STANDARD

ANSI/AMCA Standard 610-19

Laboratory Methods of Testing Airflow Measurement Stations for Performance Rating

An American National Standard
Approved by ANSI on April 9, 2019

Air Movement and Control Association International

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AMCA Standard

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Laboratory Methods of Testing
Airflow Measurement Stations for Performance Rating

1. Purpose and Scope

This standard covers field-installed airflow measurement stations for heating, ventilating and air-conditioning applications.

This standard establishes uniform test methods for the determination of the performance characteristics and accuracy of airflow measurement stations under varied airflow rates and conditions.

It is not the purpose of this standard to specify testing procedures to be used for design, production or in-field measurement practice.

Only tests that do not violate the mandatory requirements of this standard shall be designated as tests conducted in accordance with this standard.

2. Normative References

The following standards contain provisions that, through specific reference in this text, constitute provisions of AMCA Standard 610 At the time of publication, the editions indicated were valid. All standards are subject to periodic revision, and parties to agreements based on this American National Standard are encouraged to investigate the possibility of applying the most recent editions of the standard(s) listed below.

ANSI/AMCA Standard 99, Standards Handbook, Air Movement and Control Association International, Inc., 30 West University Drive, Arlington Heights, IL, 60004-1893, U.S.A.
ANSI/AMCA Standard 210, Laboratory Methods of Testing Fans for Certified Aerodynamic Performance Rating, Air Movement and Control Association International, Inc., 30 West University Drive, Arlington Heights, IL, 60004-1893, U.S.A.
ANSI/AMCA Standard 500-D, Laboratory Methods of Testing Dampers for Rating, Air Movement and Control Association International, Inc., 30 West University Drive, Arlington Heights, IL, 60004-1893, U.S.A.
SMACNA HVAC Systems Duct Design, 3rd edition. SMACNA HVAC Systems Duct Design, 3rd edition, Sheet Metal and Air Conditioning Contractors' National Association, Inc., 4201 Lafayette Center Drive, Chantilly, VA, 20151-1219, U.S.A.

3. Definitions/Units of Measure/Symbols

3.1 Definitions

3.1.1 Airflow Measurement Station (AMS)
A single- or multiple-point sensing device used to measure the airflow rate in a duct system or fan appurtenance. It may consist of a single sensor or an array of sensors in permanent position in the air system. It may be supplied as a probe to be inserted into a ductwork or in a casing approximating the size of the air system in which it is installed.

3.1.2 AMS — Differential (velocity) pressure output type
A type of AMS that converts air velocity into a differential (velocity) pressure signal that correlates to the velocity or volume of air flowing through a duct.

3.1.3 AMS — Electronic output type
A type of AMS that converts air velocity into an electronic signal that correlates directly and proportionately to the air volume flowing through a duct.

3.1.4 Test reference airflow rate
The calculated airflow rate at a measurement plane.

3.1.5 AMS performance variables

3.1.5.1 AMS airflow rate
The airflow rate, based on the output (pressure, current or voltage of the AMS under test), calculated according to the manufacturer's instructions.

3.1.5.2 AMS differential pressure
The observed differential pressure between the high-pressure output and the low-pressure output of a differential-pressure-type AMS.

3.1.5.3 AMS electronic output
The observed voltage or current output of an electronic output type AMS that correlates directly and proportionately to the velocity of airflow in a duct.

3.1.5.4 AMS face area
The total cross-sectional area of a damper, louver, filter, heat exchanger AMS or silencer.

3.1.5.5 AMS free area
The unobstructed area through the AMS if different from the AMS face area.

3.1.6 Shall and should
The word "shall" is to be understood as mandatory and the word "should" as advisory.

3.1.7 Point of operation
The relative position on the AMS input vs. output curve corresponding to a particular airflow rate. It is controlled during a test by adjusting the position of the throttling device, changing the nozzles or auxiliary fan characteristics or any combination of these.

3.1.8 Determination
A complete set of measurements at the AMS under test and the reference airflow system for one operational airflow test rate. The measurements must be sufficient to determine all applicable AMS performance variables as defined in Section 3.1.5.

3.1.9 Test
A series of determinations, one for each of the six AMS airflow test rates.

3.2 Units of measure

3.2.1 System of units
SI units (from the International System of Units — *Le Systéme International d'Unités*) are the primary units employed in this standard with I-P units (from the Imperial System) given as the secondary reference. SI units are based on the fundamental values of the International Bureau of Weights and Measures, and I-P units are based on the values of the National Institute of Standards and Technology which are, in turn, based on the values of the International Bureau. Conversion factors between SI and I-P systems are given in ANSI/AMCA Standard 99.

3.2.2 Basic units
The SI unit of length is the meter (M or the millimeter (mm); the I-P unit of length is the foot (ft) or the inch (in.). The SI unit of mass is the kilogram (kg); the I-P unit of mass is the pound mass (lbm). The unit of time is either the minute (min) or the second (s). The SI unit of temperature is the Kelvin (K) or degree Celsius (°C); the I-P unit of temperature is the degree Fahrenheit (°F) or the degree Rankine (°R). The SI unit of force is the newton (N); the I-P unit of force is the pound-force (lbf).

3.2.3 Airflow rate and velocity
The SI unit of airflow is cubic meters per second (m^3/s); the I-P unit is cubic feet per minute (ft^3/min or cfm). The SI unit of velocity is meters per second (m/s); the I-P unit is feet per minute (ft/min or fpm).

3.2.4 Pressure
The SI unit of pressure is the pascal (Pa). The I-P unit of pressure is the inch water gauge (in. wg) or the inch mercury (in. Hg). Values in mm Hg or in. Hg shall be used only for barometric pressure measurements. The in. wg shall be based on a

1-in. column of distilled water at 68°F under standard gravity and a gas column balancing effect based on standard air. The in. Hg shall be based on a 1-in. column of mercury at 32°F under standard gravity in a vacuum. The mm Hg shall be based on a 1-mm column of mercury at 0°C under standard gravity in a vacuum.

3.2.5 Power, energy and torque

The SI unit of power is the watt (W); the I-P unit is horsepower (hp). The SI unit of energy is the joule (J); the I-P unit is the foot pound-force (ft•lbf). The SI unit of torque is the newton-meter (N-m); the I-P unit is the pound-force inch (lbf-in.).

3.2.6 Efficiency

Efficiency is established on a per-unit basis. Percentages are obtained by multiplying by 100.

3.2.7 Rotational speed

Both the SI and I-P units of rotational speed are measured in revolutions per minute (rpm).

3.2.8 Density, viscosity and gas constant

The SI unit of density is the kilogram per cubic meter (kg/m^3); the I-P unit is the pound-mass per cubic foot (lbm/ft^3). The SI unit of viscosity is the pascal second (Pa-s); the I-P unit is the pound-mass per foot-second (lbm/ft-s). The SI unit of gas constant is the joule per kilogram kelvin (J/(kg-K)); the I-P unit is the foot pound-force per pound-mass degree Rankine ((ft-lb)/(lbm-°R)).

3.2.9 Dimensionless groups

Various dimensionless quantities appear in the text. Any consistent system of units may be employed to evaluate these quantities unless a numerical factor is included, in which case units must be as specified.

3.3 Symbols and subscripts

Table 1 — Symbols and Subscripts

Symbol	Description	SI	I-P
A_{face}	Area (cross section) of AMS under test	m^2	ft^2
D	Inside diameter of a circular cross-section of duct	m	ft
D_e	Equivalent duct diameter for square ducts	m	ft
I_{ams}	Output signal of AMS under test	mAdc	mAdc
M	Equivalent chamber diameter	m	ft
ΔP	Pressure differential	Pa	in. wg
ΔP_{ams}	Output signal of AMS under test, pressure differential (velocity pressure)	Pa	in. wg
p_b	Barometric pressure, corrected	Pa	in. Hg
P_s	Static pressure	Pa	in. wg
Q	Airflow rate	m^3/s	ft^3/min
Q_{ref}	Reference airflow delivered to Plane x	m^3/s	ft^3/min
t_d	Dry-bulb temperature	°C	°F
t_w	Wet-bulb temperature	°C	°F
X_{ams}	AMS under test, area conversion factor for airflow rate	m^2	ft^2
V_{ams}	Output signal of AMS under test	Volts DC	Volts DC
ρ	Air density	kg/m^3	lbm/ft^3

Subscript	Description
x	Plane 0, 1, 2, … as appropriate
1	Plane 1 (AMS inlet)

2	Plane 2 (AMS outlet)
4	Plane 4 (nozzle inlet station in duct)
5	Plane 5 (nozzle inlet station in chamber)
9	Plane 9 (test duct)

4. Instruments

Instruments for the airflow test chamber shall comply fully with the requirements given in ANSI/AMCA Standard 210.

4.1 Electronic indicating manometer

An electronic indicating manometer is an instrument used for measurement and digital indication of differential pressure, capable of receiving a differential pressure signal and displaying output in units of pressure. The device shall have a calibrated reading accuracy of ±0.05% and a resolution of 0.1 Pa (0.005 in. wg).

4.1.1 Calibration

Where an electronic indicating manometer is used in conjunction with a differential (velocity) pressure output type AMS, the manometer must be zero-adjusted at the start and finish of each series of airflow measurements. An electronic indicating manometer equipped with an automatic zeroing feature is not exempt from this requirement.

4.2 Digital multimeter (DMM)

A DMM, when used, shall be capable of measuring the quantity of voltage and/or current in direct current (DC) applications. The device's functions shall include DC volts and DC amps. The DMM shall be at least 4.5 digits and have a reading accuracy of 0.05%.

An electronic data acquisition may be used to record test readings, provided it conforms to IEEE 488 or RS-232 digital interface and the input resolution of the interface (A/D converter accuracy) be at least (±0.03% of reading, +1 count), equating to the 4.5 digit DMM resolution and the output accuracy of the other instrumentation required in this section.

5. Equipment and Setup

5.1 General

The test setup shall consist of:

1. A supply or exhaust air system, per Section 5.3.
2. Ductwork and any prescribed fittings.
3. The AMS under test.
4. Instruments' verification of the condition of supply air temperature, pressure and, when applicable, manometers or similar devices to translate the signal of the AMS under test into an observable value.

Test setups are shown in figures 1 through 5.

5.2 Leakage

The ducts, chambers and other equipment utilized should be designed to withstand the pressure and other forces to be encountered. All joints between the AMS and the nozzle measurement plane should be designed for minimum leakage because no leakage correction is permitted.

5.3 Air supply/exhaust

The air supply shall be sufficient to meet the test parameters given in Section 6. The supply air shall be delivered from a test chamber or can be ducted meeting the requirements of ANSI/AMCA Standard 210.

The supply airflow rate at the nozzle inlet shall be calculated using ANSI/AMCA Standard 210, figures 8, 9, 11, 12, 14 or 15. The reference airflow rate at the AMS under test shall be calculated using the air density at Plane 1.

5.4 Duct(s)

The ducts shown in the test setup figures are used to simulate the conditions the AMS is expected to encounter in a field application or provide a measurement location. The dimension, *D*, in the test setup figures is the inside diameter of a circular cross-section duct or the equivalent diameter, D_e, of a rectangular cross-section duct having inside traverse dimensions, *a* and *b*, where:

$$D_e = \sqrt{4ab/\pi}$$

5.5 Fittings

For rectangular ducts, the 90° elbow shall be mitered, have single-thickness turning vanes (R = 2.0) and conform to SMACNA HVAC Systems Duct Design, Table 14-10H, p.14.22. For round ducts, the 90° elbow shall be a smooth radius (die stamped) or five-piece elbow without turning vanes (R/D = 2.0) and conform to SMACNA HVAC Systems Duct Design, Table 14-10A or 14-10B, p.14.19.

5.6 AMS under test

The AMS under test shall be complete with all associated instrumentation that is to undergo the test and be listed on the test record under “test subject.”

6. Observations and Conduct of Test

Each AMS shall be tested in one or more of the test setups (figures 1, 2, 3, 4 and 5) that simulate conditions encountered in field installations and applications (see Section 5). The airflow rate through the AMS is measured according to Section 5.3.

6.1 General requirements

Where applicable, these requirements shall be met when performing the specific test procedures that follow.

6.1.1 Stability of conditions

For the duration of the test, temperature at the AMS under test shall be held within ±3°C (6°F).

6.1.2 Test airflow rates

The airflow rate through the test setup shall be varied to approximate the airflow rates at six equally spaced points across the airflow range of interest.

6.2 Data to be recorded

6.2.1 Test subject

The description of the AMS under test, including its physical size, shall be recorded. The nameplate data shall be copied.

6.2.2 Test setup

The description of the test setup shall be recorded by reference to the figure in this standard that served as the configuration for the test.

6.2.3 Instruments

The instruments and apparatus that are required by this standard and used in the test shall be listed. Names, model numbers, scale ranges and calibration information shall be recorded.

6.2.4 Test data

Test data for each determination shall be recorded. Readings shall be made simultaneously whenever possible.

6.2.4.1 All tests

For all tests, three readings of dry-bulb temperature (t_{d0}), ambient wet-bulb temperature (t_{w0}) and ambient barometric pressure (p_b) shall be recorded unless the readings are steady, in which case only one set is required to be recorded.

6.2.4.2 Chamber test
For a chamber test, one reading each of pressure drop (ΔP), approach dry-bulb temperature (t_{d5}) and approach static pressure (P_{s5}) shall be recorded. See ANSI/AMCA Standard 210.

6.2.4.3 Ducted nozzle test
One reading each of pressure drop (ΔP), approach dry-bulb temperature (t_{d4}) and approach static pressure (P_{s4}) shall be recorded. See ANSI/AMCA Standard 210.

6.2.4.4 Test duct or chamber
For figures 1, 2 or 3, one reading each of the inlet dry-bulb temperature (t_{d9}) and inlet static pressure (P_{s9}) shall be recorded.

For Figure 5, one reading each of the inlet dry-bulb temperature (t_{d8}) and inlet static pressure (P_{s8}) shall be recorded.

6.2.4.5 Low pressure test
For a test where P_{sx} is less than 1,000 Pa (4 in. wg), the temperatures may be considered uniform throughout the test setup, and only dry-bulb temperature (t_{d0}) and wet-bulb temperature (t_{w0}) shall be recorded.

6.2.5 AMS output
Record the output data from the AMS under test, be it ΔP_{ams}, V_{ams}, I_{ams} or digital display.

6.3 Airflow resistance test

A test to determine the relationship to the test airflow rate and the resistance to airflow induced by the AMS shall consist of pressure drop determinations taken at each of the specified airflow test rates using the test setup in figures 1, 2, 3, 4 or 5. The determinations shall be made according to the provisions of ANSI/AMCA Standard 500-D.

7. Calculations

7.1 Calibration correction

A calibration correction, when required, shall be applied to each applicable individual reading before averaging or other calculations. A calibration correction need not be applied if the correction is smaller than half of the maximum allowable uncertainty as specified in this or another applicable test standard.

7.2 Air density in duct or chamber

The air density at the AMS inlet shall be calculated by correcting the density of atmospheric air (ρ_0) for the static pressure (P_{s1}) and the dry-bulb temperature (t_{d1}) at Plane 1 using:

$$\rho_1 = \rho_0 \frac{(t_{d0}+273.15)/(t_{d1}+273.15)}{(P_{s1}+p_b)/p_b} \qquad \text{Eq. 7.2 SI}$$

$$\rho_1 = \rho_0 \frac{(t_{d0}+459.67)/(t_{d1}+459.67)}{(P_{s1}+13.63p_b)/13.63p_b} \qquad \text{Eq. 7.2 I-P}$$

7.3 Airflow rate at test conditions

7.3.1 Test reference airflow rate
The AMS airflow rate at test conditions (Q) shall be obtained from the equation of continuity:

Chamber test:	Q_1	=	$Q_5\,(\rho_5/\rho_1)$
Ducted nozzle test:	Q_1	=	$Q_4\,(\rho_4/\rho_1)$
Where:	Q_{ref}	=	Q_1

7.3.2 Airflow rate of unit under test

The airflow rate of the unit under test (Q_{ams}) shall be determined by measuring the output of the unit (pressure, current or voltage) and using the output in an equation supplied by the manufacturer.

8. Report and Results of Test

8.1 Report

The report of a laboratory test of an AMS unit shall include the following information:

- All items required to be recorded under Section 6.2
- Any AMS options or appurtenances included
- The equations used to calculate Q_{ams}
- The personnel conducting the test
- A test identification number
- The test date
- The laboratory name and location

For each setup tested, a summary sheet shall be prepared to provide this information:

- The test air density
- A tabulation of Q_{ref}, Q_{ams}, percent error vs. reference airflow and indicated P_{ams}

The report shall also include the items found in Sections 8.2 through 8.4, if applicable.

8.2 Performance data (curve)

The results of an AMS test shall be presented as a performance curve or plot. Test results shall be separate for each test setup used and presented individually for comparison-to-reference (relative accuracy).

8.2.1 AMS comparison-to-reference

This curve or plot shall reflect Q_{ams} as the abscissa (x) and the Q_{ref} as the ordinate (y) within a Cartesian type graph. The range of airflow values within which the AMS was tested shall be indicated on both axes. If convenient and for clarity, the axes may be scaled logarithmically.

8.2.2 Additional plot

For comparison-to-reference data, the test results also may be presented in a graph reflecting the percentage deviation from reference. In this case, Q_{ams} shall again be plotted as abscissa (x) for each determination from Q_{ref} (100%). Q_{ref} shall be plotted as the ordinate (y) for each determination. This plot is optional and in addition to the plot described in Section 8.2.1. It shall not be a substitute.

8.2.3 Airflow resistance

A plot of data shall be prepared for each six-point airflow resistance (ΔP) test conducted. The data will be plotted on log-log paper relating the pressure drop (ΔP) on the ordinate (y) axis to the free area velocity on the abscissa (x) axis.

8.3 Test points

The results for each of the six determinations required by Section 6.1.2 shall be shown on a performance curve as a series of points, one for each variable plotted.

The test results may be plotted as previously described, unconnected by a curve, and include an overlay to reference linearity or a 1:1 equivalency.

8.4 Identification

A performance curve sheet shall list the tested AMS and test setup figure. Sufficient details shall be listed to clearly identify the AMS tested, together with any related devices or appurtenances. Otherwise, the report containing such information shall be referenced.

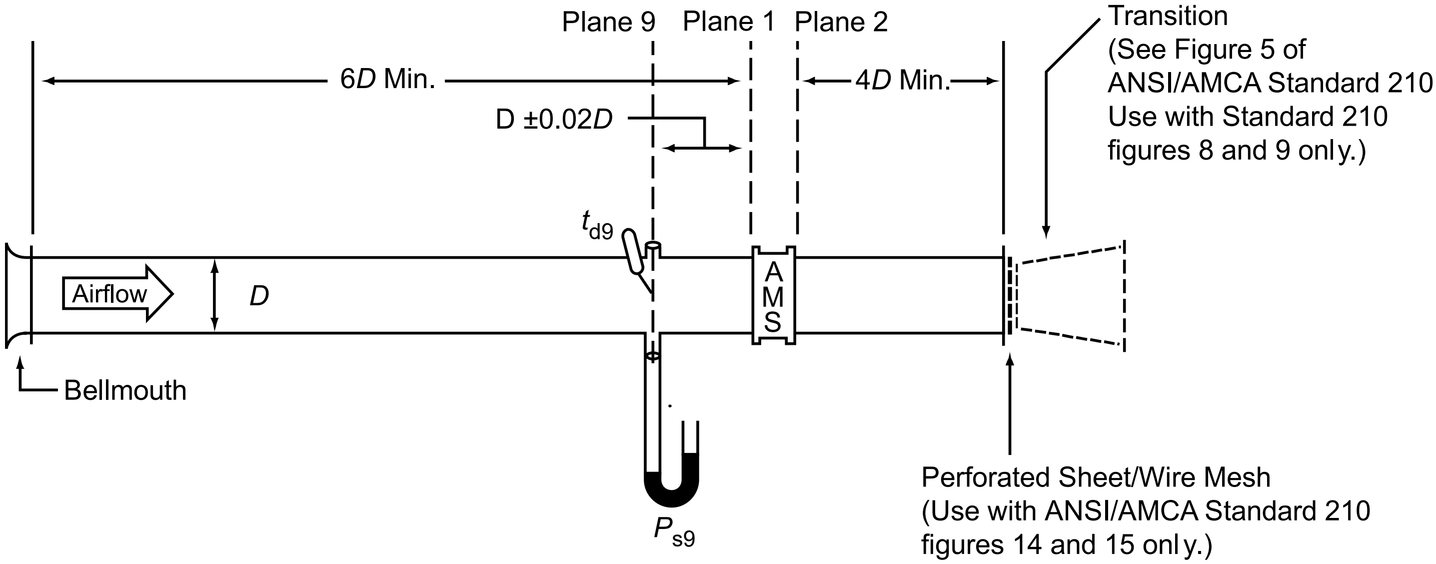

Figure 1 — Straight Run 10D

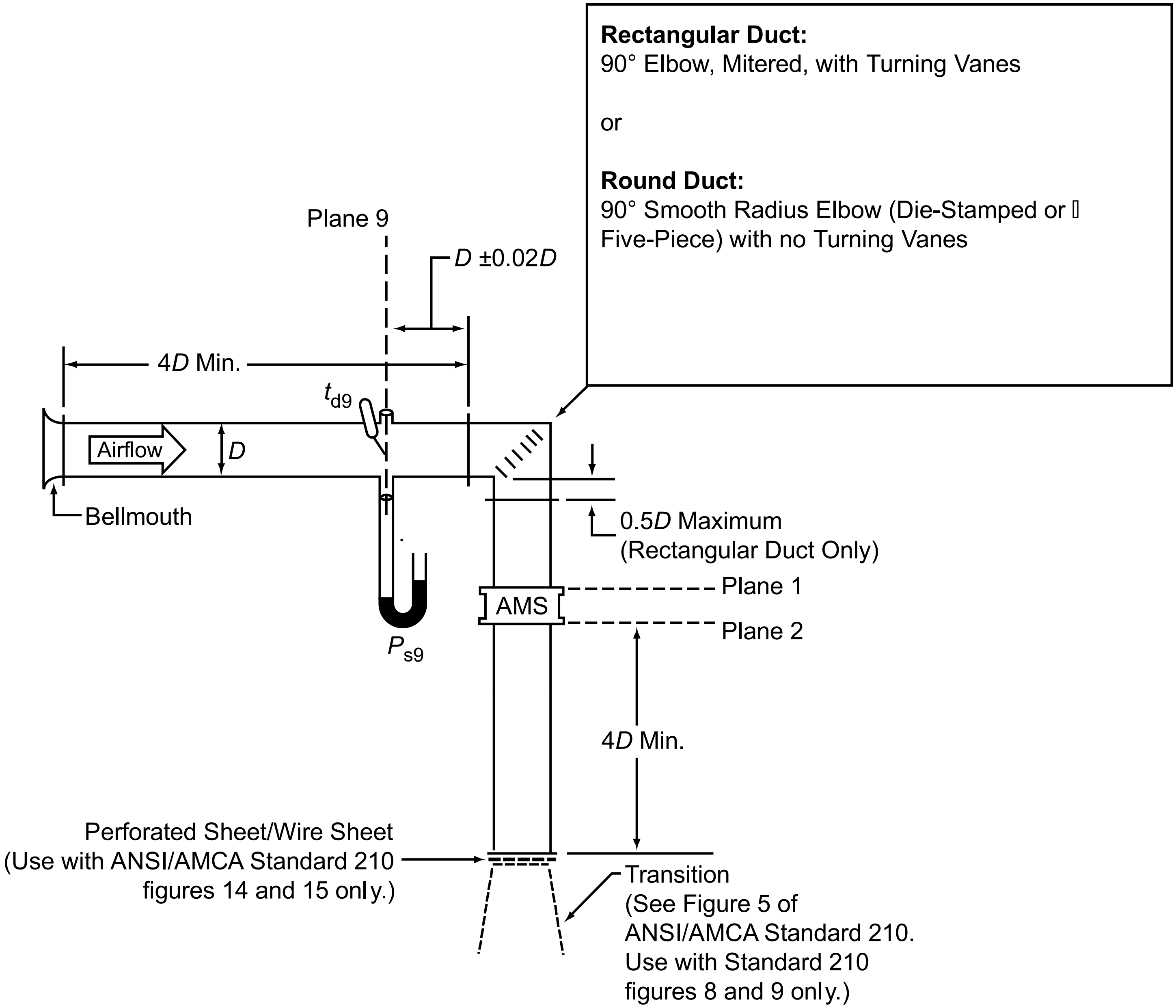

Figure 2 — With 90° Elbow

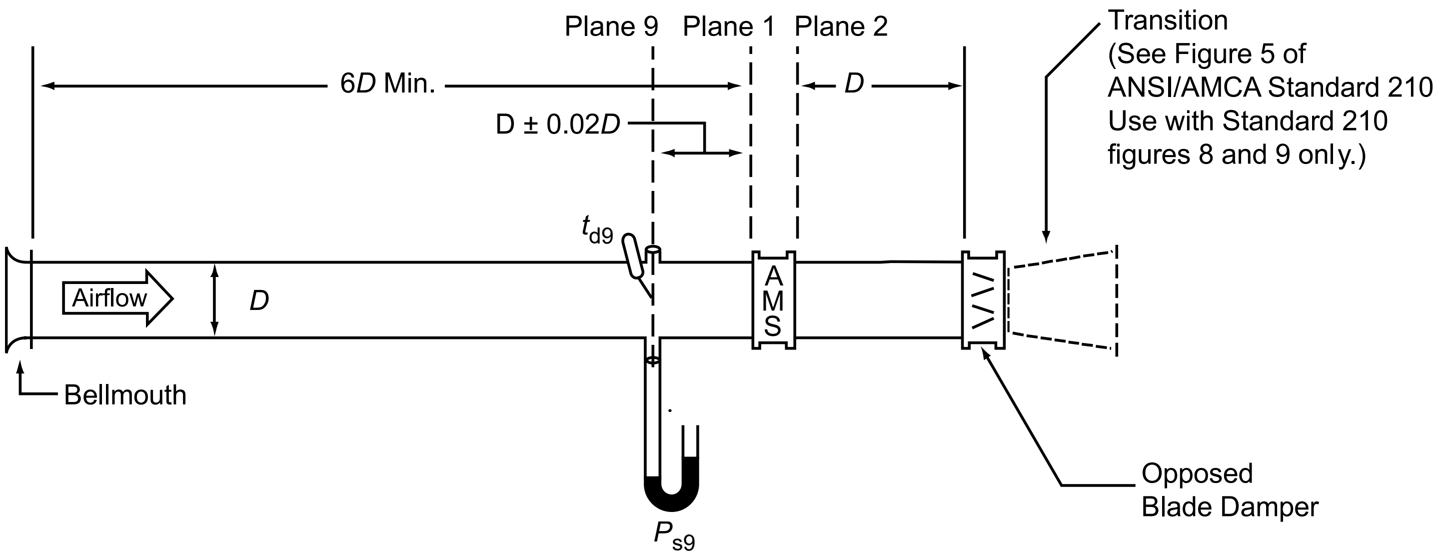

Figure 3 — Damper Proximity

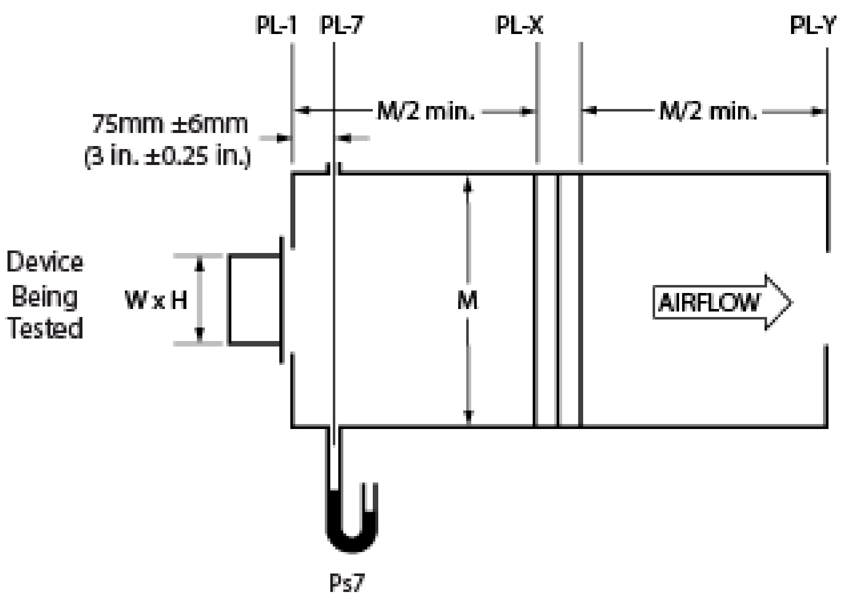

Figure 4 — Setup with Outlet Chamber

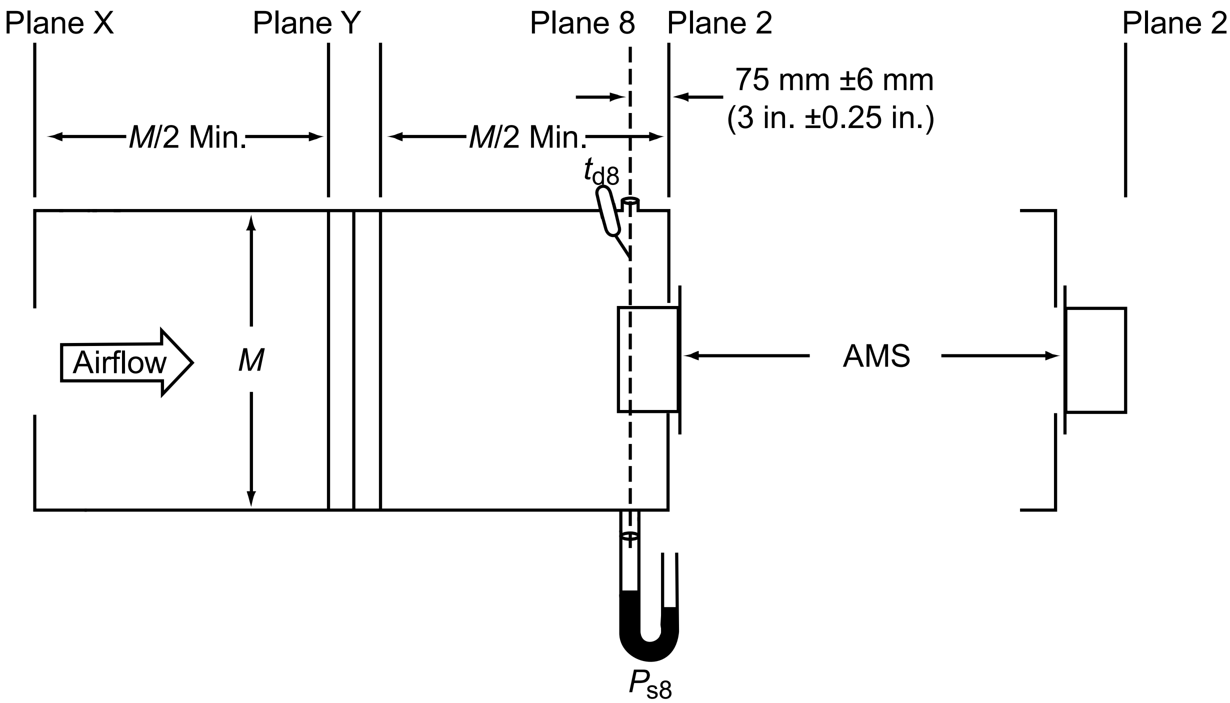

Figure 5 — Setup with Inlet Chamber

RESOURCES

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