



BSR/ASHRAE Standard SPC164.4P

Public Review Draft

Methods of Test for Commercial and Industrial Adiabatic Humidifiers

**First Public Review (December 2019)
(Draft Shows Complete Proposed New Standard)**

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(This foreword is not part of this standard. It is merely informative and does not contain requirements necessary for conformance to the standard. It has not been processed according to the ANSI requirements for a standard and may contain material that has not been subject to public review or a consensus process. Unresolved objectors on informative material are not offered the right to appeal at ASHRAE or ANSI.)

FOREWORD

This standard provides rules for the testing of adiabatic humidifiers for commercial and industrial applications. It was prepared by ASHRAE Standard Project Committee SPC 164.4. The cognizant technical committee is ASHRAE TC 5.11, Humidifying Equipment.

*The purpose of this standard is to provide a uniform method for testing in a laboratory environment. Although the method of test originated in AHRI Standard 640, **Performance Rating of Industrial and Commercial Humidifiers**, the committee has developed this separate method of test to be used independently of the AHRI rating standard so manufacturers, specifiers, installers, and users of industrial and commercial humidifiers can test humidifier's performance under a variety of conditions with uniform results.*

This method of test was prepared in cooperation with the Air Conditioning & Refrigeration Institute to utilize with AHRI Standard 640.

ASHRAE Standard 212-2019 – Method of Test for Determining Energy Performance and Water-Use Efficiency of Add-On Evaporative Precoolers for Unitary Air-Conditioning Equipment, will be referenced, where applicable, throughout this document.

This test method does not address applications of “swamp coolers” as defined by ASHRAE 133.

This test method does not address the application practices for absorbing generated moisture in an airstream or space.

1. PURPOSE

This standard method of test establishes a uniform method of laboratory performance testing of commercial and industrial adiabatic humidifiers.

2. SCOPE

2.1 *This standard describes a method of test for the humidification rate and evaporation efficiency of commercial and industrial adiabatic humidifiers as defined in Section 3.*

2.2 *This method of test describes the test apparatus, conduct of the test, and information to be recorded.*

2.3 *Information resulting from the application of this method of test is intended for use by manufacturers, specifiers, installers, and users of commercial and industrial humidifiers.*

3. DEFINITIONS

adiabatic humidifiers: a device whose primary function is to increase the humidity of unsaturated air, by the conversion of the sensible heat in the unsaturated air to latent heat by the process of evaporating water directly introduced to this air.

centrifugal type atomizer: utilizes a high-speed disk to sling water to its rim where it is thrown onto plates or a comb to produce a fine mist.

commercial and industrial humidifier (humidifier): a device designed to add moisture to air. Humidifiers designed to increase the moisture level of the air in a room, space, or ventilation system that is not primarily intended for residential applications.

compressed air and water fogging systems: pressurized air and pressurized water are combined inside the nozzle to produce a fine mist at the nozzle tip.

compressed air fogging systems: pressurized air is forced through an annular orifice at the nozzle tip creating a vortex at the tip. Water passes through an orifice in the nozzle where it is atomized on contact with the compressed air at the nozzle tip.

humidification rate: a measure of the ability of a humidifier to add moisture to its surrounding environment, expressed as a unit of mass of water evaporated per unit of time.

mist eliminator/droplet separator: a porous mesh or media barrier to prevent carrier of water droplets from an adiabatic humidifier.

nozzle type atomizers: utilizes a nozzle, compressed-air, water, or air and water, to reduce water to a fine mist.

pressurized water humidifier: a pump is used to force water through the orifice of a nozzle to produce a fine mist at the nozzle tip.

shall: the word *shall* indicates requirements of this standard.

ultrasonic atomizer: a piezoelectric transducer immersed in a reservoir of mineral free water. The transducer converts a high-frequency electronic signal into a high-frequency mechanical oscillation. The mechanical oscillation is directed at the surface of the water, where at very high frequencies, it creates a fine mist.

unit under test (UUT): the humidification system undergoing testing.

waste water: water that passes through the humidification system but does not evaporate into the air. Waste water is generated by humidifier drain cycles, as well as water collected on a mist eliminator/droplet separator device.

wetted media humidifiers: utilize a porous media core to facilitate the process of evaporation. Water is circulated over the media where it interacts with air passing through the media

4. UNITS OF MEASUREMENT

4.1 Systems of Units

The International System of Units (le Systeme International d'Unites)¹ is employed in this standard. Values shall be based on the National Institute of Standards and Technology (NIST) values which, in turn, are based on the fundamental values of the International Bureau of Weights and Measures. Inch-pound units appear in parentheses (I-P) after SI units.

4.2 Basic Units

The unit of length is either the meter (foot), designated m (ft), or the millimeter (inch), designated mm (in.). The unit of mass is the kilogram (pound mass), designated kg (lb). The unit of time is the hour, designated hr, or the minute, designated min, or the second, designated s. The unit of temperature is

the degree Celsius (Fahrenheit), designated °C (°F). The unit of conductivity is microsiemens per cm ($\mu\text{S}/\text{cm}$).

4.2.1 Flow Rate, Humidification Rate, and Velocity

The units for the flow rate for air and gases are cubic meters per hour (cubic feet per minute), designated m^3/hr (cfm). The unit for the flow rate for water is kilograms per hour (pounds mass per hour), designated kg/hr (lb/hr). The unit for velocity is meters per second (feet per minute), designated m/s (fpm).

4.2.2 Pressure

The unit of pressure is the Pascal or kiloPascal (pounds per square inch, inch water gauge, or the inch mercury column), designated Pa or kPa (psi, in. wc or in. Hg). The inch mercury column shall be based on a one-inch column of mercury at 0°C (32°F), under standard gravity (*in vacuo*).

When relative to the atmospheric pressure, the pressure is expressed in Pa gauge or kPa gauge (psig).

4.2.3 Power and Energy

In this standard, the unit of electrical voltage is the volt, designated as V. The unit of electrical power is the kilowatt, designated kW. The unit of electrical energy is the kilowatt-hour, designated kWh.

5. INSTRUMENTATIONS AND METHODS OF MEASUREMENT

5.1 Calibration

Except where noted, instruments shall be calibrated annually over the range to be encountered in the test. Calibration shall be certified traceable to the NIST or other national physical measures recognized as equivalent to NIST.

5.2 Nozzle Apparatus

Each nozzle station consists of a receiving chamber and a discharge chamber separated by a partition in which one or more nozzles of equal or unequal size are located. A detailed description of the nozzle apparatus is given in ASHRAE Standard 41.2.

5.3 Air Flow

For humidifiers intended to be installed within an air duct, an airflow-measuring apparatus is shown schematically in Figure 1. The airflow rate shall be determined by measuring the pressure differential across elliptical flow nozzles in chambers as shown in Figure 1. Determinations shall be in accordance with ASHRAE Standard 41.2. Room airflow shall be measured within 1.5 m (5 ft) of the humidifier using an instrument that has a demonstrated accuracy of $\pm 5\%$ of observed reading.

5.4 Air Temperature

Both wet- and dry-bulb air temperatures shall be measured in accordance with ANSI/ASHRAE Standard 41.1, *Standard Method for Temperature Measurement*. A measurement accuracy of $\pm 0.5^\circ\text{C}$ (1.0°F) or better shall be obtained. The smallest scale division of the instrument shall be no greater than 0.2°C (0.5°F).

5.5 Water Flow

Water flow shall be measured using a totalizing water meter connected to the humidifier inlet and a timing device to determine the rate of water flow. Water meters shall have an accuracy of $\pm 5.0\%$ of observed reading.

5.6 Water Temperature

Water and fluid temperature shall be measured using a submerged well, an insulated wrap of the supply line, or any other method with a demonstrated accuracy of 0.5°C (1.0°F) or better.

5.7 Water Conductivity Measurements

Water conductivity measurements, if required by the manufacturer, shall be measured using a conductivity meter having an accuracy of ± 1.0 $\mu\text{S}/\text{cm}$ of observed reading.

5.8 Barometric Pressure

The barometric pressure shall be measured with a mercury column barometer or other instrument and shall have an accuracy of ± 34 Pa (0.01 in. Hg) and with scale divisions no larger than 34 Pa (0.01 in. Hg).

Test shall be conducted below 1500 m (5000 ft) elevation.

5.9 Air and Water Pressure Measurement

Other than barometric pressure, static pressure in ducts or chambers shall be measured with taps designed to eliminate velocity effects. Each location requiring a static pressure measurement shall use a minimum of four taps equidistant around the perimeter of the duct or chamber. These taps shall be joined in a piezometer ring and the ring used for measurement. Static pressure taps are required on both sides of the flow nozzles and downstream of the UUT. (Figure 1).

Pressure measurement shall be made in accordance with ASHRAE Standard 41.3. The accuracy of pressure-measuring instruments shall permit measurements with $\pm 1\%$ of the reading.

Compressed air (if required by the UUT) and supply water pressure shall be measured with oil-filled gauges, electronic transducers, or other instruments that provide a maximum error of $\pm 1\%$ of the maximum observed reading or ± 3.5 kPa (0.5 psi), whichever is larger. Pressure measuring device shall be capable of measuring 125% of rated pressure. Surge arrestors may be used to stabilize excessive pressure fluctuations. Pressures shall be taken within 3 feet of first nozzle for nozzle type humidifiers.

5.10 Relative Humidity

Relative humidity shall be calculated from the dry-bulb temperature, wet-bulb temperature, and barometric pressure or read directly from a humidity measuring device that has a demonstrated accuracy of $\pm 1\%$.

5.11 Chronometer

A timepiece that displays time in seconds and keeps time accurate to within ± 2 minutes per day shall be used for all time measurements. Calibration is not necessary.

5.12 Electrical Voltage

Voltage shall be measured using a volt meter connected to the humidifier over the duration of the test. Volt meters shall have an accuracy of $\pm 1.0\%$ of the observed reading.

5.13 Power Measurement

Power shall be measured using a wattmeter connected to the humidifier over the duration of the test. Watt meters shall have an accuracy of $\pm 1.0\%$ of the observed reading.

5.14 Electrical Energy Measurement

Energy shall be measured using a watt-hour meter connected to the humidifier over the duration of the test. Watt-hour meters shall have an accuracy of $\pm 1.0\%$ of the observed reading.

6. EQUIPMENT AND SETUP

6.1 Air Treatment Facilities

The test facility shall be provided with air treating equipment to maintain the prescribed conditions of temperature, humidity, and pressure within the test area.

6.2 Duct Mounted Humidifier Test Stand

Adiabatic humidifier and instrumentation shall be installed in a test chamber as shown in Figure 1. Waste or drain water from the humidifier shall be collected in a waste water tank placed on a scale, as shown in Figure 2. The scale shall have an accuracy of ± 0.05 kg (0.1 lb).

6.2.1 Ducts

Short ducts that are used to simulate outlet duct work shall be between 2 and 3 equivalent diameters in length and have an area $\pm 0.5\%$ of the outlet area and a uniform shape to fit the outlet. If the adiabatic humidifier is tested without outlet ductwork, it shall be mounted on the end of the chamber.

6.2.2 Leakage

The ducts, chambers, and other equipment utilized shall be designed to withstand the pressure and other forces to be encountered. All joints between the adiabatic humidifier and the measuring station shall be sufficiently tight so that measurements are not affected by more than one-half the allowable instrument error.

6.2.3 Mist Elimination/Droplet Separators

If mist eliminators and/or droplet separators are required by the manufacturer, they shall be installed per the manufacturer's instructions downstream of the humidifier. The distance from the UUT to the mist eliminator shall be representative of a typical application and recorded; however, for the purpose of this test, the distance may not exceed 1.5m (5 ft.). Any water collected by mist eliminator/droplet separator shall be collected and returned to a waste water tank so it can be subtracted from the capacity of the humidifier.

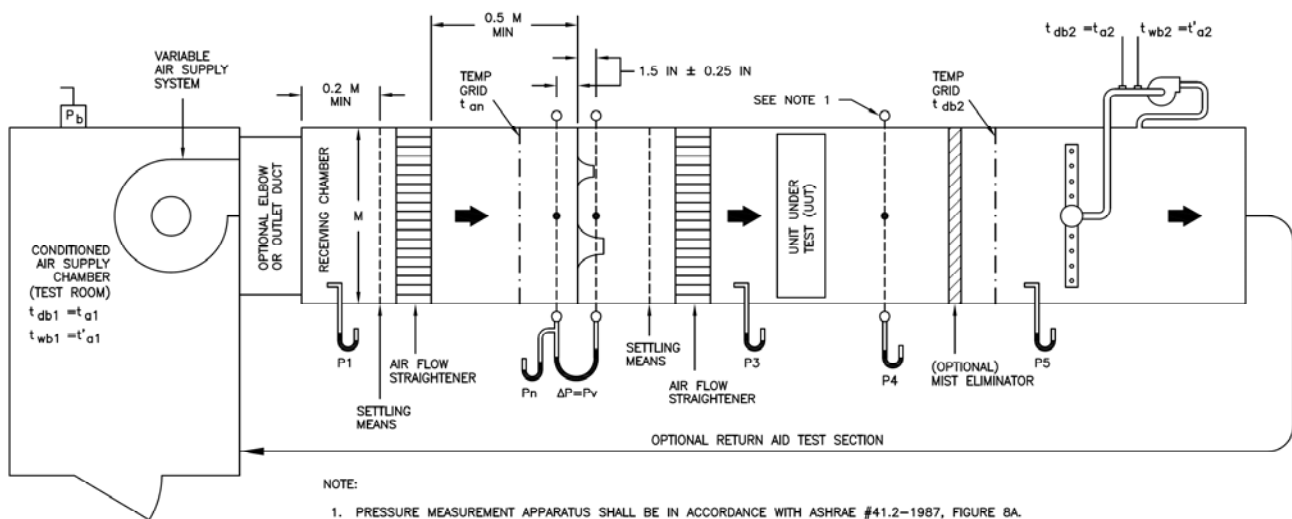


Figure 1 Test Apparatus The humidifier is installed within the test duct section and performance is measured over several successive tests with varying conditions.

6.3 Area Type Humidifier Test Stand

For area type humidifiers with affixed tanks that require manual filling and do not have a connection to supply water, the test stand shown in Figure 2 shall be utilized. With this arrangement, the humidifier is placed on a scale with an accuracy of ± 0.05 kg (0.1 lb) to measure the amount of water discharged over the duration of the test.

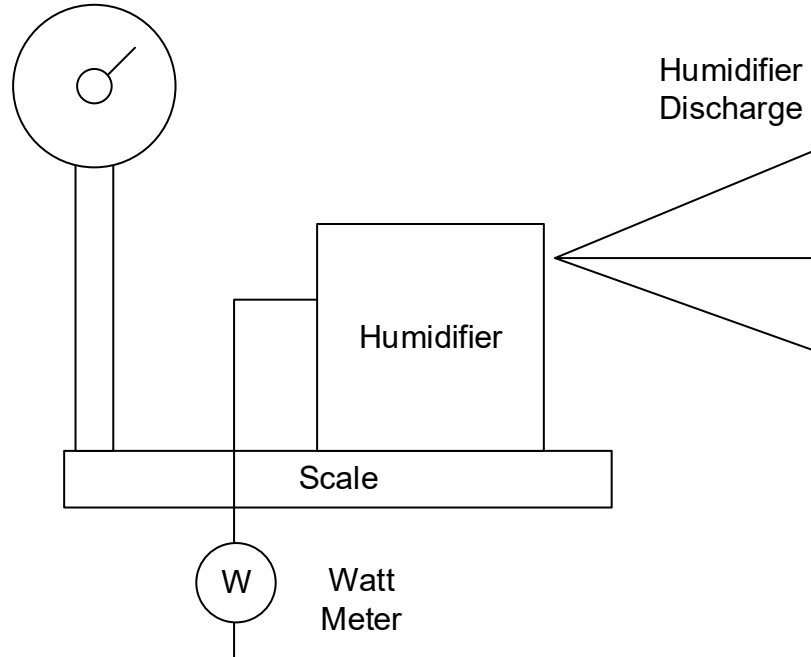


Figure 2: Area Type Humidifier Test Stand Without Supply Water Connection

For area type humidifiers with a direct connection to supply water, the humidifier shall be installed as per the manufacturer's instructions and affixed with a water flow meter on the inlet as per Section 5.5 and as shown in Figure 3.

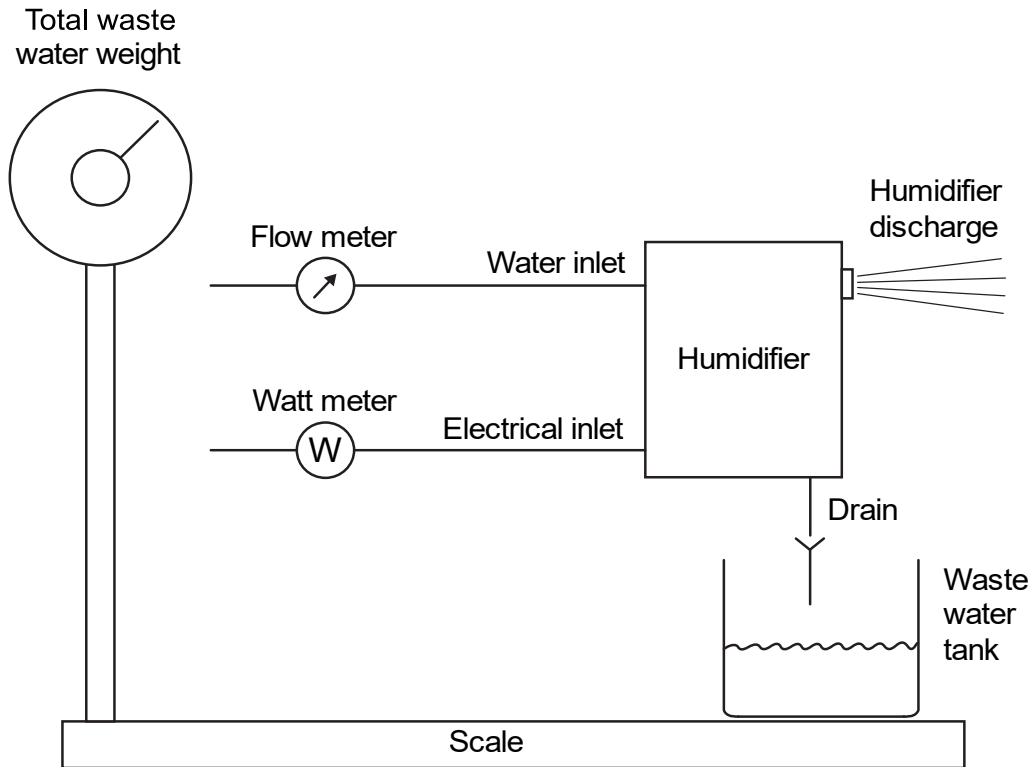


Figure 3: Area Type Humidifier with Connection to Water Line

6.4 Temperature Measuring

Air temperature measurements and fluid temperature measurements shall be made in accordance with the applicable provisions of ANSI/ASHRAE Standard 41.1, *Standard Method for Temperature Measurement*.

When necessary, mixers shall be used to provide a uniform air temperature. Mixing or other types of devices shall be used to ensure uniform temperature profiles to the humidifier and measurement devices in accordance with ANSI/ASHRAE Standard 41.1, *Standard Method for Temperature Measurement*.

7. CONDUCT OF TEST

The test methods and conditions described in this section shall be used to determine the humidification rate.

7.1 Conditions of Test

The following conditions shall be maintained throughout all tests:

7.1.1 Air Pressure in the Air Treatment Apparatus

The air pressure in the humidifier test room shall be maintained with a test tolerance of ± 250 Pa (± 0.070 in. Hg).

7.1.2 Air Temperatures

The air entering the test area or test duct shall be maintained at the dry-bulb and relative humidity in compliance with Table 1.

7.1.3 Water Supply Source

For humidifiers with a direct connection to a water supply, the water supply source shall be directly connected to the humidifier, and the water control valve on the humidifier shall regulate the water flow. The pressure of the water entering the water control valve shall be maintained at a steady state within the manufacturer's acceptable pressure range for the duration of the test: a tolerance of ± 3 psi (± 21 kPa).

For humidifiers without a direct connection to a water supply, the reservoir shall be filled to the maximum level specified by the manufacturer prior to the start of the test.

7.1.4 Water Quality

Water quality and temperature shall be maintained per the manufacturer's specifications.

7.1.5 Compressed Air

For humidifiers utilizing compressed air, air pressure shall be maintained within the manufacturer's specified tolerances.

Table 1: Environmental Conditions for Testing

Measurement	Requirement
Room Air Temperature	18 - 24 °C (64 - 75 °F)
Room Air Humidity	20 - 50 % RH
Room Airflow	0 - 0.2 m/s (0 - 40 fpm)
Entering Duct Temperature	18 - 38 °C (64 - 100 °F)
Entering Duct Humidity	20 - 50 % RH
Supply Water Temperature	10 - 35°C (50 - 95°F)

7.2 Installation

Unless a detail is specifically required by this method of test, the humidifier shall be installed as described in the installation instructions furnished by the manufacturer.

7.2.1 Direct Room/Area Type Adiabatic Humidifiers

For area type humidifiers with affixed tanks that require manual filling and do not have a connection to supply water, the humidifier shall be placed on the scale as described in Figure 2.

For area type humidifiers with a direct connection to a supply water, the humidifier shall be installed as per the manufacturer's instructions and affixed with a water flow meter on the inlet as per Section 5.5 and as shown in Figure 3.

7.2.2 Duct Mounted Adiabatic Humidifiers

The test duct section for duct mounted adiabatic humidification systems is shown in Figure 1. Evaporation distance for fogging and ultrasonic type systems should match the manufacturer's recommendation; however, the maximum allowable distance is 3m (10 feet) for the purpose of this test. This distance is measured from the trailing edge of the humidifier assembly to the leading edge of the mist eliminator/droplet separator or secondary evaporator.

The test section should include a floor drain to collect water discharged from the humidifier that collects on walls, ceilings, or floors of the duct. Water from this drain shall be collected for measurement after the completion of the test.

If a droplet separator is required at the end of the duct section, it must also have a floor drain to remove excess water. Water from this drain shall be collected for measurement after the completion of the test.

In both cases above, the floor drains shall be sized to adequately drain the water. If this size is unknown, it shall comply with DIN 1946-4:2008; the internal diameter of the drain shall be at least min 40 mm (1.6 in) with a drain capacity of min 28.5 (L/h)/m² - 0.7 (gal/h)/sq. ft.

7.3 Conduct of Test: Direct Room/Area Type Adiabatic Humidifiers without a Supply Water Connection

For area type humidifiers with affixed tanks that require manual filling and do not have a connection to supply water:

- a) The humidifier shall be filled with water and placed on the scale.
- b) The humidifier shall be configured to operate at its maximum level of performance and powered on.

Data shall not be recorded until the humidifier has achieved steady state operation.

- a) Steady state operation is determined by taking at least five sets of weight readings with a frequency of every 2 minutes. When the change in weight between the readings is equal, the unit has reached steady state and the test can begin.
- b) The duration of the test shall be at least one hour after reaching steady state conditions.

7.3.1 Data to Be Recorded Direct Room/Area Type Adiabatic Humidifiers

All data required to determine the humidification rate of the unit as well as that required to demonstrate compliance with this method of test shall be recorded. This includes:

- Initial humidifier weight
- Humidifier weight at prescribed intervals to determine steady state
- Humidifier weight at start of test
- Humidifier weight at end of test
- Weight of water added, if necessary, to complete the test
- Elapsed time of the test
- Ambient conditions during test.

7.4 Conduct of Test: Direct Room/Area Type Adiabatic Humidifiers with a Supply Water Connection

For area type humidifiers with a direct connection to supply water, the humidifier shall be configured to operate at its maximum level of performance and powered on.

- a) After prescribed rating conditions of the test have been attained, at least five sets of readings shall be taken. The duration of the test shall be at least one hour.
- b) The test shall be continued until the amount of water flowing into the humidifier is within +/- 5% for four successive test readings. This is considered representative of steady state condition.
- c) The test shall be considered invalid if wetting of the test chamber occurs as a result of inadequate evaporation.

7.4.1 Data to Be Recorded Direct Room/Area Type Adiabatic Humidifiers

All data required to determine the humidification rate of the unit as well as that required to demonstrate compliance with this method of test shall be recorded. This includes:

- Water flow rate into the humidifier
- Total amount of water consumed by the humidifier
- Amount of water directed to drain

- Ambient conditions during test.

7.5 Conduct of Test: Duct Mounted Systems

The humidifier shall be configured to operate at its maximum level of performance and powered on.

- a) After prescribed rating conditions of the test have been attained, at least five sets of readings shall be taken. The duration of the test shall be at least one hour.
- b) The test shall be continued until the amount of water evaporated or injected into the humidifier is within +/-5% for four successive test readings. This is considered steady state operation.
- c) Optionally, the test may be repeated at alternative airflows, temperatures, and entering air humidity levels to generate a curve or map describing the performance.

7.6 Data to be Recorded

All data required to determine the humidification rate of the unit as well as that required to demonstrate compliance with this method of test, shall be recorded. This includes:

- Air volume flowing in the duct
- Temperatures before and after the humidifier
- Relative humidity before and after the humidifier
- Static Pressure loss across the humidifier
- Total water input to the humidifier
- Total water discharged to drain by the humidifier, duct drain, and the mist eliminator/droplet separator (if applicable)
- Power consumption of the humidifier
- Ambient barometric pressure.

7.7 Recorded Data Format and Tolerances

7.7.1 Electrical Supply

Humidifiers that require electrical energy for proper operation shall be connected to a supply of the nameplate voltage and frequency, as measured at the electrical terminals of the humidifier. A volt meter shall be installed in the electrical circuit when a humidifier is connected to an electrical supply circuit. Tolerances on voltage shall be $\pm 10\%$ throughout the test.

7.7.2 Time

The time of each reading and the elapsed time between successive readings of all data shall be recorded, h[s].

7.7.3 Conditions

- a. Water temperature entering the humidifier, °C [°F]
- b. Water pressure during test or during preliminary water adjustment, kPa gauge [psig]
- c. Air temperature in test chamber (Area type units), °C [°F]
- d. Air humidity in test chamber, %RH
- e. Entering air temperature in test duct (Duct mounted units), °C [°F]
- f. Leaving air temperature in test duct (Duct mounted units), °C [°F]
- g. Entering air humidity in test duct (Duct mounted units), %RH
- h. Leaving air humidity in test duct (Duct mounted units), °%RH
- i. Ambient barometric pressure, kPa (Psi)
- j. For ducted systems: average air volume flowing through dut, m³/hr, [ft³/min].

7.7.4 Mass Flow to Duct Mounted Humidifiers

- a. Supply water to humidifier, kg [lb]

b. Waste water, kg [lb].

8. CALCULATION OF HUMIDIFICATION RATE

The humidification rate of the humidifier under test shall be determined using Equation 1 and shall be the average humidification rate of three successive test runs complying with Section 7.

8.1 Calculations

The humidification rate shall be calculated using the following equation:

$$H_m = (H_s - H_t)/\text{test period} \quad \text{Equation (1)}$$

where:

$$H_m^\dagger = \text{Humidification Rate, kg/h [lb/h]}$$

$$H_s^\dagger = \text{Water supply, kg [lb]}$$

$$H_t^\dagger = \text{Waste water, kg [lb]}$$

9. NORMATIVE REFERENCES

1. Page, C.H., and P. Vigoureux. *The International System of Units (SI)*, NIST SP 330, *The International System of Units (SI)* National Institute of Standards and Technology.
2. ANSI/ASHRAE Standard 41.1-2013, *Standard Method for Temperature Measurement*. American Society of Heating, Refrigerating and Air-Conditioning Engineers, 1791 Tullie Circle N.E., Atlanta, GA 30329, U.S.A.
3. *ASHRAE Standard 41.7-2015 (RA 2018) Standard Methods for Gas Flow Measurement*. American Society of Heating, Refrigerating and Air-Conditioning Engineers, 1791 Tullie Circle N.E., Atlanta, GA 30329, U.S.A.

[†]It is acceptable to use other consistent units, such as gal/day [L/day]

(This appendix is not part of this standard. It is merely informative and does not contain requirements necessary for conformance to the standard. It has not been processed according to the ANSI requirements for a standard and may contain material that has not been subject to public review or a consensus process. Unresolved objectors on informative material are not offered the right to appeal at ASHRAE or ANSI.)

APPENDIX A INFORMATIVE REFERENCES

1. *2016 ASHRAE Handbook—HVAC Systems and Equipment*, Chapter 22, American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., 2016.
2. *2017 ASHRAE Handbook—Fundamentals*, Chapter 36, American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., 2017.
3. *ANSI/ASHRAE 41.3-2014, Standard Methods for Pressure Measurement*. American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. 2014.
4. *ANSI/ASHRAE 41.6-2014, Standard Method for Humidity Measurement*. American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., 2014.
5. AHRI Standard 640-2017, *Performance Rating of Commercial and Industrial Humidifiers*, 2017 Air Conditioning Heating and Refrigeration Institute, 2111 Wilson Blvd, Suite 500, Arlington, VA 22203, USA.