ADDENDA

ANSI/ASHRAE Addendum b to
ANSI/ASHRAE Standard 200-2015

Methods of Testing Chilled Beams

Approved by ASHRAE on March 31, 2017 and by the American National Standards Institute on April 1, 2017.

This addendum was approved by a Standing Standard Project Committee (SSPC) for which the Standards Committee has established a documented program for regular publication of addenda or revisions, including procedures for timely, documented, consensus action on requests for change to any part of the standard. The change submittal form, instructions, and deadlines may be obtained in electronic form from the ASHRAE website (www.ashrae.org) or in paper form from the Senior Manager of Standards.

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FOREWORD

This addendum includes a method of test for water pressure drop, revisions to the normative references, and an update to the dew-point temperature tolerances.

This addendum modifies changes made by addendum a, which can be downloaded at https://www.ashrae.org/standards-research--technology/standards-addenda.

Note: In this addendum, changes to the current standard are indicated in the text by underlining (for additions) and ~~strikethrough~~ (for deletions) unless the instructions specifically mention some other means of indicating the changes.

Addendum b to Standard 200-2015

Revise Section 4 as follows (I-P and SI).

4.2.1 Accuracy of the temperature measuring and moist air properties instruments shall be within the following limits:

Air temperature	±0.2°F (0.1°C)
Water temperature	±0.2°F (0.1°C)
Temperature differential	±0.1°F (0.05°C) (sensors calibrated as a pair)
Room dew-point temperature	~~±0.1°F (0.05°C)~~ ±1.0°F (0.6°C)

4.2.5 Accuracy of the water pressure measuring instruments shall be within the following limits:

Water pressure	±0.05% full scale or 0.2 psi (0.1 kPa)

Modify Section 7 as shown (I-P and SI).

7. NORMATIVE REFERENCES

1. ASHRAE. ~~2006~~2013. ANSI/ASHRAE Standard 41.1-2013~~1986 (RA 2006)~~, *Standard Method for Temperature Measurement*. Atlanta: ASHRAE.
2. ASHRAE. ~~1989~~2014. ASHRAE Standard 41.3-2014, *Standard Method for Pressure Measurement*. Atlanta: ASHRAE.
3. ASHRAE. 1992. ASHRAE Standard 41.2-1987 (RA1992), *Standard Methods for Laboratory Airflow Measurement*. Atlanta: ASHRAE.
4. ASHRAE. 2006. ANSI/ASHRAE Standard 70, *Method of Testing the Performance of Air Outlets and Inlets*. Atlanta: ASHRAE.
5. SMACNA. 2005. HVAC Duct Construction Standards—Metal and Flexible, 3rd edition. Chantilly, VA: Sheet Metal and Air Conditioning Contractors' National Association.
6. ASHRAE. 2014. ANSI/ASHRAE Standard 41.6-2014, *Standard Methods for Humidity Measurement.* Atlanta: ASHRAE.
7. ASHRAE. ~~2006~~2015. ASHRAE Standard 41.7-~~1984 (RA 2006) R~~2015, *Standard Methods for Gas Flow Measurement*. Atlanta: ASHRAE.
8. AHRI. 2014. ANSI/AHRI Standard 220, *Reverberation Room Qualification and Testing Procedures for Determining Sound Power of HVAC Equipment*. Arlington, VA: AHRI.
9. ISO. 1998. ISO 7726, *Ergonomics of the Thermal Environment—Instruments for Measuring Physical Quantities*. Geneva, Switzerland: ISO.

Add new Normative Annex F as shown (I-P and SI).

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NORMATIVE ANNEX F
METHOD OF TESTING WATER PRESSURE DROP

F1. METHOD OF TESTING WATER PRESSURE DROP

F1.1 The temperatures and pressures of water entering and leaving the chilled beam shall be measured by the apparatus as illustrated in Figure F-1. The connecting piping shall be the same size as the chilled-beam supply and return connections.

F1.2 Temperature measuring instruments shall be placed so as to measure the temperature of the water entering and leaving the beam. The liquid lines shall be insulated at and adjacent to the temperature measuring instruments. Suitable insulation having an R-value of 4.5 $ft^2 \cdot °F \cdot h/Btu$ (RSI of 0.79 $m^2 \cdot °C/W$) or greater shall be applied from the unit under test to at least 6 in. (150 mm) upstream of the inlet temperature sensor and 6 in. downstream of the outlet temperature sensor. Temperature sensor stems shall be insulated. To minimize possible temperature stratification, appropriate mixers, such as "static mixers," shall be inserted in the inlet and outlet liquid lines upstream of the temperature measuring instruments. Alternatively, two close-coupled 90 degree elbows just upstream of the temperature measuring instruments can serve as mixers provided that the water velocity at the mixing section is not below 1 ft/s (0.3 m/s).

F1.3 Suitable means shall be provided for determining the liquid absolute pressure entering the beam and the liquid pressure drop through the beam and measurement apparatus as shown in Figure F-1. The piezometer rings shall be located and constructed in accordance with the dimensions shown in Figure F-1. Pressure taps may be used in lieu of piezometer rings. The test setup measurement of pressure drop between piezometer rings or pressure taps shall be reduced by the pressure drop of the total length of pipe between the piezometer rings or pressure taps and the beam. The piping loss shall be determined by calibration of the measurement apparatus.

The pressure drop in the test measurement apparatus at the test flow, including any pipe between the beam and the measuring devices, shall be calculated and subtracted from the measurement. This piping loss shall be determined by calibration of the test apparatus or by calculation of pressure drop based on type of material used for the pipe.

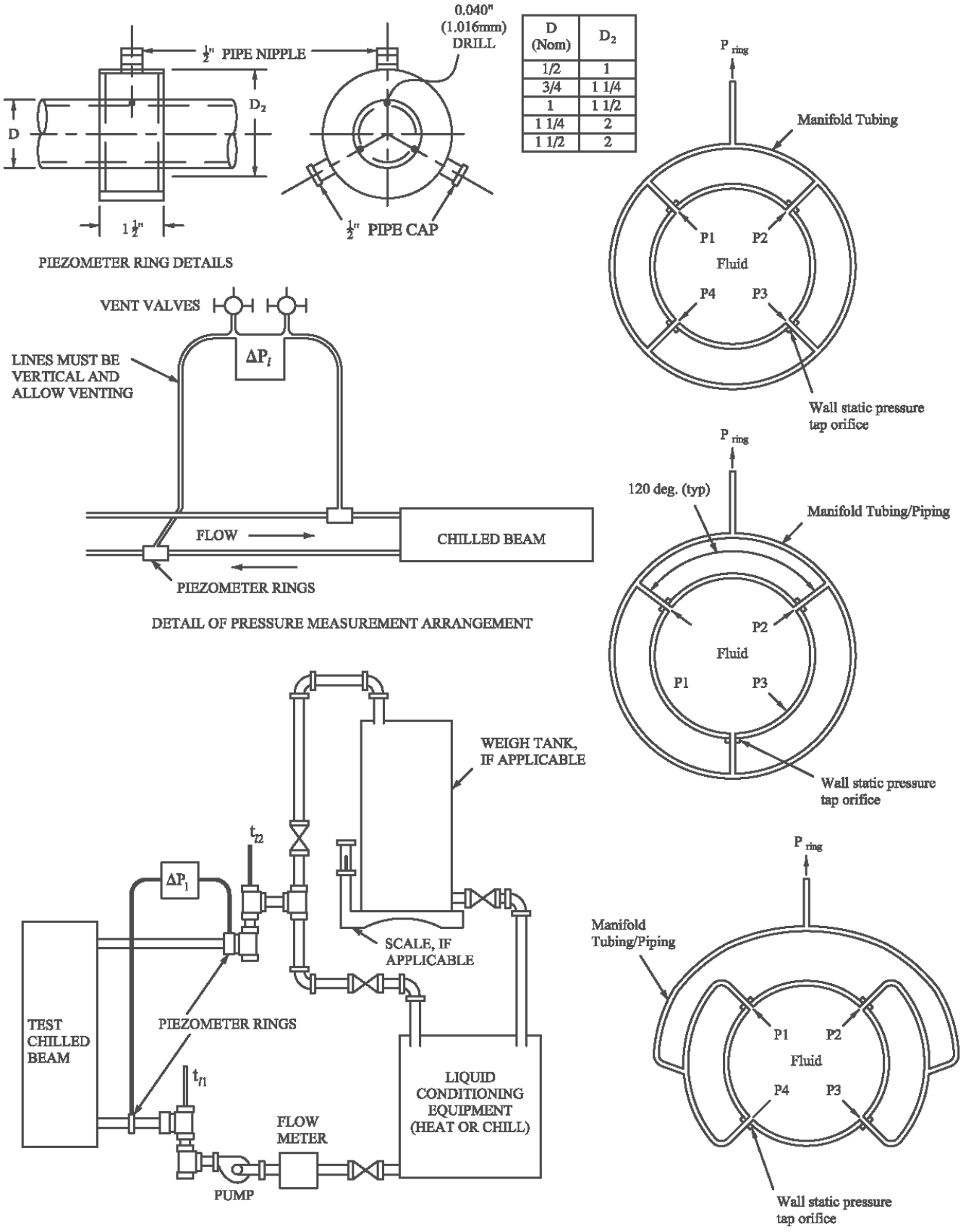

FIGURE F-1 Measuring apparatus for water pressure drop.

Add new Normative Annex G as shown (I-P and SI).

(This is a normative annex and is part of the standard.)

NORMATIVE ANNEX G
WATER-SIDE PRESSURE DROP MEASUREMENT PROCEDURE—NORMATIVE

G1. PURPOSE

The purpose of this annex is to prescribe a measurement method for water pressure drop and a correction method to compensate for friction losses associated with external piping measurement sections. The measurement method only applies to pipe of circular cross section.

G2. BACKGROUND

The water-side pressure drop needs to be determined by test with acceptable measurement uncertainty. The measured pressure drop, per this standard, will be determined by using static pressure taps external to the unit in upstream and downstream piping. When using external piping, adjustment factors are allowed to compensate the reported pressure drop measurement. Numerous studies conclude that the determination of a calculated correction term for these external components may contain significant sources of error, and therefore the use of external correction factors will be restricted to limit the magnitude of these potential errors. For units with small connection sizes, it is feasible that straight pipe sections be directly connected to the units with adequate length to obtain static pressure measurements with acceptable systematic errors due to instrument installation location.

G3. MEASUREMENT LOCATIONS

Static pressure taps shall simultaneously meet all of the following requirements.

G3.1 Static pressure taps may be in either the unit connections (i.e., nozzles) or in additional external piping provided for the purpose of test measurements.

G3.2 If using additional external piping, the piping arrangement shall use rigid pipe and may include fittings such as elbows, reducers, or enlargers between the pressure tap locations and the unit connections. Flexible hose is prohibited between the unit connections and the pressure taps.

G3.3 Static pressure taps shall maintain the lengths of cylindrical straight pipe in the flow path adjacent to each pressure tap location as shown in Table G-1.

a. The water pressure measurement apparatus shall be constructed in accordance with the length requirements outlined in Table G-1.
b. Construct the water pressure measurement apparatus using a material suitable for the rated pressure of the beam being tested. Ends shall be threaded or have flanges. An example table for schedule 40 SS piping can be found in Table G-2.
c. Straight length upstream of pressure taps: Minimum of 10 inside diameters or 6 in. (15 cm), whichever is greater. The 6 in. minimum is required for wrench clearance.
d. Straight length downstream of pressure taps: Minimum of 3 inside diameters or 6 in. (15 cm), whichever is greater. The 6 in. minimum is required for wrench clearance.

G4. STATIC PRESSURE TAPS

Static pressure taps will be in a piezometer ring or piezometer manifold arrangement with a minimum of three taps located circumferentially around the pipe, all taps at equal angle spacing. To avoid introducing measurement errors from recirculating flow within the piezometer ring, each of the pipe tap holes shall have a flow resistance that is greater than or equal to five times the flow resistance of the piezometer ring piping connections between any pair of pressure taps. A triple-tee manifold arrangement using four pipe tap holes is the preferred arrangement but is not required if meeting the flow resistance requirement.

G4.1 For design or evaluation purposes, flow resistance may be estimated by resistance coefficient K factor calculation methods as found in Crane Technical Paper No. 410. Generally, manifold tubing or piping can be evaluated using the K factor, and pressure tap holes can be evaluated using orifice flow equations.

G4.2 Provisions shall be made to bleed air out of the lines connected to pressure measurement devices. These provisions shall take into consideration the orientation of pressure taps and manifold connections.

G5. CORRECTION METHOD

Measured water pressure drop values shall be adjusted to subtract additional static pressure drop due to external piping. The additional static pressure drop shall be the sum of all losses between the unit connections and the location of static pressure taps. Record the original measured value, the calculated adjustment value, and the final calculated result for water pressure drop.

G5.1 The adjustment shall not exceed 10% of the measured water pressure drop.

G5.2 The general form of the adjustment equations use the methods in Crane Technical Paper No. 410. A Darcy friction factor is determined using the Swamee-Jain equation.

$$f = 0.25/\{\log_{10}[(\varepsilon/3.7 \times D) + (5.74/\mathrm{Re}^{0.9})]\}^2 \qquad \text{(G-1)}$$

where

ε = absolute roughness, 0.00015 ft (0.045 mm) for purposes of this standard

D = internal pipe diameter, ft (mm)

Re = Reynolds number for the flow in the pipe

The pressure drop (hL) associated with a flow component or fitting may be calculated using the friction factor as detailed above, or the equation may use a K factor. These are shown in Equation G-2.

$$\mathrm{hL} = f \times (L/D) \times (V^2/2g) \qquad \text{(G-2)}$$

when the Darcy friction factor is used for straight pipe sections, where

L = pipe length, ft (mm)

TABLE G-1 Water Pressure Measurement Apparatus (SPL PMA) Design

Unit Connection Nominal Pipe Size, in. (mm)	Straight Length in Flow Path	
	Upstream of Pressure Tap	Downstream of Pressure Tap
≤3 (75)	Minimum 10 × D_i	Minimum 3 × D_i
4, 5, or 6 (100, 125, or 150)	Minimum 6 × D_i	Minimum 2 × D_i
≥8 (200)	Minimum 3 × D_i	Minimum 1 × D_i

Notes:
1. Static pressure taps may be made with piezometer rings (annulus) or by manifolding three or four taps together with tubing.
2. Static pressure tap construction (annulus, braze joints, tubing, etc.) shall be strong enough to withstand 1.5 times maximum tube = side water pressure without leaking.
3. The upstream and downstream distances from the pressure tap shall be no less than 6 in. (150 mm).

TABLE G-2 Example SPL PMA Sizing for 40S SS Piping

Nominal Pipe Size (NPS), in.	Schedule Number	Pipe Outside Diameter D_o, in.	Wall Thickness t_w, in.	Pipe Inside Diameter D_i, in.	Min. Length Upstream of Pressure Tap, in.	Min. Length Downstream of Pressure Tap, in.	Min.Total Length SPL PMA, in.
0.25	40S	0.54	0.09	0.36	6.00	6.00	12.00
0.375	40S	0.68	0.09	0.49	6.00	6.00	12.00
0.50	40S	0.84	0.11	0.62	6.22	6.00	12.22
0.75	40S	1.05	0.11	0.82	8.24	6.00	14.24
1.00	40S	1.32	0.13	1.05	10.49	6.00	16.49
1.25	40S	1.66	0.14	1.38	13.80	6.00	19.80
1.50	40S	1.90	0.15	1.61	16.10	6.00	22.10
2.00	40S	2.38	0.15	2.07	20.67	6.20	26.87
2.50	40S	2.88	0.20	2.47	24.69	7.41	32.10
3.00	40S	3.50	0.22	3.07	30.68	9.20	39.88
3.50	40S	4.00	0.23	3.54	35.40	10.62	46.02

D = internal diameter, ft (mm)

V = average velocity calculated at the entrance to the component, ft/s (m/s)

g = standard gravitational term, 32.174 ft/s^2 (9.81 m/sec^2)

G5.3 An Excel® spreadsheet is available from AHRI for computation of the pressure drop adjustment factors.

G6. PRESSURE MEASUREMENT PIPE CALIBRATION

The pressure measurement pipes shall be calibrated by conducting the following test and comparing the measurements to calculated adjustment values.

G6.1 Connect the entering beam pressure measurement pipe exit (minimum straight length downstream of taps = 3 × D_i or 6 in. [150 mm], whichever is greater) to the leaving beam pressure measurement pipe entrance (minimum straight length upstream of taps = 10 × D_i or 6 in. [150 mm], whichever is greater). The coupling shall have the same nominal pipe size as the pressure measurement pipes. Connect the pipes to a water flow source.

G6.2 The instrumentation for the test shall consist of the following:

a. Water temperature entering beam pressure measurement pipe, °F (°C)
b. Water absolute pressure entering beam pressure measurement pipe, psi (kPa)
c. Water temperature leaving beam pressure measurement pipe, °F (°C)
d. Water pressure drop through entering beam and leaving beam pressure measurement pipes, psi (kPa)
e. Water mass flow rate, lbm/h (kg/s)

G6.3 Data to be recorded for each test run is as follows:

a. Pressure measurement pipe inside diameter, in. (mm)
b. Entering beam pressure measurement pipe straight length downstream of pressure taps, in. (mm)
c. Leaving beam pressure measurement pipe straight length upstream of pressure taps, in. (mm)
d. Pressure measurement pipe material
e. Water type (water, aqueous solution, etc.)
f. Aqueous solution composition by mass, % (if not water)

g. Water temperature entering beam pressure measurement pipe, °F (°C)
h. Water absolute pressure entering beam pressure measurement pipe, psi (kPa)
i. Water temperature leaving beam pressure measurement pipe, °F (°C)
j. Water pressure drop through entering beam and leaving beam pressure measurement pipes, psi (kPa)
k. Water mass flow rate, lbm/h (kg/s)

G6.4 Conduct the water pressure drop test with at least four different water velocities inside pressure measurement pipe covering the range of 1 to 14 ft/s (0.3 to 4.25 m/s) in approximately equally spaced velocity increments on a logarithmic scale. The water temperature and flow rate shall be in steady state. Variance of more than ±1°F (0.6°C) or ± 5% flow rate or 1 gpm (0.06 L/s), whichever is greater, make the test results invalid and they must be repeated.

G6.5 Record the test data continuously for at least 30 minutes (every 1 minute) after steady-state condition has been achieved. Average the rounds to determine each run's test values. Wait for steady-state conditions before testing at the next water velocity.

G6.6 Use the following input data and the AHRI Excel spreadsheet to calculate water pressure drop through entering beam and leaving beam pressure measurement pipes at the test input conditions.

a. Pressure measurement pipe inside diameter, in. (mm)
b. Entering beam pressure measurement pipe straight length downstream of pressure taps, in. (mm)
c. Leaving beam pressure measurement pipe straight length upstream of pressure taps, in. (mm)
d. Pressure measurement pipe material
e. ε = pressure measurement pipe absolute roughness. Start with 0.00015 ft (0.045 mm).
f. Water type (water, aqueous solution, etc.)
g. Aqueous solution composition by mass, % (if not water)
h. Water temperature entering beam pressure measurement pipe, °F (°C)
i. Water absolute pressure entering beam pressure measurement pipe, psi (kPa)
j. Water temperature leaving beam pressure measurement pipe, °F (°C)
k. Water mass flow rate, lbm/h (kg/s)

G6.7 The measurement shall not exceed the calculated adjustment by more than 10%; otherwise, additional corrections shall be applied and noted.

G6.8 If the pressure measurement pipes are made from a noncorroding material, and the water under test is soft, the pipe's absolute roughness should not change as a function of time.

G6.9 The laboratory shall conduct an annual calibration of the pressure measurement pipes.

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