AHRI Standard 1340-2023 (I-P)

2023 Standard for

Performance Rating of Commercial and Industrial Unitary Air-conditioning and Heat Pump Equipment

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ICS Code: 23.120

Note:

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

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Intent

This standard is intended for the guidance of the industry, including manufacturers, engineers, installers, contractors, federal and state regulations, and efficiency standards developed by ASHRAE 90.1, International Energy Conservation Code (IECC), Canadian Standards Association (CSA), Department of Energy (DOE), and users.

Review and Amendment

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

2023 Edition

This edition of AHRI Standard 1340, *Performance Rating of Commercial and Industrial Unitary Air-conditioning and Heat Pump Equipment*, was prepared by Commercial Unitary Standards Technical Committee. The standard was approved by the Unitary Standards Subcommittee on 16 November 2023.

Origin and Development of AHRI Standard 1340

AHRI Standard 1340 (I-P) establishes the method to rate and test unitary air-cooled air conditions and heat pumps with a capacity greater than or equal to 65,000 Btu/h cooling capacity and all water cooled and evaporatively cooled unitary products using the new cooling metric to replace IEER called the *integrated ventilation, economizer, and cooling metric* (*IVEC*) and to add a new heat pump annualized heating metric called *integrated ventilation, heating efficiency* (*IVHE*). These new metrics and rating and test procedures were developed as part of the Department of Energy (DOE) Appliance Standards Rulemaking Advisory Committee (ASRAC) Commercial Unitary Air Conditioners and Heat Pumps Working Group.

This standard does not replace AHRI Standard 340/360-2022 (I-P) where IEER and COP ratings are required but AHRI Standard 1340 (I-P) should be used for *IVEC* and *IVHE* ratings.

AHRI Standard 1340 (I-P) is intended to cover the rating and test procedure requirements to align with the DOE ASRAC negotiation rule that developed the new the *IVEC* and to add a new heat pump annualized heating metric called *IVHE*.

The ASRAC negotiations were limited to air cooled cooling only products and heat pump products with a capacity greater than or equal to 65,000 Btu/h up to 760,000 Btu/h, but this standard expands to cover the following products:

- Unitary air-cooled products with a capacity greater than or equal to 760,000 Btu/h
- Unitary heat pump products with a capacity greater than or equal to 760,000 Btu/h
- Water cooled products
- Evaporatively cooled products
- Double duct products
- Cold Climate $IVHE_C$

The derivation and background of IVEC and IVHE will be explained in a separate technical support document.

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Commercial Unitary Standards Technical Committee Scope:

The Commercial Unitary Standards Technical Committee is responsible for the development and maintenance of AHRI standards and guidelines pertaining to commercial and industrial unitary air-conditioning and heat pump equipment including split systems, remote condensing units, and packaged equipment.

The following product types are out of scope for this STC: unitary small equipment, packaged terminal AC/HP, furnaces, variable refrigerant systems (VRF), geothermal and water source HP, single package vertical unit (SPVU), and performance rating of zoning products.

For product definitions refer to the AHRI website sector pages at www.ahrinet.org.

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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 at https://ahrinet.org/about-us/ahri-industry-sectors).

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 COMMERCIAL AND INDUSTRIAL UNITARY AIR-CONDITIONING AND HEAT PUMP EQUIPMENT

Section 1. Purpose

This standard establishes definitions, classifications, test requirements, rating requirements, minimum data requirements for *published rating*s, operating requirements, marking and nameplate data, and conformance conditions that include the *IVEC* and *IVHE* efficiency metrics for commercial and industrial unitary air-conditioning and heat pump equipment.

Section 2. Scope

2.1 Scope

This standard applies to factory-made commercial and industrial unitary air-conditioning and heat pump equipment as defined in Section 3.

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

Note: Units can include furnaces that can be used for building heating and as *auxiliary heat* for heat pumps.

2.2 Exclusions

This standard does not apply to the following:

- Commercial and industrial unitary air-conditioning condensing units with a capacity greater than 135,000 Btu/h as defined in AHRI 365 (I-P)

  Note: Condensing units with a capacity ≤135,000 Btu/h are rated as a matched system with fan coil or air handler.
- Performance of fan coil units rated in accordance with AHRI 440 (I-P) or AHRI 441 (SI)
- Air-cooled unitary air-conditioners and unitary heat pumps as defined in AHRI 210/240-2023 (2020), with capacities less than 65,000 Btu/h
- Water-source heat pumps as defined in ASHRAE/AHRI/ISO 13256-1 and AHRI 600 (I-P)
- Variable refrigerant flow air-conditioners and heat pumps as defined in AHRI 1230 (I-P)
- Rating of units equipped with desuperheater/water heating devices (as defined in AHRI 470) in operation
- Units with adiabatically pre-cooled condensers

2.3 Other Applicable Standards

Commercial and industrial unitary air-conditioning and heat pump equipment can be rated using the following standards:

- Single vertical packaged air conditioners rated using AHRI 390 (I-P)
- Dedicated outdoor air systems rated with 100% outside air using AHRI 920 (I-P) or AHRI 921 (SI)
- Computer room air conditioners and condensing units serving computer rooms rated using AHRI 1360
- Performance rating of air-to-air exchangers for energy recovery ventilation equipment using AHRI 1060 (I-P) and AHRI 1061 (SI)
- Calculating the efficiency of energy recovery ventilation and how this affects efficiency and sizing of building HVAC system as defined by AHRI Guideline V (I-P)
- Packaged terminal air conditioners and heat pumps rated using AHRI 310/380

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 Sampling Device

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.

3.2.1.1 Air Sampling Tree

An assembly consisting of a manifold with branch tubes with multiple sampling holes that draws an air sample from a critical location from the unit under test (such as indoor air inlet, indoor air outlet, outdoor air inlet).

3.2.1.2 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

3.2.1.3 Auxiliary Heat

Electric, natural gas, propane, steam or hot water heat used to supplement or be used at low ambient to assist the capacity delivered by a vapor compression heat pump cycle.

3.2.1.4 Dew-point Hygrometer

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

3.2.2 Barometric Relief Damper

An assembly with dampers and means to automatically set the damper position in a closed position and one or more open positions to facilitate venting directly to the outside a portion of the building air that is returning to the unit, rather than recirculating the building air to the indoor coil and back to the building.

Note: This definition is restated in Table 36.

3.2.3 Basic Model

All systems within a single equipment class, as defined in 10 CFR Part 431, that have the same or comparably performing compressor(s), heat exchangers, and air moving system(s) that have a common nominal *cooling capacity*.

Note: This term is further described in Section D.2.1.

3.2.4 Coil-only Indoor Unit

An indoor unit that is distributed in commerce without an indoor blower or separate designated air mover.

Note: A *coil-only indoor unit* installed in the field relies on a separately installed furnace or modular blower for indoor air movement.

3.2.5 Commercial Unitary Air-conditioner and Heat Pump Equipment

Any air-cooled, water-cooled, or evaporatively-cooled commercial package air conditioning and heating equipment that consists of one or more factory-made assemblies that provide space conditioning.

3.2.5.1 Commercial and Industrial Unitary Air-Conditioning System

Commercial unitary air-conditioner equipment that contains one or more factory-made assemblies, that include a cooling coil, a compressor(s) and condenser combination, and can include an air moving device and a heating function. Where such equipment is provided in more than one assembly, the separate assemblies are designed to be used together, and the requirements of rating outlined in the standard are based upon the use of matched assemblies.

3.2.5.2 Commercial and Industrial Unitary Heat Pump System

Commercial unitary heat pump equipment that contains one or more factory-made assemblies, that include an indoor conditioning coil, compressor(s), and an outdoor coil(s), including means to provide a heating function and can include an air moving device and a cooling function. When such equipment is provided in more than one assembly, the separate assemblies are designed to be used together, and the requirements of rating outlined in the standard are based upon the use of matched assemblies.

3.2.6 Cooling Capacity (q_{CT})

The net capacity associated with the change in air enthalpy between the air entering the unit and the air leaving the unit that includes both the *latent* and *sensible capacities* expressed in Btu/h and includes the heat of circulation fan(s) and motor(s).

3.2.6.1 Latent Capacity (q_{CL})

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

3.2.6.2 Sensible Capacity (q_{CS})

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

3.2.6.3 Standard Cooling Capacity (q_{CT})

Full load *cooling capacity* at *standard rating conditions* for a unit configured in accordance with Appendix E, and when tested in accordance with the requirements of Section 5 and Section 6, expressed in Btu/h.

3.2.7 Double-duct System

An air conditioner or heat pump that has the following characteristics:

- The unit is either a horizontal single package or split-system unit; or a vertical unit that consists of two components that can be shipped or installed either connected or split; or a vertical single packaged unit that is not intended for exterior mounting on, adjacent interior to, or through an outside wall.
- The unit is intended for indoor installation with ducting of outdoor air from the building exterior to and from the unit. For example, the unit, or the unit's components, or both, are non-weatherized.

- If the unit is a horizontal unit, the complete unit has a maximum height of 35 in or the unit has components that do not exceed a maximum height of 35 in.
- If the unit is a vertical unit, the complete split, connected, or assembled unit has components that do not exceed a maximum depth of 35 in.
- The unit has a rated *cooling capacity* greater than or equal to 65,000 Btu/h and less than 300,000 Btu/h.

See Section 5.22 for test requirements specific to externally ducted condensers.

3.2.8 Defrost

A mode of operation for an air source heat pump where the cycle is reversed to temporarily heat the outdoor coil to remove ice that has built up when the heat pump is heating.

3.2.9 Desiccant Dehumidification Component

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

Note: This definition is restated in Table 36 and Table 37.

3.2.10 Drain Pan Heater

A heater that heats the drain pan to make certain that water shed from the outdoor coil during a *defrost* does not freeze.

Note: This definition is restated in Table 37.

3.2.11 Economizer

3.2.11.1 Air Economizer

An optional feature that brings in additional outside cool air to cool the building when ambient temperature and or humidity levels are lower than the return air conditions.

Note: This definition is restated in Table 36 and Table 37.

3.2.11.2 Integrating Economizing

A control mode where both the economizer and mechanical cooling are operated to satisfy the building load. The economizer is operated at maximum capacity and the mechanical cooling is used to supplement the economizer cooling.

3.2.12 Energy Efficiency Ratio 2 (EER2)

A ratio of the *cooling capacity* to power input as specified in Section 6.2.10.

3.2.13 Evaporative Cooling

Note: These definitions are restated in Table 36.

3.2.13.1 Direct Evaporative Cooling System

A system that uses water to cool ventilation air by introducing water directly into the ventilation air.

3.2.13.2 Indirect Evaporative Cooling System

A system that uses water to cool ventilation air by evaporating the water in secondary air stream removed heat through a heat exchanger.

3.2.14 Fresh Air Damper

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

Note: This definition is restated in Table 37.

3.2.15 Fire, Smoke, or Isolation Damper

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

Note: This definition is restated in Table 36 and Table 37.

3.2.16 Full Load Rated Indoor Airflow

The *standard airflow* at 100% capacity as defined by the *MII* and at the external static pressure (ESP) as determined in Section 5.17, expressed in scfm.

3.2.17 Hail Guard

A grille or comparable structure mounted to the outside of the unit covering the outdoor coil to protect the coil from hail, flying debris and damage from large objects.

Note: This definition is restated in Table 37.

3.2.18 Heating Capacity (q_H)

The capacity associated with the change in dry-bulb temperature expressed in Btu/h.

3.2.18.1 Integrated Heating Capacity (q_{Hint})

The net average *heating capacity* including the impact of capacity degradation due to *defrost* of the outdoor coil, expressed in units of units of Btu/h.

3.2.18.2 Instantaneous Heating Capacity (q_{Hinst})

The net capacity before and degradation due to frost buildup on the condenser coil.

3.2.19 Heating Coefficient of Performance 2 ($COP2_H$)

A ratio of the *heating capacity* in watts to the power input values in watts, as calculated in Section 6.3.14.

3.2.20 High-Effectiveness Indoor Air Filtration

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

Note: This definition is restated in Table 37.

3.2.21 Independent Coil Manufacturer (ICM)

A company that manufactures indoor units but does not manufacture single package units or outdoor units.

3.2.22 Indoor Single Package Air-conditioners

Non-weatherized units with factory-made assemblies of one or more evaporator fans, evaporator coils, and condensing units having means for air cooling, cleaning, dehumidification, heating with factory or field installed electric strip heaters and forced air circulation through a duct system and that can have means for humidifying and control of temperature. Included are only those units that are assembled or designed to be assembled in a single unit.

3.2.23 Integrated Ventilation, Economizing, and Cooling Efficiency (IVEC)

Total annual *cooling capacity* divided by total annual energy including mechanical cooling, economizer, cooling mode ventilation fan energy and off mode control energy and crankcase heat energy for an average building and average climate zone as defined in Section 6.2 and expressed in Btu/Wh.

3.2.24 Integrated Ventilation and Heating Efficiency (IVHE)

Total annual *heating capacity* for a heat pump including vapor compression *heating capacity* and auxiliary *heating capacity* divided by total heating model energy including mechanical vapor compression heating, *auxiliary heat* energy, heating mode ventilation fan energy and heating mode control power, and crankcase heat power as defined in Section 6.3 and expressed in Btu/Wh. $IVHE_C$ is for colder climates and uses a colder climate zone weighted average load profile and is based on ASHRAE 169 Climate Zones 5 to 8. Expressed in Btu/W·h.

3.2.25 Low-temperature Compressor Cut-in Temperature

The maximum outdoor dry-bulb temperature where the unit's internal controls prevent the compressor(s) from starting due to the outdoor dry-bulb temperature being too low. Expressed in units of °F.

Note: See Appendix H for method of test.

3.2.26 Low-temperature Compressor Cut-out Temperature

The maximum outdoor dry-bulb temperature where the unit's internal controls stop operating compressor(s) due to the outdoor dry-bulb temperature being too low. Expressed in units of °F.

Note: See Appendix H for method of test.

3.2.27 Manufacturer Instructions

3.2.27.1 Manufacturer's Installation Instructions (MII)

Manufacturer's documents that come packaged with or appear in the labels applied to the unit(s), as specified in Section 5.4.1.

3.2.27.2 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.

3.2.27.3 Manufacturer-specified

Information provided by the manufacturer through *MII* or *STI*.

3.2.28 Makeup Water

The water supplied to an evaporative cooled condenser to compensate for the water evaporated.

3.2.29 Non-standard Ducted Condenser Fan

A higher-static condenser fan/motor assembly designed for external ducting of condenser air that provides greater pressure rise and has a higher rated motor horsepower than the condenser fan provided as a standard component with the equipment.

Note: This definition is restated in Table 36.

3.2.30 Non-Standard Low-Static Indoor Fan Motor

An indoor fan motor that cannot maintain ESP as high as specified in Section 5.17.1 when operating at the *full load rated indoor airflow* and that is distributed in commerce as part of an individual model within the same *basic model* that is distributed in commerce with a different motor specified for testing that can maintain the required ESP.

3.2.31 Operating Levels

3.2.31.1 Boost Heating Operating Level (B)

The *operating level* with the maximum capacity that is allowed by the controls at 17.0°F outdoor dry-bulb temperature, with a capacity at 17.0°F outdoor dry-bulb temperature that is greater than the capacity of the *high heating operating level* at 17.0°F. See Section 6.3.6 for requirements.

3.2.31.2 Boost2 Heating Operating Level (B2)

An *operating level* allowed by the controls at 5.0°F outdoor dry-bulb temperature with a capacity at 5.0°F outdoor dry-bulb temperature that is greater than the capacity of the *boost heating operating level* at 5.0°F outdoor dry-bulb temperature and less than or equal to the maximum capacity allowed by the controls at 5.0°F outdoor dry-bulb temperature. See Section 6.3.6 for requirements.

3.2.31.3 High Heating Operating Level (H)

The *operating level* with the maximum capacity that is allowed by the controls at 47.0°F outdoor dry-bulb temperature. See Section 6.3.6 for requirements.

3.2.31.4 Low Heating Operating Level (L)

The *operating level* with the minimum capacity that is allowed by the controls at 47.0°F outdoor dry-bulb temperature. See Section 6.3.6 for requirements.

3.2.31.5 Medium Heating Operating Level (M)

An *operating level* allowed by the controls at 47.0°F outdoor dry-bulb temperature with a capacity at 47.0°F outdoor dry-bulb temperature that is greater than the capacity of the *low heating operating level* at 47.0°F outdoor dry-bulb temperature and less than the capacity of the *high heating operating level* at 47.0°F outdoor dry-bulb temperature. See Section 6.3.6 for requirements.

3.2.31.6 Operating Level

Is determined by the number of compressors operating, the modulation level of each operating compressor, and the indoor fan speed. The modulation level of a single compressor is determined by the speed, duty cycle, vapor injection setting, and state of any other operating parameters that affect the continuous capacity of the compressor at a single set of operating conditions.

3.2.32 Outdoor Unit Manufacturer (OUM)

A manufacturer of single package units, outdoor units, and indoor units or outdoor units, or both.

3.2.33 Part Load Rated Indoor Airflow (Q_{PL})

The *standard airflow* at the *manufacturer-specified* part-load ratings conditions and at the ESP as determined in Section 5.17. This can be different for each part-load rating point.

3.2.34 Power Correction Capacitor

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

Note: This definition is restated in Table 37.

3.2.35 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 allowing it to recirculate to the indoor coil and back to the building.

Note: This definition is restated in Table 36.

3.2.36 Powered Return Air Fan

A fan that draws building air into the equipment for exhausting or recirculation.

Note: This definition is restated in Table 36.

3.2.37 Process Heat Recovery, Reclaim, or Thermal Storage Coil

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.

Note: This definition is restated in Table 36 and Table 37.

3.2.38 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*.

3.2.38.1 Application Rating

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

3.2.38.2 International Ratings

A rating based on tests performed at *international rating conditions* as listed in Table 43.

3.2.38.3 Standard Rating

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

3.2.39 Rating Conditions

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

3.2.39.1 International Rating Conditions

Rating conditions used as the basis of comparison for performance characteristics for products sold outside North America as defined in Table 43.

3.2.39.2 Part Load Rating Conditions

Rating conditions used as the basis of calculating the *IVEC* and *IVHE* annualized efficiency metrics as defined in Section 6.

3.2.39.3 Standard Rating Conditions

Rating conditions used as the basis of comparison for performance characteristics as defined in Table 7.

3.2.40 Rating Power

Electrical power used to deliver capacity and during off modes of operation.

3.2.40.1 Crankcase Heat Power (P_{CCH})

The power used to keep the temperature of the compressor lubrication oil warm enough to prevent migration of the refrigerant to the oil when the compressor is off, expressed in W. See Section E.10 for requirements.

3.2.40.2 Compressor Power (P_C)

The power needed for all compressors, including any inverter losses, variable-speed drive losses, and auxiliary power required for compressor operation, expressed in W. This can include *crankcase heat power*. See Section E.10 for requirements.

3.2.40.3 Condenser Section Power (P_{CD})

The power needed for all fans, pumps, and other condenser section components, including any inverter or variable-speed drive losses, expressed in W. See Section E.10 for requirements.

3.2.40.4 Controls Power (P_{CT})

The power of all controls and all auxiliary loads that are not part of the *compressor power*, *condenser section power*, or *indoor fan power*, expressed in W. This can include *crankcase heat power*. See Section E.10 for requirements.

3.2.40.5 Indoor Fan Power (P_{IF})

The power needed for the fans, motors, belt drives, and variable-speed drive losses for all indoor fans, expressed in W. See Section E.10 for requirements.

3.2.41 Refrigerant Reheat Coil

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.

Note: This definition is restated in Table 36 and Table 37.

3.2.42 Single Package Air-conditioner

A *single package system* with factory-made assemblies of one or more evaporator fans, evaporator coils, and condensing sections having means for air cooling, cleaning, dehumidification, heating with factory or field installed electric strip heaters and forced air circulation through a duct system and that can have means for humidifying and control of temperature. These units do not have gas heat and are not heat pumps.

3.2.43 Single Package Heat Pumps

A *single package system* that can both cool and heat with the refrigeration system that can have provision for supplementary electric, hot water, or steam heat that are factory-made assemblies of one or more evaporator fans, evaporator coils, and condensing sections having means for air cooling, heating, cleaning, dehumidification, and forced air circulation through a duct system and that can have means for humidifying and control of temperature, with provision for modifying the performance so that either heating or cooling and dehumidification can be produced.

3.2.44 Single Package System

Any *commercial unitary air-conditioning system* or *commercial unitary heat pump system* that has the means for air circulation and heat removal, air cleaning, and the controls thereof, that are assembled or designed to be assembled within a single factory-made enclosure.

3.2.45 Sound Trap

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

Note: Can be called sound attenuator.

Note: This definition is restated in Table 36.

3.2.46 Split System

Any *commercial and industrial unitary air-conditioning system* or *commercial and industrial unitary heat pump system* that has one or more of the major assemblies separated from the others.

3.2.47 Standard Energy Efficiency Ratio

A ratio of the capacity to power input value obtained at *standard rating conditions*.

3.2.48 Standard Air

Air having a mass density of 0.075 lb of dry air per ft^3.

3.2.49 Standard Airflow

The volumetric flowrate of air converted to *standard air* conditions expressed in scfm.

3.2.50 Standard Filter

The filter with the lowest filter effectiveness that is distributed in commerce with a model, as specified in Section 5.6.

3.2.51 Steam or Hydronic Heat Coils

Coils used to provide supplemental heating.

Note: This definition is restated in Table 36 and Table 37.

3.2.52 Supply Air

Air delivered by a unit to the conditioned space.

3.2.53 UV Lights

A lighting fixture and lamp mounted to shine light on the indoor coil, that emits ultraviolet light to inhibit growth of organisms on the indoor coil surfaces, the condensate drip pan, and/other locations within the equipment.

Note: This definition is restated in Table 37.

3.2.54 Ventilation Air

The minimum amount of outdoor air required for the purpose of controlling air contaminant levels in buildings.

3.2.55 Ventilation Energy Recovery System (VERS)

An assembly that pre-conditions outdoor air entering equipment through direct or indirect thermal, or moisture exchange with the unit's exhaust air, or both, that is defined as the building air being exhausted to the outside from the equipment.

Note: This definition is restated in Table 36 and Table 37.

3.2.56 Year-round Single Package Air-conditioner

A *single package air-conditioner* that includes gas heating.

3.2.57 Year-round Single Package Heat Pump

A *single package heat pump* that includes gas heating.

Note: Can be referred to as dual fuel equipment.

Section 4. Classifications

Commercial and industrial unitary air-conditioning and heat pump equipment within the scope of this standard shall be classified as shown in Table 1 and Table 2.

Table 1 Classification of Commercial and Industrial Unitary Air-conditioning Equipment

Designation	AHRI Type[1,2]	Arrangement – Indoor (ID)	Arrangement – Outdoor (OD)
Single package and indoor package air-conditioner	SP-A[3, 4] SP-E[3, 4] SP-W[4, 7]	—	ELECTRIC HEAT[5] OD FAN or PUMP ID FAN COMPRESSOR EVAPORATOR CONDENSER
Year-round single package air-conditioner	SPY-A[3, 4] SPY-E[3, 4] SPY-W[4, 7]	—	GAS HEAT[6] OD FAN or PUMP ID FAN COMPRESSOR EVAPORATOR CONDENSER
Air-conditioner with remote condenser	RC-A[3] RC-E[3] RC-W[7]	ID FAN EVAPORATOR ELECTRIC HEAT[5]	OD FAN or PUMP COMPRESSOR[8] CONDENSER
Split system air-conditioners: condensing unit, coil alone	RCU-A-C[3] RCU-E-C[3] RCU-W-C[7]	EVAPORATOR	OD FAN or PUMP COMPRESSOR CONDENSER
Split system air-conditioners: condensing unit, coil and fan	RCU-A-CB[3] RCU-E-CB[3] RCU-W-CB[7]	ID FAN EVAPORATOR ELECTRIC HEAT[5]	OD FAN or PUMP COMPRESSOR CONDENSER
Year-round *split system* condensing unit, coil and fan	RCUY-A-CB[3] RCUY-E-CB[3] RCUY-W-CB[7]	GAS HEAT[6] ID FAN EVAPORATOR	OD FAN or PUMP 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. "-A" indicates air-cooled condenser, "-E" indicates evaporatively-cooled (does not apply to evaporative pre-cooled) condenser and "-W" indicates water-cooled condenser.
3. For *double-duct systems*, insert "-DD" at the end, and outdoor arrangement moves from outdoor side to indoor side.
4. Components can be installed indoors as well in accordance with *MII*.
5. Optional component.
6. Can be any other heat source except for electric strip heat.
7. For water-cooled products, outdoor arrangement can move from outdoor side to indoor side.
8. Can be installed with either the indoor or the outdoor unit.

Table 2 Classification of Commercial and Industrial Unitary Heat Pump Equipment

Designation	AHRI Type[1]	Arrangement - Indoor (ID)	Arrangement – Outdoor (OD)
Single package heat pump	HSP-A[2]	—	ELECTRIC HEAT[3] ID FAN EVAPORATOR OD FAN or PUMP COMPRESSOR CONDENSER
Year-round single package heat pump	HSPY-A	—	GAS HEAT[4] ID FAN EVAPORATOR OD FAN or PUMP COMPRESSOR CONDENSER
Heat pump with remote outdoor coil	HRC-A-CB[2]	ID FAN EVAPORATOR COMPRESSOR	OD FAN or PUMP CONDENSER
Split system heat pump with remote outdoor coil without indoor fan	HRC-A-C[2]	EVAPORATOR COMPRESSOR	OD FAN or PUMP CONDENSER
Split system heat pump with coil blower	HRCU-A-CB[2]	ELECTRIC HEAT[3] ID FAN EVAPORATOR	OD FAN or PUMP 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. For *double-duct systems*, append "-DD", and outdoor arrangement moves from outdoor side to indoor side.
3. Optional component.
4. Can be other heat sources.

Section 5. Test Requirements

5.1 Summary

All *standard ratings* shall be in accordance with the test methods and procedures as described in this standard and the appendices.

Units shall be tested in accordance with ASHRAE 37 as amended by this section and Appendix E.

5.2 Optional System Features

Use Appendix D to determine the optional system features to be included during the tests and the settings for each optional system feature during the tests.

5.3 Secondary Verification

Secondary verification measurements of *cooling* and *heating capacity* (if applicable) shall be conducted in accordance with Section E.6 of this standard.

5.4 Instructions

5.4.1 Manufacturer's Installation Instructions (MII)

Units shall be installed in accordance with the *MII*, as defined in Section 3.2.27.1. 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 referenced information from the manufacturer means *MII*.

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

5.4.2 Supplemental Test Instructions (STI)

STI are defined in Section 3.2.27.2 and shall include both:

1) all instructions that do not deviate from *MII* but provide additional specifications for test standard requirements that can have more than one option
2) all deviations from *MII* 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 *MII*. *STI* shall not include instructions that deviate from *MII* other than those described in Section 5.4.2(2).

5.4.3 Conflicting Instructions

In the event of conflicting instructions regarding the set-up of the unit under test, excluding charging instructions for *split systems* described in Section 5.4.4, priority shall be given to installation instructions that appear on the unit's label over installation instructions that are shipped with the unit.

5.4.4 Instructions for 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* other than mix-matched systems described in Section 5.4.5, if the *MII* 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.

5.4.5 Mix-Matched Split Systems

The following provisions apply for systems consisting of an *OUM* outdoor unit and an *ICM* indoor unit. If instructions for the two units differ, priority shall be given to the *ICM MII*. If instructions are provided only with the outdoor unit or are provided only with an *ICM* indoor unit, then use the provided instructions.

5.5 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 outdoor temperature shall not exceed 115°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.

5.6 Indoor Air Filter

Units with integral fans shall be tested with the *standard filter* installed.

The *standard filter* is the indoor air filter with the lowest filter efficiency that is distributed in commerce with a model. If the manufacturer does not specify what filter option has the lowest level of filtration in *MII* or marketing materials for the model, then the *standard filter* shall be the filter designated as the "default" or "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.

For units with integral fans distributed in commerce without a filter, follow the instructions in Section 5.17.1.2.

Coil-only indoor units shall be tested without a filter installed.

5.7 Recirculated Indoor Air

Use 100% recirculated indoor air in all tests.

5.8 Test Unit Duct Installation Requirements

ASHRAE 37 duct requirements and the requirements of Appendix E shall be followed. Furthermore, the test apparatus including the interconnecting ductwork shall be insulated to have a minimum R-value of 13 $ft^2 \cdot °F \cdot h/Btu$.

Calculate duct losses 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.

5.9 Defrost Controls

Defrost controls shall be left at manufacturer's factory settings if the *MII* provided with the equipment do not specify otherwise. To facilitate testing of any unit, the manufacturer shall provide information and any necessary hardware to manually initiate a *defrost* cycle.

5.10 Auxiliary Heat

Do not test with operation of *auxiliary heat* or any heating components other than the reverse cycle heat pump functionality.

5.11 Head Pressure Control

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 *MII*. If there are not any such instructions, use the as-shipped setting. If this results in unstable operation (outside test tolerances specified in Section 5.25) and testing requirements cannot be met, then the procedures in Section E.7 shall be used.

5.12 Line Length for Split Systems

All *standard ratings* for equipment where the outdoor section is separated from the indoor section shall be determined with at least 25 ft of interconnection tubing on each line of the size specified in the *MII*.

Use the absolute minimum length of tubing necessary to physically connect the system, subject to the minimum specified length, but use not 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 *MII*, shall be tested with the complete length of tubing furnished, or with 25 ft of tubing, whichever is greater. At least 10 ft of the interconnection tubing shall be exposed to the outside conditions. The line sizes, insulation, and details of installation shall be in accordance with the *MII*.

If more than 25 ft of tubing is used, the applicable *cooling capacity* correction factor in Table 3 shall be multiplied by the measured full load *cooling capacity* to determine the final full load *cooling capacity*. Do not use the *cooling capacity* correction factors when determining part-load *cooling capacity*.

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

Note: There is not any *heating capacity* correction for heat pumps.

5.13 Refrigerant Charging

5.13.1 Conditions and Criteria

Unless the unit does not require charging (per Section 5.13.5) use the test or operating conditions specified in the *MII* for charging. If the *MII* do not specify a test or operating conditions for charging or there are not any *MII*, charging shall be conducted at *standard rating conditions* in cooling mode. If the *MII* contain two sets of refrigerant charging criteria, one for field installation and one for lab testing, use the field installation criteria. Perform charging of refrigerant blends only with refrigerant in the liquid state.

5.13.2 Parameter Ranges

If the *MII* 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.

5.13.3 No Manufacturer Instructions

If there are not any *MII* or the *MII* 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.

5.13.4 Conflicting Information

In the event of conflicting information between charging instructions, use the instruction priority order indicated in Section 5.4. Conflicting information is defined as multiple *manufacturer-specified* conditions given for charge adjustment where all *manufacturer-specified* conditions cannot be met. If such instances of conflicting information occur within the highest-ranking set of instructions where refrigerant charging instructions are provided, follow the hierarchy in Table 4, for fixed orifice or expansion valve, as applicable, unless the manufacturer specifies a different priority in the outdoor unit installation instructions. Unless the *MII* 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	± 1% of nominal charge or 2.0 oz., whichever is greater
6	Charge weight	± 1% of nominal charge or 2.0 oz., whichever is greater	—	—	—

Notes:

1. Approach temperature means the refrigerant liquid temperature at the outdoor liquid service port minus the outdoor ambient temperature.

5.13.5 Single Package Unit

5.13.5.1 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 *MII* 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 *MII* if specified. Install pressure gauges depending on the parameters used to verify or set charge, as described in the following paragraphs.

5.13.5.2 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.

5.13.5.3 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.

5.13.6 No Further Changes

The refrigerant charge obtained as described in this section shall then 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 any necessary set-up steps, and repeat all tests.

5.14 Test Unit Location

5.14.1 Air-Cooled and Evaporatively-Cooled Equipment

For testing *split systems*, the indoor unit shall be located in the indoor test room (in other words, the test chamber maintained at the air conditions specified for return indoor air). A remote condenser or condensing unit shall be located in the outdoor test room (in other words, the test chamber maintained at the air conditions specified for outdoor ambient air), unless the remote condenser or condensing unit is designed and marketed for indoor installation (for example, *double-duct systems*), then the indoor remote condenser or condensing unit shall be located in the indoor test room. For testing single package units, the unit shall be located in the outdoor test room unless the unit is designed and marketed for indoor installation (for example, *double-duct systems*), then the unit shall be located in the indoor test room.

5.14.2 Water-Cooled Equipment

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

5.15 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.

Operating requirements tests shall be performed at the voltage(s) and frequency(ies) specified for each operating requirements test in Section 8.

5.16 Instrumentation

5.16.1 Induction Watt-hour Meter

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

5.16.2 Atmospheric Pressure

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

5.16.3 Electrical Frequency

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

5.17 Indoor Air External Static Pressure for Testing

5.17.1 Units with Integral Indoor Fans

5.17.1.1 Full-load Cooling Tests

Use the external static pressure specified in Table 5 for all tests that use the full-load cooling airflow.

Table 5 Full-load Cooling External Static Pressure

Full-load Cooling Capacity Measured in Section 6.2.6, kBtu/h	Testing with Economizer Dampers Present in the Airstream (in-H_2O)	Testing without Economizer Dampers Present in the Airstream (in-H_2O)
>0 and <65[1]	0.50	0.60
≥65 and <135	0.75	0.85
≥135 and <280	1.00	1.10
≥280	1.50	1.60

Note:

1. Only applicable for evaporatively and water-cooled units.

5.17.1.2 Testing Without a Filter

For units distributed in commerce without a filter, an additional static pressure allowance as specified in Equation 1 shall be added to the minimum static pressure shown in Table 5. The additional static pressure shall be based on the filter face area, as defined in the *MII*, and the rated full-load cooling airflow. 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 tests that use an airflow different than the full-load cooling airflow, the additional static pressure allowance shall be reduced in accordance with Section 5.17.1.3.

$$ESP_{filter} = 0.000108 \times \left(\frac{Q_{FL}}{A_{ft}}\right)^{1.3} \qquad \mathbf{1}$$

Where:

ESP_{filter} = additional static pressure allowance, in H_2O

Q_{FL} = Rated full-load cooling *standard airflow*, scfm

A_{ft} = Filter face area, ft^2.

5.17.1.3 Tests That Do Not Use the Full-load Cooling Airflow

When conducting tests where the *manufacturer-specified* fan control settings, or rated airflows are different than for the full-load cooling test, or both, calculate adjusted ESP requirements using Equation 2.

$$ESP_{adj} = ESP_{FL} \times \left(\frac{Q_{dif}}{Q_{FL}}\right)^{2} \qquad \mathbf{2}$$

Where:

ESP_{adj} = Adjusted ESP requirement at airflow other than full-load cooling airflow, in H_2O

ESP_{FL} = ESP requirement at full-load cooling airflow determined in Section 5.17, in H_2O

Q_{dif} = Measured airflow other than full-load cooling airflow, scfm

Q_{FL} = Measured full-load cooling airflow, scfm

5.17.1.4 Split Between Return and Supply Static Pressure

The return static pressure shall be 20% to 25% of total static pressure (TSP), unless the return static pressure is greater than 25% of TSP without inlet restriction, mixers, elbows, transitions, or sampling devices installed on the inlet duct. Use Section E.11 to set the static pressure split.

5.17.2 Coil-only Indoor units

For *coil-only indoor units*, the pressure drop across the indoor assembly shall not exceed 1.00 in H_2O for the full-load cooling test.

5.18 Indoor Airflow Target Values

5.18.1 Standard Airflow

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

5.18.2 Minimum Airflow

The indoor airflow in scfm for all tests shall not be less than the minimum indoor airflow determined in Equation 3.

$$\text{Minimum indoor airflow} = 0.008 \times q_{T,A} \tag{3}$$

Where:

$q_{T,A}$ = The *cooling capacity* measured for the full-load cooling test in Section 6.2.5, Btu/h

Note: The 0.008 is based on 24% *ventilation air* and 400 cfm/ton.

5.18.3 Units with Integral Indoor Fans

5.18.3.1 Full-load Cooling

For the full-load cooling test (except for *coil-only indoor units*), use the cooling *full load rated indoor airflow*. If there is not a cooling *full load rated indoor airflow*, use a value of 400 scfm per ton of rated *cooling capacity*.

5.18.3.2 Part-load Cooling

For part-load cooling tests, use the *part load rated indoor airflow* for that test point. If there is not a *part load rated indoor airflow* for the test point, use the airflow that results from using the *manufacturer-specified* part-load fan control settings for that test at the ESP requirement determined in accordance with Section 5.17. If *part load rated indoor airflow* and *manufacturer-specified* part-load cooling fan control settings are not provided for the test point, but the *MII* describe how to obtain steady-state part-load cooling or heating operation (for example, 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, for part-load cooling tests use the cooling full load rate indoor airflow.

Note: This standard does not include any separate airflow-setting provisions for units with control systems designed to vary the indoor air volume and refrigeration capacity at a controlled discharge air temperature and static pressure as a means of providing space temperature control to independent multiple spaces with independent thermostats. All units are now tested using the *manufacturer-specified part load rated indoor airflow*.

5.18.3.3 Heating

For each heating test (except for *coil-only indoor units*), use the *manufacturer-specified* airflow for the test. If there is not a *manufacturer-specified* airflow for the test, use the airflow that results from using the *manufacturer-specified* heating fan control settings at the adjusted ESP requirement determined in accordance with Section 5.17. If there is not a *manufacturer-specified* airflow and not any *manufacturer-specified* heating fan control settings for the test but the *MII* or *STI* describe how to obtain steady-state heating operation (for example, 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 rated indoor airflow* for the test.

Note: See Section 6.3.6 for airflow requirements for each heating *operating level*.

5.18.4 Coil-only Indoor Units

5.18.4.1 Full-load Cooling

For full-load cooling tests of *coil-only indoor units*, the indoor airflow 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 *full load rated indoor airflow*, use a value of 400 scfm per ton of rated *cooling capacity*.

5.18.4.2 All Tests Other than Full-load Cooling Tests

For all tests of *coil-only indoor units* other than full-load cooling tests, determine the target indoor airflow as follows:

If there is not a *manufacturer-specified* airflow for the test, use the measured full-load cooling airflow.

If the *manufacturer-specified* airflow for the test is greater than the measured full-load cooling airflow, use the measured full-load cooling airflow.

If the *manufacturer-specified* airflow for the test is less than or equal to the measured full-load cooling airflow and greater than or equal to the 67.0% of the measured full-load cooling airflow, use the manufacturer-specified airflow for the test.

If the *manufacturer-specifie*d airflow for the test is less than 67.0% of the measured full-load cooling airflow, use 67.0% of the measured full-load cooling airflow.

5.19 Setting Indoor External Static Pressure and Airflow for Units with Integral Fans

5.19.1 Conditions for Setting Airflow Before Test

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

5.19.2 Tolerances

All tolerances for airflow and ESP specified in Section 5.19 for setting airflow and ESP are condition tolerances that apply for each test. Specifically, 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 Section 5.25.

5.19.3 Full-load Cooling Test Static and Airflow

5.19.3.1 First Setting and Adjustment

Operate the unit using the *manufacturer-specified* fan control settings. If there are not any *manufacturer-specified* fan control settings, use the as-shipped fan control settings. Adjust the airflow-measuring apparatus to maintain total ESP within -0.00/+0.05 in H_2O of the requirement specified in Section 5.17 and to maintain the airflow within ± 3% of the cooling *full load rated indoor airflow*.

5.19.3.2 If Above Tolerance

If total ESP or airflow are higher than the tolerance range, adjust the fan control settings (for example, lower fan speed) to maintain both total ESP and airflow within tolerance. If ESP or airflow are higher than the tolerance range at the lowest fan control setting (for example lowest fan speed), adjust the airflow-measuring apparatus to maintain airflow within tolerance and operate with a total ESP as close as achievable to the minimum requirement specified in Section 5.17.

5.19.3.3 If Below Tolerance

If total ESP or airflow are lower than the tolerance range, adjust the fan control settings (for example, higher fan speed) to maintain both ESP and airflow within tolerance. If total ESP or airflow are lower than the tolerance range at the maximum fan control setting (for example, highest fan speed) and the motor is not a *non-standard low-static indoor fan motor*, adjust the airflow-measuring apparatus to maintain total 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 5.17.

5.19.3.4 If Cannot Meet Tolerance

For two adjacent fan control settings, if the lower setting is too low (such as total ESP or airflow are lower than the tolerance range) and the higher setting is too high (such as total ESP or airflow are higher than the tolerance range), use the higher fan control setting. At this higher 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 5.17.

5.19.3.5 Situations Without Condition Tolerances

If the total ESP measured after setting airflow exceeds the minimum total 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 total ESP.

If an airflow less than 97% of the cooling *full load rated indoor airflow* is used for the full-load cooling test in Section 5.19.3.3, there is not a condition tolerance for airflow.

5.19.4 All Tests Other Than Full-load Cooling Tests

5.19.4.1 Same Airflow as Full-load Cooling Airflow

For tests where the *manufacturer-specified* airflow is the same as the cooling *full load rated indoor airflow*, and for tests where there is not a *manufacturer-specified* airflow, use the fan control settings used for the full-load cooling test. Adjust the airflow-measuring apparatus to maintain the airflow within ± 3% of the measured full-load cooling airflow without regard to the resulting total ESP. Changes shall not be made to the fan control settings for the test.

5.19.4.2 Different Airflow Than Full-load Cooling Airflow

For tests where the *manufacturer-specified* airflow differs from the cooling *full load rated indoor airflow*, use the provisions described in Section 5.19.4.2.1 through Section 5.19.4.2.7.

5.19.4.2.1 First Setting

Operate the system using the *manufacturer-specified* fan control settings for that test condition. If there are not any *manufacturer-specified* fan control settings for the test, use the fan control settings for the full-load cooling test. If there are not any *manufacturer-specified* fan control settings for any tests, use the as-shipped fan control settings.

5.19.4.2.2 First Adjustment

Adjust the airflow-measuring apparatus to maintain total ESP within 0.00/+0.05 in H_2O of the adjusted total ESP requirement determined in accordance with Section 5.17 and maintain airflow within ± 3% of the *manufacturer-specified* airflow.

5.19.4.2.3 If Above Tolerance

If total ESP or airflow are higher than the tolerance range, adjust the fan control settings (for example, lower fan speed) to maintain both total ESP and airflow within tolerance, if this can be achieved. 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 a total ESP as close as achievable to the adjusted ESP requirement.

5.19.4.2.4 If Below Tolerance

If total ESP or airflow are lower than the tolerance range, adjust the fan control settings (for example, higher fan speed) to maintain both total ESP and airflow within tolerance (if this can be achieved, but without adjusting sheaves and without exceeding the final fan control settings used for the full-load cooling test). If this cannot be achieved, adjust the airflow-measuring apparatus to maintain total ESP within tolerance and operate with an airflow as close as achievable to the *manufacturer-specified* value.

5.19.4.2.5 If Cannot Meet Tolerance

For two adjacent fan control settings, if the lower setting is too low (such as total ESP or airflow are lower than the tolerance range) and the higher setting is too high (such as total ESP or airflow are higher than the tolerance range), use the higher fan control setting. At this higher fan control setting, adjust the airflow-measuring apparatus to maintain airflow within tolerance and operate with a total ESP as close as achievable to the minimum requirement specified in Section 5.17.

5.19.4.2.6 Situation Without Condition Tolerances

If the total ESP measured after setting airflow exceeds the adjusted total ESP requirement determined in accordance with Section 5.17 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 total ESP.

If an airflow less than 97% of the *manufacturer-specified* airflow is used for a test in Section 5.19.4.2.4, there is not a condition tolerance for airflow.

5.19.4.2.7 No Airflow Specified, But Settings Specified

For tests where there is not a *manufacturer-specified* airflow and the cooling *full load rated indoor airflow* is not used as the airflow for the test because there are *manufacturer-specified* fan control settings or instructions to obtain steady-state operation for the test, in accordance with the provisions of Section 5.18, use the *manufacturer-specified* fan control setting for that test condition or allow the system to automatically adjust airflow, as specified in the *MII*. Adjust the airflow-measuring apparatus to meet the adjusted total ESP requirement determined in accordance with Section 5.17 with a condition tolerance of 0.00/+0.05 in H_2O, using the measured airflow in the ESP calculation.

5.20 Setting Indoor ESP and Airflow for Coil-only Indoor Units

Set the airflow within ± 3% of the target airflow. If the maximum pressure drop specified in Section 5.17.2 is exceeded, reduce the airflow until the measured pressure drop equals the specified maximum. Maintain the airflow at this level throughout the test.

5.21 Outdoor Airflow for Units with Free Air Discharge Condensers

All *standard ratings* shall be determined at the outdoor airflow obtained without condenser ducting. Where the fan drive is non-adjustable, the *standard ratings* shall be determined at the outdoor airflow inherent in the equipment. For adjustable speed fans, the outdoor fan speed shall be set as specified in the *MII* or as determined by automatic controls. Once established, changes affecting outdoor airflow shall not be made unless automatically adjusted by unit controls or adjusted to achieve stability as described in Section E.7.3 or Section E.7.4. Outdoor airflow does not need to be measured unless using the outdoor air enthalpy method in accordance with Section E.6.5.

5.22 Outdoor Airflow and ESP for Units with Ducted Condensers

For *double-duct systems*, rate based on non-zero condenser ESP using the provisions of Section 5.22.1.

For equipment with a condenser fan/motor assembly designed for external ducting of condenser air that is not a *double-duct system* (for example, if the unit does not meet the maximum height or width requirements, or if the unit has a rated *cooling capacity* greater than 300,000 Btu/h), rate based on zero condenser ESP using the provisions of Section 5.22.2.

Note: For equipment with a condenser fan/motor assembly designed for external ducting of condenser air that is not a *double-duct system*, non-standard (for example, higher-static) ducted condenser fans are an optional feature in accordance with Section D.2.1.

5.22.1 Rating Based on Non-zero Condenser ESP

5.22.1.1 Installation and Setup

Install the unit with outdoor coil ductwork and ESP measurements made in accordance with Section 6.4 and Section 6.5 of ASHRAE 37 and manufacturer's instructions as applicable. Set outdoor air ESP by symmetrically restricting the outlet of the outdoor air outlet duct downstream of the minimum duct length specified in Section 6.4.2.1 of ASHRAE 37 (such as at least 2.5 times the mean geometric cross-sectional dimension from the equipment outlet). If using the outdoor air enthalpy method, perform a secondary verification test with the outdoor airflow measurement apparatus attached to the outdoor duct in addition to the outlet duct restrictors (do not adjust the outlet duct restrictors) for full-load cooling and heating tests, as specified in Section E.6.5.2.

5.22.1.2 Full-Load Cooling Test

If manufacturer's instructions provide guidance for setting outdoor airflow (for example, outdoor fan control settings), set the outdoor airflow in accordance with manufacturer's instructions, while maintaining the outdoor air ESP within -0.00/+0.05 in H_2O of 0.5 in H_2O. If manufacturer's instructions do not provide guidance for setting outdoor airflow, test using the as-shipped outdoor fan setting while maintaining the outdoor air ESP within -0.00/+0.05 in H_2O of 0.5 in H_2O. If the outdoor air ESP cannot be maintained within -0.00/+0.05 in H_2O of 0.5 in H_2O at the *manufacturer-specified* or as-shipped fan setting (as applicable), operate with a fan setting as close as achievable to the target fan setting (such as *manufacturer-specified* or as-shipped) so that the outdoor air ESP requirement is met.

5.22.1.3 Heating and Part Load Cooling Tests

Adjustment is not needed to change the outdoor air ESP for heating or part-load cooling tests. If *MII* specify outdoor fan settings for heating or part-load cooling tests or describe how to obtain steady-state heating or part-load cooling operation (for example, using thermostat or other control system input) that results in an automatic adjustment to outdoor airflow, operate at the outdoor airflow resulting from using the *MII*.

5.22.2 Rating Based on Zero Condenser ESP

5.22.2.1 Installation and Setup

Install the unit with outdoor coil ductwork and external static pressure measurements made in accordance with Section 6.4 and Section 6.5 of ASHRAE 37 and manufacturer's instructions as applicable. The unit shall operate at 0.0 in H_2O external static pressure with a condition tolerance of -0.00/+0.05 in H_2O. If manufacturer's instructions provide guidance for setting outdoor airflow (for example, outdoor fan control settings), set the outdoor airflow in accordance with manufacturer's instructions while maintaining the outdoor air ESP within -0.00/+0.05 in H_2O of 0.0 in H_2O. If manufacturer's instructions do not provide any guidance for setting outdoor airflow, test using the as-shipped outdoor fan setting while maintaining the outdoor air ESP within 0.00/+0.05 in H_2O of 0.0 in H_2O. If the outdoor air ESP cannot be maintained within 0.00/+0.05 in H_2O of 0.0 in H_2O at the *manufacturer-specified* or as-shipped fan setting (as applicable), operate with a fan setting as close as achievable to the target fan setting (such as *manufacturer-specified* or as-shipped) so that the outdoor air ESP requirement is met. Outdoor airflow does not need to be measured unless using the outdoor air enthalpy method in accordance with Section E.6.5.

5.22.2.2 Outdoor Air ESP Tolerance

The outdoor air ESP tolerance of -0.00/+0.05 in H_2O is a condition tolerance that applies throughout the test. Specifically, the average value of the outdoor air ESP measured over the course of the test shall vary from the target value by not more than the condition tolerance. An operating tolerance for ESP is specified in Section 5.25.

5.23 Outdoor Air Water Vapor Content

Outdoor air water vapor content shall be controlled for the following tests.

For cooling tests of air-cooled equipment that use condensate obtained from the evaporator to enhance condenser cooling, and all evaporatively-cooled equipment, entering outdoor air shall be controlled to the wet-bulb temperature requirements in Table 7 and wet-bulb tolerances in Section 5.25.

For cooling tests of air-cooled single package units that do not reject condensate to the outdoor coil, and where all or part of the indoor section of the equipment is located in the outdoor chamber, entering outdoor air shall be controlled to the dew point temperature requirements in Table 7 and dew point tolerances in Section 5.25.

For heating tests of all air-source heat pumps, entering outdoor air shall be controlled to the wet-bulb temperature requirements in Table 23 and wet-bulb tolerances in Section 5.25.

For all other tests, there are not any requirements on outdoor air water vapor content.

5.24 Water Flow Rate for Water-cooled Units

For the full-load cooling test, set water flow rate to meet the required entering and leaving water temperatures.

Except as adjusted for operation at low condenser temperatures in accordance with Section E.7, for part-load cooling tests, use *manufacturer-specified* full-load water flow rates. For all part-load cooling tests, the water flow rate shall not exceed the water flow rate used for the full-load cooling test. If the *manufacturer-specified* part-load cooling water flow rate is higher than the water flow rate used for the cooling full-load test, use the water flow rate used for the cooling full-load test. If no *manufacturer-specified* value for part-load cooling water flow rate is provided, use the water flow rate used for the cooling full-load tests. If using a target water flow rate in part-load tests, the condition tolerance on water flow rate is 1% of the target water flow rate.

5.25 Test Tolerances

5.25.1 Order of Precedence

Tolerances specified in this standard supersede tolerances specified in ASHRAE 37.

5.25.2 Operating Tolerance

Test operating tolerance is the maximum permissible range that a measurement shall vary over the specified test interval. Specifically, 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 permissible range is the specified percentage of the average value of the measured test parameter.

5.25.3 Condition Tolerance

Test condition tolerance is the maximum permissible 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.

5.25.4 Table of Tolerances

Test operating tolerances and condition tolerances are specified in Table 6.

Table 6 Tolerances

Measurement	Test Operating Tolerance	Test Condition Tolerance
Outdoor dry-bulb temperature (°F): Entering Leaving	 2.0 2.0 / 3.0[1,2]	 0.5 —
Outdoor wet-bulb temperature (°F): Entering Leaving	 1.0 1.0[2]	 0.3[3] —
Outdoor dew point temperature[4] (°F): Entering	 —	 3.0
Indoor dry-bulb temperature (°F): Entering Leaving	 2.0 2.0 / 3.0[1]	 0.5 —
Indoor wet-bulb temperature (°F): Entering Leaving	 1.0 1.0	 0.3[5] —
Water serving outdoor coil temperature (°F): Entering Leaving	 0.5 0.5	 0.2 0.2
Water serving outdoor coil flow rate, when flow rate specified (percent)	2.0	1.0
Makeup water temperature (°F):	10.0	5.0
Saturated refrigerant temperature corresponding to the measured indoor side pressure[6] (°F)	3.0	0.5
Liquid refrigerant temperature[6] (°F)	0.5	0.2
External static pressure (in H_2O)	0.05	See Section 5.19

Measurement	Test Operating Tolerance	Test Condition Tolerance
Return static pressure	—	See Section 5.17.1.4
Electrical voltage (percent of reading)	2.0	1.0
Electrical Frequency (Hz)[7]	0.4	0.2
Water flow rate (percent of reading)	2.0	See Section 5.24
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. Applies only when using the outdoor air enthalpy method.
3. Applicable for heating tests of air-cooled units and only applicable for cooling tests when testing evaporatively-cooled equipment or, air-cooled equipment that rejects condensate to the outdoor coil. See Section 5.23.
4. Applicable only when testing single package units that do not reject condensate to the outdoor coil where all or part of the indoor section of the equipment is located in the outdoor chamber. See Section 5.23.
5. Applicable only for cooling tests.
6. See Section 5.25.5.
7. When using electrical generators, tolerances can be doubled.

5.25.5 Refrigerant Temperatures

Tolerances on saturated refrigerant temperature and liquid refrigerant temperature apply only for the compressor calibration and refrigerant enthalpy methods. The saturation temperature, in this case, shall be evaluated based on the pressure transducer located between the indoor coil and the compressor for the given operating mode, heating or cooling.

Section 6. Rating Requirements

6.1 Standard Ratings

Use the requirements of Section 6 to determine all *standard ratings*. Perform all tests using the requirements of Section 5.

6.1.1 Criteria for Standard Ratings

Standard ratings shall meet the following criteria:

- Standard cooling ratings shall be established at the *standard rating conditions* specified in Table 7 for North American ratings, or Appendix F for *international ratings*.
- Standard heat pump (HP) heating ratings shall be established at the *standard rating conditions* specified in Table 23.
- *Standard ratings* related to *cooling* or *heating capacities* shall be net values, including the effects of circulating fan heat.
- *Standard ratings* shall be based on the total power input (see Appendix D regarding features to be included and activated during the test). Power used for any override controls only used for laboratory testing shall not be included in total power.
- *Standard ratings* shall be based on 100% recirculated indoor air.

6.1.2 Standard Ratings Power

6.1.2.1 Full Load Ratings

Full load *EER2*, $COP2_H$ and ratings shall not include operation of any heating components other than the reverse cycle heat pump functionality. Control power and power losses of variable speed control devices shall be included in *standard ratings* as described in Section 5 and Section 6.

6.1.2.2 Annual Rating Metrics

Annual *IVEC*, and *IVHE* efficiency metrics shall include the energy use of all electric energy using devices including compressors, condenser fans, indoor fans, controls, crankcase heat and auxiliary electric heat. The *IVEC* cooling metric procedures are defined in Section 6.2. The *IVHE* heating metric procedures are defined in Section 6.3.

6.1.2.3 IVEC Ratings

IVEC shall include the annual energy applicable to all *Commercial Unitary Air-conditioners* and *Commercial Unitary Heat Pumps*. This includes the rules for each of the components described in Section 6.1.2.3.1 through Section 6.1.2.3.5.

6.1.2.3.1 Compressor Power (PC)

During all modes of cooling operation.

6.1.2.3.2 Condenser Fan Power (PCD)

During all modes of cooling operation.

6.1.2.3.3 Indoor Fan Power (PIF)

The *indoor fan power* during mechanical-only cooling, integrated economizer cooling, and economizer-only cooling and *indoor fan power* of air conditioners for all ventilation hours or *indoor fan power* of heat pumps for ventilation that occurs above the ambient changeover temperature of 49°F.

6.1.2.3.4 Crankcase Heat and Control Power for All Cooling Only Units (PCCH and PCT)

For units that are not heat pumps the crankcase heat power that is used during cooling, as well as all ventilation and periods without cooling include hours where there is heating.

6.1.2.3.5 Crankcase Heat and Control Power for Heat Pumps (PCCH and PCT)

IVEC includes the crankcase heat power during cooling and ventilation greater than the ambient changeover temperature of 49°F.

Note: Crankcase heat power at temperatures less than or equal to 49°F is included in the *IVHE* heating metric.

6.1.2.4 IVHE Rating

The *IVHE* heating metric is applicable to all commercial unitary heat pumps.

The *IVHE* heat pump heating metric shall include all electric power described in Section 6.1.2.4.1 through Section 6.1.2.4.4.

6.1.2.4.1 Compressor Power (PC)

During all modes of heating operation.

6.1.2.4.2 Condenser Fan Power (PCD)

During all modes of heating operation.

6.1.2.4.3 Indoor Power (PIF)

The *indoor fan power* during heat pump heating operation and *indoor fan power* for ventilation that occurs at less than or equal to the ambient changeover temperature of 49°F.

6.1.2.4.4 Crankcase Heat and Control Power (PCCH and PCT)

IVHE includes the crankcase heat power during heating and ventilation at or below the ambient changeover temperature of 49°F.

Note: Crankcase heat power at temperatures greater than 49°F is included in the *IVEC* cooling metric.

Note: For all heat pumps, the IVHE heating metric includes calculated values of auxiliary electric heat in heating bins that have a load exceeding the capacity of the heat pump.

6.1.3 Standard Ratings of Coil-only Indoor Units

Standard ratings of *coil-only indoor units* shall be established by making the adjustments to capacity and power defined in Section 6.2.4 and Section 6.3.7.

6.1.4 Standards Ratings for Water Cooled Equipment

Standard ratings for water cooled equipment shall be based on a fouling factor of 0.0000 hr ft2 ºF/Btu.

6.1.5 Standards Ratings for Double-duct Systems

Standard ratings for *double-duct systems* shall be established in accordance with Section 5.22.1.

6.2 Cooling Efficiency Metrics

For cooling efficiency, the full load *EER2* the *IVEC* shall be determined using the calculation procedures defined in Section 6.2.1.

The *EER2* is a full load efficiency based on the *standard ratings* conditions for Bin A as defined in Table 7 at external static pressure as defined in Table 5.

The *IVEC* is a weighted average annual efficiency metric based on cooling mode performance including the operation for bins B, C, and D as defined in Table 7. The A bin is not used because the metric assumes a 15% oversizing of the equipment. The *IVEC* includes the benefits of an *air economizer* and energy for indoor air quality ventilation during the occupied mode and standby power for crankcase heat.

As the *IVEC* metric and rating procedures are very complex, a spreadsheet tool has been created and is accessible at https://www.ahrinet.org/search-standards/ahri-standard-1340-i-p-performance-rating-commercial-and-industrial-unitary-air-conditioning-and.

6.2.1 Cooling Rating Calculation Procedure

Determine *IVEC* using Section 6.2.2 through Section 6.2.9.

Determine *EER2* by performing the full-load test in Section 6.2.5 and calculating *EER2* using Section 6.2.10.

6.2.2 Rating Conditions

The *rating conditions* for *IVEC* and *EER2* are summarized in Table 7.

Table 7 IVEC and EER2 Rating Conditions

Conditions	Cooling Bin A	Cooling Bin B	Cooling Bin C	Cooling Bin D
Target load percentage (%)	100.0	73.0	48.0	13.0
Indoor				
Return air dry-bulb temperature (°F)	80.0	77.0	77.0	77.0
Return air wet-bulb temperature (°F)	67.0	64.0	64.0	64.0
Indoor airflow[1]	Full Airflow	Rated	Rated	Rated
Condenser (air cooled)				
Entering air Dry-bulb temperature (°F)	95.0	85.0	75.0	65.0
Entering air Dew point[2] (°F)	60.5	56.5	56.5	56.5
Entering air wet-bulb temperature (°F)[3]	75.0	66.0	58.0	53.0
Condenser airflow[4]:				
Condenser (water cooled)				
Entering water temperature (°F)	85.0	74.0	66.0	61.0
Leaving water temperature (°F)	95.0	—	—	—
Water flow rate: see Section 5.24				
Tower fan and pump power rate (TFPPR), W/(Btu/h)	0.0094	0.0066	0.0053	0.0048
Condenser (evaporatively cooled)				
Entering air dry-bulb temperature (°F)	95.0	85.0	75.0	65.0
Entering air wet-bulb temperature (°F)	75.0	66.0	58.0	53.0
Makeup water temperature (°F)	85.0	77.0	77.0	77.0
Condenser airflow[4]:				

Notes:

1. Refer to Section 5.17 through Section 5.20 for indoor airflow and ESP.
2. Applies only to air-cooled single package units that do not reject condensate to the outdoor coil, and where all or part of the indoor section of the equipment is located in the outdoor chamber. See Section 5.23.
3. Applies only to air-cooled units that reject condensate to the outdoor coil. See Section 5.23.
4. Refer to Section 5.21 and Section 5.22 for outdoor airflow and external static pressure.

6.2.3 Load Percentages

The load percentage for a mechanical cooling test is determined using Equation 4.

$$Load\ percentage = 100 \times \frac{q_t}{q_{t,A}} \qquad \textbf{4}$$

Where:

Load percentage = Mechanical cooling load percentage for tests B, C, D, %

q_t = The *cooling capacity* determined for the tests B, C, D Btu/h

q_{tA} = The *cooling capacity* measured for the full-load cooling test in Section 6.2.5, Btu/h

6.2.4 Capacity and Fan Power Adjustments for Coil-only Units

For tests of *coil-only indoor units*, subtract the applicable capacity adjustment in Section 6.2.4.1 or Section 6.2.4.2 from the total *cooling capacity* measured for each test, and add the applicable fan power adjustment in Section 6.2.4.1 or Section 6.2.4.2 to the total unit power and *indoor fan power* measured for each test. Use the airflow measured for the test.

6.2.4.1 Tests Using the Full-load Cooling Airflow

Use the values specified in Table 8 for full-load airflow for all tests that use the full-load cooling airflow.

6.2.4.2 Tests Using Airflows Other Than the Full-load Cooling Airflow

For tests using airflows other than the full-load cooling airflow, calculate the fan power adjustment in W per 1000 scfm and capacity adjustment in Btu/h per 1000 scfm using Equation 5 and Equation 6.

$$DFPC_{adj} = DFPC_{PL} + \frac{(DFPC_{FL} - DFPC_{PL}) \times (\%FL\ Airflow - 67\%)}{100\% - 67\%} \qquad \textbf{5}$$

$$DCA_{adj} = DCA_{PL} + \frac{(DCA_{FL} - DCA_{PL}) \times (\%FL\ Airflow - 67\%)}{100\% - 67\%} \qquad \textbf{6}$$

Where:

$DFPC_{adj}$	=	adjusted default fan power coefficient for test using airflow lower than full-load cooling airflow, W/(1000 scfm)
$DFPC_{FL}$	=	default fan power coefficient specified for full-load tests in Table 8, W/(1000 scfm)
$DFPC_{PL}$	=	default fan power coefficient specified for part-load tests in Table 8, W/(1000 scfm)
$\%FL\ Airflow$	=	airflow measured for the test divided by the measured airflow for the full-load cooling test, %
DCA_{adj}	=	adjusted default capacity adjustment for test using airflow lower than full-load cooling airflow, (Btu/h)/(1000 scfm)
DCA_{FL}	=	default capacity adjustment specified for full-load tests in Table 8, (Btu/h)/(1000 scfm)
DCA_{PL}	=	default capacity adjustment specified for part-load tests in Table 8, (Btu/h)/(1000 scfm)

6.2.4.3 Table of Capacity and Power Adjustments

Table 8 shows the full-load and part-load adjustments referred to in Section 6.2.4.1 and Section 6.2.4.2.

Table 8 Coil-only Cooling Capacity and Fan Power Adjustments

Full-Load Cooling Capacity Measured in Section 6.2.5, kBtu/h	Capacity Adjustment (Btu/h per 1000 scfm)		Fan Power Adjustment (W per 1000 scfm)	
	Full-load Airflow	Part-load Airflow[2]	Full-load Airflow	Part-load Airflow[2]
>0 and <65[1]	1271	636	373	186
≥65 and <135	1621	812	475	238
≥135 and <240	1948	976	571	286
≥240	2648	1324	776	388

Notes:

1. Only applicable for evaporatively and water-cooled units.
2. Part-load airflow values are based on an airflow that is 67% of the full-load airflow.

6.2.5 Full-load Test for Cooling Bin A Rating Point

Perform a full-load test using *manufacturer-specified* full-load airflow at the conditions specified for cooling bin A rating point in Table 7, and perform all applicable capacity and power adjustments in Section 6.2.4.

6.2.6 Tests and Calculations for Cooling Bins B, C, and D Rating Point

For each cooling bin B through D, perform the following three steps:

1) Determine the test and calculation method using Section 6.2.6.1.
2) Perform test(s), calculate the capacity adjustment for the bin, and calculate the total power for each operating mode in the bin using Section 6.2.6.2, Section 6.2.6.3, or Section 6.2.6.4, as specified in Section 6.2.6.1.
3) Calculate the annual energy consumption for the bin using Section 6.2.6.5. Use the power of each operating mode for the cooling bin calculated in Section 6.2.6.2, Section 6.2.6.3, or Section 6.2.6.4, as specified in Section 6.2.6.1.

6.2.6.1 Determination of Test and Calculation Method

6.2.6.1.1 Operation Within Three Percentage Points of Target Load Percentage

If the unit can operate continuously at the conditions specified in Table 7 for the cooling bin, with a measured load percentage greater than or equal to the minimum load percentage and less than or equal to the maximum load percentage specified in Table 9 for the cooling bin, determine the test to run, the capacity adjustment, and the input power of each operating mode for the cooling bin using Section 6.2.6.2.

Table 9 Minimum and Maximum Load Percentages for Operation Within Three Percentage Points of Target Load Percentage

Load Percentage	Cooling Bin B	Cooling Bin C	Cooling Bin D
Target load percentage	73.0	48.0	13.0
Minimum load percentage	70.0	45.0	10.0
Maximum load percentage	76.0	51.0	16.0

6.2.6.1.2 Interpolation Between Two Operating Levels

If the unit cannot operate continuously in the range of load percentages specified in Section 6.2.6.1.1 for the cooling bin, but the unit can operate continuously at the conditions specified in Table 7 for the cooling bin, with a measured load percentage less than the minimum load percentage specified in Table 9 for the cooling bin, determine the tests to run, the capacity adjustment, and the input power of each operating mode for the cooling bin using Section 6.2.6.3.

6.2.6.1.3 Cyclic Degradation

If the unit cannot operate continuously at the conditions specified in Table 7 for the cooling bin, with a measured load percentage less than or equal to the maximum load percentage specified in Table 9 for the cooling bin, determine the tests to run, the capacity adjustment, and the input power of each operating mode for the cooling bin using Section 6.2.6.4.

6.2.6.2 Operation Within Three Percentage Points of Target Load Percentage

6.2.6.2.1 Tests

Perform one test at the operating level that results in a measured mechanical load percentage closest to the target load percentage in Table 7 for the cooling bin. Use the conditions specified in Table 7 and the *manufacturer-specified* indoor airflow for the cooling bin. Perform all applicable capacity and power adjustments in Section 6.2.4.

6.2.6.2.2 Capacity Adjustment

Calculate the capacity adjustment for the cooling bin using Equation 7. The capacity adjustment is used in Section 6.2.9.

Note: The capacity adjustment is made to correct for test results within the 3% tolerance band but not exactly the nominal value and to align with the actual power measurements.

$$q_{t,adj} = q_{t,X} - 0.01 \times TLP \times q_{t,A} \tag{7}$$

Where:

$q_{t,adj}$ = Capacity adjustment, Btu/h

$q_{t,X}$ = The *cooling capacity* determined for the test in Section 6.2.6.2.1, Btu/h

TLP = The target load percentage for the cooling bin in Table 7, %

$q_{t,A}$ = The *cooling capacity* determined for the full-load cooling test in Section 6.2.5, Btu/h

6.2.6.2.3 Mechanical-only Mode Power

The total power in watts for mechanical-only mode is the sum of all power consumption values in the power value in watts column of Table 10. The calculated value is used in Section 6.2.6.5.

Table 10 Component Power Values for Mechanical-only Mode

Component	Power Value in Watts
Compressor (P_C)	*Compressor power* determined from the test in Section 6.2.6.2.1
Condenser section (P_{CD})	*Condenser section power* determined from the test in Section 6.2.6.2.1
Indoor fan (P_{IF})	*Indoor fan power* determined from the test in Section 6.2.6.2.1
Controls (P_{CT})	*Controls power* determined from the test in Section 6.2.6.2.1
Tower fan and condenser water pump	For water-cooled units see Equation 8. For all other units: 0.0

Equation 8 calculates tower fan and condenser water pump power.

$$q_{t,X} \times \text{TFPPR} \tag{8}$$

Where:

$q_{t,X}$ = The *cooling capacity* determined from the test for this cooling bin in Section 6.2.6.2.1, Btu/h

TFPPR = The cooling tower fan and condenser water pump power rate for this cooling bin in Table 7, W/(Btu/h)

6.2.6.2.4 Integrated-Economizing Mode Power

The total power in watts for integrated-economizing mode is the sum of all power consumption values in the power value in watts column of Table 11. The calculated value is used in Section 6.2.6.5.

Table 11 Component Power Values for Integrated Economizer Mode

Component	Power Value in Watts
Compressor (P_C)	*Compressor power* determined from the test in Section 6.2.6.2.1
Condenser section (P_{CD})	*Condenser section power* determined from the test in Section 6.2.6.2.1
Indoor fan (P_{IF})	*Indoor fan power* determined for the full-load test in Section 6.2.5
Controls (P_{CT})	*Controls power* determined from the test in Section 6.2.6.2.1
Tower fan and condenser water pump	For water-cooled units see Equation 8. For all other units: 0.0

6.2.6.2.5 Economizing-only Mode Power

The total power in watts for economizing-only mode is the sum of all power consumption values in the power value in watts column of Table 12. The calculated value is used in Section 6.2.6.5.

Table 12 Component Power Values for Economizer-only Mode

Component	Power Value in Watts
Indoor fan (P_{IF})	For cooling bins B and C: *indoor fan power* determined for the full-load test in Section 6.2.5. For cooling bin D: *indoor fan power* determined from the test in Section 6.2.6.2.1.
Controls (P_{CT})	*Controls power* determined for the full-load test in Section 6.2.5.
Crankcase heat (P_{CCH})	If *crankcase heat power* is measured in *controls power*: Sum of the *manufacturer-specified crankcase heat power* values for all compressors that are operating during the full-load test in Section 6.2.5. If *crankcase heat power* is measured in *compressor power*: Sum of the *manufacturer-specified crankcase heat power* values for all compressors

6.2.6.3 Interpolation Between Two Operating Levels

6.2.6.3.1 Tests

Perform two tests. Perform the first test at a lower operating level that results in a measured load percentage closest to but less than the minimum load percentage in Table 9 for the cooling bin. Perform the second test at a higher operating level that results in a measured load percentage closest to but greater than the maximum load percentage in Table 9 for the cooling bin. Use the conditions specified in Table 7 and the *manufacturer-specified* indoor airflow for the cooling bin. Perform all applicable capacity and power adjustments in Section 6.2.4.

6.2.6.3.2 Capacity Adjustment

The capacity adjustment is zero. The capacity adjustment is used in Section 6.2.9.

6.2.6.3.3 Higher-Level Operating Fraction

Calculate the higher-level operating fraction using Equation 9.

$$X = \frac{TLP - LP_{LR}}{LP_{HR} - LP_{LR}} \qquad \textbf{9}$$

Where:

X	=	Higher-level operating fraction
TLP	=	Target load percentage for the cooling bin in Table 7, %
LP_{LR}	=	Load percentage measured for the lower operating level in Section 6.2.6.3.1, %
LP_{HR}	=	Load percentage measured for the higher operating level in Section 6.2.6.3.1, %

6.2.6.3.4 Mechanical-only Mode Power

Using the lower and higher operating levels for the cooling bin determined in Section 6.2.6.3.1, determine the total power for mechanical-only mode in watts using two steps as follows.

1) For each of the higher operating level and lower operating level columns in Table 13, sum all power consumption values in the component rows of the column, and multiply that sum by the value in the coefficient row of the column.
2) Sum the values determined in step one.

The calculated value is used in Section 6.2.6.5.

Table 13 Coefficients and Component Power Values for Mechanical Cooling Mode

—	Higher Operating Level	Lower Operating Level
Coefficient	X	1-X
Component	—	—
Compressor (P_C)	*Compressor power* determined from the test in Section 6.2.6.3.1 for the higher operating level, W	*Compressor power* determined from the test in Section 6.2.6.3.1 for the lower operating level, W
Condenser section (P_{CD})	*Condenser section power* determined from the test in Section 6.2.6.3.1 for the higher operating level, W	*Condenser section power* determined from the test in Section 6.2.6.3.1 for the lower operating level, W
Indoor fan (P_{IF})	*Indoor fan power* determined from the test in Section 6.2.6.3.1 for the higher operating level, W	*Indoor fan power* determined from the test in Section 6.2.6.3.1 for the lower operating level, W
Controls (P_{CT})	*Controls power* determined from the test in Section 6.2.6.3.1 for the higher operating level, W	*Controls power* determined from the test in Section 6.2.6.3.1 for the lower operating level, W
Tower fan and condenser water pump	For water-cooled units see Equation 10. For all other units: 0.0	For water-cooled units see Equation 11. For all other units: 0.0

Equation 10 calculates the higher operating level tower fan and condenser water pump power. Equation 11 calculates the lower operating level tower fan and condenser water pump power.

$$q_{HR} \times \text{TFPPR} \quad (10)$$

$$q_{LR} \times \text{TFPPR} \quad (11)$$

Where:

q_{HR} = the *cooling capacity* determined for the higher operating level in Section 6.2.6.3.1, Btu/h

q_{LR} = the *cooling capacity* determined for the lower operating level in Section 6.2.6.3.1, Btu/h

TFPPR = The cooling tower fan and condenser water pump power rate for this cooling bin in Table 7, W/(Btu/h)

Symbols in Table 13:

- X = the higher-level operating fraction calculated in accordance with Section 6.2.6.3.3

6.2.6.3.5 Integrated-economizing Mode Power

Using the lower and higher operating levels for the cooling bin determined in Section 6.2.6.3.1, determine the total power for integrated-economizing mode in watts using the two steps as follows.

1) For each of the higher operating level and lower operating level columns in Table 14, sum all power consumption values in the component rows of the column, and multiply that sum by the value in the coefficient row of the column.
2) Sum the values determined in step one.

The calculated value is used in Section 6.2.6.5.

Table 14 Coefficients and Component Power Values for Integrated Economizer Mode

—	Higher Operating Level	Lower Operating Level
Coefficient	X	1-X
Component	—	—
Compressor (P_C)	*Compressor power* determined from the test in Section 6.2.6.3.1 for the higher operating level	*Compressor power* determined from the test in Section 6.2.6.3.1 for the lower operating level
Condenser section (P_{CD})	*Condenser section power* determined from the test in Section 6.2.6.3.1 for the higher operating level	*Condenser section power* determined from the test in Section 6.2.6.3.1 for the lower operating level
Indoor fan (P_{IF})	*Indoor fan power* determined for the full-load test in Section 6.2.5	*Indoor fan power* determined for the full-load test in Section 6.2.5
Controls (P_{CT})	*Controls power* determined from the test in Section 6.2.6.3.1 for the higher operating level	*Controls power* determined from the test in Section 6.2.6.3.1 for the lower operating level
Tower fan and condenser water pump	For water-cooled units see Equation 10. For all other units: 0.0	For water-cooled units see Equation 11. For all other units: 0.0

Symbols in Table 14:

- X= the higher-level operating fraction calculated in accordance with Section 6.2.6.3.3

6.2.6.3.6 Economizing-only Mode Power

The total power in watts for economizing-only mode is the sum of all values in the power value in watts column of Table 15. The calculated value is used in Section 6.2.6.5.

Table 15 Coefficient and Component Power Values for Economizer-only Mode

Component	Power Value in Watts
Indoor fan (P_{IF})	For cooling bins B and C: *indoor fan power* determined for the full-load test in Section 6.2.5. For cooling bin D see Equation 12.
Controls (PCT)	*Controls power* determined for the full-load test in Section 6.2.5
Crankcase heat (P_{CCH})	If *crankcase heat power* is measured in *controls power*: Sum of the *manufacturer-specified crankcase heat power* values for all compressors that are operating during the full-load test in Section 6.2.5 If *crankcase heat power* is measured in *compressor power*: Sum of the *manufacturer-specified crankcase heat power* values for all compressors

Symbols in Table 15:

- X = higher-level operating fraction calculated in accordance with Section 6.2.6.3.3
- $P_{IF,LR}$ = *indoor fan power* determine for the lower operating level in accordance with Section 6.2.6.3.1, W
- $P_{IF,HR}$ = *Indoor fan power* determined for the higher operating level in Section 6.2.6.3.1, W

Equation 12 calculates *indoor fan power*.

$$P_{IF} = (1 - X) \times P_{IF,LR} + X \times P_{IF,HR} \tag{12}$$

Where:

X = higher-level operating fraction calculated in accordance with Section 6.2.6.3.3

$P_{IF,LR}$ = *indoor fan power* determine for the lower operating level in accordance with Section 6.2.6.3.1, W

$P_{IF,HR}$ = *Indoor fan power* determined for the higher operating level in Section 6.2.6.3.1, W

6.2.6.4 Cyclic Degradation

6.2.6.4.1 Tests

Perform one test at the operating level that results in the lowest measured load percentage. Use the conditions specified in Table 7 and the *manufacturer-specified* indoor airflow for the cooling bin. Perform all applicable capacity and power adjustments in Section 6.2.4.

6.2.6.4.2 Capacity Adjustment

The capacity adjustment is zero. The capacity adjustment is used in Section 6.2.9.

6.2.6.4.3 Mechanical-only Mode Power

Determine the total power for mechanical-only mode in watts using two steps as follows.

1) For each of the lowest operating level and off cycle columns in Table 16, sum all power consumption values in the component rows of the column, and multiply that sum by the value in the coefficient row of the column.
2) Sum the values determined in step one.

The calculated value is used in Section 6.2.6.5.

Table 16 Coefficients and Component Power Values for Mechanical Cooling Mode Using Degradation

—	Lowest Operating Level	Off Cycle
Coefficient	LF	1 – LF
Component	—	—
Compressor (P_C)	If crankcase heat is included in *controls power:* calculate using Equation 14, expressed in W. If crankcase heat is included in *compressor power:* calculate using Equation 15, expressed in W.	$P_C = 0.0$
Condenser section (P_{CD})	Calculate using Equation 16, expressed, W.	$P_{CD} = 0.0$
Indoor fan (P_{IF})	*Indoor fan power* determined from the test in Section 6.2.6.4.1, W	*Indoor fan power* determined from the test in Section 6.2.6.4.1
Controls (P_{CT})	*Controls power* determined from the test in Section 6.2.6.4.1, W	*Controls power* determined from the test in Section 6.2.6.4.1
Crankcase heat (P_{CCH})	If crankcase heat is included in *controls power*: 0.0 If crankcase heat is included in *compressor power*: $P_{CCH,NOC}$	If crankcase heat is included in *controls power*: sum of the *manufacturer-specified crankcase heat power* values for all compressors operating during the test in Section 6.2.6.4.1 If crankcase heat is included in *compressor power*: sum of the *manufacturer-specified crankcase heat power* values for all compressors
Tower fan and condenser water pump	For water-cooled units see Equation 13 For all other units: 0.0	0.0

Equation 13 calculates tower fan and condenser pump power. Equation 14 calculates compressor power if crankcase heat is included in *controls power*. Equation 15 calculates compressor power if crankcase heat is included in *compressor power*. Equation 16 calculates condenser section power.

$$q_t \times \text{TFPPR} \quad (13)$$

$$P_C = C_d \times P_C \quad (14)$$

$$P_C = C_d \times (P_C - P_{CCH,NOC}) \quad (15)$$

$$P_{CD} = C_d \times P_{CD} \quad \mathbf{16}$$

Where:

TFPPR	=	The cooling tower fan and condenser water pump power rate for this cooling bin in Table 7, W/(Btu/h)
q_t	=	The *cooling capacity* determined from the test in Section 6.2.6.4.1, Btu/h
C_d	=	degradation factor = -0.13 x LF $+$ 1.13
P_C	=	*compressor power* determined from the test in Section 6.2.6.4.1, W
P_{CD}	=	*condenser section power* determined from the test in Section 6.2.6.4.1, W
$P_{CCH,NOC}$	=	sum of *manufacturer-specified* crankcase heat power for all compressors not operating during the test in Section 6.2.6.4.1, W

Symbols in Table 16 and Table 17:

- LF = TLP/LP
- TLP = target load percentage for the cooling bin in Table 7, %
- LP = Load percentage determined from the test in Section 6.2.6.4.1, %
- P_C = *compressor power* determined from the test in Section 6.2.6.4.1, W
- P_{CD} = *condenser section power* determined from the test in Section 6.2.6.4.1, W

6.2.6.4.4 Integrated-economizing Mode Power

Determine the total power for integrated-economizing mode in watts using two steps as follows.

1) For each of the lowest operating level and off cycle columns in Table 17, sum all power consumption values in the component rows of the column, and multiply that sum by the value in the coefficient row of the column.
2) Sum the values determined in step one.

The calculated value is used in Section 6.2.6.5.

Table 17 Component Power Values for Integrated-economizer Mode

—	**Lowest Operating Level**	**Off Cycle**
Coefficient	LF	1 – LF
Component	—	—
Compressor (P_C)	If crankcase heat is included in *controls power* calculate using Equation 14, expressed W. If crankcase heat is included in *compressor power* calculate using Equation 15, expressed W.	$P_C = 0.0$
Condenser section (P_{CD})	Calculate using Equation 16, expressed W.	$P_{CD} = 0.0$
Indoor fan (P_{IF})	*Indoor fan power* determined for the full-load test in Section 6.2.5	*Indoor fan power* determined for the full-load test in Section 6.2.5
Controls (P_{CT})	*Controls power* determined from the test in Section 6.2.6.4.1	*Controls power* determined from the test in Section 6.2.6.4.1
Crankcase heat (P_{CCH})	If crankcase heat is included in *controls power*: 0.0 If crankcase heat is included in *compressor power*: $P_{CCH,NOC}$	If crankcase heat is included in *controls power*: sum of the *manufacturer-specified crankcase heat power* values for all compressors operating during the test in Section 6.2.6.4.1 If crankcase heat is included in *compressor power*: sum of the *manufacturer-specified crankcase heat power* values for all compressors
Tower fan and condenser water pump	For water-cooled units see Equation 13 For all other units: 0.0	0.0

6.2.6.4.5 Economizing-only Mode Power

The total power in watts for economizing-only mode is the sum of all power consumption values in the power value in watts column of Table 18. The calculated value is used in Section 6.2.6.5.

Table 18 Coefficient and Component Power Values for Economizer-only Mode

Component	Power Value in Watts
Indoor fan (P_{IF})	For cooling bins B and C: *indoor fan power* determined for the full-load test in Section 6.2.5. For cooling bin D: *indoor fan power* determined from the test in Section 6.2.6.4.1.
Controls (P_{CT})	*Controls power* determined for the full-load test in Section 6.2.5.
Crankcase heat (P_{CCH})	If *crankcase heat power* is measured in *controls power*: Sum of the *manufacturer-specified crankcase heat power* values for all compressors that are operating during the full-load test in Section 6.2.5. If *crankcase heat power* is measured in *compressor power*: Sum of the *manufacturer-specified crankcase heat power* values for all compressors

6.2.6.5 Annual Energy Consumption

Calculate total annual energy consumption for the cooling bin using Equation 17 and the operating hours for each operating mode of the cooling bin in Table 19. The calculated value is used in Section 6.2.9.

If Section 6.2.6.1 specified to use Section 6.2.6.2 to calculate the total power for each operating mode of the cooling bin by operation within three percentage points of target the load percentage, use the power values calculated for each mode in section 6.2.6.2 in Equation 17.

If Section 6.2.6.1 specified to use Section 6.2.6.3 to calculate the total power for each operating mode of the cooling bin by interpolating between two operating modes, use the power values calculated for each mode in Section 6.2.6.3 in Equation 17.

If Section 6.2.6.1 specified to use Section 6.2.6.4 to calculate the total power for each operating mode of the cooling bin by cyclic degradation, use the power values calculated for each mode in Section 6.2.6.4 in Equation 17.

$$E_i = h_{MO} \times P_{MO} + h_{IE} \times P_{IE} + h_{EO} \times P_{EO} \quad (17)$$

Where:

E	=	Energy consumption for the cooling bin, W·h
P_{MO}	=	Total power in mechanical-only mode from Section 6.2.6.2.3, Section 6.2.6.3.4, or Section 6.2.6.4.3, as applicable, W
P_{IE}	=	Total power in integrated-economizing mode from Section 6.2.6.2.4, Section 6.2.6.3.5, or Section 6.2.6.4.4, as applicable, W
P_{EO}	=	Total power in economizer-only mode from Section 6.2.6.2.5, Section 6.2.6.3.6, or Section 6.2.6.4.5, as applicable, W

Table 19 Operating Hours for All Mechanical Cooling Bins and Operating Modes

Cooling Bin (*i*)	h_{MO} Mechanical-only Mode ($h_{i,MO}$), hours	h_{IE} Integrated-economizing Mode ($h_{i,IE}$), hours	h_{EO} Economizer-only Mode $h_{i,EO}$, hours
B	181	4	4
C	767	95	85
D	1114	179	1791

6.2.7 Ventilation Energy Consumption

Calculate ventilation energy consumption in W·h by taking the sum of all power consumption values in the power value in watts column of Table 20 and multiplying that sum by 338 hours. The calculated value is used in Section 6.2.9.

Table 20 Component Power Values for Ventilation Mode

Component	Power Value in Watts
Indoor fan (P_{IF})	For air conditioners: the lowest determined *indoor fan power* from all cooling tests For heat pumps: the lowest determined *indoor fan power* from all cooling and heating tests
Controls (P_{CT})	*Controls power* determined for the full-load test in Section 6.2.5
Crankcase heat (P_{CCH})	If *crankcase heat power* is measured in *controls power*: Sum of the *manufacturer-specified crankcase heat power* values for all compressors that are operating during the full-load test in Section 6.2.5 If *crankcase heat power* is measured in *compressor power*: Sum of the *manufacturer-specified crankcase heat power* values for all compressors

6.2.8 Standby Energy Consumption

Calculate standby power in W by taking the sum of all power consumption values in the power value in watts column of Table 21 using Equation 18.

$$P_S = P_{CCH} + P_{CT} \quad (18)$$

For air conditioners, calculate standby energy consumption in W·h by multiplying the standby power by 4202 hours using Equation 19.

$$E_S = P_S \times 4202 \quad (19)$$

For heat pumps, calculate standby energy consumption in W·h by multiplying the standby power by 1297 hours using Equation 20.

$$E_S = P_S \times 1297 \quad (20)$$

The calculated value is used in Section 6.2.9.

Table 21 Component Power Values for Standby Mode

Component	Power Value in Watts
Controls (P_{CT})	*Controls power* determined for the full-load test in Section 6.2.5
Crankcase heat (P_{CCH})	If *crankcase heat power* is measured in *controls power*: Sum of the *manufacturer-specified crankcase heat power* values for all compressors that are operating during the full-load test in Section 6.2.5 If *crankcase heat power* is measured in *compressor power*: Sum of the *manufacturer-specified crankcase heat power* values for all compressors

6.2.9 Cooling Annualized Efficiency Metric Calculation (IVEC)

Calculate *IVEC* in units of Btu/(W·h) using Equation 21.

$$IVEC = \frac{977.658 \times q_{t,A} + 185 \times q_{t,adj,B} + 862 \times q_{t,adj,C} + 1293 \times q_{t,adj,D}}{E_B + E_C + E_D + E_V + E_S} \quad (21)$$

Where:

$q_{t,A}$ = The *cooling capacity* measured for the full-load cooling test in Section 6.2.5, Btu/h

$q_t,adj,_B$ = Capacity adjustment for cooling bin B, determined in Section 6.2.6.2.2, Section 6.2.6.3.2, or Section 6.2.6.4.2, as applicable, Btu/h

$qAt,adj,_C$ = Capacity adjustment for cooling bin C, determined in Section 6.2.6.2.2, Section 6.2.6.3.2, or Section 6.2.6.4.2, as applicable, Btu/h

$qt,A,adj,_D$ = Capacity adjustment for cooling bin D, determined in Section 6.2.6.2.2, Section 6.2.6.3.2, or Section 6.2.6.4.2, as applicable, Btu/h

E_B = Energy consumption for cooling bin B calculated in Section 6.2.6.5, W·h

E_C = Energy consumption for cooling bin C calculated in Section 6.2.6.5, W·h

E_D = Energy consumption for cooling bin D calculated in Section 6.2.6.5, W·h

E_V = Ventilation energy consumption calculated in Section 6.2.7, W·h

E_S = Standby energy consumption calculated in Section 6.2.8, W·h

6.2.10 Full load Efficiency Metric Calculation (EER2)

Calculate *EER2* in units of Btu/(W·h) using Equation 22.

$$EER2 = \frac{q_{t,A}}{P_{C,A} + P_{CD,A} + P_{IF,A} + P_{CT,A} + TFPPR \times q_{t,A}} \quad (22)$$

Where:

$q_{t,A}$ = The *cooling capacity* measured for the full-load cooling test in Section 6.2.5, Btu/h

$P_{C,A}$ = *Compressor power* determined for the full-load cooling test in Section 6.2.5, W

$P_{CD,A}$ = *Condenser section power* determined for the full-load cooling test in Section 6.2.5, W

$P_{IF,A}$ = *Indoor fan power* determined for the full-load cooling test in Section 6.2.5, W

$P_{CT,A}$ = *Controls power* determined for the full-load cooling test in Section 6.2.5, W

TFPPR = Tower fan and condenser pump power rate, as follows:

For water-cooled units: 0.0094 W/(Btu/h)

For all other units: 0.0

6.3 Heating Efficiency Calculation Procedures

6.3.1 Heating Metric Introduction

6.3.1.1 Heating Metrics

The following metrics are used for HP heating.

6.3.1.1.1 $COP2_{H,47}$

This is a full load steady state efficiency metric for heat pump heating operation at the H47H operating conditions defined in Table 23 and calculated in accordance with Equation 45. $COP2_{H,47}$ includes operational power for the mechanical refrigeration cycle heating but does not include *auxiliary heat* or crankcase heat power. Capacity is an integrated capacity and reflects the impact of *defrost*, but the default *defrost* curve does not result in any degradation for *defrost* at 47°F.

Note: For the rating metrics used for this standard a default *defrost* curve is used that is based on a time and temperature *defrost*. Other demand *defrost* approaches and different degradation curves cannot be used.

6.3.1.1.2 $COP2_{H,17}$

This is a full load steady state efficiency metric for heat pump heating operation at the H17H operating conditions defined in Table 23 and calculated in accordance with Equation 45. Capacity is an integrated capacity and reflects the impact of the default degradation *defrost* factor.

6.3.1.1.3 $COP2_{H,5}$

This is a full load steady state efficiency metric for heat pump heating operation at the H5H operating conditions defined in Table 23 and calculated in accordance with Equation 45. Capacity is an integrated capacity and reflects the impact of the default degradation *defrost* factor.

6.3.1.1.4 IVHE

This is an annualized metric based on totally annualized capacity delivered divided by the total power used including HP heating, *auxiliary heat*, ventilation only fan power for operating hours below a building changeover temperature of 49°F, and crankcase heat power applicable to heating operating and standby below 49°F. The metric is based on a weighted average of ten reference buildings where ten rating bins have been defined with mean rating temperatures and a building load representing the average of the ten buildings. There are two versions of the *IVHE* where the *IVHE* is a weighted average of all US climate zones, and $IVHE_C$ for colder climates is based on a weighted average of ASHRAE 169 Climate Zones 5 through 8. The equation for calculating *IVHE* is defined in Equation 44 and the procedures in Section 6.3.2.

The calculation procedure is very complex and a spreadsheet tool has been created for use and can be found on the AHRI website at the following link https://www.ahrinet.org/search-standards/ahri-standard-1340-i-p-performance-rating-commercial-and-industrial-unitary-air-conditioning-and.

6.3.2 Heating Metric Calculation Summary

Determine *IVHE* or $IVHE_C$ using Section 6.3.3 through Section 6.3.13.

Determine $COP2_H$ by performing one or more high, boost, or boost 2 operating level tests in Section 6.3.6 and calculating $COP2_H$ using Section 6.3.14.

6.3.3 Building Load Profile and Heating Bins

Table 22 indicates the operating hours, outdoor dry-bulb temperature, and *defrost* degradation coefficient for each heating bin in the *IVHE* and $IVHE_C$ Cold Climate building load profiles.

Table 22 IVHE and $IVHE_C$ Building Load Profile and Weighting Hours

Heating Bin Number, i	IVHE[1]			$IVHE_C$ Cold Climate[2]		
	Operating hours, h_i	Outdoor Dry-bulb Temperature, T_i (°F)	Defrost Degradation Coefficient, CD_{DFi}[3]	Operating hours, h_i	Outdoor Dry-bulb Temperature, T_i (°F)	Defrost Degradation Coefficient, CD_{DFi}[3]
1	404	45.0	1.00000	594	41.5	1.00000
2	404	41.4	1.00000	587	37.0	0.91000
3	351	37.7	0.93100	532	31.6	0.86870
4	247	33.3	0.85983	396	25.6	0.89283
5	158	29.4	0.87878	264	20.0	0.90688
6	90	26.2	0.89088	151	15.7	0.91336
7	50	23.4	0.89921	90	12.2	0.91654
8	25	21.0	0.90488	43	9.5	0.91805
9	11	18.1	0.91014	16	6.4	0.91906
10	5	15.9	0.91312	7	2.2	0.91978

Notes:

1. Based on weighted average of ten building types in ASHRAE 169 Climate Zones 1 through 8
2. Based on a weighted average of ten building types in ASHRAE 169 Climate Zones 5 through 8
3. Default *defrost* degradation is based on time and temperature *defrost*, other demand *defrost* controls still use the default degradation

6.3.4 Building Load for Each Heating Bin

Calculate the building load for heating bins one through ten of a heating load profile using Equation 23.

$$q_{H,BLi} = \frac{q_{\mathrm{H,t},A} \times HCR \times (0.1 \times i - 0.05)}{1.15} \qquad \mathbf{23}$$

Where:

$q_{H,BLi}$ = Building load for heating bin i Btu/h

$q_{t,A}$ = The *cooling capacity* measured for the full-load cooling test in Section 6.2.5, Btu/h

HCR = The heat-to-cool ratio, based on bin ten building load divided by cooling $qt_{,A}$ as follows:

For the *IVHE* building load profile: 1.00

For the $IVHE_C$ Cold Climate building load profile: 1.35

i = Heating bin number, one through ten with ten being the coldest.

6.3.5 Total Annual Space Heating

Calculate total annual space heating for a building load profile using Equation 24. The calculated value is used in Section 6.3.13.

$$TASH = \sum_{i=1}^{10} (h_i \times q_{H,BLi}) \quad (24)$$

Where:

TASH = Total annual space heating, Btu

i = Heating bin number, one through ten

h_i = Operating hours in Table 22 for heating bin i, h

$q_{H,BLi}$ = Building load calculated in Section 6.3.4 for heating bin i, Btu/h

6.3.6 Tests

Perform all tests designated as required for the unit's configuration in Table 23. Perform all *manufacturer-specified* tests designated as optional for the unit's configuration in Table 23.

Table 23 Heating Tests

Test Name	System Configuration			Outdoor Air Condition		Heating Operating Level[1]
	Single Operating Level	Two Operating Levels	More than Two Operating Levels	Dry Bulb (°F)	Wet Bulb (°F)	
H47H	Required	Required	Required	47.0	43.0	High
H17H	Required	Required	Required	17.0	15.0	High
H5H	Optional	Optional	Optional	5.0	4.0 (max)	High
H47M	—	Optional	Optional	47.0	43.0	Medium
H17M	—	Optional	Optional	17.0	15.0	Medium
H47L	—	Optional	Optional	47.0	43.0	Low
H17L	—	Optional	Optional	17.0	15.0	Low
H17B	—	—	Optional	17.0	15.0	Boost
H5B	—	—	Optional	5.0	4.0 (max)	Boost
H5B2	—	—	Optional	5.0	4.0 (max)	Boost 2

Note:

1. See definitions of heating *operating levels* in Section 3.2.31 and requirements in Section 6.3.6.

For each test, use the outdoor air entering temperatures specified in Table 23, an indoor entering dry-bulb temperature of 70.0°F, and an indoor entering wet-bulb temperature not higher than 60.0°F.

Run all tests specified as *high heating operating level* in Table 23 with the operating level that has the maximum capacity allowed by the controls at 47.0°F outdoor dry-bulb temperature. For the H47H test, use the indoor airflow that is used by the controls at 47.0°F outdoor dry-bulb temperature when operating at the chosen operating level. For the H17H and H5H tests, use the indoor fan speed used for the H47H test.

Run all tests specified as *medium heating operating level* in Table 23 with an operating level allowed by the controls at 47.0°F outdoor dry-bulb temperature that has a capacity at 47.0°F outdoor dry-bulb temperature that is greater than the capacity of the *low heating operating level* at 47.0°F outdoor dry-bulb temperature and less than the capacity of the *high heating operating level* at 47.0°F outdoor dry-bulb temperature. For the H47M test, use the indoor airflow that is used by the controls at 47.0°F outdoor dry-bulb temperature when operating at the chosen operating level. For the H17M test, use the indoor fan speed used for the H47M test. There shall not be more than one *medium heating operating level*.

Run all tests specified as *low heating operating level* in Table 23 with the operating level that has the minimum capacity allowed by the controls at 47.0°F outdoor dry-bulb temperature. For the H47L test, use the indoor airflow that is used by the controls at 47.0°F outdoor dry-bulb temperature when operating at the chosen operating level. For the H17L test, use the indoor fan speed used for the H47L test.

Run all tests specified as *boost heating operating level* in Table 23 with the operating level that has the maximum capacity allowed by the controls at 17.0°F outdoor dry-bulb temperature. For the H17B test, use the airflow that is used by the controls at 17.0°F outdoor dry-bulb temperature when operating at the chosen operating level. For the H5B test, use the indoor fan speed used for the H17B test. *Boost heating operating level* shall have a capacity at 17.0°F that is greater than the capacity of the *high heating operating level* at 17.0°F.

Run the H5B2 test in Table 23 only if there is an operating level allowed by the controls at 5.0°F that has a capacity greater than the capacity of the *boost heating operating level*, and the H5B2 test is being used to determine the capacity at 5.0°F outdoor dry-bulb temperature or $COP2_{H,5}$, or both. Run the H5B2 test in Table 23 with an operating level allowed by the controls at 5.0°F outdoor dry-bulb temperature that has a capacity at 5.0°F outdoor dry-bulb temperature that is greater than the capacity of the *boost heating operating level* at 5.0°F outdoor dry-bulb temperature and less than or equal to the maximum capacity allowed by the controls at 5.0°F outdoor dry-bulb temperature. Use the indoor airflow that is used by the controls at 5.0°F outdoor dry-bulb temperature when operating at the chosen operating level. The H5B2 test shall not be used in the calculation of *IVHE* or $IVHE_C$.

For all tests at a given operating level in Table 23 (for example, all tests at high operating level), the same number of compressors shall be operating, and each operating compressor shall be operating with the same values of speed, duty cycle, vapor injection setting, and any other operating parameter that affects capacity. All tests at a given operating level shall have the same indoor fan speed.

For each test, perform all applicable adjustments in Section 6.3.7.

6.3.7 Capacity and Fan Power Adjustments for Coil-only Units

For tests of *coil-only indoor units*, add the applicable capacity adjustment in Section 6.2.4.1 or Section 6.2.4.2 to the *heating capacity* measured for each test, and add the applicable fan power adjustment in Section 6.2.4.1 or Section 6.2.4.2 to the total unit power and *indoor fan power* measured for each test. Use the airflow measured for the test.

6.3.8 Capacity at Each Heating Bin Temperature and Operating Level Interpolation

Using pairs of tests at the same operating level, calculate the capacity for each combination of heating bin and tested operating level.

Use Equation 25 for bin temperatures between 17°F and 47°F. Use Equation 25 for bin temperatures less than 17°F if the unit has a pair of tests at the same operating level at 17°F and 47°F, and the unit does not have a pair of tests at the same operating level at 5°F and 17°F.

Use Equation 26 for bin temperatures less than 17°F if the unit has a pair of tests at the same operating level at 5°F and 17°F. For the boost operating level, use Equation 26 for bin temperatures less than or equal to 21°F if the unit has a pair of tests at the boost operating level at 5°F and 17°F.

$$q_{H,i,X} = CD_{DFi} \times \left[q_{H,inst,X}(17) + \left(q_{H,inst,X}(47) - q_{H,inst,X}(17) \right) \times \frac{T_i - 17}{30} \right] \quad \textbf{25}$$

$$q_{H,i,X} = CD_{DFi} \times \left[q_{H,inst,X}(5) + \left(q_{H,isnt,X,}(17) - q_{H,instX}(5) \right) \times \frac{T_i - 5}{12} \right] \quad \textbf{26}$$

Where:

$q_{H,i,X}$	=	*Integrated heating capacity* at heating bin i for operating level X, Btu/h
X	=	Operating level low (L), medium (M), high (H), or boost (B)
CD_{DFi}	=	*Defrost* degradation coefficient for heating bin i, from Table 22
$q_{H,inst,X}(17)$	=	The *instantaneous heating capacity* determined for operating level X at 17°F outdoor dry-bulb temperature in Section 6.3.6, Btu/h
$q_{H,isnt,X}(47)$	=	The *instantaneous heating capacity* determined for operating level X at 47°F outdoor dry-bulb temperature in Section 6.3.6, Btu/h
T_i	=	Outdoor dry-bulb temperature for heating bin i, from Table 22, °F
$q_X(5)$	=	The *heating capacity* determined for operating level X at 5°F outdoor dry-bulb temperature in Section 6.3.6, Btu/h

6.3.9 Power for Each Component at Each Heating Bin Temperature and Operating Level

Using pairs of tests at the same operating level, calculate *compressor power*, *condenser section power*, and *indoor fan power* at each combination of heating bin and tested operating level.

Use Equation 27 for bin temperatures between 17°F and 47°F. Use Equation 27 for bin temperatures less than 17°F if the unit has a pair of tests at the same operating level at 17°F and 47°F, and the unit does not have a pair of tests at the same operating level at 5°F and 17°F.

Use Equation 28 for bin temperatures less than 17°F if the unit has a pair of tests at the same operating level at 5°F and 17°F. For the boost operating level, use Equation 28 for bin temperatures less than or equal to 21°F if the unit has a pair of tests at the boost operating level at 5°F and 17°F.

$$P_{Y,X,i} = P_{Y,X}(17) + \left(P_{Y,X}(47) - P_{Y,X}(17) \right) \times \frac{T_i - 17}{30} \quad \textbf{27}$$

$$P_{Y,X,i} = P_{Y,X}(5) + \left(P_{Y,X}(17) - P_{Y,X}(5) \right) \times \frac{T_i - 5}{12} \quad \textbf{28}$$

Where:

$P_{Y,X,i}$	=	Power at heating bin i for component Y at operating level X, W
Y	=	Component compressor, condenser section, or indoor fan
X	=	Operating level low (L), medium (M), high (H), or boost (B)
$P_{Y,X}(17)$	=	Power determined for component Y at operating level X at 17°F outdoor dry-bulb temperature in Section 6.3.6, W
$P_{Y,X}(47)$	=	Power determined for component Y at operating level X at 47°F outdoor dry-bulb temperature in Section 6.3.6, W
T_i	=	Outdoor dry-bulb temperature for heating bin i, from Table 22, °F

$P_{Y,X}(5)$ = Power determined for component Y at operating level X at 5°F outdoor dry-bulb temperature in Section 6.3.6, W

6.3.10 Heating Bin Energy Consumption

For each heating bin, perform the following three steps:

1) Determine the heating bin cut-out factor in Section 6.3.10.1.
2) Determine the method for calculating the heating bin power in Section 6.3.10.2.
3) Calculate the heating bin power using one of Section 6.3.10.3 through Section 6.3.10.6, as applicable.

Finally, calculate the total annual energy consumption for all heating bins using Section 6.3.10.7.

6.3.10.1 Heating Bin Cut-out Factor (δ)

For each heating bin, determine the cut-out factor as follows.

Note: See Appendix H for method of test for cut-out and cut-in temperatures.

If the outdoor air dry-bulb temperature for the heating bin is less than the *manufacturer-specified low-temperature compressor cut-out temperature*, the cut-out factor is equal to zero.

If the outdoor air dry-bulb temperature for the heating bin is greater than or equal to the *manufacturer-specified low-temperature compressor cut-out temperature* and less than or equal to the *manufacturer-specified low-temperature compressor cut-in temperature*, the cut-out factor is equal to 0.5.

Otherwise, the cut-out factor is equal to one.

6.3.10.2 Method for Determining Heating Bin Power

6.3.10.2.1 Cut-out Factor Equal to Zero

Determine the heating bin power using Section 6.3.10.3 if the heating bin cut-out factor is equal to zero.

6.3.10.2.2 Cut-out Factor Not Equal to Zero with Auxiliary Heat

Determine the heating bin power using Section 6.3.10.4 if the following two items are true:

1) The heating bin cut-out factor is not equal to zero.
2) The building load for the heating bin is greater than the maximum capacity calculated in Section 6.3.8 for the heating bin.

6.3.10.2.3 Interpolation Between Two Operating Levels

Determine the heating bin power using interpolation in Section 6.3.10.5 if the following three items are true:

1) The heating bin cut-out factor is not equal to zero.
2) The building load for the heating bin is less than or equal to the maximum capacity calculated in Section 6.3.8 for the heating bin.
3) The building load for the heating bin is greater than or equal to the minimum capacity calculated in Section 6.3.8 for the heating bin.

6.3.10.2.4 Cyclic Degradation

Determine the heating bin power using cyclic degradation in Section 6.3.10.6 if the following two items are true:

1) The heating bin cut-out factor is not equal to zero.
2) The building load for the heating bin is less than the minimum capacity calculated in Section 6.3.8 for heating bin.

6.3.10.3 Cut-out Factor (δ) Equal to Zero

Determine the total power in watts by taking the sum of all power consumption values in the power value in watts column of Table 24. The calculated value is used in Section 6.3.10.7.

Table 24 Heating Component Power Values

Component	Power Value in Watts
Indoor fan (PIF)	$P_{IF,H17H}$
Controls (PCT)	*Controls power* determined for the H17H test
Crankcase heat	If *crankcase heat power* is measured in *controls power*: Sum of the *manufacturer-specified crankcase heat power* values for all compressors that are operating during the H17H test. If *crankcase heat power* is measured in *compressor power*: Sum of the *manufacturer-specified crankcase heat power* values for all compressors.
Auxiliary heat (P_{aux}) in accordance with Section 5.10	See Equation 29, expressed in W

Symbols in Table 24:

- $q_{H,BLi}$ = Building load calculated in Section 6.3.3 for the heating bin, Btu/h
- $P_{IF,H17H}$ = *Indoor fan power* determined for the H17H test, W

$$P_{aux} = \frac{q_{H,BLi}}{3.412} - P_{IF,H17H} \tag{29}$$

6.3.10.4 Cut-out Factor Not Equal to Zero with Auxiliary Heat

Determine the total power for the heating bin in watts using two steps as follows.

1) For each of the compressor operating and cut out columns in Table 25, sum all power consumption values in the component rows of the column, and multiply that sum by the value in the coefficient row of the column.
2) Sum the values determined in step one. See Equation 30.

$$P_T = P_C + P_{CD} + P_{IF} + P_{CT} \tag{30}$$

The calculated value is used in Section 6.3.10.7.

Table 25 Heating Component Power Values for Use with Cut-out Temperatures

	Compressor Operating	**Cut-out**
Coefficient	δ	1 − δ
Component	—	—
Compressor (P_C)	*Compressor power* calculated in Section 6.3.9 for the highest operating level in this heating bin (that is, boost or high)	0.0
Condenser section (P_{CD})	*Condenser section power* calculated in Section 6.3.9 for the highest operating level in this heating bin (that is, boost or high)	0.0
Indoor fan (P_{IF})	*Indoor fan power* calculated in Section 6.3.9 for the highest operating level in this heating bin (that is, boost or high)	$P_{IF,H17H}$
Controls (P_{CT})	*Controls power* determined for highest operating level test performed at 17°F (that is, H17B or H17H)	*Controls power* determined for the H17H test
Crankcase heat (P_{CH})	0.0	If *crankcase heat power* is measured in *controls power*: Sum of the *manufacturer-specified crankcase heat power* values for all compressors that are operating during the H17H test. If *crankcase heat power* is measured in *compressor power*: Sum of the *manufacturer-specified crankcase heat power* values for all compressors.
Auxiliary heat in accordance with Section 5.10 (P_{aux})	See Equation 31, expressed in W	See Equation 32, expressed in W

Symbols used in Table 25:

- δ = Cut-out factor for the heating bin

Where Equation 31 calculates *auxiliary heat* power while the compressor(s) is operating. Where Equation 32 calculates *auxiliary heat* power while the compressor(s) is not operating.

$$P_{aux} = \frac{q_{H,BLi} - q_H}{3.412} \quad (31)$$

$$P_{aux} = \frac{q_{H,BLi}}{3.412} - P_{IF,H17H} \quad (32)$$

Where:

$q_{H,BLi}$ = Building load calculated in Section 6.3.4 for the heating bin, Btu/h

q_H = Capacity calculated in Section 6.3.6 for the highest operating level in this cooling bin (that is, boost or high), Btu/h

$P_{IF,H17H}$ = *Indoor fan power* determined for the H17H test, W

6.3.10.5 Interpolation Between Two Operating Levels

Determine the heating bin power using interpolation between two operating levels.

Interpolate between the following two operating levels:

1) A higher operating level, that has a capacity calculated in Section 6.3.8 for the heating bin that is the closest capacity that is greater than or equal to the building load for the heating bin.
2) A lower operating level, that has a capacity calculated in Section 6.3.8 for the heating bin that is the closest capacity that is less than or equal to the building load for the heating bin.

Calculate the higher-level operating fraction using Section 6.3.10.5.1.

Use Section 6.3.10.5.2 to calculate the power for the heating bin.

6.3.10.5.1 Higher-level Operating Fraction

Calculate the higher-level operating fraction using Equation 33.

$$X_{HR} = \frac{q_{H,BL} - q_{H,LR}}{q_{H,HR} - q_{h,LR}} \qquad \textbf{33}$$

Where:

X_{HR} = Higher-level operating fraction for the heating bin

$q_{H,BL}$ = Building load calculated in Section 6.3.4 for the heating bin, Btu/h

$q_{H,Z}$ = Capacity calculated in Section 6.3.8 for the heating bin and operating level Z (where Z is LR for the lower operating level and Z is HR for the higher operating level), Btu/h

6.3.10.5.2 Calculate Power

Using the lower and higher operating levels for the heating bin determined in Section 6.3.8, determine the total power for the heating bin in watts using two steps as follows.

1) For each of the higher operating level, lower operating level, and cut out columns in Table 26, sum all power consumption values in the component rows of the column, and multiply that sum by the value in the coefficient row of the column.
2) Sum the values determined in step one.

The calculated value is used in Section 6.3.10.7.

Table 26 Coefficients and Component Power Values for Interpolation

—	**Higher Operating Level**	**Lower Operating Level**	**Cut Out**
Coefficient	$\delta \times X_{HR}$	$\delta \times (1 - X_{HR})$	$1 - \delta$
Component	—	—	—
Compressor (P_C)	*Compressor power* calculated in Section 6.3.9 for the higher operating level	*Compressor power* calculated in Section 6.3.9 for the lower operating level	0.0
Condenser section (P_{CD})	*Condenser section power* calculated in Section 6.3.9 for the higher operating level	*Condenser section power* calculated in Section 6.3.9 for the lower operating level	0.0
Indoor fan (P_{IF})	*Indoor fan power* calculated in Section 6.3.9 for the higher operating level	*Indoor fan power* calculated in Section 6.3.9 for the lower operating level	$P_{IF,H17H}$
Controls (P_{CT})	*Controls power* determined for the higher operating level at 17°F	*Controls power* determined for the lower operating level at 17°F	*Controls power* determined for the H17H test
Crankcase heat (P_{CCH})	0.0	0.0	If *crankcase heat power* is measured in *controls power*: Sum of the *manufacturer-specified crankcase heat power* values for all compressors that are operating during the H17H test If *crankcase heat power* is measured in *compressor power*: Sum of the *manufacturer-specified crankcase heat power* values for all compressors
Auxiliary heat in accordance with Section 5.10 (P_{aux})	0.0	0.0	See Equation 34, expressed in W

Equation 34 shows *auxiliary heat* power while the compressor(s) is not operating.

$$P_{aux} = \frac{q_{H,BL}}{3.412} - P_{IF,H17H} \qquad \textbf{34}$$

Where:

$q_{H,BL}$ = Building load calculated in Section 6.3.4 for the heating bin, Btu/h

$P_{IF,H17H}$ *Indoor fan power* determined for the H17H test, W

Symbols from Table 26:

- δ = Cut-out factor
- X_{HR} = Higher-level operating fraction calculated in Section 6.3.10.5.1.

6.3.10.6 Cyclic Degradation

Determine the total power for the heating bin in watts using two steps as follows:

1) For each of the lowest operating level, off cycle, and cut out columns in Table 27, sum all power consumption values in the component rows of the column, and multiply that sum by the value in the coefficient row of the column.
2) Sum the values determined in step one.

The calculated value is used in Section 6.3.10.7.

Table 27 Coefficients and Component Power Value for Cyclic Degradation

	Lowest Operating Level	**Off Cycle**	**Cut-out**
Coefficient	$\delta \times X$	$\delta \times (1 - X)$	$1 - \delta$
Component	—	—	—
Compressor (P_C)	If crankcase heat is included in *controls power*, see Equation 35 If crankcase heat is included in *compressor power*, see Equation 36	0.0	0.0
Condenser section (P_{CD})	See Equation 37	0.0	0.0
Indoor fan (P_{IF})	*Indoor fan power* calculated in Section 6.3.9 for the lowest operating level	Lowest determined *indoor fan power* from all cooling tests, W	$P_{IF,H17H}$
Controls (P_{CT})	*Controls power* determined for the lowest operating level at 17°F	*Controls power* determined for the lowest operating level at 17°F	*Controls power* determined for the lowest operating level at 17°F
Crankcase heat (P_{CCH})	If crankcase heat is included in *controls power*: 0.0 If crankcase heat is included in *compressor power*: $P_{CCH,NOC}$	If crankcase heat is included in *controls power*: sum of the *manufacturer-specified crankcase heat power* values for all compressors operating for the lowest operating level at 17°F If crankcase heat is included in *compressor power*: sum of the *manufacturer-specified crankcase heat power* values for all compressors	If crankcase heat is included in *controls power*: sum of the *manufacturer-specified crankcase heat power* values for all compressors operating for the lowest operating level at 17°F If crankcase heat is included in *compressor power*: sum of the *manufacturer-specified crankcase heat power* values for all compressors
Auxiliary heat in accordance with Section 5.10 P_{aux}	0.0	0.0	See Equation 38

Equation 35 calculates compressor power if crankcase heat is included in *controls power* . Equation 36 calculates compressor power if crankcase heat is included in *compressor power* . Equation 37 calculates condenser section power. Equation 38 calculates *auxiliary heat* power while the compressor(s) is not operating. Equation 39 calculates part load factor.

$$P_C = \frac{P_C}{PLF} \quad \textbf{35}$$

$$P_C = \frac{P_C - P_{CCH,NOC}}{PLF} \quad \textbf{36}$$

$$P_{CD} = \frac{P_{CD}}{PLF} \quad \textbf{37}$$

$$P_{aux} = \frac{q_{H,BL}}{3.412} - P_{IF,H17H} \tag{38}$$

$$PLF = 1 - 0.25 \times (1 - X) \tag{39}$$

Where:

X	=	q_{BL}/q
q_{BL}	=	Building load calculated in Section 6.3.4 for the heating bin, Btu/h
q	=	Capacity calculated in Section 6.3.8 for the lowest operating level in the heating bin, Btu/h
PLF	=	See Equation 39
P_C	=	*Compressor power* calculated in Section 6.3.9 for the lowest operating level
P_{CD}	=	*Condenser section power* calculated in Section 6.3.9 for the lowest operating level
$P_{CCH,NOC}$	=	Sum of the *manufacturer-specified crankcase heat power* values for all compressors not operating for the lowest operating level at 17°F
$P_{IF,H17H}$	=	*Indoor fan power* determined for the H17H test, W

Symbols in Table 27:

- δ = Cut-out factor for the heating bin
- $X = q_{BL}/q$
- $P_{IF,H17H}$ = *Indoor fan power* determined for the H17H test, W

Equation 35 through Equation 39 referenced in Table 27:

6.3.10.7 Annual Energy Consumption

Calculate the total annual energy consumption for all heating bins using Equation 40 and the heating bin operating hours in Table 22. The calculated value is used in Section 6.3.13.

$$E_H = \sum_{i=1}^{10} (h_i \times P_i) \tag{40}$$

Where:

E_H	=	Energy consumption for all heating bins, W·h
i	=	Heating bin number, one through ten
h_i	=	Operating hours in Table 22 for heating bin i, h
P_i	=	Total power for heating bin i determined in Section 6.3.10.3, Section 6.3.10.4, Section 6.3.10.5.2, or Section 6.3.10.6, as applicable, W

6.3.11 Ventilation

Calculate ventilation energy consumption in W·h using two steps as follows:

1) Take the sum of all power consumption values in the power value in watts column of Table 28.
2) For *IVHE*, multiply the sum by 515 hours using Equation 41. For $IVHE_C$, multiply the sum by 568 hours using Equation 42.

$$E_V = P_V \times 515 \tag{41}$$

$$E_V = P_V \times 568 \tag{42}$$

The calculated value is used in Section 6.3.13.

Table 28 Component Power Values for Heating Ventilation Mode

Component	Power Value in Watts
Indoor fan (P_{IF})	Lowest determined *indoor fan power* from all cooling tests
Controls (P_{CT})	*Controls power* determined for the H17H test
Crankcase heat (P_{CCH})	If *crankcase heat power* is measured in *controls power*: Sum of the *manufacturer-specified crankcase heat power* values for all compressors that are operating during the H17H test If *crankcase heat power* is measured in *compressor power*: Sum of the *manufacturer-specified crankcase heat power* values for all compressors

6.3.12 Standby

Calculate standby energy consumption in W·h using two steps as follows:

1) Take the sum of all power consumption values in the power value in watts column of Table 29 using Equation 43.

$$P_T = P_{CT} + P_{CCH} \tag{43}$$

2) For *IVHE*, multiply the sum by 645 hours. For $IVHE_C$, multiply the sum by 577 hours.

The calculated value is used in Section 6.3.13.

Table 29 Component Power Values for Heating Standby

Component	Power Value in Watts
Controls	*Controls power* determined for the H17H test
Crankcase heat	If *crankcase heat power* is measured in *controls power*: Sum of the *manufacturer-specified crankcase heat power* values for all compressors that are operating during the H17H test If *crankcase heat power* is measured in *compressor power*: Sum of the *manufacturer-specified crankcase heat power* values for all compressors

6.3.13 IVHE

Calculate *IVHE* in units of Btu/(W·h) using Equation 44, and add the subscript $_C$ to *IVHE* (that is, $IVHE_C$) if the calculation used the $IVHE_C$ Cold Climate building load profile.

$$IVHE = \frac{TASH}{E_H + E_V + E_S} \tag{44}$$

Where:

TASH	=	The total annual space heating calculated in Section 6.3.5, Btu
E_H	=	Energy consumption for all heating bins calculated in Section 6.3.10.7, W·h
E_V	=	Ventilation energy consumption calculated in Section 6.3.11, W·h
E_S	=	Standby energy consumption calculated in Section 6.3.12, W·h

6.3.14 *COP2$_H$*

6.3.14.1 Summary

Calculate $COP2_{H,5}$ at 5°F, $COP2_{H,17}$ at 17°F, or $COP2_{H,47}$ at 47°F, in units of W/W using Equation 45.

$$\mathrm{COP2_{H,T}} = \frac{CD_{DF} \times \frac{q_i}{3.412}}{\mathrm{P_{C,T} + P_{CD,T} + P_{IF,T} + P_{CT,T}}} \tag{45}$$

Where:

T	=	Subscript on $COP2_H$: 5 for $\mathrm{COP2_{H,5}}$, 17 for $COP2_{H,17}$, or 47 for $\mathrm{COP2_{H,47}}$
CD_{DF}	=	0.91935 for $\mathrm{COP2_{H,5}}$, 0.91173 for $COP2_{H,17}$, or 1.00000 for $\mathrm{COP2_{H,47}}$
q_i	=	The cooling instantaneous capacity determined in Section 6.3.6 for the test specified in Section 6.3.14.2, Btu/h
P_C	=	*Compressor power* determined in Section 6.3.6 for the test specified in Section 6.3.14.2, W
P_{CD}	=	*Condenser section power* determined in Section 6.3.6 for the test specified in Section 6.3.14.2, W
P_{IF}	=	*Indoor fan power* determined in Section 6.3.6 for the test specified in Section 6.3.14.2, W
P_{CT}	=	*Controls power* determined in Section 6.3.6 for the test specified in Section 6.3.14.2, W

6.3.14.2 Tests

For $COP2_{H,17}$, use capacity and power determined for the H17H test.

For $\mathrm{COP2_{H,47}}$, use capacity and power determined for the H47H test.

For $\mathrm{COP2_{H,5}}$ for units without a boost operating level, use capacity and power determined for the H5H test. For $\mathrm{COP2_{H,5}}$ for units with a boost operating level, use capacity and power determined for the H5B or H5B2 test.

6.4 Rating Values

6.4.1 Source of Capacity and Efficiency Ratings

Ratings for capacity, *IVEC* and *IVHE* shall be based either on test data or computer simulation.

6.4.2 Ratings Generated by Test Data

Any capacity, *IVEC*, and *IVHE*, 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 *IVEC* and *IVHE* 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 46 and Equation 47, rounded in accordance with Section 6.4.5 and Section 6.4.6.

The capacity, *IVEC*, and *IVHE* rating shall be lower than or equal to the mean of the test data from the test samples, rounded in accordance with Table 30. The *cooling capacity* shall not be rated less than 95% of the mean of the capacities measured for the test samples in accordance with 10 CFR §429.43.

$$\bar{x} = \frac{\sum_{i=1}^{n} x_i}{n} \quad \mathbf{46}$$

$$LCL = \bar{x} - t_{.95}\left(\frac{s}{\sqrt{n}}\right) \quad \mathbf{47}$$

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

6.4.3 Ratings Generated by Alternative Efficiency Determination Method (AEDM)

Any capacity, *IVEC*, and *IVHE*, rating of a *basic model* generated by the results of an AEDM shall not be higher than the result of the AEDM output (rounded in accordance with Table 30). Any AEDM used shall be created in compliance with the regulations specified in 10 CFR §429.70 and 10 CFR §429.43.

6.4.4 Documentation

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

6.4.5 Precision of Standard Capacity Ratings

These ratings shall be expressed in terms of Btu/h in multiples shown in Table 30.

Table 30 Rounding of Standard Rating Capacities

Standard Cooling Capacity Ratings, Btu/h	Multiples, Btu/h for both Heating and Cooling
< 135,000	1000
From 135,000 to ≤ 400,000	2000
400,000 and greater	5000

6.4.6 Precision of Energy Efficiency Metrics

Energy efficiency metrics whenever published shall be expressed using the number of significant figures specified in Table 31.

Table 31 Published Rating Significant Figures

Metric	Abbreviation	Units	Significant Figures
Cooled energy efficiency ratio 2	*EER2*	Btu/W·h	XX.X
Heating coefficient of performance 2	$COP2_{H,47}$ $COP2_{H,17}$ $COP2_{H,5}$	W/W	X.XX
Integrated, ventilation, economizer, cooling	*IVEC*	Btu/W·h	XX.X
Integrated, ventilation, heating efficiency	*IVHE*, $IVHE_C$	Btu/W·h	XX.X
Crankcase heat power	P_{CCH}	W	XX
C = Cold			

6.5 Uncertainty

When testing a sample unit, 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 include allowances for uncertainty and variability described in Section 6.5.1 through Section 6.5.6.

6.5.1 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.

6.5.2 Uncertainty of Test Rooms

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

6.5.3 Uncertainty Due to Manufacturing

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

6.5.4 Uncertainty of Performance Simulation Tools

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

6.5.5 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.

6.5.6 Variability of System Under Test

The system under test instability cannot yield repeatable results.

6.6 Verification Testing

To comply with this standard, single sample production verification tests shall meet the *standard rating* performance metrics shown in Table 32 with the listed acceptance criteria.

Table 32 Acceptance Criteria

Performance Metric	Acceptance Criteria
Cooling Metrics	
Full load *cooling capacity*, Btu/h	≥ 95%
Full load *EER2*, Btu/(W·h)	≥ 95%
IVEC, Btu/(W)	≥ 90%
Heating Metrics	
Heating capacity at 47°F, Btu/h	≥ 95%
$COP2_{H,47}$, W/W	≥ 95%
Heating capacity at 17°F, Btu/h	≥ 95%
$COP2_{H,17}$, W/W	≥ 95%
$COP2_{H,5}$, W/W	≥ 95%
IVHE, Btu/(W·h)	≥ 90%

Section 7. Minimum Data Requirements for Published Ratings

7.1 Minimum Data Requirements for Published Ratings

As a minimum, *published ratings* shall consist of the information in Section 7.1.1 and Section 7.1.2.

7.1.1 Commercial and Industrial Unitary Air-conditioning Equipment at Standard Rating Conditions

Commercial and industrial unitary air-conditioning equipment at *standard rating conditions* shall have the following:

- *Cooling capacity*, Btu/h
- *EER2*, Btu/W·h
- *IVEC*, Btu/W
- Compressor crankcase heat rated power, W

7.1.2 Commercial and Industrial Unitary Heat Pump Equipment at Standard Rating Conditions

Commercial and industrial unitary heat pump equipment at *standard rating conditions* shall have the following:

- *Cooling capacity*, Btu/h
- *EER2*, Btu/W·h
- *IVEC*, Btu/W
- High temperature *heating capacity* at 47°F, Btu/h
- High temperature heating coefficient of performance at 47°F, $COP2_{H,47}$, W/W
- Low temperature *heating capacity* at 17°F, Btu/h
- Low temperature heating coefficient of performance at 17°F, $COP2_{H,17}$, W/W
- *IVHE*, Btu/W·h
- Low temperature *heating capacity* at 5°F, Btu/h (optional)
- Low temperature heating coefficient of performance at 5°F, $COP2_{H,5}$, W/W (optional)

- Integrated ventilation heating efficiency for cold climates, $IVHE_C$, Btu/W·h (optional)
- Compressor crankcase heat rated power, as defined by the manufacturer, W

As a minimum, *published ratings* shall include all *standard ratings*. All claims to ratings within the scope of this standard shall include the statement “Rated in accordance with AHRI Standard 1340 (I-P)”. All claims to ratings outside the scope of this standard shall include the statement “Outside the scope of AHRI Standard 1340 (I-P)”. *Application ratings* within the scope of the standard shall include a statement of the conditions under which the ratings apply.

7.2 Latent Capacity Designation

The moisture removal capacity at *standard rating conditions* listed in Table 7 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 48, and *cooling capacity*, Btu/h

Note: *Cooling capacity* is defined in Section 3.2.6 and includes both *latent* and *sensible capacity*.

$$SHR = \frac{q_{sci}}{q_{tci}} \tag{48}$$

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

Commercial and industrial unitary air-conditioning and heat pump equipment shall comply with the provisions of this section such that any production unit shall meet the requirements detailed herein. Units that are listed by a nationally recognized laboratory to UL 60335-2-40 comply with the provisions of this section.

Table 33 indicates the tests and test conditions that are required for operating requirements tests.

Table 33 Conditions for Operating Tests

Test	Indoor Section Air Entering Dry-bulb, °F	Indoor Section Air Entering Wet-bulb, °F	Outdoor Section – Air Cooled Dry-bulb, °F	Air Cooled Wet-bulb, °F	Air Cooled Dew-point °F	Evaporative Dry-bulb, °F	Evaporative Wet-bulb, °F	Evaporative *Makeup Water,* °F	Water Cooled Inlet, °F	Water Cooled Outlet, °F
Cooling Low temperature operation	67.0	57.0	67.0	—	36.2 (Max)	67.0	57.0	67.0	—	70.0
Cooling Maximum operating conditions	80.0	67.0	115.	—	77.7 (Max)	100.0	80.0	90.0	90.0	—
Cooling Insulation efficiency	80.0	75.0	80.0	75.0	—	80.0	75.	85.0	—	80.0
Cooling Condensate disposal	80.0	75.0	80.0	75.0	—	80.0	75.0	85.0	—	80.0
Heating Maximum operating conditions	80.0	—	75.0	65.0	—	—	—	—	—	—

8.2 Maximum Operating Conditions Test for Cooling and Heating

Commercial and industrial unitary air-conditioning and heat pump equipment shall pass the following maximum cooling and heating operating conditions test with an indoor coil airflow as determined under Section 5.18.3.1 or Section 5.18.4.1, as applicable.

8.2.1 Temperature Conditions

Temperature conditions shall be maintained as shown in Table 33.

8.2.2 Voltages

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.

8.2.3 Procedure

Commercial and industrial unitary air-conditioning and heat pump equipment shall be operated continuously for one hour at the temperature conditions and voltage(s) specified.

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

The equipment shall operate without failure of any of the parts of the equipment during both tests.

The unit shall resume continuous operation within one hour of restoration of power and shall then operate continuously for one hour. Safety devices can be operated and reset prior to establishment of continuous operation.

Units with water-cooled condensers shall be capable of operation under these maximum conditions at a water-pressure drop not to exceed 15 psi measured across the unit.

8.2.5 Maximum Operating Conditions Test for Equipment with Optional Outdoor Cooling Coil

Commercial and industrial unitary air-conditioning and heat pump equipment that incorporates an outdoor air-cooling coil shall use the conditions, voltages, and procedure in Section 8.2 through Section 8.2.3, and meet the requirements of Section 8.2.4 except for the following changes:

- Outdoor air set as in Section 5.21.
- Return air temperature conditions shall be 80.0°F dry-bulb, 67.0°F wet-bulb
- Outdoor air entering outdoor air-cooling coil shall be 115°F dry-bulb and 75.0°F wet-bulb

8.3 Cooling Low Temperature Operation Test

Commercial and industrial unitary air-conditioning and heat pump equipment shall pass the following low-temperature operation test when operating with initial airflows as determined in Section 5.18 and with controls and dampers set to produce the maximum tendency to frost or ice the indoor coil, provided such settings are not contrary to the *MII* to the user.

8.3.1 Temperature Conditions

Temperature conditions shall be maintained as shown in Table 33.

8.3.2 Voltage and Frequency

The test shall be performed at nameplate rated voltage and frequency. For air-conditioners and heat pumps with dual nameplate voltage ratings, tests shall be performed at the lower of the two voltages.

8.3.3 Procedure

The test shall be continuous with the unit in the cooling cycle for not less than four hours after establishment of the specified temperature conditions. The unit can start and stop under control of an automatic limit device, if provided.

8.3.4 Requirements

The equipment shall operate without damage to the equipment during the entire test.

The indoor airflow shall not drop more than 25% below that specified for the *standard rating* test during the entire test.

All ice or condensate shall be caught and removed by the drain provisions during all phases of the test and during the defrosting period after the completion of the test.

8.4 Insulation Efficiency Test for Cooling

Commercial and industrial unitary air-conditioning and heat pump equipment shall pass the following insulation efficiency test when operating with airflows as determined in Section 5.18, and with controls, fans, dampers, and grilles set to produce the maximum tendency to sweat, provided such settings are not contrary to the *MII* intended for the user.

8.4.1 Temperature Conditions

Temperature conditions shall be maintained as shown in Table 33.

8.4.2 Procedures

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

8.4.3 Requirements

Condensed water shall not drop, run, or blow off from the unit casing during the test.

8.5 Condensate Disposal Test for Cooling

Commercial and industrial unitary air-conditioning and heat pump equipment that rejects condensate to the condenser air shall pass the following condensate disposal test when operating with airflows as determined in Section 5.18, and with controls and dampers set to produce condensate at the maximum rate, provided such settings are not contrary to the *MII*.

Note: This test can be run concurrently with the insulation efficiency test in Section 8.4.

8.5.1 Temperature Conditions

Temperature conditions shall be maintained as shown in Table 33.

8.5.2 Procedure

After establishment of the specified temperature conditions, the equipment shall be started with the equipment's condensate collection pan filled to the overflowing point and shall be operated continuously for four hours after the condensate level has reached equilibrium.

8.5.3 Requirements

There shall not be dripping, running-off, or blowing-off of moisture from the unit casing during the test.

8.5.4 Tolerances

The conditions for the tests outlined in Section 8 are average values subject to tolerances of ± 1.0°F for air wet-bulb and dry-bulb temperatures, ± 0.5°F 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, refrigerant designation in accordance with ASHRAE 34, 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. AHRI Standard 110-2016, *Air-Conditioning and Refrigerating Equipment Nameplate Voltages*, 2016, Air-Conditioning, Heating and Refrigeration Institute, 2311 Wilson Blvd., Suite 400, Arlington, VA 22201 USA.

A.2. AHRI Standard 440-2019 (I-P), *Standard for Performance Rating of Fan-coil Units*, 2019, Air-Conditioning, Heating and Refrigeration Institute, 2311 Wilson Blvd., Suite 400, Arlington, VA 22201 USA.

A.3. AHRI Standard 920-2020 (I-P) with Addendum 1, *Performance Rating of DX-Dedicated Outdoor Air System Units*, 2021, Air-Conditioning, Heating and Refrigeration Institute, 2311 Wilson Blvd., Suite 400, Arlington, VA 22201, USA.

A.4. AHRI Standard 1060-2018 (I-P), *Performance Rating of Air-to-Air Exchangers for Energy Recovery Ventilation Equipment Air-Conditioning*, 2018, Heating and Refrigeration Institute, 2311 Wilson Blvd., Suite 400, Arlington, VA 22201 USA.

A.5. AHRI Standard 1360-2022 (I-P), *Performance Rating of Computer and Data Processing Room Air-conditioners*, 2022, Air-Conditioning, Heating and Refrigeration Institute, 2311 Wilson Blvd., Suite 400, Arlington, VA 22201 USA.

A.6. AMCA 211-22 (REV. 01-23), 2023, Certified Ratings Program — Product Rating Manual for Fan Air Performance, 2023, 30 W. University Drive, Arlington Heights, IL 60004-1893, USA.

A.7. ANSI/AHRI 310/380-2017 (CSA-C744-17), *Packaged Terminal Air-conditioners and Heat Pumps*, 2017, Air-Conditioning, Heating and Refrigeration Institute, 2311 Wilson Boulevard, Suite 400, Arlington, VA 22201 USA.

A.8. ANSI/AHRI Standard 365-2009 (I-P), *Commercial and Industrial Unitary Air-conditioning Condensing Units*, 2009, Air-Conditioning, Heating and Refrigeration Institute, 2311 Wilson Blvd., Suite 400, Arlington, VA 22201 USA.

A.9. ANSI/AHRI Standard 390-2021 (I-P), *Performance Rating of Single Package Vertical Air-Conditioners and Heat Pumps*, 2021, Air-Conditioning, Heating and Refrigeration Institute, 2311 Wilson Blvd., Suite 400, Arlington, VA 22201 USA.

A.10. ANSI/AHRI Standard 470-2006, *Performance Rating of Desuperheater/Water Heaters*, 2006, Air-Conditioning, Heating and Refrigeration Institute, 2311 Wilson Blvd., Suite 400, Arlington, VA 22201 USA.

A.11. ANSI/AMCA Standard 210-16/ASHRAE 51-16, *Laboratory Methods of Testing for Certified Aerodynamic Performance Rating*, 2016, Air Movement and Control Association International, 30 W. University Drive, Arlington Heights, IL 60004 USA

A.12. ANSI/ASHRAE Standard 34-2022, *Designation and Safety Classification of Refrigerant*, 2022, ASHRAE, Inc., 180 Technology Parkway NW, Peachtree Corners, GA 30092 USA.

A.13. ANSI/ASHRAE Standard 37-2009 (RA 2019), *Methods of Testing for Rating Unitary Air-Conditioning and Heat Pump Equipment*, 2019, ASHRAE, Inc., 180 Technology Parkway NW, Peachtree Corners, GA 30092 USA.

A.14. ANSI/ASHRAE Standard 41.1-2013, *Standard Method for Temperature Measurement*, 2013, ASHRAE, Inc., 180 Technology Parkway NW, Peachtree Corners, GA 30092 USA.

A.15. ANSI/ASHRAE Standard 41.1-2020, *Standard Method for Temperature Measurement*, 2020, ASHRAE, Inc., 180 Technology Parkway NW, Peachtree Corners, GA 30092 USA.

A.16. ANSI/ASHRAE Standard 41.6-2021, *Standard Method for Humidity Measurement*, 2021, ASHRAE, Inc., 180 Technology Parkway NW, Peachtree Corners, GA 30092 USA.

A.17. ANSI/ASHRAE Standard 169-2013, *Climatic Data for Building Design Standards*, 2021, ASHRAE, Inc., 180 Technology Parkway NW, Peachtree Corners, GA 30092 USA.

A.18. ANSI/ASHRAE/AHRI/ISO13256-1-1998 (RA2012), *Water-source heat pumps – Testing and rating for performance – Part 1: Water-to-air and Brine-to-air heat pumps*, 2012, International Organization for Standardization, Case Postale 56, CH-1211, Geneva 21 Switzerland.

A.19. ANSI/NEMA MG1-2021, *Motors and Generators*, 2022, National Electrical Manufacturers Association, 1300 North 17th Street, Suite 900, Rosslyn, VA 22209 USA.

A.20. ASHRAE Handbook Fundamentals - 2021, *Fundamentals*, 2021, American Society of Heating, Refrigerating and Air-Conditioning Engineers, ASHRAE, Inc., 180 Technology Parkway NW, Peachtree Corners, GA 30092 USA.

A.21. ASHRAE Terminology. Accessed September 24, 2021. https://www.ashrae.org/technical-resources/authoring-tools/terminology

A.22. 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.23. 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.24. CSA – C747:22, *Energy efficiency test methods for small motors*, 2022, CSA Group, 178 Rexdale Blvd., Toronto, Ontario M9W 1R3 Canada.

A.25. ISO 5801:2017, *Fans – Performance testing using standardized airways*, 2017, International Organization for Standardization, Case Postale 56, CH-1211, Geneva 21 Switzerland.

A.26. NIST Standard Reference Database 23, *Reference Fluid Thermodynamic and Transport Properties – REFPROP Version 10*, 2013, National Institute of Standards and Technology, 100 Bureau Drive, Gaithersburg, Md. 20899.

A.27. Title 10, Code of Federal Regulations (CFR), Part 429 and 431, US National Archives and Records Administration, 8601 Adelphi Road, College Park, MD 20740-6001 or www.ecfr.gov.

A.28. UL Standard 555-2006, *Standard for Fire Dampers*, 2006, Underwriters Laboratories, Inc., 333 Pfingsten Road, Northbrook, IL, USA.

A.29. UL Standard 555S-2014, *Standard for Smoke Dampers*, 2014, Underwriters Laboratories, Inc., 333 Pfingsten Road, Northbrook, IL, USA.

A.30. UL Standard 60335-2-40 *Household And Similar Electrical Appliances – Safety – Part 2-40: Particular Requirements for Electrical Heat Pumps, Air-Conditioners and Dehumidifiers*, 2022, Underwriters Laboratories, Inc., 333 Pfingsten Road, Northbrook, IL, USA.

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.

B.1. AHRI Standard 210/240-2023 (2020) (I-P), *Unitary Air-conditioning and Air-Source Heat Pump Equipment*, 2020, Air-Conditioning, Heating and Refrigeration Institute, 2311 Wilson Blvd., Suite 400, Arlington, VA 22201 USA.

B.2. AHRI Standard 340/360-2022, *Performance Rating of Commercial and Industrial Unitary Air-Conditioning and Heat Pump Equipment*, 2022, Air-Conditioning, Heating, and Refrigeration Institute, 2311 Wilson Blvd., Suite 400, Arlington, VA 22201, USA.

B.3. ANSI/ASHRAE Standard 62.1-2022, *Ventilation and Acceptable Indoor Air Quality*, 2022, 180 Technology Parkway NW, Peachtree Corners, GA 30092 USA.

B.4. ANSI/ASHRAE Standard 90.1-2022 (I-P), *Energy Standard for Sites and Buildings Except Low-Rise Residential Buildings*, 2022, 180 Technology Parkway NW, Peachtree Corners, GA 30092 USA.

APPENDIX C. INDOOR AND OUTDOOR AIR CONDITION MEASUREMENT – NORMATIVE

C.1. Purpose

This appendix includes modifications to the test stand setup and instrumentation as defined in ASHRAE 37.

C.2. General

Measure the indoor and outdoor air entering dry-bulb temperature and water vapor content conditions that are required to be controlled for the test in accordance with the requirements in 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. When using the outdoor air enthalpy method to measure equipment capacity, measure outdoor air leaving dry-bulb temperature and water vapor content. For measuring the indoor and outdoor air leaving dry-bulb temperature and water vapor content conditions, follow the requirements in Section C.5. 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. Outdoor Air Entering Conditions

Measure dry-bulb temperature as provided in Section C.3.1 for all tests.

Measure the water vapor content as provided in Section C.3.2 for the following four types of tests:

1) Cooling tests of single-package units where all or part of the indoor section of the equipment is located in the outdoor chamber
2) Cooling tests of evaporatively-cooled equipment
3) Cooling tests of air-cooled equipment that use condensate obtained from the evaporator to enhance condenser cooling
4) Heating tests of all air-source heat pumps

C.3.1. Temperature Measurements

Measure temperatures in accordance with ASHRAE 41.1-2020 and follow the requirements of Table 34. The specified accuracies shall apply to the full instrument systems including read-out devices. When using a grid of individual thermocouples rather than a thermopile, follow the thermopile temperature requirements of Table 34.

When measuring dry-bulb temperature for sampled air within the sampled air conduit rather than with the *aspirating psychrometer* as discussed 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.

Thermocouple wire used in thermopiles 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.

Table 34 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

Note:

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 following two methods.

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 one shall be provided to confirm this measurement using an additional or a third-party's temperature sensor probe. For applications where the humidity is required for testing of evaporatively cooled units or heat pump unitary products in heating mode, 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 one 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 1.

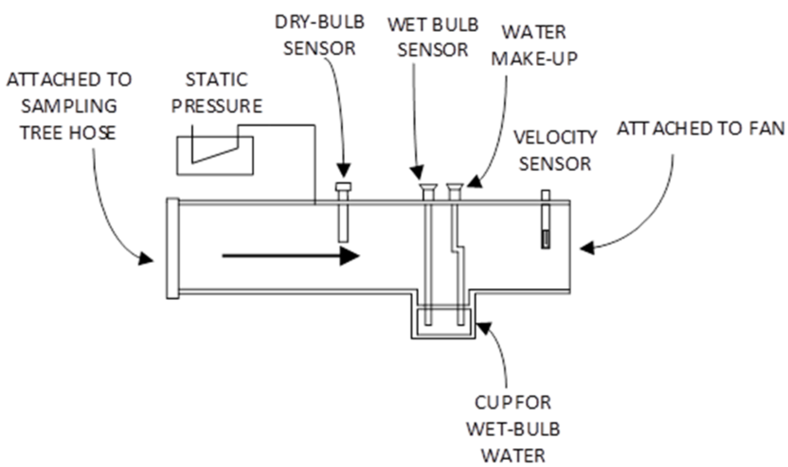

Figure 1 Example Configuration of an Aspirating Psychrometer (Informative)

C.3.2.2. Dew-point Hygrometer

Measure dew point temperature using a *dew-point hygrometer* as specified in Section 4, Section 5, Section 6, and Section 7.2 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 air-cooled or evaporatively-cooled outdoor section. An example configuration for the *air sampling tree* is shown in Figure 2 for a tree with overall dimensions of 4 ft by 4 ft sample. Other sizes and rectangular shapes shall be scaled accordingly as long as the aspect ratio (width to height) of not greater than 2:1 is maintained.

The *air sampling tree* shall be constructed of stainless steel, plastic, or other durable materials and shall have a main flow trunk tube with a series of branch tubes connected to the trunk tube. The branch tubes shall have holes spaced and sized to provide equal airflow through all the holes by increasing the hole size further from the trunk tube to account for the static pressure regain effect in the branch and trunk tubes. There shall be a minimum hole density of six holes per square foot of area 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 so that a flexible tube can be connected to the *air sampling tree* and to the *aspirating psychrometer*.

The outdoor 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 6-12 in from the unit to minimize the risk of damage to the unit while confirming that the *air sampling trees* are measuring the air going into the unit rather than the room air around the unit. Confirm that the sampling holes are not pulling in the discharge air leaving the outdoor section of the unit under test. Any sampler holes directly exposed to the outdoor coil discharge air shall be blocked to prevent sampling. Blocking holes does not necessarily prevent thermal transfer on *air sampling tree* tubes, therefore portions of the *air sampling tree* tubes directly exposed to the outdoor coil discharge air shall be thermally shielded with a material with an R-value of 4 to 6 $ft^2 \cdot °F \cdot hr/Btu$.

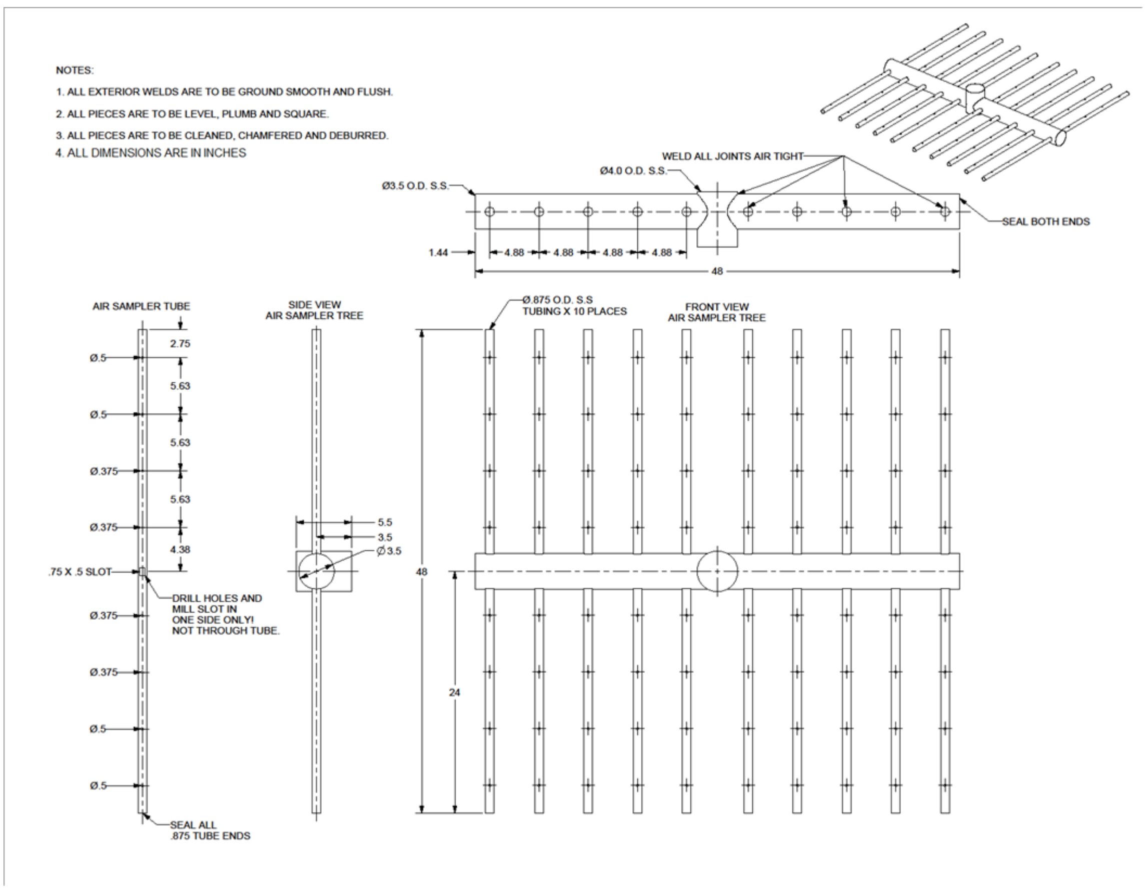

Figure 2 Example Air Sampling Tree (Informative)

Note: The 0.75 in by 0.50 in slots referenced in Figure 2 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 let air be 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 a unit shall be used except for units with three or more sides. For units with three or more sides, two sampling *aspirating psychrometers* or *dew-point hygrometers* shall be used and shall have a separate *air sampling tree* for the third side. For units that have air entering the sides and the bottom of the unit, additional *air sampling trees* shall be used. For units that require 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; either horizontal or vertical orientation of the branches can be used. The *air sampling trees* shall cover at least 80% of the height and 60% of the width of the air entrance to the unit (for long horizontal coils), or shall cover at least 80% of the width and 60% of the height of the air entrance (for tall vertical coils). 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 3 for examples of how an increasing number of *air sampling trees* are required for longer outdoor coils.

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 4 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 adjust airflow through the air sampler inlet holes as specified in Section C.3.3. Return the fan discharge air to the room where the system draws the outdoor coil intake air.

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

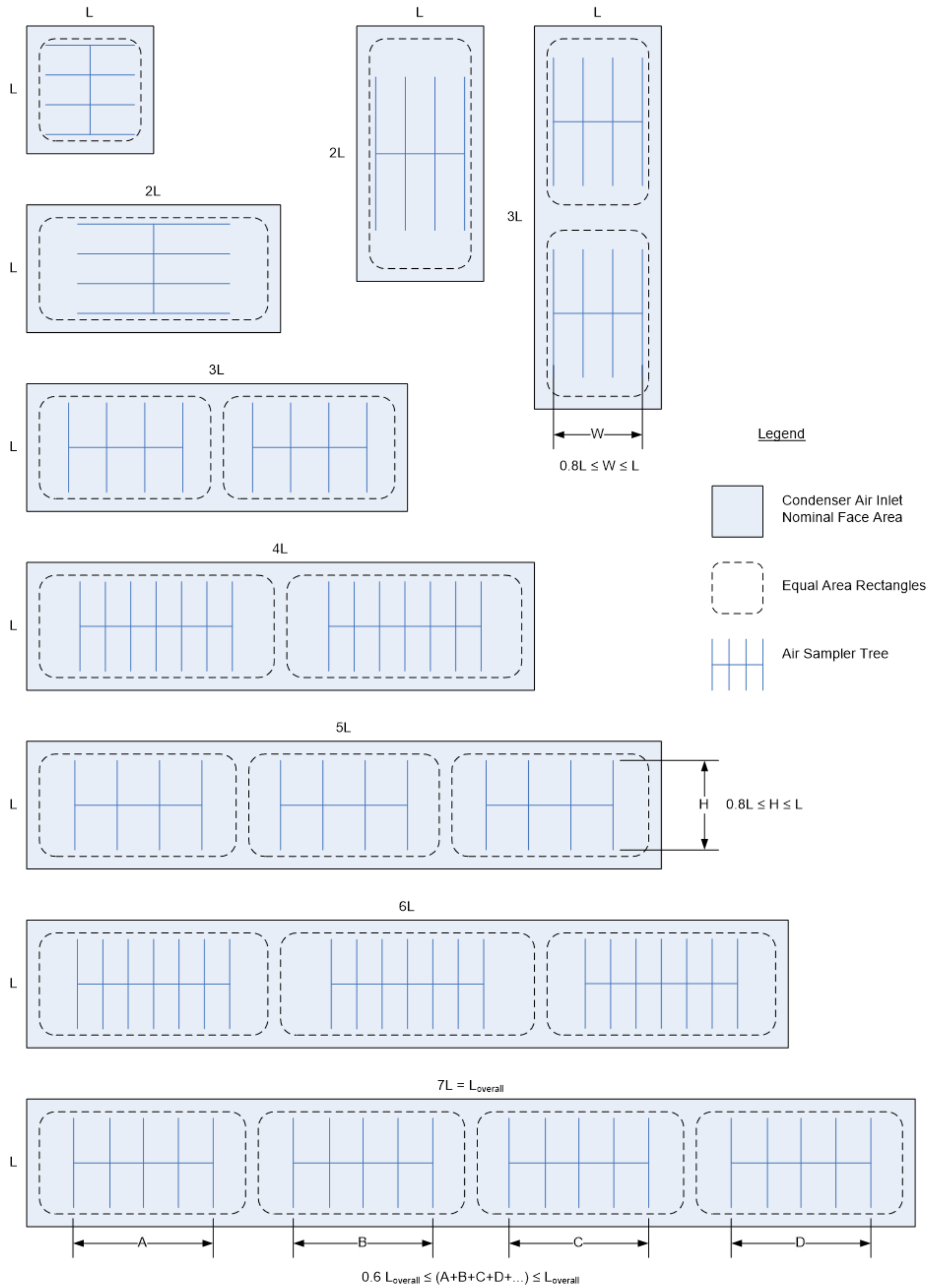

Figure 3 Example Determination of Measurement Rectangles and Required Number of Air Sampling Trees (Informative)

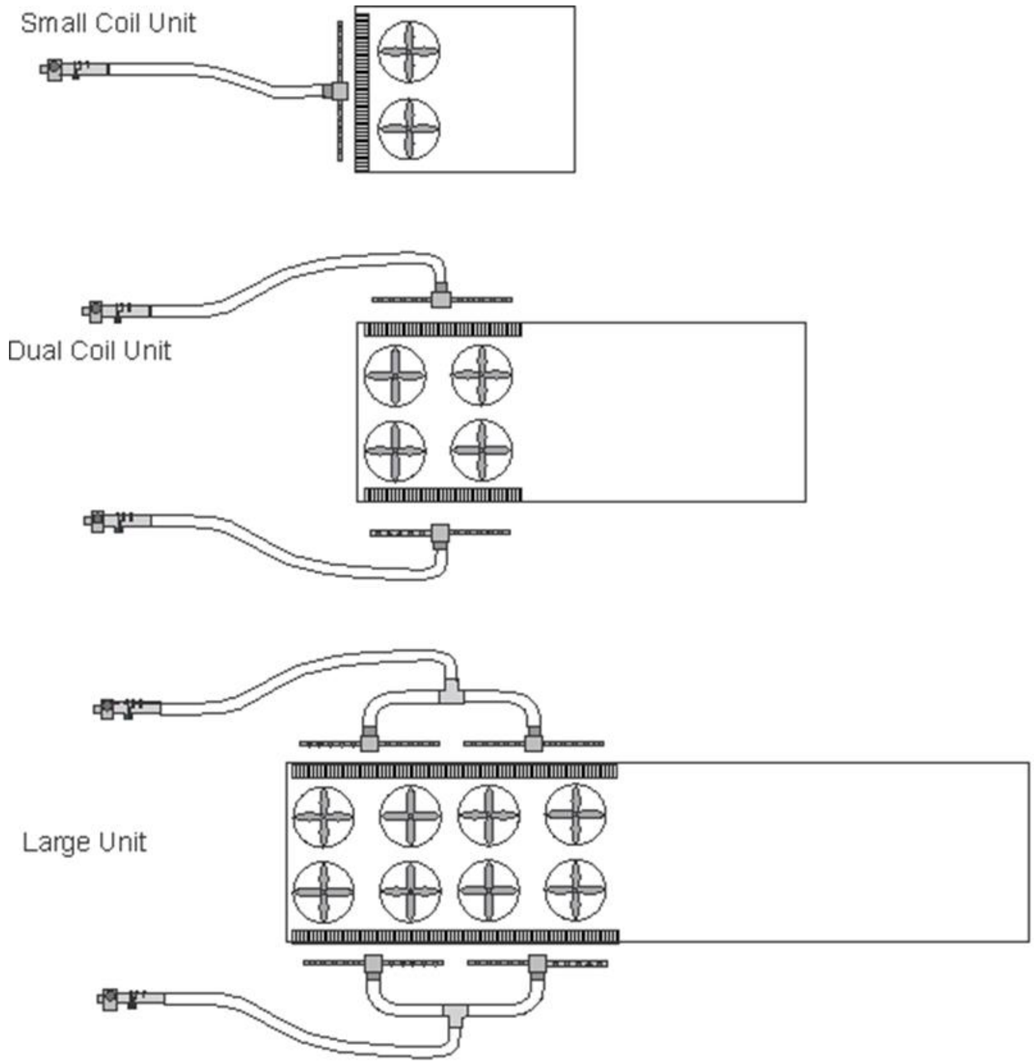

Figure 4 Example Test Setup Configurations (Informative)

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, the use of a thermocouple thermopile grid or a grid of individual thermocouples for duplicate measurement of dry-bulb temperature is not required. Use the air-sampler-exit measurement when checking temperature uniformity instead.

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 example, wet-bulb temperature or enthalpy) for the one or more affected air samplers. First, calculate the moisture level (pounds water vapor per pound dry air) 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 measured 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 moisture level, 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 was 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 was measured using multiple hygrometers, the moisture level used in this calculation shall be the average of the calculated moisture levels calculated in the first step.

C.3.7. Temperature Uniformity

To guarantee air distribution as defined in Table 35, thorough mixing, and uniform air temperature, the room and test setup shall be designed and operated as described in this section. The room conditioning equipment airflow shall be set such that recirculation of outdoor discharged air is circumvented except as can naturally occur from the equipment. To check for the recirculation of outdoor discharged air back into the outdoor coil(s) the following method shall be used:

- Multiple individual reading thermocouples (at least one per *air sampling tree* location) shall be installed around the unit air discharge perimeter so that the thermocouples are below the plane of outdoor fan exhaust and just above the top of the outdoor coil(s).
- These thermocouples shall not indicate a temperature difference greater than 5.0°F from the average inlet air.
- Air distribution at the test facility, at the point of supply to the unit, 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 outdoor air inlet. Recirculation of outdoor fan exhaust air back through the unit shall be prevented.

When not using *aspirating psychrometers*, the "*Aspirating Psychrometer* dry-bulb temperature measurement" of Table 35 refers to either of the following:

1) the dry-bulb temperature measurement in a single common air conduit serving one or more air samplers or
2) the 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 1.5°F dry-bulb temperature tolerance in Table 35 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 35).

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 35.

The wet-bulb temperature measurement shall be used for outdoor entering air for evaporatively-cooled units and heat pump units operating in heating mode.

Table 35 Uniformity Criteria for Outdoor 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. 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.

C.4. Indoor Coil Entering Air Conditions

Follow the requirements for outdoor coil entering air conditions as described in Section C.3, except for the following:

1) Both dry-bulb temperature and water vapor content measurements are required for all tests.
2) Sampled air shall be returned to the room where the system draws the indoor coil entering air, except if the loop air enthalpy test method specified in Section 6.1.2 of ASHRAE 37 is used, where 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.
3) The temperature uniformity requirements described in Section C.3.7 do not apply if a single air sampler is used.
4) 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.

C.5. Indoor Coil Leaving Air and Outdoor Coil Leaving Air Conditions

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

1) The temperature uniformity requirements described in Section C.3.7 do not apply.
2) Both dry-bulb temperature and water vapor content measurements shall be used for indoor coil leaving air for all tests and for outdoor coil leaving air for all tests using the outdoor air enthalpy method.

3) Air in the duct leaving the coil 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 coil with a blow-through fan (such as where the fan is located upstream of the coil), 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 41.1-2013 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 *standard ratings*, units shall be configured for testing as defined in this appendix.

D.2.1. Representations of a Basic Model and Individual Model Selection

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*.

Note: See the definition for *basic model* in Section 3.2.3.

Representations for a *basic model* shall be based on the least-efficient individual model(s) distributed in commerce among all otherwise comparable model groups comprising the *basic model*, with selection of the least-efficient individual model considering all options for factory-installed components and manufacturer-supplied components for field installation, except for individual models that include components listed in Table 36.

An otherwise comparable model group means a group of individual models distributed in commerce within the *basic model* that do not differ in components that affect energy consumption as measured according to this test standard other than those listed in Table 36. An otherwise comparable model group can include individual models distributed in commerce with any combination of the components listed in Table 36 or none of the components listed in Table 36. An otherwise comparable model group can consist of only one individual model.

Note: For more information on the DOE specific components requirements, see the presentation on the DOE rulemaking docket: www.regulations.gov/document/EERE-2023-BT-TP-0014-0001.

For a *basic model* that includes individual models distributed in commerce with components listed in Table 36, the requirements for determining representations apply only to the individual model(s) of a specific otherwise comparable model group distributed in commerce with the least number (that can be zero) of components listed in Table 36 included in individual models of the group. Testing shall be consistent with any component-specific test provisions specified in Table 37.

Table 36 Specific Components

Component	Definition or Description	Defined in Section
Air economizer	An optional feature that brings in additional outside cool air to cool the building when ambient temperature and or humidity levels are lower than the return air conditions.	Component defined in Section 3.2.11.1
Desiccant dehumidification component	An assembly that reduces the moisture content of the supply air through moisture transfer with solid or liquid desiccants.	Component defined in Section 3.2.9
Evaporative pre-cooling of air-cooled condenser intake air	Water is evaporated into the air entering the air-cooled condenser to lower the dry-bulb temperature and thereby increase efficiency of the refrigeration cycle.	This component is not defined in this standard.
Fire, smoke, or isolation damper	A damper assembly including means to open and close the damper mounted at the supply or return duct opening of the equipment.	Component defined in Section 3.2.15
Indirect/direct evaporative cooling of ventilation air	Water is used indirectly or directly to cool ventilation air. In a direct system the water is introduced directly into the ventilation air and in an indirect system the water is evaporated in secondary air stream and the heat is removed through a heat exchanger.	Components defined in Section 3.2.13.1 and Section 3.2.13.2
Non-standard ducted condenser fan (not applicable to double-duct systems)	A higher-static condenser fan/motor assembly designed for external ducting of condenser air that provides greater pressure rise and has a higher rated motor horsepower than the condenser fan provided as a standard component with the equipment.	Component defined in Section 3.2.29
Non-standard high-static 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*. For a non-standard high-static indoor fan motor(s) to be considered a specific component for a *basic model* (and thus subject to the provisions of section D.2.1, the following provisions shall be met: (1) The non-standard high-static indoor fan motor(s) shall meet the minimum allowable efficiency determined per section D.3.1 for non-standard high-static indoor fan motors or per section D.3.2 for non-standard high-static indoor integrated fan and motor combinations. (2) If the standard indoor fan motor can vary fan speed through control system adjustment of motor speed, all non-standard high-static indoor fan motors shall have speed control (including with the use of variable-frequency drive).	This component is not defined in this standard.

Component	Definition or Description	Defined in Section
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 allowing it to recirculate to the indoor coil and back to the building.	Component defined in Section 3.2.35.
Powered return air fan	A fan that draws building air into the equipment for exhausting or recirculation.	Component defined in Section 3.2.36.
Process heat recovery, reclaim, or thermal storage coil	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.	Component defined in Section 3.2.37.
Refrigerant reheat coil	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.	Component defined in Section 3.2.41.
Sound trap (can be called sound attenuator)	An assembly of structures that the *supply air* passes through before leaving the equipment or that the return air from the building passes through immediately after entering the equipment where the sound insertion loss is at least 6 dB for the 125 Hz octave band frequency range.	Component defined in Section 3.2.45.
Steam or hydronic heat coils	Coils used to provide supplemental heating.	Component defined in Section 3.2.51.
Ventilation energy recovery system (VERS)	An assembly that pre-conditions outdoor air entering equipment through direct or indirect thermal, or moisture exchange with the unit's exhaust air, or both, that is defined as the building air being exhausted to the outside from the equipment.	Component defined in Section 3.2.55.

D.2.2. Specific Components Present During Testing

When testing equipment that includes any of the features listed in Table 37, test in accordance with the set-up and test provisions specified in Table 37.

Table 37 Test Instructions for Specific Components Present During Testing

Component	Description or Definition	Test provisions	Term Defined in Section
Air economizers	An optional feature that brings in additional outside cool air to cool the building when ambient temperature and or humidity levels are lower than the return air conditions.	For any *air economizer* that is factory-installed, place the economizer in the 100% return position and close and seal the outside air dampers for testing. For any modular *air economizer* shipped with the unit but not factory-installed, do not install the economizer for testing.	Component defined in Section 3.2.11.1.
Barometric relief dampers	An assembly with dampers and means to automatically set the damper position in a closed position and one or more open positions to allow venting directly to the outside a portion of the building air that is returning to the unit, rather than allowing it to recirculate to the indoor coil and back to the building.	For any *barometric relief dampers* that are factory-installed, close and seal the dampers for testing. For any modular *barometric relief dampers* shipped with the unit but not factory-installed, do not install the dampers for testing.	Component defined in Section 3.2.2
Desiccant dehumidification component	An assembly that reduces the moisture content of the supply air through moisture transfer with solid or liquid desiccants.	Disable *desiccant dehumidification components* for testing.	Component defined in Section 3.2.9
Drain Pan Heater	A heater that heats the drain pan to make certain that water shed from the outdoor coil during a *defrost* does not freeze.	Disconnect *drain pan heaters* for testing.	Component defined in Section 3.2.9
Evaporative pre-cooling of air-cooled condenser intake air	Water is evaporated into the air entering the air-cooled condenser to lower the dry-bulb temperature and thereby increase efficiency of the refrigeration cycle.	Disconnect the unit from a water supply for testing, meaning operate without active evaporative cooling.	This component is not defined.

Component	Description or Definition	Test provisions	Term Defined in Section
Fire, smoke, or isolation damper	A damper assembly including means to open and close the damper mounted at the supply or return duct opening of the equipment.	For any *fire, smoke, or isolation damper* s that are factory-installed, set the dampers in the fully open position for testing. For any modular *fire, smoke, or isolation damper* s shipped with the unit but not factory-installed, do not install the dampers for testing.	Component defined in Section 3.2.15
Fresh air damper	An assembly with dampers and means to set the damper position in a closed and one open position to allow air to be drawn into the equipment when the indoor fan is operating.	For any *fresh air dampers* that are factory-installed, close and seal the dampers for testing. For any modular *fresh air dampers* shipped with the unit but not factory-installed, do not install the dampers for testing.	Component defined in Section 3.2.14.
Hail guard	A grille or comparable structure mounted to the outside of the unit covering the outdoor coil to protect the coil from hail, flying debris and damage from large objects.	Remove *hail guards* for testing.	Component defined in Section 3.2.17.
High-effectiveness indoor air filtration	Indoor air filters with greater air filtration effectiveness than the filters used for testing.	Test with the standard filter.	Component defined in Section 3.2.20.
Power correction capacitor	A capacitor that increases the power factor measured at the line connection to the equipment.	Remove *power correction capacitors* for testing.	Component defined in Section 3.2.34.
Process heat recovery, reclaim, or thermal storage coil	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.	Disconnect the heat exchanger from its heat source for testing.	Component defined in Section 3.2.37.

Component	Description or Definition	Test provisions	Term Defined in Section
Refrigerant reheat coil	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.	De-activate refrigerant reheat coils for testing to provide the minimum (none if achievable) reheat achievable by the system controls.	Component defined in Section 3.2.41.
Steam or hydronic heat coils	Coils used to provide supplemental heating.	Test with *steam or hydronic heat coils* in place but providing no heat.	Component defined in Section 3.2.51.
UV lights	A lighting fixture and lamp mounted so that it shines light on the indoor coil, that emits ultraviolet light to inhibit growth of organisms on the indoor coil surfaces, the condensate drip pan, and/other locations within the equipment.	*UV lights* shall be turned off for testing.	Component defined in Section 3.2.53.
Ventilation energy recovery system (VERS)	An assembly that pre-conditions outdoor air entering equipment through direct or indirect thermal, or moisture exchange with the unit's exhaust air, or both, that is defined as the building air being exhausted to the outside from the equipment.	For any *VERS* that is factory-installed, place the *VERS* in the 100% return position and close and seal the outside air dampers and exhaust air dampers for testing, and do not energize any *VERS* subcomponents such as the energy recovery wheel motors. For any *VERS* module shipped with the unit but not factory-installed, do not install the *VERS* for testing.	Component defined in Section 3.2.55.

D.3. Non-standard High-Static Indoor Fan Motors

The standard indoor fan motor is the motor specified in the *MII* 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 efficiency of any non-standard indoor fan motor shall be related to the efficiency of the standard motor as specified in either Section D.3.1(for non-standard indoor fan motors) or Section D.3.2 (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.3.1. Determination of Motor Efficiency for Non-standard High-Static Indoor Fan Motors

D.3.1.1. Test procedures

Standard and non-standard indoor fan motor efficiencies shall be based on the test procedures indicated in Table 38.

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 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 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 C747-09 can be applied to motors ≥ 1 hp.

D.3.1.2. Reference Motor Efficiencies

Reference motor efficiencies shall be determined for the standard and non-standard indoor fan motor as indicated in Table 38. Table 39 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.

D.3.1.3. Non-standard Motor Efficiency Criterion

Non-standard motor efficiency shall meet the criterion in Equation 49.

$$\eta_{non-standard} \geq \frac{\eta_{standard} - \eta_{reference\ standard}}{1 - \eta_{reference\ standard}} \cdot \left(1 - \eta_{reference\ non-standard}\right) + \eta_{reference\ non-standard} \qquad \mathbf{49}$$

Where:

$\eta_{standard}$	=	the tested efficiency of the standard indoor fan motor
$\eta_{non\text{-}standard}$	=	the tested efficiency of the standard indoor fan motor
$\eta_{non\text{-}standard}$	=	the reference efficiency from Table 38 for the standard indoor fan motor
$\eta_{reference\ standard}$	=	the reference efficiency from Table 38 for the non-standard indoor fan motor

Table 38 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, four pole, open motors at 10 CFR 431.446
Single Phase > 2 hp and ≤ 3 hp	10 CFR 431.444	Federal standard levels for polyphase, four pole, open motors at 10 CFR 431.446
Single Phase > 3hp	10 CFR 431.444	Federal standard levels for four pole, open motors at 10 CFR 431.25(h)
Polyphase ≤ 3 hp For cases where the standard or non-standard indoor fan motor, or both is < 1 hp	10 CFR 431.444	Federal standard levels for polyphase, four 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 two-digit frame size motors, or both (except 56-frame enclosed ≥ 1 hp) ≤ 3 hp: Federal standard levels for polyphase, four pole open motors at 10 CFR 431.446
	Appendix B to Subpart B of 10 CFR 431	For all other standard or non-standard motors ≤ 3 hp, or both: Federal standard levels for four 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 four pole, open motors at 10 CFR 431.25(h).
BLDC[1] motor or ECM[2] ≥ 1 hp	CSA C747-09	Federal standard levels for four pole, open motors at 10 CFR 431.25(h).
BLDC motor or ECM < 1 hp	CSA C747-09	Use Table 39.

Notes

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

Table 39 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.3.2. Integrated Fan and Motor

Use this section to compare 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 40 at a duty point determined in accordance with the requirements of Section D.3.2.3. The ratio of the fan input power of the non-standard fan to the standard fan shall be determined in accordance with Equation 50 and shall not exceed the max ratio of fan input powers value shown in Table 40. In this section, the word “fan” applies to either an IFM or a non-integrated assembly of a fan, motor, and motor controller.

$$R_{IF} = \frac{P_{IF,non-std}}{P_{IF,std}} \qquad \textbf{50}$$

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

$P_{IF,non\text{-}std}$ = 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 40 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.3.2.3	-0.5 / +1.0	± 0.05	110%
Outside the unit	Outside the unit	D.3.2.5	-0.5 / +1.0	± 0.05	110%
Simulated performance data	Simulated performance data	D.3.2.6	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 50.
2. The 110% value includes fan testing tolerances.

D.3.2.1. General Requirements

The methods in Section D.3.2 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.3.1.
2) The impeller diameter and number of blades of both fans shall be 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.3.2.2. 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.3.2.5 or using simulated performance data in accordance with Section D.3.2.6, only one fan from each fan array needs to be evaluated.

D.3.2.3. 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 TSP shall be determined in accordance with the requirements of Section D.3.2.3, Section D.3.2.5, or Section D.3.2.6.

D.3.2.4. Requirements If Testing Both Fans Inside a Unit

If both fans are tested inside a unit, all the requirements described in Section D.3.2.4.1 through Section D.3.2.4.6 shall be met.

D.3.2.4.1. 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.3.2.4.2. Indoor Fan Input Power

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

D.3.2.4.3. Compressor

The unit shall operate with the compressor off during testing.

D.3.2.4.4. Standard and Non-standard Fans

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.3.2.4.5. 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.3.2.4.6. 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 40. The fan input power at that duty point shall be recorded. If the airflow or ESP cannot be matched within the tolerances in Table 40, conduct testing in accordance with the requirements of Section D.3.2.6.

D.3.2.5. Requirements if Testing Both Fans Outside the Unit

If both fans are tested outside the unit, all the requirements described in Section D.3.2.5.1 through Section D.3.2.5.4 shall be met.

D.3.2.5.1. Testing and Performance

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.3.2.5.2. Standard and Non-standard Fans

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

D.3.2.5.3. 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.3.2.5.4. 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 40. The fan input power at that duty point shall be recorded. If the airflow or ESP cannot be matched within the tolerances in Table 40, conduct testing in accordance with the requirements of Section D.3.2.6.

D.3.2.6. Requirements for Using Simulated Performance Data

If the performance of both fans is determined using simulated performance data, the requirements described in Section D.3.2.6.1 through Section D.3.2.6.4 shall be met:

D.3.2.6.1. Standard and Non-standard Fans Sold in Commerce

The same standard and non-standard fans sold in commerce with the *basic model* shall have been 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.3.2.6.2. Fan Speed that Includes the Duty Point

If the tested speeds of one or both fans were 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.3.2.6.3. 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.3.2.6.4. 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 Section D.3.2.6.3.

D.3.2.7. Interpolation to Determine the Fan Input Power of the Non-standard Fan

For fans tested in accordance with the requirements of Section D.3.2.4 or Section D.3.2.5, if the airflow or pressure tolerances of Table 40 cannot be met, the fan input power shall be determined by interpolation using the following methods:

D.3.2.7.1. Test at Lower Speed to Achieve Duty Point

Test the non-standard fan at a lower fan speed than that required to achieve the duty point. Record the pressure (ESP if testing inside the unit, 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.3.2.7.2. Test at Higher Speed to Achieve Duty Point

Test the non-standard fan at a higher fan speed than that required to achieve the duty point. Record the pressure (ESP if testing inside the unit, 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.3.2.7.3. Determine Fan Input Power

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

APPENDIX E. METHOD OF TESTING UNITARY AIR-CONDITIONING PRODUCTS – NORMATIVE

E.1. Purpose

This appendix prescribes the test procedures used for testing commercial and industrial unitary air-conditioning and heat pump equipment. Testing shall comply with ASHRAE 37 and with the additional requirements in this appendix.

E.2. Atmospheric Pressure

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

E.3. Indoor and Outdoor Air Temperature Measurement

The indoor and outdoor air temperature (as applicable) shall be measured using the procedures defined in Appendix C.

E.4. Setting Indoor Airflow and External Static Pressure

Indoor airflow and ESP shall be set in accordance with Section 5.19 or Section 5.20, as applicable.

E.5. Minimum Data Collection Requirements

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.

E.6. Test Methods for Capacity Measurement

E.6.1. Primary Capacity Measurement

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

E.6.2. Secondary Capacity Measurement

Follow the provisions in Section E.6.2.1 for the following:

1) single package evaporatively-cooled equipment with rated *cooling capacity* greater than or equal to 135,000 Btu/h; and
2) air-cooled single package equipment with outdoor airflows that are either *manufacturer-specified* to be greater than 9000 scfm or are determined by testing to be greater than 9000 scfm.

For all other equipment, follow the provisions in Section E.6.2.2.

E.6.2.1. Certain Evaporatively-cooled and Air-cooled Single Package Equipment

This section applies to both of the following:

1) single package evaporatively-cooled equipment with rated *cooling capacity* greater than or equal to 135,000 Btu/h and
2) air-cooled single package equipment with outdoor airflows that are either *manufacturer-specified* or determined by testing and above 9000 scfm.

E.6.2.1.1. Equipment That Rejects Condensate to the Condenser Coil

For such equipment that rejects condensate to the condenser coil, secondary measurements shall not be used for cooling or heating tests.

E.6.2.1.2. Equipment hat Does Not Reject Condensate to the Condenser Coil

For equipment that does not reject condensate to the condenser coil, the following provisions apply. A cooling condensate measurement as described in Section E.6.6 can be used as a secondary method. Secondary measurements (using either the cooling condensate measurement or a Group B method specified in Table 1 of ASHRAE 37) are required for full-load and part-load cooling tests but are not required for heating tests. However, the agreement between primary and secondary measurements specified in Section E.6.4 is not required for part-load cooling tests.

E.6.2.2. Split Systems and Other Single Package Equipment

For equipment not covered under Section E.6.2.1, use one of the applicable Group B methods specified in Table 1 of ASHRAE 37 as a secondary method for capacity measurement for all full-load cooling and heating tests. Capacity measurement with a secondary method is required for part-load cooling tests unless the outdoor air enthalpy method is used as the secondary method for the full-load cooling test. However, the agreement between primary and secondary measurements specified in Section E.6.4 is not required for part-load cooling tests.

E.6.3. Measurements

Conduct measurements for all equipment in accordance with the provisions in Section 7.3, Section 7.4, Section 7.5, and Section 7.6 of ASHRAE 37 that are applicable to the selected test method. For the outdoor air enthalpy method, the provisions in Section E.6.4 take precedence over the provisions in Section 7.3 of ASHRAE 37. If using the refrigerant enthalpy method for secondary measurements, Section 7.5.1.3 of ASHRAE 37 does not apply for part-load cooling tests, meaning the refrigerant enthalpy method measurements shall be taken for part-load cooling tests regardless of the measured subcooling or superheat.

E.6.4. Agreement between Primary and Secondary Capacity Measurements

If using the cooling condensate measurement as the secondary method in accordance with Section E.6.2.1, follow the provisions in Section E.6.4.1. For all other secondary methods, follow the provisions in Section E.6.4.2.

E.6.4.1. Cooling Condensate Secondary Measurement

For the full-load cooling test, *latent capacity* calculated in Section 7.8.2.1 of ASHRAE 37 results shall match within ± 6% of the primary *latent capacity* calculated in Section 7.3.3.1 of ASHRAE 37. A match between primary and secondary measurements is not required for heating tests and part-load cooling tests.

E.6.4.2. Other Secondary Methods

The total *cooling* or *heating capacity* values measured with the secondary capacity measurement methods for the full-load cooling and heating tests (as applicable) as prescribed in Section E.6.2 shall match within ± 6% of the primary capacity measurement method test results for the full-load cooling and heating (if applicable) tests. A match between primary and secondary measurements is not required for part-load cooling tests.

E.6.5. Outdoor Air Enthalpy Method

When using the outdoor air enthalpy method as the secondary method for capacity measurement, first conduct a test without the outdoor air-side test apparatus connected to the outdoor unit, and then attach the outdoor air-side test apparatus and conduct a test with the apparatus connected to the outdoor unit. Use measurements from testing without the outdoor air-side test apparatus connected (such as indoor air enthalpy method capacity measurements and input power) as the applicable measurements for determination of efficiency metrics, provided the specified conditions are met.

E.6.5.1. Units with Free Air Discharge Condensers

E.6.5.1.1. Free Outdoor Air Test

For the free outdoor air test, connect the indoor air-side test apparatus to the indoor coil; do not connect the outdoor air-side test apparatus. The test room reconditioning apparatus and the unit being tested shall operate for at least one hour.

After attaining equilibrium conditions, measure the following quantities at equal intervals that span five minutes or less:

1) The evaporator and condenser temperatures or pressures
2) Parameters required according to the indoor air enthalpy method (as specified in Section 7.3 of ASHRAE 37)

Continue these measurements until the applicable test tolerances are satisfied for a thirty-minute period (for example, seven consecutive five-minute samples).

To measure evaporator and condenser pressures, solder a thermocouple onto a return bend located at the midpoints of each coil or at points not affected by vapor superheat or liquid subcooling. Alternatively, if the test unit is not sensitive to the refrigerant charge, install pressure gauges to the access valves or to ports created from tapping into the suction and discharge lines according to Section 7.4.2 and Section 8.2.5 of ASHRAE 37. The alternative approach shall be used when testing a unit charged with a zeotropic refrigerant having a temperature glide greater than 1°F at the specified test conditions.

For the free outdoor air test to constitute a valid test for determination of efficiency metrics, the following conditions shall be met:

1) For the ducted outdoor test, the capacities determined using the outdoor air enthalpy method shall agree within 6% of the capacities determined using the indoor air enthalpy method.
2) The capacity determined using the indoor air enthalpy method from the ducted outdoor air test shall agree within 2% of the capacity determined using the indoor air enthalpy method from the free outdoor air test.

E.6.5.1.2. Ducted Outdoor Air Test.

After collecting thirty minutes of steady-state data during the free outdoor air test, connect the outdoor air-side test apparatus to the unit for the ducted outdoor air test. Adjust the exhaust fan of the outdoor air-side test apparatus until averages for the evaporator and condenser temperatures, or the saturated temperatures corresponding to the measured pressures, agree within ± 0.5°F of the averages achieved during the free outdoor air test. Collect thirty minutes of steady-state data where the applicable test tolerances are satisfied.

During the ducted outdoor air test, at intervals of five minutes or less, measure the parameters required according to the indoor air enthalpy method and the outdoor air enthalpy method for the prescribed thirty minutes.

For cooling mode ducted outdoor air tests, calculate capacity based on outdoor air enthalpy measurements as specified in Section 7.3.3.2 and Section 7.3.3.3 of ASHRAE 37. For heating mode ducted tests, calculate *heating capacity* based on outdoor air enthalpy measurements as specified in Section 7.3.4.2 and Section 7.3.4.3 of ASHRAE 37. Adjust the outdoor-side capacity according to Section 7.3.3.4 of ASHRAE 37 to account for line losses when testing *split systems*. Use the outdoor airflow as measured during the ducted outdoor air test to calculate capacity for checking the agreement with the capacity calculated using the indoor air enthalpy method during the ducted outdoor test.

E.6.5.2. Units with Ducted Condensers

First conduct a test without the outdoor air-side test apparatus connected to the outdoor unit (see Section E.6.5.2.1) and then attach the outdoor air-side test apparatus and conduct a test with the apparatus connected to the outdoor unit (see Section E.6.5.2.3). Use measurements from the short duct test (in other words, use indoor air enthalpy method capacity measurements and power input) as the applicable measurements for determination of efficiency metrics, provided the conditions of Section E.6.5.2.2 are met.

E.6.5.2.1. Short Duct Test

If testing at non-zero ESP in accordance with Section 5.22.1, for the full-load cooling test, set the outdoor air ESP using symmetrical duct outlet restrictors according to Section 5.22.1.1, and for the heating tests, do not adjust the duct outlet restrictors used for the full-load cooling test. If testing at zero ESP in accordance with Section 5.22.2, adjustments of outdoor ESP are not required. For all testing, connect the indoor air-side test apparatus to the indoor coil; do not connect the outdoor air-side test apparatus. The test room reconditioning apparatus and the unit being tested shall operate for at least one hour.

After attaining equilibrium conditions, measure the following quantities at equal intervals that span five minutes or less:

1) The evaporator and condenser temperatures or pressures;
2) Parameters required according to the indoor air enthalpy method (as specified in Section 7.3 of ASHRAE 37).

Continue these measurements until the applicable test tolerances are satisfied for a thirty-minute period (for example, seven consecutive five-minute samples).

To measure evaporator and condenser pressures, solder a thermocouple onto a return bend located at the midpoints of each coil or at points not affected by vapor superheat or liquid subcooling. Alternatively, if the test unit is not sensitive to the refrigerant charge, install pressure gauges to the access valves or to ports created from tapping into the suction and discharge lines according to Section 7.4.2 and Section 8.2.5 of ASHRAE 37. The alternative approach shall be used when testing a unit charged with a zeotropic refrigerant having a temperature glide greater than 1°F at the specified test conditions.

E.6.5.2.2. Requirements for Valid Short-duct Test

For the short duct test to constitute a valid test for determination of efficiency metrics, the following conditions shall be met:

1) For the outdoor airflow measurement test (described in Section E.6.5.2.3), the capacities determined using the outdoor air enthalpy method shall agree within 6% of the capacities determined using the indoor air enthalpy method.
2) The capacity determined using the indoor air enthalpy method from the outdoor airflow measurement test shall agree within 2% of the capacity determined using the indoor air enthalpy method from the short duct test.

E.6.5.2.3. Outdoor Airflow Measurement Test

Following the short duct test (specified in Section E.6.5.2.1), connect the outdoor air-side test apparatus to the unit for the outdoor airflow measurement test. If testing at non-zero ESP in accordance with Section 5.22.1, do not adjust or remove the outlet duct restrictors. For all testing, adjust the exhaust fan of the outdoor air-side test apparatus until averages for the evaporator and condenser temperatures, or the saturated temperatures corresponding to the measured pressures, agree within ± 0.5°F of the averages achieved during the short duct test. Collect thirty minutes of steady-state data where the applicable test tolerances are satisfied.

At intervals of five minutes or less, measure the parameters required according to the indoor air enthalpy method and the outdoor air enthalpy method for the prescribed thirty minutes.

For cooling mode outdoor airflow measurement tests, calculate capacity based on outdoor air enthalpy measurements as specified in Section 7.3.3.2 and Section 7.3.3.3 of ASHRAE 37. For heating mode outdoor airflow measurement tests, calculate *heating capacity* based on outdoor air enthalpy measurements as specified in Section 7.3.4.2 and Section 7.3.4.3 of ASHRAE 37. Adjust the outdoor-side capacity according to Section 7.3.3.4 of ASHRAE 37 to account for line losses when testing *split systems*. Use the outdoor airflow as measured during the outdoor airflow measurement test to calculate capacity for checking the agreement with the capacity calculated using the indoor air enthalpy method during the outdoor airflow measurement test.

E.6.6. Cooling Condensate Method

Cooling condensate mass shall be recorded at three equal intervals of ten minutes during the thirty-minute test period, after equilibrium has been attained.

The drain connection shall be trapped to stabilize condensate flow.

The maximum deviation between any two cooling condensate mass measurements shall be less than 5%, with respect to the smaller of the two cooling condensate mass measurements. The total cooling condensate mass collected over the thirty-minute period shall be multiplied by two to yield the condensate rate in lb/hr. This shall be used as w_c when calculating *latent capacity* in accordance with Section 7.8.2.2 of ASHRAE 37.

E.6.7. Refrigerant Flow Measurement Device

Refrigerant flow measurement device(s) shall be either elevated at least two feet 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 1 ft laterally beyond each side of the exposed surfaces of the device(s).

E.7. Head Pressure Control for Air-cooled, Water-cooled, and Evaporatively-cooled Units

For units that have condenser head pressure control to provide proper flow of refrigerant through the expansion valve during low condenser temperature conditions, the head pressure controls shall be enabled and operate in automatic control mode. The setting shall be set at the factory settings or as defined in the installation instruction.

If the head pressure control is engaged by the control logic during part-load cooling tests, then use the steps described in Section E.7.1 through Section E.7.4. For all part-load cooling tests for water-cooled units, the water flow rate shall not exceed the value for the full-load cooling test.

E.7.1. Control Logic

The control logic shall control the operation of the unit. If the unit can be run and stable conditions are obtained (for example test tolerances in Table 6 are met), then a standard part-load cooling test shall be run.

E.7.2. Head Pressure Control Time Average Test

If the head pressure control results in unstable conditions (for example, test tolerances in Table 6 cannot be met), then a series of two steady-state one-hour tests shall be run. Prior to the first one-hour test the condenser entering temperature (for example outdoor air dry-bulb temperature or condenser water temperature) defined by Table 7 shall be approached from at least a 10°F higher temperature until the tolerances specified in Table 41 are met. Prior to the second one-hour test, the condenser entering temperature defined by Table 7 shall be approached from at least a 5°F lower temperature until the tolerances specified in Table 41 are met. For each test, once all tolerances in Table 41 are met, the one-hour test shall be started and test data shall be recorded every five minutes for one hour, resulting in twelve test measurements for each test parameter. During each one-hour test, the tolerances specified in Table 41 shall be met.

Table 41 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	—
Outdoor air dry-bulb temperature (°F)	Entering	3.0	1.0
	Leaving	—	—
Outdoor air wet-bulb temperature (°F)	Entering	1.5	0.5[1]
	Leaving	—	—
Water serving outdoor coil temperature (°F)	Entering	0.75	0.3
	Leaving	0.75	—
Voltage		2%	1%

Note:

1. Applies only for air-cooled systems that evaporate condensate, evaporatively-cooled systems, and single package units where the indoor coil is located in the outdoor chamber.

If the tolerances in Table 41 are met, the tests results for both one-hour steady-state test series shall then be averaged to determine the capacity and power values that are then used for the *IVEC* calculation.

E.7.3. Tolerances

If the tolerances in Table 41 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, proceed to the next step.

E.7.4. Stable Operation

If *STI* are not used to provide stable operation, the fan(s) (for air-cooled and evaporatively-cooled units) or valve(s) (for water-cooled units) 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 achievable while remaining not lower than 85°F.

E.8. Setup Provisions for Evaporatively Cooled Units.

E.8.1. Makeup Water Temperature

For evaporatively cooled units the *makeup water* shall be maintained at the temperatures specified in Table 7. This can be done using one of the following options.

E.8.1.1. Turn Off Makeup Water

Turn the makeup water off during the test and use just the water in the evaporatively cooled condenser sump.

E.8.1.2. Heat or Cool Makeup Water

Heat or cool the *makeup water* to the ambient outdoor air dry-bulb temperature or feed the *makeup water* from an external tank that is exposed to the outdoor air dry-bulb test temperature.

E.8.2. Blow-down Water

Any blow-down water used for control of material byproducts of evaporation shall be turned off during the test.

E.8.3. Piping Evaporator Condensate for Split Systems

If piping the evaporator condensate to the condenser sump is an option for a unit, and the *MII* do not require the unit to be set up using this option, test the unit without this option.

E.8.4. Purge Water Settings

For evaporatively-cooled systems that purge sump water to reduce mineral and scale buildup on the condenser heat exchanger, the purge water settings shall be set in accordance with the manufacturer's instructions.

If the manufacturer's instructions give multiple options for purge rate (for example for hard water or soft water) or indicate a range of values for the purge rate, the median of the listed purge rates shall be used.

If the median of the listed purge rates cannot be achieved, the next highest purge rate above the median that can be achieved shall be used. If the manufacturer's instructions regarding the purge rate are not given, the factory settings for the purge rate shall be used.

E.9. Test Method for Upflow Units in Chambers of Limited Height

E.9.1. General

If the height of the unit under test plus a vertical outlet duct with pressure taps for measuring ESP compliant (for units with multiple fans) 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, 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 5 if the up-flow ducted system has a single fan outlet connection. Install the test duct as shown in Figure 6 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.9.2. Units with Multiple Indoor Blowers

If either of the following provisions apply, test with a single outlet duct as shown in Figure 5:

1) the *MII* 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. External static pressure 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 6 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.9.3. Turning Vanes

Calculate the discharge velocity using Equation 51.

$$V = \frac{Q_{Rated}}{A_{TD}} \quad \textbf{51}$$

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 5 and Figure 6. 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° elbow shall have single thickness turning vanes inside, with vane radius of 2.0 inches and vane distance of 1.5 inches.

E.9.4. Vertical section

As shown in Figure 5 and Figure 6, 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 corresponding 90° elbow. The length of this straight duct shall be calculated using Equation 52.

$$L = 1.25 * \sqrt{A \times B} \quad \textbf{52}$$

Where:

A is the width of unit duct flange or fan discharge.

B is the depth of unit duct flange or fan discharge.

E.9.5. ESP Adjustment

Use the equations in Table 42 to calculate the adjusted minimum ESP requirement by subtracting ΔESP from the ESP requirement specified in Section 5.17. Round the calculated value of ΔESP to the nearest 0.01 in H_2O.

Table 42 ESP Adjustment

Discharge Velocity	Bend Type	ESP Adjustment Equation[1] (in H_2O)
Q > 800 fpm	Turning vanes, as specified in Figure 5 or Figure 6	See Equation 53
Q ≤ 800 fpm	No turning vanes	See Equation 54
Note: 1. ρ is the air density at the airflow test measurement station, lb/ft^3		

$$\Delta ESP = 0.26 * \rho \left(\frac{Q}{1097}\right)^2 \quad \textbf{53}$$

$$\Delta ESP = 1.34 * \rho \left(\frac{Q}{1097}\right)^2 \quad \textbf{54}$$

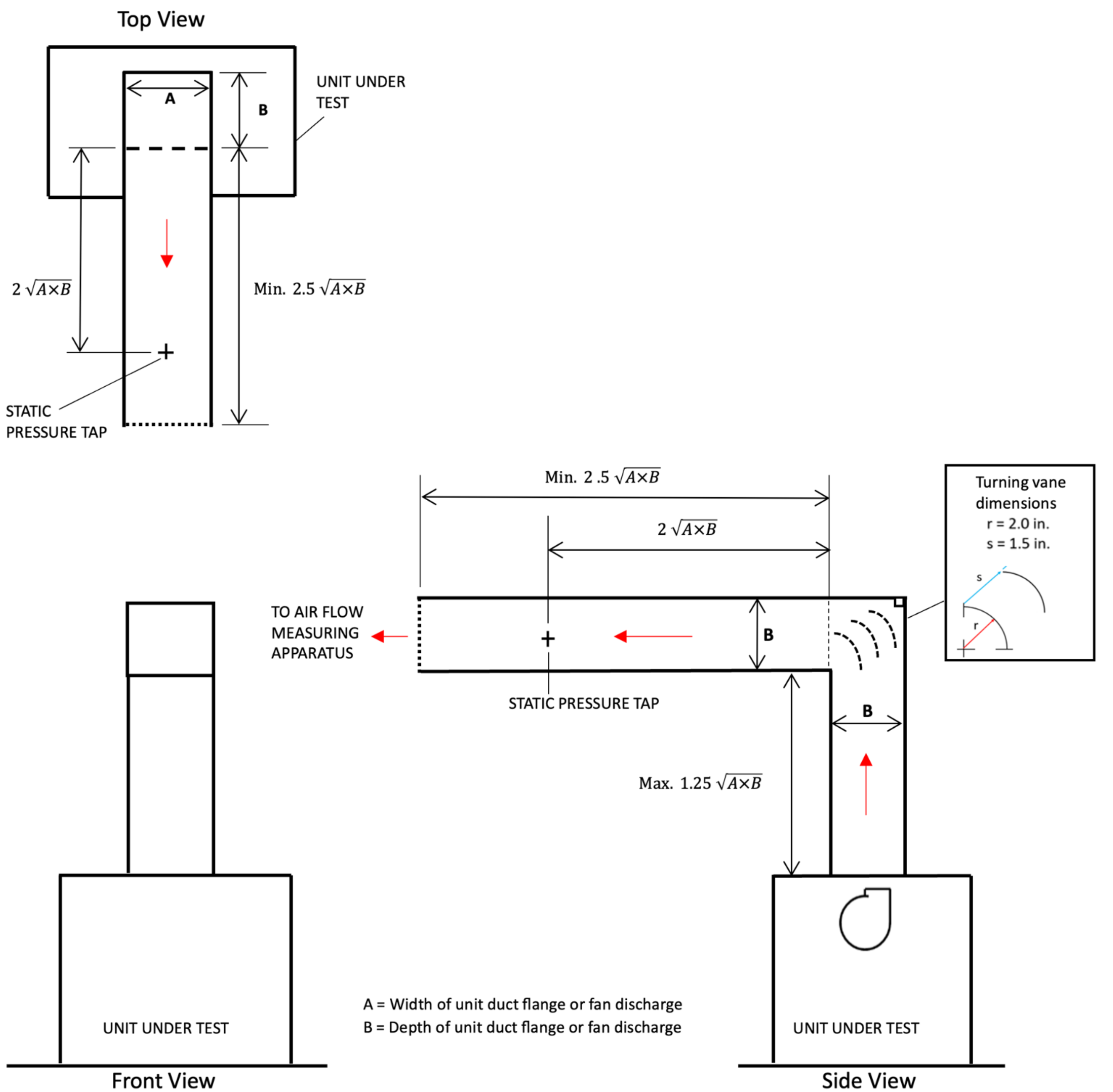

Figure 5 Test Duct Setup for Up-flow Unit with Single Fan Outlet Connection in Limited Height Test Chamber

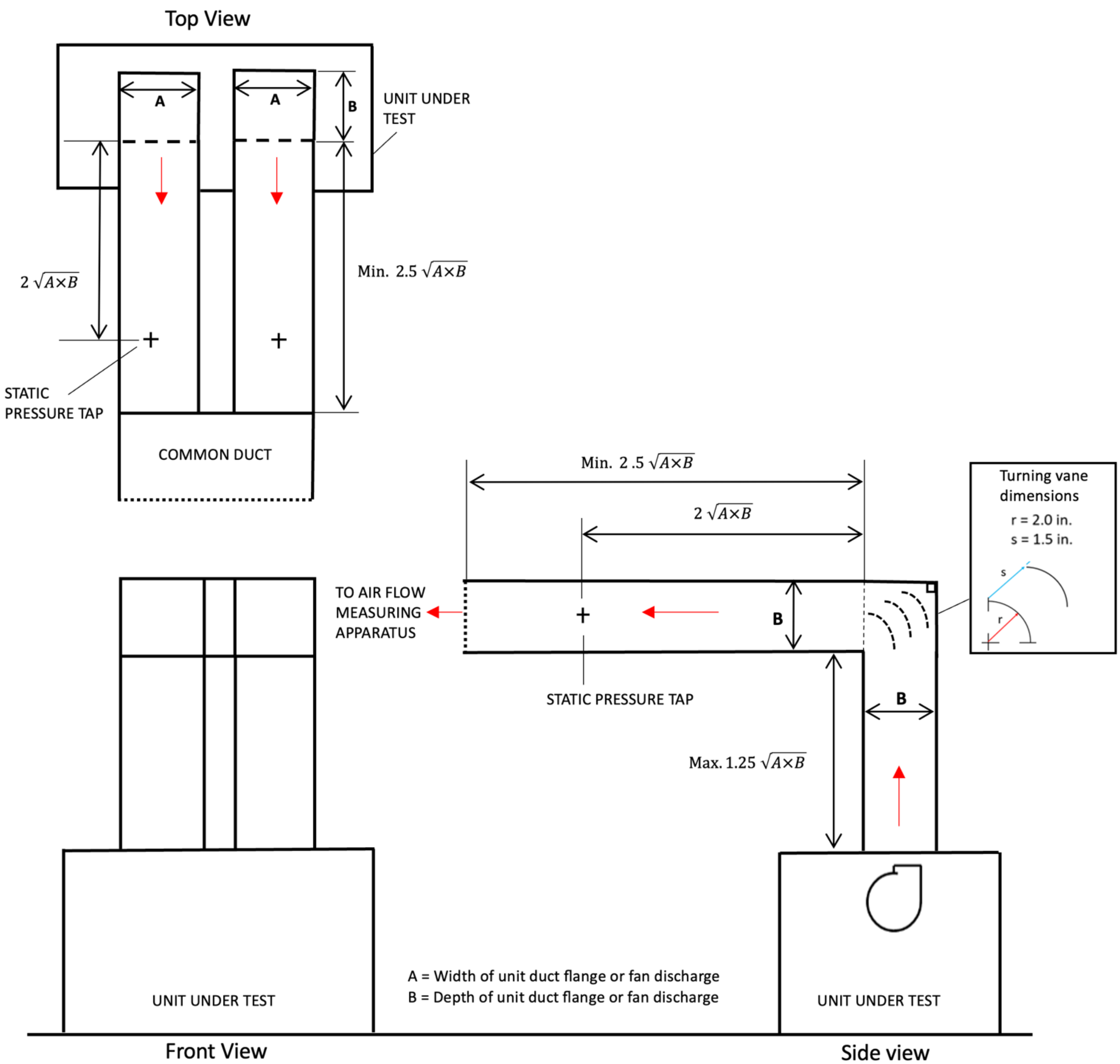

Figure 6 Test Duct Setup for Up-flow Unit with Multiple Fan Outlet Connections in Limited Height Test Chamber

E.10. Unit Power Measurement

E.10.1. Total Unit Power, Indoor Fan Power, and Controls Power

Total unit power, *indoor fan power*, and *controls power* shall be measured.

Total unit power shall include the sum of the power for all components, including compressors, condenser section, indoor fans, controls, crankcase heat, and any auxiliary loads.

Indoor fan power shall include the sum of all power needed for the fans, motors, belt drives, and variable-speed drive losses for all indoor fans.

Controls power shall include the sum of the power for all controls and all auxiliary loads that are not part of the compressor, condenser section, or indoor fan. *Controls power* can include *crankcase heat power*.

If the total unit power, *control power*, or both, include power for any override controls used only for laboratory testing, subtract the power for the override controls from the total power, *control power*, or both, as applicable.

E.10.2. Compressor Power and Condenser Section Power

Measure *compressor power* and *condenser section power* if these measurements are accessible and the test facility has enough power meters.

Compressor power shall include the sum of all power needed for all compressors, including any inverter losses, variable-speed drive losses, and auxiliary power required for compressor operation. *Compressor power* can include crankcase heat.

Condenser section power shall include the sum of all power needed for all fans, pumps, and other condenser section components, including any inverter or variable-speed drive losses.

If the *compressor power* and *condenser section power* cannot be measured separately, but the sum of compressor and *condenser section power* can be measured, measure the sum of compressor and *condenser section power*, and use that sum in all calculations.

If one or both of *compressor power* and *condenser section power* cannot be measured, and the sum of compressor and *condenser section power* cannot be measured, calculate the sum of compressor and *condenser section power* by subtracting the measured *indoor fan power* and control power from the measured total power.

If compressor and condenser power are measured, either together or separately, compare the sum of all individual component power measurements to the measured total unit power. If the sum does not equal the total unit power measured, the *compressor power* shall be adjusted so the sum of the individual power measurements equals the total unit power. If the sum of compressor and *condenser section power* is calculated, adjustment is not required.

E.10.3. Crankcase Heat Power

Crankcase heat power shall include the sum of *crankcase heat power* for all compressors that are not operating during a test.

Crankcase heat power shall be included either as part of measured control power or as part of the measured or calculated *compressor power*. Use the *MII* and *STI* to determine whether *crankcase heat power* is included in control power or *compressor power*.

Use the manufacturer installation instructions and *STI* to determine the *manufacturer-specified crankcase heat power* values where those values are required. If there is not a *manufacturer-specified crankcase heat power* value for a compressor, use one of the two following options where a *manufacturer-specified* value is required, as applicable:

1) If the compressor does not use crankcase heat, use a value of zero for the compressor.
2) Otherwise, use the default *crankcase heat power* calculated in Equation 55 for the compressor.

$$Default\ crankcase\ heat\ power\ = 80 \times \left(\frac{NCC}{120{,}000}\right)^{\frac{2}{3}} + 44 \qquad \mathbf{55}$$

Where:

NCC = Nominal capacity of the compressor, Btu/h

E.10.4. Measurement Locations

Use the manufacturer installation instructions and *STI* to determine locations for all power measurements.

E.10.5. Multiple sub-components

If any components have multiple sub-components (for example, multiple compressors or multiple control modules), either measure the power for all sub-components together, or measure the power for each sub-component separately and use the sum of the sub-component powers in all calculations.

E.10.6. Transformers

If any components are powered by a transformer, measure power for that component before the transformer.

E.11. Indoor Coil Inlet Duct Arrangement

E.11.1. Duct and Pressure Measurement Setup

Position the unit so that there is enough space to install an inlet duct as specified in Section 6.4 of ASHRAE 37 and install the inlet duct as specified in Section 6.4 of ASHRAE 37. An inlet duct shall be installed for all tests.

The inlet duct shall be as specified in Section 6.4.2.2 of ASHRAE 37, with a minimum length of 1.5 times the square root of the unit inlet area, and with static pressure taps located at a distance from the unit inlet equal to 0.5 times the square root of the unit inlet area. The minimum distance from the unit inlet to any restrictions, mixers, thermocouple grids or *air sampling trees* shall be 1.5 times the square root of the unit inlet area.

In addition to the manometer or electronic pressure transducer installed to measure total external static pressure as specified in ASHRAE 37, install a manometer or electronic pressure transducer to measure either the return static pressure as illustrated in Figure 7, or the supply static pressure as illustrated in Figure 8. The inlet duct is labeled as return side plenum in Figure 7 and Figure 8.

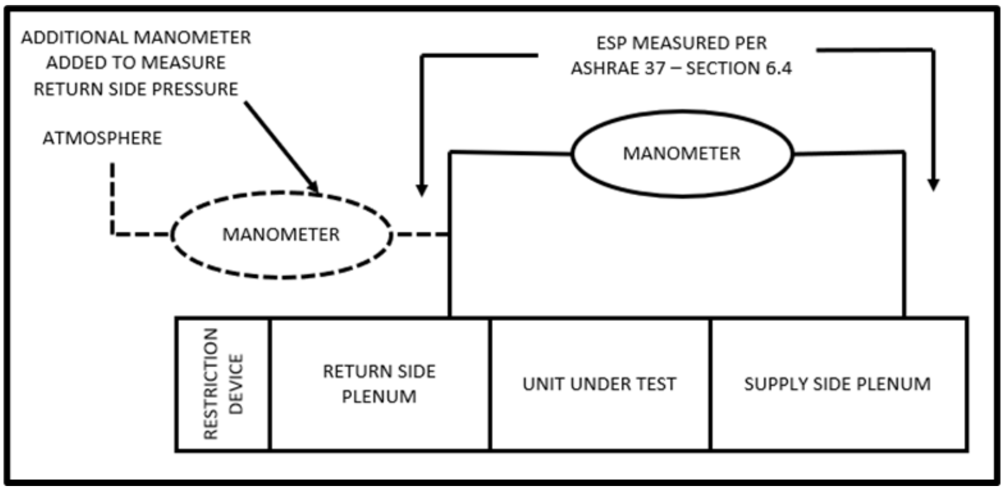

Figure 7 Return Static Pressure Measurement

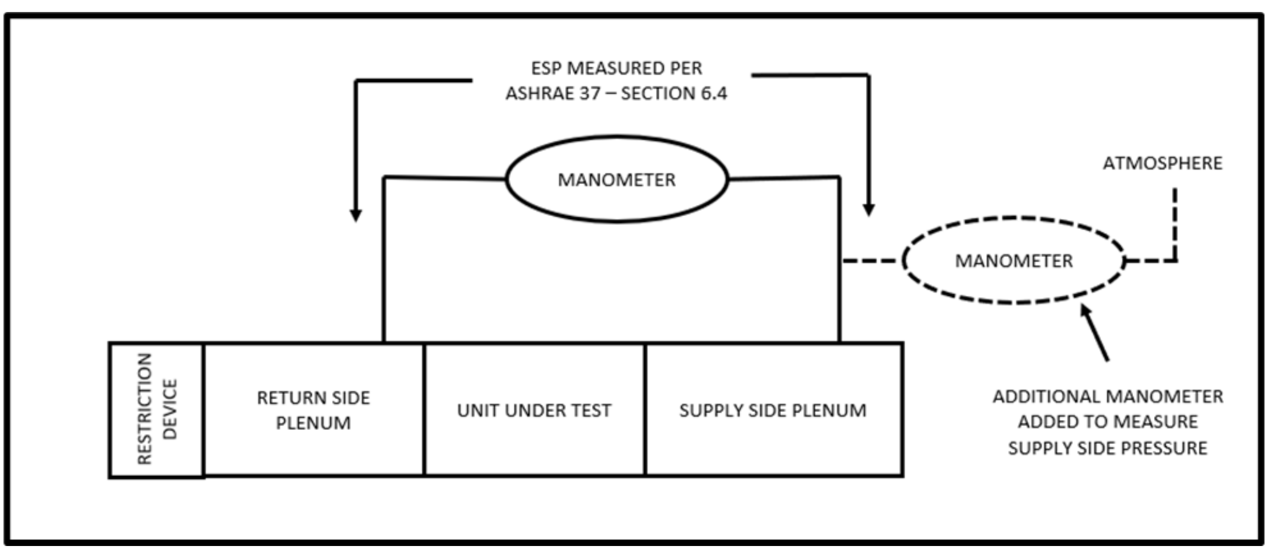

Figure 8 Supply Static Pressure Measurement

E.11.2. Measurement and Adjustment of Return Static Pressure

Measure the return static pressure as a percentage of total external static pressure while operating the unit at full-load cooling airflow and full-load cooling *standard rating conditions*.

The only way results can be valid with a return static pressure greater than 25% of total external static pressure is if there is not an inlet restriction, mixers, elbows, transitions, or sampling devices are installed within the interconnecting duct upstream of the plenum arrangement. In this case, all sampling of indoor entering air shall be performed outside of the duct, following the provisions in Section C.4.

If the return static pressure is less than 20% of total external static pressure, install an inlet restriction to increase the return static pressure to between 20% and 25% of the total external static pressure.

After installing and setting all inlet restriction, mixers, elbows, transitions, or sampling devices, as applicable, for the full load cooling test, all inlet restriction, mixers, elbows, transitions, or sampling devices shall remain unchanged for all other tests.

E.11.3. Restriction Devices

If an inlet restriction device is installed to meet the required split of total external static pressure specified in Section E.11.2, the inlet restriction device shall be concentric with the geometric center of the duct cross section. Examples of inlet restriction devices that can be used include perforated panels and opposed blade dampers. Blank-off panels with rectangular, V-shaped, or arc-shaped openings can be used if the center of their open area is in the geometric center of the duct cross section.

If the indoor coil entering air is sampled within a duct (see Section C.4) and an inlet restriction is used, the inlet restriction shall be located upstream of the sampling device and a grid of individual thermocouples shall be installed on the *air sampling tree*. 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 41.1-2013 to reduce the maximum temperature spread to less than 1.5°F.

APPENDIX F. INTERNATIONAL RATING CONDITIONS – NORMATIVE

This appendix establishes full load *rating conditions* relevant to international requirements.

F.1. Cooling Temperature Conditions

F.1.1. International Temperature Conditions T1, T2, and T3

The international T1, T2, and T3 temperature conditions specified in Table 43 shall be used as *standard rating conditions* for the determination of *cooling capacity* and energy efficiency. For equipment intended for space cooling, testing shall be conducted at one or more of the *standard rating conditions* specified in Table 43.

F.2. Heating Temperature Conditions

F.2.1. Temperature Conditions H1, H2, and H3

The H1, H2, and H3 temperature conditions specified in Table 43 shall be used as *standard rating conditions* for the determination of *heating capacity* and energy efficiency.

F.2.2. Heat Pump Ratings

All heat pumps shall be rated based on testing at the H1 temperature conditions. *Heating capacity* and energy efficiency tests shall be conducted at the H2 or H3, or both temperature conditions if the manufacturer rates the equipment for operation at one or both temperature conditions.

Table 43 International Air-cooled Full Load Standard Rating Conditions

Cooling – Temperature Conditions	**T1 (Moderate Climates)**		**T2 (Cool Climates)**		**T3 (Hot Climates)**	
	Dry-Bulb	Wet-Bulb	Dry-Bulb	Wet-Bulb	Dry-Bulb	Wet-Bulb
Indoor	80.6°F	66.2°F	69.8°F	59.0°F	84.2°F	66.2°F
Outdoor	95.0°F	75.2°F	80.6°F	66.2°F	114.8°F	75.2°F
Heating – Temperature Conditions	H1 (Warm Climates)		H2 (Moderate Climates)		H3 (Cold Climates)	
	Dry-Bulb	Wet-Bulb	Dry-Bulb	Wet-Bulb	Dry-Bulb	Wet-Bulb
Indoor	68.0°F	59.0°F maximum	68.0°F	59.0°F maximum	68.0°F	59.0°F maximum
Outdoor	44.6°F	42.8°F	35.6°F	33.8°F	19.4°F	17.6°F

F.2.3. Extra High Temperature Operating Requirement

Unitary air-cooled air-conditioners and heat pump equipment shall pass the following extra high temperature operating condition test with an indoor-coil at the T3 condition airflow as determined under this appendix.

F.2.3.1. Temperature Conditions

Temperature conditions shall be maintained as shown in Table 44.

Table 44 Conditions for Operating Requirement Tests for Air-cooled Equipment

Cooling – Temperature Conditions	
Indoor	80.0°F DB[1] & 67.0°F WB[1,2]
Outdoor	125.6°F DB[1] & 87.81°F WB[1,2]

Notes:

1. DB = dry-bulb and WB = wet-bulb
2. The wet-bulb temperature condition is not required when testing air-cooled condensers that do not evaporate condensate.

F.2.3.2. Voltages

Tests shall be run at the unit's nominal rated voltage.

F.2.3.3. Procedure

Unitary air-cooled air-conditioners and heat pump equipment shall be operated continuously at full capacity. All power to the equipment shall be interrupted for a period for a minimum period of five seconds and a maximum of seven seconds and then be restored. The unit shall resume continuous operation within one hour of restoration of power and shall then operate continuously for one hour. Units can have operation and resetting of safety devices prior to establishment of continuous operation.

F.2.3.4. Requirements

During the test, the equipment shall operate without failure of any of the equipment's parts.

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

G.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:

1) The former individual model is otherwise identical to the latter individual model.
2) The non-standard fan motor has the same or higher relative efficiency as the standard fan motor (determined in accordance with Section D.3.1).

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.3.2. This method is provided for cases where either or both 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.3.2 to determine the relative efficiency of the standard and non-standard fan and motor combinations.

G.2. Requirements

Though only one fan must be an IFM, both fans must have the same diameter impeller and the impeller must have the same number of blades. However, 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 can increase efficiency.

G.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 must not be more than 110% of that of the standard fan if both fans are tested at the duty points. The 110% 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 power is limited to 105%. Figure 9 shows an example of output from a fan manufacturer's software where there two non-standard fans.

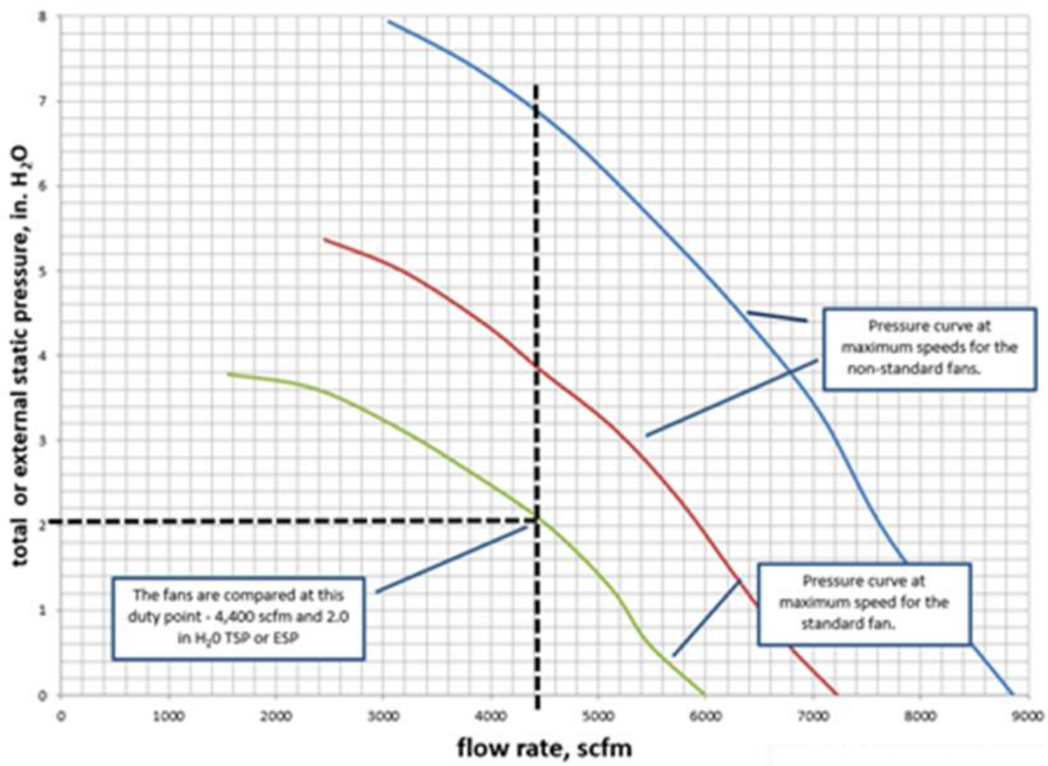

Figure 9 Illustration of the Duty Point Where Standard and Non-standard Fan Input Power is Compared

G.4. Testing Both Fans Inside a Unit

The *full load rated indoor airflow* 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 was tested. The tested airflow and ESP when compared to the non-standard fan must be within the tolerances shown in Table 40. The measured fan input power of the non-standard fan must not be more than 2310 W (2100 W X 110%). Laboratory variance is accounted for in the 110% allowance.

G.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 were 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 instead of testing can be used.

For this example, using the graph in Figure 9, the maximum speed of the standard fan is 1800 RPM, and the green line represents the fan's 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 non-standard fans, the fan input power determined cannot exceed 2100 W (2000 W • 105%).

APPENDIX H. DETERMINATION OF LOW-TEMPERATURE CUT-IN AND CUT-OUT TEMPERATURES – NORMATIVE

H.1. Purpose

The purpose of this test is to confirm the certified values for *low-temperature compressor cut-out temperature* and *low-temperature compressor cut-in temperature*.

H.2. Scope

This method is applicable to all air-source *commercial and industrial unitary heat pump*s that fall under the scope of this standard.

H.3. Setup

All labs shall be capable of reaching a temperature of not more than 2°F without the unit operating in heating mode. The system setup in the test laboratory shall be as in accordance with Section 5, Section 6, Appendix C, and Appendix E as required to measure the following values:

1) Outdoor dry-bulb temperature of the air entering the outdoor coils by either aspirating psychrometer or thermocouple grid
2) Compressor power
3) Indoor entering dry bulb temperature
4) Indoor leaving dry-bulb temperature

Measurements of values other than those listed above are not required.

H.4. Test Instructions

H.4.1. General

H.4.1.1. Target Low-temperature Compressor Cut-out Temperature

The target *low-temperature compressor cut-out temperature* shall be the greater of the manufacturer-certified cut-out temperature or 2°F.

H.4.1.2. Target Low-temperature Compressor Cut-in Temperature

The target *low-temperature compressor cut-in temperature* shall be the greater of the manufacturer-certified cut-in temperature or 2°F.

H.4.1.3. Indoor Dry-bulb Entering Temperature

The indoor entering dry-bulb temperature shall be between 65.0°F to 75.0°F for all tests.

H.4.2. Low-temperature Compressor Cut-out Temperature Test

H.4.2.1. Compressor Standby Power

When the outdoor room temperature is not more than 17.0°F, confirm the unit is energized but without a call for heating. Record the power on the circuit used to measure compressor power. The recorded value shall be used as the compressor standby power for this test.

H.4.2.2. Test Start

With the unit operating with a call for heat, reduce the temperature in the outdoor room to not less than 3°F higher than the target *low-temperature compressor cut-out temperature*. Confirm the indoor leaving dry-bulb temperature is not less than 5°F greater than the indoor entering dry-bulb temperature. If the indoor leaving dry-bulb temperature is less than 5°F greater than the indoor entering dry-bulb temperature, increase the outdoor room temperature until the indoor leaving dry-bulb temperature is not less than 5°F greater than the indoor entering dry-bulb temperature and record the outdoor room temperature. Use the recorded value as the new target *low-temperature compressor cut-out temperature* and repeat the test.

H.4.2.3. Stabilization

Remain at this temperature for not less than three minutes. During this time, the operating tolerance of the outdoor entering dry-bulb temperature shall be 0.5°F.

H.4.2.4. Temperature Ramp Down

Reduce the outdoor room temperature at an average rate not greater than 1.0°F every five minutes. The ramp down can optionally be continuous or stepwise.

H.4.2.5. End of Test

H.4.2.5.1. Heating Stops Before Reaching the Target

If the indoor leaving dry-bulb temperature falls below 5°F greater than the indoor entering dry-bulb temperature continuously for more than thirty seconds during the temperature ramp down, and the power measured on the compressor circuit is not more than the greater of 150% of the compressor standby power or 200 W, stop the test and record the outdoor entering dry bulb temperature. The recorded temperature shall be the *low-temperature compressor cut-out temperature*.

H.4.2.5.2. Heating Does Not Stop Before Reaching the Target

If the target *low-temperature compressor cut-out temperature* is achieved without the indoor leaving air discharge temperature falling below 5°F greater than the indoor entering dry-bulb temperature, end the test. The target *low-temperature compressor cut-out temperature* shall be the *low-temperature compressor cut-out temperature.*

H.4.2.5.3. Unit Enters Defrost

If the indoor leaving air discharge temperature falls below 5°F greater than the indoor entering dry-bulb temperature continuously for more than one minute during the temperature ramp down, and the power measured on the compressor circuit is greater than the greater of 150% of the compressor standby power or 200 W, the unit shall be deemed to have entered defrost mode. The defrost cycle shall finish and restart the test at Section H.4.2.2.

H.4.3. Low-temperature Compressor Cut-in Temperature Test

This test shall begin immediately upon termination of the *low-temperature compressor cut-out temperature* test.

H.4.3.1. Confirm Compressors Off

If the cut-out test ended based on the requirements in Section H.4.2.5.2, remove the call for heat and confirm the power measured on the compressor circuit is not more than 150% of the compressor standby power.

H.4.3.2. Delay Before Compressor Restart

Record data with the compressors off for the greater of the compressor short-cycle delay time in the *MII* or five minutes.

H.4.3.3. Test Start

Provide a call for heat to the unit. If the power measured in the compressor circuit is greater than the greater of 150% of the compressor standby power or 200 W, and the indoor leaving air temperature is not less than 5°F greater than the indoor entering dry-bulb temperature for one minute, end the test and record the outdoor room temperature as the *low-temperature compressor cut-in temperature*.

H.4.3.4. Temperature Ramp Up

If the test does not end during the procedure in Section H.4.3.3, increase the outdoor room temperature at a rate not greater than 1.0°F every five minutes. The ramp up can optionally be continuous or stepwise.

H.4.3.5. End of Test

H.4.3.5.1. Heating Starts Before Reaching the Target

When the indoor leaving air discharge temperature is not less than 5°F greater than the indoor entering dry-bulb temperature continuously for more than one minute during the temperature ramp up, stop the test and record the outdoor entering dry bulb temperature. The recorded temperature shall be the *low-temperature compressor cut-in temperature*.

H.4.3.5.2. Unit Enters Defrost

If the power measured on the compressor circuit is greater than the greater of 150% of the compressor standby power or 200 W, and the indoor leaving air discharge temperature is not less than 5°F greater than the indoor entering dry-bulb temperature continuously for more than one minute during the temperature ramp up, the unit shall be deemed to have entered defrost mode. The *defrost* cycle shall finish before returning to the temperatures recorded at Section H.4.3.1, and the test shall be restarted.