AHRI Standard 340/360 (I-P)-2019

2019 Standard for

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

AIR-CONDITIONING, HEATING, & REFRIGERATION INSTITUTE

we make life better®

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IMPORTANT

SAFETY DISCLAIMER

AHRI does not set safety standards and does not certify or guarantee the safety of any products, components or systems designed, tested, rated, installed or operated in accordance with this standard/guideline. It is strongly recommended that products be designed, constructed, assembled, installed and operated in accordance with nationally recognized safety standards and code requirements appropriate for products covered by this standard/guideline.

AHRI uses its best efforts to develop standards/guidelines employing state-of-the-art and accepted industry practices. AHRI does not certify or guarantee that any test conducted under its standards/guidelines will be non-hazardous or free from risk.

Note:

This 2019 standard supersedes AHRI Standard 340/360-2007 with Addendum 1 and 2 and 340/360-2015

AHRI CERTIFICATION PROGRAM PROVISIONS

Scope of the Certification Program

The Certification Program applies to 50 Hz and 60 Hz equipment including:

- Unitary Air-conditioners and Heat Pumps from 65,000 Btu/h to less than 250,000 Btu/h;
  - Single Packaged and Split Systems
  - Air-cooled and water-cooled
- Air-cooled Air-conditioning Condensing Units from 135,000 Btu/h to less than 250,000 Btu/h (covered by AHRI Standard 365);
- Air-cooled Single Packaged Unitary Air-conditioners from 250,000 Btu/h to less than 760,000 Btu/h.

Products sold in the intended market of the US and Canada must comply with the "certify all requirements". For 60 Hz and 50 Hz products sold outside the intended market of the US and Canada, certification is optional. If the participant does not wish to carry certification of a model sold for use outside the intended market, this product shall carry a separate and unique model number from an existing AHRI certified model number to avoid market confusion.

Certified Ratings

The following certified ratings are verified by test at AHRI Standard Rating Conditions:

Unitary Air-conditioners

Air-cooled, water-cooled and evaporatively-cooled from 65,000 Btu/h to below 250,000 Btu/h.

1. Cooling Capacity, Btu/h
2. Energy Efficiency Ratio, EER, Btu/W·h
3. Integrated Energy Efficiency Ratio, IEER, Btu/W·h

Unitary Air-Cooled Packaged Air-Conditioners from 250,000 Btu/h to less than 760,000 Btu/h.

1. Cooling Capacity, Btu/h
2. Energy Efficiency Ratio, EER, Btu/W·h
3. Integrated Energy Efficiency Ratio, (IEER), Btu/W·h

Air-source Unitary Heat Pump Equipment

Air-cooled from 65,000 Btu/h to below 250,000 Btu/h.

1. Cooling Capacity, Btu/h
2. Energy Efficiency Ratio, EER, Btu/W·h
3. Integrated Energy Efficiency Ratio, IEER, Btu/W·h
4. High Temperature Heating Standard Rating Capacity, Btu/h at 47 °F
5. High Temperature Heating Coefficient of Performance, COP_H, W/W, at 47 °F
6. Low Temperature Heating Standard Rating Capacity, Btu/h, at 17 °F
7. Low Temperature Heating Coefficient of Performance, COP_H, W/W, at 17 °F

Conformance to the requirements of the maximum operating condition test, cooling low temperature operation test, insulation efficiency test (cooling), and condensate disposal test (cooling) are also verified initially by test for manufacturers applying into the AHRI ULE Certification Program.

The following certified ratings are verified by test for International Rating Conditions:

Unitary Air-conditioners

Air-cooled, water-cooled and evaporatively-cooled from 65,000 Btu/h to below 250,000 Btu/h.

1. Cooling Capacity, Btu/h at T1, T2, T3 Standard International Rating Conditions as applicable
2. Energy Efficiency Ratio, EER, Btu/W·h) at T1, T2, and/or T3 International Rating Conditions as applicable
3. Extra High Temperature Operating Requirements as applicable

Unitary Air-Cooled Packaged Air-Conditioners from 250,000 Btu/h to less than 760,000 Btu/h.

1. Cooling Capacity, Btu/h at T1, T2 and/or T3 International Rating Conditions as applicable
2. Energy Efficiency Ratio, EER, Btu/W·h at T1, T2, and/or T3 International Rating Conditions as applicable
3. Extra High Temperature Operating Requirements as applicable

Air-source Unitary Heat Pump Equipment

Air-cooled from 65,000 Btu/h to below 250,000 Btu/h.

1. Cooling Capacity, Btu/h at T1, T2 and or T3 International Rating Conditions as applicable
2. Energy Efficiency Ratio, EER, Btu/W·h and Heating Coefficient of Performance (COP_C) at T1, T2, and/or T3 International Standard Rating Conditions as applicable
3. Heating Capacity at H1, H2, and or H3 International Rating Conditions as applicable
4. Heating Coefficient of Performance (COP_H) at H1, H2, and/or H3 as applicable
5. Extra High Temperature Operating Requirements as applicable

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Foreword:

AHRI Standard 340/360 (I-P) – 2019 contains many significant revisions to the 2015 standard

1. Airflow and static pressure language has been consolidated into one central section
2. Definitions have been expanded to include ICM and OUM.
3. Language has been added to provide a hierarchy of decisions when testing issues arise
4. Corrections for barometric pressure have been removed
5. Capacity corrections have been added when additional line length is used in testing
6. Additional language has been added to clarify refrigerant charge requirements
7. Operating conditions have been harmonized with AHRI 210/240 and now also include Makeup Water for evaporative cooled equipment
8. New provisions have been added for testing units with no filters
9. Test tolerances have been incorporated from ASHRAE 37 with new additions for voltage and dew point measurements.
10. Additional procedures have been added to Appendix C and Appendix E
11. Appendix D, Unit configuration, has undergone a rewrite and has changed from informative to normative
12. A new appendix (Appendix F in this 2019 version), has been added for International Rating Conditions

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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 American Society of Heating, Refrigerating, and Air-Conditioning Engineers (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 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 may also 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.

2.3.4 Commercial and industrial unitary air-conditioning condensing units rated using ANSI/AHRI Standard 365 (I-P).

Section 3. Definitions

All terms in this document shall follow the standard industry definitions in the *ASHRAE Terminology* website (https://www.ashrae.org/resources--publications/free-resources/ashrae-terminology), unless otherwise defined in this section.

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

3.2 *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.

3.3 *Commercial and Industrial Unitary Air-conditioner.* One or more factory-made assemblies, which normally include a cooling coil, an air moving device, a compressor(s) and condenser combination, and may 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 may include the functions of heating, humidifying, outdoor air ventilation, and air cleaning.

3.4 *Commercial and Industrial Unitary Heat Pump.* One or more factory-made assemblies, which 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 may or may not 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 may include the functions of air circulation, air cooling, dehumidifying or humidifying, outdoor air ventilation, and air cleaning.

3.5 *Cooling Capacity*. The net capacity associated with the change in air enthalpy between the air entering the unit and the air leaving the unit, which includes both the Latent and Sensible Capacities expressed in Btu/h and includes the heat of circulation fan(s) and motor(s).

> **3.5.1** *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.
>
> **3.5.2** *Latent Capacity*. Capacity associated with a change in humidity ratio, expressed in Btu/h.
>
> **3.5.3** *Sensible Capacity*. Capacity associated with a change in dry-bulb temperature, expressed in Btu/h.

3.6 *Double-duct System.* An air conditioner or heat pump that is either a horizontal single package or split-system unit; or a vertical unit that consists of two components that may be shipped or installed either connected or split; is intended for indoor installation with ducting of outdoor air from the building exterior to and from the unit, where the unit and/or all of its components are non-weatherized and are not marked (or listed) as being in compliance with UL 1995/CSA C22.2 No.236 or equivalent requirements for outdoor use. 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; and, a rated Cooling Capacity greater than and equal to 65,000 Btu/h and less than or equal to 300,000 Btu/h.

3.7 *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 (EER).* A ratio of the Cooling Capacity in Btu/h to the total operating power input in watts at Standard Rating Conditions 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.

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

3.9 *Full Load Rated Indoor Airflow*. The Standard Airflow rate at 100% capacity as defined by the manufacturer and at the external static pressure as listed in Table 5.

3.10 *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.

3.11 *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.

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

3.13 *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.

3.14 *Indoor 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 which may also 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).

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

3.16 *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.

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

3.18 *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 which may also 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.

3.19 *Single Package Heat Pumps*. Units that can both cool and heat with the refrigeration system which may have provision for 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 which may also have means for humidifying and control of temperature, with provision for modifying the performance so that either heating or cooling and dehumidification may 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).

3.20 *Year Round Single Package Air-conditioners*. Gas and oil Single Package Air-conditioners which 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 which may also 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).

3.21 *Part Load Rated Indoor Airflow*. The Standard Airflow at the part-load ratings conditions as defined by the manufacturer and at the external static pressure as listed in Table 5 with modifications shown in Table 6. This may be different for each part-load rating point.

3.22 *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, %.

3.23 *Proportionally Controlled Units.* Units incorporating one or more variable capacity compressors in which the compressor capacity can be modulated continuously or in steps not more than 5% of the ANSI/CAN/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 may also include combination of fixed capacity and variable capacity compressors.

3.24 *Published Rating.* A statement of the assigned values of those performance characteristics, under stated Rating Conditions, by which a unit may 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 Published Rating 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.

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

3.24.2 *Standard Rating.* A rating based on tests performed at Standard Rating Conditions as listed in Table 4.

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

3.25 *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.

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

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

3.26 *"Shall"* or *"Should"*. "Shall" or "should" shall be interpreted as follows:

3.26.1 *Shall*. Where "shall" or "shall not" is used for a provision specified, that provision is mandatory if compliance with the standard is claimed.

3.26.2 *Should*. “Should” is used to indicate provisions which are not mandatory but which are desirable as good practice.

3.27 *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, controlled by a single space thermostat input. 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.

Note: The Supply Air temperature can be one method used for the control logic.

3.28 *Split System Air-conditioners*. Units which are intended for air conditioning purposes with an air conditioning condensing unit that is installed remotely from the evaporator and requiring field connection by refrigerant lines.

3.29 *Split System Heat Pump*. Unit which is intended for heat pump purposes with an outdoor unit that is installed remotely from the indoor coil, air handler, or fan coil and requiring field connection by refrigerant lines.

3.30 *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.

3.31 *Standard Air.* Air weighing 0.075 lb/ft^3 which approximates dry air at 70.0°F and at a barometric pressure of 29.92 in Hg or an atmospheric pressure of 14.696 psia.

3.32 *Standard Airflow*. The volumetric flowrate of air corrected to Standard Air conditions expressed in scfm. When correcting measured airflow to Standard Air, the correction shall be based on the air density at the airflow test measurement station.

3.33 *Standard Filter*. The filter with the lowest level of filtration that is distributed in commerce with a model. If the manufacturer does not specify which 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 which filter option has the lowest filtration level, then the Standard Filter shall be any filter shipped by the manufacturer.

3.34 *Stepped Fan Control*. Units with control systems designed to use multiple stages of indoor fans in discrete steps based on the stages of capacity and/or defined control logic.

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

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 Tables 1 and 2.

Table 1. Classification of Commercial and Industrial Unitary Air-Conditioning Equipment

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

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 condenser and "-W" indicates water-cooled condenser.
3. For Double-duct Systems, append "-DD", and outdoor arrangement moves from outdoor side to indoor side.
4. Components could be installed indoors as well in accordance with manufacturer's installation instructions.
5. Optional component.
6. May also be 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 - ID	Arrangement – OD
Single Package Heat Pumps	HSP-A[3]		ELEC HEAT[4] | OD FAN or PUMP ID FAN | COMP EVAP | COND
Year Round Single Package	HSPY-A		GAS HEAT[5] | OD FAN or PUMP ID FAN | COMP EVAP | COND
Heat Pump with Remote Outdoor Coil	HRC-A-CB[3]	ID FAN EVAP COMP	OD FAN or PUMP COND
Split System Heat Pump with Remote Outdoor Coil with no Indoor Fan	HRC-A-C[3]	EVAP COMP	OD FAN or PUMP COND
Split System Heat Pump with Coil Blower	HRCU-A-CB[3]	ELEC HEAT[4] ID FAN EVAP	OD FAN or PUMP COMP COND

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. May also be other heat sources.

Section 5. Test Requirements

5.1 All Standard Ratings shall be based on tests conducted 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, priority shall be given to installation instructions that appear on the unit’s label over installation instructions that are shipped with the unit. If the unit is a split system and the components’ installation instructions 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. All references to “manufacturer’s instructions,” “manufacturer's published instructions,” “manufacturer’s installation instructions,” “manufacturer’s published recommendations,” “manufacturer installation and operation manuals” and other similar references in this standard refer to the first available applicable source in the above hierarchy. These references do not include online manuals.

5.2.1 Supplemental testing instructions (STI) provided by the manufacturer shall be used only for deviations from manufacturer's installation instructions that are necessary to comply with steady-state requirements. Supplemental testing instructions 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.

5.2.1.1 For products covered under AHRI's ULE certification program, additional information shall be submitted through the certification process.

5.3 *Break-in.* Conduct a compressor break-in period prior to conducting the test if specified by the manufacturer in the supplemental testing instructions. The total duration of the break-in period shall be specified by the manufacturer but shall not exceed 20 hours. When a break-in period is specified, each compressor of the unit shall undergo this break-in period. No testing shall commence until the specified break-in period is completed.

5.4 *Test Unit Duct Installation Requirements*. ANSI/ASHRAE Standard 37 duct requirements shall be followed.

5.5 *Defrost Controls*. Defrost controls shall be left at manufacturer's factory settings if the published 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 10) 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 in which 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 in which the interconnection tubing is furnished as an integral part of the machine not recommended for cutting to length 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
$3.3 < X \le 20$	1.01
$20 < X \le 40$	1.02
$40 < X \le 60$	1.03

Note:

1. Due to the refrigerant line lengths required in the test setup, 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.
4. Cooling Capacity Correction Factor shall only be applied to full load tests

5.8 *Refrigerant Charging*. Unless the unit does not require charging (per Section 5.8.5) use the tests 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 near-azeotropic and zeotropic refrigerants only with refrigerant in the liquid state.

5.8.1 If the manufacturer's installation instructions give a specified range for 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 and/or the manufacturer's installation instructions do not provide parameters and target values, 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 Except for mix-matched systems covered in Section 5.8.4, 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 conditions given for charge adjustment where all conditions specified cannot be met. If such instances of conflicting information occur within the highest ranking set of instructions for which 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. Test Condition Tolerance for Charging Hierarchy

Fixed Orifice			Expansion Valve		
Priority	Method	Tolerance	Priority	Method	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	± 1.0 °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			

5.8.4 *Mix-Matched Systems*. For systems consisting of an OUM outdoor unit and an ICM Indoor Unit with differing charging procedures the refrigerant charge shall be adjusted per the ICM 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.

5.8.5 *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 don't 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.

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

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

5.8.6 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 (*i.e.*, 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 (*i.e.*, 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, in which case 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, in which case 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.

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 Tables 5, 6, and 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 that would not normally be installed in the field 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 cfm 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 cfm of indoor air circulated.

6.1.1.7 Standard Ratings of water-cooled units from 65,000 to below 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 $hr \cdot ft^{2} \cdot {}^{o}F/Btu$.

6.1.2 *Standard Rating Values*

6.1.2.2 *Values of Standard Capacity Ratings.* These ratings shall be expressed in terms of Btu/h in multiples of 1,000.

6.1.2.2 *Values of Energy Efficiency Ratios and Heating Coefficients of Performance.* Energy Efficiency Ratio (EER) and Integrated Energy Efficiency Ratio (IEER) for cooling, whenever published, shall be expressed in multiples of 0.1. Heating Coefficients of Performance (COP_H), whenever published, shall be expressed in multiples of 0.01.

6.1.3 *Standard Rating Tests*. Table 5 and 6 indicate the tests and test conditions which 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 5. 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]	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 8	Varies with load per Table 8[1]	Varies with load per Table 8	Varies with load per Table 8	77.0	Varies with load per Table 8[2]	Varies with load per Table 8
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	47.0	43.0	--	--		--	--
Heating	Standard Rating Conditions (Low Temperature Steady State Heating)[5]	70.0	60.0	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. 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 60.5 ºF.
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 6.
5. Tests are only valid when the atmospheric pressure is greater than 13.700 psia.
6. For some product classifications, the outdoor section may be located indoors.

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

6.1.3.3 *Minimum External Static Pressure for Testing*

6.1.3.3.1 Test at the external static pressure specified in Table 4 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 6. External Static Pressure

Rated Cooling Capacity, Btu/h·1000[1]	External Static Pressure, in H_2O[2]
65 ≤ 70	0.20
71 ≤ 105	0.25
106 ≤ 134	0.30
135 ≤ 210	0.35
211 ≤ 280	0.40
281 ≤ 350	0.45
351 ≤ 400	0.55
401 ≤ 500	0.65
≥ 501	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

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 for which the manufacturer-specified fan control settings and/or rated airflow rates are different than for the full-load cooling test, calculate adjusted ESP requirements using equation 1.

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

Where:

ESP_{adj} = Adjusted ESP requirement at heating airflow or part-load cooling airflow, in H_2O
ESP_{FL} = ESP requirement at full-load cooling airflow specified in Table 6, 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 6. 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" 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.

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

Where:

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

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

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

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 *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.

6.1.3.4.2 For the full-load cooling test (except for Coil-only Indoor Units), use the rated full-load cooling airflow. If an airflow is not specified by the manufacturer, use a value of 400 standard cubic feet per minute (scfm) per ton (i.e., per 12,000 Btu/h) of rated Cooling Capacity.

6.1.3.4.3 For the heating test (except for Coil-only Indoor Units), use the rated heating airflow rate. If this airflow rate is not specified, use the airflow that results from using the specified heating fan control settings at the adjusted ESP requirement determined per Section 6.1.3.3. If neither the airflow rate nor fan control settings are specified for the heating test but the manufacturer's installation instructions describe how to obtain steady-state heating operation (e.g., using thermostat or other control system input), use those instructions. If none of this information is available, use the full-load cooling airflow rate for the heating test.

6.1.3.4.4 For part-load cooling tests for SZVAV units, use the specified part-load cooling airflow rates. If these airflow rates are not specified, use the airflow that results from using the part-load cooling fan control settings at the ESP requirement determined per Section 6.1.3.3. If neither airflow rates nor fan control settings are specified for the test point but the manufacturer's installation instructions describe how to obtain steady-state part-load cooling operation (e.g., using thermostat or other control system input), use those instructions. If none of this information is available, use the full-load cooling airflow rate for the part-load cooling tests.

6.1.3.4.5 For part-load cooling tests for MZVAV units, adjust the part-load cooling 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 ± 0.5 ºF.

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 manufacturer specified full-load cooling airflow rate; or the airflow equal to 450 scfm per ton of rated Cooling Capacity. If an airflow is not specified by the manufacturer, 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 rate. If heating or part-load cooling airflow rates are not specified, 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 *External Static Pressure and Airflow Tolerances and Set-Up (except for Coil-only Indoor Units)*

6.1.3.5.1 *Condition Tolerances*. All tolerances for airflow and ESP specified in this section for setting airflow and ESP are also condition tolerances that apply throughout 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.

6.1.3.5.2 *Full-load Cooling Test*

6.1.3.5.2.1 Operate the unit under conditions specified for the full-load cooling test using the manufacturer specified fan control settings. If the manufacturer does not specify 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 6 and to maintain the airflow within ± 3 % of the full-load cooling airflow.

6.1.3.5.2.2 If ESP or airflow are higher than the tolerance range, adjust the fan control settings (e.g., 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 (e.g., lowest fan speed), adjust the airflow-measuring apparatus to maintain airflow within tolerance and operate with the lowest possible ESP that meets the minimum requirement specified in Table 6.

6.1.3.5.2.3 If ESP or airflow are lower than the tolerance range, adjust the fan control settings (e.g., 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 (e.g., 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 full-load cooling airflow.

6.1.3.5.2.4 After setting the airflow for the full-load cooling test, no adjustments shall be made to the fan control settings for the full-load cooling test. 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), the average value of the ESP measured over the course of the test shall be within -0.00/+0.05 in H_2O of the ESP measured after setting airflow. If an airflow less than 97 % of the manufacturer specified full-load cooling 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), the average airflow rate measured over the course of the full-load cooling test shall be within ± 3 % of the full-load cooling airflow rate measured after setting 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 for which the manufacturer specified part-load cooling airflow or the manufacturer specified heating airflow is the same as the full-load cooling airflow (and for heating tests and part-load cooling tests for which an airflow is not specified and the full-load cooling 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 for which the manufacturer specified part-load cooling airflow or the heating airflow differs from the full-load cooling airflow, use the following provisions.

6.1.3.5.3.2.1 Operate the system under conditions specified for the heating test or part-load cooling test using the manufacturer specified fan control settings for that test condition. If there are no 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 the manufacturer does not specify 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 (e.g., 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 possible ESP that meets the adjusted ESP requirement. If ESP or airflow are lower than the tolerance range, adjust the fan control settings (e.g., 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. After setting the airflow, no changes are to be made to the fan control settings.

6.1.3.5.3.2.3 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), the average value of the ESP measured over the course of the test shall be within -0.00/+0.05 in H_2O of the ESP measured after setting airflow for that test. 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), the average airflow rate measured over the course of the test shall be within ± 3 % of the airflow rate measured after setting airflow for that test.

6.1.3.5.3.3 For heating tests and part-load cooling tests for which an airflow is not specified by the manufacturer and the full-load cooling airflow is not used as the airflow for the test (because the manufacturer provides 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 adjust the system control input to obtain the heating or part-load cooling operation specified by the manufacturer. 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. After setting the airflow, no changes are to be made to the fan control settings.

6.1.3.5.4 *Heating Test for MZVAV Units*

6.1.3.5.4.1 For tests for which the manufacturer specified heating airflow is the same as the manufacturer specified full-load cooling airflow (and for heating tests for which an airflow is not specified and the full-load cooling 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.

6.1.3.5.4.2 For tests for which the manufacturer specified heating airflow differs from the full-load cooling airflow, use the following provisions.

6.1.3.5.4.2.1 Operate the system under conditions specified for the heating test using the manufacturer specified fan control settings for the heating test. If the manufacturer does not specify fan control settings for the heating test, use the fan control settings for the full-load cooling test. If the manufacturer does not specify 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 manufacturer specified heating airflow. If ESP or airflow are higher than the tolerance range, adjust the fan control settings (e.g., 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 (e.g., 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. After setting the airflow, no changes are to be made to the fan control settings.

6.1.3.5.4.2.3 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), the average value of the ESP measured over the course of the test shall be within -0.00/+0.05 in H_2O of the ESP measured after setting airflow for that test. 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), the average airflow rate measured over the course of the test shall be within ± 3 % of the airflow rate measured after setting airflow for that test.

6.1.3.5.4.3 If a heating airflow is not specified by the manufacturer and the manufacturer specified full-load cooling airflow is not used as the airflow for the heating test (because the manufacturer provides 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 fan control setting for the heating test or adjust the system control input to obtain the heating operation specified by the manufacturer. 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. After setting the airflow, no changes are to be made to the fan control settings.

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 in excess of the 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 in excess of the 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 note when indoor leaving dry bulb temperature is not in tolerance.

6.1.3.6 *Outdoor Airflow Rate.* All Standard Ratings shall be determined at the outdoor airflow rate at zero external static pressure. 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 by the manufacturer or as determined by automatic controls. Once established, no changes affecting outdoor airflow shall be made unless automatically adjusted by unit controls.

6.1.3.6.1 *Double-duct System*. For products intended only to be installed with the outdoor airflow ducted, the unit shall be installed with outdoor coil ductwork installed per manufacturer's installation instructions and shall operate at 0.0 in H_2O external static pressure. External static pressure measurements shall be made in accordance with Section 6.4 and Section 6.5 of ANSI/ASHRAE Standard 37.

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

6.2.1. *IEER Requirements.* The general 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 7.

Table 7. 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 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.

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

Where:

A = EER, Btu/W·h, at 100% Capacity at AHRI Standard Rating Conditions (see Table 5)
B = EER, Btu/W·h at 75% Capacity and reduced condenser temperature (see Table 8)
C = EER, Btu/W·h at 50% Capacity and reduced condenser temperature (see Table 8)
D = EER, Btu/W·h at 25% Capacity and reduced condenser temperature (see Table 8)

The IEER rating requires that the unit efficiency be determined at 100, 75, 50, and 25 Percent Load at the conditions specified in Table 6 and at the part-load rated airflow, if different than the Full Load Rated Indoor Airflow.

The EER at 100% Capacity is the Standard Energy Efficiency Ratio. No additional test at 100% Cooling Capacity is required.

Table 8. 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 = 95.0 ºF 75 Percent Load = 81.5 ºF 50 Percent Load = 68.0 ºF 25 Percent Load = 65.0 ºF See note 2
Condenser (Water Cooled) Entering Condenser Water Temperature (EWT) Condenser Water Flow Rate, gpm	100 Percent Load = 85.0 ºF 75 Percent Load = 73.5 ºF 50 Percent Load = 62.0 ºF 25 Percent Load = 55.0 ºF See note 3
Condenser (Evaporatively Cooled) Entering Air Wet-bulb/Air Dry-bulb/Makeup Water Temperature (EWB/DB/MW)	100 Percent Load = 75.0 ºF/95.0 ºF/85.0 ºF 75 Percent Load = 66.2 ºF/81.5 ºF/81.5 ºF 50 Percent Load = 57.5 ºF/68.0 ºF/68.0 ºF 25 Percent Load = 52.8 ºF/65.0 ºF/65.0 ºF

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 5.6.
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 5. 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 at which to run the unit.

6.2.3 *Rating Adjustments.* Testing shall be performed at the 4 ratings loads and condenser conditions as defined in Table 8. 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 rating Percent Load of 75, 50 or 25 interpolation of the test points shall be used to determine the EER rating at the required load.

Note: In the 2015 and 2019 editions of AHRI Standard 340/360, the part-load rating condenser temperatures have been fixed at the 100, 75, 50 and 25 Percent Load values shown in Table 8. In the 2007 standard these were a function of the actual load. This change does not impact the units that can run at the 75, 50, and 25 Percent Load conditions; however, for interpolating ratings the condenser temperature is now fixed at the 75, 50 and 25 Percent Load rating points. As a result, two tests at different loads above and below the rating point shall be used for interpolating ratings. For example, if the unit is an air cooled unit and the rating for 75 Percent Load is being determined, but the unit can only run at 80 Percent Load and 60 Percent Load, then the unit can be run at those Percent Loads at the same outdoor air temperature and the 75 Percent Load rating can interpolated (see Figure 1). Figure 1 also shows the difference between the AHRI Standard 340/360 2007 and 2019 editions.

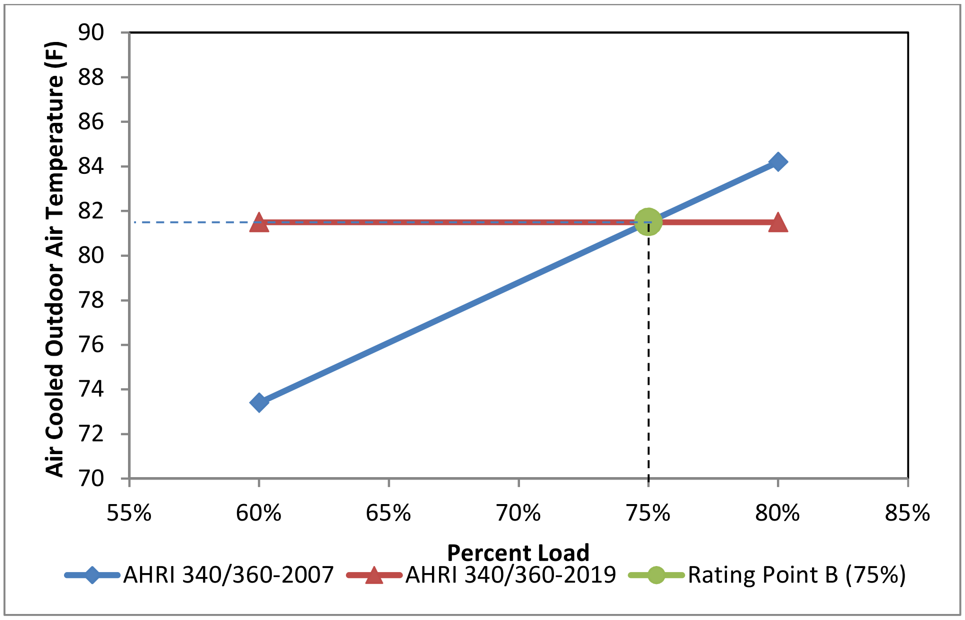

Figure 1. Example Revised Part Load Ambient Conditions for Interpolation

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 minimum rated indoor airflow at the condenser conditions defined for each of the rating Percent Load IEER points listed in Table 8 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	=	The degradation coefficient to account for cycling of the compressor for capacity less than the minimum step of capacity. C_D shall be determined using Equation 5.
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, watts. For air cooled and evaporatively cooled units this power is the power of the fans and pumps. For water cooled units with a capacity of 65,000 Btu/h to less than 135,000 Btu/h it shall be the cooling tower power allowance per Section 6.1. Above 135,000 Btu/h, it shall be 0.
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

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

Where:

LF	=	Fractional “on” time for last stage at the desired load point, Noted in Equation 6.

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

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 part-load Percent Load rating points for 75, 50 and 25 Percent Load shall be determined at the Percent Load rating condenser entering temperature defined in Table 8 within tolerances defined in Section 6.3.

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

6.2.4.2 *Step 2.* The rating 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 covered by this standard, the IEER shall be calculated using Equation 3 and the following procedures.

Staged Capacity Controlled Units, for test purposes, shall be provided with the manual 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 rating points, the unit shall be configured per the manufacturer's installation instructions, including setting of stages of refrigeration for each part-load rating point. The stages of refrigeration that result in capacity closest to the desired IEER part-load rating EER point shall be used.

The condenser entering temperature shall be adjusted per the requirements of Table 6 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, based on the full load measured test Cooling Capacity, above or below the target part-load capacity point, the EER at each load point shall be used to determine IEER without any interpolation or adjustment for cyclic degradation. See Table 9.

Table 9. 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 rating 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 8 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 8 for the target load fraction, within a tolerance of ± 0.5 ºF. Of the two tests, one test point shall be at a capacity stage above the target load point and the second test point shall be at a capacity stage below the target load point. The data from these two test points shall then be used to interpolate the rating 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 points 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 rating shall be determined at the minimum stage of unloading and part-load rating condenser entering temperature defined in Table 6 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 rating points are within 3% of the desired IEER rating point of 75, 50 and 25, Percent Load they shall be used directly. If there are ratings points above and below the desired IEER rating of 75, 50, and 25 Percent Load then the rating data the IEER rating point shall be determined using linear interpolation. If the rated 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 ratings data 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 rating point 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 Controlled Units.* For Proportionally Controlled Units covered by this standard, the IEER shall be calculated using data, Equation 3, and the following procedures.

Proportionally Controlled Units, for test purposes, shall be provided with manual means to adjust the unit refrigeration capacity in steps no greater than 5% of the full load rated capacity by adjusting variable capacity compressor(s) and or the stages of refrigeration capacity.

The following sequential steps shall be followed.

6.2.6.1 *Step 1.* For part-load rating 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 rating points. The settings that result in capacity closest to the target Percent Load rating point of 75, 50, or 25 shall be used.

The condenser entering conditions shall be adjusted per the requirements of Table 8 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 test Cooling Capacity, the EER at each load point shall be used to determine IEER without any interpolation.

If the unit, due to its capacity control logic 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 ambient test conditions shall be within tolerances defined in ANSI/ASHRAE Standard 37 and Section 6.3 of the specified ambient in Table 8 based on the IEER rating point of 75, 50 or 25 Percent Load.

6.2.6.1.2 The indoor Standard Air airflow shall be set as specified by the manufacturer 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 is closest to the IEER percent part-load rating point.

Note: For example, to obtain a 50 Percent Load rating point for a unit having test points at both 60 and 70 Percent Load, the 60 Percent Load test point shall be used.

6.2.6.1.4 The measured part-load capacity of the second test point shall be less than the part-load rating capacity point if the measured capacity of the first test is greater than the part load rated 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 rating shall be determined at the minimum stage of unloading and part-load rating condenser entering temperature defined in Table 8 within tolerances defined in ANSI/ASHRAE Standard 37 and Section 6.3.

Note: The actual Percent Load will be greater than the required Percent Load and will be adjusted for cyclic performance using the degradation calculations as per step 2. Part Load Rated Indoor Airflow and static, if different than Full Load Rated Indoor Airflow, shall be used as defined by the manufacturer and as required by Section 6.1.

6.2.6.2 *Step 3.* If any of the corrected rating points are within ±3% of the desired IEER rating point of 75, 50 and 25 Percent Load, they shall be used directly. If there are corrected ratings points above and below the desired IEER rating of 75, 50, and 25 Percent Load, then the rating data the IEER rating point shall be determined using linear interpolation. If the corrected rated Percent Load is greater than the Percent Load for 75, 50 or 25 by more than 3%, then the ratings data at the condenser conditions required for the rating point shall be used along with the degradation procedure defined in Section 6.2.3.2.

6.2.6.3 *Step 4*. The rating point 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 several 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 of 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 10.

Table 10. Tolerances

Measurement	Test Operating Tolerance	Test Condition Tolerance
Outdoor dry-bulb temperature (°F):		
Entering	2.0	0.5
Leaving	2.0 / 3.0[1,3]	-
Outdoor wet-bulb temperature (°F):		
Entering	1.0	0.3[2]
Leaving	1.0[3]	-
Outdoor dew point temperature (°F)[6]:		
Entering	6.0	3.0
Indoor dry-bulb temperature (°F):		
Entering	2.0	0.5
Leaving	2.0 / 3.0[1,4]	-
Indoor wet-bulb temperature (°F):		
Entering	1.0	0.3
Leaving	1.0	-
Water serving outdoor coil temperature (°F):		
Entering	0.5	0.2
Leaving	0.5	0.2
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	-
Electrical voltage (percent of reading)	2.0	1.0
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. Applies only when using the indoor air enthalpy method.
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 for which all or part of the indoor section of the equipment is located in the outdoor chamber.

6.4 *Secondary Verification.* Secondary verification measurements of cooling and Heating Capacity (if applicable) are described in Section E6 of this standard and shall be conducted for all full-load cooling and heating tests for equipment with Cooling Capacity less than 135,000 Btu/h. Capacity measurements from the primary and secondary tests shall match within ± 6% for the full-load cooling and heating (if applicable) tests. For equipment with a certified Cooling Capacity less than 135,000 Btu/h, 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, no match between primary and secondary measurements is required for part-load cooling tests.

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.

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

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

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*. As required by Federal Law (10 CFR §429.71), supporting documentation of all Published Ratings for products with a Cooling Capacity ≤ 760,000 Btu/h and subject to federal control shall be appropriately maintained.

6.6 *Uncertainty.* When testing a sample unit, there are uncertainties that shall be considered. 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 may not 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 may use performance prediction tools like 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 may not 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 11 with the listed Acceptance Criteria

Table 11. 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)". Wherever Application Ratings are published or printed, they shall include a statement of the conditions at which the ratings apply.

7.2 *Latent Capacity Designation.* The moisture removal capacity at Standard Rating Conditions listed in Table 5 shall be published in the manufacturer's specifications and literature. The value shall be expressed consistently in either gross capacity or net capacity in one or more of the following forms:

7.2.1 Sensible Capacity/capacity ratio (Sensible Heat Factor) and Cooling Capacity, Btu/h

7.2.2 Latent Capacity and Cooling Capacity, Btu/h
7.2.3 Sensible Capacity and Cooling Capacity, Btu/h

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

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 5.

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 period sufficient to cause the compressor to stop (not to exceed five 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 which 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 80.0 ºF dry-bulb, 67.0 ºF wet-bulb
8.2.5.3 Outdoor air entering outdoor air cooling coil shall be 115 ºF dry-bulb and 75.0 ºF 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 5.

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% from 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 5.

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 which 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 5.

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 ± 1.0 ºF for air wet-bulb and dry-bulb temperatures, ± 0.5 ºF 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 Hertz systems shall include one or more of the equipment nameplate voltage ratings shown in Table 1 of AHRI Standard 110. Nameplate voltages for 50 Hertz 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, *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.

A1.4 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.

A1.5 ANSI/AHRI Standard 390 (I-P)-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.

A1.6 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.

A1.7 ANSI/AHRI Standard 920 (I-P)-2015, *Performance Rating of DX-Dedicated Outdoor Air System Units*, 2015, Air-Conditioning, Heating and Refrigeration Institute, 2311 Wilson Boulevard, Suite 400, Arlington, VA 22201, U.S.A

A1.8 ANSI/ASHRAE Standard 34-2016, *Designation and Safety Classification of Refrigerant,* 2016, American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc., 1791 Tullie Circle N.E., Atlanta, GA 30329, U.S.A.

A1.9 ANSI/ASHRAE Standard 37-2009, *Methods of Testing for Rating Unitary Air-Conditioning and Heat Pump Equipment*, 2009, American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc., 1791 Tullie Circle N.E., Atlanta, GA 30329, U.S.A.

A1.10 ANSI/ASHRAE Standard 41.1-2013, *Standard Method for Temperature Measurement,* 2013, American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc., 1791 Tullie Circle N.E., Atlanta, GA 30329, U.S.A.

A1.11 ANSI/ASHRAE Standard 41.6-2014, *Standard Method for Humidity Measurement, 2014,* American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc., 1791 Tullie Circle N.E., Atlanta, GA 30329, U.S.A.

A1.12 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.

A1.13 ANSI/CAN/AHRI Standard 540-2015, *Standard For Performance Rating Of Positive Displacement Refrigerant Compressors And Compressor Units*, 2015, Air-Conditioning, Heating and Refrigeration Institute, 2111 Wilson Boulevard, Suite 500, Arlington, VA 22201, U.S.A.

A1.14 ANSI/NEMA MG1-2016, *Motors and Generators,* 2016, National Electrical Manufacturers Association, 1300 North 17th Street, Suite 900, Rosslyn, Virginia 22209

A1.15 ASHRAE Terminology, https://www.ashrae.org/resources--publications/free-resources/ashraeterminology, 2019, American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., 1791 Tullie Circle, N.E., Atlanta, GA 30329, U.S.A.

A1.16 ASTM B117-2018, *Standard Practice for Operating Salt Spray (Fog) Apparatus,* 2018, ASTM International, 100 Barr Harbor Drive, PO Box C700, West Conshohocken, PA 19428-2959, U.S.A.

A1.17 ASTM G85-2011, *Standard Practice for Modified Salt Spray (Fog) Testing,* 2011, ASTM International, 100 Barr Harbor Drive, PO Box C700, West Conshohocken, PA 19428-2959, U.S.A.

A1.18 CSA - C747-09 (R2014)**,** *Energy Efficiency test methods for small motors*, 2009, CSA Group, 178 Rexdale Blvd., Toronto, Ontario M9W 1R3 Canada

A1.19 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.

A1.20 UL Standard 555-2006*, Standard for Fire Dampers,* 2006, Underwriters Laboratories, Inc., 333 Pfingsten Road, Northbrook, IL, U.S.A.

A1.21 UL Standard 555S-2014*, Standard for Smoke Dampers,* 2014, Underwriters Laboratories, Inc., 333 Pfingsten Road, Northbrook, IL, U.S.A.

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.

B1.1 AHRI Guideline V (I-P)-2011, *Calculating the Efficiency of Energy Recovery Ventilation and its Effect on Efficiency and Sizing of Building HVAC Systems,* Air-Conditioning, Heating and Refrigeration Institute, 2311 Wilson Boulevard, Suite 400, Arlington, VA 22201, U.S.A.

B1.2 AHRI Standard 520-2004, *Performance Rating for Positive Displacement Condensing Units, 2004,* Air-Conditioning, Heating and Refrigeration Institute, 2311 Wilson Boulevard, Suite 400, Arlington, VA 22201, U.S.A.

B1.3 ANSI/ASHRAE/IES Standard 90.1 (I-P)-2016, *Energy Standard for Buildings Except Low-Rise Residential Buildings,* 2016, American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc., 1791 Tullie Circle N.E., Atlanta, GA 30329, U.S.A.

B1.4 ANSI/ASHRAE 62.1-2016, *Ventilation for Acceptable Indoor Air Quality,* 2016*,* American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc., 1791 Tullie Circle N.E., Atlanta, GA 30329, U.S.A.

B1.5 ISO 5151-2017, *Non-ducted air-conditioners and heat pumps – Testing and rating for performance,* 2017, International Organization for Standardization, Case Postale 56, CH-1211, Geneva 21 Switzerland.

B1.6 ISO 13253-2017, *Ducted air-conditioners and air-to-air heat pumps – Testing and rating for performance,* 2017, International Organization for Standardization, Case Postale 56, CH-1211, Geneva 21 Switzerland.

B1.7 ISO 15042-2017, *Multiple split-system air-conditioners and air-to-air heat pumps – Testing and rating for performance,* 2017, International Organization for Standardization, Case Postale 56, CH-1211, Geneva 21 Switzerland.

B1.8 UL Standard 1995/CSA Standard 22.2 No. 236-2015, *Heating and Cooling Equipment*, 2015, Underwriters Laboratories, Inc., 333 Pfingsten Road, Northbrook, IL, U.S.A./Canadian Standards Association, 178 Rexdale Boulevard, Etobicoke, Ontario, M9W 1R3, Canada.

APPENDIX C. INDOOR AND OUTDOOR AIR CONDITION MEASUREMENT - NORMATIVE

Note: 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.

C1 *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, also measure indoor air leaving dry-bulb temperature and water vapor content. When using the outdoor air enthalpy method to measure equipment capacity, also 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. Also, maintain test operating and test condition tolerances and uniformity requirements as described in Section C2.7.

C2 *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, also measure water vapor content as provided in Section C2.2.

C2.1 *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 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 Requirements

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.

C2.2 *Psychrometer or Hygrometer Requirements*. If measurement of water vapor is required, use one of the following two methods.

C2.2.1 *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 of which shall be used for the facility temperature measurement and one of which shall be available to confirm this measurement using an additional or a third-party's temperature sensor probe. For applications where the humidity is also 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 of which one shall be used for the facility wet-bulb measurement and one of which shall be available 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. A typical configuration for the Aspirating Psychrometer is shown in Figure C1.

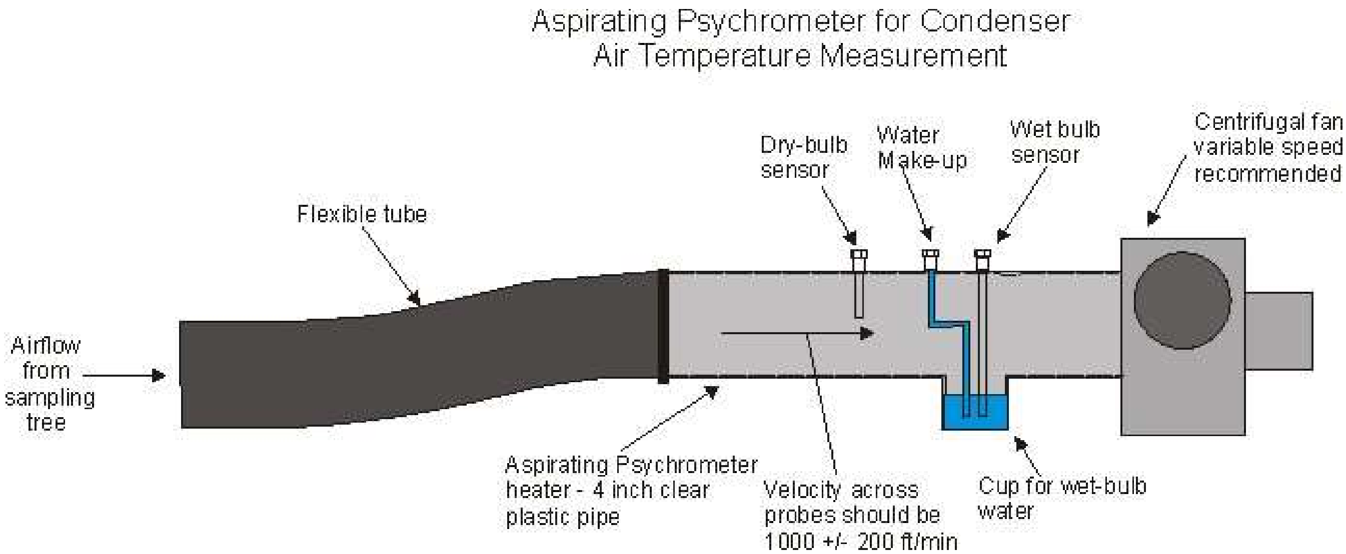

Figure C1. Aspirating Psychrometer

C2.2.2 *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.

C2.3 *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. A typical configuration for the sampling tree is shown in Figure C2 for a tree with overall dimensions of 4 ft by 4 ft sample.

Note: Other sizes and rectangular shapes can be used, and should 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 suitable, 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 sampling tree holes shall be 2.5 ft/sec 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 sampling tree and to the Aspirating Psychrometer.

The sampling tree shall also be equipped with a thermocouple thermopile grid or with individual thermocouples to measure the average temperature of the airflow over the sampling tree. The thermocouple arrangement shall have at least 16 measuring points per sampling tree, evenly spaced across the sampling tree. The air sampling trees shall be placed within 6 to 12 in from the inlet face of the unit to minimize the risk of damage to the unit while ensuring that the air sampling tubes are measuring the air going into the unit rather than the room air around the unit.

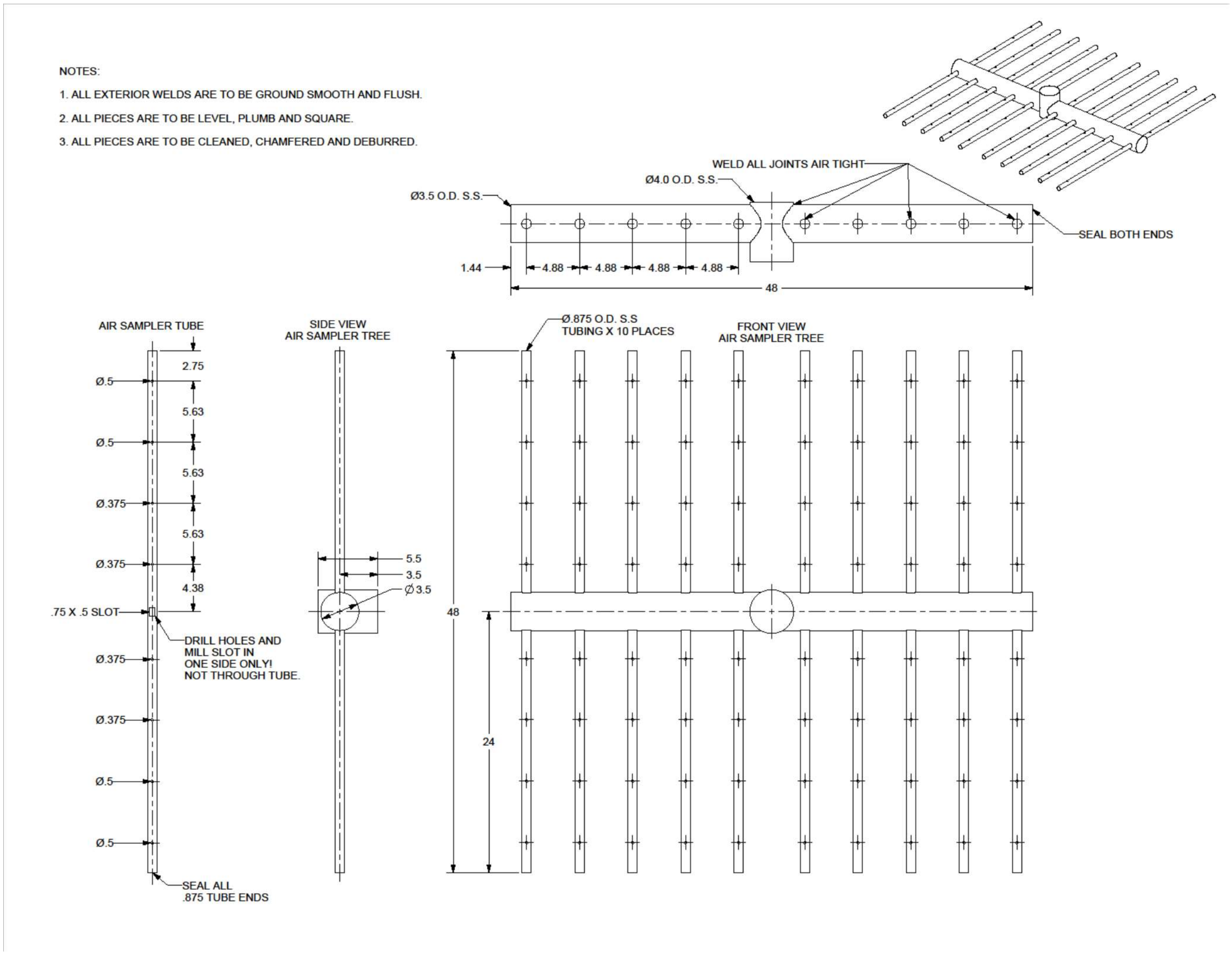

Figure C2. Typical Air sampling tree

Note: The 0.75 in by 0.50 in slots referenced in Figure C2 are cut into the branches of the sampling tree and are located inside of the trunk of the sampling tree. They are placed to allow air to be pulled into the main trunk from each of the branches.

C2.3.1 *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.

Note: The nominal face area may extend beyond the outdoor coil depending on coil configuration and orientation, and shall include all regions through which air enters the unit.

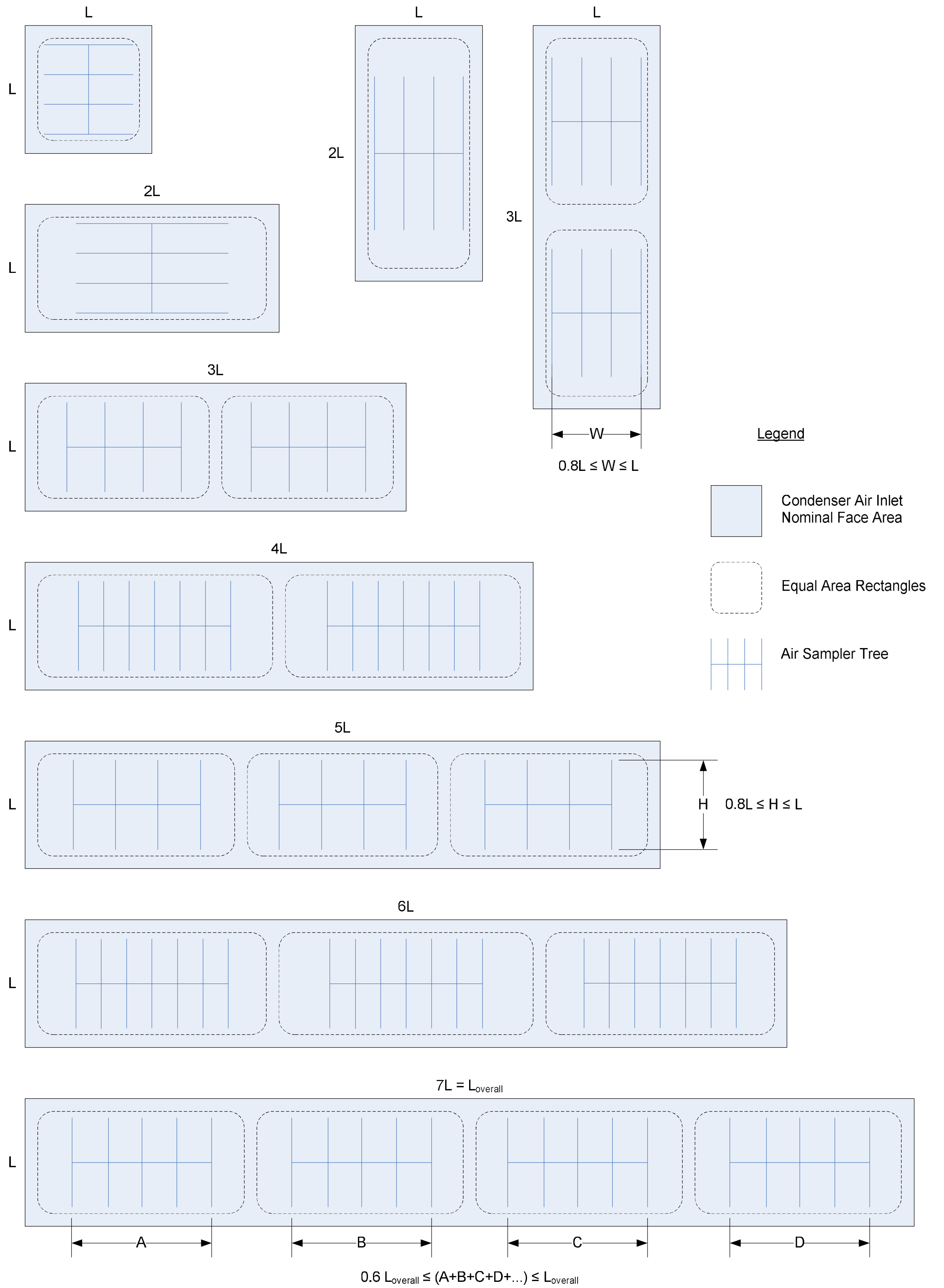

Figure C3. Determination of Measurement Rectangles and Required Number of air sampling trees

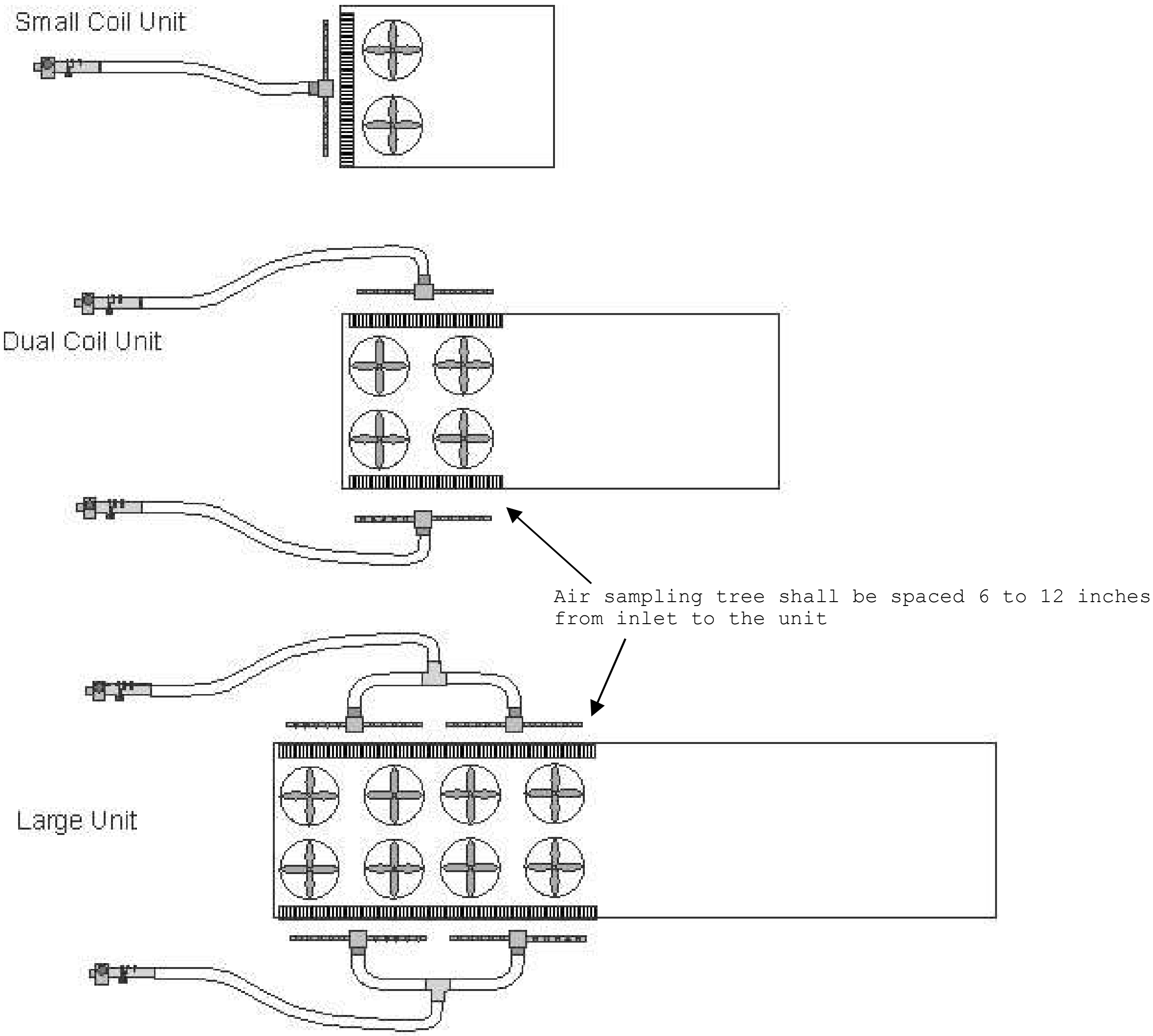

Figure C4. Typical Test Setup Configurations

A minimum of one Aspirating Psychrometer per side of a unit shall be used. For units with three (3) sides, two (2) sampling Aspirating Psychrometers can 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.

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). The sampling trees shall not extend beyond the face of the air entrance area. The sample trees shall be located 6 to 12 in from the inlet face of the unit. It is acceptable to block all branch inlet holes that extend beyond the face of the unit. 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 (4) sampling trees shall be connected to each Aspirating Psychrometer. The sampling trees shall be connected to the Aspirating Psychrometer 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 sampling trees for a given Aspirating Psychrometer, the flexible tubing shall be of equal lengths for each sampling tree. Refer to Figure C4 for some typical examples of air sampling tree and Aspirating Psychrometer 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 psychrometer(s) or, if not using psychrometers, equivalent 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 from which the system draws the outdoor coil intake air.

C2.4 *Dry-bulb Temperature Measurement*. Measure dry-bulb temperatures using the psychrometer dry-bulb sensors, or, if not using psychrometers, use dry-bulb temperature sensors with accuracy as described in Section C2.1. Measure the dry-bulb temperature within the conduit conducting air sampler air to the fan at a location between the air sampler exit to the conduit and the fan. When a fan draws air through more than one air sampler, the dry-bulb temperature may 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—instead use the air-sampler-exit measurement when checking temperature uniformity.

C2.5 *Wet-Bulb or Dew Point Temperature Measurement to Determine Air Water Vapor Content*. Measure wet-bulb temperatures using one or more psychrometers or measure dew point temperature using one or more hygrometers. If using 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 may be measured separately for each air sampler or for the combined set of air sampler flows.

When more than one air sampler feeds a single water vapor content measurement instrument, measure relative humidity as required in Section C2.7 to allow assessment of water vapor content uniformity.

C2.6 *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 (e.g., 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 psychrometer dry-bulb and wet-bulb temperature measurements or the hygrometer dew point 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 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. Also, 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.

C2.7 *Temperature Uniformity.* To ensure adequate air distribution, thorough mixing, and uniform air temperature, it is important that the room and test setup is properly designed and operated. The room conditioning equipment airflow shall be set such that recirculation of outdoor discharged air is avoided except as may 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 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 ensure adequate air distribution in the test room. If used, mixing fans shall be oriented such that they are 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 psychrometers, the “psychrometer dry-bulb temperature measurement” of Table C2 refers to either (a) the dry-bulb temperature measurement in a single common air conduit serving one or more air samplers or (b) the average of the dry-bulb temperature measurements made separately for each of the air samplers served by a single air sampler fan. Similarly, “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 1.5 ºF dry-bulb temperature tolerance in Table C2 between the air sampler thermopile (thermocouple) measurements and 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.

When water vapor content measurement is required, also confirm uniformity of wet-bulb temperature variation among air samplers. When more than one air sampler feeds a single Aspirating Psychrometer or dew point sensor, measure relative humidity of the air external to each of these air samplers using a relative humidity sensor having ± 2 % relative humidity accuracy located within 3 inches of geometric center of the air sampler. Calculate wet-bulb temperature for these air samplers using the relative humidity measurement and the dry-bulb temperature measurements from either the thermopiles (thermocouple grid averages), or the measurements at the air sampler exits. The maximum allowable difference between the calculated wet-bulb temperature for any air sampling tree and the average wet-bulb temperature for all air samplers used to measure outdoor entering air conditions is 1.00 ºF.

A valid test shall meet the criteria for adequate air distribution and control of air temperature as shown in Table C2.

Table C2. Criteria for Air Distribution and Control of Air Temperature		
Dry-bulb Temperature	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 temperature distribution	± 2.00
Difference between dry-bulb temperature measured with air sampler tree thermopile and with Aspirating Psychrometer	Uniform temperature distribution	± 1.50
Difference between mean dry-bulb air temperature and the specified target test value[2]	Test condition tolerance, for control of air temperature	± 0.50
Mean dry-bulb air temperature variation over time (from the first to the last of the data sets)	Test operating tolerance, total observed range of variation over data collection time	± 1.50
Wet-bulb Temperature[3]		
Deviation of calculated local air sampler wet-bulb temperatures and the mean wet-bulb temperature	Uniform humidity distribution	± 1.00
Deviation from the mean wet-bulb temperature and the individual temperature measurement stations	Uniform humidity distribution	± 1.00
Difference between mean wet-bulb air temperature and the specified target test value[2]	Test condition tolerance, for control of air temperature	± 1.00
Mean wet-bulb air temperature variation over time	Test operating tolerance, total observed range of variation over data collection time (from the first to the last of the data sets)	± 1.00

Notes:

1. Each measurement station represents an average value as measured by a single Aspirating Psychrometer.
2. Applies when multiple air samplers are connected to a single psychrometer or conduit dry-bulb temperature sensor. If the average of the thermopile measurements differs from the 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 mean dry-bulb temperature is the mean of all measurement stations.
4. The wet-bulb temperature measurement is only required for outdoor entering air for evaporatively-cooled units and heat pump units operating in heating mode.

C3 *Indoor Coil Entering Air Conditions.* Follow the requirements for outdoor coil entering air conditions as described in Section C2, except for the following.

C3.1 Both dry-bulb temperature and water vapor content measurements are required for all tests.

C3.2 Sampled air shall be returned to the room from which 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, in which case 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).

C3.3 The temperature uniformity requirements discussed in Section C2.7 do not apply if a single air sampler is used.

C3.4 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—this rectangle shall have dimensions that are at least 75 % of the duct's respective dimensions.

C4 *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.

The temperature uniformity requirements discussed in Section C2.7 do not apply.

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.

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. Insulate the conduit transferring the air from the air sampler fan discharge to the duct.

For a coil with a blow-through fan (i.e., 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

Purpose. This appendix is used to determine the configuration of different components for determining representations, which include the Standard Rating Cooling and Heating Capacity and efficiency metrics.

D1 *Configuration Requirements*. For the purpose of Standard Ratings, units shall be configured for testing as defined in this Appendix.

D1.1 *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.

D.1.2 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 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.

- Compressor(s)
- Outdoor coil(s) or heat exchanger(s)
- Outdoor fan/motor(s) (air-cooled systems only)
- Indoor coil(s)
- Refrigerant expansion device(s)
- Indoor fan/motor(s) (except for Coil-Only Indoor Units)
- 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:

- Reverse cycle heat pump functionality
- Gas furnace
- Electric resistance
- Steam and hydronic coils (if not optional per Section D2.10)

D2 *Optional System Features*. The following features are optional during testing. Individual models with these features may 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 so as to minimize (partially or totally) the impact on the results of the test. Alternatively, the manufacturer may 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.

D2.1 *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.

D2.2 *High-Effectiveness Indoor Air Filtration*. Indoor air filters with greater air filtration effectiveness than the Standard Filter.

D2.3 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. They provide significant energy efficiency improvements on an annualized basis, but are also a function of regional ambient conditions and are not considered 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 using tape or equivalent means to block any leakage.

D2.4 *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.

D2.5 *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 using tape or equivalent means to block any leakage.

D2.6 *Ventilation Energy Recovery System (VERS)*. An assembly that pre-conditions outdoor air entering equipment through direct or indirect thermal and/or moisture exchange with the unit's exhaust air, which 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.

D2.6.1 *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.

D2.7 *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.

D2.8 *Evaporative Pre-cooling of 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, i.e. without active evaporative cooling.

D2.9 *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.

D2.10 *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 (e.g. 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.

D2.11 *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.

D2.12 *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).

D2.13 *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.

D2.14 *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.

D2.15 *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.

D2.16 *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 in order 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 (*i.e.*, if the indoor fan VFD is installed and active for the IEER test it shall also be installed and active for the EER test).

D2.17 *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 (*i.e.*, if the compressor VFD is present and active for the IEER test it shall also be present and active for the EER test).

D2.18 *Non-Standard Ducted Condenser Fans*. 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 (either without ducts connected, or, if using the outdoor air enthalpy method, with ESP set to zero). Non-standard ducted condenser fans are not considered an optional feature for Double-duct Systems.

D2.19 *Sound Traps/Sound Attenuators*. An assembly of structures through which the Supply Air passes before leaving the equipment or through which the return air from the building passes immediately after entering the equipment for which the sound insertion loss is at least 6 dB for the 125 Hz octave band frequency range.

D2.20 *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 may 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.

D2.21 *Hot Gas Bypass*. A method for adjusting Cooling Capacity that diverts a portion of the high pressure, hot gas refrigerant from the outdoor coil and delivers it to the low pressure portion of the refrigerant system. If hot gas bypass is present for testing, set the hot gas bypass as indicated in manufacturer's supplemental testing instructions.

D3 *Non-Standard Indoor Fan Motors*. The standard indoor fan motor is the motor specified by the manufacturer 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 Section D.3.1. If the standard indoor fan motor can vary fan speed through control system adjustment of motor speed, all non-standard indoor fan motors shall also allow speed control (including with the use of VFD).

D3.1 *Determination of Motor Efficiency for Non-standard Indoor Fan Motors.*

D3.1.1 Standard and non-standard indoor fan motor efficiencies shall be based on the test procedures indicated in Table D1.

D3.1.2 Reference motor efficiencies shall be determined for the standard and non-standard indoor fan motor as indicated in Table D1.

D3.1.3 Non-standard motor efficiency shall meet the criterion in equation D1.

$$\eta_{non-standa} \geq \frac{\eta_{standard}-\eta_{reference\ sta}}{1-\eta_{reference\ stand}} \cdot \left(1-\eta_{reference\ non-standar}\ \right)+\eta_{reference\ non-standa} \qquad \text{(D1)}$$

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 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 in which 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 in which 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 747-09[5]	Federal standard levels for 4 pole, open motors at 10 CFR 431.25(h).
BLDC motor or ECM < 1 hp	CSA 747-09[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 (i.e., 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 747-09 may 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

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 (i.e., 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.

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. In general, the 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 energy (in W·h) shall be measured. Power measurements shall be made with a sampling rate of no less than 1 per second and shall be timestamped. Energy measurements shall be made with an integrating watt-hour meter with a sampling rate of no less than 1 per 15 seconds.

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*. For equipment with a certified Cooling Capacity less than 135,000 Btu/h, use one of the applicable 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. For equipment with a certified Cooling Capacity less than 135,000 Btu/h, 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 E6.3 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 (i.e., 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*. For equipment with a certified Cooling Capacity less than 135,000 Btu/h, the total Cooling or Heating Capacity values measured with the primary and secondary capacity measurement methods for the full-load cooling and heating tests (as applicable) as prescribed in Section E6.2 shall agree as specified in Section 10.1.2 of ANSI/ASHRAE Standard 37. 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 (see Section E6.5.1). 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). Use measurements from the free outdoor air test (i.e., indoor air enthalpy method capacity measurements and power input) as the applicable measurements for determination of efficiency metrics, provided the conditions of Section E6.5.1.4 are met.

E6.5.1. 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. 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).

E6.5.1.2. Continue these measurements until the applicable test tolerances are satisfied for a 30-minute period (e.g., seven consecutive 5-minute samples).

E6.5.1.3. Evaporator and Condenser Measurements. To measure evaporator and condenser pressures, solder a thermocouple onto a return bend located at or near 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 in excess of 1 °F at the specified test conditions.

E6.5.1.4. 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 and the indoor air enthalpy method shall agree within 6%.
(2) The capacity determined using the indoor air enthalpy method from the ducted outdoor air test and the capacity determined using the indoor air enthalpy method from the free outdoor air test shall agree within 2%.

E6.5.2. Ducted Outdoor Air Test.

E6.5.2.1. 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 for which the applicable test tolerances are satisfied.

E6.5.2.2. 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.

E6.5.2.3. 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.

E7 *Head Pressure Control for Air-cooled, Water-cooled, and Evaporatively-cooled Units*. For units that have condenser head pressure control to ensure 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 (*e.g.* 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 (*e.g.*, 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 (*e.g.* outdoor air dry-bulb temperature or condenser water temperature) defined by Table 6 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 6 shall be approached from at least a 5 ºF 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

		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 for which 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 require 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 – *Evaporative Cooled Condenser Makeup and Blowdown Water.*

E8.1 *Makeup Water Temperature.* For evaporative cooled units the Makeup Water shall be maintained at the test condition outdoor air dry-bulb. 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.

F8.2 *Blow-down Water*. Any blow-down water used for control of material byproducts of evaporation shall be turned off during the test.

APPENDIX F. INTERNATIONAL RATING CONDITIONS - INFORMATIVE

F1 *International Rating Conditions***.** These are optional 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 also be conducted at the H2 and/or H3 temperature conditions if the manufacturer rates the equipment for operation at one or both of these temperature conditions.

Table F1. International Air Cooled Standard Rating Conditions

Cooling – Temperature Conditions	T1 (Moderate Climates)	T2 (Cool Climates)	T3 (Hot Climates)
Indoor	80.6°F DB & 66.2°F WB	69.8°F DB & 59.0°F WB	84.2°F DB & 66.2°F WB
Outdoor	95.0°F DB & 75.2°F WB	80.6°F DB & 66.2°F WB	114.8°F DB & 75.2°F WB
Heating – Temperature Conditions	H1 (Warm Climates)	H2 (Moderate Climates)	H3 (Cold Climates)
Indoor	68.0°F DB and 59.0°F WB maximum.	68.0°F DB and 59.0°F WB maximum.	68.0°F DB and 59.0°F WB maximum.
Outdoor	44.6°F DB and 42.8°F WB	35.6°F DB and 33.8°F WB	19.4°F DB and 17.6°F WB

Note: DB = dry-bulb and WB = wet-bulb.

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 F1.

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 sufficient to cause the compressor to stop (not to exceed 5 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. For this Appendix the test descriptions will be A for 100 Percent Load, B for 75 Percent Load, C for 50 Percent Load and D for 25 Percent Load. It includes all mechanical cooling energy, fan energy and other energy required to deliver the mechanical cooling, but excludes energy and Cooling Capacity for operating hours seen for just ventilation, economizer operation and does not include system control options like demand ventilation, Supply Air reset, energy recovery and other system options that might be used in an applied configuration of the unit. It also 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 many factors including, but not limited to, local occupancy schedules, ambient conditions, building construction, building location, ventilation requirements and added features like economizers, energy recovery, evaporative cooling, etc. IEER is 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 like 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.

Table G1. Table of Contents of Examples

G3 *Fixed Capacity Control Examples*. In this section you will find example IEER calculations for Fixed Capacity Controlled Units (single stage) as defined in Section 6.2.4.

Note that per Section 3.8 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.

Rated Capacity = 91,000 Btu/h
Full Load Rated Indoor Airflow = 2,600 scfm
Rated EER = 11.2 $Btu/W \cdot h$
Rated IEER = 11.0 $Btu/W \cdot h$

Shown below are 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 Note the pressure could vary between tests and it should be measured for each test.

Table G2A 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	CFM	W	W	W	W	Btu/W·h
1	1	95.1	95.0	100.0	92,293	2,610	6,723	518	831	50	11.36
2	1	81.7	81.5	103.5	95,523	2,610	6,309	518	831	50	12.39
3	1	67.6	68.0	104.0	95,943	2,610	5,874	518	831	50	13.19
4	1	65.3	65.0	107.2	98,927	2,610	5,803	518	831	50	13.74

Because the unit only has a single stage of capacity control, the rating EER values for 75, 50, and 25 Percent Load rating points require only 3 tests to be run at the rated ambient temperatures of 81.5 ºF (75 Percent Load), 68.0 ºF (50 Percent Load), and 65 ºF (25 Percent Load) as defined in Table 6. Note that for this example all tests are acceptable as the test outdoor air temperatures are within ± 0.5 ºF 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 shall be repeated.

As per 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. Shown in table G2B are the calculations for the 4 EER rating points used to calculate the IEER.

Table G2B 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			
A	95.1	95.0	100.0	92,293	6,723	518	831	50	11.36			
			100.0	no degradation required						1.000	1.000	11.36
B	81.7	81.5	103.5	95,523	6,309	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	5,874	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	5,803	518	831	50	13.74			
Required Load			25.0	degradation required						0.233	1.100	9.22

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

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

What this means is 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.

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

What this means is 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.

$$EER = \frac{LF \cdot Q}{LF \cdot [C_D \cdot (P_C + P_{CD})] + P_{IF} + P_{CT}} = \frac{0.723 \cdot 95{,}523}{0.723 \cdot [1.036 \cdot (6{,}309 + 518)] + 831 + 50} = 11.53$$
$$= 11.39\ \mathrm{Btu/W \cdot h}$$

Similar degradation corrections are also made for the 50 and 25 Percent Load points.

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

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

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

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

That the unit is a water cooled Single Package Air-conditioners with a single compressor with no capacity control, and with a fixed speed indoor fan with the following metrics.

Rated Capacity = 76,000 Btu/h
Full Load Rated Indoor Airflow = 2,200 scfm
Rated EER = 12.1 Btu/W·h
Rated IEER = 11.2 Btu/W·h

During all the tests the atmospheric pressure was measured at 15.200 psia and was constant. Shown below is the test data for the full and part-load points

Table G3A 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	CFM	W	W	W	W	Btu/W·h
4	1	85.1	85.0	100.0	74,770	2,150	4,700	748	694	50	12.08
3	1	73.3	73.5	103.5	77,387	2,150	4,433	748	694	50	13.06
2	1	62.4	62.0	103.6	77,472	2,150	4,186	748	694	50	13.64
1	1	54.7	55.0	105.3	78,738	2,150	4,012	748	694	50	14.31

Because the unit only has a single stage of capacity the rating EER values for 75, 50, and 25 Percent Load ratings will require 3 tests to be run 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 shall 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 shall include an allowance for cooling tower fan motor and circulating water pump motor power inputs 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 calculation of the 4 rating points for calculation of the IEER. The calculations are summarized in the follow table.

Table G3B 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	4,700	748	694	50	12.08			
Required Load			100.0		no degradation required					1.0000	1.000	12.08
B	73.3	73.5	103.5	77,387	4,433	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	4,186	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 which is the 100 Percent Load rating point, the test 1 can be used directly. Because this unit only has a single stage of capacity all the B, C, and D Percent Load rating point data require the use of degradation. Looking at test rating point B which is based on test 2, you can see that the unit was targeted to be run at the 73.5 ºF condenser entering water required by Table 6 for a 75 Percent Load rating point. The actual measure condenser entering water temperature was 73.3 ºF and is within the allowable tolerance of ± 0.2 ºF as defined in ANSI/ASHRAE Standard 37 Table 2b. The actual capacity Percent Load is 103.5 which is greater than the required 75 Percent Load even with the allowable 3% tolerance so a degradation calculation shall 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 G3B
First the load factor (LF) is calculated using Equation 6.

The degradation factor calculations for point B are shown below.

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

What this means is 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.

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

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

Similar degradation corrections are also made for the 50 and 25 Percent Load points.

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

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

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

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 with no capacity control, and with a fixed speed indoor fan with the following metrics.

Rated Capacity = 86,000 Btu/h
Full Load Rated Indoor Airflow = 2,500 scfm
Rated EER = 12.2 Btu/W·h
Rated IEER = 11.5 Btu/W·h

Shown below are the test data. During all the tests the atmospheric pressure was measure at 13.900 psia and was constant so the test is acceptable as the atmospheric pressure is above minimum 13.700 psia.

Table G4A 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/h	CFM	W	W	W	W	Btu/W·h
4	1	74.3	74.5	100.0	85,617	2,110	5,283	925	789	50	12.15
3	1	66.6	66.2	101.2	86,676	2,110	5,076	925	789	50	12.67
2	1	57.7	57.5	102.6	87,878	2,110	4,838	925	789	50	13.31
1	1	52.5	52.8	103.7	88,783	2,110	4,698	925	789	50	13.74

Because the unit only has a single stage of capacity the rating EER values for 75, 50, and 25 Percent Load rating point will require 3 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 shall 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 points used for the IEER calculation and can be completed as outlined in Section 6.2.4, step 2. Shown below are the results of the calculations.

Table G4B 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/h	W	W	W	W	Btu/W·h			Btu/W·h
A	74.3	74.5	100.0	85,617	5,283	925	789	50	12.15			
Required Load			100.0		No degradation required					1.0000	1.000	12.15
B	66.6	66.2	101.2	86,676	5,076	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	4,838	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 which is the 100 Percent Load rating point the test 1 can be used directly. Because this unit only has a single stage of capacity all the B, C, and D rating point data require the use of degradation. Looking at test rating point B which is based on test 2, you can see that the unit was targeted to be run at the 66.2 ºF wet-bulb temperature required by Table 6 for a 75 Percent Load rating point. The actual measure wet-bulb 66.6 ºF and is within the allowable tolerance of ± 0.3 ºF as defined in ANSI/ASHRAE Standard 37 Table 2b. The actual capacity Percent Load is 101.2 so a degradation calculation shall 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.

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

What this means is that at a 75 Percent Load the compressor will be on 74.08% of the time and of 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.

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

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

Similar degradation corrections are also 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

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

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

G4 *Staged Capacity Controlled Unit Example Calculations.* In the following section you will find example calculations for IEER calculations for Staged Capacity Controlled Units. As defined in Section 3.3 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 procedures for these unit 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 2 refrigeration circuits with 2 manifolded compressors in each circuit for a total of 4 compressors that are all equal size. This allows for 4 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.

Rated Capacity = 368,000 Btu/h
Full Load Rated Indoor Airflow = 10,000 cfm
Fan Speed = Variable Speed
Rated EER = 10.2 Btu/W·h
Rated IEER = 11.6 Btu/W·h

Shown below are the test data. A total of 6 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 G5A 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/h	CFM	W	W	W	W	Btu/W·h
1	4	95.1	95.0	100.0	367,047	10,100	30,100	2,300	3,650	150	10.14
2	3	81.3	81.5	79.0	289,976	8,350	21,144	2,300	2,102	200	11.26
3	2	81.7	81.5	53.2	195,344	5,460	14,124	2,300	613	250	11.30
4	2	67.6	68.0	54.7	200,710	5,610	13,149	2,300	663	250	12.27
5	1	67.6	68.0	28.3	103,881	2,955	6,574	1,150	103	300	12.78
6	1	65.3	65.0	28.4	104,408	2,970	6,495	1,150	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 VAV 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

As you can see tests 2 and 3 were run at the 75 Percent Load ambient temperature of 81.5 °F. Test 2 was run with stage 3 which turns off 1 compressor and results in a measured Percent Load of 79 which is 4% greater than the required 75 Percent Load and exceeds the 3% allowable tolerance. Test 3 was run with stage 2 which turns off 2 of the compressors and results in a 53.2 Percent Load which then 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 test 4 having a Percent Load of 54.6 and test 5 having a Percent Load of 28.3. Note that 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. What this is showing is that in most cases 2 test points will be required when interpolation is going to be used to determine the rating point efficiency.

For the 25 Percent Load rating point you can see that test 6 was run at the required ambient of 65 ºF, 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 will be required.

The test data points can then be used in step 2 used to calculate the EER A, B, C, and D rating points. Shown below in Table G5B are the results 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 direct, used for interpolation and for degradation calculations.

Table G5B 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/h	W	W	0	W	Btu/W			
A	1	95.1	95.0	100.0	367,047	30,100	2,300	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	2,300	2,102	200	11.26	-	-	
	3	81.7	81.5	53.2	195,344	14,124	2,300	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	2,300	663	250	12.27	-	-	
	5	67.6	68.0	28.3	103,881	6,574	1,150	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	6,495	1,150	105	300	12.97			
	required Load			25.0	degradation of test 5 required						0.879	1.016	12.69

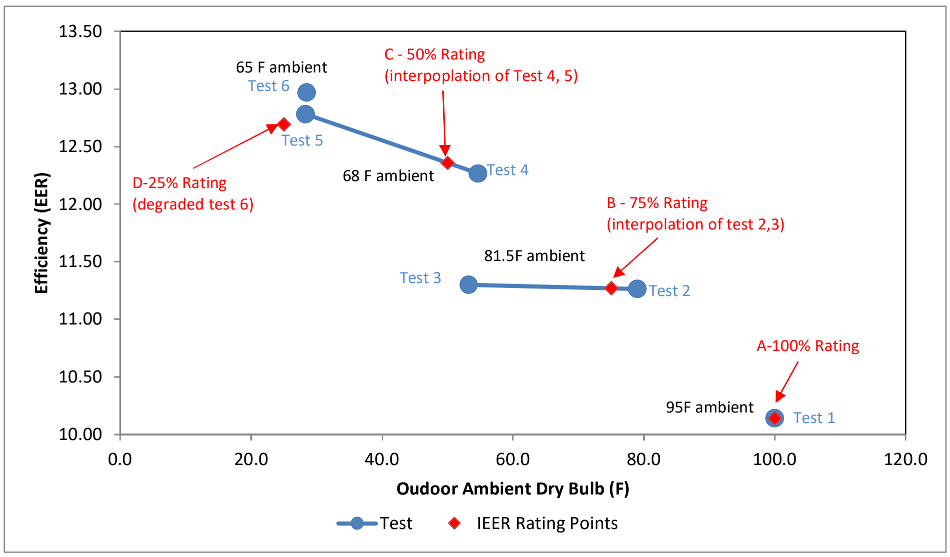

Figure G1. Example 4 Test Points Used for EER Rating Points

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

For the B rating point at 75 Percent Load interpolation shall be used. As you can see for this point we had to run test 2 and 3. Test 2 was run at stage 3 at the 75 Percent Load rating point 81.5 °F ambient as require by table 6. Test 2 was also run at the 81.5 °F ambient but with stage 2 active. Note that because this is a MZVAV unit the cfm changed to maintain the full load Dry-bulb Supply Air temperature. From these tests you can see that a Percent Load of 79.0 and 53.2 was obtained so to get to 75 Percent Load we interpolate between test 2 and 3 as shown 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 which is required to be run at 68 °F ambient as defined in table 6 we can see that test 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. Again 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, but the measured load is 28.4 Percent Load. This slightly exceeds the tolerance limit of 28% (25+3%) so a degradation calculation is performed as per Section 6.2.3 as shown below.

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

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

This implies that at the 25 Percent Load the compressor will be on for 88.03% of the time and off for 11.97% of the time.

The degradation coefficient is calculated using Equation 5.

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

What this means is 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.

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

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

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

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

G4.2 *Example 5. 2 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 2 refrigeration circuits with 1 compressor in each circuit and 2 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.

Rated Capacity = 115,000 Btu/h
Full Load Rated Indoor Airflow = 3,300 scfm
Rated EER = 11.2 Btu/W·h
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 which is just above the lower limit of 13.700 psia so the test is valid. The pressure could vary between tests and it should be measured for each test.

Table G6A 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	CFM	W	W	W	W	Btu/W·h
1	2	95.1	95.0	100.0	115,493	3,354	8,615	650	1,050	100	11.09
2	2	81.3	81.5	106.7	123,267	3,354	8,073	650	1,050	100	12.49
3	1	81.7	81.5	52.4	60,510	3,354	3,855	325	1,050	150	11.25
4	1	67.6	68.0	53.3	61,536	3,354	3,588	325	1,050	150	12.04
5	1	65.3	65.0	53.4	61,716	3,354	3,545	325	1,050	150	12.17

Overall 5 tests were required to be run to determine the IEER. Note that for test 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, for the B rating point of 75 Percent Load interpolation using test 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. Note that the procedure requires both tests to be run at the rating point ambient and this is different than the procedures in the AHRI 340/360-standard.

For the C rating point with an rating ambient of 68 °F the Percent Load is 53.4 which 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 only unload to 53.6 Percent Load when run at the D rating point ambient of 65 °F, degradation will also 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. Shown below are the results the step 2 calculations for the A, B, C and D rating points.

Table G6B 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			
A	1	95.1	95.0	100.0	115,493	8,615	650	1,050	100	11.09			
	required load			100.0	use test 1 point directly						-	-	11.09
B	2	81.3	81.5	106.7	123,267	8,073	650	1,050	100	12.49	-	-	
	3	81.7	81.5	52.4	60,510	3,855	325	1,050	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	3,588	325	1,050	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	3,545	325	1,050	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 shall be used. As you can see for this point we had to run test 2 and 3. Test 2 was run at full load but at the 75 Percent Load rating point 81.5 °F ambient as require by Table 6. Test 3 was also run at the 81.5 °F ambient but with only stage 1 operating. From these tests you can see that a load of 106.7 and 52.7 Percent Load was obtained so to get to 75 Percent Load we interpolate between test 2 and 3 as shown below.

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

For the C rating point which is required to be run at test run at 68 °F ambient as defined in Table 6 we can see from test 4 that the test Percent Load is 53.4. This exceeds allowable ± 3% tolerance so test 4 cannot be used directly to calculate the C EER rating point. In addition 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 then performed using Section 6.2.3.

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

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

What this means is that 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.

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

What this means is 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.

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

Similar degradation corrections are also made for the 25 Percent Load points.

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

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

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

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 2 refrigeration circuits with 1 compressor in each circuit and 2 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.

Rated Capacity = 115,000 Btu/h
Full Load Rated Indoor Airflow = 3,300 scfm
Part Load Rated Indoor Airflow = 1980 scfm
Rated EER = 11.2 Btu/W·h
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 G7A 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	CFM	W	W	W	W	Btu/W·h
1	2	95.1	95.0	100.0	115,493	3,354	8,615	650	1,050	100	11.09
2	2	81.3	81.5	106.7	123,267	3,354	8,073	650	1,050	100	12.49
3	1	81.7	81.5	52.7	60,888	2,020	3,915	325	262	150	13.09
4	1	67.6	68.0	53.9	62,270	2,020	3,645	325	262	150	14.21
5	1	65.3	65.0	54.4	62,772	2,020	3,601	325	262	150	14.47

Overall 5 tests were required to be 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 interpolation Test 2 and 3 were run to be used for interpolation. As required 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. Also note that 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 which 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 only unload to 54.3 Percent Load when run at the D rating point ambient of 65 °F, degradation will also 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 are done. Shown below are the results the step 2 calculations for the A, B, C and D rating points.

Table G7B 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			
A	1	95.1	95.0	100.0	115,493	8,615	650	1,050	100	11.09			
	required load			100.0	use test 1 point directly						-	-	11.09
B	2	81.3	81.5	106.7	123,267	8,073	650	1,050	100	12.49	-	-	
	3	81.7	81.5	52.7	60,888	3,915	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	3,645	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	3,601	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 shall be used. As you can see for this point we had to run test 2 and 3. Test 2 was run at full load but at the 75 Percent Load rating point 81.5 °F ambient as require by Table 6. Test 3 was also run at the 81.5 °F ambient but with only stage 1 operating. From these tests you can see that a load of 106.7 and 52.6 Percent Load was obtained so to get to 75 Percent Load we interpolate between test 2 and 3 as 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 which is required to be run at 68 °F ambient as defined in Table 6 we can see from test 4 that the test Percent Load is 53.8. This exceeds allowable ± 3% tolerance so test 4 cannot be used directly to calculate the C EER rating point. In addition 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 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 then performed using Section 6.2.3.

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

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

What this means is that 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.

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

What this means is 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 B.

$$EER = \frac{LF \cdot Q}{LF \cdot [C_D \cdot (P_C + P_{CD})] + P_{IF} + P_{CT}} = \frac{0.927 \cdot 62{,}270}{0.927 \cdot [1.009 \cdot (3{,}601 + 325)] + 262 + 150} = 14.11 \text{ Btu/W} \cdot \text{h}$$

Similar degradation corrections are also made for the 25 Percent Load points.

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

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

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

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 3 equal size compressors in a common refrigerant circuit which results in 3 stages of mechanical capacity control. The unit also has a 2 speed indoor fan that is controlled by the thermostat and is at high speed on stage 3 and low speed on stage 2 and 1. The unit has the following rated performance metrics.

Rated Capacity = 241,000 Btu/h
Full Load Rated Indoor Airflow = 7,000 scfm
Part Load Rated Indoor Airflow = 4,300 scfm
Rated EER = 12.4 Btu/W·h
Rated IEER = 16.5 Btu/W·h

Shown below are the test data. During the tests the atmospheric pressure was 14.200 psia and was constant for all tests.

Table G8A 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	CFM	W	W	W	W	Btu/W·h
1	3	85.1	85.0	100.0	242,129	7,100	17,150	0	2,350	125	12.34
2	3	73.3	73.5	102.4	247,832	7,100	16,176	0	2,350	125	13.29
3	2	73.5	73.5	66.8	161,859	4,331	9,193	0	560	150	16.34
4	2	62.1	62.0	68.0	164,530	4,331	8,637	0	560	150	17.60
5	1	61.9	62.0	38.0	92,021	4,331	4,107	0	560	200	18.91
6	1	55.0	55.0	38.6	93,384	4,331	3,941	0	560	200	19.86

Overall 6 tests were required to be run 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 you can see that two tests were run because the capacity control would 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 which delivered 102.4% capacity and test 3 was run with stage 2 which delivered 66.8% capacity. Note that 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 consider entering water temperature of 62 °F. Test 6 was run at 55 °F to allow for the determination of the D rating efficiency but as you can see the measured Percent Load was at 38.5 which is above the 25 Percent Load rating so 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. Shown below are the results of the step 2 calculations for the A, B, C and D rating points.

Table G8B 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			
A	1	95.1	95.0	100.0	242,129	17,150	0	2,350	125	12.34			
	required load			100.0	use test 1 point directly						-	-	12.34
B	2	73.3	73.5	102.4	247,832	7,100	0	2,350	125	13.29	-	-	
	3	73.5	73.5	66.8	161,859	4,331	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	4,331	0	560	150	17.60	-	-	
	5	61.9	62.0	38.0	92,021	4,331	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	3,941	0	560	200	19.86			
	required Load			25.0	degradation of test 5 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 shall be used. As you can see for this point we had to run tests 2 and 3. Test 2 was run at full load but at the 75 Percent Load rating point 73.5 °F condenser entering water as require by Table 6. Test 3 was also run at the 73.5 °F condenser entering temperature ambient but with stage 2 active. From these tests you can see that a Percent Load of 102.4 and 66.8 was obtained so to get to 75 Percent Load we interpolate between tests 2 and 3 as 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 which is required to be run at 62 °F condenser entering water as defined in table 6 we can see from test 4 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 so test 5 was run with stage 1 at the 62 °F ambient and a Percent Load of 38 was measured which 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 will have to be performed. The calculation of the degradation factor for the rating point D is shown below.

The degradation factor calculations then performed using Section 6.2.3.

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

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

What this means is that at a 25 Percent Load the last stage compressor will be on for 64.9% of the time and off for 35.1% of the time.

The degradation coefficient is calculated using Equation 5.

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

What this means is 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.

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

Similar degradation corrections are also made for the 50 Percent Load points.

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

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

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

G5 *Proportionally Controlled Unit Example Calculations.* In the following section you will find example calculations for IEER calculations for Proportionally Controlled Units. As defined in Section 6.2.6 a Proportional Controlled Unit is a unit incorporating one or more variable capacity compressors in which the compressor capacity can 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.

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

Shown below are the test data. The atmospheric pressure was measured at 14.70 psia and was constant for all tests which is above the minimum atmospheric pressure of 13.700 psia. Note that the pressure could vary between tests and it should be measured for each test.

Table G9A 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	CFM	W	W	W	W	Btu/W·h
1	100%	95.1	95.0	100.0	117,450	3,354	8,450	650	1,150	125	11.32
2	75%	81.3	81.5	75.5	88,621	3,354	5,393	650	1,150	125	12.11
3	50%	81.7	81.5	54.7	64,214	3,354	3,631	650	1,150	125	11.56
4	50%	81.4	81.5	43.0	50,463	3,354	2,772	650	1,150	125	10.74
5	25%	65.3	65.0	30.0	35,216	3,354	1,717	325	1,150	125	10.62

A total of 5 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 as you can see the measured test Percent Load is 75.5 so it is with the 3% tolerances and no additional testing is 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 so 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 could only unload to 30.0 Percent Load so this test will require 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. Shown in the following table are the calculations for the 4 EER rating points

Table G9B 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			
A	1	95.1	95.0	100.0	117,450	8,450	650	1,150	125	11.32			
	required load			100.0	use test 1 point directly						-	-	11.32
B	2	81.3	81.5	75.5	88,621	5,393	650	1,150	125	12.11			
	required load			75%	use test 2 point directly						-	-	12.11
C	3	81.7	81.5	54.7	64,214	3,631	650	1,150	125	11.56	-	-	
	4	81.4	81.5	43.0	50,463	2,772	650	1,150	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	1,717	325	1,150	125	10.62			
	required Load			25.0	degradation of test 4 required						0.834	1.022	9.74

For rating point A which is the 100 Percent Load rating point the test 1 can be used directly. For the 75 Percent Load rating point B the Percent Load is 75.5 so it is with the 3% tolerance so the test point can be used directly for the rating point B and no interpolation or degradation is required. For the 50 Percent Load rating point C, test 3 was run to get the 50 Percent Load rating but the resulting testing had a measured Percent Load of 54.7 and 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 so a second test 4 was run at a lower Percent Load of 43 and will be 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 would only unload to 30 Percent Load which is greater than the 25 Percent Load target with a 3% tolerance (25%+3%=28%). There for 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.

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

What this means is that 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.

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

What this means is 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.

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

$$EER = 9.74\ ^{Btu}/_{W\ h}$$

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

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

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

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.

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

Shown below are the test data. During the tests the atmospheric pressure was measured at 14.70 psia and was constant for all tests which is above the minimum allowable atmospheric pressure of 13.700 psia. Note that the pressure could vary between tests and it should be measured for each test.

Table G10A 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	3,354	8,450	650	1,150	125	11.32
2	75%	81.3	81.5	75.4	88,599	2,550	5,408	650	519	125	13.22
3	50%	81.7	81.5	50.9	59,765	1,720	3,725	650	166	125	12.81
4	25%	65.3	65.0	29.7	34,863	990	1,727	325	33	125	15.77

A total of 4 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 as you can see the measured test Percent Load is 75.4 so it is with the 3% tolerances and no additional testing is required. For the 50 Percent Load test 3 was run to get the 50 Percent Load rating and the test measured Percent Load is 50.9 and is also with the allowable tolerance of 3%. Test 4 was run at the 65 °F ambient for the rating point D, but the unit could only unload to 29.7 Percent Load so this test will require a degradation calculation to be performed. Note that because this is a VAV 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 the Section 6.2.6 the procedure can be performed to calculate the A, B, C and D point ratings using the test results. Shown in the following table are the calculations for the 4 EER rating points used to calculate the IEER.

Table G10B 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	8,450	650	1,150	125	11.32			
	required load			100.0	use test 1 point directly						-	-	11.32
B	2	81.3	81.5	75.4	88,599	5,408	650	650	125	13.22			
	required load			75%	use test 2 point directly						-	-	13.22
C	3	81.7	81.5	50.9	59,765	3,725	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	1,727	325	33	125	15.77			
	Required Load			25.0	degradation of test 4 required						0.842	1.021	15.27

For rating point A which is the 100 Percent Load rating point the test 1 can be used directly. For the 75 Percent Load rating point B the test load is 75.4 Percent Load so it is with the 3% tolerance so the test point can be used directly for the rating point B no interpolation or degradation is required. For the 50 Percent Load rating point C test 3 was run to get the 50 Percent Load rating and the test Percent Load is 50.9 so again it is within the 3% tolerance so it can be used directly for the point C EER determination. For the rating point D test 4 was run but due to control limits the unit would only unload to 29.7 Percent Load which is greater than the 25 Percent Load target with a 3% tolerance (25%+3%=28%). Therefore for 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.

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

What this means is that 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.

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

What this means is 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 B.

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

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

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

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

G5.3 Example 10. *Air Cooled Unit with Two Compressor 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 2 compressors in the same refrigeration circuit with 1 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 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.

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

Shown below are the test data during the tests the atmospheric pressure was measured at 14.70 psia and was constant for all tests, which is above the minimum allowable atmospheric pressure of 13.700 psia. Note that the pressure could vary between tests and it should be measured for each test.

Table G11A 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	CFM	W	W	W	W	Btu/W·h
1	1 @ 100% 2 @100%	95.1	95.0	100.0	119,500	3,300	8,725	650	1,100	125	11.27
2	1 @ 48%, 2 @100%	81.3	81.5	75.1	89,788	2,550	5,584	650	521	125	13.05
3	1 @ 98%, 2 @ off	81.7	81.5	50.7	60,563	1,720	3,846	650	166	150	12.59
4	1 @ 46%, 2 @ off	65.3	65.0	24.4	29,197	990	1,427	325	33	150	15.09

A total of 4 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 as you can see the measured Percent Load is 75.1 so it is with the 3% tolerances and no additional testing is required. Note that for this 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 run to get the 50 Percent Load rating and the test measured Percent Load is 50.7 and is also with the allowable tolerance of 3%. Note that for this test 1 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 so it also can be used directly for the EER determination. Because all the tests were be run at the required load no additional interpolation or degradation is required.

Using step 2 of the Section 6.2.6 procedure calculations are performance to determine the ratings at the A, B, C and D IEER points. Shown in the following table are the calculations for the 4 EER rating points used to calculate the IEER.

Table G11B 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			
A	1	95.1	95.0	100.0	119,500	8,725	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	5,584	650	521	125	13.05			
	required load			75%	use test 2 point directly						-	-	13.05
C	3	81.7	81.5	50.7	60,563	3,846	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	1,427	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 no additional calculations are 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.

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

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