---------------|
| | | Temp. (°F) In/Out | | | Time Min: Sec. | EIapse Time: Min. | Flow Rate CFM | Temp. (°F) In/Out | in H ₂ O In/Out | METER READ. CF | Time Min: Sec. | EIapse Time: Min. | Flow Rate CFM |
| Approx. CFM Project | Start | / | / | | | | | / | / | | | | |
| | End | / | / | | | | | / | / | | | | |
| | Avg. or Total | | | | | | | | | | | | |
| | Start | / | / | | | | | / | / | | | | |
| | End | / | / | | | | | / | / | | | | |
| | Avg. or Total | | | | | | | | | | | | |
| | Start | / | / | | | | | / | / | | | | |
| | End | / | / | | | | | / | / | | | | |
| | Avg. or Total | | | | | | | | | | | | |
| | Start | / | / | | | | | / | / | | | | |
| | End | / | / | | | | | / | / | | | | |
| | Avg. or Total | | | | | | | | | | | | |
| | Start | / | / | | | | | / | / | | | | |
| | End | / | / | | | | | / | / | | | | |
| | Avg. or Total | | | | | | | | | | | | |
| | Start | / | / | | | | | / | / | | | | |
| | End | / | / | | | | | / | / | | | | |
| | Avg. or Total | | | | | | | | | | | | |

Figure III-20
Data Sheet for Field Dry Gas Test Meter Calibration

SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT
FIELD DRY GAS TEST METER COEFFICIENT CALCULATIONS

BAROMETRIC PRESSURE

(P_{bar}) in. Hg _____ Set # _____ Date _____

AMBIENT TEMPERATURE _____

Page # _____ Calibrated by _____

CALIBRATION FOR:

Semiannual _____
 Bimonthly _____
 Other _____

| Approx. Flow Rate (Q) cfm | Reference Dry Gas Meter ID # _____ | | Correction Factor | | 1. For Non Temperature Compensated Dry Gas Meter: $Q'_{rm} = Q'_{rm} \left(\frac{320}{460 + \bar{T}} \right) \left(\frac{P_{bar} + \frac{\bar{P}}{13.6}}{29.97} \right)$ or $Q'_{fm} = Q'_{fm}$ | 2. For Temperature Compensated Dry Gas Meter: $Q'_{fm} = Q'_{fm} \left(\frac{P_{bar} + \frac{\bar{P}}{13.6}}{29.92} \right)$ | 3. $Y_{fm} = \frac{Q'_{rm}}{Q'_{fm}}$ | * CRITERIA MUST BE SATISFIED BEFORE CALCULATING \bar{V}_{fm} AND \bar{Y}_{fm} |
|---------------------------|------------------------------------|--|---|--|--|--|---------------------------------------|---|
| | Flow Rate Q _{rm} cfm | Average Meter Temperature (\bar{T}) °F | Pressure (\bar{P}) in. H ₂ O | Corr. Flow Rate (Q' _{rm}) scfm | | | | |
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| Approx. Flow Rate (Q) cfm | Field Dry Gas Test Meter ID # _____ | | STQC # _____ | Overall Avg. \bar{V}_{fm} _____ | | Correction Factor | | | | |
|---------------------------|-------------------------------------|----------------------------------|--------------|-----------------------------------|--|---|--|--------------------------------|----------------|--|
| | Flow Rate cfm | Average Meter Temperature (T) °F | | Pressure (P) in. H ₂ O | Corr. Flow Rate (Q' _{fm}) scfm | Coefficient Y _{fm} < (1 ± 0.05)* | $\frac{V_{ds} \text{ max.}}{V_{ds} \text{ min.}} \leq 0.010^*$ | Avg. Coeff. (\bar{V}_{fm}) | \bar{V}_{fm} | Avg. $\bar{Y}_{fm}/\bar{V}_{fm}$ (±0.02) |
| | | | | | | | | | | |
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Figure III-21
Field Dry Gas Test Meter Coefficient Calculations

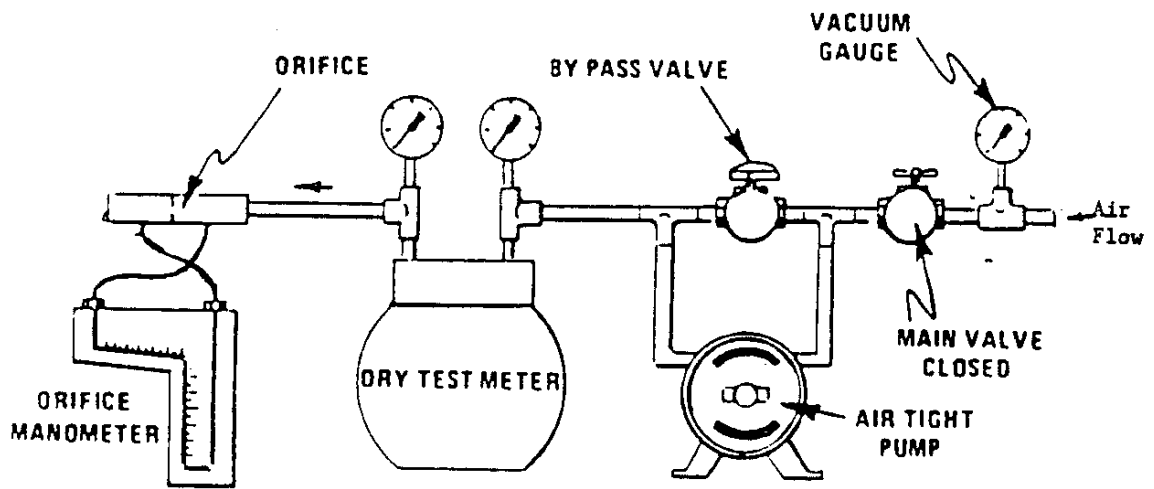


Figure III-22
Dry Gas Meter Orifice Calibration Setup

Orifice Calibration Data and Calculation Form

DATE _____

ORIFICE # _____

BAREMETRIC PRESSURE, P_{bar} = _____ in.Hg CALIBRATED BY _____

| Q (CFM) | Orifice Manometer Setting (ΔH) in. H ₂ O | Volume | Temperature | | | Time (θ), min | $\Delta H \theta_i^{**}$ in. H ₂ O |
|---------|---|------------------------------|---------------------|----------------------|---------------------|------------------------|---|
| | | Dry Gas Meter (V_m), dcf | Dry Gas Meter | | | | |
| | | | Inlet (t_{OP}), | Outlet (t_{OP}), | Avg.* (t_{OP}), | | |
| 0.25 | | | | | | | |
| 0.50 | | | | | | | |
| 0.75 | | | | | | | |
| 1.00 | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | Avg. | |

| Q (CFM) | ΔH in. H ₂ O | $\Delta H \theta_i = \frac{0.319 \times t_m \times \Delta H}{P_{bar}} \left[\frac{\theta}{Y \times V \times A} \right]^2$ |
|---------|---------------------------------|--|
| 0.25 | | |
| 0.50 | | |
| 0.75 | | |
| 1.00 | | |
| | | |
| | | |

*If there is only one thermometer on the dry gas meter, record temperature under T_m .

**Acceptable if the four values obtained differ by no more than 3.0 mm H₂O (0.15 in. H₂O) from the average.

Figure III-23

Orifice Calibration Data and Calibration Form (English Units)

Nozzle Calibration

Date _____

Calibrated by _____

| Nozzle identification number | D_1 , mm (in.) | D_2 , mm (in.) | D_3 , mm (in.) | ΔD , mm (in.) | D_{avg} |
|------------------------------------|---------------------|---------------------|---------------------|--------------------------|-----------|
| | | | | | |

where

- $D_{1,2,3}$ = nozzle diameter measured on a different diameter, mm (in.). Tolerance = measure within 0.25 mm (0.001.)
- Δ = maximum difference in any two measurements, mm (in.). Tolerance = 0.1 mm (0.004 in.)
- D_{avg} = average of D_1 , D_2 , D_3 .

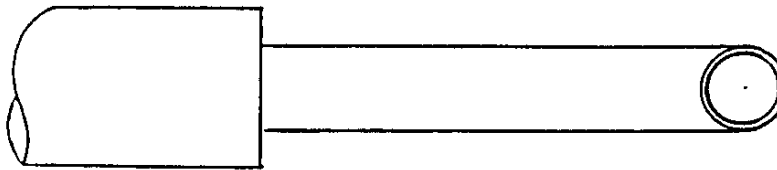


Figure III-24
Nozzle Calibration Data Sheet