

ANSI/AHRI Standard 390-2021 (I-P)

2021 Standard for

Performance Rating of Single Package Vertical Air-conditioners And Heat Pumps



Approved by ANSI on 9 June 2023



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2311 Wilson Boulevard, Suite 400
Arlington, VA 22201, USA
www.ahrinet.org
PH 703.524.8800
FX 703.562.1942

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Note:

This standard supersedes AHRI 390-2003.

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PERFORMANCE RATING OF SINGLE PACKAGE VERTICAL AIR-CONDITIONERS AND HEAT PUMPS

Section 1. Purpose

1.1 Purpose. The purpose of this standard is to establish, for Single Package Vertical Air-conditioners and Heat Pumps: 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 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-assembled commercial or industrial Single Package Vertical Air-conditioner and Heat Pump equipment as defined in Section 3.

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

2.1.2 Installation. The Single Package Vertical Air-conditioner and Heat Pump is intended for ducted or non-ducted installation with field or factory supplied grilles.

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

- Unitary air-conditioners and unitary heat pumps as defined in AHRI Standard 210/240 and AHRI Standard 340/360.
- Variable refrigerant flow multi-split air conditioners and heat pumps as defined in ANSI/AHRI Standard 1230.
- Unit Ventilators as defined in AHRI Standard 840.
- Computer and Data Processing Room Air-conditioners as defined in AHRI Standard 1360.
- Packaged Terminal Air-conditioners and heat pumps as defined in AHRI Standard 310/380.

Section 3. Definitions

All terms in this document shall follow the standard industry definitions in the current edition of *ASHRAE, Terminology*, <https://www.ashrae.org/resources--publications/free-resources/ashrae-terminology>, unless otherwise defined in this section.

3.1 Coefficient of Performance (COP). A ratio of Heating Capacity in watts to the power input values in watts at any given set of Rating Conditions, expressed in W/W.

3.2 Cooling Capacity. The Net Capacity associated with the change in air enthalpy which includes both the Latent and Sensible Capacities, expressed in Btu/h and includes the heat of circulation fan(s) and motor(s).

3.2.1 Full Load Cooling Capacity. Cooling Capacity at full load Standard Rating Conditions expressed in Btu/h.

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

3.2.3 Part-load Cooling Capacity. Cooling Capacity at Part-load Standard Rating Conditions expressed in Btu/h.

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

3.3 *Designed and Marketed.* Means the application of the equipment as stated in any publicly available document (e.g., product literature, catalogs, and packaging labels).

3.4 *Ducted Unit.* An air conditioner or heat pump that is Designed and Marketed to deliver conditioned air to the indoor space through a duct(s) or return air to the unit through a duct(s). A factory-installed wall sleeve(s) shall not be considered as a duct.

3.5 *Energy Efficiency Ratio.* 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/h)/W.

3.5.1 *Integrated Energy Efficiency Ratio (IEER).* A weighted calculation of mechanical cooling efficiencies at full load and part-load Standard Rating Conditions expressed in (Btu/h)/W

3.5.2 *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/h)/W.

3.6 *Indoor Airflow.*

3.6.1 *Full Load Indoor Airflow.* The Standard Airflow rate at 100% capacity as specified by the manufacturer and at the external static pressure as listed in sections 5.7.1.1 and 5.7.1.2, expressed in cfm.

3.6.2 *Part-load Indoor Airflow.* The Standard Airflow at the part-load ratings conditions as specified by the manufacturer and at the external static pressure as listed in Table 2 with modifications defined in section 5.7.1.3, expressed in cfm. This may be different for each part-load rating point.

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

3.8 *Manufacturer's Installation Instructions.* Manufacturer's documentation that come packaged with or appear in the labels applied to the unit. Online manuals are acceptable if referenced on the unit label or in the documents that come packaged with the unit. All references to "manufacturer's instructions," "manufacturer's published instructions," "Manufacturer's Installation Instructions," "manufacturer's published recommendations," "manufacturer installation and operation manuals," "installation instructions" and other similar references means Manufacturer's Installation Instructions.

3.8.1 *Manufacturer Specifications.* Documentation provided by the manufacturer. All references to "manufacturer-specified" values or values "specified by the manufacturer" and other similar references means Manufacturer Specifications.

3.8.2 *Supplemental Test Instructions (STI).* Additional instructions developed by the manufacturer and certified to the United States Department of Energy (DOE). STI shall include no instructions that deviate from Manufacturer's Installation Instructions other than those described below shall include:

All instructions that do not deviate from Manufacturer's Installation Instructions but provide additional specifications for test standard requirements allowing more than one option.

All deviations from Manufacturer's Installation Instructions necessary to comply with steady state requirements. STI shall provide steady operation that matches to the extent possible the average performance that would be obtained without deviating from the Manufacturer's Installation Instructions.

3.9 *Net Capacity.* The calculated system capacity that results when accounting for the heat generated from an indoor supply fan.

3.10 *Non-ducted Unit.* An air conditioner or heat pump that is not Designed and Marketed to deliver conditioned air to the indoor space through a duct(s) or return air to the unit through a duct(s). A factory-installed wall sleeve(s) shall not be considered as a duct.

3.11 *Percent Load.* The ratio of the part-load Cooling Capacity to the measured Standard Cooling Capacity, expressed in units of percent, %.

3.12 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.

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

3.12.2 Certified Rating(s). A Published Rating of certified data as defined by Section 3.9 of the AHRI Single Packaged Vertical Unit Operations Manual which is verified by audit testing.

3.12.3 Standard Rating. A rating based on tests performed at Standard Rating Conditions.

3.13 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.

3.13.1 Standard Rating Conditions. Rating Conditions used as the basis of comparison for performance characteristics, as defined in Table 3.

3.14 "Shall" or "Should". "Shall" or "should" will be interpreted as follows:

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

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

3.15 Single Package Vertical Unit (SPVU).

NOTE: The terms "Equipment" and "Unit" are used interchangeably with SPVU.

3.15.1 Single Package Vertical Air-conditioner (SPVAC). A type of air-cooled small or large package air conditioning and heating equipment; factory assembled as a single package having its major components arranged vertically, which is an encased combination of cooling and optional heating components. This equipment is intended for exterior mounting on, adjacent interior to, or through, an outside wall; and is powered by single or three phase current. It may contain separate indoor grille(s), outdoor louvers, various ventilation options, indoor free air discharge, indoor ductwork, wall plenum or sleeve. Heating components may include electrical resistance, steam, hot water, gas or no heat, but shall not include reverse cycle refrigeration as a heating means. SPVAC, either alone or in combination with a heating plant, shall provide air-circulation, air-cleaning, cooling with controlled temperature and dehumidification, and may include the function of heating, humidifying and ventilation.

3.15.2 Single Package Vertical Heat Pump (SPVHP). A SPVAC that is configured to provide only refrigeration heating or that utilizes reverse cycle refrigeration as its primary heat source to provide cooling and heating and that may also include heating by means of electrical resistance, steam, hot water, or gas.

3.16 Single Package Vertical Unit Types.

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

3.16.2 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 full load rated capacity by adjusting variable capacity compressor(s) capacity and or the stages of refrigeration capacity. The unit may also include combination of fixed capacity and variable capacity compressors.

3.16.3 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.

3.17 Standard Air. Air weighing 0.075 lb/ft³ which approximates dry air at 70°F and at a barometric pressure of 29.92 in Hg.

3.18 Standard Airflow. The volumetric flowrate of air corrected to Standard Air conditions expressed in Standard Cubic Feet per Minute (scfm). When correcting measured airflow to Standard Air, the correction should be based on the air density at the airflow test measurement station.

3.19 Standard Filter. The filter designated by the manufacturer as the “default” or “standard” filter in the marketing materials for the model.

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

Section 4. Classifications

Classifications. Equipment covered within the scope of this standard shall be classified as shown in Table 1.

Table 1. Classification of Single Packaged Vertical Units		
Designation	AHRI Type ¹	Arrangement
Single Package Vertical Air Conditioner	SPV-A	ELEC/GAS HEAT ² ID FAN EVAP OD FAN or PUMP COMP COND
Single Package Vertical Heat Pump	HSP-A HSP-A-O ³ HOSP-A HOSP-A-O ³	ELEC/GAS HEAT ² ID FAN EVAP OD FAN or PUMP COMP COND
Notes:		
1. "-A" indicates air-cooled condenser. 2. Optional component. 3. A suffix of "-O" following any of the above classifications indicates equipment not intended for use with field-installed duct systems.		

Section 5. Test Requirements

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

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

5.2 Instruction Priority. Units shall be installed per Manufacturer's Installation Instructions. In the event of conflicting instructions regarding the set-up of the unit under test, priority shall be given to installation instructions that appear on the unit's label over installation instructions that are shipped with the unit.

5.3 Manufacturer Specifications Priority. In the event of conflicting information Manufacturer Specifications, the hierarchy is:

5.3.1 Certification report (information provided to authorities having jurisdiction).

5.3.2 Manufacturer's Installation Instructions.

5.4 *Break-in.* Manufacturers may optionally specify a "break-in" period, not to exceed 20 hours, to operate the equipment under test prior to conducting the test. If an initial "break-in" period is specified by the manufacturer, no testing shall commence until the manufacturer-specified break-in period is completed. Each compressor of the unit shall undergo this "break-in" period.

5.5 *Test Unit Duct Installation Requirements.* For Ducted Units, follow ASHRAE Standard 37 duct requirements. For Non-ducted Units, use the provisions in Section E6.

5.6 *Refrigerant Charging.* Use the tests or operating conditions specified in the Manufacturer's Installation Instructions for charging. If the Manufacturer's Installation Instructions do not specify a test or operating conditions for charging or there are no manufacturer's instructions, charging shall be conducted at the full load Standard Rating Condition. If the Manufacturer's Installation Instructions contain different sets of refrigerant charging criteria for field installation and for lab testing, use the field installation criteria.

5.6.1 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.

5.6.2 In the event of conflicting information between charging instructions, use the instruction priority order indicated in section 5.2. Conflicting information is defined as multiple conditions given for charge adjustment where all conditions specified cannot be met. If such instances of conflicting information occur within the highest-ranking set of instructions for which refrigerant charging instructions are provided, follow the hierarchy in Table 1 for priority. Unless the Manufacturer's Installation Instructions specify a tighter charging tolerance, the tolerances specified in Table 1 shall be used.

Table 1. Test Condition Tolerance for Charging Hierarchy					
Fixed Orifice			Expansion Valve		
Priority	Method	Tolerance	Priority	Method	Tolerance
1	Charge Weight	± 1.0 oz	1	Charge Weight	± 1.0 oz
2	Super-heat	$\pm 2.0^{\circ}\text{F}$	2	Sub-cooling	$\pm 2.0^{\circ}\text{F}$
3	High Side Pressure or Saturation Temperature	± 4.0 psi or $\pm 1.0^{\circ}\text{F}$	3	High Side Pressure or Saturation Temperature	± 4.0 psi or $\pm 1.0^{\circ}\text{F}$
4	Low Side Pressure or Saturation Temperature	± 4.0 psi or $\pm 1.0^{\circ}\text{F}$	4	Low Side Pressure or Saturation Temperature	± 2.0 psi or $\pm 0.8^{\circ}\text{F}$
5	Low Side Temperature	$\pm 2.0^{\circ}\text{F}$	5	Approach Temperature	$\pm 1.0^{\circ}\text{F}$
6	High Side Temperature	$\pm 2.0^{\circ}\text{F}$			

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

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

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

5.6.4 The refrigerant charge obtained as described in this section shall then be used to conduct all tests used to determine performance. All tests shall run until completion without further modification. If measurements indicate that

refrigerant charge has leaked during the test, repair the refrigerant leak, repeat any necessary set-up steps, and repeat all tests.

5.7 Setting Indoor Airflow and External Static Pressure

5.7.1 Minimum External Static Pressure for Testing

5.7.1.1 Non-Ducted Units. Test at zero external static pressure (ESP) for all test conditions.

5.7.1.2 Ducted Units - Full Load Standard Rating Capacity. Tests shall use the minimum ESP specified in Table 2.

Table 2. External Static Pressure	
Capacity Ratings ¹ , x 1000 Btu/h	Minimum External Static Pressure, in H ₂ O ^{2,3}
≤ 28	0.10
> 28 and ≤ 42	0.15
> 42 and ≤ 70	0.20
> 70 and ≤ 105	0.25
> 105 and ≤ 134	0.30
> 134 and ≤ 210	0.35
> 210 and ≤ 280	0.40
> 280 and ≤ 350	0.45
> 350 and ≤ 400	0.55
> 400 and ≤ 500	0.65
> 500	0.75
Notes: 1. For units with cooling function use Standard Cooling Capacity 2. Static pressure tolerance of -0.0 in H ₂ O to +0.05 in H ₂ O 3. Standard Ratings shall be determined and tested with the Standard Filter for that model.	

5.7.1.3 Ducted Units – tests that do not use the full-load cooling airflow. When conducting heating or part-load tests for which the manufacturer-specified fan control settings and/or manufacturer-specified airflow rates are different than for the full-load cooling test, minimum ESP requirements shall be calculated using Equation 1.

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

Where:

ESP _{adj}	=	Adjusted ESP requirement at heating airflow or part-load cooling airflow, in H ₂ O
ESP _{CFL}	=	ESP requirement at full-load cooling airflow specified in Table 2, in H ₂ O
Q _{dif}	=	Measured Part-load Airflow or manufacturer-specified heating airflow, scfm
Q _{CFL}	=	Measured Full Load Cooling Airflow, scfm

5.7.2 Indoor Airflow Target Values

5.7.2.1 All airflow rates, including those used for determining capacity, shall be expressed in terms of Standard Air.

5.7.2.2 For the full-load cooling test, use the manufacturer-specified Full-Load Cooling Airflow. If an airflow is not specified by the manufacturer, use a value of 400 scfm per ton (i.e., per 12,000 Btu/h) of Full Load Cooling Capacity.

5.7.2.3 For the heating test, use the manufacturer-specified Heating Airflow rate. If this airflow rate is not specified, use the airflow that results from using the manufacturer-specified heating fan control settings at the adjusted ESP requirement determined per section 5.7.1.3. If neither the airflow rate nor fan control settings are provided for the heating test, but the manufacturer's instructions describe how to obtain steady-state heating operation (e.g., using thermostat or other control system input) that results in an automatic adjustment to airflow, use those instructions. If none of this information is available, use the full-load cooling airflow rate for the heating test.

5.7.2.4 For part-load tests, use the manufacturer-specified Part-Load Airflow rates. If these airflow rates are not specified by the manufacturer, use the airflow that results from using the manufacturer-specified part-load fan control settings at the ESP requirement determined per section 5.7.1.3. If neither airflow rates nor fan control settings are provided for the test point but the manufacturer's instructions describe how to obtain steady-state part-load operation (e.g., using thermostat or other control system input) that results in an automatic adjustment to airflow, use those instructions. If none of this information is available, use the full-load cooling airflow rate for the part-load cooling tests.

5.7.3 *Indoor External Static Pressure and Airflow Tolerances and Set-Up*

5.7.3.1 If the manufacturer does not specify a "default" or "standard" filter in the marketing materials, then the Standard Filter shall be the filter with the lowest level of filtration as specified the marketing materials for the model. If the marketing materials do not specify a "default" or "standard" filter or which filter option has the lowest filtration level, then the Standard Filter shall be any filter shipped with the unit by the manufacturer, or if no filter is shipped with the unit, any filter option identified in the marketing materials.

5.7.3.2 Condition Tolerances. All tolerances for airflow and ESP specified in this section for setting airflow and ESP are also condition tolerances that apply throughout each test. Specifically, the average value of a parameter measured over the course of the test must vary from the target value by no more than the condition tolerance.

5.7.3.3 *Non-Ducted Units*

5.7.3.3.1 Use the manufacturer-specified fan control settings for all tests for which they are provided. Use the full-load cooling fan control settings Specified by the manufacturer for all tests for which fan control settings are not specified. If there are no manufacturer-specified fan control settings for any tests, use the as-shipped fan control settings for all tests.

5.7.3.3.2 For all tests, conduct the test at zero ESP with a condition tolerance of $-0/+0.05$ in H_2O .

5.7.3.3.3 For each test, the airflow tolerance is $\pm 3\%$ of the manufacturer-specified airflow for that test. If airflow is not specified by the manufacturer for a heating or part-load test and the full-load cooling airflow is used for that test, the airflow tolerance is $\pm 3\%$ of the full-load cooling airflow. If airflow is not specified by the manufacturer for a heating or part-load test and the full-load cooling airflow is not used for that test (if the manufacturer provides instructions to obtain steady-state operation per the provisions of sections 5.7.2.3 and 5.7.2.4), there is no airflow tolerance requirement for that test.

5.7.3.3.4 If both the ESP and airflow cannot be simultaneously maintained within tolerance for any test, maintain the ESP within the required tolerance and use an airflow as close to the manufacturer-specified value as possible. Use the measured airflow as the target airflow for all subsequent tests that call for the full-load cooling airflow.

5.7.3.3.5 If an airflow is used that deviates from the target airflow for that test by more than 3% because the airflow and ESP requirements cannot be simultaneously met (see section 5.7.3.3.4), the average airflow

rate measured over the course of the test shall be within $\pm 3\%$ of the airflow rate measured after setting airflow for that test.

5.7.3.4 *Ducted Units*

5.7.3.4.1 *Full-Load Cooling Test*

5.7.3.4.1.1 Operate the unit under conditions specified for the full-load cooling test using the manufacturer-specified fan control settings. If there are no manufacturer-specified fan control settings, use the as-shipped fan control settings. Adjust the airflow-measuring apparatus to maintain ESP within $-0/+0.05$ in H₂O of the requirement specified in Table 2 and to maintain the airflow within $\pm 3\%$ of the manufacturer-specified full-load cooling airflow.

5.7.3.4.1.2 If ESP or airflow are higher than the tolerance range, adjust the fan control settings (e.g., lower fan speed) to maintain both ESP and airflow within tolerance. If ESP or airflow are higher than the tolerance range at the lowest fan control setting (e.g., lowest fan speed), adjust the airflow-measuring apparatus to maintain airflow within tolerance and operate with an ESP as close as possible to the minimum requirement specified in Table 2.

5.7.3.4.1.3 If ESP or airflow are lower than the tolerance range, adjust the fan control settings (e.g., higher fan speed) to maintain both ESP and airflow within tolerance. If ESP or airflow are lower than the tolerance range at the maximum fan control setting (e.g., highest fan speed), adjust the airflow-measuring apparatus to maintain ESP within tolerance and operate with an airflow as close as possible to the manufacturer-specified value.

5.7.3.4.1.4 If both airflow and ESP tolerances cannot be met, (e.g., decreasing fan speed when the ESP or airflow are too high causes the ESP or airflow to be lower than the tolerance range, and increasing fan speed when the ESP or airflow are too low causes the ESP or airflow to be higher than the tolerance range), use the lower fan control settings and adjust the airflow measuring apparatus to maintain the ESP within $-0/+0.05$ in H₂O of the requirement specified in Table 2 and to maintain the airflow within 90% of the manufacturer-specified full-load cooling airflow. If increasing ESP to within $-0/+0.05$ in H₂O of the requirement specified in Table 2 reduces airflow of the unit under test to less than 90% of the rated airflow rate, then the next higher fan control setting shall be utilized to obtain rated airflow. Using this higher fan control setting, maintain airflow within the tolerance specified in section 5.7.3.3.3 and the ESP as close as possible to the manufacturer-specified value.

5.7.3.4.1.5 After setting the airflow for the full-load cooling test, no adjustments may be made to the fan control settings for the full-load cooling test. If the ESP measured after setting airflow exceeds the minimum ESP requirement by more than 0.05 in H₂O (because the ESP and airflow requirements cannot be simultaneously met, see section 5.7.3.4.1.2 and 5.7.3.4.1.4), there is no condition tolerance for ESP. If an airflow less than 97% of the manufacturer-specified full-load cooling airflow is used for the full-load cooling test (because the airflow and ESP requirements cannot be simultaneously met, see section 5.7.3.4.1.3 and 5.7.3.4.1.4), there is no condition tolerance for airflow.

5.7.3.4.2 *Heating Test and Part-load Tests*

5.7.3.4.2.1 If the manufacturer-specified part-load airflow or the manufacturer-specified heating airflow is the same as the manufacturer-specified full-load cooling airflow (and for heating tests and part-load tests for which an airflow is not specified by the manufacturer and the manufacturer-specified full-load cooling airflow is used as the airflow for the test), use the fan control settings used for the full-load cooling test. Adjust the airflow-measuring apparatus to maintain the airflow within $\pm 3\%$ of the measured full-load cooling airflow without regard to the resulting ESP. No changes are to be made to the fan control settings for the test.

5.7.3.4.2.2 If the manufacturer-specified part-load airflow or the manufacturer-specified heating airflow differs from the manufacturer-specified full-load cooling airflow, use the following provisions.

5.7.3.4.2.2.1 Operate the system under conditions specified for the heating test or part-load test using the manufacturer-specified fan control settings for that test condition. If there are no manufacturer-specified fan control settings for the heating test or part-load test, use the manufacturer-specified fan control settings for the full-load cooling test. If there are no manufacturer-specified fan control settings for any tests, use the as-shipped fan control settings.

5.7.3.4.2.2.2 Adjust the airflow-measuring apparatus to maintain ESP within $-0/+0.05$ in H₂O of the adjusted ESP requirement determined per section 5.7.1.3 and maintain airflow within $\pm 3\%$ of the manufacturer-specified airflow for the heating or part-load test.

If ESP or airflow are higher than the tolerance range, adjust the fan control settings (e.g., lower fan speed) to maintain both ESP and airflow within tolerance. If ESP or airflow are higher than the tolerance range, at the lowest fan control setting (e.g., lowest fan speed), adjust the airflow-measuring apparatus to maintain airflow within tolerance and operate with an ESP as close as possible to the minimum requirement specified in Table 2.

If ESP or airflow are lower than the tolerance range, adjust the fan control settings (e.g., higher fan speed) to maintain both ESP and airflow within tolerance (but without adjusting sheaves and without exceeding the final fan control settings used for the full-load cooling test). If ESP or airflow are lower than the tolerance range at the maximum fan control setting (e.g., highest fan speed), adjust the airflow-measuring apparatus to maintain ESP within tolerance and operate with an airflow as close as possible to the manufacturer-specified value.

If both airflow and ESP tolerances cannot be met, (e.g., decreasing fan speed when the ESP or airflow are too high causes the ESP or airflow to be lower than the tolerance range, and increasing fan speed when the ESP or airflow are too low causes the ESP or airflow to be higher than the tolerance range), use the lower fan control settings and adjust the airflow measuring apparatus to maintain the ESP within $-0/+0.05$ in H₂O of the requirement specified in Table 2 and to maintain the airflow within 90% of the manufacturer-specified full-load cooling airflow. If increasing ESP to within $-0/+0.05$ in H₂O of the requirement specified in Table 2 reduces airflow of the unit under test to less than 90% of the rated airflow rate, then the next higher fan control setting shall be utilized to obtain rated airflow. Using this higher fan control setting, maintain airflow within the tolerance specified in section 5.7.3.3.3 and the ESP as close as possible to the manufacturer-specified value. After setting the airflow, no changes are to be made to the fan control settings.

5.7.3.4.2.2.3 If the ESP measured after setting airflow exceeds the adjusted ESP requirement determined per section 5.7.1.3 by more than 0.05 in H₂O (because the ESP and airflow requirements cannot be simultaneously met, see section 5.7.3.4.2.2.2), there is no condition tolerance for ESP. If an airflow less than 97% of the manufacturer-specified airflow is used for a test (because the airflow and ESP requirements cannot be simultaneously met, see section 5.7.3.4.2.2.2), there is no condition tolerance for airflow.

5.7.3.4.2.2.4 For heating tests and part-load tests for which an airflow is not specified by the manufacturer and the manufacturer-specified full-load cooling airflow is not used as the airflow for the test (because the manufacturer provides fan control settings or instructions to obtain steady-state operation for the test, per the provisions of sections 5.7.2.3 and 5.7.2.4), use the manufacturer-specified fan control setting for that test condition or adjust the system control input to obtain the heating or part-load operation specified by the manufacturer. Adjust the airflow-measuring apparatus to meet the adjusted ESP requirement determined per section 5.7.1.3 with a condition tolerance of $-0/+0.05$ in H₂O, using the measured heating or part-load airflow in the ESP calculation. After setting the airflow, no changes are to be made to the fan control settings.

5.8 Standard Rating Tests. Table 3 indicates the tests and test conditions which are required to determine values of Standard Capacity Ratings and Energy Efficiency.

5.8.1 Electrical Conditions. Nameplate voltages are shown in Table 1 of ANSI/AHRI Standard 110. Standard Rating Tests shall be performed at the nameplate rated voltage and frequency unless otherwise specified in this standard.

For equipment which is rated with 208/230 dual or 208-230 nameplate voltages, Standard Rating Tests shall be performed at 230 V.

For all other dual or range nameplate voltage equipment covered by this standard, the Standard Rating Tests shall be performed at both voltages or at the lower voltage if only a single Standard Rating is to be published.

5.8.2 *Atmospheric Pressure.* Tests shall be conducted at an atmospheric pressure of at least 13.7 psia. Atmospheric pressure measuring instruments shall be accurate to within $\pm 0.5\%$ of the reading.

5.8.3 *Supplementary Heat.* All supplementary heat sources, including electric resistance heat, shall be turned off or disconnected from power during the test.

Table 3. Standard Rating Test Conditions and Operating Requirements

Test	Air Entering Indoor Side, °F		Air Entering Outdoor Side, °F	
	Dry-bulb	Wet-bulb	Dry-bulb	Wet-bulb
Cooling Mode				
Full Load Standard Rating Capacity Test, Cooling ^{1,2}	80.0	67.0	95.0	75.0 ³
Part-load Standard Rating Conditions	80.0	67.0	Varies with load per Table 7	Varies with load per Table 7 ³
Cooling Mode Operation Tests				
Low Temperature Operation, Cooling	67.0	57.0	67.0	57.0 ³
Maximum High Temperature Operation	80.0	67.0	115.0	75.0 ³
Condensate Disposal	80.0	75.0	80.0	75.0
Insulation Effectiveness	80.0	75.0	80.0	75.0 ³
Heating Mode				
Full Load Standard Rating Capacity Test, Heating ^{1,2}	70.0	60.0 ⁴	47.0	43.0
Part-load Capacity Test Heating	70.0	60.0 ⁴	62.0	56.5
Heating Mode Operation Tests				
Low Temperature Operation, Heating ⁵	70.0	60.0 ⁴	17.0	15.0
Maximum High Temperature Operation	80.0	-	75.0	65.0
Notes:				
1. Same Conditions used for voltage tolerance tests.				
2. Refer to Appendix D for Standard Rating Conditions for products sold outside the US and Canada.				
3. Only required if unit rejects condensate to Outdoor Coil. For units that do not reject condensate to the Outdoor Coil, where all or part of the indoor section of the equipment is located in the outdoor room, maintain an outdoor room dew point temperature of 60.5°F.				
4. Maximum value for all tests. If outdoor air enthalpy method is used for Single Package Heat Pumps, then the wet bulb shall be adjusted to match as close as reasonably possible to the dew point of the outdoor entering air.				
5. Only applicable if the manufacturer's Published Rating includes low-temperature specifications.				

5.8.4 Outdoor-side Airflow Rate. All Standard Ratings shall be determined at the outdoor-side airflow rate Specified by the manufacturer where the fan drive is adjustable. Where the fan drive is non-adjustable, Standard Ratings shall be determined at the outdoor-side airflow rate inherent in the equipment. Outdoor air-side attachments used for testing shall be specified in the supplemental test instructions (if offered for sale with or without outdoor air-side attachments, one of the optional outdoor air-side attachments shall be specified by the manufacturer and used for testing). Once established, the outdoor-side air circuit of the equipment shall remain unchanged throughout all tests prescribed herein unless automatically adjusted by the unit controls.

5.8.5 Moisture Removal Determination. Indoor air moisture removed shall be determined at Standard Rating Conditions, cooling.

5.9 Test Tolerances

5.9.1 Test operating tolerance is the maximum permissible range that a measurement may vary over the specified test interval. Specifically, the difference between the maximum and minimum sampled values shall be less than or equal to the specified test operating tolerance. If the operating tolerance is expressed as a percentage, the maximum allowable variation is the specified percentage of the average value of the measured test parameter.

5.9.2 Test condition tolerance is the maximum permissible difference between the average value of the measured test parameter and the specified test condition. If the condition tolerance is expressed as a percentage, the condition tolerance is the specified percentage of the test condition.

5.9.3 Tolerances specified in this standard supersede tolerances specified in ANSI/ASHRAE Standard 37. Test operating tolerances and condition tolerances are specified in Table 4.

Table 4. Tolerances		
Measurement	Test Operating Tolerance	Test Condition Tolerance
Outdoor dry-bulb temperature (°F): Entering Leaving	2.0 2.0 / 3.0 ^{1,3}	0.5 -
Outdoor wet-bulb temperature (°F): Entering Leaving	1.0 1.0 ^c	0.3 ² -
Indoor dry-bulb temperature (°F): Entering Leaving	2.0 2.0 / 3.0 ^{1,4}	0.5 -
Indoor wet-bulb temperature (°F): Entering Leaving	1.0 1.0	0.3 -
Water serving outdoor coil temperature (°F): Entering Leaving	0.5 0.5	0.2 0.2
Saturated refrigerant temperature corresponding to the measured indoor side pressure ⁵ (°F)	3.0	0.5
Liquid refrigerant temperature ⁵ (°F)	0.5	0.2
External static pressure (in H ₂ O)	0.05	-
Electrical voltage (percent of reading)	2.0	1.0
Liquid flow rate (percent of reading)	2.0	-
Nozzle pressure drop (percent of reading)	2.0	-
Notes: 1. The test operating tolerance is 2.0°F for cooling tests and 3.0°F for heating tests 2. Applicable of heating tests of air-cooled units and only applicable for cooling tests when testing equipment that rejects condensate to the outdoor coil, or packaged equipment for which the indoor coil is located in the outdoor chamber. 3. Applies only when using the outdoor air enthalpy method. 4. Applies only when using the indoor air enthalpy method. 5. Tolerance applied only for the compressor calibration method, the saturation temperature, in this case, shall be evaluated based on the pressure transducer located between the indoor coil and the compressor for the given operating mode, heating or cooling.		

5.10 Head Pressure Control. For units with condenser head pressure controls, the head pressure controls shall be enabled and operated in automatic mode. Set head pressure controls as specified by the manufacturer's instructions. If there are no such instructions, use the as-shipped setting. If this results in unstable operation (*e.g.* test tolerances in Table E1 are exceeded) and testing requirements cannot be met, then the procedures in Appendix E shall be used.

Section 6. Rating Requirements

6.1 Rating Requirements. Standard Ratings shall be expressed in Cooling Capacity and/or Heating Capacity. Power input ratings shall be expressed in increments or multiples of 5 W. Airflow rates shall be expressed in increments of 10 scfm.

6.1.1 Values of Standard Capacity Ratings. These ratings shall be expressed only in terms of Btu/h as specified in Table 5.

Table 5. Values of Standard Capacity Ratings	
Capacity Ratings ¹ , 1000 Btu/h	Multiples, Btu/h
< 20	100
≥ 20 and < 38	200
≥ 38 and < 65	500
≥ 65	1000
Notes:	
1. Cooling Capacity for units with cooling function; high temperature Heating Capacity for heating-only units.	

6.1.2 Values of Energy Efficiency Ratios and Heating Coefficient 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 (Btu/h)/W. Heating Coefficient of Performance (COP), whenever published, shall be expressed in multiples of 0.01.

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 Requirements. The general equation used to calculate IEER is defined in Section 6.2.2.

To help in the application of the Equation 2, specific step by step procedures are included in the following sections for various Unit Types in Table 6.

Table 6. Section References for Different Single Package Vertical Unit Types	
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 C Appendix C.

6.2.2 General IEER Equations. For units covered by this standard, the IEER shall be calculated using test derived data and the Equation 2.

$$IEER = (0.010 \cdot A) + (0.233 \cdot B) + (0.456 \cdot C) + (0.301 \cdot D)$$

2

Where:

A = EER at 100% Capacity at AHRI Standard Rating full load conditions (see Table 3)

B = EER at 75% Capacity and reduced condenser temperature (see Table 7)

C = EER at 50% Capacity and reduced condenser temperature (see Table 7)

D = EER at 25% Capacity and reduced condenser temperature (see Table 7)

The IEER rating requires that the unit efficiency be determined at 100, 75, 50, and 25 Percent Load at the conditions specified in Table 7 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 7. IEER Part-Load Rating Conditions	
Conditions	Condition
Indoor Air	
Return Air Dry-bulb Temperature	80.0°F
Return Air Wet-bulb Temperature	67.0°F
Part-load Rated Indoor Airflow ¹	-
Condenser Entering Dry-bulb/Wet-bulb Temperature ²	A = 95.0°F/75.0°F B = 82.5°F/69.5°F C = 72.0°F/62.0°F D = 69.0°F/60.0°F
Condenser Airflow Rate ³ , scfm	-
Notes:	
1. Refer to Section 5.7 for Indoor Airflow and external static pressure requirements.	
2. Wet-bulb temperature only required if the unit rejects condensate to Outdoor Coil. For units that do not reject condensate to the Outdoor Coil, where all or part of the indoor section of the equipment is in the outdoor room, maintain an outdoor room dew point temperature of 60.5°F.	
3. Condenser airflow shall be adjusted, if required per Section 5.8.4.	

6.2.3 Ratings Adjustments. The IEER shall be determined at the 4 ratings loads and condenser conditions as defined in Table 7. If the unit is not capable of running at the 75, 50 or 25 Percent 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 Percent Load points within a tolerance of $\pm 3\%$ but is capable of running at load above and below the Percent Load of 75, 50 or 25 interpolation of the test points shall be used to determine the EER rating at the required load.

6.2.3.2 Degradation. If the unit cannot be unloaded to the 75, 50, or 25 Percent Load then the unit shall be run at the minimum step of unloading and minimum rated Indoor Airflow at the condenser conditions defined for each of the rating Percent Load IEER points listed in Table 7 and then the Part-load EER shall be adjusted for cyclic performance using Equation 3:

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

3

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 3.
- P_C = Compressor power at the lowest machine unloading point operating at the desired Part-load rating condition, watts
- P_{CD} = Condenser Section (not including loads captured by P_C or P_{CT}) power, if applicable at the desired Part-load rating condition, watts.

P_{CT}	=	Control circuit power and any auxiliary loads, watts
P_{IF}	=	Indoor fan power, watts
Q	=	Cooling Capacity as per Appendix E at the lowest machine unloading point operating at the desired Part-load rating condition, Btu/h

$$C_D = (-0.13 \cdot LF) + 1.13 \quad 4$$

Where:

LF = Fractional “on” time for last stage at the desired load point, Noted in the following equation:

$$LF = \frac{(PL/100) \cdot \dot{q}_{A,Full}}{\dot{q}_{i,x}} \quad 5$$

Where:

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

6.2.4 Procedure for IEER Calculations for Fixed Capacity Control Units. For Fixed Capacity Control Units (single stage), the IEER shall be calculated using data and the Equation 2 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 Percent Load shall be determined at the Part-load rating condenser entering temperature defined in Table 7 within tolerances defined in Section 5.9.

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

6.2.4.2 Step 2. The rating shall be adjusted for cyclic degradation using the procedures in Section 6.2.3.2

6.2.4.3 Step 3. The test results including adjustments for cyclic degradation from step 2 shall then be used to calculate the IEER using the procedures defined in Section 6.2.3.2.

6.2.5 IEER for Staged Capacity Controlled Units. For Staged Capacity Controlled Units, the IEER shall be calculated using Equation 2 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 5.7.3.4.2.

The following sequential steps shall be followed:

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

The condenser entering temperature shall be adjusted per the requirements of Table 7 within the tolerances defined in Section 5.9.

The indoor Standard Airflow rate and static shall be adjusted per the requirements of Section 5.7.3.4.2.

If the measured part-load rating capacity ratio is within three percentage points based on the full load measured Cooling Capacity, above or below the target, as shown in Table 9, the EER at each load point shall be used to determine IEER without any interpolation or adjustment for cyclic degradation.

Table 8. Tolerance on Part-Load Percent Load		
Required Percent Load Point	Minimum Allowable Measured Percent Load	Maximum Allowable Measured Percent Load
75%	72%	78%
50%	47%	53%
25%	22%	28%

If the unit cannot operate within 3% of the target load fraction for a given part-load test (75, 50, or 25 Percent Load), then the EER for the part-load test shall be determined using either linear interpolation or adjustment for cyclic degradation. If the unit can run both above and below the target load fraction, then an additional rating point is required and the EER for the given part-load test point is determined using linear interpolation. Data shall not be extrapolated to determine EER; therefore, if the unit cannot be unloaded to the target load fraction then the unit shall be run at the minimum step of unloading at the condenser conditions defined for the target test point in Table 7 and the EER for the part-load test shall be adjusted for cyclic degradation using Equation 4.

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

6.2.5.1.1 Both test points used for interpolation for a given target load fraction shall be conducted at the outdoor ambient temperature specified in Table 7, within a tolerance of $\pm 0.5^\circ\text{F}$. Of the two tests, one test point shall be at a capacity above the target load point and the second test point shall be at a capacity below the target load point. The data from these two test points shall then be used to interpolate the EER for the required load rating point. For example, for an air-cooled unit that cannot operate at 50 Percent Load and has capacity stages at 60 and 30 Percent Load, then tests at both load points shall be conducted at a 68°F outdoor ambient temperature. The test results are then interpolated to determine the EER for the 50 Percent Load rating point.

The indoor Standard Airflow rate and external static pressure for each part-load test shall be adjusted per section 5.7.3.4.2.

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

If the unit cannot be unloaded to the 75, 50, or 25 Percent Load points at the minimum stage of unloading then the EER shall be determined at the minimum stage of unloading and part-load rating condenser entering temperature defined in Table 7 for the target load point with a tolerance of $\pm 0.5^\circ\text{F}$. In such a case, the actual Percent Load will be greater than the target Percent Load and shall be adjusted for cyclic performance using the degradation calculations as per section 6.2.3.2. Part-load Rated Indoor Standard Airflow and external static pressure shall be set as specified in section 5.7.3.4.2.

6.2.5.2 *Step 2.* If the load fraction points are within 3% of the desired IEER rating point of 75, 50 and 25 Percent Load they shall be used directly. If there are load fraction points above and below the desired targets of 75, 50, and 25 Percent Load then the Part-load EER shall be determined using linear interpolation. If the tested Percent Load is greater than the Percent Load for 75, 50 or 25 Percent Load by more than 3% and the unit cannot unload any further then the EER at the condenser temperature required for the rating point shall be used along with the degradation procedure defined in Section 6.2.3.2.

6.2.5.3 *Step 3.* The data from step 2 shall then be used to calculate the IEER using the procedures defined in Section 6.2.3.2.

6.2.6 *IEER for Proportionally Controlled Units.* For Proportionally Controlled Units, the IEER shall be calculated using data, Equation 2, and the following procedures.

Proportionally Controlled Units, for test purposes, shall be provided with 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 Installation Instructions, including setting of stages of refrigeration and variable capacity compressor loading percent for each of the part-load test points. The settings that result in capacity closest to the target Percent Load point of 75, 50, or 25 shall be used.

The condenser entering conditions shall be adjusted per the requirements of Table 7 and be within tolerance as defined in Section 5.9.

The indoor Standard Airflow and static shall be adjusted per Section 5.7.3.4.2.

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

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

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

6.2.6.1.1 The condenser entering conditions shall be adjusted per the requirements of Table 7 and be within tolerance as defined in Section 5.9.

6.2.6.1.2 The indoor airflow shall be set as specified by the manufacturer and as required by Section 5.7.3.4.2.

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

Note: For example, to 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 target capacity point if the measured capacity of the first test is greater than the target capacity point.

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

If the unit cannot be unloaded to the 75, 50, or 25 Percent Load points at the minimum stage of unloading then the EER shall be determined at the minimum stage of unloading and Part-load rating condenser entering temperature defined in Table 7 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 2. Part-load Rated Indoor Airflow and static, if different than Full Load Indoor Airflow, shall be used as defined by the manufacturer and as required by Section 5.7.3.4.2.

6.2.6.2 *Step 2.* If any of the actual Percent Loads are within 3% of the targets of 75, 50 and 25 Percent Loads, the tested EER shall be used directly. If there are actual Percent Loads above and below the targets of 75, 50, and 25 Percent Load, then the rating data the IEER rating point shall be determined using linear interpolation. If the rated Percent Load is greater than the targets of 75, 50 or 25 by more than 3%, and the capacity cannot be reduced

to meet the target, then the EER at the condenser temperature required for the rating point shall be used along with the degradation procedure defined in Section 6.2.3.2.

6.2.6.3 *Step 3.* The data from step 2 shall then be used to calculate the IEER using the procedures defined in Section 6.2.3.2.

6.3 *Application Ratings.* Ratings at conditions other than those specified in Sections 5.8 and 6.2 may be published as Application Ratings and shall be based on data determined by the methods prescribed in Section 5.1.

6.3.1 *International Ratings.*

6.3.1.1 *Cooling Temperature Conditions.*

6.3.1.1.1 The T1, T2, and T3 temperature conditions specified in Table 9 shall be considered Standard Rating Conditions for the determination of Cooling Capacity and energy efficiency. Testing shall be conducted at one or more of the Standard Rating Conditions specified in Table 9.

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

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

6.3.1.1.4 Equipment manufactured for use only in a hot climate similar to that specified by T3 shall have ratings determined by tests conducted at T3 conditions and shall be designated type T3 equipment.

6.3.1.1.5 Equipment manufactured for use in more than one of the climates defined in Table 1 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 9.

6.3.1.2 *Heating Temperature Conditions.*

6.3.1.2.1 The H1, H2, and H3 temperature conditions specified in Table 9 shall be considered Standard Rating Conditions for the determination of Heating Capacity and energy efficiency.

6.3.1.2.2 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 9. Conditions for Standard Rating Tests and Operating Requirements for Single Capacity and Variable Capacity Systems

Test	Air Entering Indoor Side		Air Entering Outdoor Side		Air Entering Indoor Side		Air Entering Outdoor Side		Air Entering Indoor Side		Air Entering Outdoor Side	
	Dry-bulb °F	Wet-bulb °F	Dry-bulb °F	Wet-bulb °F	Dry-bulb °F	Wet-bulb °F	Dry-bulb °F	Wet-bulb °F	Dry-bulb °F	Wet-bulb °F	Dry-bulb °F	Wet-bulb °F
	T1				T2				T3			
Full Load Capacity Test Cooling ^{1,2,4}	80.6	66.2	95.0	75.2	69.8	59.0	80.6	66.2	84.2	66.2	114.8	75.2
	H1				H2				H3			
Full Load Capacity Test Heating ^{1,2,4}	68.0	59.0 ³	44.6	42.8	68	59.0 ³	35.6	33.8	68.0	59.0 ³	19.4	17.6

Notes:

1. Same conditions used for voltage tolerance tests.
2. Full load capacity is maximum capacity set point specified by manufacturer corresponding to rating point.
3. This temperature shall serve as a maximum and shall not be exceeded.
4. Variable capacity system samples under test shall be set at the maximum compressor speed corresponding to the full load capacity rating.
5. Temperature Rating Conditions derived from ISO Standard 5151.

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

6.5 Tolerances. To comply with this standard, measured test results shall meet the Standard Rating performance metrics shown in Table 10 with the listed Acceptance Criteria.

Table 10. Acceptance Criteria	
Performance Metric	Acceptance Criteria
Cooling Metrics	
Full Load Cooling Capacity, Btu/h	≥ 95%
Full Load EER, (Btu/H)/W	≥ 95%
IEER, (Btu/H)/W	≥ 90%
Heating Metrics	
Heating Capacity at 47°F, Btu/h	≥ 95%
COP at 47°F, W/W	≥ 95%

6.6 Secondary Verification. Secondary verification measurements of Cooling and Heating Capacity (if applicable) shall be as described in section E5 of this standard.

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 Single Package Air Conditioners at Standard Rating Conditions:

7.1.1.1 Cooling Capacity, Btu/h

- 7.1.1.2 Energy Efficiency Ratio, EER, (Btu/h)/W
- 7.1.1.3 Integrated Energy Efficiency Ratio, IEER, (Btu/h)/W
- 7.1.2 For Single Package Heat Pumps at Standard Rating Conditions:
 - 7.1.2.1 Cooling Capacity, Btu/h
 - 7.1.2.2 Energy Efficiency Ratio, EER, (Btu/h)/W
 - 7.1.2.3 Integrated Energy Efficiency Ratio, IEER, (Btu/h)/W
 - 7.1.2.4 Heating Capacity, Btu/h at 47°F
 - 7.1.2.5 Coefficient of Performance, COP, W/W, at 47°F

All claims to ratings within the scope of this standard shall include the verbiage “Rated in accordance with AHRI Standard 390 (I-P)-2021. All claims to ratings outside the scope of this standard shall include the verbiage “Outside the scope of AHRI Standard 390 (I-P)-2021”. Wherever Application Ratings are published or printed, they shall include a statement of the conditions at which the ratings apply.

7.1.3 Moisture Removal Designation. The moisture removal designation either shall be published in the manufacturer's specifications and literature or such publications shall include a statement to advise the user that this information is available upon request. The value shall be expressed in one or more of the following forms:

- 7.1.3.1 Sensible Capacity/total capacity ratio and Cooling Capacity, %
- 7.1.3.2 Latent Capacity and Cooling Capacity, Btu/h
- 7.1.3.3 Sensible Capacity and Cooling Capacity, Btu/h

Section 8. Operating Requirements

8.1 Operating Requirements. To comply with this standard, any production unit shall meet the requirements of Section 7.

8.2 Maximum High-Temperature Operation Test. SPVAC/SPVHP equipment shall pass the appropriate high temperature operation tests required with an indoor-side airflow rate as determined under Section 5.7 and outdoor-side airflow rate as determined under Section 5.8.4.

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

8.2.2 Voltages. The test shall be run at the Range A minimum utilization voltage from ANSI/AHRI Standard 110, Table 1, based upon the unit's nameplate rated published voltage(s). This voltage shall be supplied at the unit's service connection and at rated frequency.

8.2.3 Procedure. The unit shall be operated for one hour at the temperature conditions and voltage specified.

8.2.4 Requirements. The unit shall operate continuously without interruption for one hour.

8.3 Voltage Tolerance Test. SPVAC/SPVHP equipment shall pass the following voltage tolerance test at the manufacturer's maximum rated compressor speed with an indoor-side airflow rate as determined under Section 5.7 and outdoor-side airflow rate as determined under Section 5.8.4.

8.3.1 Temperature Conditions. Temperature conditions shall be maintained at the standard cooling (and/or standard heating, as required) steady state conditions as shown in Table 3.

8.3.2 Voltages.

8.3.2.1 Steady State. Two separate tests shall be performed, one test at the Range B minimum utilization voltage and one test at the Range B maximum utilization voltage from ANSI/AHRI Standard 110, Table 1, based upon the unit's nameplate rated voltage(s). These voltages shall be supplied at the unit's service

connection and at rated frequency. A lower minimum or a higher maximum voltage shall be used, if listed, on the nameplate.

8.3.2.2 Power Interrupt. During the power interrupt portion of each test, the voltage supplied to the equipment (single phase and three phase) shall be adjusted just prior to the shut-down period (Section 8.3.3.2) such that the resulting voltage at the unit's service connection is 86% of nameplate rated voltage when the compressor motor is on locked-rotor. (For 200 V or 208 V nameplate rated equipment the restart voltage shall be set at 180 V when the compressor motor is on locked rotor). Open circuit voltage for three phase equipment shall not be greater than 90% of nameplate rated voltage.

8.3.2.3 Resume Operation. During the resume operation portion of the test, the voltage supplied to the equipment shall be the same as the voltage as per Section 8.3.2.1.

8.3.3 Procedure.

8.3.3.1 Steady State. The equipment shall be operated for one hour at the temperature conditions and each voltage identified in Sections 8.3.1 and 8.3.2.

8.3.3.2 Power Interrupt. All power to the equipment shall be shut off for a period sufficient to cause the compressor to stop (not to exceed five seconds) and then immediately restored.

8.3.3.3 Resume Operation. Within one minute after the equipment has resumed continuous operation (Section 8.3.4.3), the voltage shall be restored to the values identified in Section 8.3.2.1. During the remainder of resume operations phase, voltage and temperature conditions shall be retained as identified in Section 8.3.3.1. Refer to Figure 1.

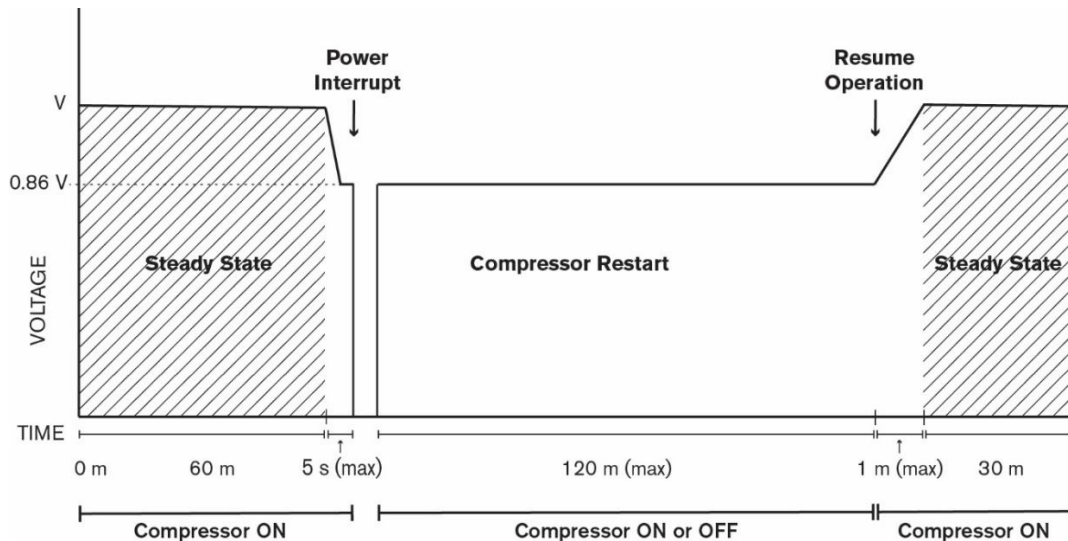


Figure 1. Voltage Tolerance Test Power Interrupt Procedure.

8.3.4 Requirements.

8.3.4.1 During the entire test, the equipment shall operate without damage or failure of any of its parts.

8.3.4.2 Steady State. During the steady state portion of the test, the equipment shall operate continuously without interruption for any reason.

8.3.4.3 Resume Operation. During the resume operation portion of the test, the unit shall resume continuous operation within two hours of restoration of power and shall then operate continuously for one half hour. Operation and resetting of safety devices prior to establishment of continuous operation is permitted.

8.4 Low-Temperature Operation Test (Cooling). SPVAC/SPVHP equipment shall pass the following low-temperature operation test when operating with an indoor-side airflow rate as determined under Section 5.7 and outdoor-side airflow rate as determined under Section 5.8.4 with controls, fans, dampers, and grilles set to produce the maximum tendency to frost or ice the evaporator, provided such settings are not contrary to the manufacturer's instructions to the user. For equipment utilizing variable capacity compressors, the maximum rated compressor speed and corresponding manufacturer-specified airflow shall be used during this test.

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

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

8.4.3 Requirements.

8.4.3.1 During the entire test, the equipment shall operate without damage or failure of any of its parts.

8.4.3.2 During the entire test, the airflow rate shall not drop more than 25% from that determined under the Standard Rating Full Load test.

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

8.5 Insulation Effectiveness Test (Cooling). SPVAC/SPVHP equipment shall pass the following insulation effectiveness test when operating with an indoor-side airflow rate as determined under Section 5.7 and outdoor-side airflow rate as determined under Section 5.8.4 with controls, fans, dampers, and grilles, as shipped with basic production models set to produce the maximum tendency to sweat, provided such settings are not contrary to the manufacturer's instructions to the user.

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 unit shall be operated continuously for a period of four hours.

8.5.3 Requirements. During the test, no condensed water shall drip, run, or blow off from the unit's casing.

8.6 Condensate Disposal Test (Cooling). SPVAC/SPVHP equipment which rejects condensate to the condenser air shall pass the following condensate disposal test when operating with an indoor-side airflow rate as determined under Section 5.7 and outdoor-side airflow rate as determined under Section 5.8.4. Controls, fans, dampers, and grilles, as shipped with basic production models, shall be 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 effectiveness test (See Section 8.5).

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

8.6.2 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.

8.6.3 Requirements. During the test and after the unit is turned off, there shall be no dripping, running-off, or blowing-off of moisture from the unit casing.

8.7 Tolerances. The conditions for the tests outlined in Section 8 are average values subject to condition tolerances of $\pm 1.0^{\circ}\text{F}$ for air dry-bulb and wet-bulb temperatures, and $\pm 1.0\%$ of the reading for voltages.

Section 9. Marking and Nameplate Data

9.1 *Marking and Nameplate Data.* As a minimum, the nameplate shall display the manufacturer's name, model designation, and electrical characteristics.

Nameplate voltages for 60 Hertz systems shall include one or more of the equipment nameplate voltage ratings shown in Table 1 of AHRI Standard 110. Nameplate voltages for 50 Hertz systems shall include one or more of the utilization voltages shown in Table 1 of IEC Standard Publication 60038.

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 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 cannot 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 standards. All references in this appendix are considered as part of the standard.

A1.1 AHRI Standard 110-2016, *Air-Conditioning and Refrigerating Equipment Nameplate Voltages*, Air-Conditioning, Heating and Refrigeration Institute, 2016, 23111 Wilson Boulevard, Suite 400, Arlington, VA 22201, U.S.A.

A1.2 AHRI Standard 210/240-2017, *Unitary Air-Conditioning and Air- Source Heat Pump Equipment*, Air-Conditioning, Heating, and Refrigeration Institute, 2017, 2311 Wilson Boulevard, Suite 400, Arlington, VA 22201, U.S.A.

A1.3 ANSI/AHRI Standard 340/360-2019, *Commercial and Industrial Unitary Air-Conditioning and Heat Pump Equipment*, Air-Conditioning, Heating, and Refrigeration Institute, 2019, 2311 Wilson Boulevard, Suite 400, Arlington, VA 22201, U.S.A.

A1.4 ANSI/AHRI Standard 1230-2014 with Addendum 2, *Performance Rating of Variable Refrigerant Flow (VRF) Multi-Split Air-Conditioning and Heat Pump Equipment*, Air-Conditioning, Heating, and Refrigeration Institute, 2014, 2311 Wilson Boulevard, Suite 400, Arlington, VA 22201, U.S.A.

A1.5 ANSI/ASHRAE Standard 37-2009, *Methods of Testing for Rating Unitary Air-Conditioning and Heat Pump Equipment*, 1988, ASHRAE, 180 Technology Pkwy NW, Peachtree Corners, GA 30092, U.S.A.

A1.6 ANSI/ASHRAE Standard 41.1-2013, *Standard Method for Temperature Measurement*, 2013, ASHRAE, 180 Technology Pkwy NW, Peachtree Corners, GA 30092, U.S.A.

A1.7 ANSI/ASHRAE Standard 41.6-2014, *Standard Method for Humidity Measurement*, 2014, ASHRAE, 180 Technology Pkwy NW, Peachtree Corners, GA 30092, U.S.A.

A1.8 ANSI/UL Standard 555-2006, *Standard for Fire Dampers*, Underwriters Laboratories, 333 Pfingsten Road Northbrook, IL 60062-2096 U.S.A.

A1.9 ANSI/UL Standard 555S-2014, *Standard for Smoke Dampers*, Underwriters Laboratories, 333 Pfingsten Road Northbrook, IL 60062-2096 U.S.A.

A1.10 ASHRAE Terminology, <https://www.ashrae.org/resources--publications/free-resources/ashrae-terminology>, 2014, ASHRAE, 180 Technology Pkwy NW, Peachtree Corners, GA 30092, U.S.A.

A1.11 IEC Standard Publication 60038, *IEC Standard Voltages, 2009*, International Electrotechnical Commission, 3, rue de Varembe, P.O. Box 131, 1211 Geneva 20, Switzerland.

A1.12 ISO Standard 5151-2010, *Non-ducted air conditioners and heat pumps – Testing and rating for performance*, Chemin de Blandonnet 8, CP 401, 1214 Vernier, Geneva, Switzerland.

APPENDIX B. REFERENCES – INFORMATIVE

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

None.

APPENDIX C. EXAMPLES OF IEER CALCULATIONS – INFORMATIVE

C1 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. It includes 4 rating points at 100, 75, 50 and 25 Percent Load at condenser conditions seen during these load points. The test descriptions for this appendix are:

- A for 100 Percent Load;
- B for 75 Percent Load;
- C for 50 Percent Load;
- D for 25 Percent Load.

It includes all mechanical cooling energy, fan energy, and other energy required to deliver the mechanical cooling. It excludes energy and Cooling Capacity for operating hours seen for just ventilation and economizer operation. It also does not include system control options like demand ventilation, Supply Air reset, energy recovery, and other system options that might be used in an applied configuration of the unit. It assumes no oversizing of the unit. The purpose of the metric is to allow for comparison of mechanical cooling systems at a common industry metric set of conditions. It is not intended to be a metric for prediction of building energy use for the HVAC systems.

Building energy consumption varies significantly based on many factors including, but not limited to, local occupancy schedules, ambient conditions, building construction, building location, ventilation requirements and added features like economizers, energy recovery, evaporative cooling, etc. IEER is a comparative metric representing the integrated full load and part-load annualized performance of the mechanical cooling of the air- conditioning unit over a range of operating conditions. It does not include performance of hybrid system features 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.

C2 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 different Single Package Vertical Unit Types covered by this standard. The examples are grouped by the capacity control methods as defined in Sections 6.2.4, 6.2.5, and 6.2.6 and as outlined in Table C1.

Table C1. Table of Contents of Examples		
Section	Description	Page No.
C3	<i>Fixed Capacity Control Examples.</i>	
C3.1	<i>Example 1. Fixed Capacity Control Unit with Fixed Speed Indoor Fan IEER Example Calculations.</i>	27
C4	<i>Staged Capacity Controlled Unit Example Calculations.</i>	
C4.1	<i>Example 2. 2 Stage Unit with a Fixed Speed Indoor Fan Example Calculations IEER Example Calculation.</i>	28
C5	<i>Proportionally Controlled Unit Example Calculations.</i>	
C5.1	<i>Example 3. Unit with a Variable Speed Compressor and a Variable Speed Fan IEER Example Calculations.</i>	30

C3 Fixed Capacity Control Example. In this section you will find example IEER calculations for Fixed Capacity Controlled Units (single stage) as defined in Section 6.2.4.

Note that per Section 3.16.1 a Fixed Capacity Controlled Unit is defined as a Product limited by the controls to a single stage of

refrigeration capacity.

C3.1 *Example 1. Air-cooled Fixed Capacity Control Unit with Fixed Speed Indoor Fan IEER Example Calculations.*

The unit is an air-cooled Single Package Air-conditioner 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 = 58,000 Btu/h
 Full Load Rated Indoor Airflow = 1800 scfm
 Rated EER = 11.5 (Btu/h)/W
 Rated IEER = 11 (Btu/h)/W

The test data measurements are shown in Table C2A. During the tests, the atmospheric pressure was measured at 14.500 psia and was constant for all tests. The test is acceptable because the atmospheric pressure is greater than the minimum allowable 13.700 psia. Note the pressure could vary between tests and it should be measured for each test.

Table C2A Example 1. Test Results

Test	Stage	Test OAT	Req OAT	Actual Percent Load	Test Net Cap	Test SCFM (Std Air)	Total Power	Cmpr (P _c) (Test)	Cond (P _{cd}) (Test)	Indoor (P _{if}) (Test)	Control (P _{ct}) (Test)	EER (Test)
		°F	°F	%	Btu/h	SCFM	W	W	W	W	W	(Btu/h)/W
1	1	95.1	95	100	57,481	1814	5040	4150	400	450	40	11.4
2	1	82.0	82.5	103.5	59,493	1814	4517	3627	400	450	40	13.2
3	1	71.8	72	104	59,780	1814	4351	3461	400	450	40	13.7
4	1	69.1	69	107.2	61,620	1814	4244	3390	400	450	40	14.5

Because the unit has a single stage of capacity control, the rating EER values for 75, 50, and 25 Percent Load rating points require 3 tests to be run at the rated ambient temperatures of 82.5°F (75 Percent Load), 72.0°F (50 Percent Load), and 69°F (25 Percent Load) as defined in Table 7. Note that for this example all tests are acceptable as the test outdoor air temperatures are within $\pm 0.5^\circ\text{F}$ of the required condenser entering air temperature as defined in Table 4. If the temperature variation is greater than the allowable tolerance, then the test shall be repeated.

As per step 2 of the procedure in the Section 6.2.3.2, the test data is used to calculate the degradation corrections and the Percent Load IEER rating points for the 75, 50 and 25 Percent Load. The calculations for the 4 EER rating points used to calculate the IEER are shown in Table C2B.

Table C2B Example 1. IEER Rating Points and Degradation Calculations

Rating Point	Test OAT	Req OAT	Actual Percent Load	Net Cap (Test)	Cmpr (P _c) (Test)	Cond (P _{cd}) (Test)	Indoor (P _{if}) (Test)	Control (P _{ct}) (Test)	EER (Test)	LF	CD	Rating EER
	°F	°F	%	Btu/h	W	W	W	W	(Btu/h)/W			(Btu/h)/W
A	95.1	95	100	57,481	4150	400	450	40	11.4			
			100	no degradation required						1	1	11.4
B	82.0	82.5	103.5	59,493	3627	400	450	40				
	required load		75	degradation required						0.725	1.036	12.3
C	71.8	72	104	59,780	3461	400	450	40				
	required load		50	degradation required						0.465	1.07	11.5
D	69.1	69	107.2	61,620	3390	400	450	40				
	required load		25	degradation required						0.233	1.1	9.8

For rating point A, which is the 100 Percent Load rating point, 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. In test rating point B, which is based on test 2, the unit was supposed to be run at the 82.5°F ambient condition as required by Table 7 for a 75 Percent Load B rating point. The actual measured ambient temperature was 82.0°F and is within the required tolerance of $\pm 0.5^\circ\text{F}$ as defined by Table 4. The actual test capacity Percent Load is 103.5%, therefore a degradation calculation shall be performed to determine the EER rating for the 75 Percent Load point because the capacity is greater than the $\pm 3\%$ tolerance required by Section 6.2.3.1.

The degradation factor calculations are performed using the requirements of Section 6.2.3.2.

First the load factor (LF) is calculated using Equation 5.

$$LF = \frac{(PL/100) \cdot \dot{q}_{A,Full}}{\dot{q}_{i,x}} = \frac{(75/100) \cdot 57,481}{59,493} = 0.725$$

This shows that at a 75 Percent 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 4.

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

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 3 for the rating point B.

$$EER_B = \frac{LF \cdot Q}{LF \cdot [C_D \cdot (P_C + P_{CD})] + P_{IF} + P_{CT}} = \frac{0.725 \cdot 59,493}{0.725 \cdot [1.036 \cdot (3,627 + 400)] + 450 + 40} = 12.3 \text{ (Btu/h)/W}$$

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

The last procedural step is to calculate the IEER using Equation 2.

$$\begin{aligned} IEER &= (0.010 \cdot A) + (0.233 \cdot B) + (0.456 \cdot C) + (0.301 \cdot D) \\ &= (0.010 \cdot 11.4) + (0.233 \cdot 12.3) + (0.456 \cdot 11.5) + (0.301 \cdot 9.8) = 11.2 \text{ (Btu/h)/W} \end{aligned}$$

C4 *Staged Capacity Controlled Unit Example Calculations.* The following section provides example calculations for IEER calculations for Staged Capacity Controlled Units. As defined in Section 3.16.3, 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 units are defined in Section 6.2.5.

C4.1 *Example 2. 2 Stage Air Cooled Unit with a Fixed Speed Indoor Fan IEER Example Calculations.*

The unit is an air-cooled Single Package Air-conditioner 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. The unit has the following rated performance metrics:

Rated Capacity = 67,000 Btu/h
 Rated Full Load Indoor Airflow = 2,150 scfm
 Rated EER = 11.5 (Btu/h)/W
 Rated IEER = 10.1 (Btu/h)/W

The test data are shown in Table C3A. During the tests the atmospheric pressure was 13.900 psia and was constant for all tests which is just above the lower limit of 13.700 psia, therefore the test is valid. The pressure could vary between

tests and it should be measured for each test.

Table C3A Example 2. Test Results

Test	Stage	Test OAT	Req OAT	Actual Percent Load	Test Net Cap	Test SCFM (Std Air)	Total Power	Cmpr (P _C) (Test)	Cond (P _{CD}) (Test)	Indoor (P _{IF}) (Test)	Control (P _{CT}) (Test)	EER (Test)
		°F	°F	%	Btu/h	SCFM	W	W	W	W	W	(Btu/h)/W
1	2	94.9	95	100	67,550	2150	5845	4675	560	560	50	11.6
2	2	82.7	82.5	103.5	69,914	2150	5450	4280	560	560	50	12.8
3	1	82.8	82.5	67.5	45,596	2150	4134	3024	450	560	100	11.0
4	1	71.8	72	67.2	45,394	2150	3945	2835	450	560	100	11.5
5	1	69.1	69	66.8	45,123	2150	3850	2740	450	560	100	11.7

In total, five tests were required to determine the IEER. Note that for tests 3, 4, and 5, the control power increased based on the use of a crankcase heater in the inactive compressor. Test 1 is a full load test and can be used directly for the A rating point. Because the unit has two stages of capacity control and can unload to 60% displacement, for the B rating point of 75 Percent Load interpolation using tests 2 and 3 is required. Test 2 has a Percent Load of 103.5%, and test 3 has a Percent Load of 67.5% when run at the B rating point ambient of 82.5°F. For the C rating point with a rating ambient of 72°F, the Percent Load is 67.2%, 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 67.2%, Percent Load when run at the D rating point ambient of 69°F, degradation will also have to be applied to test 5.

The test data can then be used with the step 2 procedures to calculate the EER A, B, C, and D rating. The results the step 2 calculations for the A, B, C and D rating points are shown in Table C3B.

Table C3B Example 2. IEER Rating Points and Degradation Calculations

Rating Point	Test	Test OAT	Req OAT	Actual Percent Load	Net Cap (Test)	Cmpr (P _C) (Test)	Cond (P _{CD}) (Test)	Indoor (P _{IF}) (Test)	Control (P _{CT}) (Test)	EER (Test)	LF	CD	Rating EER
		°F	°F	%	Btu/h	W	W	0	W	(Btu/h)/W			(Btu/h)/W
A	1	94.9	95	100	67,550	4675	560	560	50	11.56			
	required load			100	use test 1 point directly								11.6
B	2	82.7	82.5	103.5	69,914	4280	560	560	50	12.83	-	-	
	3	82.8	82.5	67.5	45,596	3024	450	560	100	11.03	-	-	
	required load			75	interpolate between test 2 and 3								11.4
C	4	71.8	72	67.2	45,394	2835	450	560	100	11.51			
	required load			50	degradation of test 4 required						0.744	1.033	10.6
D	5	69.1	69	66.8	45,123	2740	450	560	100	11.72			
	required load			25	degradation of test 5 required						0.374	1.081	8.7

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

For the B rating point at 75 Percent Load interpolation shall be used. This was accomplished through tests 2 and 3. Test 2 was run at full load, but at the 75 Percent Load rating point 82.5°F ambient as required by Table 7. Test 3 was also run at the 82.5°F ambient, but with only stage 1 operating. From these tests a load of 103.5 and 67.5 Percent Load was obtained to interpolate a 75 Percent Load. Interpolation between test 2 and 3 is shown below.

$$EER_B = \left(\left(\frac{12.83 - 11.03}{103.5 - 67.5} \right) \cdot (75 - 67.5) \right) + 11.03 = 11.4 \text{ (Btu/h)/W}$$

For the C rating point, which is required to be run at test run at 72°F ambient as defined in Table 7, test 4 was run at a Percent Load of 67.2. This exceeds allowable $\pm 3\%$ tolerance, so test 4 cannot be used directly to calculate the C EER rating point. In addition, because the unit is operating at the lowest stage of capacity, interpolation cannot be used because a capacity point above and below the 50 Percent Load rating point would be required. Therefore, a degradation factor has to be applied to test 4 to get the C rating point EER. The calculation of the degradation factor is shown below.

The degradation factor calculations then performed using Section 6.2.3.2.

First the load factor (LF) is calculated using Equation 5.

$$LF = \frac{(PL/100) \cdot \dot{q}_{A,Full}}{\dot{q}_{i,x}} = \frac{(50/100) \cdot 67,550}{45,394} = 0.744$$

This shows that at a 50 Percent Load the compressor will be on for 74.4% of the time and off for 25.6% of the time.

The degradation coefficient is calculated using Equation 4.

$$C_D = (-0.13 \cdot LF) + 1.13 = (-0.13 \cdot 0.744) + 1.13 = 1.033$$

This shows that the EER will degrade 3.3% 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 3 for the rating point C.

$$EER = \frac{LF \cdot Q}{LF \cdot [C_D \cdot (P_C + P_{CD})] + P_{IF} + P_{CT}} = \frac{0.938 \cdot 45,394}{0.744 \cdot [1.033 \cdot (2,835 + 450)] + 560 + 100} = 10.6 \text{ (Btu/h)/W}$$

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

The last procedural step is then to calculate the IEER using Equation 2.

$$\begin{aligned} IEER &= (0.010 \cdot A) + (0.233 \cdot B) + (0.456 \cdot C) + (0.301 \cdot D) \\ &= (0.010 \cdot 11.6) + (0.233 \cdot 11.40) + (0.456 \cdot 10.60) + (0.301 \cdot 8.7) = 10.2 \text{ (Btu/h)/W} \end{aligned}$$

C5 *Proportionally Controlled Unit Example Calculations.* The following section provides example calculations for IEER calculations for Proportionally Controlled Units. As defined in Section 3.16.2, a Proportional Controlled Unit is a unit incorporating one or more variable capacity compressors in which the compressor capacity can modulated continuously.

C5.1 *Example 3. Air Cooled Unit with a Single Variable Speed Compressor and a Fixed Speed Indoor Fan IEER Example Calculations.*

The unit has a single variable speed compressor and a fixed speed indoor fan. The unit has the following rated performance metrics.

Rated Capacity = 123,000 Btu/h
Full Load Rated Indoor Airflow = 4000 scfm
Rated EER = 11.3 (Btu/h)/W
Rated IEER = 11.0 (Btu/h)/W

Shown in Table C4A are the test data. The atmospheric pressure was measured at 14.70 psia and was constant for all tests which is above the minimum atmospheric pressure of 13.700 psia. Note that the pressure could vary between tests and it should be measured for each test.

Table C4A Example 3. Test Results

Test	Stage	Test OAT	Req OAT	Actual Percent Load	Test Net Cap	Test SCFM (Std Air)	Cmpr (P _C) (Test)	Cond (P _{CD}) (Test)	Indoor (P _{IF}) (Test)	Control (P _{CT}) (Test)	EER (Test)
		°F	°F	%	Btu/h	SCFM	W	W	W	W	(Btu/h)/W
1	100%	95.1	95	100	122,945	4050	9085	650	950	100	11.40
2	75%	82.4	82.5	75.5	92,823	4050	6150	650	950	100	11.82
3	50%	82.8	82.5	54.7	67,251	4050	4025	650	950	100	11.75
4	50%	71.8	72	43	52,866	4050	2950	650	950	100	11.37
5	25%	69.1	69	30	36,884	4050	2230	325	950	100	10.23

A total of 5 tests were run to use in the calculation of the EER rating points A, B, C, and D and the calculation of the IEER. Test 1 is the full load rating point. Test 2 was targeted to run at the 75 Percent Load rating point and the measured test Percent Load is 75.5 so it is within the 3% tolerances and no additional testing is required. For the C rating point test 3 was run to get the 50 Percent Load rating, but the test had a measured Percent Load of 54.7, which is greater than the 3% tolerance. The test could have been repeated, but the unit had control limits that would not allow 50% ± 3% to be obtained. A second test 4 was run at a lower Percent Load of 43.0 and interpolation will be required to determine the 50 Percent Load rating. Test 5 was run at the 69°F ambient for the rating point D, but the unit could only unload to 30.0 Percent Load, and will require a degradation calculation to be performed to determine the 25 Percent Load rating.

As per step 2 of the procedure outlined in Section 6.2.3 interpolation and degradation calculations can be performed using the test results. The calculations for the four EER rating points are shown in Table C4B.

Table C4B Example 3. IEER Rating Points and Degradation Calculations

Rating Point	Test	Test OAT	Req OAT	Actual Percent Load	Net Cap (Test)	Cmpr (P _C) (Test)	Cond (P _{CD}) (Test)	Indoor (P _{IF}) (Test)	Control (P _{CT}) (Test)	EER (Corr)	LF	CD	Rating EER
		°F	°F	%	Btu/h	W	W	W	W	(Btu/h)/W			(Btu/h)/W
A	1	95.1	95	100	122,945	9085	650	950	100	11.3996			
	required load			100.0	use test 1 point directly						-	-	11.40
B	2	82.7	82.5	75.5	92,823	6150	650	950	100	11.8246			
	required load			75%	use test 2 point directly						-	-	11.82
C	3	82.8	82.5	54.7	67,251	4025	650	950	100	11.7469	-	-	
	4	71.8	72	43	52,866	2950	650	950	100	11.3690	-	-	
	required load			50.0	interpolate between test 3 and 4								11.60
D	5	69.1	69	30	36,884	2230	325	950	100	10.6200			
	required load			25.0	degradation of test 4 required						0.833	1.022	9.53

For rating point A which is the 100 Percent Load rating point, test 1 can be used directly. For the 75 Percent Load rating point B, the Percent Load is 75.5, which is within the 3% tolerance, so the test point can be used directly for the rating point B and no interpolation or degradation is required. For the 50 Percent Load rating point C, test 3 was run to get the 50 Percent Load rating, but the test had a measured Percent Load of 54.7, which is greater than the 3% tolerance. The test could have been repeated but the unit had control limits that would not allow 50% ± 3% to be obtained, so a second test 4 was run at a lower Percent Load of 43.0, which will be used for interpolation. The interpolation calculations are shown below.

$$EER_C = \left(\left(\frac{11.74 - 11.36}{54.7 - 43.0} \right) \cdot (50 - 43.0) \right) + 11.36 = 11.60 \text{ (Btu/h)/W}$$

For the rating point D test 5 was run, but due to control limits the unit would only unload to 30 Percent Load, which is greater than the 3% tolerance from the 25 Percent Load target.

The degradation factor calculations are performed using the requirements of Section 6.2.3.2.

First the load factor (LF) is calculated using Equation 5.

$$LF = \frac{(PL/100) \cdot \dot{q}_{A,Full}}{\dot{q}_{i,x}} = \frac{(25/100) \cdot 122,945}{36,884} = 0.833$$

This shows that a 25 Percent Load, the compressor will be on for 83.3% of the time and off for 16.7% of the time.

The degradation coefficient is then calculated using Equation 4.

$$C_D = (-0.13 \cdot LF) + 1.13 = (-0.13 \cdot 0.833) + 1.13 = 1.022$$

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 3 for the rating point D.

$$EER = \frac{LF \cdot Q_P}{LF \cdot [C_D \cdot (P_C + P_{CD})] + P_{IF} + P_{CT}} = \frac{0.833 \cdot 36,884}{0.833 \cdot [1.022 \cdot (2230 + 325)] + 950 + 100} = 9.53 \text{ (Btu/h)/W}$$

The last procedural step is to calculate the IEER using Equation 2.

$$IEER = (0.010 \cdot A) + (0.233 \cdot B) + (0.456 \cdot C) + (0.301 \cdot D)$$

$$= (0.010 \cdot 11.40) + (0.233 \cdot 11.82) + (0.456 \cdot 11.60) + (0.301 \cdot 9.53) = 11.0 \text{ (Btu/h)/W}$$

APPENDIX D. INDOOR AND OUTDOOR AIR CONDITION 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.

D1 *General.* Measure the indoor and outdoor air entering dry-bulb temperature and water vapor content conditions that are required to be controlled for the test per the requirements in sections D2 and D3. When using the indoor air enthalpy method to measure equipment capacity, also measure indoor air leaving dry-bulb temperature and water vapor content. When using the outdoor air enthalpy method to measure equipment capacity, also measure outdoor air leaving dry-bulb temperature and water vapor content. For measuring the indoor and outdoor air leaving dry-bulb temperature and water vapor content conditions, follow the requirements in section D4. Make these measurements as described in the following sections. Also, maintain test operating and test condition tolerances and uniformity requirements as described in section D2.7.

D2 *Outdoor Air Entering Conditions.* For cooling tests of air-cooled equipment that uses condensate obtained from the evaporator to enhance condenser cooling, measure the water vapor content as provided in section D2.2. For heating tests of all air-source heat pumps, also measure water vapor content as provided in section D2.2.

D2.1 *Temperature Measurements.* Measure temperatures in accordance with ANSI/ASHRAE Standard 41.1 and follow the requirements of Table D1. The specified accuracies shall apply to the full instrument systems including read-out devices. When using a grid of individual thermocouples rather than a thermopile, follow the thermopile temperature requirements of Table D1.

When measuring dry-bulb temperature for sampled air within the sampled air conduit rather than with the psychrometer as discussed in section D2.4, use a temperature sensor and instrument system, including read-out devices, with accuracy of $\leq \pm 0.2^\circ\text{F}$ and display resolution of $\leq 0.1^\circ\text{F}$.

Table D1. Temperature Measurement Requirements		
Measurement	Accuracy, $^\circ\text{F}$	Display Resolution, $^\circ\text{F}$
Dry-bulb and Wet-bulb Temperatures ¹	$\leq \pm 0.2$	≤ 0.1
Thermopile Temperature ²	$\leq \pm 1.0$	≤ 0.1
Notes: 1. The accuracy specified is for the temperature indicating device and does not reflect the operation of the aspirating psychrometer. 2. To meet this requirement, thermocouple wire shall have special limits of error and all thermocouple junctions in a thermopile shall be made from the same spool of wire; thermopile junctions are wired in parallel.		

D2.2 *Psychrometer or Hygrometer Requirements.* If measurement of water vapor is required, use one of the following two methods.

D2.2.1 *Aspirating Psychrometer.* The Aspirating Psychrometer consists of a flow section and a fan to draw air through the flow section and measures an average value of the sampled air stream. The flow section shall be equipped with two dry-bulb temperature probe connections, one of which shall be used for the facility temperature measurement and one of which shall be available to confirm this measurement using an additional or a third-party's temperature sensor probe. For applications where the humidity is also required, or heat pump products in heating mode, the flow section shall be equipped with two wet-bulb temperature probe connection zones of which one shall be used for the facility wet-bulb measurement and one of which shall be available to confirm the wet-bulb measurement using an additional or a third-party's wet-bulb sensor probe. The aspirating psychrometer shall include a fan that can either be adjusted manually or automatically to maintain the required average velocity of $1,000 \pm 200$ fpm across the sensors. A typical configuration for the aspirating psychrometer

is shown in Figure D1.

D2.2.2 Dew Point Hygrometer. Measure dew point temperature using a dew point hygrometer as specified in sections 4, 5, 6, 7.1, and 7.4 of ANSI/ASHRAE Standard 41.6 with an accuracy of within $\pm 0.4^{\circ}\text{F}$. Use a dry-bulb temperature sensor within the sampled air conduit and locate the dew point hygrometer downstream of the dry-bulb temperature sensor.

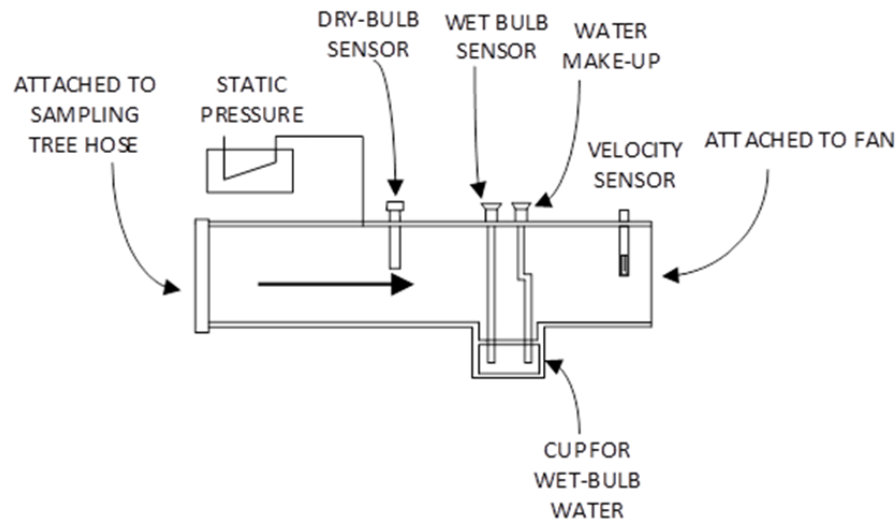


Figure D1. Aspirating Psychrometer

D2.3 Air Sampling Tree Requirements. The air sampling tree is intended to draw a uniform sample of the airflow entering the air-cooled outdoor coil section. A typical configuration for the sampling tree is shown in Figure D2 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. The branch tubes shall have appropriately spaced holes, sized to provide equal airflow through all the holes by increasing the hole size as you move further from the trunk tube to account for the static pressure regain effect in the branch and trunk tubes. A minimum hole density of six holes per square foot of area to be sampled is required. The minimum average velocity through the sampling tree holes shall be 2.5 ft/sec as determined by evaluating the sum of the open area of the holes as compared to the flow area in the aspirating psychrometer. The assembly shall have a tubular connection to allow a flexible tube to be connected to the sampling tree and to the aspirating psychrometer.

The sampling tree shall also be equipped with a thermocouple thermopile grid or with individual thermocouples to measure the average temperature of the airflow over the sampling tree. The thermocouple arrangement shall have at least 16 measuring points per sampling tree, evenly spaced across the sampling tree. The air sampling trees shall be placed within 6-12 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.

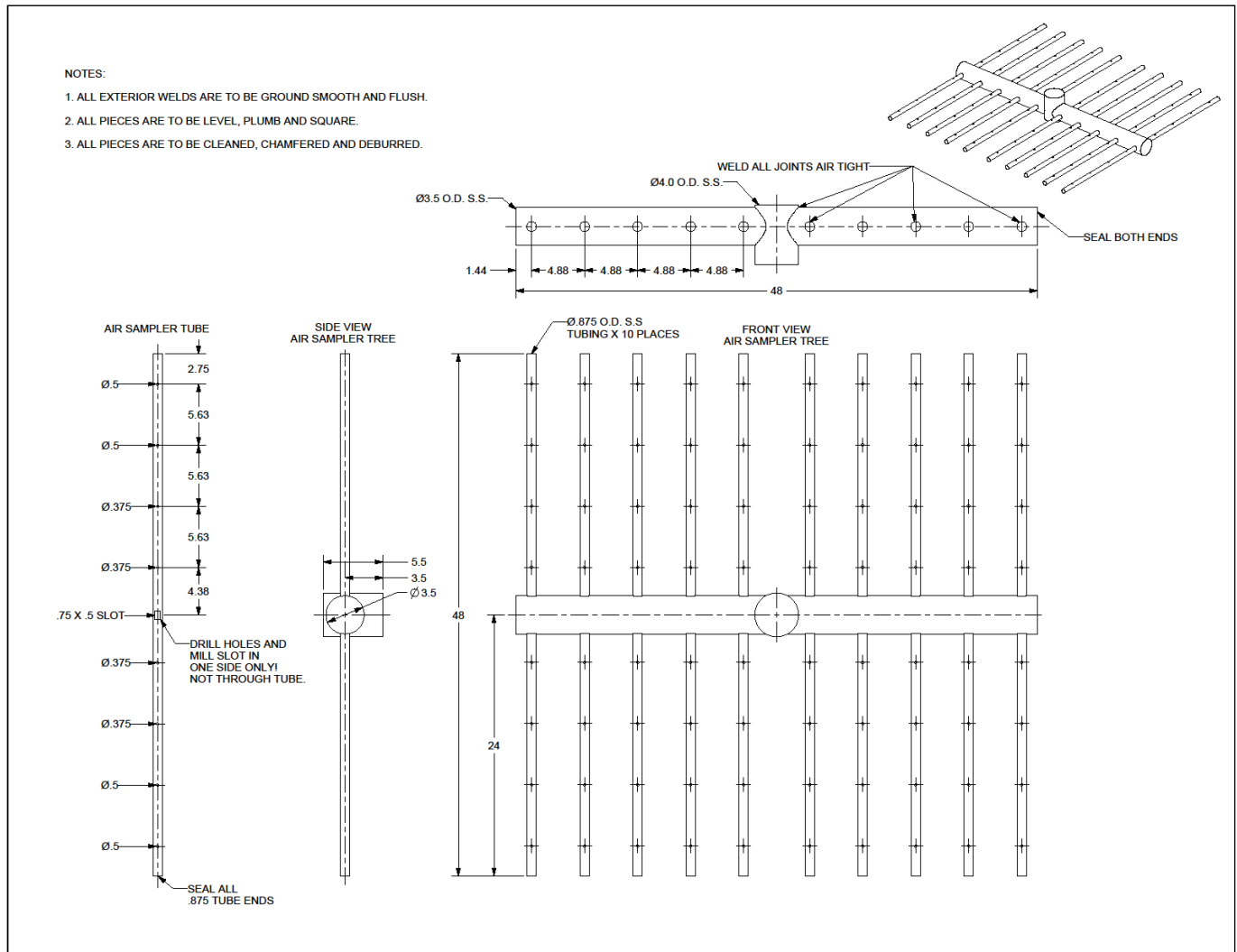


Figure D2. Typical Air Sampling Tree

Note: The .75 in X .50 in slots referenced in Figure D2 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.

D2.3.1 Test Setup Description. The nominal face area of the airflow shall be divided into a number of equal area sampling rectangles with aspect ratios no greater than 2 to 1. Each rectangular area shall have one air sampler tree.

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

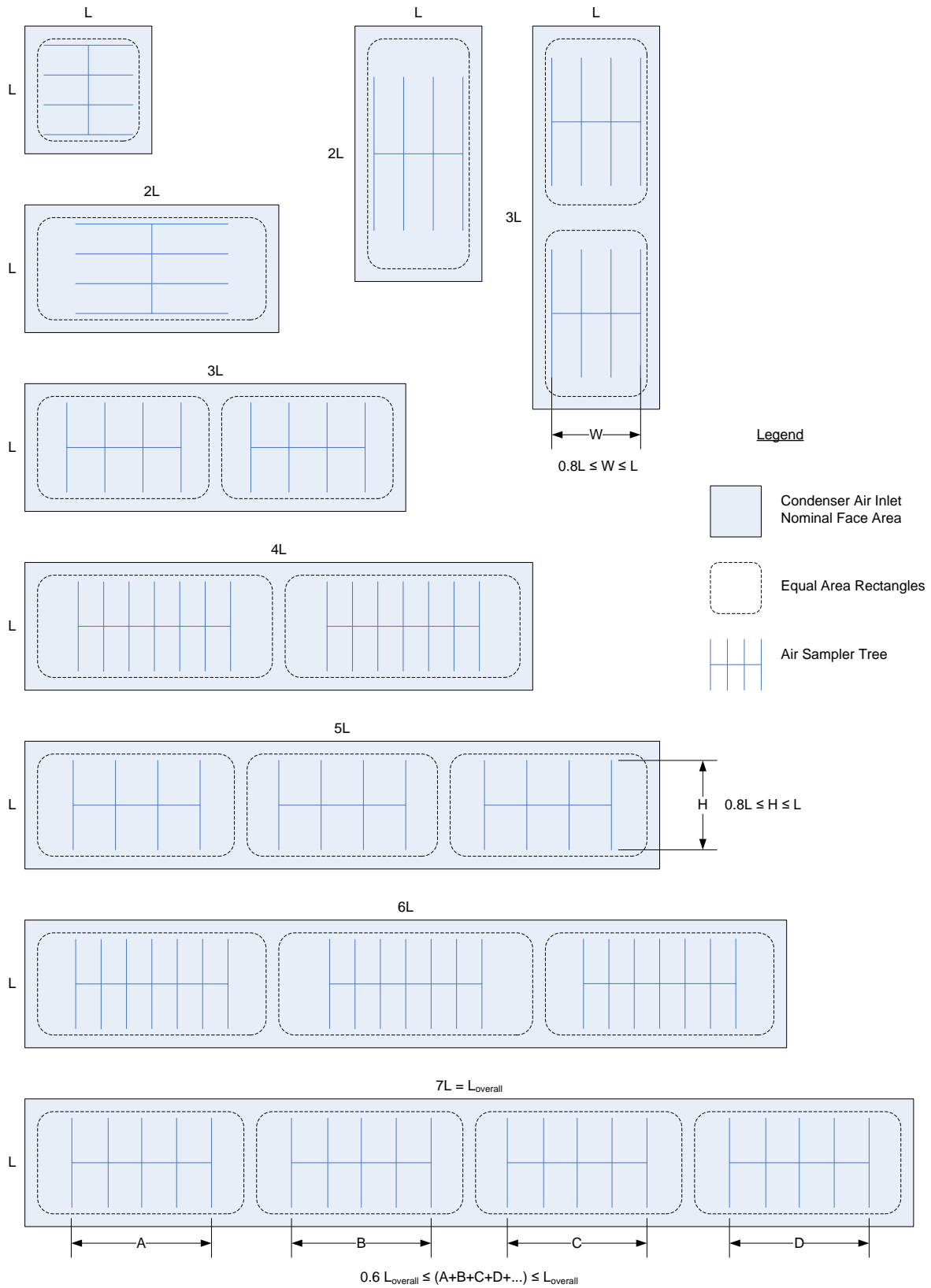


Figure D3. Determination of Measurement Rectangles and Required Number of Air Sampler Trees

A minimum of one Aspirating Psychrometer per side of a unit shall be used. For units with three sides, two 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.

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 D3 for examples of how an increasing number of air sampler trees are required for longer outdoor coils.

A maximum of four 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.

If using more than one air sampling tree, all air sampling trees shall be of the same size and have the same number of inlet holes.

Draw air through the air samplers using the fans of the psychrometer(s) or, if not using psychrometers, equivalent fans allowing adjustment of airflow through the air sampler inlet holes as specified in section D2.3. Return the fan discharge air to the room from which the system draws the outdoor coil intake air.

D2.4 *Dry-bulb Temperature Measurement.* Measure dry-bulb temperatures using the psychrometer dry-bulb sensors, or, if not using psychrometers, use dry-bulb temperature sensors with accuracy as described in section D2.1. Measure the dry-bulb temperature within the conduit conducting air sampler air to the fan at a location between the air sampler exit to the conduit and the fan. When a fan draws air through more than one air sampler, the dry-bulb temperature may be measured separately for each air sampler or for the combined set of air sampler flows. If dry-bulb temperature is measured at the air sampler exit to the conduit, the use of a thermocouple thermopile grid or a grid of individual thermocouples for duplicate measurement of dry-bulb temperature is not required—instead use the air-sampler-exit measurement when checking temperature uniformity.

D2.5 *Wet-Bulb or Dew Point Temperature Measurement to Determine Air Water Vapor Content.* Measure wet-bulb temperatures using one or more psychrometers or measure dew point temperature using one or more hygrometers. If using hygrometers, measure dew point temperature within the conduit conducting air sampler air to the air-sampling fan at a location downstream of the dry-bulb temperature measurement. When a fan draws air through more than one air sampler, the dew point temperature may be measured separately for each air sampler or for the combined set of air sampler flows.

When more than one air sampler feeds a single water vapor content measurement instrument, measure relative humidity as required in section D2.7 to allow assessment of water vapor content uniformity.

D2.6 *Monitoring and Adjustment for Air Sampler Conduit Temperature Change and Pressure Drop.* If dry-bulb temperature is measured at a distance from the air sampler exits, determine average conduit temperature change as the difference in temperature between the remote dry-bulb temperature and the average of thermopiles or thermocouple measurements of all air samplers collecting air that is measured by the remote dry-bulb temperature sensor. If this difference is greater than 0.5°F, measure dry-bulb temperature at the exit of each air sampler (as described in section D2.4), and use these additional sensors to determine average indoor entering air dry-bulb temperature.

Measure gauge pressure at the sensor location of any instrument measuring water vapor content. If the pressure differs from room pressure by more than 2 in H₂O, use this gauge pressure measurement to adjust the atmospheric pressure used to calculate the humidity ratio (in units of pounds of moisture per pound of dry air) at the measurement location.

If either the 0.5°F temperature difference threshold or the 2 in H₂O pressure difference threshold are exceeded, use a two-step process to calculate adjusted air properties (e.g., wet-bulb temperature or enthalpy) for the one or more affected air samplers. First, calculate the moisture level (pounds water vapor per pound dry air) at the humidity

measurement location(s) using either the psychrometer dry-bulb and wet-bulb temperature measurements or the hygrometer dew point measurement, using for either approach the adjusted pressure, if it differs from the room atmospheric pressure by 2 in H₂O or more. Then calculate the air properties for the air sampler location based on the moisture level, the room atmospheric pressure, and the dry-bulb temperature at the air sampler location. If the air sampler fan or psychrometer serves more than one air sampler, and the 0.5°F threshold was exceeded, the dry-bulb temperature used in this calculation shall be the average of the air sampler exit measurements. Also, for multiple air samplers, if humidity was measured using multiple hygrometers, the moisture level used in this calculation shall be the average of the calculated moisture levels calculated in the first step.

D2.7 Temperature Uniformity. To ensure adequate air distribution, thorough mixing, and uniform air temperature, it is important that the room and test setup is properly designed and operated. The room conditioning equipment airflow shall be set such that recirculation of outdoor coil discharged air is avoided except as may naturally occur from the equipment. To check for the recirculation of outdoor coil discharged air back into the outdoor coil(s) the following method shall be used: Multiple individual reading thermocouples (at least one per sampling tree location) shall be installed around the unit air discharge perimeter so that they are either side of the outdoor coil fan exhaust and just above the top of the outdoor coil(s). These thermocouples shall not indicate a temperature difference greater than 5.0°F from the average inlet air. Air distribution at the test facility, at the point of supply to the unit, shall be reviewed to determine if it requires remediation prior to beginning testing.

Mixing fans can be used to ensure adequate air distribution in the test room. If used, mixing fans shall be oriented such that they are pointed away from the air intake so that the mixing fan exhaust direction is at an angle of 90°-270° to the air entrance to the outdoor coil air inlet. Pay particular attention to prevent recirculation of outdoor coil fan exhaust air back through the unit.

When not using psychrometers, the “psychrometer dry-bulb temperature measurement” of Table D2 refers to either (a) the dry-bulb temperature measurement in a single common air conduit serving one or more air samplers or (b) the average of the dry-bulb temperature measurements made separately for each of the air samplers served by a single air sampler fan. Similarly, “wet-bulb temperature” refers to calculated wet-bulb temperatures based on dew point measurements.

Adjust measurements if required by section D2.6 prior to checking uniformity.

The 1.5°F dry-bulb temperature tolerance in Table D2 between the air sampler thermopile (thermocouple) measurements and psychrometer measurements only applies when more than one air sampler serves a given psychrometer (see note 2 to Table D2).

The uniformity requirements apply to test period averages rather than instantaneous measurements.

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

A valid test shall meet the criteria for adequate air distribution and control of air temperature as shown in Table D2.

Table D2. Uniformity Criteria for Outdoor Air Temperature and Humidity Distribution		
Uniformity Criterion ¹	Purpose	Maximum Variation, °F
Deviation from the mean air dry-bulb temperature to the air dry-bulb temperature at any individual temperature measurement station ¹	Uniform dry-bulb temperature distribution	± 2.00
Difference between dry-bulb temperature measured with air sampler tree thermopile and with aspirating psychrometer ²	Uniform dry bulb temperature distribution	± 1.50
Deviation of calculated local air sampler wet-bulb temperatures and the mean wet-bulb temperature ³	Uniform humidity distribution	± 1.00
Deviation from the mean wet-bulb temperature and the individual temperature measurement stations ³	Uniform humidity distribution	± 1.00
Notes: 1. The uniformity requirements apply to test period averages for each parameter rather than instantaneous measurements. Each measurement station represents a single Aspirating Psychrometer. The mean temperature is the mean of temperatures measured from all measurement stations. 2. Applies when multiple air samplers are connected to a single psychrometer or conduit dry-bulb temperature sensor. If the average of the thermopile measurements differs from the psychrometer or conduit dry-bulb temperature sensor measurement by more than 0.5°F, use air-sampler exit dry-bulb temperature sensors. For this case, the uniformity requirement is based on comparison of each of the air-sampler exit measurements with the average of these measurements. 3. The wet-bulb temperature measurement is only required for outdoor entering air for air-cooled equipment that uses condensate obtained from the evaporator to enhance condenser cooling, and heat pump units operating in the heating mode.		

D3 *Indoor Coil Entering Air Conditions.* Follow the requirements for outdoor coil entering air conditions as described in section D2, except for the following.

D3.1 Both dry-bulb temperature and water vapor content measurements are required for all tests.

D3.2 Sampled air shall be returned to the room from which the system draws the indoor coil entering air (except if the loop air enthalpy test method specified in Section 6.1.2 of ANSI/ASHRAE Standard 37 is used, in which case the sampled air shall be returned upstream of the air sampler in the loop duct between the airflow-measuring apparatus and the room conditioning apparatus or to the airflow-measuring apparatus between the nozzles and the fan).

D3.3 The temperature uniformity requirements discussed in Section D2.7 do not apply if a single air sampler is used.

D3.4 If air is sampled within a duct, the air sampling tree shall be installed with the rectangle defined by the air sampler inlet holes oriented parallel with and centered in the duct cross section—this rectangle shall have dimensions that are at least 75% of the duct's respective dimensions.

D3.5 Additionally, if an inlet plenum is not connected to the air inlet during testing (e.g., for a Non-ducted Unit),

set up air sampling tree(s) as described Section D2.3.1.

D4 *Indoor Coil Leaving Air and Outdoor Coil Leaving Air Conditions.* Follow the requirements for measurement of outdoor coil entering air conditions as described in section D2, except for the following.

The temperature uniformity requirements discussed in section D2.7 do not apply.

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

Air in the duct leaving the coil that is drawn into the air sampling tree for measurement shall be returned to the duct just downstream of the air sampling tree and upstream of the airflow-measuring apparatus. Insulate the conduit transferring the air from the air sampler fan discharge to the duct.

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

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

APPENDIX E. METHOD OF TESTING SINGLE PACKAGE VERTICAL UNITS - NORMATIVE

E1 *Purpose.* The purpose of this appendix is to prescribe the test procedures used for testing Single Package Vertical Units. The testing of AHRI Standard 390 products shall comply with ASHRAE Standard 37 with the following additional requirements.

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

E3 *Indoor and Outdoor Air Temperature Measurement.* The condenser air temperature for air cooled products shall be measured using the procedures defined in Appendix E.

E4 *Setting Indoor Airflow and External Static Pressure.* Indoor airflow and ESP shall be set in accordance with section 5.7.

E5 *Test Methods for Capacity Measurement.*

E5.1 *Primary Capacity Measurement.* Indoor air enthalpy method specified in section 7.3 of ANSI/ASHRAE 37 shall be used as the primary method for capacity measurement.

E5.2 *Secondary Capacity Measurement.* Secondary measurements shall be conducted for all full-load cooling and heating tests for equipment with Cooling Capacity less than 135,000 Btu/h. Secondary measurements are not required for part-load tests. Use any one of the applicable methods specified in Table 1 of ANSI/ASHRAE Standard 37 as a secondary method for capacity measurement for all full-load cooling and heating tests. Conduct secondary measurements in accordance with the provisions in sections 7.3, 7.4, and 7.6 of ANSI/ASHRAE Standard 37 that are applicable to the selected test method. For the outdoor air enthalpy method, the provisions in section E5.4 take precedence over the provisions in section 7.3 of ANSI/ASHRAE Standard 37.

E5.3 *Agreement between Primary and Secondary Capacity Measurements.* For equipment with a certified Cooling Capacity less than 135,000 Btu/h, the total Cooling or Heating Capacity values measured with the primary and secondary capacity measurement methods for the full-load cooling and heating tests (as applicable) as prescribed in section E5.2 shall match within $\pm 6\%$ of the primary capacity measurement method test results for the full-load cooling and heating (if applicable) tests. No match between primary and secondary measurements is required for part-load cooling tests.

E5.4 *Outdoor Air Enthalpy Method.* When using the outdoor air enthalpy method as the secondary method for capacity measurement, first conduct a test without the outdoor air-side test apparatus connected to the unit (“free outdoor air” test). Then attach the outdoor air-side test apparatus and conduct a test with the apparatus connected to the unit (“ducted outdoor air” test). Use measurements from the free outdoor air test (i.e., indoor air enthalpy method capacity measurements and power input) as the applicable measurements for determination of efficiency metrics, provided the conditions of section E5.4.1.4 are met.

E5.4.1 *Free Outdoor Air Test.* For the free outdoor air test, connect the indoor air-side test apparatus to the indoor coil; do not connect the outdoor air-side test apparatus. Allow the test room reconditioning apparatus and the unit being tested to operate for at least one hour.

E5.4.1.1 After attaining equilibrium conditions, measure the following quantities at equal intervals that span 5 minutes or less:

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

E5.4.1.2 Continue these measurements until the applicable test tolerances are satisfied for a 30-minute period (e.g., seven consecutive 5-minute samples).

E5.4.1.3 Evaporator and Condenser Measurements. To measure evaporator and condenser pressures, solder a thermocouple onto a return bend located at or near the midpoints of each coil or at points not affected by vapor superheat or liquid subcooling. Alternatively, if the test unit is not sensitive to the refrigerant charge, install pressure gauges to the access valves or to ports created from tapping into the suction and discharge lines according to sections 7.4.2 and 8.2.5 of ANSI/ASHRAE Standard 37. The alternative approach shall be used when testing a unit charged with a zeotropic refrigerant having a temperature glide in excess of 1°F at the specified test conditions.

E5.4.1.4 For the free outdoor air test to constitute a valid test for determination of efficiency metrics, the following conditions shall be met:

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

E5.4.2 *Ducted Outdoor Air Test.*

E5.4.2.1 After collecting 30 minutes of steady-state data during the free outdoor air test, connect the outdoor air-side test apparatus to the unit for the ducted outdoor air test. Adjust the exhaust fan of the outdoor air-side test apparatus until averages for the evaporator and condenser temperatures, or the saturated temperatures corresponding to the measured pressures, agree within $\pm 0.5^\circ\text{F}$ of the averages achieved during the free outdoor air test. Collect 30 minutes of steady-state data for which the applicable test tolerances are satisfied.

E5.4.2.2 During the ducted outdoor air test, at intervals of 5 minutes or less, measure the parameters required according to the indoor air enthalpy method and the outdoor air enthalpy method for the prescribed 30 minutes.

E5.4.3 For cooling mode ducted outdoor air tests, calculate capacity based on outdoor air enthalpy measurements as specified in sections 7.3.3.2 and 7.3.3.3 of ANSI/ASHRAE Standard 37. For heating mode ducted tests, calculate Heating Capacity based on outdoor air enthalpy measurements as specified in sections 7.3.4.2 and 7.3.4.3 of ANSI/ASHRAE Standard 37. Adjust the outdoor-side capacity according to section 7.3.3.4 of ANSI/ASHRAE Standard 37 to account for line losses when testing split systems. Use the outdoor airflow rate as measured during the ducted outdoor air test to calculate capacity for checking the agreement with the capacity calculated using the indoor air enthalpy method during the ducted outdoor test.

E6 *Test Set-up for Non-Ducted Units*

E6.1 *Free Air Test.* A preliminary free air test shall be conducted prior to connecting a plenum (as specified in section E6.2), ducting, and indoor air-side test apparatus to the unit. Airflow rate shall be set in accordance with section 5.7. Operating tolerances defined in Table 4 (as applicable) shall be met for at least 10 minutes, except for tolerances for outdoor leaving air dry-bulb temperature, outdoor leaving air wet-bulb temperature, indoor leaving air dry-bulb temperature, indoor leaving air wet-bulb temperature, external static pressure, and nozzle pressure drop. Record the average indoor fan power and average refrigerant temperature at approximately the midpoint of the return bend of the indoor coil. After connecting the plenum, duct, and indoor air-side test apparatus to the unit, adjust the fan of the indoor air-side test apparatus attached to the duct as necessary to achieve the required plenum pressure of zero ESP with a tolerance of $-0/+0.05$ in H_2O . The fan settings used for the preliminary free indoor air test shall remain unchanged throughout the full-load cooling test. Airflow rate for heating tests and part-load tests shall be set in accordance with section 5.7. Confirm that indoor fan power measured with the indoor air-side test apparatus connected is within 2% of the average values measured for the free air test. Also, confirm that refrigerant temperature at approximately the midpoint of the return bend of the indoor coil is within 0.5°F of the average values measured for the free air test. Increase plenum size if necessary, to match the measured values within this 2% tolerance.

E6.2 *Inlet Plenum.* Never use an inlet plenum for Non-ducted Units.

E6.3 *Outlet Plenum and Duct Requirements.* For Non-ducted Units, a plenum (enlarged duct box) shall be installed between the duct and the unit(s). The plenum shall have a cross-sectional area at least 2 times the area of the unit(s) combined outlet. For all outlets, the plenum shall extend for a distance of at least 3.5 times the square root of the cross-sectional area of the units combined outlet prior to any duct transitions, elbows, or air sampling tree used for air condition measurement.

E6.3.1 If used, elbows connected to the end of the plenum shall have a centerline radius equal to at least 1.5 times the duct width in the radial direction or have turning vanes. Air velocities calculated as measured volume flow divided by duct or plenum cross-sectional area shall not exceed 250 feet per minute inside the plenum and 500 feet per minute in the connecting duct at its connection to the plenum.

E6.3.2 Manifolded static pressure taps shall be installed in the plenum in at least four locations spaced uniformly around the plenum per Section 6.5 of ANSI/ASHRAE Standard 37. The static pressure taps shall be 2.8 times the square root of the cross-sectional area of the combined outlets.

E6.3.3 Air samplers used for temperature measurement shall be placed in the duct between the airflow measurement apparatus and the minimum required plenum length.

E7 *Head Pressure Control.* For units that have condenser head pressure control to ensure proper flow of refrigerant through the expansion valve during low condenser temperature conditions, the head pressure controls shall be enabled and operate in automatic control mode. The setting should be set at the factory settings or as defined in the installation instruction.

If the head pressure control is engaged by the control logic during part-load tests, then use the following steps.

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

E7.2 *Head Pressure Control Time Average Test.* If the head pressure control results in unstable conditions (*e.g.*, test tolerances in Table 10 cannot be met), then a series of two steady-state 1-hour tests shall be run. Prior to the first 1-hour test the condenser entering temperature (*e.g.* outdoor air dry-bulb temperature) defined by Table 7 shall be approached from at least a 10°F higher temperature until the tolerances specified in Table E1 are met. Prior to the second 1-hour test, the condenser entering temperature defined by Table 7 shall be approached from at least a 5°F lower temperature until the tolerances specified in Table E1 are met. For each test, once all tolerances in Table E1 are met, the 1-hour test shall be started and test data shall be recorded every 5 minutes for 1 hour, resulting in 12 test measurements for each test parameter. During each 1-hour test, the tolerances specified in Table E1 shall be met

Table E1. Tolerances for Head Pressure Control Time Average Test			
		Operating Tolerance	Condition Tolerance
Indoor air dry-bulb temperature (°F)	Entering	3.0	1.0
	Leaving	3.0	-
Indoor air wet-bulb temperature (°F)	Entering	1.5	0.5
	Leaving	1.5	-
Outdoor air dry-bulb temperature (°F)	Entering	3.0	1.0
	Leaving	-	-
Outdoor air wet-bulb temperature (°F)	Entering	1.5	0.5 ¹
	Leaving	-	-
Water serving outdoor coil temperature (°F)	Entering	0.75	0.3
	Leaving	0.75	
Voltage		2%	1%
Notes:			
1. Applies only for air-cooled systems that evaporate condensate, evaporatively-cooled systems, and packaged systems for which the indoor coil is located in the outdoor chamber			

If the tolerance in Table E1 are met, the tests results for both 1-hour steady-state test series shall then be averaged to determine the capacity and efficiency that is then used for the IEER calculation.

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

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

APPENDIX F. UNIT CONFIGURATION FOR STANDARD EFFICIENCY DETERMINATION - NORMATIVE

Purpose. Use this appendix to determine the configuration of different components determining representations, which include the Standard Rating Cooling and Heating Capacity and efficiency metrics.

F1 *Configuration Requirements.* For the purpose of Standard Ratings, units shall be configured for testing as defined in this Appendix.

F1.1 *Basic Model.* A Basic Model means all units manufactured by one manufacturer within a single equipment class, having the same primary energy source (e.g., electric or gas), and which have the same or comparably performing compressor(s), heat exchangers, and air moving system(s) that have a rated Cooling Capacity within 1500 Btu/h of one another.

F1.2 All components indicated in the following list shall be present and installed for all testing and shall be the components distributed in commerce with the model. Individual models that contain/use (different or alternate) versions of the same component shall either be represented separately as a unique basic model or certified within the same basic model based on testing of the least efficient configuration.

- Compressor(s)
- Outdoor coil(s) or heat exchanger(s)
- Outdoor fan/motor(s)
- Indoor coil(s)
- Refrigerant expansion device(s)
- Indoor fan/motor(s)
- System controls

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

- Gas furnace;
- Electric resistance.

F1.3 *Optional System Features.* The following features are optional during testing. Individual models with these features may be represented separately as a unique basic model or certified within the same basic model as otherwise identical individual models without the feature pursuant to the definition of “basic model” in section F1.1.

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

If an otherwise identical model (within the basic model) without the feature is not distributed in commerce, conduct tests with the feature present but configured and de-activated so as to minimize (partially or totally) the impact on the results of the test, unless otherwise noted in the following sections. Alternatively, the manufacturer may indicate in the supplemental testing instructions (STI) that the test shall be conducted using a specially-built otherwise identical unit that is not distributed in commerce and does not have this feature.

F1.3.1 *Economizers.* An economizer is an automatic system that enables a cooling system to supply outdoor air to reduce or eliminate the need for mechanical cooling during mild or cold weather. They provide significant energy efficiency improvements on an annualized basis but are also a function of regional ambient conditions and are not considered in the EER or IEER metric. If an economizer is installed during the test, it shall be in the 100% return position with the outside air dampers fully sealed.

F1.3.2 *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. If fresh air dampers are installed during the test, test with the fresh air dampers fully sealed.

F1.3.3 Barometric Relief Dampers. An assembly with dampers and means to automatically set the damper position in a closed position and one or more open positions to allow venting directly to the outside a portion of the building air that is returning to the unit, rather than allowing it to recirculate to the indoor coil and back to the building. If barometric relief dampers are installed during the test, test with the barometric relief dampers fully sealed.

F1.3.4 Ventilation Energy Recovery System (VERS). An assembly that preconditions outdoor air entering the equipment through direct or indirect thermal and/or moisture exchange with the exhaust air, which is defined as the building air being exhausted to the outside from the equipment. If a VERS is installed during the test, test with outside air and exhaust dampers fully sealed.

F1.3.5 Power Correction Capacitors. A capacitor that increases the power factor measured at the line connection to the equipment. Power correction capacitors shall be removed for testing.

F1.3.6 Hail Guards. A grille or similar structure mounted to the outside of the unit covering the outdoor coil to protect the coil from hail, flying debris and damage from large objects. Hail guards shall be removed for testing.

F1.3.7 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/or other locations within the equipment. UV lights shall be removed for testing.

F1.3.8 Dehumidification Components. An assembly that reduces the moisture content of the Supply Air through moisture transfer with solid or liquid desiccants.

F1.3.9 Steam/Hydronic Heat Options. A heat exchanger located inside the equipment that heats the equipment's supply or outdoor air using heat delivered by steam or hot water.

F1.3.10 Hot Gas Reheat. 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.

F1.3.11 Powered Exhaust/Powered Return Air. Powered exhaust is provided by 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. Powered return air is provided by a fan that draws building air into the equipment.

F1.3.12 Hot Gas Bypass. A method to adjust the cooling delivered by the equipment in which some portion of the hot high-pressure refrigerant from the discharge of the compressor(s) is diverted from its normal flow to the outdoor coil and is instead allowed to enter the indoor coil to modulate the capacity of a refrigeration circuit or to prevent evaporator coil freezing.

F1.3.13 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. If an otherwise identical individual model without sound traps/sound attenuators is not distributed in commerce, removable sound traps/sound attenuators shall be removed for testing. Otherwise, test with sound traps/attenuators in place.

F1.3.14 Fire, Smoke and/or 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. If a fire/smoke/isolation damper is installed, test with the damper fully open.