AHRI Standard 340/360-2022 (I-P)

2022 Standard for

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

AIR-CONDITIONING, HEATING, & REFRIGERATION INSTITUTE

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ICS codes: 23.120 and 27.080

Note:

This standard supersedes AHRI Standard 340/360 (I-P)-2019.

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Foreword:

AHRI Standard 340/360-2022 (I-P) includes additional provisions in Section D3 to cover Determinations of Fan and Motor Efficiency for Non-standard Indoor Fan and Motors with the addition of Appendix I to provide an example, and new provisions were included for Double-duct systems in sections 6.1.1.9, 6.1.3.6, 6.1.3.7 and Appendix I.

AHRI Standard 340/360-2022 (I-P) contains the following technical and administrative update(s) to the previous edition:

- Updated definitions of Indoor Single Package Air-conditioners, Single Package Heat Pumps, Split System Air-conditioners, Split System Heat Pumps, Staged Capacity Controlled Units, and Stepped Fan Control for clarity.
- Changed the defined term Proportionally Controlled Units to Proportionally Capacity Controlled Units throughout the document.
- Corrected instances that referred to Table 4 instead of Table 7 in Standard Rating definition and Section 6.1.3.3.1.
- Updated Section 6.5 to reflect that Standard Ratings can be based on simulation.
- Updated Table 3 to clarify that corrections apply when exceeding the minimum.
- Updated Section 5.8.1 to clarify that other charging metrics than listed may be used.
- Updated instances of "cfm" to "scfm" throughout.
- Updated section 6.1.1.8 for clarity.
- Updated Table 6 to restore the term "(max)" to the heating test wet-bulb requirements. Footnote 1 was clarified to correct the dew point for the 25 Percent Load test.
- Updated phrases to use the defined terms Full Load Rated Indoor Airflow and Part Load Rated Indoor Airflow throughout Section 6.1.3.
- Updated phrases of "part load cooling airflow rate" to "cooling indoor airflow rate" in Section 6.1.3.4.5.
- Corrected Table 9 to reference proper wet-bulb and make up water temperatures for evaporatively cooled products. Corrected Note 1 to reference Section 6.1.3.6.
- Updated phrases to use the defined term Percent Load and EER throughout Section 6.2.
- Removed references to "manual" means of adjustment from Section 6.2.5.
- Updated Section 6.2.6 to correctly reflect testing requirements and technology used in Proportionally Capacity Controlled Units.
- Updated Table 11 to include Make Up Water temperature requirements and corrected note 4.
- Corrected Section 6.4 by removing duplicate information about secondary capacity checks. Remaining information was moved to Section E6.4
- Corrected Section 6.5.3 to better reflect regulatory requirements.
- Corrected Section 7.2 to identify acceptable forms of publishing capacity.
- Updated references in Appendix A and B.
- Removed duplicate requirements from Table C2.
- Corrected Section E6.2 to refer to Section E6.4 instead of E6.3.
- Updated Section E6.5 to account for new Double-duct provisions.
- Updated Section E8.1 to reference Table 6.
- Included temperature requirements for Extra High Temperature Operating Requirement in Appendix F.
- Minor technical and grammatical changes to Appendix G

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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.

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, 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.

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

2.2.1 Rating and testing of individual assemblies, such as condensing units or coils, for separate use.

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

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

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

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

2.2.6 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).

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.

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

2.3.3 Air conditioners and condensing units serving computer rooms rated using AHRI Standard 1360.

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 *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.

3.3 *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.

3.4 *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(s) and condenser combination, and can include a heating function as well. 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.

3.5 *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.

3.6 *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(s) and motor(s).

3.6.1 *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 Appendix F, expressed in Btu/h.

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

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

3.7 *Double-duct System.* An air conditioner or heat pump that complies with all of the following:

1. 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
2. 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

3. 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
4. Has a rated Cooling Capacity greater than and equal to 65,000 Btu/h and less than or equal to 300,000 Btu/h.

Informative Note: 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), provisions for testing at zero outdoor ESP are specified in Section 6.1.3.7.1. For such equipment, non-standard (for example, higher-static) ducted condenser fans are considered an optional feature per Section D2.18. See Sections D2 and D2.18 for further provisions regarding testing without this optional feature, as applicable.

3.8 *Energy Efficiency Ratio (EER)*. A ratio of the Cooling Capacity in Btu/h to the power input values in watts at any given set of Rating Conditions, expressed in Btu/(W·h).

3.7.1 *Standard Energy Efficiency Ratio.* A ratio of the capacity to power input value obtained at Standard Rating Conditions.

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

3.10 *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 listed in Table 6.

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

3.12 *Heating Coefficient of Performance (COP_H).* A ratio of the Heating Capacity in watts to the power input values in watts at any given set of Rating Conditions expressed in W/W. For COP_H, supplementary resistance heat shall be excluded.

3.13 *Independent Coil Manufacturer (ICM).* A company that manufactures indoor units but does not manufacture single package units or outdoor units.

3.14 *Integrated Energy Efficiency Ratio (IEER)*. A weighted calculation of mechanical cooling efficiencies at full load and part-load Standard Rating Conditions, defined in Section 6.2, expressed in Btu/(W·h). See Appendix G for background and application.

3.15 *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).

3.16 *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.

3.16.1 *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.

3.16.2 *Manufacturer-specified.* Information provided by the manufacturer through Manufacturer's Installation Instructions.

3.17 *Makeup Water (MW)*. The water supplied to an evaporative cooled condenser to compensate for the water evaporated.

3.18 *Multi Zone Variable Air Volume (MZVAV)*. Units with control systems designed to vary the indoor air volume and refrigeration capacity/staging at a controlled discharge air temperature and static pressure as a means of providing space temperature control to independent multiple spaces with independent thermostats.

3.19 *Outdoor Unit Manufacturer (OUM)*. A manufacturer of single package units, outdoor units, and indoor units. or outdoor units, or both.

3.20 *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 listed in Table 6 with modifications shown in Table 7. This can be different for each part-load rating point.

3.21 *Percent Load.* The ratio of the part-load Cooling Capacity over the measured full load Cooling Capacity at Standard Rating Conditions, expressed in units of percent, %.

3.22 *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 the AHRI Standard 540, Table 2, rating test point A capacity (45/130/20/15). The modulating compressor or compressors shall be capable of modulating the unit capacity over a range of at least 50% to 100%. The unit can include combination of fixed capacity and variable capacity compressors.

3.23 *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.

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

3.23.2 *Standard Rating.* A rating based on tests performed at Standard Rating Conditions as listed in Table 6.

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

3.24 *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.

3.24.1 *Standard Rating Conditions.* Rating Conditions used as the basis of comparison for performance characteristics.

3.24.2 *International Rating Conditions.* Rating Conditions used as the basis of comparison for performance characteristics for products sold outside North America.

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

3.25.1 *"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.

3.25.2 *"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.

3.26 *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.

3.27 *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).

3.28 *Single Zone Variable Air Volume (SZVAV)*. Units with a control system designed to vary the indoor air volume and refrigeration capacity/staging as a means to provide zone control to a single or common zones, The capacity, as well as the Supply Air shall be controlled either through modulation, discrete steps or combinations of modulation and step control based on the defined control logic.

3.29 *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.

3.30 *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.

3.31 *Staged Capacity Controlled Units.* Units incorporating only fixed capacity or discrete steps of compression and limited by the controls to multiple stages of refrigeration capacity. Units that have multiple stages of refrigeration that do not meet the definition of Section 3.22, Proportionally Capacity Controlled Units, meet this definition.

3.32 *Standard Air.* Dry air having a mass density of 0.075 lb/ft^3.

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

3.34 *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.

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

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

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

5.2 *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 5.2.1), priority shall be given to installation instructions that appear on the unit's label over installation instructions that are shipped with the unit.

5.2.1 *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 5.2.1.1), 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.

5.2.1.1 *Mix-Matched 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.

5.3 *Break-in.* Conduct a compressor break-in period prior to conducting the test if there is a Manufacturer-specified break-in period. Conduct the break-in period using the Manufacturer-specified duration and conditions; however, the duration shall not exceed 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.

5.4 *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 $ft^2 \cdot °F \cdot hr/Btu$. Duct losses can be calculated using conduction factors, inside air and outside ambient temperature difference, and the total duct surface area between the unit and the temperature measurement location. Ducts that are exposed to multiple ambient temperatures shall be divided into zones and each zone calculated separately.

5.5 *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.

5.6 *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 in Table 11) and testing requirements cannot be met then the procedures in Appendix E Section E7 shall be used.

5.7 *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. 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. Refer to Table 3 for Cooling Capacity correction factors that shall be applied to the full load Cooling Capacity when the tested refrigerant line length exceeds the minimum values.

Table 3. Refrigerant Line Length Correction Factors[1, 2, 3, 4]

Piping length beyond the requirement (X), ft	Cooling Capacity Correction Factor
3.3 < X ≤ 20	1.01
20 < X ≤ 40	1.02
40 < X ≤ 60	1.03

Note:
1. If the refrigerant line lengths required in the test setup exceed the minimum specified length, the tested capacity shall be multiplied by the correction factor to yield the final capacity result.
2. The piping length X is the cumulative additional line length above the minimum.
3. The absolute minimum length necessary to physically connect the system shall be used subject to the minimum specified length.
4. Cooling Capacity Correction Factor shall only be applied to full load test results.

5.8 *Refrigerant Charging.* Unless the unit does not require charging (per Section 5.8.5) 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.

5.8.1 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.

5.8.2 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.

5.8.3 In the event of conflicting information between charging instructions, use the instruction priority order indicated in Section 5.2. 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.

5.8.4 *Single Package Unit.* 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.

5.8.4.1 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.

5.8.4.2 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.

5.8.5 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.

5.9 *Test Unit Location*

5.9.1 *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.

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

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

5.11 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.

5.12 *Instrumentation Accuracy*. In addition to the instrument accuracy requirements specified in section 5 of ASHRAE Standard 37, measurements shall be made in accordance with the following provisions.

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

5.12.2 *Electrical Frequency*. Measurement devices used to measure electrical frequency shall be accurate to within ± 0.2 Hz.

Section 6. Rating Requirements

6.1 *Standard Ratings*

6.1.1 Standard Ratings shall meet the following criteria:

6.1.1.1 Standard ratings shall be established at the Standard Rating Conditions specified in Table 5, Table 6, and Table 8 for North American Ratings, or Appendix F for International Ratings.

6.1.1.2 Standard Ratings related to Cooling or Heating Capacities shall be net values, including the effects of circulating fan heat, but not including supplementary heat.

6.1.1.3 Standard Ratings shall be based on the total power input (see appendix D regarding features to be included and activated during the test). Power used for any override controls only used for laboratory testing shall not be included in total power.

6.1.1.4 Standard Ratings shall be based on 100% recirculated indoor air.

6.1.1.5 Standard Ratings tests shall not include operation of any heating components other than the reverse cycle heat pump functionality.

6.1.1.6 Standard Ratings of Coil-Only Indoor Units shall be established by subtracting 1,250 Btu/h per 1,000 scfm from the total Cooling Capacity, and by adding the same amount to the Heating Capacity. Total power input for both heating and cooling shall be increased by 365 W per 1,000 scfm of indoor air circulated.

6.1.1.7 Standard Ratings of water-cooled units from less than 135,000 Btu/h shall include a total allowance for cooling tower fan motor and circulating water pump motor power inputs to be added in the amount of 10.0 W per 1,000 Btu/h Cooling Capacity.

6.1.1.8 Standard ratings for water cooled equipment shall be based on a fouling factor of 0.0000 $hr \cdot ft^2 \cdot {}^oF/Btu$

6.1.1.9 Standard ratings for Double-duct Systems shall be established in accordance with Section 6.1.3.7.

6.1.2 *Standard Rating Values*

6.1.2.1 *Values of Standard Capacity Ratings.* These ratings shall be expressed in terms of Btu/h in multiples shown in Table 5.

Table 5. Rounding of Standard Rating Capacities

Standard Cooling Capacity Ratings, Btu/h	**Multiples, Btu/h for both Heating and Cooling**
From 65,000 to 135,000	1000
From 135,000 to ≤ 400,000	2000
400,000 and greater	5000

6.1.2.2 *Values of Energy Efficiency Ratios and Heating Coefficients of Performance.* Energy Efficiency Ratio (EER, EER_{DD}) and Integrated Energy Efficiency Ratio (IEER, $IEER_{DD}$) for cooling, whenever published, shall be expressed in multiples of 0.1, and expressed in Btu/(W·h) for a unit configured in accordance with Appendix D, and when tested in accordance with the requirements of Appendix E. Heating Coefficients of Performance (COP_H, $COP_{H,DD}$), whenever published, shall be expressed in multiples of 0.01.

6.1.3 *Standard Rating Tests*. Table 6 and Table 7 indicate the tests and test conditions that are required to determine values of standard full load capacity ratings and values of energy efficiency. Standard cooling ratings are not applicable for heating-only heat pumps.

6.1.3.1 *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.

Table 6. Conditions for Standard Rating and Operating Tests

Test		Indoor Section[4]		Outdoor Section[6]						
		Air Entering		Test Conditions based on Condenser Type						
				Air Cooled		Evaporative			Water Cooled	
		Dry-bulb, ºF	Wet-bulb, ºF	Dry-bulb, ºF	Wet-bulb, ºF	Dry-bulb, ºF	Wet-bulb, ºF	Makeup Water, ºF	Inlet, ºF	Outlet, ºF
Cooling	Standard Rating Conditions Cooling[3, 5]	80.0	67.0	95.0	75.0[1,7]	95.0	75.0	85.0	85.0	95.0
Cooling	Low Temperature Operating Cooling[3, 5]	67.0	57.0	67.0	57.0	67.0	57.0	67.0	--	70.0[2]
Cooling	Maximum Operating Conditions[3, 5]	80.0	67.0	115	--	100	80.0[4]	90.0	90.0[2]	--
Cooling	Standard Rating Part-Load Conditions (IEER)[3, 5]	80.0	67.0	Varies with load per Table 9	Varies with load per Table 9[1,7]	Varies with load per Table 9	Varies with load per Table 9	77.0	Varies with load per Table 9[2]	Varies with load per Table 9
Cooling	Insulation Efficiency[3, 5]	80.0	75.0	80.0	75.0	80.0	75.0	85.0	--	80.0
Cooling	Condensate Disposal[3, 5]	80.0	75.0	80.0	75.0	80.0	75.0	85.0	--	80.0
Heating	Standard Rating Conditions (High Temperature Steady State Heating)[5]	70.0	60.0 (max)	47.0	43.0	--	--	--	--	--
Heating	Standard Rating Conditions (Low Temperature Steady State Heating)[5]	70.0	60.0 (max)	17.0	15.0	--	--	--	--	--
Heating	Maximum Operating Conditions[5]	80.0	--	75.0	65.0	--	--	--	--	--

Footnotes:

1. Only required if unit rejects condensate to Outdoor Coil.
2. Water flow rate as determined from Standard Rating Conditions test.
3. Cooling rating and operating tests are not required for heating only heat pumps.
4. Indoor fan system external static pressure shall be set per Table 7.
5. Tests are only valid when the atmospheric pressure is greater than 13.700 psia.
6. For some product classifications, the outdoor section can be located indoors per section 5.9.
7. For 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 room, maintain an outdoor room dew point temperature of 60.5ºF for 100, 75, and 50 Percent Load tests and 58.7ºF for 25 Percent Load tests.

6.1.3.2 *Atmospheric Pressures*. Cooling and Heating Capacity, EER, IEER and COP_H measurements obtained during test are only valid when atmospheric pressure is greater than 13.700 psia. The test shall not be conducted if the atmospheric pressure is below 13.700 psia.

6.1.3.3 *Minimum Indoor Air External Static Pressure for Testing*

6.1.3.3.1 Test at the external static pressure specified in Table 7 for full-load cooling tests for all units (except for Coil-only Indoor Units and heating-only units) and high temperature Heating Capacity tests for heating-only units.

Table 7. External Static Pressure

Rated Cooling Capacity, Btu/h·1000[1]	External Static Pressure, in H_2O[2]
From 0 to 28.8[3]	0.10
From 29 to 42.5[3]	0.15
From 43 to 64.5[3]	0.20
From 65 to 70	0.20
From 71 to 105	0.25
From 106 to 134	0.30
From 135 to 210	0.35
From 211 to 280	0.40
From 281 to 350	0.45
From 351 to 400	0.55
From 401 to 500	0.65
501 and greater	0.75

Footnotes:

1. Rated full load Cooling Capacity for units with cooling function; high temperature Heating Capacity for heating-only units.
2. Standard Ratings shall be determined and tested with the Standard Filter for that model. For units distributed in commerce without filters, refer to Section 6.1.3.3.3
3. Only applicable for evaporatively and water-cooled units.

6.1.3.3.2 Heating and Part Load Cooling Tests that do not use the full-load cooling airflow (except for Coil-only Indoor Units). When conducting heating or part-load cooling 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 1.

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

Where:

ESP_{adj} = Adjusted ESP requirement at heating airflow or part-load cooling airflow, in H_2O

ESP_{FL} = ESP requirement at full-load cooling airflow specified in Table 7, in H_2O

Q_{dif} = Measured part-load cooling airflow or Manufacturer-specified heating airflow, scfm

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

6.1.3.3.3 For units distributed in commerce without a filter (except for Coil-only Indoor Units), an additional static pressure allowance shall be added to the minimum static pressure shown in Table 7. 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 heating tests and part load tests, the additional static pressure allowance shall be reduced per equation 1.

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

Where:

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

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

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

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

6.1.3.4 *Indoor Airflow Target Values*

6.1.3.4.1 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.

6.1.3.4.2 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.

6.1.3.4.3 For the 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 6.1.3.3. 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.

6.1.3.4.4 For part-load cooling tests for units other than MZVAV units and Coil-only Indoor Units, use the cooling Part Load Rated Indoor Airflow. If there is no cooling Part Load Rated Indoor Airflow, use the airflow that results from using the Manufacturer-specified part-load cooling fan control settings at the ESP requirement determined per Section 6.1.3.3. If there is no cooling 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 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 Rate Indoor Airflow for the part-load cooling tests.

6.1.3.4.5 For part-load cooling tests for MZVAV units, adjust the cooling indoor airflow rate to achieve an indoor air leaving dry-bulb temperature equal to the average value measured over the course of the full-load cooling test, within a tolerance of ± 0.5ºF.

6.1.3.4.6 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.

6.1.3.4.7 For heating tests and part-load cooling tests of Coil-only Indoor Units, the indoor airflow rate shall be the lesser of: the Manufacturer-specified airflow rate for that test; or the measured full-load cooling airflow. If there is no heating Full Load Rated Indoor Airflow or cooling Part Load Rated Indoor Airflow, use the measured full-load cooling airflow for the heating test or part-load cooling test. Maintain the airflow within ± 3% of the target airflow throughout the test.

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

6.1.3.5.1 *General*. For each test, set indoor airflow while operating the unit at the rating conditions specified in Table 6 and Table 9 for the test. After setting the airflow, no adjustments can be made to the fan control settings during the test.

6.1.3.5.1.1 *Tolerances*. All tolerances for airflow and ESP specified in Section 6.1.3.5 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 Table 11.

6.1.3.5.2 *Full-load Cooling Test*

6.1.3.5.2.1 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 ESP within -0.00/+0.05 in H_2O of the requirement specified in Table 7 and to maintain the airflow within ± 3% of the cooling Full Load Rated Indoor Airflow.

6.1.3.5.2.2 If ESP or airflow are higher than the tolerance range, adjust the fan control settings (for example, lower fan speed) to maintain both 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 an ESP as close as possible to the minimum requirement specified in Table 7.

6.1.3.5.2.3 If 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 ESP or airflow are lower than the tolerance range at the maximum fan control setting (for example, highest fan speed), adjust the airflow-measuring apparatus to maintain 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.

6.1.3.5.2.4 For two adjacent fan control settings, if the lower setting is too low (such as ESP or airflow are lower than the tolerance range) and the higher setting is too high (such as 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 Table 7.

6.1.3.5.2.5 If the ESP measured after setting airflow exceeds the minimum ESP requirement by more than 0.05 in H_2O (because the ESP and airflow requirements cannot be simultaneously met, see Section 6.1.3.5.2.2), there is no condition tolerance for 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 ESP requirements cannot be simultaneously met, see Section 6.1.3.5.2.3), there is no condition tolerance for airflow.

6.1.3.5.3 *Heating Test and Part-load Cooling for Units other than MZVAV Units*

6.1.3.5.3.1 For tests where the cooling Part Load Rated Indoor Airflow or the heating Full Load Rated Indoor Airflow is the same as the cooling Full Load Rated Indoor Airflow (and for heating tests and part-load cooling 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 ESP. No changes are to be made to the fan control settings for the test.

6.1.3.5.3.2 For tests where the cooling Part Load Rated Indoor Airflow or the heating Full Load Rated Indoor Airflow differs from the cooling Full Load Rated Indoor Airflow, use the following provisions.

6.1.3.5.3.2.1 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 heating test or part-load cooling 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.

6.1.3.5.3.2.2 Adjust the airflow-measuring apparatus to maintain ESP within -0.00/+0.05 in H_2O of the adjusted ESP requirement determined per Section 6.1.3.3 and maintain airflow within ± 3% of the Manufacturer-specified airflow for the heating or part-load cooling test. If ESP or airflow are higher than the tolerance range, adjust the fan control settings (for example, lower fan speed) to maintain both 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 an ESP as close as possible to the adjusted ESP requirement. If 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 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 ESP within tolerance and operate with an airflow as close as possible to the Manufacturer-specified value.

6.1.3.5.3.2.3 For two adjacent fan control settings, if the lower setting is too low (such as ESP or airflow are lower than the tolerance range) and the higher setting is too high (such as 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 Table 7.

6.1.3.5.3.2.4 If the ESP measured after setting airflow exceeds the adjusted ESP requirement determined per Section 6.1.3.3 by more than 0.05 in H_2O (because the ESP and airflow requirements cannot be simultaneously met, see Section 6.1.3.5.3.2.2), there is no condition tolerance for ESP. If an airflow less than 97% of the Manufacturer-specified airflow is used for a test (because the airflow and ESP requirements cannot be simultaneously met, see Section 6.1.3.5.3.2.2), there is no condition tolerance for airflow.

6.1.3.5.3.3 For heating tests and part-load cooling 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 6.1.3.4), 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 ESP requirement determined per Section 6.1.3.3 with a condition tolerance of -0.00/+0.05 in H_2O, using the measured heating or part-load cooling airflow in the ESP calculation.

6.1.3.5.4 *Heating Test for MZVAV Units*

6.1.3.5.4.1 For tests where the heating Full Load Rated Indoor Airflow is the same as the cooling Full Load Rated Indoor Airflow (and for heating tests where there is no heating Full Load Rated Indoor 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 airflow measured during the full-load cooling test without regard to the resulting ESP. No changes are to be made to the fan control settings for the test.

6.1.3.5.4.2 For tests where the heating Full Load Rated Indoor Airflow differs from the cooling Full Load Rated Indoor Airflow, use the following provisions.

6.1.3.5.4.2.1 Operate the system using the Manufacturer-specified fan control settings for the heating test. If there are no Manufacturer-specified fan control settings for the heating 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.

6.1.3.5.4.2.2 Adjust the airflow-measuring apparatus to maintain ESP within -0.00/+0.05 in H_2O of the adjusted ESP requirement determined per Section 6.1.3.3 and maintain airflow within ± 3% of the heating Full Load Rated Indoor Airflow. If ESP or airflow are higher than the tolerance range, adjust the fan control settings (for example, lower fan speed) to maintain both 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 the lowest ESP that meets the adjusted ESP requirement. If ESP or airflow are lower than the tolerance range, adjust the fan control settings (for example, lower fan speed) to maintain both 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 ESP within tolerance and operate with an airflow as close as possible to the Manufacturer-specified value.

6.1.3.5.4.2.3 For two adjacent fan control settings, if the lower setting is too low (such as ESP or airflow are lower than the tolerance range) and the higher setting is too high (such as 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 Table 7.

6.1.3.5.4.2.4 If the ESP measured after setting airflow exceeds the adjusted ESP requirement determined per Section 6.1.3.3 by more than 0.05 in H_2O (because the ESP and airflow requirements cannot be simultaneously met, see Section 6.1.3.5.4.2.2), there is no condition tolerance for ESP. If an airflow less than 97% of the Manufacturer-specified airflow is used for a test (because the airflow and ESP requirements cannot be simultaneously met, see Section 6.1.3.5.4.2.2), there is no condition tolerance for airflow

6.1.3.5.4.3 If there is no heating Full Load Rated Indoor Airflow and the cooling Full Load Rated Indoor Airflow is not used as the airflow for the heating test (because there are Manufacturer-specified fan control settings or instructions to obtain steady-state operation for the heating test, per the provisions of Section 6.1.3.4), use the Manufacturer-specified fan control setting for the heating test 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 ESP requirement determined per Section 6.1.3.3 with a condition tolerance of -0.00/+0.05 in H_2O, using the measured heating airflow in the ESP calculation.

6.1.3.5.5 *Part-Load Cooling Tests for MZVAV Units*. For each part-load cooling test point, the unit fan control settings shall be adjusted to achieve an average indoor air leaving dry-bulb temperature for the test period equal to the average value measured over the course of the full-load cooling test, within a tolerance of ± 0.5 ºF. The airflow-measuring apparatus shall be adjusted to meet the adjusted ESP requirement determined per Section 6.1.3.3 with a condition tolerance of -0.00/+0.05 in H_2O, using the measured part-load cooling airflow in the ESP calculation. If the indoor air leaving dry-bulb temperature is greater than the full-load average by more than the allowable tolerance and airflow cannot be reduced while simultaneously meeting the adjusted ESP requirement, adjust the fan control settings and airflow-measuring apparatus to run at the minimum fan speed allowed by the controls while maintaining ESP within tolerance of the adjusted ESP requirement per Section 6.1.3.3. If the indoor air leaving dry bulb temperature is less than the full-load average by more than the allowable tolerance and the temperature tolerance cannot be met while simultaneously meeting the adjusted ESP requirement, adjust the fan control settings and airflow-measuring apparatus to achieve an indoor air leaving dry bulb temperature as close to meeting the tolerance as possible while maintaining ESP within tolerance of the adjusted ESP requirement per Section 6.1.3.3. The test report shall indicate when indoor leaving dry bulb temperature is not in tolerance.

6.1.3.6 *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, unless 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.

6.1.3.7 *Outdoor Airflow Rate and External Static Pressure for Units with Ducted Condensers*. For rating Double-duct Systems to EER_{DD}, $IEER_{DD}$, or $COP_{H,DD}$ (based on non-zero condenser ESP), follow the provisions of Appendix I. For rating units with condensers intended for ducting of outdoor air to EER, IEER, or COP (based on zero condenser ESP), follow the provisions of this section.

6.1.3.7.1. 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.

6.1.3.7.2 *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 Table 11.

6.2 *Part Load Rating.* All equipment rated in accordance with this standard shall include an Integrated Energy Efficiency Ratio (IEER) Rating, even if there is one stage of Cooling Capacity control.

6.2.1. *IEER Requirements.* The equations used for calculation of the IEER are defined in Section 6.2.2.

To help in the application of the general equations specific step by step procedures have been included in the following sections for various product classifications in Table 8.

Table 8. Section References for Different Product Classifications	
Product Classifications	**Section Reference**
IEER for Fixed Capacity Controlled Units	6.2.4
IEER for Staged Capacity Controlled Units	6.2.5
IEER for Proportionally Capacity Controlled Units	6.2.6

For calculation examples showing the procedures for calculating the IEER see Appendix G.

6.2.2 *General IEER Equations.* For units covered by this standard, the IEER shall be calculated using test derived data and the Equation 3.

$$IEER = (0.020 \cdot A) + (0.617 \cdot B) + (0.238 \cdot C) + (0.125 \cdot D) \quad \textbf{3}$$

Where:

A = EER, (Btu/h)/W, at 100% Capacity at AHRI Standard Rating Conditions (see Table 6)
B = EER, (Btu/h)/W, at 75% Capacity and reduced condenser temperature (see Table 9)
C = EER, (Btu/h)/W, at 50% Capacity and reduced condenser temperature (see Table 9)
D = EER, (Btu/h)/W, at 25% Capacity and reduced condenser temperature (see Table 9)

The IEER rating requires that the unit efficiency be determined at 100, 75, 50, and 25 Percent Load at the conditions specified in Table 9 and at the part-load rated airflow, if different than the Full Load Rated Indoor Airflow.

Table 9. IEER Part-Load Rating Conditions

Conditions	Condition
Indoor Air Return Air Dry-bulb Temperature Return Air Wet-bulb Temperature Part Load Rated Indoor Airflow	 80.0°F 67.0°F See note 1
Condenser (Air Cooled) Entering Dry-bulb Temperature (OAT) Condenser Airflow Rate, cfm	100 Percent Load = 95.0ºF[4,5] 75 Percent Load = 81.5ºF[4,5] 50 Percent Load = 68.0ºF[4,5] 25 Percent Load = 65.0ºF[4,5] See note 2
Condenser (Water Cooled) Entering Condenser Water Temperature (EWT) Condenser Water Flow Rate, gpm	100 Percent Load = 85.0ºF 75 Percent Load = 73.5ºF 50 Percent Load = 62.0ºF 25 Percent Load = 55.0ºF See note 3
Condenser (Evaporatively Cooled) Entering Air Wet-bulb/Air Dry-bulb/Makeup Water Temperature (EWB/DB/MW)	100 Percent Load = 75.0ºF/95.0ºF/85.0ºF 75 Percent Load = 66.2ºF/81.5ºF/77.0ºF 50 Percent Load = 57.5ºF/68.0ºF/77.0ºF 25 Percent Load = 52.8ºF/65.0ºF/77.0ºF

Notes:

1. Refer to Section 6.1.3 for indoor airflow and external static pressure.
2. Condenser airflow shall be adjusted, if required per Section 6.1.3.6 or 6.1.3.7.
3. At 100 Percent Load, the condenser water flow rate shall be equal to the flow rate determined for the Standard Rating Condition for cooling, described in Table 6. Except as noted in Section E7, at 75, 50, and 25 Percent Load, the supplemental testing instructions (10 CFR §429.43) shall describe the conditions to run the unit.
4. For testing Air-cooled units that reject condensate to the condenser coil, the condenser air wet bulb temperature requirements specified for evaporatively cooled products apply.
5. For 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 room, maintain an outdoor room dew point temperature of 60.5ºF for 100, 75, and 50 Percent Load and 58.7°F for 25 Percent Load.

6.2.3 *Rating Adjustments.* Testing shall be performed at the four load points and condenser conditions as defined in Table 9. If the unit is not capable of running at any of the 75, 50, or 25 Percent Load points then Section 6.2.3.1 or Section 6.2.3.2 shall be followed to determine the EER rating at the required load.

6.2.3.1 *Interpolation.* If the units cannot run at any of the 75, 50 or 25 Percent Load points within a tolerance of ± 3% but is capable of running at load above and below the Percent Load of 75, 50 or 25 interpolation of the test points shall be used to determine the EER at the required load.

6.2.3.2 *Degradation*. If the unit cannot be unloaded to the 75, 50, or 25 Percent Load then the unit shall be run at the minimum step of unloading and the rated indoor airflow at the condenser conditions defined for each of the percent load points listed in Table 9 and then the part-load EER shall be adjusted for cyclic performance using Equation 4.

$$EER = \frac{LF \cdot q}{LF[C_D \cdot (P_C + P_{CD})] + P_{IF} + P_{CT}} \tag{4}$$

Where:

C_D = Degradation coefficient, (Btu/h)/(Btu/h)
P_C = Compressor power at the lowest machine unloading point operating at the applicable part-load Rating Condition, W
P_{CD} = Condenser Section power, at the applicable part-load Rating Condition, W
P_{CT} = Control circuit power and any auxiliary loads, W

P_{IF} = Indoor Fan power, W
q = Cooling Capacity at the lowest machine unloading point operating at the applicable part-load Rating Condition, Btu/h

P_{CD} for air-cooled and evaporatively cooled units is the power of the fans and pumps. P_{CD} for water cooled units with a capacity of 65,000 Btu/h to less than 135,000 Btu/h shall be the cooling tower power allowance per Section 6.1. For capacities above 135,000 Btu/h, P_{CD} shall be 0.

The degradation coefficient, to account for cycling of the compressor for capacity less than the minimum step of capacity, shall be calculated per Equation 5.

$$C_D = (-0.13 \cdot LF) + 1.13 \quad \textbf{5}$$

Where:

LF = Fractional "on" time for last stage at the tested load point, noted in Equation 6.

$$LF = \frac{\left(PL/_{100}\right) \cdot \dot{q}_{A,Full}}{\dot{q}_{i,x}} \quad \textbf{6}$$

Where:

PL = Percent Load
$\dot{q}_{A,Full}$ = Full load Net Capacity, Btu/h
$\dot{q}_{i,x}$ = Part load Net Capacity, Btu/h

6.2.4 Procedure for *IEER Calculations for Fixed Capacity Control Units***.** For Fixed Capacity Controlled Units (single stage), the IEER shall be calculated using data and the Equation 4 and the following procedures.

The following sequential steps shall be followed.

6.2.4.1 *Step 1.* Each of the three percent load EER rating-points for 75, 50 and 25 Percent Load shall be determined at the Percent Load-condenser entering temperatures defined in Table 9 within tolerances defined in Section 6.3.

Note: Because the unit only has a single stage of capacity, the three percent load capacities will be greater than the required Percent Load and the cyclic performance will be adjusted using the degradation calculations as per step 2.

6.2.4.2 *Step 2.* The EER shall be adjusted for cyclic degradation using the procedures in Section 6.2.3.

6.2.4.3 *Step 3.* The test results including adjustments for cyclic degradation from step 2 shall then be used to calculate the IEER using the procedures defined in Section 6.2.2. For example calculations, see Appendix G.

6.2.5 *IEER for Staged Capacity Controlled Units.* For Staged Capacity Controlled Units, the IEER shall be calculated using Equation 3 and the following procedures.

Staged Capacity Controlled Units, for test purposes, shall be provided with means to adjust the stages of refrigeration capacity and the indoor fan speed to obtain the rated airflow with the tolerance specified in Section 6.1.

The following sequential steps shall be followed.

6.2.5.1 *Step 1.* For part-load tests, the unit shall be configured per the Manufacturer's Installation Instructions, including setting of stages of refrigeration for each part-load point. The stages of refrigeration that result in capacity closest to the tested part-load point shall be used.

The condenser entering temperature shall be adjusted per the requirements of Table 9 within the tolerances defined in Section 6.3.

The indoor Standard Airflow rate and static shall be adjusted per Section 6.1.

If the measured part-load rating capacity ratio is within three percentage points of the target, based on the full load measured Cooling Capacity, above or below the target, the EER at each load point shall be used to determine IEER without any interpolation or adjustment for cyclic degradation. See Table 10.

Table 10. Tolerance on Part Load Percent Load

Required Percent Load Point	Minimum Allowable Measured Percent Load	Maximum Allowable Measured Percent Load
75%	72%	78%
50%	47%	53%
25%	22%	28%

If the unit, cannot operate within 3% of the target load fraction for a given part-load test (75, 50, or 25 Percent Load) then the EER for the part-load test shall be determined using either linear interpolation or adjustment for cyclic degradation. If the unit is capable of running both above and below the target load fraction, then an additional test point is required and the EER for the given part-load test point is determined using linear interpolation. Data shall not be extrapolated to determine EER; therefore, if the unit cannot be unloaded to the target load fraction, then the unit shall be run at the minimum step of unloading at the condenser conditions defined for the target test point in Table 9 and the EER for the part-load test shall be adjusted for cyclic degradation using Equation 4.

The additional test point(s) for interpolations shall be run as follows:

6.2.5.1.1 Both test points used for interpolation for a given target load fraction shall be conducted at the outdoor ambient temperature specified in Table 9, within a tolerance of ± 0.5 ºF. Of the two tests, one test point shall use the nearest stage that yields a capacity above the target load point. The second test point shall use the nearest stage that yields a capacity below the target load point. The data from these two test points shall then be used to interpolate the EER for the required load rating point. For example, for an air-cooled unit that cannot operate at 50 Percent Load and has capacity stages at 60 and 30 Percent Load, then tests at both load point tests shall be conducted at a 68ºF outdoor ambient temperature. The test results are then interpolated to determine the EER for the 50 Percent Load rating point.

The indoor Standard Airflow rate and external static pressure for each part-load test shall be adjusted per Section 6.1.

6.2.5.1.2 The test points used for interpolation shall be at load fractions as close as possible to the target load fraction. For example, to interpolate for a 50 Percent Load rating point for a unit having capacity stages at both 60 and 70, the 60 Percent Load test point shall be used for interpolation (along with the highest possible capacity stage below 50 Percent Load).

If the unit cannot be unloaded to the 75, 50, or 25 Percent Load points at the minimum stage of unloading then the EER shall be determined at the minimum stage of unloading and part-load rating condenser entering temperature defined in Table 9 for the target load point with a tolerance of ± 0.5ºF. In such a case, the actual Percent Load will be greater than the target Percent Load and shall be adjusted for cyclic performance using the degradation calculations as per Section 6.2. Part load Rated Indoor Airflow and external static pressure shall be set as specified in Section 6.1.

6.2.5.2 *Step 2*. If the load fraction points are within 3% of the required IEER rating point of 75, 50 and 25 Percent Load, then these they shall be used directly. If there are load fraction points above and below the required targets of 75, 50, and 25 Percent Load then the part load EER shall be determined using linear interpolation. If the tested Percent Load is greater than the Percent Load for 75, 50 or 25 by more than 3% and the unit cannot unload any further then the EER at the condenser temperature required for the rating point shall be used along with the degradation procedure defined in Section 6.2.

6.2.5.3 *Step 3*. The data from step 2 shall then be used to calculate the IEER using the procedures defined in Section 6.2.3.

6.2.6 *IEER for Proportionally Capacity Controlled Units.* For Proportionally Capacity Controlled Units, the IEER shall be calculated using data, Equation 3, and the following procedures.

Proportionally Capacity Controlled Units, for test purposes, shall be provided with means to adjust the unit refrigeration capacity and the indoor fan speed to obtain the rated airflow with the tolerance specified in Section 6.1.

The following sequential steps shall be followed.

6.2.6.1 *Step 1.* For part-load tests, the unit shall be configured per the Manufacturer's Installation Instructions, including setting of stages of refrigeration and variable capacity compressor loading percent for each of the part-load test points. The settings that result in capacity closest to the target percent load point of 75, 50, or 25 shall be used.

The condenser entering conditions shall be adjusted per the requirements of Table 9 and be within tolerance as defined in Section 6.3. The indoor Standard Airflow and external static pressure shall be adjusted per Section 6.1.

If the measured part-load rating capacity ratio is within ± 3%, based on the full load measured Cooling Capacity, the EER at each load point shall be used to determine IEER without any interpolation.

If the unit cannot be operated at the 75, 50, or 25 Percent Load within 3%, then an additional rating point(s) is required and the 75, 50, or 25 percent load EER is determined by using linear interpolation. Extrapolation of the data is not allowed.

The additional test point(s) for interpolations shall be run as follows:

6.2.6.1.1 The condenser entering conditions shall be adjusted per the requirements of Table 9 and be within tolerance as defined in Section 6.3.

6.2.6.1.2 The indoor Standard Air airflow shall be set as specified in the Manufacturer's Installation Instructions and as required by Section 6.1.

6.2.6.1.3 The stages of refrigeration capacity shall be increased or decreased within the limit of the controls and until the measured part-load capacity is closest to the target percent load.

Note: For example, to calculate the EER at 50 Percent Load for a unit having control points at both 60 and 70 Percent Load, a test point at 60 Percent Load should be used.

6.2.6.1.4 The measured part-load capacity of the second test point shall be less than the target capacity point if the measured capacity of the first test is greater than the target capacity point.

6.2.6.1.5 The measured part-load capacity of the second test point shall be more than the part-load rating capacity point if the measured capacity of the first test is less than the part load rated capacity point.

If the unit cannot be unloaded to the 75, 50, or 25 Percent Load points at the minimum stage of unloading then the EER shall be determined at the minimum stage of unloading per Table 9.

Note: The actual Percent Load will be greater than the required Percent Load and the part load EER will be adjusted for cyclic performance using the degradation calculations as per step 2.

6.2.6.2 *Step 3.* If any of the actual Percent Loads are within ± 3% of the targets of 75, 50 and 25 Percent

Load, the tested EER shall be used directly. If there are actual Percent Loads above and below the targets of 75, 50, and 25 Percent Load, then the EER rating point shall be determined using linear interpolation. If the actual Percent Load is greater than the targets of 75, 50 or 25 by more than 3%, and the capacity cannot be reduced to meet the target, then the EER at the condenser conditions required for the load point shall be used along with the degradation procedure defined in Section 6.2.3.2.

6.2.6.3 *Step 4*. The data from step 3 shall then be used to calculate the IEER using the procedures defined in Section 6.2.3.

6.2.7 *Example calculations.* Appendix G contains examples that explain calculation of IEER and calculation of tolerances. The examples are grouped by the three rating categories defined in Section 6.2.

6.3 *Test Tolerances*

6.3.1 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.

6.3.2 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.

6.3.3 Tolerances specified in this standard supersede tolerances specified in ANSI/ASHRAE Standard 37. Test operating tolerances and condition tolerances are specified in Table 11.

Table 11. Tolerances

Measurement	Test Operating Tolerance	Test Condition Tolerance
Outdoor dry-bulb temperature (°F): Entering Leaving	 2.0 2.0 / 3.0[1,3]	 0.5 -
Outdoor wet-bulb temperature (°F): Entering Leaving	 1.0 1.0[3]	 0.3[2] -
Outdoor dew point temperature (°F)[6]: 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[4] -
Water serving outdoor coil temperature (°F): Entering Leaving	 0.5 0.5	 0.2 0.2
Make Up Water temperature (°F):	10.0	5.0
Saturated refrigerant temperature corresponding to the measured indoor side pressure[5] (°F)	3.0	0.5
Liquid refrigerant temperature[5] (°F)	0.5	0.2
External static pressure (in H_2O)	0.05	See sections 6.1.3.5 and 6.1.3.7
Electrical voltage (percent of reading)	2.0	1.0
Electrical Frequency (Hz)[7]	0.4	0.2
Liquid flow rate (percent of reading)	2.0	-
Nozzle pressure drop (percent of reading)	2.0	-

Notes:
1. The test operating tolerance is 2.0°F for cooling tests and 3.0°F for heating tests.
2. Applicable 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.
3. Applies only when using the outdoor air enthalpy method.
4. Applicable only for cooling tests.
5. 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.
6. Tolerance only applies 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.
7. When using electrical generators, tolerances can be doubled.

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

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

6.5.1 *Ratings Generated by Test Data.* Any capacity, EER, IEER, or COP_H (47°F) 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 IEER or COP_H (47°F) 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 7 and 8), rounded per Sections 6.1.2.

The capacity, EER, or COP_H (17°F) ratings 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.

$$\bar{x} = \frac{\sum_{i=1}^{n} x_i}{n} \qquad \mathbf{7}$$

$$LCL = \bar{x} - t_{.95}\left(\frac{s}{\sqrt{n}}\right) \qquad \mathbf{8}$$

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

6.5.2 *Ratings Not Generated by Test Data*. Any capacity, EER, IEER, or COP_H 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.

6.5.3 *Documentation*. For products covered under 10 CFR §429.71, supporting documentation of all Published Ratings subject to federal control shall be appropriately maintained.

6.6 *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.

6.7 *Verification Testing.* To comply with this standard, single sample production verification tests, shall meet the Standard Rating performance metrics shown in Table 12 with the listed Acceptance Criteria

Table 12. Acceptance Criteria	
Performance Metric	**Acceptance Criteria**
Cooling Metrics	
Full Load Cooling Capacity, Btu/h	≥ 95%
Full Load EER, Btu/(W·h)	≥ 95%
IEER, Btu/(W·h)	≥ 90%
Heating Metrics	
Heating Capacity at 47°F, Btu/h	≥ 95%
COP_H at 47°F, W/W	≥ 95%
Heating Capacity at 17°F, Btu/h	≥ 95%
COP_H at 17°F, W/W	≥ 95%

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 Energy Efficiency Ratio, IEER, Btu/W·h

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, EER, Btu/W·h
7.1.2.3 Integrated Energy Efficiency Ratio, IEER, Btu/W·h
7.1.2.4 High temperature Heating Capacity, Btu/h at 47°F
7.1.2.5 High temperature Heating Coefficient of Performance, COP_H, W/W, at 47°F
7.1.2.6 Low temperature Heating Capacity, Btu/h, at 17°F
7.1.2.7 Low temperature Heating Coefficient of Performance, COP_H, W/W, at 17°F

All claims to ratings within the scope of this standard shall include the statement "Rated in accordance with AHRI Standard 340/360 (I-P)". All claims to ratings outside the scope of this standard shall include the statement "Outside the scope of AHRI Standard 340/360 (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 6 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 9) and Cooling Capacity, Btu/h

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

$$SHR = \frac{q_{sci}}{q_{tci}} \quad (9)$$

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.

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 6.

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 6.

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 6.

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.

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 6.

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*, 2016, Air-Conditioning, Heating and Refrigeration Institute, 2311 Wilson Boulevard, Suite 400, Arlington, VA 22201, U.S.A.

A1.2 AHRI Standard 1360 (I-P)-2017, *Performance Rating of Computer and Data Processing Room Air Conditioners,* 2017, Air-Conditioning, Heating and Refrigeration Institute, 2311 Wilson Boulevard, Suite 400, Arlington, VA 22201, U.S.A.

A1.3 AHRI Standard 210/240-2017 with Addendum 1, *Unitary Air-Conditioning and Air-Source Heat Pump Equipment,* 2017, Air-Conditioning, Heating and Refrigeration Institute, 2311 Wilson Boulevard, Suite 400, Arlington, VA 22201, U.S.A.

A1.4AHRI Standard 540-2020 (SI/I-P), *Standard for Performance Rating of Positive Displacement Refrigerant Compressors and Compressor Units*, 2020, 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, *Performance Rating of DX-Dedicated Outdoor Air System Units*, 2020, 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*, 2009, Air-Conditioning, Heating and Refrigeration Institute, 2311 Wilson Boulevard, Suite 400, Arlington, VA 22201, U.S.A.

A1.7 ANSI/AHRI Standard 390 -2003, *Performance Rating of Single Package Vertical Air-Conditioners and Heat Pumps*, 2003, 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,* 2006, Air-Conditioning, Heating and Refrigeration Institute, 2311 Wilson Boulevard, Suite 400, Arlington, VA 22201, U.S.A.

A1.9 ANSI/AMCA Standard 208-18, *Calculation of the Fan Energy Index*, 2018, Air Movement and Control Association International, 30 W. University Drive, Arlington Heights, IL 60004, 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 34-2019, *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 41.1-2013, *Standard Method for Temperature Measurement,* 2013, ASHRAE, Inc., 180 Technology Parkway NW, Peachtree Corners, GA 30092.

A1.14 ANSI/ASHRAE Standard 41.6-2014, *Standard Method for Humidity Measurement, 2014,* 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.

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 Standard 37 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 C2 and C3. 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 C4. Make these measurements as described in the following sections. Maintain test operating and test condition tolerances and uniformity requirements as described in Section C2.7.

C3 *Outdoor Air Entering Conditions.* For cooling tests of both evaporatively-cooled equipment and air-cooled equipment that uses condensate obtained from the evaporator to enhance condenser cooling, measure the water vapor content as provided in Section C2.2. For heating tests of all air-source heat pumps, measure water vapor content as provided in Section C2.2.

C3.1 *Temperature Measurements.* Measure temperatures in accordance with ANSI/ASHRAE Standard 41.1 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 C2.4, 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.

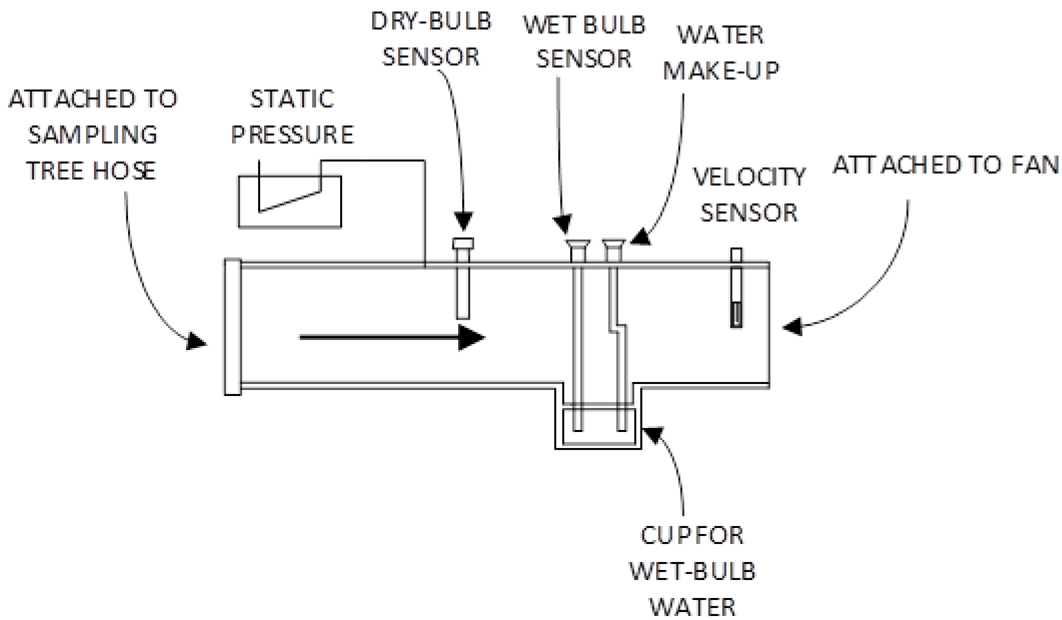

Figure C1. Aspirating Psychrometer

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 $ft^2 \cdot °F \cdot hr/Btu$.

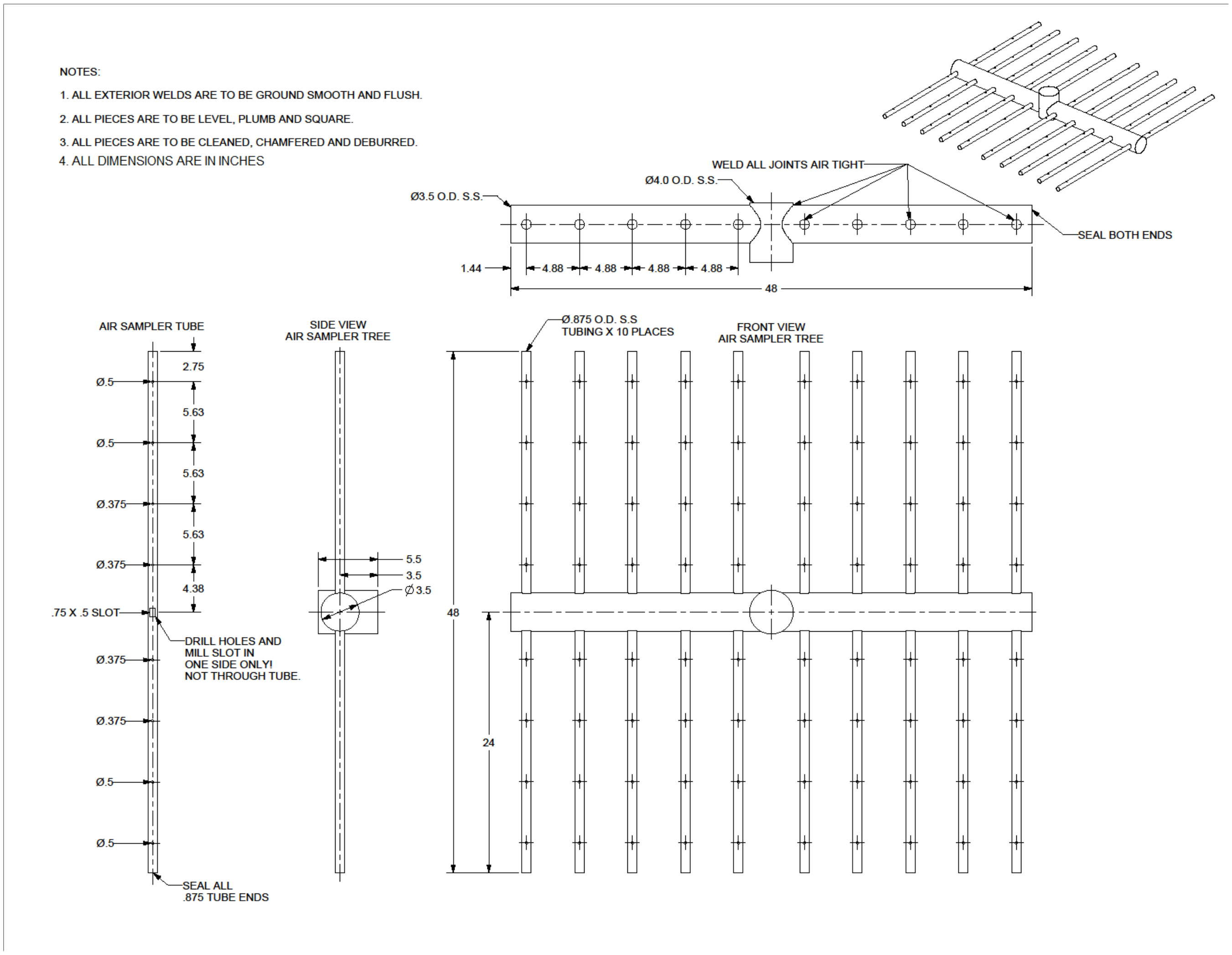

Figure C2. Typical Air Sampling Tree

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.

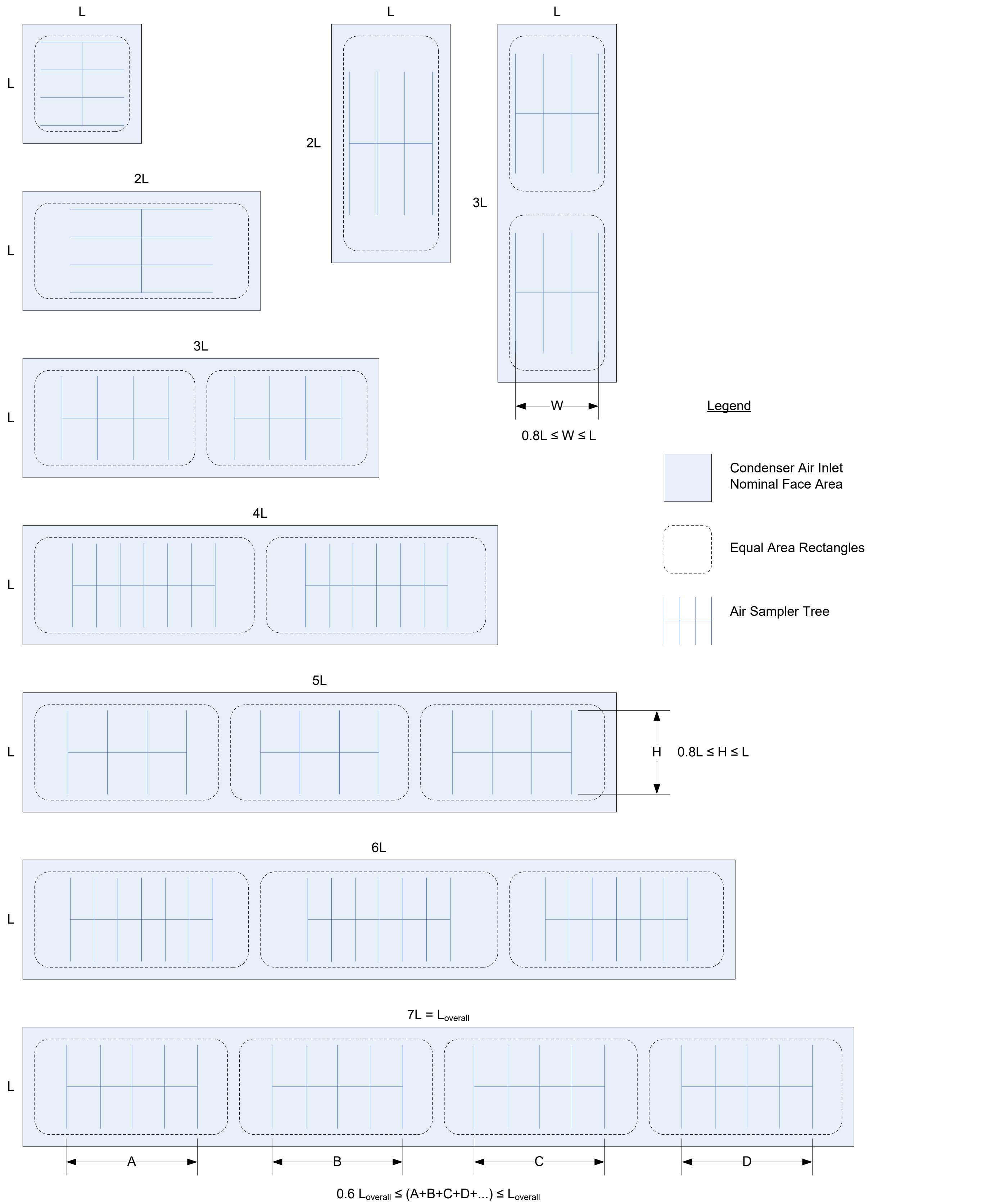

Figure C3. Determination of Measurement Rectangles and Required Number of Air Sampling Trees

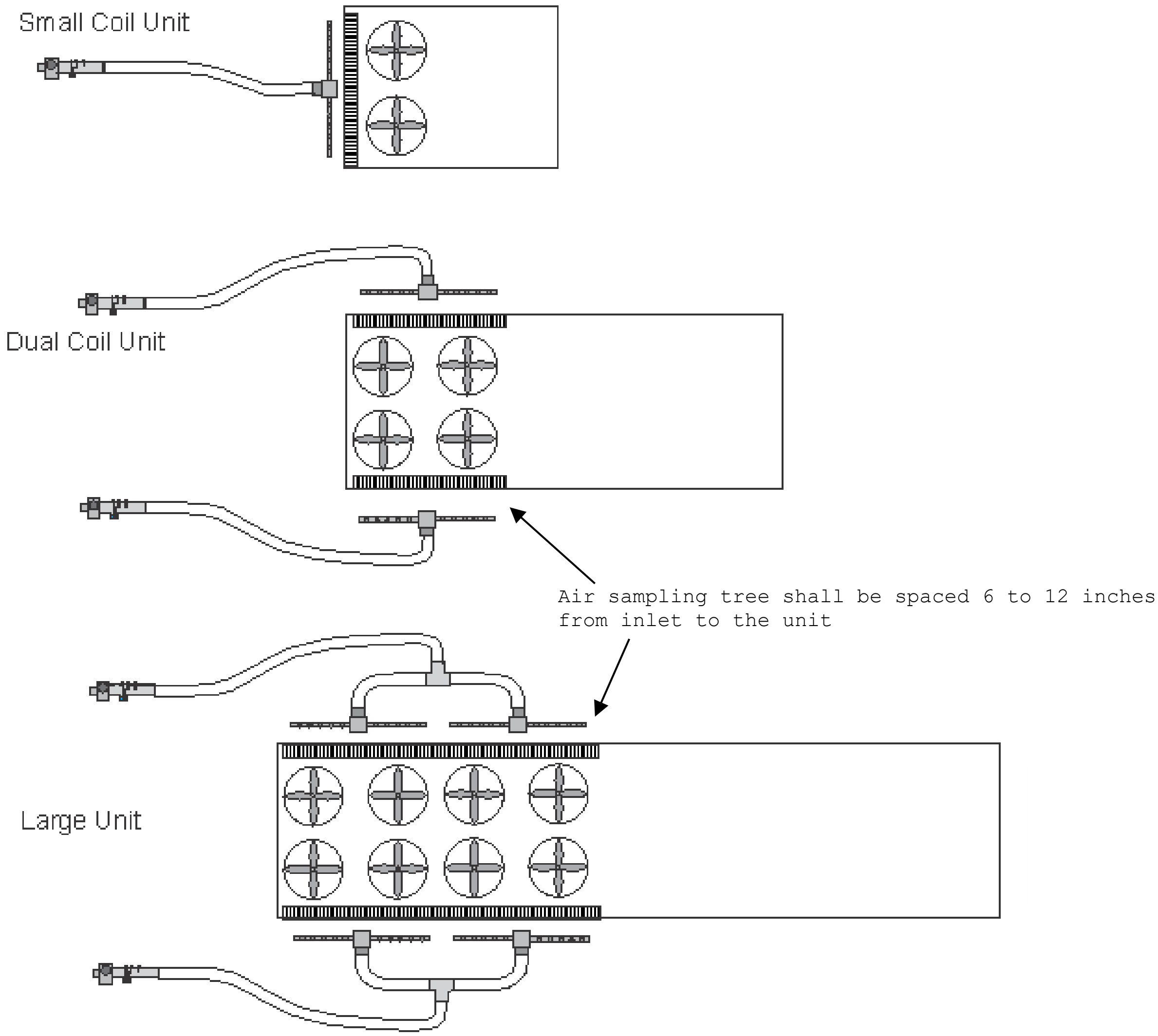

Figure C4. Typical Test Setup Configurations

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 C2.3. 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 C2.1. 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 C2.4), 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 C2.6 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[1]	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 C2, 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 C2.7 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 C2, except for the following:

1) The temperature uniformity requirements discussed in Section C2.7 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 D2.10)

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.

D3.16 *Indoor Fan Variable Frequency Drive (VFD) (water-cooled and evaporatively cooled units only)*. A device connected electrically between the equipment's power supply connection and the indoor fan motor that can vary the frequency of power supplied to the motor to allow variation of the motor's rotational speed. For water-cooled and evaporatively-cooled units, if the manufacturer chooses to test and rate for IEER, indoor fan VFDs shall be treated consistently for EER and IEER tests for the Basic Model (such as if the indoor fan VFD is installed and active for the IEER test, it shall be installed and active for the EER test).

D3.17 *Compressor VFD (water-cooled and evaporatively cooled units only)*. A device connected electrically between the equipment's power supply connection and the compressor that can vary the frequency of power supplied to the compressor in order to allow variation of the compressor's rotational speed for capacity control. For water-cooled and evaporatively-cooled units, if the manufacturer chooses to test and rate for IEER, compressor VFDs shall be treated consistently for EER and IEER tests for the Basic Model (in other words if the compressor VFD is present and active for the IEER test it shall be present and active for the EER test).

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 6.1.3.7.1.

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 Indoor Fan Motors*. The standard indoor fan motor is the motor specified in the Manufacturer's Installation Instructions for testing and shall be distributed in commerce as part of a particular model. A non-standard motor is an indoor fan motor that is not the standard indoor fan motor and that is distributed in commerce as part of an individual model within the same Basic Model. The minimum allowable efficiency of any non-standard indoor fan motor shall be related to the efficiency of the standard motor as specified in either Section D.3.1(for non-standard indoor fan motors) or Section D.3.2 (for non-standard indoor integrated fan and motor combinations). If the standard indoor fan motor can vary fan speed through control system adjustment of motor speed, all non-standard indoor fan motors shall allow speed control (including with the use of VFD).

D4.1 *Determination of Motor Efficiency for Non-standard 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.

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

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 D.3.2.2. 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.

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

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.
$P_{IF,non-std}$ = 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	D3.2.3	-0.5 / +1.0	± 0.05	110%
Outside the unit	Outside the unit	D3.2.4	-0.5 / +1.0	± 0.05	110%
Simulated performance data	Simulated performance data	D3.2.5	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 D3.2 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 D3.1.

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 D3.2.4 or using simulated performance data per D3.2.5, 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 D3.2.3, Section D3.2.4, or Section D3.2.5.

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 D3.2.6.

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 D3.2.5.

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 D3.2.5.3

D4.2.6 *Interpolation to determine the fan input power of the non-standard fan.* For fans tested per the requirements of Sections D3.2.3 or D3.2.4, 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 of AHRI Standard 340/360 products 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 6.1.

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 37-2009. If using the refrigerant enthalpy method for secondary measurements, Section 7.5.1.3 of ANSI/ASHRAE 37-2009 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 37-2009 results shall match within ± 6% of the primary Latent Capacity calculated in Section 7.3.3.1 of ANSI/ASHRAE 37-2009. 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 Appendix I, for the full-load cooling test, set the outdoor air ESP using symmetrical duct outlet restrictors according to section I3.1, 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 6.1.3.7.1, 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 Appendix I, 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 $hr \cdot ft^2 \cdot °F/Btu$ 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 10 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 9 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 9 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 efficiency that is then used for the IEER 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 6. 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 6.2.4.1. 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		

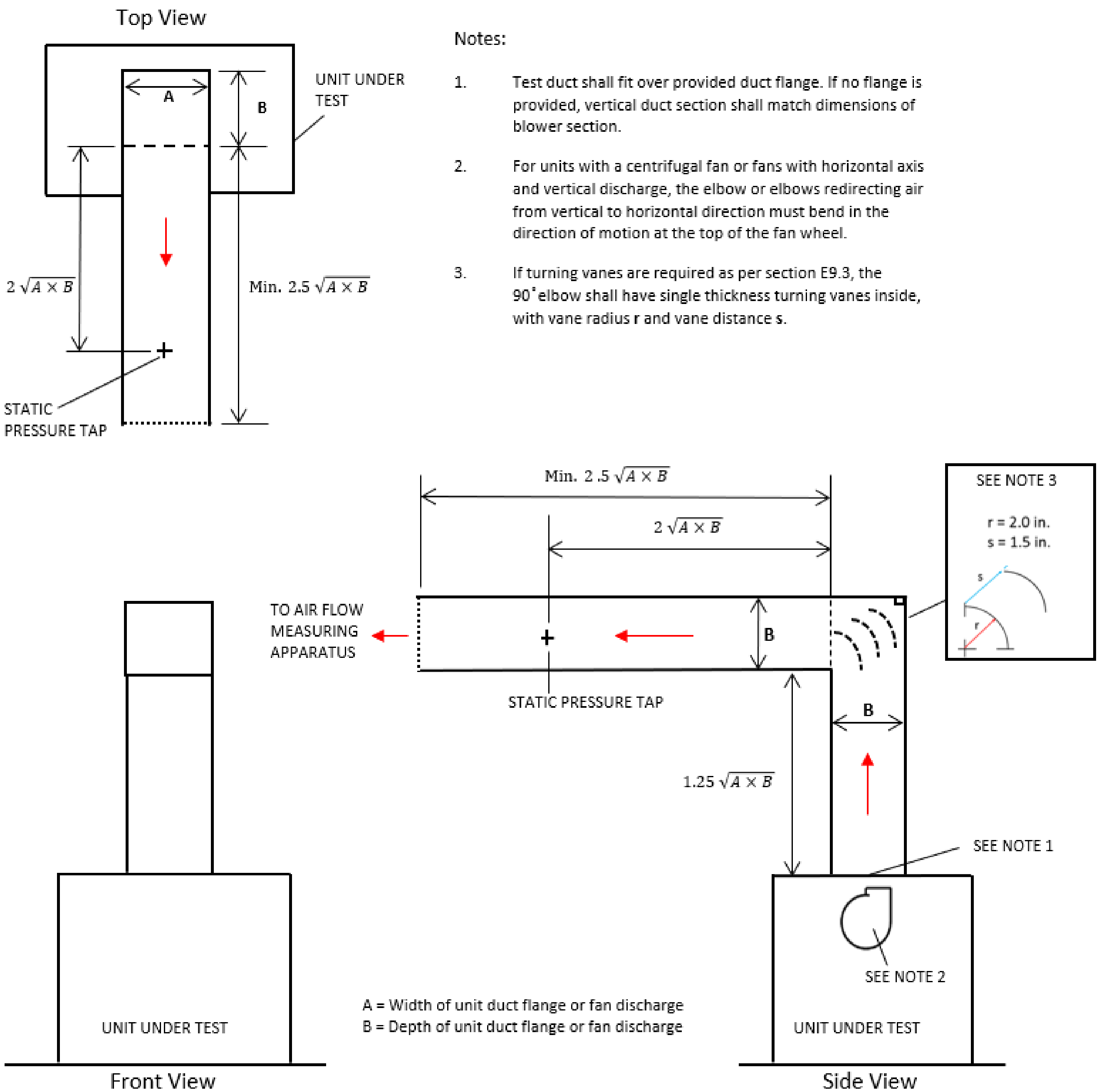

Figure E1. Test Duct Setup for Up-flow Unit with Single Fan Outlet Connection in Limited Height Test Chamber

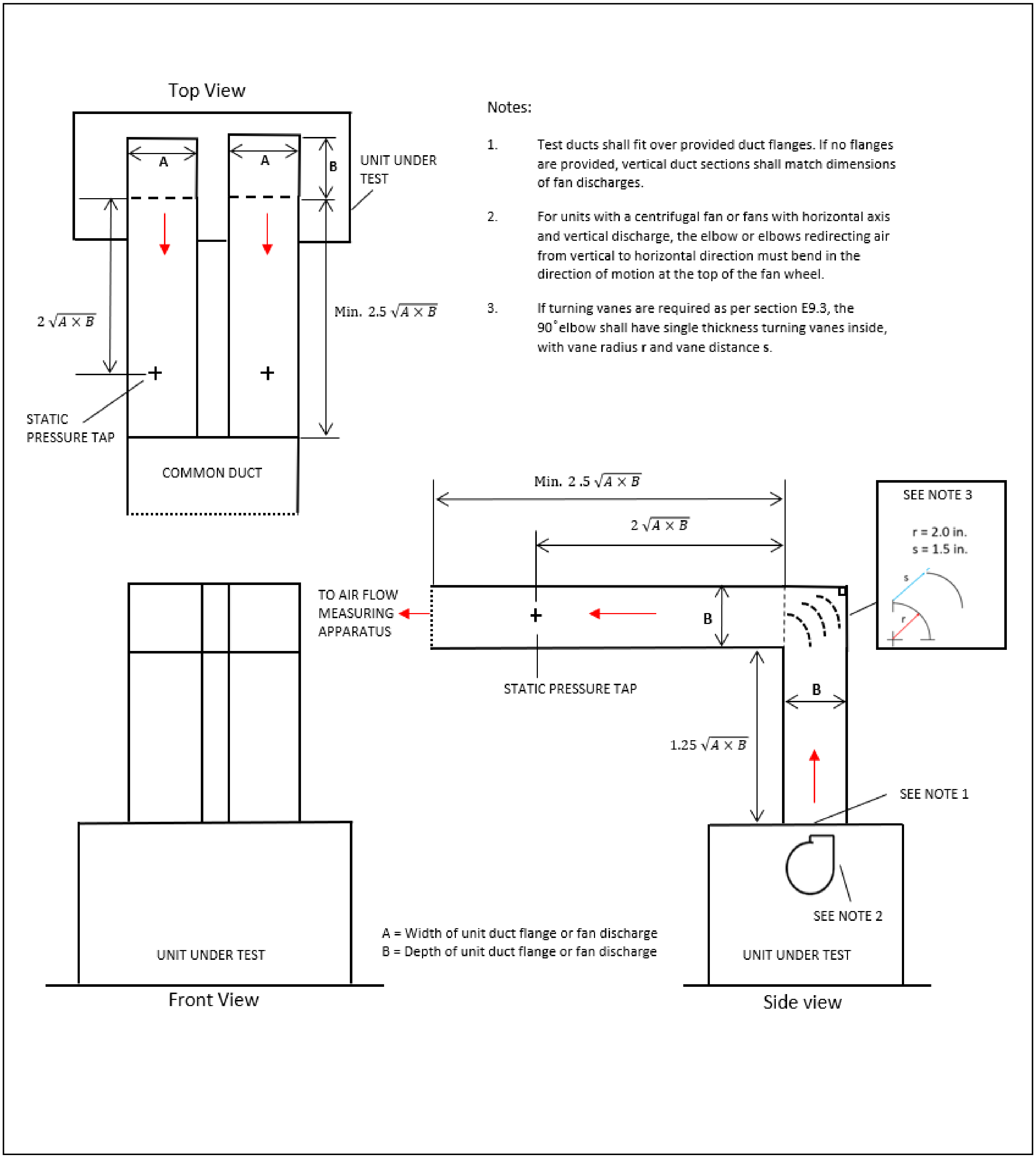

Figure E2. Test Duct Setup for Up-flow Unit with Multiple Fan Outlet Connections in Limited Height Test Chamber

APPENDIX F. INTERNATIONAL RATING CONDITIONS - NORMATIVE

F1 *International Rating Conditions***.** These are full load Rating Conditions relevant to international requirements.

F1.1 *Cooling Temperature Conditions.*

F1.1.1 The international T1, T2, and T3 temperature conditions specified in Table F1 shall be considered Standard Rating Conditions for the determination of Cooling Capacity and energy efficiency. For equipment intended for space cooling, testing shall be conducted at one or more of the Standard Rating Conditions specified in Table F1.

F1.2 *Heating Temperature Conditions.*

F1.2.1 The H1, H2, and H3 temperature conditions specified in Table F1 shall be considered Standard Rating Conditions for the determination of Heating Capacity and energy efficiency.

F1.2.2 All heat pumps shall be rated based on testing at the H1 temperature conditions. Heating Capacity and energy efficiency tests shall be conducted at the H2 and/or H3 temperature conditions if the manufacturer rates the equipment for operation at one or both temperature conditions.

Table F1. International Air-cooled Standard Rating Conditions

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

F1.3 *Extra High Temperature Operating Requirement*. Unitary Air-cooled Air-Conditioners and Heat Pump Equipment shall pass the following extra high temperature operating condition test with an indoor-coil at the T3 condition airflow rate as determined under this appendix.

F1.3.1 *Temperature Conditions.* Temperature conditions shall be maintained as shown in Table F2.

Table F2. Conditions for Operating Requirement Tests for Air-cooled Equipment	
Cooling – Temperature Conditions	
Indoor	80.0°F DB[1] & 67.0°F WB[1,2]
Outdoor	125.6°F DB[1] & 87.81°F WB[1,2]
Notes: 1. DB = dry-bulb and WB = wet-bulb 2. The wet-bulb temperature condition is not required when testing air-cooled condensers that do not evaporate condensate.	

F1.3.2 *Voltages*. Tests shall be run at the unit's nominal rated voltage.

F1.3.3 *Procedure*. Unitary Air-Cooled Air-Conditioners and Heat Pump Equipment shall be operated continuously at full capacity. All power to the equipment shall be interrupted for a period for a minimum period of five seconds and a maximum of seven seconds and then be restored. The unit shall resume continuous operation within one hour of restoration of power and shall then operate continuously for one hour. Operation and resetting of safety devices prior to establishment of continuous operation is permitted.

F1.3.4 *Requirements*. During the test, the equipment shall operate without failure of any of its parts.

APPENDIX G. EXAMPLES OF IEER CALCULATIONS - INFORMATIVE

G1 *IEER Background*. The IEER has been developed to represent a single metric for the annualized performance of the mechanical cooling system**.** It is based on a volume weighted average of 3 building types and 17 climate zones and includes 4 rating points at 100, 75, 50 and 25 Percent Load at condenser conditions seen during these load points. The test descriptions are

1) A for 100 Percent Load;
2) B for 75 Percent Load;
3) C for 50 Percent Load; and
4) D for 25 Percent Load.

It includes:

1) all mechanical cooling energy;
2) fan energy; and
3) other energy required to deliver the mechanical cooling.

It excludes:

1) energy and Cooling Capacity for operating hours seen in just ventilation;
2) economizer operation system control options such as demand ventilation, Supply Air reset, and energy recovery; and
3) other system options that can be used in an applied configuration of the unit.

It assumes no oversizing of the unit. The purpose of the metric is to allow for comparison of mechanical cooling systems at a common industry metric set of conditions. It is not intended to be a metric for prediction of building energy use for the HVAC systems.

Building energy consumption varies significantly based on factors including, but not limited to, local occupancy schedules, ambient conditions, building construction, building location, ventilation requirements, and added features such as economizers, energy recovery, and evaporative cooling. IEER is a comparative metric representing the integrated full load and part-load annualized performance of the mechanical cooling of the air- conditioning unit over a range of operating conditions. It does not include performance of hybrid system features such as economizers, energy recovery and heat reclaim. IEER is not intended to be a predictor of the annual energy consumption of a specific building in a given climate zone. To more accurately estimate energy consumption of a specific building, an energy analysis using an hour-by-hour analysis program should be performed for the intended building using the local weather data.

G2 *Example Calculations.* This appendix contains informative examples that help explain the procedures for calculating the IEER as defined in Section 6.2. It is not intended to replace the prescriptive requirements in Section 6.2 and is intended to help in the application of the IEER to various products covered by this standard. The examples are grouped by the capacity control methods as defined in Sections 6.2.4, 6.2.5, and 6.2.6 and as outlined in Table G1.

G3 *Fixed Capacity Control Examples*. This section provides example IEER calculations for Fixed Capacity Controlled Units (single stage) as defined in Section 6.2.4.

Per Section 3.9, a Fixed Capacity Controlled Unit is defined as a Product limited by the controls to a single stage of refrigeration capacity.

G3.1 *Example 1***.** *Fixed Capacity Control Air-cooled Unit with Fixed Speed Indoor Fan IEER Example Calculations.*

The unit is an air-cooled Single Package Air-conditioners with a single compressor without any capacity control and with a fixed speed indoor fan. The capacity is controlled by a single stage room thermostat. The unit has the following rated performance metrics:

1) Rated Capacity = 91,000 Btu/h (rounded to the nearest 1,000 per 6.1.2)
2) Full Load Rated Indoor Airflow = 2,600 scfm
3) Rated EER = 11.2 $\mathrm{Btu/(W \cdot h)}$
4) Rated IEER = 11.0 $\mathrm{Btu/(W \cdot h)}$

Table G2 shows the test data measurements. During the tests, the atmospheric pressure was measured at 14.500 psia and was constant for all tests. The test is acceptable because the atmospheric pressure is greater than the minimum allowable 13.700 psia. The pressure could vary between tests, and it should be measured for each test.

Table G2. Example 1. Test Results

Test	Stage	Test OAT	Req OAT	Actual Percent Load	Test Net Cap	Test CFM (Std Air)	Cmpr (P_C) (Test)	Cond (P_{CD}) (Test)	Indoor (P_{IF}) (Test)	Control (P_{CT}) (Test)	EER (Test)
-	-	°F	°F	%	Btu/h	scfm	W	W	W	W	Btu/(W·h)
1	1	95.1	95.0	100.0	92,293	2610	6723	518	831	50	11.36
2	1	81.7	81.5	103.5	95,523	2610	6309	518	831	50	12.39
3	1	67.6	68.0	104.0	95,943	2610	5874	518	831	50	13.19
4	1	65.3	65.0	107.2	98,927	2610	5803	518	831	50	13.74

Because the unit has a single stage of capacity control, the rating EER values for 75, 50, and 25 Percent Load rating points require three tests to be run at the rated ambient temperatures of 81.5ºF (75 Percent Load), 68.0ºF (50 Percent Load), and 65ºF (25 Percent Load) as defined in Table 6. For this example, all tests are acceptable as the test outdoor air temperatures are within ± 0.5ºF of the required condenser entering air temperature as defined in ANSI/ASHRAE Standard 37 Test Tolerance Table 2b for an air-cooled unit. If the temperature variation is greater than the allowable tolerance, then the test must be repeated.

Pursuant to step 2 of the procedure in the Section 6.2.4.3, the test data is used to calculate the degradation corrections and the Percent Load IEER rating points for the 75, 50 and 25 Percent Load. Table G3 shows the calculations for the 4 EER rating points used to calculate the IEER.

Table G3. Example 1. IEER Rating Points and Degradation Calculations

Rating Point	Test OAT	Req OAT	Actual Percent Load	Net Cap (Test)	Cmpr (P_C) (Test)	Cond (P_{CD}) (Test)	Indoor (P_{IF}) (Test)	Control (P_{CT}) (Test)	EER (Test)	LF	CD	Rating EER
-	°F	°F	%	Btu/h	W	W	W	W	Btu/(W·h)	-	-	Btu/(W·h)
A	95.1	95.0	100.0	92,293	6723	518	831	50	11.36	-	-	-
-			100.0	degradation not required						1.000	1.000	11.36
B	81.7	81.5	103.5	95,523	6309	518	831	50	12.39	-	-	-
Required Load			75.0	degradation required						0.725	1.036	11.53
C	67.6	68.0	104.0	95,943	5874	518	831	50	13.19	-	-	-
Required Load			50.0	degradation required						0.481	1.067	11.09
D	65.3	65.0	107.2	98,927	5803	518	831	50	13.74	-	-	-
Required Load			25.0	degradation required						0.233	1.100	9.22

For rating point A, the 100 Percent Load rating point, the test 1 can be used directly. Because this unit has a single stage of capacity, all the B, C, and D rating point data require the use of degradation in test rating point B, based on test 2, the unit was supposed to be run at the 81.5ºF ambient condition as required by Table 5. The actual measured ambient temperature was 81.7ºF and is within the required tolerance of ± 0.5ºF as defined ANSI/ASHRAE Standard 37 Table 2b. The actual test capacity Percent Load is 103.5 therefore a degradation calculation must be performed to determine the rating EER for the 75 Percent Load point because the capacity is greater than the ± 3% tolerance required by Section 6.2.

The degradation factor calculations are performed using the requirements of Section 6.2.3.

First the load factor (LF) is calculated using Equation 6.

$$LF = \frac{\left({}^{Percent\ Load}/_{100}\right) \cdot Full\ Load\ Net\ Capacity}{Part\ Load\ Net\ Capacity} = \frac{\left({}^{75}/_{100}\right) \cdot 92{,}293}{95{,}523} = 0.723$$

This shows that at a 75 Percent Load, the compressor will be on for 72.3% of the time and off for 27.7% of the time.

The degradation coefficient is then calculated using Equation 5.

$C_D = (-0.13 \cdot LF) + 1.13 = (-0.13 \cdot 0.723) + 1.13 = 1.036$

This shows that the EER will degrade 3.6% due to the cycling of the compressor over a steady state on all the time performance.

Once the degradation factor is calculated, the rating point EER is calculated using Equation 4 for the rating point B.

$$EER = \frac{LF \cdot Q}{LF \cdot [C_D \cdot (P_C + P_{CD})] + P_{IF} + P_{CT}} = \frac{0.723 \cdot 95{,}523}{0.723 \cdot [1.036 \cdot (6{,}309 + 518)] + 831 + 50} = 11.53 \text{Btu/(W} \cdot \text{h)}$$

Degradation corrections are made for the 50 and 25 Percent Load points.

The last procedural step 3 is to calculate the IEER using Equation 3.

$IEER = (0.020 \cdot A) + (0.617 \cdot B) + (0.238 \cdot C) + (0.125 \cdot D)$

$= (0.02 \cdot 11.36) + (0.617 \cdot 11.53) + (0.238 \cdot 11.09) + (0.125 \cdot 9.22) = 11.13 \text{ Btu/(W} \cdot \text{h)}$

The IEER is then rounded as required by 6.1.2 to 11.1 Btu/(W·h) (nearest 0.1)

G3.2 *Example 2. Fixed Capacity Control Water Cooled Unit with Fixed Speed Indoor Fan IEER Example Calculations.*

The unit is a water-cooled Single Package Air-conditioner with a single compressor without capacity control, and with a fixed speed indoor fan with the following metrics:

1) Rated Capacity = 76,000 Btu/h (rounded to the nearest 1,000 per 6.1.2)
2) Full Load Rated Indoor Airflow = 2,200 scfm
3) Rated EER = 12.1 Btu/(W·h)
4) Rated IEER = 11.2 Btu/(W·h)

During all the tests the atmospheric pressure was measured at 15.200 psia and was constant. Table G4 shows the test data for the full and part-load points

Table G4. Example 2. Test Results

Test	Stage	Test EWT	Req EWT	Actual Percent Load	Test Net Cap	Test CFM (Std Air)	Cmpr (P_C) (Test)	Tower (P_{CD}) (Allow)	Indoor (P_{IF}) (Test)	Control (P_{CT}) (Test)	EER (Test)
-	-	°F	°F	%	Btu/h	scfm	W	W	W	W	Btu/(W·h)
4	1	85.1	85.0	100.0	74,770	2150	4700	748	694	50	12.08
3	1	73.3	73.5	103.5	77,387	2150	4433	748	694	50	13.06
2	1	62.4	62.0	103.6	77,472	2150	4186	748	694	50	13.64
1	1	54.7	55.0	105.3	78,738	2150	4012	748	694	50	14.31

Because the unit has a single stage of capacity, the rating EER values for 75, 50, and 25 Percent Load ratings require three tests to be performed at the rating condenser entering water temperature 73.5°F (75 Percent Load), 62.0°F (50 Percent Load), and 55.0°F (25 Percent Load) as defined in Table 6, and then must be corrected using the degradation calculations as defined in Section 6.2.

The full load test capacity is 74,770 Btu/h, and as required by Section 6.1, if the capacity is greater than or equal to 65,000 Btu/h, but below 135,000 Btu/h. then the rating must include an allowance for cooling tower fan motor and circulating water pump motor input power allowance of 10.0 W per 1000 Btu/h Cooling Capacity.

$$P_{CD} = 10.0 \cdot \frac{Q}{1000} = 10.0 \cdot \frac{74{,}770}{1000} = 748\, W$$

As per step 2 the test data is used in the calculation of the four rating points for calculation of the IEER. The calculations are summarized in the Table G5.

Table G5 Example 2. Degradation Calculations												
Test	Test EWT	Req EWT	Actual Percent Load	Net Cap (Test)	Cmpr (PC) (Test)	Tower (PCD) (Allow)	Indoor (PIF) (Test)	Control (PCT) (Test)	EER (Test)	LF	CD	Rating EER
-	°F	°F	%	Btu/h	W	W	W	W	Btu/(W·h)	-	-	Btu/(W·h)
A	85.1	85.0	100.0	74,770	4700	748	694	50	12.08	-	-	-
Required Load			100.0	-	degradation not required					1.0000	1.000	12.08
B	73.3	73.5	103.5	77,387	4433	748	748	50	13.06	-	-	-
Required Load			75.0	-	degradation required					0.7246	1.036	11.97
C	62.4	62.0	103.6	77,472	4186	748	748	50	13.64	-	-	-
Required Load			50.0	-	degradation required					0.4826	1.067	11.20
D	54.7	55.0	105.3	78,738	4012	748	748	50	14.31	-	-	-
Required Load			25.0	-	degradation required					0.2374	1.099	9.16

For rating point A, the 100 Percent Load rating point, test 1 can be used directly. Because this unit has a single stage of capacity, all the B, C, and D Percent Load rating point data require the use of degradation. Test rating point B, based on test 2, it shows that the unit was targeted to be run at the must 73.5ºF condenser entering water temperature, required by Table 6 for a 75 Percent Load rating point. The actual measured condenser entering water temperature was 73.3ºF and is within the allowable tolerance of ± 0.2ºF as defined in ANSI/ASHRAE Standard 37 Table 2b. The actual capacity Percent Load is 103.5 is greater than the required 75 Percent Load with the allowable 3% tolerance, meaning a degradation calculation be performed to determine the EER rating for the 75 Percent Load point.

The degradation calculations for the 75 Percent Load ratings point B are shown below in table G5.
First the load factor (LF) is calculated using Equation 6.

The degradation factor calculations for point B are shown below.

$$LF = \frac{\left(\mathit{Percent\ Load}/_{100}\right) \cdot \mathit{Full\ Load\ Net\ Capacity}}{\mathit{Part\ Load\ Net\ Capacity}} = \frac{\left(75/_{100}\right) \cdot 74{,}770}{77{,}387} = 0.7246$$

This shows that at 75 Percent Load the compressor will be on 72.46% of the time and of 27.54% of the time.

The degradation coefficient is calculated using Equation 5.

$$C_D = (-0.13 \cdot LF) + 1.13 = (-0.13 \cdot 0.7246) + 1.13 = 1.036$$

Once the degradation factor is calculated the rating point EER can be calculated.

$$EER = \frac{LF \cdot Q}{LF \cdot [C_D \cdot (P_C + P_{CD})] + P_{IF} + P_{CT}}$$

$$= \frac{0.7246 \cdot 77{,}387}{0.7246 \cdot [1.036 \times (4{,}433 + 748)] + 694 + 50} = 11.97\ \mathrm{Btu/(W \cdot h)}$$

Degradation corrections are made for the 50 and 25 Percent Load points.

The last step 3 is to calculate the IEER using Equation 3.

$$IEER = (0.020 \cdot A) + (0.617 \cdot B) + (0.238 \cdot C) + (0.125 \cdot D)$$

$$= (0.02 \cdot 120.08) + (0.617 \cdot 11.97) + (0.238 \cdot 11.20) + (0.125 \cdot 9.16) = 11.44\ \mathrm{Btu/(W \cdot h)}$$

The IEER is then rounded as required by 6.1.2 to 11.4 Btu/(W·h) (nearest 0.1)

G3.3 *Example 3. Fixed Capacity Control Evaporatively Cooled Unit with Fixed Speed Indoor Fan IEER Example Calculations.*

The unit is an evaporatively cooled Single Package Air-conditioners with a single compressor without capacity control, and with a fixed speed indoor fan with the following metrics:

1) Rated Capacity = 86,000 Btu/h (rounded to the nearest 1,000 per 6.1.2)
2) Full Load Rated Indoor Airflow = 2,500 scfm
3) Rated EER = 12.2 Btu/(W·h)
4) Rated IEER = 11.5 Btu/(W·h)Btu/(W·h)

Table G6 shows the test data. During all the tests the atmospheric pressure was measured at 13.900 psia and was constant, meaning the test is acceptable as the atmospheric pressure is above minimum 13.700 psia.

Table G6. Example 3. Test Results

Test	Stage	Test Enter WB	Required Enter WB	Actual Percent Load	Test Net Cap	Test CFM (Std Air)	Cmpr (P_C) (Test)	Cond (P_{CD}) (Test)	Indoor (P_{IF}) (Test)	Control (P_{CT}) (Test)	EER (Test)
-	-	°F	°F	%	Btu/(W·h)	scfm	W	W	W	W	Btu/(W·h)
4	1	74.3	74.5	100.0	85,617	2110	5283	925	789	50	12.15
3	1	66.6	66.2	101.2	86,676	2110	5076	925	789	50	12.67
2	1	57.7	57.5	102.6	87,878	2110	4838	925	789	50	13.31
1	1	52.5	52.8	103.7	88,783	2110	4698	925	789	50	13.74

Because the unit has a single stage of capacity, the rating EER values for 75, 50, and 25 Percent Load rating point require three tests to be run at the rating ambient wet-bulb temperature of 66.2 °F (75 Percent Load), 57.5 °F (50 Percent Load), and 52.8 °F (25 Percent Load) as defined in Table 6, and then must be corrected using the degradation calculations as defined in Section 6.2.

The test points can then be used for the calculation of the four rating point EERs used for the IEER calculation and can be completed as outlined in Section 6.2.4, step 2. Table G7 shows the results of the calculations.

Table G7. Example 3. Degradation Calculations

Test	Test Enter WB	Req Enter WB	Actual Percent Load	Net Cap (Test)	Cmpr (PC) (Test)	Tower (PCD) (Test)	Indoor (PIF) (Test)	Control (PCT) (Test)	EER (Test)	LF	CD	Rating EER
-	°F	°F	%	Btu/(W·h)	W	W	W	W	Btu/(W·h)	-	-	Btu/(W·h)
A	74.3	74.5	100.0	85,617	5283	925	789	50	12.15	-	-	-
Required Load			100.0	-	degradation not required					1.0000	1.000	12.15
B	66.4	66.2	101.2	86,676	5076	925	789	50	12.67	-	-	
Required Load			75.0	-	degradation required					0.7408	1.034	11.82
C	57.7	57.5	102.6	87,878	4838	925	789	50	13.31	-		
Required Load			50.0	-	degradation required					0.4871	1.067	11.17
D	52.5	52.8	103.7	88,783	4698	925	789	50	13.74	-		
Required Load			25.0	-	degradation required					0.2411	1.099	9.19

For rating point A, the 100 Percent Load rating point, test 1 can be used directly. Because this unit has a single stage of capacity, all the B, C, and D rating point data require the use of degradation. Test rating point B, based on test 2, shows that the unit was targeted to be run at the 66.2ºF wet-bulb temperature required by Table 6 for a 75 Percent Load rating point. The actual measured wet-bulb was 66.4ºF and is within the allowable tolerance of ± 0.3ºF as defined in ANSI/ASHRAE Standard 37 Table 2b. The actual capacity Percent Load is 101.2, meaning a degradation calculation must be performed to determine the EER rating for the 75 Percent Load point because the capacity is greater than the ± 3% tolerance.

The degradation factor calculations then performed using Section 6.2.3.

First the load factor (LF) is calculated using Equation 6.
The degradation factor calculations for point 2 are shown below.

$$LF = \frac{\left(Percent\ Load/_{100}\right) \cdot Full\ Load\ Net\ Capacity}{Part\ Load\ Net\ Capacity} = \frac{\left(75/_{100}\right) \cdot 85{,}617}{86{,}676} = 0.7408$$

At a 75 Percent Load the compressor will be on 74.08% of the time and off 25.92% of the time.

The degradation coefficient is calculated using Equation 5.

$$C_D = (-0.13 \cdot LF) + 1.13 = (-0.13 \cdot 0.7408) + 1.13 = 1.034$$

Once the degradation factor is calculated, the rating point EER can be calculated.

$$EER = \frac{LF \cdot Q}{LF \cdot [C_D \cdot (P_C + P_{CD})] + P_{IF} + P_{CT}}$$

$$= \frac{0.7408 \cdot 86{,}676}{0.7408 \cdot [1.034 \times (5{,}076 + 925)] + 705 + 50} = 11.82\ \mathrm{Btu/(W \cdot h)}$$

Degradation corrections are made for the 50 and 25 Percent Load points.

The last 6.2.4 procedural step 3 is to calculate the IEER using Equation 3

$$IEER = (0.020 \cdot A) + (0.617 \cdot B) + (0.238 \cdot C) + (0.125 \cdot D)$$

$$= (0.02 \cdot 12.15) + (0.617 \cdot 11.82) + (0.238 \cdot 11.17) + (0.125 \cdot 9.19) = 11.34\ \mathrm{Btu/(W \cdot h)}$$

The IEER is then rounded as required by 6.1.2 to 11.3 Btu/(W·h) (nearest 0.1)

G4 *Staged Capacity Controlled Unit Example Calculations.* This section provides example calculations for IEER calculations for Staged Capacity Controlled Units. As defined in Section 3.31, a Staged Capacity Controlled Unit is a unit incorporating only fixed capacity or discrete steps of compression and limited by the controls to multiple stages of refrigeration capacity. The procedure for these units is defined in Section 6.2.5

G4.1 *Example 4. 4 Stage Air-cooled MZVAV Unit with a Variable Speed Indoor Fan IEER Example Calculation*.

The unit is an air-cooled MZVAV Single Package Air-conditioner with two refrigeration circuits with two manifolded compressors in each circuit for a total of four compressors that are all equal size. This allows for four stages of mechanical cooling. The indoor fan is a variable speed fan and is controlled by duct pressure. Capacity is controlled to provide a constant leaving air temperature. There are two condenser fans that are controlled by each refrigerant circuit. The unit has the following rated performance metrics:

1) Rated Capacity = 368,000 Btu/h (rounded to the nearest 2,000 per 6.1.2)
2) Full Load Rated Indoor Airflow = 10,000 scfm
3) Fan Speed = Variable Speed
4) Rated EER = 10.2 Btu/(W·h)
5) Rated IEER = 11.6 Btu/(W·h)

Table G8 shows the test data. A total of six tests were run to generate the EER values for the IEER calculation. During the tests the atmospheric pressure was 14.3 psia and was constant for all tests and is above the minimum allow atmospheric pressure of 13.700 psia. The pressure could vary between tests, and it should be measured for each test.

Table G8. Example 4. Test Results

Test	Stage	Test OAT	Req OAT	Actual Percent Load	Test Net Cap	Test CFM (Std Air)	Cmpr (P_C) (Test)	Cond (P_{CD}) (Test)	Indoor (P_{IF}) (Test)	Control (P_{CT}) (Test)	EER (Test)
-	-	°F	°F	%	Btu/(W·h)	scfm	W	W	W	W	Btu/(W·h)
1	4	95.1	95.0	100.0	367,047	10,100	30,100	2300	3650	150	10.14
2	3	81.3	81.5	79.0	289,976	8350	21,144	2300	2102	200	11.26
3	2	81.7	81.5	53.2	195,344	5460	14,124	2300	613	250	11.30
4	2	67.6	68.0	54.7	200,710	5610	13,149	2300	663	250	12.27
5	1	67.6	68.0	28.3	103,881	2955	6574	1150	103	300	12.78
6	1	65.3	65.0	28.4	104,408	2970	6495	1150	105	300	12.97

Test 1 is a full load test and can be used directly for the A rating point.

Because this is a MZVAV unit, the part-load tests for the B, C, and D EER values were run with variable indoor cfm with the value determined to provide the same leaving air temperature as the full load with a tolerance of ± 0.5°F as defined in Section 6.1.3.3.3

Tests 2 and 3 were run at the 75 Percent Load ambient temperature of 81.5°F. Test 2 was run with stage 3, that turns off one compressor and results in a measured Percent Load of 79 that is 4% greater than the required 75 Percent Load and exceeds the 3% allowable tolerance. Test 3 was run with stage 2 that turns off two of the compressors and results in a 53.2 Percent Load that can be used for interpolation.

For the 50 Percent Load rating point C, tests 4 and 5 were run. These were run at the C rating point target ambient of 68°F and resulted in test 4 having a Percent Load of 54.6 and test 5 having a Percent Load of 28.3. Test 3 cannot be used for the interpolation of rating point C, as it was run at the 75 Percent Load rating point B ambient of 81.5°F. This shows that in most cases two test points will be required when interpolation is used to determine the rating point efficiency.

For the 25 Percent Load rating point test 6 was run at the required ambient of 65ºF, but because the measured Percent Load is 28.4, it cannot be used directly for the D EER determination. Because it is the last stage of capacity, interpolation cannot be used, and a degradation calculation is required.

The test data points can then be used in step 2 to calculate the EER A, B, C, and D rating points. Table G9 shows the results of the step 2 calculations for the A, B, C and D rating points. To help understand how all the test points are used to calculate the IEER, Figure G1 shows graphically how the tests points are used directly for interpolation and for degradation calculations and demonstrates how all the test points are used to calculate the IEER.

Table G9. Example 4. IEER Rating Points and Degradation Calculations

Rating Point	Test	Test OAT	Req OAT	Actual Percent Load	Net Cap (Test)	Cmpr (P_C) (Test)	Cond (P_{CD}) (Test)	Indoor (P_{IF}) (Test)	Control (P_{CT}) (Test)	EER (Test)	LF	CD	Rating EER
-	-	°F	°F	%	Btu/(W·h)	W	W	W	W	Btu/W·h	-	-	Btu/(W·h)
A	1	95.1	95.0	100.0	367,047	30,100	2300	3,650	150	10.14	-	-	-
	required load			100.0	use test 1 point directly						-	-	10.14
B	2	81.3	81.5	79.0	289,976	21,144	2300	2,102	200	11.26	-	-	-
	3	81.7	81.5	53.2	195,344	14,124	2300	613	250	11.30	-	-	-
	required load			75.0	interpolate between test 2 and 3								11.27
C	4	67.6	68.0	54.7	200,710	13,149	2300	663	250	12.27	-	-	-
	5	67.6	68.0	28.3	103,881	6574	1150	103	300	12.78	-	-	-
	required load			50.0	interpolate between test 4 and 5						-	-	12.36
D	6	65.3	65.0	28.4	104,408	6495	1150	105	300	12.97	-	-	-
	required load			25.0	degradation of test 6-required						0.879	1.016	12.69

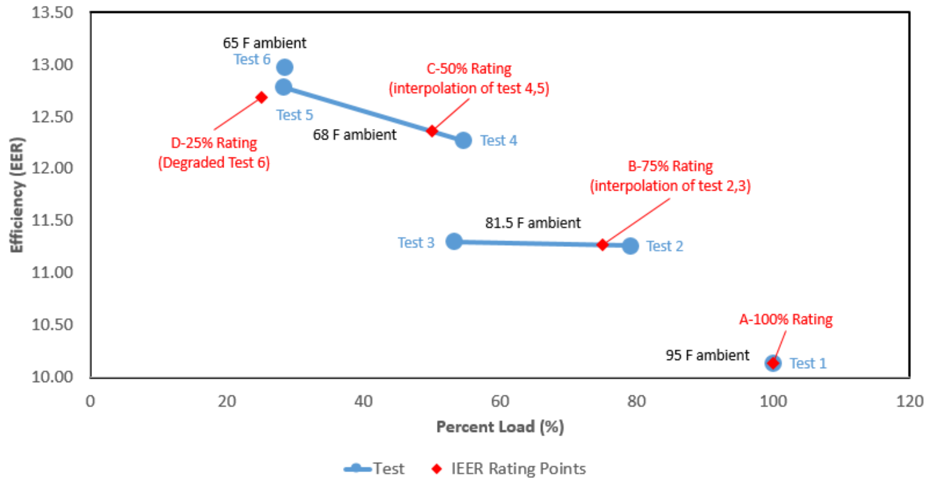

Figure G1. Example 4 Test Points Used for EER Rating Points

For the A rating point, test 1 can be used directly.

For the B rating point at 75 Percent Load, interpolation must be used. For this point tests 2 and 3 were performed. Test 2 was run at stage 3 at the 75 Percent Load rating point 81.5°F ambient as required by table 6. Test 2 was run at the 81.5°F ambient but with stage 2 active. Because this is a MZVAV unit, the cfm changed to maintain the full load Dry-bulb Supply Air temperature. These tests show that a Percent Load of 79.0 and 53.2 was obtained to get to 75 Percent Load and interpolate between test 2 and 3 as shown in equation ? below.

$$EER_B = \left(\left(\frac{11.26 - 11.30}{79.0 - 53.2}\right) \cdot (75 - 53.2)\right) + 11.30 = 11.27 \text{ Btu/(W} \cdot \text{h)}$$

For the C rating point, required to be run at 68 °F ambient as defined in table 6, tests 4 and 5 were run at the 68°F ambient with test 4 operating with stage 2, and test 5 operating with stage 1, resulting in a 54.6 Percent Load and 28.3 Percent Load. This shows interpolation is applied similar to the rating point B.

For the D rating point, test 6 was run at the D rating point ambient of 65°F, with the measured load 28.4 Percent Load. This exceeds the tolerance limit of 28% (25+3%), meaning a degradation calculation is required as per Section 6.2.3 shown below.

First the load factor (LF) is calculated using Equation 6.

$$LF = \frac{\left(\frac{Percent\ Load}{100}\right) \cdot Full\ Load\ Net\ Capacity}{Part\ Load\ Net\ Capacity} = \frac{\left(\frac{25.0}{100}\right) \cdot 367{,}047}{104{,}408} = 0.879$$

This implies that at the 25 Percent Load the compressor will be on for 87.9% of the time and off for 12.1% of the time.

The degradation coefficient is calculated using Equation 5.

$$C_D = (-0.13 \cdot LF) + 1.13 = (-0.13 \cdot 0.879) + 1.13 = 1.016$$

This shows the EER will degrade 1.6% due to the cycling of the compressor over a steady state on all the time performance.

Once the degradation factor is calculated the rating point EER can be calculated using Equation 4 for the rating point B.

$$EER = \frac{LF \cdot Q_{\square}}{LF \cdot [C_D \cdot (P_C + P_{CD})] + P_{IF} + P_{CT}} = \frac{0.879 \cdot 104{,}408}{0.879 \cdot [1.016 \cdot (6{,}495 + 1{,}150)] + 105 + 300} = 12.71 \text{ Btu/(W} \cdot \text{h)}$$

The last step 3 is then to calculate the IEER using Equation 3.

$$IEER = (0.020 \cdot A) + (0.617 \cdot B) + (0.238 \cdot C) + (0.125 \cdot D)$$

$$= (0.02 \cdot 10.14) + (0.617 \cdot 11.27) + (0.238 \cdot 12.36) + (0.125 \cdot 12.69) = 11.68 \text{ Btu/(W} \cdot \text{h)}$$

The IEER is then rounded as required by 6.1.2 to 11.7 Btu/(W·h) (nearest 0.1)

G4.2 *Example 5. Two Stage Air-cooled Unit with a Fixed Speed Indoor Fan Example Calculations IEER Example Calculation.*

The unit is an air-cooled Single Package Air-conditioner with two refrigeration circuits with one compressor in each circuit and two stages of capacity control based on a room thermostat. The indoor fan is a fixed speed fan. There are two condenser fans that are controlled by each refrigerant circuit. The unit has the following rated performance metrics:

1) Rated Capacity = 115,000 Btu/h (rounded to the nearest 1,000 per 6.1.2)
2) Full Load Rated Indoor Airflow = 3,300 scfm
3) Rated EER = 11.2 Btu/(W·h)
4) Rated IEER = 12.0 Btu/(W·h)

Table G10 shows the test data. During the tests the atmospheric pressure was 13.900 psia and was constant for all tests and is above the lower limit of 13.700 psia, meaning the test is valid. The pressure could vary between tests and it should be measured for each test.

Table G10. Example 5. Test Results

Test	Stage	Test OAT	Req OAT	Actual Percent Load	Test Net Cap	Test CFM (Std Air)	Cmpr (P_C) (Test)	Cond (P_{CD}) (Test)	Indoor (P_{IF}) (Test)	Control (P_{CT}) (Test)	EER (Test)
-	-	°F	°F	%	Btu/h	scfm	W	W	W	W	Btu/(W·h)
1	2	95.1	95.0	100.0	115,493	3354	8615	650	1050	100	11.09
2	2	81.3	81.5	106.7	123,267	3354	8073	650	1050	100	12.49
3	1	81.7	81.5	52.4	60,510	3354	3855	325	1050	150	11.25
4	1	67.6	68.0	53.3	61,536	3354	3588	325	1050	150	12.04
5	1	65.3	65.0	53.4	61,716	3354	3545	325	1050	150	12.17

Five tests were run to determine the IEER. For tests 3, 4, and 5, the control power increased based on the use of a crankcase heater in the inactive compressor. Test 1 is a full load test and can be used directly for the A rating point. Because the unit has two stages of capacity control and can unload to 50% displacement, the B rating point of 75 Percent Load interpolation using tests 2 and 3 is required. Test 2 has a load of 106.7 Percent Load, and test 3 has a Percent Load of 52.6 when run at the B rating point ambient of 81.5°F. The procedure requires both tests to be run at the rating point ambient and this is different from the procedures in AHRI Standard 340/360-2007. For the C rating point with a rating ambient of 68°F, the Percent Load is 53.4 exceeds the 3% tolerance limit. Because the unit is operating at the lowest stage of capacity, a degradation will have to be applied for the C rating point EER determination. Because the unit can only unload to 53.6 Percent Load when run at the D rating point ambient of 65°F, degradation will have to be applied to test 5.

The test data can then be used with the step 2 procedures to calculate the EER A, B, C, and D rating. Table G11 shows the results of the step 2 calculations for the A, B, C and D rating points.

Table G11. Example 5. IEER Rating Points and Degradation Calculations

Rating Point	Test	Test OAT	Req OAT	Actual Percent Load	Net Cap (Test)	Cmpr (P_C) (Test)	Cond (P_{CD}) (Test)	Indoor (P_{IF}) (Test)	Control (P_{CT}) (Test)	EER (Test)	LF	CD	Rating EER
-	-	°F	°F	%	Btu/h	W	W	0	W	Btu/(W·h)	-	-	Btu/(W·h)
A	1	95.1	95.0	100.0	115,493	8615	650	1050	100	11.09	-	-	-
	required load			100.0	use test 1 point directly						-	-	11.09
B	2	81.3	81.5	106.7	123,267	8073	650	1050	100	12.49	-	-	-
	3	81.7	81.5	52.4	60,510	3855	325	1050	150	11.25	-	-	-
	required load			75.0	interpolate between test 2 and 3						-	-	11.76
C	4	67.6	68.0	53.3	61,536	3588	325	1050	150	12.04	-	-	-
	required load			50.0	degradation of test 4 required						0.938	1.008	11.78
D	5	65.3	65.0	53.4	61,716	3545	325	1050	150	12.17	-	-	-
	required load			25.0	degradation of test 5 required						0.468	1.069	9.21

For the A rating point test 1 can be used directly.

For the B rating point at 75 Percent Load, interpolation must be used and tests 2 and 3 were performed. Test 2 was run at full load and at the 75 Percent Load rating point 81.5°F ambient as required by Table 6. Test 3 was run at the 81.5°F ambient with stage 1 operating. These tests show that a load of 106.7 and 52.7 Percent Load was obtained to reach 75 Percent Load. The interpolation between tests 2 and 3 is in the equation below.

$$EER_B = \left(\left(\frac{12.49 - 11.25}{106.7 - 52.4}\right) \cdot (75 - 52.6)\right) + 11.25 = 11.76 \text{ Btu/(W} \cdot \text{h)}$$

The C rating point is required to be run at 68°F ambient as defined in Table 6. Test 4 shows that the test Percent Load is 53.4and exceeds allowable ± 3% tolerance, meaning test 4 cannot be used directly to calculate the C EER rating point. Because the unit is operating at the lowest stage of capacity, interpolation cannot be used because a capacity point above and below the 50 Percent Load rating point would be required. Therefore, a degradation factor has to be applied to test 4 to get the C rating point EER. The calculation of the degradation factor is shown below.

The degradation factor calculations are then performed using Section 6.2.3.

First the load factor (LF) is calculated using Equation 6.

$$LF = \frac{\left({}^{Percent\ Load}/_{100}\right) \cdot Full\ Load\ Net\ Capacity}{Part\ Load\ Net\ Capacity} = \frac{\left({}^{50}/_{100}\right) \cdot 115{,}493}{61{,}536} = 0.938$$

At a 50 Percent Load the compressor will be on for 93.8% of the time and off for 6.2% of the time.

The degradation coefficient is calculated using Equation 5.

$$C_D = (-0.13 \cdot LF) + 1.13 = (-0.13 \cdot 0.938) + 1.13 = 1.008$$

The EER will degrade 0.8% due to the cycling of the compressor over a steady state on all the time performance.

Once the degradation factor is calculated, the rating point EER can be calculated using Equation 4 for the rating point C.

$$EER = \frac{LF \cdot Q}{LF \cdot [C_D \cdot (P_C + P_{CD})] + P_{IF} + P_{CT}} = \frac{0.938 \cdot 61{,}536}{0.938 \cdot [1.008 \cdot (3{,}545 + 325)] + 1{,}050 + 150} = 12.12 \text{ Btu/(W} \cdot \text{h)}$$

Degradation corrections are made for the 25 Percent Load points.

The last step 3 is then to calculate the IEER using Equation 3.

$$IEER = (0.020 \cdot A) + (0.617 \cdot B) + (0.238 \cdot C) + (0.125 \cdot D)$$

$$= (0.02 \cdot 11.09) + (0.617 \cdot 11.76) + (0.238 \cdot 11.78) + (0.125 \cdot 9.21) = 11.43\ \mathrm{Btu/(W \cdot h)}$$

The IEER is then rounded as required by 6.1.2 to 11.4 Btu/(W·h) (nearest 0.1)

G4.3 *Example 6. 2 Stage Air-cooled Single Package Unit with a 2 Speed Indoor Fan Controlled by the Thermostat IEER Example Calculation*.

The unit is an air-cooled Single Package Air-conditioner with two refrigeration circuits, with one compressor in each circuit, and two stages of capacity control based on a room thermostat. The indoor fan is a 2-speed fan controlled by the thermostat and runs at full speed on stage 2 and low speed on stage 1. There are two condenser fans that are controlled by each refrigerant circuit. The unit has the following rated performance metrics:

1) Rated Capacity = 115,000 Btu/h (rounded to the nearest 1,000 per 6.1.2)
2) Full Load Rated Indoor Airflow = 3,300 scfm
3) Part Load Rated Indoor Airflow = 1980 scfm
4) Rated EER = 11.2 Btu/(W·h)
5) Rated IEER = 12.0 Btu/(W·h)

Shown below are the test data. During the tests the atmospheric pressure was 13.900 psia and was constant for all tests and the test is good because the atmospheric pressure is above 13.700 psia minimum atmospheric pressure. The pressure could vary between tests, and it should be measured for each test.

Table G12. Example 6. Test Results

Test	Stage	Test OAT	Req OAT	Actual Percent Load	Test Net Cap	Test CFM (Std Air)	Cmpr (P_C) (Test)	Cond (P_{CD}) (Test)	Indoor (P_{IF}) (Test)	Control (P_{CT}) (Test)	EER (Test)
-	-	°F	°F	%	Btu/h	scfm	W	W	W	W	Btu/(W·h)
1	2	95.1	95.0	100.0	115,493	3354	8615	650	1,050	100	11.09
2	2	81.3	81.5	106.7	123,267	3354	8073	650	1,050	100	12.49
3	1	81.7	81.5	52.7	60,888	2020	3915	325	262	150	13.09
4	1	67.6	68.0	53.9	62,270	2020	3645	325	262	150	14.21
5	1	65.3	65.0	54.4	62,772	2020	3601	325	262	150	14.47

Five tests were run to determine the IEER. Test 1 is a full load test and can be used directly for the A rating point. Because the unit has two stages of capacity control and can unload to 50 Percent Load, for the B rating point of 75 Percent Load, tests 2 and 3 were run to determine interpolation. Both tests were run at an ambient temperature of 81.5 °F and were within the allowable tolerance of ± 0.5°F as defined by ANSI/ASHRAE Standard 37 Table 2b. Test 2 has a Percent Load of 106.7 and test 3 has a Percent Load of 52.6. Test 2 was run with full mechanical Cooling Capacity and with the Full Load Rated Indoor Airflow, but Test 3 was run with the part-load cfm because the fan speed is controlled by the thermostat. For the C rating point with a rating ambient of 68 °F, the Percent Load is 53.8. This exceeds the 3% tolerance limit and because the unit is operating at the lowest stage of capacity, a degradation will have to be applied for the C rating point EER determination. Because the unit can unload to 54.3 Percent Load when run at the D rating point ambient of 65 °F, degradation will have to be applied to Test 5.

The test data is then used in step 2 procedures to calculate the EER A, B, C, and D rating points using the test results. Table G13 shows the results the step 2 calculations for the A, B, C and D rating points.

Table G13. Example 6. IEER Rating Points and Degradation Calculations													
Rating Point	**Test**	**Test OAT**	**Req OAT**	**Actual Percent Load**	**Net Cap (Test)**	**Cmpr (P_C) (Test)**	**Cond (P_{CD}) (Test)**	**Indoor (P_{IF}) (Test)**	**Control (P_{CT}) (Test)**	**EER (Test)**	**LF**	**CD**	**Rating EER**
-	-	°F	°F	%	Btu/h	W	W	W	W	Btu/(W·h)	-	-	Btu/(W·h)
A	1	95.1	95.0	100.0	115,493	8615	650	1050	100	11.09	-	-	
	required load			100.0	use test 1 point directly						-	-	11.09
B	2	81.3	81.5	106.7	123,267	8073	650	1050	100	12.49	-	-	-
	3	81.7	81.5	52.7	60,888	3915	325	262	150	13.09	-	-	-
	required load			75.0	interpolate between test 2 and 3						-	-	12.84
C	4	67.6	68.0	53.9	62,270	3645	325	262	150	14.21	-	-	-
	Required load			50.0	degradation of test 4 required						0.927	1.009	13.99
D	5	65.3	65.0	54.4	62,772	3601	325	262	150	14.47	-	-	-
	Required load			25.0	degradation of test 5 required						0.460	1.070	12.31

For the A rating point test 1 can be used directly.

For the B rating point at 75 Percent Load, interpolation must be used and tests 2 and 3 were required. Test 2 was run at full load but at the 75 Percent Load rating point 81.5°F ambient as required by Table 6. Test 3 was run at the 81.5°F ambient but with only stage 1 operating. A load of 106.7 and 52.6 Percent Load was obtained to achieve 75 Percent Load and interpolation between test 2 and 3 is shown below.

$$EER_B = \left(\left(\frac{12.49 - 13.09}{106.7 - 52.7}\right) \cdot (75 - 52.7)\right) + 13.09 = 12.84\ \text{Btu/(W} \cdot \text{h)}$$

For the C rating point that is required to be run at 68°F ambient as defined in Table 6, test 4 shows that the test Percent Load is 53.8. This exceeds allowable ± 3% tolerance meaning test 4 cannot be used directly to calculate the C EER rating point. When a unit is operating at the lowest stage of capacity, interpolation cannot be used because a capacity point above and below the 50 Percent Load would be required. Therefore, a degradation factor has to be applied to test 4 to achieve the C rating point EER. The calculation of the degradation factor is shown below.

The degradation factor calculations are then performed using Section 6.2.3.

First the load factor (LF) is calculated using Equation 6.

$$LF = \frac{\left(Percent\ Load/_{100}\right) \cdot Full\ Load\ Net\ Capacity}{Part\ Load\ Net\ Capacity} = \frac{\left(^{50}/_{100}\right) \cdot 115{,}493}{62{,}270} = 0.927$$

At a 50 Percent Load the compressor will be on for 92.7% of the time and off for 7.3% of the time.

The degradation coefficient is calculated using Equation 5.

$$C_D = (-0.13 \cdot LF) + 1.13 = (-0.13 \cdot 0.927) + 1.13 = 1.009$$

The EER will degrade 0.9% due to the cycling of the compressor over a steady state on all the time performance.

Once the degradation factor is calculated, the rating point EER can be calculated using Equation 4 for the rating point C.

$$EER = \frac{LF \cdot Q}{LF \cdot [C_D \cdot (P_C + P_{CD})] + P_{IF} + P_{CT}} = \frac{0.927 \cdot 62{,}270}{0.927 \cdot [1.009 \cdot (3{,}645 + 325)] + 262 + 150} = 13.99\ Btu/(W \cdot h)$$

Degradation corrections are made for the 25 Percent Load points.

The last step 3 is then to calculate the IEER using Equation 3.

$$IEER = (0.020 \cdot A) + (0.617 \cdot B) + (0.238 \cdot C) + (0.125 \cdot D)$$

$$= (0.02 \cdot 11.09) + (0.617 \cdot 12.84) + (0.238 \cdot 13.99) + (0.125 \cdot 12.31) = 13.01\ Btu/(W \cdot h)$$

The IEER is then rounded as required by 6.1.2 to 13.0 Btu/(W·h) (nearest 0.1)

G4.4 *Example 7. 3 Stage Water Cooled Unit with a 2 Speed Indoor Fan Controlled by the Thermostat IEER Example Calculation*.

The unit is a water-cooled Single Package Air-conditioner with three equal size compressors in a common refrigerant circuit that results in three stages of mechanical capacity control. The unit has a 2-speed indoor fan that is controlled by the thermostat and is at high speed on stage 3 and low speed on stages 2 and 1. The unit has the following rated performance metrics:

1) Rated Capacity = 241,000 Btu/h (rounded to the nearest 1,000 per 6.1.2)
2) Full Load Rated Indoor Airflow = 7,000 scfm
3) Part Load Rated Indoor Airflow = 4,300 scfm
4) Rated EER = 12.4 Btu/(W·h)
5) Rated IEER = 16.5 Btu/(W·h)

Table G14 shows the test data. During the tests the atmospheric pressure was 14.200 psia and was constant for all tests.

Table G14. Example 7. Test Results

Test	Stage	Test EWT	Req EWT	Actual Percent Load	Test Net Cap	Test CFM (Std Air)	Cmpr (P_C) (Test)	Cond (P_{CD}) (Test)	Indoor (P_{IF}) (Test)	Control (P_{CT}) (Test)	EER (Test)
-	-	°F	°F	%	Btu/h	scfm	W	W	W	W	Btu/(W·h)
1	3	85.1	85.0	100.0	242,129	7100	17,150	0	2,350	125	12.34
2	3	73.3	73.5	102.4	247,832	7100	16,176	0	2,350	125	13.29
3	2	73.5	73.5	66.8	161,859	4331	9193	0	560	150	16.34
4	2	62.1	62.0	68.0	164,530	4331	8637	0	560	150	17.60
5	1	61.9	62.0	38.0	92,021	4331	4107	0	560	200	18.91
6	1	55.0	55.0	38.6	93,384	4331	3941	0	560	200	19.86

Six tests were required to determine the IEER. Test 1 is a full load test and can be used directly for the A rating point. For the 75 Percent Load rating point two tests were run because the capacity control did not allow capacity to be adjusted to 75% ± 3% to allow for interpolation. Both tests were required to be run at the 75 Percent Load rating point condenser entering water temperature of 73.5°F as defined in Table 6. Test 2 was run with the full load stage 3 at the 73.5°F that delivered 102.4% capacity. and test 3 was run with stage 2 that delivered 66.8% capacity. The fan speed for test 2 was at full speed and test 3 was run with the fan at reduced speed. This allows for interpolation to get to the 75 Percent Load point. For the rating point C two tests were also run to allow for interpolation at the 50 Percent Load rating point condenser entering water temperature of 62°F. Test 6 was run at 55°F to allow for the determination of the D rating efficiency but the measured Percent Load was at 38.5. This is above the 25 Percent Load rating, meaning it will require the use of a degradation calculation and interpolation cannot be used.

The test points the Section 6.2.5 step 2 procedures are used to calculate the EER A, B, C, and D rating points. Table G15 shows the results of the step 2 calculations for the A, B, C and D rating points.

Table G15. Example 7. IEER Rating Points and Degradation Calculations

Rating Point	Test	Test OAT	Req OAT	Actual Percent Load	Net Cap (Test)	Cmpr (P_C) (Test)	Cond (P_{CD}) (Test)	Indoor (P_{IF}) (Test)	Control (P_{CT}) (Test)	EER (Corr)	LF	CD	Rating EER
-	-	°F	°F	%	Btu/h	W	W	W	W	Btu/(W·h)	-	-	Btu/(W·h)
A	1	95.1	95.0	100.0	242,129	17,150	0	2350	125	12.34	-	-	-
	required load			100.0	use test 1 point directly						-	-	12.34
B	2	73.3	73.5	102.4	247,832	7100	0	2350	125	13.29	-	-	-
	3	73.5	73.5	66.8	161,859	4331	0	560	150	16.34	-	-	-
	required load			75.0	interpolate between test 2 and 3								15.64
C	4	62.1	62.0	68.0	164,530	4331	0	560	150	17.60	-	-	-
	5	61.9	62.0	38.0	92,021	4331	0	560	200	18.91	-	-	-
	required load			50.0	interpolate between test 4 and 5						-	-	18.38
D	6	55	55.0	38.6	93,384	3941	0	560	200	19.86	-	-	-
	required load			25.0	degradation of test 6 required						0.648	1.046	17.64

For the A rating point test 1 is used directly.

For the B rating point at 75 Percent Load interpolation must be used. For this point, tests 2 and 3 were performed. Test 2 was run at full load but at the 75 Percent Load rating point 73.5°F condenser entering water as required by Table 6. Test 3 was run at the 73.5°F condenser entering temperature but with stage 2 active. These tests show that a Percent Load of 102.4 and 66.8 was obtained to achieve 75 Percent Load and interpolation between tests 2 and 3 is shown below.

$$EER_B = \left(\left(\frac{13.29 - 16.34}{102.4 - 66.8}\right) \cdot (75 - 66.8)\right) + 16.34 = 15.64 \text{ Btu/(W} \cdot \text{h)}$$

For the C rating point that is required to be run at 62°F condenser entering water as defined in table 6, test 4 shows that the test Percent Load is 67.9. This exceeds allowable ± 3% tolerance so test 4 cannot be used directly to calculate the C EER rating point. Test 5 was run with stage 1 at the 62°F ambient and a Percent Load of 38 was measured. This can then be used for interpolation. For the D rating point test 6 was run at 55°F and the Percent Load was measured as 38.5. This is above the 25 Percent Load rating load requirement by more than 3%, and because this is the lowest capacity control point, a degradation calculation is required. The calculation of the degradation factor for the rating point D is shown below.

The degradation factor calculations are then performed using Section 6.2.3.

First the load factor (LF) is calculated using Equation 6.

$$LF = \frac{\left(^{Percent\ Load}/_{100}\right) \cdot Full\ Load\ Net\ Capacity}{Part\ Load\ Net\ Capacity} = \frac{\left(^{25}/_{100}\right) \cdot 242{,}129}{93{,}384} = 0.648$$

At a 25 Percent Load the last stage compressor will be on for 64. 8% of the time and off for 35. 2% of the time.

The degradation coefficient is calculated using Equation 5.

$$C_D = (-0.13 \cdot LF) + 1.13 = (-0.13 \cdot 0.648) + 1.13 = 1.046$$

The EER will degrade 4.6% due to the cycling of the compressor over a steady state on all the time performance.

Once the degradation factor is calculated, the rating point EER can be calculated using Equation 4 for the rating point B.

$$EER = \frac{LF \cdot Q_{\square}}{LF \cdot [C_D \cdot (P_C + P_{CD})] + P_{IF} + P_{CT}} = \frac{0.648 \cdot 93{,}384}{0.648 \cdot [1.046 \cdot (3{,}941 + 0)] + 560 + 200} = 17.64 \text{ Btu/(W} \cdot \text{h)}$$

The last step 3 is then to calculate the IEER using Equation 3.

$$IEER = (0.020 \cdot A) + (0.617 \cdot B) + (0.238 \cdot C) + (0.125 \cdot D)$$

$$= (0.02 \cdot 12.34) + (0.617 \cdot 15.64) + (0.238 \cdot 18.38) + (0.125 \cdot 17.64) = 16.48\ \mathrm{Btu/(W \cdot h)}$$

G5 *Proportionally Capacity Controlled Unit Example Calculations.* This section provides example calculations for IEER calculations for Proportionally Capacity Controlled Units. As defined in Section 6.2.6, a Proportionally Capacity Controlled Unit is a unit incorporating one or more variable capacity compressors where the compressor capacity can be modulated continuously.

G5.1 *Example 8. Air-cooled Unit with a Single Variable Speed Compressor and a Fixed Speed Indoor Fan IEER Example Calculations.*

The unit is an air-cooled unit with a single variable speed compressor and a fixed speed indoor. The unit has the following rated performance metrics:

1) Rated Capacity = 118,000 Btu/h
2) Full Load Rated Indoor Airflow = 3,400 scfm
3) Rated EER = 11.2 Btu/(W·h)
4) Rated IEER = 12.0 Btu/(W·h)

Table G16 shows the test data. The atmospheric pressure was measured at 14.70 psia and was constant for all tests. This is above the minimum atmospheric pressure of 13.700 psia. The pressure could vary between tests, and it should be measured for each test.

Table G16. Example 8. Test Results

Test	Stage	Test OAT	Req OAT	Actual Percent Load	Test Net Cap	Test CFM (Std Air)	Cmpr (P_C) (Test)	Cond (P_{CD}) (Test)	Indoor (P_{IF}) (Test)	Control (P_{CT}) (Test)	EER (Test)
-	-	°F	°F	%	Btu/h	scfm	W	W	W	W	Btu/(W·h)
1	100%	95.1	95.0	100.0	117,450	3354	8450	650	1150	125	11.32
2	75%	81.3	81.5	75.5	88,621	3354	5393	650	1150	125	12.11
3	50%	67.7	68	54.7	64,214	3354	3631	650	1150	125	11.56
4	50%	68.14	68	43.0	50,463	3354	2772	650	1150	125	10.74
5	25%	65.3	65.0	30.0	35,216	3354	1717	325	1150	125	10.62

Five tests were run to use in the calculation of the EER rating points A, B, C, and D and the calculation of the IEER. Test 1 is the full load rating point. Test 2 was targeted to run at the 75 Percent Load rating point and the measured test Percent Load is 75.5 and it is with the 3% tolerances and additional testing is not required. For the C rating point test 3 was run to get the 50 Percent Load rating but the resulting testing had a measured Percent Load of 54.7 and it was greater than the 3% tolerance. The test could have been repeated, but the unit had control limits that would not allow 50% ± 3% to be obtained. so a second test 4 was run at a lower Percent Load of 43.0 and will be used for interpolation. Test 5 was run at the 65°F ambient for the rating point D, but the unit unloaded to 30.0 Percent Load, meaning this test requires a degradation calculation to be performed.

As per step 2 of the procedure outlined in Section 6.2.6, interpolation and degradation calculations can be performed using the test results. Table G17 shows the calculations for the 4 EER rating points

Table G17. Example 8. IEER Rating Points and Degradation Calculations

Rating Point	Test	Test OAT	Req OAT	Actual Percent Load	Net Cap (Test)	Cmpr (P_C) (Test)	Cond (P_{CD}) (Test)	Indoor (P_{IF}) (Test)	Control (P_{CT}) (Test)	EER (Corr)	LF	CD	Rating EER
-	-	°F	°F	%	Btu/h	W	W	W	W	Btu/(W·h)	-	-	Btu/(W·h)
A	1	95.1	95.0	100.0	117,450	8450	650	1150	125	11.32	-	-	-
	required load			100.0	use test 1 point directly						-	-	11.32
B	2	81.3	81.5	75.5	88,621	5393	650	1150	125	12.11	-	-	-
	required load			75%	use test 2 point directly						-	-	12.11
C	3	67.7	68.0	54.7	64,214	3631	650	1150	125	11.56	-	-	-
	4	68.1	68.0	43.0	50,463	2772	650	1150	125	10.74	-	-	-
	required load			50.0	interpolate between test 3 and 4						-	-	11.23
D	5	65.3	65.0	30.0	35,216	1717	325	1150	125	10.62	-	-	-
	required load			25.0	degradation of test 54 required						0.834	1.022	9.74

For rating point A. the 100 Percent Load rating point, test 1 can be used directly. For the 75 Percent Load rating point B, the Percent Load is 75.5 so it is within the 3% tolerance, meaning the test point can be used directly for the rating point B and neither interpolation nor degradation are required. For the 50 Percent Load rating point C, test 3 was run to achieve the 50 Percent Load rating but the resulting testing had a measured Percent Load of 54.7 that is greater than the 3% tolerance. The test could have been repeated, but the unit had control limits that would not allow 50% ± 3% to be obtained. A second test 4 was run at a lower Percent Load of 43 and is used for interpolation. The interpolation calculations are shown below.

$$EER_C = \left(\left(\frac{11.56 - 10.74}{54.7 - 43.0}\right) \cdot (50 - 43.0)\right) + 10.74 = 11.23 \text{ Btu/(W} \cdot \text{h)}$$

For the rating point D, test 5 was run but due to control limits the unit unloaded to 30 Percent Load. This is greater than the 25 Percent Load target with a 3% tolerance (25%+3%=28%). Therefore, degradation calculation is required as shown below.

The degradation factor calculations are performed using the requirements of Section 6.2.3.

First the load factor (LF) is calculated using Equation 6.

$$LF = \frac{\left({Percent\ Load}/{100}\right) \cdot Full\ Load\ Net\ Capacity}{Part\ Load\ Net\ Capacity} = \frac{\left({25}/{100}\right) \cdot 117{,}450}{35{,}216} = 0.834$$

At a 25 Percent Load, the compressor will be on for 83.4% of the time and off for 16.6% of the time.

The degradation coefficient is then calculated using Equation 5.

$$C_D = (-0.13 \cdot LF) + 1.13 = (-0.13 \cdot 0.834) + 1.13 = 1.022$$

The EER will degrade 2.2% due to the cycling of the compressor over a steady state on all the time performance.

Once the degradation factor is calculated the rating point EER is calculated using Equation 1 for the rating point D.

$$EER = \frac{LF \cdot Q}{LF \cdot [C_D \cdot (P_C + P_{CD})] + P_{IF} + P_{CT}} = \frac{0.834 \cdot 35{,}216}{0.834 \cdot [1.022 \cdot (1{,}717 + 325)] + 125 + 125}$$

$$EER = 9.74\ Btu/(W \cdot h)$$

The last procedural step 3 is to calculate the IEER using Equation 3.

$$IEER = (0.020 \cdot A) + (0.617 \cdot B) + (0.238 \cdot C) + (0.125 \cdot D)$$

$$= (0.02 \cdot 11.32) + (0.617 \cdot 12.11) + (0.238 \cdot 11.23) + (0.125 \cdot 9.74) = 11.59 \text{ Btu/(/W} \cdot \text{h)}$$

The IEER is then rounded as required by 6.1.2 to 11.6 Btu/(W·h) (nearest 0.1)

G5.2 *Example 9 - Air-cooled Unit with a Single Variable Speed Compressor and a Variable Speed Fan IEER Example Calculations*.

The unit is an air-cooled unit with a single variable speed compressor and a variable speed fan that is configured as a SZVAV unit where the thermostat controls the airflow, and the capacity is controlled to a leaving air temperature. The unit has the following rated performance metrics:

1) Rated Capacity = 118,000 Btu/h
2) Full Load Rated Indoor Airflow = 3,400 scfm
3) Rated EER = 11.2 Btu/(W·h)
4) Rated IEER = 12.0 Btu/(W·h)

Table G18 shows the test data. During the tests the atmospheric pressure was measured at 14.70 psia and was constant for all tests. This is above the minimum allowable atmospheric pressure of 13.700 psia. The pressure could vary between tests, and it should be measured for each test.

Table G18. Example 9. Test Results

Test	Stage	Test OAT	Req OAT	Actual Percent Load	Test Net Cap	Test CFM (Std Air)	Cmpr (P_C) (Test)	Cond (P_{CD}) (Test)	Indoor (P_{IF}) (Test)	Control (P_{CT}) (Test)	EER (Test)
-	-	°F	°F	%	Btu/h	CFM	W	W	W	W	Btu/W·h
1	100%	95.1	95.0	100.0	117,455	3354	8450	650	1150	125	11.32
2	75%	81.3	81.5	75.4	88,599	2550	5408	650	519	125	13.22
3	50%	68.2	68.0	50.9	59,765	1720	3725	650	166	125	12.81
4	25%	65.3	65.0	29.7	34,863	990	1727	325	33	125	15.77

Four tests were run to use in the calculation of the EER rating points A, B, C, and D and the calculation of the IEER. Test 1 was performed at the full load rating point. Test 2 was targeted to run at the 75 Percent Load rating point and the measured test Percent Load is 75.4. This is with the 3% tolerances and additional testing was not required. Test 3 was run to get the 50 Percent Load rating and the test measured Percent Load was 50.9. This is within the allowable tolerance of 3%. Test 4 was run at the 65°F ambient for rating point D, but the unit unloaded to 29.7 Percent Load, meaning this test required a degradation calculation to be performed. Because this is a MZVAV unit, the cfm was adjusted to maintain the leaving air temperature at the full load test dry-bulb temperature ± 0.5°F.

As defined in step 2 of Section 6.2.6, the procedure can be performed to calculate the A, B, C and D point ratings using the test results. Table G19 shows the calculations for the four EER rating points used to calculate the IEER.

Table G19. Example 9. IEER Rating Points and Degradation Calculations

Rating Point	Test	Test OAT	Req OAT	Actual Percent Load	Net Cap (Test)	Cmpr (P_C) (Test)	Cond (P_{CD}) (Test)	Indoor (P_{IF}) (Test)	Control (P_{CT}) (Test)	EER (Test)	LF	CD	Rating EER
-	-	°F	°F	%	Btu/h	W	W	W	W	Btu/W	-	-	-
A	1	95.1	95.0	100.0	117,455	8450	650	1150	125	11.32	-	-	-
	required load			100.0	use test 1 point directly						-	-	11.32
B	2	81.3	81.5	75.4	88,599	5408	650	650	125	13.22	-	-	-
	required load			75%	use test 2 point directly						-	-	13.22
C	3	68.2	68.0	50.9	59,765	3725	650	650	125	12.81	-	-	-
	required load			50.0	use test 3 point directly						-	-	12.81
D	4	65.3	65.0	29.7	34,863	1727	325	33	125	15.77	-	-	-
	required load			25.0	degradation of test 4 required						0.842	1.021	15.27

For rating point A, the 100 Percent Load rating point, test 1 can be used directly. For the 75 Percent Load rating point B, the test load is 75.4 Percent Load. This is within the 3% tolerance, meaning the test point can be used directly for the rating point B, and neither interpolation nor degradation was required. For the 50 Percent Load rating point C, test 3 was performed to achieve 50 Percent Load rating and the test Percent Load was 50.9. This is within the 3% tolerance, meaning it can be used directly for the point C EER determination. For the rating point D, test 4 was performed, but due to control limits the unit unloaded to 29.7 Percent Load. This is greater than the 25 Percent Load target with a 3% tolerance (25%+3%=28%). Therefore, a degradation calculation is required as shown below.

The degradation factor calculations are performed using the requirements of Section 6.2.3.

First the load factor (LF) is calculated using Equation 6.

$$LF = \frac{\left(\frac{Percent\ Load}{100}\right) \cdot Full\ Load\ Net\ Capacity}{Part\ Load\ Net\ Capacity} = \frac{\left(\frac{25}{100}\right) \cdot 117{,}445}{34{,}863} = 0.842$$

At a 25 Percent Load, the compressor will be on for 84.2% of the time and off for 15.8% of the time.

The degradation coefficient is then calculated using Equation 5.

$$C_D = (-0.13 \cdot LF) + 1.13 = (-0.13 \cdot 0.842) + 1.13 = 1.021$$

The EER will degrade 2.1% due to the cycling of the compressor over a steady state on all the time performance.

Once the degradation factor is calculated the rating point EER is calculated using Equation 1 for the rating point D.

$$EER = \frac{LF \cdot Q_{\square}}{LF \cdot [C_D \cdot (P_C + P_{CD})] + P_{IF} + P_{CT}} = \frac{0.842 \cdot 34{,}863}{0.842 \cdot [1.021 \cdot (1{,}727 + 325)] + 33 + 125} = 15.27\ \text{Btu}/(\text{W} \cdot \text{h})$$

The last procedural step 3 is to calculate the IEER using Equation 3.

$$IEER = (0.020 \cdot A) + (0.617 \cdot B) + (0.238 \cdot C) + (0.125 \cdot D)$$

$$= (0.02 \cdot 11.32) + (0.617 \cdot 13.22) + (0.238 \cdot 12.81) + (0.125 \cdot 15.27) = 13.34\ \text{Btu}/(\text{W} \cdot \text{h})$$

The IEER is then rounded as required by 6.1.2 to 13.3 Btu/(W·h) (nearest 0.1)

G5.3 Example 10. *Air-cooled Unit with Two Compressors with One Being Fixed Speed and the Other Being Variable Speed Compressor and a Variable Speed Indoor Fan IEER Example Calculations.*

The unit is an air-cooled unit with two compressors in the same refrigeration circuit with one being variable speed and the other being a fixed capacity compressor. The indoor fan is a variable speed fan and is controlled to be a SZVAV unit with a single variable speed compressor where the thermostat controls the airflow, and the capacity is controlled to a leaving air temperature. The unit has the following rated performance metrics:

1) Rated Capacity = 118,000 Btu/h
2) Full Load Rated Indoor Airflow = 3,400 scfm
3) Rated EER = 11.2 Btu/(W·h)
4) Rated IEER = 13.0 Btu/(W·h)

Table G20 shows the test data. The atmospheric pressure was measured at 14.70 psia and was constant for all tests. This is above the minimum allowable atmospheric pressure of 13.700 psia. The pressure could vary between tests, and it should be measured for each test.

Table G20. Example 10. Test Results

Test	Stage	Test OAT	Req OAT	Actual Percent Load	Test Net Cap	Test CFM (Std Air)	Cmpr (P_C) (Test)	Cond (P_{CD}) (Test)	Indoor (P_{IF}) (Test)	Control (P_{CT}) (Test)	EER (Test)
-	-	°F	°F	%	Btu/h	scfm	W	W	W	W	Btu/(W·h)
1	1 @ 100% 2 @100%	95.1	95.0	100.0	119,500	3300	8725	650	1,100	125	11.27
2	1 @ 48%, 2 @100%	81.3	81.5	75.1	89,788	2550	5584	650	521	125	13.05
3	1 @ 98%, 2 @ off	68.0	68.0	50.7	60,563	1720	3846	650	166	150	12.59
4	1 @ 46%, 2 @ off	65.3	65.0	24.4	29,197	990	1427	325	33	150	15.09

Four tests were run to use in the calculation of the EER rating points A, B, C, and D and the calculation of the IEER. Test 1 is the full load rating point. Test 2 was targeted to run at the 75 Percent Load rating point and the measured Percent Load is 75.1. This is within the 3% tolerances and additional testing was not required. the test 1 compressor was at full capacity and the variable speed compressor was at 48 Percent Load capacity. For the 50 Percent Load rating point, test 3 was performed to achieve the 50 Percent Load rating and the test measured Percent Load is 50.7. This is within the allowable tolerance of 3%. During test 1 the compressor was turned off and the variable speed compressor was run at 98 Percent Load capacity. Test 4 was run at the 65°F ambient for the rating point D and the measured Percent Load was 24.4, meaning it can be used directly for the EER determination. Because all the tests were be run at the required load, neither interpolation nor degradation was required. Using step 2 of the Section 6.2.6 procedure, calculations are performed to determine the ratings at the A, B, C and D IEER points. Table G21 shows the calculations for the 4 EER rating points used to calculate the IEER.

Table G21. Example 10. IEER Rating Points and Degradation Calculations

Rating Point	Test	Test OAT	Req OAT	Actual Percent Load	Net Cap (Test)	Cmpr (P_C) (Test)	Cond (P_{CD}) (Test)	Indoor (P_{IF}) (Test)	Control (P_{CT}) (Test)	EER (Corr)	LF	CD	Rating EER
-	-	°F	°F	%	Btu/h	W	W	0	W	Btu/(W·h)	-	-	Btu/(W·h)
A	1	95.1	95.0	100.0	119,500	8725	650	1,100	125	11.27	-	-	-
	required load			100.0	use test 1 point directly						-	-	11.27
B	2	81.3	81.5	75.1	89,788	5584	650	521	125	13.05	-	-	-
	required load			75%	use test 2 point directly						-	-	13.05
C	3	68.1	68.0	50.7	60,563	3846	650	166	150	12.59	-	-	-
	required load			50.0	use test 3 point directly						-	-	12.59
D	4	65.3	65.0	24.4	29,197	1427	325	33	150	15.09	-	-	-
	required load			25.0	use test 4 point directly						-	-	15.09

Because all 4 tests could be run at the required load within the tolerance, additional calculations are not required and the test EER can be used directly for the IEER calculations.
The last procedural step 4 is to calculate the IEER using Equation 3.

$$IEER = (0.020 \cdot A) + (0.617 \cdot B) + (0.238 \cdot C) + (0.125 \cdot D)$$

$$= (0.02 \cdot 11.27) + (0.617 \cdot 13.05) + (0.238 \cdot 12.59) + (0.125 \cdot 15.09) = 13.16 \text{ Btu/(W} \cdot \text{h)}$$

The IEER is then rounded as required by 6.1.2 to 13.2 Btu/(W·h) (nearest 0.1)

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

H1 *Background.* An individual model with a non-standard indoor fan motor can be rated within the same Basic Model as an individual model with a standard fan motor if: (1) the former individual model is otherwise identical to the latter individual model; and (2) the non-standard fan motor has the same or higher relative efficiency as the standard fan motor (determined per section D3.1). However, for certain direct-drive indoor fans, the motor and fan cannot be separated, or the fans are not rated separately, or both. For such fans, the efficiency of the fan and motor combination, rather than the efficiency of the fan motor alone, is used to compare performance of the standard and non-standard fans, per the approach provided in Section D3.2. This method is provided for cases where either or both of the standard or non-standard fans are integrated fans and motors (IFM). This appendix includes an example to help in the application of the procedures specified in section D3.2 to determine the relative efficiency of the standard and non-standard fan and motor combinations.

H2 *Requirements.* Though only one fan must be an IFM, both fans must have the same diameter impeller and the impeller must have the same number of blades. However, it is not requirement that the impeller width be the same, since for a given airflow and impeller diameter, as pressure rise increases the use of a narrower impeller usually increases efficiency.

H3 *The concept*. The standard and non-standard fans are operated at the same airflow and pressure rise, referred to as the duty point. The electrical power required to run the non-standard fan must not be more than 110% of that of the standard fan if both fans are tested at the duty points. The 110% includes the allowance for variance due to testing inaccuracies and biases. The fan performance may be compared without testing. This can be achieved by using the fan manufacturer's software. In that case, without testing, the ratio of fan powers is limited to 105%. Figure H1 shows an example of output from a fan manufacturer's software where there two non-standard fans:

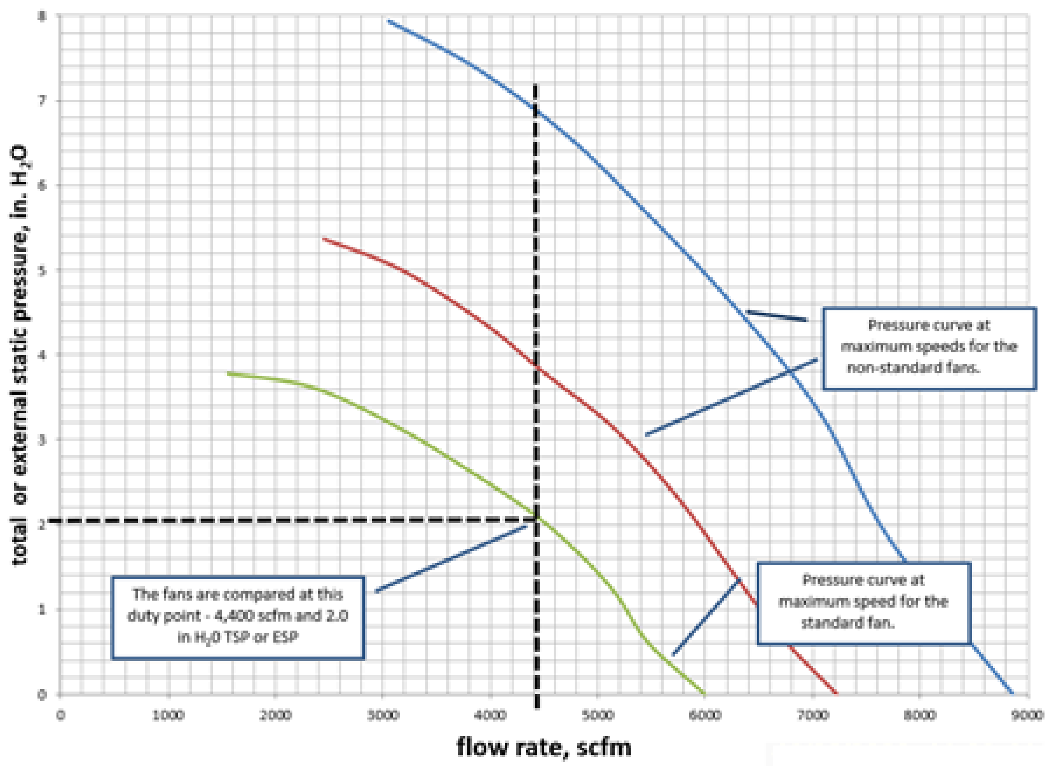

Figure H1. Illustration of the duty point where standard and non-standard fan input power is compared.

H4 *Testing both fans inside a unit.* The Full Load Rated Indoor Airflow Rate for the unit is 4,400 scfm. The standard fan is set to its highest speed, and the ESP is adjusted so that the airflow is 4,402 scfm, that is within 2% of the Full Load Rated Indoor Airflow. An ESP of 2.0 in H_2O is measured. The fan power of 2,100 W is recorded. Then, a unit with a non-standard fan is tested with the goal of operating at the same airflow and ESP where the standard fan was tested. The tested airflow and ESP when compared to the non-standard fan must be within the tolerances allowed in Table D3. The measured fan input power of the non-standard fan must not be more than 2,310 W (2,100 W X 110%). Laboratory variance is accounted for in the 110% allowance.

H5 *Example – Comparison using software based on testing by either the requirements of AMCA 210 or ISO 5801.* Often, the fan manufacturer can provide software that calculates the fan input power at any airflow and total static pressure within the fan's operating envelope. If the underlying tests were performed using either AMCA 210 or ISO 5801, and performance for non-tested speeds is interpolated per the requirements of Annex I of AMCA 211 (in the software calculations), then use of the manufacturer's software in lieu of testing is acceptable.

For this example, using the graph in Figure H1, the maximum speed of the standard fan is 1800 RPM, and the green line represents its performance at that speed. The TSP of the operating point is equal to the value of the green line at 4,400 scfm. This shows a total static pressure of 2.0 in. H_2O. The software shows that fan input power of the standard fan at this operating point is 2,000 W. The fan input power of the other fans is determined at the same duty point. For both of the non-standard fans, the fan input power determined cannot exceed 2100 W (2000 W • 105%).

APPENDIX I. DOUBLE-DUCT SYSTEM EFFICIENCY METRICS WITH NON-ZERO OUTDOOR AIR EXTERNAL STATIC PRESSURE (ESP) - NORMATIVE

I1 *Background*. Double-duct Systems are intended for indoor installation with ducting of outdoor air. This appendix provides metrics for Double-duct Systems that allow for testing and rating with non-zero outdoor air external static pressure (ESP).

I2 *Standard Ratings*. In addition to Standard Rating requirements outlined in Section 6.1, Standard ratings of Double-duct Systems measured per this appendix shall bear the subscript DD for Efficiency values whenever published. This includes EER_{DD}, $COP_{H,DD}$ and $IEER_{DD}$.

I3 *Outdoor Airflow and External Static Pressure*

I3.1 *Set-Up.* 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.

I3.2 *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 the requirement specified in Table I1. 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 the requirement specified in Table I1. If the outdoor air ESP cannot be maintained within -0.00/+0.05 in H_2O of the applicable ESP requirement 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.

Table I1. Outdoor External Static Pressure for Double-duct Systems

Rated Cooling Capacity, Btu/h·1000	Outdoor External Static Pressure, in H_2O
From 65 to 300	0.5

I3.3 *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.