AHRI Standard 1365-2024 (SI/I-P)

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

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ICS Codes: 3.120 and 27.080

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, and users.

Review and Amendment

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

2024 Edition

This edition of AHRI Standard 1365, *Performance Rating of Commercial and Industrial Unitary Air-conditioning and Heat Pump Condensing Units*, was prepared by the AHRI 365 Standards Work Group and the Commercial Unitary Standards Technical Committee. The standard was approved by the Standards Committee on 5 December 2024.

Origin and Development of AHRI Standard 1365

The first edition of AHRI 1340 (SI/I-P) was published in December 2023 to introduce new metrics for commercial and industrial air-conditioners and heat pumps, IVEC, and IVHE. AHRI 1365-2024 (SI/I-P) was created to align the product metrics for split outdoor units greater than or equal to 135,000 Btu/h to be referenced in ASHRAE 90.1 and other efficiency standards.

AHRI Standard 1365-2024 (SI/I-P) does not replace AHRI 365-2009 (I-P) where IEER ratings are required. AHRI 1365-2024 (SI/I-P), to be effective at a later date, should be used for IVEC and IVHE ratings.

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Standards Work Group (SWG)-365 and 1365 Scope:

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Commercial Unitary Standards Technical Committee (STC) Scope:

The Commercial Unitary STC is responsible for the development and maintenance of AHRI standards and guidelines pertaining to Commercial & Industrial Unitary Air-conditioning and Heat Pump Equipment including split systems, remote condensing units, and packaged equipment.

Out of scope: Unitary Small Equipment, Packaged Terminal AC/HP, Furnaces, Variable Refrigerant Systems (VRF), Geothermal and Water Source HP, Single Package Vertical Unit (SPVU), Performance Rating of Zoning products, DX-Dedicated Outdoor Air System Units (DOAS) Demand response and smart grid interface

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

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PERFORMANCE RATING OF COMMERCIAL AND INDUSTRIAL UNITARY AIR-CONDITIONING AND HEAT PUMP CONDENSING UNITS

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 cooling *IVEC* annualized metric and full load *EER2* metric and heat pump *IVHE* and $IVEC_C$ annualized efficiency metrics and full load $COP2_H$ at 47°F (8.3°C), 17°F (-8.3°C), and 5°F (-15°C) for commercial and industrial unitary air-conditioning and heat pump split condensing units.

Section 2. Scope

2.1 Scope

This standard applies to factory-made commercial and industrial air cooled, water cooled and evaporatively cooled unitary air-conditioning and air source heat pump condensing units greater than or equal to 135,000 Btu/h as defined in Section 3.2.

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

2.2 Exclusions

This standard does not apply to the following:

- Commercial and industrial unitary air-conditioning and heat pump equipment with a capacity less than or equal to 135,000 Btu/h (39.5 kW) and greater than or equal to 65,000 Btu/h (19 kW) as defined in AHRI 340/360 (I-P) and AHRI 1340 (I-P)

  Note: Condensing units with a capacity ≤135,000 Btu/h (39.5 kW) are rated as a matched system with fan coil or air handler.

- Air-cooled unitary air-conditioners and unitary heat pumps as defined in AHRI 210/240-2024 (I-P) and AHRI 1600 (I-P), with capacities less than 65,000 Btu/h (19 kW)
- Testing and rating of condensing units for refrigeration purposes, as defined in AHRI 520
- Testing and rating of condensing units for dedicated outdoor air systems, as defined in AHRI 920 (I-P) and AHRI 921 (SI) with Addendum 1
- Potable water heating equipment units covered by AHRI 1300 (I-P) and AHRI 1301 (SI)
- Water-source heat pumps as defined in 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
- Units with adiabatically pre-cooled condensers

2.3 Other Applicable Standards

Commercial and industrial unitary air-conditioning and heat pump outdoor condensing units can be rated using AHRI 365 (SI/I-P).

Section 3. Definitions

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

3.1 Expression of Provisions

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

3.1.1 "Can" or "cannot"

Express an option or capability.

3.1.2 "May"

Signifies a permission expressed by the document.

3.1.3 "Must"

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

3.1.4 "Shall" or "shall not"

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

3.1.5 "Should" or "should not"

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

3.2 Standard-specific Definitions

3.2.1 Air 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 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 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.

3.2.3 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 Commercial and Industrial Unitary Air-conditioning Condensing Unit

A factory-made assembly of refrigeration components designed to compress and liquefy a specific refrigerant that consists of one or more refrigerant compressors, refrigerant condensers such as air cooled, evaporatively cooled, or water cooled, or a combination thereof, condenser fans and motors where used, and factory-supplied accessories.

3.2.5 Commercial and Industrial Unitary Heat Pump Condensing Unit

Commercial unitary heat pump condensing unit that contains one or more factory-made assemblies, that include compressor(s), and an air-cooled outdoor coil(s), including means to provide a heating function.

3.2.6 Cooling Capacity (q_t)

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_l)

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

3.2.6.2 Sensible Capacity (q_{sci})

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

3.2.6.3 Standard Cooling Capacity ($q_{t,A}$)

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.

Note: The measured capacity is gross capacity and the rating standard cooling capacity shall be net capacity including the added heat from the *indoor fan power allowance*.

3.2.7 Ducted Condensing Unit

An air-cooled air conditioner or heat pump condensing unit that has the following characteristics:

- 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 (89 cm) or the unit has components that do not exceed a maximum height of 35 in (89 cm).
- 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 (89 cm).
- The unit has a rated *cooling capacity* greater than or equal to 65,000 Btu/h (19 kW) and less than 300,000 Btu/h (88 kW).

  Note: See Section 5.16 for test requirements for 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 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 39.

3.2.10 Economizer

3.2.10.1 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 38 and Table 39.

3.2.10.2 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.

3.2.11 Energy Efficiency Ratio 2 (EER2)

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

3.2.12 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 39.

3.2.13 Heating Capacity (q_H)

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

Note: The heating capacity measured during the test is gross heating capacity and the rated heating capacity shall be net heating capacity and include the heat due to the *indoor fan power allowance heat*.

3.2.13.1 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 Btu/h.

3.2.13.2 Instantaneous Heating Capacity (q_{Hinst})

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

3.2.14 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 6.3.13.

3.2.15 Indoor Fan Power Allowance

A factor that enables the use of the *IVEC* and *IVHE* metrics to represent the power of the indoor fan. See Section 5.16.

3.2.16 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 (W/W).

3.2.17 Integrated Ventilation and Heating Efficiency (IVHE and $IVHE_C$)

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 (W/W). $IVHE_C$ 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/Wh (W/W).

3.2.18 Low-temperature Compressor Cut-in Temperature

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

Note: See Appendix G for method of test.

3.2.19 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 (°C).

Note: See Appendix G for method of test.

3.2.20 Manufacturer Instructions

3.2.20.1 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 5.3.1.

3.2.20.2 Supplemental Test Instructions (STI)

Additional instructions developed by the manufacturer and certified to the United States Department of Energy (DOE), as specified in Section 5.3.2.

3.2.20.3 Manufacturer-specified

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

3.2.21 Makeup Water

The water supplied to an evaporative cooled condenser to compensate for the water evaporated and for use in control of cycles of concentration and blowdown rate.

3.2.22 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 38.

3.2.23 Operating Levels

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.

3.2.23.1 Boost Heating Operating Level (B)

The *operating level* with the maximum capacity that is allowed by the controls at 17.0°F (-8.3°C) outdoor dry-bulb temperature, with a capacity at 17.0°F (-8.3°C) outdoor dry-bulb temperature that is greater than the capacity of the *high heating operating level* at 17.0°F (-8.3°C). See Section 6.3.6 for requirements.

3.2.23.2 Boost 2 Heating Operating Level (B2)

An *operating level* allowed by the controls at 5.0°F (-15°C) outdoor dry-bulb temperature with a capacity at 5.0°F (-15°C) outdoor dry-bulb temperature that is greater than the capacity of the *boost heating operating level* at 5.0°F (-15°C) outdoor dry-bulb temperature and less than or equal to the maximum capacity allowed by the controls at 5.0°F(-15°C) outdoor dry-bulb temperature. See Section 6.3.6 for requirements.

Note: This is not used in the determination of *IVHE* and is intended to define the maximum *heating capacity* at 5.0 °F (-15 °C).

3.2.23.3 High Heating Operating Level (H)

The *operating level* with the maximum capacity that is allowed by the controls at 47.0°F (8.3°C) outdoor dry-bulb temperature. See Section 6.3.6 for requirements.

3.2.23.4 Low Heating Operating Level (L)

The *operating level* with the minimum capacity that is allowed by the controls at 47.0°F (8.3°C) outdoor dry-bulb temperature. See Section 6.3.6 for requirements.

3.2.23.5 Medium Heating Operating Level (M)

An *operating level* allowed by the controls at 47.0°F (8.3°C) outdoor dry-bulb temperature with a capacity at 47.0°F (8.3°C) outdoor dry-bulb temperature that is greater than the capacity of the *low heating operating level* at 47.0°F (8.3°C) outdoor dry-bulb temperature and less than the capacity of the *high heating operating level* at 47.0°F (8.3°C) outdoor dry-bulb temperature. See Section 6.3.6 for requirements.

3.2.24 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 39.

3.2.25 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*.

3.2.25.1 Application Rating

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

3.2.25.2 International Ratings

A rating based on tests performed at *international rating conditions* as listed in Table 41.

3.2.25.3 Standard Rating

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

3.2.26 Rating Conditions

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

3.2.26.1 International Rating Conditions

Rating conditions used as the basis of comparison for performance characteristics for products sold outside North America as defined in Table 41.

3.2.26.2 Part Load Rating Conditions

Rating conditions used as the basis of calculating the *IVEC* and *IVHE* annualized efficiency metrics as defined in Table 7.

3.2.26.3 Standard Rating Conditions

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

3.2.27 Rating Power

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

3.2.27.1 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.8 for requirements.

3.2.27.2 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.8 for requirements.

3.2.27.3 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.8 for requirements.

3.2.27.4 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.8 for requirements.

3.2.27.5 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.8 for requirements.

Note: For condensing units, a required indoor fan power allowance is used as calculated by Equation 1.

3.2.28 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.

3.2.29 Standard Energy Efficiency Ratio (EER2)

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

3.2.30 Standard Air

Air having a mass density of 0.075 lb (0.034 kg) of dry air per ft^3 (1.201 kg/m^3).

3.2.31 Ventilation Air

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

Section 4. Classifications

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

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

Designation	AHRI Type	Condenser Type	Arrangement
Remote condensing unit	RCU-A	Air	COMPRESSOR CONDENSOR
	RCU-E	Evaporatively	
	RCU-W	Water	
Heat pump remote condensing unit	HRCU-A	Air	COMPRESSOR CONDENSOR

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 and ASHRAE 30 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 Instructions

5.3.1 Manufacturer's Installation Instructions (MII)

Units shall be installed in accordance with the *MII*, as defined in Section 3.2.20.1. 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*.

5.3.2 Supplemental Test Instructions (STI)

STI are defined in Section 3.2.20.2 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 5.3.2(2).

5.3.3 Conflicting Instructions

In the event of conflicting instructions regarding the set-up of the unit under test, excluding charging instructions for condensing units described in Section 5.3.4, priority shall be given to installation instructions that appear on the unit's label over installation instructions that are shipped with the unit.

5.3.4 Instructions for Condensing Units

In the event of conflicting charging instructions for condensing units, 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.

5.4 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 (46.1°C). 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.

5.5 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.

5.6 Auxiliary Heat

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

5.7 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, such as outside of the test tolerances specified in Section 5.19, and testing requirements cannot be met, then the procedures in Section E.6 shall be used.

5.8 Line Length for Condensing units

All *standard ratings* for condensing units where the condensing unit is separated from the indoor section shall be determined with at least 25 ft (7.6 m) 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 (7.6 m). 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 (7.6 m) of tubing, whichever is greater. At least 10 ft (3.0 m) 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 (7.6 m) of tubing is used, the applicable *cooling capacity* correction factor in Table 2 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*.

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

Table 2 Refrigerant Line Length Correction Factors

Tubing length (X) Beyond the Required 25 ft (7.6 m) of Tubing, ft (m)	*Cooling Capacity* Correction Factor
3.3 (1.0) < X ≤ 20 (6.1)	1.01
20 (6.1) < X ≤ 40 (12.2)	1.02
40 (12.2) < X ≤ 60 (18.3)	1.03

5.9 Simulated Indoor Fan Coil

Because this standard is only for rating the condensing unit a simulated indoor heat exchanger needs to be used. For ease of testing, this standard requires that a refrigerant to water heat exchanger and a water test loop be used following the testing procedure outlined in ASHRAE 30 for chiller water systems. The water loop shall have the capabilities for controlling the water temperature for cooling and heating to obtain the rating midpoint saturated suction or midpoint saturated condensing temperature.

Note: The test setup should include an external separately controlled subcooler heat exchanger that can be used to obtain the rating liquid temperature. See Appendix D for testing requirements.

5.10 Refrigerant Charging

5.10.1 Conditions and Criteria

For refrigerant charging 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* contains 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.

5.10.2 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.

5.10.3 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 (-11°C) for fixed orifice systems or set subcooling to a target value of 10°F (-12°C) for expansion valve systems.

5.10.4 Conflicting Information

In the event of conflicting information between charging instructions, use the instruction priority order indicated in Section 5.3. 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 3, 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 3 shall be used.

Table 3 Tolerances for Charging Hierarchy

Expansion Valve		
Priority	**Parameter**	**Tolerance**
1	Liquid Temperature	± 2.0°F (± 1.1°C)
2	High side pressure or saturation temperature	± 4.0 psi (± 27.5 kPa) or ± 1.0°F (± 0.59°C)
3	Low side pressure or saturation temperature	± 2.0 psi (± 13.8 kPa) or ± 0.8°F (± 0.44°C)
4	Approach temperature[1]	± 1.0°F (± 0.59°C)
5	Charge weight	± 1% of nominal charge or 2.0 oz (56 g), whichever is greater

Notes:

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

5.10.4.1 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.

5.10.4.2 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.

5.10.5 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.

5.11 Test Unit Location

5.11.1 Air-Cooled and Evaporatively-Cooled Equipment

A condensing unit shall be located in the outdoor test room, meaning, the test chamber is maintained at the air conditions specified for outdoor ambient air, unless the condensing unit is designed and marketed for indoor installation, for example, a ducted condenser, then the indoor condensing unit shall be located in the indoor test room.

5.11.2 Water-Cooled Equipment

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

5.12 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.

5.13 Instrumentation

5.13.1 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.

5.13.2 Atmospheric Pressure

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

5.13.3 Electrical Frequency

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

5.14 Indoor Fan Power Allowance

5.14.1 Background

To support the use of the IVEC and IVHE rating an allowance shall be included for indoor fan power. The objective is to align with the values that can be used for products rated as matched systems in accordance with AHRI 1340. The *indoor fan power allowance* is based on an assumed operating airflow of 350 cfm/ton (724 L^3/h kW) at full load for the cooling A point and assumes variable air volume operation with 350 cfm/ton (724 L^3/h kW) at each of the part load rating capacities.

Note: The indoor fan power allowances shall be added to the measure cooling and heating capacity measured during the test which is gross capacity and all calculations shall be based on net capacity.

For the cooling IVEC rating the operation the fan speed has been assumed to reduce with the capacity down to the minimum rated capacity but not any lower. The lowest fan speed shall be used for the IVEC ventilation. The values to use are listed in Table 4.

For heat pump heating the indoor fan power allowance is assumed to be the full load cooling A point indoor fan power allowance and is assumed to be held constant for all IVEC heating ratings except for ventilation For heating ventilation the *indoor airflow power allowance* shall be the IVEC D test point indoor fan power allowance. The full load and part load indoor fan power allowance values are listed in Table 5.

The cooling IVEC power allowances are show in Table 4.

Table 4 IVEC Cooling Fan Power Allowance

Full Load Cooling A Point Capacity Btu/h (kW)	Full Load Cooling A Point *Indoor Fan Power Allowance* W/cfm (Wh/m³)	Part Load *Indoor Fan Power Allowance* W/cfm (Wh/m³)	Ventilation *Indoor Fan Power Allowance* W/cfm (Wh/m³)
≥ 135,000 and < 280,000 (≥ 39.5 and < 82.0)	0.432(0.733)	See Equation 1	See Equation 1[1]
≥ 280,000 (≥ 82.0)	0.609 (1.034)	See Equation 1	See Equation 1[1]

Note:

1. Ventilation *fan power allowance* is determined using the lowest load percentage (LP) from the *IVEC* or *IVHE* test points but not less than 24% *ventilation air* based on 400 cfm/ton (827 L^3/h kW), or 27.4% at 350 cfm/ton (724 L^3/h kW).

Table 5 IVHE Heat Pump Fan Power Allowance

Full Load Cooling A Point Capacity Btu/h (kW)	Full load *Indoor Fan Power Allowance* All Heating Test Points W/cfm (Wh/m³)	Ventilation *Indoor Fan Power Allowance* W/cfm (Wh/m³)
≥ 135,000 and < 280,000 (≥ 39.5 and < 82.0)	0.432 (0.733)	See Equation 1[1]
≥ 280,000 (≥ 82.0)	0.609 (1.034)	See Equation 1[1]

Note:

1. Ventilation *indoor fan power allowance* is determined using the lowest load percentage (LP) from the *IVEC* or *IVHE* test points but not less than 24% *ventilation air* based on 400 cfm/ton (827 L³/h kW), or 27.4% at 350 cfm/ton (724 L³/h kW).

5.14.2 Part Load Fan Power Allowance

For part load fan power allowance use the following Equation 1 as a function of the load percentage (LP) shown in Equation 5.

Note: The LP shown in Equation 5 should not be lower than the minimum rating LP that the unit is capable of running.

$$FP_X = FP_A \times (a \times LP^7 + b \times LP^6 + c \times LP^5 + d \times LP^4 + e \times LP^3 + f \times LP^2 + g \times LP + h) \quad (1)$$

Where:

FP_A = Part load fan power allowance (W/cfm)
LP = Load percentage as shown in Equation 5
A = Full load rating point
a = 230.357 (135.583)
b = 947.3889 (557.612)
c = -1604.35 (-944.285)
d = 1443.171 (849.4183)
e = 739.241 (-435.101)
f = 214.9772 (126.5308)
g = -32.7921 (-19.3007)
h = 2.20288 (1.296566)
x = Cooling rating point

5.15 Outdoor Airflow for Units with Free Air Discharge Condensers

All *standard ratings* shall be determined by 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.6.3 or Section E.6.4.

5.16 Outdoor Airflow and ESP for Units with Ducted Condensers

For ratings for applications with ducted condensers, the condensing units shall be rated with 0.5 in (0.12 kPa) condenser ESP using the provisions of Section 5.16.1.

5.16.1 Rating Based on Non-zero Condenser ESP

5.16.1.1 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.

5.16.1.2 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 (- 0.00/+ 0.012 kPa) of 0.5 in H_2O (0.12 kPa). 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 (- 0.00/+ 0.012 kPa) of 0.5 in H_2O (0.12 kPa). If the outdoor air ESP cannot be maintained within - 0.00/+ 0.05 in H_2O (- 0.00/+ 0.012 kPa) of 0.5 in H_2O (0.12 kPa) 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.

5.16.1.3 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 that results in an automatic adjustment to outdoor airflow, for example, using thermostat or other control system input, operate at the outdoor airflow resulting from using the *MII*.

5.16.2 Rating Based on Zero Condenser ESP

5.16.2.1 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. The unit shall operate at 0.0 in H_2O (0.0 kPa) ESP with a condition tolerance of - 0.00/+ 0.05 in H_2O (- 0.00/+ 0.012 kPa). 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 (- 0.00/+ 0.012 kPa) of 0.0 in H_2O (0.0 kPa). 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 (- 0.00/+ 0.012 kPa) of 0.0 in H_2O (0.0 kPa). If the outdoor air ESP cannot be maintained within -0.00/+ 0.05 in H_2O (- 0.00/+ 0.012 kPa) of 0.0 in H_2O (0.0 kPa) 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.

5.16.2.2 Outdoor Air ESP Tolerance

The outdoor air ESP tolerance of - 0.00/+ 0.05 in H_2O (- 0.00/+ 0.012 kPa) 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 5.19.

5.17 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 5.19.

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 5.19.

For heating tests of all air-source heat pumps, entering outdoor air shall be controlled to the wet-bulb temperature requirements in Table 22 and wet-bulb tolerances in Section 5.19.

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

5.18 Water Flow Rate for Water-cooled Condensing 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.6, 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.

5.19 Test Tolerances

5.19.1 Order of Precedence

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

5.19.2 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.

5.19.3 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.

5.19.4 Table of Tolerances

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

5.19.5 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.

Table 6 Tolerances

Measurement	Test Operating Tolerance	Test Condition Tolerance
Outdoor dry-bulb temperature, °F (°C): Entering Leaving	 2.0 (1.1) 2.0/3.0 (1.1/1.67)[1,2]	 0.5 (0.28) —
Outdoor wet-bulb temperature, °F (°C): Entering Leaving	 1.0 (0.56) 1.0 (0.56)[2]	 0.3 (0.17)[3] —
Outdoor dew point temperature[4], °F (°C): Entering	 —	 3.0 (1.67)
Water serving water cooled condenser temperature, °F (°C): Entering Leaving	 0.5 (0.28) 0.5 (0.28)	 0.2 (0.11) 0.2 (0.11)
Water serving water cooled condenser flow rate, when flow rate specified (percent)	2.0	1.0
Evaporative Condenser Makeup water temperature, °F (°C)	10.0 (5.5)	5.0 (2.8)
Midpoint Saturated refrigerant temperature[5], °F (°C):	3.0 (1.7)	0.5 (0.28)
Liquid refrigerant temperature[5], °F (°C):	0.5 (0.28)	0.2 (0.11)
Midpoint Saturated Condensing temperature, °F (°C):	3.0 (1.7)	0.5 (0.28)
Electrical voltage (percent of reading)	2.0	1.0
Electrical Frequency[6], Hz	0.4	0.2
Water flow rate (percent of reading)	2.0	See Section 5.18

Notes:
1. The test operating tolerance is 2.0°F (1.1°C) for cooling tests and 3.0°F (1.7°C) 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 5.17.
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 5.17.
5. See Section 5.19.5.
6. When using electrical generators, tolerances can be doubled.

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 22.
- 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 (P_C)

During all modes of cooling operation.

6.1.2.3.2 Condenser Section Power (P_{CD})

During all modes of cooling operation.

6.1.2.3.3 Indoor Fan Power Allowance (P_{IF})

Because this standard only applies to the condensing unit, an *indoor fan power allowance* 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 (9.4°C) shall be used based on Section 5.16.

6.1.2.3.4 Crankcase Heat and Control Power for All Cooling Only Units (P_{CCH} and P_{CT})

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 (P_{CCH} and P_{CT})**

IVEC includes the crankcase heat power during cooling and ventilation greater than the ambient changeover temperature of 49°F (9.4°C).

Note: *Crankcase heat power* at temperatures less than or equal to 49°F (9.4°C) 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 (P_C)**

During all modes of heating operation.

6.1.2.4.2 **Condenser Section Power (P_{CD})**

During all modes of heating operation.

6.1.2.4.3 **Indoor Fan Power Allowance (P_{IF})**

Because this standard only covers the condensing unit, an 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 (9.4°C). This shall be based on assuming the same cfm as cooling and the airflow during mechanical heat pump heating shall be assumed to be full load airflow based on a nominal 350 cfm/ton (724 L^3/h kW) using a fan power allowance as described in Section 5.16. For ventilation the lowest rated airflow from cooling shall be used to determine the fan power allowance.

6.1.2.4.4 **Crankcase Heat and Control Power (P_{CCH} and P_{CT})**

IVHE includes the *crankcase heat power* during heating and ventilation at or below the ambient changeover temperature of 49°F (9.4°C).

Note: Crankcase heat power at temperatures greater than 49°F (9.4°C) 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 **Standards Ratings for Water Cooled Equipment**

Standard ratings for water cooled equipment shall be based on a fouling factor of 0.0000 h ft^2 °F/Btu (0.0000 m^2K/kW).

6.1.4 **Standards Ratings for Ducted condenser Systems**

Standard ratings for *double-duct systems* shall be established in accordance with Section 5.16.1.

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 using the fan power allowance defined in Section 5.16.

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. The *IVEC* for the condensing unit shall include the fan power allowance defined in Section 5.16.

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-1340-i-p-performance-rating-commercial-and-industrial-unitary-air-conditioning-and-heat-pump.

Note: The *IVEC* calculations are complex and for SI rating and test results, the values should be converted to I-P and the calculations run and then convert the results to SI. The spreadsheet tool referenced above can be used for this calculation approach.

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
Condenser (air cooled)				
Entering air dry-bulb temperature, °F (°C)	95.0 (35.0)	85.0 (29.4)	75.0 (23.9)	65.0 (18.3)
Entering air dew point[2], °F (°C)	60.5 (15.8)	56.5 (13.6)	56.5 (13.6)	56.5 (13.6)
Entering air wet-bulb temperature[3], °F (°C)	75.0 (23.9)	66.0 (18.9)	58.0 (14.4)	53.0 (11.7)
Condenser airflow[4]				
Condenser (water cooled)				
Entering water temperature, °F (°C)	85.0 (29.4)	74.0 (23.3)	66.0 (18.9)	61.0 (16.1)
Leaving water temperature, °F (°C)	95.0 (35.0)	—	—	—
Water flow rate: See Section 5.18				
Indoor Fan Power Allowance	See Table 4	See Table 4	See Table 4	See Table 4
Compressor Midpoint Suction Saturated Suction Temperature, °F (°C)	50.0 (10.0)	50.0 (10.0)	50.0 (10.0)	50.0 (10.0)
Compressor Suction Superheat, °F (°C)	15.0 (8.3)	15.0 (8.3)	15.0 (8.3)	15.0 (8.3)
Tower fan and pump power rate (TFPPR), W/(Btu/h) (W/kW)	0.0094 (0.0321)	0.0066 (0.0225)	0.0053 (0.181)	0.0048 (0.0164)
Condenser (evaporatively cooled)				
Entering air dry-bulb temperature, °F (°C)	95.0 (35.0)	85.0 (29.4)	75.0 (23.9)	65.0 (18.3)
Entering air wet-bulb temperature, °F (°C)	75.0 (23.9)	66.0 (18.9)	58.0 (14.4)	53.0 (11.7)
Makeup water temperature, °F (°C)	85.0 (29.4)	77.0 (25.0)	77.0 (25.0)	77.0 (25.0)
Condenser airflow[4]				

Notes:
1. Refer to Section 5.16 for indoor airflow and *indoor fan power*.
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 5.17.
3. Applies only to air-cooled units that reject condensate to the outdoor coil. See Section 5.17.
4. Refer to Section 5.15 and Section 5.16 for outdoor airflow and external static pressure.

6.2.3 Measure Cooling Capacity Adjustment

The test capacity measured during laboratory testing is gross capacity and does not include the heat from the *indoor fan power allowance* the measured test capacity shall be adjusted for *the indoor fan power allowance* using Equation 2.

$$q_{t,i} = q_{measured} - P_{IF} \times 3412 \qquad \mathbf{2}$$

Where:

q_t	=	measure cooling capacity adjusted for fan power allowance (Btu/h)
$q_{measured}$	=	measured capacity from test for A, B, C, and D tests
i	=	performance test A, B, C, and D

6.2.4 Load Percentages

The load percentage for a mechanical cooling test is determined using Equation 3.

$$Load\ percentage\ (LP) = 100 \times \frac{q_t}{q_{t,A}} \qquad \mathbf{3}$$

Where:

Load percentage (LP)	=	Mechanical cooling load percentage for tests B, C, and D, %
q_t	=	The net cooling capacity determined for the tests B, C, and D adjusted for *indoor fan power allowance* using Equation 2, Btu/h (kW)
q_{tA}	=	The cooling capacity measured for the full-load cooling test in Section 6.2.6, Btu/h (kW)

6.2.5 Full-load Test for Cooling Bin A Rating Point

Perform a full-load test using the prescribed 350 cfm/ton (724 L^3/h kW) air flow and calculated *indoor fan power allowance* at the conditions specified for cooling bin A rating point in Table 7, and perform all applicable capacity adjustments in Section 6.2.3.

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

For each cooling bin B through bin 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 8 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 8 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 8 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 8 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 fan power allowance based on 350 cfm/ton (724 L^3/h kW) for the cooling bin. Perform all applicable capacity adjustments in Section 6.2.3.

6.2.6.2.2 Capacity Adjustment

Calculate the capacity adjustment for the cooling bin using Equation 4. 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.

$$q_{t,adj} = q_{t,X} - 0.01 \times TLP \times q_{t,A} \quad (4)$$

Where:

$q_{t,adj}$	=	Capacity adjustment, Btu/h (kW)
$q_{t,X}$	=	The *cooling capacity* determined for the test in Section 6.2.6.2.1, Btu/h (kW)
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 (kW)

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 9. The calculated value is used in Section 6.2.6.5.

Table 9 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, W
Condenser section (P_{CD})	*Condenser section power* determined from the test in Section 6.2.6.2.1, W
Indoor fan (P_{IF})	*Indoor fan power* determined using the *indoor fan power allowance* determined from Section 5.16, W
Controls (P_{CT})	*Controls power* determined from the test in Section 6.2.6.2.1, W
Tower fan and condenser water pump	For water-cooled condensing units see Equation 5, W For all other units: 0.0

Equation 5 calculates tower fan and condenser water pump power expressed in W.

$$q_{t,X} \times \text{TFPPR} \quad (5)$$

Where:

$q_{t,X}$	=	The cooling capacity determined from the test for this cooling bin in Section 6.2.6.2.1, Btu/h (W)°
TFPPR	=	The cooling tower fan and condenser water pump power rate for this cooling bin in Table 7, W/(Btu/h) (W/kW)

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 10. The calculated value is used in Section 6.2.6.5.

Table 10 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, W
Condenser section (P_{CD})	*Condenser section power* determined from the test in Section 6.2.6.2.1, W
Indoor fan (P_{IF})	*Indoor fan power allowance* determined using the *indoor fan power* determined from Section 5.16, W
Controls (P_{CT})	*Controls power* determined from the test in Section 6.2.6.2.1, W
Tower fan and condenser water pump	For water-cooled condensing units see Equation 5, W 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 11. The calculated value is used in Section 6.2.6.5.

Table 11 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 allowance* determined for the full-load test in Section 6.2.5 For cooling bin D: *indoor fan power* determined using the *indoor fan power* determined from Section 5.16, W
Controls (P_{CT})	*Controls power* determined for the full-load test in Section 6.2.5, W
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, W 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 8 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 8 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 adjustments in Section 6.2.3.

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 6.

$$X = \frac{TLP - LP_{LR}}{LP_{HR} - LP_{LR}} \quad (6)$$

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 12, 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 12 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 allowance* determined using the *indoor fan power* determined from Section 5.16, W	*Indoor fan power allowance* determined using the *indoor fan power* determined from Section 5.16, 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 condensing units see Equation 7, W. For all other units: 0.0	For water-cooled condensing units see Equation 8, W. For all other units: 0.0

Symbol in Table 12:

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

Equation 7 calculates the higher operating level tower fan and condenser water pump power. Equation 8 calculates the lower operating level tower fan and condenser water pump power.

$$q_{HR} \times \text{TFPPR} \quad (7)$$

$$q_{LR} \times \text{TFPPR} \qquad \textbf{8}$$

Where:

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

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

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

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 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 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, 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 using the *indoor fan power* determined from Section 5.16, W	*Indoor fan power* determined using the *indoor fan power* determined from Section 5.16, 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 condensing units see Equation 7, W For all other units: 0.0	For water-cooled condensing units see Equation 8, W For all other units: 0.0

Symbol in Table 13:

- 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 14. The calculated value is used in Section 6.2.6.5.

Table 14 Coefficient and Component Power Values for Economizer-only Mode

Component	Power Value in Watts
Indoor fan (P_{IF})	For cooling bin B and bin C: *indoor fan power allowance* W using the *indoor fan power allowance* determined from Section 5.16. For cooling bin D see Equation 9.
Controls (P_{CT})	*Controls power* determined for the full-load test in Section 6.2.5
Crankcase heater (P_{CCH})	If *crankcase heat power* is measured in *controls power*: Sum of the *manufacturer-specified crankcase heat power* W 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 14:

- X = higher-level operating fraction calculated in accordance with Section 6.2.6.3.3
- $P_{IF,LR}$ = *indoor fan power* determined using the *indoor fan power* determined from Section 5.16, W
- $P_{IF,HR}$ = *Indoor fan power* determined using the *indoor fan power* determined from Section 5.16, W

Equation 9 calculates *indoor fan power*.

$$P_{IF} = (1 - X) \times P_{IF,LR} + X \times P_{IF,HR} \quad (9)$$

Where:

X	=	Higher-level operating fraction calculated in accordance with Section 6.2.6.3.3
$P_{IF,LR}$	=	Indoor fan power determined 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 adjustments in Section 6.2.3.

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 15, 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 15 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 11, expressed in W If crankcase heat is included in *compressor power:* calculate using Equation 12, expressed in W	$P_C = 0.0$
Condenser section (P_{CD})	Calculate using Equation 13, expressed in W	$P_{CD} = 0.0$
Indoor fan (P_{IF})	*Indoor fan power* using the *indoor fan power allowance* determined from Section 5.16, W	*Indoor fan power allowance* using the *indoor fan power* determined from Section 5.16
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 heater (P_{CCH})	If crankcase heat is included in *controls power*: 0.0 If crankcase heat is included in *compressor power*: $P_{CCH,NOC}$, W	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 condensing units see Equation 10, W For all other units: 0.0	0.0

Equation 10 calculates tower fan and condenser pump power. Equation 11 calculates *compressor power* if crankcase heat is included in *controls power*. Equation 12 calculates *compressor power* if crankcase heat is included in *compressor power*. Equation 13 calculates condenser section power.

$$q_t \times \text{TFPPR} \quad \textbf{10}$$

$$P_C = C_d \times P_C \quad \textbf{11}$$

$$P_C = C_d \times (P_C - P_{CCH,NOC}) \quad \textbf{12}$$

$$P_{CD} = C_d \times P_{CD} \quad \textbf{13}$$

Where:

TFPPR	=	The cooling tower fan and condenser water pump power rate for this cooling bin in Table 7, W/(Btu/h) (W/kW)
q_t	=	The *cooling capacity* determined from the test in Section 6.2.6.4.1, Btu/h (kW)
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 15 and Table 16:

- 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 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 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 11, expressed in W If crankcase heat is included in *compressor power* calculate using Equation 12, expressed in W	$P_C = 0.0$
Condenser section (P_{CD})	Calculate using Equation 13, expressed in W	$P_{CD} = 0.0$
Indoor fan (P_{IF})	*Indoor fan power allowance* using the *indoor fan power* determined from Section 5.16, expressed in W	*Indoor fan power allowance* determined using the *indoor fan power* determined from Section 5.16
Controls (P_{CT})	*Controls power* determined from the test in Section 6.2.6.4.1, expressed in W	*Controls power* determined from the test in Section 6.2.6.4.1
Crankcase heater (P_{CCH})	If crankcase heat is included in *controls power*: 0.0 W	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*: $P_{CCH,NOC}$, W	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 condensing units: See Equation 10 For all other units: 0.0 W	0.0 W

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 17. The calculated value is used in Section 6.2.6.5.

Table 17 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* using the *indoor fan power* determined from Section 5.16, W
Controls (P_{CT})	*Controls power* determined for the full-load test in Section 6.2.5, W
Crankcase heater (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, W 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 14 and the operating hours for each operating mode of the cooling bin in Table 18. 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 14.

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 14.

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 14.

$$E_i = h_{MO} \times P_{MO} + h_{IE} \times P_{IE} + h_{EO} \times P_{EO} \quad (14)$$

Where:

E = Energy consumption for the cooling bin, Wh

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 18 Operating Hours for All Mechanical Cooling Bins and Operating Modes

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

6.2.7 Ventilation Energy Consumption

Calculate ventilation energy consumption in Wh by taking the sum of all power consumption values in the power value in watts column of Table 19 and multiplying that sum by 338 hours. The calculated value is used in Section 6.2.9.

Table 19 Component Power Values for Ventilation Mode

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

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 20 using Equation 15.

$$P_S = P_{CCH} + P_{CT} \qquad \textbf{15}$$

For air conditioners, calculate standby energy consumption in Wh by multiplying the standby power by 4202 hours using Equation 16.

$$E_S = P_S \times 4202 \qquad \textbf{16}$$

For heat pumps, calculate standby energy consumption in Wh by multiplying the standby power by 1297 hours using Equation 17.

$$E_S = P_S \times 1297 \qquad \textbf{17}$$

The calculated value is used in Section 6.2.9.

Table 20 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, W
Crankcase heater (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, W If crankcase heat power is measured in compressor power: Sum of the *manufacturer-specified crankcase heat power* values for all compressors ,W

6.2.9 Cooling Annualized Efficiency Metric Calculation (IVEC)

Calculate *IVEC* in units of Btu/(Wh) (W/W) using Equation 18.

$$IVEC(IP) = \frac{977.658 \times q_{t,A} + 185 \times q_{t,adj,B} + 862 \times q_{t,adj,C} + 1293 \times q_{t,adj,D}}{E_B + E_C + E_D + E_V + E_S} \quad (18)$$

$$IVEC(SI) = \frac{IVEC(IP)}{3.412}$$

Where:

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

$q_{t,adj,B}$ = 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 (W)

$q_{At,adj,C}$ = 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 (W)

$q_{t,A,adj,D}$ = 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 (W)

E_B = Energy consumption for cooling bin B calculated in Section 6.2.6.5, Wh

E_C = Energy consumption for cooling bin C calculated in Section 6.2.6.5, Wh

E_D = Energy consumption for cooling bin D calculated in Section 6.2.6.5, Wh

E_V = Ventilation energy consumption calculated in Section 6.2.7, Wh

E_S = Standby energy consumption calculated in Section 6.2.8, Wh

6.2.10 Full load Efficiency Metric Calculation (EER2)

Calculate *EER2* in units of Btu/(Wh) (W/W) using Equation 19.

$$EER2 = \frac{q_{t,A}}{P_{C,A}+P_{CD,A}+P_{IF,A}+P_{CT,A}+TFPPR \times q_{t,A}} \quad (19)$$

$$COP2_C = \frac{EER2}{3,412}$$

Where:

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

$P_{C,A}$ = *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

$P_{IF,A}$	=	Using the *indoor fan power* determined from Section 5.16, 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 condensing units: 0.0094 W/(Btu/h) (W/kW) 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 shown in Table 22 (Table 23) and calculated in accordance with Equation 59. $COP2_{H,47}$ 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 (8.3°C).

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.

Note: Because this is a condensing unit only rating standard, an *indoor fan power allowance* is used so that a representative $COP2_H$ that is comparable to a full system $COP2_H$ can 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 shown in Table 22 (Table 23) and calculated in accordance with Equation 59. Capacity is an integrated capacity and reflects the impact of the default degradation *defrost* factor. The $COP2_{H,17}$ includes the impact of the *indoor fan power allowance* so that the value is representative and comparable to a full system.

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 shown in Table 22 (Table 23) and calculated in accordance with Equation 59. Capacity is an integrated capacity and reflects the impact of the default degradation *defrost* factor. The $COP2_{H,5}$ includes the impact of the *indoor fan power allowance* so that the value is representative and comparable to a full system.

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 (9.4°C), and *crankcase heat power* applicable to heating operating and standby below 49°F (9.4°C). 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 57 and the procedures in Section 6.3.2.

The *IVHE* for a condensing unit rating includes an allowance for *indoor fan power* so that the metric is representative of a full system including the indoor fan coil.

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-1340-i-p-performance-rating-commercial-and-industrial-unitary-air-conditioning-and-heat-pump.

Note: Because of the complexity and the number of calculations, the procedure is in I-P units, but for SI data the test and rating results should be converted to I-P and the calculations run and then covert the output to SI units. The spreadsheet tool can be used for this procedure.

6.3.2 Heating Metric Calculation Summary

Determine IVHE or $IVHE_C$ using Section 6.3.3 through Section 6.3.12.

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 6.3.13.

6.3.3 Building Load Profile and Heating Bins

Table 21 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 21 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 (°C)	*Defrost* Degradation Coefficient, CD_{DFi}[3]	Operating hours, h_i	Outdoor Dry-bulb Temperature, T_i, °F (°C)	*Defrost* Degradation Coefficient, CD_{DFi}[3]
1	404	45.0 (7.2)	1.00000	594	41.5 (5.3)	1.00000
2	404	41.4 (5)	1.00000	587	37.0 (2.8)	0.91000
3	351	37.7 (3.2)	0.93100	532	31.6 (-0.2)	0.86870
4	247	33.3 (0.7)	0.85983	396	25.6 (-3.6)	0.89283
5	158	29.4 (-1.4)	0.87878	264	20.0 (-6.7)	0.90688
6	90	26.2 (-3.2)	0.89088	151	15.7 (-9.1)	0.91336
7	50	23.4 (-4.8)	0.89921	90	12.2 (-11.0)	0.91654
8	25	21.0 (-6.1)	0.90488	43	9.5 (-12.5)	0.91805
9	11	18.1 (-7.7)	0.91014	16	6.4 (-14.2)	0.91906
10	5	15.9 (-8.9)	0.91312	7	2.2 (-16.5)	0.91978

Notes:

1. Based on a 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 20.

$$q_{H,BLi} = \frac{q_{t,A} \times HCR \times (0.1 \times i - 0.05)}{1.15} \quad \textbf{20}$$

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 (W)

HCR = The heat-to-cool ratio, based on bin 10 building load divided by cooling $q_{t,A}$ 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 21. The calculated value is used in Section 6.3.12.

$$TASH = \sum_{i=1}^{10} (h_i \times q_{H,BLi}) \quad \textbf{21}$$

Where:

$TASH$ = Total annual space heating, Btu (W)

i = Heating bin number, 1 through 10

h_i = Operating hours in Table 21 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

6.3.6.1 Provisions Applicable to All Heating Tests

Perform all tests designated as required for the unit's configuration in Table 22 (Table 23). Perform all manufacturer-specified tests designated as optional for the unit's configuration in Table 22 (Table 23).

For each test, use the outdoor air entering temperatures specified in Table 22 (Table 23), an indoor entering dry-bulb temperature of 70.0°F (21.1°C), and an indoor entering wet-bulb temperature not higher than 60.0°F (15.5°C).

Adjust the measured heating capacity, gross capacity, to account for the heat of the *indoor fan power allowance* using Equation 22.

$$q_{H,,L} = q_{H,measured} + P_{IF,L} \times 3412 \quad (22)$$

Where:

q_H = Rating point from Table 22 capacity, Btu/h
PIF = Indoor fan power allowance, W
L = Test name from Table 22

Table 22 Heating Tests (I-P)

Test Name	System Configuration			Outdoor Air Condition		Indoor Coil Conditions		Heating Operating Level[1]
	Single Operating Level	Two *Operating Levels*	More than Two *Operating Levels*	Dry Bulb (°F)	Wet Bulb (°F)	Midpoint Saturated Condensing Temperature (°F)	Liquid Temperature (°F)	
H47H	Required	Required	Required	47.0	43.0	109.0	100.0	High
H17H	Required	Required	Required	17.0	15.0	97.0	87.0	High
H5H	Optional	Optional	Optional	5.0	4.0 (max)	92.0	82.0	High
H47M	—	Optional	Optional	47.0	43.0	Equation 26	Equation 32	Medium
H17M	—	Optional	Optional	17.0	15.0	Equation 27	Equation 33	Medium
H47L	—	Optional	Optional	47.0	43.0	Equation 28	Equation 34	Low
H17L	—	Optional	Optional	17.0	15.0	Equation 27	Equation 33	Low
H17B	—	—	Optional	17.0	15.0	Equation 27	Equation 33	*Boost*
H5B	—	—	Optional	5.0	4.0 (max)	Equation 28	Equation 34	*Boost*
H5B2	—	—	Optional	5.0	4.0 (max)	Equation 28	Equation 34	*Boost 2*

Note:
1. See definitions of heating *operating levels* in Section 3.2.23 and requirements in Section 6.3.6.

Table 23 Heating Tests (SI)

Test Name	System Configuration			Outdoor Air Condition		Indoor Coil Conditions		Heating Operating Level[1]
	Single Operating Level	Two *Operating Levels*	More than Two *Operating Levels*	Dry-bulb (°C)	Wet-bulb (°C)	Midpoint Saturated Condensing Temperature (°C)	Liquid Temperature (°C)	
H47H	Required	Required	Required	8.3	43.0	42.8	37.8	High
H17H	Required	Required	Required	-8.3	15.0	36.1	30.5	High
H5H	Optional	Optional	Optional	-15.0	-15.5 (max)	33.3	27.8	High
H47M	—	Optional	Optional	-15.0	6.1	Equation 29	Equation 35	Medium
H17M	—	Optional	Optional	-8.3	-9.4	Equation 30	Equation 36	Medium
H47L	—	Optional	Optional	8.3	6.10	Equation 31	Equation 37	Low
H17L	—	Optional	Optional	-8.3	9.4	Equation 30	Equation 36	Low
H17B	—	—	Optional	-8.3	9.4	Equation 30	Equation 36	*Boost*
H5B	—	—	Optional	-15.0	-15.5 (max)	Equation 31	Equation 37	*Boost*
H5B2	—	—	Optional	-15.0	-15.5 (max)	Equation 31	Equation 37	*Boost 2*

Note:

1. See definitions of heating *operating levels* in Section 3.2.23 and requirements in Section 6.3.6.

Determine the heating load capacity ratio for I-P using Equation 23, Equation 24, and Equation 25.

$$HPLR_{47} = \frac{q_{H,i,47,x}}{q_{H,i,47H}} \quad (23)$$

$$HPLR_{17} = \frac{q_{H,i,17,x}}{q_{H,i,17H}} \quad (24)$$

$$HPLR_{5} = \frac{q_{H,i,5,x}}{q_{H,i,5H}} \quad (25)$$

Where:

$q_{H,47x}$ = The part load or *boost* integrated test capacity at 47°F (8.3°C) ambient

$q_{H,17x}$ = The part load or *boost* integrated test capacity at 17°F (-8.3°C) ambient

$q_{H,5x}$ = The part load or *boost* integrated test capacity at 5° F (-15°C) ambient

$q_{H,47H}$ = The full load integrated test capacity at 47°F (8.3°C) ambient

$q_{H,17H}$ = The full load integrated test capacity at 17°F (-8.3°C) ambient

$q_{H,5H}$ = The full load integrated test capacity at 5°F (-15°C) ambient

x = capacity at *boost*, medium, and low

Determine the test midpoint saturated condensing temperature using Equation **26** through Equation **31**.

For I-P units expressed in °F, use Equation 26, Equation 27, and Equation 28.

$$SCT_{47} = 39\ x\ HPLR_{47} + 70 \quad \textbf{26}$$

$$SCT_{17} = 27\ x\ HPLR_{17} + 70 \quad \textbf{27}$$

$$SCT_{5} = 22\ x\ HPLR_{5} + 70 \quad \textbf{28}$$

For SI units expressed in °C, use Equation **29**, Equation **30**, and Equation **31**.

$$SCT_{47} = 21.7\ x\ HPLR_{47} + 21.1 \quad \textbf{29}$$

$$SCT_{17} = 15\ x\ HPLR_{17} + 21.1 \quad \textbf{30}$$

$$SCT_{5} = 12.2\ x\ HPLR_{5} + 21.1 \quad \textbf{31}$$

Where:

SCT_X = The midpoint saturated condenser temperature, °F (°C)

Determine the test liquid temperature using Equation 32 through Equation 37.

For I-P units expressed in °F, use Equation **32**, Equation **33**, and Equation **34**.

$$LiqT_{47} = 30\ x\ HPLR_{47} + 70 \quad \textbf{32}$$

$$LiqT_{17} = 17\ x\ HPLR_{17} + 70 \quad \textbf{33}$$

$$LiqT_{5} = 12\ x\ HPLR_{5} + 70 \quad \textbf{34}$$

For SI units expressed in °C, use Equation 35, Equation 36, and Equation 37.

$$LiqT_{47} = 11.1\ x\ HPLR_{47} + 21.1 \quad \textbf{35}$$

$$LiqT_{17} = 9.4\ x\ HPLR_{17} + 21.1 \quad \textbf{36}$$

$$LiqT_{5} = 6.7\ x\ HPLR_{5} + 21.1 \quad \textbf{37}$$

Where:

$LiqTx$ = The liquid refrigerant temperature leaving the condensing unit

6.3.6.2 High Heating Operating Levels

Run all tests specified as high heating operating level in Table 22 (Table 23) with the operating level that has the maximum capacity allowed by the controls at 47.0°F (8.3°C) outdoor dry-bulb temperature.

6.3.6.3 Medium Heating Operating Levels

Run all tests specified as *medium heating operating level* in Table 22 (Table 23) with an operating level allowed by the controls at 47.0°F (8.3 °C) outdoor dry-bulb temperature that has a capacity at 47.0°F (8.3°C) outdoor dry-bulb temperature that is greater than the capacity of the *low heating operating level* at 47.0°F (8.3°C) outdoor dry-bulb temperature and less than the capacity of the *high heating operating level* at 47.0°F (8.3°C) outdoor dry-bulb temperature.

6.3.6.4 Low Heating Operating Levels

Run all tests specified as *low heating operating level* in Table 22 (Table 23) with the operating level that has the minimum capacity allowed by the controls at 47.0°F (8.3°C) outdoor dry-bulb temperature.

6.3.6.5 Boost Heating Operating Levels

Run all tests specified as *boost heating operating level* in Table 22 (Table 23) with the operating level that has the maximum capacity allowed by the controls at 17.0°F (8.3°C) outdoor dry-bulb temperature.

6.3.6.6 Boost 2 Heating Operating Levels

Run the H5B2 test in Table 22 (Table 23) only if there is an operating level allowed by the controls at 5.0°F (-15°C)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 (-15°C) outdoor dry-bulb temperature or $COP2_{H,5}$, or both. Run the H5B2 test in Table 22 (Table 23) with an operating level allowed by the controls at 5.0°F (-15°C) outdoor dry-bulb temperature that has a capacity at 5.0°F (-15°C) outdoor dry-bulb temperature that is greater than the capacity of the *boost heating operating level* at 5.0°F (-15°C) outdoor dry-bulb temperature and less than or equal to the maximum capacity allowed by the controls at 5.0°F (-15°C) outdoor dry-bulb temperature. 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 22 (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.

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

6.3.7 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 38 for bin temperatures between 17°F (-8.3°C) and 47°F (8.3°C). Use Equation 38 for bin temperatures less than 17°F if the unit has a pair of tests at the same operating level at 17°F (-8.3°C) and 47°F (8.3°C), and the unit does not have a pair of tests at the same operating level at 5°F (-15°C) and 17°F (-8.3°C).

Use Equation 39 for bin temperatures less than 17°F (-8.3°C) if the unit has a pair of tests at the same operating level at 5°F (-15°C) and 17°F (-8.3°C). For the *boost* operating level, use Equation 39 for bin temperatures less than or equal to 21°F (-6.1°C) if the unit has a pair of tests at the *boost* operating level at 5°F (-15°C) and 17°F (-8.3°C).

$$q_{H,i,X} = CD_{DFi} \times \left[q_{H,inst,X}(17) + \left(q_{H,inst,X}(47) - q_{H,inst,X}(17)\right) \times \frac{T_i - 17}{30}\right] \text{(I-P)} \quad 38$$

$$q_{H,i,X} = CD_{DFi} \times \left[q_{H,inst,X}(5) + \left(q_{H,isnt,X,}(17) - q_{H,instX}(5)\right) \times \frac{T_i - 5}{12}\right] \text{(I-P)} \quad 39$$

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 21
$q_{H,inst,X(17)}$	=	The *instantaneous heating capacity* determined for operating level X at 17°F (-8.3°C) 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
Ti	=	Outdoor dry-bulb temperature for heating bin *i*, from Table 21, °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

6.3.8 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 40 for bin temperatures between 17°F (-8.3°C) and 47°F (8.3°C). Use Equation 40 for bin temperatures less than 17°F (-8.3°C) if the unit has a pair of tests at the same operating level at 17°F (-8.3°C) and 47°F (8.3°C), and the unit does not have a pair of tests at the same operating level at 5°F and 17°F.

Use Equation 41 for bin temperatures less than 17°F (-8.3°C) if the unit has a pair of tests at the same operating level at 5°F and 17°F (-8.3°C). For the *boost* operating level, use Equation 41 for bin temperatures less than or equal to 21°F (-6.1°C) if the unit has a pair of tests at the *boost* operating level at 5°F (-15°C) and 17°F (-8.3°C).

$$P_{Y,X,i} = P_{Y,X}(17) + \left(P_{Y,X}(47) - P_{Y,X}(17)\right) \times \frac{T_i - 17}{30} \text{ (I-P)} \quad \textbf{40}$$

$$P_{Y,X,i} = P_{Y,X}(5) + \left(P_{Y,X}(17) - P_{Y,X}(5)\right) \times \frac{T_i - 5}{12} \text{ (I-P)} \quad \textbf{41}$$

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 (-8.3°C) 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 (8.3°C) outdoor dry-bulb temperature in Section 6.3.6, W
T_i	=	Outdoor dry-bulb temperature for heating bin *i*, from Table 21, °F (°C)
$P_{Y,X}(5)$	=	Power determined for component Y at operating level X at 5°F (-15°C) outdoor dry-bulb temperature in Section 6.3.6, W

6.3.9 Heating Bin Energy Consumption

For each heating bin, perform the following three steps:

1) Determine the heating bin cut-out factor in Section 6.3.9.1.
2) Determine the method for calculating the heating bin power in Section 6.3.9.2.
3) Calculate the heating bin power using one of Section 6.3.9.3 through Section 6.3.9.6, as applicable.

Finally, calculate the total annual energy consumption for all heating bins using Section 6.3.9.7.

6.3.9.1 Heating Bin Cut-out Factor (δ)

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

Note: See Appendix G 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.

6.3.9.2 Method for Determining Heating Bin Power

6.3.9.2.1 Cut-out Factor Equal to Zero

Determine the heating bin power using Section 6.3.9.3 if the heating bin cut-out factor is equal to zero.

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

Determine the heating bin power using Section 6.3.9.4 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 6.3.7 for the heating bin.

6.3.9.2.3 Interpolation Between Two Operating Levels

Determine the heating bin power using interpolation in Section 6.3.9.5 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 6.3.7 for the heating bin.
3) The building load for the heating bin is greater than or equal to the minimum capacity calculated in Section 6.3.7 for the heating bin.

6.3.9.2.4 Cyclic Degradation

Determine the heating bin power using cyclic degradation in Section 6.3.9.6 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 6.3.7 for heating bin.

6.3.9.3 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 6.3.9.7.

Table 24 Heating Component Power Values

Component	Power Value in Watts
Indoor fan (P_{IF})	$P_{IF,H17H}$ based on the *indoor fan power allowance* as described in Section 5.16
Controls (P_{CT})	*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 5.6	See Equation 42, 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 allowance* determined for the H17H test, W

Equation 42 shows how to determine auxiliary heat power, measured in W.

$$P_{aux} = \frac{q_{H,BLi}}{3.412} - P_{IF,H17H} \qquad \textbf{42}$$

6.3.9.4 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 43.

$$P_T = P_C + P_{CD} + P_{IF} + P_{CT} \qquad \textbf{43}$$

The calculated value is used in Section 6.3.9.7.

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 6.3.8 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 6.3.8 for the highest operating level in this heating bin (that is, *boost* or high)	0.0
Indoor fan (P_{IF})	*Indoor fan power allowance* calculated in Section 5.16 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 5.6 (P_{aux})	See Equation 44, expressed in W	See Equation 45, expressed in W

Symbol used in Table 25:

- δ = Cut-out factor for the heating bin

Where Equation 44 calculates *auxiliary heat* power while the compressor(s) is operating. Where Equation 45 calculates *auxiliary heat* power while the compressor(s) is not operating.

$$P_{aux} = \frac{q_{H,BLi} - q_H}{3.412}\ \mathrm{W} \qquad \textbf{44}$$

$$P_{aux} = \frac{q_{H,BLi}}{3.412} - \mathrm{P}_{IF,H17H}\ \mathrm{W} \qquad \textbf{45}$$

Where:

qH,BLi = Building load calculated in Section 6.3.4 for the heating bin, Btu/h

qH = *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 allowance* determined for the H17H test, W

6.3.9.5 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 6.3.7 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 6.3.7 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 6.3.9.5.1.

Use Section 6.3.9.5.2 to calculate the power for the heating bin.

6.3.9.5.1 Higher-level Operating Fraction

Calculate the higher-level operating fraction for I-P units using Equation 46.

$$X_{HR} = \frac{q_{H,BL} - q_{H,Z}}{q_{H,HR} - q_{H,LR}} \quad \textbf{46}$$

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

$q_{H,Z}$ = Integrated capacity calculated in Section 6.3.7 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

6.3.9.5.2 Calculate Power

Using the lower and higher *operating levels* for the heating bin determined in Section 6.3.7, 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 6.3.9.7.

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 6.3.8 for the higher operating level	*Compressor power* calculated in Section 6.3.8 for the lower operating level	0.0
Condenser section (P_{CD})	*Condenser section power* calculated in Section 6.3.8 for the higher operating level	*Condenser section power* calculated in Section 6.3.8 for the lower operating level	0.0
Indoor fan (P_{IF})	*Indoor fan power allowance* calculated in Section 5.16 for the higher operating level	*Indoor fan power allowance* calculated in Section 5.16 for the lower operating level	$P_{IF,H17H}$
Controls (PCT)	*Controls power* determined for the higher operating level at 17°F (-8.3°C)	*Controls power* determined for the lower operating level at 17°F(-8.3°C)	*Controls power* determined for the H17H test
Crankcase heater (PCCH)	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 5.6 (P_{aux})	0.0	0.0	See Equation 47, expressed in W

Symbols from Table 26:

- δ = Cut-out factor
- X_{HR} = Higher-level operating fraction calculated in Section 6.3.9.5.1.

Equation 47 shows *auxiliary heat* power while the compressor(s) is not operating.

$$P_{aux} = \frac{q_{H,BL}}{3.412} - P_{IF,H17H} \qquad \textbf{47}$$

Where:

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

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

6.3.9.6 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 6.3.9.7.

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 (PC)	If crankcase heat is included in *controls power*, see Equation 48 If crankcase heat is included in *compressor power*, see Equation 49, W	0.0 W	0.0 W
Condenser section (P_{CD})	See Equation 50	0.0 W	0.0 W
Indoor fan (P_{IF})	*Indoor fan power allowance* calculated in Section 5.16 for the lowest operating level, W	Lowest determined *indoor fan power allowance* from all cooling tests, W	$P_{IF,H17H}$ using the fan power allowance defined in Section 5.16 W
Controls (P_{CT})	*Controls power* determined for the lowest operating level at 17°F (-8.3°C), W	*Controls power* determined for the lowest operating level at 17°F (-8.3°C), W	*Controls power* determined for the lowest operating level at 17°F (-8.3°C), W
Crankcase heater (P_{CCH})	If crankcase heat is included in *controls power*: 0.0 If crankcase heat is included in *compressor power*: $P_{CCH,NOC}$, W	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 (-8.3°C) If crankcase heat is included in *compressor power*: sum of the *manufacturer-specified crankcase heat power* values for all compressors, W	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 (-8.3°C) If crankcase heat is included in *compressor power*: sum of the *manufacturer-specified crankcase heat power* values for all compressors, W
Auxiliary heat in accordance with Section 5.6 P_{aux}	0.0 W	0.0 W	See Equation 51

Symbols in Table 27:

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

Equation 48 through Equation 52 referenced in Table 27:

Equation 48 calculates *compressor power* if crankcase heat is included in *controls power*. Equation 49 calculates *compressor power* if crankcase heat is included in *compressor power*. Equation 50 calculates condenser section power. Equation 51 calculates *auxiliary heat* power while the compressor(s) is not operating. Equation 52 calculates part load factor.

$$P_C = \frac{P_C}{PLF} \qquad \textbf{48}$$

$$P_C = \frac{P_C - P_{CCH,NOC}}{PLF} \qquad \textbf{49}$$

$$P_{CD} = \frac{P_{CD}}{PLF} \tag{50}$$

$$P_{aux} = \frac{q_{H,BL}}{3.412} - P_{IF,H17H} \tag{51}$$

$$PLF = 1 - 0.25 \times (1 - X) \tag{52}$$

Where:

X	=	$q_{BL}/qint$
q_{BL}	=	Building load calculated in Section 6.3.4 for the heating bin, Btu/h
q_{int}	=	Integrated capacity calculated in Section 6.3.7 for the lowest operating level in the heating bin, Btu/h
PLF	=	See Equation 52
P_C	=	*Compressor power* calculated in Section 6.3.8 for the lowest operating level, W
P_{CD}	=	*Condenser section power* calculated in Section 6.3.8 for the lowest operating level, W
$P_{CCH,NOC}$	=	Sum of the *manufacturer-specified crankcase heat power* values for all compressors not operating for the lowest operating level at 17°F (-8.3°C)
$PIF,H17H$	=	Indoor fan power allowance determined for the H17H test, W, using the fan power as defined in Section 5.16, W

6.3.9.7 Annual Energy Consumption

Calculate the total annual energy consumption for all heating bins using Equation 53 and the heating bin operating hours in Table 21. The calculated value is used in Section 6.3.12.

$$E_H = \sum_{i=1}^{10} (h_i \times P_i) \tag{53}$$

Where:

EH	=	Energy consumption for all heating bins, Wh
i	=	Heating bin number, one through ten
hi	=	Operating hours in Table 21 for heating bin *i*, h
Pi	=	Total power for heating bin *i* determined in Section 6.3.9.3, Section 6.3.9.4, Section 6.3.9.5.2, or Section 6.3.9.6, as applicable, W

6.3.10 Ventilation

Calculate ventilation energy consumption in Wh 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 54. For $IVHE_C$, multiply the sum by 568 hours using Equation 55.

$$E_V = P_V \times 515 \tag{54}$$

$$E_V = P_V \times 568 \quad (55)$$

The calculated value is used in Section 6.3.12.

Table 28 Component Power Values for Heating Ventilation Mode

Component	Power Value in Watts
Indoor fan (P_{IF})	Lowest determined *indoor fan power allowance* from all cooling tests using the *indoor fan power allowance* as defined in Section 5.16, W
Controls (P_{CT})	*Controls power* determined for the H17H test W
Crankcase heater (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, W

6.3.11 Standby

Calculate standby energy consumption in Wh 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 56.

$$P_T = P_{CT} + P_{CCH} \quad (56)$$

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 6.3.12.

Table 29 Component Power Values for Heating Standby

Component	Power Value in Watts
Controls	*Controls power* determined for the H17H test, W
Crankcase heater (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, W If crankcase heat power is measured in compressor power: Sum of the manufacturer-specified crankcase heat power values for all compressors

6.3.12 IVHE

Calculate *IVHE* in units of Btu/(Wh) using Equation 57 or in units of W/W using Equation 58, and add the subscript $_C$ to *IVHE* (that is, $IVHE_C$) if the calculation used the $IVHE_C$ cold climate building load profile.

$$IVHE \text{ or } IVHE_c = \frac{TASH}{E_H + E_V + E_S} \text{ (I-P)} \quad (57)$$

$$IVHE \text{ or } IVHE_C = \frac{IVHE\ (IP)}{3.412} \text{ (SI)} \quad (58)$$

Where:

IVHE = Integrated ventilation heating efficiency, Btu/(Wh) (W/W)

TASH = The total annual space heating calculated in Section 6.3.5, Btu

E_H = Energy consumption for all heating bins calculated in Section 6.3.9.7, Wh

E_V = Ventilation energy consumption calculated in Section 6.3.10, Wh

E_S = Standby energy consumption calculated in Section 6.3.11, Wh

6.3.13 COP2$_H$

6.3.13.1 Summary

Calculate COP2$_{H,5}$ at 5°F (-15°C), COP2$_{H,17}$ at 17°F (-8.3°C), or COP2$_{H,47}$ at 47°F (8.3°C), in units of W/W using Equation 59 for I-P units and Equation 60 for SI units.

Note: Subscripts are names and same name is being used for I-P and SI.

$$\mathrm{COP2_{H,T}} = \frac{CD_{DF} \times \frac{q_i}{3.412}}{\mathrm{P_{C,T}+P_{CD,T}+P_{IF,T}+P_{CT,T}}} \text{ (IP)} \qquad 59$$

$$\mathrm{COP2_{H,T}} = \frac{CD_{DF} \times q_i}{\mathrm{P_{C,T}+P_{CD,T}+P_{IF,T}+P_{CT,T}}} \text{ (SI)} \qquad 60$$

Where:

T = Subscript on *COP2$_H$*: 5 for COP2$_{H,5}$, 17 for *COP2$_{H,17}$*, or 47 for COP2$_{H,47}$

CD$_{DF}$ = 0.91935 for COP2$_{H,5}$, 0.91173 for *COP2$_{H,17}$*, or 1.00000 for COP2$_{H,47}$

q_i = The cooling instantaneous capacity determined in Section 6.3.6 for the test specified in Section 6.3.13.2, Btu/h

PC = *Compressor power* determined in Section 6.3.6 for the test specified in Section 6.3.13.2, W

P_{CD} = *Condenser section power* determined in Section 6.3.6 for the test specified in Section 6.3.13.2, W

P_{IF} = *Indoor fan power allowance* determined in Section 5.16 for the test specified in Section 6.3.13.2, W

P_{CT} = *Controls power* determined in Section 6.3.6 for the test specified in Section 6.3.13.2, W

6.3.13.2 Tests

For COP2$_{H,17}$, use capacity and power determined for the H17H test.

For COP2$_{H,47}$, use capacity and power determined for the H47H test.

For COP2$_{H,5}$ for units without a *boost* operating level, use capacity and power determined for the H5H test. For 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 (223 kW) 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 61 and Equation 62, 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.

$$\bar{x} = \frac{\sum_{i=1}^{n} x_i}{n} \tag{61}$$

$$LCL = \bar{x} - t_{.95}\left(\frac{s}{\sqrt{n}}\right) \tag{62}$$

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 (kW)**	**Multiples, Btu/h (kW) for Both Heating and Cooling**
≥135,000 to ≤ 400,000 (39.5 to <117)	2000 (0.5)
≥400,000 (117)	5000 (1)

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 (I-P)

Metric	Abbreviation	Units	Significant Figures
Cooled *EER2*	*EER2*	Btu/Wh	XX.X
$COP2_H$	$COP2_{H,47}$ $COP2_{H,17}$ $COP2_{H,5}$	W/W	X.XX
Integrated, ventilation, *economizer*, cooling	*IVEC*	Btu/Wh	XX.X
Integrated, ventilation, heating efficiency	*IVHE*, $IVHE_C$	Btu/Wh	XX.X
Crankcase heat power	P_{CCH}	W	XX
C = Cold			

Table 32 Published Rating Significant Figures (SI)

Metric	Abbreviation	Units	Significant Figures
Cooling *EER2*	$COP2_C$	W/W	X,XX
$COP2_H$	$COP2_{H,47}$ $COP2_{H,17}$ $COP2_{H,5}$	W/W	X.XX
Integrated, ventilation, *economizer*, cooling	*IVEC*	W/W	X,XX
Integrated, ventilation, heating efficiency	*IVHE*, $IVHE_C$	W/W	X,XX
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 33 with the listed acceptance criteria.

Table 33 Acceptance Criteria

Performance Metric	Acceptance Criteria
Cooling Metrics	
Full load *cooling capacity*, Btu/h (kW)	≥ 95%
Full load *EER2*, Btu/(Wh) Full load *COP2*$_C$ (W/W)	≥ 95%
IVEC, Btu/(W) (W/W)	≥ 90%
Heating Metrics	
Heating capacity at 47°F (8.3°C), Btu/h (kW)	≥ 95%
$COP2_{H,47}$, W/W	≥ 95%
Heating capacity at 17°F (-8.3°C), Btu/h (kW)	≥ 95%
$COP2_{H,17}$, W/W	≥ 95%
$COP2_{H,5}$, W/W	≥ 95%
IVHE, Btu/(Wh) (W/W)	≥ 90%
IVHE$_C$, Btu/(Wh) (W/W)	≥ 90%

Section 7. Minimum Data Requirements for Published Ratings

As a minimum, *published ratings* shall consist of the information in Section 7.1 and Section 7.2.

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 1365 (SI/I-P)". All claims to ratings outside the scope of this standard shall include the statement "Outside the scope of AHRI Standard 1365 (SI/I-P)". *Application ratings* within the scope of the standard shall include a statement of the conditions under which the ratings apply.

7.1 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 (kW)
- *EER2*, Btu/Wh, or *COP2*$_C$, W/W
- *IVEC*, Btu/W (W/W)
- Compressor crankcase heat rated power, W

7.2 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 (kW)
- *EER2*, Btu/Wh, or *COP2*$_C$, W/W
- *IVEC*, Btu/W (W/W)
- High temperature *heating capacity* at 47°F (8.3°C), Btu/h (kW)
- High temperature heating coefficient of performance at 47°F (8.3°C), $COP2_{H,47}$, W/W
- Low temperature *heating capacity* at 17°F (-8.3C), Btu/h (kW)

- Low temperature heating coefficient of performance at 17°F (-8.3°C), $COP2_{H,17}$, W/W
- *IVHE*, Btu/Wh (W/W)
- Low temperature *heating capacity* at 5°F (-8.3°C), Btu/h (kW) (optional)
- Low temperature heating coefficient of performance at 5°F (-15°C), $COP2_{H,5}$, W/W (optional)
- Integrated ventilation heating efficiency for cold climates, $IVHE_C$, Btu/Wh (W/W) (optional)
- Compressor crankcase heat rated power, as defined by the manufacturer, W

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 34 (Table 35) indicates the tests and test conditions that are required for operating requirements tests.

Table 34 Conditions for Operating Tests (I-P)

Test	Indoor Section		Outdoor Section							
	Air Entering		Test Conditions Based on Condenser Type							
			Air Cooled			Evaporative			Water Cooled	
	Dry-bulb, °F	Wet-bulb, °F	Dry-bulb, °F	Wet-bulb, °F	Dew-point °F	Dry-bulb, °F	Wet-bulb, °F	*Makeup Water* , °F	Inlet, °F	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	—
Heating Maximum operating conditions	80.0	—	75.0	65.0	—	—	—	—	—	—

Table 35 Conditions for Operating Tests (SI)

Test	Indoor Section		Outdoor Section							
	Air Entering		Test Conditions Based on Condenser Type							
			Air Cooled			Evaporative			Water Cooled	
	Dry-bulb, °C	Wet-bulb, °C	Dry-bulb, °C	Wet-bulb, °C	Dew-point °C	Dry-bulb, °C	Wet-bulb, °C	*Makeup Water,* °C	Inlet, °C	Outlet, °C
Cooling Low temperature operation	19.40	13.90	19.4	—	2.33 (Max)	19.4	13.9	19.4	—	21.1
Cooling Maximum operating conditions	26.7	19.4	46.1.	—	25.4 (Max)	37.8	26.7	32.2	32.2	—
Heating Maximum operating conditions	26.7	—	23.9	18.3	—	—	—	—	—	—

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.

8.2.1 Temperature Conditions

Temperature conditions shall be maintained as shown in Table 34 and Table 35.

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 8.2.1 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 5.15
- Return air temperature conditions shall be 80.0°F (26.7°C) dry-bulb, 67.0°F (19.4°C) wet-bulb
- Outdoor air entering outdoor air-cooling coil shall be 115°F (46.1°C) dry-bulb and 75.0°F (23.9°C) wet-bulb

8.3 Cooling Low Temperature Operation Test

Commercial and industrial unitary air-conditioning and heat pump condensing unit 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 34 and Table 35.

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.

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 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

This appendix lists all standards, handbooks, and other publications essential to the development and implementation of the standard. All references in this appendix are part °°°the standard.

A.1 ANSI/AHRI Standard 110-2024, *Air-Conditioning and Refrigerating Equipment Nameplate Voltages*, 2024, Air-Conditioning, Heating and Refrigeration Institute, 2311 Wilson Blvd., Suite 400, Arlington, VA 22201 USA.

A.2 AHRI Standard 440-2019 (R2024) (I-P), (I-P), *Performance Rating of Fan-coil Units,* 2019 (R2024), Air-Conditioning, Heating and Refrigeration Institute, 2311 Wilson Blvd., Suite 400, Arlington, VA 22201 USA.

A.3 AHRI Standard 441-2019 (R2024), (SI), *Performance Rating of Fan-coil Units*, 2019 (R2024), Air-Conditioning, Heating and Refrigeration Institute, 2311 Wilson Blvd., Suite 400, Arlington, VA 22201 USA.

A.4 AHRI Standard 520-2004, *Performance Rating of Positive Displacement Condensing Units*, 2004, Air-Conditioning, Heating and Refrigeration Institute, 2311 Wilson Blvd., Suite 400, Arlington, VA 22201 USA.

A.5 AHRI Standard 600-2023 (I-P), *Performance Rating of Water/Brine to Air Heat Pump Equipment*, 2023, Air-Conditioning, Heating and Refrigeration Institute, 2311 Wilson Blvd., Suite 400, Arlington, VA 22201 USA.

A.6 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.7 AHRI Standard 921-2020 (SI) 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.8 AHRI Standard 1060-2023 (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.9 AHRI Standard 1061-2023 (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.10 AHRI Standard 1230-2023 (I-P), *Performance Rating of Variable Refrigerant Flow (VRF) Multi-split Air-conditioning and Heat Pump Equipment*, 2023 Heating and Refrigeration Institute, 2311 Wilson Blvd., Suite 400, Arlington, VA 22201 USA.

A.11 ANSI/AHRI Standard 1300-2013 (R2023) (I-P), *Performance Rating of Commercial Heat Pump Water Heaters, Air-conditioning and Heat Pump Equipment*, 2013 (R2023) Heating and Refrigeration Institute, 2311 Wilson Blvd., Suite 400, Arlington, VA 22201 USA.

A.12 ANSI/AHRI Standard 1301-2013 (R2023) (SI), *Performance Rating of Commercial Heat Pump Water Heaters, Air-conditioning and Heat Pump Equipment*, 2013 (R2023) Heating and Refrigeration Institute, 2311 Wilson Blvd., Suite 400, Arlington, VA 22201 USA.

A.13 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.14 AHRI Standard 1361-2022 (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.15 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.16 AHRI Standard 470-2006 (SI/I-P), *Performance Rating of Desuperheater/Water Heaters*, 2006, Air-Conditioning, Heating and Refrigeration Institute, 2311 Wilson Blvd., Suite 400, Arlington, VA 22201 USA**.**

A.17 ANSI/ASHRAE Standard 34-2022, *Designation and Safety Classification of Refrigerant*, 2022, ASHRAE, Inc., 180 Technology Parkway NW, Peachtree Corners, GA 30092 USA.

A.18 ANSI/ASHRAE Standard 30-2019, *Method of Testing Liquid Chillers*, 2019, ASHRAE, Inc., 180 Technology Parkway NW, Peachtree Corners, GA 30092 USA.

A.19 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.20 ANSI/ASHRAE Standard 41.1-2020, *Standard Methods for Temperature Measurement*, 2020, ASHRAE, Inc., 180 Technology Parkway NW, Peachtree Corners, GA 30092 USA.

A.21 ANSI/ASHRAE Standard 41.6-2021, *Standard Method for Humidity Measurement*, 2021, ASHRAE, Inc., 180 Technology Parkway NW, Peachtree Corners, GA 30092 USA.

A.22 ANSI/ASHRAE Standard 169-2013, *Climatic Data for Building Design Standards*, 2021, ASHRAE, Inc., 180 Technology Parkway NW, Peachtree Corners, GA 30092 USA.

A.23 ANSI/NEMA MG1-2021, *Motors and Generators*, 2022, National Electrical Manufacturers Association, 1300 North 17th Street, Suite 900, Rosslyn, VA 22209 USA.

A.24 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.25 ASHRAE Terminology. Accessed September 24, 2021. https://www.ashrae.org/technical-resources/authoring-tools/terminology

A.26 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.27 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.28 CSA – C747:22, *Energy efficiency test methods for small motors*, 2022, CSA Group, 178 Rexdale Blvd., Toronto, Ontario M9W 1R3 Canada.

A.29 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.30 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.31 UL Standard 555-2006, *Standard for Fire Dampers*, 2006, Underwriters Laboratories, Inc., 333 Pfingsten Road, Northbrook, IL, USA.

A.32 UL Standard 555S-2014, *Standard for Smoke Dampers*, 2014, Underwriters Laboratories, Inc., 333 Pfingsten Road, Northbrook, IL, USA.

A.33 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

This appendix lists all standards, handbooks, and other publications that can provide useful information and background but are not essential for the use of this standard. All references in this appendix are not 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 340/360-2023 (I-P), *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 AHRI Standard 1340-2024 (I-P), *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.4 AHRI Standard 1600-2024 (I-P), *Performance Rating of Unitary Air-conditioning and Air-source Heat Pump Equipment*, 2024 Air-Conditioning, Heating and Refrigeration Institute, 2311 Wilson Blvd., Suite 400, Arlington, VA 22201 USA

B.5 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. 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 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. For measuring the outdoor air leaving dry-bulb temperature and water vapor content conditions, follow the requirements in Section C.4. 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 36. 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 36.

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 an accuracy of ≤ ± 0.2°F (0.11°C) and a display resolution of ≤ 0.1°F (0.055 °C).

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 36 Temperature Measurement Instrument Tolerance

Measurement	Accuracy	Display Resolution
Dry-bulb and wet-bulb temperatures[1]	≤ ± 0.2°F (0.11°C)	≤ 0.1°F (0.055°C)
Thermopile temperature	≤ ± 1.0°F (0.59°C)	≤ 0.1°F (0.055°C)

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 1000 fpm ± 200 fpm (305 m/min ±31 m/min) across the sensors. An example configuration for the *aspirating psychrometer* is shown in Figure 1.

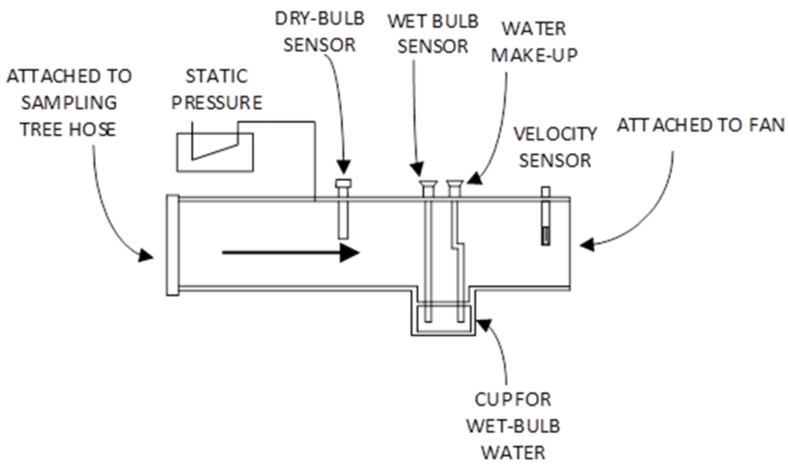


Figure 1 Example Configuration of an Aspirating Psychrometer (Informative)

C.3.2.2 Dew-point Hygrometer

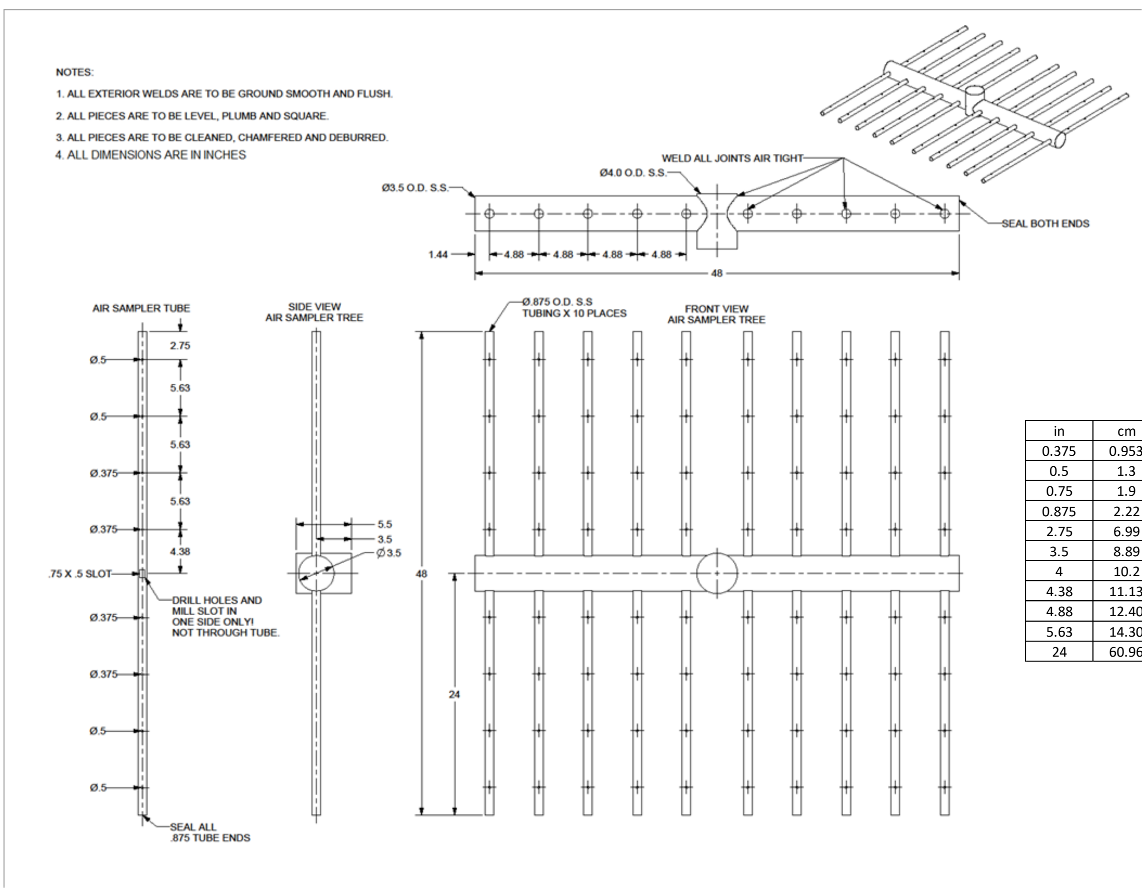
Measure dew point temperature using a *dew-point hygrometer* as specified in Section 4, Section 5, Section 6, and Section 7.2 of ASHRAE 41.6 with an accuracy of within ± 0.4°F (0.2°C). Use a dry-bulb temperature sensor within the sampled air conduit and locate the *dew-point hygrometer* downstream of 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 (1.2 m by 1.2 m) 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 (0.76 m/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 (15-30 cm) 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·°F·h/Btu (0.7-1.0 m^2·°C/W).



in	cm
0.375	0.953
0.5	1.3
0.75	1.9
0.875	2.22
2.75	6.99
3.5	8.89
4	10.2
4.38	11.13
4.88	12.40
5.63	14.30
24	60.96

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 inches to twelve inches from the inlet to the unit.

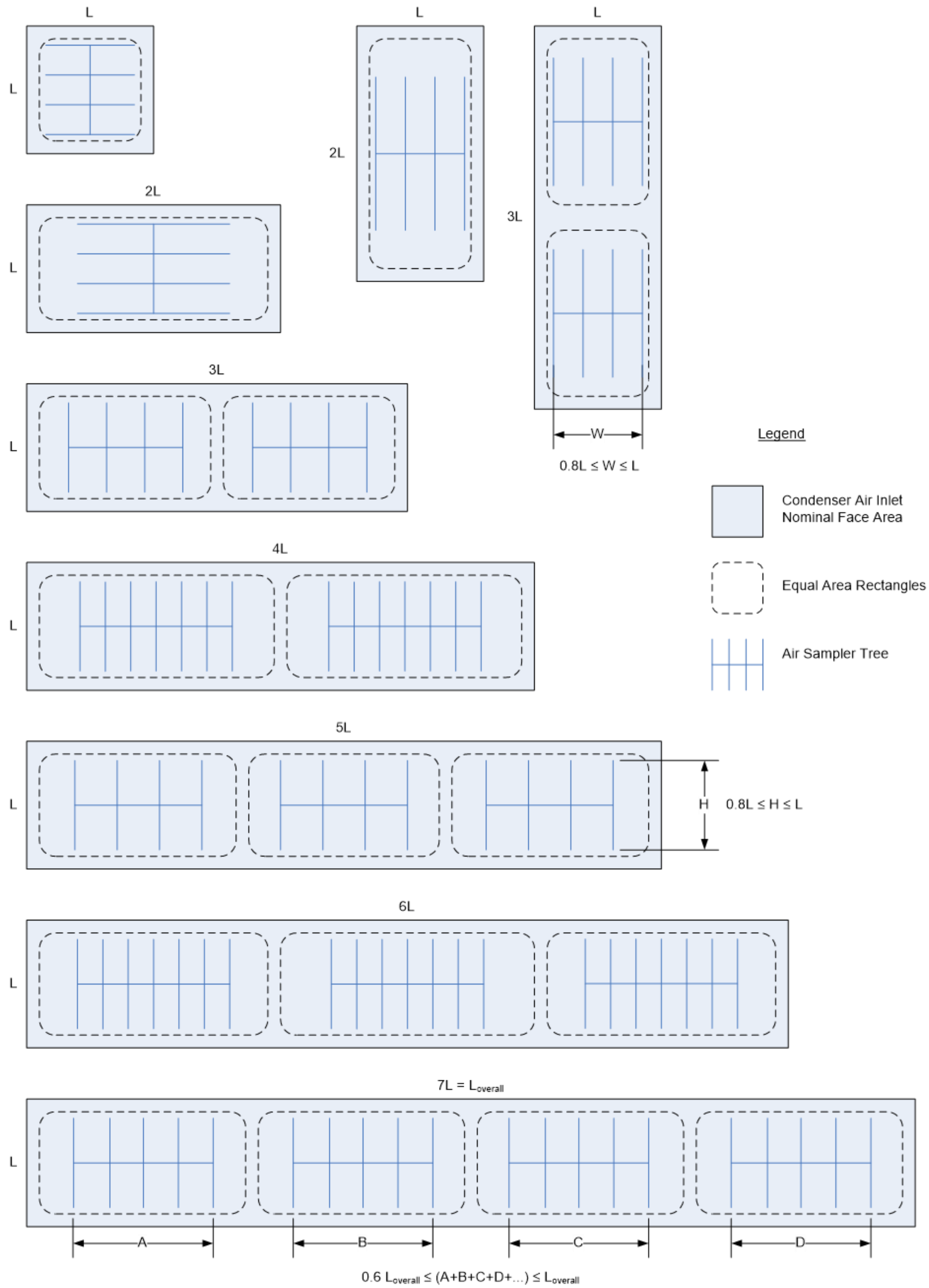


Figure 3 Example Determination of Measurement Rectangles and Required Number of Air Sampling Trees (Informative)

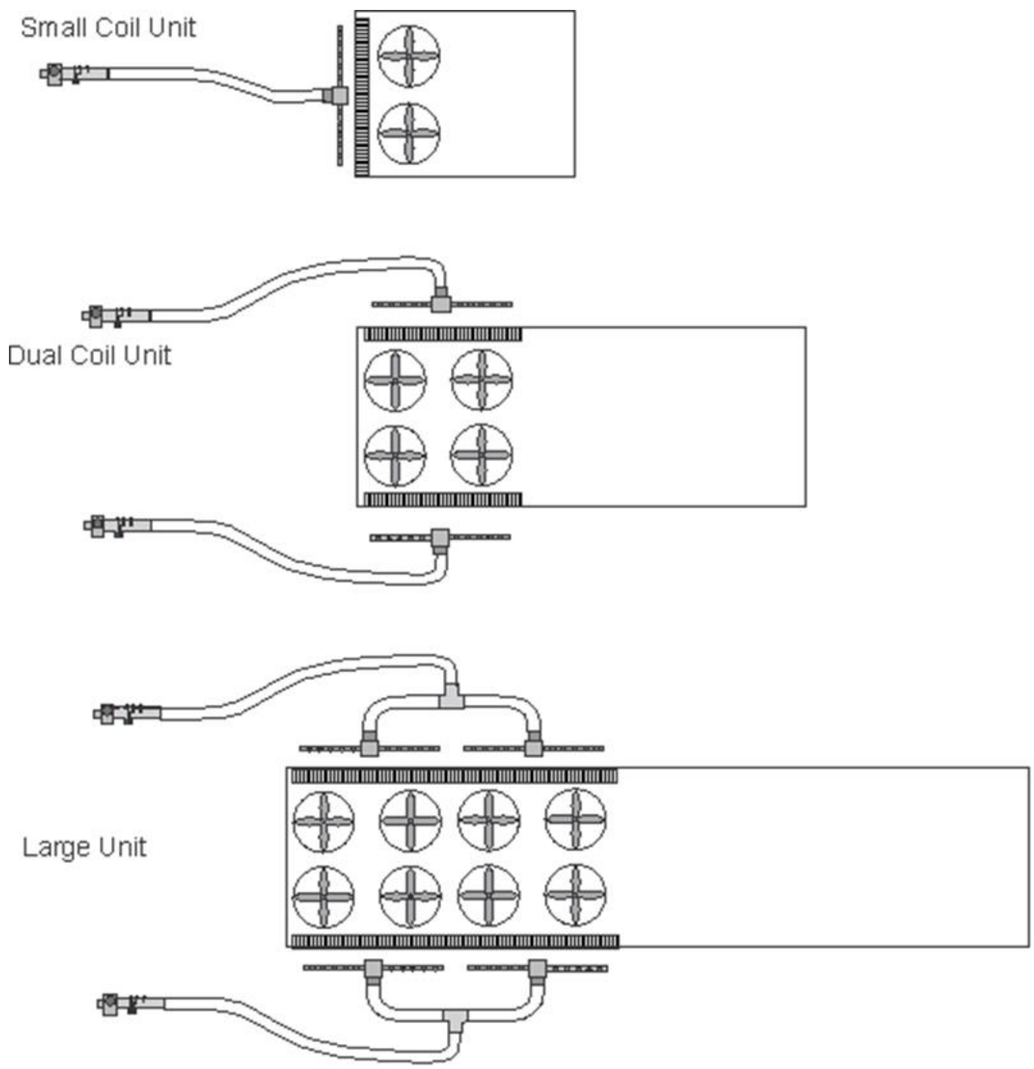


Figure 4 Example Test Setup Configurations (Informative)

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 (0.28°C), 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 (0.50 kPa), 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 (0.28°C), temperature difference threshold or the 2 in H_2O (0.50 kPa) 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 (0.50 kPa), 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 (0.28°C), 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 37, 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 (2.8 °C) 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 37 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 (0.82°C) dry-bulb temperature tolerance in Table 37 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 37).

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 37.

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 37 Uniformity Criteria for Outdoor Air Temperature and Humidity Distribution

Uniformity Criterion[1]	Purpose	Maximum Variation, °F (°C)
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 (± 1.1)
Difference between dry-bulb temperature measured with *air sampler tree* thermopile and with *aspirating psychrometer*[2]	Uniform dry-bulb temperature distribution	± 1.5 (± 0.83)
Deviation from the mean wet-bulb temperature and the individual temperature measurement stations	Uniform humidity distribution	± 1.0 (± 0.59)

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 (.28°C), 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 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 (0.83°C), install mixing devices such as those described in Section 5.3.2 and Section 5.3.3 of ASHRAE 41.1-2020 to reduce the maximum temperature spread to less than 1.5°F (0.83°C).

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 3.2.2.

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 38.

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 38. An otherwise comparable model group can include individual models distributed in commerce with any combination of the components listed in Table 38 or none of the components listed in Table 38. An otherwise comparable model group can consist of only one individual model.

For a *basic model* that includes individual models distributed in commerce with components listed in Table 38, 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 38 included in individual models of the group. Testing shall be consistent with any component-specific test provisions specified in Table 39.

Table 38 Specific Components

Component	Definition or Description	Defined in Section
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.
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 3.2.22

D.2.2 Specific Components Present During Testing

When testing equipment that includes any of the features listed in Table 39, test in accordance with the set-up and test provisions specified in Table 39.

Table 39 Test Instructions for Specific Components Present During Testing

Component	Description or Definition	Test provisions	Term Defined in Section
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.
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 3.2.12.
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 3.2.24.

APPENDIX E. METHOD OF TESTING UNITARY CONDENSING UNIT 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 Outdoor Air Temperature Measurement

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

E.4 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.5 Test Methods for Capacity Measurement

E.5.1 Primary Capacity Measurement

Use the ASHRAE 30 procedures for the laboratory supplied simulated load as the primary method for capacity measurement.

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

E.5.2 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 and ASHRAE 30 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.

E.6 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.6.1 through Section E.6.4. For all part-load cooling tests for water-cooled condensing units, the water flow rate shall not exceed the value for the full-load cooling test.

E.6.1 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.6.2 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 (-12.2°C) higher temperature until the tolerances specified in Table 40 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 (15°C) lower temperature until the tolerances specified in Table 40 are met. For each test, once all tolerances in Table 40 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 40 shall be met.

Table 40 Tolerances for Head Pressure Control Time Average Test

Measured Value		Operating Tolerance	Condition Tolerance
Outdoor air dry-bulb temperature, °F (°C)	Entering	3.0°F (1.7°C)	1.0°F (0.55°C)
	Leaving	—	—
Outdoor air wet-bulb temperature, °F (°C)	Entering	1.5°F (0.83°C)	0.5°F (0.28°C)[1]
	Leaving	—	—
Water serving outdoor coil temperature, °F (°C)	Entering	0.75°F (0.42°C)	0.3°F (0.17°C)
	Leaving	0.75°F (0.42°C)	—
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 40 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.6.3 Tolerances

If the tolerances in Table 40 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 (22.9°C), proceed to the next step.

E.6.4 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 condensing 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 (29.4°C) as achievable while remaining not lower than 85°F (29.4°C).

E.7 Setup Provisions for Evaporatively Cooled Units.

E.7.1 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.7.1.1 Turn Off Makeup Water

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

E.7.1.2 **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.7.2 **Blow-down Water**

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

E.7.3 **Piping Evaporator Condensate for Condensing Units**

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.7.4 **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.8 **Unit Power Measurement**

E.8.1 **Total Unit 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.8.2 **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.8.3 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 63 and Equation 64 for the compressor, measured in watts (W).

$$Default\ crankcase\ heat\ power\ = 80 \times \left(\frac{NCC}{120{,}000}\right)^{\frac{2}{3}} + 44\ \text{(IP)} \quad \textbf{63}$$

$$Default\ crankcase\ heat\ power\ = 80 \times \left(\frac{NCC}{35.16999}\right)^{\frac{2}{3}} + 44\ \text{(SI)} \quad \textbf{64}$$

Where:

NCC = Nominal capacity of the compressor, Btu/h (W)

E.8.4 Measurement Locations

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

E.8.5 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.8.6 Transformers

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

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 41 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 41.

F.2 Heating Temperature Conditions

F.2.1 Temperature Conditions H1, H2, and H3

The H1, H2, and H3 temperature conditions specified in Table 41 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 41 International Air-cooled Full Load Standard Rating Conditions (I-P)

Cooling – Temperature Conditions	T1 (Moderate Climates)		T2 (Cool Climates)		T3 (Hot Climates)	
	Dry-bulb	**Wet-bulb**	**Dry-bulb**	**Wet-bulb**	**Dry-bulb**	**Wet-bulb**
Outdoor	95.0°F	75.2°F	80.6°F	66.2°F	114.8°F	75.2°F
Midpoint saturated suction	50°F	—	50°F	—	50°F	—
Suction superheat	15°F	—	15°F	—	15°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**
Outdoor	44.6°F	42.8°F	35.6°F	33.8°F	19.4°F	17.6°F
Midpoint saturated condensing temperature	109°F	—	109°F	—	109°F	—
Liquid temperature	100°F	—	100°F	—	100°F	—

Table 42 International Air-cooled Full Load Standard Rating Conditions (SI)

Cooling – Temperature Conditions	T1 (Moderate Climates)		T2 (Cool Climates)		T3 (Hot Climates)	
	Dry-bulb	**Wet-bulb**	**Dry-bulb**	**Wet-bulb**	**Dry-Bulb**	**Wet-bulb**
Outdoor	35°C	24°C	27°C	19°C	46°C	24°C
Midpoint saturated Suction	10°C	—	10°C	—	10°C	—
Suction superheat	8.3°C	—	8.3°C	—	8.3°C	—
Heating – temperature conditions	**H1 (Warm Climates)**		**H2 (Moderate Climates)**		**H3 (Cold Climates)**	
	Dry-bulb	**Wet-bulb**	**Dry-bulb**	**Wet-bulb**	**Dry-bulb**	**Wet-bulb**
Outdoor	7°C	6°C	2°C	1°C	-7°C	-8°C
Midpoint saturated discharge	42.8°C	—	42.8°C	—	42.8°C	—
Liquid temperature	37.8°C	—	37.8°C	—	37.8°C	—

F.2.3 Extra High Temperature Operating Requirement

Unitary air-cooled air-conditioners and heat pump condensing unit 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 43.

Table 43 Conditions for Operating Requirement Tests for Air-cooled Equipment

Cooling – Temperature Conditions	
Simulated indoor	
Midpoint saturation	50°F (10°C)
Suction superheat	15.0°F (8.3°C)
Outdoor	125.6°F (52°C) DB[1] and 87.81°F (31°C) 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. DETERMINATION OF LOW-TEMPERATURE CUT-IN AND CUT-OUT TEMPERATURES – NORMATIVE

G.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*.

G.2 Scope

This method is applicable to all air-source *commercial and industrial unitary heat pumps* that fall under the scope of this standard.

G.3 Setup

All labs shall be capable of reaching a temperature of not more than 2°F (1.1°C) 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.

G.4 Test Instructions

G.4.1 General

G.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 (1.1°C).

G.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 (1.1°C).

G.4.1.3 Indoor Dry-bulb Entering Temperature

The indoor entering dry-bulb temperature shall be between 65.0°F (18.3°C) to 75.0°F (23.9°C) for all tests.

G.4.2 Low-temperature Compressor Cut-out Temperature Test

G.4.2.1 Compressor Standby Power

When the outdoor room temperature is not more than 17.0°F (-8.3°C), 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.

G.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 (1.6°C) higher than the target *low-temperature compressor cut-out temperature*. Confirm the indoor leaving dry-bulb temperature is not less than 5°F (-15°C) greater than the indoor entering dry-bulb temperature. If the indoor leaving dry-bulb temperature is less than 5°F (-15°C) 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 (-15°C) 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.

G.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 (0.28°C).

G.4.2.4 Temperature Ramp Down

Reduce the outdoor room temperature at an average rate not greater than 1.0°F (0.59°C) every five minutes. The ramp down can optionally be continuous or stepwise.

G.4.2.5 End of Test

G.4.2.5.1 Heating Stops Before Reaching the Target

If the indoor leaving dry-bulb temperature falls below 5°F (-15°C) 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*.

G.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 (-15°C) 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.*

G.4.2.5.3 Unit Enters Defrost

If the indoor leaving air discharge temperature falls below 5°F (-15°C) 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 G.4.2.2.

G.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.

G.4.3.1 Confirm Compressors Off

If the cut-out test ended based on the requirements in Section G.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.

G.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.

G.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 (-15°C) 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*.

G.4.3.4 Temperature Ramp Up

If the test does not end during the procedure in Section G.4.3.3, increase the outdoor room temperature at a rate not greater than 1.0°F (0.55°C) every five minutes. The ramp up can optionally be continuous or stepwise.

G.4.3.5 End of Test

G.4.3.5.1 Heating Starts Before Reaching the Target

When the indoor leaving air discharge temperature is not less than 5°F (-15°C) 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*.

G.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 (-15°C) 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 G.4.3.1, and the test shall be restarted.