AHRI Standard 340/360 (I-P)-2015

2015 Standard for

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

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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 2015 standard supersedes AHRI Standard 340/360-2007 with Addendum 1 and 2 and shall be effective January 1, 2017.

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:

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 Standard Rating Conditions
2. Energy Efficiency Ratio, EER, Btu/W·h at Standard Rating Conditions
3. Integrated Energy Efficiency Ratio, (IEER), Btu/W·h at Standard Rating Conditions

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

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

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 Standard Rating Conditions
2. Energy Efficiency Ratio, EER, Btu/W·h at Standard Rating Conditions
3. Integrated Energy Efficiency Ratio, IEER, Btu/W·h at Standard Rating Conditions
4. High Temperature Heating Standard Rating Capacity, Btu/h at 47°F
5. High Temperature 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 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.

Foreword:

AHRI Standard 340/360 – 2015 contains many significant revisions to the 2007 standard.

1. The revised standard includes definition and test requirements for Double-duct commercial unitary equipment.
2. Definitions have been expanded and clarified including an updated definition for IEER.
3. Table 1, *Classification of Commercial and Industrial Unitary Air-Conditioner Equipment* has been rewritten for clarity.
4. Table 2, *Classification of Commercial and Industrial Unitary Heat Pump* Equipment has been rewritten for clarity.
5. The part load efficiency, IEER, test method is simplified by eliminating the iterative OD test conditions needed to achieve a desired load point. The new method requires an additional test point at known conditions to be run in order to interpolate to the desired load point. This simplifies the test procedure (Table 6). This method also reduces the uncertainty with the addition of a 3% tolerance for part load percent.
6. Section 5, *Test Requirements*, has been expanded to cover items not documented in ASHRAE Standard 37.
7. The standard adds a tolerance of 3% on required part load Percent Load point where interpolation and degradation is not required (Table 7).
8. The revised standard includes optional *International Rating Conditions* (Section 6.3) relevant to international requirements that may be used optionally. The Rating Conditions are intended to align with ISO 5151, 13253 and 15042 conditions.
9. The standard includes a step by step procedure to generate IEER ratings based on either test method or computer simulation. This also includes clarification on procedures for fixed, capacity, staged capacity and variable capacity units (Section 6.4).
10. Verification test uncertainty allowances have been explained and clarified for the performance metrics in the standard. (Section 6.5 & Section 6.6).
11. Documentation of the confidence level has been added at 90% for EER, IEER and COP.
12. Tolerances have been added for airflow at ± 3%.
13. Appendix D, *Atmospheric Pressure Correction*, has been added to the standard, which prescribes a computational method to correct measured product performance for air density variations resulting from atmospheric pressure changes due to weather conditions and altitude. Revisions were made throughout the standard to reflect the atmospheric pressure corrections.
14. Appendix E. *Unit Configuration for Standard Efficiency Determination*, has also been added to the standard, which prescribes the requirements for the configuration of a unit that is used for determining the Standard Rating Cooling and Heating Capacity and efficiency metrics. Appendix E documents DOE certification requirements agreed to with the development of the AEDM procedure.
15. The revised standard tightens the tolerances on external static pressure and airflow. (Appendix F, Section F4 & F5).
16. Appendix G, *Examples of IEER Calculations*, provides a comprehensive set of IEER calculation examples covering many potential product configurations.
17. References have been updated to reflect the latest available standards.
18. Appendix F, *Method of Testing Unitary Air Conditioning Products*, has been updated to reflect test procedures not defined by ASHRAE 37-2009.

TABLE OF CONTENTS

SECTION Page

TABLES

FIGURES

TABLE OF CONTENTS (continued)

APPENDICES

TABLES FOR APPENDICES

TABLE OF CONTENTS (continued)

FIGURES FOR APPENDICES

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 ANSI/AHRI Standard 210/240, with capacities less than 65,000 Btu/h.

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

2.2.4 Variable Refrigerant Flow Air Conditioners and Heat Pumps as defined in ANSI/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 Condensing Units with a capacity greater than 135,000 Btu/h as defined in ANSI/AHRI Standard 365 (I-P), *Performance Rating of Commercial and Industrial Unitary Air-conditioning Condensing Units*.

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 using ANSI/AHRI Standard 920 (I-P).

2.3.3 Air conditioners and condensing units serving computer rooms rated using ANSI/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 and which have the same or comparably performing compressor(s), condensing coil(s), evaporator coil(s), and air moving system(s) that have a common "nominal" Cooling Capacity.

Note: See 10 CFR §429 for DOE definition.

3.2 *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.

3.3 *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 function of air circulation, air cooling, dehumidifying or humidifying, outdoor air ventilation, and air cleaning.

3.4 *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).

> **3.4.1** *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.
>
> **3.4.2** *Latent Capacity*. Capacity associated with a change in humidity ratio, expressed in Btu/h.
>
> **3.4.3** *Sensible Capacity*. Capacity associated with a change in dry-bulb temperature, expressed in Btu/h.

3.5 *Double-duct System.* Double-duct air conditioner or heat pump means air-cooled commercial package air conditioning and heating equipment 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 inches or the unit shall have components that do not exceed a maximum height of 35 inches. If it is a vertical unit, the complete (split, connected, or assembled) unit shall have components that do not exceed maximum depth of 35 inches; and, a rated Cooling Capacity greater than and equal to 65,000 Btu/h and less than or equal to 300,000 Btu/h.

3.6 *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.

> **3.6.1** *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 E, and when tested in accordance with the requirements of Appendix F.

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

3.8 *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. The airflow shall be expressed as Standard Air with a density of 0.075 lb/ft^3.

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

3.10 *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 heating COP, supplementary resistance heat shall be excluded.

3.11 *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.

3.12 *Indoor 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).

3.13 *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.

3.14 *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.

3.15 *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).

3.16 *Package Year Round Air-conditioners*. Gas and oil 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).

3.17 *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. The airflow is expressed as Standard Air, expressed in units of ft^3/min.

3.18 *Percent Load.* The ratio of the part load Cooling Capacity over the measured full load Cooling Capacity at Standard Rating Conditions, expressed as a decimal.

3.19 *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 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.

3.20 *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.

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

3.20.2 *Standard Rating.* A rating based on tests performed at Standard Rating Conditions as listed in Table 3.

3.21 *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.

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

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

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

3.22.2 *Should*. "Should" is used to indicate provisions which are not mandatory but which are desirable as good practice.

3.23 *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.

3.24 *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.

3.25 *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.

3.26 *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.

3.27 *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.

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

3.29 *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.

3.30 *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
Package and Indoor Package Air-conditioners	SP-A[5, 6] SP-E[6] SP-W[6, 7]		ELEC HEAT[3] | OD FAN or PUMP ID FAN | COMP EVAP | COND
Package Year Round Air -conditioners	SPY-A[5, 6] SPY-E[6] SPY-W[6, 7]		GAS HEAT[4] | OD FAN or PUMP ID FAN | COMP EVAP | COND
Air-conditioner with Remote Condenser	RC-A RC-E RC-W[7]	ID FAN EVAP	OD FAN or PUMP COMP COND
Split System Air-conditioners: Condensing Unit, Coil Alone	RCU-A-C RCU-E-C RCU-W-C[7]	EVAP	OD FAN or PUMP COMP COND
Split System Air-conditioners: Condensing Unit, Coil and Fan	RCU-A-CB[5] RCU-E-CB RCU-W-CB[7]	ID FAN EVAP ELEC HEAT[3]	OD FAN or PUMP COMP COND
Split System: Year Round Condensing Unit, Coil and Fan	RCUY-A-CB[5] RCUY-E-CB RCUY-W-CB[7]	GAS 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. A suffix of "-A" indicates air-cooled condenser, "-E" indicates evaporatively-cooled condenser and "-W" indicates water-cooled condenser.
3. Optional component.
4. May also be other heat source except for electric strip heat.
5. For Double-duct, append “-DD” and outdoor arrangement moves from outdoor side to indoor side.
6. Components could be installed indoors as well in accordance with manufacturer’s installation instructions.
7. For water-cooled products, outdoor arrangement can move from outdoor side to indoor side.

Table 2. Classification of Commercial and Industrial Unitary Heat Pump Equipment

Designation	AHRI Type[1,2]	Arrangement - ID	Arrangement – OD
Package Heat Pumps	HSP-A[4]		ELEC HEAT[3, 5] / OD FAN or PUMP ID FAN / COMP EVAP / COND
Year Round Package	HSPY-A		GAS HEAT / OD FAN or PUMP ID FAN / COMP EVAP / COND
Heat Pump with Remote Outdoor Coil	HRC-A-CB[4]	ID FAN EVAP COMP	OD FAN or PUMP COND
Heat Pump with Remote Outdoor Coil with no Indoor Fan	HRC-A-C[4]	EVAP COMP	OD FAN or PUMP COND
Split System Heat Pump	HRCU-A-CB[4]	ELEC HEAT[3] 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. Optional component.
4. For Double-duct, append “-DD” and outdoor arrangement moves from outdoor side to indoor side.
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 F.

5.1.1.1 Units shall be installed per manufacturer’s installation instructions. For products covered under ULE certification program, additional information shall be submitted through the certification process.

5.1.2 It is permissible for equipment for test to have manufacturer authorized personnel with knowledge of the control software present upon initial set-up during laboratory testing.

5.1.2.1 If equipment cannot be maintained at steady state conditions by its normal controls, then the manufacturer shall provide a method to modify or over-ride such controls so that steady state conditions are achieved, but the modifications shall represent the actual performance that would occur in normal operation.

5.1.2.2 Power used for any override controls that would not normally be installed in the field shall not be included in total power.

5.1.3 *Break-in.* If an initial break-in period is required to achieve performance, the break-in conditions and duration shall be specified by the manufacturer, but shall not exceed 75 hours at room ambient conditions (≥60ºF), or 20 hours inside the test chamber at test conditions specified by the manufacturers. No testing shall commence until the specified break-in period is completed.

5.1.4 *Test Unit Installation Requirements*. For units that have horizontal and down flow configurations, due considerations shall be given to ASHRAE Standard 37 duct requirements.

5.1.5 *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.

5.1.6 *Head Pressure Control*. Head pressure controls shall be left at manufacturer's settings and operated in automatic mode. If this results in unstable operation and the requirements of ASHRAE Standard 37 cannot be met then the procedures in Appendix F Section F7 for a time averaged head pressure control test shall be used.

5.1.7 *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 recommended by the manufacturer. 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 5 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 published recommendation.

5.1.8 *Refrigerant Charging.* All test samples shall be charged at Standard Rating Conditions (or conditions specified by the manufacturer in the installation instructions) in accordance with the manufacturer's installation instructions or labels applied to the unit. If the manufacturer's installation instructions give a specified range for superheat, sub-cooling, or refrigerant pressure, the average of the range shall be used to determine the refrigerant charge.

Note: After completion of all required tests, it is good laboratory practice to achieve cooling full load test conditions for 30 continuous minutes and compare results to the previous set of full load tests after running part load cooling tests and/or heating tests. When comparing results, measured pressures and temperatures of refrigerant state points should be evaluated for any change since the initial full load test.

5.1.9 *Pressure Gauge*. When specified by the manufacturer, pressure gauges shall be installed during the setup and refrigerant charge verified based on manufacturer's installation instructions.

If refrigerant charging instructions are not available or the manufacturer does not specify to install the pressure gauges, then testing shall be performed at factory refrigerant charge without adjustment.

Section 6. Rating Requirements

6.1 *Standard Ratings.* Standard Ratings shall be established at the Standard Rating Conditions specified in Tables 3, 4, and 6. Standard Ratings related to Cooling or Heating Capacities shall be net values, including the effects of circulating fan heat, but not including supplementary heat. Standard Ratings shall be stated as total Cooling Capacity and total Heating Capacity.

Standard Ratings shall be based on the total power input to the compressor(s) and fan(s), plus controls and other items required as part of the system for operation at Standard Rating Conditions.

Standard Ratings of units which do not have indoor air-circulating fans furnished as part of the model, i.e., split systems with indoor coil alone, 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.

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.

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

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

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

Table 3. Conditions for Standard Rating and Operating Tests

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

Footnotes:

1. The wet-bulb temperature condition is not required when testing air cooled condensers which do not evaporate condensate.
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. Make-up water temperature shall be 90ºF.
5. Indoor fan system external static pressure shall be set per Table 4.
6. All ratings are at standard atmospheric pressure. Measured data shall be corrected to an atmospheric pressure of 14.696 psia in accordance with Appendix D.
7. For some product classifications, the outdoor section may be located indoors.

6.1.3 *Standard Rating Tests*. Table 3 indicates 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.

6.1.3.2 *Atmospheric Pressure Corrections*. Standard Ratings for all products covered by this standard shall be based on a standard air atmospheric pressure of 14.696 psi. Cooling and Heating Capacity, EER, IEER and COP measurements obtained during test shall be corrected to Standard Air using the procedure in Appendix D. The test shall not be conducted if the atmospheric pressure is below 13.7 psia.

6.1.3.3 *Indoor Airflow Rate.*

6.1.3.3.1 All full load Standard Ratings shall be determined at the Full Load Rated Indoor Airflow. All airflow rates shall be expressed in terms of Standard Air, which has a density of 0.075 lb/ft^3. Recirculated air at 100% shall be used. A tolerance of ± 3% is allowed for tested values relative to the rated airflow.

6.1.3.3.2 All Part Load tests as required for the determination of IEER, other than MZVAV rated units shall be conducted at the Part Load Rated Indoor Airflow as specified by the manufacturer. Recirculated air at 100% shall be used. A tolerance of ± 3% is allowed for tested values relative to the rated airflow.

6.1.3.3.3 For MZVAV units, the airflow rate at part load shall be adjusted to maintain the supply air dry-bulb temperature measured at full load. Recirculated air at 100% shall be used.

6.1.3.3.4 Equipment which does not incorporate an indoor fan, but is rated in combination with a device employing a fan shall be rated as described under Section 6.1. For equipment of this class which is rated for general use to be applied to a variety of heating units, the indoor airflow rate shall be the lesser of:

6.1.3.3.4.1 The manufacturer specified Standard Ratings, not to exceed 37.5 scfm/1000 Btu/h of rated capacity; or

6.1.3.3.4.2 The airflow rate obtained through the indoor coil assembly when the pressure drop across the indoor coil assembly and the recommended enclosures and attachment means is not greater than 0.30 in H_2O.

6.1.3.3.5 For combined heating and cooling units the heating airflow and static shall be based on one of the following procedures

6.1.3.3.5.1 *Common Cooling and Heating Full Load Airflow*. For units that only have one rated airflow for cooling then when in heating operation the heating standard airflow (scfm) shall be the same as the cooling airflow ± 3% without regard to the resulting external static. The fan speed should first be set in the cooling mode and then when in heating no adjustments shall be made to the unit and only the code tester adjusted to obtain the rating airflow.

6.1.3.3.5.2 *Different Cooling and Heating Full Load Airflow*. If the unit is equipped with automatic controls that adjust the fan speed in heating, the airflow shall be at the Standard Air, scfm, specified by the manufacturer and using the static per Equation 1.

$$ESP_{HFL} = ESP_{CFL} \cdot \left(\frac{scfm_{HFL}}{scfm_{CFL}}\right)^2 \qquad 1$$

Where:

ESP_{CFL}= External static pressure at full load cooling rated, in H_2O
ESP_{HFL}= External static pressure at full load heating rated airflow, in H_2O
$scfm_{CFL}$ = Standard Supply Airflow at cooling full load rated conditions, scfm
$scfm_{HFL}$ = Standard Supply Airflow at heating full load rated conditions, scfm

Table 4. External Static Pressure

Rated Cooling Capacity, Btu/h•1000[1]	External Static Pressure, in H_2O[2, 3]
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. The tolerance for external static pressure shall be determined using Section F4, Appendix F.
3. Standard ratings shall be determined and tested with manufacturer standard, lowest level of air filtration. For units with no filters or optional filters, refer to Section E3.2.1.

6.1.3.4 *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.

6.1.3.4.1 *Double-ducted*. For product intended to be installed with the outdoor airflow ducted, the unit shall be installed with outdoor coil ductwork installed per manufacturer 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 ASHRAE Standard 37.

6.1.3.5 *Requirements for Separate Assemblies.* All Standard Ratings for split systems shall be determined with 25 ft of interconnecting tubing on each line, with a maximum vertical separation of 10 ft. When interconnecting tubing is furnished as an integral part of the equipment and is not recommended for cutting to length, the equipment shall be tested with the complete length of tubing furnished, or with 25 ft of tubing, whichever is greater. At least 5.0 ft of the interconnecting tubing shall be exposed to the outside conditions. The line sizes, insulation and details of installation shall be in accordance with the manufacturer's published recommendation.

6.1.3.6 *Full Load Indoor Fan External Static Pressures.* Commercial and Industrial Unitary Air-Conditioning and Heat Pump Equipment shall be rated at the external static pressures in Table 4 at the Full Load Rated Indoor Airflow and capacity specified in Section 6.1.3.3. The tolerance for external static pressure shall be determined using Section F4, Appendix F.

Indoor air-moving equipment not intended for use with field installed duct systems (free discharge) shall be rated at 0.0 in H_2O external pressure.

6.1.3.7 *Part Load External Static and Airflow*. For part load testing the following procedures shall be used for indoor airflow and static.

6.1.3.7.1 *Fixed Speed Indoor Fan* Control - For fixed speed indoor fans the airflow rate shall be held constant at the Full Load Rated Indoor Airflow ±3%.

6.1.3.7.2 *Discrete Step Indoor Fan Control* - For units using discrete step fan speed control, the fan speed shall be adjusted as specified by the controls and the external static shall be reduced per Equation 2 below based on Part Load Rated Indoor Airflow and shall be maintained at the value -0.00 /+0.05 in H_2O.

$$ESP_{PL} = ESP_{FL} \cdot \left(\frac{scfm_{PL}}{scfm_{FL}}\right)^2 \qquad 2$$

Where:

ESP_{FL}= External static pressure at full load airflow, in H_2O
ESP_{PL}= External static pressure at part load airflow, in H_2O
$scfm_{FL}$ = Standard Supply Airflow at full load rated conditions, scfm
$scfm_{PL}$ = Standard Supply Airflow at part load rated conditions, scfm

6.1.3.7.3 Variable Speed SZVAV Fan Control - For SZVAV units, the fan speed shall be adjusted as specified by the controls and the minimum external static shall be reduced per Equation 2 based on Part Load Rated Indoor Airflow.

6.1.3.7.4 Variable Speed MZVAV Fan Control - For MZVAV units, the Part Load Rated Indoor Airflow shall be adjusted to maintain the supply air dry-bulb temperature measured at full load within a tolerance of ± 0.5ºF and the minimum external static shall be reduced per Equation 2 based on the resulting part load airflow.

If the full load measured leaving air dry-bulb temperature cannot be met at part load Rating Conditions due to controls limitations of the unit capacity and airflow modulation, then the part load rating point shall be run at the minimum step of unloading and minimum fan speed allowed by the controls, and the external static per Equation 2.

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

6.2.1 *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% load at condenser conditions seen during these load points. It includes all mechanical cooling energy, fan energy and other energy required to deliver the mechanical cooling, but excludes operating hours seen for just ventilation, economizer operation and does not include system options like demand ventilation, Supply Air reset, energy recovery and other system options that might be applied on a job. 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.

6.2.1.1 *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 5.

Table 5. 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.

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

Where:

A = EER at 100% Capacity at AHRI Standard Rating Conditions (see Table 3)
B = EER at 75% Capacity and reduced condenser temperature (see Table 6)
C = EER at 50% Capacity and reduced condenser temperature (see Table 6)
D = EER at 25% Capacity and reduced condenser temperature (see Table 6)

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 airflow.

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

Table 6. IEER Part-Load Rating Conditions[1, 2, 3]	
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 Note 1
Condenser (Air Cooled) Entering Dry-bulb Temperature (OAT) Condenser Airflow Rate, cfm	100% Load = 95ºF 75% Load = 81.5ºF 50% Load = 68.0ºF 25% Load = 65.0ºF Note 2
Condenser (Water Cooled) Entering Condenser Water Temperature (EWT) Condenser Water Flow Rate, gpm	100% Load = 85ºF 75% Load = 73.5ºF 50% Load = 62.0ºF 25% load = 55.0ºF full load flow
Condenser (Evaporatively Cooled) Entering Wet-Bulb Temperature (EWB)	100% Load = 74.5ºF 75% load = 66.2ºF 50% Load = 57.5ºF 25% Load = 52.8ºF
Notes: 1. Refer to Section 6.1.3.7 for indoor airflow and static 2. Condenser airflow shall be adjusted, if required per Section 5.1.6. 3. The atmospheric pressure is standard atmospheric pressure, 14.696 psia (See Appendix D for test correction procedure and limitations).	

6.2.3 *Rating Adjustments.* The IEER shall be determined at the 4 ratings loads and condenser conditions as defined in Table 6. If the unit is not capable of running at the 75%, 50% or 25% load then Section 6.2.3.1 or Section 6.2.3.2 shall be followed to determine the rating at the required load.

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

Note: In this edition of the AHRI Standard 340/360, the part load rating condenser temperatures have been fixed at the 100%, 75%, 50% and 25% values shown in Table 6. 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% load conditions; however, for interpolating ratings the condenser temperature is now fixed at the 75%, 50% and 25% 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 at a 75% load is being determined, but the unit can only run at 80% load and 60% load, then the unit can be run at those percent part loads at the same outdoor air temperature and the 75% rating can interpolated (see Figure 1). Figure 1 also shows the difference between the AHRI Standard 340/360 2007 and 2015 editions.

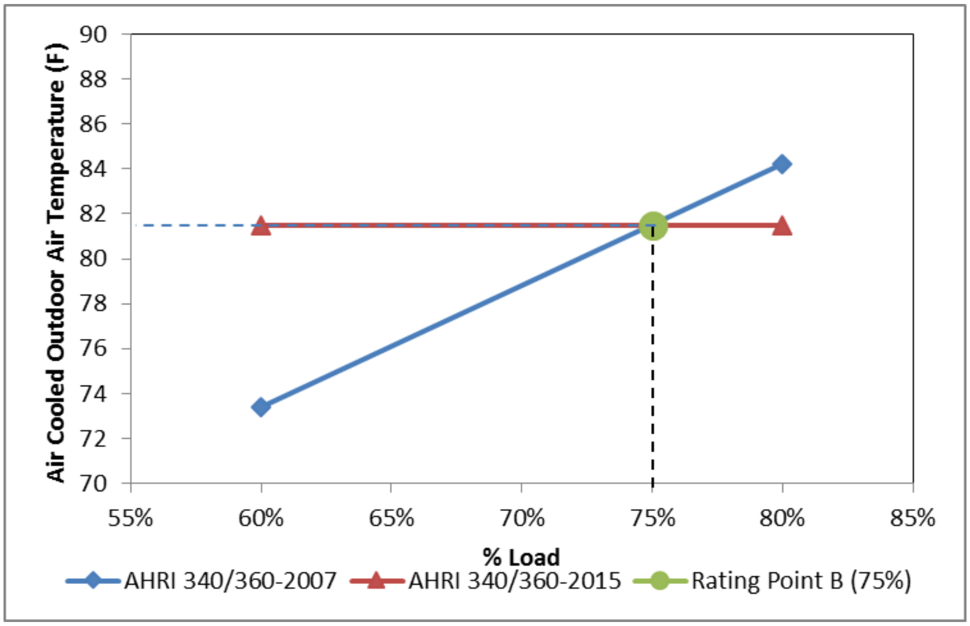

Figure 1. Example Revised Part Load Ambient Conditions for Interpolation

6.2.3.2 *Degradation*. If the unit cannot be unloaded to the 75%, 50%, or 25% 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 6 and then the part load EER shall be adjusted for cyclic performance using Equation 4. All rating test data shall be adjusted to standard atmospheric pressure per Appendix E.

$$EER = \frac{LF \times Q_{corr}}{LF \times [C_D \times (P_C + P_{CD})] + P_{IF\,corr} + P_{CT}} \qquad 4$$

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 desired part load rating condition, watts

P_{CD} = Condenser Section power, if applicable at the desired 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, watts

$P_{IF\ corr}$ = Atmospheric pressure corrected indoor fan motor power as per Appendix D at the fan speed for the minimum step of capacity, watts

Q_{corr} = Atmospheric pressure corrected Cooling Capacity as per Appendix D at the lowest machine unloading point operating at the desired part load rating condition, Btu/h

$$C_D = (-0.13 \cdot LF) + 1.13 \qquad 5$$

Where:

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

$$LF = \frac{\left({}^{Percent\ Load}/_{100}\right) \cdot Full\ Load\ Net\ Capacity}{Part\ Load\ Net\ Capacity} \qquad 6$$

Note: For test verified ratings the Load Factor shall be based on test data corrected to standard atmospheric pressure.

6.2.4 Procedure for *IEER Calculations for Fixed Capacity Control Units.* For fixed capacity control 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 rating points for 75%, 50% and 25% load shall be determined at the part load rating condenser entering temperature defined in Table 6 within tolerances defined in ASHRAE Standard 37 Table 2b.

Note: Because the unit only has a single stage of capacity, the actual Percent Load will be greater than the required rating Percent Load and the cyclic performance will be adjusted using the degradation calculations as per step 3. Part-load rated airflow, if different than full load airflow, shall be used as defined by the manufacturer, and with an external static as specified in the Section 6.1.3.7.

6.2.4.2 *Step 2.* All test data shall then be corrected for atmospheric pressure, as defined in Appendix D.

6.2.4.3 *Step 3.* The atmospheric pressure corrected rating shall be adjusted for cyclic degradation using the procedures in Section 6.2.3.

6.2.4.4 *Step 4.* The atmospheric corrected test results including adjustments for cyclic degradation from step 3 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 defined in Section 6.1.3.7.

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 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 ASHRAE Standard 37 Table 2b.

The indoor standard air airflow rate and static shall be adjusted per the requirements of Section 6.1.3.7.

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 part load rated capacity point, the EER at each load point shall be used to determine IEER without any interpolation. See Table 7.

Table 7. 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, due to its capacity control logic cannot be operated at the 75%, 50%, or 25% Percent Load within 3% tolerance, then an additional rating point is required and the 75%, 50%, or 25% EER is determined by using linear interpolation. Data shall not be extrapolated to determine EER.

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

6.2.5.1.1 The ambient test conditions shall be within tolerances defined in ASHRAE Standard 37 Table 2b for the specified ambient in Table 6 for the required IEER part load rating of 75%, 50% or 25%. Two tests points are required at the fixed temperature for the desired IEER part load point; one test point at a capacity stage above required load point and a second test point at a capacity stage below required load point. The data from the 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 is being run to determine the EER rating at 50% load that has a capacity stage at 60% and 30% displacement then it shall require one test at 60% displacement at a 68ºF ambient and another test at 30% displacement at a 68ºF ambient. The test results are then interpolated to determine the 50% load rating point.

The indoor Standard Airflow rate and static shall be adjusted per the requirements of Section 6.1.3.7.

6.2.5.1.2 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 is obtained.

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

6.2.5.1.3 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.

6.2.5.1.4 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 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 6 with a tolerance of ± 0.5ºF.

Note: The actual Percent Load will be greater than the required Percent Load and should be adjusted for cyclic performance using the degradation calculations as per step 3. Part Load Rated Indoor Airflow, if different than full load airflow, shall be used as defined by the manufacturer, and with an external static as specified in Section 6.1.3.7.

6.2.5.2 *Step 2.* The test data shall then be corrected for atmospheric pressure as defined by Appendix D.

6.2.5.3 *Step 3*. If the corrected rating points are within 3% of the desired IEER rating point of 75%, 50% and 25%, they shall be used directly. If there are corrected ratings points above and below the desired IEER rating of 75%, 50%, and 25% then the rating data the IEER rating point shall be determined using linear interpolation. If the corrected rated Percent Load is greater than the pPercent Load for 75%, 50% or 25% by more than 3% 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.

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

6.2.6 *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) capacity 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 instructions, including setting of stages of refrigeration and variable capacity compressor loading percent for each of the part load rating points. The stages of refrigeration and variable capacity compressor loading percent that result in capacity closest to the desired part load rating point of 75%, 50%, or 25%.

The condenser entering temperature shall be adjusted per the requirements of Table 6 and be within tolerance as defined in ASHRAE Standard 37 Table 2b.

The indoor airflow and static shall be adjusted per Section 6.1.3.7.

If the measured part load rating capacity ratio is within ± 3%, based on the full load measured test Cooling Capacity, above or below the part load rated capacity point, 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% 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 ASHRAE Standard 37 of the specified ambient in Table 6 based on the IEER rating point of 75%, 50% or 25%.

Note: The condenser temperature shall be fixed for the two interpolation rating points at the values listed in Table 6.

6.2.6.1.2 The indoor airflow shall be set as specified by the manufacturer and as required by Section 6.1.3.7.

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 is obtained.

Note: For example, to obtain a 50% rating point for a unit having test points at both 60% and 70%, the 60% 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 6 within tolerances defined in ASHRAE Standard 37.

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 3. Part Load Rated Indoor Airflow and static, if different than full load airflow, shall be used as defined by the manufacturer and as required by Section 6.1.3.7.

6.2.6.2 *Step 2.* The test data shall then be corrected for atmospheric pressure as defined by Appendix D.

6.2.6.3 *Step 3.* If any of the corrected rating points are within 3% of the desired IEER rating point of 75%, 50% and 25%, they shall be used directly. If there are corrected ratings points above and below the desired IEER rating of 75%, 50%, and 25%, 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 temperature required for the rating point shall be used along with the degradation procedure defined in Section 6.2.3.2.

6.2.6.4 *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 the correction for atmospheric pressure, calculation of IEER and calculation of tolerances. The examples are grouped by the three rating categories defined in Section 6.2.

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

6.3.1 *Cooling Temperature Conditions.*

6.3.1.1 The international T1, T2, and T3 temperature conditions specified in Table 8 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 8.

6.3.1.2 Equipment manufactured for use only in a moderate climate similar to that specified in Column T1 of Table 8 shall have ratings determined by tests conducted at T1 conditions and shall be designated type T1 equipment.

6.3.1.3 Equipment manufactured for use only in a cool climate similar to that specified in Column T2 of Table 8 shall have ratings determined by tests conducted at T2 conditions and shall be designated type T2 equipment.

6.3.1.4 Equipment manufactured for use only in a hot climate similar to that specified in Column T3 of

Table 8 shall have ratings determined by tests conducted at T3 conditions and shall be designated type T3 equipment.

6.3.1.5 Equipment manufactured for use in more than one of the climates defined in Table 8 shall have marked on the nameplate the designated type (T1, T2, and/or T3). The corresponding ratings shall be determined by the Standard Rating Conditions specified in Table 8.

6.3.2 *Heating Temperature Conditions.*

6.3.2.1 The H1, H2, and H3 temperature conditions specified in Table 8 shall be considered Standard Rating Conditions for the determination of Heating Capacity and energy efficiency.

6.3.2.2 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 8. International 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 max.	68.0°F DB & 59.0°F WB max.	68.0°F DB and 59.0°F WB max.
Outdoor	44.6°F DB and 42.8°F WB	35.6°F DB & 33.8°F WB	19.4°F DB & 17.6°F WB
Note: DB = dry-bulb and WB = wet-bulb.			

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

6.4.1 *Ratings Generated by Test Data*. Any capacity, EER, IEER, or COP_H 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 capacity, EER, IEER, or COP_H ratings shall be lower than or equal to the lower of a) the test sample mean ($\bar{x}$), or b) the lower 90% confidence limit (LCL) divided by 0.95 (as defined by the formulas below), rounded per Sections 6.1.1 and 6.1.2.

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

$$LCL = \bar{x} - t_{.90}\left(\frac{s}{\sqrt{n}}\right) \quad 8$$

Where:

LCL = Lower 90% confidence limit
n = Number of test samples
s = Standard deviation
$t_{.90}$ = t statistic for a 90% one-tailed confidence interval with n-1 degrees of freedom (see Appendix A of 10 CFR §429)

x_i = Test result value for test sample i
$\bar{x}$ = Test sample mean

6.4.2 *Ratings Generated by Computer Simulation*. 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 6.1.1 and 6.1.2). Any AEDM used shall be created in compliance with the regulations specified in 10 CFR §429.70.

6.4.3 *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.

6.5 *Verification Testing Uncertainty*. When verifying the ratings by testing a sample unit, there are uncertainties that must be considered. Verification tests, including tests conducted under the AHRI certification program shall be conducted in a laboratory that meets the requirements referenced in this standard and ASHRAE Standard 37 and must demonstrate performance with an allowance for uncertainty. The following make up the uncertainty for products covered by this standard.

6.5.1 *Uncertainty of Measurement*. When testing a unit, there are variations that result from instrumentation as well as measurements of temperatures, pressure, and flow rates.

6.5.2 *Uncertainty of Test Rooms*. The same unit tested in multiple rooms and due to setup variations is not expected to yield the same performance.

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

6.5.4 *Uncertainty of Performance Simulation Tools*. Due to the large complexity of options, manufacturers shall use performance prediction tools like an alternative efficiency determination method (AEDM).

6.6 *Uncertainty Allowances.* To comply with this standard, verification tests shall meet the Published Ratings with an uncertainty allowance not greater than the following:

Table 9. Uncertainty Allowances

Performance Metric	Uncertainty Allowance	Acceptance Criteria
Cooling Metrics		
Full Load Cooling Capacity	5%	≥ 95%
Full Load EER	5%	≥ 95%
IEER	10%	≥ 90%
Heating Metrics		
Heating Capacity at 47°F	5%	≥ 95%
COP_H at 47°F	5%	≥ 95%
Heating Capacity at 17°F	5%	≥ 95%
COP_H at 17°F	5%	≥ 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
7.1.2.5 High temperature coefficient of performance
7.1.2.6 Low temperature heating capacity, Btu/h
7.1.2.7 Low temperature coefficient of performance

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 3 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 and capacity, Btu/h
7.2.2 Latent Capacity and capacity, Btu/h
7.2.3 Sensible Capacity and capacity, Btu/h

Note: Capacity is Cooling Capacity as defined in Section 3.4 and includes both latent and net sensible.

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-Conditioners 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 6.1.3.3 (refer to test for equipment with optional air cooling coils in Section 6.1.3.6).

8.2.1 *Temperature Conditions.* Temperature conditions shall be maintained as shown in Table 3.

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 ANSI/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-Conditioners 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 6.1.3.4
8.2.5.2 Return air temperature conditions shall be 80.0ºF dry-bulb, 67.0ºF wet-bulb
8.2.5.3 Outdoor air entering outdoor air cooling coil shall be 115ºF dry-bulb and 75.0ºF wet-bulb

8.3 *Cooling Low Temperature Operation Test*. Commercial and Industrial Unitary Air-Conditioning and Heat Pump Equipment shall pass the following low-temperature operation test when operating with initial airflow rates as determined in Sections 6.1.3.2, 6.1.3.3, 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 instructions to the user.

8.3.1 *Temperature Conditions.* Temperature conditions shall be maintained as shown in Table 3.

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 meltage must 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 6.1.3.3, 6.1.3.4, 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 instructions to the user.

8.4.1 *Temperature Conditions*. Temperature conditions shall be maintained as shown in Table 3.

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 6.1.3.3, 6.1.3.4, and with controls and dampers set to produce condensate at the maximum rate, provided such settings are not contrary to the manufacturer's 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 3.

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

8.5.3 *Requirements*. During the test, there shall be no dripping, running-off, or blowing-off of moisture from the unit casing.

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

Section 9. Marking and Nameplate Data

9.1 *Marking and Nameplate Data.* At a minimum, the nameplate shall display the manufacturer's name, model designation, refrigerant designation per 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 ANSI/AHRI Standard 110. Nameplate voltages for 50 Hertz systems shall include one or more of the utilization voltages shown in Table 2 of ANSI/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 ANSI/AHRI Standard 920 (I-P)-2015, *Performance Rating of DX-Dedicated Outdoor Air System Units.* Air-Conditioning, Heating and Refrigeration Institute, 2111 Wilson Boulevard, Suite 500, Arlington, VA 22201, U.S.A.

A1.2 ANSI/AHRI Standard 110-2012 , *Air-Conditioning and Refrigerating Equipment Nameplate Voltages*, 2012, Air-Conditioning, Heating and Refrigeration Institute, 2111 Wilson Boulevard, Suite 500, Arlington, VA 22201, U.S.A.

A1.3 ANSI/AHRI Standard 210/240-2008, *Unitary Air-Conditioning and Air-Source Heat Pump Equipment,* 2008, Air-Conditioning, Heating and Refrigeration Institute, 2111 Wilson Boulevard, Suite 500, 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, 2111 Wilson Boulevard, Suite 500, 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, 2111 Wilson Boulevard, Suite 500, 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, 2111 Wilson Boulevard, Suite 500, Arlington, VA 22201, U.S.A.

A1.7 ANSI/AHRI Standard 1360 (I-P)-2013 with Addendum 1, *Performance Rating of Computer and Data Processing Room Air Conditioners*, 2013, Air-Conditioning, Heating and Refrigeration Institute, 2111 Wilson Boulevard, Suite 500, Arlington, VA 22201, U.S.A.

A1.8 ASHRAE Standard 34-2013, *Designation and Safety Classification of Refrigerant, 2013,* American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc., 1791 Tullie Circle N.E., Atlanta, GA 30329, U.S.A.

A1.9 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 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 ASHRAE Terminology, https://www.ashrae.org/resources--publications/free-resources/ashraeterminology, 2015, American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., 1791 Tullie Circle, N.E., Atlanta, GA 30329, U.S.A.

A1.12 ASHRAE/ANSI/AHRI/ISO13256-12012 *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/AHRI Standard 540-2004, *Standard For Performance Rating Of Positive Displacement Refrigerant Compressors And Compressor Units*, 2004, Air-Conditioning, Heating and Refrigeration Institute, 2111 Wilson Boulevard, Suite 500, Arlington, VA 22201, U.S.A.

A1.14 Title 10, *Code of Federal Regulations (CFR)*, Part 429, Subparts 429.70 and 429.71 (c), U.S. National Archives and Records Administration, 8601 Adelphi Road, College Park, MD 20740-6001 or www.ecfr.gov.

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, 2111 Wilson Boulevard, Suite 500, 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, 2111 Wilson Boulevard, Suite 500, Arlington, VA 22201, U.S.A.

B1.2 ANSI/ASHRAE/IES Standard 90.1-2013, *Energy Standard for Buildings Except Low-Rise Residential Buildings*, 2013, American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc., 1791 Tullie Circle N.E., Atlanta, GA 30329, U.S.A.

B1.3 ANSI/ASTM B117-2011, *Standard Practice for Operating Salt Spray (Fog) Apparatus, 2011,* ASTM International, 100 Barr Harbor Drive, PO Box C700, West Conshohocken, PA 19428-2959, U.S.A.

B1.4 ANSI/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.

B1.3 ASHRAE 62.1, *Ventilation for Acceptable Indoor Air Quality,* American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc., 1791 Tullie Circle N.E., Atlanta, GA 30329, U.S.A.

B1.5 ISO 5151-2010, *Non-ducted air-conditioners and heat pumps – Testing and rating for performance,* 2010, International Organization for Standardization, Case Postale 56, CH-1211, Geneva 21 Switzerland.

B1.6 ISO 13253-2011, *Ducted air-conditioners and air-to-air heat pumps – Testing and rating for performance*, 2011, International Organization for Standardization, Case Postale 56, CH-1211, Geneva 21 Switzerland.

B1.7 ISO 15042-2010, *Multiple split-system air-conditioners and air-to-air heat pumps – Testing and rating for performance,* 2010, International Organization for Standardization, Case Postale 56, CH-1211, Geneva 21 Switzerland.

B1.8 UL Standard 1995/CSA Standard 22.2 No. 236, 5th edition, 31 July 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. CONDENSER ENTERING AIR TEMPERATURE MEASUREMENT - NORMATIVE

Note: This appendix includes modifications to the test stand setup and instrumentation as defined in ASHRAE Standard 37 and shall be used to be compliant with this standard.

C1 *Purpose.* The purpose of this appendix is to prescribe a method for measurement of the air temperature entering the air-cooled or evaporatively-cooled condenser section. The appendix also defines the requirements for controlling the air stratification and what is considered acceptable for a test. Measurement of the air temperatures are needed to establish that the conditions are within the allowable tolerances of this Standard. For air-cooled unitary products operating in cooling mode, only the dry-bulb temperature is required. For evaporatively-cooled and heat pump unitary products operating in heating mode, both the dry-bulb and wet-bulb temperatures are required for the test.

C2 *Definitions.*

C2.1 *Air Sampling Tree*. The air sampling tree is an air sampling tube assembly that draws air through sampling tubes in a manner to provide a uniform sampling of air entering the condenser coil. See Section C4 for design details.

C2.2 *Aspirating Psychrometer*. A piece of equipment with a monitored airflow section that draws a uniform airflow velocity through the measurement section and has probes for measurement of air temperature and humidity. See Section C5 for design details.

C3 *General Requirements.* Temperature measurements shall be made in accordance with ANSI/ASHRAE Standard 41.1. Where there are differences between this document and ANSI/ASHRAE Standard 41.1, this document shall prevail.

Temperature measurements shall be made with an instrument or instrument system, including read-out devices, meeting or exceeding the following accuracy and precision requirements detailed in Table C1.

Table C1. Temperature Measurement Requirements

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

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

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 condenser discharged air is avoided except as may naturally occur from the equipment. To check for the recirculation of condenser discharged air back into the condenser 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 condenser fan exhaust and just above the top of the condenser 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.

Note: Mixing fans can be used to ensure adequate air distribution in the test room. If used, mixing fans must 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 condenser air inlet. Pay particular attention to prevent recirculation of condenser fan exhaust air back through the unit.

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 from the mean wet-bulb temperature and the individual temperature measurement stations	uniform humidity distribution	± 1.00
Difference between mean wet-bulb air wet-bulb 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. The mean dry-bulb temperature is the mean of all measurement stations.
3. The wet-bulb temperature measurement is only required for evaporatively-cooled units and heat pump unitary products operating in the heating mode.

C4 *Air Sampling Tree Requirements.* The air sampling tree is intended to draw a uniform sample of the airflow entering the air-cooled condenser section. A typical configuration for the sampling tree is shown in Figure C1 for a tree with overall dimensions of 4 feet by 4 feet 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. It shall have from 10 to 20 branch tubes. 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. The number of sampling holes shall be greater than 50. 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 6-12 inches 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.

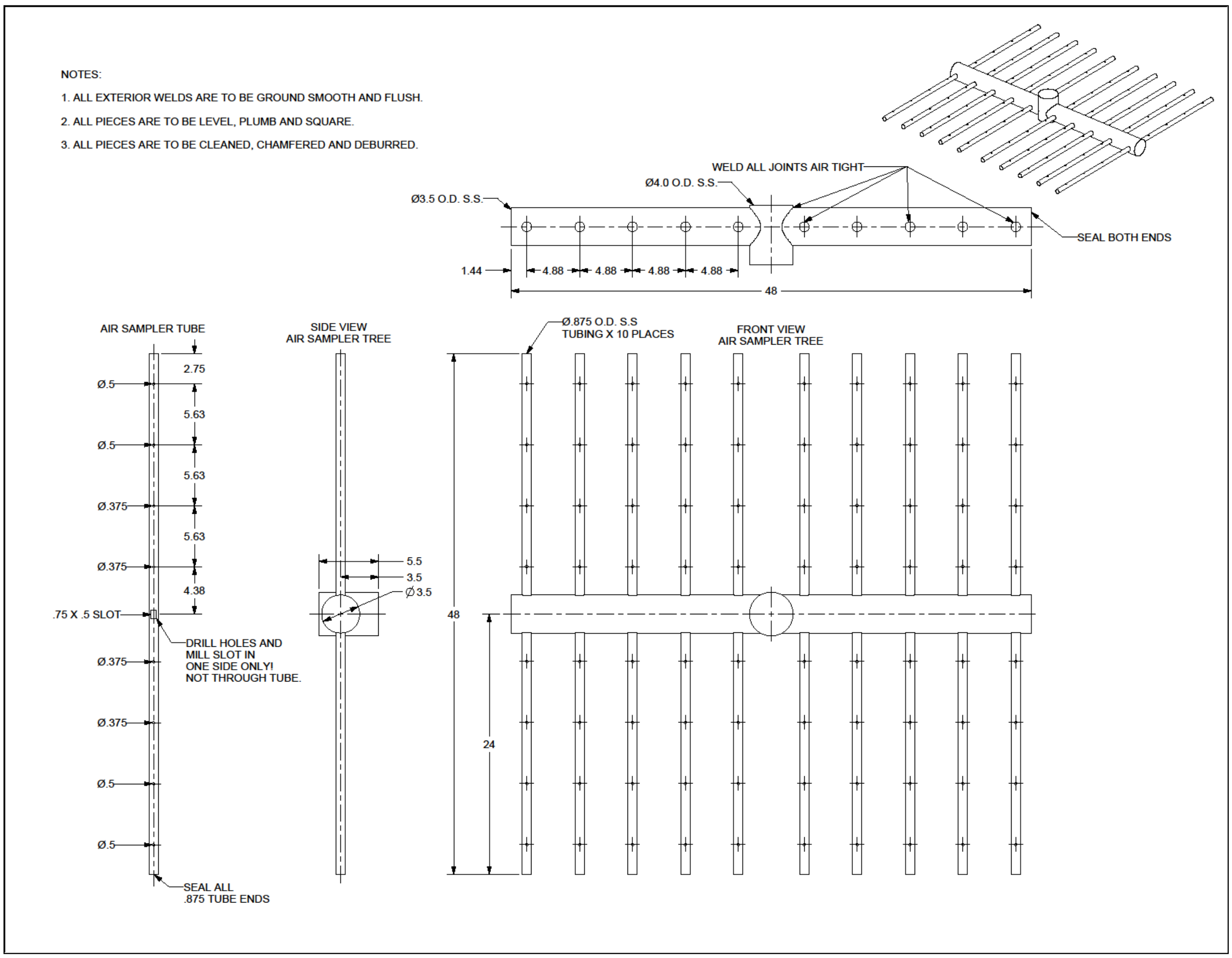

Figure C1. Typical Air Sampling Tree

Note: The .75in X .50in slots referenced in Figure C1 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.

C5 *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 psychrometer shall include a fan that can either be adjusted manually or automatically to maintain average velocity across the sensors. A typical configuration for the aspirating psychrometer is shown in Figure C2.

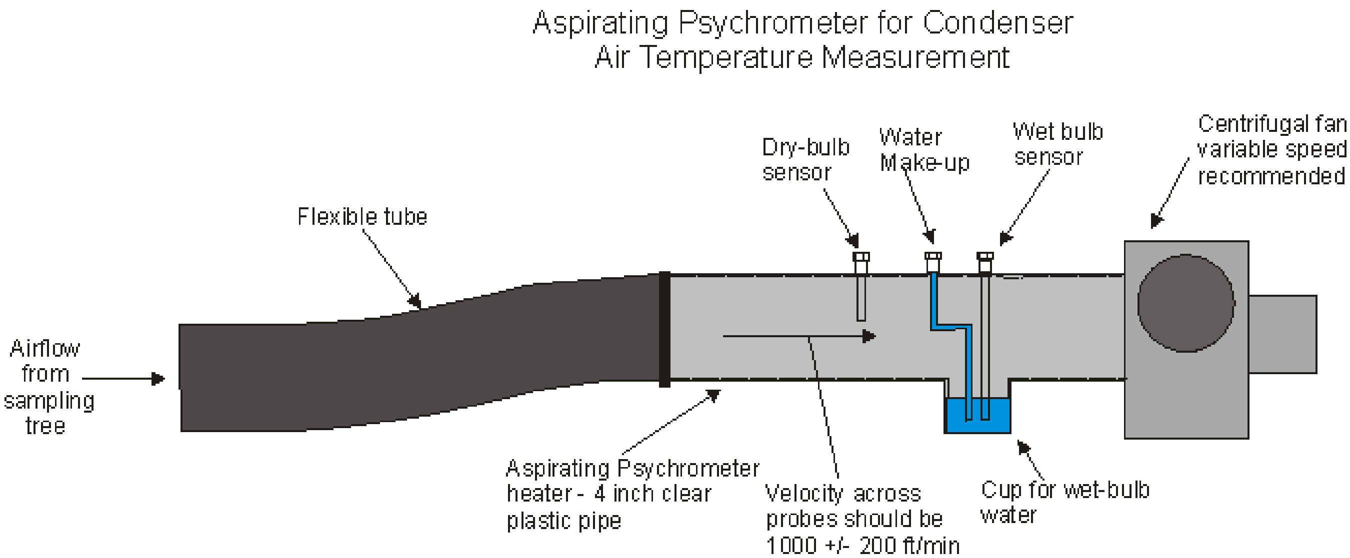

Figure C2. Aspirating Psychrometer

C6 *Test Setup Description.* Air wet-bulb and/or dry-bulb temperature shall be measured at multiple locations entering the condenser, based on the airflow nominal face area at the point of measurement. Multiple temperature measurements shall be used to determine acceptable air distribution and the mean air temperature.

The use of air sampling trees as a measuring station reduces the time required to setup a test and allows an additional or third party sensor(s) for redundant dry-bulb and wet-bulb temperatures. Only the dry-bulb sensors need to be used for air-cooled condensers, but wet-bulb temperature shall be used with evaporatively cooled and heat pump unitary products running in the heating mode.

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 sampler tree.

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

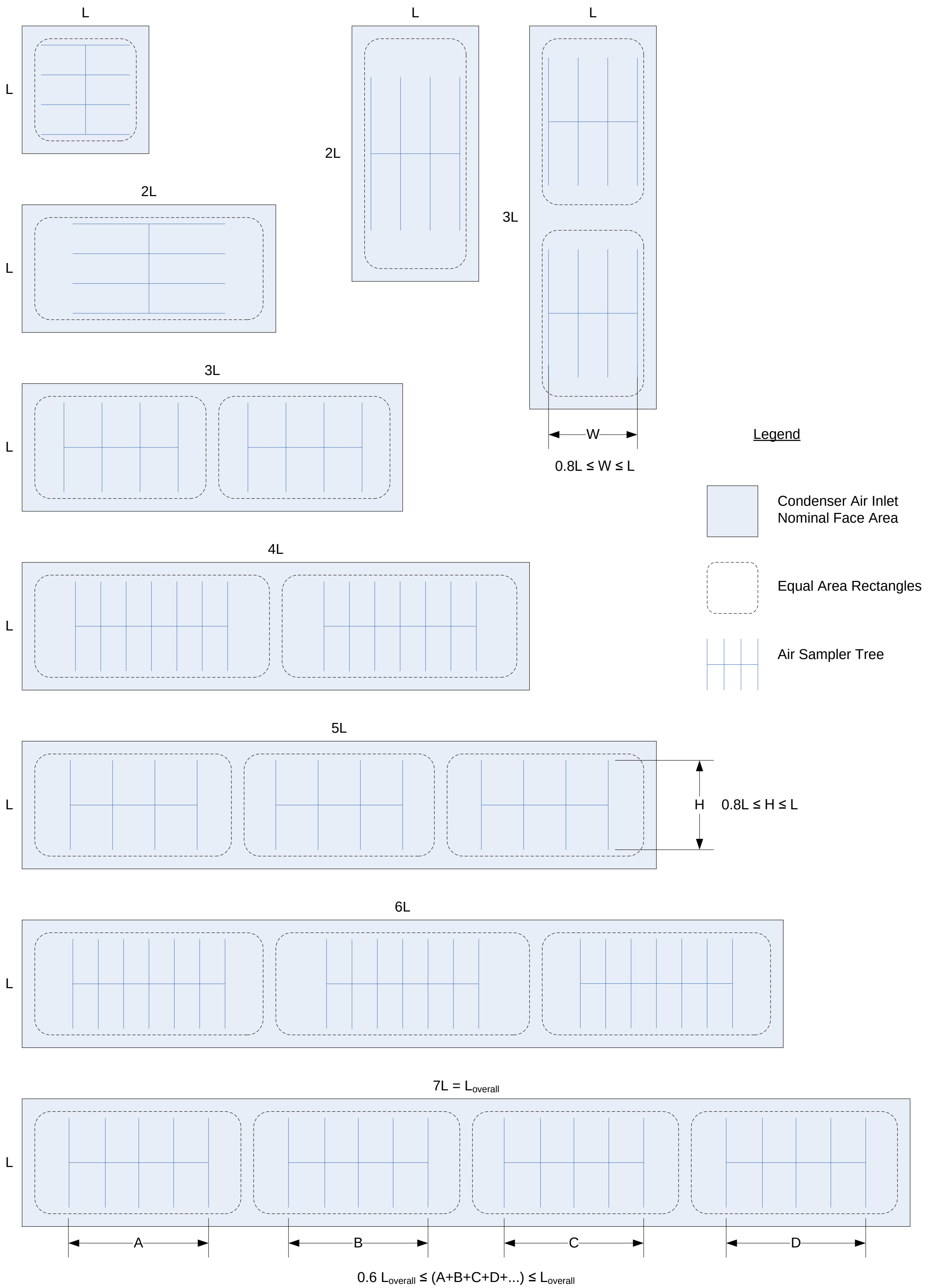

Figure C3. Determination of Measurement Rectangles and Required Number of Air Sampler Trees

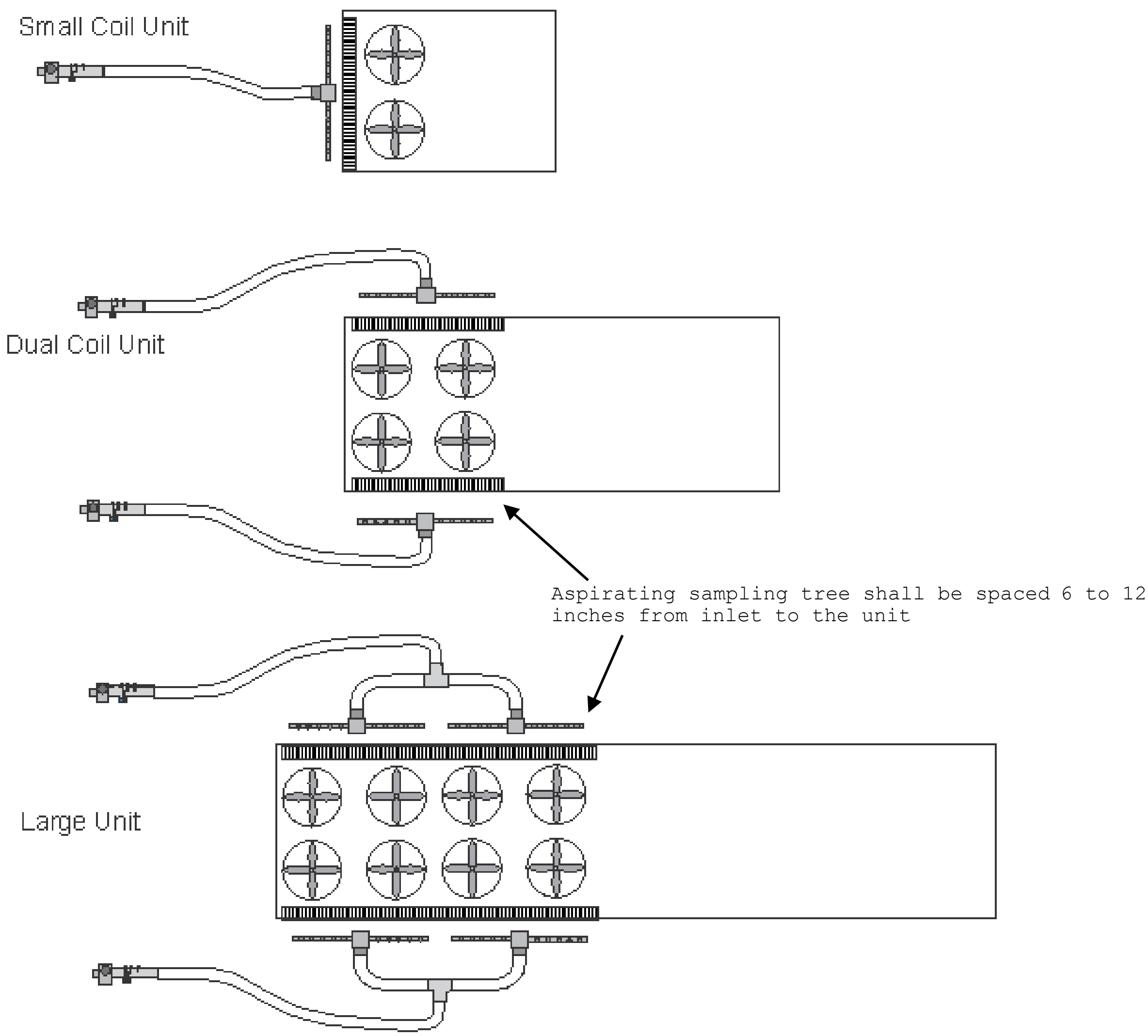

Figure C4. Typical Test Setup Configurations

A minimum of one aspirating psychrometer per side of a unitary product shall be used. For units with three (3) sides, two (2) sampling aspirating psychrometers can be used but shall require a separate air sampler 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.

A minimum total of two (2) air sampler trees shall be used in any case, in order to assess air temperature uniformity.

The air sampler 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 inches from the enter 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 sampler trees are required for longer condenser 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 sampler tree and aspirating psychrometer setups.

APPENDIX D. ATMOSPHERIC PRESSURE CORRECTION – NORMATIVE

D1 *Purpose.* The purpose of this appendix is to prescribe a method for adjusting measured test data and resulting capacity and efficiency to the standard air atmospheric pressure of 14.696 psia (29.92 in Hg). All test data shall be corrected using this procedure to account for the corrected local atmospheric pressure to the standard air atmospheric pressure.

D2 *Atmospheric Pressure Correction Background.* The following provides informative background for the impact and correction for changes in atmospheric pressure.

In order to ensure that performance can be uniformly compared from one unit to another and from one manufacturer to another, performance testing for products shall be corrected for air density variations resulting from atmospheric pressure changes which result from weather conditions and altitude.

For capacity measurements the test procedures defined in ASHRAE Standard 37 require the measured indoor airflow to be corrected to standard air density of 0.075 lb/ft^3, which approximates dry air at 70°F and an atmospheric pressure of 14.696 psia (29.92 in Hg). This is done so that standard air psychometric properties can be used to calculate capacity and be equivalent to the capacity that would be determined if non-standard air properties and measured airflow were used such that no correction needs to be made to the measured capacity. The correction is done by using the air temperature dry-bulb and wet-bulb temperature obtained at the location of air flow measurement along with the actual atmospheric pressure to determine the actual air density at test conditions which is then used to correct the measure airflow to standard airflow. Typically the flow is measured on the leaving airside of the equipment using a code tester as required by ASHRAE 37. Therefore the temperatures leaving the unit are used.

The ASHRAE Standard 37 airflow correction does not factor in the impact on the indoor fan power which will also change as the fan is run faster for lower atmospheric pressure and air density and slower for higher atmospheric pressures and air density. It also does not take into account the impact on air cooled condenser airflow and the impact on condenser performance which then impacts the condenser fan power and compressor power due to decreases or increases in condenser heat transfer performance. Therefore additional corrections need to be made for the indoor fan power on all unit tests and for the compressor and condenser fan power and unit capacity for air cooled and evaporatively cooled units.

Correction for the indoor fan power can be calculated using standard fan laws which can be used to adjust the indoor fan power as a function of the ratio of the measured air density to the standard air density raised to the second power as shown in Equation D1. The fan laws would indicate that it should be varied to the cube of the density, but because the correction for airflow is also being made the correction is modified to be a function of the square of the density.

$$P_{IF\ corr} = P_{IF\ test} \cdot \left(\frac{\rho_{test}}{\rho_{std}}\right)^2 \qquad \text{D1}$$

Where;

$P_{IF\ corrt}$ = Indoor fan motor power corrected to a standard pressure of 14.696 psia[3] in watts
$P_{IF\ test}$ = Indoor fan motor power measured during the test at test air density in watts
ρ_{test} = Test air density at the air measurement station, dry bulb and wet bulb temperature at atmospheric pressure (lb/ft^3)
ρ_{std} = The density of air at the air measurement station, dry bulb and wet bulb temperature at ~~a~~ standard barometric pressure, 14.696 psia (lb/ft^3)

Correcting for the outdoor coil fan impact due to atmospheric pressure is complicated. As the atmospheric pressure changes so does the density of the air. The change in density will impact the airflow and the power of the outdoor coil fans in a direct relationship to the density change. This can be calculated using the fan laws, but as the airflow changes, the performance of the condenser in cooling and the outdoor coil in heat pumps will change. This will impact the capacity and power of the refrigeration system. The outdoor coil performance depends on the amount of coil surface and face velocity as well as the coil design attributes. Units can have face velocities that range from 150 fpm to 600 fpm and this will result in larger and smaller coil face areas, number of rows, and fin densities for the same performance.

The impact of atmospheric pressure and air density will have different effects depending on the combination of face velocity and coil design. Therefore, a direct correction methodology cannot be easily derived using a physics based fundamental modeling approach. The only option currently being used is an empirical correlation based on measured test results and applying a correction factor. Some standards have developed empirical correlations to approximate a correction for their products but for this standard the approach chosen has been to not use an empirical correlation and instead limit the atmospheric pressure to greater than 13.7 psia which will limit the error in measurement relative to sea level to less than 1% assuming that the indoor fan power correction is applied. This should not be a problem with the current laboratories being used by manufacturers and the verification labs as they are all below 1,200 ft altitude and the limit of 13.7 psia should not be an issue unless there was a very low pressure atmospheric condition.

D3 *Correction Procedure*. To correction for atmospheric pressure and the resulting change in air Equation D2 shall be used to determine the corrected fan power.

$$P_{IF\ corr} = P_{IF\ test} \cdot \left(\frac{\rho_{test}}{\rho_{std}}\right)^2 \quad \text{D2}$$

Where:

$P_{IF\ corr}$ = Indoor fan motor power corrected to standard pressure, ~~of~~ 14.696 psi in watts
$P_{IF\ test}$ = Indoor fan motor power measured during the test at test air density in watts
ρ_{test} = Test air density at the air measurement station, dry bulb and wet bulb temperature at atmospheric pressure in lb/ft^3
ρ_{std} = The density of air at the air measurement station, dry bulb and wet bulb temperature at ~~a~~ standard barometric pressure, 14.696 psia (lb/ft^3)

Once the fan power is corrected it shall then be used to determine the impact on capacity and efficiency.

As defined in the definitions capacity is actually the Cooling Capacity of the unit and includes the impact of the fan power on the Cooling Capacity.

For a Cooling Capacity test the tested capacity (net capacity) shall be corrected using the Equation D3.

$$Q_{corr} = Q_{Test} + (P_{IF\ test} - P_{IFCorr}) \cdot 3.412 \quad \text{D3}$$

For a heating test the tested capacity (net capacity) shall be corrected using Equation D4.

$$Q_{corr} = Q_{Test} + (P_{IF\ Corr} - P_{IF\ Test}) \cdot 3.412 \quad \text{D4}$$

Where:

Q_{corr} = Atmospheric corrected capacity
Q_{Test} = Test capacity at the tested atmospheric pressure. Note pressure must be greater than 13.7 psia

Once the indoor fan power and the capacity are corrected Equation 4 shall then be used to calculate the EER for a cooling test.

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

D4. *Example Cooling Test Full Load EER Calculation.*

Indoor Measured CFM = 3,354 scfm
Indoor Fan Power =1,055 watt
Compressor Power = 10,230 watts
Outdoor Fan Power = 678 watts
Control Power = 100 watts

Indoor Leaving air dry-bulb temperature = 55.00°F
Indoor Leaving air wet-bulb temperature = 54.00°F
Measured Atmospheric Pressure = 13.999 psia
Tested air density = 0.0730 lb/ft^3 (at 55.00°F DB, 54.00°F WB and 13.999 psia pressure)
Air Density at Standard Pressure = 0.0767 lb/ft^3 (at 55.00°F DB, 54.00°F WB and 14.696 psia pressure)
Measured Capacity (net) = 134,367 Btu/h
Measured EER = 11.14 Btu/h w

$$P_{IF\,corr} = P_{IF\,test} \cdot \left(\frac{\rho_{test}}{\rho_{STD}}\right)^2 = 1055 \cdot \left(\frac{0.0730}{0.0767}\right)^2 = 955.67\,W$$

Corrected Fan Power = 955.67 W

$$Q_{corr} = 134{,}367 + (1{,}055 - 955.67) \cdot 3.412 = 134{,}706\,Btu/h$$

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

$$EER = \frac{1.0 \cdot 134{,}706}{1.0 \cdot [1.0 \cdot (10{,}230 + 678)] + 955.67 + 100} = 11.26 \text{ Btu/W·h}$$

Similar to cooling, once the capacity and indoor fan power are calculated the heating COP_H shall be calculated

D5. *Example Heating Test at Full Load*.

Indoor Measured scfm = 3,254 scfm(Standard Air)
Indoor Fan Power = 1,033 W
Compressor Power = 10,550 W
Outdoor Fan Power = 680 W
Control Power = 100 W
Indoor Leaving air dry-bulb temperature = 118.00°F
Indoor Leaving air wet-bulb temperature = 77.69°F
Measured Atmospheric Pressure = 13.999 psia
Tested air density = 0.0650 lb/ft^3 (at 118.00°F DB, 77.69°F WB and 13.999 psia pressure)
Air Density at Standard Pressure = 0.0682 lb/ft^3 (at 118.00°F DB, 77.69°F WB and 14.696 psia pressure)
Measured Capacity (net) = 140,506 Btu/h
COP_H Test =3.33 W/W

$$P_{IF\,corr} = P_{IF\,test} \cdot \left(\frac{\rho_{test}}{\rho_{STD}}\right)^2 = 1{,}033 \cdot \left(\frac{0.0650}{0.0682}\right)^2 = 938.33\,W$$

Corrected Fan Power = 938.33 W

$$Q_{corr} = 140{,}506 + (938.33 - 1{,}033) \cdot 3.412 = 140{,}183\,Btu/h$$

$$COP_H = \frac{Q_{corr}}{(P_C + P_{CF} + P_{IF\,corr} + P_{CT}) \cdot 3.412}$$

$$COP_H = \frac{140{,}182}{(10{,}550 + 680 + 938.33 + 100) \cdot 3.412} = 3.35 \text{ W/W}$$

APPENDIX E. UNIT CONFIGURATION FOR STANDARD EFFICIENCY DETERMINATION - INFORMATIVE

E1 *Purpose.* The purpose of this appendix is to prescribe the requirements for the configuration of a unit that is used for determining the Cooling and Heating Capacity at Standard Rating Conditions and efficiency metrics at Standard Rating Conditions. This will allow for a uniform approach to determine minimum and other Standard Rating metrics. This appendix is provided for the convenience of users. For official requirements, refer to CFR 431.

E2 *Background*. The Standard Ratings are intended to be ratings that define the performance of a Basic Model at a defined set of Rating Conditions. The ratings include the following at Standard Rating Conditions:

E2.1 Standard cooling capacity
E2.2 Standard EER
E2.3 IEER
E2.4 High temperature heating capacity
E2.5 High temperature COP_H
E2.6 Low temperature heating capacity
E2.7 Low temperature COP_H

Commercial Unitary products can be complex pieces of equipment that are adapted to operate in a building HVAC system and often for non-standard Rating Conditions and applications. This can include capabilities for higher external statics due to the ductwork design in the building, enhanced dehumidification capabilities due to local weather conditions and other system related features. They can also include system features for overall annual efficiency improvement like economizers, energy recovery, evaporative cooling, ventilation air requirements, and enhanced IAQ features and filtration.

Many of these features are addressed in building efficiency standards where they compensate for features such as economizers, energy recovery, fan power, and indoor air quality (IAQ) features.

E3 *Configuration Requirements*.

E3.1 *Indoor Airside Motor and Drive Configuration*. Units may have fans and drives that can be configured for non-Standard Rating airflows and non-Standard Rating static pressures. Standard Ratings shall be determined and tested with the standard indoor fan assembly, for the rating cfm and static as defined in Table 4 if the following is true.

i. The standard indoor fan assembly is distributed for commerce, and
ii. The non-standard motors have the same relative efficiency as the standard motor.

For example, if the above motor selected for Table 4 conditions is 2% more efficient than the appropriate NEMA minimum efficiency, and all optional motors are at least 2% more efficient than their appropriate NEMA minimum efficiency, then the Standard Ratings shall be determined and tested with the Table 4 condition motor. Sheave adjustment or other speed adjustment shall be made to obtain the required static pressure at the rated full load Airflow with the tolerances as defined in Table 4. For Standard Ratings the unit shall be configured with the lowest NEMA efficiency class being offered for that model or model group.

E3.2 *IAQ Features and Filtration*.

E3.2.1 Standard Ratings shall be determined and tested with manufacturer standard, lowest level of air filtration. For units with no filters, static pressure allowance of 0.08 in H_2O shall be added to the minimum static pressure shown in Table 5. If higher filtration is offered then the unit shall be tested without filters, at an additional 0.08 in H_2O external static pressure.

E3.2.2 *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. Standard Ratings shall be determined and tested with UV Lights turned off unless the UV Lights are standard for a model and the model is not offered without UV Lights.

E3.3 *System Features Excluded from Testing*. Commercial equipment can have many features that enhance the operation of the unit on an annualized basis. Standards like ASHRAE Standard 90.1 include performance allowances and prescriptive requirements for many of these features. Standard Ratings shall be determined and tested without the following features if the manufacturer distributes in commerce an otherwise identical unit that does not have that feature.

E3.3.1 *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.

E3.3.2 *Ventilation Energy Recovery*. An assembly that pre-conditions outdoor air entering equipment through direct or indirect thermal and/or moisture exchange with the unit's exhaust air and provides significant annualized energy efficiency improvements depending on the regional ambient and building operating load conditions. They are not considered in the EER and IEER metric and energy recovery is addressed separately by the AHRI Guideline V (I-P).

E3.3.2.1 *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 and provide significant annualized energy efficiency improvements depending on the regional ambient and building operating load conditions. They are not considered in the EER and IEER metric.

E3.3.3 *Indirect/Direct Evaporative Cooling of Ventilation Air*. Water is used indirectly or directly to cool ventilation air. In dry climates, the water is evaporated to pre-cool the 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. This feature has limited applicability at the Standard Rating Conditions and is intended for dry climates where significant performance improvements are obtained

E3.3.4 *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. This feature has limited applicability at the Standard Rating Conditions and is intended for dry climates.

E3.3.5 *Desiccant Dehumidification Components*. An assembly that reduces the moisture content of the Supply Air through moisture transfer with solid or liquid desiccants.

E3.3.6 *Steam/Hydronic Heat Coils*. Coils used instead of electric coils to provide primary or supplemental heating.

E3.3.7 *Hot Gas 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.

E3.3.8 *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.

E3.3.9 *Customer System Features*.

E3.3.9.1 *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.

E3.3.9.2 *Power Correction Capacitors*. A capacitor that increases the power factor measured at the line connection to the equipment. These devices are a requirement of the power distribution system supplying the unit.

E3.3.9.3 *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.

E3.3.9.4 *Indoor Fan VFD (Constant Volume Units)*. 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 convenience of quickly setting up the constant air flow

E3.3.9.5 *Compressor VFD*. 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.

E3.3.9.6 *Ducted Condenser Fans*. A condenser fan/motor assembly designed for optional 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.

E3.3.9.7 *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.

E3.3.9.8 *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 UL555S.

E3.3.9.9 *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.

E3.4 *Dampers.* Standard Ratings shall be determined and tested without dampers. If the sample has outdoor air or exhaust air dampers while testing, they shall be fully sealed to prevent operation.

E3.4.1 *Barometric Relief Dampers*. An assembly with dampers and means to automatically set the damper position in a closed position and one or more open positions to allow venting directly to the outside a portion of the building air that is returning to the unit, rather than allowing it to recirculate to the indoor coil and back to the building. For the Standard Ratings, Barometric Relief Dampers shall be fully sealed.

E3.4.2 *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. For the Standard Ratings, fresh air dampers shall be fully sealed.

E3.5 *Engineered To Order Options*. Manufacturers may sell options not listed in their catalogs, selection software or other marketing literature and these options may impact the performance ratings listed in E2. If an engineered-to-order option is only sold once in a 2 year period on a given Basic Model then it remains an engineered-to-order option for that Basic Model. Standard Ratings are determined and tested without engineered to order options.

On the other hand, if this engineered to order option is sold more than once in 2 year period on a given Basic Model, then it no longer qualifies as an engineered-to-order option for that Basic Model, and the option must be considered when rating or testing the model unless it is excluded in Sections E3.3, E3.4 or E3.5.

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

F1 *Purpose.* The purpose of this appendix is to prescribe the test procedures used for testing Commercial and Industrial Unitary Air Conditioning Products. In general, the testing of AHRI Standard 340/360 products shall comply with ASHRAE Standard 37 with the following additional requirements.

F2 *Atmospheric Pressure Corrections*. The test derived capacity and efficiency shall be corrected to a standard atmospheric pressure of 14.696 psia (29.92 in Hg) using the procedure defined in Appendix D.

F3 *Condenser Air Temperature Measurement*. The condenser air temperature for air cooled products and evaporatively cooled products shall be measured using the procedures defined in Appendix C.

F4 *Tolerance on External Static Pressure*. For Full Load Cooling Capacity and EER, testing shall be conducted at the rated indoor airflow and the required external static pressure per Table 4 with a static pressure tolerance of -0.0 in H_2O to +0.05 in H_2O.

F5 *Tolerance on Airflow.* The tolerance on airflow shall be ± 3% of the rated airflow. The speed of the fan motor shall be adjusted or alternate drives shall be supplied in order to bring the airflow and static within tolerance of the rated airflow.

Note. See Section 6.1.3.7 for part load airflow requirements and section 6.1.3.3.5 for combined cooling and heating units.

F6 *Water Cooled Product Heat Balance*. For water cooled products a heat balance (HB) shall be calculated using the following procedures. The maximum acceptable HB is ± 4%.

F6.1 *Calculation of Heat Balance additional test Measurements*. For units with a water cooled condenser additional measurements shall be taken to measure the condenser flow and entering and leaving water temperatures.

The net heating rejection of the condenser shall be calculated using the Equation F1;

$$q_{cd} = m_w \cdot c_p \cdot (t_l - t_e)\ (\frac{Btu}{h}) \qquad \text{F1}$$

Where:

c_p = Specific heat of water, Btu/lb
m_w = Condenser water massflow rate, lb/hr
q_{cd} = Condenser net heat rejection in Btu/h
t_e = Condenser entering water temperature, ºF
t_l = Condenser leaving water temperature, ºF

The gross heat rejection of the condenser shall be calculated using Equation F2;

$$q'_{cd} = q_{cd} - \frac{K_3 \cdot \Delta p}{\rho}\ (\frac{Btu}{h}) \qquad \text{F2}$$

Where:

K_3 = 0.18505 = 144 in^2 / ft^2·Btu / 778.17, ft·lbf
ρ = Water density determined at the average of the entering and leaving water temperatures, lbm/ft^3
Δp = Water-side pressure drop for the heat exchanger, psid
q'_{cd} = Condenser gross heat rejection, Btu/h

For these calculations the following correlations shall be used for the water properties.

Water Density:

$$\rho = (-7.4704 \cdot 10^{-10} \cdot t^4) + (5.2643 \cdot 10^{-7} \cdot t^3) - (1.8846 \cdot 10^{-4} \cdot t) + 62.227\ (\frac{lbm}{ft^3}) \qquad \text{F3}$$

Water Specific Heat:

$$c_p = (-4.0739 \cdot 10^{-13} \cdot t^5) + (3.1031 \cdot 10^{-10} \cdot t^4) - (9.2501 \cdot 10^{-8} \cdot t^3) + (1.4071 \cdot 10^{-5} \cdot t^2) - (1.0677 \cdot 10^{-3} \cdot t) + 1.0295 \left(\frac{BTU}{lbm \cdot {}^{\circ}F}\right) \quad \text{F4}$$

Where:

t = Average water temperature, ºF, $(t_l+t_e)/2$

The HB shall then be calculated using Equation F5. The HB shall be within ± 4%.

$$HB = \frac{(q'_{ev}+W_{input} \cdot 3{,}412.14) - q'_{cd}}{(q'_{ev}+W_{input} \cdot 3{,}412.14)} \cdot 100\% \quad \text{F5}$$

Where:

HB = Heat balance
q'_{cd} = Condenser heat rejection, Btu/h
q'_{ev} = Cooling Gross Capacity (Capacity(Net) $-P_{IF} \cdot 3{,}412.14$), Btu/hr
W_{input} =Compressor power input, W

F7 *Head Pressure Control*. For units that have head pressure control to insure 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 should be set at the factory settings or as defined in the installation instruction.

If during part load testing for IEER if the head pressure control is engaged by the control logic then it shall be allowed to control the operation of the unit. If the unit can be run and stable conditions are obtained as required by ASHRAE Standard 37 test procedures then a standard test as defined by ASHRAE Standard 37 shall be run. If the head pressure control results in cycling of the condenser fans and unstable conditions, as defined by ASHRAE Standard 37, then the following modified test procedure defined in F7.1 shall be used.

F7.1 *Head Pressure Control Time Average Test Procedure*. A series of two 1 hour tests shall be run. Prior to the first hour test the condenser operating condition as defined by Table 6 shall be approached from at least a 10ºF higher temperature until the temperature is within tolerances as defined by ASHRAE Standard 37, Table 2b. When on conditions, the first one hour test shall be started and a test shall be recorded every 5 minutes for 1 hour resulting in 12 test measurements of the unit capacity and efficiency. During the 1 hour time average, test the requirements of ASHRAE Standard 37, Table 2b for heat with defrost as defined for the heat portion.

Following the first 1 hour test completion, the condenser condition shall be reduced at least 5ºF below the desired temperature. It shall then be gradually increased until the temperature is within tolerance as defined by ASHRAE Standard 37, Table 2b. When on conditions, the first one hour test shall be started and a test shall be recorded every 5 minutes for 1 hour resulting in 12 test measurements of the unit capacity and efficiency. During the 1 hour time average test the requirements of ASHRAE Standard 37, Table 2b for heat with defrost as defined for the heat portion.

The tests results for both 1 hour test series shall then be averaged to determine the rated performance for the rating point capacity and efficiency that is then used for the IEER calculation.

APPENDIX G. EXAMPLES OF IEER CALCULATIONS - INFORMATIVE

G1 *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.

Table G1. Table of Contents of Examples

G2 *Fixed Capacity Control Examples*. In this section you will find example IEER calculations for fixed capacity control 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.

G2.1 *Example 1. Fixed Capacity Control Air-cooled Unit with Fixed Speed Indoor Fan IEER Example Calculations.*

The unit is an air cooled Packaged 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
Rated Standard Airflow = 2,600 scfm
Rated EER = 11.2 Btu/W · h
Rated IEER = 11.0 Btu/W · h

Shown below are the test data and the corrections for atmospheric pressure as defined in the procedures in Section 6.2.4

step 1 and 2. During the tests the atmospheric pressure was measured at 14.50 psia and was constant for all tests. Note the pressure could vary between tests and it should be measured for each test.

Table G2A Example 1. Test Resuts with Adjustment for Atmospheric Pressure

Test	Stage	Test OAT	Req OAT	Actual % Load	Test Net Cap	Test CFM (Std Air)	Test Leaving Air DB	Test Leaving Air WB	Test Leaving Air Density	14.696 psia Leaving Air Density	Cmpr (P_C) (Test)	Cond (P_{CD}) (Test)	Indoor (P_{IF}) (Test)	Control (P_{CT}) (Test)	EER (Test)	Indoor (P_{IF}) (Corr)	Net Cap (Corr)	EER (Corr)
		ºF	ºF	%	Btu/h	CFM	ºF	ºF	lbm/ft^3	lbm/ft^3	W	W	W	W	Btu/h W	W	Btu/h	Btu/h W
1	1	95.1	95.0	100.0	92,293	2,610	56.50	55.82	0.0754	0.0764	6,723	518	831	50	11.36	809	92,369	11.40
2	1	81.7	81.5	103.5	95,523	2,610	56.20	55.52	0.0755	0.0765	6,309	518	831	50	12.39	810	95,595	12.44
3	1	67.6	68.0	103.9	95,943	2,610	56.00	55.32	0.0756	0.0765	5,874	518	831	50	13.19	811	96,011	13.24
4	1	65.3	65.0	107.2	98,927	2,610	55.60	54.93	0.0756	0.0766	5,803	518	831	50	13.74	810	99,000	13.79

Because the unit only has a single stage of capacity control, the rating EER values for this 75%, 50%, and 25% rating points require only 3 tests to be run at the rated ambient temperatures of 81.5ºF (75% load), 68.0ºF (50% load), and 65ºF (25% load) as defined in Table 6 which must then be corrected for atmospheric pressure using the degradation calculations as defined in Section 6.2. Note that for this example all tests are acceptable as the test outdoor air temperatures are within ± 0.5ºF of the required condenser entering air temperature as defined in ASHRAE Standard 37 Test Tolerance table 2b for an air cooled unit. If the temperature variation is greater than the allowable tolerance then the test must be repeated.

Step 2 of the procedure requires the test data for the indoor fan power and capacity be adjusted for atmospheric pressure as defined in Appendix D. For example, looking at test 1, the following are the details of the calculations for atmospheric pressure correction. The density of the unit leaving air temperature is 0.754 lb_m/ft^3 based on the air temperature conditions entering the indoor fan of 56.50ºF dry-bulb, 55.82ºF wet-bulb and 14.50 psia atmospheric pressure.

First the corrected indoor fan power is calculated using Equation D1.

$$P_{IF\ corr} = P_{IF\ test} \cdot \left(\frac{\rho_{test}}{\rho_{STD}}\right)^2 = 831 \cdot \left(\frac{0.0754}{0.0764}\right)^2 = 809\ watts$$

Then the corrected net Cooling Capacity (Q_{corr}) is determined using Equation D2

$$Q_{corr} = Q_{Test} + (P_{IF\ Corr} - P_{IF\ Test}) \cdot 3.412 = 92{,}293 + (831 - 809) \cdot 3.412 = 92{,}369\ Btu/h$$

Once the corrected fan power and corrected net capacity are determined a corrected EER can be calculated using Equation 4 as shown below.

$$EER_{corr} = \frac{Q_{corr}}{P_C + P_{CD} + P_{IF\ corr} + P_{CT}} = \frac{92{,}369}{6{,}723 + 518 + 809 + 50} = 11.40\ \mathrm{Btu/W \cdot h}$$

Similar calculations are also required for the test point 2, 3, and 4 to develop the atmospheric pressure corrected rating data.

Once the test points have been corrected for atmospheric pressure then the calculations as outlined in step 3 of the Section 6.2.4.3 procedure can be performed using the atmospheric pressure corrected test results. 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 % Load	Net Cap (Corr)	Cmpr (P_C) (Test)	Cond (P_{CD}) (Test)	Indoor (P_{IF}) (Corr)	Control (P_{CT}) (Test)	EER (Corr)	LF	CD	Rating EER
	ºF	ºF	%	Btu/h	W	W	W	W	Btu/W			
A	95.1	95.0	100.0	92,369	6,723	518	809	50	11.40			
			100.0	no degradation required						1.000	1.000	11.40
B	81.7	81.5	103.5	95,595	6,309	518	810	50	12.44			
	Required Load		75.0	degradation required						0.725	1.036	11.58
C	67.6	68.0	103.9	96,011	5,874	518	811	50	13.24			
	Required Load		50.0	degradation required						0.481	1.067	11.15
D	65.3	65.0	107.2	99,000	5,803	518	810	50	13.79			
	Required Load		25.0	degradation required						0.233	1.100	9.31

For rating point A which is the 100% 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 corrected rating point B which is based on test 2, you can see that the unit was supposed to be run at the 81.5ºF ambient condition as required by table 5 for a 75% B rating point. The actual measured ambient temperature was 81.7ºF and is within the required tolerance of ± 0.5ºF as defined ASHRAE Standard 37 Table 2b. The actual corrected capacity Percent Load is 103.5% so a degradation calculation must be performed to determine the EER rating for the 75% load point because the capacity is greater than the ± 3% tolerance required by Section 6.2.

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

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

$$LF = \frac{\left(^{Percent\ Load}/_{100}\right) \cdot Full\ Load\ Net\ Capacity}{Part\ Load\ Net\ Capacity} = \frac{\left(^{75}/_{100}\right) \cdot 92{,}369}{95{,}595} = 0.725$$

What this means is that at a 75% load, the compressor will be on for 72.5% of the time and off for 27.5% of the time.

The degradation coefficient is then calculated using Equation 5.

$$C_D = (-0.13 \cdot LF) + 1.13 = (-0.13 \cdot 0.725) + 1.13 = 1.036$$

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.

$$EER = \frac{LF \cdot Q_{corr}}{LF \cdot [C_D \cdot (P_C + P_{CD})] + P_{IF\ corr} + P_{CT}} = \frac{0.725 \cdot 95{,}595}{0.725 \cdot [1.036 \cdot (6{,}309 + 518)] + 810 + 50} = 11.39\ \mathrm{Btu/W \cdot h}$$

Similar degradation corrections are also made for the 50% and 25% load points.

The last procedural step 4 is to calculate the IEER using Equation 3.

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

$$= (0.02 \cdot 11.40) + (0.617 \cdot 11.58) + (0.238 \cdot 11.15) + (0.125 \cdot 9.31) = 11.02\ \mathrm{Btu/W \cdot h}$$

G2.2 *Example 2***.** *Fixed Capacity Control Water Cooled Unit with Fixed Speed Indoor Fan IEER Example Calculations.*

That the unit is a water cooled Packaged 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
Rated Standard Airflow = 2,200 scfm
Rated EER = 12.1 Btu/W·h

Rated IEER = 11.2 Btu/W·h

Shown below are the test data and the corrections for atmospheric pressure. During all the tests the atmospheric pressure was measured at 15.200 psia and was constant.

Figure G3A Example 2. Test Resuts with Adjustment for Atmospheric Pressure

Test	Stage	Test EWT	Req EWT	Actual % Load	Test Net Cap	Test CFM (Std Air)	Test Leaving Air DB	Test Leaving Air WB	Test Leaving Air Density	14.696 psia Leaving Air Density	Cmpr (P_C) (Test)	Tower (P_{CD}) (Allow)	Indoor (P_{IF}) (Test)	Control (P_{CT}) (Test)	EER (Test)	Indoor (P_{IF}) (Corr)	Net Cap (Corr)	EER (Corr)
		ºF	ºF	%	Btu/h	CFM	ºF	ºF	lbm/ft^3	lbm/ft^3	W	W	W	W	Btu/h W	W	Btu/hr	Btu/W
4	1	85.1	85.0	100.0	74,770	2,150	56.30	55.62	0.0791	0.07648	4,700	746	694	50	12.08	742	74,605	11.96
3	1	73.3	73.5	103.5	77,387	2,150	56.00	55.34	0.0792	0.076528	4,433	746	694	50	13.07	743	77,219	12.93
2	1	62.4	62.0	103.6	77,472	2,150	55.82	55.14	0.0792	0.076558	4,186	746	694	50	13.65	743	77,306	13.50
1	1	54.7	55.0	105.3	78,738	2,150	55.60	54.94	0.0792	0.076594	4,012	746	694	50	14.31	742	78,574	14.16

Because the unit only has a single stage of capacity the rating EER values for 75%, 50%, and 25% will require 3 tests to be run at the rating condenser entering water temperature 73.5°F (75% load), 62.0 F (50% load), and 55.0°F (25% load) as defined in Table 6 and then must be corrected using the degradation calculations as defined in Section 6.2.

Because this is a water cooled unit and the corrected capacity is 74,605 Btu/h, and as required by Section 6.1, if the capacity is greater than or equal to 65,000, but below 135,000 Btu/h then the rating must 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.

$$P_{CD} = 10.0 \cdot \frac{Q_{corr}}{1000} = 10.0 \cdot \frac{74{,}605}{1000} = 746\ W$$

The second step in the 6.2.4 is to adjust the indoor fan power and capacity for atmospheric pressure as defined in Appendix D. For example, looking at test 1, the following are the details for the calculations for atmospheric pressure correction. The density of the leaving air temperature is 0.791 lb_m/ft^3 based on the air temperature conditions entering the indoor fan of 56.30ºF dry-bulb, 55.62ºF wet-bulb and 15.20 psia atmospheric pressure.

First the corrected indoor fan power is calculated using Equation D1.

$$P_{IF\ corr} = P_{IF\ test} \cdot \left(\frac{\rho_{test}}{\rho_{test}}\right)^2 = 694 \cdot \left(\frac{0.0791}{0.0765}\right)^2 = 742\ watts$$

Then the corrected net Cooling Capacity is determined using Equation D2.

$$Q_{corr} = 74{,}770 + (694 - 742) \cdot 3.412 = 74{,}605\ Btu/h$$

Once the corrected fan power and corrected Cooling Capacity are determined a corrected EER can be calculated using Equation 4 as shown below.

$$EER_{corr} = \frac{Q_{corr}}{P_C + P_{CD} + P_{IF\ corr} + P_{CT}} = \frac{74{,}605}{4{,}700 + 746 + 742 + 50} = 11.96\ \mathrm{Btu/W \cdot h}$$

Similar atmospheric calculations are also required for the test point 2, 3, and 4

Once the test points have been corrected for atmospheric pressure the EER rating points can be used for calculation of the IEER as required by step 4 of the 6.2.4 procedure. The calculations are summarized in the follow table.

Figure G3B Example 2. Degradation Calculations												
Test	Test EWT	Req EWT	Actual % Load	Net Cap (Corr)	Cmpr (P_C) (Test)	Tower (P_{CD}) (Allow)	Indoor (P_{IF}) (Corr)	Control (P_{CT}) (Test)	EER (Corr)	LF	CD	Rating EER
	ºF	ºF	%	Btu/h	W	W	W	W	Btu/h W			Btu/h W
A	85.1	85.0	100.0	74,605	4,700	746	742	50	11.96			
	Required Load		100.0		no degradation required					1.0000	1.000	11.96
B	73.3	73.5	103.5	77,219	4,433	746	743	50	12.93			
	Required Load		75.0		degradation required					0.7246	1.036	11.95
C	62.4	62.0	103.6	77,306	4,186	746	743	50	13.50			
	Required Load		50.0		degradation required					0.4825	1.067	11.19
D	54.7	55.0	105.3	78,574	4012	746	742	50	14.16			
	Required Load		25.0		degradation required					0.2374	1.099	9.17

For rating point A which is the 100% 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 corrected rating point B which is based on test 2, you can see that the unit was targeted to be run at the 73.5ºF condenser entering water required by Table 6 for a 75% rating point. The actual measure condenser entering water temperature was 73.3ºF and is within the allowable tolerance of ± 0.2ºF as defined in ASHRAE Standard 37 Table 2b. The actual capacity Percent Load is 103.5% which is greater than the required 75% load even with the allowable 3% tolerance so a degradation calculation must be performed to determine the EER rating for the 75% load point.

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 B are shown below.

$$LF = \frac{\left(^{Percent\ Load}/_{100}\right) \cdot Full\ Load\ Net\ Capacity}{Part\ Load\ Net\ Capacity} = \frac{\left(^{75}/_{100}\right) \cdot 74{,}605}{77{,}2219} = 0.7246$$

What this means is that at a 75% loading 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.

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

$$= \frac{0.7246 \cdot 77{,}219}{0.7246 \cdot [1.036 \times (4{,}433 + 744)] + 743 + 50} = 11.95\ \mathrm{Btu/W \cdot h}$$

Similar degradation corrections are also made for the 50% and 25% load points.

The last step 4 is to calculate the IEER using Equation 3.

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

$$= (0.02 \cdot 11.96) + (0.617 \cdot 11.95) + (0.238 \cdot 11.19) + (0.125 \cdot 9.17) = 11.43\ \mathrm{Btu/W \cdot h}$$

G2.3 *Example 3. Fixed Capacity Control Evaporatively Cooled Unit with Fixed Speed Indoor Fan IEER Example Calculations*.

The unit is an evaporatively cooled 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

Rated Standard Airflow = 2,500 scfm
Rated EER = 12.1 Btu/h W
Rated IEER = 11.5 Btu/W·h

Shown below are the test data and the corrections for atmospheric pressure as required by step 2 of the Section 6.2.4 procedure. During all the tests the atmospheric pressure was measure at 13.900 psia and was constant.

Figure G4A Example 3. Test Resuts with Adjustment for Atmospheric Pressure

Test	Stage	Test Enter WB	Req Enter WB	Actual % Load	Test Net Cap	Test CFM (Std Air)	Test Leaving Air DB	Test Leaving Air WB	Test Leaving Air Density	14.696 psia Leaving Air Density	Cmpr (P_C) (Test)	Cond (P_{CD}) (Allow)	Indoor (P_{IF}) (Test)	Control (P_{CT}) (Test)	EER (Test)	Indoor (P_{IF}) (Corr)	Net Cap (Corr)	EER (Corr)
		ºF	ºF	%	Btu/h	CFM	ºF	ºF	lbm/ft^3	lbm/ft^3	W	W	W	W	Btu/h W	W	Btu/hr	Btu/W
4	1	74.3	74.5	100.0	85,617	2,110	55.05	54.37	0.0725	0.0767	5,283	925	789	50	12.15	705	85,903	12.34
3	1	66.6	66.2	101.2	86,676	2,110	54.87	54.20	0.0725	0.0767	5,076	925	789	50	12.67	705	86,964	12.87
2	1	57.7	57.5	102.6	87,878	2,110	54.66	53.99	0.0726	0.0768	4,838	925	789	50	13.31	704	88,167	13.53
1	1	52.5	52.8	103.7	88,783	2,110	54.51	53.84	0.0726	0.0768	4,698	925	789	50	13.74	706	89,068	13.96

Because the unit only has a single stage of capacity the rating EER values for 75%, 50%, and 25% will require 3 tests to be run at the rating ambient wet-bulb temperature of 66.2°F (75% load), 57.5 F (50% load), and 52.8°F (25% load) as defined in Table 6 and then must be corrected using the degradation calculations as defined in Section 6.2.

Per the Section 6.2.4 procedure the second step is to adjust the indoor fan power and capacity for atmospheric pressure as defined in Appendix D. For example, looking at test 1, the following are the details of the calculations for atmospheric pressure correction. The density of the leaving air temperature is 0.0725 lb_m/ft^3 based on the air temperature conditions entering the indoor fan of 55.05ºF dry-bulb, 54.37ºF wet-bulb and 13.9 psia atmospheric pressure.

First the corrected indoor fan power is calculated using Equation D1.

$$P_{IF\ corr} = P_{IF\ test} \cdot \left(\frac{\rho_{test}}{\rho_{STD}}\right)^2 = 789 \cdot \left(\frac{0.0725}{0.0767}\right)^2 = 705\ watts$$

Then the corrected net Cooling Capacity is determined using Equation D2

$$Q_{corr} = 85{,}617 + (789 - 705) \cdot 3.412 = 85{,}903\ Btu/h$$

Once the corrected fan power and corrected Cooling Capacity are determined a corrected EER can be calculated using Equation 4 as shown below.

$$EER_{corr} = \frac{Q_{corr}}{P_C + P_{CD} + P_{IF\ corr} + P_{CT}} = \frac{85{,}903}{5{,}283 + 925 + 705 + 50} = 12.87\ \text{Btu/W} \cdot \text{h}$$

Similar calculations are also required for the test point 2, 3, and 4

Once the test points have been corrected for atmospheric pressure then the ERR rating points for the IEER calculation can be completed as outlined in Section 6.2.4, step 3. Shown below are the results of the calculations.

Figure G4B Example 3. Degradation Calculations												
Test	Test Enter WB	Req Enter WB	Actual % Load	Net Cap (Corr)	Cmpr (P_C) (Test)	Tower (P_{CD}) (Allow)	Indoor (P_{IF}) (Corr)	Control (P_{CT}) (Test)	EER (Corr)	LF	CD	Rating EER
	ºF	ºF	%	Btu/h	W	W	W	W	Btu/h W			Btu/h W
A	74.3	74.5	100.0	85,903	5,283	925	705	50	12.34			
	Required Load		100.0		No degradation required					1.0000	1.000	12.34
B	66.6	66.2	101.2	86,964	5,076	925	705	50	12.87			
	Required Load		75.0		degradation required					0.7409	1.034	12.04
C	57.7	57.5	102.6	88,167	4,838	925	704	50	13.53			
	Required Load		50.0		degradation required					0.4872	1.067	11.46
D	52.5	52.8	103.7	89,068	4698	925	706	50	13.96			
	Required Load		25.0		degradation required					0.2411	1.099	9.57

For rating point A which is the 100% 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 corrected rating point B which is based on test 2, you can see that the unit was targeted to be run at the 66.2ºF wet-bulb temperature required by Table 6 for a 75% rating point. The actual measure wet-bulb 66.6ºF and is within the allowable tolerance of ± 0.3ºF as defined in ASHRAE Standard 37 Table 2b. The actual capacity Percent Load is 101.2% so a degradation calculation must be performed to determine the EER rating for the 75% 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.

$$LF = \frac{\left(Percent\ Load/_{100}\right) \cdot Full\ Load\ Net\ Capacity}{Part\ Load\ Net\ Capacity} = \frac{\left(75/_{100}\right) \cdot 86{,}964}{85{,}903} = 0.7592$$

What this means is that at a 75% load the compressor will be on 75.92% of the time and of 24.08% of the time.

The degradation coefficient is calculated using Equation 5.

$$C_D = (-0.13 \cdot LF) + 1.13 = (-0.13 \cdot 0.7409) + 1.13 = 1.034$$

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

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

$$= \frac{0.7409 \cdot 86{,}936}{0.7409 \cdot [1.034 \times (5{,}076 + 925)] + 705 + 50} = 12.04\ \mathrm{Btu/W \cdot h}$$

Similar degradation corrections are also made for the 50% and 25% load points.

The last 6.2.4 procedural step 4 is to calculate the IEER using Equation 3

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

$$= (0.02 \cdot 12.34) + (0.617 \cdot 12.04) + (0.238 \cdot 11.46) + (0.125 \cdot 9.57) = 11.60\ \mathrm{Btu/W \cdot h}$$

G3 *Staged Capacity Controlled Unit Example Calculations*. In the following section you will find example calculations for IEER calculations for staged capacity control units. As defined in 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

G3.1 *Example 4. 4 Stage Air Cooled Multizone VAV Unit with a Variable Speed Indoor Fan IEER Example Calculation*.

The unit is an air cooled Mutizone VAV Packaged 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
Rated Full Load Standard 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 and corrections for atmospheric pressure as defined in Section 6.2.4 step 1 and 2. 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. The pressure could vary between tests and it should be measured for each test.

Table G5A Example 4. Test Resuts with Adjustment for Atmospheric Pressure

Test	Stage	Test OAT	Req OAT	Actual % Load	Test Net Cap	Test CFM (Std Air)	Test Leaving Air DB	Test Leaving Air WB	Test Leaving Air Density	14.696 psia Leaving Air Density	Cmpr (P_C) (Test)	Cond (P_{CD}) (Test)	Indoor (P_{IF}) (Test)	Control (P_{CT}) (Test)	EER (Test)	Indoor (P_{IF}) (Corr)	Net Cap (Corr)	EER (Corr)
		ºF	ºF	%	Btu/h	CFM	ºF	ºF	lbm/ft^3	lbm/ft^3	W	W	W	W	Btu/h W	W	Btu/h	Btu/h W
1	4	95.1	95.0	100.0	367,047	10,100	56.28	55.60	0.0744	0.0765	30,100	2,300	3,650	150	10.14	3,454	367,716	10.21
2	3	81.3	81.5	79.0	289,976	8,350	56.85	56.16	0.0743	0.0764	21,144	2,300	2,102	200	11.26	1,989	290,363	11.33
3	2	81.7	81.5	53.2	195,344	5,460	56.48	55.80	0.0744	0.0765	14,124	2,300	613	250	11.30	581	195,455	11.33
4	2	67.6	68.0	54.6	200,710	5,610	56.48	55.80	0.0744	0.0765	13,149	2,300	663	250	12.27	628	200,830	12.30
5	1	67.6	68.0	28.3	103,881	2,955	56.70	56.01	0.0743	0.0764	6,574	1,150	103	300	12.78	98	103,900	12.79
6	1	65.3	65.0	28.4	104,408	2,970	56.70	56.01	0.0743	0.0764	6,495	1,150	105	300	12.97	99	104,428	12.98

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 6.1.3.3.3

As you can see tests 2 and 3 were run at the 75% ambient temperature of 81.5°F. Test 2 was run with stage 3 which turns off 1 compressor and results in a measured capacity of 79% which is 4% greater than the required 75% 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% load which then can be used for interpolation.

For the 50% 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 load of 54.6% and test 5 having a 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% 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% rating point you can see that test 6 was run at the required ambient of 65ºF, but because the measured 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 second step in the procedures defined in 6.2.5 is to adjust the tested indoor fan power and capacity for atmospheric pressure as defined in Appendix D. For example, looking at test 1, the following are the details of the calculations for atmospheric pressure correction. The density of the unit leaving air temperature is 0.744 lb_m/ft^3 based on the air temperature conditions entering the indoor fan of 56.28ºF dry-bulb, 55.60ºF wet-bulb and 14.30 psia atmospheric pressure.

First the corrected indoor fan power is calculated using Equation D1.

$$P_{IF\ corr} = P_{IF\ test} \cdot \left(\frac{\rho_{test}}{\rho_{STD}}\right)^2 = 3{,}650 \cdot \left(\frac{0.0744}{0.0765}\right)^2 = 3{,}454\ watts$$

Then the corrected net Cooling Capacity is determined using Equation D2.

$$Q_{corr} = Q_{Test} + (P_{IF\ Corr} - P_{IF\ Test}) \cdot 3.412 = 367{,}047 + (3{,}650 - 3{,}454) \cdot 3.412 = 367{,}716\ Btu/h$$

Once the corrected fan power and corrected Cooling Capacity are determined a corrected EER can be calculated using Equation 4 as shown below.

$$EER_{corr} = \frac{Q_{corr}}{P_C + P_{CD} + P_{IF\ corr} + P_{CT}} = \frac{367{,}716}{30{,}100 + 2{,}300 + 3{,}454 + 150} = 10.21\ \text{Btu/W} \cdot \text{h}$$

Similar calculations are also required for the test points 2, 3, 4, 5 and 6 to develop the rating data for the A, B, C and D IEER points.

Once the test points have been corrected for atmospheric pressure then Section 6.2.5, step 3 procedures can be used to calculate the EER A, B, C, and D rating points using the step 2 atmospheric pressure corrected test results. Shown below are the results the step 3 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 % Load	Net Cap (Corr)	Cmpr (P_C) (Test)	Cond (P_{CD}) (Test)	Indoor (P_{IF}) (Corr)	Control (P_{CT}) (Test)	EER (Corr)	LF	CD	Rating EER
		ºF	ºF	%	Btu/h	W	W	W	W	Btu/W			
A	1	95.1	95.0	100.0	367,716	30,100	2,300	3,454	150	10.21			
		required load		100.0	use test 1 point directly						-	-	10.21
B	2	81.3	81.5	79.0	290,363	21,144	2,300	1,989	200	11.33	-	-	
	3	81.7	81.5	53.2	195,455	14,124	2,300	581	250	11.33	-	-	
		required load		75.0	interpolate between test 2 and 3								11.33
C	4	67.6	68.0	54.6	200,830	13,149	2,300	628	250	12.30	-	-	
	5	67.6	68.0	28.3	103,900	6,574	1,150	98	300	12.79	-	-	
		required load		50.0	interpolate between test 4 and 5								12.39
D	6	65.3	65.0	28.4	104,428	6,495	1,150	99	300	12.98			
		Required Load		25.0	degradation of test 5 required						0.880	1.016	12.71

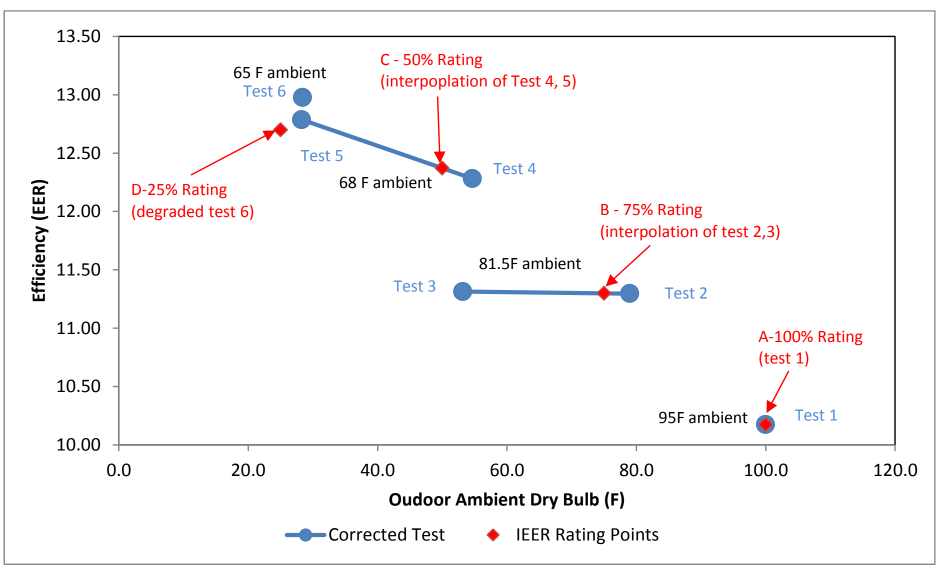

Figure G1. Example 4 Test Points Used for EER Rating Points

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

For the B rating point at 75% load interpolation must 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% 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 load of 79.0% and 53.2% was obtained so to get to 75% load we interpolate between test 2 and 3 as shown below.

$$EER_B = \left(\left(\frac{11.33 - 11.33}{79.0 - 53.2}\right) \cdot (75 - 53.2)\right) + 11.33 = 11.33 \text{ Btu/W} \cdot \text{h}$$

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% load and 28.3% 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%. 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.

$$LF = \frac{\left(^{Percent\ Load}/_{100}\right) \cdot Full\ Load\ Net\ Capacity}{Part\ Load\ Net\ Capacity} = \frac{\left(^{25.0}/_{100}\right) \cdot 367{,}716}{104{,}428} = 0.8803$$

This implies that at the 25% 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.

$$C_D = (-0.13 \cdot LF) + 1.13 = (-0.13 \cdot 0.880) + 1.13 = 1.016$$

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.

$$EER = \frac{LF \cdot Q_{corr}}{LF \cdot [C_D \cdot (P_C + P_{CD})] + P_{IF\ corr} + P_{CT}} = \frac{0.880 \cdot 104{,}428}{0.880 \cdot [1.016 \cdot (6{,}495 + 1{,}150)] + 99 + 300}$$
$$= 12.71 \text{ Btu/W} \cdot \text{h}$$

The last step 4 is then to calculate the IEER using Equation 3.

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

$$= (0.02 \cdot 10.21) + (0.617 \cdot 11.33) + (0.238 \cdot 12.39) + (0.125 \cdot 12.71) = 11.73 \text{ Btu/W} \cdot \text{h}$$

G3.2 *Example 5. 2 Stage Air Cooled Unit with a Fixed Speed Indoor Fan Example Calculations IEER Example Calculation.*

The unit is an air cooled 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
Rated Standard Airflow = 3,300 scfm
Rated EER = 11.2 Btu/W·h
Rated IEER = 12.0 Btu/W·h

Shown below are the test data and corrections for atmospheric pressure as defined in Section 6.2.4 step 1 and 2. During the tests the atmospheric pressure was 13.900 psia and was constant for all tests. The pressure could vary between tests and it should be measured for each test.

Table G6A Example 5. Test Resuts with Adjustment for Atmospheric Pressure

Test	Stage	Test OAT	Req OAT	Actual % Load	Test Net Cap	Test CFM (Std Air)	Test Leaving Air DB	Test Leaving Air WB	Test Leaving Air Density	14.696 psia Leaving Air Density	Cmpr (P_C) (Test)	Cond (P_{CD}) (Test)	Indoor (P_{IF}) (Test)	Control (P_{CT}) (Test)	EER (Test)	Indoor (P_{IF}) (Corr)	Net Cap (Corr)	EER (Corr)
		ºF	ºF	%	Btu/h	CFM	ºF	ºF	lbm/ft^3	lbm/ft^3	W	W	W	W	Btu/h W	W	Btu/h	Btu/h W
1	2	95.1	95.0	100.0	115,493	3,354	57.20	56.50	0.0722	0.0763	8,615	650	1,050	100	11.09	939	115,870	11.24
2	2	81.3	81.5	106.7	123,267	3,354	56.40	55.71	0.0722	0.0765	8,073	650	1,050	100	12.49	936	123,655	12.67
3	1	81.7	81.5	52.6	60,510	3,354	62.50	61.74	0.0713	0.0755	3,855	325	1,050	150	11.25	937	60,895	11.56
4	1	67.6	68.0	53.4	61,536	3,354	62.40	61.54	0.0713	0.0755	3,588	325	1,050	150	12.04	937	61,922	12.39
5	1	65.3	65.0	53.6	61,716	3,354	62.39	61.63	0.0714	0.0755	3,545	325	1,050	150	12.17	939	62,093	12.52

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% load interpolation using test 2 and 3 is required. Test 2 has a load of 106.7% and test 3 has a load of 52.6% when run at the B rating point ambient of 81.5ºF. 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 340/360-2007 standard. For the C rating point with an rating ambient of 68°F the 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% when run at the D rating point ambient of 65ºF, degradation will also have to be applied to test 5.

The second step in the procedures defined in Section 6.2.5 is to adjust the indoor fan power and capacity for atmospheric pressure as defined in Appendix D. For example, looking at test 1, the following are the details of the calculations for atmospheric pressure correction. The density of the unit leaving air temperature is 0.722 lb_m/ft^3 based on the air temperature conditions entering the indoor fan of 57.2ºF dry-bulb, 56.50ºF wet-bulb and 13.90 psia atmospheric pressure.

First the corrected indoor fan power is calculated using Equation D1.

$$P_{IF\ corr} = P_{IF\ test} \cdot \left(\frac{\rho_{test}}{\rho_{STD}}\right)^2 = 1050 \cdot \left(\frac{0.0722}{0.076}\right)^2 = 939\ watts$$

Then the corrected net Cooling Capacity is determined using Equation D2.

$$Q_{corr} = Q_{Test} + (P_{IF\ Corr} - P_{IF\ Test}) \cdot 3.412 = 115{,}493 + (1050 - 939) \cdot 3.412 = 115{,}870\ Btu/h$$

Once the corrected fan power and corrected Cooling Capacity are determined a corrected EER can be calculated using Equation 4 as shown below.

$$EER_{corr} = \frac{Q_{corr}}{P_C + P_{CD} + P_{IF\ corr} + P_{CT}} = \frac{115{,}870}{8{,}615 + 650 + 939 + 50} = 11.24\ \mathrm{Btu/W \cdot h}$$

Similar calculations are also required for the test point 2, 3, 4, and 5 to develop the rating data for the B, C and D IEER points.

Once the test points have been corrected for atmospheric pressure then 6.2.5 step 3 procedures to calculate the EER A, B, C, and D rating points using the step 2 atmospheric pressure corrected test results. Shown below are the results the step 3 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 % Load	Net Cap (Corr)	Cmpr (P_C) (Test)	Cond (P_{CD}) (Test)	Indoor (P_{IF}) (Corr)	Control (P_{CT}) (Test)	EER (Corr)	LF	CD	Rating EER
		ºF	ºF	%	Btu/h	W	W	W	W	Btu/W			
A	1	95.1	95.0	100.0	115,870	8,615	650	939	100	11.24			
	required load			100.0	use test 1 point directly						-	-	11.24
B	2	81.3	81.5	106.7	123,655	8,073	650	936	100	12.67	-	-	
	3	81.7	81.5	52.6	60,895	3,855	325	937	150	11.56	-	-	
	required load			75.0	interpolate between test 2 and 3								12.02
C	4	67.6	68.0	53.4	61,922	3,588	325	937	150	12.39			
	Required Load			50.0	degradation of test 4 required						0.936	1.008	12.12
D	5	65.3	65.0	53.6	62,093	3,545	325	939	150	12.52			
	Required Load			25.0	degradation of test 5 required						0.467	1.069	9.59

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

For the B rating point at 75% load interpolation must 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% rating point 81.5ºF ambient as require by Table 6. Test 3 was also run at the 81.5ºF ambient but with only stage 1 operating. From these tests you can see that a load of 106.7% and 52.7% was obtained so to get to 75% load we interpolate between test 2 and 3 as shown below.

$$EER_B = \left(\left(\frac{12.67 - 11.56}{106.7 - 52.6}\right) \cdot (75 - 52.6)\right) + 11.56 = 12.02 \text{ Btu/W} \cdot \text{h}$$

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 corrected 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% rating 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.

$$LF = \frac{\left(Percent\ Load/_{100}\right) \cdot Full\ Load\ Net\ Capacity}{Part\ Load\ Net\ Capacity} = \frac{\left(50/_{100}\right) \cdot 115{,}870}{61{,}922} = 0.936$$

What this means is that at a 50% load the compressor will be on for 93.6% of the time and off for 6.4% of the time.

The degradation coefficient is calculated using Equation 5.

$$C_D = (-0.13 \cdot LF) + 1.13 = (-0.13 \cdot 0.936) + 1.13 = 1.008$$

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.

$$EER = \frac{LF \cdot Q_{corr}}{LF \cdot [C_D \cdot (P_C + P_{CD})] + P_{IF\ corr} + P_{CT}} = \frac{0.936 \cdot 61{,}922}{0.936 \cdot [1.009 \cdot (3{,}588 + 325)] + 937 + 150} = 12.12 \text{ Btu/W} \cdot \text{h}$$

Similar degradation corrections are also made for the 25% load points.

The last step 4 is then to calculate the IEER using Equation 3.

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

$= (0.02 \cdot 11.24) + (0.617 \cdot 12.02) + (0.238 \cdot 12.12) + (0.125 \cdot 9.59) = 11.73 \text{ Btu/W} \cdot \text{h}$

G3.3 *Example 6. 2 Stage Air Cooled Packaged Unit with a 2 Speed Indoor Fan Controlled by the Thermostat IEER Example Calculation*.

The unit is an air cooled 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
Rated Full Load Standard Airflow = 3,300 scfm
Rated Part Load Standard Airflow = 1980 scfm
Rated EER = 11.2 Btu/W·h
Rated IEER = 13.1 Btu/W·h

Shown below are the test data and corrections for atmospheric pressure as defined in Section 6.2.4 step 1 and 2. During the tests the atmospheric pressure was 13.900 psia and was constant for all tests. The pressure could vary between tests and it should be measured for each test.

Table G7A Example 6. Test Resuts with Adjustment for Atmospheric Pressure

Test	Stage	Test OAT	Req OAT	Actual % Load	Test Net Cap	Test CFM (Std Air)	Test Leaving Air DB	Test Leaving Air WB	Test Leaving Air Density	14.696 psia Leaving Air Density	Cmpr (P_C) (Test)	Cond (P_{CD}) (Test)	Indoor (P_{IF}) (Test)	Control (P_{CT}) (Test)	EER (Test)	Indoor (P_{IF}) (Corr)	Net Cap (Corr)	EER (Corr)
		ºF	ºF	%	Btu/h	CFM	ºF	ºF	lbm/ft^3	lbm/ft^3	W	W	W	W	Btu/h W	W	Btu/h	Btu/h W
1	2	95.1	95.0	100.0	115,493	3,354	57.20	56.50	0.0722	0.0763	8,615	650	1,050	100	11.09	939	115,870	11.24
2	2	81.3	81.5	106.7	123,267	3,354	56.40	55.71	0.0722	0.0765	8,073	650	1,050	100	12.49	936	123,655	12.67
3	1	81.7	81.5	52.6	60,888	2,020	58.93	58.21	0.0719	0.0761	3,915	325	262	150	13.09	235	60,983	13.19
4	1	67.6	68.0	53.8	62,270	2,020	58.71	57.99	0.0719	0.0761	3,645	325	262	150	14.21	234	62,366	14.32
5	1	65.3	65.0	54.3	62,772	2,020	58.63	57.91	0.0720	0.0761	3,601	325	262	150	14.47	235	62,866	14.58

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% displacement, for the B rating point of 75% 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 ± 0.5ºF as defined by ASHRAE Standard 37 Table 2b. Test 2 has a load of 106.7% and test 3 has a load of 52.6%. Also note that Test 2 was run with full mechanical Cooling Capacity and with the full load cfm, 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 an rating ambient of 68ºF the 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% when run at the D rating point ambient of 65ºF, degradation will also have to be applied to Test 5

The second step in the procedures defined in Section 6.2.5 is to adjust the tested indoor fan power and capacity for atmospheric pressure as defined in Appendix D. For example, looking at test 1, the following are the details of the calculations for atmospheric pressure correction. The density of the unit leaving air temperature is 0.722 lb_m/ft^3 based on the air temperature conditions entering the indoor fan of 57.2ºF dry-bulb, 56.50ºF wet-bulb and 13.90 psia atmospheric pressure.

First the corrected indoor fan power is calculated using Equation D1.

$$P_{IF\ corr} = P_{IF\ test} \cdot \left(\frac{\rho_{test}}{\rho_{STD}}\right)^2 = 1050 \cdot \left(\frac{0.0722}{0.0765}\right)^2 = 939\ watts$$

Then the corrected net Cooling Capacity is determined using Equation D2.

$$Q_{corr} = Q_{Test} + (P_{IF\ Corr} - P_{IF\ Test}) \cdot 3.412 = 115{,}493 + (1050 - 939) \cdot 3.412 = 115{,}870\ Btu/h$$

Once the corrected fan power and corrected Cooling Capacity are determined a corrected EER can be calculated using Equation 4 as shown below.

$$EER_{corr} = \frac{Q_{corr}}{P_C + P_{CD} + P_{IF\,corr} + P_{CT}} = \frac{115{,}870}{8{,}615 + 650 + 939 + 100} = 11.24 \text{ Btu/W} \cdot \text{h}$$

Similar calculations are also required for the test points 2, 3, 4, and 5 to develop the rating date for the A, B, C and D IEER points.

Once the test points have been corrected for atmospheric pressure then Section 6.2.5 step 3 procedures to calculate the EER A, B, C, and D rating points using the step 2 atmospheric pressure corrected test results are done. Shown below are the results the step 3 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 % Load	Net Cap (Corr)	Cmpr (P_C) (Test)	Cond (P_{CD}) (Test)	Indoor (P_{IF}) (Corr)	Control (P_{CT}) (Test)	EER (Corr)	LF	CD	Rating EER
		ºF	ºF	%	Btu/h	W	W	W	W	Btu/W			
A	1	95.1	95.0	100.0	115,870	8,615	650	939	100	11.24			
	required load			100.0	use test 1 point directly						-	-	11.24
B	2	81.3	81.5	106.7	123,655	8,073	650	936	100	12.67	-	-	
	3	81.7	81.5	52.6	60,983	3,915	325	235	150	13.19	-	-	
	required load			75.0	interpolate between test 2 and 3								12.97
C	4	67.6	68.0	53.8	62,366	3,645	325	234	150	14.32			
	Required Load			50.0	degradation of test 4 required						0.929	1.009	14.11
D	5	65.3	65.0	54.3	62,866	3,601	325	235	150	14.58			
	Required Load			25.0	degradation of test 5 required						0.461	1.070	12.48

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

For the B rating point at 75% load interpolation must 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% rating point 81.5ºF ambient as require by Table 6. Test 3 was also run at the 81.5ºF ambient but with only stage 1 operating. From these tests you can see that a load of 106.7% and 52.6% was obtained so to get to 75% load we interpolate between test 2 and 3 as shown below.

$$EER_B = \left(\left(\frac{12.67 - 13.19}{106.7 - 52.6}\right) \cdot (75 - 52.6)\right) + 13.19 = 12.97 \text{ Btu/W} \cdot \text{h}$$

For the C rating point which is required to be run at 68ºF ambient as defined in Table 6 we can see from test 4 that the corrected 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% rating 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.

$$LF = \frac{\left({}^{Percent\ Load}/_{100}\right) \cdot Full\ Load\ Net\ Capacity}{Part\ Load\ Net\ Capacity} = \frac{\left({}^{50}/_{100}\right) \cdot 115{,}870}{62{,}366} = 0.929$$

What this means is that at a 50% load the compressor will be on for 92.9% of the time and off for 7.1% of the time.

The degradation coefficient is calculated using Equation 5.

$$C_D = (-0.13 \cdot LF) + 1.13 = (-0.13 \cdot 0.929) + 1.13 = 1.009$$

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.

$$EER = \frac{LF \cdot Q_{corr}}{LF \cdot [C_D \cdot (P_C + P_{CD})] + P_{IF\ corr} + P_{CT}} = \frac{0.929 \cdot 62{,}366}{0.929 \cdot [1.009 \cdot (3{,}645 + 325)] + 234 + 150} = 14.11\ \mathrm{Btu/W \cdot h}$$

Similar degradation corrections are also made for the 25% load points.

The last step 4 is then to calculate the IEER using Equation 3.

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

$$= (0.02 \cdot 11.24) + (0.617 \cdot 12.97) + (0.238 \cdot 14.11) + (0.125 \cdot 12.48) = 13.15\ \mathrm{Btu/W \cdot h}$$

G3.4 *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 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. There are two condenser fans that are controlled by the thermostat and 1 runs on stage 1 and 2 and 2 run on stage 3. The unit has the following rated performance metrics.

Rated Capacity = 241,000 Btu/h
Rated Full Load Standard Airflow = 7,000 scfm
Rated Part Load Standard Airflow = 4300 scfm
Rated EER = 12.4 Btu/W·h
Rated IEER = 16.5 Btu/W·h

Shown below are the test data and corrections for atmospheric pressure as defined in Section 6.2.4 step 1 and 2. During the tests the atmospheric pressure was 14.200 psia and was constant for all tests. The pressure could vary between tests and it should be measured for each test.

Table G8A Example 7. Test Resuts with Adjustment for Atmospheric Pressure

Test	Stage	Test EWT	Req EWT	Actual % Load	Test Net Cap	Test CFM (Std Air)	Test Leaving Air DB	Test Leaving Air WB	Test Leaving Air Density	14.696 psia Leaving Air Density	Cmpr (P_C) (Test)	Cond (P_{CD}) (Test)	Indoor (P_{IF}) (Test)	Control (P_{CT}) (Test)	EER (Test)	Indoor (P_{IF}) (Corr)	Net Cap (Corr)	EER (Corr)
		ºF	ºF	%	Btu/h	CFM	ºF	ºF	lbm/ft³	lbm/ft³	W	W	W	W	Btu/h W	W	Btu/h	Btu/h W
1	3	85.1	85.0	100.0	242,129	7,100	57.13	56.44	0.0738	0.0763	17,150	0	2,350	125	12.34	2,196	242,654	12.46
2	3	73.3	73.5	102.4	247,832	7,100	56.85	56.16	0.0738	0.0764	16,176	0	2,350	125	13.29	2,193	248,366	13.43
3	2	73.5	73.5	66.8	161,859	4,331	55.98	55.30	0.0739	0.0765	9,193	0	560	150	16.34	523	161,988	16.42
4	2	62.1	62.0	67.9	164,530	4,331	55.76	55.08	0.0740	0.0766	8,637	0	560	150	17.60	523	164,656	17.68
5	1	61.9	62.0	38.0	92,021	4,331	61.40	60.66	0.0731	0.0756	4,107	0	560	200	18.91	523	92,148	19.08
6	1	55.0	55.0	38.5	93,384	4,331	61.30	60.56	0.0731	0.0757	3,941	0	560	200	19.86	523	93,511	20.05

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% 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% rating point condenser entering water temperature of 73.5ºF as defined in Table 6. Test 2 was run with the full load stage 3 at the 73.5ºF 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% point. For the rating point C two tests were also run to allow for interpolation at the 50% rating point consider entering water temperature of 62ºF. Test 6 was run at 55ºF to allow for the determination of the D rating efficiency but as you can see the measured load was at 38.5% which is above the 25% rating so it will require the use of a degradation calculation and interpolation cannot be used.

The second step in the procedures defined in Section 6.2.5 is to adjust the tested indoor fan power and capacity for atmospheric pressure as defined in Appendix D. For example, looking at test 1, the following are the details of the calculations for atmospheric pressure correction. The density of the unit leaving air temperature is 0.738 lb_m/ft^3 based on the air temperature conditions entering the indoor fan of 57.13ºF dry-bulb, 56.44ºF wet-bulb and 14.20 psia

atmospheric pressure.
First the corrected indoor fan power is calculated using Equation D1.

$$P_{IF\ corr} = P_{IF\ test} \cdot \left(\frac{\rho_{test}}{\rho_{STD}}\right)^2 = 2{,}350 \cdot \left(\frac{0.0738}{0.0763}\right)^2 = 2{,}196\ watts$$

Then the corrected net Cooling Capacity is determined using Equation D2.

$$Q_{corr} = Q_{Test} + (P_{IF\ Corr} - P_{IF\ Test}) \cdot 3.412 = 242{,}129 + (2{,}350 - 2{,}196) \times 3.412 = 242{,}654\ Btu/h$$

Once the corrected fan power and corrected Cooling Capacity are determined a corrected EER can be calculated using Equation 4 as shown below.

$$EER_{corr} = \frac{Q_{corr}}{P_C + P_{CD} + P_{IF\ corr} + P_{CT}} = \frac{242{,}654}{15{,}150 + 0 + 2{,}196 + 125} = 12.46\ \mathrm{Btu/W \cdot h}$$

Similar calculations are also required for the test point 2, 3, 4, 5, and 6 to develop the rating date for the A, B, C and D IEER points.

Once the test points have been corrected for atmospheric pressure then use Section 6.2.5 step 3 procedures to calculate the EER A, B, C, and D rating points using the step 2 atmospheric pressure corrected test results are done. Shown below are the results the step 3 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 % Load	Net Cap (Corr)	Cmpr (P_C) (Test)	Cond (P_{CD}) (Test)	Indoor (P_{IF}) (Corr)	Control (P_{CT}) (Test)	EER (Corr)	LF	CD	Rating EER
		ºF	ºF	%	Btu/h	W	W	W	W	Btu/W			
A	1	95.1	95.0	100.0	242,654	17,150	0	2,196	125	12.46			
		required load		100.0	use test 1 point directly						-	-	12.46
B	2	73.3	73.5	102.4	248,366	7,100	0	2,350	125	13.43	-	-	
	3	73.5	73.5	66.8	161,988	4,331	0	560	150	16.42	-	-	
		required load		75.0	interpolate between test 2 and 3								15.73
C	4	62.1	62.0	67.9	164,656	4,331	0	560	150	17.68	-	-	
	5	61.9	62.0	38.0	92,148	4,331	0	560	200	19.08	-	-	
		required load		50.0	interpolate between test 4 and 5								18.52
D	6	55	55.0	38.5	93,511	3,941	0	523	200	20.05			
		Required Load		25.0	degradation of test 5 required						0.649	1.046	17.86

For the A rating point test 1 is used directly.

For the B rating point at 75% load interpolation must 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% rating point 73.5ºF condenser entering water as require by Table 6. Test 3 was also run at the 73.5ºF condenser entering temperature ambient but with stage 2 active. From these tests you can see that a load of 102.4% and 66.8% was obtained so to get to 75% load we interpolate between test 2 and 3 as shown below.

$$EER_B = \left(\left(\frac{13.43 - 16.42}{102.4 - 66.8}\right) \cdot (75 - 66.8)\right) + 16.42 = 15.73\ \mathrm{Btu/W \cdot h}$$

For the C rating point which is required to be run at 62ºF condenser entering water as defined in table 6 we can see from test 4 that the corrected 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 62ºF ambient and a load of 38% was measured which can then be used for interpolation. For the D rating point test 6 was run at 55ºF and the Percent Load was measured as 38.5%. This is above the 25% 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.

$$LF = \frac{\left(^{Percent\ Load}/_{100}\right) \cdot Full\ Load\ Net\ Capacity}{Part\ Load\ Net\ Capacity} = \frac{\left(^{25}/_{100}\right) \cdot 242{,}654}{93{,}511} = 0.649$$

What this means is that at a 25% 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.

$$C_D = (-0.13 \cdot LF) + 1.13 = (-0.13 \cdot 0.649) + 1.13 = 1.046$$

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.

$$EER = \frac{LF \cdot Q_{corr}}{LF \cdot [C_D \cdot (P_C + P_{CD})] + P_{IF\ corr} + P_{CT}} = \frac{0.649 \cdot 93511}{0.648 \cdot [1.046 \cdot (3{,}941 + 0)] + 523 + 200} = 17.86\ \mathrm{Btu/W \cdot h}$$

Similar degradation corrections are also made for the 50% load points.

The last step 4 is then to calculate the IEER using Equation 3.

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

$$= (0.02 \cdot 12.46) + (0.617 \cdot 15.73) + (0.238 \cdot 18.52) + (0.125 \cdot 17.86) = 16.59\ \mathrm{Btu/W \cdot h}$$

G4 *Proportional Capacity Control 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 Capacity Control Unit is a unit incorporating one or more variable capacity compressors in which the compressor capacity can modulated continuously.

G4.1 *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
Rated Standard Airflow = 3,400 scfm
Rated EER = 11.2 Btu/W·h
Rated IEER = 12.0 Btu/W·h

Shown below are the test data and the corrections for atmospheric pressure as defined in the procedures in Section 6.2.6 steps 1 and 2. During the tests the atmospheric pressure was measured at 14.70 psia and was constant for all tests. Note that the pressure could vary between tests and it should be measured for each test.

Table G9A Example 8. Test Resuts with Adjustment for Atmospheric Pressure

Test	Stage	Test OAT	Req OAT	Actual % Load	Test Net Cap	Test CFM (Std Air)	Test Leaving Air DB	Test Leaving Air WB	Test Leaving Air Density	14.696 psia Leaving Air Density	Cmpr (P_C) (Test)	Cond (P_{CD}) (Test)	Indoor (P_{IF}) (Test)	Control (P_{CT}) (Test)	EER (Test)	Indoor (P_{IF}) (Corr)	Net Cap (Corr)	EER (Corr)
		ºF	ºF	%	Btu/h	CFM	ºF	ºF	lbm/ft^3	lbm/ft^3	W	W	W	W	Btu/h W	W	Btu/h	Btu/h W
1	100%	95.1	95.0	100.0	117,450	3,354	56.50	55.88	0.0765	0.0764	8,450	650	1,150	125	11.32	1,151	117,448	11.32
2	75%	81.3	81.5	75.5	88,621	3,354	59.50	58.79	0.0760	0.0760	5,393	650	1,150	125	12.11	1,151	88,619	12.11
3	50%	68.0	68.0	54.7	64,214	3,354	61.90	61.16	0.0756	0.0756	3,631	650	1,150	125	11.56	1,151	64,212	11.56
4	50%	68.0	68.0	43.0	50,463	3,354	62.30	61.39	0.0755	0.0755	2,772	650	1,150	125	10.74	1,151	50,461	10.74
5	25%	65.3	65.0	30.0	35,216	3,354	64.60	63.83	0.0751	0.0751	1,717	325	1,150	125	10.62	1,151	35,214	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% rating point and as you can see the measured corrected 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% rating but the resulting testing had a measured 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 load of 43.0% and will be used for interpolation. Test 5 was run at the 65ºF ambient for the rating point D, but the unit could only unload to 30.0% so this test will require a degradation calculation to be performed.

Step 2 of the procedure requires the test data for the indoor fan power and capacity be adjusted for atmospheric pressure as defined in Appendix D. For example, looking at test 1, the following are the details of the calculations for atmospheric pressure correction. The density of the unit leaving air temperature is 0.765 lb_m/ft^3 based on the air temperature conditions entering the indoor fan of 56.50ºF dry-bulb, 55.88ºF wet-bulb and 14.70 psia atmospheric pressure.

First the corrected indoor fan power is calculated using Equation D1.

$$P_{IF\ corr} = P_{IF\ test} \cdot \left(\frac{\rho_{test}}{\rho_{STD}}\right)^2 = 1{,}150 \cdot \left(\frac{0.0765}{0{,}0765}\right)^2 = 1{,}151\ watts$$

Then the corrected net Cooling Capacity (Q_{corr}) is determined using Equation D2.

$$Q_{corr} = Q_{Test} + (P_{IF\ Corr} - P_{IF\ Test}) \cdot 3.412 = 117{,}450 + (1{,}150 - 1{,}151) \times 3.412 = 117{,}448\ Btu/h$$

Once the corrected fan power and corrected Cooling Capacity are determined a corrected EER can be calculated using Equation 4 as shown below.

$$EER_{corr} = \frac{Q_{corr}}{P_C + P_{CD} + P_{IF\ corr} + P_{CT}} = \frac{117{,}448}{8450 + 650 + 1{,}151 + 125} = 11.32\ \mathrm{Btu/W \cdot h}$$

Similar calculations are also required for the test point 2, 3, 4, and 5 to develop the atmospheric pressure corrected rating data.

Once the test points have been corrected for atmospheric pressure then the calculations as outlined in step 3 of the procedure outlined in Section 6.2.6 can be performed using the atmospheric pressure corrected test results. Shown in the following table are the calculations for the 4 EER rating points used to calculate the IEER.

Table G9B Example 8. IEER Rating Points and Degradation Calculations														
Rating Point	Test	Test OAT	Req OAT	Actual % Load	Net Cap (Corr)	Cmpr (P_C) (Test)	Cond (P_{CD}) (Test)	Indoor (P_{IF}) (Corr)	Control (P_{CT}) (Test)	EER (Corr)	LF	CD	Rating EER
		ºF	ºF	%	Btu/h	W	W	W	W	Btu/W			
A	1	95.1	95.0	100.0	117,448	8,450	650	1,151	125	11.32			
	required load			100.0	use test 1 point directly						-	-	11.32
B	2	81.3	81.5	75.5	88,619	5,393	650	1,151	125	12.11			
	required load			75%	use test 2 point directly						-	-	12.11
C	3	68.0	68.0	54.7	64,212	3,631	650	1,151	125	11.56	-	-	
	4	68.0	68.0	43.0	50,461	2,772	650	1,151	125	10.74	-	-	
	required load			50.0	interpolate between test 3 and 4								11.59
D	5	65.3	65.0	30.0	35,214	1,717	325	1,151	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% rating point the test 1 can be used directly. For the 75% rating point B the corrected 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% rating point C, test 3 was run to get the 50% rating but the resulting testing had a measured 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 load of 43% and will be used for interpolation. The interpolation calculations are shown below.

$$EER_C = \left(\left(\frac{11.56 - 10.74}{54.7 - 43.0}\right) \cdot (50 - 43.0)\right) + 10.74 = 11.59\ \text{Btu/W} \cdot \text{h}$$

For the rating point D test 5 was run but due to control limits the unit would only unload to 30% which is greater than the 25% 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.

$$LF = \frac{\left(^{Percent\ Load}/_{100}\right) \cdot Full\ Load\ Net\ Capacity}{Part\ Load\ Net\ Capacity} = \frac{\left(^{25}/_{100}\right) \cdot 117{,}448}{35{,}214} = 0.834$$

What this means is that at a 25% 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.

$$EER = \frac{LF \cdot Q_{corr}}{LF \cdot [C_D \cdot (P_C + P_{CD})] + P_{IF\ corr} + P_{CT}} = \frac{0.834 \cdot 35{,}214}{0.834 \cdot [1.022 \cdot (1{,}717 + 325)] + 1{,}151 + 125}$$

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

The last procedural step 4 is to calculate the IEER using Equation 3.

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

$$= (0.02 \cdot 11.32) + (0.617 \cdot 12.11) + (0.238 \cdot 11.59) + (0.125 \cdot 9.74) = 11.67\ \text{Btu/W} \cdot \text{h}$$

G4.2 *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 single zone VAV 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
Rated Standard Airflow = 3,400 scfm
Rated EER = 11.2 Btu/W·h
Rated IEER = 12.0 Btu/W·h

Shown below are the test data and the corrections for atmospheric pressure as defined in the procedures in Section 6.2.6 step 1 and 2. During the tests the atmospheric pressure was measured at 14.70 psia and was constant for all tests. Note that the pressure could vary between tests and it should be measured for each test.

Table G10A Example 9. Test Resuts with Adjustment for Atmospheric Pressure

Test	Stage	Test OAT	Req OAT	Actual % Load	Test Net Cap	Test CFM (Std Air)	Test Leaving Air DB	Test Leaving Air WB	Test Leaving Air Density	14.696 psia Leaving Air Density	Cmpr (P_C) (Test)	Cond (P_{CD}) (Test)	Indoor (P_{IF}) (Test)	Control (P_{CT}) (Test)	EER (Test)	Indoor (P_{IF}) (Corr)	Net Cap (Corr)	EER (Corr)
		ºF	ºF	%	Btu/h	CFM	ºF	ºF	lbm/ft^3	lbm/ft^3	W	W	W	W	Btu/h W	W	Btu/h	Btu/h W
1	100%	95.1	95.0	100.0	117,455	3,354	56.50	55.88	0.0765	0.0764	8,450	650	1,150	125	11.32	1,152	117,449	11.32
2	75%	81.3	81.5	75.4	88,599	2,550	56.60	55.92	0.0765	0.0764	5,408	650	519	125	13.22	520	88,596	13.22
3	50%	68.0	68.0	50.9	59,765	1,720	56.30	55.63	0.0765	0.0765	3,725	650	166	125	12.81	166	59,765	12.81
4	25%	65.3	65.0	29.7	34,863	990	56.30	55.63	0.0765	0.0765	1,727	325	33	125	15.77	33	34,863	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% rating point and as you can see the measured corrected load is 75.4% so it is with the 3% tolerances and no additional testing is required. For the 50% test 3 was run to get the 50% rating and the corrected measured load is 50.9% and is also with the allowable tolerance of 3%. Test 4 was run at the 65ºF ambient for the rating point D, but the unit could only unload to 29.7% 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 ± 0.5ºF.

Step 2 of the procedure requires the test data for the indoor fan power and capacity be adjusted for atmospheric pressure as defined in Appendix D. For example, looking at test 1, the following are the details of the calculations for atmospheric pressure correction. The density of the unit leaving air temperature is 0.765 lb_m/ft^3 based on the air temperature conditions entering the indoor fan of 56.50ºF dry-bulb, 55.88ºF wet-bulb and 14.70 psia atmospheric pressure.

First the corrected indoor fan power is calculated using Equation D1.

$$P_{IF\ corr} = P_{IF\ test} \cdot \left(\frac{\rho_{test}}{\rho_{STD}}\right)^2 = 1{,}150 \cdot \left(\frac{0.0765}{0.0765}\right)^2 = 1{,}152\ watts$$

Then the corrected net Cooling Capacity (Q_{corr}) is determined using Equation D2.

$$Q_{corr} = Q_{Test} + (P_{IF\ Corr} - P_{IF\ Test}) \cdot 3.412 = 117{,}455 + (1{,}150 - 1{,}152) \times 3.412 = 117{,}449\ Btu/h$$

Once the corrected fan power and corrected Cooling Capacity are determined a corrected EER can be calculated using Equation 4 as shown below.

$$EER_{corr} = \frac{Q_{corr}}{P_C + P_{CD} + P_{IF\ corr} + P_{CT}} = \frac{117{,}749}{8450 + 650 + 1{,}152 + 125} = 11.32\ \mathrm{Btu/W \cdot h}$$

Similar calculations are also required for the test point 2, 3, and 4 to develop the atmospheric pressure corrected rating data.

Once the test points have been corrected for atmospheric pressure then the calculations as outlined in step 3 of the

Section 6.2.6 procedure can be performed using the atmospheric pressure corrected 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 % Load	Net Cap (Corr)	Cmpr (P_C) (Test)	Cond (P_{CD}) (Test)	Indoor (P_{IF}) (Corr)	Control (P_{CT}) (Test)	EER (Corr)	LF	CD	Rating EER
		ºF	ºF	%	Btu/h	W	W	W	W	Btu/W			
A	1	95.1	95.0	100.0	117,449	8,450	650	1,152	125	11.32			
		required load		100.0	use test 1 point directly						-	-	11.32
B	2	81.3	81.5	75.4	88,596	5,408	650	520	125	13.22			
		required load		75%	use test 2 point directly						-	-	13.22
C	3	68.0	68.0	50.9	59,765	3,725	650	166	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	15.25

For rating point A which is the 100% rating point the test 1 can be used directly. For the 75% rating point B the corrected load is 75.4% 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% rating point C test 3 was run to get the 50% rating and the corrected 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% which is greater than the 25% 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.

$$LF = \frac{\left(Percent\ Load/_{100}\right) \cdot Full\ Load\ Net\ Capacity}{Part\ Load\ Net\ Capacity} = \frac{\left(25/_{100}\right) \cdot 117{,}449}{34{,}863} = 0.842$$

What this means is that at a 25% 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.

$$EER = \frac{LF \cdot Q_{corr}}{LF \cdot [C_D \cdot (P_C + P_{CD})] + P_{IF\ corr} + P_{CT}} = \frac{0.842 \cdot 34{,}863}{0.842 \cdot [1.021 \cdot (1{,}727 + 325)] + 33 + 125} = 15.25\ \text{Btu/W} \cdot \text{h}$$

The last procedural step 4 is to calculate the IEER using Equation 3.

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

$$= (0.02 \cdot 11.32) + (0.617 \cdot 13.22) + (0.238 \cdot 12.81) + (0.125 \cdot 15.25) = 13.34\ \text{Btu/W} \cdot \text{h}$$

G4.3 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 single zone VAV unit with a single variable speed compressor and a variable speed fan that is configured as a single zone VAV 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
Rated Standard Airflow = 3,400 scfm
Rated EER = 11.2 Btu/W·h
Rated IEER = 13.0 Btu/W·h

Shown below are the test data and the corrections for atmospheric pressure as defined in the procedures in Section 6.2.6 step 1 and 2. During the tests the atmospheric pressure was measured at 14.70 psia and was constant for all tests. Note that the pressure could vary between tests and it should be measured for each test.

Table G11A Example 10. Test Resuts with Adjustment for Atmospheric Pressure

Test	Stage	Test OAT	Req OAT	Actual % Load	Test Net Cap	Test CFM (Std Air)	Test Leaving Air DB	Test Leaving Air WB	Test Leaving Air Density	14.696 psia Leaving Air Density	Cmpr (P_C) (Test)	Cond (P_{CD}) (Test)	Indoor (P_{IF}) (Test)	Control (P_{CT}) (Test)	EER (Test)	Indoor (P_{IF}) (Corr)	Net Cap (Corr)	EER (Corr)
		ºF	ºF	%	Btu/h	CFM	ºF	ºF	lbm/ft^3	lbm/ft^3	W	W	W	W	Btu/h W	W	Btu/h	Btu/h W
1	1 @ 100% 2 @100%	95.1	95.0	100.0	119,500	3,300	56.50	55.88	0.0765	0.0764	8,725	650	1,100	125	11.27	1,102	119,495	11.27
2	1 @ 48%, 2 @100%	81.3	81.5	75.1	89,788	2,550	56.60	55.92	0.0765	0.0764	5,584	650	521	125	13.05	522	89,785	13.05
3	1 @ 98%, 2 @ off	68.0	68.0	50.7	60,563	1,720	56.60	55.92	0.0765	0.0764	3,846	650	166	150	12.59	167	60,562	12.58
4	1 @ 46%, 2 @ off	65.3	65.0	24.4	29,197	990	56.40	55.72	0.0765	0.0765	1,427	325	33	150	15.09	34	29,196	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% rating point and as you can see the measured corrected 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% capacity. For the 50% rating point test 3 was run to get the 50% rating and the corrected measured 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% capacity. Test 4 was run at the 65ºF ambient for the rating point D and the measured 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.

Step 2 of the procedure requires the test data for the indoor fan power and capacity be adjusted for atmospheric pressure as defined in Appendix D. For example, looking at test 1, the following are the details of the calculations for atmospheric pressure correction. The density of the unit leaving air temperature is 0.765 lb_m/ft^3 based on the air temperature conditions entering the indoor fan of 56.50ºF dry-bulb, 55.88ºF wet-bulb and 14.70 psia atmospheric pressure.

First the corrected indoor fan power is calculated using Equation D1.

$$P_{IF\ corr} = P_{IF\ test} \cdot \left(\frac{\rho_{test}}{\rho_{STD}}\right)^2 = 1{,}110 \cdot \left(\frac{0.0765}{0.0764}\right)^2 = 1{,}102\ watts$$

Then the corrected net Cooling Capacity (Q_{corr}) is determined using Equation D2.

$$Q_{corr} = Q_{Test} + (P_{IF\ Corr} - P_{IF\ Test}) \cdot 3.412 = 119{,}500 + (1{,}100 - 1{,}102) \cdot 3.412 = 119{,}495\ Btu/h$$

Once the corrected fan power and corrected Cooling Capacity are determined a corrected EER can be calculated using Equation 2 as shown below.

$$EER_{corr} = \frac{Q_{corr}}{P_C + P_{CD} + P_{IF\ corr} + P_{CT}} = \frac{119{,}495}{8725 + 650 + 1{,}102 + 125} = 11.27\text{Btu/W} \cdot \text{h}$$

Similar calculations are also required for the test point 2, 3, and 4 to develop the atmospheric pressure corrected rating data.

Once the test points have been corrected for atmospheric pressure then the calculations as outlined in step 3 of the Section 6.2.6 procedure can be performed using the atmospheric pressure corrected test results. 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 % Load	Net Cap (Corr)	Cmpr (P_C) (Test)	Cond (P_{CD}) (Test)	Indoor (P_{IF}) (Corr)	Control (P_{CT}) (Test)	EER (Corr)	LF	CD	Rating EER
		ºF	ºF	%	Btu/h	W	W	W	W	Btu/W			
A	1	95.1	95.0	100.0	119,495	8,725	650	1,102	125	11.27			
	required load			100.0	use test 1 point directly						-	-	11.27
B	2	81.3	81.5	75.1	89,785	5,584	650	522	125	13.05			
	required load			75%	use test 2 point directly						-	-	13.05
C	3	68.0	68.0	50.7	60,562	3,846	650	167	150	12.58			
	required load			50.0	use test 3 point directly						-	-	12.58
D	4	65.3	65.0	24.4	29,196	1,427	325	34	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 corrected EER can be used directly for the IEER calculations.

The last procedural step 4 is to calculate the IEER using Equation 3.

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

$$= (0.02 \cdot 11.27) + (0.617 \cdot 13.05) + (0.238 \cdot 12.58) + (0.125 \cdot 15.09) = 13.16 \text{ Btu/W} \cdot \text{h}$$