AHRI Standard 1340(I-P)-202X Draft

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

Draft Standard (May 23, 2023)

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Note:

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

AHRI 1340(I-P)-202X Draft has been developed to establish the method to rate and test unitary air conditions with a capacity greater than or equal to 65,000 Btu/h cooling capacity using the new cooling metric to replace IEER called the Integrated Ventilation, Economizer, and Cooling Metric (IVEC) and to add a new HP annualized heating metric called Integrated Ventilation, Heating Efficiency (IVHE). These new metrics and rating and test procedures were developed as part of the DOE ASRAC Central Air Conditioners and Heat Pumps 2022 and 2023 negotiations.

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Price $10.00 (M) $20.00 (NM)
Printed in U.S.A.

Foreword:

AHRI Standard 1340(I-P) is intended to cover the rating and test procedure requirements to align with the DOE ASRAC negotiation rule that developed the new the Integrated Ventilation, Economizer, and Cooling Metric (IVEC) and to add a new HP annualized heating metric called Integrated Ventilation, Heating Efficiency (IVHE).

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

- Unitary Air-Cooled Products with a capacity greater than or equal to 760,000 Btu/h
- Unitary Heat Pump Products with a capacity greater than or equal to 760,000 Btu/h
- Water Cooled Products
- Evaporatively Cooled Products
- Double Duct Products

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

Section 1 Purpose

1.1 *Purpose*. The purpose of this standard is to establish for Commercial and Industrial Unitary Air-conditioning and Heat Pump Equipment: definitions; classifications; test requirements; rating requirements; minimum data requirements for Published Ratings; operating requirements; marking and nameplate data; and conformance conditions that include the IVEC and IVHE efficiency metrics.

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

1.1.2 *Review and Amendment.* This standard is subject to review and amendment as technology advances.

Section 2 Scope

2.1 *Scope.* This standard applies to factory-made Commercial and Industrial Unitary Air-conditioning and Heat Pump Equipment as defined in Section 3.

2.1.1 *Energy Source.* This standard applies only to electrically operated, vapor compression refrigeration systems.

Informative note: units may also include gas heat exchangers that can be used for building heating and as auxiliary heat for heat pumps

2.2 *Exclusions.* This standard does not apply to the following:

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

Note that condensing units with a capacity ≤135,000 Btu/h must be rated as a matched system with fan coil or air handler.

2.2.2 Performance of fan coil units rated per AHRI 440 (I-P) or AHRI 441 (SI)

2.2.3 Air-cooled Unitary Air-conditioners and Unitary Heat Pumps as defined in AHRI Standard 210/240-2023, with capacities less than 65,000 Btu/h.

2.2.4 Water-Source Heat Pumps as defined in ANSI/ASHRAE/AHRI/ISO Standard 13256-1.

2.2.5 Variable Refrigerant Flow Air-conditioners and Heat Pumps as defined in AHRI Standard 1230 or AHRI Standard 1231.

2.2.6 Rating of units equipped with desuperheater/water heating devices (as defined in ANSI/AHRI Standard 470) in operation.

2.3 *Other Applicable Standards*. Commercial and Industrial Unitary Air-conditioning and Heat Pump Equipment can be rated using the following standards:

2.3.1 Single vertical packaged air conditioners rated using ANSI/AHRI Standard 390 (I-P).

2.3.2 Dedicated outdoor air systems rated with 100% outside air using AHRI Standard 920 (I-P) or AHRI Standard 921 (SI).

2.3.3 Computer room air conditioners and condensing units serving computer rooms rated using AHRI Standard 1360.

2.3.4 Performance Rating of Air-to-air Exchangers for Energy Recovery Ventilation Equipment

2.3.5 Calculating the Efficiency of Energy Recovery Ventilation and its Effect on Efficiency and Sizing of Building HVAC system as defined by AHRI Guideline V (I-P)

2.3.6 Packaged terminal air conditioners and heat pumps rated using AHRI Standard 380

Section 3 Definitions

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

3.1 *Air Sampling Device(s)***.**

A combination of Air Sampling Tree(s), conduit, fan and Aspirating Psychrometer or Dew-point Hygrometer used to determine dry-bulb temperature and moisture content of an air sample from critical locations.

3.1.1 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 (for example, indoor air inlet, indoor air outlet, outdoor air inlet).

3.1.2 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.

3.1.3 Dew-point Hygrometer.

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

3.2 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.

3.3 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.

3.4 Coil-only Indoor Unit.

An indoor unit that is distributed in commerce without an indoor blower or separate designated air mover. A Coil-only Indoor Unit installed in the field relies on a separately installed furnace or modular blower for indoor air movement.

3.5 Commercial and Industrial Unitary Air-conditioning Equipment.

One or more factory-made assemblies that normally include a cooling coil, an air moving device, a compressor and condenser combination, and can include a heating function other than vapor compression. Where such equipment is provided in more than one assembly, the separate assemblies shall be designed to be used together, and the requirements of rating outlined in this standard shall be based upon the use of matched assemblies. The functions of Commercial and Industrial Unitary Air-conditioners, either alone or in combination with a heating plant, are to provide air-circulation, cooling, dehumidification, and can include the functions of heating, humidifying, outdoor air ventilation, and air cleaning.

3.6 Commercial and Industrial Unitary Heat Pump.

One or more factory-made assemblies, that normally include an indoor conditioning coil, an air moving device, compressor(s), and an outdoor coil(s), including means to provide a heating function and can include a cooling function. When such equipment is provided in more than one assembly, the separate assemblies shall be designed to be used together, and the requirements of rating outlined in the standard shall be based upon the use of matched assemblies. Commercial and Industrial Unitary Heat Pumps shall provide the function of heating and can include the functions of air circulation, air cooling, dehumidifying or humidifying, outdoor air ventilation, and air cleaning.

3.7 Cooling Capacity.

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 and motor.

3.7.1 Standard Cooling Capacity.

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 Sections 5 and 6, expressed in Btu/h.

3.7.2 Latent Capacity.

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

3.7.3 Sensible Capacity.

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

3.8 Crankcase Heating 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.

3.9 *Compressor Power (P_C)*

The power of the compressor or compressors including the power of variable speed control devices.

3.10 Condenser Section Power (P_{CD})

The power of condenser section fans, pumps, and other components, including the power of variable speed control devices

3.11 Control Power (P_{CT})

The power of all controls and all auxiliary loads that are not part of the compressor, condenser section, or indoor fan.

3.12 Double-duct System.

An air conditioner or heat pump that complies with all of the following:

Is either a horizontal single package or split-system unit; or a vertical unit that consists of two components that can be shipped or installed either connected or split; or a vertical single packaged unit that is not intended for exterior mounting on, adjacent interior to, or through an outside wall

Is intended for indoor installation with ducting of outdoor air from the building exterior to and from the unit, where the unit or its components are non-weatherized or both

If it is a horizontal unit, the complete unit shall have a maximum height of 35 in or the unit shall have components that do not exceed a maximum height of 35 in. If it is a vertical unit, the complete (split, connected, or assembled) unit shall have components that do not exceed maximum depth of 35 in

Has a rated Cooling Capacity greater than and equal to 65,000 Btu/h and less than or equal to 300,000 Btu/h.

See Section 5.21 for test requirements specific to externally-ducted condensers.

3.13 *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.

3.14 Economizer

3.14.1 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 space conditions.

3.14.2 Integrated 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.

3.14.3 Standard Energy Efficiency Ratio (EER2).

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

3.15 Fixed Capacity Controlled Units.
Products limited by the controls to a single stage of refrigeration capacity.

3.16 Full Load Rated Indoor Airflow.
The Standard Airflow rate at 100% capacity as defined by the Manufacturer's Installation Instructions and at the external static pressure as determined in section 5.17.

3.17 Heating Capacity.

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

3.18 Heating Coefficient of Performance 2 (COP2).

A ratio of the Heating Capacity in watts to the power input values in watts, as calculated in Section 6.3.13.

3.19 Independent Coil Manufacturer (ICM).

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

3.20 Indoor Single Package Air-conditioners.

Non-weatherized units with factory-made assemblies of one or more evaporator fans, evaporator coils, and condensing units having means for air cooling, cleaning, dehumidification, heating with factory or field installed electric strip heaters and forced air circulation through a duct system and that can have means for humidifying and control of temperature. These units do not have gas heat and are not heat pumps. Included are only those units that are assembled or designed to be assembled in a single unit (within a single factory-made enclosure).

3.21 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 a typical building and typical climate zone as defined in section 6.2 and expressed in Btu/Wh.

3.22 Integrated Ventilation and Heating Efficiency (IVHE)

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

3.23** Manufacturer's Installation Instructions**.

Manufacturer's documents that come packaged with or appear in the labels applied to the unit(s). Online manuals are acceptable if referenced on the unit label or in the documents that come packaged with the unit. All references to "manufacturer's instructions," "manufacturer's published instructions," "manufacturer's published recommendations," "manufacturer installation and operation manuals," "installation instructions" and other similar references means Manufacturer's Installation Instructions. This includes certification reports (information provided to authorities having jurisdiction) provided by the manufacturer. These certified parameters shall not deviate from the manufacturer's installation instructions.

3.23.1 Supplemental Test Instructions (STI).

Additional instructions developed by the manufacturer and certified to the United States Department of Energy (DOE). STI shall include (a) all instructions that do not deviate from Manufacturer's Installation Instructions but provide additional specifications for test standard requirements allowing more than one option, and (b) all deviations from Manufacturer's Installation Instructions necessary to comply with steady state requirements. STI shall provide steady operation that matches to the extent possible the average performance that would be obtained without deviating from the Manufacturer's Installation Instructions. STI shall include no instructions that deviate from Manufacturer's Installation Instructions other than those described in (b) above.

3.23.2 Manufacturer-specified.

Information provided by the manufacturer through Manufacturer's Installation Instructions.

3.24 Makeup Water

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

3.25 Non-Standard Low-Static Indoor Fan Motor

An indoor fan motor that cannot maintain ESP as high as specified in Section 5.17.1 when operating at the Full Load Rated Indoor Airflow and that is distributed in commerce as part of an individual model within the same basic model that is distributed in commerce with a different motor specified for testing that can maintain the required ESP.

3.26 Outdoor Unit Manufacturer (OUM).

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

3.27 Part Load Rated Indoor Airflow.

The Standard Airflow at the part-load ratings conditions as defined by the Manufacturer's Installation Instructions and at the external static pressure as determined in section 5.17. This can be different for each part-load rating point.

3.28 *Proportionally Capacity Controlled Units.*

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

3.29 Published Rating.

A statement of the assigned values of those performance characteristics, under stated Rating Conditions, where a unit can be chosen to fit its application. These values apply to all units of like nominal size and type (identification) produced by the same manufacturer. As used herein, the term 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.

3.29.1 Application Rating.

A rating based on tests performed at Application Rating Conditions (other than Standard Rating conditions).

3.29.2 Standard Rating.

A rating based on tests performed at Standard Rating Conditions and determined as specified in Section 6.

3.29.3 International Ratings.

A rating based on tests performed at International Rating Conditions as listed in Table F1.

3.30 Rating Conditions.

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

3.30.1 Standard Rating Conditions.

Rating Conditions used as the basis of comparison for performance characteristics as defined in table 7

3.30.2 Part Load Rating Conditions.

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

3.30.3 International Rating Conditions.

Rating Conditions used as the basis of comparison for performance characteristics for products sold outside North America. As defined in table F1

3.31 *"Shall" or "shall not" and" should" or "should not"*

3.31.1 "Shall" or "shall not."

Indicate mandatory requirements to be strictly followed in order to conform to the standard and from which deviation is not permitted.

3.31.2 "Should" or "should not."

Express recommendations rather than requirements. In the negative form, a recommendation is the expression that a suggested possible choice or course of action is not preferred but not prohibited.

3.32 Single Package Air conditioners.

Units with factory-made assemblies of one or more evaporator fans, evaporator coils, and condensing units having means for air cooling, cleaning, dehumidification, heating with factory or field installed electric strip heaters and forced air circulation through a duct system and that can have means for humidifying and control of temperature. These units do not have gas heat and are not heat pumps. Included are only those units that are assembled or designed to be assembled in a single unit (within a single factory-made enclosure). Single package (cooling only) roof top units are included in this category.

3.33 Single Package Heat Pumps.

Units that can both cool and heat with the refrigeration system that can have provision for supplementary electric, hot water, steam or gas heat (dual fuel) that are factory-made assemblies of one or more evaporator fans, evaporator coils, and condensing units having means for air cooling, heating, cleaning, dehumidification, and forced air circulation through a duct system and that can have means for humidifying and control of temperature, with provision for modifying the performance so that either heating or cooling and dehumidification can be produced. Included are only those units that are assembled or designed to be assembled in a single unit (within a single factory-made enclosure).

3.34 Split System Air-conditioners.

Air-conditioners designed with an air conditioning condensing unit that is installed remotely from the evaporator and requiring field connection by refrigerant lines.

3.35 Split System Heat Pump.

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

3.36 Standard Air.

Dry air having a mass density of 0.075 lb/ft^3.

3.37 Standard Airflow.

The volumetric flowrate of air converted to Standard Air conditions expressed in scfm.

3.38 Standard Filter.

The filter with the lowest level of filtration that is distributed in commerce with a model. If the manufacturer does not specify what filter option has the lowest level of filtration in Manufacturer's Installation Instructions or marketing materials for the model, then the Standard Filter shall be the filter designated as the "default" or "standard" filter in the marketing materials for the model. If the manufacturer does not specify a default filter option or the filter option that has the lowest filtration level, then the Standard Filter shall be any filter shipped by the manufacturer.

3.39 Supply Air.

Air delivered by a unit to the conditioned space expressed as Standard Air.

3.40 Ventilation Air

Air delivered by the unit for space ventilation and indoor air quality control.

3.41 Year-Round Single Package Air-conditioners.

Gas and oil Single Package Air-conditioners that are factory-made assemblies of one or more evaporator fans, evaporator coils, and condensing units and equipped with gas or oil-fired heating sections and means for air cooling, cleaning, dehumidification, heating and forced air circulation through a duct system and that can have means for humidifying and control of temperature. Included are only those units that are assembled or designed to be assembled in a single unit (within a single factory-made enclosure).

Section 4 Classifications

4.1 Commercial and Industrial Unitary Air-conditioning and Heat Pump Equipment within the scope of this standard shall be classified as shown in Table 1 and

Table 2.

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

Designation	AHRI Type[1,2]	Arrangement – Indoor (ID)	Arrangement – Outdoor (OD)
Single Package and Indoor Package Air-conditioners	SP-A[3, 4] SP-E[3, 4] SP-W[4, 7]	--	ELECTRIC HEAT[5] ID FAN EVAPORATOR OD FAN or PUMP COMPRESSOR CONDENSER
Year Round Single Package Air-conditioners	SPY-A[3, 4] SPY-E[3, 4] SPY-W[4, 7]	--	GAS HEAT[6] ID FAN EVAPORATOR OD FAN or PUMP COMPRESSOR CONDENSER
Air-conditioner with Remote Condenser	RC-A[3] RC-E[3] RC-W[7]	ID FAN EVAPORATOR ELECTRIC HEAT[5]	OD FAN or PUMP COMPRESSOR[8] CONDENSER
Split System Air-conditioners: Condensing Unit, Coil Alone	RCU-A-C[3] RCU-E-C[3] RCU-W-C[7]	EVAPORATOR	OD FAN or PUMP COMPRESSOR CONDENSER
Split System Air-conditioners: Condensing Unit, Coil and Fan	RCU-A-CB[3] RCU-E-CB[3] RCU-W-CB[7]	ID FAN EVAPORATOR ELECTRIC HEAT[5]	OD FAN or PUMP COMPRESSOR CONDENSER
Year Round Split System Condensing Unit, Coil and Fan	RCUY-A-CB[3] RCUY-E-CB[3] RCUY-W-CB[7]	GAS HEAT[6] ID FAN EVAPORATOR	OD FAN or PUMP COMPRESSOR CONDENSER

Notes:

1. A suffix of "-O" following any of the above classifications indicates equipment not intended for use with field-installed duct systems.
2. "-A" indicates air-cooled condenser, "-E" indicates evaporatively-cooled (does not apply to evaporative pre-cooled) condenser and "-W" indicates water-cooled condenser.
3. For Double-duct Systems, insert "-DD" at the end, and outdoor arrangement moves from outdoor side to indoor side.
4. Components can be installed indoors as well in accordance with Manufacturer's Installation Instructions.
5. Optional component.
6. May be any other heat source except for electric strip heat.
7. For water-cooled products, outdoor arrangement can move from outdoor side to indoor side.
8. May be installed with either the indoor or the outdoor unit.

Table 2 Classification of Commercial and Industrial Unitary Heat Pump Equipment

Designation	AHRI Type[1,2]	Arrangement - Indoor (ID)	Arrangement – Outdoor (OD)
Single Package Heat Pumps	HSP-A[3]	--	ELECTRIC HEAT[4] ID FAN EVAPORATOR OD FAN or PUMP COMPRESSOR CONDENSER
Year Round Single Package Heat Pump	HSPY-A	--	GAS HEAT[5] ID FAN EVAPORATOR OD FAN or PUMP COMPRESSOR CONDENSER
Heat Pump with Remote Outdoor Coil	HRC-A-CB[3]	ID FAN EVAPORATOR COMPRESSOR	OD FAN or PUMP CONDENSER
Split System Heat Pump with Remote Outdoor Coil with no Indoor Fan	HRC-A-C[3]	EVAPORATOR COMPRESSOR	OD FAN or PUMP CONDENSER
Split System Heat Pump with Coil Blower	HRCU-A-CB[3]	ELECTRIC HEAT[4] ID FAN EVAPORATOR	OD FAN or PUMP COMPRESSOR CONDENSER

Notes:
1. A suffix of "-O" following any of the above classifications indicates equipment not intended for use with field-installed duct systems.
2. For heating only, change the initial “H” to “HO”.
3. For Double-duct Systems, append “-DD”, and outdoor arrangement moves from outdoor side to indoor side.
4. Optional component.
5. Can be other heat sources.

Section 5 Test Requirements

5.1 Summary

All Standard Ratings shall be in accordance with the test methods and procedures as described in this standard and its appendices.

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

5.2 Optional system features

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

5.3 Secondary Verification.

Secondary verification measurements of cooling and Heating Capacity (if applicable) shall be conducted per Section E6 of this standard.

5.4 Instruction Priority.

Units shall be installed per Manufacturer’s Installation Instructions. In the event of conflicting instructions regarding the set-up of the unit under test (excluding charging instructions for split systems, see Section 5.4.1), priority shall be given to installation instructions that appear on the unit’s label over installation instructions that are shipped with the unit.

5.4.1 Instructions for Split Systems.

In the event of conflicting charging instructions for split systems, priority shall be given to the installation instructions that are shipped with the unit over the installation instructions that appear on the unit's label. For split systems other than mix-matched systems (see section 5.4.2), if the Manufacturer's Installation Instructions for the components conflict, priority shall be given to the outdoor unit instructions over the indoor unit instructions, except for provisions regarding setting indoor airflow and external static pressure (ESP). For setting indoor airflow and ESP for such a split system, priority shall be given to the indoor unit instructions over the outdoor unit instructions.

5.4.2 Mix-Matched Split Systems.

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

5.5 Break-in.

Conduct a compressor break-in period prior to conducting the test if there is a Manufacturer-specified break-in period. Conduct the break-in period using the Manufacturer-specified duration and conditions; however, the duration shall not exceed 20 hours and the outdoor temperature shall not exceed 115°F. When there is a Manufacturer-specified break-in period, each compressor of the unit shall undergo this break-in period. No testing shall commence until the Manufacturer-specified break-in period is completed.

5.6 Recirculated indoor air

Use 100 percent recirculated indoor air in all tests.

5.7 Test Unit Duct Installation Requirements.

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

Calculate duct losses using conduction factors, inside air and outside ambient temperature difference, and the total duct surface area between the unit and the temperature measurement location. Ducts that are exposed to multiple ambient temperatures shall be divided into zones and each zone calculated separately.

5.8 *Defrost Controls.*

Defrost controls shall be left at manufacturer's factory settings if the Manufacturer's Installation Instructions 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.

5.9 Auxiliary heat

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

5.10 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 Manufacturer's Installation Instructions. If there are no such instructions, use the as-shipped setting. If this results in unstable operation (outside test tolerances specified in Section 5.24) and testing requirements cannot be met, then the procedures in Appendix E Section E7 shall be used.

5.11 Line Length for Split Systems.

All Standard Ratings for equipment where the outdoor section is separated from the indoor section shall be determined with at least 25 ft of interconnection tubing on each line of the size specified in the Manufacturer's Installation Instructions.

Use the absolute minimum length of tubing necessary to physically connect the system, subject to the minimum specified length, but use no less than 25 ft. Such equipment where the interconnection tubing is furnished as an integral part of the machine and not intended to be cut to length per the Manufacturer's Installation Instructions, shall be tested with the complete length of tubing furnished, or with 25 ft of tubing, whichever is greater. At least 10 ft of the interconnection tubing shall be exposed to the outside conditions. The line sizes, insulation, and details of installation shall be in accordance with the Manufacturer's Installation Instructions.

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

Table 3 Refrigerant Line Length Correction Factors

Tubing length (X) beyond the required 25 ft of tubing, ft	Cooling Capacity Correction Factor
3.3 < X ≤ 20	1.01
20 < X ≤ 40	1.02
40 < X ≤ 60	1.03

5.12 Refrigerant Charging.

5.12.1 Conditions and criteria

Unless the unit does not require charging (per Section 5.12.5) use the test or operating conditions specified in the Manufacturer's Installation Instructions for charging. If the Manufacturer's Installation Instructions do not specify a test or operating conditions for charging or there are no Manufacturer's Installation Instructions, charging shall be conducted at Standard Rating Conditions in cooling mode. If the Manufacturer's Installation Instructions contain two sets of refrigerant charging criteria, one for field installation and one for lab testing, use the field installation criteria. Perform charging of refrigerant blends only with refrigerant in the liquid state.

5.12.2 Parameter ranges

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

5.12.3 No manufacturer instructions

If there are no Manufacturer's Installation Instructions or the Manufacturer's Installation Instructions do not provide parameters and target values, or both, set superheat to a target value of 12°F for fixed orifice systems or set subcooling to a target value of 10°F for expansion valve systems.

5.12.4 Conflicting information

In the event of conflicting information between charging instructions, use the instruction priority order indicated in Section 5.4. Conflicting information is defined as multiple Manufacturer-specified conditions given for charge adjustment where all Manufacturer-specified conditions cannot be met. If such instances of conflicting information occur within the highest-ranking set of instructions where refrigerant charging instructions are provided, follow the hierarchy in Table 4, as appropriate, unless the manufacturer specifies a different priority in the outdoor unit installation instructions. Unless the Manufacturer's Installation Instructions specify a tighter charging tolerance, the tolerances specified in Table 4 shall be used.

Table 4 Tolerances for Charging Hierarchy

Fixed Orifice			Expansion Valve		
Priority	**Parameter**	**Tolerance**	**Priority**	**Parameter**	**Tolerance**
1	Superheat	± 2.0°F	1	Subcooling	± 2.0°F
2	High Side Pressure or Saturation Temperature	± 4.0 psi or ± 1.0°F	2	High Side Pressure or Saturation Temperature	± 4.0 psi or ± 1.0°F
3	Low Side Pressure or Saturation Temperature	± 4.0 psi or ± 1.0°F	3	Low Side Pressure or Saturation Temperature	± 2.0 psi or ± 0.8°F
4	Low Side Temperature	± 2.0°F	4	Approach Temperature[1]	± 1.0°F
5	High Side Temperature	± 2.0°F	5	Charge Weight	± 2.0 oz.
6	Charge Weight	± 1% of nominal charge or 2.0 oz., whichever is greater	--	--	--

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

5.12.5 Single Package Unit.

5.12.5.1 Install refrigerant line pressure gauges

Install one or more refrigerant line pressure gauges during the setup of the unit unless either of the following conditions are met: (1) the Manufacturer's Installation Instructions indicate that pressure gauges shall not be installed; or (2) charging is based only on parameters, such as charge weight, that do not require measurement of refrigerant pressure. Use methods for installing pressure gauge(s) at the required location(s) as indicated in Manufacturer's Installation Instructions if specified. Install pressure gauges depending on the parameters used to verify or set charge, as described in the following paragraphs.

5.12.5.2 Pressure gauge on liquid line

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

5.12.5.3 Pressure gauge on suction line

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

5.12.6 No further changes

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

5.13 Test Unit Location

5.13.1 Air-Cooled and Evaporatively-Cooled Equipment.

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

5.13.2 Water-Cooled Equipment.

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

5.14 Pan heater

If the Outdoor Unit or the outdoor portion of a Single Package Unit has a drain pan heater to prevent freezing of defrost water, the heater shall be energized, subject to control to de-energize it when not needed by the heater's thermostat or the unit's control system, for all tests.

5.15 Voltage and Frequency.

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

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

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

5.16 Instrumentation

5.16.1 Induction watt-hour meter

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

5.16.2 Atmospheric pressure.

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

5.16.3 Electrical Frequency.

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

5.17 Indoor Air External Static Pressure for Testing

5.17.1 Full-load cooling tests

Test at the external static pressure specified in Table 5 for full-load cooling tests for all units (except for Coil-only Indoor Units).

Table 5 Full-load Cooling External Static Pressure (in H_2O)

Full-Load Cooling Capacity Measured in Section 6.2.5, kBtu/h	Testing with economizer dampers present	Testing without economizer dampers present
>0 and <65[1]	0.50	0.60
≥65 and <135	0.75	0.85
≥135 and <280	1.00	1.10
≥280	1.50	1.60

Footnotes:

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

5.17.2 Testing without a filter (except coil-only)

For units distributed in commerce without a filter (except for Coil-only Indoor Units), an additional static pressure allowance as specified in Equation 1 shall be added to the minimum static pressure shown in Table 5. The additional static pressure shall be based on the filter face area, as defined in the Manufacturer's Installation Instructions, and the rated full-load cooling airflow rate. For units that do not specify a filter face area or units where a 2 in filter rack is not an option, the face area of the evaporator shall be used. For tests that use an airflow rate different than the full-load cooling airflow rate, the additional static pressure allowance shall be reduced per Section 5.17.3.

$$ESP_{filter} = 0.000108 \times \left(\frac{\dot{V}_{FL}}{A_{ft}}\right)^{1.3} \quad (1)$$

Where:

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

$\dot{V}_{FL}$ = Rated full-load cooling airflow, scfm

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

5.17.3 Tests that do not use the full-load cooling airflow (except for Coil-only Indoor Units)

When conducting tests where the Manufacturer-specified fan control settings, or rated airflow rates are different than for the full-load cooling test, or both, calculate adjusted ESP requirements using equation 2.

$$ESP_{adj} = ESP_{FL} \times \left(\frac{\dot{V}_{dif}}{\dot{V}_{FL}}\right)^{2} \quad (2)$$

Where:

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

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

$\dot{V}_{dif}$ = Measured airflow other than full-load cooling airflow, scfm.

$\dot{V}_{FL}$ = Measured full-load cooling airflow, scfm

5.17.4 Coil-only systems

For Coil-only Indoor Units, the pressure drop across the indoor assembly shall not exceed 1.00 in H_2O for the full-load cooling test. If this pressure drop is exceeded, reduce the airflow rate until the measured pressure drop equals the specified maximum. Test Coil-only Indoor Units without a filter.

5.17.5 Split between return and supply static pressure

The return static pressure shall be 20 to 25 percent of total static pressure, unless the return static pressure is greater than 25 percent of total static pressure with no inlet restriction, mixers, elbows, transitions, or sampling devices installed on the inlet duct. Use Section E11 to set the static pressure split.

5.18 Indoor Airflow Target Values

5.18.1 Standard airflow

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

5.18.2 Minimum airflow rate

The indoor airflow rate in scfm for all tests must be no less than the minimum indoor airflow rate determined in Equation MIAR.

Equation MIAR

$$\text{Minimum indoor airflow rate} = 0.008 \times Q_A$$

Where:

Q_A = The cooling capacity measured for the full-load cooling test in Section 6.2.5, Btu/h

5.18.3 Units with integral fans (not coil only)

5.18.3.1 Full-load cooling

For the full-load cooling test (except for Coil-only Indoor Units), use the cooling Full Load Rated Indoor Airflow. If there is no cooling Full Load Rated Indoor Airflow, use a value of 400 scfm per ton (in other words, per 12,000 Btu/h) of rated Cooling Capacity.

5.18.3.2 Full-load heating

For the full load heating tests (except for Coil-only Indoor Units), use the heating Full Load Rated Indoor Airflow. If there is no heating Full Load Rated Indoor Airflow, use the airflow that results from using the Manufacturer-specified heating fan control settings at the adjusted ESP requirement determined per Section 5.17. If there is no heating Full Load Rated Indoor Airflow and no Manufacturer-specified heating fan control settings but the Manufacturer's Installation Instructions describe how to obtain steady-state heating operation (for example, using thermostat or other control system input) that results in an automatic adjustment to airflow, use those instructions. If none of this information is accessible, use the cooling Full Load Rated Indoor Airflow for the heating tests.

5.18.3.3 Part-load tests

For part-load tests, use the Part Load Rated Indoor Airflow for that test point. If there is no Part Load Rated Indoor Airflow for the test point, use the airflow that results from using the Manufacturer-specified part-load fan control settings for that test at the ESP requirement determined per Section 5.17. If there is no Part Load Rated Indoor Airflow and no Manufacturer-specified part-load cooling fan control settings for the test point but the Manufacturer's Installation Instructions describe how to obtain steady-state part-load cooling or heating operation (for example, using thermostat or other control system input) that results in an automatic adjustment to airflow, use those instructions. If none of this information is accessible, for part-load cooling tests use the cooling Full Load Rate Indoor Airflow, and for part-load heating tests determine target airflow per section 5.18.3.2.

Informative Note: There are no longer separate airflow-setting provisions for units with control systems designed to vary the indoor air volume and refrigeration capacity at a controlled discharge air temperature and static pressure as a means of providing space temperature control to independent multiple spaces with independent thermostats. All units are now tested using the manufacturer-specified Part Load Rated Indoor Airflow.

5.18.4 Coil-only indoor units

5.18.4.1 Full-load cooling

For full-load cooling tests of Coil-only Indoor Units, the indoor airflow rate shall be the lesser of: the cooling Full Load Rated Indoor Airflow; or the airflow equal to 450 scfm per ton of rated Cooling Capacity. If there is no Full Load Rated Indoor Airflow, use a value of 400 scfm per ton of rated Cooling Capacity. Maintain the airflow within ± 3% of the target airflow throughout the test.

5.18.4.2 All tests other than full-load cooling tests

For all tests of Coil-only Indoor Units other than full-load cooling tests, the indoor airflow rate shall be the lesser of: the Manufacturer-specified airflow rate for that test; or the measured full-load cooling airflow. If there is no heating manufacturer-specified airflow, use the measured full-load cooling airflow. Maintain the airflow within ± 3% of the target airflow throughout the test.

5.19 Indoor External Static Pressure and Airflow Tolerances and Set-Up (except for Coil-only Indoor Units)

5.19.1 Conditions for setting airflow before test

For each test, set indoor airflow while operating the unit at the rating conditions specified for the test. After setting the airflow, no adjustments can be made to the fan control settings during the test.

5.19.2 Tolerances.

All tolerances for airflow and ESP specified in Section 5.19 for setting airflow and ESP are condition tolerances that apply for each test. Specifically, the average value of a parameter measured over the course of the test shall vary from the target value by no more than the condition tolerance. Operating tolerances for ESP and nozzle pressure drop are specified in Section 5.24.

5.19.3 Full-load Cooling Test Static and Airflow

5.19.3.1 First setting and adjustment

Operate the unit using the Manufacturer-specified fan control settings. If there are no Manufacturer-specified fan control settings, use the as-shipped fan control settings. Adjust the airflow-measuring apparatus to maintain total ESP within -0.00/+0.05 in H_2O of the requirement specified in Section 5.17 and to maintain the airflow within ± 3% of the cooling Full Load Rated Indoor Airflow.

5.19.3.2 If above tolerance

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

5.19.3.3 If below tolerance

If total ESP or airflow are lower than the tolerance range, adjust the fan control settings (for example, higher fan speed) to maintain both ESP and airflow within tolerance. If total ESP or airflow are lower than the tolerance range at the maximum fan control setting (for example, highest fan speed) and the motor is not a Non-Standard Low-Static Indoor Fan Motor, adjust the airflow-measuring apparatus to maintain total ESP within tolerance and operate with an airflow as close as possible to the Manufacturer-specified value. Use the measured lower airflow as the target airflow for all subsequent tests that call for the cooling Full Load Rated Indoor Airflow.

If the motor is a Non-Standard Low-Static Indoor Fan Motor, use the maximum available fan speed that does not overload the motor or motor drive and adjust the airflow-measuring apparatus to maintain airflow within tolerance, and operate with an ESP as close as possible to the minimum requirement specified in Section 5.17.

5.19.3.4 If cannot meet tolerance

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

5.19.3.5 Situations with no condition tolerance

If the total ESP measured after setting airflow exceeds the minimum total ESP requirement by more than 0.05 in H_2O (because the ESP and airflow requirements cannot be simultaneously met, see Sections 5.19.3.2 or 5.19.3.4), there is no condition tolerance for total ESP.

If an airflow less than 97% of the cooling Full Load Rated Indoor Airflow is used for the full-load cooling test (because the airflow and total ESP requirements cannot be simultaneously met, see Section 5.19.3.3), there is no condition tolerance for airflow.

5.19.4 All tests other than full-load cooling tests

5.19.4.1 Same airflow as full-load cooling airflow

For tests where the manufacturer-specified airflow is the same as the cooling Full Load Rated Indoor Airflow (and for tests where there is no Manufacturer-specified airflow, and the cooling Full Load Rated Indoor Airflow is used as the airflow for the test), use the fan control settings used for the full-load cooling test. Adjust the airflow-measuring apparatus to maintain the airflow within ± 3% of the measured full-load cooling airflow without regard to the resulting total ESP. No changes are to be made to the fan control settings for the test.

5.19.4.2 Different airflow than full-load cooling airflow

For tests where the manufacturer-specified airflow differs from the cooling Full Load Rated Indoor Airflow, use the following provisions.

5.19.4.2.1 First setting

Operate the system using the Manufacturer-specified fan control settings for that test condition. If there are no Manufacturer-specified fan control settings for the test, use the fan control settings for the full-load cooling test. If there are no Manufacturer-specified fan control settings for any tests, use the as-shipped fan control settings.

5.19.4.2.2 First adjustment

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

5.19.4.2.3 If above tolerance

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

5.19.4.2.4 If below tolerance

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

5.19.4.2.5 If cannot meet tolerance

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

5.19.4.2.6 Situations with no condition tolerance

If the total ESP measured after setting airflow exceeds the adjusted total ESP requirement determined per Section 5.17 by more than 0.05 in H_2O (because the ESP and airflow requirements cannot be simultaneously met, see Sections 5.19.4.2.3 or 5.19.4.2.5), there is no condition tolerance for total ESP.

If an airflow less than 97% of the Manufacturer-specified airflow is used for a test (because the airflow and total ESP requirements cannot be simultaneously met, see Section 5.19.4.2.4), there is no condition tolerance for airflow.

5.19.4.2.7 No airflow rate specified, but settings specified

For tests where there is no Manufacturer-specified airflow and the cooling Full Load Rated Indoor Airflow is not used as the airflow for the test (because there are Manufacturer-specified fan control settings or instructions to obtain steady-state operation for the test, per the provisions of Section 5.18), use the Manufacturer-specified fan control setting for that test condition or allow the system to automatically adjust airflow, as specified in the Manufacturer's Installation Instructions. Adjust the airflow-measuring apparatus to meet the adjusted total ESP requirement determined per Section 5.17 with a condition tolerance of -0.00/+0.05 in H_2O, using the measured airflow in the ESP calculation.

5.20 Outdoor Airflow Rate for units with Free Air Discharge Condensers.

All Standard Ratings shall be determined at the outdoor airflow rate obtained with no condenser ducting. Where the fan drive is non-adjustable, the Standard Ratings shall be determined at the outdoor airflow rate inherent in the equipment. For adjustable speed fans, the outdoor fan speed shall be set as specified in the Manufacturer's Installation Instructions or as determined by automatic controls. Once established, no changes affecting outdoor airflow shall be made unless automatically adjusted by unit controls or adjusted to achieve stability as described in Sections E7.3 or E7.4. Outdoor airflow rate does not need to be measured unless using the outdoor air enthalpy method per Section E6.5.

5.21 Outdoor Airflow Rate and External Static Pressure for Units with Ducted Condensers.

5.21.1 Summary

For Double-duct Systems, rate based on non-zero condenser ESP using the provisions of Section 5.21.2.

For equipment with a condenser fan/motor assembly designed for external ducting of condenser air that is not a Double-duct System (for example, if the unit does not meet the maximum height or width requirements, or if the unit has a rated Cooling Capacity greater than 300,000 Btu/h), rate based on zero condenser ESP using the provisions of Section 5.21.3. For such equipment, non-standard (for example, higher-static) ducted condenser fans are considered an optional feature per Section D3.18. See Sections D2 and D3.18 for further provisions regarding testing without this optional feature, as applicable.

5.21.2 Rating based on non-zero condenser ESP

5.21.2.1 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 ANSI/ASHRAE Standard 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 ANSI/ASHRAE Standard 37 (such as at least 2.5 times the mean geometric cross-sectional dimension from the equipment outlet). If using the outdoor air enthalpy method, perform a secondary verification test with the outdoor airflow measurement apparatus attached to the outdoor duct in addition to the outlet duct restrictors (do not adjust the outlet duct restrictors) for full-load cooling and heating tests, as specified in section E6.5.2.

5.21.2.2 Full-Load Cooling Test.

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

5.21.2.3 Heating and Part Load Cooling Tests.

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

5.21.3 Rating based on zero condenser ESP

5.21.3.1 Installation and setup

Install the unit with outdoor coil ductwork and external static pressure measurements made in accordance with Section 6.4 and Section 6.5 of ANSI/ASHRAE Standard 37 and manufacturer's instructions as applicable. The unit shall operate at 0.0 in H_2O external static pressure with a condition tolerance of -0.00/+0.05 in H_2O. If manufacturer's instructions provide guidance for setting outdoor airflow (for example, outdoor fan control settings), set the outdoor airflow per manufacturer's instructions while maintaining the outdoor air ESP within -0.00/+0.05 in H_2O of 0.0 in H_2O. If manufacturer's instructions do not provide any guidance for setting outdoor airflow, test using the as-shipped outdoor fan setting while maintaining the outdoor air ESP within -0.00/+0.05 in H_2O of 0.0 in H_2O. If the outdoor air ESP cannot be maintained within -0.00/+0.05 in H_2O of 0.0 in H_2O at the Manufacturer-specified or as-shipped fan setting (as applicable), operate with a fan setting as close as possible to the target fan setting (such as Manufacturer-specified or as-shipped) that allows for meeting this outdoor air ESP requirement. Outdoor airflow rate does not need to be measured unless using the outdoor air enthalpy method per Section E6.5.

5.21.3.2 Outdoor Air ESP Tolerance.

The outdoor air ESP tolerance of -0.00/+0.05 in H_2O is a condition tolerance that applies throughout the test. Specifically, the average value of the outdoor air ESP measured over the course of the test shall vary from the target value by no more than the condition tolerance. An operating tolerance for ESP is specified in Section 5.24.

5.22 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 5.24.

For cooling tests of single package units that do not reject condensate to the outdoor coil, and for which 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 5.24.

For heating tests of all air-source heat pumps, entering outdoor air shall be controlled to the wet-bulb temperature requirements in Table 26 and wet-bulb tolerances in Section 5.24.

For all other tests, there are no requirements on outdoor air water vapor content.

5.23 Water flow rate for water-cooled units

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

Except as adjusted for operation at low condenser temperatures per Section E7, for part-load cooling tests, use manufacturer-specified 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.

5.24 Test Tolerances

5.24.1 Order of precedence

Tolerances specified in this standard supersede tolerances specified in ANSI/ASHRAE Standard 37.

5.24.2 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 allowable variation is the specified percentage of the average value of the measured test parameter.

5.24.3 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.

5.24.4 Table of tolerances

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

Table 6 Tolerances

Measurement	Test Operating Tolerance	Test Condition Tolerance
Outdoor dry-bulb temperature (°F): Entering Leaving	 2.0 2.0 / 3.0[1,2]	 0.5 -
Outdoor wet-bulb temperature (°F): Entering Leaving	 1.0 1.0[2]	 0.3[3] -
Outdoor dew point temperature (°F)[4]: Entering	 -	 3.0
Indoor dry-bulb temperature (°F): Entering Leaving	 2.0 2.0 / 3.0[1]	 0.5 -
Indoor wet-bulb temperature (°F): Entering Leaving	 1.0 1.0	 0.3[5] -
Water serving outdoor coil temperature (°F): Entering Leaving	 0.5 0.5	 0.2 0.2
Water serving outdoor coil flow rate, when flow rate specified (percent)	2.0	1.0
Make Up Water temperature (°F):	10.0	5.0
Saturated refrigerant temperature corresponding to the measured indoor side pressure[6] (°F)	3.0	0.5
Liquid refrigerant temperature[6] (°F)	0.5	0.2
External static pressure (in H_2O)	0.05	See Section 5.19
Return static pressure	-	See Section 5.17.5
Electrical voltage (percent of reading)	2.0	1.0
Electrical Frequency (Hz)[7]	0.4	0.2
Water flow rate (percent of reading)	2.0	See Section 5.23
Nozzle pressure drop (percent of reading)	2.0	-

Notes:
1. The test operating tolerance is 2.0°F for cooling tests and 3.0°F for heating tests.
2. Applies only when using the outdoor air enthalpy method.
3. Applicable for heating tests of air-cooled units and only applicable for cooling tests when testing evaporatively-cooled equipment or, equipment that rejects condensate to the outdoor coil.
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.
5. Applicable only for cooling tests.
6. Tolerance applies 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.
7. 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.

6.2 Cooling Efficiency

6.2.1 Summary

Determine IVEC using Sections 6.2.2 through 6.2.9.

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

6.2.2 Rating conditions

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

Table 7 IVEC and EER2 Rating Conditions

Conditions	**Cooling Bin A**	**Cooling Bin B**	**Cooling Bin C**	**Cooling Bin D**
Target load percentage	100.0	73.0	48.0	13.0
Indoor				
Return Air Dry-Bulb Temperature (°F)	80.0	77.0	77.0	77.0
Return Air Wet-Bulb Temperature (°F)	67.0	64.0	64.0	64.0
Indoor Airflow[1]	Full Airflow	Rated	Rated	Rated
Condenser (Air Cooled)				
Entering Air Dry-Bulb Temperature (°F)	95.0	85.0	75.0	65.0
Entering Air Dew Point (°F)[2]	60.5	56.5	56.5	56.5
Entering Air Wet-Bulb Temperature (°F)[3]	75.0	65.0	57.0	52.0
Condenser Airflow: see note 4				
Condenser (Water Cooled)				
Entering Water Temperature (°F)	85.0	72.0	62.0	55.0
Leaving Water Temperature (°F)	95.0			
Water Flow Rate: see Section 5.23				
Condenser (Evaporatively Cooled)				
Entering Air Dry-bulb Temperature (°F)	95.0	85.0	75.0	65.0
Entering Air Wet-Bulb Temperature (°F)	75.0	65.0	57.0	52.0
Makeup Water Temperature (°F)	85.0	77.0	77.0	77.0
Condenser Airflow: see note 4				

Notes

1. Refer to sections 5.17 through 5.19 for indoor airflow and external static pressure.

2. Applies only to single package units that do not reject condensate to the outdoor coil, and for which all or part of the indoor section of the equipment is located in the outdoor chamber. See Section 5.22.

3. Applies only to units that reject condensate to the outdoor coil. See Section 5.22.

4. Refer to sections 5.20 and 5.21 for outdoor airflow and external static pressure.

6.2.3 Load percentages

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

Equation LP

$$Load\ percentage = 100 \times \frac{Q}{Q_A}$$

Where:

Q = The cooling capacity determined for the test, Btu/h

Q_A = The cooling capacity measured for the full-load cooling test in Section 6.2.5, Btu/h

6.2.4 Adjustments to measured cooling capacity and power values

6.2.4.1 Summary

For each test, determine the adjusted total cooling capacity and power values by applying all adjustments in Section 6.2.4, as applicable.

6.2.4.2 Fan power and capacity for coil-only units

For tests of coil-only indoor units, subtract the applicable capacity adjustment in Table 8 from the total Cooling Capacity measured for each test, and add the applicable fan power adjustment in Table 8 to the total unit power and indoor fan power measured for each test. Use the airflow rate measured for the test. Use the values specified in Table 8 for full-load airflow for all tests that use full-load cooling airflow, and use the values specified for part-load airflow for all other tests.

Table 8 Coil-only cooling capacity and fan power adjustments

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

Footnotes:

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

2. Part-load airflow values are based on an airflow rate that is 67% of the full-load airflow rate.

6.2.4.3 Cooling tower and system pump power for water-cooled units

For water-cooled units, add 10 W per 1000 Btu/h Cooling Capacity to the total unit power and condenser section power measured for each test.

6.2.5 Full-load test for cooling bin A

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

6.2.6 Tests and calculations for cooling bins B, C, and D

6.2.6.1 Summary

For each cooling bin B through D, perform the following 3 steps:

1) Determine the test and calculation method using Section 6.2.6.2.

2) Perform test(s), calculate the capacity adjustment for the bin, and calculate the total power for each operating mode in the bin using sections 6.2.6.3, 6.2.6.4, or 6.2.6.5, as applicable.

3) Calculate the annual energy consumption for the bin using section 6.2.6.6.

6.2.6.2 Determination of test and calculation method

6.2.6.2.1 Operation within 3 percentage points of target load percentage

If the unit can operate continuously at the conditions specified in Table 7 for the cooling bin, with a measured load percentage greater than or equal to the minimum load percentage and less than or equal to the maximum load percentage specified in Table 9 for the cooling bin, determine the test to run, the capacity adjustment, and the input power of each operating mode for the cooling bin using section 6.2.6.3.

Table 9 Minimum and maximum load percentages for operation within 3 percentage points of target load percentage

	Cooling Bin B	Cooling Bin C	Cooling Bin D
Nominal 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

6.2.6.2.2 Interpolation between two operating levels

If the unit cannot operate continuously in the range of load percentages specified in Section 6.2.6.2.1, but it can operate continuously at the conditions specified in Table 7 for the cooling bin, with a measured load percentage less than the minimum load percentage specified in Table 9 for the cooling bin, determine the tests to run, the capacity adjustment, and the input power of each operating mode for the cooling bin using section 6.2.6.4.

6.2.6.2.3 Cyclic degradation

If the unit cannot operate continuously in the range of load percentages specified in Sections 6.2.6.2.1 or 6.2.6.2.2, determine the test to run, the capacity adjustment, and the input power of each operating mode for the cooling bin using section 6.2.6.5.

6.2.6.3 Operation within 3 percentage points of target load percentage

6.2.6.3.1 Tests

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

6.2.6.3.2 Capacity adjustment

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

Equation QA

$$QA = Q - 0.01 \times TLP \times Q_A$$

Where:

QA	=	Capacity adjustment, Btu/h
Q	=	The cooling capacity determined for the test in section 6.2.6.3.1, Btu/h
TLP	=	The target load percentage for the cooling bin in Table 7
Q_A	=	The cooling capacity determined for the full-load cooling test in Section 6.2.5, Btu/h

6.2.6.3.3 Mechanical-only mode power

The total power in watts for mechanical-only mode is the sum of all values in the Power Value in Watts column of Table 10.

Table 10 Component power values

Component	**Power Value in Watts**
Compressor	Compressor power determined in section 6.2.6.3.1
Condenser section	Condenser section power determined in section 6.2.6.3.1
Indoor fan	Indoor fan power determined in section 6.2.6.3.1
Controls	Controls power determined in section 6.2.6.3.1

6.2.6.3.4 Integrated-economizing mode power

The total power in watts for integrated-economizing mode is the sum of all values in the Power Value in Watts column of Table 11.

Table 11 Component power values

Component	**Power Value in Watts**
Compressor	Compressor power determined in section 6.2.6.3.1
Condenser section	Condenser section power determined in section 6.2.6.3.1
Indoor fan	Indoor fan power determined for the full-load test in Section 6.2.5
Controls	Controls power determined in section 6.2.6.3.1

6.2.6.3.5 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 12.

Table 12 Component power values

Component	**Power Value in Watts**

Indoor fan	For cooling bins B and C: indoor fan power determined for the full-load test in section 6.2.5. For cooling bin D: indoor fan power determined in section 6.2.6.3.1.
Controls	Controls power determined for the full-load test in Section 6.2.5
Crankcase heat	Sum of the manufacturer-specified crankcase heat power values for all compressors

6.2.6.4 Interpolation between two operating levels

6.2.6.4.1 Tests

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

6.2.6.4.2 Capacity adjustment

The capacity adjustment is zero.

6.2.6.4.3 Higher-level operating fraction

Calculate the higher-level operating fraction using Equation HLFC.

Equation HLFC

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

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 6.2.6.4.1
LP_{HR}	=	Load percentage measured for the higher operating level in section 6.2.6.4.1

6.2.6.4.4 Mechanical-only mode power

Using the lower and higher operating levels for the heating bin determined in Section 6.2.6.4.1, determine the total power for mechanical-only mode in watts using two steps as follows.

1) For each of the Higher Operating Level and Lower Operating Level columns in Table 13, sum all 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.

All symbols in Table 13 are defined in Table 14.

Table 13 Coefficients and Component Power Values in Watts

	Higher Operating Level	**Lower Operating Level**
Coefficient	X	1-X
Component		
Compressor	Compressor power determined in Section 6.2.6.4.1 for the higher operating level	Compressor power determined in Section 6.2.6.4.1 for the lower operating level
Condenser section	Condenser section power determined in Section 6.2.6.4.1 for the higher operating level	Condenser section power determined in Section 6.2.6.4.1 for the lower operating level
Indoor fan	Indoor fan power determined in Section 6.2.6.4.1 for the higher operating level	Indoor fan power determined in Section 6.2.6.4.1 for the lower operating level
Controls	Controls power determined in Section 6.2.6.4.1 for the higher operating level	Controls power determined in Section 6.2.6.4.1 for the lower operating level

Table 14 Symbols

Symbol	Meaning
X	Higher-level operating fraction calculated in Section 6.2.6.4.3

6.2.6.4.5 Integrated-economizing mode power

Using the lower and higher operating levels for the heating bin determined in Section 6.2.6.4.1, determine the total power for integrated-economizing mode in watts using two steps as follows.

1) For each of the Higher Operating Level and Lower Operating Level columns in Table 15, sum all 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.

All symbols in Table 15 are defined in Table 14.

Table 15 Coefficients and Component Power Values in Watts

	Higher Operating Level	**Lower Operating Level**
Coefficient	X	1-X
Component		
Compressor	Compressor power determined in Section 6.2.6.4.1 for the higher operating level	Compressor power determined in Section 6.2.6.4.1 for the lower operating level
Condenser section	Condenser section power determined in Section 6.2.6.4.1 for the higher operating level	Condenser section power determined in Section 6.2.6.4.1 for the lower operating level
Indoor fan	Indoor fan power determined for the full-load test in Section 6.2.5	Indoor fan power determined for the full-load test in Section 6.2.5
Controls	Controls power determined in Section 6.2.6.4.1 for the higher operating level	Controls power determined in Section 6.2.6.4.1 for the lower operating level

6.2.6.4.6 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 16. All symbols in Table 16 are defined in Table 17.

Table 16 Component power values

Component	**Power Value in Watts**
Indoor fan	For cooling bins B and C: indoor fan power determined for the full-load test in Section 6.2.5. For cooling bin D: $(1 - X) * P_{IF,LR} + X * P_{IF,HR}$
Controls	Controls power determined for the full-load test in Section 6.2.5
Crankcase heat	Sum of the manufacturer-specified crankcase heat power values for all compressors

Table 17 Symbols

Symbol	Meaning
X	Higher-level operating fraction calculated in Section 6.2.6.4.3
$P_{IF,LR}$	Indoor fan power determined for the lower operating level in section 6.2.6.4.1, W
$P_{IF,HR}$	Indoor fan power determined for the higher operating level in section 6.2.6.4.1, W

6.2.6.5 Cyclic degradation

6.2.6.5.1 Tests

Perform one test at the operating level that results in the lowest measured load percentage. Perform all applicable capacity and power adjustments in Section 6.2.4.

6.2.6.5.2 Capacity adjustment

The capacity adjustment is zero.

6.2.6.5.3 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 18, sum all 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.

All symbols in Table 18 are defined in Table 19.

Table 18 Coefficients and Component Power Values in Watts

	Lowest Operating Level	**Off Cycle**
Coefficient	LF	1 – LF
Component		
Compressor	If crankcase heat is not included in compressor power: $C_d \times P_C$ If crankcase heat is included in compressor power: $C_d \times (P_C - P_{CCH,NOC})$	Zero
Condenser section	$C_d \times P_{CD}$	Zero
Indoor fan	Indoor fan power determined in Section 6.2.6.5.1	Indoor fan power determined in Section 6.2.6.5.1
Controls	Controls power determined in Section 6.2.6.5.1	Controls power determined in Section 6.2.6.5.1
Crankcase heat	If crankcase heat is included in controls power: zero If crankcase heat is included in compressor power: $P_{CCH,NOC}$	If crankcase heat is included in controls power: sum of the manufacturer-specified crankcase heat power values for all compressors operating during the test in Section 6.2.6.5.1 If crankcase heat is included in compressor power: sum of the manufacturer-specified crankcase heat power values for all compressors

Table 19 Symbols

Symbol	**Meaning**
LF	$\frac{TLP}{LP}$
TLP	Target load percentage for the cooling bin in Table 7
LP	Load percentage determined for the test in section 6.2.6.5.1
C_d	$-0.013 \times \text{LF} + 1.13$
P_C	Compressor power determined in section 6.2.6.5.1, W
P_{CD}	Condenser section power determined in section 6.2.6.5.1, W

$P_{CCH,NOC}$	Sum of the manufacturer-specified crankcase heat power values for all compressors not operating during the test in section 6.2.6.5.1, W

6.2.6.5.4 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 20, sum all 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.

All symbols in Table 20 are defined in Table 19.

Table 20 Coefficients and Component Power Values in Watts

	Lowest Operating Level	**Off Cycle**
Coefficient	LF	1 – LF
Component		
Compressor	If crankcase heat is not included in compressor power: $C_d \times P_C$ If crankcase heat is included in compressor power: $C_d \times (P_C - P_{CCH,NOC})$	Zero
Condenser section	$C_d \times P_{CD}$	Zero
Indoor fan	Indoor fan power determined for the full-load test in Section 6.2.5	Indoor fan power determined for the full-load test in Section 6.2.5
Controls	Controls power determined in Section 6.2.6.5.1	Controls power determined in Section 6.2.6.5.1
Crankcase heat	If crankcase heat is included in controls power: zero If crankcase heat is included in compressor power: $P_{CCH,NOC}$	If crankcase heat is included in controls power: sum of the manufacturer-specified crankcase heat power values for all compressors operating during the test in Section 6.2.6.5.1 If crankcase heat is included in compressor power: sum of the manufacturer-specified crankcase heat power values for all compressors

6.2.6.5.5 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 21.

Table 21 Component power values

Component	**Power Value in Watts**
Indoor fan	For cooling bins B and C: indoor fan power determined for the full-load test in Section 6.2.5. For cooling bin D: indoor fan power determined in Section 6.2.6.5.1.
Controls	Controls power determined for the full-load test in Section 6.2.5
Crankcase heat	Sum of the manufacturer-specified crankcase heat power values for all compressors

6.2.6.6 Annual energy consumption

Calculate total annual energy consumption for the cooling bin using Equation CAEC and the operating hours for each operating mode of the cooling bin in Table 22.

Equation CAEC

$$E = h_{MO} \times P_{MO} + h_{IE} \times P_{IE} + h_{EO} \times P_{EO}$$

Where:

E	=	Energy consumption for the cooling bin, Wh
P_{MO}	=	Total power in mechanical-only mode from Section 6.2.6.3.3, 6.2.6.4.4, or 6.2.6.5.3, as applicable, W
P_{IE}	=	Total power in integrated-economizing mode from Section 6.2.6.3.4, 6.2.6.4.5, or 6.2.6.5.4, as applicable, W
P_{EO}	=	Total power in economizer-only mode from Section 6.2.6.3.5, 6.2.6.4.6, or 6.2.6.5.5, as applicable, W

Table 22 Operating hours for all cooling bins and operating modes

Cooling Bin	h_{MO} Mechanical-only mode hours	h_{IE} Integrated-economizing mode hours	h_{EO} Economizer-only mode hours
B	4	85	1791
C	4	95	179
D	181	767	1114

6.2.7 Ventilation energy consumption

Calculate ventilation energy consumption in Wh by taking the sum of all values in the Power Value in Watts column of Table 23, and multiplying that sum by 338 hours.

Table 23 Component power values

Component	**Power Value in Watts**
Indoor fan	For air conditioners: the lowest determined indoor fan power from all cooling tests For heat pumps: the lowest determined indoor fan power from all cooling and heating tests
Controls	Controls power determined for the full-load test in Section 6.2.5
Crankcase heat	Sum of the manufacturer-specified crankcase heat power values for all compressors

6.2.8 Standby energy consumption

Calculate standby power in W by taking the sum of all values in the Power Value in Watts column of Table 24.

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

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

Table 24 Component power values

Component	**Power Value in Watts**
Controls	Controls power determined for the full-load test in Section 6.2.5
Crankcase heat	Sum of the manufacturer-specified crankcase heat power values for all compressors

6.2.9 IVEC

Calculate IVEC in units of Btu/Wh using Equation IVEC.

Equation IVEC

$$IVEC = \frac{977.658 \times Q_A + 185 \times QA_B + 862 \times QA_C + 1293 \times QA_D}{E_B + E_C + E_D + E_V + E_S}$$

Where:

Q_A = The cooling capacity measured for the full-load cooling test in Section 6.2.5, Btu/h

QA_B = Capacity adjustment for cooling bin B, determined in Section 6.2.6.3.2, 6.2.6.4.2, or 6.2.6.5.2, as applicable, Btu/h

QA_C = Capacity adjustment for cooling bin C, determined in Section 6.2.6.3.2, 6.2.6.4.2, or 6.2.6.5.2, as applicable, Btu/h

QA_D = Capacity adjustment for cooling bin D, determined in Section 6.2.6.3.2, 6.2.6.4.2, or 6.2.6.5.2, as applicable, Btu/h

E_B = Energy consumption for cooling bin B calculated in section 6.2.6.6, Wh

E_C = Energy consumption for cooling bin C calculated in section 6.2.6.6, Wh

E_D = Energy consumption for cooling bin D calculated in section 6.2.6.6, 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 EER2

Calculate EER2 in units of Btu/Wh using equation 4.

$$EER2 = \frac{Q_A}{P_{C,A}+P_{CD,A}+P_{IF,A}+P_{CT,A}} \quad (4)$$

Where:

Q_A = The cooling capacity measured for the full-load cooling test in Section 6.2.5, Btu/h

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

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

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

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

6.3 Heating Efficiency

6.3.1 Summary

Determine IVHE or $IVHE_C$ using Sections 6.3.2 through 6.3.12.

Determine COP2 by performing one or more high operating level tests in Section 6.3.5 and calculating COP2 using Section 6.3.13.

6.3.2 Building load profile and heating bins

Table 25 indicates the operating hours, outdoor dry-bulb temperature, and defrost degradation coefficient for each heating bin in the IVHE U.S. average and $IVHE_C$ cold average building load profiles.

Table 25 IVHE and $IVHE_C$ Building Load Profile and Weighting Hours

Heating bin number, i	IVHE U.S. Average			$IVHE_C$ Cold Average		
	Operating hours, h_i	Outdoor dry-bulb temperature, T_i (°F)	Defrost degradation coefficient, CD_{DFi}	Operating hours, h_i	Outdoor dry-bulb temperature, T_i (°F)	Defrost degradation coefficient, CD_{DFi}
1	404	45.0	1.00000	594	41.5	1.00000
2	404	41.4	1.00000	587	37.0	0.91000
3	351	37.7	0.93100	532	31.6	0.86870

4	247	33.3	0.85983	396	25.6	0.89283
5	158	29.4	0.87878	264	20.0	0.90688
6	90	26.2	0.89088	151	15.7	0.91336
7	50	23.4	0.89921	90	12.2	0.91654
8	25	21.0	0.90488	43	9.5	0.91805
9	11	18.1	0.91014	16	6.4	0.91906
10	5	15.9	0.91312	7	2.2	0.91978

6.3.3 Building load for each heating bin

Calculate the building load for heating bins 1 through 10 of a heating load profile using Equation QBL.

Equation QBL

$$Q_{BLi} = \frac{Q_A \times HCR \times (0.1 \times i - 0.05)}{1.15}$$

Where:

Q_{BLi} = Building load for heating bin i, Btu/h

Q_A = The cooling capacity measured for the full-load cooling test in Section 6.2.5, Btu/h

HCR = The heat-to-cool ratio, as follows:

For the IVHE U.S. average building load profile: 1.00

For the $IVHE_C$ cold average building load profile: 1.35

i = Heating bin number, 1 through 10

6.3.4 Total annual space heating

Calculate total annual space heating for a building load profile using Equation TASH.

Equation TASH

$$TASH = \sum_{i=1}^{10} (h_i \times Q_{BLi})$$

Where:

TASH = Total annual space heating, Btu

i = Heating bin number, 1 through 10

h_i = Operating hours in Table 25 for heating bin i, h

Q_{BLi} = Building load calculated in Section 6.3.3 for heating bin i, Btu/h

6.3.5 Tests

Perform all tests designated as required for the unit's configuration in Table 26. Optionally perform any additional tests specified as optional for the unit's configuration in Table 26.

Table 26 Heating Tests

Test Name	System Configuration	Outdoor Air Condition	Operating level

	Fixed Capacity Controlled	Two or More Stages	Proportionally Capacity Controlled	Dry Bulb (ºF)	Wet Bulb (ºF)	
H47L	-	Optional	Optional	47.0	43.0	Low
H47M	-	Optional	Optional	47.0	43.0	Medium
H47H	Required	Required	Required	47.0	43.0	High
H17L	-	Optional	Optional	17.0	15.0	Low
H17M	-	Optional	Optional	17.0	15.0	Medium
H17H	Required	Required	Required	17.0	15.0	High
H17B	-	-	Optional	17.0	15.0	Boost
H5H	Optional	Optional	Optional	5.0	4.0 (max)	High
H5B	-	-	Optional	5.0	4.0 (max)	Boost

For each test, use the outdoor air entering temperatures specified in Table 26, an indoor entering dry-bulb temperature of 70.0 °F, and an indoor entering wet-bulb temperature no higher than 60.0 °F.

Run all tests specified as high operating level in Table 26 with the maximum compressor operating capacity that is allowed by the controls at 47 °F, and the airflow rate that is used by the controls at 47 °F when operating at the chosen compressor operating capacity.

Run all tests specified as low operating level in Table 26 with the minimum compressor operating capacity that is allowed by the controls at 47 °F, and the airflow rate that is used by the controls at 47 °F when operating at the chosen compressor operating capacity.

Run all tests specified as boost operating level in Table 26 with the maximum compressor operating capacity that is allowed by the controls at 17 °F, and the airflow rate that is used by the controls at 17 °F when operating at the chosen compressor operating capacity.

Run all tests specified as medium operating level in Table 26 with an intermediate (that is, neither maximum nor minimum) compressor operating capacity that is allowed by the controls at 47 °F, and the airflow rate that is used by the controls at 47 °F when operating at the chosen compressor operating capacity.

For all tests at a given operating level in Table 26 (for example, all tests at high operating level), the same number of compressors shall be operating, and each operating compressor shall be operating with the same values of speed, duty cycle, vapor injection setting, and any other operating parameter that affects capacity. All tests at a given operating level shall have the same airflow rate.

For each test, perform all applicable adjustments in Section 6.3.6.

6.3.6 Adjustments to measured heating capacity and power values

For tests of coil-only indoor units, add the applicable capacity adjustment in Table 8 to the Heating Capacity measured for each test, and add the applicable fan power adjustment in Table 8 to the total unit power and indoor fan power measured for each test. Use the airflow rate measured for the test. Use the values specified in Table 8 for full-load airflow for all tests that use full-load heating airflow, and use the values specified for part-load airflow for all other tests.

6.3.7 Capacity at each heating bin temperature and operating level

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

Use Equation CI1 for temperatures between at 17 ºF and 47 ºF. Use Equation CI1 for temperatures below 17 ºF if the unit has a pair of tests at the same operating level at 17 ºF and 47 ºF, and the unit does not have a pair of tests at the same operating level at 5 ºF and 17 ºF.

Use Equation CI2 for temperatures between 5 ºF and 17 ºF if the unit has a pair of tests at the same operating level at 5 ºF and 17 ºF.

Equation CI1

$$Q_{i,X} = CD_{DFi} \times \left[Q_X(17) + \left(Q_X(47) - Q_X(17)\right) \times \frac{T_i - 17}{30}\right]$$

Equation CI2

$$Q_{i,X} = CD_{DFi} \times \left[Q_X(5) + \left(Q_X(17) - Q_X(5)\right) \times \frac{T_i - 5}{12}\right]$$

Where:

$Q_{i,X}$	=	Integrated Heating capacity at heating bin i for operating level X, Btu/h
X	=	Operating level low, medium, high, or boost
CD_{DFi}	=	Defrost degradation coefficient for heating bin i, from Table 25
$Q_X(17)$	=	The instantaneous heating capacity determined for operating level X at 17 °F outdoor dry-bulb temperature in Section 6.3.5, Btu/h
$Q_X(47)$	=	The instantaneous heating capacity determined for operating level X at 47 °F outdoor dry-bulb temperature in Section 6.3.5, Btu/h
T_i	=	Outdoor dry-bulb temperature for heating bin i, from Table 25, °F
$Q_X(5)$	=	The heating capacity determined for operating level X at 5 °F outdoor dry-bulb temperature in Section 6.3.5, 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 PI1 for temperatures between at 17 ºF and 47 ºF. Use Equation PI1 for temperatures below 17 ºF if the unit has a pair of tests at the same operating level at 17 ºF and 47 ºF, and the unit does not have a pair of tests at the same operating level at 5 ºF and 17 ºF.

Use Equation PI2 for temperatures between 5 ºF and 17 ºF if the unit has a pair of tests at the same operating level at 5 ºF and 17 ºF.

Equation PI1

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

Equation PI2

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

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, medium, high, or boost
$P_{Y,X}(17)$	=	Power determined for component Y at operating level X at 17 °F outdoor dry-bulb temperature in Section 6.3.5, W
$P_{Y,X}(47)$	=	Power determined for component Y at operating level X at 47 °F outdoor dry-bulb temperature in Section 6.3.5, W
T_i	=	Outdoor dry-bulb temperature for heating bin i, from Table 25, °F
$P_{Y,X}(5)$	=	Power determined for component Y at operating level X at 5 °F outdoor dry-bulb temperature in Section 6.3.5, W

6.3.9 Heating bin energy consumption

6.3.9.1 Summary

For each heating bin, perform the following 3 steps:

1) Determine the heating bin cut-out factor in Section 6.3.9.2.

2) Determine the method for calculating the heating bin power in Section 6.3.9.3.

3) Calculate the heating bin power using one of Sections 6.3.9.4 through 6.3.9.7, as applicable.

Finally, calculate the total annual energy consumption for all heating bins using section 6.3.9.8.

6.3.9.2 Heating bin cut-out factor

For each heating bin, determine the cut-out factor as follows. If the outdoor air dry-bulb temperature for the heating bin is less than the manufacturer-specified 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 cut-out temperature and less than or equal to the manufacturer-specified cut-in temperature, the cut-out factor is equal to 0.5. Otherwise, the cut-out factor is equal to 1.

6.3.9.3 Method for determining heating bin power

6.3.9.3.1 Temperature below cut-out temperature

Determine the heating bin power using Section 6.3.9.4 if the heating bin cut-out factor is equal to zero.

6.3.9.3.2 Temperature above cut-out temperature with auxiliary heat

Determine the heating bin power using Section 6.3.9.5 if the following 2 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 capacity calculated in Section 6.3.7 for the highest tested operating level.

6.3.9.3.3 Interpolation between two operating levels

Determine the heating bin power using interpolation in Section 6.3.9.6 if the following 3 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 capacity calculated in Section 6.3.7 for the highest tested operating level.

3) The building load for the heating bin is greater than or equal to the capacity calculated in Section 6.3.7 for the lowest tested operating level.

6.3.9.3.4 Cyclic degradation

Determine the heating bin power using cyclic degradation in Section 6.3.9.7 if the following 2 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 capacity calculated in Section 6.3.7 for the lowest tested operating level.

6.3.9.4 Temperature below cut-out temperature

For each heating bin with a temperature below the cut-out temperature, determine the total power in watts by taking the sum of all values in the Power Value in Watts column of Table 27, where all symbols in Table 27 are defined in Table 28.

Table 27 Component power values

Component	**Power Value in Watts**
Compressor	Zero
Condenser section	Zero
Indoor fan	$P_{IF,H17H}$
Controls	Controls power determined for the H17H test
Crankcase heat	Sum of the manufacturer-specified crankcase heat power values for all compressors

Auxiliary heat per 5.9	$\frac{Q_{BL}}{3.412} - P_{IF,H17H}$

Table 28 Symbols

Symbol	Meaning
Q_{BL}	Building load calculated in Section 6.3.3 for the heating bin, Btu/h
$P_{IF,H17H}$	Indoor fan power determined for the H17H test, W

6.3.9.5 Temperature above cut-out temperature with auxiliary heat

For each heating bin with a non-zero cut-out factor, and for which the building load for the heating bin is greater than the capacity calculated for the highest tested stage, 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 29, sum all 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.

All symbols in Table 29 are defined in Table 30.

Table 29 Component power values in watts

	Compressor Operating	Cut Out
Coefficient	δ	1 − δ
Component		
Compressor	Compressor power calculated in Section 6.3.8 for the highest operating level in this cooling bin (that is, boost or high)	Zero
Condenser section	Condenser section power calculated in Section 6.3.8 for the highest operating level in this cooling bin (that is, boost or high)	Zero
Indoor fan	Indoor fan power calculated in Section 6.3.8 for the highest operating level in this cooling bin (that is, boost or high)	$P_{IF,H17H}$
Controls	Controls power determined for the H17H test	Controls power determined for the H17H test
Crankcase heat	Zero	Sum of the manufacturer-specified crankcase heat power values for all compressors
Auxiliary heat	$\frac{Q_{BL} - Q}{3.412}$	$\frac{Q_{BL}}{3.412} - P_{IF,H17H}$

Table 30 Symbols

Symbol	Meaning
δ	Cut-out factor for the heating bin
Q_{BL}	Building load calculated in Section 6.3.3 for the heating bin, Btu/h
Q	Capacity calculated in Section 6.3.7 for the highest operating level in this cooling bin (that is, boost or high), Btu/h
$P_{IF,H17H}$	Indoor fan power determined for the H17H test, W

6.3.9.6 Interpolation between two operating levels

6.3.9.6.1 Summary

For each heating bin with a non-zero cut-out factor, for which the building load for the heating bin is less than or equal to the capacity calculated in Section 6.3.7 for the highest operating level, and for which the building load for the heating bin is greater than or equal to the capacity calculated for the lowest tested operating level, determine the heating bin power using interpolation between two operating levels.

Interpolate between the following 2 operating levels:

1) A higher operating level, for which the capacity calculated in Section 6.3.7 is the closest capacity that is greater than or equal to the building load for the heating bin.

2) A lower operating level, for which the capacity calculated in Section 6.3.7 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 6.3.9.6.2.

Use Section 6.3.9.6.3 to calculate the power for the heating bin.

6.3.9.6.2 Higher-level operating fraction

Calculate the higher-level operating fraction using Equation HLF.

Equation HLF

$$X_{HR} = \frac{Q_{BL} - Q_{LR}}{Q_{HR} - Q_{LR}}$$

Where:

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

Q_{BL} = Building load calculated in Section 6.3.3 for the heating bin, Btu/h

Q_Z = Capacity calculated in section 6.3.7 for operating level Z (where Z is LR for the lower operating level and Z is HR for the higher operating level), Btu/h

6.3.9.6.3 Calculate power

Using the lower and higher operating levels for the heating bin determined in Section 6.3.9.6.1, 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 31, sum all 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.

All symbols in Table 31 are defined in Table 32.

Table 31 Coefficients and Component Power Values in Watts

	Higher Operating Level	**Lower Operating Level**	**Cut Out**
Coefficient	$\delta \times X_{HR}$	$\delta \times (1 - X_{HR})$	$1 - \delta$
Component			
Compressor	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	Zero
Condenser section	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	Zero

Indoor fan	Indoor fan power calculated in Section 6.3.8 for the higher operating level	Indoor fan power calculated in Section 6.3.8 for the lower operating level	$P_{IF,H17H}$
Controls	Controls power determined for the higher operating level at 17 °F	Controls power determined for the lower operating level at 17 °F	Controls power determined for the H17H test
Crankcase heat	Zero	Zero	Sum of the manufacturer-specified crankcase heat power values for all compressors
Auxiliary heat	Zero	Zero	$\frac{Q_{BL}}{3.412} - P_{IF,H17H}$

Table 32 Symbols

Symbol	Meaning
δ	Cut-out factor
X_{HR}	Higher-level operating fraction calculated in Section 6.3.9.6.2
Q_{BL}	Building load calculated in Section 6.3.3 for the heating bin, Btu/h
$P_{IF,H17H}$	Indoor fan power determined for the H17H test, W

6.3.9.7 Cyclic degradation

If the heating bin cut-out factor is not equal to zero, and the building load for the heating bin is less than the capacity calculated for the lowest tested stage, 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 33, sum all 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.

All symbols in Table 33 are defined in Table 34.

Table 33 Coefficients and Component Power Values in Watts

	Lowest Operating Level	**Off Cycle**	**Cut Out**
Coefficient	$\delta \times X$	$\delta \times (1 - X)$	$1 - \delta$
Component			
Compressor	If crankcase heat is not included in compressor power: $\frac{P_C}{PLF}$ If crankcase heat is included in compressor power: $\frac{P_C - P_{CCH,NOC}}{PLF}$	Zero	Zero
Condenser section	$\frac{P_{CD}}{PLF}$	Zero	Zero
Indoor fan	Indoor fan power calculated in Section 6.3.8 for the lowest operating level	Lowest determined indoor fan power from all cooling tests, W	$P_{IF,H17H}$
Controls	Controls power determined for the lowest operating level at 17	Controls power determined for the lowest operating level at 17 °F	Controls power determined for the lowest operating level at 17 °F

	°F		
Crankcase heat	If crankcase heat is included in controls power: zero If crankcase heat is included in compressor power: $P_{CCH,NOC}$	If crankcase heat is included in controls power: sum of the manufacturer-specified crankcase heat power values for all compressors operating for the lowest operating level at 17 °F If crankcase heat is included in compressor power: sum of the manufacturer-specified crankcase heat power values for all compressors	If crankcase heat is included in controls power: sum of the manufacturer-specified crankcase heat power values for all compressors operating for the lowest operating level at 17 °F If crankcase heat is included in compressor power: sum of the manufacturer-specified crankcase heat power values for all compressors
Auxiliary heat see 5.9	Zero	Zero	$\frac{Q_{BL}}{3.412} - P_{IF,H17H}$

Table 34 Symbols

Symbol	Meaning
δ	Cut-out factor for the heating bin
X	$\frac{Q_{BL}}{Q}$
Q_{BL}	Building load calculated in Section 6.3.3 for the heating bin, Btu/h
Q	Capacity calculated in Section 6.3.7 for the lowest operating level in the heating bin, Btu/h
PLF	$1 - 0.25 \times (1 - X)$
P_C	Compressor power calculated in Section 6.3.8 for the lowest operating level
P_{CD}	Condenser section power calculated in Section 6.3.8 for the lowest operating level
$P_{CCH,NOC}$	Sum of the manufacturer-specified crankcase heat power values for all compressors not operating for the lowest operating level at 17 °F
$P_{IF,H17H}$	Indoor fan power determined for the H17H test, W

6.3.9.8 Annual energy consumption

Calculate the total annual energy consumption for all heating bins using Equation AEC and the heating bin operating hours in Table 25.

Equation AEC

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

Where:

E_H = Energy consumption for all heating bins, Wh

i = Heating bin number, 1 through 10

h_i = Operating hours in Table 25 for heating bin i, h

P_i = Total power for heating bin i determined in section 6.3.9.4, 6.3.9.5, 6.3.9.6.3, or 6.3.9.7, as applicable, W

6.3.10 Ventilation

Calculate ventilation energy consumption in Wh by taking the sum of all values in the Power Value in Watts column of Table 35, and multiplying that sum by 515 hours.

Table 35 Component power values

Component	Power Value in Watts
Indoor fan	Lowest determined indoor fan power from all cooling tests
Controls	Controls power determined for the H17H test
Crankcase heat	Sum of the manufacturer-specified crankcase heat power values for all compressors

6.3.11 Standby

Calculate standby energy consumption in Wh by taking the sum of all values in the Power Value in Watts column of Table 36, and multiplying that sum by 645 hours.

Table 36 Component power values

Component	Power Value in Watts
Controls	Controls power determined for the H17H test
Crankcase heat	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 IVHE, and add the subscript C to IVHE (that is, $IVHE_C$) if the calculation used the $IVHE_C$ Cold Average building load profile.

Equation IVHE

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

Where:

TASH = The total annual space heating calculated in Section 6.3.4, Btu

E_H = Energy consumption for all heating bins calculated in section 6.3.9.8, 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

Calculate $COP2_5$ at 5 °F, $COP2_{17}$ at 17 °F, or $COP2_{47}$ at 47 °F, in units of W/W using Equation COP2.

Equation COP2

$$COP2_T = \frac{CD_{DF} \times \frac{Q}{3.412}}{P_C + P_{CD} + P_{IF} + P_{CT}}$$

Where:

T = Subscript on COP2: 5 for $COP2_5$, 17 for $COP2_{17}$, or 47 for $COP2_{47}$

CD_{DF} = 0.91935 for $COP2_5$, 0.91173 for $COP2_{17}$, or 1.00000 for $COP2_{47}$

Q = The cooling capacity determined in Section 6.3.5 for the H5H test for $COP2_5$, the H17H test for $COP2_{17}$, or the H47H test for $COP2_{47}$, Btu/h

P_C = Compressor power determined in Section 6.3.5 for the H5H test for $COP2_5$, the H17H test for $COP2_{17}$, or the H47H test for $COP2_{47}$, W

P_{CD} = Condenser section power determined in Section 6.3.5 for the H5H test for $COP2_5$, the H17H test for $COP2_{17}$, or the H47H test for $COP2_{47}$, W

P_{IF} = Indoor fan power determined in Section 6.3.5 for the H5H test for $COP2_5$, the H17H test for $COP2_{17}$, or the H47H test for $COP2_{47}$, W

P_{CT} = Controls power determined in Section 6.3.5 for the H5H test for $COP2_5$, the H17H test for

$COP2_{17}$, or the H47H test for $COP2_{47}$, W

6.4 Rating Values

6.4.1 Source of capacity and efficiency ratings

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

***6.4.2** Ratings Generated by Test Data.*

Any capacity, IVEC, and IVHE, rating of a Basic Model with a Cooling Capacity ≤ 760,000 Btu/h generated by test data shall be based on the results of at least two individual test samples tested in accordance with all applicable portions of this standard. The IVEC and IVHE ratings shall be lower than or equal to the lower of a) the test sample mean ($\bar{x}$), or b) the lower 95% confidence limit (LCL) divided by 0.95 (as defined by Equations 101 and 102), rounded per Sections 6.1.2.

The capacity, IVEC, and IVHE rating shall be lower than or equal to the mean of the test data from the test samples, rounded per Sections 6.1.2. The Cooling Capacity shall be rated no less than 95% of the mean of the capacities measured for the test samples per 10 CFR §429.43.

$$\bar{x} = \frac{\sum_{i=1}^{n} x_i}{n} \quad 101$$

$$LCL = \bar{x} - t_{.95}\left(\frac{s}{\sqrt{n}}\right) \quad 102$$

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 AEDM.

Any capacity, IVEC, and IVHE, rating of a Basic Model generated by the results of an alternative efficiency determination method (AEDM) shall be no higher than the result of the AEDM output (rounded per Sections 6.1.2). 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 appropriately maintained.

6.4.5 Precision of Standard Capacity Ratings.

These ratings shall be expressed in terms of Btu/h in multiples shown in Table 37.

Table 37 Rounding of Standard Rating Capacities

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

6.4.6 Precision of Energy Efficiency Metrics.

Energy Efficiency Metrics whenever published shall be expressed using the number of significant figures specified in Table 38.

Table 38 Published Rating Significant Figures

Metric	Abbreviation	Units	Significant Figures
Cooled Energy Efficiency Ratio	EER2	Btu/W·h	XX.X

Heating Coefficient of Performance	$COP2_{47}$ $COP2_{17}$ $COP2_{5}$	W/W	X.XX
Integrated, Ventilation, Economizer, Cooling	IVEC	Btu/Wh	XX.X
Integrated, Ventilation, Heating Efficiency	IVHE, $IVHE_C$	Btu/Wh	XX.X
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 ANSI/ASHRAE Standard 37. Uncertainty for Standard Ratings covered by this standard include the following:

6.6.1 *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.

6.6.2 *Uncertainty of Test Rooms*. The same unit tested in multiple rooms cannot yield the same performance due to setup variations and product handling.

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

6.6.4 *Uncertainty of Performance Simulation Tools*. Due to the large complexity of options, manufacturers can use performance prediction tools such as an alternative efficiency determination method (AEDM).

6.6.5 *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.

6.6.6 *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 39 with the listed Acceptance Criteria

Table 39 Acceptance Criteria

Performance Metric	**Acceptance Criteria**
Cooling Metrics	
Full Load Cooling Capacity, Btu/h	≥ 95%
Full Load EER, Btu/(W·h)	≥ 95%
IVEC, Btu/(W)	≥ 90%
Heating Metrics	
Heating Capacity at 47°F, Btu/h	≥ 95%
COP_{47}, W/W	≥ 95%
Heating Capacity at 17°F, Btu/h	≥ 95%
COP_{17}, W/W	≥ 95%
COP_{5}, W/W	≥ 95%
IVHE, Btu/(Wh)	≥ 90%

Section 7 **Minimum Data Requirements for Published Ratings**

7.1 *Minimum Data Requirements for Published Ratings.* As a minimum, Published Ratings shall consist of the following information:

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

7.1.1.1 Cooling Capacity, Btu/h
7.1.1.2 Energy Efficiency Ratio, EER, Btu/W·h
7.1.1.3 Integrated Ventilation, Economizer, Cooling Energy Efficiency, IVEC, Btu/W
7.1.1.4 Compressor crankcase heater rated power, W

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

7.1.2.1 Cooling Capacity, Btu/h
7.1.2.2 Energy Efficiency Ratio 2, EER2, Btu/Wh
7.1.2.3 Integrated Ventilation, Economizer, Cooling Energy Efficiency, IVEC, Btu/Wh
7.1.2.4 High temperature Heating Capacity at 47 °F, Btu/h
7.1.2.5 High temperature Heating Coefficient of Performance at 47 °F, $COP2_{47}$, W/W
7.1.2.6 Low temperature Heating Capacity at 17 °F, Btu/h
7.1.2.7 Low temperature Heating Coefficient of Performance at 17 °F, $COP2_{17}$, W/W
7.1.2.8 Integrated Ventilation Heating Efficiency, IVHE, Btu/Wh
7.1.2.6 Low temperature Heating Capacity at 5 °F, Btu/h
7.1.2.10 Low Temperature Heating Coefficient of Performance at 5 °F, $COP2_5$, W/W (optional)
7.1.2.11 Integrated Ventilation Heating Efficiency for cold climates, $IVHE_C$, Btu/Wh (optional)
7.1.2.12 Compressor crankcase heater rated power, W

All claims to ratings within the scope of this standard shall include the statement "Rated in accordance with AHRI Standard 1340 (I-P)". All claims to ratings outside the scope of this standard shall include the statement "Outside the scope of AHRI Standard 1340 (I-P)". Application Ratings within the scope of the standard shall include a statement of the conditions under which the ratings apply.

7.2 *Latent Capacity Designation.* The moisture removal capacity at Standard Rating Conditions listed in Table 7 shall be published in the manufacturer's specifications and literature. The value shall be expressed consistently one or more of the following forms:

7.2.1 Latent Capacity and Cooling Capacity, Btu/h
7.2.2 Sensible Capacity and Cooling Capacity, Btu/h
7.2.3 Sensible heat ratio (as defined by equation 103) and Cooling Capacity, Btu/h

Informative Note: Cooling Capacity is defined in Section 3.5 and includes both Latent and Sensible Capacity.

$$SHR = \frac{q_{sci}}{q_{tci}} \qquad 103$$

Where:

SHR = Sensible Heat Ratio
q_{sci} = Sensible Capacity, Btu/h
q_{tci} = Cooling Capacity, Btu/h

Section 8 Operating Requirements

8.1 *Operating Requirements.* Commercial and Industrial Unitary Air-Conditioning and Heat Pump Equipment shall comply with the provisions of this section such that any production unit shall meet the requirements detailed herein.

Table 7 indicates the tests and test conditions that are required for operating requirements tests.

Table 7. Conditions for Operating Tests

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	115.0		77.7 (Max)	100.0	80.0	90.0	90.0	--
Cooling Insulation Efficiency	80.0	75.0	80.0	75.0	--	80.0	75.0	85.0	--	80.0
Cooling Condensate Disposal	80.0	75.0	80.0	75.0	--	80.0	75.0	85.0	--	80.0
Heating Maximum Operating Conditions	80.0	--	75.0	65.0		--	--	--	--	--

8.2 *Maximum Operating Conditions Test (Cooling and Heating).* Commercial and Industrial Unitary Air-Conditioning and Heat Pump Equipment shall pass the following maximum cooling and heating operating conditions test with an indoor coil airflow rate as determined under Section 6.1.3.4.2.

8.2.1 *Temperature Conditions.* Temperature conditions shall be maintained as shown in Table 7.

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 Standard 110, at the unit's service connection and at rated frequency.

8.2.3 *Procedure.*

8.2.3.1 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.

8.2.3.2 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.*

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

8.2.4.2 The unit shall resume continuous operation within one hour of restoration of power and shall then operate continuously for one hour. Operation and resetting of safety devices prior to establishment of continuous operation is permitted.

8.2.4.3 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 (Sections 8.2 thru 8.2.3) and meet the requirements of Section 8.2.4 except for the following changes:

8.2.5.1 Outdoor air set as in Section 6.1.3.6
8.2.5.2 Return air temperature conditions shall be 80.0ºF dry-bulb, 67.0ºF wet-bulb
8.2.5.3 Outdoor air entering outdoor air-cooling coil shall be 115ºF dry-bulb and 75.0ºF wet-bulb

8.3 *Cooling Low Temperature Operation Test*. Commercial and Industrial Unitary Air-conditioning and Heat Pump Equipment shall pass the following low-temperature operation test when operating with initial airflow rates as determined in Sections 6.1, 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 Manufacturer's Installation Instructions to the user.

8.3.1 *Temperature Conditions.* Temperature conditions shall be maintained as shown in Table 7.

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 shall be permitted to start and stop under control of an automatic limit device, if provided.

8.3.4 *Requirements.*

8.3.4.1 During the entire test, the equipment shall operate without damage to the equipment.

8.3.4.2 During the entire test, the indoor airflow rate shall not drop more than 25% below that specified for the Standard Rating test.

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

8.4 *Insulation Efficiency Test (Cooling) (Not Required for Heating-Only Units).* Commercial and Industrial Unitary Air-conditioning and Heat Pump Equipment shall pass the following insulation efficiency test when operating with airflow rates as determined in Sections 6.1, and with controls, fans, dampers, and grilles set to produce the maximum tendency to sweat, provided such settings are not contrary to the Manufacturer's Installation Instructions to the user.

8.4.1 *Temperature Conditions*. Temperature conditions shall be maintained as shown in Table 7.

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

8.4.3 *Requirements*. During the test, no condensed water shall drop, run, or blow off from the unit casing.

8.5 *Condensate Disposal Test (Cooling) (Not Required for Heating-only Units).* Commercial and Industrial Unitary Air-conditioning and Heat Pump Equipment that rejects condensate to the condenser air shall pass the following condensate disposal test when operating with airflow rates as determined in Sections 6.1, and with controls and dampers set to produce condensate at the maximum rate, provided such settings are not contrary to the Manufacturer's Installation Instructions to the user.

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

8.5.1 *Temperature Conditions.* Temperature conditions shall be maintained as shown in Table 7.

8.5.2 *Procedure.* After establishment of the specified temperature conditions, the equipment shall be started with its condensate collection pan filled to the overflowing point and shall be operated continuously for four hours after the condensate level has reached equilibrium.
8.5.3 *Requirements*. During the test, there shall be no dripping, running-off, or blowing-off of moisture from the unit casing.

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

Section 9 Marking and Nameplate Data

9.1 *Marking and Nameplate Data.* At a minimum, the nameplate shall display the manufacturer's name, model designation, refrigerant designation per ANSI/ASHRAE Standard 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 Standard 110. Nameplate voltages for 50 Hz systems shall include one or more of the utilization voltages shown in Table 2 of AHRI Standard 110.

Section 10 Conformance Conditions

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

APPENDIX A. REFERENCES – NORMATIVE

A1 Listed here are all standards, handbooks and other publications essential to the formation and implementation of the standard. All references in this appendix are considered as part of the standard.

A1.1 AHRI Standard 110(2016), *Air-Conditioning and Refrigerating Equipment Nameplate Voltages*, , Air-Conditioning, Heating and Refrigeration Institute, 2311 Wilson Boulevard, Suite 400, Arlington, VA 22201, U.S.A.

A1.2 AHRI Standard 1360 (I-P)-2022, *Performance Rating of Computer and Data Processing Room Air Conditioners,* , Air-Conditioning, Heating and Refrigeration Institute, 2311 Wilson Boulevard, Suite 400, Arlington, VA 22201, U.S.A.

A1.3 AHRI Standard 210/240-2023 (2020), *Unitary Air-Conditioning and Air-Source Heat Pump Equipment,* , Air-Conditioning, Heating and Refrigeration Institute, 2311 Wilson Boulevard, Suite 400, Arlington, VA 22201, U.S.A.

A1.4 AHRI Standard 440-2019 (SI), *Standard for Performance Rating of Fan-coil Units,* Air-Conditioning, Heating and Refrigeration Institute, 2111 Wilson Boulevard, Suite 500, Arlington, VA 22201, U.S.A.

A1.5 AHRI Standard 920 (I-P)/2020 with Addendum 1, *Performance Rating of DX-Dedicated Outdoor Air System Units*, , Air-Conditioning, Heating and Refrigeration Institute, 2311 Wilson Boulevard, Suite 400, Arlington, VA 22201, U.S.A

A1.6 ANSI/AHRI Standard 365 (I-P)/2009, *Commercial and Industrial Unitary Air-Conditioning Condensing Units*, , Air-Conditioning, Heating and Refrigeration Institute, 2311 Wilson Boulevard, Suite 400, Arlington, VA 22201, U.S.A.

A1.7 ANSI/AHRI Standard 390, *Performance Rating of Single Package Vertical Air-Conditioners and Heat Pumps*, Air-Conditioning, Heating and Refrigeration Institute, 2311 Wilson Boulevard, Suite 400, Arlington, VA 22201, U.S.A.

A1.8 ANSI/AHRI Standard 470(2006), *Performance Rating of Desuperheater/Water Heaters,* Air-Conditioning, Heating and Refrigeration Institute, 2311 Wilson Boulevard, Suite 400, Arlington, VA 22201, U.S.A.

A1.9 AHRI 310/380-2017: Packaged Terminal Air-conditioners and Heat Pumps (CSA-C744-17) Air-Conditioning, Heating and Refrigeration Institute, 2311 Wilson Boulevard, Suite 400, Arlington, VA 22201, U.S.A.

A1.10 ANSI/AMCA Standard 210-16/ASHRAE 51-16, *Laboratory Methods of Testing for Certified Aerodynamic Performance Rating,* 2016, Air Movement and Control Association International, 30 W. University Drive, Arlington Heights, IL 60004, U.S.A

A1.11 ANSI/ASHRAE Standard 34-2022, *Designation and Safety Classification of Refrigerant,* 201919, ASHRAE, Inc., 180 Technology Parkway NW, Peachtree Corners, GA 30092.

A1.12 ANSI/ASHRAE Standard 37-2009 (RA 2019), *Methods of Testing for Rating Unitary Air-Conditioning and Heat Pump Equipment,* 2009, ASHRAE, Inc., 180 Technology Parkway NW, Peachtree Corners, GA 30092.

A1.13 ANSI/ASHRAE Standard 41.1-2020, *Standard Method for Temperature Measurement,* ASHRAE, Inc., 180 Technology Parkway NW, Peachtree Corners, GA 30092.

A1.14 ANSI/ASHRAE Standard 41.6-2021, *Standard Method for Humidity Measurement,* , ASHRAE, Inc., 180 Technology Parkway NW, Peachtree Corners, GA 30092.

A1.15 ANSI/ASHRAE/AHRI/ISO13256-1-1998 (RA2012), *Water-source heat pumps – Testing and rating for performance – Part 1: Water-to-air and Brine-to-air heat pumps*, 2012, International Organization for Standardization, Case Postale 56, CH-1211, Geneva 21 Switzerland.

A1.16 ANSI/NEMA MG1-2016, *Motors and Generators,* 2016, National Electrical Manufacturers Association, 1300 North 17th Street, Suite 900, Rosslyn, Virginia 22209

A1.17 ASHRAE Terminology. Accessed September 24, 2021. https://www.ashrae.org/technical-resources/authoring-tools/terminology.

A1.18 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, U.S.A.

A1.19 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, U.S.A.

A1.20 CSA – C747-09 (R2014)**,** *Energy Efficiency test methods for small motors*, 2009, CSA Group, 178 Rexdale Blvd., Toronto, Ontario M9W 1R3 Canada

A1.21 Title 10, *Code of Federal Regulations (CFR)*, Part 429 and 431, U.S. National Archives and Records Administration, 8601 Adelphi Road, College Park, MD 20740-6001 or www.ecfr.gov.

A1.22 UL Standard 555-2006, *Standard for Fire Dampers*, 2006, Underwriters Laboratories, Inc., 333 Pfingsten Road, Northbrook, IL, U.S.A.

A1.23 UL Standard 555S-2014, *Standard for Smoke Dampers*, 2014, Underwriters Laboratories, Inc., 333 Pfingsten Road, Northbrook, IL, U.S.A.

A1.24 ISO 5801:2017, *Fans – Performance testing using standardized airways*, 2017, International Organization for Standardization, Case Postale 56, CH-1211, Geneva 21 Switzerland.

A1.25 AHRI Standard 340/360-2022, *Performance Rating of Commercial and Industrial Unitary Air-Conditioning and Heat Pump Equipment*, 2019, Air-Conditioning, Heating, and Refrigeration Institute, 2311 Wilson Boulevard, Suite 400, Arlington, VA 22201, U.S.A.

A1.26. ANSI/ASHRAE Standard 41.1-2013, *Standard Method for Temperature Measurement*, ASHRAE, Inc., 180 Technology Parkway NW, Peachtree Corners, GA 30092.

APPENDIX B. REFERENCES – INFORMATIVE

B1 Listed here are standards, handbooks and other publications which may provide useful information and background but are not considered essential. References in this appendix are not considered part of the standard.

None

APPENDIX C. INDOOR AND OUTDOOR AIR CONDITION MEASUREMENT – NORMATIVE

C1 *Purpose*: This appendix includes modifications to the test stand setup and instrumentation as defined in ANSI/ASHRAE 37-2009 and shall be used in order to be compliant with this standard.

C2 *General.* Measure the indoor and outdoor air entering dry-bulb temperature and water vapor content conditions that are required to be controlled for the test per the requirements in Sections C3 and C4. When using the indoor air enthalpy method to measure equipment capacity, measure indoor air leaving dry-bulb temperature and water vapor content. When using the outdoor air enthalpy method to measure equipment capacity, measure outdoor air leaving dry-bulb temperature and water vapor content. For measuring the indoor and outdoor air leaving dry-bulb temperature and water vapor content conditions, follow the requirements in Section C5. Make these measurements as described in the following sections. Maintain test operating and test condition tolerances and uniformity requirements as described in Section C3.7.

C3 *Outdoor Air Entering Conditions.*

Measure dry-bulb temperature as provided in Section C3.1 for all tests.

Measure the water vapor content as provided in Section C3.2 for the following 4 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

C3.1 *Temperature Measurements.* Measure temperatures in accordance with ANSI/ASHRAE Standard 41.1-2020 and follow the requirements of Table C1. 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 C1.

When measuring dry-bulb temperature for sampled air within the sampled air conduit rather than with the Aspirating Psychrometer as discussed in Section C3.4, use a temperature sensor and instrument system, including read-out devices, with accuracy of ≤ ± 0.2°F and display resolution of ≤ 0.1°F.

Table C1. Temperature Measurement Instrument Tolerance

Measurement	Accuracy, °F	Display Resolution, °F
Dry-bulb and Wet-bulb Temperatures[1]	≤ ± 0.2	≤ 0.1
Thermopile Temperature[2]	≤ ± 1.0	≤ 0.1

Notes:
1. The accuracy specified is for the temperature indicating device and does not reflect the operation of the Aspirating Psychrometer.
2. To meet this requirement, thermocouple wire shall have special limits of error and all thermocouple junctions in a thermopile shall be made from the same spool of wire; thermopile junctions are wired in parallel.

C3.2 *Aspirating Psychrometer or Dew-point Hygrometer Requirements*. If measurement of water vapor is required, use one of the following two methods.

C3.2.1 Aspirating *Psychrometer.* The Aspirating Psychrometer consists of a flow section and a fan to draw air through the flow section and measures an average value of the sampled air stream. The flow section shall be equipped with two dry-bulb temperature probe connections, one shall be used for the facility temperature measurement, and one shall be provided to confirm this measurement using an additional or a third-party's temperature sensor probe. For applications where the humidity is required for testing of evaporatively cooled units or heat pump Unitary products in heating mode, the flow section shall be equipped with two wet-bulb temperature probe connection zones, and one shall be used for the facility wet-bulb measurement and one shall be provided to confirm the wet-bulb measurement using an additional or a third-party's wet-bulb sensor probe. The Aspirating Psychrometer shall include a fan that can either be adjusted manually or automatically to maintain the required velocity of 1,000 ± 200 fpm across the sensors. An example configuration for the Aspirating Psychrometer is shown in Figure C1.

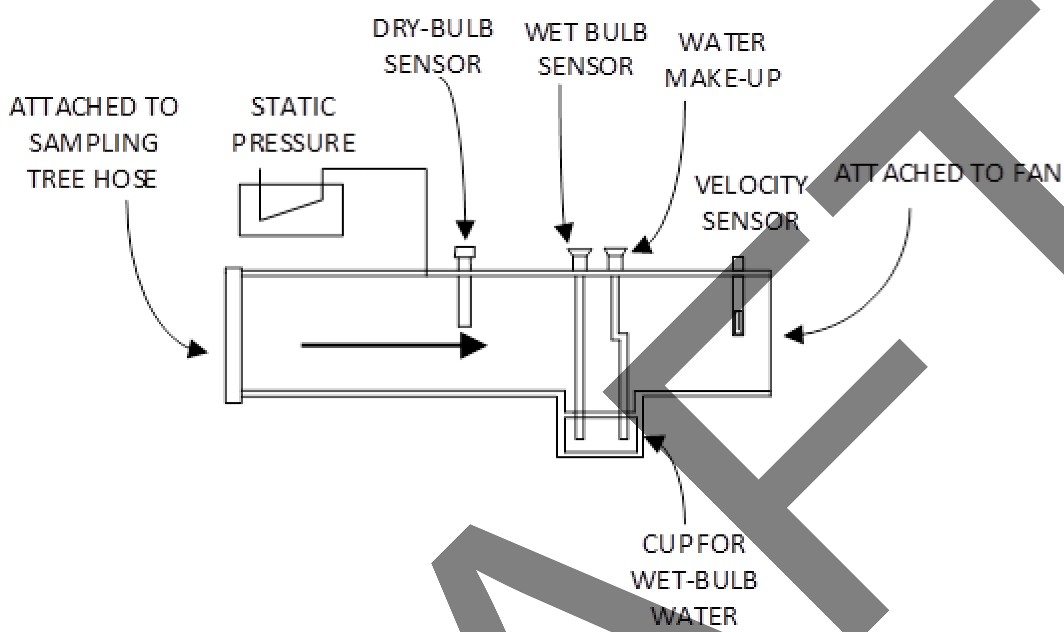

Figure C1. Aspirating Psychrometer

C3.2.2 *Dew-point Hygrometer*. Measure dew point temperature using a Dew-point Hygrometer as specified in Sections 4, 5, 6, 7.1, and 7.4 of ANSI/ASHRAE Standard 41.6 with an accuracy of within ± 0.4°F. Use a dry-bulb temperature sensor within the sampled air conduit and locate the Dew-point Hygrometer downstream of the dry-bulb temperature sensor, and upstream of the fan.

C3.3 *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 C2 for a tree with overall dimensions of 4 ft by 4 ft sample. Other sizes and rectangular shapes shall be permitted and shall be scaled accordingly as long as the aspect ratio (width to height) of no greater than 2 to 1 is maintained.

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

The outdoor inlet Air Sampling Tree shall be equipped with a thermocouple thermopile grid or individual thermocouples to measure the average temperature of the airflow over the Air Sampling Tree. Angled or wrap-around Air Sampling Trees shall have a thermocouple thermopile grid or a grid of individual thermocouples to separately measure the average temperature for each plane (such as. each set of co-planar air sampling holes) of the Air Sampling Tree. The Air Sampling Trees shall be placed within 6-12 in from the unit to minimize the risk of damage to the unit while ensuring that the Air Sampling Trees are measuring the air going into the unit rather than the room air around the unit. Assure that no sampling holes are 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·hr/Btu.

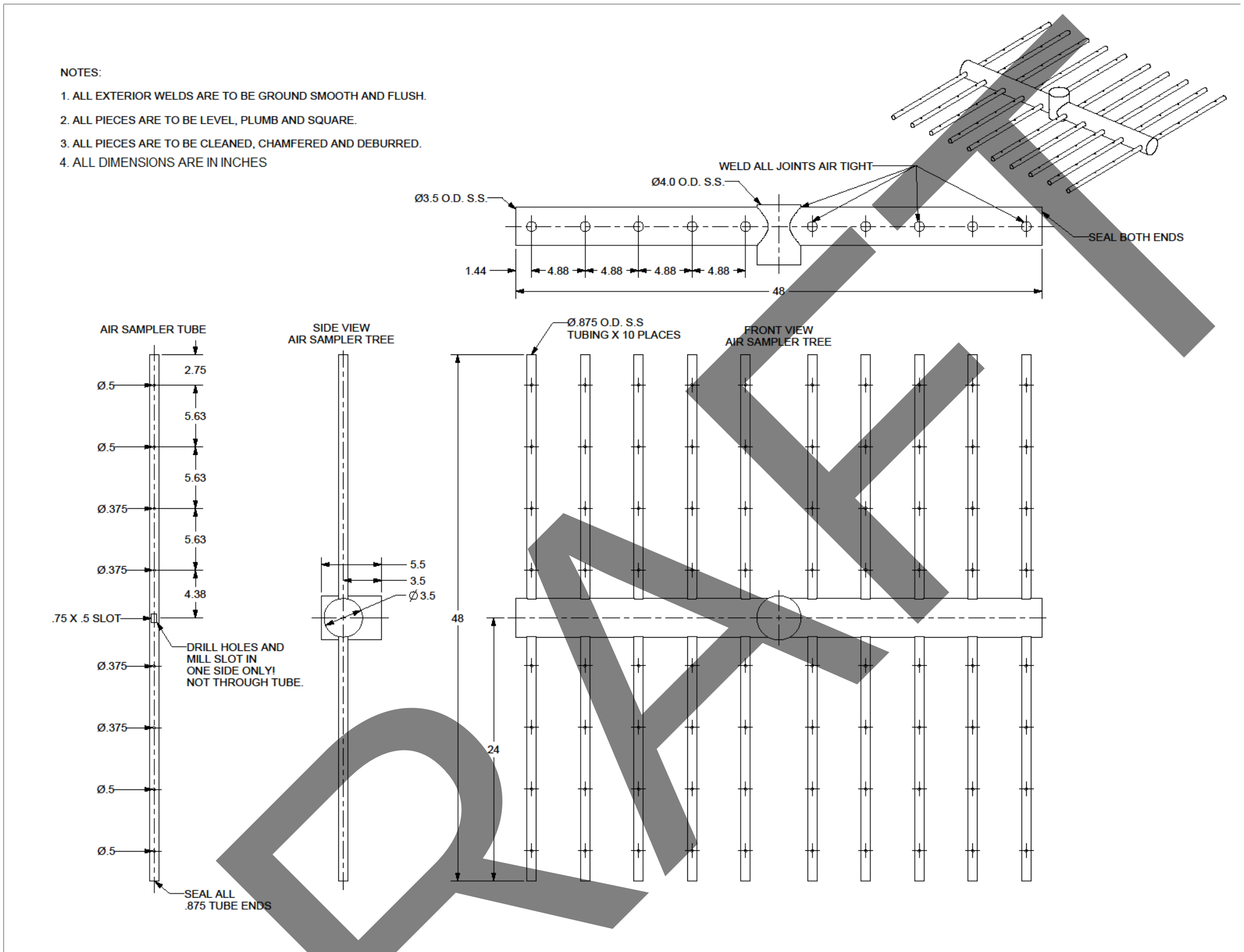

Figure C2. Typical Air Sampling Tree

Note: The 0.75 in by 0.50 in slots referenced in Figure C2 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 allow air to be pulled into the main trunk from each of the branches.

C3.3.1 *Test Setup Description.*

The nominal face area of the airflow shall be divided into a number of equal area sampling rectangles with aspect ratios no greater than 2 to 1. Each rectangular area shall have one Air Sampling Tree.

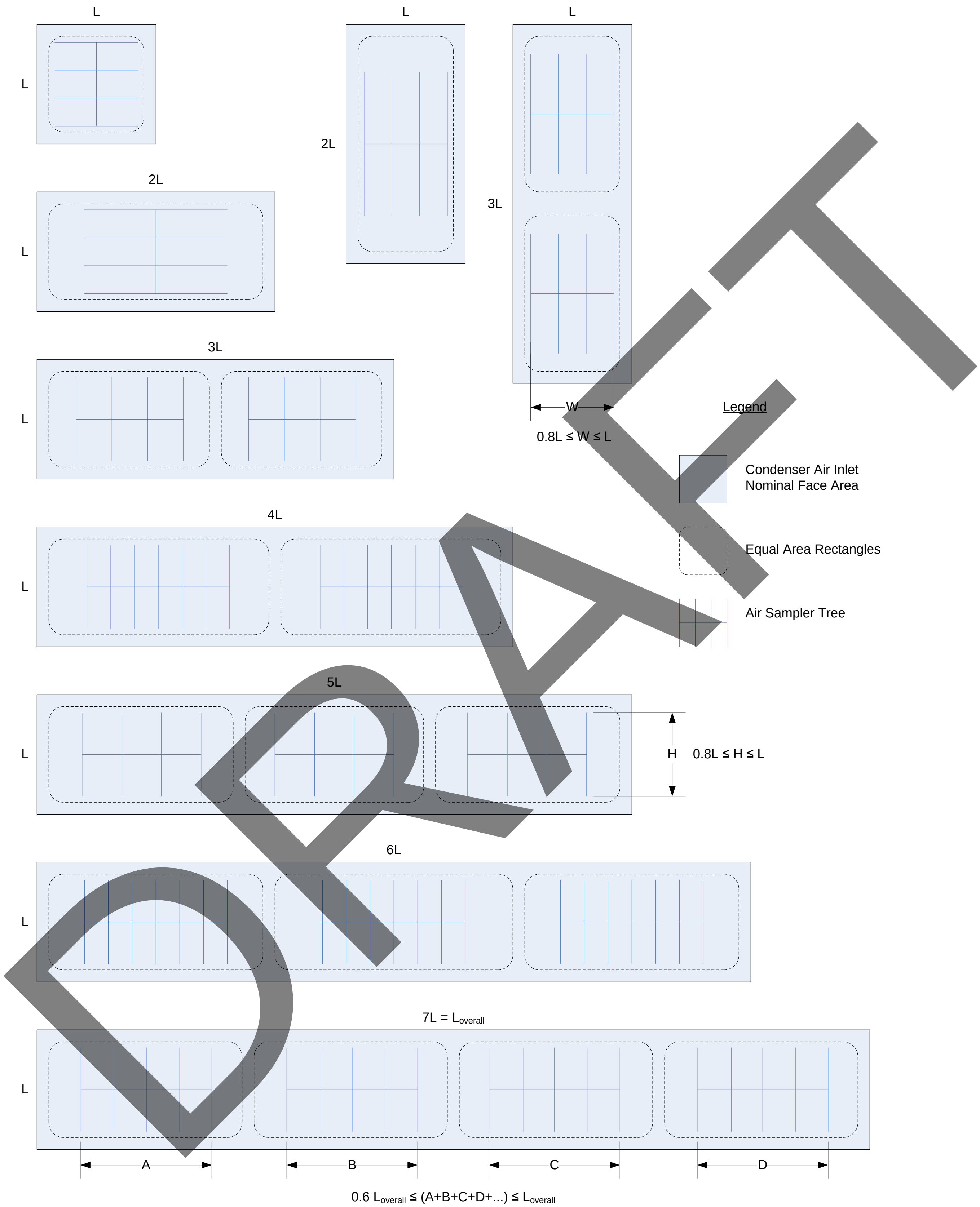

Figure C3. Determination of Measurement Rectangles and Required Number of Air Sampling Trees

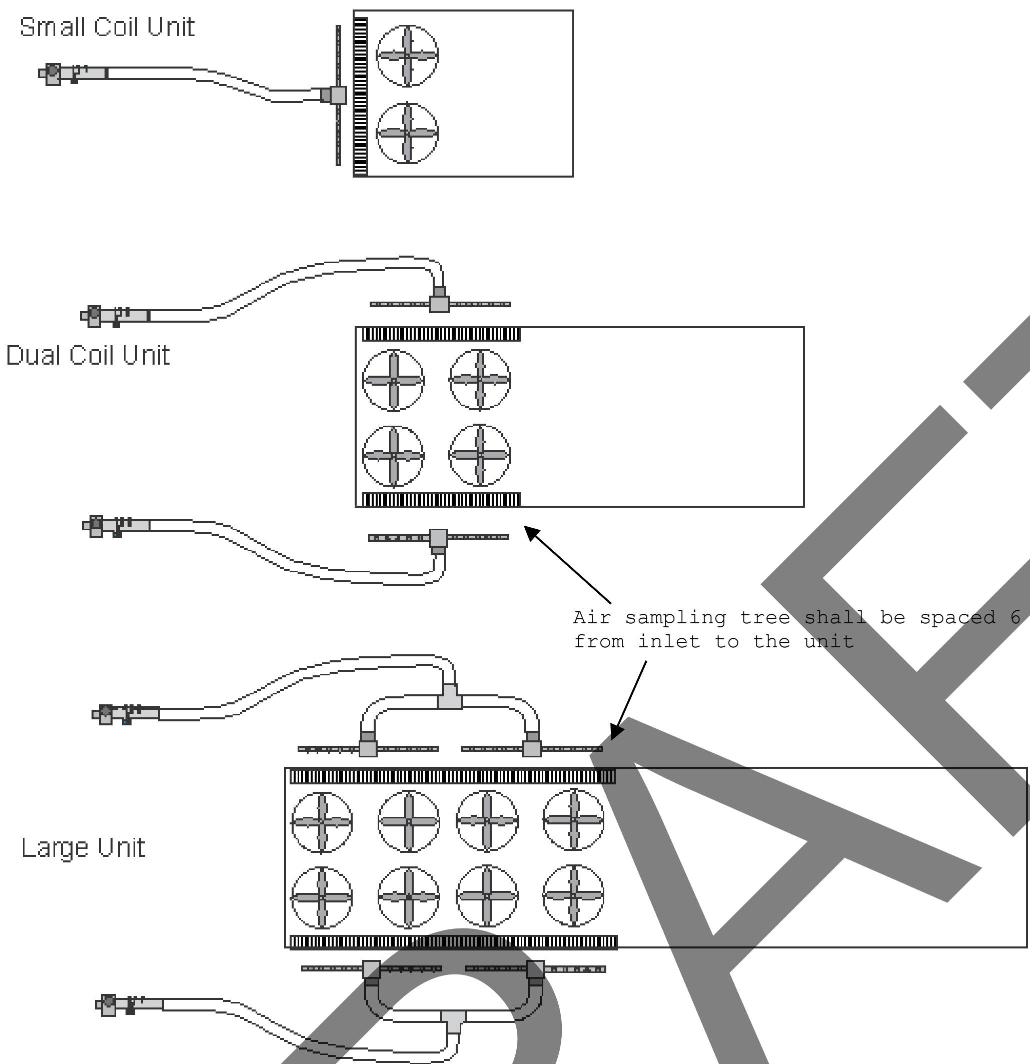

Figure C4. Typical Test Setup Configurations

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 but shall require 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 is acceptable. The 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 C3 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. In order 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 C4 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 allowing adjustment of airflow through the air sampler inlet holes as specified in Section C3.3. Return the fan discharge air to the room where the system draws the outdoor coil intake air.

C3.4 *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 C3.1. 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.

C3.5 *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.

C3.6 *Monitoring and Adjustment for Air Sampler Conduit Temperature Change and Pressure Drop*. If dry-bulb temperature is measured at a distance from the air sampler exits, determine average conduit temperature change as the difference in temperature between the remote dry-bulb temperature and the average of thermopiles or thermocouple measurements of all air samplers collecting air that is measured by the remote dry-bulb temperature sensor. If this difference is greater than 0.5°F, measure dry-bulb temperature at the exit of each air sampler (as described in Section C3.4), and use these additional sensors to determine average indoor entering air dry-bulb temperature.

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

If either the 0.5°F temperature difference threshold or the 2 in H_2O pressure difference threshold are exceeded, use a two-step process to calculate adjusted air properties for example, wet-bulb temperature or enthalpy) for the one or more affected air samplers. First, calculate the moisture level (pounds water vapor per pound dry air) at the humidity measurement location(s) using either the Aspirating Psychrometer dry-bulb and wet-bulb temperature measurements or the Dew-point Hygrometer measurement, using for either approach the adjusted pressure, if it differs from the room atmospheric pressure by 2 in H_2O or more. Then calculate the air properties for the air sampler location based on the moisture level, the room atmospheric pressure, and the dry-bulb temperature at the air sampler location. If the air sampler fan or Aspirating Psychrometer serves more than one air sampler, and the 0.5°F threshold was exceeded, the dry-bulb temperature used in this calculation shall be the average of the air sampler exit measurements. For multiple air samplers, if humidity was measured using multiple hygrometers, the moisture level used in this calculation shall be the average of the calculated moisture levels calculated in the first step.

C3.7 *Temperature Uniformity*. To guarantee air distribution as defined in Table C2, thorough mixing, and uniform air temperature, it is important that the room and test setup is correctly designed and operated. 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 they are below the plane of outdoor fan exhaust and just above the top of the outdoor coil(s). These thermocouples shall not indicate a temperature difference greater than 5.0°F from the average inlet air. Air distribution at the test facility, at the point of supply to the unit, shall be reviewed to determine if it 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.

Pay particular attention to prevent recirculation of outdoor fan exhaust air back through the unit.

When not using Aspirating Psychrometers, the "Aspirating Psychrometer dry-bulb temperature measurement" of Table C2 refers to either

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 C3.6 prior to checking uniformity.

The 1.5ºF dry-bulb temperature tolerance in Table C2 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 to Table C2).

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 C2.

Table C2. Uniformity Criteria for Outdoor Air Temperature and Humidity Distribution

Uniformity Criterion[1]	Purpose	Maximum Variation, °F
Deviation from the mean air dry-bulb temperature to the air dry-bulb temperature at any individual temperature measurement station	Uniform dry-bulb temperature distribution	± 2.0
Difference between dry-bulb temperature measured with Air Sampler Tree thermopile and with Aspirating Psychrometer[2]	Uniform dry-bulb temperature distribution	± 1.5
Deviation from the mean wet-bulb temperature and the individual temperature measurement stations[3]	Uniform humidity distribution	± 1.0

Notes:
1. The uniformity requirements apply to test period averages for each parameter rather than instantaneous measurements. Each measurement station represents a single Aspirating Psychrometer. The mean temperature is the mean of temperatures measures from all measurement stations.
2. Applies when multiple air samplers are connected to a single Aspirating Psychrometer or conduit dry-bulb temperature sensor. If the average of the thermopile measurements differs from the Aspirating Psychrometer or conduit dry-bulb temperature sensor measurement by more than 0.5°F, use air-sampler exit dry-bulb temperature sensors. For this case, the uniformity requirement is based on comparison of each of the air-sampler exit measurements with the average of these measurements.
3. The wet-bulb temperature measurement is only required for outdoor entering air for evaporatively-cooled units and heat pump units operating in heating mode.

C4 *Indoor Coil Entering Air Conditions.* Follow the requirements for outdoor coil entering air conditions as described in Section C3, except for the following:

1) Both dry-bulb temperature and water vapor content measurements are required for all tests.

2) Sampled air shall be returned to the room where the system draws the indoor coil entering air (except if the loop air enthalpy test method specified in Section 6.1.2 of ANSI/ASHRAE Standard 37 is used, where the sampled air shall be returned upstream of the air sampler in the loop duct between the airflow-measuring apparatus and the room conditioning apparatus or to the airflow-measuring apparatus between the nozzles and the fan).

3) The temperature uniformity requirements discussed in Section C3.7 do not apply if a single air sampler is used.

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

C5 *Indoor Coil Leaving Air and Outdoor Coil Leaving Air Conditions*. Follow the requirements for measurement of outdoor coil entering air conditions as described in Section C3, except for the following:

1) The temperature uniformity requirements discussed in Section C3.7 do not apply.

2) Both dry-bulb temperature and water vapor content measurements are required for indoor coil leaving air for all tests and for outdoor coil leaving air for all tests using the outdoor air enthalpy method.

3) Air in the duct leaving the coil that is drawn into the Air Sampling Tree for measurement shall be returned to the duct just downstream of the Air Sampling Tree and upstream of the airflow-measuring apparatus.

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

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

APPENDIX D. UNIT CONFIGURATION FOR STANDARD EFFICIENCY DETERMINATION – NORMATIVE

D1 *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.

D2 *Configuration Requirements*. For the purpose of Standard Ratings, units shall be configured for testing as defined in this Appendix.

D2.1 *Basic Model.* Basic Model means all units manufactured by one manufacturer within a single equipment class, having the same or comparably performing compressor(s), heat exchangers, and air moving system(s) that have a common "nominal" Cooling Capacity.

D2.2 All components indicated in the following list shall be present and installed for all testing for each indoor unit and outdoor unit, as applicable, and shall be the components distributed in commerce with the model. Individual models that contain/use (different or alternate) versions of the same component or controls shall either be represented separately as a unique Basic Model or certified within the same Basic Model based on testing of the least efficient configuration.

1) Compressor(s)
2) Outdoor coil(s) or heat exchanger(s)
3) Outdoor fan/motor(s) (air-cooled systems only)
4) Indoor coil(s)
5) Refrigerant expansion device(s)
6) Indoor fan/motor(s) (except for Coil-Only Indoor Units)
7) System controls

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

1) Reverse cycle heat pump functionality
2) Gas furnace
3) Electric resistance
4) Steam and hydronic coils (if not optional per Section D3.10)

D3 *Optional System Features*. The following features are optional during testing. Individual models with these features can be represented separately as a unique Basic Model or certified within the same Basic Model as otherwise identical individual models without the feature pursuant to the definition of "Basic Model".

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

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

D3.1 *UV Lights*. A lighting fixture and lamp mounted so that it shines light on the indoor coil, that emits ultraviolet light to inhibit growth of organisms on the indoor coil surfaces, the condensate drip pan, and/other locations within the equipment. UV lights shall be turned off for testing.

D3.2 *High-Effectiveness Indoor Air Filtration*. Indoor air filters with greater air filtration effectiveness than the Standard Filter.

D3.3 Air *Economizers*. An automatic system that enables a cooling system to supply and use outdoor air to reduce or eliminate the need for mechanical cooling during mild or cold weather. Air Economizers provide energy efficiency improvements on an annualized basis, are a function of regional ambient conditions and are not included in the EER or IEER metric. If an air economizer is installed during the test, it shall be in the 100% return position with outside air dampers closed and sealed to block any leakage.

D3.4 *Fresh Air Dampers*. An assembly with dampers and means to set the damper position in a closed and one open position to allow air to be drawn into the equipment when the indoor fan is operating. If fresh air dampers are installed during the test, test with the fresh air dampers closed and sealed using tape or equivalent means to block any leakage.

D3.5 *Barometric Relief Dampers*. An assembly with dampers and means to automatically set the damper position in a closed position and one or more open positions to allow venting directly to the outside a portion of the building air that is returning to the unit, rather than allowing it to recirculate to the indoor coil and back to the building. If barometric relief dampers are installed during the test, test with the barometric relief dampers closed and sealed to block any leakage.

D3.6 *Ventilation Energy Recovery System (VERS)*. An assembly that pre-conditions outdoor air entering equipment through direct or indirect thermal, or moisture exchange with the unit's exhaust air, or both, that is defined as the building air being exhausted to the outside from the equipment. If a VERS is installed during the test, test with the outside air and exhaust air dampers closed and sealed using tape or equivalent means to block any leakage.

D3.6.1 *Process Heat recovery / Reclaim Coils / Thermal Storage*. A heat exchanger located inside the unit that conditions the equipment's Supply Air using energy transferred from an external source using a vapor, gas, or liquid. If such a feature is present for testing, it shall be disconnected from its heat source.

D3.7 *Indirect/Direct Evaporative Cooling of Ventilation Air*. Water is used indirectly or directly to cool ventilation air. In a direct system the water is introduced directly into the ventilation air and in an indirect system the water is evaporated in secondary air stream and the heat is removed through a heat exchanger.

D3.8 *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. If an evaporative pre-cooler is present for testing, operate disconnected from a water supply, in other words, without active evaporative cooling.

D3.9 *Desiccant Dehumidification Components*. An assembly that reduces the moisture content of the Supply Air through moisture transfer with solid or liquid desiccants. If such a feature is present for testing, it shall be deactivated.

D3.10 *Steam/Hydronic Heat Coils*. Coils used to provide supplemental heating. Steam/hydronic heat coils are an optional system feature only if all otherwise identical individual models without the steam/hydronic heat coils that are part of the same Basic Model have another form of primary heating other than reverse cycle heating (for example electric resistance heating or gas heating). If all individual models of the Basic Model have either steam or hydronic heat coils and no other form of heat, test with steam/hydronic heat coils in place but providing no heat.

D3.11 *Refrigerant Reheat Coils*. A heat exchanger located downstream of the indoor coil that heats the Supply Air during cooling operation using high pressure refrigerant in order to increase the ratio of moisture removal to Cooling Capacity provided by the equipment. If this feature is present for testing, it shall be de-activated so as to provide the minimum (none if possible) reheat achievable by the system controls.

D3.12 *Powered Exhaust/Powered Return Air Fans*. A Powered Exhaust Fan is a fan that transfers directly to the outside a portion of the building air that is returning to the unit, rather than allowing it to recirculate to the indoor coil and back to the building. A Powered Return Fan is a fan that draws building air into the equipment. If a powered exhaust or return fan is present for testing, it shall be set up as indicated by the Supplemental Testing Instructions (STI).

D3.13 *Coated Coils*. An indoor coil or outdoor coil whose entire surface, including the entire surface of both fins and tubes, is covered with a thin continuous non-porous coating to reduce corrosion. Corrosion durability of these coil coatings shall be confirmed through testing per ANSI/ASTM B117 or the ANSI/ASTM G85 salt spray test to a minimum of 500 hours or more.

D3.14 *Power Correction Capacitors*. A capacitor that increases the power factor measured at the line connection to the equipment. Power correction capacitors shall be removed for testing.

D3.15 *Hail Guards*. A grille or similar 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. Hail guards shall be removed for testing.

D3.18 *Non-Standard Ducted Condenser Fans (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. If a non-standard ducted condenser fan is installed for the test, operate the non-standard ducted condenser fan at zero ESP in accordance with Section 5.21.3.

D3.19 *Sound Traps/Sound Attenuators*. An assembly of structures where the Supply Air passes before leaving the equipment or where the return air from the building passes immediately after entering the equipment where the sound insertion loss is at least 6 dB for the 125 Hz octave band frequency range.

D3.20 *Fire/Smoke/Isolation Dampers*. A damper assembly including means to open and close the damper mounted at the supply or return duct opening of the equipment. Such a damper can be rated by an appropriate test laboratory according to the appropriate safety standard, such as UL 555 or UL 555S. If a fire/smoke/isolation damper is present for testing, set the damper in the fully open position.

D4 *Non-Standard High-Static Indoor Fan Motors*. The standard indoor fan motor is the motor specified in the Manufacturer's Installation Instructions for testing and shall be distributed in commerce as part of a particular model. A non-standard motor is an indoor fan motor that is not the standard indoor fan motor and that is distributed in commerce as part of an individual model within the same Basic Model. The minimum allowable efficiency of any non-standard indoor fan motor shall be related to the efficiency of the standard motor as specified in either Section D4.1(for non-standard indoor fan motors) or Section D4.2 (for non-standard indoor integrated fan and motor combinations). If the standard indoor fan motor can vary fan speed through control system adjustment of motor speed, all non-standard indoor fan motors shall allow speed control (including with the use of VFD).

D4.1 *Determination of Motor Efficiency for Non-standard High-Static Indoor Fan Motors.*

D4.1.1 Standard and non-standard indoor fan motor efficiencies shall be based on the test procedures indicated in Table D1.

D4.1.2 Reference motor efficiencies shall be determined for the standard and non-standard indoor fan motor as indicated in Table D1. Table D2 shows BLDC Motor and ECM fractional hp reference efficiencies.

D4.1.3 Non-standard motor efficiency shall meet the criterion in equation D1.

$$\eta_{non-standard} \geq \frac{\eta_{standard} - \eta_{reference\ standard}}{1 - \eta_{reference\ standard}} \cdot \left(1 - \eta_{reference\ non-standard}\right) + \eta_{reference\ non-standard} \qquad \textbf{D1}$$

Where:

$\eta_{standard}$ = the tested efficiency of the standard indoor fan motor

$\eta_{non-standard}$ = the tested efficiency of the non-standard indoor fan motor

$\eta_{reference\ standard}$ = the reference efficiency from Table D1 for the standard indoor fan motor

$\eta_{reference\ non-standard}$ = the reference efficiency from Table D1 for the non-standard indoor fan motor

Table D1. Test Procedures and Reference Motor Efficiency

Motor – Standard or Non-standard	Test Procedure[1]	Reference Motor Efficiency[2]
Single Phase ≤ 2 hp	10 CFR 431.444	Federal standard levels for capacitor-start capacitor-run and capacitor-start induction run, 4 pole, open motors at 10 CFR 431.446

Single Phase > 2 hp and ≤ 3 hp	10 CFR 431.444	Federal standard levels for polyphase, 4 pole, open motors at 10 CFR 431.446.
Single Phase > 3hp	10 CFR 431.444	Federal standard levels for 4 pole, open motors at 10 CFR 431.25(h).
Polyphase ≤ 3 hp For cases where the standard and/or non-standard indoor fan motor is <1 hp	10 CFR 431.444	Federal standard levels for polyphase, 4 pole, open motors at 10 CFR 431.446.
Polyphase ≤ 3 hp For cases where both the standard and non-standard indoor fan motor are ≥ 1 hp	10 CFR 431.444 Appendix B to Subpart B of 10 CFR 431	For standard and/or non-standard 2-digit frame size motors (except 56-frame enclosed ≥ 1 hp) ≤3 hp: Federal standard levels for polyphase, 4 pole open motors at 10 CFR 431.446 For all other standard and/or non-standard motors ≤3 hp: Federal standard levels for 4 pole, open motors at 10 CFR 431.25(h).
Polyphase > 3 hp	Appendix B to Subpart B of 10 CFR 431	Federal standard levels for 4 pole, open motors at 10 CFR 431.25(h).
BLDC[3] motor or ECM[4] ≥ 1 hp	CSA C747-09[5]	Federal standard levels for 4 pole, open motors at 10 CFR 431.25(h).
BLDC motor or ECM < 1 hp	CSA C747-09[5]	Use Table D2.

Notes

1. Air-over motors shall be tested to the applicable test procedure based on the motor's phase count and horsepower, except that the NEMA MG1-2016, Supplement 2017 procedure for air-over motor temperature stabilization shall be used rather than the temperature stabilization procedure specified in the applicable test procedure based on the motor's phase count and horsepower. The NEMA MG1-2016, Supplement 2017 procedure for air-over motor temperature stabilization offers three options – the same option shall be used by the manufacturer for both the standard and non-standard motor.
2. For standard or non-standard motors with horsepower ratings between values given in the references, use the steps at 10 CFR 431.446(b) to determine the applicable reference motor efficiency (in other words, use the efficiency of the next higher reference horsepower for a motor with a horsepower rating at or above the midpoint between two consecutive standard horsepower ratings or the efficiency of the next lower reference horsepower for a motor with a horsepower rating below the midpoint between two consecutive standard horsepower ratings.
3. Brushless DC (BLDC) permanent magnet motor.
4. Electronically commutated motor.
5. BLDC motors and ECMs shall be tested and rated for efficiency at full speed and full rated load. CSA C747-09 can be applied to motors ≥ 1 hp.

Table D2. BLDC Motor and ECM – Fractional hp – Reference Efficiencies	
Motor hp	**Reference Motor Efficiency[1,2]**
0.25	78.0
0.33	80.0
0.50	82.5
0.75	84.0

Notes
1. For standard or non-standard motors with horsepower ratings between values given in Table D2, use the steps at 10 CFR 431.446(b) to determine the applicable reference motor efficiency (in other words, use the efficiency of the next higher reference horsepower for a motor with a horsepower rating at or above the midpoint between two consecutive standard horsepower ratings or the efficiency of the next lower reference horsepower for a motor with a horsepower rating below the midpoint between two consecutive standard horsepower ratings).
2. For BLDC motors and ECMs > 0.75 and < 1 hp, use Table D2 for motors < 0.875 hp, and use Federal standard levels for 1 hp, 4 pole, open motors at 10 CFR 431.25(h) for motors ≥ 0.875 hp.

D4.2 *Comparison of the fan input power of the standard indoor fan and a non-standard indoor fan at a single duty point if at least one fan is an integrated fan and motor (IFM).* The fan input power of the standard and non-standard fans shall be compared using one of the methods listed in Table D3 at a duty point determined per the requirements of Section D4.2.2. The ratio of the fan input power of the non-standard fan to the standard fan shall be determined per equation D2 and shall not exceed the max ratio of fan input powers value shown in Table D3. In this section, the word "fan" applies to either an IFM or a non-integrated assembly of a fan, motor, and motor controller.

$$R_{IF} = \frac{P_{IF,non-std}}{P_{IF,std}} \quad \textbf{D2}$$

Where:

R_{IF} = The ratio of the fan input power of the non-standard fan to the fan input power of the standard fan, W/W.
$P_{IF,non\text{-}std}$ = The fan input power of the non-standard fan at the compared fan duty point, W.
$P_{IF,std}$ = The fan input power of the standard fan at the compared fan duty point, W.

Table D3. Values for Evaluating the Fan Input Power for Non-standard Fans					
Method of Fan Input Power Determination			**Tolerances for the Non-Standard Fan Test**		
Standard Fan	**Non-standard Fan**	**Section**	**Airflow Tolerance (%)**	**Pressure Tolerance (in H_2O)**	**Max Ratio of Fan Input Powers[1,2]**
Inside the unit	Inside the unit	D4.2.3	-0.5 / +1.0	± 0.05	110%
Outside the unit	Outside the unit	D4.2.4	-0.5 / +1.0	± 0.05	110%
Simulated performance data	Simulated performance data	D4.2.5	N/A	N/A	105%

Notes
1. The ratio of the fan input power of the non-standard fan to the standard fan as shown in equation D2.
2. The 110% value includes fan testing tolerances.

D4.2.1 *General requirements.* The methods in D4.2 can only be applied if the standard and non-standard fans meet all the following requirements:

1) At least one of the fans is an IFM such that the motor efficiency cannot be tested using one

of the methods in D4.1.

2) The impeller diameter and number of blades of both fans must be the same.
3) The maximum ESP at the Full Load Rated Indoor Airflow of a unit with the non-standard fan is greater than that of the same unit with the standard fan.

D4.2.1.4 *Fan arrays.* If fan arrays are used, all fans and motors shall be identical in any standard or non-standard fan array. When testing outside a unit per D4.2.4 or using simulated performance data per D4.2.5, only one fan from each fan array needs to be evaluated.

D4.2.2 *Determination of the fan duty point.* The airflow for the fan duty point is the Full Load Rated Indoor Airflow and the maximum ESP or total static pressure (TSP) shall be determined per the requirements of Section D4.2.3, Section D4.2.4, or Section D4.2.5.

D4.2.3 *Requirements if testing both fans inside a unit.* If both fans are tested inside a unit, all the following requirements shall be met.

D4.2.3.1 Airflow and ESP shall be determined per the requirements of ASHRAE 37, and airflow shall be corrected to Standard Airflow.

D4.2.3.2 The indoor fan input power shall be measured per the requirements of Section 5 of ASHRAE 37.

D4.2.3.3 The unit shall operate with the compressor off during testing.

D4.2.3.4 If testing the standard and non-standard fans within different units, the two units shall be of identical construction, other than the fan, motor, and motor controller.

D4.2.3.5 *Determination of the fan duty point ESP.* The fan speed of the standard fan shall be set to the highest permitted by the unit controls. The airflow shall be adjusted so that the airflow is within ± 2% of the Full Load Rated Indoor Airflow. The ESP at that airflow shall be recorded and is the duty point ESP. The fan input power at that duty point shall be recorded.

D4.2.3.6 *Testing the non-standard fan.* The fan speed of the non-standard fan shall be such that the airflow and ESP match the duty point within the tolerances listed in Table D3. The fan input power at that duty point shall be recorded. If it is not possible to match the airflow or ESP within the tolerances in Table D3, conduct testing per the requirements of Section D4.2.6.

D4.2.4 *Requirements if testing both fans outside the unit.* If both fans are tested outside the unit, all the following requirements shall be met.

D4.2.4.1 Testing shall be performed per the requirements of ANSI/AMCA 210 or ISO 5801. Performance shall be converted to standard air density per the requirements of ANSI/AMCA 210.

D4.2.4.2 The same standard and non-standard fans distributed in commerce with the Basic Model shall be used.

D4.2.4.3 *Determination of the fan duty point TSP.* The fan speed of the standard fan shall be set to the highest speed that is permitted by the unit controls. The airflow shall be adjusted so that the airflow is within ± 2% of the Full Load Rated Indoor Airflow. The TSP at that airflow shall be recorded and is the duty point TSP. The fan input power at that duty point shall be recorded.

D4.2.4.4 *Testing the non-standard fan.* The fan speed of the non-standard fan shall be such that the airflow and TSP match the duty point within the tolerances listed in Table D3. The fan input power at that duty point shall be recorded. If it is not possible to match the airflow or ESP within the tolerances in Table D3, conduct testing per the requirements of Section D4.2.5.

D4.2.5 *Requirements for using simulated performance data.* If the performance of both fans is determined by the use of simulated performance data, the following requirements shall be met:

D4.2.5.1 The same standard and non-standard fans sold in commerce with the Basic Model shall have been tested per the requirements of ANSI/AMCA 210 or ISO 5801 (this includes tests performed by the fan manufacturer that are used to develop a fan manufacturer's simulated performance software).

D4.2.5.2 If the tested speeds of one or both fans were not tested at a fan speed that includes the duty point, fan performance shall be determined using the method in Annex I - Wire-to-Air Measurement - Calculation to Other Speeds and Densities (Normative) of AMCA Publication 211. If a fan manufacturer's software is used to simulate performance, the software shall comply with this requirement.

D4.2.5.3 *Determination of the fan duty point TSP.* The TSP and fan input power of the standard fan shall be determined at the Full Load Rated Indoor Airflow and the highest speed that the fan permitted by the unit controls.

D4.2.5.4 *Determination of the non-standard fan input power.* The fan input power of the non-standard fan shall be determined for the same airflow and TSP determined in D4.2.5.3

D4.2.6 *Interpolation to determine the fan input power of the non-standard fan.* For fans tested per the requirements of Sections D4.2.3 or D4.2.4, if it is not possible to meet the airflow or pressure tolerances of Table D3, the fan input power shall be determined by interpolation using the following method:

D4.2.6.1 Test the non-standard fan at a lower fan speed than that required to achieve the duty point. Record the pressure (ESP if testing inside the unit, TSP if testing outside the unit), Standard Airflow, and fan input power for at least three points. At least one point shall be at greater than Full Load Rated Indoor Airflow, and at least one point shall be at less than Full Load Rated Indoor Airflow.

D4.2.6.2 Test the non-standard fan at a higher fan speed than that required to achieve the duty point. Record the pressure (ESP if testing inside the unit, TSP if testing outside the unit), Standard Airflow, and fan input power for at least three points. At least one point shall be at greater than Full Load Rated Indoor Airflow, and at least one point shall be at less than Full Load Rated Indoor Airflow.

D4.2.6.3 Determine the fan input power at the duty point by interpolation using the method in Annex I of AMCA Publication 211.

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

E1 *Purpose.* The purpose of this appendix is to prescribe the test procedures used for testing Commercial and Industrial Unitary Air-conditioning and Heat Pump Equipment. Testing shall comply with ANSI/ASHRAE Standard 37 with the following additional requirements.

E2 *Atmospheric Pressure*. Test data is only valid for tests conducted when the atmospheric pressure is greater than 13.700 psia.

E3 *Indoor and Outdoor Air Temperature Measurement*. The indoor and outdoor air temperature (as applicable) shall be measured using the procedures defined in Appendix C.

E4 *Setting Indoor Airflow and External Static Pressure*. Indoor airflow and ESP shall be set in accordance with Section 5.19.

E5 *Minimum Data Collection Requirements.* Either power (in W) or integrated power (in W·h) shall be measured. Units with digitally modulating compressors require either: (1) an integrated power measurement or (2) power measurements recorded at intervals no longer than one second.

E6 *Test Methods for Capacity Measurement*.

E6.1 *Primary Capacity Measurement.* Use the indoor air enthalpy method specified in Section 7.3 of ANSI/ASHRAE 37 as the primary method for capacity measurement.

E6.2 *Secondary Capacity Measurement*. Follow the provisions in Section E6.2.1 for (1) single package evaporatively-cooled equipment with rated Cooling Capacity greater than or equal to 135,000 Btu/h; and (2) air-cooled single package equipment with outdoor airflow rates (either Manufacturer-specified or determined by testing) greater than 9,000 scfm. For all other equipment, follow the provisions in Section E6.2.2.

E6.2.1 *Certain Evaporatively-Cooled and Air-Cooled Single Package Equipment.* This section applies to: (1) single package evaporatively-cooled equipment with rated Cooling Capacity greater than or equal to 135,000 Btu/h and (2) air-cooled single package equipment with outdoor airflow rates (either Manufacturer-specified or determined by testing) above 9000 scfm.

E6.2.1.1. For such equipment that rejects condensate to the condenser coil, no secondary measurements are required for cooling or heating tests.

E6.2.1.2. For such equipment that does not reject condensate to the condenser coil, the following provisions apply. A cooling condensate measurement as described in Section E6.6 of this standard shall be allowed as an acceptable secondary method. Secondary measurements (using either the cooling condensate measurement or a “Group B” method specified in Table 1 of ANSI/ASHRAE Standard 37) are required for full-load and part-load cooling tests but are not required for heating tests. However, the agreement between primary and secondary measurements specified in Section E6.4 is not required for part-load cooling tests.

E6.2.2 *Split Systems and Other Single Package Equipment*. For equipment not covered under Section E6.2.1, use one of the applicable “Group B” methods specified in Table 1 of ANSI/ASHRAE 37-2009 as a secondary method for capacity measurement for all full-load cooling and heating tests. Capacity measurement with a secondary method is required for part-load cooling tests unless the outdoor air enthalpy method is used as the secondary method for the full-load cooling test. However, the agreement between primary and secondary measurements specified in Section E6.4 is not required for part-load cooling tests.

E6.3 Conduct measurements for all equipment in accordance with the provisions in Sections 7.3, 7.4, 7.5, and 7.6 of ANSI/ASHRAE 37-2009 that are applicable to the selected test method. For the outdoor air enthalpy method, the provisions in Section E6.4 take precedence over the provisions in Section 7.3 of ANSI/ASHRAE 37. If using the refrigerant enthalpy method for secondary measurements, Section 7.5.1.3 of ANSI/ASHRAE 37 does not apply for part-load cooling tests (in other words, refrigerant enthalpy method measurements shall be taken for part-load cooling tests regardless of the measured subcooling or superheat).

E6.4 *Agreement between Primary and Secondary Capacity Measurements*. If using the cooling condensate measurement as the secondary method (per Section E6.2.1), follow the provisions in Section E6.4.1. For all other secondary methods, follow the provisions in Section E6.4.2.

E6.4.1 *Cooling condensate secondary measurement.* For the full-load cooling test, Latent Capacity calculated in Section 7.8.2.1 of ANSI/ASHRAE 37 results shall match within ± 6% of the primary Latent Capacity calculated in Section 7.3.3.1 of ANSI/ASHRAE 37. No match between primary and secondary measurements is required for heating tests and part-load cooling tests.

E6.4.2 *Other Secondary Methods***.** The total Cooling or Heating Capacity values measured with the secondary capacity measurement methods for the full-load cooling and heating tests (as applicable) as prescribed in Section E6.2 shall match within ± 6% of the primary capacity measurement method test results for the full-load cooling and heating (if applicable) tests. No match between primary and secondary measurements is required for part-load cooling tests.

E6.5 *Outdoor Air Enthalpy Method.* When using the outdoor air enthalpy method as the secondary method for capacity measurement first conduct a test without the outdoor air-side test apparatus connected to the outdoor unit) and then attach the outdoor air-side test apparatus and conduct a test with the apparatus connected to the outdoor unit. Use measurements from testing without the outdoor air-side test apparatus connected (such as indoor air enthalpy method capacity measurements and input power) as the applicable measurements for determination of efficiency metrics, provided the specified conditions are met.

E6.5.1 Units with Free Air Discharge Condensers.

E6.5.1.1 *Free Outdoor Air Test.* For the free outdoor air test, connect the indoor air-side test apparatus to the indoor coil; do not connect the outdoor air-side test apparatus. Allow the test room reconditioning apparatus and the unit being tested to operate for at least one hour.

E6.5.1.1.1 After attaining equilibrium conditions, measure the following quantities at equal intervals that span 5 minutes or less:

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

E6.5.1.1.2. Continue these measurements until the applicable test tolerances are satisfied for a 30-minute period (for example, seven consecutive 5-minute samples).

E6.5.1.1.3. Evaporator and Condenser Measurements. To measure evaporator and condenser pressures, solder a thermocouple onto a return bend located at the midpoints of each coil or at points not affected by vapor superheat or liquid subcooling. Alternatively, if the test unit is not sensitive to the refrigerant charge, install pressure gauges to the access valves or to ports created from tapping into the suction and discharge lines according to Sections 7.4.2 and 8.2.5 of ANSI/ASHRAE Standard 37. The alternative approach shall be used when testing a unit charged with a zeotropic refrigerant having a temperature glide greater than 1°F at the specified test conditions.

E6.5.1.1.4 For the free outdoor air test to constitute a valid test for determination of efficiency metrics, the following conditions shall be met:

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

E6.5.1.2 *Ducted Outdoor Air Test.*

E6.5.1.2.1. After collecting 30 minutes of steady-state data during the free outdoor air test, connect the outdoor air-side test apparatus to the unit for the ducted outdoor air test. Adjust the exhaust fan of the outdoor air-side test apparatus until averages for the evaporator and condenser temperatures, or the saturated temperatures corresponding to the measured pressures, agree within ± 0.5°F of the averages achieved during the free outdoor air test. Collect 30 minutes of steady-state data where the applicable test tolerances are satisfied.

E6.5.1.2.2. During the ducted outdoor air test, at intervals of 5 minutes or less, measure the parameters required according to the indoor air enthalpy method and the outdoor air enthalpy method for the prescribed 30 minutes.

E6.5.1.2.3. For cooling mode ducted outdoor air tests, calculate capacity based on outdoor air enthalpy measurements as specified in Sections 7.3.3.2 and 7.3.3.3 of ANSI/ASHRAE Standard 37. For heating mode ducted tests, calculate Heating Capacity based on outdoor air enthalpy measurements as specified in Sections 7.3.4.2 and 7.3.4.3 of ANSI/ASHRAE Standard 37. Adjust the outdoor-side capacity according to Section 7.3.3.4 of ANSI/ASHRAE Standard 37 to account for line losses when testing split systems. Use the outdoor airflow rate as measured during the ducted outdoor air test to calculate capacity for checking the agreement with the capacity calculated using the indoor air enthalpy method during the ducted outdoor test.

E6.5.2 *Units with Ducted Condensers.* First conduct a test without the outdoor air-side test apparatus connected to the outdoor unit (see Section E6.5.2.1) and then attach the outdoor air-side test apparatus and conduct a test with the apparatus connected to the outdoor unit (see Section E6.5.2.2). Use measurements from the short duct test (in other words, use indoor air enthalpy method capacity measurements and power input) as the applicable measurements for determination of efficiency metrics, provided the conditions of Section E6.5.2.1.4 are met.

E6.5.2.1. *Short Duct Test.* If testing at non-zero ESP in accordance with Section 5.21.2, for the full-load cooling test, set the outdoor air ESP using symmetrical duct outlet restrictors according to section 5.21.2.1, and for the full-load heating test, do not adjust the duct outlet restrictors used for the full-load cooling test. If testing at zero ESP in accordance with Section 5.21.3, no adjustments of outdoor ESP are required. For all testing, connect the indoor air-side test apparatus to the indoor coil; do not connect the outdoor air-side test apparatus. Allow the test room reconditioning apparatus and the unit being tested to operate for at least one hour.

E6.5.2.1.1 After attaining equilibrium conditions, measure the following quantities at equal intervals that span 5 minutes or less:

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

E6.5.2.1.2. Continue these measurements until the applicable test tolerances are satisfied for a 30-minute period (for example, seven consecutive 5-minute samples).

E6.5.2.1.3 *Evaporator and Condenser Measurements.* To measure evaporator and condenser pressures, solder a thermocouple onto a return bend located at the midpoints of each coil or at points not affected by vapor superheat or liquid subcooling. Alternatively, if the test unit is not sensitive to the refrigerant charge, install pressure gauges to the access valves or to ports created from tapping into the suction and discharge lines according to Sections 7.4.2 and 8.2.5 of ANSI/ASHRAE Standard 37. The alternative approach shall be used when testing a unit charged with a zeotropic refrigerant having a temperature glide greater than 1°F at the specified test conditions.

E6.5.2.1.4 For the short duct test to constitute a valid test for determination of efficiency metrics, the following conditions shall be met:

1) For the outdoor airflow measurement test (described in Section E6.5.2.2), the capacities determined using the outdoor air enthalpy method shall agree within 6% of the capacities determined using the indoor air enthalpy method.
2) The capacity determined using the indoor air enthalpy method from the outdoor airflow measurement test shall agree within 2% of the capacity determined using the indoor air enthalpy method from the short duct test.

E6.5.2.2 *Outdoor Airflow Measurement Test.* Following the short duct test (specified in section E6.5.2.1), connect the outdoor air-side test apparatus to the unit for the outdoor airflow measurement test. If testing at non-zero ESP in accordance with Section 5.21.2, do not adjust or remove the outlet duct restrictors. For all testing, adjust the exhaust fan of the outdoor air-side test apparatus until averages for the evaporator and condenser temperatures, or the saturated temperatures corresponding to the measured pressures, agree within ± 0.5°F of the averages achieved during the short duct test. Collect 30 minutes of steady-state data where the applicable test tolerances are satisfied.

E6.5.2.2.1 At intervals of 5 minutes or less, measure the parameters required according to the indoor air enthalpy method and the outdoor air enthalpy method for the prescribed 30 minutes.

E6.5.2.2.2 For cooling mode outdoor airflow measurement tests, calculate capacity based on outdoor air enthalpy measurements as specified in Sections 7.3.3.2 and 7.3.3.3 of ANSI/ASHRAE Standard 37. For heating mode outdoor airflow measurement tests, calculate Heating Capacity based on outdoor air enthalpy measurements as specified in Sections 7.3.4.2 and 7.3.4.3 of ANSI/ASHRAE Standard 37. Adjust the outdoor-side capacity according to Section 7.3.3.4 of ANSI/ASHRAE Standard 37 to account for line losses when testing split systems. Use the outdoor airflow rate as measured during the outdoor airflow measurement test to calculate capacity for checking the agreement with the capacity calculated using the indoor air enthalpy method during the outdoor airflow measurement test.

E6.6 *Cooling Condensate Method.* Cooling condensate mass shall be recorded at three equal intervals of 10 minutes during the 30-minute test period, after equilibrium has been attained. The drain connection should be trapped to stabilize condensate flow. The maximum deviation between any two cooling condensate mass measurements shall be less than 5%, with respect to the smaller of the two cooling condensate mass measurements. The total cooling condensate mass collected over the 30-minute period shall be multiplied by two to yield the condensate rate in lb/hr. This shall be used as w_c when calculating Latent Capacity per section 7.8.2.2 of ANI/ASHRAE Standard 37.

E6.7 *Refrigerant Flow Measurement Device.* Refrigerant flow measurement device(s) shall be either elevated at least two feet from the test chamber floor or placed upon insulating material having a total thermal resistance (R-value) of at least 12 hr·ft^2 · °F/Btu and extending at least 1 ft laterally beyond each side of the exposed surfaces of the device(s).

E7 *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 following steps. For all part-load cooling tests for water-cooled units, the water flow rate shall not exceed the value for the full-load cooling test.

E7.1 Allow the control logic to control the operation of the unit. If the unit can be run and stable conditions are obtained (for example test tolerances in Table 10 are met), then a standard part-load cooling test shall be run.

E7.2 *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 1-hour tests shall be run. Prior to the first 1-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 10ºF higher temperature until the tolerances specified in Table E1 are met. Prior to the second 1-hour test, the condenser entering temperature defined by Table 7 shall be approached from at least a 5ºF lower temperature until the tolerances specified in Table E1 are met. For each test, once all tolerances in Table E1 are met, the 1-hour test shall be started and test data shall be recorded every 5 minutes for 1 hour, resulting in 12 test measurements for each test parameter. During each 1-hour test, the tolerances specified in Table E1 shall be met.

Table E1. Tolerances for Head Pressure Control Time Average Test			
Measured Value		**Operating Tolerance**	**Condition Tolerance**
Indoor air dry-bulb temperature (°F)	Entering	3.0	1.0
	Leaving	3.0	-
Indoor air wet-bulb temperature (°F)	Entering	1.5	0.5
	Leaving	1.5	-
Outdoor air dry-bulb temperature (°F)	Entering	3.0	1.0
	Leaving	-	-
Outdoor air wet-bulb temperature (°F)	Entering	1.5	0.5[1]
	Leaving	-	-
Water serving outdoor coil temperature (°F)	Entering	0.75	0.3
	Leaving	0.75	
Voltage		2%	1%
Notes: 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 E1 are met, the tests results for both 1-hour steady-state test series shall then be averaged to determine the capacity and power values that are then used for the IVEC calculation.

E7.3 If the tolerances in Table E1 cannot be met for the head pressure control time average test, STI shall be used to determine the settings required to stabilize operation. However, if STI do not provide guidance for stable operation or operation in accordance with supplemental testing instructions results in a condensing (liquid outlet) pressure corresponding to a bubble point temperature less than 75°F, proceed to the next step.

E7.4 If STI are not used to provide stable operation, the fan(s) (for air-cooled and evaporatively-cooled units) or valve(s) (for water-cooled units) causing the instability shall be set manually at a speed, operating state (on/off), or position to achieve a condensing (liquid outlet) pressure corresponding to a bubble point temperature as close to 85°F as possible while remaining no lower than 85°F.

E8 *Setup Provisions for Evaporatively Cooled Units.*

E8.1 *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.

E8.1.1 Turn the Makeup Water off during the test and use just the water in the evaporatively cooled condenser sump

E8.1.2 Heat or cool the Makeup Water to the ambient outdoor air dry-bulb temperature or feed it from an external tank that is exposed to the outdoor air dry-bulb test temperature.

E8.2 *Blow-down Water*. Any blow-down water used for control of material byproducts of evaporation shall be turned off during the test.

E8.3 *Piping Evaporator Condensate for Split Systems.* If piping the evaporator condensate to the condenser sump is an option for a unit, and the Manufacturer's Installation Instructions do not require the unit to be set up using this option, test the unit without this option.

E8.4 *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 per 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 should 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.

E9 *Test Method for Upflow Units in Chambers of Limited Height*

E9.1 *General*. If the height of the unit under test plus a vertical outlet duct with pressure taps for measuring ESP compliant with section 6.4.2.1 or section 6.4.3 (for units with multiple fans) of ANSI/ASHRAE 37 is both greater than 14 ft and too tall for the test chamber, this limited height approach can be used. Refer to Figure E1 of this appendix for test duct requirements if the up-flow ducted system has a single fan outlet connection and refer to Figure E2 if the up-flow system has multiple fan outlet connections. For units with a centrifugal fan or fans with horizontal axis and vertical discharge, the elbow or elbows redirecting air from vertical to horizontal direction must bend in the direction of motion at the top the fan impeller. If the unit was shipped with a discharge plenum, do not test with the plenum.

E9.2 *Units with Multiple Indoor Blowers*. If either of the following provisions apply, test with a single outlet duct as shown in Figure E1: (1) the Manufacturer Installation Instructions indicate the unit is intended to be installed with a single discharge duct; or (2) the unit has a single outlet duct connection flange. For other units with multiple blowers, attach a duct with a 90° elbow for each fan outlet connection to redirect airflow horizontally. External static pressure in each duct shall be measured as specified in section 6.4.2 of ANSI/ASHRAE 37. Combine all air ducts into a single horizontal "common duct" downstream of the static pressure taps. Refer to Figure E2 for test setup details. If needed to equalize the static pressure in each duct, an adjustable restrictor shall be in the plane where each individual duct enters the common duct section.

E9.3 *Turning Vanes*. Calculate the discharge velocity using equation E1:

$$V = \frac{Q_{Rated}}{A_{TD}} \qquad \textbf{E1}$$

Where,

Q_{Rated} = Full Load Rated Indoor Airflow, scfm
A_{TD} = Total Discahrge Area, ft^2

For units with discharge velocity greater than 800 fpm, turning vanes must be used in the 90° elbow, as specified in Figure E1 and Figure E2. For units with discharge velocity less than or equal to 800 fpm, turning vanes shall not be used in the 90° elbow.

E9.4 *Vertical section*. As shown in Figure E1 and Figure E2, for up-flow systems tested in a limited height setup, a vertical straight duct shall be installed between each fan discharge of the tested unit and its corresponding 90° elbow. The length of this straight duct shall be calculated using equation E2.

$$L = 1.25 \ * \sqrt{A \times B} \qquad \textbf{E2}$$

Where,

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

E9.5. *ESP Adjustment*. Use the equations in Table E2 to calculate the adjusted minimum ESP requirement by subtracting ΔESP from the ESP requirement specified in section 5.17. Round the calculated value of ΔESP to the nearest 0.01 in. H_2O.

Table E2. ESP Adjustment

Discharge Velocity	Bend Type	ESP Adjustment Equation[1]
V > 800 fpm	Turning vanes, as specified in Figure E1 or E2	$\Delta ESP = 0.26 * \rho\left(\frac{V}{1097}\right)^2$
V ≤ 800 fpm	No turning vanes	$\Delta ESP = 1.34 * \rho\left(\frac{V}{1097}\right)^2$

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

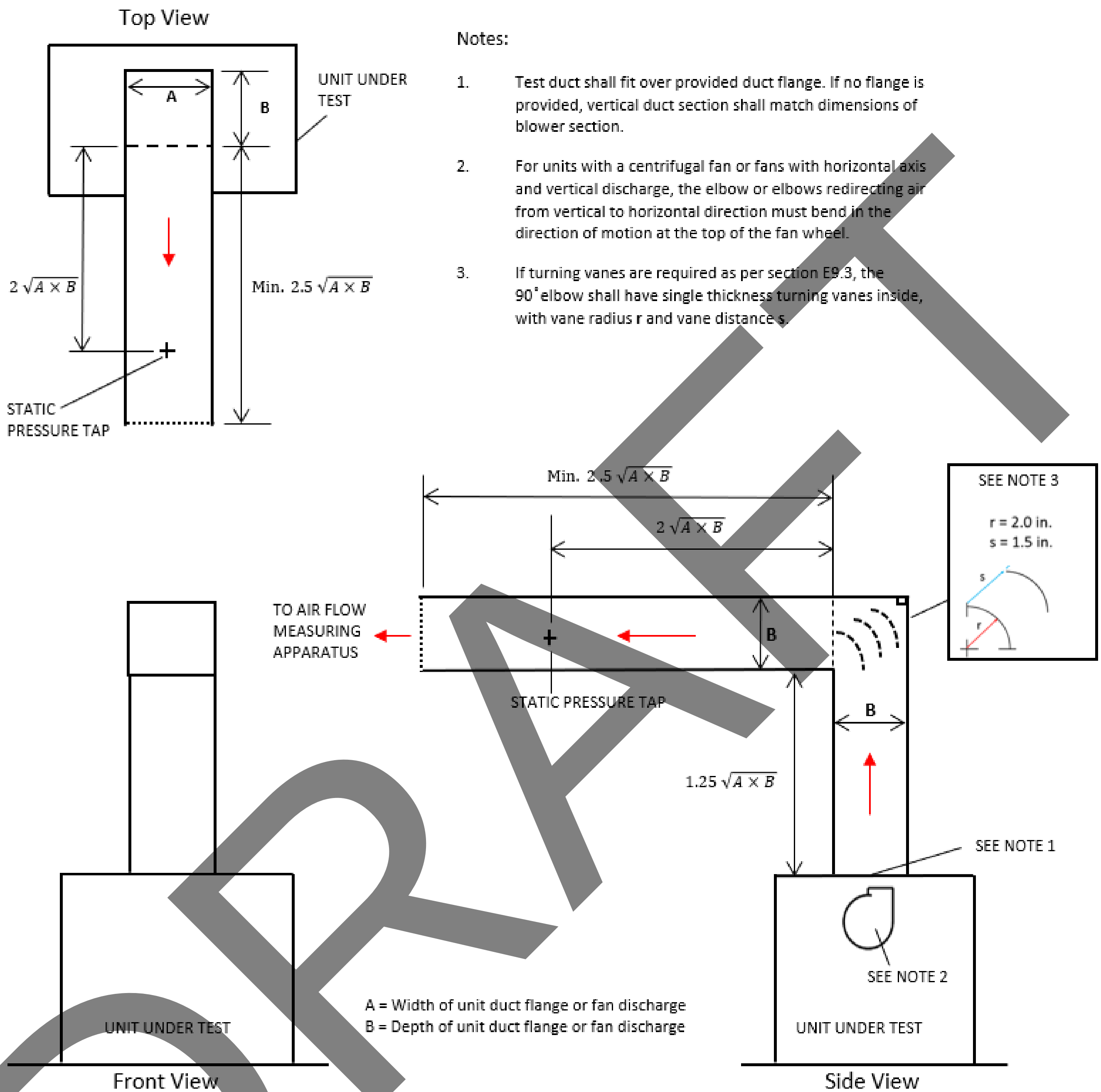

Figure E1. Test Duct Setup for Up-flow Unit with Single Fan Outlet Connection in Limited Height Test Chamber

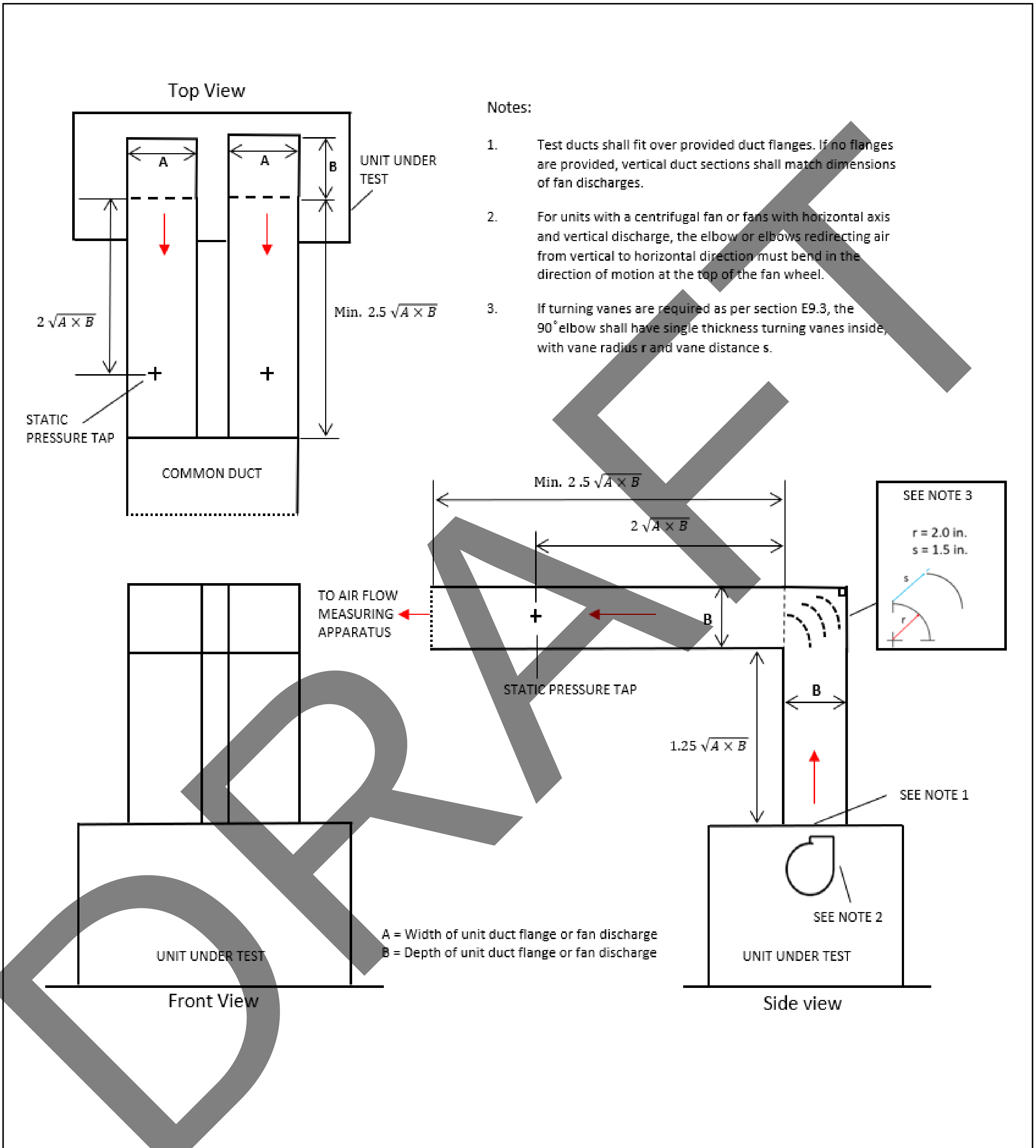

Figure E2. Test Duct Setup for Up-flow Unit with Multiple Fan Outlet Connections in Limited Height Test Chamber

E.10 Unit Power Measurement

E10.1 Total unit power, indoor fan power, and controls power

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

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

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

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

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.

E10.2 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 or variable-speed drive losses, and 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, no adjustment is required.

E10.3 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 manufacturer installation instructions 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 no 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 it is clear that the compressor does not use crankcase heat, use a value of zero for the compressor.

2) If it is clear that the compressor uses crankcase heat, or it is unclear whether the compressor uses crankcase heat, use the value calculated in Equation DCH for the compressor.

Equation DCH

$$Default\ crankcase\ heat\ power\ in\ watts = 80 \times \left(\frac{NTR}{10}\right)^{\frac{2}{3}} + 44$$

Where:

NTR = Nominal capacity of the compressor in tons of refrigeration (that is, in multiples of 12,000 Btu/h)

E10.4 Measurement locations

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

E10.5 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.

E10.6 Transformers

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

E11 *Indoor Coil Inlet Duct Arrangement*

E11.1 Duct and pressure measurement setup

Position the unit to allow enough space to install an inlet duct as specified in ANSI/ASHRAE 37-2009 Section 6.4, and install the inlet duct as specified in ANSI/ASHRAE 37 Section 6.4. An inlet duct shall be installed for all tests.

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

In addition to the manometer or electronic pressure transducer installed to measure total external static pressure as specified in ANSI/ASHRAE 37, install a manometer or electronic pressure transducer to measure either the return static pressure as illustrated in Figure E3 or the supply static pressure as illustrated in Figure E4. The inlet duct is labeled as return side plenum in Figures E3 and E4.

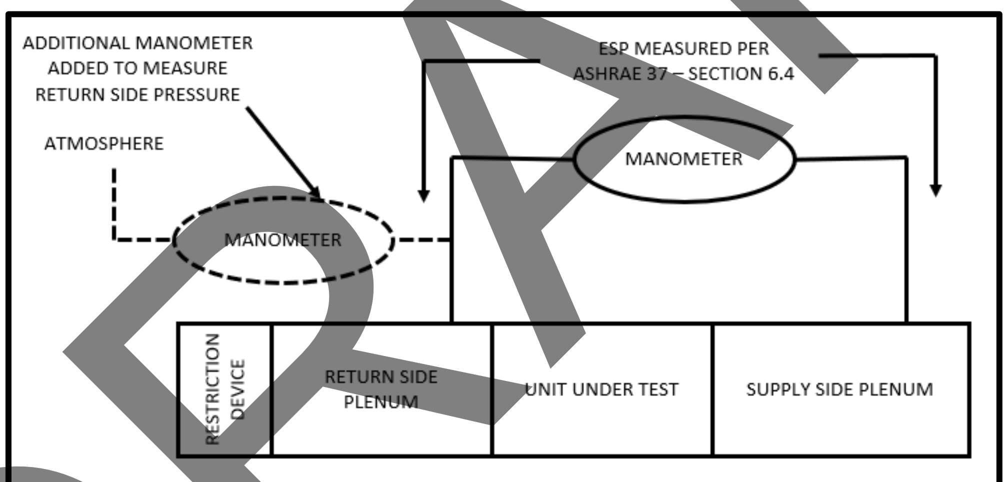

Figure E3. Return Static Pressure Measurement

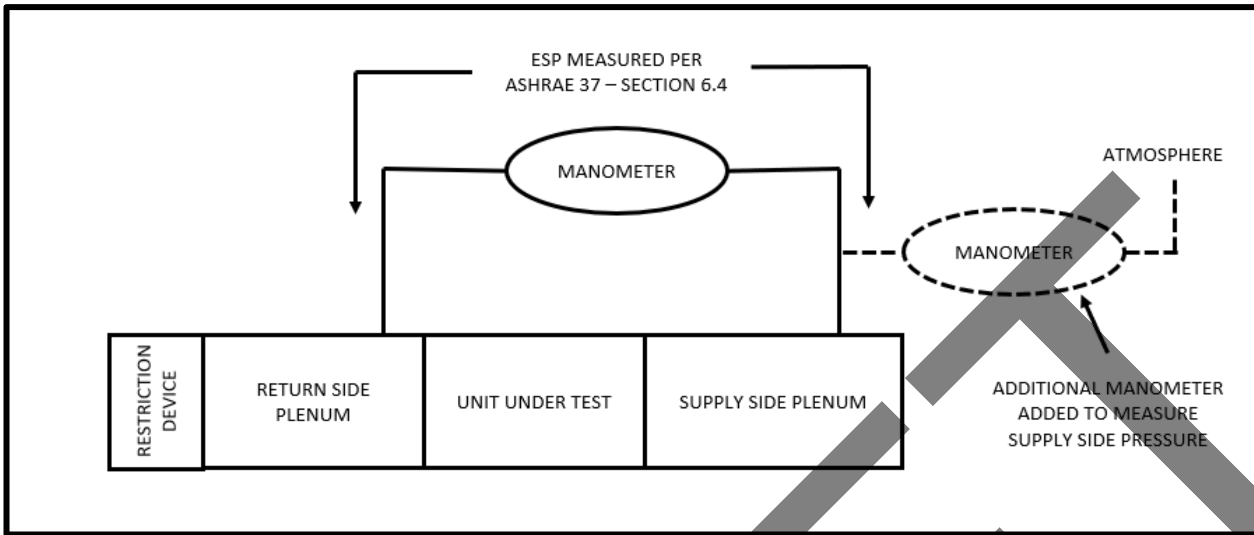

Figure E4. Supply Static Pressure Measurement

E11.2 Measurement and adjustment of return static pressure

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

The only way results can be valid with a return static pressure greater than 25% of total external static pressure is if no inlet restriction, mixers, elbows, transitions, or sampling devices are installed within the interconnecting duct upstream of the plenum arrangement. In this case, all sampling of indoor entering air shall be performed outside of the duct, following the provisions in section C4.

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

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

E11.3 Restriction devices

If an inlet restriction device is installed to meet the required split of total external static pressure specified in section E11.2, the inlet restriction device shall be concentric with the geometric center of the duct cross section. Examples of allowed inlet restriction devices include perforated panels and opposed blade dampers. Blank-off panels with rectangular, V-shaped or arc-shaped openings are allowed if the center of their open area is in the geometric center of the duct cross section.

If the indoor coil entering air is sampled within a duct (see section C4) and an inlet restriction is used, the inlet restriction shall be located upstream of the sampling device and a grid of individual thermocouples shall be installed on the Air Sampling Tree. If the difference between the maximum time-averaged thermocouple measurement and the minimum time-averaged thermocouple measurement is greater than 1.5 °F, install mixing devices such as those described in Sections 5.3.2 and 5.3.3 of ANSI/ASHRAE 41.1 to reduce the maximum temperature spread to less than 1.5 °F.