AHRI Standard 600-2023 (I-P)

2023 Standard for

Performance Rating of Water/Brine to Air Heat Pump Equipment

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IMPORTANT

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ICS Code: 27.080

Note:

This is a new standard; a prior version does not exist.

For SI ratings, see AHRI Standard 601 (SI), which is currently under development.

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Intent

This standard is intended for the guidance of the industry, including manufacturers, engineers, installers, contractors, and users.

Review and Amendment

This standard is subject to review and amendment as technology advances.

2023 Edition

This edition of AHRI Standard 600, *Performance Rating of Water/Brine to Air Heat Pump Equipment*, was prepared by the Geothermal and Water-Source Heat Pump Standards Technical Committee. The standard was approved by the Unitary Standards Subcommittee on 11 September 2023.

Origin and Development of AHRI Standard 600

In the last few years the DOE has promoted moving commercial WSHP's to IEER metric. IEER is not a recognized metric by ISO so AHRI began the development of a separate AHRI 600 IEER Calculation Methodology Standard for WSHP as simply an IEER calculation methodology using original ISO/AHRI/ANSI/ASHRAE 13256:98 performance data. This draft AHRI 600 WSHP IEER calculation standard did go out for public review in the fourth quarter of 2022, but development was shortly thereafter halted.

After a review, the WSHP standards committee felt the recommended DOE changes diverged so significantly from ISO/AHRI/ANSI/ASHRAE 13256:98 standard that it warranted development of a new AHRI standard and recommended eventually abandoning ISO/AHRI/ANSI/ASHRAE 13256:98. Therefore, beginning in first quarter 2023 a new expanded AHRI 600 Performance Rating of Water/Brine to Air Heat Pump Equipment was developed using AHRI 340/360 as a framework and included the IEER methodology from the original AHRI 600. The current version is complete with commercial metrics and includes IEER calculation requirements. The committee's next task is to add in the residential seasonal metric sections using AHRI 210/240 as inspiration.

Committee Personnel

Geothermal and WSHP Standards Technical Committee

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Geothermal and WSHP Standards Technical Committee Scope:

The Geothermal and Water Source Heat Pump Standards Technical Committee is responsible for the development and maintenance of AHRI standards and guidelines pertaining to Water-Source, Ground Water-Source, and Ground-Source Closed-Loop Heat Pumps equipment; Calculation of Integrated Energy Efficiency Ratio (IEER) and Simultaneous Heating and Cooling Efficiency (SCHE) for Water-Source Heat Pumps; Direct Geo exchange Heat Pumps; Water-to-Air Heat Pumps and Brine-to-Air Heat Pumps Seasonal Efficiency Ratings Calculations.

The following product types are out of scope for this STC: Unitary Small Equipment, Packaged Terminal AC/HP, Commercial or Industrial AC/HP, Furnaces, Variable Refrigerant Flow (VRF), Single Package Vertical Unit (SPVU), and Performance Rating of Zoning products.

For product definitions refer to the AHRI website sector pages.

Unitary Standards Subcommittee

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Unitary Standards Subcommittee Scope:

The scope of the Unitary Standards Subcommittee is standards and guidelines related to the end products that are part of the AHRI Unitary Industry Sector. (The definition of and list of products associated with each sector are found on the AHRI website sector pages.)

These lists represent the membership at the time the Standards Technical Committee and Standards Subcommittee were balloted on the final text of this edition. Since that time, changes in the membership may have occurred. Membership on these committees shall not in and of itself constitute an endorsement by the committee members or their employers of any document developed by the committee on which the member serves.

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PERFORMANCE RATING OF WATER/BRINE TO AIR HEAT PUMP EQUIPMENT

Section 1. Purpose

This standard establishes definitions, classifications, test requirements, rating requirements, minimum data requirements for *published ratings*, operating requirements, marking and nameplate data, and conformance conditions for *water/brine to air heat pump equipment*:

Section 2. Scope

2.1 Scope

This standard applies to factory-made *water/brine to air heat pump equipment* as defined in Section 3.

This standard applies only to electrically operated, vapor compression refrigeration systems.

2.2 Exclusions

This standard does not apply to the following:

- Rating and testing of independent components, such as condensing units or coils, for separate use
- Air-cooled unitary air-conditioners and unitary heat pumps as defined in AHRI 210/240, with capacities less than 65,000 Btu/h
- Commercial and industrial unitary air-conditioning and heat pump equipment as defined in AHRI 340/360 (I-P)
- Variable refrigerant flow air-conditioners and heat pumps as defined in AHRI 1230
- Rating of units equipped with *desuperheater*/water heating devices, as defined in AHRI 470, in operation
- Commercial and industrial unitary air-conditioning condensing units with a capacity greater than 135,000 Btu/h as defined in AHRI 365 (I-P)

Section 3. Definitions

All terms in this document shall follow the standard industry definitions in the ASHRAE Terminology website unless otherwise defined in this section.

3.1 Expression of Provisions

Terms that provide clear distinctions between requirements, recommendations, permissions, options, and capabilities.

3.1.1 "Can" or "cannot"

Express an option or capability.

3.1.2 "May"

Signifies a permission expressed by the document.

3.1.3 "Must"

Indication of unavoidable situations and does not mean that an external constraint referred to is a requirement of the document.

3.1.4 "Shall" or "shall not"

Indication of mandatory requirements to strictly conform to the standard and where deviation is not permitted.

3.1.5 “Should” or “should not”

Indication of recommendations rather than requirements. In the negative form, a recommendation is the expression of potential choices or courses of action that is not preferred but not prohibited.

3.2 Standard Specific Definitions

3.2.1 Air Economizer

An automatic system that enables a cooling system to supply and use outdoor air to reduce or eliminate the need for mechanical cooling during mild or cold weather, provides energy efficiency improvements on an annualized basis, and is a function of regional ambient conditions.

3.2.2 Air Sampling Device(s)

A combination of *air sampling tree(s)*, conduit, fan and *aspirating psychrometer* or *dew-point hygrometer* used to determine dry-bulb temperature and moisture content of an air sample from critical locations.

3.2.2.1 Air Sampling Tree

An assembly consisting of a manifold with branch tubes with multiple sampling holes that draws an air sample from the indoor air inlet or outlet.

3.2.2.2 Aspirating Psychrometer

An instrument used to determine the humidity of air by simultaneously measuring both the wet-bulb and dry-bulb temperatures. The difference between these temperatures is referred to as the wet-bulb depression.

3.2.2.3 Dew-point Hygrometer

An instrument used to determine the humidity of air by detecting visible condensation of moisture on a cooled surface.

3.2.3 Barometric Relief Dampers

An assembly with dampers that open when there is a positive pressure differential.

3.2.4 Basic Model

All systems within a single equipment class, as defined in 10 CFR Part 431, having the same primary energy source, such as electricity or natural gas, and that have the same or comparable compressors, same or comparable heat exchangers, and same or comparable nominal capacity.

3.2.5 Coated Coils

An indoor coil or outdoor coil whose entire surface, including the entire surface of both fins and tubes, is covered with a thin continuous non-porous coating to reduce corrosion.

3.2.6 Coefficients of Performance

3.2.6.1 Coefficient of Performance (COP)

A ratio of the *heating capacity* in watts to the power input values in watts at any given set of *rating conditions* expressed in watts/watt.

3.2.6.2 Applied Coefficient of Performance (ACOP)

A ratio of the *heating capacity* in watts to the power input values in watts at *standard rating conditions* H2, including system pump and cooling tower power, expressed in watts/watt, as determined in Section 6.4.5.

3.2.7 Coil-only Indoor Unit

An *indoor unit* that is distributed in commerce without an indoor fan or separate designated air mover, and when installed in the field, relies on a separately installed furnace or modular blower for indoor air movement.

3.2.8 Compressor Modulation

3.2.8.1 Compressor Modulation Level

The level of operation of the unit that is determined by the number of compressors operating and the modulation level of each operating compressor. The modulation level of a single compressor is determined by the speed, pulse width, mechanical loading, and any other operating parameters that affect the continuous capacity of the compressor at a single set of operating conditions.

3.2.8.2 Intermediate Compressor Modulation Level

A *compressor modulation level* that results in a continuous capacity between that of the minimum and *maximum compressor modulation levels*. Section 6.3.2.4 and Section 6.3.2.5 specify requirements used in this standard.

3.2.8.3 Maximum Compressor Modulation Level

The *compressor modulation level* that results in the maximum continuous capacity allowed by the controls at a single set of operating conditions.

3.2.8.4 Minimum Compressor Modulation Level

The *compressor modulation level* that results in the minimum continuous capacity allowed by the controls at a single set of operating conditions.

3.2.9 Condenser Pump/Valves/Fittings

Additional components in the water/brine circuit for flow control or filtering.

3.2.10 Condenser Water Reheat

A heat exchanger located downstream of the indoor coil that heats the supply air during cooling operation using water from the condenser coil to increase the ratio of moisture removal to *cooling capacity* provided by the equipment.

3.2.11 Constant-Volume Fan

A fan with automatic adjustment of operating speed to provide a fixed airflow rate.

3.2.12 Cooling Capacity

The capacity associated with the change in air enthalpy that includes both the latent and sensible capacities expressed in Btu/h.

3.2.12.1 Latent Capacity

Capacity associated with a change in humidity ratio, expressed in Btu/h.

3.2.12.2 Sensible Capacity

Capacity associated with a change in dry-bulb temperature, expressed in Btu/h.

3.2.13 Desiccant Dehumidification Components

An assembly that reduces the moisture content of the *supply air* through moisture transfer with solid or liquid desiccants.

3.2.14 Desuperheater

A heat exchanger located downstream of the compressor on the high-pressure vapor line that moves heat to an external source, such as potable water.

3.2.15 Energy Efficiency Ratios

3.2.15.1 Energy Efficiency Ratio (EER)

A ratio of the *cooling capacity* in Btu/h to the power input values in watts at any given set of *rating conditions*, expressed in Btu/(W·h).

3.2.15.2 Applied Energy Efficiency Ratio (AEER)

A ratio of the full-load *cooling capacity* in Btu/h to the power input values in watts at *standard rating conditions* C3, including system pump and cooling tower power, expressed in Btu/(W·h), as determined in Section 6.3.11.2.

3.2.16 Evaporative Cooling of Ventilation Air

Indirectly or directly cooling ventilation air with water.

3.2.16.1 Direct Evaporative Cooling of Ventilation Air

A system that introduces water directly into the ventilation air.

3.2.16.2 Indirect Evaporative Cooling of Ventilation Air

A system where water is evaporated in secondary air stream and the heat is removed through a heat exchanger.

3.2.17 Fire/Smoke/Isolation Dampers

A damper assembly that includes means to open and close the damper mounted at the supply or return duct opening of the equipment.

3.2.18 Fixed Capacity Controlled Units

Products limited by the controls to a single stage of refrigeration capacity.

3.2.19 Fresh Air Dampers

An assembly with dampers and means to set the damper position in a closed and one open position to draw air into the equipment when the indoor fan is operating.

3.2.20 Full Load Rated Indoor Airflow

The *standard airflow* rate at 100% capacity as defined by the *manufacturer's installation instructions* and at the full-load cooling external static pressure (ESP).

3.2.21 Grill Options

Special grills used to direct airflow in unique applications such as up and away from a rear wall.

3.2.22 Heating Capacity

The capacity associated with the change in dry-bulb temperature between the air entering the unit and the air leaving the unit and includes the heat of circulation fan(s) and motor(s) but does not include supplementary heat, expressed in Btu/h.

3.2.23 High-effectiveness Indoor Air Filtration

Indoor air filters with greater air filtration effectiveness than the *standard filter*.

3.2.24 Hot Gas Bypass

A method for adjusting *cooling capacity* that diverts a portion of the high pressure, hot gas refrigerant from the source heat exchanger to the low-pressure portion of the refrigerant system.

3.2.25 Indoor Side

The part of the system that removes heat from or adds heat to the indoor airstream.

3.2.26 Indoor Unit

The portion of a split heat pump that houses the *indoor side* and can include other components.

3.2.27 Integrated Energy Efficiency Ratio (IEER)

A weighted calculation of mechanical cooling efficiencies at *standard rating conditions*, expressed in Btu/(W·h), as determined in Section 6.3.9.

3.2.28 Low-static Heat Pump

Ducted equipment that produces greater than 0.10 in H_20 ESP and less than 0.40 in H_20 ESP when operated at the full load cooling airflow rate.

3.2.29 Manufacturer Instructions

3.2.29.1 Manufacturer's Installation Instructions

Manufacturer's documents that come packaged with or appear in the labels applied to the unit(s), as specified in Section 5.4.2.1.

3.2.29.2 Supplemental Test Instructions (STI)

Additional instructions developed by the manufacturer and certified to the United States Department of Energy (DOE), as specified in Section 5.4.2.2.

3.2.29.3 Manufacturer-specified

Information provided by the manufacturer through *manufacturer's installation instructions* or *STI*.

3.2.30 Non-Standard Low-Static Indoor Fan Motor

An indoor fan motor for a unit with a rated cooling capacity of 75,000 Btu/h, or greater, that cannot maintain ESP as high as specified in Section 5.5 when operating at the *full load rated indoor airflow* and is distributed in commerce as part of an individual model within the same basic model distributed in commerce with a different motor specified for testing that can maintain the required ESP.

3.2.31 Outdoor Side

The part of the system that rejects heat to or absorbs heat from the water or brine.

3.2.32 Outdoor Unit

The portion of a split heat pump that houses the *outdoor side* and can include other components.

3.2.33 Part Load Rated Indoor Airflow

The *standard airflow* at the part-load rating conditions as defined by the *manufacturer's installation instructions* and at the part-load ESP. This can be different for each part-load rating point.

3.2.34 Percent Load

The ratio of the *cooling capacity* at any set of *rating conditions*, to the calculated *cooling capacity* at IEER point A in in Table 10, expressed in units of percent, %.

3.2.35 Power Correction Capacitors

A capacitor that increases the power factor measured at the line connection to the equipment.

3.2.36 Powered Exhaust Air Fan

A fan that transfers directly to the outside a portion of the building air that is returning to the unit, rather than the building air recirculating to the indoor coil and back to the building.

3.2.37 Powered Return Air Fan

A fan that draws building air into the equipment.

3.2.38 Process Heat Recovery / Reclaim Coils / Thermal Storage

A heat exchanger located inside the unit that conditions the equipment's *supply air* using energy transferred from an external source using a vapor, gas, or liquid.

3.2.39 Proportionally Capacity Controlled Units

Units incorporating one or more variable-speed or variable-capacity compressors where the unit capacity can be modulated continuously or in steps not more than 5% of full-load capacity over a range of at least 50% to 100% of full-load capacity.

3.2.40 Published Rating

A statement of the assigned values of those performance characteristics, under stated *rating conditions*, where a unit can be chosen to fit the application. These values apply to all units of the same nominal size and type (identification) produced by the same manufacturer. This includes the rating of all performance characteristics shown on the unit or published in specifications, advertising or other literature controlled by the manufacturer, at stated *rating conditions*.

3.2.40.1 Application Rating

A rating based on tests performed at rating conditions other than *standard rating conditions*.

3.2.40.2 Standard Rating

A rating based on tests performed at *standard rating conditions*.

3.2.41 Rating Conditions

Any set of operating conditions where a single level of performance results and causes only that level of performance to occur.

3.2.42 Refrigerant Reheat Coils

A heat exchanger located downstream of the indoor coil that heats the *supply air* during cooling operation using high pressure refrigerant to increase the ratio of moisture removal to *cooling capacity* provided by the equipment.

3.2.43 Single Package Heat Pumps

Units that are assembled or designed to be assembled in a single unit (within a single factory-made enclosure).

3.2.44 Sound Traps/Sound Attenuators

An assembly of structures where the supply air passes before leaving the equipment or where the return air from the building passes immediately after entering the equipment where the sound insertion loss is at least 6 dB for the 125 Hz octave band frequency range.

3.2.45 Split System Heat Pump

Heat pump designed with an *outdoor unit* that is installed remotely from the indoor coil, air handler, or fan coil and requiring field connection by refrigerant lines.

3.2.46 Staged Capacity Controlled Units

Units incorporating only fixed capacity or discrete steps of compression and are limited by the controls to multiple stages of refrigeration capacity. Units that have multiple stages of refrigeration that do not meet the definition of Section 3.2.39, *proportionally capacity controlled units*, meet this definition.

3.2.47 Standard Air

In I-P units, air weighing 0.075 lb/ft^3 that approximates dry air at 70°F and at a barometric pressure of 29.92 in Hg.

3.2.48 Standard Airflow

The volumetric flowrate of air converted to *standard air* conditions expressed in standard cubic feet per minute (scfm).

3.2.49 Standard Filter

The filter with the lowest level of filtration that is distributed in commerce with a model, as specified in Section 5.4.5.

3.2.50 Standard Rating Conditions

Rating conditions used as the basis of comparison for performance characteristics.

3.2.51 Steam/Hydronic Heat Coils

Coils used to provide supplemental heating that use steam or liquid as the working fluid.

3.2.52 Supply Air

Air delivered by a unit to the conditioned space expressed as *standard air*.

3.2.53 UV Lights

A lighting fixture and lamp that shines light on the indoor coil, emitting ultraviolet light to inhibit growth of organisms on the indoor coil surfaces, the condensate drip pan, or other locations within the equipment.

3.2.54 Ventilation Energy Recovery System (VERS)

A system that preconditions outdoor air entering the unit through direct or indirect thermal or moisture exchange, or both thermal and moisture exchange, with the exhaust air.

3.2.55 Water/Brine to Air Heat Pump Equipment

A heat pump that consists of one or more factory-made assemblies with an indoor conditioning coil with air-moving means (except that *coil-only indoor units* do not have air-moving means), compressor(s), and refrigerant-to-water or refrigerant-to-brine heat exchanger(s), including means to provide both cooling and heating, cooling-only, or heating-only functions.

3.2.56 Waterside Economizer

A heat exchanger located upstream of the indoor coil that conditions the *supply air* when system water loop conditions are favorable so as not to utilize compressor operation.

Section 4. Classifications

Water/brine to air heat pump equipment within the scope of this standard shall be classified as shown in Table 1 and Table 2.

Table 1 Classification of Water/Brine to Air Conditioning Equipment

Designation	AHRI Type[1,2]	Arrangement – Indoor (ID)	Arrangement – Outdoor (OD)
Single Package and Indoor Package Air-conditioners	WBAC[4]	—	ELECTRIC HEAT[3] CD PUMP[3] ID FAN COMPRESSOR EVAPORATOR CONDENSER
Indoor Package Air-conditioners	WBAC-O[4]	ELECTRIC HEAT3 CD PUMP[3] ID FAN COMPRESSOR EVAPORATOR CONDENSER	—
Split System Air-conditioners: Condensing Unit, Coil Alone	WBAC-C[4]	ELECTRIC HEAT[3] EVAPORATOR	CD PUMP[3] ELECTRIC HEAT3 COMPRESSOR ID FAN CONDENSER
Split System Air-conditioners: Condensing Unit, Coil and Fan	WBAC-CB	ELECTRIC HEAT[3] ID FAN EVAPORATOR	CD PUMP[3] COMPRESSOR CONDENSER

Notes:

1. A suffix of "-O" following any of the above classifications indicates equipment not intended for use with field-installed duct systems.
2. Components can be installed indoors as well in accordance with the *manufacturer's installation instructions*.
3. Optional component.
4. Can be any other heat source except for electric strip heat.

Table 2 Classification of Water/Brine to Air Heat Pump Equipment

Designation	AHRI Type[1,2]	Arrangement - Indoor (ID)	Arrangement – Outdoor (OD)
Single Package and Indoor Package Heat Pumps	WBAHP[4]	—	ELECTRIC HEAT[3] ID FAN EVAPORATOR CD PUMP[3] COMPRESSOR CONDENSER
Indoor Package Heat Pump	WBAHP-O[4]	ELECTRIC HEAT[3] ID FAN EVAPORATOR CD PUMP[3] COMPRESSOR CONDENSER	—
Split System Heat Pump: Condensing Unit, Coil Alone	WBAHP-C[4]	ELECTRIC HEAT[3] EVAPORATOR	CD PUMP[3] COMPRESSOR CONDENSER
Split System Heat Pump: Condensing Unit, Coil and Fan	WBAHP-CB	ELECTRIC HEAT[4] ID FAN EVAPORATOR	CD PUMP[3] COMPRESSOR CONDENSER

Notes:
1. A suffix of "-O" following any of the above classifications indicates equipment not intended for use with field-installed duct systems.
2. Components can be installed indoors as well in accordance with the *manufacturer's installation instructions*.
3. Optional component.
4. Can be any other heat source except for electric strip heat.

Section 5. Test Requirements

5.1 Summary

Perform all *standard rating* tests in accordance with ASHRAE 37, including the errata sheet issued 27 March 2019, and the additional requirements in Section 5 of this standard. In cases where there is a conflict, the language of this standard takes precedence over the language of ASHRAE 37.

5.2 Capacity Measurement

5.2.1 Primary Capacity Measurement

Use the indoor air enthalpy method specified in Section 7.3 of ASHRAE 37 as the primary method for capacity measurement.

5.2.2 Secondary Capacity Measurement

Use the outdoor liquid coil method, refrigerant enthalpy method, or compressor calibration method specified in Table 1 of ASHRAE 37 as a secondary method for capacity measurement for all tests.

5.2.2.1 Outdoor Liquid Coil Method

5.2.2.1.1 ASHRAE 37 Requirements

If using the outdoor liquid coil method for secondary capacity measurement, follow all requirements in ASHRAE 37 relevant for the outdoor liquid coil method.

5.2.2.1.2 Agreement with Primary Capacity Measurement

The secondary capacity measurement from the outdoor liquid coil method shall be within ± 6% of the primary capacity measurement for all tests, including part-load tests.

5.2.2.2 Refrigerant Enthalpy Method

5.2.2.2.1 ASHRAE 37 Requirements

If using the refrigerant enthalpy method for secondary capacity measurement, follow all requirements in ASHRAE 37 relevant for the refrigerant enthalpy method, except that Section 7.5.1.3 of ASHRAE 37 does not apply for part-load cooling tests. Refrigerant enthalpy method measurements shall be taken for part-load tests regardless of the measured subcooling or superheat.

5.2.2.2.2 Agreement with Primary Capacity Measurement

The secondary capacity measurement from the refrigerant enthalpy method shall be within ± 6% of the primary capacity measurement for all full-load cooling tests and all heating tests. A match between primary and secondary measurements is not required for part-load cooling tests.

5.2.2.2.3 Refrigerant Flow Measurement Device

Refrigerant flow measurement device(s) shall be either elevated at least two ft from the test chamber floor or placed upon insulating material having a total thermal resistance R-value of at least 12 hr · ft^2 · °F/Btu and extending at least one ft laterally beyond each side of the exposed surfaces of the device(s).

5.2.2.2.4 Evaluation of Saturation Temperature

Saturation temperature shall be evaluated based on the pressure transducer located between the indoor coil and the compressor for the given operating mode, that is heating or cooling.

5.2.2.3 Compressor Calibration Method

5.2.2.3.1 ASHRAE 37 Requirements

If using the compressor calibration method for secondary capacity measurement, follow all requirements in ASHRAE 37 relevant for the compressor calibration method.

5.2.2.3.2 Evaluation of Saturation Temperature

Saturation temperature shall be evaluated based on the pressure transducer located between the indoor coil and the compressor for the given operating mode, that is heating or cooling.

5.3 Instrumentation

5.3.1 Power Measurements

Either power (in W) or integrated power (in W·h) shall be measured. Units with digitally modulating compressors require either an integrated power measurement or power measurements recorded at intervals not longer than one second.

5.3.2 Air Conditions

The air conditions shall be measured using the procedures defined in Appendix C.

5.3.3 Induction Watt-hour Meter

When testing air conditioners and heat pumps that have a variable speed drive, an induction watt-hour meter shall not be used.

5.3.4 Atmospheric Pressure Instrument Accuracy

Atmospheric pressure measuring instruments shall be accurate to within ± 0.5% of the reading.

5.3.5 Electrical Frequency Instrument Accuracy

Measurement devices used to measure electrical frequency shall be accurate to within ± 0.2 Hz.

5.3.6 Methanol Content Measurement Uncertainty

The uncertainty of measurement for the methanol content of the aqueous methanol solution shall be ± 1.5 percentage points of solution concentration by mass or less.

5.4 Installation and Setup

5.4.1 Optional System Features

Use Appendix D to determine the optional system features to be included and activated during the tests.

5.4.2 Instructions

5.4.2.1 Manufacturer’s Installation Instructions

Units shall be installed in accordance with the *manufacturer’s installation instructions*. Online manuals can be used if referenced on the unit label or in the documents that come packaged with the unit.

All references to “manufacturer’s instructions,” “manufacturer's published instructions,” “manufacturer’s published recommendations,” “manufacturer installation and operation manuals,” “installation instructions,” and other similar references means *manufacturer’s installation instructions*.

The *manufacturer’s installation instructions* include certification reports provided to regulatory bodies by the manufacturer. The certified parameters in the certification reports shall not deviate from the *manufacturer’s installation instructions*.

5.4.2.2 Supplemental Test Instructions (STI)

STI are defined in Section 3.2.29.2 and shall include both:

1) all instructions that do not deviate from *manufacturer’s installation instructions* but provide additional specifications for test standard requirements that can have more than one option
2) all deviations from *manufacturer’s installation instructions* necessary to comply with steady state requirements

STI shall provide steady operation that matches to the extent achievable the average performance that can be obtained without deviating from the *manufacturer’s installation instructions*. *STI* shall not include instructions that deviate from *manufacturer’s installation instructions* other than those described in Section 5.4.2.2(2).

5.4.2.3 Conflicting Instructions

In the event of conflicting instructions regarding the setup of the unit under test, excluding charging instructions for split systems, priority shall be given to installation instructions that appear on the unit’s label over installation instructions that are shipped with the unit.

In the event of conflicting charging instructions for split systems, see Section 5.4.2.4.

5.4.2.4 Split Systems

In the event of conflicting charging instructions for split systems, priority shall be given to the installation instructions that are shipped with the unit over the installation instructions that appear on the unit's label. For split systems, if the *manufacturer's installation instructions* for the components conflict, priority shall be given to the *outdoor unit* instructions over the *indoor unit* instructions, except for provisions regarding setting indoor airflow and ESP. For setting indoor airflow and ESP for such a split system, priority shall be given to the *indoor unit* instructions over the *outdoor unit* instructions.

5.4.3 Break in

Conduct a compressor break-in period prior to conducting the test if there is a *manufacturer-specified* break-in period. Conduct the break-in period using the *manufacturer-specified* duration and conditions; however, the duration shall not exceed twenty hours and the liquid entering temperature shall not exceed 104°F. When there is a *manufacturer-specified* break-in period, each compressor of the unit shall undergo this break-in period. Testing shall not commence until the *manufacturer-specified* break-in period is completed.

5.4.4 Recirculated Indoor Air

Use 100% recirculated indoor air in all tests.

5.4.5 Indoor Air Filter

Tests shall be completed with the *standard filter* installed. The *standard filter* is the indoor air filter with the lowest level of filtration that is distributed in commerce with a model. If the manufacturer does not specify what filter option has the lowest level of filtration in *manufacturer's installation instructions* or marketing materials for the model, then the *standard filter* shall be the filter designated as the default filter or the standard filter in the marketing materials for the model. If the manufacturer does not specify a default filter option or the filter option that has the lowest filtration level, then the *standard filter* shall be any filter shipped by the manufacturer.

5.4.6 Duct Installation Requirements

ASHRAE 37 duct requirements shall be followed, except as specified in Section 5.4.7.

The test apparatus including the interconnecting ductwork shall be insulated to have a minimum R-value of 13 $ft^2 \cdot °F \cdot hr/Btu$. Duct losses can be calculated using conduction factors, inside air and outside ambient temperature difference, and the total duct surface area between the unit and the temperature measurement location. Ducts that are exposed to multiple ambient temperatures shall be divided into zones and each zone calculated separately.

5.4.7 Non-Ducted Units

5.4.7.1 Free Air Test

A preliminary free air test shall be conducted prior to connecting a plenum, as specified in Section 5.4.7.3, ducting, and indoor air-side test apparatus to the unit. Airflow rate shall be set in accordance with Section 5.6. Operating tolerances defined in Table 7 shall be met for at least ten minutes, except for tolerances for indoor leaving air dry-bulb temperature, indoor leaving air wet-bulb temperature, ESP, and nozzle pressure drop. Record the average indoor fan power and average refrigerant temperature at the midpoint of the return bend of the indoor coil. After connecting the plenum, duct, and indoor air-side test apparatus to the unit, adjust the fan of the indoor air-side test apparatus attached to the duct as necessary to achieve the required plenum pressure of 0.00 in H_2O ESP with a tolerance of -0.00/+0.05 in H_2O.

The fan settings used for the preliminary free indoor air test shall remain unchanged throughout the full-load cooling test. Confirm that indoor fan power measured with the indoor air-side test apparatus connected is within 2% of the average values measured for the free air test. Confirm that refrigerant temperature at the midpoint of the return bend of the indoor coil is within 0.5°F of the average values measured for the free air test. Increase plenum size if necessary to match the measured values within these tolerances.

5.4.7.2 Inlet Plenum

An inlet plenum for non-ducted units shall not be used.

5.4.7.3 Outlet Plenum and Duct Requirements

For non-ducted units, a plenum (enlarged duct box) shall be installed between the duct and the *indoor unit*, as depicted in Figure 1. The plenum shall have a cross-sectional area at least two times the area of the *indoor unit* combined outlet. For all outlets, the plenum shall extend for a distance of at least 3.5 times the square root of the cross-sectional area of the units combined outlet prior to any duct transitions, elbows, or *air sampling tree* used for air condition measurement.

If elbows are connected to the end of the plenum, the elbows shall have a centerline radius equal to at least 1.5 times the duct width in the elbow's radial direction or have turning vanes. Air velocities calculated as measured volume flow divided by duct or plenum cross-sectional area shall not exceed 250 ft per minute inside the plenum and 500 ft per minute in the connecting duct at the connection to the plenum. Figure 1 shows a plenum construction example.

Manifolded static pressure taps shall be installed in the plenum in at least four locations spaced uniformly around the plenum in accordance with Section 6.5 of ASHRAE 37. The static pressure taps shall be located at a distance from the outlet equal to 2.8 times the square root of the cross-sectional area of the combined outlets. Static pressure in the plenum shall be maintained within 0.05 in H_2O of ambient pressure.

Air sampling trees used for temperature measurement shall be placed in the duct between the airflow measurement apparatus and the minimum required plenum length.

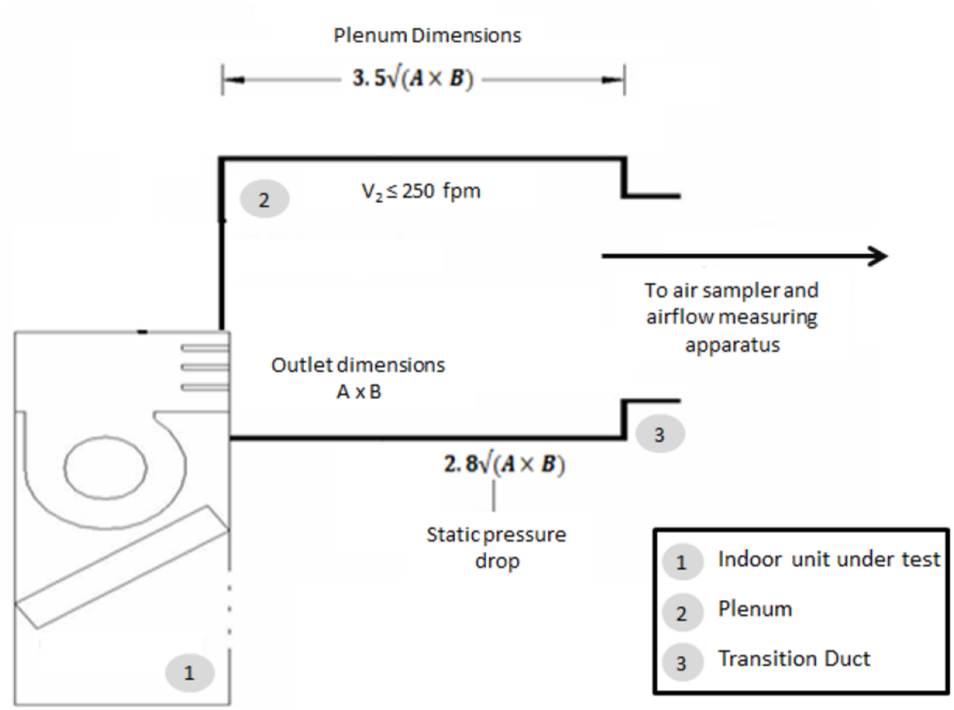

Figure 1 Example Test Setup for Outlet Plenum for Non-Ducted Units (Informative)

5.4.8 Units Too Tall for Test Chamber

If the height of the unit under test plus a vertical outlet duct with pressure taps for measuring ESP compliant with Section 6.4.2.1 or Section 6.4.3 of ASHRAE 37 is both greater than 14 ft and too tall for the test chamber, use the limited-height approach in Appendix E.

5.4.9 Test Unit Location

The unit, including both units for split systems, shall be located in the indoor test room.

5.4.10 Line Length for Split Systems

All *standard ratings* for equipment where the *outdoor unit* is separated from the *indoor unit* shall be determined with at least 25 ft of interconnection tubing on each line of the size specified in the *manufacturer's installation instructions*. The line sizes, insulation, and details of installation shall be in accordance with the *manufacturer's installation instructions*.

Use the absolute minimum length tubing necessary to physically connect the system, subject to the minimum specified length, but not use less than 25 ft. Such equipment where the interconnection tubing is furnished as an integral part of the machine and not intended to be cut to length in accordance with the *manufacturer's installation instructions*, shall be tested with the complete length of tubing furnished, or with 25 ft of tubing, whichever is greater.

If more than 25 ft of tubing is used, refer to Table 3 for *cooling capacity* correction factors that shall be applied only to the full load *cooling capacity* when the tested refrigerant line length exceeds the minimum values.

Table 3 Refrigerant Line Length Correction Factors

Tubing Length (X) Beyond the Required 25 ft of Tubing, ft	Cooling Capacity Correction Factor
$3.3 < X \leq 20$	1.01
$20 < X \leq 40$	1.02
$40 < X \leq 60$	1.03

5.4.11 Refrigerant Charging

5.4.11.1 Conditions and Criteria

Use the test or operating conditions specified in the *manufacturer's installation instructions* for charging. If the *manufacturer's installation instructions* do not specify a test or operating conditions for charging or if *manufacturer's installation instructions* are not provided, charging shall be conducted at *standard rating conditions* in cooling mode. If the *manufacturer's installation instructions* contain separate refrigerant charging criteria for field installation and lab testing, the field installation criteria shall be used. Perform charging of refrigerant blends only with refrigerant in the liquid state.

5.4.11.2 Parameter Ranges

If the *manufacturer's installation instructions* give a *manufacturer-specified* range for a charging parameter (for example, superheat, subcooling, or refrigerant pressure) the average of the range shall be used to determine the refrigerant charge.

5.4.11.3 No Manufacturer Instructions

If *manufacturer's installation instructions* are not provided or the *manufacturer's installation instructions* do not provide parameters and target values, or both, set superheat to a target value of 12°F for fixed orifice systems or set subcooling to a target value of 10°F for expansion valve systems.

5.4.11.4 Conflicting Information

If there are multiple *manufacturer-specified* conditions given for charge adjustment and not all *manufacturer-specified* conditions can be met, use the instruction priority order indicated in Section 5.4.2.

If the highest-ranking set of instructions where refrigerant charging instructions are provided give multiple conditions charge adjustment and not all the conditions can be met, follow the hierarchy in Table 4 unless the manufacturer specifies a different priority in the unit installation instructions. If the *manufacturer's installation instructions* do not specify a tighter charging tolerance, the tolerances specified in Table 4 shall be used.

Table 4 Tolerances for Charging Hierarchy

Fixed Orifice			Expansion Valve		
Priority	**Parameter**	**Tolerance**	**Priority**	**Parameter**	**Tolerance**
1	Superheat	± 2.0°F	1	Subcooling	± 2.0°F
2	High Side Pressure or Saturation Temperature	± 4.0 psi or ± 1.0°F	2	High Side Pressure or Saturation Temperature	± 4.0 psi or ± 1.0°F
3	Low Side Pressure or Saturation Temperature	± 4.0 psi or ± 1.0°F	3	Low Side Pressure or Saturation Temperature	± 2.0 psi or ± 0.8°F
4	Low Side Temperature	± 2.0°F	4	Approach Temperature[1]	± 1.0°F
5	High Side Temperature	± 2.0°F	5	Charge Weight	± 2.0 oz
6	Charge Weight	± 1% of nominal charge or 2.0 oz, whichever is greater	—	—	—
Note: 1. Approach temperature means the refrigerant temperature at the condenser liquid line minus the entering water/brine temperature.					

5.4.11.5 Single Package Unit

5.4.11.5.1 Install Refrigerant Line Pressure Gauges

Install one or more refrigerant line pressure gauges during the setup of the unit unless either of the following conditions are met:

1) the *manufacturer's installation instructions* indicate that pressure gauges shall not be installed
2) charging is based only on parameters, such as charge weight, that do not require measurement of refrigerant pressure

Use methods for installing pressure gauge(s) at the required location(s) as indicated in *manufacturer's installation instructions* if specified. Install pressure gauges depending on the parameters used to verify or set charge, as described in the following paragraphs.

5.4.11.5.2 Pressure Gauge on Liquid Line

Install a pressure gauge at the location of the service connections on the liquid line if charging is based on subcooling, or high side pressure, or corresponding saturation, or dew point temperature.

5.4.11.5.3 Pressure Gauge on Suction Line

Install a pressure gauge at the location of the service connection on the suction line if charging is based on superheat, or low side pressure or corresponding saturation or dew point temperature.

5.4.11.6 No Further Changes

The refrigerant charge obtained as described in this section shall be used to conduct all tests used to determine performance. All tests shall run until completion without further modification. If measurements indicate that refrigerant charge has leaked during the test, repair the refrigerant leak, repeat all setup steps from Section 5.4, and repeat all tests.

5.4.12 Supplementary Heat

Supplementary heat or operation of any heating components other than the reverse cycle heat pump functionality shall not be included.

5.4.13 Integral Pump

5.4.13.1 Commercial Ratings

For commercial ratings, if the unit has an integral pump, set the liquid ESP to 0.0 psi, or the minimum liquid ESP without added restriction if that minimum is greater than 0.0 psi.

5.4.13.2 Residential Ratings

For residential ratings, if the unit has an integral pump, set the liquid ESP to 7.0 psi, or the minimum liquid ESP without added restriction if that minimum is greater than 7.0 psi.

5.4.13.3 Tolerances

Maintain a -0.0/+1.0 psi condition tolerance and a 1.0 psi operating tolerance.

5.4.14 Test Liquid

The test liquid for all *standard rating* tests shall be a 15.0% ± 2.0% solution by mass of methanol in water. The solution concentration shall be verified prior to starting the *standard rating* tests and after completion of all *standard rating* tests. Valid *standard rating* tests shall have both concentration measurements within tolerance.

The thermodynamic properties of the aqueous methanol solution shall be calculated using the polynomial equations in Melinder (2010).

5.4.15 Liquid Flow Rate

Use a single *manufacturer-specified* liquid flow rate for all tests, unless automatic adjustment of the liquid flow rate is provided by the equipment, or the liquid flow rate is adjusted for operation at low condenser temperatures in accordance with Section 5.9. A separate control signal output for each step of liquid flow rate can be used as a form of automatic adjustment.

If there is not a *manufacturer-specified* liquid flow rate, and automatic adjustment of the liquid flow rate is not provided by the equipment, use a liquid flow rate of 0.250 gpm per kBtu/h for all tests.

The mean liquid flow rate for each full load cooling test shall not be higher than 0.275 gpm per kBtu/h. The mean liquid flow rate in each heating and part-load cooling test shall not be higher than the mean liquid flow rate measured for the full-load cooling test at *standard rating conditions* C3 in Table 8.

If using a target liquid flow rate, the condition tolerance on liquid flow rate is 1.0% of the target. If the liquid flow rate is adjusted automatically by the unit, there is not a condition tolerance on liquid flow rate.

5.5 Indoor Airflow External Static Pressure

5.5.1 Ducted Units with Integral Fans

5.5.1.1 Full-load Cooling Tests for Commercial Ratings

For commercial ratings of ducted units with integral fans, test at the ESP specified in Table 5 for full-load cooling tests. For units distributed in commerce without filters, add the additional static pressure allowance from Section 5.5.1.4 to the ESP specified in Table 5.

Table 5 External Static Pressure

Rated Cooling Capacity, Btu/h·1000[1]	External Static Pressure, in H_2O
From 0 to 28.8	0.10
From 29 to 42.9	0.15
From 43 to 74.9	0.20
From 75 to 134	0.75
From 135 to 280	1.00
281 and greater	1.50
Note: 1. Full-load *cooling capacity* measured for *standard rating condition* C3.	

5.5.1.2 Full-load Cooling Tests for Residential Ratings

For residential ratings of ducted units with integral fans, other than *low-static heat pumps*, operate at an ESP of 0.50 in H_2O for full-load cooling tests. For residential ratings of *low-static heat pumps*, operate at an ESP of 0.10 in H_20 for full-load cooling tests.

5.5.1.3 All Tests Other Than Full-load Cooling Tests

When conducting heating or part-load tests of ducted units where the *manufacturer-specified* fan control settings, or rated airflow rates are different than for the full-load cooling test, or both, calculate adjusted ESP requirements using Equation 1.

$$ESP_{adj} = ESP_{FL}\left(\frac{Q_{dif}}{Q_{FL}}\right)^2 \quad (1)$$

Where:

ESP_{adj}	=	Adjusted ESP requirement at heating airflow or part-load airflow, in H_2O
ESP_{FL}	=	ESP requirement at full-load cooling airflow, in H_2O
Q_{dif}	=	Measured part-load or heating airflow, scfm
Q_{FL}	=	Measured full-load cooling airflow, scfm

5.5.1.4 Testing Without a Filter

For units distributed in commerce without a filter that are not classified as *coil-only indoor units*, an additional static pressure allowance shall be added to the minimum static pressure for full-load cooling tests. The additional static pressure shall be based on the filter face area, as defined in the *manufacturer's installation instructions*, and the rated full-load cooling airflow rate. For units that do not specify a filter face area or units where a 2 in filter rack is not an option, the face area of the evaporator shall be used. For all tests other than full-load cooling tests, the additional static pressure allowance shall be reduced in accordance with Equation 2.

$$ESP_{filter} = 0.000108\left(\frac{Q_{FL}}{A_{ft}}\right)^{1.3} \quad (2)$$

Where:

ESP_{filter}	=	Additional static pressure allowance, in H_2O
Q_{FL}	=	Rated full-load cooling airflow, scfm
A_{ft}	=	Filter face area, ft^2

5.5.2 Coil-only Systems

For *coil-only indoor units*, the pressure drop across the indoor assembly shall not exceed 0.30 in H_2O for the full-load cooling test. If this pressure drop is exceeded, reduce the airflow rate until the measured pressure drop equals the specified maximum. Test *coil-only indoor units* without a filter.

5.5.3 Non-ducted Systems

For non-ducted systems, test at an ESP for all units of 0.00 in H_2O for all test conditions.

5.6 Indoor Airflow Target Values

5.6.1 Standard Airflow

All airflow rates, including those used for determining capacity, shall be expressed in terms of *standard airflow*. When converting measured airflow to *standard air*, the conversion shall be based on the air density at the airflow test measurement station.

5.6.2 Units with Integral Fans

5.6.2.1 Full-load Cooling

For the full-load cooling test, use the cooling *full load rated indoor airflow*. If there is not a *manufacturer-specified* cooling *full load rated indoor airflow*, use a value of 400 scfm per 12,000 Btu/h of rated *cooling capacity*.

5.6.2.2 Heating

For the heating tests, use the heating *full load rated indoor airflow*. If there is not a *manufacturer-specified* heating *full load rated indoor airflow*, use the airflow that results from using the *manufacturer-specified* heating fan control settings at the adjusted ESP requirement determined in accordance with Section 5.5. If there is not a *manufacturer-specified* heating *full load rated indoor airflow* and *manufacturer-specified* heating fan control settings are not provided, but the *manufacturer's installation instructions* describe how to obtain steady-state heating operation using thermostat or other control system input that result in an automatic adjustment to airflow, use those instructions. If none of this information is accessible, use the cooling *full load rated indoor airflow* for the heating tests.

5.6.2.3 Part-load Cooling Tests

For part-load tests, use the *part load rated indoor airflow*. If there is not a *manufacturer-specified* cooling *part load rated indoor airflow*, use the airflow that results from using the *manufacturer-specified* part-load fan control settings at the ESP requirement determined in accordance with Section 5.5. If there is not a *manufacturer-specified* cooling *part load rated indoor airflow* and *manufacturer-specified* part-load fan control settings for the test point are not provided, but the *manufacturer's installation instructions* describe how to obtain steady-state part-load operation using thermostat or other control system input that results in an automatic adjustment to airflow, use those instructions. If none of this information is accessible, use the cooling *full load rate indoor airflow* for the part-load tests.

5.6.3 Coil-only Units

5.6.3.1 Full-load Cooling

For full-load cooling tests of *coil-only indoor units*, the indoor airflow rate shall be the lesser of the cooling *full load rated indoor airflow*, or the airflow equal to 450 scfm per ton of rated *cooling capacity*. If there is not a *manufacturer-specified* cooling *full load rated indoor airflow*, use a value of 400 scfm per ton of rated *cooling capacity*. Maintain the airflow within ± 3% of the target airflow throughout the test.

5.6.3.2 Heating and Part-load

For heating tests and part-load tests of *coil-only indoor units*, the indoor airflow rate shall be the lesser of the *manufacturer-specified* airflow rate for that test; or the measured full-load cooling airflow. If there is not a *manufacturer-specified* airflow rate for that test, use the measured full-load cooling airflow rate. Maintain the airflow within ± 3% of the target airflow throughout the test.

5.7 Setting Airflow and ESP for Ducted Units with Integral Fans

5.7.1 Conditions for Setting Airflow Before Test

For each test, set indoor airflow while operating the unit at the *rating conditions* specified in Table 8 for the test. After setting the airflow, adjustments shall not be made to the fan control settings during the test.

5.7.2 Tolerances

All tolerances for airflow and ESP specified in Section 5.7 for setting airflow and ESP are condition tolerances that apply for each test. The average value of a parameter measured over the course of the test shall vary from the target value by not more than the condition tolerance. Operating tolerances for ESP and nozzle pressure drop are specified in Table 7.

5.7.3 Setting ESP with a Constant-Volume Fan

5.7.3.1 Initial ESP Value

When testing with a *constant-volume fan*, achieve the ESP as close to but not less than the applicable Section 5.5 or Section 5.6 value that does not cause either air volume rate variations Q_{Var} of more than 10% or an automatic shutdown of the indoor fan. See Equation 3.

$$Q_{var} = \left[\frac{\dot{Q}_{max} - \dot{Q}_{min}}{\left(\frac{\dot{Q}_{max} + \dot{Q}_{min}}{2} \right)} \right] \cdot 100 \qquad (3)$$

Where:

Q_{max} = Maximum measured airflow, cfm

Q_{min} = Minimum measured airflow, cfm

Section 5.7.3.2 through Section 5.7.3.6 are required if the mean measured ESP exceeds the target minimum value by more than 0.05 in H_2O.

5.7.3.2 Thirty-minute Interval

Measure and record the average power consumption of the indoor fan and the mean ESP (ESP_1) during the thirty-minute interval used for determining capacity.

5.7.3.3 Adjust to Higher ESP

After completing the thirty-minute interval, adjust the exhaust fan of the airflow measuring apparatus until the ESP increases to $ESP_{2,target}$, as defined by Equation 4, with a condition tolerance of -0.00/+0.05 in H_2O, where ESP_{min} is equal to the target minimum ESP from Section 5.5.

$$ESP_{2,target} = ESP_1 + (ESP_1 - ESP_{min}) \qquad (4)$$

5.7.3.4 Five-minute Interval

Upon achieving a steady state at the higher external static pressure ESP_2 condition, record average power consumption and average ESP for a minimum five-minute interval.

5.7.3.5 Adjust Measured Power

Subtract the power adjustment (P_{adj}) as calculated in accordance with Equation 5 from the total power measured during the thirty-minute interval in Section 5.7.3.2.

$$P_{adj} = \frac{(P_{fan,2} - P_{fan,1})}{(ESP_2 - ESP_1)} \cdot (ESP_{min} - ESP_1) \qquad (5)$$

Where:

$P_{fan,2}$	=	Measured power input of the indoor fan at ESP_2, W
$P_{fan,1}$	=	Measured power input of the indoor fan at ESP_1, W
ESP_1	=	mean ESP measured during thirty-minute interval in Section 5.7.3.2, in H_2O
ESP_2	=	mean ESP measured during five-minute interval in Section 5.7.3.4, in H_2O

5.7.3.6 Adjust Measured Capacity

For cooling tests, add the capacity adjustment (q_{adj}) as calculated in accordance with Equation 6 to the total *cooling capacity* measured during the thirty-minute interval in Section 5.7.3.2.

For heating tests, subtract the capacity adjustment (q_{adj}) as calculated in accordance with Equation 6 from the *heating capacity* measured during the thirty-minute interval in Section 5.7.3.2.

$$q_{adj} = 3.412 \cdot P_{adj} \quad (6)$$

Where:

P_{adj}	=	Power adjustment calculated in Section 5.7.3.5.

5.7.4 Full-load Cooling Tests

5.7.4.1 First Setting and Adjustment

Operate the unit using the *manufacturer-specified* fan control settings. If there are not *manufacturer-specified* fan control settings, use the as-shipped fan control settings. Adjust the airflow-measuring apparatus to maintain ESP within -0.00/+0.05 in H_2O of the requirement specified in Section 5.5 and to maintain the airflow within ± 3% of the cooling *full load rated indoor airflow*.

For units with a *constant-volume fan*, if the ESP exceeds the minimum or targeted ESP by +0.05 in H_2O, or the setting causes air volume rate variations (Q_{var} in Section 5.7.3.1) more than 10% or an automatic shutdown of the indoor fan, use the procedure from Section 5.7.3.

5.7.4.2 If Above Tolerance

If ESP or airflow are higher than the tolerance range, adjust the fan control settings to maintain both ESP and airflow within tolerance. If ESP or airflow are higher than the tolerance range at the lowest fan control setting, adjust the airflow-measuring apparatus to maintain airflow within tolerance and operate with an ESP as close as achievable to the minimum requirement specified in Section 5.5. Use the measured higher airflow as the target airflow for all subsequent tests that call for the cooling *full load rated indoor airflow*.

5.7.4.3 If Below Tolerance

If ESP or airflow are lower than the tolerance range, adjust the fan control settings to maintain both ESP and airflow within tolerance. If ESP or airflow are lower than the tolerance range at the maximum fan control setting and the motor is not a *non-standard low-static indoor fan motor*, adjust the airflow-measuring apparatus to maintain ESP within tolerance and operate with an airflow as close as achievable to the *manufacturer-specified* value. Use the measured lower airflow as the target airflow for all subsequent tests that call for the cooling *full load rated indoor airflow*.

If the motor is a *non-standard low-static indoor fan motor*, use the maximum fan speed that does not overload the motor or motor drive and adjust the airflow-measuring apparatus to maintain airflow within tolerance, and operate with an ESP as close as achievable to the minimum requirement specified in Section 5.5.

5.7.4.4 If Tolerance Cannot be Met

For two adjacent fan control settings, if the ESP or airflow is lower than the tolerance for the lower setting and the ESP or airflow is higher than the tolerance for the higher setting, operate at the lower fan control setting, adjust the airflow measuring apparatus to maintain the ESP within -0.00/+0.05 in H_2O of the requirement determined in Section 5.5, and maintain the airflow at a rate not lower than 90% of the manufacturer-specified airflow. If increasing ESP to within -0.00/+0.05 in H_2O of the requirement determined in Section 5.5 reduces airflow of the unit under test to less than 90% of the manufacturer-specified airflow, then use the next higher fan control setting. When using this higher fan control setting, adjust the airflow-measuring apparatus to maintain airflow within tolerance and maintain the ESP as close as achievable to the value determined in Section 5.5.

5.7.4.5 Situations Without Condition Tolerance

If the ESP measured in Section 5.7.4.2 or Section 5.7.4.4 after setting airflow exceeds the minimum ESP requirement by more than 0.05 in H_2O because the ESP and airflow requirements cannot be simultaneously met, there is not a condition tolerance for ESP.

If an airflow less than 97% of the cooling *full load rated indoor airflow* is used in Section 5.7.4.3 or Section 5.7.4.4 for the full-load cooling test because the airflow and ESP requirements cannot be simultaneously met, there is not a condition tolerance for airflow.

5.7.5 All Tests Other Than Full-load Cooling Tests

5.7.5.1 Same Airflow as Full-load Cooling

Use the fan control settings used for the full-load cooling test where:

- *Part load rated indoor airflow*, or the heating *full load rated indoor airflow* is the same as the cooling *full load rated indoor airflow*
- Section 5.6.2 specifies to use the cooling *full load rated indoor airflow* as the airflow

Adjust the airflow-measuring apparatus to maintain the airflow within ± 3% of the measured full-load cooling airflow without regard to the resulting ESP. Changes shall not be made to the fan control settings for the test.

For units with a *constant-volume fan*, if the ESP exceeds the minimum or targeted ESP by +0.05 in H_2O, or the setting causes air volume rate variations (Q_{var} in Section 5.7.3.1) more than 10% or an automatic shutdown of the indoor fan, then use procedure from Section 5.7.3.

5.7.5.2 Different Airflow Than Full-load Cooling

For tests where the *part load rated indoor airflow* or the heating *full load rated indoor airflow* differs from the cooling *full load rated indoor airflow*, use the provisions in Section 5.7.5.2.1 through Section 5.7.5.3.

5.7.5.2.1 First Setting and Adjustment

If the unit does not automatically adjust to different fan control settings, *manufacturer-specified* fan control settings for heating and part-load cooling tests are only valid if the fan control setting adjustment does not involve manually changing the motor speed taps, drive sheaves, or other components that will cause the airflow measured for the full-load cooling test to change. If the *manufacturer-specified* fan control settings for that test condition are valid, operate the system using the *manufacturer-specified* fan control settings for that test condition. If there are not *manufacturer-specified* fan control settings for the heating test or part-load test, or the product does not have automatic control of airflow-control settings, or the *manufacturer-specified* fan control settings are invalid, use the fan control settings for the full-load cooling test. If there are not *manufacturer-specified* fan control settings for any tests, use the as-shipped fan control settings.

Adjust the airflow-measuring apparatus to maintain ESP within -0.00/+0.05 in H_2O of the requirement specified in Section 5.5 and to maintain the airflow within ± 3% of the *rated indoor airflow*.

For units with a *constant-volume fan*, if the ESP exceeds the minimum or targeted ESP by +0.05 in H_2O, or the setting causes air volume rate variations (Q_{var} in Section 5.7.3.1) more than 10% or an automatic shutdown of the indoor fan, then use procedure from Section 5.7.3.

5.7.5.2.2 If Above Tolerance

If ESP or airflow are higher than the tolerance range, adjust the fan control settings to maintain both ESP and airflow within tolerance, if achievable. If ESP or airflow are higher than the tolerance range at the lowest fan control setting, adjust the airflow-measuring apparatus to maintain airflow within tolerance and operate with an ESP as close as achievable to the adjusted ESP requirement.

5.7.5.2.3 If Below Tolerance

If ESP or airflow are lower than the tolerance range, adjust the fan control settings to maintain both ESP and airflow within tolerance without adjusting sheaves and without exceeding the final fan control settings used for the full-load cooling test. If this is not achievable, adjust the airflow-measuring apparatus to maintain ESP within tolerance and operate with an airflow as close as achievable to the *manufacturer-specified* value.

5.7.5.2.4 If Cannot Meet Tolerance

For two adjacent fan control settings, if the ESP or airflow is lower than the tolerance for the lower setting and the ESP or airflow is higher than the tolerance for the higher setting, operate at the lower fan control setting, adjust the airflow measuring apparatus to maintain the ESP within -0.00/+0.05 in H_2O of the requirement determined in Section 5.5, and maintain the airflow at a rate not lower than 90% of the *manufacturer-specified* airflow. If increasing ESP to within -0.00/+0.05 in H_2O of the requirement determined in Section 5.5 reduces airflow of the unit under test to less than 90% of the manufacturer-specified airflow, then use the next higher fan control setting. When using this higher fan control setting, adjust the airflow-measuring apparatus to maintain airflow within tolerance and maintain the ESP as close as achievable to the value determined in Section 5.5.

5.7.5.2.5 Situations Without Condition Tolerance

If the ESP measured after setting airflow in Section 5.7.5.2.2 or Section 5.7.5.2.4 exceeds the adjusted ESP requirement determined in Section 5.5 by more than 0.05 in H_2O because the ESP and airflow requirements cannot be simultaneously met, there is not a condition tolerance for ESP. If an airflow less than 97% of the *manufacturer-specified* airflow is used in Section 5.7.5.2.3 or Section 5.7.5.2.4 because the airflow and ESP requirements cannot be simultaneously met, there is not a condition tolerance for airflow.

5.7.5.3 No Airflow Specified, But Settings Specified

For heating tests and part-load tests where a *manufacturer-specified* airflow is not provided and the cooling *full load rated indoor airflow* is not used as the airflow for the test because *manufacturer-specified* fan control settings or instructions to obtain steady-state operation for the test are provided, in accordance with the provisions in Section 5.6, use the *manufacturer-specified* fan control setting for that test condition or the system can automatically adjust airflow, as specified in the *manufacturer's installation instructions*. Adjust the airflow-measuring apparatus to meet the adjusted ESP requirement determined in accordance with Section 5.5 with a condition tolerance of -0.00/+0.05 in H_2O, using the measured heating or part-load airflow in the ESP calculation.

5.8 Setting Airflow and ESP for Non-ducted Units with Integral Fans

For each test, set indoor airflow while operating the unit at the *rating conditions* specified for the test. After setting the airflow, further adjustments shall not be made to the fan control settings during the test.

5.8.1 Tolerances

All tolerances for airflow and ESP specified in Section 5.8 for setting airflow and ESP are condition tolerances that apply for each test. The average value of a parameter measured over the course of the test shall vary from the target value by not more than the condition tolerance. Operating tolerances for ESP and nozzle pressure drop are specified in Table 7.

5.8.2 External Static Pressure

All tests shall be conducted at 0.00 in H_2O with a condition tolerance of -0.00/+0.05 in H_2O.

5.8.3 Full Load Cooling Tests

5.8.3.1 First Setting and Adjustment

Operate the unit using the *manufacturer-specified* fan control settings. If there are not *manufacturer-specified* fan control settings, use the as-shipped fan control settings. Adjust the airflow-measuring apparatus to maintain ESP within -0.00/+0.05 in H_2O of 0.00 in H_2O and to maintain the airflow within ± 3% of the cooling *full load rated indoor airflow*.

5.8.3.2 If Above Tolerance

If ESP or airflow are higher than the tolerance range, adjust the fan control settings to maintain both ESP and airflow within tolerance. If ESP or airflow are higher than the tolerance range at the lowest fan control setting, adjust the airflow-measuring apparatus to maintain ESP within tolerance. Use the measured higher airflow as the target airflow for all subsequent tests that call for the cooling *full load rated indoor airflow*.

5.8.3.3 If Below Tolerance

If ESP or airflow are lower than the tolerance range, adjust the fan control settings to maintain both ESP and airflow within tolerance. If ESP or airflow are lower than the tolerance range at the maximum fan control setting, adjust the airflow-measuring apparatus to maintain ESP within tolerance. Use the measured lower airflow as the target airflow for all subsequent tests that call for the cooling *full load rated indoor airflow*.

5.8.3.4 If Tolerance Cannot be Met

For two adjacent fan control settings, if the ESP or airflow is lower than the tolerance for the lower setting and the ESP or airflow is higher than the tolerance for the higher setting, use the lower fan control setting. At this lower fan control setting, adjust the airflow-measuring apparatus to maintain ESP within tolerance and there is not a condition tolerance for airflow.

5.8.4 All Tests Other Than Full-load Cooling Tests

5.8.4.1 Same Airflow as Full-load Cooling

Use the fan control settings used for the full-load cooling test where:

- *Part load rated indoor airflow,* or the heating *full load rated indoor airflow* is the same as the *full load rated indoor airflow*
- Section 5.6.2 specifies to use the cooling *full load rated indoor airflow* as the airflow

Adjust the airflow-measuring apparatus to maintain ESP within -0.00/+0.05 in H_2O of 0.00 in H_2O without regard to the resulting airflow. Changes shall not be made to the fan control settings for the test.

5.8.4.2 Different Airflow Than Full-load Cooling

For tests where the *part load rated indoor airflow* or the heating *full load rated indoor airflow* differs from the cooling *full load rated indoor airflow,* use the provisions in Section 5.8.4.2.1 through Section 5.8.4.2.4.

5.8.4.2.1 First Setting and Adjustment

If the unit does not automatically adjust to different fan control settings, *manufacturer-specified* fan control settings for heating and part-load cooling tests are only valid if the fan control setting adjustment does not involve manually changing the motor speed taps, drive sheaves, or other components that will cause the airflow measured for the full-load cooling test to change. If the *manufacturer-specified* fan control settings for that test condition are valid, operate the system using the *manufacturer-specified* fan control settings for that test condition. If there are not *manufacturer-specified* fan control settings for the heating test or part-load test, or the product does not have automatic control of airflow-control settings, or the *manufacturer-specified* fan control settings are invalid, use the fan control settings for the full-load cooling test. If there are not *manufacturer-specified* fan control settings for any tests, use the as-shipped fan control settings.

Adjust the airflow-measuring apparatus to maintain ESP within -0.00/+0.05 in H_2O of the requirement specified in Section 5.5 and to maintain the airflow within ± 3% of the rated indoor airflow.

5.8.4.2.2 If Above Tolerance

If ESP or airflow are higher than the tolerance range, adjust the fan control settings to maintain both ESP and airflow within tolerance. If ESP or airflow are higher than the tolerance range at the lowest fan control setting, adjust the airflow-measuring apparatus to maintain ESP within tolerance.

5.8.4.2.3 If Below Tolerance

If ESP or airflow are lower than the tolerance range, adjust the fan control settings to maintain both ESP and airflow within tolerance. If this is not achievable, adjust the airflow-measuring apparatus to maintain ESP within tolerance and operate with an airflow as close as achievable to the *manufacturer-specified* value.

5.8.4.2.4 If Cannot Meet Tolerance

For two adjacent fan control settings, if the ESP or airflow is lower than the tolerance for the lower setting and the ESP or airflow is higher than the tolerance for the higher setting, operate at the lower fan control setting, adjust the airflow measuring apparatus to maintain the ESP within -0.00/+0.05 in H_2O of the requirement specified in Section 5.5, and maintain the airflow at a rate not lower than 90% of the manufacturer-specified airflow. If increasing ESP to within -0.00/+0.05 in H_2O in accordance with Section 5.8.2 reduces airflow of the unit under test to less than 90% of the manufacturer-specified airflow, then use the next higher fan control setting. When using this higher fan control setting, adjust the airflow-measuring apparatus to maintain ESP within tolerance and there is not a condition tolerance for airflow.

5.9 Head Pressure Control

5.9.1 Setup

For units with condenser head pressure controls, the head pressure controls shall be enabled and operated in automatic mode. Set head pressure controls as specified by the *manufacturer's installation instructions*. If the *manufacturer's installation instructions* do not specify the head pressure control setup, or if there are not *manufacturer's installation instructions*, use the as-shipped setting.

5.9.2 Operate Using Control Logic

The control logic shall control the operation of the equipment. If the equipment can be run and stable conditions are obtained by meeting the test tolerances in Table 7, then a standard part-load cooling test shall be run.

If the head pressure control results in unstable conditions that do not meet the test tolerances in Table 7, perform the head pressure control time average test in Section 5.9.3.

5.9.3 Head Pressure Control Time Average Test

If the head pressure control results in unstable conditions that do not meet the test tolerances in Table 7, a series of two steady-state tests shall be run.

Prior to the first test, the liquid entering temperature defined by Table 8 shall be approached from at least a 10 ºF higher temperature until the tolerances specified in Table 6 are met. Prior to the second test, the condenser entering temperature defined by Table 8 shall be approached from at least a 5ºF lower temperature until the tolerances specified in Table 6 are met.

For each test, once all tolerances in Table 6 are met, the test shall be started and test data shall be recorded at the start and every five minutes for the thirty-minute test, resulting in seven test measurements for each test parameter. During each test, the tolerances specified in Table 6 shall be met. See operating and condition tolerance definitions in Section 5.10.3.2 and Section 5.10.3.3.

Table 6 Tolerances for Head Pressure Control Time Average Test

Measured Value		Operating Tolerance	Condition Tolerance
Indoor air dry-bulb temperature (°F)	Entering	3.0	1.0
	Leaving	3.0	—
Indoor air wet-bulb temperature (°F)	Entering	1.5	0.5
	Leaving	1.5	—
Water/Brine serving outdoor heat exchanger temperature (°F)	Entering	0.75	0.3
	Leaving	0.75	—
Voltage		2%	1%

If the tolerances in Table 6 are met, the test results for both steady-state test series shall then be averaged to determine the capacity and efficiency that is then used for the *IEER* calculation. If the tolerances in Table 6 are not met, follow the requirements in Section 5.9.4.

5.9.4 Follow STI

If the tolerances in Table 6 cannot be met for the head pressure control time average test, *STI* shall be used to determine the settings required to stabilize operation. However, if *STI* do not provide guidance for stable operation or operation in accordance with supplemental testing instructions results in a condensing (liquid outlet) pressure corresponding to a bubble point temperature less than 75°F, follow the requirements in Section 5.9.5.

5.9.5 Set Manually

If *STI* are not used to provide stable operation, the valve(s) or pump(s) causing the instability shall be set manually at a speed, operating state (on/off), or position to achieve a condensing (liquid outlet) pressure corresponding to a bubble point temperature as close to 85°F as manageable while remaining not lower than 85°F.

5.10 Test Conduct

5.10.1 Atmospheric Pressure

Test data is only valid for tests conducted when the atmospheric pressure is greater than 13.700 psia.

5.10.2 Ambient Air Conditions

The ambient air condition and tolerance requirements are the same as the requirements for indoor entering air.

5.10.3 Test Tolerances

5.10.3.1 Order of Precedence

Tolerances specified in this standard supersede tolerances specified in ASHRAE 37. Test operating tolerances and condition tolerances are specified in Table 7.

5.10.3.2 Operating Tolerance

Test operating tolerance is the maximum range that a measurement shall vary over the specified test interval. The difference between the maximum and minimum sampled values shall be less than or equal to the specified test operating tolerance. If the operating tolerance is expressed as a percentage, the maximum variation is the specified percentage of the average value of the measured test parameter.

5.10.3.3 Condition Tolerance

Test condition tolerance is the maximum difference between the average value of the measured test parameter and the specified test condition. If the condition tolerance is expressed as a percentage, the condition tolerance is the specified percentage of the test condition.

Table 7 Tolerances

Measurement	Test Operating Tolerance	Test Condition Tolerance
Air dry-bulb temperature (°F): Entering Leaving	 2.0 2.0 / 3.0[1]	 0.5 —
Air wet-bulb temperature (°F): Entering Leaving	 1.0 1.0	 0.3[2] —
Liquid entering temperature (°F):	0.5	0.2
Saturated refrigerant temperature corresponding to the measured *indoor side* pressure[3] (°F)	3.0	0.5
Liquid refrigerant temperature[3] (°F)	0.5	0.2
Air ESP for integral fan (in H_2O)	0.05	See Section 5.7 and Section 5.8
Liquid ESP for integral pump (psi)	−0.0/+1.0	1.0
Electrical voltage (percent of reading)	2.0	1.0
Electrical Frequency (Hz)[4]	0.4	0.2
Liquid flow rate (percent of reading)	2.0	See Section 5.4.15
Nozzle pressure drop (percent of reading)	2.0	—

Notes:
1. The test operating tolerance is 2.0 °F for cooling tests and 3.0 °F for heating tests.
2. Applicable only for cooling tests.
3. Tolerance applies only for the compressor calibration and refrigerant enthalpy methods.
4. When using electrical generators, tolerances can be doubled.

5.10.4 Temperature for Liquid Properties

The values for specific heat (c_{pl}) and density (ρ_l) of the test liquid used in Section 7.6 of ASHRAE 37, shall be based upon the average liquid temperature across the heat exchanger calculated in Equation 7.

$$t = (t_{l3} + t_{l4})/2 \quad (7)$$

Where:

t = average liquid temperature across the heat exchanger, °F

t_{l3} = temperature of liquid entering the *outdoor side*, °F

t_{l4} = temperature of liquid leaving the *outdoor side*, °F

When calculating the *heating capacity*, use the total *heating capacity* formula for Section 7.6.5.1 of ASHRAE 37 specified in the errata sheet to ASHRAE 37 issued 27 March 2019 and in Equation 8.

$$q_{tho} = w_l c_{p_l} * (t_{l3} - t_{l4}) + 3.41 * E_t \quad (8)$$

Where:

q_{tho} = total *heating capacity*, *outdoor side* data, (Btu/h)
w_l = mass flow rate, liquid, (lbm/h)
c_{pl} = specific heat of the liquid, (Btu/lbm·°F)
t_{l3} = temperature of liquid entering the *outdoor side*, °F
t_{l4} = temperature of liquid leaving the *outdoor side*, °F
E_t = power input, total, W

Section 6. Rating Requirements

6.1 Standard Ratings

Use the requirements of the *rating requirements* section to determine all *standard ratings*.

6.2 Standard Rating Tests

6.2.1 Air and Water Conditions

Table 8 indicates the tests and test conditions that are required to determine capacity ratings and values of energy efficiency. Standard cooling ratings are not applicable for heating-only heat pumps.

Table 8 Conditions for Standard Rating and Operating Tests

Rating Condition		Air Entering Temperature (°F)		Liquid Entering Temperature (°F)
		Dry – Bulb	Wet – Bulb	
Cooling	*Standard Rating Conditions* C3	80.0	67.0	86.0
	Standard Rating Conditions C2	80.0	67.0	68.0
	Standard Rating Conditions C1	80.0	67.0	50.0
	Maximum Operating Conditions	90.0	73.0	104.0
	Minimum Operating Conditions	67.0	57.0	50.0
	Insulation Efficiency and Condensate Disposal	80.0	75.0	50.0
Heating	*Standard Rating Conditions* H3	70.0	60.0 (max)	68.0
	Standard Rating Conditions H2	70.0	60.0 (max)	50.0
	Standard Rating Conditions H1	70.0	60.0 (max)	32.0
	Maximum Operating Conditions	80.0	—	86.0
	Minimum Operating Conditions	59.0	—	23.0

6.2.2 Voltage and Frequency

Standard rating tests shall be performed at the nameplate rated voltage(s) and frequency.

For air-conditioners and heat pumps with dual nameplate voltage ratings, *standard rating* tests shall be performed at both voltages, or at the lower of the two voltages if only a single *standard rating* is published.

6.3 Commercial Cooling Capacity and Efficiency

6.3.1 Summary

Determine commercial *cooling capacity* and efficiency representations using the requirements of Section 6.3.

6.3.2 Measure Capacity and Power at Standard Rating Conditions

6.3.2.1 Summary

Perform tests at maximum, minimum, and *intermediate compressor modulation levels*, as applicable, as outlined in Section 6.3.2.2 through Section 6.3.2.5.

No part-load cooling tests are required for *fixed capacity controlled units*.

Perform all tests in accordance with Section 5 and the voltage and frequency requirements of Section 6.2.2.

6.3.2.2 Maximum Compressor Modulation Level

For all units, conduct full-load cooling *standard rating* tests using the *maximum compressor modulation level* and the full-load airflow at *standard rating conditions* C1, C2, and C3 in Table 8.

6.3.2.3 Minimum Compressor Modulation Level

For all staged capacity controlled and proportionally controlled units, conduct part-load cooling *standard rating* tests using the *minimum compressor modulation level* at *standard rating conditions* C1, C2, and C3 in Table 8.

6.3.2.4 Intermediate Compressor Modulation Level for Staged Capacity Controlled Units

For *staged capacity controlled units* with three or more *compressor modulation levels*, perform one part-load cooling test using an *intermediate compressor modulation level* at each of the *standard rating conditions* C1, C2, and C3 in Table 8.

For each of the *standard rating conditions* C1, C2, and C3 in Table 8, use the *compressor modulation level* allowed by the controls at those operating conditions that has a continuous capacity closest to the arithmetic mean of the capacities from the minimum and *maximum compressor modulation levels* at the same set of operating conditions.

If the continuous capacities of two *compressor modulation levels* allowed by the controls at a single set of operating conditions are equidistant from the arithmetic mean of the capacities from the *minimum* and *maximum compressor modulation levels* at the same set of operating conditions, use the *compressor modulation level* with the lower capacity as the *intermediate compressor modulation level*.

6.3.2.5 Intermediate Compressor Modulation Level for Proportionally Capacity Controlled Units

For all *proportionally capacity controlled units*, perform one part-load cooling test using an *intermediate compressor modulation level* at each of the *standard rating conditions* C1, C2, and C3 in Table 8.

For each of the *standard rating conditions* C1, C2, and C3 in Table 8, use a *compressor modulation level* allowed by the controls at those operating conditions with an absolute difference between the continuous capacity and the arithmetic mean of the capacities from the minimum and *maximum compressor modulation levels* at the same set of operating conditions that is less than 5% of the capacity from the *maximum compressor modulation level* at those operating conditions. If there is not a *compressor modulation level* that has a capacity within this range, use the *compressor modulation level* with a continuous capacity that is closest to, but less than the mean of the capacities from the *minimum* and *maximum compressor modulation levels*.

6.3.3 Adjust Measured Total Cooling Capacity and Total Power Values

6.3.3.1 Summary

Calculate the adjusted total *cooling capacity* and power values by applying all adjustments in Section 6.3.3.2 through Section 6.3.3.4, as applicable.

6.3.3.2 Methanol Solution to Water Adjustment

Multiply all measured total capacity values by 1.01 and multiply all measured total power values by 0.99.

6.3.3.3 Pump Power Adjustment

6.3.3.3.1 Non-integral Pump

If the liquid pump is not integral to the equipment, add the pump power adjustment calculated in Equation 9 to the total power measured for each test.

$$\varphi_{pa} = \frac{q \cdot \Delta p_{int} \cdot 0.4349}{\eta} \tag{9}$$

Where:

φ_{pa}	=	Pump power adjustment, W
q	=	Mean measured fluid flow rate for the test, gpm
Δp_{int}	=	Internal static pressure difference measured for the test, psi
0.4349	=	Conversion factor, W·GPM·psi
η	=	Pump efficiency, 0.75 by convention for commercial

6.3.3.3.2 Integral Pump

If the liquid pump is integral to the equipment, subtract the pump power adjustment calculated in Equation 10 from the total power measured for each test.

$$\varphi_{pa} = \frac{q \cdot \Delta p_{ext} \cdot 0.4349}{\eta} \tag{10}$$

Where:

φpa	=	Pump power adjustment, W
q	=	Mean measured fluid flow rate for the test, gpm
Δp_{ext}	=	ESP difference measured for the test, psi
0.4349	=	Conversion factor, W·GPM·psi
η	=	Pump efficiency, 0.75 by convention for commercial

6.3.3.4 Coil-only Units

6.3.3.4.1 Ducted Units

For ducted coil-only units, subtract 1,245 Btu/h per 1000 measured scfm from the total *cooling capacity* measured for each test.

Add 365 W per 1000 measured scfm to the total power measured for each test.

6.3.3.4.2 Non-ducted Units

For non-ducted coil-only units, subtract 940 Btu/h per 1000 measured scfm from the total *cooling capacity* measured for each test.

Add 275 W per 1000 measured scfm to the total power measured for each test.

6.3.3.5 Override Controls Used for Testing

If measured total power for a test includes power for any override controls used only for laboratory testing, subtract the power for the override controls from the total power measured for that test.

6.3.4 Interpolate Capacity and Power to IEER Entering Liquid Temperatures.

For the *maximum*, *minimum*, and *intermediate compressor modulation levels*, as applicable, interpolate the *cooling capacity* and total power values calculated for each *standard rating condition* in Section 6.3.3 from the liquid entering water temperatures in Table 8 to the *IEER* liquid entering temperatures specified in Table 9 using Equation 11 and the parameters outlined in Table 10. The interpolated value of each parameter is designated by V_{calc} in Equation 11.

Perform interpolation only between tests performed using the same *compressor modulation level* (meaning *maximum*, *minimum*, or *intermediate*).

Table 9 IEER Points

IEER Point	IEER Percent Load	IEER Liquid Entering Temperature [°F]	Minimum IFT Percent Load	Maximum IFT Percent Load	Pump and Tower Power Rate [W/(Btu/h)]
A	100.0	85.0	Not applicable	Not applicable	0.0072
B	75.0	73.5	72.0	78.0	0.0044
C	50.0	62.0	47.0	53.0	0.0027
D	25.0	55.0	22.0	28.0	0.0018

$$\mathbf{V_{calc} = \frac{(T_{calc} - T_{low}) * (V_{high} - V_{low})}{T_{high} - T_{low}} + V_{low}} \qquad \mathbf{11}$$

Table 10 Interpolation Parameters

IEER Point	T_{low} [°F]	T_{high} [°F]	T_{calc} [°F]	V_{low}	V_{high}
A	68.0	86.0	85.0	Value from *standard rating condition* 2	Value from *standard rating condition* 3
B	68.0	86.0	73.5	Value from *standard rating condition* 2	Value from *standard rating condition* 3
C	50.0	68.0	62.0	Value from *standard rating condition* 1	Value from *standard rating condition* 2
D	50.0	68.0	55.0	Value from *standard rating condition* 1	Value from *standard rating condition* 2

6.3.5 Determine Interpolated-From-Test (IFT) Percent Load at IEER Points B Through D

For the *maximum*, *minimum*, and *intermediate compressor modulation levels*, as applicable, use Equation 12 to divide the interpolated capacity values at *IEER* points B through D by the full-load capacity at *IEER* point A (all determined in Section 6.3.4).

The values calculated at this stage are referred to as "IFT *percent load*" in Section 6.3.6.

$$\mathbf{PL_{IFT} = \frac{q_x}{q_{A,FL}} * 100} \qquad 12$$

Where:

PL_{IFT}	=	The full-load or part-load IFT *percent load* at a given *IEER* point
q_x	=	The capacity at a given *IEER* point and *compressor modulation level* calculated in Section 6.3.4, Btu/h
$q_{A,\,FL}$	=	The full-load capacity at the *maximum compressor modulation level* calculated in Section 6.3.4 for *IEER* point A, Btu/h

6.3.6 Determine Capacity and Total Power at the IEER Percent Load for IEER Points B Through D

6.3.6.1 Summary

For each of the *IEER* points B through D of Table 9, determine the capacity and total power at the *IEER percent load* specified in Table 9 using Section 6.3.6.2, Section 6.3.6.3, or Section 6.3.6.4, as applicable.

If the IFT *percent load* calculated in Section 6.3.5 for one of the tested *compressor modulation levels* is greater than or equal to the minimum IFT *percent load* and less than or equal to the maximum IFT *percent load* specified in Table 9 for the *IEER* point, determine the capacity and total power at the *IEER percent load* for the *IEER* point using Section 6.3.6.2.

If there are none of the IFT *percent loads* calculated in Section 6.3.5 are greater than or equal to the minimum IFT *percent load* and less than or equal to the maximum IFT *percent load* specified in Table 9, but the IFT *percent load* at the *minimum compressor modulation level* is below the minimum IFT *percent load* in Table 9, calculate the capacity and total power for this *IEER* point by interpolating between two *compressor modulation levels* as specified in Section 6.3.6.3.

If the minimum IFT *percent load* calculated in Section 6.3.5 for an *IEER* point is greater than the maximum IFT *percent load* specified in Table 9, calculate the capacity and total power for this *IEER* point using cyclic degradation as specified in Section 6.3.6.4.

6.3.6.2 IFT Percent Load Within 3 Percentage Points of IEER Percent Load

The capacity and total power at the *IEER* point are equal to the values calculated in Section 6.3.4 for the *compressor modulation level* with the IFT *percent load* closest to the *IEER percent load* for the *IEER* point.

6.3.6.3 Interpolation Between Compressor Modulation Levels

Calculate capacity and total power at the *IEER* point using Equation 13 with values from the two *compressor modulation levels* with the IFT *percent loads* closest to the *IEER percent load* for the *IEER* point.

$$\mathbf{V = \frac{\left(PL_{IEER} - PL_{IFT,L}\right) * (V_H - V_L)}{\left(PL_{IFT,H} - PL_{IFT,L}\right)} + V_L} \qquad 13$$

Where:

V	=	The value (that is, capacity or total power) calculated for the *IEER* point, Btu/h or W
PL_{IEER}	=	The *IEER percent load* for the *IEER* point from Table 9

$PL_{IFT,H}$	=	The IFT *percent load* calculated in Section 6.3.5 for the *compressor modulation level* with a IFT *percent load* closest to but greater than the *IEER percent load* for the *IEER* point
$PL_{IFT,L}$	=	The IFT *percent load* calculated in Section 6.3.5 for the *compressor modulation level* with a IFT *percent load* closest to but less than the *IEER percent load* for the *IEER* point
V_H	=	The value (that is, capacity or total power) calculated in Section 6.3.4 for the *compressor modulation level* with an IFT *percent load* closest to but greater than the *IEER percent load* for the *IEER* point, Btu/h or W
V_L	=	The value (that is, capacity or total power) calculated in Section 6.3.4 for the *compressor modulation level* with a IFT *percent load* closest to but less than the *IEER percent load* for the *IEER* point, Btu/h or W

6.3.6.4 Cyclic Degradation

Calculate capacity and total power at the *IEER* point using Equation 14 through Equation 17 with values from the *compressor modulation level* with the minimum IFT *percent load* at the *IEER* point.

$$\mathbf{q = LF * q_x} \qquad \mathbf{14}$$

$$\mathbf{P = LF * C_D * P_T} \qquad \mathbf{15}$$

$$\boldsymbol{C_D = -0.13 * LF + 1.13} \qquad \mathbf{16}$$

$$\mathbf{LF = \frac{PL_{IEER}}{PL_{IFT}}} \qquad \mathbf{17}$$

Where:

q	=	The total *cooling capacity* calculated for the *IEER* point, Btu/h
P	=	The total power calculated for the *IEER* point, W
PL_{IFT}	=	The IFT *percent load* calculated in Section 6.3.5 at the *IEER* point for the *compressor modulation level* with the minimum IFT *percent load* at the *IEER* point
PL_{IEER}	=	The *IEER percent load* from Table 9
PT	=	Total power calculated in Section 6.3.4 at the *IEER* point for the *compressor modulation level* with the minimum IFT *percent load* at the *IEER* point, W
q_x	=	Total *cooling capacity* calculated in Section 6.3.4 at the *IEER* point for the *compressor modulation level* with the minimum IFT *percent load* at the *IEER* point, Btu/h
LF	=	Ratio between *IEER percent load* and IFT *percent load*

6.3.7 Add Power for External Pump and Cooling Tower

For each of the *IEER* points A through D of Table 9, calculate total power by adding the power for the external pump and cooling tower to the total power calculated for the *IEER* point using Equation 18 and the pump and tower power rate for the *IEER* point in Table 9.

$$\mathbf{P = P_T + q * PTPR} \quad \mathbf{18}$$

Where:

P	=	The total power calculated for the *IEER* point, W
P_T	=	For *IEER* point A: total power calculated in Section 6.3.4 for the *IEER* point A full-load cooling test, W For *IEER* points B through D: total power determined in Section 6.3.6 for the *IEER* point, W
q	=	For *IEER* point A: total *cooling capacity* calculated in Section 6.3.4 for the *IEER* point A full-load cooling test, Btu/h For *IEER* points B through D: total *cooling capacity* determined in Section 6.3.6 for the *IEER* point, Btu/h
PTPR	=	The pump and tower power rate for the IEER point in Table 9, W/(Btu/h)

6.3.8 Calculate EERs for IEER Points

For *IEER* point A, calculate the *EER* as the ratio of the total *cooling capacity* calculated in Section 6.3.4 for the *IEER* point A full-load cooling test, to the total power calculated for *IEER* point A in Section 6.3.7.

For *IEER* points B through D, calculate the *EER* as the ratio of the total *cooling capacity* determined for the IEER point in Section 6.3.6, to the total power calculated for the IEER point in Section 6.3.7.

6.3.9 Calculate IEER

Use Equation 19 to calculate *IEER* as a weighted mean of the *EERs* determined at each of the *IEER* points.

$$\mathbf{IEER = (0.020 * EER_A) + (0.617 * EER_B) + (0.238 * EER_C) + (0.125 * EER_D)} \quad \mathbf{19}$$

Where:

EER_A	=	*EER* at *IEER* point A determined in Section 6.3.8
EER_B	=	*EER* at *IEER* point B determined in Section 6.3.8
EER_C	-	*EER* at *IEER* point C determined in Section 6.3.8
EER_D	=	*EER* at *IEER* point D determined in Section 6.3.8

6.3.10 Representations of Cooling Capacity

Use the total *cooling capacity* calculated in Section 6.3.3 for the full-load cooling test at *standard rating condition* C3 as the rated *cooling capacity* for the unit.

6.3.11 Representations of AEER

6.3.11.1 Add Power for External Pump and Cooling Tower

For the full-load cooling test at *standard rating condition* C3, calculate total power by adding the power for the external pump and cooling tower to the total power calculated in Section 6.3.3 using Equation 20.

$$\mathbf{P = P_T + q * 0.0072} \quad \mathbf{20}$$

Where:

P	=	The total power calculated for the full-load cooling test at *standard rating condition* C3, W
PT	=	Total power calculated in Section 6.3.3 for the full-load cooling test at *standard rating condition* C3, W
q	=	*Cooling capacity* calculated in Section 6.3.3 for the full-load cooling test at *standard rating condition* C3, Btu/h

6.3.11.2 Calculate AEER

Calculate *AEER* as the ratio of the total *cooling capacity* calculated in Section 6.3.3 for the full-load cooling test at *standard rating condition* C3, to the total power calculated in Section 6.3.11.1 for the full-load cooling test at *standard rating condition* C3.

6.3.12 Optional Representations of Capacity and EER for Modeling

For representations of total *cooling capacity* for modeling at any of the tested *compressor modulation levels* and *standard rating conditions*, use the total *cooling capacity* calculated in Section 6.3.3.

Calculate representations of *EER* for modeling at any of the tested *compressor modulation levels* and *standard rating conditions* as the ratio of the total *cooling capacity* calculated in Section 6.3.3 to the total power calculated in Section 6.3.3.

6.4 Commercial Heating Capacity and Efficiency

6.4.1 Summary

Determine commercial *heating capacity* and efficiency representations using the requirements of Section 6.4.2 through Section 6.4.7.

6.4.2 Measure Capacity and Power at Standard Rating Conditions

For all units, conduct a heating *standard rating* test using the *maximum compressor modulation level* at *standard rating conditions* H2 in Table 8.

Heating *standard rating* tests at any other combination of *compressor modulation level* and *standard rating conditions* H1, H2, and H3 in Table 8 are optional.

Perform all tests according to the test requirements in Section 5 and the voltage and frequency requirements of Section 6.2.2.

6.4.3 Adjust Measured Heating Capacity and Total Power Values

6.4.3.1 Summary

Calculate the adjusted *heating capacity* and total power values by applying all adjustments in Section 6.4.3.2 through Section 6.4.3.5, as applicable.

6.4.3.2 Methanol Solution to Water Adjustment

Multiply the measured total capacity values for *standard rating conditions* H2 and H3 by 1.01.

6.4.3.3 Pump Power Adjustment

6.4.3.3.1 Non-integral Pump

If the liquid pump is not integral to the equipment, add the pump power adjustment calculated in Equation 21 to the total power measured for each test.

$$\varphi_{pa} = \frac{q \cdot \Delta p_{int} \cdot 0.4349}{\eta} \qquad (21)$$

Where:

φ_{pa}	=	Pump power adjustment, W
q	=	Mean measured fluid flow rate for the test, gpm
Δp_{int}	=	Internal static pressure difference measured for the test, psi
0.4349	=	Conversion factor, W·GPM·psi
η	=	Pump efficiency, 0.75 by convention for commercial

6.4.3.3.2 Integral Pump

If the liquid pump is integral to the equipment, subtract the pump power adjustment calculated in Equation 22 from the total power measured for each test.

$$\varphi_{pa} = \frac{q \cdot \Delta p_{ext} \cdot 0.4349}{\eta} \quad 22$$

Where:

φ_{pa}	=	Pump power adjustment, W
q	=	Mean measured fluid flow rate for the test, gpm
Δp_{ext}	=	ESP difference measured for the test, psi
0.4349	=	Conversion factor, W·GPM·psi
η	=	Pump efficiency, 0.75 by convention for commercial

6.4.3.4 Coil-only Fan Adjustment

6.4.3.4.1 Ducted Units

For ducted coil-only units, add 1245 Btu/h per 1000 measured scfm to the *heating capacity* measured for each test.

Add 365 W per 1000 measured scfm to the total power measured for each test.

6.4.3.4.2 Non-ducted Units

For non-ducted coil-only units, add 940 Btu/h per 1000 measured scfm to the *heating capacity* measured for each test.

Add 275 W per 1000 measured scfm to the total power measured for each test.

6.4.3.5 Override Controls Used for Testing

If measured total power for a test includes power for any override controls used only for laboratory testing, subtract the power for the override controls from the total power measured for that test.

6.4.4 Add Power for External Pump and Cooling Tower

For the H2 *maximum compressor modulation level* test, calculate total power by adding the power for the external pump and cooling tower to the total power calculated in Section 6.4.3 using Equation 23.

$$\mathbf{P = P_T + q * 0.0025} \quad 23$$

Where:

P	=	The total power calculated for the H2 *maximum compressor modulation level* test, W
P_T	=	Total power calculated in Section 6.4.3 for the H2 maximum compressor modulation level test, W
q	=	*Heating capacity* calculated in Section 6.4.3 for the H2 maximum compressor modulation level test, Btu/h

6.4.5 Calculate ACOP

Calculate *ACOP* as the ratio of the *heating capacity* calculated in Section 6.4.3 for the H2 *maximum compressor modulation level* test, to the total power calculated in Section 6.4.4 for the H2 *maximum compressor modulation level* test, both in units of W.

6.4.6 Representations of Heating Capacity

Use the *heating capacity* calculated in Section 6.4.3 for the H2 *maximum compressor modulation level* test as the rated *heating capacity* for the unit.

6.4.7 Optional Representations of Capacity and COP for Modeling

For representations of *heating capacity* for modeling at any of the tested *compressor modulation levels* and *standard rating conditions*, use the *heating capacity* calculated in Section 6.4.3.

Calculate representations of heating *COP* for modeling at any of the tested *compressor modulation levels* and *standard rating conditions* as the ratio of the *heating capacity* calculated in Section 6.4.3 to the total power calculated in Section 6.4.3.

6.5 Residential Cooling Capacity and Efficiency

Representations for determination of residential cooling capacity and efficiency to be added in a future revision.

6.6 Residential Heating Capacity and Efficiency

Representations for determination of residential heating capacity and efficiency to be added in a future revision.

6.7 Test Data vs Computer Simulation

Ratings for capacity, *EER*, *IEER*, and *ACOP* shall be based either on test data or computer simulation.

6.7.1 Ratings Generated by Test Data.

Any capacity, *EER*, *IEER*, or *ACOP* (H2) rating of a *basic model* with a *cooling capacity* ≤ 760,000 Btu/h generated by test data shall be based on the results of at least two individual test samples tested in accordance with all applicable portions of this standard. The capacity, *EER*, *IEER*, or *ACOP* (H2) ratings shall be lower than or equal to the lower of a) the test sample mean ($\bar{x}$), or b) the lower 95% confidence limit (LCL) divided by 0.95, as defined by Equation 24 and Equation 25, rounded in accordance with Section 6.8.

$$\bar{x} = \frac{\sum_{i=1}^{n} x_i}{n} \quad (24)$$

$$LCL = \bar{x} - t_{.95}\left(\frac{s}{\sqrt{n}}\right) \quad (25)$$

Where:

LCL	=	Lower 95% confidence limit
n	=	Number of test samples
s	=	Standard deviation
t_{95}	=	t statistic for a 95% one-tailed confidence interval with n-1 degrees of freedom. See Appendix A of 10 CFR Part 429.
x_i	=	Test result value for test sample i
$\bar{x}$	=	Test sample mean

6.7.2 Ratings Not Generated by Test Data

Any capacity, *EER*, *IEER*, or *ACOP* rating of a *basic model* generated by the results of an alternative efficiency determination method (AEDM) shall not be higher than the result of the AEDM output rounded in accordance with Section 6.8. Any AEDM used shall be created in compliance with the regulations specified in 10 CFR §429.70 and 10 CFR §429.43.

6.7.3 Documentation

For products covered under 10 CFR §429.71, supporting documentation of all *published ratings* subject to federal control shall be maintained.

6.8 Rounding and Precision

6.8.1 Values of Standard Capacity Ratings

These ratings shall be expressed in terms of Btu/h in multiples shown in Table 11, using a value that is less than or equal to the measured *cooling capacity*.

Table 11 Rounding of Standard Rating Capacities

Cooling Capacity Ratings, Btu/h	Multiples, Btu/h for Both Heating and Cooling
< 20,000	100
From 20,000 to 38,000	200
From 38,000 to 65,000	500
From 65,000 to 135,000	1000
From 135,000 to ≤ 400,000	2000
400,000 and greater	5000

6.8.2 Values of Energy Efficiency Ratios and Heating Coefficients of Performance

EER, *AEER* and *IEER* for cooling, whenever published, shall be expressed in multiples of 0.1, and expressed in Btu/(W·h) for a unit configured in accordance with Section 5. *COP* and *ACOP*, whenever published, shall be expressed in multiples of 0.01, and expressed in W/W for a unit configured in accordance with Section 5.

6.9 Uncertainty

All tests shall be conducted in a laboratory that meets the requirements referenced in this standard and ASHRAE 37. Uncertainty for *standard ratings* covered by this standard are described in Section 6.9.1 through Section 6.9.6.

6.9.1 Uncertainty of Measurement

When testing a unit, there are variations that result from instrumentation and laboratory constructed subsystems for measurements of temperatures, pressure, and flow rates.

6.9.2 Uncertainty of Test Rooms

The same unit tested in multiple rooms cannot yield the same performance due to setup variations and product handling.

6.9.3 Uncertainty Due to Manufacturing

During the manufacturing of units, there are variations due to manufacturing production tolerances that impact the performance of the unit.

6.9.4 Uncertainty of Performance Simulation Tools

Due to the large complexity of options, manufacturers can use performance prediction tools such as an AEDM.

6.9.5 Variability due to Environmental Conditions

Changes to ambient conditions such as inlet temperature conditions and barometric pressure can alter the measured performance of the unit.

6.9.6 Variability of System Under Test

The system under test instability cannot yield repeatable results.

6.10 Verification Testing

To comply with this standard, single sample production verification tests, shall meet the *standard rating* performance metrics shown in Table 12 with the listed acceptance criteria.

Table 12 Acceptance Criteria

Performance Metric	Acceptance Criteria
Cooling Metrics	
Full load *cooling capacity*, Btu/h	≥ 95%
Full load *EER*, Btu/Wh	≥ 95%
IEER, Btu/Wh	≥ 90%
Heating Metrics	
Heating capacity at H2, Btu/h	≥ 95%
ACOP at H2, W/W	≥ 95%

Section 7. Minimum Data Requirements for Published Ratings

As a minimum, *published ratings* shall consist of the following information, as determined in Section 6.3 and Section 6.4:

7.1 For Commercial Water/Brine to Air Heat Pump Equipment at Standard Rating Conditions

- *Cooling capacity*, Btu/h
- *AEER*, Btu/Wh
- *IEER*, Btu/Wh
- *Heating capacity*, Btu/h at H2
- Heating *coefficient of performance*, *ACOP*, W/W, at H2

All claims to ratings within the scope of this standard shall include the statement "Rated in accordance with AHRI Standard 600 (I-P)". All claims to ratings outside the scope of this standard shall include the statement "Outside the scope of AHRI Standard 600 (I-P)". *Application ratings* within the scope of the standard shall include a statement of the application conditions for the ratings.

7.2 Latent Capacity Designation

The moisture removal capacity at *standard rating conditions* listed in Table 8 shall be published in the manufacturer's specifications and literature. The value shall be expressed consistently one or more of the following forms:

- *Latent capacity* and *cooling capacity*, Btu/h
- *Sensible capacity* and *cooling capacity*, Btu/h
- Sensible heat ratio (as defined by Equation 26) and *cooling capacity*, Btu/h

Note: *Cooling capacity* is defined in Section 3 and includes both *latent capacity* and *sensible capacity*.

$$SHR = \frac{q_{sci}}{q_{tci}} \quad \mathbf{26}$$

Where:

SHR	=	Sensible heat ratio
q_{sci}	=	*Sensible capacity*, Btu/h
q_{tci}	=	*Cooling capacity*, Btu/h

Section 8. Operating Requirements

8.1 Operating Requirements

Water/brine to air heat pump equipment shall comply with the provisions of this section such that any production unit shall meet the requirements detailed herein.

8.2 Maximum Operating Conditions Test (Cooling and Heating)

Water/brine to air heat pump equipment shall pass the following maximum cooling and heating operating conditions test with an indoor coil airflow rate as determined under Section 5.6.2.1.

8.2.1 Temperature Conditions

Temperature conditions shall be maintained as shown in Table 8.

8.2.2 Voltage and Frequency

Tests shall be run at both the minimum and maximum utilization voltages of Voltage Range B as shown in Table 1 of AHRI 110, at the unit's service connection and at rated frequency. For heat pumps with dual nameplate voltage ratings, tests shall be performed at both voltages or at the lower of the two voltages if only a single rating is published.

8.2.3 Procedure

Water/brine to air heat pump equipment shall be operated continuously for one hour at the temperature conditions and voltage(s) specified.

At the conclusion of the one-hour test at the minimum utilization voltage, all power to the equipment shall be interrupted for a minimum period of five seconds and a maximum period of seven seconds and then be restored.

8.2.4 Requirements

During both tests, the equipment shall operate without failure of any parts.

The equipment shall resume continuous operation within one hour of restoration of power and shall then operate continuously for one hour. The motor overload protective device can trip only during the first five minutes of operation after the interruption of power but shall not trip during the remainder of the test period. Models designed so that resumption of operation does not occur within the first five minutes shall remain out of operation for not longer than thirty minutes. The equipment shall then operate continuously for the remainder of the test. Manual resetting of safety devices is not permitted.

8.3 Minimum Cooling and Heating Operating Conditions Test

Water/brine to air heat pump equipment shall pass the following minimum operating conditions test when operating with an indoor coil airflow rate as determined in Section 5.6.2.1, and with controls and dampers set to produce the maximum tendency to frost or ice the indoor coil during cooling, provided such settings are not contrary to the *manufacturer's installation instructions* to the user.

8.3.1 Temperature Conditions

Temperature conditions shall be maintained as shown in Table 8.

8.3.2 Voltage and Frequency

The test shall be performed at nameplate rated voltage and frequency. For heat pumps with dual nameplate voltage ratings, tests shall be performed at both voltages, or at the lower of the two voltages if only a single rating is published.

8.3.3 Procedure

The equipment shall be operated continuously in the cooling cycle for not less than thirty minutes after establishment of the specified temperature conditions. In the heating cycle, the equipment shall soak for a minimum of ten minutes at the specified temperature conditions with liquid circulating through the water/brine heat exchanger. The equipment shall then be started and operated continuously for thirty minutes.

8.3.4 Requirements

During the entire test, the protective devices shall not trip, and the equipment shall operate without damage to the equipment.

8.4 Insulation Efficiency and Condensate Disposal Test (Cooling)

Water/brine to air heat pump equipment shall pass the following insulation efficiency test when operating with airflow rates as determined in Section 5.6.2.1, and with controls, fans, dampers, and grilles set to produce the maximum tendency to sweat, provided such settings are not contrary to the *manufacturer's installation instructions* to the user.

8.4.1 Temperature Conditions

Temperature conditions shall be maintained as shown in Table 8.

8.4.2 Procedure

After establishment of the specified temperature conditions, the unit shall be operated continuously for a period of four hours.

8.4.3 Requirements

During the test, condensed water shall not drop, run, or blow off from the unit casing.

8.5 Tolerances

The conditions for the tests outlined in Section 8 are average values subject to tolerances of ± 1.0ºF for air wet-bulb and dry-bulb temperatures, ± 0.5ºF for water temperatures, and ± 1.0% of the readings for specified voltage.

Section 9. Marking and Nameplate Data

At a minimum, the nameplate shall display the manufacturer's name, model designation, serial number, refrigerant designation in accordance with ASHRAE 34, refrigerant mass charge, and electrical characteristics.

Nameplate voltages for 60 Hz systems shall include one or more of the equipment nameplate voltage ratings shown in Table 1 of AHRI 110. Nameplate voltages for 50 Hz systems shall include one or more of the utilization voltages shown in Table 2 of AHRI 110.

Section 10. Conformance Conditions

While conformance with this standard is voluntary, conformance shall not be claimed or implied for products or equipment within the standard's Purpose (Section 1) and Scope (Section 2) unless such product claims meet all of the requirements of the standard and all of the testing and rating requirements are measured and reported in complete compliance with the standard. Any product that has not met all the requirements of the standard shall not reference, state, or acknowledge the standard in any written, oral, or electronic communication.

APPENDIX A. REFERENCES — NORMATIVE

Listed here are all standards, handbooks, and other publications essential to the formation and implementation of the standard. All references in this appendix are considered as part of the standard.

A.1. AMCA 211-22 (Rev. 01-23), *Certified Ratings Program Product Rating Manual for Fan Air Performance*, 2022, Air Movement and Control Association, 30 W. University Drive, Arlington Heights, IL 60004-1893, USA.

A.2. ANSI/AMCA 210-2016, *Laboratory Methods of Testing Fans for Certified Aerodynamic Performance Rating*, 2016, Air Movement and Control Association, 30 W. University Drive, Arlington Heights, IL 60004-1893, USA.

A.3. ANSI/ASHRAE 34-2022, *Designation and Safety Classification of Refrigerants*, 2022, ASHRAE, 180 Technology Parkway NW, Peachtree Corners, GA 30092, USA.

A.4. ANSI/ASHRAE 37-2009, *Methods of Testing for Rating Electrically Driven Unitary Air-Conditioning and Heat Pump Equipment*, 2009, ASHRAE, 180 Technology Parkway NW, Peachtree Corners, GA 30092, USA.

A.5. Errata Sheet for ANSI/ASHRAE Standard 37-2009, 27 March 2019, ASHRAE, 180 Technology Parkway NW, Peachtree Corners, GA 30092, USA.

A.6. ANSI/ASHRAE 41.1-2013, *Standard Methods for Temperature Measurement*, 2013, ASHRAE, 180 Technology Parkway NW, Peachtree Corners, GA 30092, USA.

A.7. ANSI/ASHRAE 41.6-2014, *Standard Methods for Humidity Measurements*, 2021, ASHRAE, 180 Technology Parkway NW, Peachtree Corners, GA 30092, USA.

A.8. ANSI/NEMA MG1-2016, *Motors and Generators*, 2016, National Electrical Manufacturers Association, 1300 North 17th Street, Suite 900, Rosslyn, VA 22209, USA.

A.9. ASHRAE Terminology. Accessed September 24, 2021. https://www.ashrae.org/technical-resources/authoring-tools/terminology.

A.10. ASTM B117-2019, *Standard Practice for Operating Salt Spray (Fog) Apparatus*, 2019, ASTM International, 100 Barr Harbor Drive, PO Box C700, West Conshohocken, PA 19428-2959, USA.

A.11. ASTM G85-2019, *Standard Practice for Modified Salt Spray (Fog) Testing*, 2019, ASTM International, 100 Barr Harbor Drive, PO Box C700, West Conshohocken, PA 19428-2959, USA.

A.12. CSA – C747-09 (R2019), *Energy Efficiency test methods for small motors*, 2009, CSA Group, 178 Rexdale Blvd., Toronto, Ontario M9W 1R3 Canada

A.13. ISO 5801:2017, *Fans – Performance testing using standardized airways*, 2017, International Organization for Standardization, Chemin de Blandonnet, 8 CP 401, 1214 Vernier, Geneva, Switzerland.

A.14. Melinder, A. 2010. *Properties of secondary working fluids for indirect systems*. Paris, France: International Institute of Refrigeration.

A.15. Title 10, Code of Federal Regulations (CFR), Part 429 and 431, U.S. National Archives and Records Administration, 8601 Adelphi Road, College Park, MD 20740-6001 or www.ecfr.gov.

APPENDIX B. REFERENCES — INFORMATIVE

Listed here are standards, handbooks and other publications which may provide useful information and background but are not considered essential. References in this appendix are not considered part of the standard.

None

APPENDIX C. INDOOR AIR CONDITION MEASUREMENT — NORMATIVE

C.1. Purpose

This appendix provides modifications to the test stand setup and instrumentation as defined in ASHRAE 37 and shall be used to be compliant with this standard.

C.2. Summary

Measure the indoor air entering and leaving dry-bulb temperature and water vapor content conditions that are required to be controlled for the test in accordance with Section C.3 and Section C.4. When using the indoor air enthalpy method to measure equipment capacity, measure indoor air leaving dry-bulb temperature and water vapor content. Make these measurements as described in the following sections. Maintain test operating and test condition tolerances and uniformity requirements as described in Section C.3.7.

C.3. Indoor Air Entering Conditions

Follow the requirements for cooling and heating tests as defined in the Section C.3.1 through Section C.3.7.

C.3.1. Temperature Measurements

Measure temperatures in accordance with ASHRAE 41.1 and follow the requirements of Table 13. The specified accuracies shall apply to the full instrument systems including read-out devices.

For thermopiles, thermocouple wire shall have special limits of error and all thermocouple junctions in a thermopile shall be made from the same spool of wire; thermopile junctions are wired in parallel.

When using a grid of individual thermocouples rather than a thermopile, follow the thermopile temperature requirements of Table 13.

When measuring dry-bulb temperature for sampled air within the sampled air conduit rather than with the *aspirating psychrometer* as described in Section C.3.4, use a temperature sensor and instrument system, including read-out devices, with accuracy of ≤ ± 0.2°F and display resolution of ≤ 0.1°F.

Table 13 Temperature Measurement Instrument Tolerance

Measurement	Accuracy, °F	Display Resolution, °F
Dry-bulb and Wet-bulb Temperatures[1]	≤ ± 0.2	≤ 0.1
Thermopile Temperature	≤ ± 1.0	≤ 0.1

Notes:

1. The accuracy specified is for the temperature indicating device and does not reflect the operation of the *aspirating psychrometer*.

C.3.2. Aspirating Psychrometer or Dew-point Hygrometer Requirements

If measurement of water vapor is required, use one of the two methods described in Section C.3.2.1 and Section C.3.2.2.

C.3.2.1. Aspirating Psychrometer

The *aspirating psychrometer* consists of a flow section and a fan to draw air through the flow section and measures an average value of the sampled air stream. The flow section shall be equipped with two dry-bulb temperature probe connections. One shall be used for the facility temperature measurement, and the other shall be provided to confirm this measurement using an additional or a third-party's temperature sensor probe. The flow section shall be equipped with two wet-bulb temperature probe connection zones, and one shall be used for the facility wet-bulb measurement, and the other shall be provided to confirm the wet-bulb measurement using an additional or a third-party's wet-bulb sensor probe. The *aspirating psychrometer* shall include a fan that can either be adjusted manually or automatically to maintain the required velocity of 1,000 ± 200 fpm across the sensors. An example configuration for the *aspirating psychrometer* is shown in Figure 2.

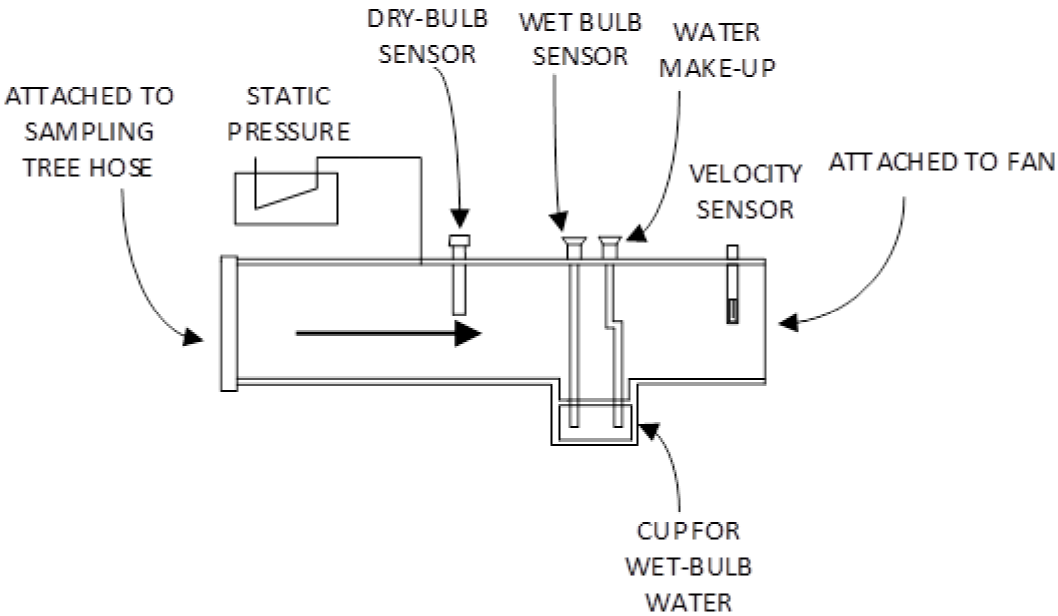

Figure 2 Example Aspirating Psychrometer Configuration (Informative)

C.3.2.2. Dew-point Hygrometer

Measure dew point temperature using a d*ew-point hygrometer* as specified in Section 4, Section 5, Section 6, Section 7.1, and Section 7.4 of ASHRAE 41.6 with an accuracy of within ± 0.4°F. Use a dry-bulb temperature sensor within the sampled air conduit and locate the *dew-point hygrometer* downstream of the dry-bulb temperature sensor, and upstream of the fan.

C.3.3. Air Sampling Tree Requirements

The *air sampling tree* is intended to draw a uniform sample of the airflow entering the equipment indoor heat exchanger. An example configuration for the *air sampling tree* is shown in Figure 3 for a tree with overall dimensions of 4 ft by 4 ft sample. Other sizes and rectangular shapes can be used and shall be scaled accordingly as long as the aspect ratio (width to height) of not greater than 2 to 1 is maintained.

The air sampling tree shall be constructed of stainless steel, plastic, or other durable materials. The *air sampling tree* shall have a main flow trunk tube with a series of branch tubes connected to the trunk tube. The branch tubes shall have evenly spaced holes, sized to provide equal airflow through all the holes by increasing the hole size as you move further from the trunk tube to account for the static pressure regain effect in the branch and trunk tubes. The branch tubes shall have a minimum hole density of six holes per square foot of area to be sampled. The minimum average velocity through the *air sampling tree holes* shall be 2.5 ft/s as determined by evaluating the sum of the open area of the holes as compared to the flow area in the *aspirating psychrometer*. The assembly shall have a tubular connection and have a flexible tube connected to the *air sampling tree* and to the *aspirating psychrometer*.

The inlet *air sampling tree* shall be equipped with a thermocouple thermopile grid or individual thermocouples to measure the average temperature of the airflow over the *air sampling tree*. Angled or wrap-around *air sampling trees* shall have a thermocouple thermopile grid or a grid of individual thermocouples to separately measure the average temperature for each plane (such as each set of co-planar air sampling holes) of the *air sampling tree*. The *air sampling trees* shall be placed within six to twelve inches from the equipment to minimize the risk of damage to the equipment while ensuring that the *air sampling trees* are measuring the air going into the equipment rather than the room air around the equipment. Sampling holes shall not pull in the discharge air leaving the indoor section of the unit under test.

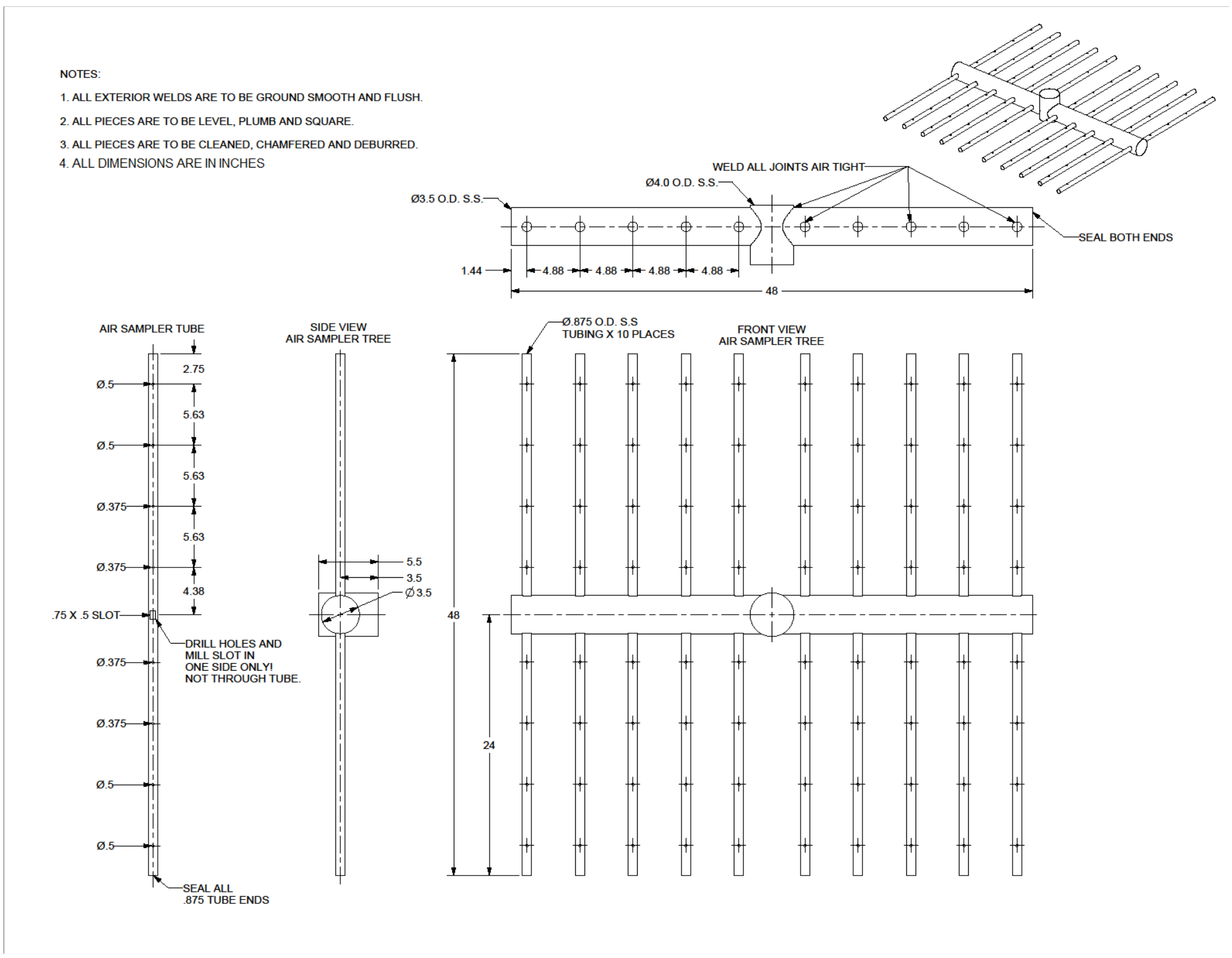

Figure 3 Example Air Sampling Tree Configuration (Informative)

Note: The 0.75 in by 0.50 in slots referenced in Figure 3 are cut into the branches of the *air sampling tree* and are located inside of the trunk of the *air sampling tree*. The slots are placed to have air pulled into the main trunk from each of the branches.

C.3.3.1. Test Setup Description

The nominal face area of the airflow shall be divided into equal area sampling rectangles with aspect ratios not greater than two to one. Each rectangular area shall have one *air sampling tree*. A minimum of one *aspirating psychrometer* or *dew-point hygrometer* per side of an equipment shall be used except for equipment with three or more sides. For equipment with three or more sides, two sampling *aspirating psychrometer*s or *dew-point hygrometers* shall be used but shall require a separate *air sampling tree* for the third side. For equipment that has air entering the sides and the bottom, additional *air sampling trees* shall be used. For equipment that requires more than eight *air sampling trees*, install a thermocouple thermopile grid or individual thermocouples on each rectangular area where an *air sampling tree* is not installed.

The *air sampling trees* shall be located at the geometric center of each rectangle and either horizontal or vertical orientation of the branches can be used. The sampling trees shall cover at least 80% of the height and 60% of the width of the air entrance to the equipment for long horizontal heat exchangers or shall cover at least 80% of the width and 60% of the height of the air entrance for tall vertical heat exchangers. If the *air sampling trees* extend beyond the face of the air entrance area, block all branch inlet holes that extend beyond that area. Refer to Figure 4 for examples of how an increasing number of *air sampling trees* are required for longer heat exchangers.

A maximum of four *air sampling trees* shall be connected to each *aspirating psychrometer* or *dew-point hygrometer*. The *air sampling trees* shall be connected to the *aspirating psychrometer* or *dew-point hygrometer* using flexible tubing that is insulated and routed to prevent heat transfer to the air stream. To proportionately divide the flow stream for multiple *air sampling trees* for a given *aspirating psychrometer* or *dew-point hygrometer*, the flexible tubing shall be of equal lengths for each *air sampling tree*. Refer to Figure 5 for examples of *air sampling tree* and *aspirating psychrometer* or *dew-point hygrometer* setups.

If using more than one *air sampling tree*, all *air sampling trees* shall be of the same size and have the same number of inlet holes.

Draw air through the air samplers using the fans of the *aspirating psychrometer(s)* or, if using a *dew-point hygrometer*, comparable fans that can adjust airflow through the air sampler inlet holes as specified in Section C.3.3. Sampled air shall be returned to the room where the system draws the indoor heat exchanger entering air., If the loop air enthalpy test method specified in Section 6.1.2 of ASHRAE 37 is used, then the sampled air shall be returned upstream of the air sampler in the loop duct between the airflow-measuring apparatus and the room conditioning apparatus or to the airflow-measuring apparatus between the nozzles and the fan.

If air is sampled within a duct, the *air sampling tree* shall be installed with the rectangle defined by the air sampler inlet holes oriented parallel with and centered in the duct cross section. The rectangle shall have dimensions that are at least 75% of the duct's respective dimensions.

The *air sampling tree* shall be spaced six to twelve inches from the inlet to the equipment.

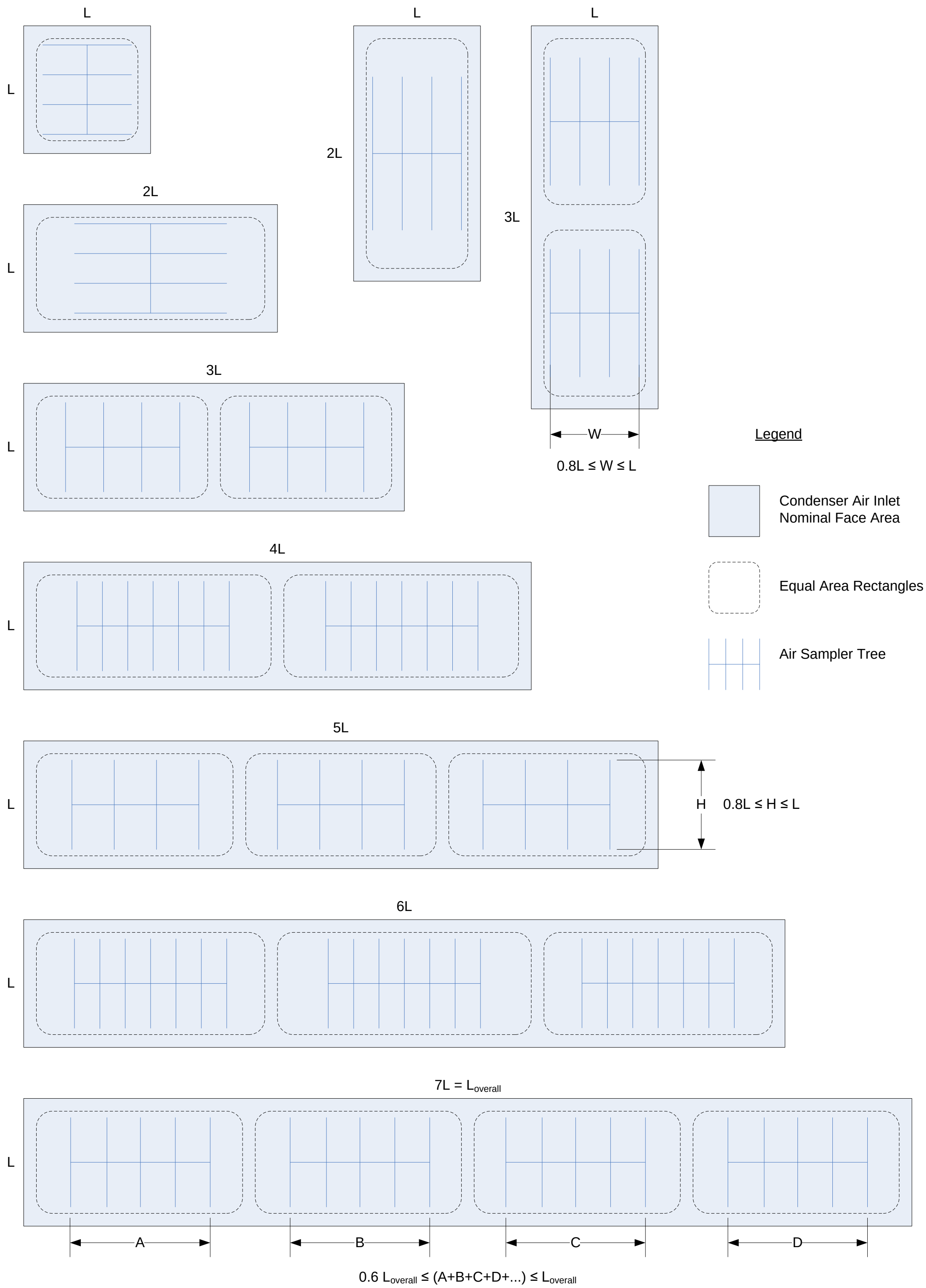

Figure 4 Example of Determination of Measurement Rectangles and Required Number of Air Sampling Trees (Informative)

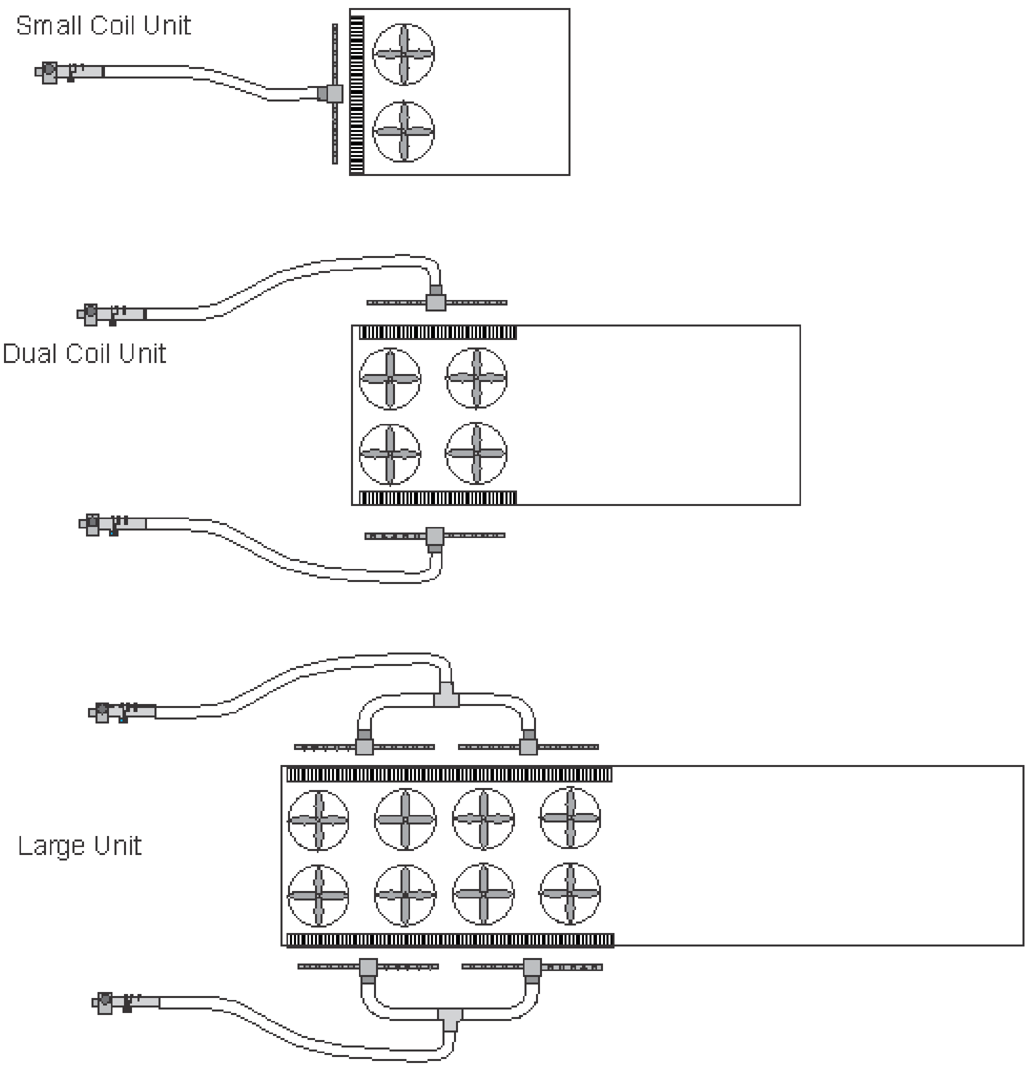

Figure 5 Example Test Setup Configurations (Informative)

C.3.4. Dry-bulb Temperature Measurement

Measure dry-bulb temperatures using the *aspirating psychrometer* or *dew-point hygrometer* dry-bulb sensors, or, if not using *aspirating psychrometer* or *dew-point hygrometer*, use dry-bulb temperature sensors with accuracy as described in Section C.3.1. Measure the dry-bulb temperature within the conduit at a location between the air sampler exit to the conduit and the air sampler fan. When a fan draws air through more than one air sampler, the dry-bulb temperature can be measured separately for each air sampler or for the combined set of air sampler flows. If dry-bulb temperature is measured at the air sampler exit to the conduit, a thermocouple thermopile grid, or a grid of individual thermocouples for duplicate measurement of dry-bulb temperature is not required, and the air-sampler-exit measurement shall be used when checking temperature uniformity.

C.3.5. Wet-Bulb or Dew Point Temperature Measurement to Determine Air Water Vapor Content

Measure wet-bulb temperatures using one or more *aspirating psychrometers* or measure dew point temperature using one or more *dew-point hygrometers*. If using *dew-point hygrometers*, measure dew point temperature within the conduit conducting air sampler air to the air-sampling fan at a location downstream of the dry-bulb temperature measurement. When a fan draws air through more than one air sampler, the dew point temperature can be measured separately for each air sampler or for the combined set of air sampler flows.

C.3.6. Monitoring and Adjustment for Air Sampler Conduit Temperature Change and Pressure Drop

If dry-bulb temperature is measured at a distance from the air sampler exits, determine average conduit temperature change as the difference in temperature between the remote dry-bulb temperature and the average of thermopiles or thermocouple measurements of all air samplers collecting air that is measured by the remote dry-bulb temperature sensor. If this difference is greater than 0.5°F, measure dry-bulb temperature at the exit of each air sampler as described in Section C.3.4, and use these additional sensors to determine average indoor entering air dry-bulb temperature.

Measure gauge pressure at the sensor location of any instrument measuring water vapor content. If the pressure differs from room pressure by more than 2 in H_2O, use this gauge pressure measurement to adjust the atmospheric pressure used to calculate the humidity ratio in units of pounds of moisture per pound of dry air at the measurement location.

If either the 0.5°F temperature difference threshold or the 2 in H_2O pressure difference threshold are exceeded, use a two-step process to calculate adjusted air properties for the one or more affected air samplers.

First, calculate the humidity ratio at the humidity measurement location(s) using either the *aspirating psychrometer* dry-bulb and wet-bulb temperature measurements or the *dew-point hygrometer* measurement, using for either approach the adjusted pressure, if the adjusted pressure differs from the room atmospheric pressure by 2 in H_2O or more. Then calculate the air properties for the air sampler location based on the humidity ratio, the room atmospheric pressure, and the dry-bulb temperature at the air sampler location. If the air sampler fan or *aspirating psychrometer* serves more than one air sampler, and the 0.5 °F threshold is exceeded, the dry-bulb temperature used in this calculation shall be the average of the air sampler exit measurements. For multiple air samplers, if humidity is measured using multiple hygrometers, the humidity ratio used in this calculation shall be the average of the calculated humidity ratios calculated in the first step.

C.3.7. Temperature Uniformity

To guarantee air distribution as defined in Table 14, thorough mixing, and uniform air temperature, the room and test setup shall be correctly designed and operated. Air distribution at the test facility at the point of supply to the equipment shall be reviewed to determine if the air distribution requires remediation prior to beginning testing.

Mixing fans can be used to provide air distribution in the test room. If used, mixing fans shall be pointed away from the air intake so that the mixing fan exhaust direction is at an angle of 90°-270° to the air entrance to the indoor air inlet.

When not using *aspirating psychrometers*, the *Aspirating psychrometer* dry-bulb temperature measurement in Table 14 refers to either:

1) dry-bulb temperature measurement in a single common air conduit serving one or more air samplers
2) average of the dry-bulb temperature measurements made separately for each of the air samplers served by a single air sampler fan

"Wet-bulb temperature" refers to calculated wet-bulb temperatures based on dew point measurements.

Adjust measurements if required by Section C.3.6 prior to checking uniformity.

The 1.5ºF dry-bulb temperature tolerance in Table 14 between the air sampler thermopile (thermocouple) measurements and *aspirating psychrometer* measurements only applies when more than one air sampler serves a given psychrometer (see note 2 in Table 14). If the average of the thermopile measurements differs from the *aspirating psychrometer* or conduit dry-bulb temperature sensor measurement by more than 0.5 °F, use air-sampler exit dry-bulb temperature sensors. For this case, the uniformity requirement is based on comparison of each of the air-sampler exit measurements with the average of these measurements.

The uniformity requirements apply to test period averages rather than instantaneous measurements.

A valid test shall meet the criteria for air distribution and control of air temperature as shown in Table 14.

Table 14 Uniformity Criteria for Indoor Air Temperature and Humidity Distribution

Uniformity Criterion[1]	Purpose	Maximum Variation, °F
Deviation from the mean air dry-bulb temperature to the air dry-bulb temperature at any individual temperature measurement station	Uniform dry-bulb temperature distribution	± 2.0
Difference between dry-bulb temperature measured with *air sampler tree* thermopile and with *aspirating psychrometer*[2]	Uniform dry-bulb temperature distribution	± 1.5
Deviation from the mean wet-bulb temperature and the individual temperature measurement stations	Uniform humidity distribution	± 1.0

Notes:

1. The uniformity requirements apply to test period averages for each parameter rather than instantaneous measurements. Each measurement station represents a single *aspirating psychrometer*. The mean temperature is the mean of temperatures measures from all measurement stations.
2. Applies when multiple air samplers are connected to a single *aspirating psychrometer* or conduit dry-bulb temperature sensor.

C.4. Indoor Heat Exchanger Leaving Air Conditions

Follow the requirements for measurement of indoor heat exchanger entering air conditions as described in Section C.3, except for the following:

1) The temperature uniformity requirements discussed in Section C.3.7 do not apply.
2) Both dry-bulb temperature and water vapor content measurements are required for indoor heat exchanger leaving air for all tests.
3) Air in the duct leaving the heat exchanger that is drawn into the *air sampling tree* for measurement shall be returned to the duct just downstream of the *air sampling tree* and upstream of the airflow-measuring apparatus.

For a heat exchanger with a blow-through fan, such as where the fan is located upstream of the heat exchanger, use a grid of individual thermocouples rather than a thermopile on the *air sampling tree*, even if air-sampler-exit dry-bulb temperature measurement instruments are installed. If the difference between the maximum time-averaged thermocouple measurement and the minimum time-averaged thermocouple measurement is greater than 1.5°F, install mixing devices such as those described in Section 5.3.2 and Section 5.3.3 of ASHRAE 41.1 to reduce the maximum temperature spread to less than 1.5°F.

The *air sampling tree* used within the duct transferring air to the airflow-measuring apparatus shall be installed with the rectangle defined by the air sampler inlet holes oriented parallel with and centered in the duct cross section. This rectangle shall have dimensions that are at least 75% of the duct's respective dimensions.

APPENDIX D. UNIT CONFIGURATION FOR STANDARD EFFICIENCY DETERMINATION — NORMATIVE

D.1. Purpose

This appendix is used to determine the configuration of different components for determining representations, that include the *standard rating cooling* and *heating capacity* and efficiency metrics.

D.2. Configuration Requirements

For the purpose of *standard ratings*, units shall be configured for testing as defined in this appendix.

D.2.1. Basic Model

Basic model means all units manufactured by one manufacturer within a single equipment class, having the same or comparably performing compressor(s), heat exchangers, and air moving system(s) that have a common "nominal" *cooling capacity*.

All components indicated in the following list shall be present and installed for all testing for each *indoor unit* and *outdoor unit*, as applicable, and shall be the components distributed in commerce with the model. Individual models that contain/use (different or alternate) versions of the same component or controls shall either be represented separately as a unique *basic model* or certified within the same *basic model* based on testing of the least efficient configuration.

1) Compressor(s)
2) Water/Brine heat exchanger(s)
3) Indoor coil(s) or heat exchanger(s)
4) Refrigerant expansion device(s)
5) Indoor fan/motor(s) (except for *coil-only indoor units*)
6) System controls

For an individual model distributed in commerce with any of the following heating components, these heating components shall be present and installed for testing:

1) Reverse cycle heat pump functionality
2) Gas furnace
3) Electric resistance
4) Steam and hydronic coils (if not optional in accordance with Section D.3.10)

D.3. Optional System Features

The following features are optional during testing. Individual models with these features can be represented separately as a unique *basic model* or certified within the same *basic model* as otherwise identical individual models without the feature pursuant to the definition of "*basic model*".

If an otherwise identical model (within the same *basic model*) without the feature is distributed in commerce, test the otherwise identical model.

If an otherwise identical model (within the *basic model*) without the feature is not distributed in commerce, conduct tests with the feature present but configured and de-activated to minimize (partially or totally) the impact on the results of the test. Alternatively, the manufacturer can indicate in the *STI* that the test shall be conducted using a specially built otherwise identical unit that is not distributed in commerce and does not have the feature.

D.3.1. UV Lights

UV lights shall be turned off for testing.

D.3.2. High-effectiveness Indoor Air Filtration

If present during the test, *high-effectiveness indoor air filters* shall be replaced with the *standard filter*.

D.3.3. Air Economizers

If an *air economizer* is present during the test, the economizer shall be in the 100% return position with outside air dampers closed and sealed to block any leakage.

D.3.4. Fresh Air Dampers

If *fresh air dampers* are present during the test, test with the *fresh air dampers* closed and sealed using tape or other means to block any leakage.

D.3.5. Barometric Relief Dampers

If *barometric relief dampers* are present during the test, test with the *barometric relief dampers* closed and sealed to block any leakage.

D.3.6. Ventilation Energy Recovery System (VERS)

If a *VERS* is present during the test, test with the outside air and exhaust air dampers closed and sealed using tape or other means to block any leakage.

D.3.7. Process Heat Recovery / Reclaim Coils / Thermal Storage

If a *process heat recovery / reclaim coil / thermal storage* is present for testing, disconnect the feature from the external source.

D.3.8. Indirect/Direct Evaporative Cooling of Ventilation Air

If *indirect/direct evaporative cooling* is present for testing, the feature shall be deactivated.

D.3.9. Desiccant Dehumidification Components

If *desiccant dehumidification components* are present for testing, the feature shall be deactivated.

D.3.10. Steam/Hydronic Heat Coils

Steam/hydronic heat coils are an optional system feature only if all otherwise identical individual models without the *steam/hydronic heat coils* that are part of the same *basic model* have another form of primary heating other than reverse cycle heating (for example electric resistance heating or gas heating). If all individual models of the *basic model* have either steam or hydronic heat coils and do not have other forms of heat, test with steam/hydronic heat coils in place but without providing heat.

D.3.11. Refrigerant Reheat Coils

If *refrigerant reheat coils* are present for testing, the feature shall be de-activated to provide the minimum reheat achievable by the system controls including none.

D.3.12. Powered Exhaust/Powered Return Air Fans

If a *powered exhaust* or *return fan* is present for testing, this feature shall be set up as indicated by the *STI*.

D.3.13. Coated Coils

Corrosion durability of these coil coatings shall be confirmed through testing in accordance with ASTM B117 or the ASTM G85 salt spray test to a minimum of 500 hours or more.

D.3.14. Power Correction Capacitors

Power correction capacitors shall be removed for testing.

D.3.15. Sound Traps/Sound Attenuators

Sound traps/Sound Attenuators are optional during testing.

D.3.16. Fire/Smoke/Isolation Dampers

Fire/smoke/isolation dampers can be rated by a test laboratory according to the safety standard, such as UL 555 or UL 555S. If a *fire/smoke/isolation damper* is present for testing, set the damper in the fully open position.

D.3.17. Hot Gas Bypass

If a *hot gas bypass* is present for testing, set the *hot gas bypass* as indicated in manufacturer's supplemental testing instructions.

D.3.18. Condenser Pump/Valves/Fittings

If a *condenser pump* or *valve* or *fitting* is present for testing, set the *condenser pump* or *valve* or *fitting* as indicated in manufacturer's *STI*.

D.3.19. Condenser Water Reheat

If *condenser water reheat* is present for testing, set the *condenser water reheat* as indicated in manufacturer's *STI*.

D.3.20. Grill Options

If a special *grill* is present for testing, set the special grill as indicated in manufacturer's *STI*.

D.3.21. Waterside Economizer

If a *waterside economizer* is present for testing, set the *waterside economizer* as indicated in manufacturer's *STI*.

D.3.22. Desuperheater

If a *desuperheater* is present for testing, the *desuperheater* shall be de-activated as indicated in the manufacturer's *STI*.

D.4. Non-Standard Indoor Fan Motors

The standard indoor fan motor is the motor specified in the *manufacturer's installation instructions* for testing and shall be distributed in commerce as part of a particular model. A non-standard motor is an indoor fan motor that is not the standard indoor fan motor and that is distributed in commerce as part of an individual model within the same *basic model*. The minimum allowable efficiency of any non-standard indoor fan motor shall be related to the efficiency of the standard motor as specified in either Section D.4.1 for non-standard indoor fan motors or Section D.4.2 for non-standard indoor integrated fan and motor combinations. If the standard indoor fan motor can vary fan speed through control system adjustment of motor speed, all non-standard indoor fan motors shall have speed control including with the use of VFD.

D.4.1. Determination of Motor Efficiency for Non-standard Indoor Fan Motors

D.4.1.1. Standard and Non-standard Indoor Fan Motor Efficiencies

Standard and non-standard indoor fan motor efficiencies shall be based on the test procedures indicated in Table 15.

Air-over motors shall be tested to the applicable test procedure based on the motor's phase count and horsepower, except that the NEMA MG1-2016, Supplement 2017 procedure for air-over motor temperature stabilization shall be used rather than the temperature stabilization procedure specified in the applicable test procedure based on the motor's phase count and horsepower. The NEMA MG1-2016, Supplement 2017 procedure for air-over motor temperature stabilization offers three options – the same option shall be used by the manufacturer for both the standard and non-standard motor.

BLDC motors and ECMs shall be tested and rated for efficiency at full speed and full rated load. CSA C747 can be applied to motors ≥ 1 hp.

D.4.1.2. Reference Motor Efficiencies

Reference motor efficiencies shall be determined for the standard and non-standard indoor fan motor as indicated in Table 15. Table 16 shows BLDC Motor and ECM fractional hp reference efficiencies.

For standard or non-standard motors with horsepower ratings between values given in the references, use the steps at 10 CFR 431.446(b) to determine the applicable reference motor efficiency. Use the efficiency of the next higher reference horsepower for a motor with a horsepower rating at or above the midpoint between two consecutive standard horsepower ratings or the efficiency of the next lower reference horsepower for a motor with a horsepower rating below the midpoint between two consecutive standard horsepower ratings.

If the motor horsepower is below the 0.25 hp limit in Table 16, use the reference motor efficiency of 0.25 hp.

For BLDC motors and ECMs > 0.75 and < 1 hp, use Table 16 for motors < 0.875 hp, and use federal standard levels for 1 hp, 4 pole, open motors at 10 CFR 431.25(h) for motors ≥ 0.875 hp.

D.4.1.3. Non-standard Motor Efficiency Criterion

Non-standard motor efficiency shall meet the criterion in Equation 27.

$$\eta_{non-standard} \geq \frac{\eta_{standard} - \eta_{reference\ standard}}{1 - \eta_{reference\ standard}} \cdot \left(1 - \eta_{reference\ non-standard}\right) + \eta_{reference\ non-standard} \qquad \textbf{27}$$

Where:

$\eta_{standard}$	=	the tested efficiency of the standard indoor fan motor
$\eta_{non-standard}$	=	the tested efficiency of the non-standard indoor fan motor
$\eta_{reference\ standard}$	=	the reference efficiency from Table 15 for the standard indoor fan motor
$\eta_{reference\ non-standard}$	=	the reference efficiency from Table 15 for the non-standard indoor fan motor

Table 15 Test Procedures and Reference Motor Efficiency

Motor – Standard or Non-standard	Test Procedure	Reference Motor Efficiency
Single Phase ≤ 2 hp	10 CFR 431.444	Federal standard levels for capacitor-start capacitor-run and capacitor-start induction run, 4 pole, open motors at 10 CFR 431.446
Single Phase > 2 hp and ≤ 3 hp	10 CFR 431.444	Federal standard levels for polyphase, 4 pole, open motors at 10 CFR 431.446.
Single Phase > 3hp	10 CFR 431.444	Federal standard levels for 4 pole, open motors at 10 CFR 431.25(h).
Polyphase ≤ 3 hp for cases where the standard or non-standard, or both, indoor fan motor is <1 hp	10 CFR 431.444	Federal standard levels for polyphase, 4 pole, open motors at 10 CFR 431.446.
Polyphase ≤ 3 hp for cases where both the standard and non-standard indoor fan motor are ≥ 1 hp	10 CFR 431.444	For standard or non-standard, or both, 2-digit frame size motors (except 56-frame enclosed ≥ 1 hp) ≤3 hp: Federal standard levels for polyphase, 4 pole open motors at 10 CFR 431.446
	Appendix B to Subpart B of 10 CFR 431	For all other standard or non-standard, or both, motors ≤3 hp: Federal standard levels for 4 pole, open motors at 10 CFR 431.25(h).
Polyphase > 3 hp	Appendix B to Subpart B of 10 CFR 431	Federal standard levels for 4 pole, open motors at 10 CFR 431.25(h).
BLDC[1] motor or ECM[2] ≥ 1 hp	CSA C747	Federal standard levels for 4 pole, open motors at 10 CFR 431.25(h).
BLDC motor or ECM < 1 hp	CSA C747	Use Table 16.

Notes:
1. Brushless DC (BLDC) permanent magnet motor
2. Electronically commutated motor

Table 16 BLDC Motor and ECM – Fractional hp – Reference Efficiencies

Motor hp	Reference Motor Efficiency
0.25	78.0
0.33	80.0
0.50	82.5
0.75	84.0

D.4.2. Comparison of the Fan Input Power of the Standard Indoor Fan and a Non-standard Indoor Fan at a Single Duty Point if at Least One Fan is an Integrated Fan and Motor (IFM)

The fan input power of the standard and non-standard fans shall be compared using one of the methods listed in Table 17 at a duty point determined in accordance with the requirements of Section D.4.2.2. The ratio of the fan input power of the non-standard fan to the standard fan shall be determined in accordance with Equation 28 and shall not exceed the max ratio of fan input powers value shown in Table 17. In this section, the word "fan" applies to either an IFM or a non-integrated assembly of a fan, motor, and motor controller.

$$R_{IF} = \frac{P_{IF,non-std}}{P_{IF,std}} \quad (28)$$

Where:

R_{IF} = The ratio of the fan input power of the non-standard fan to the fan input power of the standard fan, W/W.

$P_{IF,non-std}$ = The fan input power of the non-standard fan at the compared fan duty point, W.

$P_{IF,std}$ = The fan input power of the standard fan at the compared fan duty point, W.

Table 17 Values for Evaluating the Fan Input Power for Non-standard Fans

Method of Fan Input Power Determination			Tolerances for the Non-Standard Fan Test		
Standard Fan	**Non-standard Fan**	**Section**	**Airflow Tolerance (%)**	**Pressure Tolerance (in H_2O)**	**Max Ratio of Fan Input Powers[1,2]**
Inside the unit	Inside the unit	D.4.2.3	-0.5 / +1.0	± 0.05	110%
Outside the unit	Outside the unit	D.4.2.4	-0.5 / +1.0	± 0.05	110%
Simulated performance data	Simulated performance data	D.4.2.5	N/A	N/A	105%

Notes:
1. The ratio of the fan input power of the non-standard fan to the standard fan as shown in Equation 28.
2. The 110% value includes fan testing tolerances.

D.4.2.1. Fan Requirements

The methods in Section D.4.2 can only be applied if the standard and non-standard fans meet all the following requirements:

1) At least one of the fans is an IFM such that the motor efficiency cannot be tested using one of the methods in Section D.4.1.
2) The impeller diameter and number of blades of both fans are the same.
3) The maximum ESP at the *full load rated indoor airflow* of a unit with the non-standard fan is greater than that of the same unit with the standard fan.

D.4.2.1.1. Fan Arrays

If fan arrays are used, all fans and motors shall be identical in any standard or non-standard fan array. When testing outside a unit in accordance with Section D.4.2.4 or using simulated performance data in accordance with Section D.4.2.5, only one fan from each fan array needs to be evaluated.

D.4.2.2. Determination of the Fan Duty Point

The airflow for the fan duty point is the *full load rated indoor airflow* and the maximum ESP or total static pressure (TSP) shall be determined in accordance with the requirements of Section D.4.2.3, Section D.4.2.4, or Section D.4.2.5.

D.4.2.3. Requirements If Testing Both Fans Inside a Unit

If both fans are tested inside a unit, all the requirements in Section D.4.2.3.1 through Section D.4.2.3.6 shall be met.

D.4.2.3.1. Airflow and ESP

Airflow and ESP shall be determined in accordance with the requirements of ASHRAE 37, and airflow shall be corrected to *standard airflow*.

D.4.2.3.2. Indoor Fan Input Power

The indoor fan input power shall be measured in accordance with the requirements of Section 5 of ASHRAE 37.

D.4.2.3.3. Compressor Off

The unit shall operate with the compressor off during testing.

D.4.2.3.4. Standard and Non-standard Fans Within Different Units

If testing the standard and non-standard fans within different units, the two units shall be of identical construction, other than the fan, motor, and motor controller.

D.4.2.3.5. Determination of the Fan Duty Point ESP

The fan speed of the standard fan shall be set to the highest permitted by the unit controls. The airflow shall be adjusted so that the airflow is within ± 2% of the *full load rated indoor airflow*. The ESP at that airflow shall be recorded and is the duty point ESP. The fan input power at that duty point shall be recorded.

D.4.2.3.6. Testing the Non-standard Fan

The fan speed of the non-standard fan shall be such that the airflow and ESP match the duty point within the tolerances listed in Table 17. The fan input power at that duty point shall be recorded. If the fan cannot be operated with airflow or ESP within the tolerances in Table 17, conduct testing in accordance with the requirements of Section D.4.2.6.

D.4.2.4. Requirements If Testing Both Fans Outside the Unit

If both fans are tested outside the unit, all the requirements in Section D.4.2.4.1 through Section D.4.2.4.4 shall be met.

D.4.2.4.1. Testing and Performance Requirements

Testing shall be performed in accordance with the requirements of AMCA 210 or ISO 5801. Performance shall be converted to *standard air* density in accordance with the requirements of AMCA 210.

D.4.2.4.2. Standard and Non-standard Fans Distributed in Commerce

The same standard and non-standard fans distributed in commerce with the *basic model* shall be used.

D.4.2.4.3. Determination of the Fan Duty Point TSP

The fan speed of the standard fan shall be set to the highest speed that is permitted by the unit controls. The airflow shall be adjusted so that the airflow is within ± 2% of the *full load rated indoor airflow*. The TSP at that airflow shall be recorded and is the duty point TSP. The fan input power at that duty point shall be recorded.

D.4.2.4.4. Testing the Non-standard Fan

The fan speed of the non-standard fan shall be such that the airflow and TSP match the duty point within the tolerances listed in Table 17. The fan input power at that duty point shall be recorded. If the fan cannot be operated with the airflow or ESP within the tolerances in Table 17, conduct testing in accordance with the requirements of Section D.4.2.6.

D.4.2.5. Requirements for Using Simulated Performance Data

If the performance of both fans is determined using simulated performance data, the requirements in Section D.4.2.5.1 through Section D.4.2.5.4 shall be met.

D.4.2.5.1. Standard and Non-standard Fans in Commerce with the Basic Model

The same standard and non-standard fans sold in commerce with the *basic model* shall be tested in accordance with the requirements of AMCA 210 or ISO 5801. This includes tests performed by the fan manufacturer that are used to develop a fan manufacturer's simulated performance software.

D.4.2.5.2. Fans Not Tested at a Fan Speed that Includes the Duty Point

If the tested speeds of one or both fans are not tested at a fan speed that includes the duty point, fan performance shall be determined using the method in Annex I of AMCA 211. If a fan manufacturer's software is used to simulate performance, the software shall comply with this requirement.

D.4.2.5.3. Determination of the Fan Duty Point TSP

The TSP and fan input power of the standard fan shall be determined at the *full load rated indoor airflow* and the highest speed that the fan permitted by the unit controls.

D.4.2.5.4. Determination of the Non-standard Fan Input Power

The fan input power of the non-standard fan shall be determined for the same airflow and TSP determined in D.4.2.5.3.

D.4.2.6. Interpolation to Determine the Fan Input Power of the Non-standard Fan

If fans tested in accordance with the requirements of Section D.4.2.3 or Section D.4.2.4 that cannot be adjusted to meet the airflow or pressure tolerances of Table 17, the fan input power shall be determined by interpolation using the methods in Section D.4.2.6.1 through Section D.4.2.6.3.

D.4.2.6.1. Non-standard Fan at Lower Fan Speed

Test the non-standard fan at a lower fan speed than that required to achieve the duty point. Record the pressure of the ESP if testing inside the unit or the TSP if testing outside the unit, *standard airflow*, and fan input power for at least three points. At least one point shall be at greater than *full load rated indoor airflow*, and at least one point shall be at less than *full load rated indoor airflow*.

D.4.2.6.2. Non-standard Fan at Higher Fan Speed

Test the non-standard fan at a higher fan speed than that required to achieve the duty point. Record the pressure of the ESP if testing inside the unit or the TSP if testing outside the unit, *standard airflow*, and fan input power for at least three points. At least one point shall be at greater than *full load rated indoor airflow*, and at least one point shall be at less than *full load rated indoor airflow*.

D.4.2.6.3. Determine Fan Input Power at Duty Point by Interpolation

Determine the fan input power at the duty point by interpolation in accordance with Annex I of AMCA 211.

APPENDIX E. TEST METHOD FOR UPFLOW UNITS IN CHAMBERS OF LIMITED HEIGHT — NORMATIVE

E.1. Summary

If the height of the unit under test plus a vertical outlet duct with pressure taps for measuring ESP that is compliant with Section 6.4.2.1 or Section 6.4.3 of ASHRAE 37 is both greater than 14 ft tall and too tall for the test chamber, this limited height approach can be used.

If the unit is shipped with a discharge plenum, do not test with the plenum. Install the test duct as shown in Figure 6 of this appendix for test duct requirements if the up-flow ducted system has a single fan outlet connection. Install the test duct as shown in **Figure 7** if the up-flow system has multiple fan outlet connections. The test duct shall fit over the provided duct flange. If a flange is not provided, the vertical duct section shall match the dimensions of the blower section.

For units with a centrifugal fan or fans with horizontal axis and vertical discharge, the elbow or elbows redirecting air from vertical to horizontal direction shall bend in the direction of motion at the top of the fan impeller.

E.2. Units with Multiple Indoor Fans

If either of the following provisions apply, test with a single outlet duct as shown in Figure 6:

1) The *manufacturer installation instructions* indicate the unit is intended to be installed with a single discharge duct.
2) The unit has a single outlet duct connection flange.

For other units with multiple blowers, attach a duct with a 90° elbow for each fan outlet connection to redirect airflow horizontally. ESP in each duct shall be measured as specified in Section 6.4.2 of ASHRAE 37. Combine all air ducts into a single horizontal common duct downstream of the static pressure taps. Refer to Figure 7 for test setup details. If needed to equalize the static pressure in each duct, an adjustable restrictor shall be in the plane where each individual duct enters the common duct section.

E.3. Turning Vanes

Calculate the discharge velocity using Equation 29:

$$V = \frac{Q_{Rated}}{A_{TD}} \qquad (29)$$

Where:

Q_{Rated} = *Full load rated indoor airflow*, scfm

A_{TD} = Total discharge area, ft^2

For units with discharge velocity greater than 800 fpm, turning vanes shall be used in the 90° elbow, as specified in Figure 6 and Figure 7. For units with discharge velocity less than or equal to 800 fpm, turning vanes shall not be used in the 90° elbow.

If turning vanes are required, the 90-degree elbow shall have single thickness turning vanes inside, with vane radius of 2.0 inches and vane distance of 1.5 inches.

E.4. Vertical Section

As shown in Figure 6 and Figure 7, for up-flow systems tested in a limited height setup, a vertical straight duct shall be installed between each fan discharge of the tested unit and the downstream 90° elbow. The length of this straight duct shall be calculated using Equation 30:

$$L = 1.25 * \sqrt{A \times B} \qquad (30)$$

Where:

A is the width of unit duct flange or fan discharge

B is the depth of unit duct flange or fan discharge

E.5. ESP Adjustment

Use the equations in Table 18 to calculate the adjusted minimum ESP requirement by subtracting ΔESP from the ESP requirement specified in Section 5.5. Round the calculated value of ΔESP to the nearest 0.01 in. H_2O.

Table 18 ESP Adjustment

Discharge Velocity	Bend Type	ESP Adjustment Equation[1]
V > 800 fpm	Turning vanes, as specified in Figure 6 or Figure 7	$\Delta ESP = 0.26 * \rho \left(\frac{V}{1097}\right)^2$
V ≤ 800 fpm	No turning vanes	$\Delta ESP = 1.34 * \rho \left(\frac{V}{1097}\right)^2$

Note:

1. ρ is the air density at the airflow test measurement station, lb/ft^3

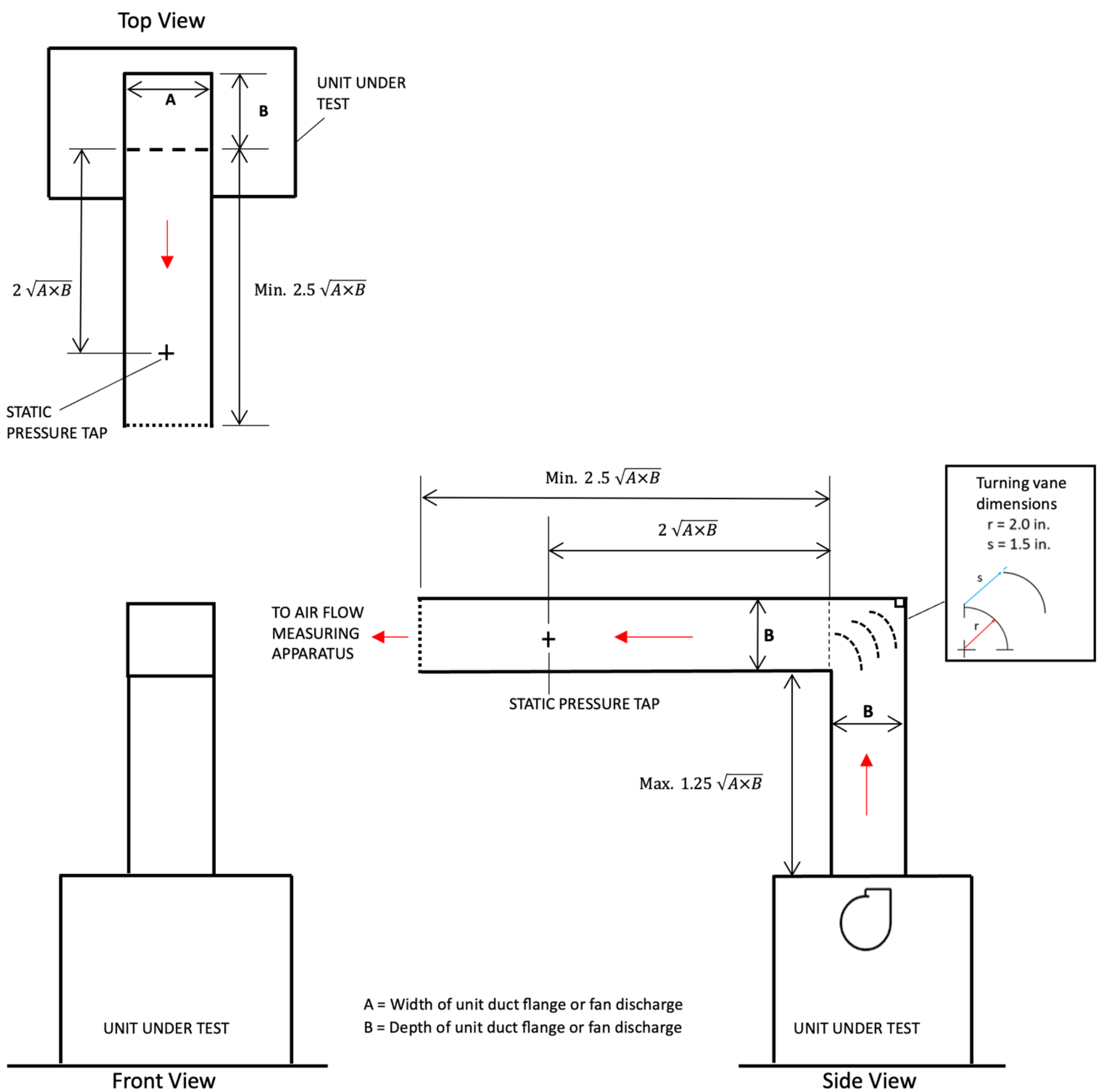

Figure 6 Test Duct Setup for Up-flow Unit with Single Fan Outlet Connection in Limited Height Test Chamber

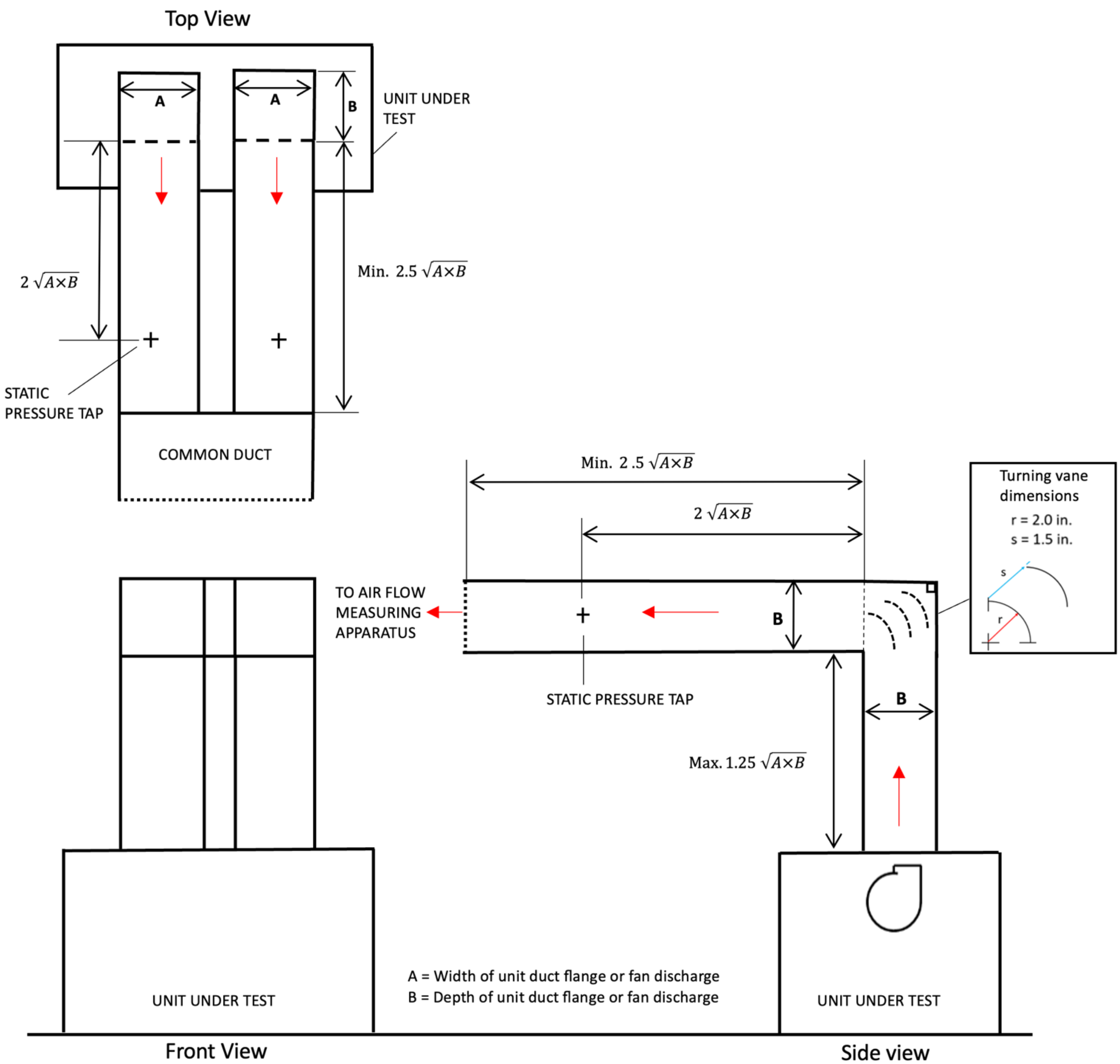

Figure 7 Test Duct Setup for Up-flow Unit with Multiple Fan Outlet Connections in Limited Height Test Chamber

APPENDIX F. EXAMPLE OF DETERMINATION OF FAN AND MOTOR EFFICIENCY FOR NON-STANDARD INTEGRATED INDOOR FAN AND MOTORS — INFORMATIVE

F.1. Background

An individual model with a non-standard indoor fan motor can be rated within the same *basic model* as an individual model with a standard fan motor if the former individual model is otherwise identical to the latter individual model, and the non-standard fan motor has the same or higher relative efficiency as the standard fan motor in accordance with Section D.4.1. However, for certain direct-drive indoor fans, the motor and fan cannot be separated, or the fans are not rated separately, or both. For such fans, the efficiency of the fan and motor combination, rather than the efficiency of the fan motor alone, is used to compare performance of the standard and non-standard fans, in accordance with the approach provided in Section D.4.2. This method is provided for cases where either or both of the standard or non-standard fans are integrated fans and motors (IFM). This appendix includes an example to help in the application of the procedures specified in Section D.4.2 to determine the relative efficiency of the standard and non-standard fan and motor combinations.

F.2. Requirements

Though only one fan is an IFM, both fans have the same diameter impeller and both impellers have the same number of blades. The impeller width is not required to be the same, since for a given airflow and impeller diameter, as pressure rise increases, the use of a narrower impeller often increases efficiency.

F.3. The Concept

The standard and non-standard fans are operated at the same airflow and pressure rise, referred to as the duty point. The electrical power required to run the non-standard fan is not more than 110% of that of the standard fan if both fans are tested at the duty points. The 110% of the standard fan includes the allowance for variance due to testing inaccuracies and biases. The fan performance can be compared without testing. This can be achieved by using the fan manufacturer's software. In that case, without testing, the ratio of fan powers is limited to 105%. Figure 8 shows an example of output from a fan manufacturer's software where there two non-standard fans:

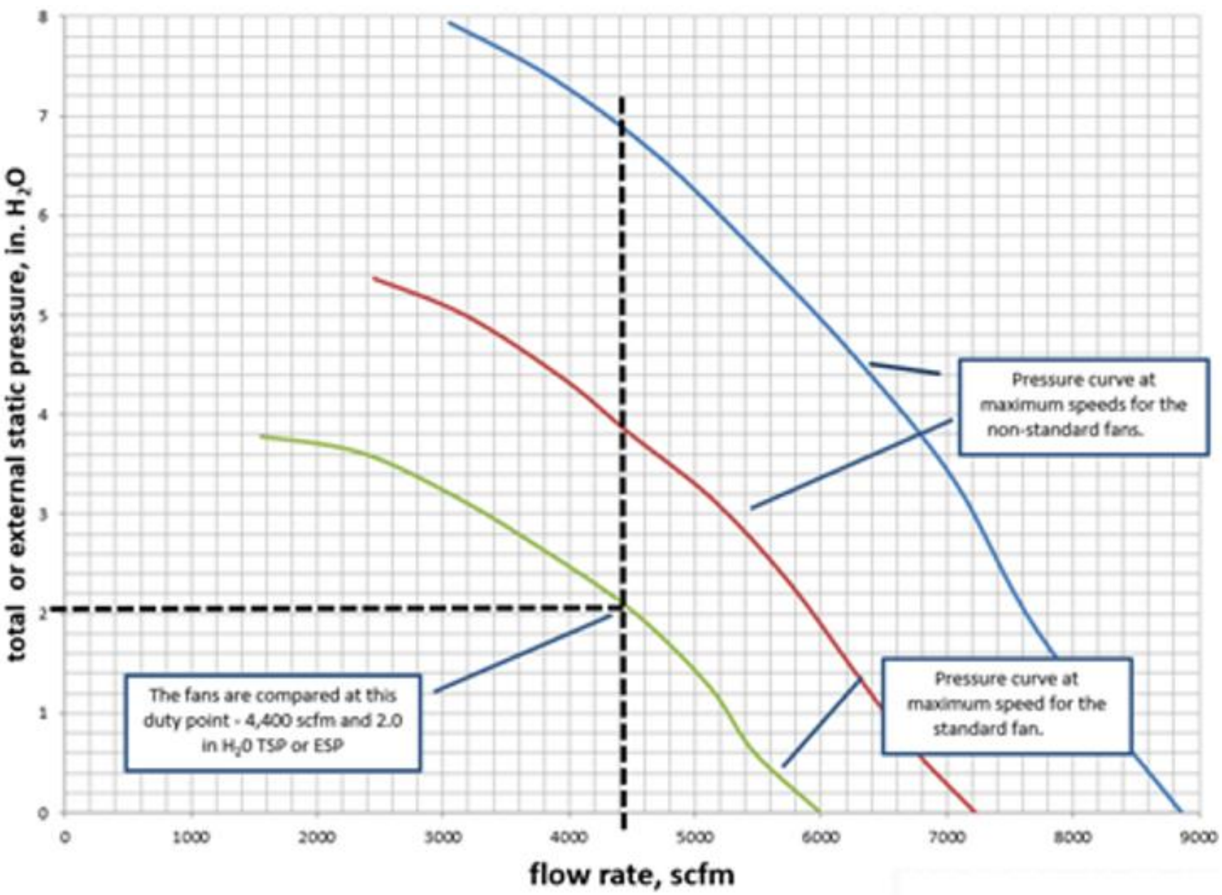

Figure 8 Illustration of the Duty Point Where Standard and Non-standard Fan Input Power is Compared

F.4. Testing Both Fans Inside a Unit

The *full load rated indoor airflow* rate for the unit is 4400 scfm. The standard fan is set to the highest speed, and the ESP is adjusted so that the airflow is 4402 scfm, that is within 2% of the *full load rated indoor airflow*. An ESP of 2.0 in H_2O is measured. The fan power of 2100 W is recorded. Then, a unit with a non-standard fan is tested with the goal of operating at the same airflow and ESP where the standard fan is tested. The tested airflow and ESP when compared to the non-standard fan is within the tolerances shown in Table 17. The measured fan input power of the non-standard fan is not be more than 2310 W (2100 W X 110%). Laboratory variance is accounted for in the 110% allowance.

F.5. Example – Comparison Using Software Based on Testing by the Requirements of AMCA 210 or ISO 5801

Often, the fan manufacturer can provide software that calculates the fan input power at any airflow and TSP within the fan's operating envelope. If the underlying tests are performed using either AMCA 210 or ISO 5801, and performance for non-tested speeds is interpolated in accordance with the requirements of Annex I of AMCA 211 in the software calculations, then the manufacturer's software can be used instead of testing.

For this example, using the graph in Figure 8, the maximum speed of the standard fan is 1800 RPM, and the green line represents the performance at that speed. The TSP of the operating point is equal to the value of the green line at 4400 scfm. This shows a TSP of 2.0 in H_2O. The software shows that fan input power of the standard fan at this operating point is 2000 W. The fan input power of the other fans is determined at the same duty point. For both of the non-standard fans, the fan input power determined cannot exceed 2100 W (2000 W • 105%).