AHRI Standard 211/241-0B/1B-2021 (SI)

2021 Standard for

Performance Rating of Unitary Air-conditioning & Air-source Heat Pump Equipment

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IMPORTANT

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Note:

This is a new Standard

For I-P ratings, see AHRI Standard 210/240 (I-P)-2017 (with Addendum 1).

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FOREWORD

The standard has been developed as an SI version of AHRI Standard 210/240 (I-P)-2017 (with Addendum 1) for application outside of the United States and Canada with the following major revisions:

- Update the Section 11 SEER calculation to support hot climate conditions. Additional global requirements may be added when required.
- Remove references to AHRI Certification and the U.S. Department of Energy.
- Remove evaporatively-cooled, water-cooled, and heating only equipment from the scope.
- Remove heating rating and heating testing conditions. Heat pump products remain because they can be tested in cooling mode.
- Convert all I-P units to SI.
- Remove reference to ASHRAE 116-2010 but retained information required to perform cyclic testing.

For informational purposes, in this standard "fan" and "blower" are used synonymously.

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Section 1. Purpose

1.1. *Purpose.* The purpose of this standard is to establish the following for Unitary Air-conditioners and Unitary Air-source Heat Pumps: definitions, classifications, test requirements, rating requirements, operating requirements, minimum data requirements for Published Ratings, 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-made Unitary Air-conditioners and Unitary Air-source Heat Pumps with capacities less than 19 kW as defined in Section 3.

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

2.2. *Exclusions.* This standard does not apply to the rating and testing of:

a. Heating mode of heat pump equipment.
b. Packaged Terminal Air-conditioners/Heat Pumps, as defined in AHRI Standard 310/380 and CSA C744.
c. Room air-conditioners/heat pumps.
d. Water-source Heat Pumps, Ground Water-source Heat Pumps, or ground-source closed-loop Heat Pumps as defined in ISO/ANSI/ASHRAE/AHRI Standards 13256-1 and 13256-2.
e. Water heating heat pumps.
f. Units equipped with desuperheater/water heating devices in operation.
~~g.~~ Variable Refrigerant Flow Air Conditioners and Heat Pumps as defined in AHRI Standard 1230.
h. Single Packaged Vertical Units as defined in ANSI/AHRI Standard 390.
i. Evaporatively-cooled air-conditioning/heat pump equipment.
j. Water-cooled air-conditioning/heat pump equipment.
k. Heating only equipment.

Section 3. Definitions and Acronyms

All terms in this document will follow the standard industry definitions in the *ASHRAE Terminology* website (https://www.ashrae.org/resources–publications/free-resources/ashrae-terminology) unless otherwise defined in this section. Further definitions are found in Appendices C and D. Throughout the standard, defined terms are capitalized.

3.1. *Air Moving System* (AMS).

3.1.1. *Constant-torque AMS*. A fan system that maintains constant motor shaft torque over a broad range of loads.

3.1.2. C*onstant-volume AMS*. A fan system that varies its operating speed to provide a fixed air-volume-rate from a Ducted System.

3.1.3. *Permanent Split Capacitor Air Moving System (PSC AMS)*. A fan system connected to an induction motor that develops motor shaft torque proportional to the RPM slip from synchronous speed.

3.2. *Airflow-control Setting(s)*. Programmed or wired control system configurations that control a fan to achieve discrete, differing ranges of airflow—often designated for performing a specific function (e.g., cooling, heating, or constant circulation)—without manual adjustment other than interaction with a user-operable control (i.e., a thermostat) that meets the manufacturer specifications for installed-use. For the purposes of this standard, manufacturer specifications for installed-use are those found in the product literature shipped with the unit.

3.3. *Airflow Prevention Device.* A device that prevents airflow via natural convection by using mechanical means, such as an air Damper Box, or by means of changes in duct height, such as an upturned duct.

3.4. *Alternative Efficiency Determination Method (AEDM)*. As an alternative to testing a basic model, a simulated efficiency value may be acceptable if the alternative method complies with the following criteria:

a. The AEDM is derived from a mathematical model that estimates the energy efficiency or energy consumption characteristics of the basic model as measured by this test procedure.

b. The AEDM is based on engineering or statistical analysis, computer simulation or modeling, or other analytic evaluation of performance data.

3.5. *Approach Temperature*. The refrigerant temperature at the outdoor liquid service port minus the outdoor ambient temperature.

3.6. *Blower Coil System.* A Split System that includes one or more Blower Coil Indoor Units.

3.7. *Coil-only System.* A system that includes (one or more) coil-only Indoor Units.

3.8. *Cooling Load Factor (CLF)*. The ratio having as its numerator the total cooling delivered during a cyclic operating interval consisting of one ON period and one OFF period. The denominator is the total cooling that would be delivered, given the same ambient conditions, if the unit operated continuously at its steady-state space cooling capacity for the same total time (ON plus OFF) interval.

3.9. *Cyclic Test.* A test where the unit's compressor is cycled on and off for specific time intervals. A Cyclic Test provides half the information needed to calculate a Degradation Coefficient.

3.10. *Damper Box*. A short section of insulated duct having a means to block airflow during the off cycle of the Cyclic Test.

3.11. *Degradation Coefficient (C_D).* A parameter used in calculating the Part Load Factor, which is a measure of the efficiency loss due to the cycling of the units. The Degradation Coefficient for cooling is denoted by C_D^c.

3.12. *Double-duct System.* Double-duct Air-conditioner or Heat Pump means air-cooled commercial package air-conditioning and heating equipment that that is either a horizontal Single Package Unit or Split System; or a vertical unit that consists of two components that shall be shipped or installed either connected or split; is intended for indoor installation with ducting of outdoor air from the building exterior to and from the unit, where the unit and/or all of its components are non-weatherized and are not marked (or listed) as being in compliance with UL 1995/CSA C22.2 No.236 or equivalent requirements for outdoor use; if it is a horizontal unit, the complete unit shall have a maximum height of 89 cm or the unit shall have components that do not exceed a maximum height of 89 cm; if it is a vertical unit, the complete (split, connected, or assembled) unit shall have components that do not exceed maximum depth of 89 cm.

3.13. *Ducted System*. An air-conditioner or heat pump that is designed to be permanently installed and delivers all conditioned air through ductwork. The air-conditioner or heat pump may be either a Split System unit or a Single Package Unit.

3.14. *Energy Efficiency Ratio (EER).* A ratio of the cooling capacity in watts to the Total Power in watts at any given set of Rating Conditions expressed in W/W.

3.14.1. $EER_{T1,Full}$. The EER at $T_{1,Full}$ test conditions.

3.15. *Gross Capacity*. The calculated system capacity that results when not accounting for the heat generated from an indoor supply fan.

3.16. *Indoor Unit*. A separate assembly of a Split System that includes both an arrangement of refrigerant-to-air heat transfer coil(s) for transfer of heat between the refrigerant and the indoor air and a condensate drain pan. An Indoor Unit may or may not include sheet metal or plastic parts not part of external cabinetry to direct/route airflow over the coil(s), a cooling mode expansion device, external cabinetry, air temperature sensing device and an integrated indoor blower (i.e. a device to move air including its associated motor). A separate designated air mover that may be a furnace or a Modular Blower may be considered to be part of the Indoor Unit. A Service Coil is not an Indoor Unit.

3.16.1. *Blower Coil Indoor Unit*. An Indoor Unit with either a) an indoor blower housed with the coil or b) a separate designated air mover such as a furnace or Modular Blower.

3.17. *Installation Instructions.* Manufacturer's documentation that come packaged with, or appear in, the labels applied to the unit. This does not include online manual.

3.18. *Latent Cooling Capacity*. The rate, expressed in KW, at which the equipment removes latent heat (reduces the moisture content) of the air passing through it under specified conditions of operation.

3.19. *Multiple-circuit (or Multi-circuit) System.* A Split System that has one Outdoor Unit and that has two or more Indoor Units installed on two or more refrigeration circuits such that each refrigeration circuit serves a compressor and one and only one Indoor Unit, and refrigerant is not shared from circuit to circuit.

3.20. *Multiple Capacity (Multiple Stage) Compressor*. A compressor having three or more pre-determined discrete stages of capacity or a group of compressors with three or more stages of capacity.

3.20.1. *Full Compressor Stage*. The staging of compressor(s) as specified by the manufacturer at which the unit operates at full load test conditions. The Full Compressor Stage for heating mode tests may be the same or different from the cooling mode value.

3.20.2. *Intermediate Compressor Stage*.

3.20.2.1 *Multi-split Systems*. The staging of compressor(s) as specified by the manufacturer that falls within one-fourth and three-fourths of the difference between the Low Compressor Stage and Full Compressor Stage for both cooling and heating, separately.

3.20.2.2 For all other Multiple Stage Compressors include the stage within a 5% tolerance of the Low Compressor Stage plus one-third of the difference between Low Compressor Stage and Full Compressor or the next higher stage.

3.20.3. *Low Compressor Stage*. The staging of compressor(s) as specified by the manufacturer at which the unit operates at low load test conditions. The Low Compressor Stage for heating mode tests may be the same or different from the cooling mode value.

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

3.22. *Nominal Capacity.* The capacity that is claimed by the manufacturer on the product name plate.

3.22.1. *Nominal Cooling Capacity*. A capacity approximately equal to the air conditioner cooling capacity tested at A or A2 condition.

3.23. *Non-ducted Indoor Unit*. An Indoor Unit designed to be permanently installed, mounted to/in ceilings and/or room walls, and/or to floors, and that directly heats or cools air within the conditioned space.

3.24. *Non-ducted System*. A Split System with one or more Non-ducted Indoor Units. The system components may be of a modular design.

3.25. *Non-tested Combination (NTC)*. Any manufacturer approved combination of an Outdoor Unit(s) with one or more Indoor Units whose Certified Ratings are based on an AEDM.

3.26. *Outdoor Coil.* A heat exchange surface that transfers heat between outdoor air and the refrigerant. The Outdoor Coil may be located internal or external to the building.

3.27. *Outdoor Unit.* A separate assembly of a Split System that transfers heat between the refrigerant and the outdoor air, and consists of an Outdoor Coil, compressor(s), an air moving device, and in addition for heat pumps, may include a heating mode expansion device, reversing valve, and/or defrost controls.

3.28. *Overspeeding.* A temporary-basis speed of an indoor blower above design operating speed.

3.29. *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 Capacity 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.

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

3.29.2. *Standard Rating*. A rating based on tests performed at Standard Rating Conditions.

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

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

3.31. *Seasonal Energy Efficiency Ratio (SEER$_{Tx}$).* The total heat removed from the conditioned space during the annual cooling season divided by the total electrical energy consumed by the air-conditioner or heat pump during the same season, expressed in W/W.

3.32. *Sensible Cooling Capacity*. The rate, expressed in kW, at which the equipment lowers the dry-bulb temperature (removes sensible heat) of the air passing through it under specified conditions of operation.

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

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

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

3.34. *Single Unit (Single Package Air-conditioner or Single Package Heat Pump)*. Any central air-conditioner or heat pump that has all major assemblies enclosed in one cabinet.

3.35. *Single System (Single Stage Air-conditioner or Single Stage Heat Pump).* An air-conditioner or heat pump that has a single, fixed capacity compressor.

3.36. *Small-duct, High-velocity System.* A Split System for which all Indoor Units are Blower Coil Indoor Units that produce at least 0.30 kPa of external static pressure when operated at the full-load air volume rate certified by the manufacturer of at least 106 m^3/h (Standard Air) per rated kW of cooling.

3.37. *Space Constrained Product.* A central air-conditioner or heat pump that has (1) rated cooling capacities no greater than 8.8 kW, and (2) an Outdoor Unit or Indoor Unit having at least two overall exterior dimensions or an overall displacement that:

a. is substantially smaller than those of other units that are currently usually installed in site built single family homes, of a similar cooling, and, if a heat pump, heating capacity; and

b. if increased, would certainly result in a considerable increase in the usual cost of installation or would certainly result in a significant loss in the utility of the product to the consumer.

3.38. *Split System (Split System Air-conditioner or Split System Heat Pump)*. Any air-conditioner or heat pump that has at least two separate assemblies that are connected with refrigerant piping when installed. At least one of these assemblies is an Indoor Unit and at least one of these assemblies is an Outdoor Unit. Split Systems may be either Blower Coil System or Coil-only Systems.

3.38.1. *Multi-head Mini-split System*. A Split System that has one Outdoor Unit and that has two or more Indoor Units connected with a single refrigeration circuit. The Indoor Units operate in unison in response to a single indoor thermostat.

3.38.2. *Multi-split System (Multi-split Air-conditioner or Multi-split Heat Pump)*. A Split System that has one Outdoor Unit and having two or more Indoor Units connected with a single refrigeration circuit. The Indoor Units operate independently and can be used to condition multiple zones in response to at least two indoor thermostats or temperature sensors. The Outdoor Unit operates in response to independent operation of the Indoor Units based on control input of at least two indoor thermostats or temperature sensors, and/or based on refrigeration circuit sensor input.

3.38.3. *Single-split System (Single-split Air-conditioner or Single-split Heat Pump)*. A Split System that has one Outdoor Unit and one Indoor Unit connected with a single refrigeration circuit.

3.39. *Standard Air.* Dry air having a mass density of 1.2 kg/m^3.

3.40. *Steady-state Test*. A test where the controlled test parameters are regulated to remain constant within the specified tolerances while the unit operates continuously in the same mode.

3.41. *System Controls.* These devices may include but are not limited to:

a. An integral network operations and communications system with sensors to monitor the status of items such as temperature, pressure, oil, refrigerant levels, and fan speed.

b. A micro-processor, algorithm-based control scheme to: (1) communicate with a managed variable capacity compressor, fan speed of Indoor Units, fan speed of the Outdoor Unit, solenoids, various accessories; (2) manage metering devices; and (3) concurrently operate various parts of the system.

c. Regulate system efficiency and refrigerant flow through an engineered distributed refrigerant system to conduct zoning operations, matching capacity to the load in each of the zones.

3.42. *Temperature Bin*. The temperature (°C) increments used to partition the outdoor dry-bulb temperature ranges of the cooling season.

3.43. *Test Condition Tolerance.* The maximum permissible difference between the average value of the measured test parameter and the specified test condition.

3.44. *Test Operating Tolerance.* The maximum permissible range a measurement may vary over the specified test interval. When expressed as a percentage, the maximum allowable variation is the specified percentage of the average value. The difference between the maximum and minimum sampled values shall be less than or equal to the specified Test Operating Tolerance.

3.45. *Tested Combination.* A specific combination of an Outdoor Unit(s) with one or more Indoor Units having measured performance in a laboratory psychrometric facility.

3.45.1. *Multi-split Tested Combination.* A specific combination of an Outdoor Unit with between two and five Indoor Units.

3.45.2. *Single-split Tested Combination.* A specific combination of an Outdoor Unit with either one Indoor Unit or multiple Indoor Units which operate in unison.

3.46. *Total Cooling Capacity*. The sum of Sensible and Latent Capacity the equipment can remove from the conditioned space in a defined interval of time in kW (Net Capacity in the cooling mode).

3.47. *Total Power*. The sum of the power consumed by all components of a system, including the power consumed by the compressor(s), indoor supply fan motor(s), outdoor condenser fan motor(s), System Controls, factory installed condensate pumps and other devices required for normal operating modes.

3.48. *Two-capacity (or Two-stage) Compressor*. A compressor or group of compressors operating with only two stages of capacity.

3.48.1. *Full Compressor Stage*. The staging of compressor(s) as specified by the manufacturer at which the unit operates at full load test conditions.

3.48.2. *Low Compressor Stage*. The staging of compressor(s) as specified by the manufacturer at which the unit operates at low load test conditions. The Low Compressor Stage for heating mode tests may be the same or different from the cooling mode value.

3.49. *Two-capacity (or Two-stage) System (Two-stage Air-conditioner or Two-stage Heat Pump)*. An air -conditioner(s) or heat pump(s) that use a Two-capacity Compressor, or two single stage Outdoor Units connected to a single Indoor Unit, where each Outdoor Unit can operate independently or jointly.

3.50. *Unitary Air-conditioner (Air-conditioner).* One or more factory-made assemblies which normally include an indoor coil(s), compressor(s), Outdoor Coil(s), indoor fan(s), outdoor fan(s), and expansion device(s). When such equipment is provided in more than one assembly, the separated assemblies shall be designed to be used together, and the requirements of rating outlined in the standard are based upon the use of matched assemblies. Air-conditioners shall provide the function of air-circulation, air cleaning, cooling with controlled temperature and dehumidification, and may optionally include the function of heating and/or humidifying.

3.51. *Unitary Air-source Heat Pump (Heat Pump).* One or more factory-made assemblies which normally include an indoor coil(s), compressor(s), Outdoor Coil(s), indoor fan(s), outdoor fan(s), and expansion device(s) including means to provide a heating function. When such equipment is provided in more than one assembly, the separated assemblies shall be designed to be used together, and the requirements of rating outlined in the standard are based upon the use of matched assemblies. Heat Pumps shall provide the function of air heating with controlled temperature, and may include the functions of air-cooling, air-circulating, air-cleaning, dehumidifying or humidifying.

3.52. *Variable Capacity (or Variable Stage or Variable Speed) System (Variable Stage Air-conditioner or Variable Stage Heat Pump).* Air-conditioner(s) or heat pump(s) that has either a Variable Speed Compressor or a Multiple Capacity Compressor.

3.53. *Variable Refrigerant Flow (VRF) System.* A Multi-split System with at least three compressor capacity stages, distributing refrigerant through a piping network to multiple indoor blower coil units each capable of individual zone temperature control, through proprietary zone temperature control devices and a common communications network. Single-phase VRF systems less than 19 kW are central air-conditioners and central air conditioning heat pumps, also referred to as Unitary Air-conditioners and Unitary Air-source Heat Pumps.

3.54. *Variable Speed Compressor.* A compressor that has capability of varying its rotational speed in non-discrete stages or steps from low to full using an inverter or variable frequency drive.

3.54.1. *Full Compressor Speed (Full)*. The speed as specified by the manufacturer at which the unit operates at full load test conditions.

3.54.2. *Intermediate Compressor Speed*

3.54.2.1 *For Multi-split Systems.* The speed as specified by the manufacturer that falls within one-fourth and three-fourths of the difference between the Low Compressor Speed and Full Compressor Speed for both cooling and heating, separately.

3.54.2.2 *For all other Variable Stage Systems.* Low Compressor Speed plus one-third of the difference between Low Compressor Speed and Full Compressor Speed with a tolerance of plus 5% or the next higher inverter frequency step.

3.54.3. *Low Compressor Speed (Low)*. The speed as specified by the manufacturer at which the unit operates at low load test conditions.

3.55. *Wet-coil Test.* A test conducted at test conditions that typically cause water vapor to condense on the test unit evaporator coil.

Section 4. Classifications

4.1. *Classifications*. Equipment covered within the scope of this standard shall be classified as shown in Tables 1, 2 and 3.

Table 1. Classification of Unitary Air-conditioners

Designation	AHRI Type [1,2]	Arrangement – ID	Arrangement – OD
Single Package Unit	SP-A [7]		ELEC HEAT [3,8] / ID FAN / EVAP; OD FAN or PUMP / COMP / COND
Year-Round Single Package Unit	SPY-A [5,7]		GAS HEAT [4,8] / ID FAN / EVAP; OD FAN or PUMP / COMP / COND
Remote Condenser	RC-A	ID FAN EVAP COMP	OD FAN or PUMP COND
Split System Air-conditioner with Coil-only		EVAP	OD FAN or PUMP COMP COND
Split System Air-conditioner with Coil Blower	RCU-A-CB [6,7]	ID FAN EVAP	OD FAN or PUMP COMP COND
Year-Round Split System Air-conditioner with Coil Blower	RCUY-A-CB [5,6,7]	GAS HEAT [4,8] ID FAN EVAP	OD FAN or PUMP COMP COND

Notes:

1. A suffix of "-O" following any of the above classifications indicates a Non-ducted System.
2. "-A" indicates air-cooled condenser, "-E" indicates evaporatively cooled condenser and "-W" indicates water-cooled condenser.
3. Optional component.
4. May also be other heat source except for electric strip heat.
5. For Space Constrained Products, insert "SCP-" at the beginning.
6. For Small-duct, High-velocity System, insert "SDHV-" at the beginning.
7. For Double-duct System, append "-DD", and outdoor arrangement moves from outdoor side to indoor side.
8. System components intended for heating operation are included, however, the standard only covers cooling performance of these systems.

Table 2. Classification of Unitary Air-source Heat Pumps			
Designation	AHRI Type [1]	Arrangement – ID	Arrangement – OD
Single Package Unit	HSP-A [4,6]		ELEC HEAT [2,7] ID FAN EVAP OD FAN or PUMP COMP COND
Year-Round Single Package Unit	HSPY-A [4,6]		GAS HEAT [3,7] ID FAN EVAP OD FAN or PUMP COMP COND
Remote Outdoor Coil	HRC-A-CB [6]	ID FAN EVAP COMP	OD FAN or PUMP COND
Remote Outdoor Coil, Coil-only	HRC-A-C [6]	EVAP COMP	OD FAN or PUMP COND
Year Round Split System Heat Pump with Coil Blower	HRCUY-A-CB	ELEC HEAT [3,7] ID FAN EVAP	OD FAN or PUMP COMP COND
Split System Heat Pump with Coil Blower	HRCU-A-CB [5,6]	ELEC HEAT [2,7] ID FAN EVAP	OD FAN or PUMP COMP COND
Split System Heat Pump with Coil-only	HRCU-A-C [5,6]	EVAP	OD FAN or PUMP COMP COND

Notes:

1. A suffix of "-O" following any of the above classifications indicates a Non-ducted System.
2. Optional component
3. May also be other heat source except for electric strip heat.
4. For Space Constrained Products, insert "SCP-" at the beginning.
5. For Small-duct, High-velocity System, insert "SDHV-" at the beginning.
6. For Double-duct System, append "-DD", and outdoor arrangement moves from outdoor side to indoor side.
7. System components intended for heating operation are included, however, the standard only covers cooling performance of these systems.

Table 3. Classification of Multi-split Systems			
Attribute \ System Identification		Multi-split	Heat Recovery Multi-split
Refrigerant Circuits		One shared to all Indoor Units	One shared to all Indoor Units
Compressors		One or more variable speed or alternative method resulting in three or more steps of capacity	One or more variable speed or alternative method resulting in three or more steps of capacity
Indoor Units	Quantity	Greater than one Indoor Unit	Greater than one Indoor Unit
	Operation	Individual Zones/Temperature	Individual Zones/Temperature
Outdoor Unit/s	Quantity	One Outdoor Unit or multiple manifolded Outdoor Units with a specific model number.	One Outdoor Unit or multiple manifolded Outdoor Units with a specific model number.
	Steps of Control	Three or More	Three or More
	Mode of Operation	Cooling, Heating	Cooling, Heating, Heat Recovery
	Heat Exchanger	One or more circuits of shared refrigerant flow	One or more circuits of shared refrigerant flow
Classification [1,2]	Air-conditioner (air-to-air)	MSV-A-CB	
	Heat Pump (air-to-air)	HMSV-A-CB	HMSR-A-CB
Notes: 1. A suffix of "-O" following any of the above classifications indicates a Non-ducted System. 2. "-A" indicates air-cooled condenser			

Section 5. Test Requirements

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

5.1.1. Air-cooled units shall be tested in accordance with ANSI/ASHRAE Standard 37 as amended by Appendix C and Appendix D. In ANSI/ASHRAE Standards 37, wherever terms "may" or "should" are used, they shall be taken to be mandatory requirements.

5.1.2. *Variable Speed Equipment*. A means to override the controls of the Variable Speed System under test shall be provided by the manufacturer that claims the performance of the particular system, when needed, prior to initial set-up during laboratory testing.

5.1.2.1 The means for overriding the controls of the test unit shall necessitate ability to control the compressor, outdoor fan, indoor blower and expansion device(s) such that the compressor(s) operates at the specified speed or capacity, the outdoor fan operates per the manufacturer specification, the indoor blower operates at the specified speed or delivers the specified air volume rate, and the expansions device(s) operate per manufacturer specification.

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

5.1.3. *Break-in.* If an initial break-in period is required to achieve performance, the break-in conditions and duration shall be specified by the manufacturer but shall not exceed 20 hours in length. No testing per Section 6 shall commence until the specified break-in period is completed.

5.1.4. *Test Unit Installation Requirements*. For units designed for both horizontal and vertical installation or for both up-flow and down-flow vertical installations, the manufacturer shall specify the orientation used for testing. Conduct testing with the following installed:

5.1.4.1 Factory installed supplementary resistance heat; and

5.1.4.2 Other equipment specified as part of the unit. For Small-duct, High-velocity Systems, configure all balance dampers or restrictor devices on or inside the unit to fully open or lowest restriction.

5.1.5. *Requirements for Separated Assemblies*. All Standard Ratings for Split Systems shall be determined with at least 7.6 m of interconnecting tubing on each line of the size recommended by the manufacturer. Equipment in which the interconnecting tubing is furnished as an integral part of the system not recommended for cutting to length shall be tested with the complete length of tubing furnished, or with 7.6 m of tubing, whichever is greater. At least 3.0 m of the interconnecting tubing shall be exposed to the outside conditions. The line sizes, insulation, and details of installation shall be in accordance with the manufacturer's published recommendation.

5.1.5.1 When testing Multi-split Systems, connect each indoor fan-coil to the Outdoor Unit using: (a) 7.6 m of tubing, or (b) tubing furnished by the manufacturer, whichever is longer, per Indoor Unit. If a branching device is used, the common piping between the Outdoor Unit and the branching device shall be included in the overall length between indoor and outdoor sections.

5.1.5.1.1. *Multi-split Line Length Correction*. For test setups where the laboratory's physical limitations require use of more than the required line length, refer to Table 4 for Cooling Capacity correction factors that shall be used when the refrigerant line length exceeds the minimum as specified in Section 5.1.5.1. Cooling capacity correction factor, F_{CCC}, is used in Section 11.1 to adjust cooling capacity.

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

Piping length beyond the requirement (X), m	Cooling Capacity Correction Factor, F_{CCC}
$1 < X \leq 6$	1.01
$6 < X \leq 12$	1.02
$12 < X \leq 18$	1.03
$18 < X \leq 24$	1.04
$24 < X \leq 30$	1.05
$30 < X \leq 37$	1.06

Note:
1. Due to the refrigerant line lengths required in the test setup as determined by laboratory personnel, a correction factor shall be applied to normalize the measured cooling capacity
2. The piping length X is the additional refrigerant piping length above the minimum described in Section 5.1.5.1 that has been applied to at least 33% (minimum of 2) of the Indoor Units in the testing configuration.
3. In all cases, the absolute minimum length necessary to physically connect the system shall be used.
4. Average piping length in addition to the minimum in Table 4 (X), m for at least 33% (minimum of 2) of the Indoor Units. (The length (X) is the differential distance between the actual piping length between the Outdoor Unit and the Indoor Unit and the minimum requirement).

5.1.6. *Refrigerant Charging.* All test samples shall be charged at Standard Rating Conditions (or condition at which the manufacturer indicates in the Installation Instructions) in accordance with the Installation Instructions or labels applied to the unit. If the 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. Perform charging of near-azeotropic and zeotropic refrigerants only with refrigerant in the liquid state.

If there are no Installation Instructions and/or the Installation Instructions do not provide parameters and target values, set superheat to a target value of 6.7°C for fixed orifice systems or set subcooling to a target value of 5.6°C for expansion valve systems.

5.1.6.1 *Charging Hierarchy Instructions*. In the event of conflicting information between charging instructions, the Outdoor Unit label prevails, followed by Installation Instructions of the Outdoor Unit, followed by the Installation Instructions of the Indoor Unit. For Multi-split Systems, the hierarchy is Outdoor Unit installation instructions prevail, followed by the Outdoor Unit label, followed by the Indoor Units' installation instructions. Conflicting information is defined as multiple conditions given for charge adjustment where all conditions specified cannot be met. In such instances of conflicting information, follow the hierarchy in Table 5 for priority. Unless the manufacturer specifies a different charging tolerance, the tolerances specified in Table 5 shall be used for all products.

Table 5. Test Condition Tolerance for Charging Hierarchy

Fixed Orifice			Expansion Valve		
Priority	Method	Tolerance	Priority	Method	Tolerance
1	Super-heat	± 1.1°C	1	Sub-cooling	10% of the Target Value; No less than ± 0. 0.28°C, No more than ± 1.1°C
2	High Side Pressure or Saturation Temperature	± 28 kPa or ± 0.56°C	2	High Side Pressure or Saturation Temperature	± 28 kPa or ± 0.56°C
3	Low Side Pressure or Saturation Temperature	± 14 kPa or ± 0.44°C	3	Low Side Pressure or Saturation Temperature	± 14 kPa or ± 0.44°C
4	Low Side Temperature	± 1.1°C	4	Approach Temperature	± 0.56°C
5	High Side Temperature	± 1.1°C	5	Charge Weight	0.5% or 28 g, whichever is greater
6	Charge Weight	± 57 g			

The refrigerant charge obtained at the Standard Rating Condition shall then be used to conduct all cooling cycle and heating cycle tests unless an adjustment is required based on the sections below. Once the correct refrigerant charge is determined, all tests shall run until completion without further modification.

Note: After completion of all required tests, it is good laboratory practice to achieve $T_{1,Full}$ test conditions for 30 continuous minutes and compare results to the previous set of $T_{1,Full}$ tests. When comparing results, measured charge parameters outside of those listed in Table 5 is an indication refrigerant charge or other parameters may have changed and analysis should be performed, and corrective actions should be made.

5.1.6.2 *Heat Pumps.* Refrigerant charge shall be set at the $T_{1,Full}$ conditions or as specified by the manufacturer.

5.1.6.3 *Single Package Unit.* Unless otherwise directed by the Installation Instructions, install one or more refrigerant line pressure gauges during the setup of the unit, located depending on the parameters used to verify or set charge, as described in this section. Use methods for installing pressure gauge(s) at the required location(s) as indicated in Installation Instructions if specified.

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

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

5.2. *Cyclic Test Requirements*. For tests utilizing the Degradation Coefficient, the following procedure shall be followed in addition to the requirements of ASHRAE Standard 37.

Test set up, temperature and electrical measurements methods shall be identical for both the dry steady state and their corresponding Cyclic Tests (e.g. “C” and “D” tests) in order to minimize errors in the cyclic Degradation Coefficient.

5.2.1. *Damper Box.* A damper shall be installed on the inlet and outlet of the test unit capable of being completely opened or completely closed within a time period not to exceed 5 seconds for each action. Airflow through the equipment being tested should stop within 5 seconds after the airflow measuring device is de-energized.

For the outlet air Damper Box, install it within the interconnecting duct at a location upstream of the location where air from the sampling device is reintroduced or upstream of the in-duct sensor that measures water vapor content of the outlet air.

5.2.1.1 *Leakage.* The leakage rate from the combination of the outlet plenum, the closed damper, and the duct section that connects these two components shall not exceed 34 m^3/h when a negative pressure of 0.25 kPa is maintained at the outlet of the outlet air damper.

5.2.1.2 *Non-Ducted Systems.* Inlet dampers shall not be used on Non-ducted Systems.

5.2.1.3 *Arrangement and Size.* Components may be altered to meet the physical requirements of the unit to be tested. Dampers shall have a cross-sectional flow area of the Damper Box that shall be equal to or greater than the flow area of the inlet plenum.

5.2.1.4 *Airflow Prevention Device.* For space constrained testing, an alternative to the inlet damper system may be used as defined in this section.

When using an upturned duct Airflow Prevention Device, place a dry bulb temperature sensor near the inlet opening of the indoor duct at a centerline location not higher than the lowest elevation of the duct edges at the inlet, and ensure that the variation of the dry bulb temperature at this location, measured at least every minute during the compressor OFF period of the Cyclic Test, does not exceed 0.56°C.

Construct the Airflow Prevention Device having a cross-sectional flow area equal to or greater than the flow area of the inlet plenum. Install the Airflow Prevention Device immediately upstream of the inlet plenum (if installed, otherwise immediately upstream of the Indoor Unit) and construct ductwork connecting it to the inlet plenum. If needed, use an adaptor plate or a transition duct section to connect the Airflow Prevention Device with the inlet plenum. If an inlet plenum is not used, add static pressure taps at the center of each face of a rectangular Airflow Prevention Device Insulate the ductwork and inlet plenum with thermal insulation that has a nominal overall resistance (R-value) of at least 3.3 $m^2 \cdot K/W$.

5.2.2. *Temperature Measurement.* The temperature difference between inlet air and outlet air shall be measured by a thermopile, two thermocouple grids or other temperature measuring device with a response time of 10 seconds or less.

The outlet plenum, minimum of 9 individual dry bulb temperature sensors, shall not exceed a difference of 0.83 °C during any ON cycle. Use of mixers and/or perforated screen shall be used to meet this requirement.

5.2.2.1 *Grid Differential Temperature*.

5.2.2.1.1. While conducting the steady state test associated with the Cyclic Test, observe the difference between the entering dry bulb and leaving dry bulb temperature using both the grid/thermopile and the primary psychrometer sensors.

Determine the value of F_{CD} from Equations 5.1 or 5.2. When sample rates are less than 1 minute apart, Equation 5.1 shall be used to integrate results. When sample rates are 1 minute or more apart, Equation 5.2 shall be used.

$$F_{CD} = \int_0^6 \frac{\Delta T_{RTD}}{\Delta T_{TC}} \qquad 5.1$$

$$F_{CD} = \frac{1}{7} \sum_{i-6}^{i} \frac{\Delta T_{RTD}}{\Delta T_{TC}} \qquad 5.2$$

ΔT_{RTD} shall be the temperature differential between inlet air stream and outlet air stream as measured by Resistance Temperature Devices (RTDs), or equivalent, meeting the accuracy requirements for steady state testing. ΔT_{TC} shall be the temperature differential between inlet air stream and outlet air stream as measured by thermocouple grid, thermocouple thermopile, or equivalent, meeting the response requirements for cyclic testing.

5.2.2.1.2. If any F_{CD} calculated throughout the steady state test (total of 5 values) is outside the range of 0.94 to 1.06 then stop the test and recalibrate the temperature sensors.

5.2.2.1.3. The final value of the F_{CD} ratio shall be set to F_{CD}^{*}. Use F_{CD}^{*} as a correction factor applied to the grid or thermopile measurement during the Cyclic Test. If the temperature sensors used to provide the primary measurement of the indoor-side dry bulb temperature difference during the steady-state dry-coil test and the subsequent cyclic dry-coil test are the same, set F_{CD}^{*}= 1.

5.2.3. *Electrical Voltage, Power and Energy Measurement*.

5.2.3.1 *Supply Voltage.* The supply voltage at the terminals on the test unit shall be measured by using a voltage meter that provides a reading that is accurate to within ±1.0% of the measured quantity. During the ON and OFF cycle, the voltage total observed range, excluding the 30 seconds after compressor startup and shutdown, shall not exceed 2.0% and the set-point average error shall not exceed 1.5%.

5.2.3.2 *Integrated Power.* Use an integrating power (watt-hour) measuring system to determine the electrical energy or average electrical power supplied to all components of the air-conditioner or heat pump (including auxiliary components such as controls, transformers, crankcase heater, integral condensate pump on Non-ducted Indoor Units, etc.). Activate the scale or meter having the lower power rating within 15 seconds after beginning an OFF cycle. Activate the scale or meter having the higher power rating active within 15 seconds prior to beginning an ON cycle. When testing air-conditioners and heat pumps having a Variable Speed Compressor, do not use an induction watt/watt-hour meter.

Watt-hour measurement system shall be accurate within ±0.5% or 0.5 W•h, whichever is greater, for both ON and OFF cycles. If two measurement systems are used, then the meters shall be switched within 15 seconds of the start of the OFF cycle and switched within 15 seconds prior to the start of the ON cycle.

5.2.3.3 *Non-Ducted System Tests.* When performing Cyclic Tests on Non-ducted Systems, provide instrumentation to determine the average electrical power consumption of the indoor fan motor to within ±1.0%. This same instrumentation requirement applies when testing air-conditioners and heat pumps having a Constant-torque AMS or a Constant-volume AMS."

When performing test that are not Steady State Tests on Non-ducted Systems, provide instrumentation to determine the average electrical power consumption of the indoor blower motor to within ±1.0%.

5.2.4. *Cycle Stability Requirements*. Conduct three complete compressor OFF/ON cycles with the test tolerances given in Table 6 satisfied. Calculate the Degradation Coefficient C_D for each complete cycle using Equation 5.3.

$$C_D = \frac{1-\frac{EER_{cyc}}{EER_{SS}}}{1-CLF^x} \quad 5.3$$

Where:

$$EER_{cyc} = \frac{q_{cyc,x}}{E_{cyc,x}} \quad 5.4$$

$$EER_{ss} = \frac{\dot{q}_{tci,x}}{E_{m,x}} \quad 5.5$$

$$CLF^x = \frac{q_{cyc.x}}{\dot{q}_{tci,x} \cdot \theta_{cyc}} \quad 5.6$$

$$q_{cyc,x} = q'_{cyc,x} + q_{ts} \quad 5.7$$

$$q'_{cyc,x} = \frac{60\dot{Q}_{mi}c_{pa}\Gamma}{v'_n(1+W_n)} \quad 5.8$$

$$\Gamma = \int_{\theta_2}^{\theta_1}[t_{a1}(\theta) - t_{a2}(\theta)]\, d\theta \quad 5.9$$

$$q_{ts} = m_{ts}c_{pm}(t_{m1} - t_{m2}) \quad 5.10$$

Table 6. Test Operating and Test Condition Tolerances for Cyclic Dry Coil Cooling Mode Tests

Measurements	Test operating tolerance	Test condition tolerance
Indoor entering dry-bulb temperature,[1] °C	1.0	0.3
Indoor entering wet-bulb temperature, °C		See Note 2
Outdoor entering dry-bulb temperature,[1] °C	1.0	0.3
External pressure resistance to airflow,[1] Pa	12.5	
Airflow nozzle pressure difference or velocity pressure,[1]% of reading	2.0	2.0[3]
Electrical voltage,[4] % of reading	2.0	1.5

1. Applies during the interval that air flows through the indoor (outdoor) coil except for the first 30 seconds after flow initiation. For units having a variable-speed indoor blower that ramps, the tolerances listed for the external pressure resistance to airflow apply from 30 seconds after achieving full speed until ramp down begins.
2. Shall at no time exceed a wet-bulb temperature that results in condensate forming on the indoor coil.
3. The test condition must be the average nozzle pressure difference or velocity pressure measured during the steady-state dry coil test.
4. Applies during the interval when at least one of the following—the compressor, the outdoor fan, or, if applicable, the indoor blower—are operating except for the first 30 seconds after compressor start-up.

If all three C_D values are within 0.02 of the average C_D then stability has been achieved, and the highest C_D value of these three shall be used. If stability has not been achieved, conduct additional cycles, up to a maximum of eight cycles total, until stability has been achieved between three consecutive cycles. Once stability has been achieved, use the highest C_D value of the three consecutive cycles that establish stability. If stability has not been achieved after eight cycles, use the highest C_D from cycle one through cycle eight, or the default C_D, whichever is lower.

5.2.4.2 *Optional Cycle Tests.* If optional Cyclic Tests are conducted, they shall follow immediately after the Steady-state Test that requires the same test conditions. When testing heat pumps during the compressor OFF cycles, leave the reversing valve in the same position as used for the compressor ON cycles, unless automatically changed by the controls of the unit.

5.2.4.3 *ON Cycle Length.* For Blower Coil Systems or Coil-only Systems rated with an indoor fan time delay, the ON cycle lasts from compressor ON to indoor fan OFF. For Ducted Systems tested without an indoor fan time delay, the ON cycle lasts from compressor ON to compressor OFF. For Non-ducted Systems, the ON cycle lasts from indoor fan ON to indoor fan OFF.

5.2.4.4 *Artificial Loads.* Inside the indoor and outdoor psychrometric rooms, use artificial loads during Cyclic Tests, if needed, to produce stabilized room air temperatures. For the outdoor psychrometric room, select an electric resistance heater(s) having a heating capacity that is approximately equal to the heating capacity of the test unit's condenser. For the indoor psychrometric room, select a heater(s) having a capacity that is close to the Sensible Cooling Capacity of the test unit's evaporator. When applied, cycle the heater located in the same room as the test unit evaporator coil ON and OFF when the test unit cycles ON and OFF. Cycle the heater located in the same room as the test unit condensing coil ON and OFF when the test unit cycles OFF and ON.

5.2.4.5 *Indoor Fan Control.* For units having a Constant-volume AMS or Constant-torque AMS, the manufacturer has the option of electing at the outset whether to conduct the Cyclic Test with the indoor fan enabled or disabled. Conduct the cyclic dry coil test using the draw-through approach described below if any of the following occur when testing with the fan operating:

5.2.4.5.1. The test unit automatically cycles off;
5.2.4.5.2. Its blower motor reverses; or
5.2.4.5.3. The unit operates for more than 30 seconds at an external static pressure that is 0.025 kPa or more, higher than the value measured during the prior Steady-state Test.

For the draw-through approach, disable the indoor fan and use the exhaust fan of the airflow measuring apparatus to generate the specified flow nozzles static pressure difference or velocity pressure. If the exhaust fan cannot deliver the required pressure difference because of resistance created by the unpowered blower, temporarily remove the blower.

5.2.4.6 *Additional Measurement Requirements.* Continuously record the dry-bulb temperature of the air entering both the Indoor Coil and Outdoor Coils during periods when air flows through the respective coils. Sample the water vapor content of the indoor coil inlet air at least every 2 minutes during periods when air flows through the coil. Record external static pressure and the air volume rate indicator (either nozzle pressure difference or velocity pressure) at least every minute during the interval that air flows through the indoor coil. (These regular measurements of the airflow rate indicator are in addition to the required measurement at 15 seconds after flow initiation.) Sample the electrical voltage at least every 10 seconds beginning 30 seconds after compressor start-up. Continue until the compressor, the outdoor fan, and the indoor fan (if it is installed and operating) cycle off.

For Ducted Systems, continuously record the dry-bulb temperature of the air entering leaving the indoor coil. Or if using a thermopile, continuously record the difference between these two temperatures during the interval that air flows through the Indoor Coil. For Non-ducted Systems, make the same dry-bulb temperature measurements beginning when the compressor cycles on and ending when indoor coil airflow ceases.

Integrate each complete cycle as follows:

5.2.4.6.1. For Blower Coil Systems tested with an indoor fan installed and operating or Coil-only Systems rated with an indoor fan time delay, integrate electrical power from indoor fan OFF to indoor fan OFF.

5.2.4.6.2. For all other Ducted Systems and for Non-ducted Systems, integrate electrical power from compressor OFF to compressor OFF.

5.2.4.6.3. Capacity integration of all systems is from indoor fan ON to indoor fan OFF.

5.2.4.7 *Ducted system procedures for the optional cyclic dry-coil cooling-mode tests (D_{Full}, D_{Low}, and I_{Low}).* The automatic controls that are normally installed with the test unit shall govern the OFF/ON cycling of the air moving equipment on the indoor side (exhaust fan of the airflow measuring apparatus and, if installed, the indoor fan of the test unit). For Coil-only Systems rated based on using a fan time delay, the indoor coil airflow shall be controlled according to the rated ON and/or OFF delays provided by the fan time delay. For Ducted Systems having a Constant-volume AMS or Constant-torque AMS that has been disabled (and possibly removed), the indoor airflow shall be started and stopped at the same instances as if the fan were enabled. For all other Ducted Systems tested without an indoor fan installed, the indoor coil airflow shall be cycled in unison with the cycling of the compressor. Air dampers shall be closed on the inlet and outlet side the OFF period.

Blower Coil Systems with Constant-volume AMS or Constant-torque AMS which has the blower disabled for Cyclic Test, adjust energy based on Equation 5.11 and capacity per Equation 5.12

$$Ec_{adj,x} = E_{fan,x} \cdot [\theta_2 - \theta_1] \qquad 5.11$$

$$qc_{adj,x} = P_{fan,x} \cdot [\theta_2 - \theta_1] \quad 5.12$$

The following algorithm shall be used to calculate $Ec_{adj,x}$ and $qc_{adj,x}$ in lieu of Equations 5.11 and 5.12, at the manufacturer's discretion, if the indoor fan ramps its speed when cycling.

5.2.4.7.1. Measure the electrical power consumed by the Constant-volume AMS or Constant-torque AMS at a minimum of three operating conditions: at the speed/air volume rate/external static pressure that was measured during the Steady-state Test, at operating conditions associated with the midpoint of the ramp-up interval, and at conditions associated with the midpoint of the ramp-down interval. For these measurements, the tolerances on the airflow volume or the external static pressure are the same as required for the Steady-state Test.

5.2.4.7.2. For each case, determine the indoor fan power from the average of measurements made over a minimum of 5 minutes.

5.2.4.7.3. Approximate the electrical energy consumption of the indoor fan if it had operated during the Cyclic Test using all three power measurements. Assume a linear profile during the ramp intervals. The manufacturer shall provide the durations of the ramp-up and ramp-down intervals. If a manufacturer-supplied ramp interval exceeds 45 seconds, use a 45-second ramp interval nonetheless when estimating the fan energy.

5.2.4.8 *Non-ducted System procedures for the optional cyclic dry-coil cooling-mode tests (D_{Full}, D_{Low}, and I_{Low})*. Do not use dampers when conducting Cyclic Tests on Non-ducted Systems. Until the last OFF/ON compressor cycle, airflow through the Indoor Coil must cycle off and on in unison with the compressor. For the last OFF/ON compressor cycle—the one used to determine energy and capacity—use the exhaust fan of the airflow measuring apparatus and the indoor fan of the test unit to have indoor airflow start 3 minutes prior to compressor cut-on and end three minutes after compressor cutoff. Subtract the electrical energy used by the indoor fan during the 3 minutes prior to compressor cut-on from the integrated electrical energy. Add the electrical energy used by the indoor fan during the 3 minutes after compressor cutoff to the integrated cooling capacity. For the case where the Non-ducted System uses a variable-speed indoor fan which is disabled during the Cyclic Test, correct $E_{cyc,dry}$ and $q_{cyc,dry}$ using the same approach as prescribed for Blower Coil Systems with Constant-volume AMS or Constant-torque AMS which has the blower disabled for Cyclic Test."

5.2.4.9 *Outdoor Equipment Cycling.* The outdoor air-moving equipment (on the condenser side) shall cycle ON and OFF when the compressor cycles ON and OFF unless controls supplied with the product preclude this.

5.3. For reference purposes only, Table 7 summarizes the various sections of this standard that are applicable to different types of equipment.

Section 6. Rating Requirements

6.1. *Standard Ratings.* Standard Ratings shall be established at the Standard Rating Conditions specified per Tables 8, 9, and 10. Standard Ratings shall be established for all refrigerants listed on the nameplate of product.

Standard Ratings relating to cooling capacities shall be net values, including the effects of circulating-fan heat, but not including supplementary electric heat. Power input used for calculating efficiency shall be the Total Power.

Standard Ratings of units which do not have indoor air-circulating fans furnished as part of the model, i.e., Coil-only System, shall be established by subtracting from the total cooling capacity 365 W per 1700 m^3/h. Total Power for cooling shall be increased by 365 W per 1700 m^3/h of indoor air circulated.

Table 7. Informative Guidance for Using AHRI Standard 211/241-0B/1B (SI)

			General Testing and Set-up Issues	Rating Procedure Issues		Calculations
				General	Cooling	Cooling
Requirements for all units			5.1.1, 5.1.3, 5.1.4, 5.1.6, 5.2, Section 5, Section 6, Appendix C, Appendix D, D1, D3, D4, D7, D8, D9, D11, D13, D14, D15.2, D16, D17, F1	5.1.1, 6.1, Table 8, Table 9, 6.1.1, 6.1.2, 6.1.3, 6.1.4, 6.1.5.1, Table 12, 6.1.8, 6.5, 6.5.4, 6.5.5	6.1.5	11.1.1 to 11.1.6, 11.2.1
Requirements for all Heat Pumps			5.1.5, 5.1.6.2	6.1.6, 6.1.7		
Additional Requirements	System Configurations (more than one may	Blower Coil System	5.1.5, D5, C4.5, C5.1.1, C7.1.2.1			
		Non-ducted System	D12		6.1.5.1.4, 6.1.5.3.4	
		Single-package	5.1.6.3, D5, C5.2.1	6.1.8.5		
		SDHV	D6			
		Multi-split	5.1.5.1, D10	6.1.8.4		
	Modulation	Single speed compressor		6.1.8.1	6.1.3.1.1	11.2.1.1
		Two-capacity compressor		6.1.8.2	6.1.3.1.2, 6.1.5.3	11.2.1.2
		Variable Speed Compressor	5.1.2, D2		6.1.3.1.3, 6.1.5.4	11.2.1.3
	Special	Units with a Multi-speed Outdoor Fan	D15.1			

Table 7. Required Tests[1] – T1 Climate

Test Name	Air-cooled Product Type		
	Single Stage System	Two-stage System	Variable Stage System
Cooling Mode			
$T_{1,Full}$	R	R	R
B_{Full}	R	R	R
B_{Low}		R	R
C_{Full}	O [2]	O [2]	
C_{Low}		O [2]	
D_{Full}	O [2]	O [2]	
D_{Low}		O [2]	
E_{Int}			R
F_{Low}		R	R
G_{Low}			O [2]
I_{Low}			O [2]
Cooling Mode Operation Tests			
Voltage Tolerance	R	R	R
Low Temperature Cooling	R	R	R
Insulation Efficiency	R	R	R
Condensate Disposal	R	R	R
Maximum Operating Conditions	R	R	R

Notes:
1. "R" means Required, "O" means Optional, and a blank cell indicates test is not applicable for the given product type.
2. Refer to Section 6.1.3.1.

Table 8. Required Tests[1] – Hot Climate			
Test Name	Air-cooled Product Type		
	Single Stage System	Two-stage System	Variable Stage System
Cooling Mode			
$T_{3,Full}$ or $T_{4,Full}$ [2]	R	R	R
$T_{1,Full}$	R	R	R
$T_{1,Int}$			R
$T_{1,Low}$		R	R
B_{Full}	R		
B_{Low}		R	R
C_{Full}	O [3]	O [3]	
C_{Low}		O [3]	
D_{Full}	O [3]	O [3]	
D_{Low}		O [3]	
F_{Low}		O [3]	O [3]
G_{Low}			O [3]
I_{Low}			O [3]
Cooling Mode Operation Tests			
Voltage Tolerance	R	R	R
Low Temperature Cooling	R	R	R
Insulation Efficiency	R	R	R
Condensate Disposal	R	R	R
Maximum Operating Conditions	R	R	R
Extra High Maximum Operating Conditions	O[4]	O[4]	O[4]

Notes:
1. "R" means Required, "O" means Optional, and a blank cell indicates test is not applicable for the given product type.
2. Where required, depending on climate zone.
3. Refer to Section 6.1.3.1.
4. May be required in some regions

Table 9. Test Conditions for Air-cooled Products[1]				
Test Name	Air Entering Outdoor Unit [2] (ºC)	Air Entering Indoor Unit [2] (ºC)	Compressor Speed [3]	Indoor Airflow [4]
Cooling Mode				
$T_{3,Full}$	46.0 / 24.0 [5,6]	29.0 / 19.0	$Full_C$[8]	$Full_C$
$T_{4,Full}$	48.0 / 24.0 [5,6]	26.6 / 19.4	$Full_C$[8]	$Full_C$
$T_{1,Full}$	35.0 / 24.0 [5,6]	27.0 / 19.0	$Full_C$	$Full_C$
$T_{1,Int}$	35.0 / 24.0 [5,6]	27.0 / 19.0	Int_C	Int_C
$T_{1,Low}$	35.0 / 24.0 [5,6]	27.0 / 19.0	Low_C	Low_C
B_{Full}	27.8 / 18.3 [5,6]	26.7 / 19.4	$Full_C$	$Full_C$
B_{Low}	27.8 / 18.3 [5,6]	26.7 / 19.4	Low_C	Low_C
C_{Full}	27.8 / 14.4 [5,6]	26.7 / 13.9 [7]	$Full_C$	$Full_C$
C_{Low}	27.8 / 14.4 [5,6]	26.7 / 13.9 [7]	Low_C	Low_C
D_{Full}	27.8 / 14.4 [5,6]	26.7 / 13.9 [7]	$Full_C$	$Full_C$ [9]
D_{Low}	27.8 / 14.4 [5,6]	26.7 / 13.9 [7]	Low_C	Low_C [9]
E_{Int}	30.6 / 20.6 [5,6]	26.7 / 19.4	Int_C	Int_C
F_{Low}	19.4 / 11.9 [5,6]	26.7 / 19.4	Low_C	Low_C
G_{Low}	19.4 / 14.4 [5,6]	26.7 / 13.9 [7]	Low_C	Low_C
I_{Low}	19.4 / 14.4 [5,6]	26.7 / 13.9 [7]	Low_C	Low_C [9]
Cooling Mode Operation Tests				
Voltage Tolerance	35.0 / 23.9 [6]	26.7 / 19.4	$Full_C$	$Full_C$
Low Temperature	19.4 / 13.9	19.4 / 13.9	$Full_C$	$Full_C$
Insulation Efficiency	26.7 / 23.9	26.7 / 23.9	$Full_C$	$Full_C$
Condensate Disposal	26.7 / 23.9	26.7 / 23.9	$Full_C$	$Full_C$
Extra High Maximum Operation (Optional)	52.0 / 31.0	26.7 / 19.4	$Full_C$[8]	$Full_C$

Notes:
1. Test condition tolerances are defined within ASHRAE Standard 37, Section 5.2 for cyclic, and Section 8.7 of this standard.
2. Values listed are dry bulb temperature / wet bulb temperature, °C.
3. Refer to Section 3 for definition of "Full", "Low", and "Intermediate" for each compressor type.
4. Refer Section 6.1.5 for airflow details.
5. Wet-bulb required only if unit rejects condensate to Outdoor Coil.
6. For Single Package Units that do not reject condensate to the Outdoor Coil, where all or part of the equipment is located in the outdoor room, run a wet bulb such that the dew point is 15.8 ± 1.7°C.
7. The entering air must have a low enough moisture content so no condensate forms on the indoor coil. It is recommended that an indoor wet-bulb temperature of 14°C or less be used.
8. Set the compressor speed to the highest speed allowed by the system control at the condition.
9. For Cyclic Tests use the same airflow as steady state test which is defined as the same static pressure difference or velocity pressures across the nozzle(s) during the ON period.

6.1.1. *Values of Standard Capacity Ratings.* These ratings shall be expressed only in terms of kW as shown in Table 10.

Table 10. Values of Standard Capacity Ratings	
Capacity Ratings, kW	Multiples, kW
< 6	0.02
≥ 6 and < 11	0.05
≥ 11 and < 19	0.15

6.1.2. *Values of Measures of Energy Efficiency and Power.* Standard measures of energy efficiency, whenever published, shall be expressed in multiples of the nearest 0.02 W/W for EER and $SEER_{Tx}$.

6.1.3. *Standard Rating Tests*.

6.1.3.1 *Default Cooling Degradation Coefficient.*

6.1.3.1.1. For Single Stage Systems, if the optional C_{Full} and D_{Full} tests are not performed, a default value of 0.20 shall be used for the cooling Degradation Coefficient, C_D^c.

6.1.3.1.2. For Two-capacity Systems, if the optional C_{Low} and D_{Low} tests are not performed, a default value of 0.20 shall be used for the low stage cooling Degradation Coefficient, $C_D^{c,Low}$. In this case, if using default value for $C_D^{c,Low}$, use default value for $C_D^{c,Full}$. For Two-capacity Systems that lock out low capacity operation at high outdoor temperatures, if the optional C_{Full} and D_{Full} tests are not performed, the default value for high stage shall be the value used for low stage.

6.1.3.1.3. For Variable Capacity Systems, if the optional G_{Low} and I_{Low} tests are not performed, a default value of 0.25 shall be used for the cooling Degradation Coefficient, C_D^c.

6.1.3.2 *Test Sequence.* When testing a Ducted System, conduct the $T_{1,Full}$ test first to establish the cooling full-load air volume rate. When conducting a Cyclic Test, always conduct it immediately after the Steady State Test that requires the same test conditions. For Variable Speed Systems, the first test using the cooling minimum air volume rate shall precede the E_{Int} or $T_{1,Int}$ test. The test laboratory makes all other decisions on the test sequence.

6.1.4. *Electrical Conditions*. For products with a single nameplate rated voltage, Standard Rating tests shall be performed at the nameplate rated voltage. For dual nameplate voltage equipment where 230 V or 240 V is the higher of the dual nameplate voltages, Standard Rating tests shall be performed at 230 V. For all other dual nameplate voltage equipment covered by this standard, the Standard Rating tests shall be performed at both voltages or at the lower of the two voltages if only a single Standard Rating is to be published. For Split Systems, if the Indoor Unit has a different nameplate voltage than the Outdoor Unit, use the Indoor Unit nameplate voltage for the operation of the Indoor Unit. However, if either the indoor or the Outdoor Unit has a 208 V or 200 V nameplate voltage and the other unit has a 230 V nameplate rating, select the voltage supply on the Outdoor Unit for testing. Otherwise, supply each unit with its own nameplate voltage.

6.1.4.1 *Frequency*. For equipment which is 60 Hz only or 50 Hz only, Standard Ratings shall be provided at rated frequency. For equipment which can be operated at both 50 and 60 Hz, Standard Ratings shall be provided for each frequency.

6.1.5. *Airflow Through the Indoor Coil*.

6.1.5.1 *General Indoor Airflow Concerns*.

6.1.5.1.1. *Airflow-control Setting*. Airflow-control Setting(s) shall be determined before testing begins. Unless otherwise specified within Section 6.1.5 or its subsections, no changes shall be made to the Airflow-control Setting(s) after initiation of testing.

6.1.5.1.2. *Ducted Systems with a PSC AMS or a Constant-torque AMS Operating on Intermediate or Low Stage*. For any test other than $T_{1,Full}$, the specified airflow rate for a given test shall not cause the external static pressure during any test calling for low or intermediate airflow rate to go below the minimum external static pressure values specified in Equation 6.1.

$$\Delta P_{st_i} = \Delta P_{st_{A,Full}} \cdot \left[\frac{\dot{Q}_{i,x}}{\dot{Q}_{A,Full}}\right]^2 \quad 6.1$$

6.1.5.1.3. *Constant-volume AMS Static Settings*. For any Steady-State Test using a Constant-volume AMS, if attempts to achieve the minimum external static pressure causes either air volume rate variations Q_{Var} (as defined by Equation 6.2) of more than 10% or an automatic shutdown of the indoor blower, then the following procedure shall be used. These additional test steps are required if the measured external static pressure exceeds the target value by more than 0.0075 kPa.

$$Q_{Var} = \left[\frac{\dot{Q}_{max} - \dot{Q}_{min}}{\left(\frac{\dot{Q}_{max} + \dot{Q}_{min}}{2}\right)}\right] \cdot 100 \quad 6.2$$

6.1.5.1.3.1. Measure and record the average power consumption of the indoor fan motor ($P_{fan,1}$) and record the corresponding external static pressure (ESP_1) at the ambient conditions for the given test at the lowest external static pressure where the unit will run with stability (Q_{var} remains below 10%) for a minimum of 5 minutes.

6.1.5.1.3.2. After completing the 5-minute minimum interval and while maintaining the same test conditions, adjust the exhaust fan of the airflow measuring apparatus until the external static pressure increases to approximately the value defined by Equation 6.3:

$$ESP_2 \approx ESP_1 + (ESP_1 - ESP_{min}) \quad 6.3$$

6.1.5.1.3.3. Upon achieving steady state at the higher external static pressure ESP_2 condition, record average power consumption and average external static pressure.

6.1.5.1.3.4. Calculate the average power consumption of the indoor fan motor at ESP_{min} using linear extrapolation. For all Steady-state Tests, the Total Power consumption shall be adjusted by P_{adj} as calculated per Equation 6.4.

$$P_{adj} = \frac{(P_{fan,2} - P_{fan,1})}{(ESP_2 - ESP_1)} \cdot (ESP_{min} - ESP_1) \quad 6.4$$

6.1.5.1.3.5. For all Steady-state Tests, total cooling capacity shall be increased by $Q_{adj} = P_{adj}$ as calculated per Equation 6.4.

6.1.5.1.4. *Non-ducted Systems*. All airflow rates shall be the air volume rate that results during each test when the unit is operated at an external static pressure of 0.00 kPa.

6.1.5.1.5. *Overspeeding*. If a unit's controls allow for overspeeding the indoor blower (usually on a temporary basis), take the necessary steps to prevent overspeeding during all tests.

6.1.5.1.6. *Full Airflow Adjustment to Meet Minimum External Static Pressure*. For cooling full airflow rate, if external static pressure is lower than the minimum values specified in Table 11 at the manufacturer's specified cooling full airflow rate, the external static pressure shall be increased by reducing the airflow rate of the airflow measuring apparatus. If increasing external static pressure reduces airflow of the unit under test to less than 90% of rated airflow rate and the minimum external static pressure is still not achieved, then the next higher Airflow-control Setting (if available) shall be utilized to obtain rated airflow. If a higher Airflow-control Setting is not available, continue to decrease airflow rate of the airflow measuring apparatus until the required minimum external static pressure is achieved and use the resulting airflow of the unit under test as the cooling full airflow rate. Any manual Airflow-control Setting shall remain unchanged for all other tests.

6.1.5.1.7. *Other Airflow Adjustment to Meet Minimum External Static Pressure*. During a Low Stage or Intermediate Stage test, if the external static pressure is lower than the minimum values calculated per Equation 6.1 at manufacturer specified airflow rate, the external static pressure shall be increased by reducing the airflow rate of the airflow measuring apparatus. If increasing external static pressure reduces airflow of the unit under test to less than 90% of rated manufacturer specified airflow rate and the minimum external static pressure is still not achieved, then the next higher Airflow-control Setting (if available) shall be utilized to obtain rated airflow. If a higher Airflow-control Setting is not available, continue to decrease airflow rate of the airflow measuring apparatus until the required minimum external static pressure is achieved and use the resulting airflow of the unit under test as the cooling full airflow rate. Manual adjustments of Airflow-control Settings are not permitted.

6.1.5.1.8. *Units That Control to Different Constant Airflow at Each Test Condition Using the Same Blower Setting.* Use full-load, intermediate, and minimum air volume rates at each test condition that represent normal installation. Additionally, if conducting the dry-coil tests on variable speed equipment, operate the unit in the same control mode as used for the F1 Test. If performed, conduct the steady-state C Test and the cyclic D Test with the single speed or two speed unit operating in the same control mode as used for the B or B1 Test.

The target external static pressure, ΔP_{st_x}, for any test "x" with a measured air volume rate not equal to the Cooling full-load air volume rate is determined as follows:

$$\Delta P_{st_x} = \Delta P_{st_{Full}} \cdot \left[\frac{\dot{Q}_{i,x}}{\dot{Q}_{Full}}\right]^2 \quad 6.5$$

External static pressure shall be controlled within -0.00 to +0.0075 kPa of the target minimum external static pressure.

6.1.5.2 *Cooling Full Airflow Rate*. The manufacturer shall specify the cooling full airflow rate, $Q_{A,Full}$. The specified cooling full airflow rate value shall be utilized for all tests that call for cooling full airflow rate, unless otherwise modified by the following subsections. If modified, that same modified value shall be utilized for all tests that call for cooling full airflow rate. Static pressure requirements only apply to the $T_{1,Full}$ test unless otherwise indicated.

6.1.5.2.1. *PSC AMS or Constant-torque AMS Ducted Systems*. The specified cooling full airflow rate shall not cause the external static pressure during the $T_{1,Full}$ to go below the minimum values specified in Table 11. See Section 6.1.5.1.6.

Table 11. Minimum External Static Pressure for Ducted Systems

Rated Cooling[1] Capacity, kW	Minimum External Resistance[2], kPa	
	All Other Systems	Small-duct, High-velocity Systems[3]
≤ 8.5	0.025	0.274
> 8.5 and ≤ 13	0.037	0.286
> 13 and ≤ 19	0.050	0.299

Note:
1. For air-conditioners and heat pumps, the value cited by the manufacturer in published literature for the unit's capacity when operated at the $T_{1,Full}$ Test conditions.
2. For Ducted Systems tested without an air filter installed, increase the applicable tabular value by 0.020 kPa.
3. If a closed-loop, air-enthalpy test apparatus is used on the indoor side, limit the resistance to airflow on the inlet side of the Indoor Unit to a maximum value of 0.025 kPa. Impose the balance of the airflow resistance on the outlet side of the Indoor Unit.

6.1.5.2.2. *Constant-volume AMS Ducted Systems*. All tests requiring cooling full airflow rate shall be performed at the minimum external static pressure values specified in Table 11, with a tolerance of 0.00 to +0.0075 kPa using the manufacturer's specified Airflow-control Setting. If the manufacturer does not specify an Airflow-control Setting, the manufacturer's airflow tables shall be used to determine the appropriate Airflow-control Setting.

6.1.5.3 *Cooling Low Airflow Rate*. The manufacturer shall specify the cooling low airflow rate. The specified cooling low airflow rate value shall be utilized for all tests that call for cooling low airflow rate, unless otherwise modified by the following subsections. If modified, that same modified value shall be utilized for all tests that call for cooling full airflow rate.

6.1.5.3.1. *PSC AMS or Constant-torque AMS Ducted Systems*. The specified cooling low airflow rate shall not cause the external static pressure during any test calling for cooling low airflow rate to go below the minimum values calculated by Equation 6.1. Refer to Section 6.1.5.1.7. For products that do not have automatic control of Airflow-control Settings, the manual Airflow-control Setting from cooling full airflow rate shall remain unchanged.

For products that allow independent Airflow-control Settings, all low stage cooling tests shall be performed at cooling low airflow rate at the lowest Airflow-control Setting that meets the low stage minimum external static pressure per Equation 6.1. Refer to Section 6.1.5.1.7.

6.1.5.3.2. *Constant-volume AMS Ducted Systems*. All tests requiring cooling low airflow rate shall be performed at the minimum external static pressure values specified in Equation 6.1, with a tolerance of 0.00 to +0.0075 kPa using the manufacturer's specified Airflow-control Setting. If the manufacturer does not specify an Airflow-control Setting, the manufacturer's airflow tables shall be used to determine the appropriate Airflow-control Setting. If the static pressure setting causes air volume rate variations (Q_{var}) more than 10% or an automatic shutdown of the indoor blower, the procedure from Section 6.1.5.1.3 shall be used.

6.1.5.3.3. *Non-ducted Systems.* The cooling low airflow rate is the air volume rate that results during each test when the unit is operated at an external static pressure of 0.00 kPa and at the indoor fan setting used at Low Compressor Stage (Two-capacity System) or OUM's Minimum Compressor Speed (Variable Capacity System). For units having a single speed compressor and a Constant-volume AMS or a Constant-torque AMS, use the lowest Airflow-control Setting allowed for cooling.

6.1.5.4 *Cooling Intermediate Airflow Rate.* The manufacturer shall specify the cooling intermediate airflow rate. The specified cooling intermediate airflow rate value shall be utilized for all tests that call for cooling intermediate airflow rate, unless otherwise modified by subsections of Section 6.1.5.1.2. If modified, that same modified value shall be utilized for all tests that call for cooling intermediate airflow rate.

6.1.5.4.1. *PSC AMS or Constant-torque AMS Ducted Systems*. The specified cooling intermediate airflow rate shall not cause the external static pressure during any test calling for cooling intermediate airflow rate to go below the minimum values calculated by Equation 6.1. Refer to Section 6.1.5.1.7. For products that do not have automatic control of Airflow-control Settings, the manual Airflow-control Setting from cooling full airflow rate shall remain unchanged.

For products that allow independent Airflow-control Setting selection, all intermediate stage cooling tests shall be performed at cooling intermediate airflow rate at the lowest Airflow-control Setting that meets the intermediate stage minimum external static pressure in Equation 6.1. Refer to Section 6.1.5.1.7.

6.1.5.4.2. *Constant-volume AMS Ducted Systems*. All tests requiring cooling intermediate airflow rate shall be performed at the minimum external static pressure values calculated using Equation 6.1, with a tolerance of 0.00 to +0.0075 kPa.

6.1.6. *Outdoor-Coil Airflow Rate.* All Standard Ratings shall be determined at the outdoor coil airflow rate specified by the manufacturer where the fan drive is adjustable. Where the fan drive is non-adjustable, performance shall be determined at the outdoor coil airflow rate inherent in the equipment when operated with all of the resistance elements associated with inlets, louvers, and any ductwork and attachments considered by the manufacturer as normal installation practice, as determined by the manufacturer literature. Once established, the Outdoor Coil air circuit of the equipment shall remain unchanged throughout all tests prescribed herein.

6.1.6.1 *Double-duct System*. For product intended to be installed with the outdoor airflow ducted, the unit shall be installed with Outdoor Coil ductwork installed per the Installation Instructions and shall operate between 0.025 and 0.037 kPa external static pressure. External static pressure measurements shall be made in accordance with ASHRAE Standard 37 Sections 6.4 and 6.5.

6.1.7. *Control of Auxiliary Resistive Heating Elements.* Except as noted, disable heat pump resistance elements used for heating indoor air at all times.

6.1.8. *Tested Combinations or Tested Units.* As a minimum, Tested Combinations of Split Systems or tested samples of Single Package Unit shall include the following combination for the specific types of equipment listed. Unless otherwise specified below, there is no restriction on the Tested Combination (i.e., single split air conditioners and heat pumps not listed below shall be tested as a Coil-only System or a Blower Coil System).

6.1.8.1 *Single Stage Air-conditioner (Distributed in commerce by an OUM)*. Any Single Stage Air Conditioner (including space-constrained and SDHV) shall be tested, as a minimum, as a Coil-only System.

6.1.8.2 *Two-stage Air Conditioner (Distributed in commerce by an OUM)*. Any Two-stage Air Conditioner (including space-constrained and SDHV) shall be tested, as a minimum, as a Coil-only System.

6.1.8.3 *Single-split System Air Conditioner Tested Combination (Distributed in Commerce by an ICM)*. Manufacturers shall test a model of Indoor Unit with the least efficient model of Outdoor Unit with which it shall be paired where the least efficient model of Outdoor Unit is the model of Outdoor Unit in the lowest $SEER_{Tx}$ combination as certified by the OUM. If there are multiple models of Outdoor Unit with the same lowest $SEER_{Tx}$ represented value, the ICM shall select one for testing purposes.

6.1.8.4 Outdoor Unit with the same lowest $SEER_{Tx}$ represented value, the ICM shall select one for testing purposes.

6.1.8.5 *Multi-split, Multi-head Mini-Split, or Multi-Circuit System Tested Combinations (including space-constrained and SDHV)*. (See also Section 6.5.1.1.). An arrangement of Indoor Units and Outdoor Units that are production units, or are representative of production units and provides representative performance values, having the following features:

6.1.8.5.1. The system consists of one Outdoor Unit with one or more compressors matched with at least two but no more than five Indoor Units;

6.1.8.5.2. The Indoor Units shall:

6.1.8.5.2.1. Collectively, have a Nominal Cooling Capacity greater than or equal to 95% and less than or equal to 105% of the Nominal Cooling Capacity of the Outdoor Unit;

6.1.8.5.2.2. Each represent the highest sales volume model family (at the time the rating is established), if this is possible while meeting all the requirements of this section. If this is not possible, one or more of the Indoor Units shall represent another indoor model family in order that all the other requirements of this section are met.

6.1.8.5.2.3. Individually not have a Nominal Cooling Capacity greater than 50% of the Nominal Cooling Capacity of the Outdoor Unit, unless the Nominal Cooling Capacity of the Outdoor Unit is 7 kW or less;

6.1.8.5.2.4. Operate at fan speeds consistent with manufacturer's specifications; and

6.1.8.5.2.5. All be subject to the same minimum external static pressure requirement while able to produce the same external static pressure at the exit of each outlet plenum when connected in a manifold configuration as required by the test procedure.

6.1.8.6 *Single Package Air-conditioners and Single Package Heat Pumps (including space-constrained) Selected for Testing*. Manufacturers shall test the individual model with the lowest $SEER_{Tx}$.

6.2. *Application Ratings.* Ratings at conditions of temperature or airflow rate other than those specified in Sections 6.1.3 and 6.2.1 may be published as Application Ratings and shall be based on data determined by the methods prescribed in Section 6.5.1 or Section 6.5.2. Application Ratings in the defrost region shall include Net Capacity and COP based upon a complete defrost cycle (instantaneous capacity may be provided as long as Net Capacity is also provided).

6.3. *Publication of Ratings.* Wherever Application Ratings are published or printed, they shall include, or be accompanied by the Standard Ratings, shall be clearly designated as Application Ratings, including a statement of the conditions at which the ratings apply.

6.3.1. *Capacity Designation.* The capacity designation used in published specifications, literature or advertising, controlled by the manufacturer, for equipment rated under this standard, shall be expressed only in kW at the Standard Rating Conditions specified in 6.1.3 and in the terms described in 6.1.1 and 6.1.2. Horsepower, tons or other units shall not be used as capacity designation.

6.4. *Ratings.* Standard Ratings for capacity, EER or $SEER_{Tx}$ shall be based either on test data or computer simulation.

6.4.1. *NTC Ratings Generated by Computer Simulation*. Any capacity, EER or $SEER_{Tx}$ rating of a system generated by the results of an Alternative Efficiency Determination Method (AEDM) shall be no higher than the result of the AEDM (after rounding per Sections 6.1.1 and 6.1.2).

6.4.2. *Documentation*. Supporting documentation of all Published Ratings shall be appropriately maintained.

6.4.3. *Multiple Standard Ratings*. A single product may have more than one Standard Rating. If multiple Standard Ratings exist, the conditions for each Standard Rating shall be clearly identified for each individual Standard Rating.

6.5. *Uncertainty.* When testing a sample unit, there are uncertainties that shall be considered. All tests shall be conducted in a laboratory that meets the requirements referenced in this standard, ANSI/ASHRAE Standard 37. The uncertainty for Standard Ratings covered by this standard includes the following.

6.5.1. *Uncertainty of Measurement*. When testing a unit, there are variations that result from instrumentation and laboratory constructed subsystems for measurements of temperatures, pressure, power, and flow rates.

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

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

6.5.4. *Uncertainty of Performance Simulation Tools*. Due to the large complexity of options, manufacturers may use performance prediction tools like an AEDM.

6.5.5. *Variability due to Environmental Conditions*. Changes to ambient conditions such as inlet temperature conditions and barometric pressure can alter the measured performance of the unit.

6.5.6. *Variability of System Under Test*. The system under test instability may not yield repeatable results.

Section 7. Minimum Data Requirements for Published Ratings

7.1. *Minimum Data Requirements for Published Ratings*. As a minimum, Published Ratings shall include all Standard Ratings shown below:

7.1.1. For Unitary Air-conditioners (air-cooled) and Air-source Heat Pumps

7.1.1.1 AHRI Standard Rating cooling capacity, W
7.1.1.2 Energy Efficiency Ratio ($EER_{Tx,Full}$), ·W/W
7.1.1.3 Seasonal Energy Efficiency Ratio ($SEER_{Tx}$), W/W·

7.2. For Split Systems, Standard Ratings shall be published for every refrigerant listed as permissible for use on the nameplate of the Outdoor Unit. If multiple refrigerants are listed as permissible for use on the nameplate of the Outdoor Unit and a single Standard Rating is applied for all refrigerants, a statement shall be included noting the single Standard Rating applies for all refrigerants.

7.3. *Latent Cooling Capacity Designation*. The Latent Cooling Capacity used in published specifications, literature or advertising, controlled by the manufacturer, for equipment rated under this standard, total or Sensible Cooling Capacity shall be expressed consistently in either Gross Capacity or Net Capacity in one or more of the following forms:

7.3.1. Sensible Cooling Capacity / Net Capacity ratio and Net Capacity
7.3.2. Latent Cooling Capacity and Net Capacity
7.3.3. Sensible Cooling Capacity and Net Capacity

7.4. All claims to ratings within the scope of this standard shall include the statement "Rated in accordance with AHRI Standard 211/241." All claims to ratings outside the scope of this standard shall include the statement "Outside the scope of AHRI Standard 211/241." Wherever Application Ratings are published or printed, they shall include a statement of the conditions at which the ratings apply.

Section 8. Operating Requirements

8.1. *Operating Requirements.* Unitary equipment shall comply with the provisions of this section such that any production unit shall meet the requirements detailed herein.

8.2. *Maximum Operating Conditions Test.* Unitary equipment shall pass the following maximum operating conditions test with indoor-coil full-load airflow rate as determined under Section 6.1.5.

8.2.1. *Temperature Conditions.* Temperature conditions shall be maintained as shown in Table 9, as applicable, in accordance with the unit's nameplate. For equipment marked for application for more than one Standard Rating condition the most stringent outdoor ambient conditions shall be used.

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

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

8.2.4. *Requirements.* The equipment shall operate continuously without interruption for any reason for one hour. For hot climate countries run for two hours at extra high maximum operating condition.

8.3. *Voltage Tolerance Test.* Unitary equipment shall pass the following voltage tolerance test with a cooling coil airflow rate as determined under Section 6.1.5.

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 9, as applicable, in accordance with the unit's nameplate. For equipment marked for applications for more than one Standard Rating condition (T1 and/or T3 and T4) the most stringent outdoor ambient conditions shall be used.

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 as specified in 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 specified 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 specified in Section 8.3.2.1. During the remainder of resume operations phase, voltage and temperature conditions shall be retained as specified in Section 8.3.3.1. Refer to Figure 1.

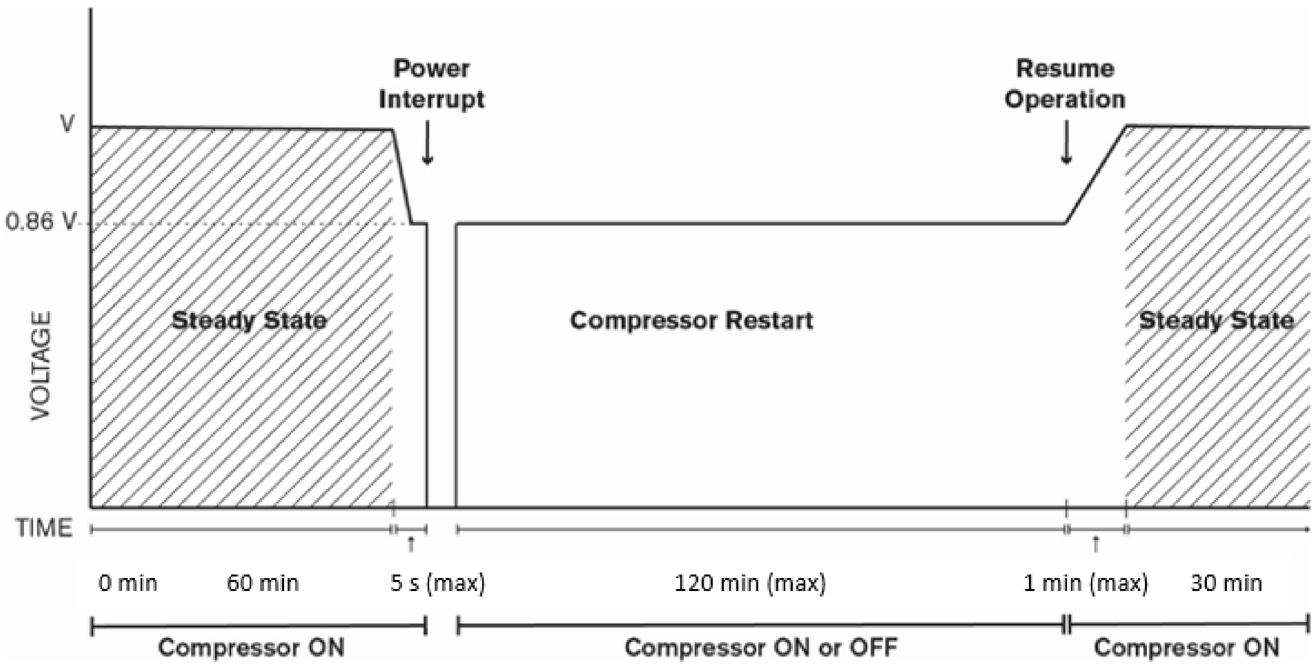

Figure 1. Voltage Tolerance Test Power Interrupt Procedure.

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 automatic resetting of safety devices prior to re-establishment of continuous operation is permitted.

8.4. *Low-Temperature Operation Test (Cooling).* Unitary equipment shall pass the following low-temperature operation test when operating with initial airflow rate, $\dot{Q}_{i,T1,Full}$, as determined in Section 6.1.5 and with controls and dampers 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.

8.4.1. *Temperature Conditions.* Temperature Conditions shall be maintained as shown in Table 9.

8.4.2. *Procedure.* The test shall be continuous with the unit on the cooling cycle, for not less than four hours after establishment of the specified temperature conditions. The unit shall be permitted to start and stop under control of an automatic limit device, if provided.

8.4.3. *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 saturated evaporating temperature shall not be less than 0°C + half of refrigerant temperature glide.

8.5. *Insulation Effectiveness Test (Cooling)*. Unitary equipment shall pass the following insulation effectiveness test when operating with airflow rate, $\dot{Q}_{T1,Full}$, as determined in Sections 6.1.5 and 6.1.6 with controls, fans, dampers, and grilles set to produce the maximum tendency to sweat, provided such settings are not contrary to the manufacturer's instructions to the user.

8.5.1. *Temperature Conditions.* Temperature conditions shall be maintained as shown in Table 9.

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 drop, run, or blow off from the unit casing.

8.6. *Condensate Disposal Test (Cooling).* Unitary equipment which rejects condensate to the condenser air shall pass the following condensate disposal test when operating with airflow rates as determined in Section 6.1.5 and with controls and dampers set to produce condensate at the maximum rate, provided such settings are not contrary to the manufacturer's instructions to the user.

Note: This test may be run concurrently with the insulation effectiveness test (Section 8.5).

8.6.1. *Temperature Conditions.* Temperature conditions shall be maintained as shown in Table 9.

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, there shall be no dripping, running-off, or blowing-off of moisture from the unit casing.

8.7. *Tolerances.* The room ambient conditions for the tests outlined in Section 8 are average values subject to tolerances of ± 0.56°C for air wet-bulb and dry-bulb temperatures and ± 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 manufacture's name, model designation, electrical characteristics and refrigerants approved for use by the manufacturer.

9.2. *Nameplate Voltages*. Nameplate voltages for 60 Hz systems shall include one or more of the equipment nameplate voltage ratings shown in Table 1 of AHRI Standard 110. Nameplate voltages for 50 Hz systems shall include one or more of the utilization voltages shown in Table 1 of IEC Standard 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 of the requirements of the standard, and all of the testing and rating requirements are measured and reported in complete compliance with the standard. Any product that has not met all the requirements of the standard shall not reference, state, or acknowledge the standard in any written, oral, or electronic communication.

10.2. *Verification Testing Criteria.* To comply with this standard, single sample production verification tests shall meet the certified Standard Rating performance metrics shown in Table F1 with the listed acceptance criteria.

Section 11. Calculations

All steady state capacity calculations in this standard are in principle the same as the capacity calculations in ANSI/ASHRAE Standard 37. In this standard the capacity subscripts are included for the individual tests. Seasonal efficiency calculations in this standard are in principle the same as the seasonal efficiency calculations in ANSI/ASHRAE Standard 116, except that they use the subscripted capacity nomenclature. The calculations in this standard shall take precedence over ASHRAE calculations. Indoor air enthalpy method shall be the primary calculation used to determine system capacity. Outdoor enthalpy or refrigerant enthalpy method shall only be used for secondary calculation methods.

11.1. *Individual Test Calculations.* For this section subscript lowercase "x" is used for the individual test measurement. For example, the symbol for Total Cooling Capacity for the $T_{1,Full}$ test is $q_{tci,T1,Full}$, in this calculation section q_x is used, where "x" is equal to $T_{1,Full}$. For all capacities calculated in Section 11, round the calculated value to the nearest integer. For all Degradation Coefficients, round the calculated value to the nearest 0.01. If the calculated Degradation Coefficient is negative, set the Degradation Coefficient equal to zero.

For all Steady State Tests and for frost accumulation (H2 tests), air volume rate through the indoor coil, $\dot{Q}_{mi}$, and air volume rate through the Outdoor Coil, $\dot{Q}_{mo}$, shall be calculated per the equations specified in Sections 7.7.2.1 and 7.7.2.2 of ANSI/ASHRAE Standard 37. The standard airflow rate, $\dot{Q}_s$, shall be calculated from Section 7.7.2.3 of ANSI/ASHRAE Standard 37.

11.1.1. *Cooling Steady State Net Capacity.*

11.1.1.1 *Total Cooling Capacity (Indoor Air Enthalpy Method).* The Net Capacity for all steady state cooling tests shall be calculated using Equation 11.2 for Blower Coil Systems or using Equation 11.3 for Coil-only Systems.

$$\dot{q}_x = \frac{60 \cdot \dot{Q}_{mi}(h_{a1} - h_{a2})}{v'_n(1+W_n)} \quad 11.1$$

$$\dot{q}_{tci,x} = \dot{q}_x + \dot{q}_{duct,ci} \quad 11.2$$

$$\dot{q}_{tci,x} = \dot{q}_x + \dot{q}_{duct,ci} - \dot{q}s_{adj,x} \quad 11.3$$

Where Equation 11.4 shall be used when the Indoor Unit is in the indoor psychrometric chamber, Equation 11.5 shall be used when the indoor section is completely in the outdoor chamber. Equation 11.6 is shown for reference. Duct loss, $\dot{q}_{duct,ci}$, shall be set to 0 for steady state tests C and G.

$$\dot{q}_{duct,ci} = UA_{ID,si}(t_{a1} - t_{a2}) \quad 11.4$$

$$\dot{q}_{duct,ci} = UA_{ID,ro}(t_{a0} - t_{a1}) + UA_{ID,so}(t_{a0} - t_{a2}) + UA_{ID,si}(t_{a1} - t_{a2}) \quad 11.5$$

$$v_n = v'_n(1 + W_n) \quad 11.6$$

11.1.1.2 *Total Cooling Capacity (Outdoor Air Enthalpy Method).* The Net Capacity for all steady state cooling tests shall be calculated using Equation 11.7 for units that do re-evaporate drained condensate from the indoor coil or Equation 11.8 for units that do not re-evaporate drained condensate from the indoor coil.

$$\dot{q}_{tco,x} = \frac{60 \cdot \dot{Q}_{mo}(h_{a4} - h_{a3})}{v'_n(1+W_n)} - P_{tot,x} \quad 11.7$$

$$\dot{q}_{tco,x} = \frac{60 \cdot \dot{Q}_{mo} c_{pa4}(t_{a4} - t_{a3})}{v'_n(1+W_n)} - P_{tot,x} \quad 11.8$$

11.1.1.3 *Total Cooling Capacity (Refrigerant Enthalpy Method).* The Net Capacity for all steady state cooling tests shall be calculated per Equation 11.9. See Section C6.3.2 of this Standard for information about mass flow ratio, *x*.

$$\dot{q}_{ref,x} = x\dot{m}_{ref,x}(h_{r2} - h_{r1}) - \dot{q}s_{adj,x} \qquad 11.9$$

11.1.1.4 Indoor motor heat capacity adjustment, $\dot{q}s_{adj}$.

For Coil-only Systems use Equation 11.10:

$$\dot{q}s_{adj,x} = \frac{0.365}{1700} \cdot \dot{Q}_s \qquad 11.10$$

Where 0.365 kW is the heat generated from default blower power per 1700 m^3/h (Standard Air).

For all Blower Coil Systems use Equation 11.11:

$$\dot{q}s_{adj,x} = P_{fan,x} \qquad 11.11$$

11.1.1.5 *Heat Balance.* If using the outdoor enthalpy as an alternate method, use Equation 11.12, or if using refrigerant enthalpy as an alternate method, use Equation 11.13.

$$HB_x = \frac{\dot{q}_{tci,x} - \dot{q}_{tco,x}}{\dot{q}_{tci,x}} \qquad 11.12$$

$$HB_x = \frac{\dot{q}_{tci,x} - \dot{q}_{ref,x}}{\dot{q}_{tci,x}} \qquad 11.13$$

11.1.2. *Cooling Steady State Power.* The steady state power, $P_{tot,x}$, shall be as measured during test, adjusted as follows, using Equation 11.14 for Blower Coil Systems or using Equation 11.15 for Coil-only Systems.

$$P_{tot,x} = P_{m,x} + P_{adj} \qquad 11.14$$

$$P_{tot,x} = P_{m,x} + Ps_{adj,x} \qquad 11.15$$

Where:

$$Ps_{adj,x} = \frac{365}{1700} \cdot \dot{Q}_s \qquad 11.16$$

Where 365 W is a default power consumption per 1700 m^3/h, and P_{adj} only applies for Constant-volume AMS per Section 6.1.5.1.3 (P_{adj} is 0 for all other Blower Coil Systems).

11.1.3. *Cooling Steady State Efficiency, EER.* The steady state efficiency shall be calculated using Equation 11.17.

$$EER_x = \frac{\dot{q}_{tci,x}}{P_{tot,x}} \qquad 11.17$$

11.1.4. *Cooling Cyclic Net Capacity*. The Net Capacity for all cyclic cooling tests (tests D and I) shall be calculated using Equation 11.18. $\dot{Q}_{mi}$, c_{pa}, v'_n, $P_{fan,x}$, and W_n shall be the average values recorded during the corresponding dry coil steady state tests (tests C and G).

$$q'_{cyc,x} = \frac{60 \cdot \dot{Q}_{mi} c_{pa2} \Gamma}{v'_n(1+W_n)} - qc_{adj,x} \qquad 11.18$$

Where:

$$\Gamma = F_{CD}^{*} \int_{\theta_1}^{\theta_2} [t_{a1}(\theta) - t_{a2}(\theta)] d\theta \qquad 11.19$$

Where F_{CD}^{*} is calculated per Section 5.2.3.1 using values measured during C & D tests.

For Coil-only Systems use Equation 11.20:

$$qc_{adj,x} = \frac{0.366}{1700} \cdot \dot{Q}_s[\theta_2 - \theta_1] \quad 11.20$$

For Blower Coil Systems with Constant-volume AMS or Constant-torque AMS which has the blower disabled for Cyclic Test use Equation 11.21:

$$qc_{adj,x} = P_{fan,x} \cdot [\theta_2 - \theta_1] \quad 11.21$$

For all other Blower Coil Systems use Equation 11.22:

$$qc_{adj,x} = 0 \quad 11.22$$

For all other Non-ducted Systems use Equation 11.23:

$$qc_{adj,x} = E_{fan,x} \quad 11.23$$

For Non-ducted Systems, subtract the electrical energy used by the indoor fan, $E_{fan,x}$, during the 3 minutes after compressor cutoff from the Non-ducted System's integrated cooling capacity, $q'_{cyc,x}$.

11.1.5. *Cooling Cyclic Energy.* The energy used during Cyclic Tests, $E_{cyc,x}$, shall be as measured during test, adjusted as follows, using Equation 11.24 for Blower Coil Systems (except Blower Coil Systems with variable speed blower Constant-volume AMS or Constant-torque AMS which has the blower disabled for Cyclic Test) or using Equation 11.25 for Coil-only Systems and for Blower Coil Systems with Constant-volume AMS or Constant-torque AMS which has the blower disabled for Cyclic Test.

$$E_{cyc,x} = E_{m,x} \quad 11.24$$

$$E_{cyc,x} = E_{m,x} + Ec_{adj,x} \quad 11.25$$

Where for Blower Coil Systems with Constant-volume AMS or Constant-torque AMS which has the blower disabled for Cyclic Test $Ec_{adj,x}$ is calculated per Equation 5.11 and for Coil-only System $Ec_{adj,x}$ is calculated per Equation 11.26.

$$Ec_{adj,x} = \frac{365}{1700} \cdot \dot{Q}_s \cdot [\theta_2 - \theta_1] \quad 11.26$$

11.1.6. *Cooling Cyclic Efficiency, EER.* The cyclic efficiency shall be calculated per Equation 11.27.

$$EER_x = \frac{q'_{cyc,x}}{E_{cyc,x}} \quad 11.27$$

11.2. *Seasonal Efficiency Calculations.* Seasonal efficiency descriptors, $SEER_{Tx}$ shall be calculated per the equations in this section using the tests and conditions defined in Tables 8, 9, and 10, with results from the individual test calculations from Section 11.1.

11.2.1. *$SEER_{T1}$ for T1 Climates.* $SEER_{T1}$ calculations for T1 climates require user defined climate or region-specific bin numbers, outdoor bin temperatures, and respective cooling hours. An example set of these values is shown in Table 12 below.

Table 12. Fractional Bin Hours to Be Used in Calculation of SEER$_{T1}$ (T1 Example)		
Bin Number (j)	Bin Temperature (t_j), °C	Fractional Bin Hours (n_j)
1	19.4	0.214
2	22.2	0.231
3	25.0	0.216
4	27.8	0.161
5	30.6	0.104
6	33.3	0.052
7	36.1	0.018
8	38.9	0.004

11.2.1.1 *Single Stage System*. SEER$_{T1}$ for a Single Stage System shall be calculated per Equation 11.28.

$$SEER_{T1} = \frac{\sum_{j=1} \dot{q}_x(t_j)}{\sum_{j=1} E_x(t_j)} \qquad 11.28$$

The quantities $\dot{q}_x(t_j)$ and $E_x(t_j)$ are calculated for each individual Temperature Bin using the appropriate formula for each bin depending on the operating characteristics of the system. When the building load is less than low stage capacity use Section 11.2.1.1.1. When the building load is greater than the low stage capacity, but less than the high stage capacity, either Section 11.2.1.2.2 or 11.2.1.2.3 is used, depending on the operating characteristics of the system. See Figure 2 for a graphical representation.

The estimated building load for each bin temperature shall be calculated using Equation 11.29.

$$BL(t_j) = \left(\frac{t_j - t_0}{35 - t_0}\right) \cdot \left(\frac{\dot{q}_{T1,Full}}{SF}\right) \qquad 11.29$$

Where:
t_0 = the outdoor temperature that the building load falls into zero. For instance, when Table 12 is used for cooling bin temperatures and bin hours t_0 = 18°C

$$SF = 1.1 \qquad 11.30$$

The calculated high stage system capacity at each bin temperature shall be calculated by Equation 11.31.

$$\dot{q}_{Full}(t_j) = \dot{q}_{B,Full} + \left\{\frac{\dot{q}_{T1,Full} - \dot{q}_{B,Full}}{35 - 27.8}\right\} \cdot (t_j - 27.8) \qquad 11.31$$

The calculated high stage energy consumption at each bin temperature shall be calculated by Equation 11.32.

$$P_{Full}(t_j) = P_{B,Full} + \left\{\frac{P_{T1,Full} - P_{B,Full}}{35 - 27.8}\right\} \cdot (t_j - 27.8) \qquad 11.32$$

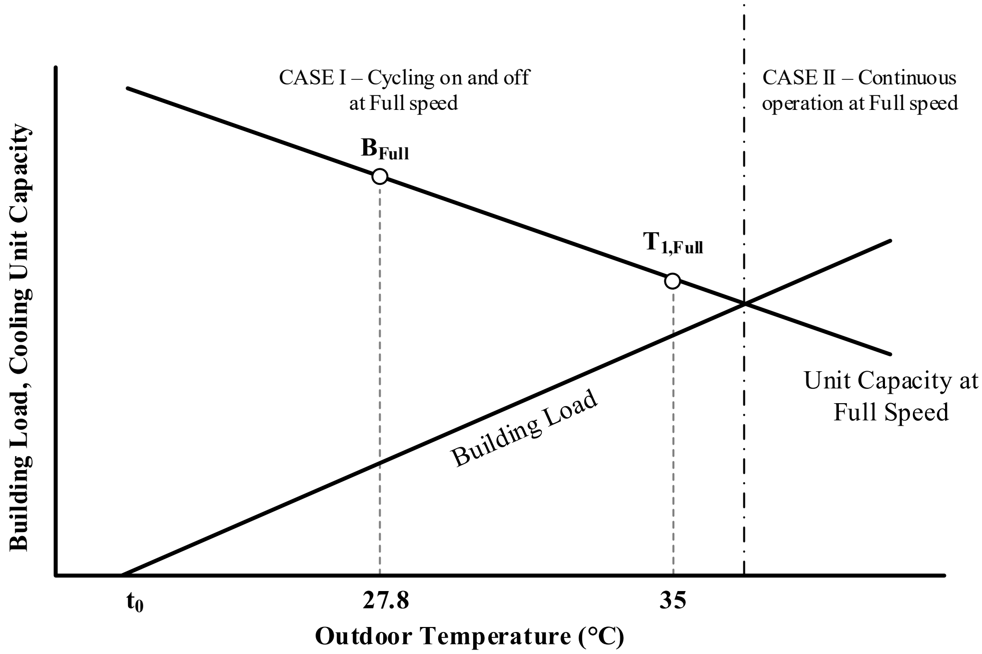

Figure 2. Single-speed System Operation in the Cooling Mode – T1 Climate

Note: See Table 8 for required tests.

11.2.1.1.1. *Case I. Building load is less than or equal to full load cooling capacity*, $BL(t_j) \le \dot{q}_{Full}(t_j)$. Calculate total bin capacity by using Equation 11.33 and total bin energy by using Equation 11.34.

$$\dot{q}(t_j) = CLF(t_j) \cdot \dot{q}_{Full}(t_j) \cdot n_j \quad 11.33$$

$$E(t_j) = \frac{CLF(t_j) \cdot P_{Full}(t_j) \cdot n_j}{PLF(t_j)} \quad 11.34$$

Where:

$$CLF(t_j) = \frac{BL(t_j)}{\dot{q}_{Full}(t_j)} \quad 11.35$$

$$PLF(t_j) = 1 - C_D^c \cdot [1 - CLF(t_j)] \quad 11.36$$

$$C_D^c = \frac{\left\{1 - \frac{EER_{D,Full}}{EER_{C,Full}}\right\}}{1 - CLF^{cyc,Full}} \quad 11.37$$

Where:

$$CLF^{cyc,Full} = \frac{q_{cyc,D,Full}}{(\dot{q}_{C,Full} \cdot \theta_{cyc})} \quad 11.38$$

If the optional Tests C and D (refer to Table 8) are not performed, or the calculated result for C_D^c is greater than the default value of 0.20, the default value shall be used.

11.2.1.1.2. *Case II. Building load is greater than to the unit capacity*, $BL(t_j) > \dot{q}_{Full}(t_j)$. Calculate total bin capacity by using Equation 11.39 and total bin energy by using Equation 11.40.

$$\dot{q}(t_j) = \dot{q}_{Full}(t_j) \cdot n_j \quad 11.39$$

$$E(t_j) = P_{Full}(t_j) \cdot n_j \quad 11.40$$

11.2.1.2 *Two-stage System.* $SEER_{T1}$ for a Two-stage System shall be calculated by Equation 11.28.

The quantities $\dot{q}(t_j)$ and $E(t_j)$ are calculated for each individual Temperature Bin using the appropriate formula for each bin depending on the operating characteristics of the system. When the building load is less than low stage capacity use Section 11.2.1.2.1. When the building load is greater than the low stage capacity, but less than the high stage capacity, either Section 11.2.1.2.2 or is used, depending on the operating characteristics of the system. See Figure 3 for a graphical representation.

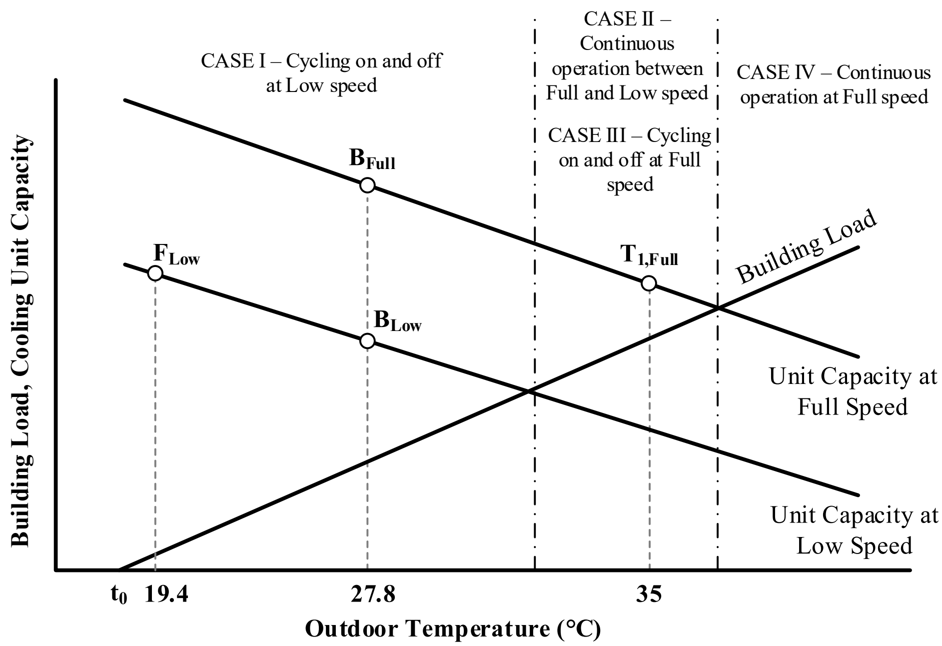

Figure 3. Two-speed System Operation in the Cooling Mode – T1 Climate

Note: See Table 8 for required tests.

The estimated building load for each bin temperature shall be calculated using Equation 11.29.

The calculated low stage system capacity rate at each bin temperature shall be calculated by Equation 11.41.

$$\dot{q}_{Low}(t_j) = \dot{q}_{F,Low} + \left\{\frac{\dot{q}_{B,Low} - \dot{q}_{F,Low}}{27.8 - 19.4}\right\} \cdot (t_j - 19.4) \qquad 11.41$$

The calculated low stage energy consumption at each bin temperature shall be calculated by Equation 11.42.

$$P_{Low}(t_j) = P_{F,Low} + \left\{\frac{P_{B,Low} - P_{F,Low}}{27.8 - 19.4}\right\} \cdot (t_j - 19.4) \qquad 11.42$$

The calculated high stage system capacity at each bin temperature shall be calculated by Equation 11.43.

$$\dot{q}_{Full}(t_j) = \dot{q}_{B,Full} + \left\{\frac{\dot{q}_{T1,Full} - \dot{q}_{B,Full}}{35 - 27.8}\right\} \cdot (t_j - 27.8) \qquad 11.43$$

The calculated high stage energy consumption at each bin temperature shall be calculated by Equation 11.44.

$$P_{Full}(t_j) = P_{B,Full} + \left\{\frac{P_{T1,Full} - P_{B,Full}}{35 - 27.8}\right\} \cdot (t_j - 27.8) \qquad 11.44$$

11.2.1.2.1. *Case I. Building load is less than low stage capacity,* $BL(t_j) \leq \dot{q}_{Low}(t_j)$. Calculate total bin capacity by using Equation 11.45 and total bin energy by using Equation 11.46.

$$\dot{q}(t_j) = CLF^{Low}(t_j) \cdot \dot{q}_{Low}(t_j) \cdot n_j \qquad 11.45$$

$$E(t_j) = \frac{CLF^{Low}(t_j) \cdot P_{Low}(t_j) \cdot n_j}{PLF^{Low}(t_j)} \quad 11.46$$

Where:

$$CLF^{Low}(t_j) = \frac{BL(t_j)}{\dot{q}_{Low}(t_j)} \quad 11.47$$

$$PLF^{Low}(t_j) = 1 - C_D^{c,Low} \cdot \left[1 - CLF^{Low}(t_j)\right] \quad 11.48$$

$$C_D^{c,Low} = \frac{\left\{1 - \frac{EER_{D,Low}}{EER_{C,Low}}\right\}}{1 - CLF^{cyc,Low}} \quad 11.49$$

Where:

$$CLF^{cyc,Low} = \frac{q_{cyc,D,Low}}{(\dot{q}_{C,Low} \cdot \theta_{cyc})} \quad 11.50$$

If the optional Tests C and D (refer to Table 8) are not performed, or the calculated result for $C_D^{c,Low}$ is greater than the default value of Section 6.1.3.1, the default value shall be used.

11.2.1.2.2. Case II. Building load is greater than the low stage capacity, but less than the high stage capacity, $\dot{q}_{Low}(t_j) < BL(t_j) \leq \dot{q}_{Full}(t_j)$ and the unit cycles between low stage operation and high stage operation. Calculate total bin capacity by using Equation 11.51 and total bin energy by using Equation 11.52.

$$\dot{q}(t_j) = [CLF^{Low} \cdot \dot{q}_{Low}(t_j) + CLF^{Full} \cdot \dot{q}_{Full}(t_j)] \cdot n_j \quad 11.51$$

$$E(t_j) = [CLF^{Low} \cdot P_{Low}(t_j) + CLF^{Full} \cdot P_{Full}(t_j)] \cdot n_j \quad 11.52$$

Where:

$$CLF^{Low} = \frac{\dot{q}_{Full}(t_j) - BL(t_j)}{\dot{q}_{Full}(t_j) - \dot{q}_{Low}(t_j)} \quad 11.53$$

$$CLF^{Full} = 1 - CLF^{Low} \quad 11.54$$

11.2.1.2.3. *Case III. Building load is greater than the low stage capacity*, but less than the high stage capacity, $\dot{q}_{Low}(t_j) < BL(t_j) \leq \dot{q}_{Full}(t_j)$ and the unit cycles between off and high stage operation. Calculate total bin capacity by using Equation 11.55 and total bin energy by using Equation 11.56.

$$\dot{q}(t_j) = CLF^{Full} \cdot \dot{q}_{Full}(t_j) \cdot n_j \quad 11.55$$

$$E(t_j) = \frac{CLF^{Full} \cdot P_{Full}(t_j) \cdot n_j}{PLF^{Full}} \quad 11.56$$

Where:

$$CLF^{Full} = \frac{BL(t_j)}{\dot{q}_{Full}(t_j)} \quad 11.57$$

$$PLF^{Full} = 1 - C_D^{c,Full} \cdot [1 - CLF^{Full}] \quad 11.58$$

If the optional C_{Full} and D_{Full} Tests (see Table 8) are not conducted, set $C_D^{c,Full}$ equal to the lower of a) the $C_D^{c,Low}$ value calculated as per Equation 11.49; or b) the default value specified in section 6.1.3.1. If this optional test is conducted, set $C_D^{c,Full}$ to the value calculated as per Equation 11.59.

$$C_D^{c,Full} = \frac{\left\{1 - \frac{EER_{D,Full}}{EER_{C,Full}}\right\}}{1 - CLF^{cyc,Full}} \quad 11.59$$

Where $CLF^{cyc,Full}$ is calculated per Equation 11.65.

11.2.1.2.4. *Case IV. Building load is greater than or equal to the unit capacity*, $BL(t_j) > \dot{q}_{Full}(t_j)$. Calculate total bin capacity by using Equation 11.60 and total bin energy by using Equation 11.61.

$$\dot{q}(t_j) = \dot{q}_{Full}(t_j) \cdot n_j \qquad 11.60$$

$$E(t_j) = P_{Full}(t_j) \cdot n_j \qquad 11.61$$

11.2.1.3 *Variable Speed System.* $SEER_{T1}$ for a Variable Speed System shall be calculated using Equation 11.28 where the quantities $\dot{q}(t_j)$ and $E(t_j)$ are calculated for each individual Temperature Bin using the appropriate formula for each bin depending on the operating characteristics of the Variable Speed System as defined in this section. When the building load is less than the unit capacity at low speed use Section 11.2.1.3.1. When the building load is greater than the unit capacity at low speed, but less than the unit capacity at full speed, use Section 11.2.1.3.2. When the building load is greater than the unit capacity at full speed use Section 11.2.1.3.3. See Figure 4 for a graphical representation.

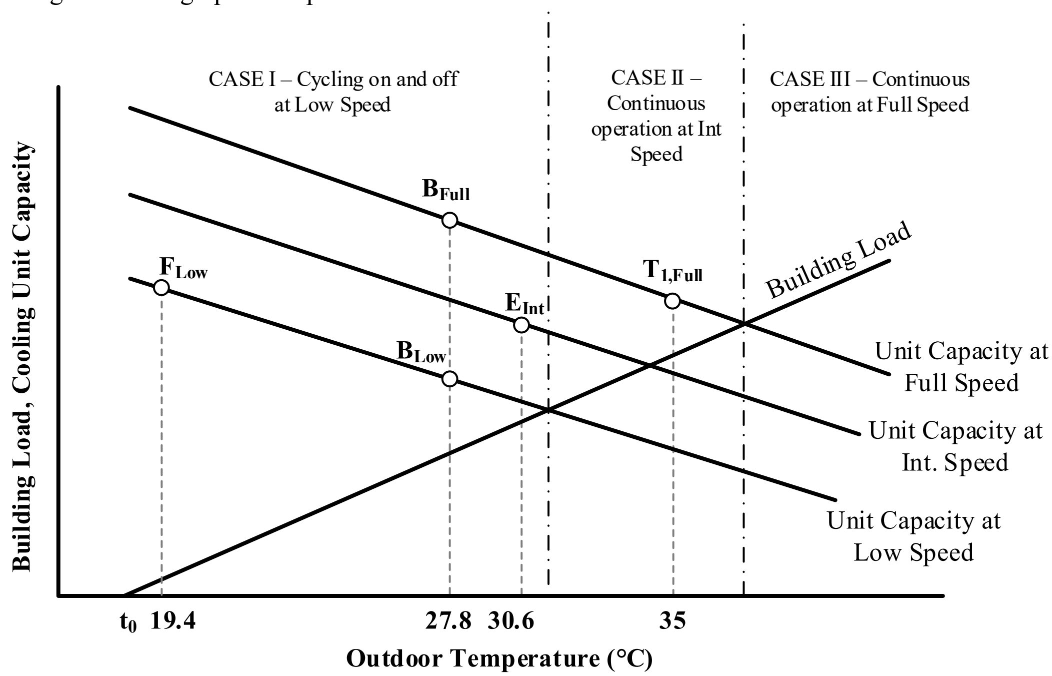

Figure 4. Variable Speed System Operation in the Cooling Mode – T1 Climate

Note: See Table 8 for required tests.

For each bin temperature, the building load, $BL(t_j)$, shall be calculated per Equation 11.29.

The calculated steady state capacity and energy consumption at the Low and Full Compressor Speeds for each bin temperature shall be calculated per Equations 11.41 through 11.44.

The Total Cooling Capacity and energy at an intermediate speed for each bin temperature shall be calculated per Equations 11.62 and 11.63.

$$\dot{q}_{Int-Bin}(t_j) = BL(t_j) \qquad 11.62$$

$$E_{Int-Bin}(t_j) = \frac{\dot{q}_{Int-Bin}(t_j)}{EER_{Int-Bin}(t_j)} \cdot n_j \qquad 11.63$$

Intermediate steady state capacity for each bin temperature, $\dot{q}_{Int}(t_j)$, shall be calculated per Equation 11.64, for Intermediate Compressor Speed capacity rate, power and efficiency.

$$\dot{q}_{Int}(t_j) = \dot{q}_{E,Int} + M_{CQ}[t_j - 30.6] \quad 11.64$$

Where:

$$M_{CQ} = \left[\frac{\dot{q}_{B,Low} - \dot{q}_{F,Low}}{27.8 - 19.4} \cdot (1 - N_{CQ})\right] + \left[N_{CQ} \cdot \frac{\dot{q}_{T1,Full} - \dot{q}_{B,Full}}{35 - 27.8}\right] \quad 11.65$$

$$N_{CQ} = \frac{\dot{q}_{E,Int} - \dot{q}_{Low}(30.6)}{\dot{q}_{Full}(30.6) - \dot{q}_{Low}(30.6)} \quad 11.66$$

$\dot{q}_{Low}(30.6)$ shall be calculated per Equation 11.41.

$\dot{q}_{Full}(30.6)$ shall be calculated per Equation 11.43.

$\dot{q}_{E,Int}$ is determined from the E_{Int} test.

Intermediate steady state power for each bin temperature, $P_{Int}(t_j)$, shall be calculated per Equation 11.67.

$$P_{Int}(t_j) = P_{E,Int} + M_{CE}[t_j - 35] \quad 11.67$$

Where:

$$M_{CE} = \frac{P_{B,Low} - P_{F,Low}}{27.8 - 19.4} \cdot (1 - N_{CE}) + \frac{P_{T1,Full} - P_{B,Full}}{35 - 27.8} \cdot N_{CE} \quad 11.68$$

$$N_{CE} = \frac{P_{E,Int} - P_{Low}(30.6)}{P_{Full}(30.6) - P_{Low}(30.6)} \quad 11.69$$

$P_{Low}(30.6)$ shall be calculated per Equation 11.42.

$P_{Full}(30.6)$ shall be calculated per Equation 11.44.

$P_{E,Int}$ is determined from the E_{Int} test.

Intermediate efficiency, $EER_{Int-Bin}(t_j)$, shall be calculated per Equations 11.70 or 11.71.

For each temperature bin where $\dot{q}_{Low}(t_j) < BL(t_j) < \dot{q}_{Int}(t_j)$,

$$EER_{Int-Bin}(t_j) = EER_{Low}(t_j) + \frac{EER_{Int}(t_j) - EER_{Low}(t_j)}{\dot{q}_{Int}(t_j) - \dot{q}_{Low}(t_j)} \cdot [BL(t_j) - \dot{q}_{Low}(t_j)] \quad 11.70$$

For each temperature bin where $\dot{q}_{Int}(t_j) \leq BL(t_j) < \dot{q}_{Full}(t_j)$,

$$EER_{Int-Bin}(t_j) = EER_{Int}(t_j) + \frac{EER_{Full}(t_j) - EER_{Int}(t_j)}{\dot{q}_{Full}(t_j) - \dot{q}_{Int}(t_j)} \cdot [BL(t_j) - \dot{q}_{Int}(t_j)] \quad 11.71$$

Where:

$EER_{Low}(t_j)$ is the steady-state Energy Efficiency Ratio of the test unit when operating at minimum compressor speed and temperature t_j, Btu/h per W, calculated using capacity $\dot{q}_{Low}(t_j)$ calculated using Equation 11.41 and electrical power consumption $P_{Low}(t_j)$ calculated using Equation 11.42;

$EER_{Int}(t_j)$ is the steady-state Energy Efficiency Ratio of the test unit when operating at Intermediate Compressor Speed and temperature t_j, Btu/h per W, calculated using capacity $\dot{q}_{Int}(t_j)$ calculated using Equation 11.64 and electrical power consumption $P_{Int}(t_j)$ calculated using Equation 11.67; i.e.,

$$EER_{Int}(t_j) = \frac{\dot{q}_{Int}(t_j)}{P_{Int}(t_j)} \quad 11.72$$

$EER_{Full}(t_j)$ is the steady-state Energy Efficiency Ratio of the test unit when operating at full compressor speed and temperature t_j, Btu/h per W, calculated using capacity $\dot{q}_{Full}(t_j)$ calculated using Equation 11.43 and electrical power consumption $P_{Full}(t_j)$ calculated using Equation 11.44.

11.2.1.3.1. *Case I. Building load is no greater than unit capacity at low speed,* $BL(t_j) \leq \dot{q}_{Low}(t_j)$. Equations from Section 11.2.1.2.1 shall be used to calculate capacity and energy consumption for each bin temperature using Equations 11.45 and 11.46 for the calculated system capacity and energy consumption at the Low Compressor Speed for each bin temperature and calculate $C_D^{c,Low}$ per Equation 11.73.

$$C_D^{c,Low} = \frac{\left\{1 - \frac{EER_{I,Low}}{EER_{G,Low}}\right\}}{1 - CLF^{cyc,Low}} \qquad 11.73$$

Use Equation 11.50 to calculate $CLF^{cyc,Low}$ except substitute Tests G and I for Test C and D. If the optional Tests G and I (refer to Table 8) are not performed, or the calculated result for $C_D^{c,Low}$ is greater than the default value of Section 6.1.3.1, the default value shall be used.

11.2.1.3.2. *Case II. Building load can be matched by modulating the compressor speed between low speed and full speed,* $\dot{q}_{Low}(t_j) < BL(t_j) \leq \dot{q}_{Full}(t_j)$. Use Equations 11.62 and 11.63 to calculate the Total Cooling Capacity and energy calculations for each bin.

11.2.1.3.3. *Case III. Building load is equal to or greater than unit capacity at full stage.* $BL(t_j) > \dot{q}_{Full}(t_j)$. Use the equations in Section 11.2.1.2.4 to calculate the Total Cooling Capacity and energy for each bin.

11.2.2. *$SEER_{T3/4}$* for Hot Climates.

11.2.2.1 *T3/4 (Hot Climates) outdoor bin temperature and cooling hours*. $SEER_{T3/4}$ calculations for hot climate conditions require user defined climate or region-specific bin numbers, outdoor bin temperatures, and respective cooling hours. All calculations in this section must use measured values at either T3 or T4 test conditions, but not both of them in a single SEER2 computation. An example set of these values is shown in Table 13 and Table 14 below.

Table 13. Fractional Bin Hours to Be Used in Calculation of $SEER_{T3}$ (T3 Example)		
Bin Number (j)	Bin Temperature (t_j), °C	Fractional Bin Hours (n_j)
1	20	0.00000
2	21	0.03173
3	22	0.03316
4	23	0.03339
5	24	0.03731
6	25	0.03672
7	26	0.04052
8	27	0.04242
9	28	0.04349
10	29	0.04884
11	30	0.05169
12	31	0.05514
13	32	0.05954
14	33	0.05847
15	34	0.05419
16	35	0.04848
17	36	0.04694
18	37	0.04278
19	38	0.04242
20	39	0.03981
21	40	0.03862
22	41	0.03446
23	42	0.02852
24	43	0.02377
25	44	0.01545
26	45	0.00927
27	46	0.00285
28	47	0.00000
29	48	0.00000
30	49	0.00000
31	50	0.00000

Table 14. Fractional Bin Hours to Be Used in Calculation of $SEER_{T4}$ (T4 Example)		
Bin Number (j)	Bin Temperature (t_j), °C	Fractional Bin Hours (n_j)
1	19	0.107
2	22	0.105
3	25	0.102
4	28	0.127
5	31	0.132
6	33	0.107
7	36	0.085
8	39	0.072
9	42	0.074
10	44	0.061
11	47	0.025
12	50	0.003

11.2.2.2 *Degradation Coefficient (C_D^c).* For the T3 or T4 Climate $SEER_{T3/4}$ calculation, a default Degradation Coefficient (C_D^c) is set to 0.27 when the optional cyclic tests are not conducted.

11.2.2.3 *Single Stage System*. $SEER_{T3/4}$ for a Single Stage System shall be calculated per Equation 11.74.

$$SEER_{T3/4} = \frac{\sum_{j=1} q(t_j)}{\sum_{j=1} E(t_j)} \tag{11.74}$$

The quantities $\dot{q}(t_j)$ and $E(t_j)$ are calculated for each individual Temperature Bin using the appropriate formula for each bin depending on the operating characteristics of the system. Bin temperatures and bin hours can be used for T3 or T4 (Hot Climates) Conditions by referring to the Section 11.2.2.1 (see example). When the building load is less than or equal to full load cooling capacity use Section 11.2.2.3.1 When the building load is greater than the full load cooling capacity use Section 11.2.2.3.2. See Figure 5 for a graphical representation.

The estimated building load for each bin temperature shall be calculated using Equation 11.75 and 11.76

$$BL(t_j) = \left(\frac{t_j - t_0}{46 - t_0}\right) \cdot \left(\frac{\dot{q}_{T3,Full}}{SF}\right) \quad for\ T3\ test\ condition \tag{11.75}$$

$$BL(t_j) = \left(\frac{t_j - t_0}{48 - t_0}\right) \cdot \left(\frac{\dot{q}_{T4,Full}}{SF}\right) \quad for\ T4\ test\ condition \tag{11.76}$$

Where:
t_0 = the outdoor temperature that the building load falls into zero. For instance, when Table 13 or Table 14 is used for cooling bin temperatures and bin hours t_0 = 19°C

$q_{T3,Full}$ = the full load cooling capacity determined from the T3 (Hot Climates) Standard Temperature Conditions (46°C DB & 24°C WB).
$q_{T4,Full}$ = the full load cooling capacity determined from the T4 (Hot Climates) Standard Temperature Conditions (48°C DB & 24°C WB).

$$SF = 1.1 \tag{11.77}$$

The calculated high stage system capacity at each bin temperature shall be calculated by Equation 11.78 (T3) or 11.79 (T4).

$$\begin{pmatrix} \dot{q}_{Full}(t_j) = \dot{q}_{T1,Full} + \frac{\dot{q}_{T3,Full} - \dot{q}_{T1,Full}}{46-35} \cdot (t_j - 35) \;\; for\; t_j \geq 35°C \\ \dot{q}_{Full}(t_j) = \dot{q}_{B,Full} + \frac{\dot{q}_{T1,Full}(95) - \dot{q}_{B,Full}}{35-27.8} \cdot (t_j - 27.8) \;\; for\; t_j < 35°C \end{pmatrix} for\; T3 \qquad 11.78$$

$$\begin{pmatrix} \dot{q}_{Full}(t_j) = \dot{q}_{T1,Full} + \frac{\dot{q}_{T4,Full} - \dot{q}_{T1,Full}}{48-35} \cdot (t_j - 35) \;\; for\; t_j \geq 35°C \\ \dot{q}_{Full}(t_j) = \dot{q}_{B,Full} + \frac{\dot{q}_{T1,Full}(95) - \dot{q}_{B,Full}}{35-27.8} \cdot (t_j - 27.8) \;\; for\; t_j < 35°C \end{pmatrix} for\; T4 \qquad 11.79$$

The calculated high stage energy consumption at each bin temperature shall be calculated by Equation 11.80 (T3) or 11.81 (T4).

$$\begin{pmatrix} P_{Full}(T_j) = P_{T1,Full} + \frac{P_{T3,Full} - P_{T1,Full}}{46-35} \cdot (t_j - 35) \;\; for\; t_j \geq 35°C \\ P_{Full}(T_j) = P_{B,Full} + \frac{P_{T1,Full} - P_{B,Full}}{35-27.8} \cdot (t_j - 27.8) \;\; for\; t_j < 35°C \end{pmatrix} for\; T3 \qquad 11.80$$

$$\begin{pmatrix} P_{Full}(T_j) = P_{T1,Full} + \frac{P_{T4,Full} - P_{T1,Full}}{48-35} \cdot (t_j - 35) \;\; for\; t_j \geq 35°C \\ P_{Full}(T_j) = P_{B,Full} + \frac{P_{T1,Full} - P_{B,Full}}{35-27.8} \cdot (t_j - 27.8) \;\; for\; t_j < 35°C \end{pmatrix} for\; T4 \qquad 11.81$$

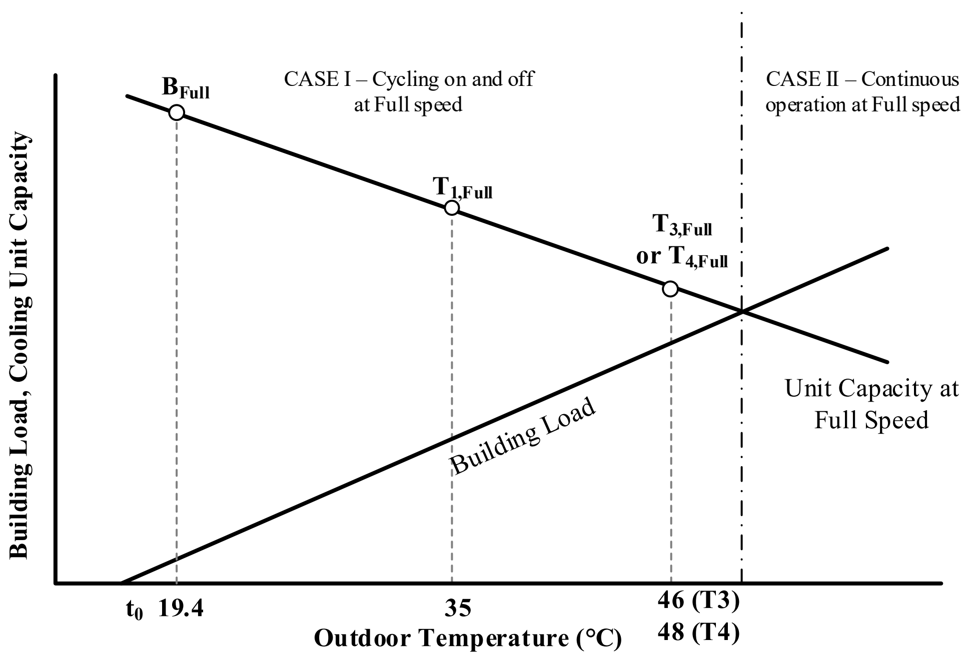

Figure 5. Single-speed System Operation in the Cooling Mode – Hot Climate

Note: See Table 9 for required tests.

11.2.2.3.1. *Case I. Building load is less than full load cooling capacity,* $BL(t_j) \leq \dot{q}_{Full}(t_j)$. Calculate total bin capacity by using Equation 11.82 and total bin energy by using Equation 11.83.

$$q(t_j) = CLF(t_j) \cdot \dot{q}_{Full}(t_j) \cdot n_j \qquad 11.82$$

$$E(t_j) = \frac{CLF(t_j) \cdot P_{Full}(t_j) \cdot n_j}{PLF(t_j)} \qquad 11.83$$

Where:

$$CLF(t_j) = \frac{BL(t_j)}{\dot{q}_{Full}(t_j)} \qquad 11.84$$

$$PLF(t_j) = 1 - C_D^c \cdot [1 - CLF(t_j)] \tag{11.85}$$

$$C_D^c = \frac{\left\{1 - \frac{EER_{D,Full}}{EER_{C,Full}}\right\}}{1 - CLF^{cyc,Full}} \tag{11.86}$$

Where:

$$CLF^{cyc,Full} = \frac{q_{cyc,D,Full}}{(\dot{q}_{C,Full} \cdot \theta_{cyc})} \tag{11.87}$$

If the optional Tests C and D (refer to Table 9) are not performed, or the calculated result for C_D^c is greater than the default value of 0.27 for T3/4 Conditions, the default value shall be used.

11.2.2.3.2. *Case II. Building load is greater than or equal to the unit capacity*, $BL(t_j) > \dot{q}_{Full}(t_j)$. Calculate total bin capacity by using Equation 11.88 and total bin energy by using Equation 11.89.

$$q(t_j) = \dot{q}_{Full}(t_j) \cdot n_j \tag{11.88}$$

$$E(t_j) = P_{Full}(t_j) \cdot n_j \tag{11.89}$$

11.2.2.4 *Two-stage System.* $SEER_{T3/4}$ for a Two-stage System shall be calculated by Equation 11.74.

When the building load is less than low stage capacity use Section 11.2.2.4.1. When the building load is greater than the low stage capacity, but less than the high stage capacity, either Section 11.2.2.4.2 or 11.2.2.4.3 is used, depending on the operating characteristics of the system. When the building load is greater than the unit capacity use Section 11.2.2.4.4. See Figure 6 for a graphical representation.

The estimated building load for each bin temperature shall be calculated using Equation 11.75 (T3) or 11.76 (T4) in Section 11.2.2.3.

The calculated low stage system capacity rate at each bin temperature shall be calculated by Equations 11.78 (T3) or 11.79 (T4).

When an optional F_{Low} Test is conducted:

$$\begin{pmatrix} \dot{q}_{Low}(t_j) = \dot{q}_{B,Low} + \frac{\dot{q}_{T1,Low} - \dot{q}_{B,Low}}{35 - 27.8} \cdot (t_j - 27.8) \; for \; t_j \geq 27.8°C \\ \dot{q}_{Low}(t_j) = \dot{q}_{F,Low} + \frac{\dot{q}_{B,Low} - \dot{q}_{F,Low}}{27.8 - 19.4} \cdot (t_j - 19.4) \; for \; t_j < 27.8°C \end{pmatrix} \tag{11.90}$$

When an optional F_{Low} Test is not conducted:

$$\dot{q}_{Low}(t_j) = \dot{q}_{B,Low} + \frac{\dot{q}_{T1,Low} - \dot{q}_{B,Low}}{35 - 27.8} \cdot (t_j - 27.8) \; for \; all \; t_j \tag{11.91}$$

The calculated low stage energy consumption at each bin temperature shall be calculated by Equations 11.92 or 11.93.

When an optional F_{Low} Test is conducted:

$$\begin{pmatrix} P_{Low}(t_j) = P_{B,Low} + \frac{P_{T1,Low} - P_{B,Low}}{35 - 27.8} \cdot (t_j - 27.8) \; for \; t_j \geq 27.8°C \\ P_{Low}(t_j) = P_{F,Low} + \frac{P_{B,Low} - P_{F,Low}}{27.8 - 19.4} \cdot (t_j - 19.4) \; for \; t_j < 27.8°C \end{pmatrix} \tag{11.92}$$

When an optional F_{Low} Test is not conducted:

$$P_{Low}(t_j) = P_{B,Low} + \frac{P_{T1,Low} - P_{B,Low}}{35 - 27.8} \cdot (t_j - 27.8) \; for \; all \; t_j \tag{11.93}$$

The calculated high stage system capacity at each bin temperature shall be calculated by Equation 11.94 (T3) or 11.95 (T4).

$$\dot{q}_{Full}(t_j) = \dot{q}_{T1,Full} + \frac{\dot{q}_{T3,Full} - \dot{q}_{T1,Full}}{46 - 35} \cdot (t_j - 35) \; for \; T3 \tag{11.94}$$

$$\dot{q}_{Full}(t_j) = \dot{q}_{T1,Full} + \frac{\dot{q}_{T4,Full} - \dot{q}_{T1,Full}}{48 - 35} \cdot (t_j - 35) \; for \; T4 \tag{11.95}$$

The calculated high stage energy consumption at each bin temperature shall be calculated by Equation 11.96 (T3) or 11.97 (T4).

$$P_{Full}(T_j) = P_{T1,Full} + \frac{P_{T3,Full}-P_{T1,Full}}{46-35} \cdot (t_j - 35)\ for\ T3 \quad 11.96$$

$$P_{Full}(T_j) = P_{T1,Full} + \frac{P_{T4,Full}-P_{T1,Full}}{48-35} \cdot (t_j - 35)\ for\ T4 \quad 11.97$$

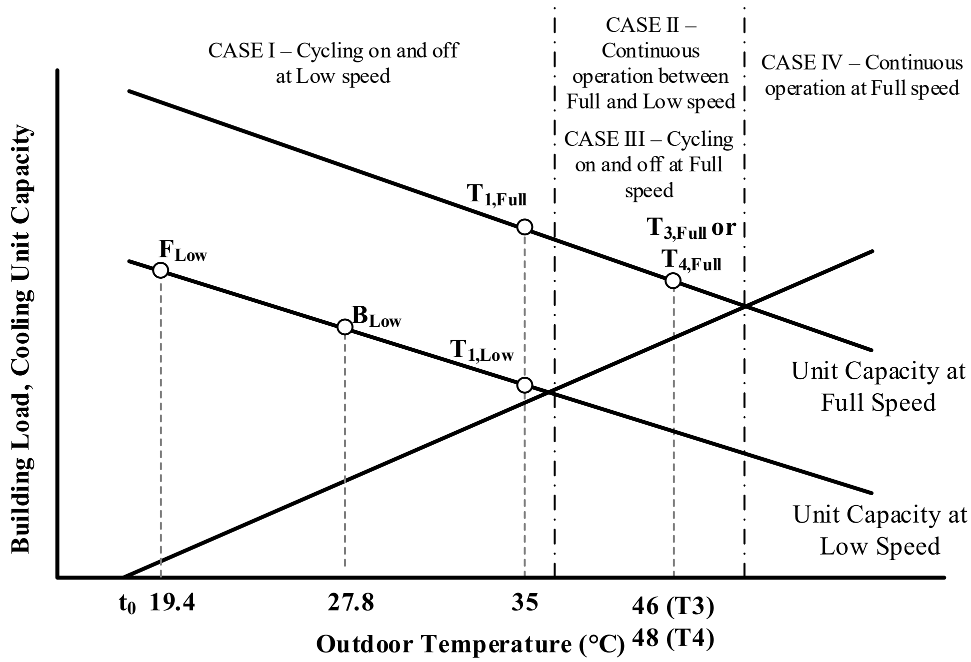

Figure 6. Two-speed System Operation in the Cooling Mode – Hot Climate

Note: See Table 9 for required tests.

11.2.2.4.1. *Case I. Building load is less than low stage capacity,* $BL(t_j) \leq \dot{q}_{Low}(t_j)$. Calculate total bin capacity by using Equation 11.98 and total bin energy by using Equation 11.99.

$$\dot{q}(t_j) = CLF^{Low}(t_j) \cdot \dot{q}_{Low}(t_j) \cdot n_j \quad 11.98$$

$$E(t_j) = \frac{CLF^{Low}(t_j) \cdot P_{Low}(t_j) \cdot n_j}{PLF^{Low}(t_j)} \quad 11.99$$

Where:

$$CLF^{Low}(t_j) = \frac{BL(t_j)}{\dot{q}_{Low}(t_j)} \quad 11.100$$

$$PLF^{Low}(t_j) = 1 - C_D^{c,Low} \cdot [1 - CLF^{Low}(t_j)] \quad 11.101$$

$$C_D^{c,Low} = \frac{\left\{1 - \frac{EER_{D,Low}}{EER_{C,Low}}\right\}}{1 - CLF^{cyc,Low}} \quad 11.102$$

Where:

$$CLF^{cyc,Low} = \frac{q_{cyc,D,Low}}{(\dot{q}_{C,Low} \cdot \theta_{cyc})} \quad 11.103$$

If the optional Tests C and D (refer to Table 9) are not performed, or the calculated result for $C_D^{c,Low}$ is greater than the default value of Section 0.27 for T3/4 Conditions, the default value shall be used.

11.2.2.4.2. Case II. Building load is greater than the low stage capacity, but less than the high stage capacity, $\dot{q}_{Low}(t_j) < BL(t_j) \leq \dot{q}_{Full}(t_j)$ and the unit cycles between low stage operation and high stage operation. Calculate total bin capacity by using Equation 11.104 and total bin energy by using Equation 11.105.

$$\dot{q}(t_j) = [CLF^{Low} \cdot \dot{q}_{Low}(t_j) + CLF^{Full} \cdot \dot{q}_{Full}(t_j)] \cdot n_j \quad 11.104$$

$$E(t_j) = [CLF^{Low} \cdot P_{Low}(t_j) + CLF^{Full} \cdot P_{Full}(t_j)] \cdot n_j \quad 11.105$$

Where:

$$CLF^{Low} = \frac{\dot{q}_{Full}(t_j) - BL(t_j)}{\dot{q}_{Full}(t_j) - \dot{q}_{Low}(t_j)} \quad 11.106$$

$$CLF^{Full} = 1 - CLF^{Low} \quad 11.107$$

11.2.2.4.3. Case III. Building load is greater than the low stage capacity, but less than the high stage capacity, $\dot{q}_{Low}(t_j) < BL(t_j) \leq \dot{q}_{Full}(t_j)$ and the unit cycles between off and high stage operation. Calculate total bin capacity by using Equation 11.108 and total bin energy by using Equation 11.109.

$$\dot{q}(t_j) = CLF^{Full} \cdot \dot{q}_{Full}(t_j) \cdot n_j \quad 11.108$$

$$E(t_j) = \frac{CLF^{Full} \cdot P_{Full}(t_j) \cdot n_j}{PLF^{Full}} \quad 11.109$$

Where:

$$CLF^{Full} = \frac{BL(t_j)}{\dot{q}_{Full}(t_j)} \quad 11.110$$

$$PLF^{Full} = 1 - C_D^{c,Full} \cdot [1 - CLF^{Full}] \quad 11.111$$

If the optional C_{Full} and D_{Full} Tests (see Table 9) are not conducted, set $C_D^{c,Full}$ equal to the lower of a) the $C_D^{c,Low}$ value calculated as per Equation 11.102; or b) the default value of 0.27 for T3/4 Conditions. If these optional tests are conducted, set $C_D^{c,Full}$ to the value calculated as per Equation 11.112.

$$C_D^{c,Full} = \frac{\left\{1 - \frac{EER_{D,Full}}{EER_{C,Full}}\right\}}{1 - CLF^{cyc,Full}} \quad 11.112$$

Where:

$$CLF^{cyc,Full} = \frac{q'_{cyc,D,Full}}{(\dot{q}_{C,Full} \cdot \theta_{cyc})} \quad 11.113$$

11.2.2.4.4. Case IV. Building load is greater than or equal to the unit capacity, $BL(t_j) > \dot{q}_{Full}(t_j)$. Calculate total bin capacity by using Equation 11.114 and total bin energy by using Equation 11.115.

$$q(t_j) = \dot{q}_{Full}(t_j) \cdot n_j \quad 11.114$$

$$E(t_j) = P_{Full}(t_j) \cdot n_j \quad 11.115$$

11.2.2.5 *Variable Speed System.* $SEER_{T3/4}$ for a Variable Speed System shall be calculated using Equation 11.74 where the quantities $\dot{q}(t_j)$ and $E(t_j)$ are calculated for each individual Temperature Bin using the appropriate formula for each bin depending on the operating characteristics of the Variable Speed System as defined in this section. When the building load is less than the unit capacity at low speed use Section 11.2.2.5.1. When the building load is greater than the unit capacity at low speed, but less than the unit capacity at full speed, use Section 11.2.2.5.2. When the building load is greater than the unit capacity at full speed use Section 11.2.2.5.3. See Figure 7 for a graphical representation.

For each bin temperature, the building load, $BL(t_j)$, shall be calculated per Equation 11.75 (T3) or 11.76 (T4).

The calculated steady state capacity and energy consumption at the Low and Full Compressor Speed for each bin temperature shall be calculated per Equations 11.90 through 11.97 in Section 11.2.2.4.

The Total Cooling Capacity and energy at an intermediate speed for each bin temperature shall be calculated per Equations 11.116 and 11.117.

$$\dot{q}_{Int-Bin}(t_j) = BL(t_j) \quad 11.116$$

$$E_{Int-Bin}(t_j) = \frac{\dot{q}_{Int-Bin}(t_j)}{EER_{Int-Bin}(t_j)} \cdot n_j \quad 11.117$$

Intermediate steady state capacity for each bin temperature, $\dot{q}_{Int}(t_j)$, shall be calculated per Equation 11.118, for Intermediate Compressor Speed capacity rate, power and efficiency.

$$\dot{q}_{Int}(t_j) = \dot{q}_{T1,Int} + M_{CQ}[t_j - 35] \quad 11.118$$

Where:

$$M_{CQ} = \left[\frac{\dot{q}_{T1,Low} - \dot{q}_{B,Low}}{35-27.8} \cdot (1 - N_{CQ})\right] + \left[N_{CQ} \cdot \frac{\dot{q}_{T3,Full} - \dot{q}_{T1,Full}}{46-35}\right] \; for\ T3 \quad 11.119$$

$$M_{CQ} = \left[\frac{\dot{q}_{T1,Low} - \dot{q}_{B,Low}}{35-27.8} \cdot (1 - N_{CQ})\right] + \left[N_{CQ} \cdot \frac{\dot{q}_{T4,Full} - \dot{q}_{T1,Full}}{48-35}\right] \; for\ T4 \quad 11.120$$

$$N_{CQ} = \frac{\dot{q}_{T1,Int} - \dot{q}_{T1,Low}}{\dot{q}_{T1,Full} - \dot{q}_{T1,Low}} \quad 11.121$$

$\dot{q}_{T1,Full}$, $\dot{q}_{T1,Int}$, and $\dot{q}_{T1,Low}$ are determined from $T_{1,Full}$, $T_{1,Int}$, and $T_{1,Low}$ tests, respectively.
Intermediate steady state power for each bin temperature, $P_{Int}(t_j)$, shall be calculated per Equation 11.1122.

$$P_{Int}(t_j) = P_{T1,Int} + M_{CE}[t_j - 35] \quad 11.122$$

Where:

$$M_{CE} = \left[\frac{P_{T1,Low} - P_{B,Low}}{35-27.8} \cdot (1 - N_E)\right] + \left[N_{CE} \cdot \frac{P_{T3,Full} - P_{T1,Full}}{46-35}\right] \; for\ T3 \quad 11.123$$

$$M_{CE} = \left[\frac{P_{T1,Low} - P_{B,Low}}{35-27.8} \cdot (1 - N_E)\right] + \left[N_{CE} \cdot \frac{P_{T4,Full} - P_{T1,Full}}{48-35}\right] \; for\ T4 \quad 11.124$$

$$N_{CE} = \frac{P_{T1,Int} - P_{T1,Low}}{P_{T1,Full} - P_{T1,Low}} \quad 11.125$$

Intermediate efficiency, $EER_{Int-Bin}(t_j)$, shall be calculated per Equations 11.126 and 11.127.

For each temperature bin where $\dot{q}_{Low}(t_j) < BL(t_j) < \dot{q}_{Int}(t_j)$,

$$EER_{Int-Bin}(t_j) = EER_{Low}(t_j) + \frac{EER_{Int}(t_j) - EER_{Low}(t_j)}{\dot{q}_{Int}(t_j) - \dot{q}_{Low}(t_j)} \cdot \left[BL(t_j) - \dot{q}_{Low}(t_j)\right] \quad 11.126$$

For each temperature bin where $\dot{q}_{Int}(t_j) \le BL(t_j) < \dot{q}_{Full}(t_j)$,

$$EER_{Int-Bin}(t_j) = EER_{Int}(t_j) + \frac{EER_{Full}(t_j) - EER_{Int}(t_j)}{\dot{q}_{Full}(t_j) - \dot{q}_{Int}(t_j)} \cdot \left[BL(t_j) - \dot{q}_{Int-Bin}(t_j)\right] \quad 11.127$$

Where:

$EER_{Low}(t_j)$ is the steady-state Energy Efficiency Ratio of the test unit when operating at minimum compressor speed and temperature t_j, Btu/h per W, calculated using capacity $\dot{q}_{Low}(t_j)$ calculated using Equation 11.90 or 11.91, whichever applicable, and electrical power consumption $P_{Low}(t_j)$ calculated using Equation 11.92 or 11.93, whichever applicable;

$EER_{Int}(t_j)$ is the steady-state Energy Efficiency Ratio of the test unit when operating at Intermediate Compressor Speed and temperature t_j, Btu/h per W, calculated using capacity $\dot{q}_{Int}(t_j)$ calculated using Equation 11.118 and electrical power consumption $P_{Int}(t_j)$ calculated using Equation 11.122; i.e.,

$$EER_{Int-Bin}(t_j) = \frac{\dot{q}_{Int-Bin}(t_j)}{P_{Int-Bin}(t_j)} \qquad 11.128$$

$EER_{Full}(t_j)$ is the steady-state Energy Efficiency Ratio of the test unit when operating at full compressor speed and temperature t_j, Btu/h per W, calculated using capacity $\dot{q}_{Full}(t_j)$ calculated using Equation 11.94 (T3) or 11.95 (T4) and electrical power consumption $P_{Full}(t_j)$ calculated using Equation 11.96 (T3) or 11.97 (T4).

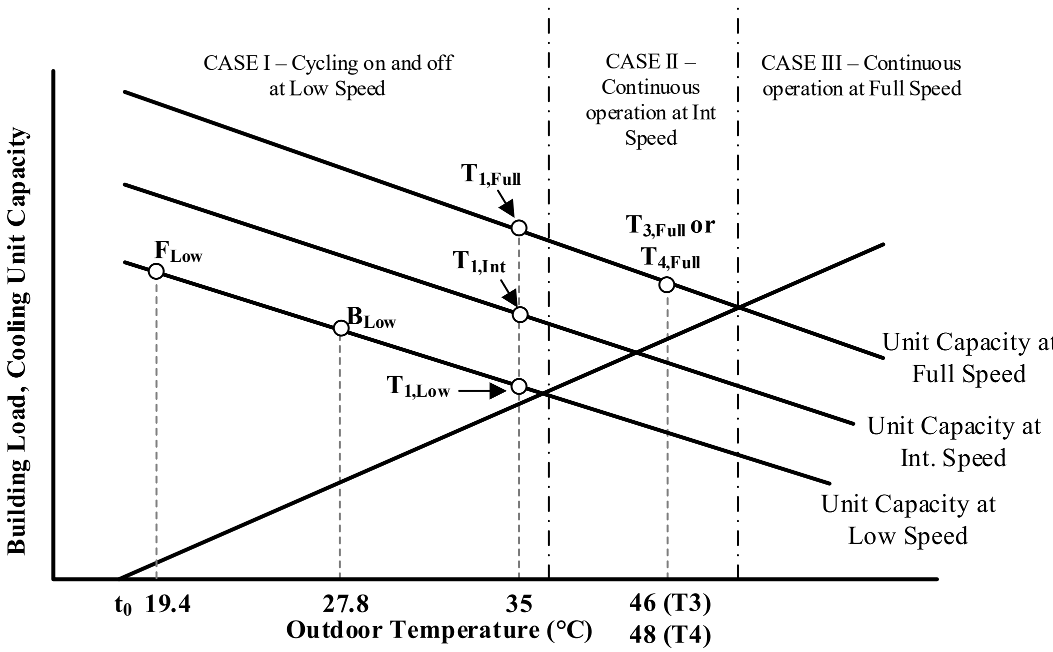

Figure 7. Variable Speed System Operation in the Cooling Mode – Hot Climate

Note: See Table 9 for required tests.

11.2.2.5.1. *Case I. Building load is less than unit capacity at low speed,* $BL(t_j) \le \dot{q}_{Low}(t_j)$. Equations from Section 11.2.2.3.1 shall be used to calculate capacity and energy consumption for each bin temperature using Equations 11.82 and 11.83 for the calculated system capacity and energy consumption at the Low Compressor Speed for each bin temperature and calculate $C_D^{c,Low}$ per Equation 11.122.

$$C_D^{c,Low} = \frac{\left\{1 - \frac{EER_{I,Low}}{EER_{G,Low}}\right\}}{1 - CLF^{cyc,Low}} \qquad 11.129$$

Use Equation 11.103 to calculate $CLF^{cyc,low}$ except substitute Tests G and I for Test C and D. If the optional Tests G and I (refer to Table 9) are not performed, or the calculated result for $C_D^{c,Low}$ is greater than the default value of 0.27, the default value shall be used.

11.2.2.5.2. *Case II - Building load can be matched by modulating the compressor speed between low speed and full speed,* $\dot{q}_{Low}(t_j) < BL(t_j) < \dot{q}_{Full}(t_j)$. Use Equations 11.116 and 11.117 to calculate the Total Cooling Capacity and energy calculations for each bin.

11.2.2.5.3. *Case III - Building load is equal to or greater than unit capacity at full stage.* $BL(t_j) \geq \dot{q}_{Full}(t_j)$. Use the equations in Section 11.2.2.4.4 to calculate the Total Cooling Capacity and energy for each bin.

Section 12. Symbols, Subscripts and Superscripts

12.1. Symbols,

$BL(t_j)$	Building load at bin temperature t_j, kW
c_{pa}	Specific heat of air, kJ/kg·K
c_{pa2}	Specific heat of air leaving the indoor side, kJ/kg·K
c_{pa4}	Specific heat of air leaving the outdoor side, kJ/kg·K
c_{pm}	Specific heat of thermal storage device, kJ/kg·K
C_D	The Degradation Coefficient to account for cycling of the compressor for capacity less than the minimum step of capacity
$C_D^{c,x}$	Cooling Degradation Coefficient, where x equals "Full" or "Low"
$CLF^x(t_j)$	Cooling load factor for condition *x,* where *x* is blank, "cyc," "Full" or "Low"*,* at temperature t_j,
$E_x(t_j)$	Total bin energy for test *x*, W·h, where *x* is blank, "Full" or "Low"
$E_{fan,x}$	Electrical energy used by the indoor fan for test *x*, W·h
$E_{m,x}$	Electrical energy consumed during test *x* as directly measured by instrumentation, W·h
$E_{cyc,x}$	Total electrical energy consumed for test *x*, W·h
$Ec_{adj,x}$	Electrical energy adjusted calculated for Cyclic Test x, W·h
EER_x	Energy Efficiency Ratio for test *x*, W/W
$EER_x(y)$	Energy Efficiency Ratio for condition *x*, at *y*, where *y* can be t_j, t_I, t_{II}, etc., W/W
ESP_1	Lowest external static pressure where the unit is run with stability, kPa
ESP_2	Higher measured external static pressure, kPa
ESP_{FL}	External static pressure at full load airflow, kPa, as specified in Table 11
ESP_{min}	Target or minimum external static pressure, kPa
$E_{tot,x}$	The energy used during Cyclic Tests at test condition *x* in Table 9, W·h
F_{CD}	Cyclic correction factor
F_{CD}^*	Cyclic correction factor applied to the grid or thermopile measurement during the Cyclic Test
F_{CCC}	Cooling capacity correction factor
h_{a1}	Enthalpy, air entering indoor side, kJ/kg
h_{a2}	Enthalpy, air leaving indoor side, kJ/kg
h_{a3}	Enthalpy, air entering outdoor side, kJ/kg
h_{a4}	Enthalpy, air leaving outdoor side, kJ/kg
h_{r1}	Enthalpy, vapor refrigerant indoor side, kJ/kg
h_{r2}	Enthalpy, liquid refrigerant indoor side, kJ/kg
HB_x	Heat balance for test *x*
ID	In door
N_{CE}	A coefficient to calculate compressor variable speed power, a power slope factor
N_{CQ}	A coefficient to calculate compressor variable speed cooling capacity, a capacity slope factor
m_{ts}	Mass of thermal device in indoor airstream, kg
$\dot{m}_{ref,x}$	Mass flow of refrigerant-oil mixture for condition *x*, kg/h
N_{CE}	A coefficient to calculate compressor variable speed power, a power fraction
N_{CQ}	A coefficient to calculate compressor variable speed cooling capacity, a cooling capacity fraction
n_j	Fractional bin hours in the jth Temperature Bin
OD	Out-door
$PLF^x(t_j)$	Part Load Factor for condition *x* at Temperature Bin *j*, where *x* is blank, "Full" or "Low"
P_{adj}	Indoor fan power adjustment, W
$P_{fan,1}$	Measured power input of the indoor fan at external static pressure 1, W
$P_{fan,2}$	Measured power input of the indoor fan at external static pressure 2, W

$P_{fan,x}$	Fan power during test *x*, W
$P_{Int-Bin}$	Intermediate electrical power in a linear relationship, W
$P_{m,x}$	System power measured during test *x*, W
$P_{tot,x}$	Total power for test *x*, W
Px (t_j)	Power at condition *x, W,* at temperature t_j, where *x* is blank, "Full," "Int" or "Low" and t_j is any Temperature Bin
$Ps_{adj,x}$	Power adjustment for steady state test *x*, kW
q_x	Capacity, kJ
$\dot{q}_x$	Rated Net Capacity for Test *x*, kW
$\dot{q}_x$	Indoor capacity for test *x* before any duct or blower adjustments, kW, kW
$\dot{q}_x(t_j)$	Total bin capacity rate for condition *x*, kW, where *x* is blank, "Full" or "Low"
$\dot{q}_{duct,ci}$	Indoor duct loss rate in cooling, kW
$\dot{q}_{Int-Bin}$	Intermediate cooling capacity in a linear relationship, kW
$\dot{q}_{ref,x}$	Total capacity as measured by the refrigerant enthalpy method, kW
$\dot{q}s_{adj,x}$	Capacity adjustment for indoor motor heat during Steady State Test *x*, kW
$\dot{q}_{tci,x}$	Total cooling capacity for test *x*, indoor side data, kW
$\dot{q}_{tco,x}$	Total cooling capacity for test *x*, outdoor side data, kW
$q'_{cyc,x}$	Cooling Cyclic Net Total Capacity for Test *x*, kJ
$q_{cyc,x}$	Corrected Cooling Cyclic Net Total Capacity for Test *x*, kJ
$\dot{q}_{adj}$	Capacity adjustment, kW
$qc_{adj,x}$	Capacity adjustment for indoor motor heat during Cyclic Test x, kW
q_{ts}	Thermal storage capacity, kJ
$\dot{Q}_{A,Full}$	Cooling full airflow rate, m^3/h (Standard Air)
$\dot{Q}_{Full}$	Cooling full airflow rate as measured after setting and/or the adjustment as described in Section 6.1.5.2, m^3/h (Standard Air)
$\dot{Q}_{i,x}$	Airflow Rate for test *i*, m^3/h (Standard Air)
$\dot{Q}_{max}$	Maximum measured airflow value, m^3/h
$\dot{Q}_{mi}$	Airflow, indoor, measured, m^3/h
$\dot{Q}_{mo}$	Airflow, outdoor, measured, m^3/h
$\dot{Q}_{min}$	Minimum measured airflow value, m^3/h
$\dot{Q}_s$	Standard airflow, indoor, m^3/h
Q_{var}	Airflow variance, percent
$SEER_{Tx}$	Seasonal Energy Efficiency Ratio calculated at a defined set of fractional bin hours (Tx), W/W
SF	Sizing factor, by convention
t_0	The outdoor temperature that the building load falls into zero.
t_{a0}	Temperature, outdoor ambient, dry bulb, °C
t_{a1}	Temperature, air entering indoor side, dry bulb, °C
$t_{a1}(\theta)$	Dry-bulb temperature of air entering the indoor coil at elapsed time τ, °C; only recorded when indoor airflow is occurring
t_{a2}	Temperature, air leaving indoor side, dry bulb, °C
$t_{a2}(\theta)$	Dry-bulb temperature of air leaving the indoor coil at elapsed time τ, °C; only recorded when indoor Airflow is occurring
t_{a3}	Temperature, air entering outdoor side, dry bulb, °C
t_{a4}	Temperature, air leaving outdoor side, dry bulb, °C
t_j	Bin reference temperature, °C
t_{m1}	Temperature of the thermal storage device at the beginning of the cycle ON period, °C
t_{m2}	Temperature of the thermal storage device at the end of the cycle ON period, °C
$UA_{ID,ro}$	Product of the overall heat transfer coefficient and surface area for the indoor coil return duct that is located in the outdoor test room, W/(m²·°C)
$UA_{ID,si}$	Product of the overall heat transfer coefficient and surface area for the indoor coil supply duct that is located in the indoor test room, W/(m²·°C)
$UA_{ID,so}$	Product of the overall heat transfer coefficient and surface area for the indoor coil supply duct that is located in the outdoor test room, W/(m²·°C)
v_n	Specific volume of air at dry- and wet-bulb temperature conditions existing at nozzle but at standard barometric pressure, m^3/kg of dry air
v'_n	Specific volume of air at the nozzle, m^3/kg of air-water vapor mixture
W_n	Humidity ratio at the nozzle, kg_{wv}/kg_{da}

x	Mass ratio, refrigerant to refrigerant/oil mixture

12.2. Greek Symbols.

Γ	The integrated (with respect to elapsed time) air temperature difference across the indoor coil, °C·h
θ	Time, hours
θ_{cyc}	Duration of time for one complete cycle consisting of one compressor ON time and one compressor OFF time, hours
θ_1	For Ducted Systems, the elapsed time when airflow is initiated through the Indoor Coil; for Non-ducted Systems, the elapsed time when the compressor is cycled on, h
θ_2	The elapsed time when indoor coil airflow ceases, h
ΔP_{st_x}	Target minimum external static pressure for test x, kPa
$\Delta P_{st_{A,Full}}$	Minimum external static pressure target from A_{Full} test (Table 11), kPa
$\Delta P_{st_{Full}}$	Minimum external static pressure target for test A or A_{Full} (Table 11), kPa
ΔT_{RTD}	Temperature differential between inlet air stream and outlet air stream as measured by RTDs, or equivalent, meeting the accuracy requirements for steady state testing
ΔT_{TC}	Temperature differential between inlet air stream and outlet air stream as measured by thermo couple grid, thermos couple pile, or equivalent, meeting the response requirements for Cyclic Testing

12.3. Subscripts and Superscripts.

adj	Adjustment
a_0	Outdoor ambient
a_1	Air entering Indoor Unit
a_2	Air leaving Indoor Unit
a_3	Air entering Outdoor Unit
a_4	Air leaving Outdoor Unit
B_{Full}	B_{Full} test. See Table 8 and Table 9 for the testing condition.
B_{Low}	B_{Low} test. See Table 8 and Table 9 for the testing condition.
C_{Full}	C_{Full} test. See Table 8 and Table 9 for the testing condition.
C_{Low}	C_{Low} test. See Table 8 and Table 9 for the testing condition.
D_{Full}	D_{Full} test. See Table 8 and Table 9 for the testing condition.
D_{Low}	D_{Low} test. See Table 8 and Table 9 for the testing condition.
E_{Int}	E_{Int} test. See Table 8 and Table 9 for the testing condition.
F_{Low}	F_{Low} test. See Table 8 and Table 9 for the testing condition.
G_{Low}	G_{Low} test. See Table 8 and Table 9 for the testing condition.
I_{Low}	I_{Low} test. See Table 8 and Table 9 for the testing condition.
Tx	Fractional bin hours used to calculate $SEER_{Tx}$ including climate or region-specific bin numbers, outdoor bin temperatures, and respective cooling hours. 'x' refers to the specific set of conditions used. Unless otherwise defined by the user, Table 12 (T1) values shall be used.
cyc	Cyclic
dry	Dry-coil
duct-ci	Indoor duct loss during cooling
Full	Operation/compressor speed at full load test
i	Indoor
ID-ro	Indoor airflow, return side in outdoor room
ID-si	Indoor airflow, supply side in indoor room
ID-so	Indoor airflow, return side in outdoor room
Int	Operation/compressor speed at intermediate speed test
Int-Bin	Operation/compressor speed at part load bin condition
j	Bin number
Low	Operation/compressor speed at low load test
m	Measured
mi	Measured indoor
mo	Measured outdoor
ref	Refrigerant
ss	Steady State
tci	Total cooling indoor

tco	Total cooling outdoor
test	Test
tot	Total
Tx	Specific set of conditions used. Unless otherwise defined by the user, *Tx* shall be used to designate T1, T3 or T4 climate.

APPENDIX A. REFERENCES – NORMATIVE

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

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

A1.2 AHRI Standard 310/380-2017, *Standard for Packaged Terminal Air-Conditioners and Heat Pumps (CSA.C744-17)*, 2017, Air-Conditioning, Heating, and Refrigeration Institute, 2311 Wilson Boulevard, Suite 400, Arlington, VA 22201, U.S.A.

A1.3 ANSI/ASHRAE Standard 37-2009 (RA2015), *Methods of Testing for Rating Electrically Driven Unitary Air-Conditioning and Heat Pump Equipment*, 2009, ASHRAE, 180 Technology Parkway, Peachtree Corners, GA 30092, U.S.A.

A1.4 ANSI/ASHRAE Standard 41.1-2013, *Standard Method for Temperature Measurement*, 2013, ASHRAE, 180 Technology Parkway, Peachtree Corners, GA 30092, U.S.A.

A1.5 ASHRAE Standard 41.2-1987 (RA 1992), *Standard Methods for Laboratory Airflow Measurement*, 1992, ASHRAE, 180 Technology Parkway, Peachtree Corners, GA 30092, U.S.A.

A1.6 ANSI/ASHRAE Standard 41.4-2015, *Standard Method for Measuring the Proportion of Lubricant in Liquid Refrigerant*, 2013, ASHRAE, 180 Technology Parkway, Peachtree Corners, GA 30092, U.S.A.

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

A1.8 ANSI/ASHRAE Standard 41.10-2013, *Standard Methods for Refrigerant Mass Flow Measurement Using Flowmeters*, 2013, ASHRAE, 180 Technology Parkway, Peachtree Corners, GA 30092, U.S.A.

A1.9 ANSI/ASHRAE/AMCA Standard 51-2016, *Laboratory Methods of Testing Fans for Aerodynamic Performance Rating* (ANSI/AMCA Standard 210-16), 2016, ASHRAE, 180 Technology Parkway, Peachtree Corners, GA 30092, U.S.A., Air Movement and Control Association International, Inc., 30 West University Drive, Arlington Heights, Il 60004-1893. U.S.A.

A1.10 ASHRAE Terminology. ASHRAE. Accessed July 23, 2021. https://www.ashrae.org/resources–publications/free-resources/ashrae-terminology.

A1.11 ASTM Standard B117-2016, *Standard Practice for Operating Salt Spray (Fog) Apparatus*, 2011, American Society for Testing and Materials, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA, 19428-2959, USA.

A1.12 ASTM Standard G85-2011, *Standard Practice for Modified Salt Spray (Fog) Testing*, 2011, American Society for Testing and Materials, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA, 19428-2959, USA.

A1.13 IEC Standard 60038, *IEC Standard Voltages*, 2009, International Electrotechnical Commission, 3, rue de Varembe, P.O. Box 131, 1211 Geneva 20, Switzerland.

A1.14 ISO/IEC 17025-2005, *General Requirements for the Competence of Testing and Calibration Laboratories,* 2005, International Organization for Standardization, Case Postale 56, CH-1211, Geneva 21 Switzerland.

A1.15 NIST Standard Reference Database 23, *Reference Fluid Thermodynamic and Transport Properties – REFPROP Version 9.1*, 2010, National Institute of Standards and Technology, 100 Bureau Drive, Gaithersburg, Md. 20899.

A1.16 UL Standard 1995/CSA C22.2 No 236, 2015, Heating and Cooling Equipment, Underwriters Laboratories, Inc., 333 Pfingsten Road, Northbrook, IL, U.S.A.

A1.17 UL Standard 555, *Standard for Fire Dampers,* 2006, Underwriters Laboratories, Inc., 333 Pfingsten Road, Northbrook, IL, U.S.A.

A1.18 UL Standard 555S, *Standard for Smoke Dampers,* 2014, Underwriters Laboratories, Inc., 333 Pfingsten Road, Northbrook, IL, U.S.A.

APPENDIX B. REFERENCES – INFORMATIVE

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

B1.1 AHRI Standard 1230-2014 with Addendum 1, *Performance Rating of Variable Refrigerant Flow (VRF) Multi-Split Air-Conditioning and Heat Pump Equipment*, 2017, Air-Conditioning, Heating, and Refrigeration Institute, 2311 Wilson Boulevard, Suite 400, Arlington, VA 22201, U.S.A.

B1.1.1 AHRI 1230-2014 with Addendum 1 includes air-source mini-splits and multi-splits in the scope.

B1.2 AHRI Standard 340/360-2015, *Performance Rating of Commercial and Industrial Unitary Air-Conditioning and Heat Pump Equipment*, 2015, Air-Conditioning, Heating, and Refrigeration Institute, 2311 Wilson Boulevard, Suite 400, Arlington, VA 22201, U.S.A.

B1.2.1 AHRI340/360-2015 covers Air Source products over 65,000 Btu/h the size limits in the scope of AHRI 211/241.

B1.3 ANSI/AHRI Standard 390-2003, *Performance Rating of Single Package Vertical Air-Conditioners and Heat Pumps*, 2003, Air-Conditioning, Heating, and Refrigeration Institute, 2311 Wilson Boulevard, Suite 400, Arlington, VA 22201, U.S.A.

B1.3.1 ANSI/AHRI Standard 390-2003 covers air-cooled commercial package air conditioning and heating equipment that has major components that are arranged vertically and are relevant to equipment configurations that are not in the scope of AHRI 211/241.

B1.4 AHRI Guideline V, *Calculating the Efficiency of Energy Recovery Ventilation and its Effect on Efficiency and Sizing of Building HVAC Systems*, 2011, Air-Conditioning, Heating, and Refrigeration Institute, 2311 Wilson Boulevard, Suite 400, Arlington, VA 22201, U.S.A.

B1.4.1 AHRI Guideline V applies to unit configurations in Appendix E.

B1.5 ANSI/ASHRAE Standard 90.1-2019, *Energy Standard for Buildings Except Low-Rise Residential Buildings*, 2019, ASHRAE, 180 Technology Parkway, Peachtree Corners, GA 30092, U.S.A.

B1.5.1 ANSI/ASHRAE Standard 90.1-2019 covers hot climates bin hours where T3 or T4 conditions are used for the SEER determination.

B1.6 ANSI/ASHRAE Standard 116-2010 (RA2015), *Methods of Testing for Rating Seasonal Efficiency of Unitary Air Conditioners and Heat Pumps*, 2010, ASHRAE, 1791 Tullie Circle, N.E., Atlanta, GA 30329, U.S.A.

B1.6.1 ANSI/ASHARE Standard 116-2010 provides an example of the cyclic degradation formulation while AHRI 211/241 covers most comprehensive reference for the determination.

B1.7 ASHRAE Handbook - 2017, *Fundamentals*, 2017, ASHRAE, 180 Technology Parkway, Peachtree Corners, GA 30092, U.S.A.

B1.7.1 ASHRAE Handbook – 2017, Fundamentals contains comprehensive information of psychrometrics properties of the air and its relevant formulations for heat transfer rate calculations.

B1.8 ANSI/AHRI/ASHRAE/ISO 13256-1:1998 (R2012), *Water-source heat pumps – Testing and rating for performance – Part 1: Water-to-air and Brine-to-air heat pumps,* 2012, International Organization for Standardization, Case Postale 56, CH-1211, Geneva 21 Switzerland.

B1.8.1 ANSI/AHRI/ASHRAE/ISO 13256-1:1998 (R2012) covers water-source air conditioning and heating equipment and therefore was discussed by the drafting committee as equipment outside the scope of AHRI 211/241.

B1.9 ANSI/AHRI/ASHRAE/ISO Standard 13256-2:1998 (R2012), *Water-source heat pumps – Testing and rating for performance – Part 2: Water-to-water and Brine-to-water heat pumps,* 2012, International Organization for Standardization, Case Postale 56, CH-1211, Geneva 21 Switzerland.

B1.9.1 ANSI/AHRI/ASHRAE/ISO 13256-2:1998 (R2012) covers water-source air conditioning and heating equipment outside the scope of AHRI 211/241.

APPENDIX C. SECONDARY CAPACITY CHECK REQUIREMENTS - NORMATIVE

C1 *Purpose.* The purpose of this appendix is to specify requirements for the outdoor air enthalpy and refrigerant enthalpy secondary capacity checks.

C2 *Scope*.

C2.1 The requirements of this appendix shall apply to all testing of:

C2.1.1 Unitary Small Air-Conditioners which are air-cooled.

C2.1.2 Unitary Small Air-Source Heat Pumps which are air-cooled.

C2.2 The requirements of this appendix are not applicable to Water-cooled or Evaporatively-cooled Air-conditioners.

C3 *Definitions*.

C3.1 *Code Tester.* A nozzle airflow measuring apparatus as defined by ANSI/ASHRAE Standard 37 Section 6.2.

C3.2 *Flow Meter Assembly.* A mass flow meter and associated tubing, valve assemblies, sight glasses and/or other components used to measure refrigerant mass flow rate but that add internal volume to the operating system.

C3.3 *Pressure Transducer Assembly.* A pressure transducer and associated tubing, valve assemblies, and/or other components used to measure refrigerant pressures but that add internal volume to the operating system.

C4 *Symbols*.

C4.1 q_{tia} = Total capacity, indoor, air, kW

C4.2 q_{tir} = Total capacity, indoor, refrigerant, kW

C4.3 q_{toa} = Total capacity, outdoor, air, kW

C4.4 For applications having a blower motor, total capacity as defined in C4.1, C4.2 and C4.3 shall be defined as Net Capacity.

C4.5 HB = heat balance = $\frac{(q_{tia}-q_{tir})}{q_{tia}}$ or = $\frac{(q_{tia}-q_{toa})}{q_{tia}}$

C5 *Requirements*.

C5.1 *Usage of Refrigerant Mass Flow Method*.

C5.1.1 All Split Systems, whether ducted or non-ducted, shall use the refrigerant mass flow method as the secondary capacity check.

C5.1.1.1. Excluded from Section C5.1.1 requirements is any Split System with an expansion device located upstream of the liquid line mass flow meter (i.e. systems with a cooling expansion device in the Outdoor Unit).

C5.1.1.2. This method shall not be used on specific tests if ANSI/ASHRAE Standard 37 Section 7.5 cannot be met. The air enthalpy method shall be substituted in these cases.

C5.1.2 The absolute value of HB shall be 4.0% or less on all steady state tests utilizing the refrigerant mass flow method.

C5.2 *Usage of Outdoor Air Enthalpy Method*.

C5.2.1 All Single Package Units shall use the outdoor air enthalpy method as the secondary capacity check.

C5.2.1.1. The absolute value of HB shall be 6.0% or less on all tests.

C5.3 The first Steady State Test in each mode (cooling) shall have a secondary capacity check completed. For all other tests in each mode, it is permissible to not use a secondary capacity check.

C6 *Refrigerant Mass Flow Method Requirements*.

C6.1 *Pressure Measurement Requirements*.

C6.1.1 Pressure measurements shall be taken at the indoor coil, per ANSI/ASHRAE Standard 37 Section 7.5.3 and ANSI/ASHRAE Standard 41.3.

C6.1.1.1. Vapor pressures at the Outdoor Unit may be measured and used as an alternate to vapor pressure at the Indoor Unit, if required to achieve 2.8°C superheat, as long as appropriate adjustments are made per Section C6.4.3.1.

C6.1.2 Taken within 30 cm of the field connection of the Indoor Unit.

C6.1.3 Taken on the top half of the tube, unless the tubing is vertical, in which case any side is acceptable. Pressure taps shall be installed such that oil may not fill the pressure tap line.

C6.1.4 Made no closer than 10 tube diameters upstream or downstream of any bends that are greater than 30 degrees nor within 10 tube diameters of short radius bends. Tubing shall be inspected to verify there are no kinks or restrictions.

C6.2 *Temperature Measurement Requirements*.

C6.2.1 Temperature measurements shall be made with instrumentation according to ANSI/ASHRAE Standard 41.1.

C6.2.2 The preferred method of refrigerant temperature measurements is resistance temperature devices (RTDs) per ANSI/ASHRAE Standard 41.1 Section 7.4. If used, RTDs shall be installed with tubing arrangement such that pressure drops due to application do not exceed 3.5 kPa.

C6.2.3 When thermocouples (TCs) are used for measurement of refrigerant temperature by application to the outside of tubing, the following requirements shall be met:

C6.2.3.1. The TC material used shall have special limits of error of 0.42°C or less.

C6.2.3.2. For non-vertical tubes, the TCs shall be placed in the upper half of refrigerant tubes, as there may be oil in the lower half.

C6.2.3.3. For each liquid and vapor measurement, two TCs shall be applied within 8 cm of each other, with one TC at the 10 o'clock position and one TC at the 2 o'clock position. Each TC shall be measured individually. The average of the two temperatures on each liquid and vapor line shall be used for calculations.

C6.2.3.4. Every TC shall be applied to the tubes per ANSI/ASHRAE Standard 41.1 Section 7.2. This entails ensuring that:

C6.2.3.4.1. There shall be no more than three turns of wires contacting each other;

C6.2.3.4.2. The wires shall be 'tinned' or soldered together before application to the tube;

C6.2.3.4.3. The wires shall be secured to the tube via soldering or welding (without burning insulation or melting wire), or thermally conductive epoxy or secure mechanical attachment;

C6.2.3.4.4. The wires outside of the joint described in Section C6.2.3.4.3 shall be prevented from touching each other or other metallic surfaces, preferably by applying electrical tape between the wire and the tube outside of the solder bed; and

C6.2.3.4.5. The wires shall have a strain relief.

C6.2.3.5. Every TC shall be applied per ANSI/ASHRAE Standard 41.1 Section 5.5.2 with insulation having an R-value of at least 0.55 $m^2 \cdot K/W$ that extends along the tube for at least 15 cm on either side of the TC.

C6.2.4 TCs shall be applied at the exiting side of the refrigerant mass flow meter assembly. For heat pumps, this means both sides of the refrigerant mass flow meter assembly shall have TCs applied.

C6.2.5 It is preferred, but not required, that TCs be individually calibrated per ANSI/ASHRAE Standard 41.1 Section 7.2.4.

C6.3 *Refrigerant Mass Flow/Refrigerant Properties*.

C6.3.1 NIST REFPROP 9.1 or higher shall be used for refrigerant properties (saturated values and enthalpies)

C6.3.2 Refrigerant mass flow rate calculations shall account for the mass flow rate of oil in the refrigerant line, as oil contributes to the mass flow rate but not productive heat transfer.

C6.3.2.1. If oil circulation rate is not measured, a 1.0% oil circulation rate shall be assumed ($x = 0.99$).

C6.3.2.2. If the quantity of oil circulation is measured, the calculation shall follow ANSI/ASHRAE Standard 37 Section 7.5.2.3, referencing ANSI/ASHRAE Standard 41.4.

C6.3.3 Mass flow rates shall be measured by equipment meeting ANSI/ASHRAE Standard 41.10 requirements.

C6.4 *Mass Flow Procedure Requirements*.

C6.4.1 The actual internal volume of Pressure Transducer Assemblies and Flow Meter Assemblies shall be measured or calculated prior to setup and recorded with the test report data. Inside diameter and lengths of hoses or tubes, or internal volume of hoses shall be documented. This information shall be recorded along with all other test data.

C6.4.1.1. The entire length of liquid line outside of flow meter assembly connections shall be the diameter specified by the Installation Instructions.

C6.4.2 If a manufacturer specifies a refrigerant charge by weight, then charge shall be adjusted by adding the cumulative internal volume of the flow meter assemblies and pressure transducer assemblies, m^3, times the liquid density of the refrigerant, kg/m^3, used at the charging test condition, as measured at the indoor section.

C6.4.3 Refrigerant side capacity (q_{tri}) shall be calculated per ANSI/ASHRAE Standard 37 Section 7.5.4 for cooling mode.

C6.4.3.1. If vapor refrigerant at the indoor coil pressure tap is not superheated by at least 2.8°C, or the liquid refrigerant at the indoor coil pressure tap is not sub-cooled by at least 1.7°C, then refrigerant properties at the Outdoor Unit may be substituted, as long as refrigerant side capacity is adjusted by line loss calculations per ANSI/ASHRAE Standard 37 Section 7.3.3.4. If the minimum superheat values are not met at the Outdoor Unit, then the outdoor air enthalpy method shall be used per Section C7 of this appendix.

C6.4.4 The following adjustments shall be made when the difference in elevation between the pressure tap location and pressure transducer is greater than 30.5 cm. The adjustment is optional for elevation differences less than one 30.5 cm.

C6.4.4.1. If the pressure transducer is located higher than the pressure tap location, add the elevation head difference to the pressure transducer measurement. If the pressure transducer is located lower than the pressure tap location, subtract the elevation head different from the pressure transducer measurement.

C6.4.5 If pressure transducers are located in the outdoor or indoor test environment, they shall be temperature compensated in accordance with the manufacturer's instrument instructions. Pressure transducer temperature range shall be suitable for the mounting location.

C7 *Outdoor Air Enthalpy Method Requirements*.

C7.1 *Pressure Measurement Requirements*.

C7.1.1 Pressure measurements shall be made with instrumentation according to ANSI/ASHRAE Standard 41.2.

C7.1.2 Refrigerant pressure measurements shall be made at the service connections provided on the product.

C7.1.2.1. Split Systems that meet the requirements of Section C5.1 shall have pressures and temperatures measured at the Indoor Unit per Section C6.1 and C6.2.

C7.1.3 Airside pressure measurements shall be taken with static pressure taps compliant with Figure 7A of ANSI/ASHRAE Standard 41.2.

C7.2 *Temperature Measurement Requirements*.

C7.2.1 Temperature measurements shall be made with instrumentation according to ANSI/ASHRAE Standard 41.1.

C7.2.2 Outdoor air inlet temperatures shall be measured with RTDs using a sampling device per Appendix D.

C7.2.3 Outdoor air outlet temperatures, when the duct is connected, shall be measured with RTDs using a sampling device per Appendix D.

C7.2.4 When thermocouples (TCs) are used for measurement of refrigerant temperature by application to the outside of tubing, the requirements of Section C6.2.3 shall be met.

C7.2.5 TCs shall be applied to the condenser coil tubing halfway between the vapor connection and the liquid connection of the individual circuit, in two separate locations, in order to determine saturation temperature at the midpoint of the circuit.

C7.2.6 It is preferred, but not required, that TCs be individually calibrated per ANSI/ASHRAE Standard 41.1 Section 7.2.4.

C7.3 *Fan Motor Properties*.

C7.3.1 Fan speed measurements, when measured, shall be taken with an instrument accurate to ± 1 rpm.

C7.3.2 Fan current, when measured, shall be taken with an ammeter having an accuracy of 2.0%, or better, of the fan motor current being measured.

C7.3.3 Fan power, when measured, shall be taken with an instrument having accuracy of 2.0% or better of the fan motor power being measured.

C7.4 *Airflow Rate/Air Properties*.

C7.4.1 Airflow rate shall be measured using a code tester per ANSI/ASHRAE Standard 37, Section 6.2.

C7.4.2 Air properties shall be calculated per the ASHRAE Fundamentals Handbook, using measurements of properties as specified in this appendix.

C7.5 *Ductwork*.

C7.5.1 For units that discharge air completely vertically or completely horizontally, the inside dimensions of the duct including insulation shall be at least 15 cm greater than the corresponding dimensions for the discharge air opening of the unit. Additionally, the duct shall be centered over the discharge air opening. The following exceptions apply:

C7.5.1.1. For units that have air outlet next to air inlet, the 15 cm minimum is not required.

C7.5.1.2. For units that have air outlets next to the ground, the 15 cm minimum is not required.

C7.5.1.3. For units with flanges, the duct shall be the same size as the duct flanges.

C7.5.2 For units that discharge air partially horizontally, the outside dimensions of the duct shall be at least 0.6 meter greater than the air outside diameter opening of the unit.

C7.5.3 Rectangular ducts may be used on units with round openings, and round ducts may be used on units with rectangular openings. In either case, the 15 cm minimum applies, and the ducts shall be centered over the opening.

C7.5.4 For rectangular ducts, one pressure tap per side (a total of 4) shall be applied to the center of each duct face. For round ducts, four pressure taps shall be applied at 90° spacing.

C7.5.4.1. All pressure taps shall be located the same distance downstream from the discharge air opening.

C7.5.4.2. All pressure taps shall be located at a distance of at least one full length of the greatest duct dimension downstream of the discharge air opening.

C7.6 *Outdoor Air Enthalpy Calculation Procedure Requirements*.

C7.6.1 Operational mode is identified by the operational speed of the outdoor equipment; that is the outdoor airflow rate changes. The most common operational modes are:

C7.6.1.1. For Single Stage Systems with single speed outdoor fan (cooling mode):

C7.6.1.2. For two stage products with two speed outdoor fan:

C7.6.1.2.1. Cooling mode high stage

C7.6.1.2.2. Cooling mode low stage

C7.6.1.3. For variable speed product, each individual test per Tables 7 and 8 of this standard shall be considered an operational mode.

C7.6.1.4. The independent third-party lab shall work with the manufacturer to identify any other test where free air may be required.

C7.6.2 For each operational mode identified in Section C7.6.1, there shall be one free air (FA) test performed with no ductwork or attachments added to the Unit Under Test (UUT). This FA test may be conducted on any test in a given operational mode. All steady state requirements per Section C5 and C6 shall be met. During this FA test, the following items shall be recorded along with all other data requirements:

C7.6.2.1. At least one of fan motor current (A), fan motor speed (rpm) or fan motor power (W).

C7.6.2.2. When applicable, refrigerant pressures at the high side and low side unit service connections closest to compressor.

C7.6.2.3. When pressures cannot be measured on round tube plate fin coils, the temperature at the midpoint of the uppermost refrigerant circuit, and the temperature at the midpoint of the lowermost refrigerant circuit of the Outdoor Coil.

C7.6.3 Outdoor duct losses shall be calculated for all closed duct tests per ANSI/ASHRAE Standard 37 Section 7.3.3.3 for cooling mode and ANSI/ASHRAE Standard 37 Section 7.3.4.3 for heating mode. Net capacities shall be adjusted accordingly.

C7.6.4 Immediately following the FA test conducted per Section C7.6.2, the ductwork meeting requirements of Section C7.5 shall be added to the Outdoor Unit, and a Closed Duct (CD) test shall be conducted. During this CD test the following requirements shall be met:

C7.6.4.1. The average inlet indoor DB temperature shall be within 0.14°C of the FA test.

C7.6.4.2. The average inlet indoor WB temperature shall be within 0.083°C of the FA test, except for split-system heating mode tests.

C7.6.4.3. The average inlet outdoor DB temperature shall be within 0.14°C of the FA test.

C7.6.4.4. The average inlet outdoor WB temperature shall be within 0.083°C of the FA test., except for split-system cooling mode tests.

C7.6.4.5. Fan motor current, if measured, shall be within 3.0% of the value measured in Section C7.6.2.1.

C7.6.4.6. Fan motor speed, if measured, shall be within 5 rpm of the value measured in C7.6.2.1.

C7.6.4.7. Fan motor power, if measured, shall be within 3.0% of the value measured in C7.6.2.1.

C7.6.4.8. Refrigerant high side pressures of the CD test measured per Section C7.6.1.3 shall be within 0.28°C saturation temperatures of the FA test for all refrigerants (14 kPa for systems using refrigerants R-410A or R-22).

C7.6.4.9. Refrigerant low side pressures of the CD test measured per Section C7.6.1.3 shall be within 0.17°C saturation temperatures of the FA test for all refrigerants (3.4 kPa for systems using refrigerants R-410A or R-22).

C7.6.4.10. Pressure variation for both high side and low side shall be in the same direction. If high side pressure is higher in close duct test, low side pressures are not permitted to be lower than CD test (when rounded to closest 0.7 kPa).

C7.6.4.11. Refrigerant tube temperatures measured per Section C7.6.2.3 shall be within 0.28°C of the FA test.

C7.6.4.12. Measured q_{tia} shall be within 2.0% of the FA test.

C7.6.4.13. Absolute value of HB shall be 6.0% or less.

C7.6.4.14. Outdoor duct static pressure during this CD test shall be recorded with all other parameters, including average, minimum and maximum.

C7.6.5 All other tests in each operational mode may be made with the outdoor duct remaining connected to the Outdoor Unit as long as the same average outdoor duct static pressure recorded per Section C7.6.4.14 is maintained, within 0.0025 kPa. Additionally, the total observed range (maximum value minus the minimum value) for each additional test may be no greater than the total observed range of the previous CD test.

APPENDIX D. ANSI/ASHRAE STANDARD 37 CLARIFICATIONS/EXCEPTIONS – NORMATIVE

The following sections are clarifications and exceptions to ANSI/ASHRAE Standard 37.

D1 Section 5.1 of ANSI/ASHRAE 37 shall have the following clarifications made for temperature measuring instruments:

Add the following section: "*Water vapor content measurement.* As specified in ANSI/ASHRAE 41.1, the temperature sensor (wick removed) shall be accurate to within 0.11°C. If used, apply dew point hygrometers as specified in Sections 5 and 8 of ANSI/ASHRAE Standard 41.6. The dew point hygrometers shall be accurate to within 0.22°C when operated at conditions that result in the evaluation of dew points above 1.7°C, or if used, a relative humidity (RH) meter shall be accurate to within 0.7% RH (both at the $T_{1,Full}$). Other means to determine the psychrometric state of air may be used as long as the measurement accuracy is equivalent to or better than the accuracy achieved from using a wet-bulb temperature sensor that meets the above specifications."

D2 Add the following as Section 5.4.5 to ANSI/ASHRAE Standard 37: "When testing air conditioners and heat pumps having a Variable Speed Compressor, an induction watt/watt hour meter shall not be used."

D3 Section 6.1.2 of ANSI/ASHRAE Standard 37 shall be modified by replacing the last sentence with the following, "Maintain the dry bulb temperature within the test room within 2.8°C of the required dry bulb temperature test condition for the air entering the Indoor Unit. Dew point shall be within 1.1°C of the required inlet conditions."

D4 Section 6.2.7 of ANSI/ASHRAE Standard 37 shall have the following references added for static pressure tap positioning:

D4.1 Add the following section: "*Airflow Measuring Apparatus.* Refer to Figure 12 of ANSI/ASHRAE Standard 51/AMCA Standard 210 or Figure 14 of ANSI/ASHRAE Standard 41.2 (RA 92) for guidance on placing the static pressure taps and positioning the diffusion baffle (settling means) relative to the chamber inlet."

D5 Section 6.4.2.2 of ANSI/ASHRAE Standard 37 shall have the following corrections and clarifications for the inlet plenum:

D5.1 Add the following sentences: "For Blower Coil Systems and Single Package Units, an inlet plenum, equaling the size of the inlet opening meeting the requirements of Figures 7b and 7c shall be installed, unless an Airflow Prevention Device is installed, in which case the inlet plenum is optional. For Coil-Only Systems, an inlet plenum shall be installed per Figure 8. Four static pressure taps shall be located in the center of each face. This inlet plenum shall be connected directly to the inlet of the unit."

D6 Section 6.4.3 of ANSI/ASHRAE Standard 37 shall have the following corrections and clarifications made for Small-duct, High-velocity Systems added:

D6.1 Add the following sentences: "For Small-duct, High-velocity Systems, install an outlet plenum that has a diameter that is equal to or less than the value listed below. The limit depends only on the Cooling Full-Load Air Volume Rate and is effective regardless of the flange dimensions on the outlet of the unit (or an air supply plenum adapter accessory, if installed in accordance with the Installation Instructions)."

Cooling Full-load Air Volume Rate, m^3/h	Maximum Diameter[1] of Outlet Plenum, cm
≤ 850	15
> 850 and ≤ 1190	18
> 1190 and ≤ 1530	20
> 1530 and ≤ 1870	23
> 1870 and ≤ 2380	25
> 2380 and ≤ 2790	28
Note 1. If the outlet plenum is rectangular, calculate its equivalent diameter using $(4A)/P$, where A is the area and P is the perimeter of the rectangular plenum, and compare it to the listed maximum diameter.	

D7 Section 6.5 of ANSI/ASHRAE Standard 37 shall have the following information added regarding static pressure measurement:

D7.1 Add the following sections: "*Indoor coil static pressure difference measurement.* Connect one side of the differential pressure instrument to the manifolded pressure taps installed in the outlet plenum. Connect the other side of the instrument to the manifolded pressure taps located in the inlet plenum. For Non-ducted systems that are tested with multiple outlet plenums, measure the static pressure within each outlet plenum relative to the surrounding atmosphere.

D7.2 *Test set-up on the outlet side of the indoor coil*.

D7.2.1 Install an interconnecting duct between the indoor coil outlet plenum and the airflow measuring apparatus. The cross-sectional flow area of the interconnecting duct shall be equal to or greater than the flow area of the outlet plenum or the common duct used when testing Non-ducted Systems having multiple indoor coils. If needed, use adaptor plates or transition duct sections to allow the connections. To minimize leakage, tape joints within the interconnecting duct (and the outlet plenum). Construct or insulate the entire flow section with thermal insulation having a nominal overall resistance (R-value) of at least 3.3 $m^2 \cdot K/W$.

D7.2.2 Install a grid(s) of dry-bulb temperature sensors inside the interconnecting duct. Also, install an air sampling device, or the sensor(s) used to measure the water vapor content of the outlet air, inside the interconnecting duct. Locate the dry-bulb temperature grid(s) upstream of the air sampling device (or the in-duct sensor(s) used to measure the water vapor content of the outlet air). Air that circulates through an air sampling device and past a remote water-vapor-content sensor(s) shall be returned to the interconnecting duct at a point which needs the following requirements:

D7.2.2.1. Downstream of the air sampling device;

D7.2.2.2. Upstream of the outlet air Damper Box, if installed;

D7.2.2.3. Upstream of the airflow measuring apparatus.

D7.2.3 *Minimizing Air Leakage.* For Small-duct, High-velocity Systems, install an air damper near the end of the interconnecting duct, just prior to the transition to the airflow measuring apparatus. To minimize air leakage, adjust this damper such that the pressure in the receiving chamber of the airflow measuring apparatus is no more than 0.125 kPa higher than the surrounding test room ambient. In lieu of installing a separate damper, use the outlet air Damper Box if it allows variable positioning. Also apply these steps to any conventional indoor blower unit that creates a static pressure within the receiving chamber of the airflow measuring apparatus that exceeds the test room ambient pressure by more than 0.125 kPa."

D8 **S**ection 6.6.1 of ANSI/ASHRAE Standard 37 shall have the following corrections and clarifications made for duct insulation requirements:

D8.1 Add the following section: "*Indoor coil inlet and outlet duct connections.* Insulate and/or construct the outlet plenum and the inlet plenum with thermal insulation having a nominal overall resistance (R-value) of at least 3.3 $m^2 \cdot K/W$".

D8.2 Add the following sentences: "Add a static pressure tap to each face of each outlet plenum, if rectangular, or at four evenly distributed locations along the circumference of an oval or round plenum. Create a manifold that connects the four static pressure taps. Figure D1 of AHRI Standard 211 shows the options allowed for the manifold configuration. See Figures 7a, 7b, 7c, and 8 (of ANSI/ASHRAE Standard 37) for the cross-sectional dimensions and minimum length of each plenum and the locations for adding the static pressure taps for units tested with and without an indoor fan installed."

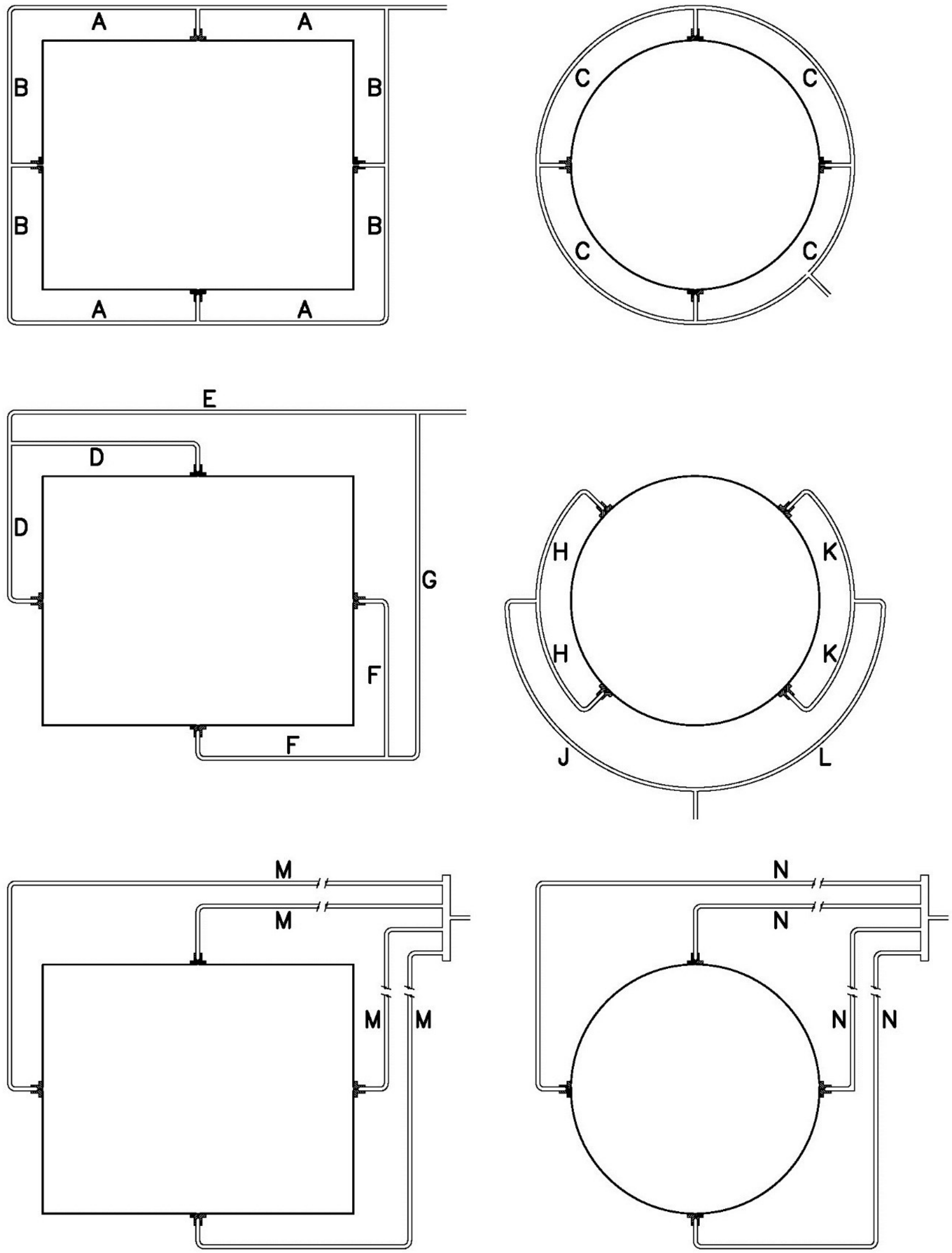

Figure D1. Configurations for Manifolding the Static Pressure Taps

D9 Append the following sentence to the end of Section 7.5.2.1 of ANSI/ASHRAE Standard 37: "Refrigerant flow measurement device(s) shall be either elevated at least 0.6m from the test chamber floor or placed upon insulating material having a total thermal resistance (R-value) of at least 2.1 $m^2 \cdot K/W$. and extending at least 0.3m laterally beyond each side of the device(s)' exposed surfaces."

D10 Sections 8 of ANSI/ASHRAE Standard 37 shall be modified by inserting a new Section 8.9 as follows,

D10.1 ***8.9.*** *Test Operating Procedures for Variable Speed Products*.

D10.1.1 **8.9.1** Special Requirements for Multi-split Air-conditioners and Heat Pumps, and Systems Composed of Multiple Mini-Split Units (Outdoor Units Located Side-by-Side) that would normally operate using two or more Indoor Thermostats. For any test where the system is operated at part load (i.e., one or more compressors OFF, operating at the intermediate or minimum compressor speed, or at low compressor capacity), the manufacturer shall specify the parameters for indoor coil operation during the part load test. For Variable Speed Systems, the manufacturer shall designate the operating blower speeds for all Indoor Units for all tests conducted at minimum compressor speed. For all other part load tests, the manufacturer shall choose to turn off one, two, or more Indoor Units. The chosen configuration shall remain unchanged for all tests conducted at the same compressor speed/capacity. For any indoor coil that is turned off during a test, take steps to cease forced airflow through this indoor coil and block its outlet duct. Because these types of systems will have more than one indoor fan and possibly multiple outdoor fans and compressor systems, references in this test procedure to a single indoor fan, outdoor fan, and compressor means all indoor fans, all outdoor fans, and all compressor systems that are turned on during the test."

D11 Section 8.2 of ANSI/ASHRAE Standard 37 shall have the following changes:

D11.1 Add General Requirements. "*General Requirements*. If, during the testing process, an equipment set-up adjustment is made that would alter the performance of the unit when conducting an already completed test, then repeat all tests affected by the adjustment."

D11.2 Section 8.2.2 of ANSI/ASHRAE Standard 37 shall have the following corrections and clarifications made for indoor coils supplied without an enclosure:

D11.2.1 Modify the sentence to read: "No alterations to the equipment shall be made except for the attachment of required test apparatus and instruments in the prescribed manner and disabling heat pump resistance elements used for heating indoor air at all times."

D11.2.2 Add the following sentence: "For Uncased Coils enclosure, create an enclosure using 2.5 cm thick fiberglass ductboard. Or alternatively, use some other insulating material having a thermal resistance ("R" value) between 0.7 to 1.06 $m^2 \cdot K/W$. For Cased Coils, no extra insulating or sealing is allowed."

D11.3 Section 8.2.3 of ANSI/ASHRAE Standard 37 shall have the following corrections and clarifications made for refrigerant charging:

D11.3.1 Add the following section: "*Additional Refrigerant Charging Requirements.* For Split Systems, unless specifically stated for an outdoor to indoor match, adjust the charge to the outdoor unit instructions. When multiple methods are provided, the manufacturer shall specify the recommended method. If a method is not recommended by the manufacturer, for systems that use a TXV, charge the system to sub-cooling, for systems that use a fixed orifice charge to super heat."

D11.4 Section 8.2.4 of ANSI/ASHRAE Standard 37 shall have the following requirements and modifications added regarding interconnecting tubing.

D11.4.1 *Requirements for Separated Assemblies*. Such equipment in which the interconnection tubing is furnished as an integral part of the machine not recommended for cutting to length shall be tested with the complete length of tubing furnished. An exception is made for Split Systems units that are meant to be installed indoors. The line sizes, insulation, and details of installation shall be in accordance with the manufacturer's published recommendation.

D11.4.2 For those systems where the outdoor section is located in the exterior ambient space, at least 40% of the total line set of the interconnecting tubing shall be exposed to the outside conditions. The line sizes, insulation, and details of insulation shall be in accordance with the manufacturer's published recommendations.

D11.4.3 For those systems where the outdoor section is not located in the exterior ambient space, all of the interconnecting tubing shall be exposed to the inside conditions. The line sizes, insulation, and details of insulation shall be in accordance with the manufacturer's published recommendations.

D11.4.4 Modify by appending "At a minimum, insulate the interconnecting vapor line(s) of a split-system with insulation having an inside diameter that matches the refrigerant tubing and an R value between 0.7 to 1.06 $m^2 \cdot K/W$."

D11.5 Replace Section 8.2.5 of ANSI/ASHRAE Standard 37 with the following: "If pressure measurement devices are connected to a cooling/heating heat pump refrigerant circuit, the refrigerant charge M_t that could potentially transfer out of the connected pressure measurement systems (transducers, gauges, connections, and lines) between operating modes shall be less than 2% of the factory refrigerant charge listed on the nameplate of the Outdoor Unit. If the outdoor unit nameplate has no listed refrigerant charge, or the heat pump is shipped without a refrigerant charge, use a factory refrigerant charge equal to 0.24 kg/kW of rated cooling capacity. Use Equation D1 to calculate M_t for heat pumps that have a single expansion device located in the Outdoor Unit to serve each Indoor Unit and use Equation D2 to calculate M_t for heat pumps that have two expansion devices per Indoor Unit."

$$M_t = \rho\,(V_5 \cdot f_5 + V_6 \cdot f_6 + V_3 + V_4 - V_2) \qquad \text{D1}$$

$$M_t = \rho\,(V_5 \cdot f_5 + V_6 \cdot f_6) \qquad \text{D2}$$

Where

V_i = Internal volume of pressure measurement system (pressure lines, fittings, gauges and/or transducers) at location i, cm^3
f_i = Tubing routing factor, 0 if the pressure measurement system is pitched upwards from the pressure tap location to the gauge or transducer, 1 if it is not.

Table D1. Pressure Measurement Location

Location	Number
Compressor Discharge	1
Between Outdoor Coil and Outdoor Expansion Valve	2
Liquid Service Valve	3
Indoor Coil Inlet	4
Indoor Coil Outlet	5
Common Suction Port (i.e. vapor Service Valve)	6
Compressor Suction	7

Calculate the internal volume of each pressure measurement system using internal volume reported for pressure transducers and gauges in product literature, if available. If such information is not available, use the value of 1.6 cm^3 internal volume for each pressure transducer, and 3.3 cm^3 for each pressure gauge. In addition, for heat pumps that have a single expansion device located in the Outdoor Unit to serve each Indoor Unit, the internal volume of the pressure system at location 2 (as indicated in Table D2 of AHRI Standard 211/241) shall be no more than 16 cm^3. Once the pressure measurement lines are set up, no change shall be made until all tests are finished.

D11.6 Insert a new Section 8.2.8 into Section 8.2 of ANSI/ASHRAE Standard 37: "8.2.8. If the Outdoor Unit or the outdoor portion of a Single Package Unit has a drain pan heater to prevent freezing of defrost water, the heater shall be energized, subject to control to de-energize it when not needed by the heater's thermostat or the unit's control system, for all tests."

D12 *Test Unit Installation Requirements*. Append the following to Section 8.5.3 of ANSI/ASHRAE Standard 37. "In the case of Non-ducted Systems having multiple indoor coils, locate a grid approximately 15 cm upstream from the inlet of each indoor coil. Position an air sampling device, or the sensor used to measure the water vapor content of the inlet air, immediately upstream of the (each) entering air dry-bulb temperature sensor grid. If a grid of sensors is not used, position the entering air sampling device (or the sensor used to measure the water vapor content of the inlet air) as if the grid were present."

D13 Add the following (Sections D13.1 to D13.6 of this Standard) to make a new Section 8.5.6, with subsections, of ANSI/ASHRAE Standard 37 entitled: "*Air Sampling Requirements.*"

D13.1 *Purpose.* The purpose of this section is to prescribe a method for the sampling of air to measure the dry bulb and wet bulb temperatures for indoor inlet and outlet as well as outdoor inlet measurements. This section also defines the requirements for controlling the air stratification and what is considered acceptable for a test. Measurement of the air temperatures are needed to establish that the conditions are within the allowable tolerances of this Standard as well as used for the calculation of the psychrometric capacity.

D13.2 *Definitions*.

D13.2.1 *Air Sampling Device*. A combination of Air Sampling Tree(s), conduit, fan and Aspirating Psychrometer or Dew-point Hygrometer used to determine dry-bulb temperature and moisture content of an air sample from critical locations.

D13.2.1.1. *Air Sampling Tree.* The Air Sampling Tree is an assembly consisting of a manifold with several branch tubes with multiple sampling holes that draws an air sample from a critical location from the unit under test (e.g. indoor air inlet, indoor air outlet, outdoor air inlet, etc.). See Section D13.4 for design requirements.

D13.2.1.2. *Aspirating Psychrometer.* A piece of equipment with a monitored airflow section that draws uniform airflow through the measurement section and has probes for measurement of air temperature and humidity. See Section D13.5 for design requirements.

D13.2.1.3. *Dew-point Hygrometer*. An instrument used to determine the humidity of air by detecting visible condensation of moisture on a cooled surface.

D13.3 *General Requirements.* Temperature measurements shall be made in accordance with ANSI/ASHRAE Standard 41.1. Where there are differences between this document and ANSI/ASHRAE Standard 41.1, this document shall prevail.

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. To check for uniformity of outdoor inlet air, a grid of individual thermocouples on the sampler tree(s) shall be installed, and a maximum of 1.1°C between individual thermocouple and the average grid inlet air temperature shall be maintained. Air distribution at the test facility point of supply to the unit shall be reviewed and may require remediation prior to the beginning of 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 cannot be directed at or away from the air entrance to the condenser air inlet. Particular attention should be given to prevent recirculation of condenser fan exhaust air back through the unit.

D13.4 *Air Sampling Tree Requirements.* The Air Sampling Tree is intended to draw a sample of the air at the critical locations of a unit under test. A typical configuration for the Air Sampling Tree is shown in Figure D2 of AHRI Standard 211/241. 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. Holes shall be on the side of the sampler facing the upstream direction of the air source. Other sizes and rectangular shapes can be used, and shall be scaled accordingly with the following guidelines:

D13.4.1 Minimum hole density of 6 holes per 930 cm^2 of area to be sampled

D13.4.2 Sampler branch tube pitch (spacing) of 15 ± 8 cm

D13.4.3 Manifold trunk to branch diameter ratio having a minimum of 3:1 ratio

D13.4.4 Hole pitch (spacing) shall be equally distributed over the branch (1/2 pitch from the closed end to the nearest hole)

D13.4.5 Maximum individual hole to branch diameter ratio of 1:2 (1:3 preferred)

The minimum average velocity through the Air Sampling Tree holes shall be 0.76 m/s as determined by evaluating the sum of the open area of the holes as compared to the flow area in the Aspirating Psychrometer. Preferentially, the Air Sampling Tree should be hard connected to the Aspirating Psychrometer, but if space constraints do not allow this, the assembly shall have a means of allowing a flexible tube to connect the Air Sampling Tree to the Aspirating Psychrometer.

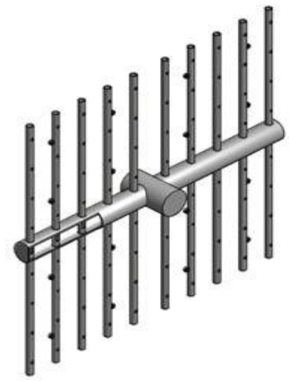

Figure D2. Typical Air Sampling Tree

The Air Sampling Tree shall also be equipped with a thermocouple thermopile, thermocouple grid or individual thermocouples to measure the average temperature of the airflow over the Air Sampling Tree. Per ANSI/ASHRAE Standard 116, the thermocouple arrangement per Air Sampling Tree shall have at least 16 measuring points, spaced evenly across the Air Sampling Tree. In the outdoor inlet location, the Air Sampling Trees shall be placed within 15 to 61 cm 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 and care shall be taken to assure that the upper sampling holes are not pulling in the discharge air leaving the outdoor section of the unit under test. Any sampler holes outside of the plane perpendicular to the condenser fan discharge shall be blocked to prevent the sampling of recirculated air. Blocking holes does not necessarily prohibit thermal transfer on samplers therefore the portion beyond the plane shall be thermally shielded with a material with an R value between 0.7 to 1.06 $m^2 \cdot K/W$.

D13.5 *Psychrometer.* The 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. At a minimum, the flow section shall have a means for measuring the dry bulb temperature (typically, a resistance temperature device (RTD) and a means for measuring the humidity (RTD with wetted sock, chilled mirror hygrometer, or relative humidity sensor). In most typical applications, there are typically two sets of measurements for temperature and humidity, one for the rough room control, and the other for the fine control and actual measurement. The Aspirating Psychrometer shall include a fan that either can be adjusted manually or automatically to maintain required velocity across the sensors. A typical configuration for the Aspirating Psychrometer is shown in Figure D3.

The psychrometer shall be made from suitable material which may be plastic (such as polycarbonate), aluminum or other metallic materials. Outside diameters are typically 10 cm but may be as small as 5 cm or as large as 15 cm. All psychrometers for a given system being tested, shall be constructed of the same material. Psychrometers shall be designed such that radiant heat from the motor does not affect sensor measurements. For Aspirating Psychrometers, velocity across the wet bulb sensor shall be 5 ± 1 m/s. For all other psychrometers, velocity shall be as specified by the sensor manufacturer.

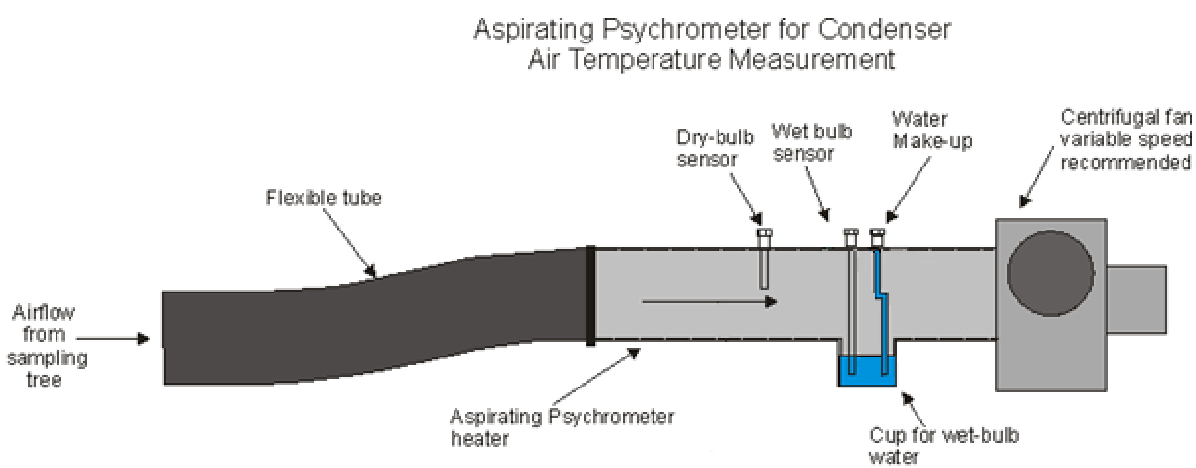

Figure D3. Aspirating Psychrometer

D13.6 *Test Setup Description.* For the outdoor air inlet location, wet-bulb and/or dry-bulb temperature shall be measured at multiple locations entering the outdoor section, based on the airflow nominal face area at the point of measurement. Multiple temperature measurements shall be used to determine acceptable air distribution and the mean air temperature.

The Air Sampling Trees in the outdoor air inlet location shall be sized such that they cover at least 75% of the face area of the side of the coil that they are measuring. The Air Sampler Tree may be larger than the face area of the side being measured, however care shall be taken to prevent discharge air from being sampled (if an Air Sampler Tree dimension extends beyond the inlet area of the unit, holes shall be blocked in the Air Sampler Tree to prevent sampling of discharge air). Each outdoor coil side shall have one Air Sampler Tree.

The Air Sampler Trees shall be located at the geometric center of each side; either horizontal or vertical orientation of the branches is acceptable. A maximum of four Air Sampling Trees shall be connected to each Aspirating Psychrometer. The Air Sampling Trees shall be connected to the Aspirating Psychrometer using tubing that is insulated with thermal insulation with a nominal thermal resistance (R-value) of at least 3.3 $m^2 \cdot K/W$ and routed to prevent heat transfer to the air stream. In order to proportionately divide the flow stream for multiple Air Sampling Trees for a given Aspirating Psychrometer, the tubing shall be of equivalent lengths for each Air Sampling Tree. Alternative to insulating the tubing between the Air Sampling Tree and the Aspirating Psychrometer, a dry-bulb measuring device may be located at both the immediate exit of the Air Sampling Tree and internal to the Aspirating Psychrometer, with both measurements utilized to determine the water vapor content of sampled air.

D14 Add the following to make a new Section 8.5.7 of ANSI/ASHRAE Standard 37:

D14.1 "The Air Sampling Tree and Psychrometer shall be used to measure inlet air properties for all tests and to measure outlet air properties for all Steady State Tests. The Air Sampling Tree and Pyschrometer shall not be used to measure the indoor outlet air properties for tests other than Steady State Tests, which shall have outlet air properties measured with a thermopile or thermocouple grid." [thermopile or thermocouple grid as defined in Section D7.2].

D14.2 "In lieu of an Air Sampling Tree and Psychrometer on every air-inlet side of an Outdoor Unit, it is permissible to use an Air Sampling Tree on one or more faces of the Outdoor Unit and demonstrate air temperature uniformity as follows. Install a grid of evenly distributed thermocouples on each air-permitting face on the inlet of the Outdoor Unit. Install the thermocouples on the air sampling device, locate them individually or attach them to a wire structure. If not installed on the air sampling device, install the thermocouple grid 15 to 60 cm from the unit. The thermocouples shall be evenly spaced across the coil inlet surface and be installed to avoid sampling of discharge air or blockage of air recirculation. The grid of thermocouples shall provide at least 16 measuring points per face or one measurement per 0.1m^2 of inlet face area, whichever is less. This grid shall be constructed and used as per Section 5.3 of ANSI/ASHRAE Standard 41.1. The maximum difference between the readings of any two pairs of these individual thermocouples located at any of the faces of the inlet of the Outdoor Unit, shall not exceed 1.1°C."

D15 Section 8.7 of ANSI/ASHRAE Standard 37 shall have the following changes:

D15.1 Section 8.7 of ANSI/ASHRAE Standard 37 shall have the following corrections and clarifications made for multiple speed outdoor fan motors. Add the following section: "*Special Requirements for Units having a Multiple Speed Outdoor Fan*. The controls of the unit shall regulate the operation of the outdoor fan during all laboratory tests except dry coil cooling mode tests. For dry coil cooling mode tests, the outdoor fan shall operate at the same speed used during the required Wet-coil Test conducted at the same outdoor test conditions."

D15.2 Section 8.7.1 of ANSI/ASHRAE Standard 37 shall be modified by appending the following sentence, "The test room reconditioning apparatus and equipment under test shall be operated under equilibrium conditions for at least 30 minutes before test data are reported."

D16 Section 10.1 of ANSI/ASHRAE Standard 37 shall have the following changes:

D16.1 Insert the following as a new Section 10.1.2.1 to ANSI/ASHRAE Standard 37: For this capacity (heat balance) comparison, use the Indoor Air Enthalpy Method capacity that is calculated in Sections 7.3.3 and 7.3.4 of ANSI/ASHRAE Standard 37 (except, if testing a Coil-only System, do not make the after-test fan heat adjustments).

D17 Tables 2a and 2b of ANSI/ASHRAE Standard 37 shall have the following data added:

D17.1 2.0% Electrical voltage test operating tolerance.

D17.2 1.5% Electrical voltage test condition tolerance.

APPENDIX E. UNIT CONFIGURATION FOR STANDARD EFFICIENCY DETERMINATION - NORMATIVE

E1 *Purpose.* The purpose of this appendix is to prescribe the requirements for the configuration of a unNorit used for determining the Standard Rating cooling and heating capacity and efficiency metrics. This allows for a uniform approach to determine minimum and other standard rating metrics.

E2 *Background*. The Standard Ratings are intended to be ratings that define the performance of a Basic Model at a defined set of conditions.

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

Many of these features are addressed in building efficiency standards or programs where the building efficiency or energy consumption calculations compensate for total building energy consumption, including HVAC products having features such as economizers, energy recovery, fan power, and IAQ treatment.

E3 *Configuration Requirements*. For the purpose of Standard Ratings, units shall be configured for testing as defined in this Appendix.

E3.1 *Basic Model*. A Basic Model means all systems within a single equipment class and which has the same or comparably performing compressor(s), condensing coil(s), evaporator coil(s), and Air Moving System(s) that have a common "nominal" cooling capacity.

E3.2 *Indoor Airside Configuration*. A unit for test shall be configured with a standard blower, motor and sheave/drive combination. A high static indoor blower/oversized motor is an indoor fan assembly including a motor that drives the fan, that can deliver higher external static pressure than the standard indoor fan assembly sold with the equipment. For standard ratings the unit shall be configured with the lowest NEMA efficiency class motor being offered for that model or model group.

E3.3 *IAQ Features and Filtration*.

E3.3.1 *Filtration.* High efficiency air filtration is an assembly of air filters and filter brackets or racks that provide greater air filtration than the air filtration assembly available for sale with the equipment that provides the lowest level of air filtration. Units shall be tested with manufacturer standard filters or have an adjustment to the tested external static pressure (refer to Table 11) if no filters are present. If a unit has high efficiency air filtration, the air filters and filter brackets or rack assembly shall be removed, and the unit shall be tested with the adjustment to the tested external static pressure.

E3.3.2 *UV Lights*. A lighting fixture and lamp mounted so that it shines light on the indoor coil that emits ultraviolet light to inhibit growth of organisms on the indoor coil surfaces, the condensate drip pan, and other locations within the equipment. Standard efficiency ratings shall be based on performance without UV Lights unless that feature is not optional.

E3.4 *System Features Excluded from Testing.* These products can have many features that enhance the operation of the unit on an annualized basis. Standards like ANSI/ASHRAE Standard 90.1 include performance allowances and prescriptive requirements for many of these features. Standard efficiency ratings shall be based on performance without the following features unless that feature is not optional.

E3.4.1 *Economizers*. An economizer is an automatic system that enables a cooling system to use outdoor air to reduce or eliminate the need for mechanical cooling during mild or cold weather. Economizers provide significant energy efficiency improvements on an annualized basis but are also a function of regional ambient conditions and are not considered in the $SEER_{Tx}$ metric.

E3.4.2 *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. Also known as exhaust air energy recovery. Energy recovery devices recover energy from the ventilation or exhaust air and provide significant annualized energy efficiency improvements depending on the regional ambient and building operating load conditions. They are not considered in the $SEER_{Tx}$ metric and are addressed separately by AHRI Guideline V.

E3.4.3 *Indirect/Direct Evaporative Cooling of Ventilation Air*. Water is used to cool Outdoor Air Supply (OAS) without adding moisture to the airstream using a heat exchanger with dry and wet side. This is referred to as “indirect” evaporative cooling. In very dry climates moisture can be added by a “direct” evaporative section to further reduce the OAS dry bulb temperature. This feature has limited applicability at the standard rating conditions and is intended for dry climates where significant performance improvements are obtained.

E3.4.4 *Evaporative Pre-cooling of Condenser Intake Air.* Water is evaporated into the air entering the air-cooled condenser to lower the dry bulb temperature and thereby increase efficiency of the refrigeration cycle. This feature has limited applicability at the standard rating conditions and is intended for dry climates.

E3.4.5 *Desiccant Dehumidification Components*. An assembly that reduces the moisture content of the supply air through moisture transfer with solid or liquid desiccants.

E3.4.6 *Steam/Hydronic Heat Coils*. A heat exchanger located inside the equipment that heats the equipment’s supply or outdoor air using heat delivered by steam or hot water.

E3.4.7 *Hot Gas Reheat Coils*. A heat exchanger located downstream of the indoor coil that heats the supply air during cooling operation using high pressure refrigerant in order to increase the ratio of moisture removal to cooling capacity provided by the equipment.

E3.4.8 *Powered Exhaust/Powered Return Air Fans*. A powered exhaust fan is a fan that transfers directly to the outside a portion of the building air that is returning to the unit, rather than allowing it to recirculate to the indoor coil and back to the building. A powered return air fan is a fan that draws building air into the equipment.

E3.4.9 *Customer System Features*. These features shall not be tested, unless the unit is not offered for sale without the feature.

E3.4.9.1. *Coated Coils*. A coated coil is an optional coil coating that is selected to provide resistance and durability to corrosive effects of alkalis, acids, alcohols, petroleum, seawater, salty air, and other corrosive environments. Typical processes include baked phenolic, cathodic epoxy type electrodeposition coating or thermoset vinyl coating that is bonded after coil is assembled covering the coil, tubes, headers and fin surface. Coils can be assembled from fin stock that has been coated prior to the fin stamping process. Corrosion durability shall be confirmed through testing per ASTM Standard B117 or ASTM Standard G85 Salt Spray test to a minimum of 500 hours.

E3.4.9.2. *Power Correction Capacitors*. A capacitor that increases the displacement power factor measured at the line connection to the equipment. These devices are a requirement of the power distribution system supplying the unit.

E3.4.9.3. *Hail Guards*. A grille or similar structure mounted to the outside of the unit covering the Outdoor Coil to protect the coil from hail, flying debris and damage from large objects.

E3.4.9.4. *Indoor or Outdoor Fan Motor with Variable Frequency Drive (VFD)*. A device connected electrically between the equipment’s power supply connection and the fan motor that can vary the frequency of power supplied to the motor in order to allow variation of the motor’s rotational speed. This is commonly used for convenience of quickly setting up constant airflow.

E3.4.9.5. *Compressor VFD*. A device connected electrically between the equipment’s power supply connection and the compressor that can vary the frequency of power supplied to the compressor in order to allow variation of the compressor’s rotational speed. This is commonly used for capacity control.

E3.4.9.6. *Condenser Fan Motor Option*. A condenser fan/motor assembly designed for optional external ducting of condenser air that provides greater pressure rise and has a higher rated motor horsepower than the condenser fan provided as a standard component with the equipment.

E3.4.9.7. *Sound Traps/Sound Attenuator*. An assembly of structures through which the supply air passes before leaving the equipment or through which the return air from the building passes immediately after entering the equipment for which the sound insertion loss is at least 6 dB for the 125 Hz octave band frequency range.

E3.4.9.8. *Fire/Smoke/Isolation Damper*. 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 shall be rated by an appropriate test laboratory according to the appropriate safety standard, such as UL Standard 555 or UL Standard 555S.

E3.4.9.9. *Desuperheater*. A heat exchanger that provides water heating external to the unit with the hot refrigerant gas from the compressor.

E3.4.9.10. *Process Heat Recovery/Reclaim Coils/Thermal Storage*. A heat exchanger located inside the equipment that conditions the equipment's supply air using energy transferred from an external source using a vapor, gas, or liquid.

E3.5 *Dampers.* Standard ratings for basic models are determined without dampers. If a sample has dampers while being tested, the dampers shall be fully sealed to prevent operation and air leakage.

E3.5.1 *Barometric Relief Dampers*. An assembly with dampers and means to automatically set the damper position in a closed position and one or more open positions to allow venting directly to the outside a portion of the building air that is returning to the unit, rather than allowing it to recirculate to the indoor coil and back to the building. For Standard Ratings, barometric relief dampers shall be fully sealed.

E3.5.2 *Fresh Air Dampers*. An assembly with dampers and means to set the damper position in a closed and one open position to allow air to be drawn into the equipment when the indoor fan is operating. For Standard Ratings, fresh air dampers shall be fully sealed.

APPENDIX F. VERIFICATION TESTING - NORMATIVE

F1 To comply with this standard, single sample production verification tests shall meet the certified Standard Rating performance metrics shown in Table F1 with the listed acceptance criteria.

Table F1. Acceptance Criteria

Performance Metric	Acceptance Criteria
Cooling Metrics	
Capacity[1]	≥ 95%
$SEER_{Tx}$	≥ 95%
$EER_{Tx,Full}$	≥ 95%

Notes:
1. Cooling capacity at $Tx_{,Full}$ conditions