AHRI Standard 210/240-202x (I-P)

202x Standard for

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

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ICS Code: 23.120

Note:

This standard supersedes AHRI Standard 210/240-2023 (2020) (I-P).

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FOREWORD

The primary changes in this edition of AHRI 210/240 are those required to align with the new performance metrics and requirements of Appendix M1 of 10 CFR 430, as issued by the US Department of Energy (DOE) (82 FR 1426, January 2017). A working group of many stakeholders (including but not limited to AHRI members, independent laboratories, energy advocates and DOE consultants) met periodically over the course of two years to evaluate necessary changes and improvements in language.

Because compliance with the Appendix M1 test procedure and ratings are not mandatory until January 1, 2023, AHRI has chosen to use "2023" as the year version of this standard.

Significant changes from AHRI 210/240-2017 with Addendum 1 include:

- Updates to comply with Appendix M1.
    - Added definitions
    - Change of performance metrics:
        - EER to EER2
        - SEER to SEER2
        - HSPF to HSPF2
        - COP to COP2
- Removal of water-cooled and evaporatively-cooled products from the scope.
    - These products will be transitioned to 340/360.
    - Removal of sections on IEER/Part Load (only applicable to water-cooled and evaporatively-cooled products).
- Addition of requirements and calculations for the following:
    - Triple-capacity Northern Heat Pumps
    - Multiple Indoor Blowers
- Updates to tables.
- Updates to calculations.
- Updated Appendix G with latest verbiage from 340/360.

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PERFORMANCE RATING OF UNITARY AIR-CONDITIONING AND AIR-SOURCE HEAT PUMP EQUIPMENT

Section 1. Purpose

1.1 *Purpose.* This standard establishes definitions, classifications, test requirements, rating requirements, operating requirements, minimum data requirements for Published Ratings, marking and nameplate data, and conformance conditions for Unitary Air-conditioners and Unitary Air-source Heat Pumps.

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 65,000 Btu/h 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:

2.2.1 Heat operated air-conditioning/heat pump equipment.

2.2.2 Packaged Terminal Air-conditioners/Heat Pumps, as defined in AHRI 310/380.CSA C744.

2.2.3 Room air-conditioners/heat pumps.

2.2.4 Unitary Air-conditioners and Unitary Air-source Heat Pumps as defined in AHRI 340/360 with capacities of 65,000 Btu/h or greater.

2.2.5 Water-source Heat Pumps, Ground Water-source Heat Pumps, or ground-source closed-loop Heat Pumps as defined in ISO/ASHRAE 13256-1 and ISO/ASHRAE 13256-2.

2.2.6 Water heating heat pumps.

2.2.7 Units equipped with desuperheater/water heating devices in operation.

2.2.8 Variable Refrigerant Flow Air Conditioners and Heat Pumps as defined in AHRI 1230 with capacities of 65,000 Btu/h and greater.

2.2.9 Single Packaged Vertical Units as defined in AHRI 390.

Section 3. Definitions and Acronyms

All terms in this document shall follow the standard industry definitions in the ASHRAE Terminology website unless otherwise defined in Section 3.2.

Further definitions are found in Appendices C, D and E. For reference purposes, the user of this standard is informed there are also pertinent definitions in Title 10, *Code of Federal Regulations*, Part 430, Subpart 430.2. Throughout the standard defined terms are capitalized.

3.1 *Expressions of Provision*. Terms that provide clear distinctions between requirements, recommendations, permissions, options, and capabilities.

3.1.1 *"Can" or "cannot"*. Express an option or capability.

3.1.2 *"May"*. Signifies a permission expressed by the document.

3.1.3 *"Must"*. Indication of unavoidable situations and does not mean that an external constraint referred to is a requirement of the document.

3.1.4 *"Shall" or "shall not"*. Indication of mandatory requirements to strictly conform to the standard and where deviation is not permitted.

3.1.5 *"Should" or "should not"*. Indication of recommendations rather than requirements. In the negative form, a recommendation is the expression of potential choices or courses of action that is not preferred but not prohibited.

3.2 *Standard Specific Definitions.*

3.2.1 *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.

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

3.2.3 *Air Moving System (AMS).*

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

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

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

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

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

3.2.6 *Ceiling-mount Blower Coil System.* A ducted split system for which all of the following apply:

- The Outdoor Unit has a Specified cooling capacity less than or equal to 36,000 Btu/h.
- The Indoor Unit(s) is/are shipped with manufacturer-supplied installation instructions that specify to secure the indoor unit only to the ceiling, within a furred-down space, or above a dropped ceiling of the conditioned space, with return air directly to the bottom of the unit without ductwork, or through the furred-down space, or optional insulated return air plenum that is shipped with the indoor unit.
- The installed height of the Indoor Unit is no more than twelve inches (not including condensate drain lines) and the installed depth (in the direction of airflow) of the indoor unit is no more than thirty inches.
- Supply air is discharged horizontally.

3.2.7

Coefficient of Performance. A ratio of the cooling/heating capacity in watts to the power input values in watts at any given set of Rating Conditions expressed in watt/watt (a dimensionless quantity).

3.2.7.1 *Coefficient of Performance (COP2).* For heating COP2, supplemental resistance heat is excluded. See equations 11.49, 11.52, and 11.61.

3.2.7.2 *Peak Load Coefficient of Performance (COP_{Peak}).* The coefficient of performance when meeting the building load at 5°F, calculated in accordance with Appendix K.

3.2.8 *Coil-only System (Coil-only Air-conditioner or Coil-only Heat Pump).* A system that includes only (one or more) Coil-only Indoor Units.

3.2.9 *Cold Climate Heat Pump*. A heat pump for which both low-temperature compressor cut-out and cut-in temperatures are Specified to be less than 5 °F and for which capacity for the $H4_{full}$ test (at 5 ⁰F) is certified to be at least 70% of the capacity for the nominal full capacity test conducted at 47 ⁰F ($H1_{Full}$ or $H1_{Nom}$).

3.2.10 *Controls Verification Procedure (CVP).* The procedure outlined in Appendix I of this standard that validates Native Control operation, including determination of a Variable Capacity system and demonstration of operating parameters used in the regulatory tests.

3.2.11 *Crankcase Heater.* Any electrically powered device or mechanism for intentionally generating heat within and/or around the compressor sump volume. Crankcase Heater control can be achieved either using a timer or be based on a change in temperature or some other measurable parameter, such that the Crankcase Heater is not required to operate continuously. A Crankcase Heater without controls operates continuously when the compressor is not operating.

3.2.12 *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.

3.2.13 *Defrost Control System.*

3.2.13.1 *Demand-defrost Control System*. A system that defrosts the heat pump Outdoor Coil only when measuring a predetermined degradation of performance, can include time-initiated defrosts if such defrosts do not occur sooner than six hours of compressor operating time, and the heat pump's controls are capable of one of the following:

- Monitoring one or more parameters that always vary with the amount of frost accumulated on the Outdoor Coil (*e.g.*, coil to air differential temperature, coil differential air pressure, outdoor fan power or current, optical sensors, etc.) at least once for every ten minutes of compressor ON-time when space heating.
- Operating as a feedback system that measures the length of the defrost period and adjusts defrost frequency accordingly. In all cases, when the frost parameter(s) reaches a predetermined value, the system initiates a defrost.

Note: Systems that vary defrost intervals solely according to outdoor dry-bulb temperature are not demand defrost systems.

3.2.13.2 *Time Adaptive Defrost Control System*. A Demand-defrost Control System that measures the length of the prior defrost period(s) and uses that information to automatically determine when to initiate the next defrost cycle.

3.2.13.3 *Time-temperature Defrost Control System*. A control system that initiates or evaluates initiating a defrost cycle only when a predetermined cumulative compressor ON-time is obtained. This predetermined ON-time is a fixed value (e.g., thirty, forty-five, ninety minutes) although it can vary based on the measured outdoor dry-bulb temperature. The ON-time counter accumulates if controller measurements (e.g., outdoor temperature, evaporator temperature) indicate that frost formation conditions are present, and it is reset/remains at zero at all other times. In one application of the control scheme, a defrost is initiated whenever the counter time equals the predetermined ON-time. The counter is reset when the defrost cycle is completed.

In a second application of the control scheme, one or more parameters are measured (*e.g.*, air and/or refrigerant temperatures) at the predetermined, cumulative, compressor ON-time. A defrost is initiated only if the measured parameter(s) falls within a predetermined range. The ON-time counter is reset regardless of whether a defrost is initiated.

Note: If systems of this second type use cumulative ON-time intervals of ten minutes or less, then the heat pump may qualify as having a Demand-defrost Control System.

3.2.14 *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 $\boldsymbol{C_D^c}$. The Degradation Coefficient for heating is denoted by $\boldsymbol{C_D^h}$.

3.2.15 *Double-duct System.* Air-cooled commercial package air-conditioning and heating equipment that is either a horizontal Single Package Unit or Split System, or a vertical unit that consists of two components that are shipped or installed either connected or split, and is intended for indoor installation with ducting of outdoor air from the building exterior to and from the unit, where the unit 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 , UL60335-2-40 (C22.2) or equivalent requirements for outdoor use.

- If it is a horizontal unit, the complete unit has a maximum height of 35 in or the unit has components that do not exceed a maximum height of 35 in.
- If it is a vertical unit the complete (split, connected, or assembled) unit has components that do not exceed maximum depth of 35 in; and a Specified cooling capacity less than 65,000 Btu/h.

3.2.16 *Ducted System*. An air-conditioner or heat pump that is designed to be permanently installed and delivers conditioned air to the indoor space through a duct(s). The air-conditioner or heat pump can be either a Split System unit or a Single Package Unit.

3.2.17 *Energy Efficiency Ratio (EER2)*. A ratio of the cooling capacity in Btu/h to the Total Power in watts at any given set of Rating Conditions expressed in Btu/(W·h).

3.2.17.1 *$EER2_{A,Full}$*. The EER2 at A_{Full} test conditions.

3.2.18 Evaporator *coil*. An assembly that absorbs heat from a space and transfers the heat to a refrigerant. A split-system indoor coil is the evaporator coil in cooling mode.

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

3.2.20 *Heat Comfort Controller*. A heat pump control that regulates the operation of the electric resistance elements to assure that the air temperature leaving the indoor section does not fall below a Specified temperature even if the heat pump capacity exceeds the building load. This Specified temperature can be field adjustable and the temperature is Specified by the manufacturer as part of the equipment rating.

Note: Heat pumps that actively regulate the rate of electric resistance heating when operating below the balance point (as the result of a second stage call from the thermostat) but do not operate to maintain a minimum delivery temperature are not considered as having a Heat Comfort Controller.

3.2.21 *Heating Season.* The months of the year that require heating, *e.g.,* typically, and roughly, October through April.

3.2.22 *Heating Seasonal Performance Factor (HSPF2).* The total space heating required during the space heating season, Btu, divided by the total electrical energy, W·h, consumed by the heat pump system during the same season, Btu/(W·h). HSPF2 varies depending on the region (refer to Section 11). The HSPF2 used to evaluate compliance with 10 CFR 430.32(c) is based on Region IV and the sampling plan stated in 10 CFR 429.16(a).

3.2.23 *Independent Coil Manufacturer (ICM)*. A company that manufactures Indoor Units but does not manufacture Single Package Units or Outdoor Units.

3.2.24 *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, and can consist of the following:

- 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, and an integrated indoor blower (i.e. a device to move air including its associated motor)
- A separate designated air mover that is either a furnace or a Modular Blower

Note: A Service Coil is not an Indoor Unit.

3.2.24.1 *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.

3.2.24.2 *Air Handler*. An arrangement of refrigerant-to-air heat transfer coil(s), condensate drain pan, sheet metal or plastic parts to direct/route airflow over the coil(s), air moving device, and external cabinetry.

Note: An Air Handler may include a cooling mode expansion device or supplemental resistance heating elements.

3.2.24.3 *Modular Blower*. A product which only uses single-phase electric current, and which meets all of the following:

3.2.24.3.1 Is designed to be the principal air circulation source for the living space of a residence.
3.2.24.3.2 Is not contained within the same cabinet as a furnace or central air-conditioner.
3.2.24.3.3 Is designed to be paired with HVAC products that have a heat input rate of less than 225,000 Btu per hour and cooling capacity less than 65,000 Btu per hour.

3.2.24.4 *Coil-only Indoor Unit*. An Indoor Unit that is distributed in commerce without an indoor blower or separate designated air mover. A Coil-only Indoor Unit installed in the field relies on a separately installed furnace or a Modular Blower for indoor air movement.

3.2.24.4.1 *Cased Coil*. A Coil-only Indoor Unit with external cabinetry.
3.2.24.4.2 *Uncased Coil*. A Coil-only Indoor Unit without external cabinetry.

3.2.24.5 *Service Coil*. An arrangement of refrigerant-to-air heat transfer coil(s), condensate drain pan, sheet metal or plastic parts to direct/route airflow over the coil(s), sold specifically for the intent of replacing an Uncased Coil or Cased Coil that has already been placed into service, and that has been labeled “for indoor coil replacement only” on the nameplate and in manufacturer technical and product literature. The model number for any Service Coil includes a mechanism (e.g., an additional letter or number) for differentiating a Service Coil from a coil intended for an Indoor Unit.

Note: A Service Coil may include external cabinetry and/or a cooling mode expansion device.

3.2.25 *Installation Instructions.* Manufacturer’s documentation that comes packaged with or appear in the labels applied to the unit. This does not include an online manual.

3.2.26 *Latent Cooling Capacity*. The rate, expressed in Btu/h, at which the equipment removes latent heat (reduces the moisture content) of the air passing through it under standard conditions of operation.

3.2.27 *Low Compressor Stage (Low)*. 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 can be the same or different from the cooling mode value.

3.2.28 *Low-static Blower Coil System.* A ducted multi-split or multi-head mini-split system for which all indoor units produce greater than 0.01 in H_2O and a maximum of 0.35 in H_2O ESP when operated at the Specified cooling full-load airflow not exceeding 400 scfm per Specified ton of cooling.

3.2.29 *Low-static Single-Split Blower Coil System*. A ducted single-split system air conditioner or heat pump for which all of the following apply:

3.2.29.1 The Outdoor Unit has a Specified cooling capacity less than or equal to 24,000 Btu/h;

3.2.29.2 If the Outdoor Unit is a heat pump or a variable capacity air conditioner, is separately Specified with a blower-coil indoor unit tested with a minimum 0.5 in H_2O ESP, otherwise it is separately Specified with a coil-only indoor unit; and

3.2.29.3 The Indoor Unit is marketed for and produces a maximum ESP less than 0.5 in H_2O when operated at the Specified cooling full-load airflow not exceeding 400 scfm per Specified ton of cooling.

3.2.30 *Mandatory Constant Circulation System*. An air conditioner or heat pump that operates the indoor fan continuously when power is applied to the unit regardless of control settings.

3.2.31 *Mid-static Blower Coil System.* A ducted multi-split or multi-head mini-split system for which all indoor units produce greater than 0.20 in H_2O and a maximum of 0.65 in H_2O ESP when operated at the Specified cooling full-load airflow not exceeding 400 scfm per Specified ton of cooling.

3.2.32 *Minimum-speed-limiting Variable-speed Heat Pump.* A heat pump for which the minimum compressor speed (represented by revolutions per minute or motor power input frequency) is higher than its minimum value for operation in a 47°F ambient temperature for any bin temperature t_j for which the calculated heating load is less than the calculated intermediate-speed capacity.

3.2.33 *Mobile Home Blower Coil System.* A split system that contains an outdoor unit and an indoor unit that meet the following criteria:

3.2.33.1 Both the indoor and outdoor unit are shipped with manufacturer-supplied installation instructions that stipulate installation only in a mobile home with the home and equipment complying with HUD Manufactured Home Construction Safety Standard 24 CFR part 3280;
3.2.33.2 The indoor unit cannot exceed 0.40 in H_2O when operated at the cooling full-load airflow not exceeding 400 cfm per Specified ton of cooling; and

3.2.33.3 The indoor and outdoor unit each bears a label in at least 1⁄4 in font that reads “For installation only in HUD manufactured home per Construction Safety Standard 24 CFR part 3280.”

3.2.34 *Mobile Home Coil-only System.* A coil-only split system that includes an outdoor unit and coil-only indoor unit that meet the following criteria:

3.2.34.1 The outdoor unit is shipped with manufacturer-supplied installation instructions that stipulate installation only for mobile homes that comply with HUD Manufactured Home Construction Safety Standard 24 CFR part 3280;

3.2.34.2 The coil-only indoor unit is shipped with manufacturer-supplied installation instructions that stipulate installation only in or with a mobile home furnace, modular blower, or designated air mover that complies with HUD Manufactured Home Construction Safety Standard 24 CFR part 3280, and has dimensions no greater than 20 in wide, 34 in high and 21 in deep; and

3.2.34.3 The coil-only indoor unit and outdoor unit each has a label in at least 1⁄4 in font that reads ‘For installation only in HUD manufactured home per Construction Safety Standard 24 CFR part 3280.”

3.2.35 *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.

3.2.36 *Nominal Compressor Stage (Nom)*. A heating mode compressor stage equal to or higher than Full Compressor Stage in cooling.

3.2.37 *Native Control*. The configuration of a unit under test to operate with settings Specified for field use and to avoid all regulatory test overrides, in accordance with Appendix I.

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

3.2.39 *Nominal Cooling Capacity*. A capacity approximately equal to the air conditioner cooling capacity tested at A_{full} condition.

Note: For Indoor Units, the highest cooling capacity is listed in published product literature for 95°F outdoor dry-bulb temperature and 80°F dry-bulb, 67°F wet-bulb indoor conditions. For Outdoor Units, the lowest cooling capacity is listed in published product literature for these conditions. If incomplete or no operating conditions are published, the highest (for Indoor Units) or lowest (for Outdoor Units) such cooling capacity available for sale is used.

3.2.40 *Nominal Heating Capacity.* A capacity approximately equal to the heat pump capacity tested at the $H1_{Nom}$ condition.

3.2.41 *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.

3.2.42 *Non-ducted System*. A Split System with only Non-ducted Indoor Unit(s).

Note: The system components may be of a modular design.

3.2.43 *Non-tested Combination (NTC)*. Any manufacturer approved combination of an Outdoor Unit(s) with one or more Indoor Units whose ratings are based on an Alternative Efficiency Determination Method (AEDM).

3.2.44 *Normalized Gross Indoor Fin Surface (NGIFS).* The gross fin surface area of the indoor coil divided by the cooling capacity measured for the A_{full} test.

3.2.45 *Off-mode Power Consumption.* The power consumption when the unit is connected to its main power source but is neither providing cooling nor heating to the building it serves.

3.2.46 *Off-mode Season.* For central air-conditioners other than heat pumps, the Shoulder Season and the entire Heating Season; and for heat pumps, the Shoulder Season only.

3.2.47 *Oil Recovery Mode*. An automatic system operation that returns oil to the compressor crank case when the control system determines that the oil level in the Outdoor Unit is low.

3.2.48 *Outdoor Coil.* A heat exchange surface that transfers heat between outdoor air and the refrigerant.

Note: The Outdoor Coil may be located internal or external to the building.

3.2.49 *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, can include a heating mode expansion device, reversing valve, and/or defrost controls.

3.2.50 *Outdoor Unit Manufacturer (OUM).* A manufacturer of Single Package units, Outdoor Units, and/or both Indoor Units and Outdoor Units.

3.2.51 *Part Load Factor (PLF).* The ratio of the cyclic EER2 (or COP2 for heating) to the steady-state EER2 (or COP2), where both EER2s (or COP2s) are determined based on operation at the same ambient conditions.

3.2.52 *Published Rating.* A statement of the assigned values of those performance characteristics, under stated Rating Conditions, where a unit can be chosen to fit the application. These values apply to all units of the same nominal size and type (identification) produced by the same manufacturer. This 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.

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

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

3.2.53 *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**.**

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

3.2.54 *Seasonal Energy Efficiency Ratio (SEER2).* The total heat removed from the conditioned space during the annual cooling season, Btu, divided by the total electrical energy, W·h, consumed by the air-conditioner or heat pump during the same season, Btu/(W·h).

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

3.2.56 *Shoulder Season.* The months of the year in between those months that require cooling and those months that require heating, *e.g.,* typically, and roughly, April through May, and September through October.

3.2.57 *Single Package 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.

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

3.2.59 *Small-duct, High-velocity System.* A Split System for which all Indoor Units are Blower Coil Indoor Units that produce at least 1.2 in H_2O of ESP when operated at the full-load airflow Specified by the manufacturer of at least 220 scfm per Specified ton of cooling.

3.2.60 *Space Constrained Product.* A central air-conditioner or heat pump:

- that has Specified cooling capacities no greater than 30,000 Btu/h
- that has an outdoor or Indoor Unit having at least two overall exterior dimensions or an overall displacement that:
    - is substantially smaller than those of other units that are:
        - currently usually installed in site built single family homes; and
        - of a similar cooling, and, if a heat pump, heating capacity; and
    - 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; and
- of a product type that was available for purchase in the United States as of December 1, 2000

3.2.60.1 that has Specified cooling capacities no greater than 30,000 Btu/h;

3.2.60.2 that has an outdoor or Indoor Unit having at least two overall exterior dimensions or an overall displacement that:

3.2.60.2.1 is substantially smaller than those of other units that are:

3.2.60.2.1.1 currently usually installed in site built single family homes; and
3.2.60.2.1.2 of a similar cooling, and, if a heat pump, heating capacity; and

3.2.60.2.2 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; and

3.2.60.3 of a product type that was available for purchase in the United States as of December 1, 2000.

3.2.61 *Specified*. Documentation provided by the manufacturer or values determined in the test procedure. In the event of conflicting information, the hierarchy is:

3.2.61.1 Test procedure provisions requiring alternate values (e.g. modified airflow to comply with static)

3.2.61.2 Certification report (information provided to authorities having jurisdiction).
3.2.61.3 Installation Instructions.
3.2.61.4 Test instructions or test plan provided by the manufacturer.

3.2.62 *Split System (Split System Air-conditioner or Split System Heat Pump)*. Any central 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 can be either Blower Coil Systems or Coil-only Systems.

3.2.62.1 *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.

3.2.62.2 *Multi-split System (Multi-split Air-conditioner or Multi-split Heat Pump)*. A Split System that has one Outdoor Unit and 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.

3.2.62.3 *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.

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

3.2.64 *Standard Filter*. The filter that meets the following definition in hiearchal order:

- the lowest level of filtration that is distributed in commerce with a model.
- If the manufacturer does not stipulate which filter option has the lowest level of filtration in manufacturer's installation instructions or marketing materials for the model, the filter designated as the "default" or "standard" filter in the marketing materials for the model.
- If the manufacturer does not stipulate a default filter option or which filter option has the lowest filtration level, the filter shipped by the manufacturer.

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

3.2.66 *System Controls.* Can include but are not limited to:

3.2.66.1 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.

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

3.2.66.3 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.

3.2.67 *Temperature Bin*. The 5°F increments used to partition the outdoor dry-bulb temperature ranges of the cooling and heating seasons.

3.2.68 *Test Condition Tolerance.* The maximum permissible difference between the average value of the measured test parameter and the test condition identified in the standard.

3.2.69 *Test Operating Tolerance.* The maximum permissible range a measurement can vary over the test interval identified in the standard. When expressed as a percentage, the maximum variation is the percentage identified in the standard of the average value.

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

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

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

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

3.2.72 *Total Heating Capacity*. The amount of Sensible Capacity (Net Capacity in the heating mode) the equipment can add to the conditioned space in a defined interval of time in Btu/h

3.2.73 *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.

3.2.74 *Triple-capacity, Northern Heat Pump.* A heat pump that provides two stages of cooling and three stages of heating. The two common stages for both the cooling and heating modes are the low capacity stage and the high capacity stage. The additional heating mode stage is the booster capacity stage, which offers the highest heating capacity output for a given set of ambient operating conditions.

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

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

3.2.75.2 *Low Compressor Stage (Low)*. 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 can be the same or different from the cooling mode value.

3.2.76 *Two-capacity Northern Heat Pump*. A heat pump that has a factory or field-selectable lock-out feature to prevent space cooling at high-capacity. Two-capacity heat pumps having this feature will typically have two sets of ratings, one with the feature disabled and one with the feature enabled. The heat pump is a Two-capacity Northern Heat Pump only when this feature is enabled at all times. The indoor coil model number shall reflect whether the ratings pertain to the lockout enabled option via the inclusion of an extra identifier, such as "+LO". When testing as a Two-capacity, Northern Heat Pump, the lockout feature shall remain enabled for all tests.

3.2.77 *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.

3.2.78 *Unit Having Multiple Indoor Blowers (MIB).* A Split-system or Single Package Unit which contains multiple indoor blowers where the indoor blowers are designed to cycle on and off independently of one another and are not controlled such that all indoor blowers are modulated to always operate at the same airflow or speed.

3.2.79 *Unitary Air-conditioner (Air-conditioner, Air-cooled Air-conditioner, Central 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.

3.2.79.1 Air Conditioner *Function*. Air-conditioners provide air-circulation, air cleaning, cooling with controlled temperature and dehumidification, and can include heating and/or humidifying.

3.2.80 *Unitary Heat Pump (Heat Pump, Air-source Heat Pump, Central Heat Pump).* One or more factory-made assemblies which normally include an indoor conditioning 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.

3.2.80.1 *Heat Pump Function*. Heat Pumps provide air heating with controlled temperature, and can include air-cooling, air-circulating, air-cleaning, dehumidifying or humidifying.

3.2.80.2 *Heat pump having a Heat Comfort Controller.* A heat pump with controls that can regulate the operation of the electric resistance elements to assure that the air temperature leaving the indoor section does not fall below a Specified temperature. Heat pumps that actively regulate the rate of electric resistance heating when operating below the balance point (as the result of a second stage call from the thermostat) but do not operate to maintain a minimum delivery temperature are not considered as having a Heat Comfort Controller.

3.2.81 *Variable Capacity System*. Variable-capacity system means an air conditioner or heat pump that has either a) a compressor that uses a variable-speed drive or inverter to vary the compressor speed by four or more speeds in each mode of operation (i.e., cooling/heating), or b) a digital compressor that mechanically modulates output using a duty cycle; and which controls the system by monitoring system operation and automatically modulating the compressor output, indoor air flow and other system parameters as required in order to maintain the indoor room temperature.

3.2.81.1 *Variable Capacity Certified, Two-Capacity System.* A system that is certified as a variable capacity system, but demonstrates Two-Capacity System behavior during the Variable capacity Determination CVP in Appendix I.

3.2.81.2 *Variable Capacity Certified, Single-Capacity System.* A system that is certified as a variable capacity system but demonstrates Single-Capacity System behavior during the Variable capacity Determination CVP in Appendix I.

3.2.81.3 *Variable Refrigerant Flow (VRF) System.* A Multi-split System that distributes 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.

Note: Single-phase VRF systems less than 65,000 Btu/h are central air-conditioners and central air conditioning heat pumps, can be referred to as Unitary Air-conditioners and Unitary Air-source Heat Pumps.

3.2.82 *Variable Capacity Compressor.* A compressor capable of varying its rotational speed in non-discrete stages or steps from low to full using an inverter or variable frequency drive.

3.2.82.1 *Boost Compressor Speed (Boost)*. A speed faster than Full Compressor Speed, as Specified by the manufacturer, at which the unit operates to achieve increased capacity. The Boost Compressor Speed for heating mode tests can be the same or different from the cooling mode value. Also applies to Triple-capacity, Northern Heat Pumps.

3.2.82.2 *Full Compressor Speed (Full)*. The speed as Specified by the manufacturer at which the unit operates at full load test conditions. The Full Compressor Speed for heating mode tests can be the same or different from the cooling mode value.

3.2.82.3 *Intermediate Compressor Speed (Int)*.

3.2.82.3.1 *For Multi-split Systems*. A speed as Specified by the manufacturer that is (a) greater than or equal to the sum of the minimum speed and one-fourth of the difference between the Low Compressor Speed and Full Compressor Speed and (b) less than or equal to the sum of the minimum speed and three-fourths of the difference between Low Compressor Speed and Full Compressor Speed. The compressor speeds for cooling and heating modes are calculated separately.

3.2.82.3.2 *For All Other Variable Capacity 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.

3.2.82.4 *Low Compressor Speed (Low)*. The speed as Specified by the manufacturer at which the unit operates at low load test conditions. The Low Compressor Speed for heating mode tests can be the same or different from the cooling mode value.

3.2.83 *Virtual Load.* An element of the CVP conducted under Native Controls, by which the software that controls the indoor test room conditions (i.e., operates the indoor room reconditioning system) is programmed to mimic the response of a building to space conditioning under a heating or cooling load in real time, by monitoring the capacity of the unit under test and adjusting the indoor room conditions according to the virtual model defined by the parameters in Appendix I4. The virtual model defines the time-dependent rate of change of the indoor room conditions as a function of the target building load and the measured capacity of the tested system.

3.2.84 *Wall-mount Blower Coil System.* A ducted split system air conditioner or heat pump for which all of the following apply:

3.2.84.1 The outdoor unit has a Specifiedcooling capacity less than or equal to 36,000 Btu/h.
3.2.84.2 The indoor unit(s) is/are shipped with manufacturer-supplied installation instructions that stipulate mounting only by:
3.2.84.2.1 Securing the back side of the unit to a wall within the conditioned space, or
3.2.84.2.2 Securing the unit to adjacent wall studs or in an enclosure, such as a closet, such that the indoor unit's front face is flush with a wall in the conditioned space.
3.2.84.3 Has front air return without ductwork and is not capable of horizontal air discharge.
3.2.84.4 Has a height no more than 45 in, a depth (perpendicular to the wall) no more than 22 in (including tubing connections), and a width no more than 24 in (parallel to the wall).

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

3.3 *Acronyms.*

3.3.1 *AEDM.* Alternative Efficiency Determination Method.
3.3.2 *AHRI*. Air-Conditioning, Heating, and Refrigeration Institute.
3.3.3 *ASHRAE.* American Society of Heating, Refrigerating and Air-Conditioning Engineers.
3.3.4 *CFR*. Code of Federal Regulations.
3.3.5 *ESP*. External Static Pressure.

Section 4. Classifications

4.1 *Classifications*. Equipment covered within the scope of this standard shall be classified as shown in Table 1, Table 2 and Table 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] ID FAN EVAP OD FAN or PUMP COMP COND
Year-Round Single Package Unit	SPY-A [5,7]	—	GAS HEAT [4] 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	RCU-A-C	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] 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.
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.

Table 2. Classification of Unitary Air-source Heat Pumps

Designation	AHRI Type [1,2]	Arrangement - ID	Arrangement - OD
Single Package Unit	HSP-A [5,7]	—	ELEC HEAT [3] ID FAN EVAP OD FAN or PUMP COMP COND
Year-Round Single Package Unit	HSPY-A [5,7]	—	GAS HEAT [4] ID FAN EVAP OD FAN or PUMP COMP COND
Remote Outdoor Coil	HRC-A-CB [2,7]	ID FAN EVAP COMP	OD FAN or PUMP COND
Remote Outdoor Coil, Coil-only	HRC-A-C [2,7]	EVAP COMP	OD FAN or PUMP COND
Year Round Split System Heat Pump with Coil Blower	HRCUY-A-CB	GAS HEAT [4] ID FAN EVAP	OD FAN or PUMP COMP COND
Split System Heat Pump with Coil Blower	HRCU-A-CB [6,7]	ELEC HEAT [3] ID FAN EVAP	OD FAN or PUMP COMP COND
Split System Heat Pump with Coil-only	HRCU-A-C [6,7]	GAS HEAT [8] 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. For Heating Only, change the initial “H” to “HO”
3. Optional component
4. May also be other heat source except for gas 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. Not included in testing

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 capacity or alternative method resulting in three or more steps of capacity	One or more variable capacity 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 Ducted Air-conditioners, Ducted Heat Pumps, and Non-ducted Heat Pumps shall be tested in accordance with ASHRAE 37 as amended by Appendix D, and ASHRAE 116 as amended by Appendix E. Non-ducted Air-conditioners shall be tested in accordance with ASHRAE 37 as amended by Appendix D, and ASHRAE 116 as amended by Appendix E or in accordance with ASHRAE 16. When testing a Non-ducted Air-conditioner in accordance with ASHRAE 16, the default cyclic degradation coefficient (Cd) shall be used unless Section 6.1.3.1.1 mandatory constant circulation system requirement applies. In ASHRAE 16, ASHRAE 37 and ASHRAE 116, wherever terms "may" or "should" are used, they shall be taken to be mandatory requirements.

5.1.1.1 Units shall be installed per Installation Instructions. Installation Instructions that appear in the labels applied to the unit take precedence over installation instructions that are shipped with the unit. For ICM Split Systems, follow the Installation Instructions provided with the Indoor Unit. For products in a certification program, additional information required for testing shall be submitted through the certification process.

5.1.2 *Variable Capacity System.* The manufacturer that claims the performance of the particular system shall provide a means to override the controls of the Variable-capacity System under test, when needed, prior to initial set-up during laboratory testing. This shall apply to Variable-capacity-certified, Single-capacity Systems and Variable-capacity-certified, Two-capacity Systems.

5.1.2.1 The means for overriding the controls of the test unit shall have the ability to control the compressor and indoor blower such that the compressor(s) operates at the Specified speed or capacity, and the indoor blower operates at the Specified speed or delivers the Specified airflow. These Specified speeds, capacities and airflows shall be consistent with the speeds, capacities, and airflows observed when the system is tested per Appendix I.

5.1.2.1.1 For a Variable-capacity-certified, Single-capacity System operating with a proprietary controller, the control system shall provide a single level of compressor operation.

5.1.2.1.2 For a Variable-capacity-certified, Two-capacity System operating with a proprietary controller, the control system shall provide two levels of compressor operation.

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

5.1.2.3 Systems with digital compressor(s) require an integrating watt-hour measuring instrument.

5.1.3 *Break-in.* Before making test measurements used to calculate performance, operate the equipment for the "break-in" period Specified by the manufacturer, which may not exceed twenty hours. Each compressor of the unit must undergo this "break-in" period.

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 stipulate the orientation used for testing. Conduct testing with the following installed:

5.1.4.1 Factory installed supplementary resistance heat.

5.1.4.2 Other equipment Specified as part of the unit, including all hardware used by a Heat Comfort Controller if so equipped. For Small-duct, High-velocity Systems, configure all balance dampers or restrictor devices on or inside the unit to fully open or lowest restriction.

5.1.4.3 The most restrictive filter Specified by the manufacturer for the Indoor Unit unless default filter pressure drop from Table 10 is utilized.

5.1.5 Defrost controls shall be set for Region IV (refer to Section 11.2.2) or left at manufacturer's factory settings if the published Installation Instructions provided with the equipment do not stipulate a Region IV selection. For heat pumps that use a Time-temperature Defrost Control System, this may require changing the time setting. For heat pumps that use a Time Adaptive Defrost Control System, the frosting interval to be used during frost accumulation tests shall be Specified by the manufacturer and the manufacturer shall provide the procedure for manually initiating the defrost at the time identified in the standard. The manufacturer shall provide information and any necessary hardware to manually initiate a defrost cycle.

5.1.6 *Requirements for Separated Assemblies*. All Standard Ratings for Split Systems shall be determined with at least 25 ft 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, and not recommended for cutting to length, shall be tested with the complete length of tubing furnished, or with 25 ft of tubing, whichever is greater. At least 10 ft of the 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. Install refrigerant pressure measuring instruments as described in Section 8.2.5 of ASHRAE 37 if they are needed to make a secondary measurement of capacity or for verification of refrigerant charge.

5.1.6.1 When testing Multi-split Systems, connect each indoor fan-coil to the Outdoor Unit using: (a) 25 ft 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.

5.1.6.1.1 *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 identified in Section 5.1.6.1. Cooling capacity correction factor, F_{CCC}, is used in Section 11.1 to adjust cooling capacity.

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. In all cases, the absolute minimum length necessary to physically connect the system shall be used.

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

Piping length beyond the requirement (X), ft	Cooling Capacity Correction Factor, F_{CCC}
$3.3 < X \leq 20$	1.01
$20 < X \leq 40$	1.02
$40 < X \leq 60$	1.03
$60 < X \leq 80$	1.04
$80 < X \leq 100$	1.05
$100 < X \leq 120$	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 5.1.6.1 that has been applied to at least 33% (minimum of two) 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.

Average piping length in addition to the minimum in Table 4 (X), ft for at least 33% (minimum of two) 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.)

Notes:

- The piping length X is the additional refrigerant piping length above the minimum described in Section 5.1.6.1 that has been applied to at least 33% (minimum of two) of the Indoor Units in the testing configuration.
- Average piping length in addition to the minimum in Table 4 (X), ft for at least 33% (minimum of two) 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.)

5.1.6.2 *Outdoor Unit with No Match.* An Outdoor Unit that is not distributed in commerce with any indoor units and is intended for use with R22 or R22-like refrigerants shall be deemed an Outdoor Unit with No Match (OUWNM). An OUWNM shall be tested with an indoor coil having nominal tube diameter of 0.375 in and an NGIFS of 1.0 or less (as determined in Section 5.1.6.3). An R22-like refrigerant is any refrigerant that has a 95°F midpoint saturation absolute pressure that is ± 18% of the 95°F midpoint saturation absolute pressure of R22.

5.1.6.2.1 *Dry-ship Units*. Any Outdoor Unit shipped without a Specified refrigerant from the point of manufacture, or if the unit is shipped such that more than two pounds of refrigerant is required to be added for testing to this standard shall be tested as an OUWNM. This shall not apply if either a) the factory charge is equal to or greater than 70% of the Outdoor Unit internal volume times the liquid density of refrigerant at 95°F, or b) an A2L refrigerant is approved for use.

5.1.6.3 *Indoor Coil NGIFS.* The Normalized Gross Indoor Fin Surface (NGIFS), square inch per British thermal unit per hour (sq. in./Btu/hr), shall be calculated as follows:

$$NGIFS = 2 \cdot L_f \cdot W_f \cdot N_f \;/\; \dot{q}_{A,Full} \qquad 5.1$$

5.1.7 *System Cooling Mode Expansion Device*. For cases when cooling mode expansion device is not Specified in Manufacturer Installation Instructions, nor shipped with either the Indoor Unit or Outdoor Unit, test the system using a fixed orifice or piston type expansion device that is sized appropriately for the system.

5.1.8 *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, for field installation (laboratory charging instructions shall not be used). 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 12°F for fixed orifice systems, or set subcooling to a target value of 10°F for expansion valve systems.

5.1.8.1 Except for mix-matched systems covered in Section 5.1.8.2 and Multi-split Systems, 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 identified 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	± 2.0°F	1	Sub-cooling	10% of the Target Value; No less than ± 0.5°F, No more than ± 2.0°F
2	High Side Pressure or Saturation Temperature	± 4.0 psi or ± 1.0°F	2	High Side Pressure or Saturation Temperature	± 4.0 psi or ± 1.0°F
3	Low Side Pressure or Saturation Temperature	± 2.0 psi or ± 0.8°F	3	Low Side Pressure or Saturation Temperature	± 2.0 psi or ± 0.8°F
4	Low Side Temperature	± 2.0°F	4	Approach Temperature	± 1.0°F
5	High Side Temperature	± 2.0°F	5	Charge Weight	0.5% or 1.0 oz, whichever is greater
6	Charge Weight	± 2.0 oz			

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, A_{Full} test conditions for thirty continuous minutes should be achieved and results should be compared to the previous set of A_{Full} tests. When comparing results, measured charge parameters outside of those listed in the manufacturer's Installation Instructions or Table 5 can be an indication refrigerant charge or other parameters have changed. An analysis should be performed and if measurements indicate that refrigerant charge has leaked during the test, repair the refrigerant leak, repeat any necessary set-up steps, and repeat all tests.

5.1.8.2 *Mix-Matched Systems.* For systems consisting of an OUM Outdoor Unit and an ICM Indoor Unit with differing charging procedures the refrigerant charge shall be adjusted per the ICM Installation Instructions. If instructions are provided only with the Outdoor Unit or are provided only with an ICM Indoor Unit, then use the provided instructions.

5.1.8.3 *Heat Pumps.* The refrigerant charge shall be set at the A_{Full} conditions or as Specified by the manufacturer. The initial heating test shall be $H1_{Full}$ or $H1_{Nom}$ test, charge parameters shall be checked per the Installation Instructions (if provided). If conditions are within the range Specified by Installation Instructions, then continue with the remainder of the tests. For heating-only heat pumps, use the $H1_{Full}$ test.

5.1.8.3.1 If heating refrigerant charge parameters are not within the range Specified by the Installation Instructions then the smallest adjustment to refrigerant charge to get within the heating refrigerant charge parameters shall be made. After making this adjustment in the $H1_{Full}$ or $H1_{Nom}$ test, refrigerant charge shall be verified in the cooling mode to be within the greater of the installation instruction tolerances or the tolerances listed in the Table 5 above before re-running the cooling tests. For heating-only heat pumps, use the $H1_{Full}$ test.

5.1.8.4 *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:

5.1.8.4.1 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.

5.1.8.4.2 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.

Use methods for installing pressure gauge(s) at the required location(s) as indicated in Installation Instructions if Specified.

5.1.9 *Psychrometric testing of non-ducted units.* When the psychrometric method is used for testing non-ducted units, it is necessary to ascertain whether the attachment of the indoor side test apparatus changes the performance of the equipment being tested, and if so, to correct for this change.

5.1.9.1 The equipment shall have temperature measuring devices attached to return bends at approximately the midpoints of each indoor coil and outdoor coil circuit or at points not affected by vapor superheat or liquid subcooling. Equipment not sensitive to refrigerant charge can, as an alternative, install pressure measuring devices connected to access valves or tapped into the suction and discharge lines. Indoor fan power shall be sub-metered.

5.1.9.2 The equipment shall then be operated at the initial full-load test conditions, with the indoor-side test apparatus disconnected. Data shall be sampled at equal intervals that span five minutes or less for a period of one-half hour after equilibrium has been attained.

5.1.9.3 The indoor side test apparatus shall then be connected to the equipment and the temperatures or saturated temperatures corresponding to the measured pressures indicated by the aforementioned instrumentation shall be noted.

5.1.9.4 After equilibrium is again attained, the average indoor fan power shall agree within 2% of the average indoor fan power observed during the preliminary test, and the temperatures of coils or pressure-equivalent saturation temperatures shall agree within ±0.3°C (±0.5°F) of the average coil or saturation temperatures observed during the preliminary test. If these tolerances are exceeded, the airflow measurement apparatus fan shall be adjusted to change indoor airflow as needed such that the specified agreement is attained. If the adjustment of the airflow measurement apparatus fan results in violating the eternal static pressure tolerance, adjust the outlet plenum(s) such that the specified agreement and external static pressure tolerance is attained,

5.2 *Cyclic Test Requirements*. For Single-stage or Two-stage Systems, cycle the compressor OFF for twenty-four minutes and then ON for six minutes (total cycle time is thirty minutes). For units having a Variable-Capacity compressor, cycle the compressor OFF for forty-eight minutes and then ON for twelve minutes (total cycle time is sixty minutes). Repeat the OFF/ON compressor cycling pattern until the test is completed. The controls of the unit shall regulate cycling of the outdoor fan.

5.3 Table 6 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 identified per Table 7 and Table 8. Standard Ratings shall be established for all refrigerants listed on the nameplate of the product.

Standard Ratings relating to cooling or heating 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. Supplementary electric heat is used in HSPF2 calculations as described in Section 11.

Standard Ratings of systems (other than mobile-home and Space Constrained units) which do not have indoor air-circulating fans furnished as part of the model, i.e., Coil-only Systems, shall be established by subtracting from the total cooling capacity 1,505 Btu/h per 1,000 scfm of indoor air circulated for tests using 100% airflow and 1,143 Btu/h per 1,000 scfm of indoor air circulated for tests using 75% airflow, and by adding the same amount to the heating capacity. Total Power for both heating and cooling shall be increased by the fan power coefficient 441 W per 1,000 scfm of indoor air circulated for tests using 100% airflow and the fan power coefficient 335 W per 1,000 scfm of indoor air circulated for tests using 75% airflow.

For mobile home and Space Constrained Coil-only Systems, Standard Ratings shall be established by subtracting from the total cooling capacity 1,385 Btu/h per 1,000 scfm of indoor air circulated for tests using 100% airflow and 1,051 Btu/h per 1,000 scfm of indoor air circulated for tests using 75% airflow, and by adding the same amount to the heating capacity. Total Power for both heating and cooling shall be increased by the fan power coefficient 406 W per 1,000 scfm of indoor air circulated for tests using 100% airflow and the fan power coefficient 308 W per 1,000 scfm of indoor air circulated for tests using 75% airflow.

For all Coil-only Systems, in any case where the Specified intermediate or low airflow is greater than 75% of the full-load airflow, use linear interpolation of the default fan power coefficients based on the Specifiedreduced airflow between the specified fan power coefficient at 75% of full-load airflow and the specified fan power coefficient at 100%.

Table 6. Guidance for Using AHRI 210/240 (Informative)

			General Testing and Set-up Issues	Rating Procedure Issues			Calculations		
				General	Cooling	Heating	General	Cooling	Heating
Requirements for all units			5.1.1, 5.1.3, 5.1.4, 5.1.8, 5.2, Section 5, Section 6, Appendix C, Appendix D, D1, D3, D4, D7, D8, D9, D11, D13, D14, D15.2, D17, D18, DYY, E1, E2, E3.2, E4, E5, E6, E7, E8, E9, E13, Appendix G	5.1.1, 6.1, Table 7, Table 8, 6.1.1, 6,1.2, 6.1.3, 6.1.4, 6.1.5.1, Table 10, 6.1.8, 6.4, 6.4.2, 6.4.3, 6.4.4, 6.4.5,	6.1.5	—	11.3	11.1.1 to 11.1.6, 11.2.1	—
Requirements for all Heat Pumps			5.1.5, 5.1.8.3, D16, E10	6.1.6, 6.1.7, 6.1.8.4, 6.4.1.4	E11	6.1.5.5, 6.1.5.7, E10, E12	—	—	11.1.7 to 11.1.15, 11.2.2
Additional Requirements	System Configurations (more than one may apply)	Blower Coil System	5.1.6, D5, C4.5, C5.1.1, C7.1.2.1, DX, DY	—	—	—	—	—	—
		Coil-only System	5.1.6, C4.4, C5.1.1, C7.1.2.1, DX, DY	6.1	6.1.5.3.1	—	—	—	—
		Non-ducted System	D12, E3.1 , E3.3, DXX	—	6.1.5.1.4, 6.1.5.3.4, F11.9	6.1.5.6.4	—	—	—
		Outdoor Unit with no match	5.1.6.2, 5.1.6.3	6.1.8.6, 6.4.1.6	6.1.3.1.4	—	—	—	—
		Single-package	5.1.8.4, D5, C5.2.1,	6.1.8.7, 6.4.1.1	—	—	—	—	—
		Heat pump Heating-only heat pump	—	—	—	6.1.5.5.5, 6.1.5.6.6, 6.1.5.6.7	—	—	—
		Two-capacity Northern Heat Pump	—	—	6.1.5.3	6.1.3.4, 6.1.5.5.4, 6.1.5.6.5	—	—	—
		Triple-capacity Northern Heat Pump	—	—	6.1.5.3, 6.1.5.4	6.1.3.4, 6.1.5.5.4, 6.1.5.6.5	—	—	—
		SDHV	D6	Table 10, 6.4.3.3.3	—	—	—	—	—
		Multi-split	5.1.6.1, D10, DZ	6.1.8.5, 6.4.1.7, 6.4.3.3	—	—	—	—	—
	Modulation	Single speed compressor	—	6.1.8.1, 6.4.1.2	6.1.3.1.1	6.1.3.2.1	—	11.2.1.1	11.2.2.1
		Two-capacity compressor	—	6.1.8.2, 6.4.1.2	6.1.3.1.2, 6.1.5.3,	6.1.3.2.2, 6.1.3.4, 6.1.5.6	—	11.2.1.2	11.2.2.2
		Variable capacity Compressor	5.1.2, D2	—	6.1.3.1.3, 6.1.5.4	6.1.3.2.3, 6.1.5.7, 6.1.5.8	—	11.2.1.3	11.2.2.3
	Special	Heat Pump with Heat Comfort Controller	—	—	—	—	—	—	11.2.2.4
		Units with a Multi-speed Outdoor Fan	D15.1	—	—	—	—	—	—
		MIB	D5.2	6.1.5.9	6.1.5.2.5, 6.1.5.3.4	—	—	11.2.1.1.1, 11.2.1.2	11.2.2.1.3, 11.2.2.2

		ICM	5.1.1.1, 5.1.8.2	6.1.8.3, 6.4.1.4, 6.4.1.5	—	—	—	—	—

Table 7. Required Tests[1]

Test Name	Single Stage System	Single Stage with VAV/MIB	Variable Capacity Certified, Single-Capacity System	Two-stage System[8]	Two-stage Northern	Variable Capacity Certified, Two-Capacity System	Variable Capacity Compressor System	Triple-capacity Northern
Cooling Mode [2]								
A_{Full}	R	R	R	R	R	R	R	R
A_{Low}	—	R	—	—	—	—	—	—
B_{Full}	R	R	R	R	R	R	R	R
B_{Low}	—	R	—	R	—	R	R	R
C_{Full}	O[3]	—	O[3]	O[3]	O[3]	O[3]	—	O[3]
C_{Low}		O	—	O[3]	—	O[3]	—	O[3]
D_{Full}	O[3]	—	O[3]	O[3]	O[3]	O[3]	—	O[3]
D_{Low}	—	O	—	O[3]	—	O[3]	—	O[3]
E_{Int}	—	—	—	—	—	—	R	—
F_{Low}	—	—	—	R	—	R	R	R
G_{Low}	—	—	—	—	—	—	O[3]	—
I_{Low}	—	—	—	—	—	—	O[3]	—
Heating Mode [4]								
$H0_{Low}$	—	—	—	R	R	R[11]	R[11]	R
$H1_{Full}$	R	R	O[9]	R	R	O[9]	O[9]	R
$H1_{Low}$	—	R	—	R	R	R[11]	R[11]	R
$H1C_{Full}$	O[5]	—	O[5]	O[5]	O[5]	—	—	O[5]
$H1C_{Low}$	—	O[5]	—	O[5]	O[5]	O[5,11]	O[5]	O[5]
$H1_{Nom}$	—	—	R[10]	—	—	R[10]	R[10]	—
$H2_{Boost}$	—	—	—	—	—	—	—	O
$H2_{Full}$	R	R	R	R	R	O	O	R
$H2_{Low}$	—	O	—	O[6]	O[6]	R	—	R
$H2_{Int}$	—	—	—	—	—	—	R	—
$H3_{Full}$	R	R	R[9]	R	R	R[9]	R[9]	R
$H3_{Low}$	—	R	—	R[7]	R[7]	R	—	R[7]
$H3_{Boost}$	—	—	—	—	—	—	—	R
$H3C_{Boost}$	—	—	—	—	—	—	—	O
$H4_{Full}$	O[12]	O[12]	O[12]	O[12]	O[12]	O[12]	O[12]	—
$H4_{Boost}$	—	—	—	—	—	—	—	R

Notes:
1. "R" means Required, "O" means Optional, and a blank cell indicates test is not applicable for the given product type.
2. Required for any unit that has a cooling mode function.
3. Refer to Section 6.1.3.1. Required for systems having a mandatory constant circulation system
4. Required for any unit that has a heating mode function.
5. Refer to Section 6.1.3.2. Required for systems having a mandatory constant circulation system
6. Not required if the heat pump locks out low capacity at outdoor temperatures less than 37.0°F. Also, instead of testing, the $H2_{Low}$ capacity and electrical power may be approximated based on $H1_{Low}$ and $H3_{Low}$ tests per equations 11.42 and 11.48.
7. Not required if the heat pump locks out low capacity at outdoor temperatures less than 37.0°F.
8. Two-stage tests apply for MIB.
9. The compressor shall operate for the $H1_{Full}$ and $H3_{Full}$ tests at the same heating full speed, measured by RPM or power input frequency (Hz), as the maximum speed at which the system controls would operate the compressor in normal operation in 17 °F ambient temperature.
10. The compressor shall operate for the $H1_{Nom}$ test at the maximum speed at which the system controls would operate the compressor in normal operation in 47 °F ambient temperature. Additionally, for a cooling/heating heat pump, the

compressor shall operate for the $H1_{Nom}$ test at a speed, measured by RPM or power input frequency (Hz), no lower than the speed used in the A_{Full} test if the tested $H1_{Nom}$ heating capacity is less than the tested A_{Full} cooling capacity

11. The compressor shall operate at the same heating minimum speed, measured by RPM or power input frequency (Hz), for the $H0_{Low}$, $H1C_{Low}$, and $H1_{Low}$ tests.
12. Required for all systems certified as Cold Climate Heat Pump.

Table 8. Test Conditions[1, 13, 14]				
Test Name	**Air Entering Outdoor Unit [2] (°F)**	**Air Entering Indoor Unit [2] (°F)**	**Compressor Capacity [3]**	**Indoor Airflow [4]**
Cooling Mode				
A_{Full}	95.0 / 75.0 [5,6]	80.0 / 67.0	$Full_C$ [12]	$Full_C$ [12]
A_{Low}	95.0 / 75.0 [5,6]	80.0 / 67.0	$Full_C$ [12,16]	Low_C
B_{Full}	82.0 / 65.0 [5,6]	80.0 / 67.0	$Full_C$	$Full_C$
B_{Low}	82.0 / 65.0 [5,6]	80.0 / 67.0	Low_C [16]	Low_C
C_{Full}	82.0 / 58.0 [5,6]	80.0 / 57.0 [7]	$Full_C$	$Full_C$
C_{Low}	82.0 / 58.0 [5,6]	80.0 / 57.0 [7]	Low_C [16]	Low_C
D_{Full}	82.0 / 58.0 [5,6]	80.0 / 57.0 [7]	$Full_C$	$Full_C$ [8]
D_{Low}	82.0 / 58.0 [5,6]	80.0 / 57.0 [7]	Low_C [16]	Low_C [8]
E_{Int}	87.0 / 69.0 [5,6]	80.0 / 67.0	Int_C	Int_C
F_{Low}	67.0 / 53.5 [5,6]	80.0 / 67.0	Low_C [16]	Low_C
G_{Low}	67.0 / 58.0 [5,6]	80.0 / 57.0 [7]	Low_C [16]	Low_C
I_{Low}	67.0 / 58.0 [5,6]	80.0 / 57.0 [7]	Low_C [16]	Low_C [8]
Heating Mode				
$H0_{Low}$	62.0 / 56.5	70.0 / 60.0 [9]	Low_H [16]	Low_H
$H0C_{Low}$	62.0 / 56.5	70.0 / 60.0 [9]	Low_H [16]	Low_H
$H1_{Full}$	47.0 / 43.0	70.0 / 60.0 [9]	$Full_H$ [17]	$Full_H$
$H1_{Low}$	47.0 / 43.0	70.0 / 60.0 [9]	Low_H [16]	Low_H
$H1C_{Full}$	47.0 / 43.0	70.0 / 60.0 [9]	$Full_H$	$Full_H$ [8]
$H1C_{Low}$	47.0 / 43.0	70.0 / 60.0 [9]	Low_H [16]	Low_H [8]
$H1_{Nom}$	47.0 / 43.0	70.0 / 60.0 [9]	Nom_H [15]	Nom_H [10]
$H2_{Boost}$	35.0 / 33.0	70.0 / 60.0 [9]	$Boost_H$	$Full_H$
$H2_{Full}$	35.0 / 33.0	70.0 / 60.0 [9]	$Full_H$ [17]	$Full_H$
$H2_{Low}$	35.0 / 33.0	70.0 / 60.0 [9]	Low_H [16]	Low_H
$H2_{Int}$	35.0 / 33.0	70.0 / 60.0 [9]	Int_H	Int_H
$H3_{Full}$	17.0 / 15.0	70.0 / 60.0 [9]	$Full_H$ [17]	$Full_H$
$H3_{Low}$	17.0 / 15.0	70.0 / 60.0 [9]	Low_H [16]	Low_H
$H3_{Boost}$	17.0 / 15.0	70.0 / 60.0 [9]	$Boost_H$	$Full_H$
$H3C_{Boost}$	17.0 / 15.0	70.0 / 60.0 [9]	$Boost_H$	$Full_H$
$H4_{Full}$	5.0 / 4.0 [11]	70.0 / 60.0 [9]	$Full_H$ [18]	$Full_H$
$H4_{Boost}$	5.0 / 4.0 [11]	70.0 / 60.0 [9]	$Boost_H$	$Full_H$

Notes:

1. Test condition tolerances are defined within ASHRAE Standard 37, ASHRAE Standard 116 Table 3b for cyclic, and Section 8.7 of this standard.
2. Values listed are dry-bulb temperature / wet-bulb temperature, °F.
3. Refer to Section 3 for definition of "Full", "Low", "Int" and "Boost" for each compressor type.
4. Refer Section 6.1.5 for airflow details.
5. Wet-bulb temperature specification 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, adjust the outdoor wet-bulb temperature such that the dew point is 60.5 ± 3.0ºF.
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 57.0°F or less be used.)
8. 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.
9. Maximum value for all tests. If outdoor air enthalpy method is used for Single Package Heat Pumps, then the indoor wet-bulb temperature shall be adjusted to match as close as reasonably possible to the dew point of the outdoor entering air.
10. Refer to Section 6.1.5.8.
11. 4.0 Maximum.
12. For Two-stage Northern Heat Pump, $Full_C$ means operating compressor and airflow at Low Stage.
13. For Three-stage Northern Heat Pump, $Full_C$ means operating compressor and airflow at middle stage, Low_C means compressor and airflow at Low Stage. Note: Tests D_{Full}, D_{Low}, I_{Low}, $H1C_{Full}$, and $H1C_{Low}$ are cyclic in nature. Some heating tests, particularly $H2_{Full}$ and $H2_{Low}$ will be transient in nature. All other tests are Steady State Tests.

14. 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, outdoor wet-bulb temperature must be less than 58°F.
15. Maximum speed that the system controls would operate the compressor in normal operation in 47°F ambient temperature.
16. For all Low tests of MIB with Single-stage products, compressor capacity is Full.
17. Maximum speed that the system controls would operate the compressor in normal operation in 17°F ambient temperature. The $H1_{Full}$ test is not needed if the $H1_{Nom}$ test uses this same compressor speed.
18. Maximum speed that the system controls would operate the compressor in normal operation in 5°F ambient temperature.

6.1.1 *Values of Standard Capacity Ratings.* These ratings shall be expressed only in terms of Btu/h as shown in Table 9.

Table 9. Values of Standard Capacity Ratings

Capacity Ratings, Btu/h	Multiples, Btu/h
< 20,000	100
≥ 20,000 and < 38,000	200
≥ 38,000 and < 65,000	500

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 COP2, 0.05 Btu/(W·h) for EER2, SEER2 and HSPF2. Standard measures of Off-mode Power Consumption, $P_{W,Off}$, shall be rounded to the nearest watt.

6.1.3 *Standard Rating Tests.*

6.1.3.1 *Default Cooling Degradation Coefficient.*

Required for systems having a mandatory constant circulation system.

6.1.3.1.1 For systems having a mandatory constant circulation system, the optional cyclic test shall be performed. The degradation coefficient shall be evaluated using the respective cyclic tests in Table 7 conducted in accordance with section E12 of Appendix E. The following subsections of 6.1.3.1 shall not apply for systems having a mandatory constant circulation system.

6.1.3.1.2 For Single Stage Systems, if the optional C_{Full} and D_{Full} tests are not performed, or the calculated result for $C_D^{c,Full}$ is greater than the default value of 0.20, the default value shall be used for the cooling Degradation Coefficient, C_D^c.

6.1.3.1.3 For Variable Capacity Certified, Single Capacity Systems, if the optional C_{Full} and D_{Full} tests are not performed, or the calculated result for $C_D^{c,Full}$ is greater than the default value of 0.25, the default value shall be used for the cooling Degradation Coefficient, C_D^c.

6.1.3.1.4 For Two-capacity Systems, if the optional C_{Low} and D_{Low} tests are not performed, or the calculated result for $C_D^{c,low}$ is greater than 0.20, 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, or the calculated result for $C_D^{c,Full}$ is greater than 0.20, the default value for Full Stage shall be the value used for Low Stage.

6.1.3.1.5 For Variable Capacity Certified, Two-Capacity Systems, , if the optional C_{Low} and D_{Low} tests are not performed, or the calculated result for $C_D^{c,low}$ is greater than 0.25, a default value of 0.25 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, or the calculated result for $C_D^{c,Full}$ is greater than 0.25, the default value for Full Stage shall be the value used for Low Stage.

6.1.3.1.6 For Variable Capacity Systems, if the optional G_{Low} and I_{Low} tests are not performed, or the calculated result for $C_D^{c,Low}$ is greater than the default value of 0.25, the default value shall be used for the cooling Degradation Coefficient, C_D^c.

6.1.3.1.7 For OUWNM, if the optional C_{Full} and D_{Full} 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 *Default Heating Degradation Coefficient.*

6.1.3.2.1. For systems having a mandatory constant circulation system, the optional cyclic test shall be performed. The heating degradation coefficient shall be evaluated using the respective cyclic tests in Table 7 conducted in accordance with section E12 of Appendix E. The following subsections of 6.1.3.2 shall not apply for systems having a mandatory constant circulation system.

6.1.3.2.2 For Single Stage Systems and Variable Capacity Certified, Single Capacity Systems, if the optional $H1C_{Full}$ test or $H1C_{Low}$ is not performed, or the calculated result for $C_D^{c,Full}$ is greater than the default value of 0.25, the default value shall be used for the heating Degradation Coefficient, C_D^h.

6.1.3.2.3 For Two-capacity Systems, Triple-capacity Northern Heat Pumps, and Variable Capacity Certified, Two-Capacity Systems, if the optional $H1C_{Full}$ and $H1C_{Low}$ tests are not performed, or the calculated result for $C_D^{h,Low}$ is greater than 0.25, a default value of 0.25 shall be used for the Low Stage heating Degradation Coefficient, $C_D^{h,Low}$. In this case, if using default value for $C_D^{h,Low}$, use default value for $C_D^{h,Full}$. For Two-capacity Systems that lock out low-capacity operation at low outdoor temperatures, if the optional $H1C_{Full}$ test is not performed, or the calculated results for $C_D^{h,Full}$ is greater than 0.25, the default value for Full Stage shall be the value used for Low Stage. Additionally, for Triple-capacity Northern Heat Pumps if the optional $H3C_{Boost}$ is not performed, the default value 0.25 shall be used.

6.1.3.2.4 For Variable Capacity Systems, if the optional $H1C_{Full}$ and $H1C_{Low}$ tests are not performed, or the calculated result for C_D^h is greater than 0.25, the default value shall be used for the heating Degradation Coefficient, C_D^h.

6.1.3.3 *Test Sequence.* When testing a Ducted System (except if a heating-only heat pump), conduct the A_{Full} test first to establish the cooling full airflow. For ducted heat pumps where the heating and cooling full airflows are different, make the first heating mode test one that requires the heating full airflow. For ducted heating-only heat pumps, conduct the $H1_{Full}$ Test first to establish the heating full airflow. When conducting a Cyclic Test, always conduct it immediately after the Steady State Test that requires the same test conditions. For Variable capacity Systems, the first test using the cooling minimum airflow shall precede the E_{Int} test, and the first test using the heating minimum airflow shall precede the $H2_{Int}$ test. The test laboratory makes all other decisions on the test sequence.

6.1.3.4 *Low-Capacity Heating Tests in 35°F Conditions for Two-Stage Heat Pumps and Northern Two-stage and Triple-capacity Northern Heat Pumps.* Instead of conducting the $H2_{Low}$ test, capacity and power for this condition shall be calculated per Equation 11.42 and Equation 11.48.

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, but tests shall be performed, at a minimum, at 60 Hz.

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 identified within Section 6.1.5 or its subsections, no changes shall be made to the Airflow-control Setting(s) after initiation of testing. Specified instructions for setting fan speed or controls shall be used. If there are no instructions for setting fan speed or controls, use the as-shipped settings. If there is no Specified cooling full airflow, use Equation 6.1. If there is no Specified heating full airflow, use Equation 6.2.

$$\dot{Q}_{A,Full} = \frac{\dot{q}^{C}_{Cert}}{12{,}000} \cdot 400 \qquad 6.1$$

$$\dot{Q}_{H1,Full} = \frac{\dot{q}^{H}_{Cert}}{12{,}000} \cdot 400 \qquad 6.2$$

6.1.5.1.2 *Ducted Systems with a PSC AMS,Constant-torque AMS, or Constant-volume AMS Operating on Intermediate or Low Stage*. For any test other than A_{Full}, the Specified airflow for a given test shall not cause the ESP during any test calling for low or intermediate airflow to go below the minimum ESP values identified in Equation 6.3.

$$\Delta P_{st_i} = \Delta P_{st_{A,Full}} \cdot \left[\frac{\dot{Q}_{i,x}}{\dot{Q}_{A,Full}}\right]^2 \qquad 6.3$$

6.1.5.1.3 *Constant-volume AMS Static Settings*. For any Steady-State Test using a Constant-volume AMS, achieve the ESP as close to (but not less than) the applicable Table 10 value that does not cause either airflow variations Q_{Var} (as defined by Equation 6.4) of more than 10% or an automatic shutdown of the indoor blower.

$$Q_{Var} = \left[\frac{\dot{Q}_{max} - \dot{Q}_{min}}{\left(\frac{\dot{Q}_{max} + \dot{Q}_{min}}{2}\right)}\right] \cdot 100 \qquad 6.4$$

The following additional test steps are required if the measured ESP exceeds the target value by more than 0.03 in H_2O.

6.1.5.1.3.1 Measure and record the average power consumption of the indoor fan motor ($\dot{E}_{fan,1}$) and record the corresponding ESP (ESP_1) during or immediately following the thirty-minute interval used for determining capacity.

6.1.5.1.3.2 After completing the thirty-minute interval, adjust the exhaust fan of the airflow measuring apparatus until the ESP increases to approximately the value defined by Equation 6.5:

$$ESP_2 \approx ESP_1 + (ESP_1 - ESP_{min}) \qquad 6.5$$

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 ESP for a minimum five-minute interval.

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 6.6. The adjustments are as shown in Section 11 equations.

$$P_{adj} = \frac{(P_{fan,2} - P_{fan,1})}{(ESP_2 - ESP_1)} \cdot (ESP_{min} - ESP_1) \qquad 6.6$$

6.1.5.1.3.5 For all Steady-state Tests, total cooling capacity shall be increased and total heating capacity shall be decreased by $\dot{q}_{adj}$ as calculated per Equation 6.7, as shown in Section 11.

$$\dot{q}_{adj} = 3.412 \cdot P_{adj} \qquad 6.7$$

6.1.5.1.4 *Non-ducted Systems*. Specified instructions for setting fan speed or controls shall be used. If there are no instructions for setting fan speed or controls, use the as-shipped settings.

6.1.5.1.5 *Overspeeding*. If a unit's controls can overspeed the indoor blower (can be 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, or for heating full airflow on heating-only heat pumps, if ESP is lower than the minimum values identified in Table 10 at the manufacturer's Specified cooling full airflow or heating full airflow, the ESP shall be increased by reducing the airflow of the airflow measuring apparatus. If increasing ESP reduces airflow of the unit under test to less than 90% of Specified airflow and the minimum ESP is still not achieved, then the next higher Airflow-control Setting (if available) shall be utilized to obtain Specified airflow. If a higher Airflow-control Setting is not available, continue to decrease airflow of the airflow measuring apparatus until the required minimum ESP is achieved and use the resulting airflow of the unit under test as the cooling full airflow or heating full airflow as appropriate. 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 ESP is lower than the minimum values calculated per Equation 6.3 at manufacturer Specified airflow, the ESP shall be increased by reducing the airflow of the airflow measuring apparatus. If increasing ESP reduces airflow of the unit under test to less than 90% of Specified airflow and the minimum ESP is still not achieved, then the next higher Airflow-control Setting (if available) shall be utilized to obtain Specified airflow. If a higher Airflow-control Setting is not available, continue to decrease airflow of the airflow measuring apparatus until the required minimum ESP is achieved and use the resulting airflow of the unit under test as the cooling full airflow. Manual adjustments of Airflow-control Settings shall not be made.

6.1.5.1.8 *Units That Control To Different Constant Airflow At Each Test Condition Using The Same Blower Setting.* Use full, intermediate, and minimum airflows at each test condition that represent normal installation. Additionally, if conducting the dry-coil tests on variable capacity 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. ESP shall be controlled within -0.00 to +0.03 in H_2O of the target minimum ESP.

6.1.5.1.9 For units having a variable-speed indoor blower that is modulated to adjust the sensible to total (S/T) cooling capacity ratio, use cooling full-load and cooling minimum airflows that represent a normal installation. Additionally, if conducting the dry-coil tests, operate the unit in the same S/T capacity control mode as used for the B1 Test.

6.1.5.2 *Cooling Full Airflow*. The manufacturer shall have Specified the cooling full airflow, $Q_{A,Full}$. The Specified cooling full airflow value shall be utilized for all tests that call for cooling full airflow, 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. Static pressure requirements only apply to the A_{Full} test unless otherwise indicated.

6.1.5.2.1 *Coil-only Systems*. The Specified cooling full airflow shall not cause air static pressure drop across the Indoor Unit during the A_{Full} test to exceed 0.30 in H_2O. If this maximum static is exceeded, reduce the airflow with no minimum until the maximum static is achieved. Use this reduced airflow for all tests that require the cooling full airflow.

6.1.5.2.2 *PSC AMS or Constant-torque AMS Ducted Systems*. The Specified cooling full airflow shall not cause the ESP during the A_{Full} to go below the minimum values identified in Table 10. See Section 6.1.5.1.6. For single-split low-static blower-coil systems, test at the Specified full airflow (not to exceed 400 scfm per Specified ton of cooling capacity) at the maximum airflow setting. If ESP achieved at the Specified airflow is less than 0.1 in H2O, adjust the airflow measurement apparatus fan to reduce airflow and increase ESP until this level is achieved.

Table 10. Minimum ESP for Ducted Systems Tested with an Indoor AMS Installed

Product Type[1]	Minimum ESP (in H_2O)[2,3]
Conventional (*i.e.,* all central air conditioners and heat pumps not otherwise listed in this table)	0.50
Ceiling-mount and Wall-mount Blower-coil Systems	0.30
Mobile Home Blower-coil Systems	0.30
Low-static Blower-coil Systems	0.10
Low-static single-split blower-coil systems	See Section 6.1.5.2.2
Mid-static Blower-coil Systems	0.30
Small-duct, High-velocity	1.15
Space Constrained Product	0.30

Notes:

1. Refer to Definitions, Section 3.
2. For ducted units tested without an air filter installed, increase the applicable tabular value by 0.08 in H_2O.
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 blower coil to a maximum value of 0.1 in H_2O

6.1.5.2.3 *Constant-volume AMS Ducted Systems*. All tests requiring cooling full airflow shall be performed at the minimum ESP values identified in Table 10, with a tolerance of 0.00 to +0.03 in H_2O using the manufacturer's Specified Airflow-control Setting. If the manufacturer does not provide a Specified Airflow-control Setting, the manufacturer's airflow tables shall be used to determine the appropriate Airflow-control Setting. Refer to Section 6.1.5.1.3.

6.1.5.2.4 *Non-ducted Systems.* The cooling full airflow is the airflow rate that results during each test when the unit is operated at an ESP of 0.00 +0.02 in H_2O and at the Airflow-control Setting used at Full Compressor capacity.

6.1.5.2.5 *MIB Systems.* Obtain the full airflow with all indoor blowers operating unless prevented by the controls of the unit. In such cases, turn on the maximum number of indoor blowers permitted by the unit's controls. Where more than one option exists for meeting this "on" indoor blower requirement, which indoor blower(s) are turned on shall match that Specified in the report. Section 6.1.5.2 shall apply to each indoor blower separately. If two or more indoor blowers are connected to a common duct, temporarily divert their air volume to the test room when confirming or adjusting the setup configuration of individual indoor blowers. The allocation of the system's cooling full airflow assigned to each "on" indoor blower shall match the Specified value by the manufacturer.

6.1.5.3 *Cooling Low Airflow*. The manufacturer shall have Specified the cooling low airflow, $Q_{B,Low}$. The Specified cooling low airflow value shall be utilized for all tests that call for cooling low airflow unless otherwise modified by the following subsections. If there is no Specified cooling low airflow, use the final indoor blower control settings as determined when setting the cooling full airflow, and reduce the airflow with no minimum until the maximum static is achieved if necessary to reset to the cooling full airflow obtained in Section 6.1.5.2. If modified, that same modified value shall be utilized for all tests that call for cooling low airflow

6.1.5.3.1 *Coil-only Systems.* For Two-Stage Systems and Variable capacity Systems, the manufacturer Specified cooling low airflow shall not be less than 75% of the cooling full airflow, otherwise the 75% of the cooling full air flow shall be utilized. This cooling low airflow shall be utilized regardless of the pressure drop across the indoor coil assembly.

6.1.5.3.2 *PSC AMS or Constant-torque AMS Ducted Systems*. The Specified cooling low airflow shall not cause the ESP during the B_{Low} test to go below the minimum values calculated by Equation 6.3 For all other tests, the cooling low airflows Specified by the manufacturer shall be run at the same airflow as the B_{Low} test. For products that do not have automatic control of Airflow-control Settings, the manual Airflow-control Setting from cooling full airflow shall remain unchanged.

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

6.1.5.3.3 *Constant-volume AMS Ducted Systems*. All tests requiring cooling low airflow shall be performed at the minimum ESP values identified in Equation 6.3, with a tolerance of 0.00 to +0.03 in H_2O using the manufacturer's Specified Airflow-control Setting. If the manufacturer has not Specified an Airflow-control Setting, the manufacturer's airflow tables shall be used to determine the appropriate Airflow-control Setting. Refer to Section 6.1.5.1.3 and 6.1.5.1.7.

6.1.5.3.4 *Ducted Systems Having MIB*. For ducted systems having multiple indoor blowers within a single indoor section, operate the indoor blowers such that the lowest airflow allowed by the unit's controls is obtained when operating the lone single-speed compressor or when operating at low compressor capacity while meeting the requirements of Section 6.1.5.3 for the minimum number of blowers that shall be turned off. Minimum ESP shall use the procedure described in Section 6.1.5.1.2. The sum of the individual "on" indoor blowers' airflows is the cooling low airflow for the system.

6.1.5.3.5 *Non-ducted Systems.* The cooling low airflow is the airflow that results during each test when the unit is operated at an ESP of 0.00 + 0.02 in H_2O and at the indoor blower setting used at low compressor capacity (two-capacity system) or minimum compressor speed (variable-speed system). For units having a single-speed compressor and a variable-speed variable-air-volume-rate indoor blower, use the lowest fan setting allowed for cooling. Refer to Section 6.1.5.1.7.

6.1.5.4 *Cooling Intermediate Airflow.* The manufacturer shall have Specified the cooling intermediate airflow, $Q_{E,Int}$. The Specified cooling intermediate airflow value shall be utilized for all tests that call for cooling intermediate airflow, unless otherwise modified by the following subsections. If modified, that same modified value shall be utilized for all tests that call for cooling intermediate airflow. If there is no Specified cooling intermediate airflow, use the final indoor blower control settings as determined when setting the cooling full airflow, and reduce the airflow with no minimum until the maximum static is achieved if necessary to reset to the cooling full airflow obtained in Section 6.1.5.2.

6.1.5.4.1 *Coil-only Systems*. Variable capacity Coil-only Systems shall be run at the cooling low airflow.

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

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

6.1.5.4.3 *Constant-volume AMS Ducted Systems*. All tests requiring cooling intermediate airflow shall be performed at the minimum ESP values calculated using Equation 6.3, with a tolerance of 0.00 to +0.03 in H_2O. Refer to Section 6.1.5.1.3 and 6.1.5.1.8.

6.1.5.4.4 *Non-ducted Systems.* The cooling intermediate airflow is the airflow that results during each test when the unit is operated at an ESP of 0.00 + 0.02 in H_2O and at the fan speed selected by the controls of the unit for the E_V Test conditions. Refer to Section 6.1.5.1.8.

6.1.5.5 *Heating Full Airflow.* The manufacturer shall have Specified a heating full airflow, $\dot{Q}_{H1,Full}$, except as required by 6.1.5.5.1. The Specified heating full airflow value shall be utilized for all tests that call for heating full airflow, unless otherwise modified by the following subsections. If modified, that same modified value shall be utilized for all tests that call for heating full airflow. Unless otherwise indicated, static pressure requirements only apply to the $H1_{Full}$ test.

6.1.5.5.1 *Ducted Heat Pumps where the Heating Full Airflow and Cooling Full Airflow are the Same.* Use the cooling full airflow as the heating full airflow for:

6.1.5.5.1.1 Coil-only Heat Pumps (except Two-capacity Northern Heat Pumps tested only at low capacity in cooling – see Section 6.1.5.5.5), or

6.1.5.5.1.2 PSC AMS or Constant-torque AMS ducted heat pumps which operate at the same indoor Airflow-control Setting during both A_{Full} and $H1_{Full}$ tests, or

6.1.5.5.1.3 Constant-volume AMS ducted heat pumps which deliver the same airflow during both the A_{Full} and $H1_{Full}$ tests.

No ESP requirements apply for heat pumps of Sections 6.1.5.5.1.1 and 6.1.5.5.1.2. Use the final indoor blower control settings as determined when setting the cooling full airflow, and readjust the exhaust fan of the airflow measuring apparatus if necessary to reset to the cooling full airflow obtained in Section 6.1.5.2. For heat pumps where Section 6.1.5.5.1.3 is applicable, test at the minimum ESP identified in Table 10 (0.00 to +0.03 in H_2O). If the static pressure exceeds the minimum or targeted ESP by +0.03 in H_2O, or the setting causes airflow variations (Q_{var}) more than 10% or an automatic shutdown of the indoor blower, then use procedure from Section 6.1.5.1.3.

6.1.5.5.2 *PSC AMS or Constant-torque AMS Ducted Heat Pumps where the Heating Full Airflow and Cooling Full Airflows are Different Due to Automatic Indoor Fan or Controls Operation.* The Specified heating full airflow shall not cause the ESP during any test calling for heating full airflow to go below the minimum values identified in Equation 6.3. Refer to Section 6.1.5.1.7.

6.1.5.5.3 *Constant-volume AMS Ducted Heat Pumps where the Heating Full Airflow and Cooling Full Airflows are Different Due to Automatic Indoor Fan or Controls Operation*. All tests shall be performed at the minimum ESP values identified in Equation 6.3, with a tolerance of 0.00 to +0.03 in H_2O.

6.1.5.5.4 *Ducted Two-capacity and Triple-capacity Northern Heat Pumps*. Select the appropriate approach from 6.1.5.5.2 or 6.1.5.5.3 cases above for units that are tested with an indoor fan installed. For coil-only northern heat pumps, the heating full airflow is the lesser of the rate Specified by the manufacturer or 133% of the cooling full airflow. For this latter case, obtain the heating full airflow regardless of the pressure drop across the indoor coil assembly.

6.1.5.5.5 *Heating Only Coil-only Heat Pumps*. The manufacturer Specified heating full airflow shall not cause the pressure drop across the indoor coil during the $H1_{Full}$ to exceed 0.30 in H_2O. If the maximum static is exceeded, reduce airflow until maximum static is achieved. Use this reduced airflow for all tests that require the heating full airflow.

6.1.5.5.6 *PSC AMS or Constant-torque AMS Ducted Heating-Only Heat Pumps*. The manufacturer Specified heating full airflow shall not cause the ESP during the $H1_{Full}$ to go below the minimum values identified in Table 10. Refer to Section 6.1.5.1.6.

6.1.5.5.7 *Constant-volume AMS Ducted Heating-Only Heat Pumps*. The manufacturer Specified heating full airflow shall be performed at the minimum values identified in Table 10, with a tolerance of 0.00 to +0.03 in H_2O.

6.1.5.5.8 *Non-ducted Heat Pumps.* The heating full airflow is the airflow that results during each test when the unit is operated at an ESP of 0.00 in H_2O. Refer to Section 6.1.5.1.8

6.1.5.5.9 *Ducted Systems where the Heating Full Airflow and Cooling Full Airflows are Different Due to Controls*. For ducted systems having multiple indoor blowers within a single indoor section, obtain the heating full airflow using the same "on" indoor blowers as used for the Cooling full airflow. Using the target ESP and the Specified airflows, follow the procedures as described in Section 6.1.5.5.2 if the indoor blowers are not constant-air-volume indoor blowers or as described in Section 6.1.5.5.3 if the indoor blowers are constant-air-volume indoor blowers. The sum of the individual "on" indoor blowers' airflows is the heating full airflow for the system.

6.1.5.5.10 *Ducted Systems where the Heating Full Airflow and Cooling Full Airflows are Different Due Indoor Blower Operation*. For ducted systems with multiple indoor blowers within a single indoor section, obtain the heating low airflow using the same "on" indoor blowers as used for the cooling low airflow. Using the target ESP and the Specified airflows, follow the procedures as described in Section 6.1.5.5.2 if the indoor blowers are not constant-air-volume indoor blowers or as described in Section 6.1.5.5.3 if the indoor blowers are constant-air-volume indoor blowers. The sum of the individual "on" indoor blowers' airflows is the heating full airflow for the system.

6.1.5.5.11 *Variable capacity Coil-only Systems*. Variable capacity Coil-only Systems shall be run at the cooling full airflow.

6.1.5.6 *Heating Low Airflow.* The manufacturer shall have Specified a heating low airflow except as required by Section 6.1.5.6.1. The Specified heating low airflow value shall be utilized for all tests that call for heating low airflow, unless otherwise modified by the following subsections. If modified, that same modified value shall be utilized for all tests that call for heating low airflow.

6.1.5.6.1 *Ducted Heat Pumps where the Heating Low Airflow and Cooling Low Airflow are the Same.* Use the cooling low airflow as the heating low airflow for:

6.1.5.6.1.1 *Coil-only Heat Pumps*, or

6.1.5.6.1.2 PSC AMS or Constant-torque AMS ducted heat pumps which operate at the same Airflow-control Setting during both B_{Low} and $H1_{Low}$ tests, or

6.1.5.6.1.3 Constant-volume AMS ducted heat pumps which deliver the same airflow during both the B_{Low} and $H1_{Low}$ tests.

For Sections 6.1.5.6.1.1 and 6.1.5.6.1.2, use the final indoor blower control settings as determined when setting the cooling minimum airflow, and readjust the exhaust fan of the airflow measuring apparatus if necessary to reset to the cooling minimum airflow obtained in Section 6.1.5.3. For heat pumps where Section 6.1.5.6.1.3 is applicable, test at the minimum ESP as was identified for the B_{Low} cooling mode test (0.00 to +0.03 in H_2O). If the static pressure exceeds the minimum or targeted ESP by +0.03 in H_2O, or the setting causes airflow variations (Qvar) more than 10% or an automatic shutdown of the indoor blower, then use procedure from Section 6.1.5.1.3.

6.1.5.6.2 *PSC AMS or Constant-torque AMS Ducted Heat Pumps where the Heating Low Airflow and Cooling Low Airflows are Different Due to Automatic Indoor Fan or Controls Operation.* For the initial test requiring the heating low airflow, the Specified heating low airflow shall not cause the ESP to go below the minimum values identified in Equation 6.3. Refer to Section 6.1.5.1.7. For all subsequent tests requiring the heating low airflow, use the same heating low airflow from the initial test requiring the heating low airflow.

6.1.5.6.3 *Constant-volume AMS Ducted Heat Pumps where the Heating Low Airflow and Cooling Low Airflows are Different Due to Automatic Indoor Fan or Controls Operation*. All tests requiring heating low airflow shall be performed at the minimum ESP values identified in Equation 6.1, with a tolerance of 0.00 to +0.03 in H_2O. Refer to Section 6.1.5.1.3 and 6.1.5.1.8

6.1.5.6.4 *Non-ducted Heat Pumps, Including Non-ducted Heating-only Heat Pumps*. The heating low airflow is the airflow that results during each test when the unit operates at an ESP of 0.00 + 0.02 in H_2O and at the indoor blower setting used at low compressor capacity. For units having a single-speed compressor and a variable-speed, variable-air-volume-rate indoor blower, use the lowest fan setting allowed for heating. Refer to Section 6.1.5.1.8.

6.1.5.6.5 *Ducted Two-capacity and Triple Capacity Northern Heat Pumps*. Select the appropriate approach from 6.1.5.6.2 or 6.1.5.6.3 cases above for units that are tested with an indoor fan installed. For Coil-only Heat Pumps, the heating low airflow is the higher of cooling full airflow or 75% of the heating full airflow. For *Coil-only Heat Pumps*, obtain the heating low airflow regardless of the pressure drop across the indoor coil assembly.

6.1.5.6.6 *Heating Only Coil-only Heat Pumps*. The manufacturer Specified heating low airflow shall not be less than 75% of the heating full airflow.

6.1.5.6.7 *PSC AMS or Constant-torque AMS Ducted Heating-Only Heat Pumps*. The manufacturer Specified heating low airflow shall not cause the ESP during any Low Stage heating test to go below the minimum values calculated from Equation 6.3.

6.1.5.6.8 *Constant-volume AMS Ducted Heating-Only Heat Pumps*. The manufacturer Specified heating low airflow shall be performed at the minimum values calculated from Equation 6.3 with a tolerance of 0.00 to +0.03 in H_2O.

6.1.5.6.9 *Variable capacity Coil-only Systems*. Variable capacity Coil-only Systems shall run at the cooling low airflow.

6.1.5.7 *Heating Intermediate Airflow.* The manufacturer shall have Specified a heating intermediate airflow except as required by 6.1.5.7.1. The Specified heating intermediate airflow value shall be utilized for all tests that call for heating intermediate airflow, unless otherwise modified by subsections of Section 6.1.5.7. If modified, that same modified value shall be utilized for all tests that call for heating intermediate airflow. If there is no Specified heating intermediate airflow, use the final indoor blower control settings as determined when setting the heating full airflow, and readjust the exhaust fan of the airflow measuring apparatus if necessary to reset to the cooling full airflow obtained in Section 6.1.5.2. Calculate the target minimum ESP as described in Section 6.1.5.2.

6.1.5.7.1 Coil-only Heat Pumps where the Heating Intermediate Airflow and Cooling Intermediate Airflow are the Same. See Section 6.1.5.4.1.

6.1.5.7.2 PSC AMS or Constant-torque AMS Ducted Systems. The Specified heating intermediate airflow shall not cause the ESP during any test calling for heating intermediate airflow to go below the minimum values identified in Equation 6.3. Refer to Section 6.1.5.1.7.

6.1.5.7.3 *Constant-volume AMS Ducted Systems*. All tests requiring heating intermediate airflow shall be performed at the minimum ESP values identified by Equation 6.3, with a tolerance of 0.00 to +0.03 in H_2O. Refer to Section 6.1.5.1.7 and 6.1.5.1.8.

6.1.5.7.4 *Non-ducted Heat Pumps, Including Non-ducted Heating-only Heat Pumps*. The heating intermediate airflow is the airflow that results during each test when the unit operates at an ESP of 0.00 + 0.02 in H_2O and at the fan speed selected by the controls of the unit for the $H2_V$ Test conditions. Refer to Section 6.1.5.1.8

6.1.5.7.5 *Variable capacity Coil-only Systems*. Variable capacity Coil-only Systems shall run at the cooling full airflow.

6.1.5.8 *Heating Nominal Airflow*. The manufacturer shall have Specified a heating nominal airflow and the instructions for setting fan speed and controls. The Specified heating nominal airflow value shall be utilized for all tests that call for heating nominal airflow, except as noted below. If modified, that same modified value shall be utilized for all tests that call for heating nominal airflow. For variable capacity coil-only systems, the heating nominal airflow shall be the same as the cooling full airflow.

The Specified heating nominal airflow shall not cause the ESP during any test calling for heating nominal airflow to go below the minimum values identified in Equation 6.3.

6.1.5.9 *MIB Airflow.* For any test where a MIB system is operated at its lowest capacity—i.e., the lowest total airflow allowed when operating the single-speed compressor or when operating at low compressor capacity—turn off indoor blowers accounting for at least one-third of the full airflow unless prevented by the controls of the unit. In such cases, turn off as many indoor blowers as permitted by the unit's controls. Where more than one option exists for meeting this "off" requirement, the manufacturer shall indicate in its certification report which indoor blower(s) are turned off. The chosen configuration shall remain unchanged for all tests conducted at the same lowest capacity configuration. For any indoor coil turned off during a test, cease forced airflow through any outlet duct connected to a switched-off indoor blower.

6.1.6 *Outdoor-Coil Airflow.* All Standard Ratings shall be determined at the outdoor coil airflow 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 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 products 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 0.10 and 0.15 in H_2O ESP. ESP measurements shall be made in accordance with ASHRAE Standard 37 Sections 6.4 and 6.5.

6.1.7 *Control of Auxiliary Resistance Heating Elements.* Except as noted, disable heat pump resistance elements used for heating indoor air at all times, including during defrost cycles and non-defrost tests for units with a Heat Comfort Controller. For heat pumps equipped with a Heat Comfort Controller, enable the heat pump resistance elements only during the below-described, short test. The short test follows the $H1_{Full}$ test or, if conducted, the $H1C_{Full}$ test. Set the Heat Comfort Controller to provide the maximum supply air temperature. With the heat pump operating and while maintaining $Q_{H1\text{-}Full}$, measure the temperature of the air leaving the indoor-side beginning five minutes after activating the Heat Comfort Controller. Sample the outlet dry-bulb temperature at regular intervals that span five minutes or less. Collect data for ten minutes, obtaining at least three samples. Measure the outlet temperature (T_{cc}), °F, averaged over the ten-minute interval.

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 stated 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 (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 SEER2 combination as Specified by the OUM. If there are multiple models of Outdoor Unit with the same lowest SEER2 represented value, the ICM shall select one for testing purposes.

6.1.8.4 *Single Split System Heat Pump (Distributed in Commerce by an ICM)*. Does not need to be tested as long as an equivalent air conditioner basic model has been tested. If an equivalent model has not been tested, manufacturers shall test a model of Indoor Unit with a model of Outdoor Unit meeting the same requirements listed as in Section 6.1.8.3 for Single-split Air-conditioner distributed in commerce by an ICM.

6.1.8.5 *Multi-split, Multi-Head Mini-Split, or Multi-Circuit System (including Space Constrained Product and SDHV)*. (See also Section 6.4.1.1.). 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 24,000 Btu/h 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 ESP requirement while able to produce the same ESP at the exit of each outlet plenum when connected in a manifold configuration as required by the test procedure.

6.1.8.6 *Outdoor Unit with No Match*. The model of Outdoor Unit shall be tested with a model of Coil-only Indoor Unit meeting the requirements of Section 5.1.6.2.

6.1.8.7 *Single Package Air Conditioners and Heat Pumps (Including Space Constrained) Selected for Testing.* Manufacturers shall test the individual model with the lowest SEER2.

6.2 *Application Ratings.* Ratings at conditions of temperature or airflow other than those identified in Sections 6.1.3 can be published as Application Ratings and shall be based on data determined by the methods prescribed in Section 6.4.1 or Section 6.4.2. Application Ratings in the defrost region shall include Net Capacity and COP2 based upon a complete defrost cycle (instantaneous capacity can be provided as long as Net Capacity is also provided).

6.2.1 *International Ratings.*

6.2.1.1 *Cooling Temperature Conditions*.

6.2.1.1.1 The T1, T2, and T3 temperature conditions identified in Table 11 shall be considered Rating Conditions for the determination of cooling capacity and energy efficiency.

6.2.1.1.2 Equipment manufactured for use only in a moderate climate similar to that identified in Column T1 of Table 11 shall have ratings at T1 conditions and shall be designated type T1 equipment.

6.2.1.1.3 Equipment manufactured for use only in a cool climate similar to that identified in Column T2 of Table 11 shall have ratings at T2 conditions and shall be designated type T2 equipment.

6.2.1.1.4 Equipment manufactured for use only in a hot climate similar to that identified in Column T3 of Table 11 shall have ratings at T3 conditions and shall be designated type T3 equipment.

6.2.1.1.5 Equipment manufactured for use in more than one of the climates defined in Table 11 shall have marked on the nameplate the designated type (T1, T2, and/or T3). The corresponding ratings shall be determined by the Rating Conditions identified in Table 11.

6.2.1.2 *Heating Temperature Conditions*.

6.2.1.2.1 The H1, H2, and H3 temperature conditions identified in Table 11 shall be considered Rating Conditions for the determination of heating capacity and energy efficiency.

6.2.1.2.2 All heat pumps shall be rated at the H1 temperature conditions.

6.2.1.2.3 Equipment manufactured for use in more than one of the climates defined in Table 11 shall have marked on the nameplate the designated type (H1, H2, and/or H3). The corresponding ratings shall be determined by the Rating Conditions identified in Table 11.

Table 11. Application Rating Conditions for I-P Standards[1]

Cooling – Standard Temperature Conditions	T1 (Moderate Climates)	T2 (Cool Climates)	T3 (Hot Climates)
Indoor	80.6°F DB & 66.2°F WB	69.8°F DB & 59.0°F WB	84.2°F DB & 66.2°F WB
Outdoor	95.0°F DB & 75.2°F WB	80.6°F DB & 66.2°F WB	114.8°F DB & 75.2°F WB
Cooling – Maximum Temperature Conditions	T1 (Moderate Climates)	T2 (Cool Climates)	T3 (Hot Climates)
Indoor	89.6°F DB & 73.4°F WB	80.6°F DB & 66.2°F WB	89.6°F DB & 73.4°F WB
Outdoor	109.4°F DB & 78.8°F WB	95.0°F DB & 75.2°F WB	125.6°F DB & 73.4°F WB
Heating – Standard Temperature Conditions	H1 – (Warm Climates)	H2 – (Moderate Climates)	H3 – (Cold Climates)
Indoor	68.0°F DB and 59.0°F WB max.	68.0°F DB & 59.0°F WB max.	68.0°F DB and 59.0°F WB max.
Outdoor	44.6°F DB and 42.8°F WB	35.6°F DB & 33.8°F WB	19.4°F DB & 17.6°F WB
Heating – Maximum Temperature Conditions	H1 – (Warm Climates)	H2 – (Moderate Climates)	H3 – (Cold Climates)
Indoor	75.2°F DB and 64.4°F WB		
Outdoor	80.6°F DB		

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

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 Btu/h at the Standard Rating Conditions identified 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, EER2, SEER2, HSPF2 or $P_{w,Off}$ shall be based either on test data or computer simulation. For three-phase systems refer to Appendix F.

6.4.1 Note that DOE requires represented values for individual models, individual combinations, and Tested Combinations as identified in 10 CFR 429.16(a)(1). For consistency, this also applies to Standard Ratings:

6.4.1.1 *Single-package Air Conditioners and Single-package Heat Pumps (Including Space Constrained).* Manufacturers shall determine represented values for every individual model distributed in commerce.

6.4.1.2 *Single-split Air-conditioners with Single-stage or Two-stage Compressors (Including Space Constrained and SDHV) Distributed in Commerce by an OUM.* Manufacturers shall determine represented values for every individual combination distributed in commerce. For each model of Outdoor Unit, this shall include at least one Coil-only System that is representative of the least efficient combination distributed in commerce with that particular model of Outdoor Unit.

Note: Additional representations for Blower Coil Systems are may be made for any applicable individual combinations, if distributed in commerce.

6.4.1.3 *Single-split Air-conditioners with Other Than Single-stage or Two-stage Compressors (Including Space Constrained and SDHV) Distributed In Commerce By An OUM*. Manufacturers shall determine represented values for every individual combination distributed in commerce, including all Coil-only Systems and Blower Coil System.

6.4.1.4 *Single-split Heat Pumps (Including Space Constrained and SDHV) distributed in commerce by an OUM*. Manufacturers shall determine represented values for every individual combination distributed in commerce. If a manufacturer offers combinations of both Coil-only Systems and Blower Coil Systems, represented values shall be required for both.

6.4.1.5 *Single-split Air-Conditioners and Single-split Heat Pumps (Including Space Constrained and SDHV) distributed in commerce by an ICM*. Manufacturers shall determine represented values for every individual combination distributed in commerce.

6.4.1.6 *Outdoor Unit With No Match.* Manufacturers shall determine represented values for every model of Outdoor Unit distributed in commerce (tested with a model of Coil-only Indoor Unit as identified in 10 CFR 429.16(b)(2)(i)).

6.4.1.7 *Multi-split, Multi-circuit System or Multi-head Mini-split (Including SDHV and Space Constrained).* See Section 6.4.3.3.

6.4.2 *Refrigerants.*

6.4.2.1 If a model of Outdoor Unit (used in a Single-split System, Multi-split System, Multi-circuit System, Multi-head Mini-split System, and/or Outdoor Unit with no match system) is distributed in commerce and approved for use with multiple refrigerants, a manufacturer shall determine Standard Ratings for that model using each refrigerant that can be used in an individual combination of the basic model (including Outdoor Units with no match or "Tested Combinations"). This requirement shall apply across the listed categories in the table in paragraph (a)(1) of 10 CFR 429.16. A refrigerant is considered approved for use if it is listed on the nameplate of the Outdoor Unit. If any of the refrigerants approved for use is HCFC-22 or has a 95°F midpoint saturation absolute pressure that is ± 18% of the 95°F saturation absolute pressure for HCFC-22, or if there are no refrigerants designated as approved for use, a manufacturer shall determine represented values (including SEER2, EER2, HSPF2, $P_{W,Off}$, cooling capacity, and heating capacity, as applicable) for, at a minimum, an Outdoor Unit with no match. If a model of Outdoor Unit is not charged with a Specified refrigerant from the point of manufacture or if the unit is shipped requiring the addition of more than two pounds of refrigerant to meet the charge required for the A_{Full} test per Table 8 when charged per Section 5.1.8 (unless either (a) the factory charge is equal to or greater than 70% of the Outdoor Unit internal volume times the liquid density of refrigerant at 95°F or (b) an A2L refrigerant is approved for use and listed in the certification report), a manufacturer shall determine Standard Ratings (including SEER2, EER2, HSPF2, $P_{W,Off}$, cooling capacity, and heating capacity, as applicable) for, at a minimum, an Outdoor Unit with no match.

6.4.2.2 If a model is approved for use with multiple refrigerants, Standard Ratings shall be either a) multiple Standard Ratings, with one Standard Rating provided for the performance of the model with each individual refrigerant or b) if a single Standard Rating is to be provided, the least-efficient refrigerant shall be used to create the Standard Rating. A single Standard Rating made for multiple refrigerants shall not include equipment in multiple categories or equipment subcategories listed in the table in paragraph 10 CFR 429.16(a)(1).

6.4.3 *Ratings Generated by Test Data.*

6.4.3.1 *Ratings Where Higher Values are Favorable.* Any capacity, EER2, SEER2 or HSPF2 rating of a system generated by test data shall be based on the results of at least two unique production or production representative samples tested in accordance with all applicable portions of this standard. The capacity, EER2, SEER2 or HSPF2 or ratings shall not be higher than the lower of a) the test sample mean ($\bar{x}$), or b) the lower 90% confidence limit (LCL) divided by 0.95 (as defined by the formulas below), rounded per Sections 6.1.1 and 6.1.2.

$$\bar{x} = \frac{\sum_{i=1}^{n} x_i}{n} \qquad 6.8$$

$$LCL = \bar{x} - t_{.90}\left(\frac{s}{\sqrt{n}}\right) \qquad 6.9$$

For $t_{.90}$ see Table 12 (See also Appendix A of Subpart B of 10 CFR §429).

Table 12. t Statistic	
Number of Systems Tested[1]	$t_{.90}$
2	3.078
3	1.886
4	1.638
5	1.533
6	1.476

Note:
From Appendix A of Subpart B of 10 CFR §429

6.4.3.2 *Ratings Where Lower Values are Favorable.* Any $P_{w,Off}$ rating, or other measure of Off-mode Power Consumption for which consumers would favor lower values, generated by test data shall be based on the results of at least two unique production or production representative samples tested in accordance with all applicable portions of this standard. The $P_{w,Off}$ ratings shall not be lower than the higher of a) the test sample mean ($\bar{x}$) per Equation 6.8, or b) the upper 90% confidence limit (UCL) divided by 1.05 (as defined by the formulas below), rounded per Sections 6.1.1 and 6.1.2.

$$UCL = \bar{x} + t_{.90}\left(\frac{s}{\sqrt{n}}\right) \quad 6.10$$

6.4.3.3 *Multi-split, Multi-circuit and Multi-head Mini-split System Ratings Determined by Test.*

6.4.3.3.1 For manufacturers that offer only non-ducted combinations, ratings for each model of Outdoor Unit shall be determined by testing at least two complete system samples of the same Tested Combination of Non-ducted Indoor Units (following the sampling plan in 10 CFR 429.16).

6.4.3.3.1.1 In general, this rating applies to all combinations of a Multi-split system having the same Outdoor Unit and only Non-ducted Indoor Units, including those Non-tested Combinations (NTCs) unless a manufacturer wants to represent the rating of a specific combination.

6.4.3.3.1.2 A manufacturer shall choose to make representations for other individual combinations of models of Non-ducted Indoor Units for the same model of Outdoor Unit, but these shall be rated as separate basic models, following the sampling plan in 10 CFR 429.16.

6.4.3.3.2 Manufacturers, offering both non-ducted combinations and non-SDHV ducted combinations of Indoor Units, shall determine ratings for each model of Outdoor Unit by test according to the sampling plan in 10 CFR 429.16. Non-ducted system ratings and ducted systems ratings shall each be determined by testing two or more complete system samples of each system with all samples for each system type having the same Tested Combination.

6.4.3.3.2.1 In general, these ratings apply to all combinations of a Multi-split system having the same Outdoor Unit and using only Non-ducted Indoor Units and all combinations of a Multi-split system having the same Outdoor Unit and using only ducted Indoor Units, respectively, including those NTCs unless a manufacturer wants to represent the rating of a specific combination.

6.4.3.3.2.2 The rating given to any NTCs of Multi-split System having the same Outdoor Unit and a mix of non-ducted and ducted Indoor Units shall be set equal to the average of the ratings for the two required Tested Combinations.

6.4.3.3.2.3 A manufacturer shall choose to make representations for other individual combinations of models of Indoor Units for the same model of Outdoor Unit, but these shall be rated as separate basic models, following the sampling plan in

10 CFR 429.16

6.4.3.3.3 For manufacturers that offer SDHV combinations, ratings for each model of Outdoor Unit shall be determined by testing at least two complete system samples of the same Tested Combination of SDHV Indoor Units (following the sampling plan in 10 CFR 429.16). For Independent Coil Manufacturers, the Outdoor Unit is the least efficient model of Outdoor Unit with which the SDHV Indoor Unit shall be paired. The least efficient model of Outdoor Unit is the model of Outdoor Unit in the lowest SEER2 combination. If there are multiple models of Outdoor Unit with the same lowest SEER2 represented value, the ICM shall select one for testing purposes.

6.4.3.3.3.1 In general, this rating applies to all combinations of a Multi-split system having the same Outdoor Unit and using only SDHV Indoor Units, including those NTCs.

6.4.3.3.3.2 For basic models composed of both SDHV and non-ducted or ducted combinations, the represented value for the mixed SDHV/non-ducted or SDHV/ducted combination is the mean of the represented values for the SDHV, non-ducted, or ducted combinations, as applicable, as determined in accordance with the sampling plan in 10 CFR 429.16.

6.4.3.3.3.3 A manufacturer shall choose to make representations for other individual combinations of models of Indoor Units for the same model of Outdoor Unit, but these shall be rated as separate basic models, following the sampling plan in 10 CFR 429.16.

6.4.3.3.4 *External Static Pressure*. For Non-ducted Systems, all Indoor Units shall be subject to the same ESP (i.e., 0.00 in H_2O). For ducted, all Indoor Units shall be subject to the same minimum ESP (see Table 10) while being configurable to produce the same static pressure at the exit of each outlet plenum.

6.4.3.4 $P_{w,Off}$. If individual models of Single Package Units or individual combinations (or "Tested Combinations") of Split System that are otherwise identical are offered with multiple options for off-mode-related components, determine the represented value for the individual model/combination with the Crankcase Heater and controls that are the most consumptive. A manufacturer can determine represented values for individual models/combinations with less consumptive off-mode options; however, all such options shall be identified with different model numbers for single-package systems or for Outdoor Units (in the case of Split Systems).

6.4.4 *Ratings Generated by Computer Simulation*. Any capacity, EER2, SEER2 or HSPF2 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). Any $P_{w,Off}$ rating of a system generated by the results of an AEDM shall be no lower than or equal to the output of the AEDM. Any AEDM used shall be created in compliance with the regulations identified in 10 CFR §429.70.

6.4.4.1 No model of OUWNM shall be rated by computer simulation. All models of OUWNM shall be rated by test.

6.4.5 *Documentation*. As required by federal law (10 CFR §429.71), supporting documentation of all Published Ratings subject to federal control shall be appropriately maintained.

6.4.6 *Multiple Standard Ratings*. A single product can 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 (e.g. A Two-capacity Heat Pump can be rated as a Two-Capacity Northern Heat Pump by locking out Full Stage cooling).

6.5 *Uncertainty and Variability*. 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, ASHRAE 37 and ASHRAE 116. The uncertainty for Standard Ratings covered by this standard include 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)

7.1.1.1 AHRI Standard Rating cooling capacity, Btu/h
7.1.1.2 Energy Efficiency Ratio ($EER2_{A,Full}$), Btu/(W·h)
7.1.1.3 Seasonal Energy Efficiency Ratio (SEER2), Btu/(W·h)

7.1.2 For all Unitary Air-source Heat Pumps

7.1.2.1 AHRI Standard Rating cooling capacity, Btu/h
7.1.2.2 Energy Efficiency Ratio ($EER2_{A,Full}$) , Btu/(W·h)
7.1.2.3 Seasonal Energy Efficiency Ratio (SEER2), Btu/(W·h)
7.1.2.4 High temperature heating Standard Rating capacity, Btu/h
7.1.2.5 Region IV Heating Seasonal Performance Factor, HSPF2, Btu/(W·h)

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 to 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 210/240." All claims to ratings outside the scope of this standard shall include the statement "Outside the scope of AHRI 210/240." 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. Tests required for this Section shall be per Tables 13 and Table 14.

Table 13 Operational Mode Tests[1]

Test Name	Single Stage System	Single Stage with VAV/MIB	Variable Capacity Certified, Single-Capacity System	Two-stage System[4]	Two-stage Northern	Variable Capacity Certified, Two-Capacity System	Variable Capacity Compressor System	Triple-capacity Northern
Cooling Mode Operation Tests [1,2,3]								
Voltage Tolerance	R	R	R	R	R	R	R	R
Low Temperature Cooling	R	R	R	R	R	R	R	R
Insulation Efficiency	R	R	R	R	R	R	R	R
Condensate Disposal	R	R	R	R	R	R	R	R
Maximum Operating Conditions	R	R	R	R	R	R	R	R
Heating Mode Operation Tests [1,3]								
Voltage Tolerance	R	R	R	R	R	R	R	R
Maximum Operating Conditions	R	R	R	R	R	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. Required for any unit that has a cooling mode function.
3. See AHRI Unitary Small Equipment Operation Manual for details.
4. Maximum value for all tests. If outdoor air enthalpy method is used for Single Package Heat Pumps, then the indoor wet-bulb temperature shall be adjusted to match as close as reasonably possible to the dew point of the outdoor entering air.

Table 14 Operation Mode Tests[1]

Test Name	Air Entering Outdoor Unit [2] (°F)	Air Entering Indoor Unit [2] (°F)	Compressor Capacity [3]	Indoor Airflow [4]
Cooling Mode Operation Tests				
Voltage Tolerance	95.0 / 75.0 [5, 6]	80.0 / 67.0	Full_C	Full_C
Low Temperature	67.0 / 57.0	67.0 / 57.0 [7]	Full_C	Full_C
Insulation Efficiency	80.0 / 75.0	80.0 / 75.0	Full_C	Full_C
Condensate Disposal	80.0 / 75.0	80.0 / 75.0	Full_C	Full_C
Maximum Operation	115.0 / --	80.0 / 67.0	Full_C	Full_C
Extra High Maximum Operation (Optional)	125.6 / --	80.0 / 67.0	Full_C	Full_C
Heating Mode Operation Tests				
Voltage Tolerance	47.0 / 43.0	70.0 / 60.0 [8]	Full_H	Full_H
Maximum Operation	75.0 / 65.0	80.0 / --	Full_H	Full_H

Notes:

1. Test condition tolerances are defined within ASHRAE 37, ASHRAE 116 Table 3b for cyclic, and Section 8.7 of this standard.
2. Values listed are dry-bulb temperature / wet-bulb temperature, °F.
3. Refer to Section 3 for definition of "Full", "Low", "Int" and "Boost" for each compressor type.
4. Refer to Section 6.1.5 for airflow details.
5. Wet-bulb temperature specification 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, adjust the outdoor wet-bulb temperature such that the dew point is 60.5 ± 3.0ºF.
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 57.0°F or less be used.)
8. Maximum value for all tests. If outdoor air enthalpy method is used for Single Package Heat Pumps, then the indoor wet-bulb temperature shall be adjusted to match as close as reasonably possible to the dew point of the outdoor entering air.

Refer to Section 6.1.5.8.

8.2 *Maximum Operating Conditions Test.* Unitary equipment shall pass the following maximum operating conditions test with indoor-coil airflow $\dot{Q}_{A,Full}$ as determined under Section 6.1.5.

8.2.1 *Temperature Conditions.* Temperature conditions shall be maintained as shown in Table 8, 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 identified in the standard.

8.2.4 *Requirements.* The equipment shall operate continuously without interruption for any reason for one hour.

8.3 *Voltage Tolerance Test.* Unitary equipment shall pass the following voltage tolerance test with a cooling coil airflow 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 8, as applicable, in accordance with the unit's nameplate. For equipment marked for applications for more than one Standard Rating condition (T1, T2, and/or T3) 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 from AHRI Standard 110, Table 1, based upon the unit's nameplate rated voltage(s). These voltages shall be supplied at the unit's service connection and at rated frequency. A lower minimum or a higher maximum voltage shall be used, if listed on the nameplate.

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

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

8.3.3 *Procedure.*

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

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

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

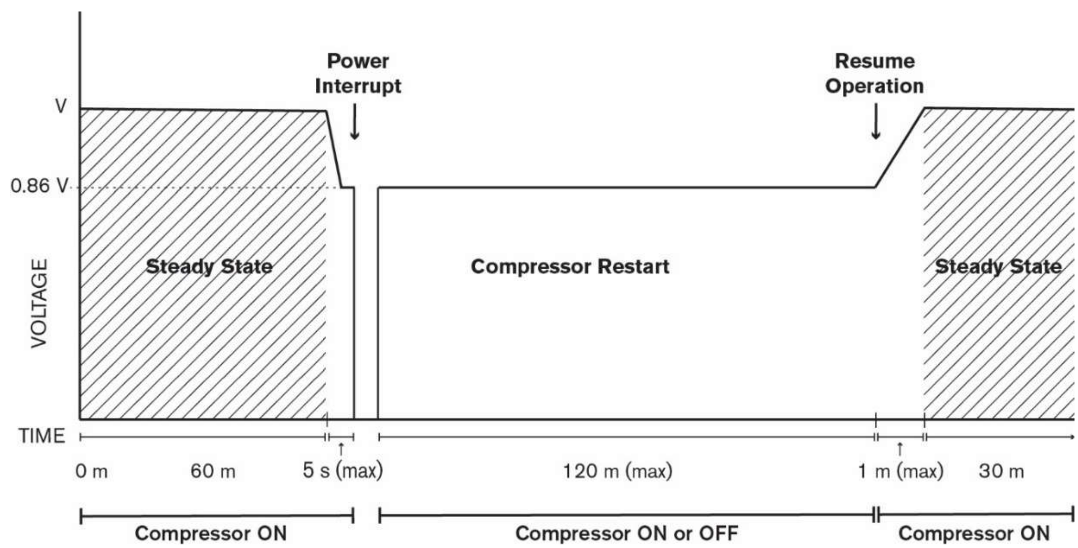

Figure 1. Voltage Tolerance Test Power Interrupt Procedure.

8.3.4 *Requirements.*

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

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

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

8.4 *Low-Temperature Operation Test (Cooling) (Not Required For Heating-only Units).* Unitary equipment shall pass the following low-temperature operation test when operating with initial airflow, $\dot{Q}_{A,Full}$, 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 8.

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 temperature conditions identified in the standard. 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 32°F + half of refrigerant temperature glide.

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

8.5 *Insulation Effectiveness Test (Cooling) (not required for heating-only units)*. Unitary equipment shall pass the following insulation effectiveness test when operating with airflow, $\dot{Q}_{A,Full}$, 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 8.

8.5.2 *Procedure.* After establishment of the temperature conditions identified in the standard, 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)* (not required for heating-only units).* Unitary equipment which rejects condensate to the condenser air shall pass the following condensate disposal test when operating with airflows 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.

* 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 8.

8.6.2 *Procedure.* After establishment of the temperature conditions identified in the standard, 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 ± 1.0 °F for air wet-bulb and dry-bulb temperatures and ± 1.0% of the reading for voltages.

Section 9. Marking and Nameplate Data

11.2 *Marking and Nameplate Data.* As a minimum, the nameplate shall display the manufacturer's name, model designation, electrical characteristics and refrigerants approved for use by the manufacturer.

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 Specified Standard Rating performance metrics shown in Table H1 of Appendix H 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 ASHRAE 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 ASHRAE 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 methods shall only be used for secondary calculation methods. All air properties shall be calculated per the ASHRAE Fundamentals Handbook.

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 A_{Full} test is $q_{tci,A,Full}$, in this calculation section q_x is used, where "x" is equal to A_{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 ($H2_x$ tests), airflow through the indoor coil, $\dot{Q}_{mi}$, and airflow through the Outdoor Coil, $\dot{Q}_{mo}$, shall be calculated per the equations identified in Section 7.7.2.1 and Section 7.7.2.2 of ASHRAE 37. The standard airflow, $\dot{Q}_s$, shall be calculated from Section 7.7.2.3 of ASHRAE 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. For Multi-split Systems, capacity adjustment factor, F_{ccc}, shall only be applied to full load cooling tests. Refer to Table 4.

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

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

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

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.

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

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

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

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. For Multi-split Systems, capacity adjustment factor, F_{ccc}, shall only be applied to full load cooling tests. Refer to Table 4.

$$\dot{q}_{tco,x} = \frac{60 \cdot \dot{Q}_{mo}(h_{a4} - h_{a3})}{v'_n(1+W_n)} - 3.412 \cdot P_{tot,x} \qquad 11.7$$

$$\dot{q}_{tco,x} = \frac{60 \cdot \dot{Q}_{mo} c_{pa4}(t_{a4} - t_{a3})}{v'_n(1+W_n)} - 3.412 \cdot P_{tot,x} \qquad 11.8$$

11.1.1.3 *Total Cooling Capacity (Refrigerant Enthalpy Method).* The Net Capacity for all steady state cooling tests shall be calculated as follows. See Section D6.3.2 of this Standard for information about mass flow ratio, *x*. For Multi-split Systems, capacity adjustment factor, F_{ccc}, shall only be applied to full load cooling tests. Refer to Table 4.

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

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

$$\dot{q}s_{adj,x} = 3.412 \cdot P_{fan,x} \qquad 11.10$$

Where for all Blower Coil Systems, $P_{fan,x}$ is the measured indoor power.

For Non-mobile home, non-Space Constrained Coil-only Systems:

$$P_{fan,x} = \frac{DFPC_C}{1000} \cdot \dot{Q}_s \qquad 11.11$$

For Mobile home, Space Constrained Coil-only Systems:

$$P_{fan,x} = \frac{DFPC_{MHSC}}{1000} \cdot \dot{Q}_s \qquad 11.12$$

Where $DFPC_C$ is the default fan power coefficient (watts) for non-mobile-home and non-space-constrained systems:

$$\mathbf{DFPC}_{C} = 335 + \frac{(441 - 335) * (\%FLAVR - 75\%)}{100\% - 75\%}$$

$DFPC_{MHSC}$ is the default fan power coefficient (watts) for mobile-home and space-constrained systems:

$$\mathbf{DFPC}_{MHSC} = 308 + \frac{(406 - 308) * (\%FLAVR - 75\%)}{100\% - 75\%}$$

and %FLAVR is the airflow used for the test, expressed as a percentage of the cooling full load airflow.

For all tests specifying the full-load airflow (e.g., the A_{full} and B_{full} tests), set %FLAVR to 100%. For tests that specify the cooling minimum airflow or cooling intermediate airflow (i.e., the A_{low}, B_{low}, E_{int}, and F_{low} tests) set %FLAVR to 75%, except in cases for which the Specified minimum or intermediate airflow is greater than or equal to 75% of the cooling full-load airflow—for these latter cases, set %FLAVR to the ratio of the Specified airflow and the cooling full-load airflow, expressed as a percentage.

11.1.1.5 *Heat Balance.* If using the outdoor enthalpy as an alternate method, use Equation 11.13, or if using refrigerant enthalpy as an alternate method, use Equation 11.14.

$$HB_x = \frac{\dot{q}_{tci,x} - \dot{q}_{tco,x}}{\dot{q}_{tci,x}} \quad 11.13$$

$$HB_x = \frac{\dot{q}_{tci,x} - \dot{q}_{ref,x}}{\dot{q}_{tci,x}} \quad 11.14$$

11.1.2 *Cooling Steady State Power.* The steady state power, $\boldsymbol{P_{tot,x}}$, shall be as measured during test, adjusted as follows, using Equation 11.15 for Blower Coil Systems or using Equation 11.16 for Coil-only Systems.

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

$$P_{tot,x} = P_{m,x} + Ps_{adj,x} \quad 11.16$$

Where:

For Non-mobile home, Non-Space Constrained Coil-only Systems:

$$Ps_{adj,x} = \frac{DFPC_C}{1000} \cdot \dot{Q}_s \quad 11.17$$

For Mobile home, Space Constrained Coil-only Systems:

$$Ps_{adj,x} = \frac{DFPC_{MHSC}}{1000} \cdot \dot{Q}_s \quad 11.18$$

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, EER2.* The steady state efficiency shall be calculated as follows.

$$EER2_x = \frac{\dot{q}_{tci,x}}{P_{tot,x}} \quad 11.19$$

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

$$q'_{cyc,x} = \frac{60 \cdot \dot{Q}_{mi} c_{pa2} \Gamma}{v'_n(1+W_n)} - qc_{adj,x} \quad 11.20$$

Where:

$$\Gamma = F^*_{CD} \int_{\theta_1}^{\theta_2} [t_{a1}(\theta) - t_{a2}(\theta)] d\theta \quad 11.21$$

Where F^*_{CD} is calculated per Appendix E16.3 using values measured during C & D tests.

$$qc_{adj,x} = 3.412 \cdot E_{fan,x} \quad 11.22$$

Where for all Blower Coil Systems, $P_{fan,x}$ is the measured indoor power.

For Non-mobile home, Non-Space Constrained Coil-only Systems:

$$E_{fan,x} = \frac{DFPC_C}{1000} \cdot \dot{Q}_s[\theta_2 - \theta_1] \qquad 11.23$$

For Mobile home, Space Constrained Coil-only Systems:

$$E_{fan,x} = \frac{DFPC_{MHSC}}{1000} \cdot \dot{Q}_s[\theta_2 - \theta_1] \qquad 11.24$$

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

$$qc_{adj,x} = 3.412 \cdot P_{fan,x} \cdot [\theta_2 - \theta_1] \qquad 11.25$$

For all other Blower Coil Systems:

$$qc_{adj,x} = 0 \qquad 11.26$$

For all other Non-ducted Systems:

$$qc_{adj,x} = 3.412 \cdot E_{fan,x} \qquad 11.27$$

For Non-ducted Systems, subtract the electrical energy used by the indoor fan, E_{fan}, during the three 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, $\boldsymbol{E_{tot,x}}$, shall be as measured during test, adjusted as follows, using Equation 11.28 for Blower Coil Systems (except Blower Coil Systems with variable capacity blower Constant-volume AMS or Constant-torque AMS which has the blower disabled for Cyclic Test) or using Equation 11.29 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.

$$E_{cyc,x} = E_{m,x} \qquad 11.28$$

$$E_{cyc,x} = E_{m,x} + Ec_{adj,x} \qquad 11.29$$

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 as follows

$$Ec_{adj,x} = P_{fan,x} \cdot [\theta_2 - \theta_1] \qquad 11.30$$

For Non-mobile home, Non-Space Constrained Coil-only System $Ec_{adj,x}$ is calculated per Equation 11.31.

$$Ec_{adj,x} = \frac{DFPC_C}{1000} \cdot \dot{Q}_s \cdot [\theta_2 - \theta_1] \qquad 11.31$$

For Mobile home, Space Constrained Coil-only System $Ec_{adj,x}$ is calculated per Equation 11.32.

$$Ec_{adj,x} = \frac{DFPC_{MHSC}}{1000} \cdot \dot{Q}_s \cdot [\theta_2 - \theta_1] \qquad 11.32$$

11.1.6 *Cooling Cyclic Efficiency, EER2.* The cyclic efficiency shall be calculated as follows.

$$EER2_x = \frac{q'_{cyc,x}}{E_{cyc,x}} \qquad 11.33$$

11.1.7 *Heating Steady State Net Capacity*.

11.1.7.1 *Total Heating Capacity (Indoor Air Enthalpy Method)*. The total Net Capacity, $\dot{q}_{thi,x}$, for all steady state heating tests shall be calculated using Equation 11.34 for Blower Coil Systems or using Equation 11.35 for Coil-only Systems. For the purpose of calculation of degradation coefficient, C_D^h, duct loss shall not be considered, therefore capacity without duct loss, $\dot{q}'_{thi,x}$, shall be calculated using Equation 11.36 for Blower Coil Systems or using Equation 11.37 for Coil-only Systems.

$$\dot{q}_{thi,x} = \frac{60 \cdot \dot{Q}_{mi} c_{pa2}(t_{a2} - t_{a1})}{v'_n(1+W_n)} + q_{duct,hi} \quad 11.34$$

$$\dot{q}_{thi,x} = \frac{60 \cdot \dot{Q}_{mi} c_{pa2}(t_{a2} - t_{a1})}{v'_n(1+W_n)} + q_{duct,hi} + \dot{q}s_{adj,x} \quad 11.35$$

$$\dot{q}'_{thi,x} = \frac{60 \cdot \dot{Q}_{mi} c_{pa2}(t_{a2} - t_{a1})}{v'_n(1+W_n)} \quad 11.36$$

$$\dot{q}'_{thi,x} = \frac{60 \cdot \dot{Q}_{mi} c_{pa2}(t_{a2} - t_{a1})}{v'_n(1+W_n)} + \dot{q}s_{adj,x} \quad 11.37$$

Where:

$$c_{pa2} = 0.24 + 0.444W_n \quad 11.38$$

and where Equation 11.39 shall be used when the Indoor Unit is in the indoor psychrometric chamber, Equation 11.40 shall be used when the indoor section is completely in the outdoor chamber.

$$\dot{q}_{duct,hi} = UA_{ID,si}(t_{a2} - t_{a1}) \quad 11.39$$

$$\dot{q}_{duct,hi} = UA_{ID,ro}(t_{a1} - t_{a0}) + UA_{ID,so}(t_{a2} - t_{a0}) + UA_{ID,si}(t_{a2} - t_{a1}) \quad 11.40$$

For the heating mode Equation 11.41 applies.

$$W_n = W_1 = W_2 \quad 11.41$$

For only test $H2_x$, in lieu of conducting the test, the capacity shall per calculated per Equation 11.42, where $\dot{q}_{thi,H1_x}$ and $\dot{q}_{thi,H3_x}$ are determined by test. *X* can be either Full or Low.

$$\dot{q}_{thi,H2_x} = 0.90 \cdot \{\dot{q}_{thi,H3_x} + 0.6 \cdot (\dot{q}_{thi,H1_x} - \dot{q}_{thi,H3_x})\} \quad 11.42$$

11.1.7.2 *Total Heating Capacity (Outdoor Air Enthalpy Method)*. The Net Capacity for all steady state heating tests shall be calculated as follows.

$$\dot{q}_{tho,x} = \frac{60 \cdot \dot{Q}_{mo}(h_{a3} - h_{a4})}{v'_n(1+W_n)} + 3.412 \cdot P_{tot,x} \quad 11.43$$

where for Equation 11.6

$$W_n = W_4 \quad 11.44$$

11.1.7.3 *Total Heating Capacity (Refrigerant Enthalpy Method)*. The Net Capacity for all steady state heating tests shall be calculated as follows.

$$\dot{q}_{ref,x} = x\dot{m}_{ref,x}(h_{r1} - h_{r2}) + \dot{q}s_{adj,x} \quad 11.45$$

11.1.8 *Heating Steady State Power.* The steady state power, $\boldsymbol{P_{tot,x}}$, shall be as measured during test, adjusted as follows, using Equation 11.46 for Blower Coil Systems or using Equation 11.47 for Coil-only Systems.

$$P_{tot,x} = P_{m,x} + P_{adj} \quad 11.46$$

$$P_{tot,x} = P_{m,x} + Ps_{adj,x} \quad 11.47$$

P_{adj} only applies for Constant-volume AMS per Section 6.1.5.1.3. For only test $H2_x$, in lieu of conducting the test, the power shall per calculated per Equation 11.48, where P_{H1_x} and P_{H3_x} are determined by test.

$$P_{H2_x} = 0.985 \cdot \left\{P_{H3_x} + 0.6 \cdot \left(P_{H1_x} - P_{H3_x}\right)\right\} \quad 11.48$$

11.1.9 *Heating Steady State Efficiency, COP2.* The steady state efficiency shall be calculated as follows.

$$COP2_x = \frac{\dot{q}_{thi,x}}{3.412 \cdot P_{tot,x}} \quad 11.49$$

11.1.10 *Heating Cyclic Net Capacity.* The Net Capacity for all cyclic heating tests shall be calculated using Equation 11.50. $\boldsymbol{Q_{mi}}$, $\boldsymbol{c_{pa}}$, $\boldsymbol{v'_n}$, and $\boldsymbol{W_n}$ shall be the values recorded during the corresponding steady state tests.

$$q'_{cyc,x} = \frac{60 \cdot \dot{Q}_{mi} c_{pa} \Gamma}{v'_n(1+W_n)} + qc_{adj,x} \quad 11.50$$

Where:

$$\Gamma = F^{*}_{CD} \int_{\theta_1}^{\theta_2} [t_{a2}(\theta) - t_{a1}(\theta)] d\theta \quad 11.51$$

Where F^{*}_{CD} is calculated per Appendix E16.3 using values measured during H1 & H1C tests.

To determine $qc_{adj,x}$, for Coil-only Systems, see Equation 11.22. For Blower Coil Systems with Constant-volume AMS which has the blower disabled for Cyclic Test, see Equation 11.25. For all Blower Coil Systems, see Equation 11.26. For all other Non-ducted Systems, see Equation 11.27. For Non-ducted Heat Pumps, subtract the electrical energy used by the indoor fan, $E_{fan,x}$, during the three minutes after compressor cutoff from the Non-ducted Heat Pump's integrated heating capacity, $q_{cyc,x}$.

11.1.11 *Heating Cyclic Energy.* The energy used during heating Cyclic Tests, $\boldsymbol{E_{cyc,x}}$, shall be as measured during test, adjusted using Equations 11.28 to 11.31.

11.1.12 *Heating Cyclic Efficiency, COP2*. The cyclic efficiency shall be calculated as follows.

$$COP2_{cyc,x} = \frac{q'_{cyc,x}}{3.412 \cdot E_{cyc,x}} \quad 11.52$$

11.1.13 *Heating Frost Accumulation Capacity.* The heating capacity for all frost accumulation tests shall be calculated as follows. Values in Equation 11.53 are averages from the defrost termination to defrost termination, unless otherwise stated. The average airflow, $\boldsymbol{\dot{Q}_{mi}}$ shall be evaluated while the fan is operating.

$$q_{def,x} = \frac{60 \cdot \dot{Q}_{mi} \cdot c_{pa} \cdot \Gamma_{ON}}{v'_n \cdot (1+W_n)} + qc_{adj,x} \qquad 11.53$$

where $qc_{adj,x}$ is calculated per Equations 11.23 to 11.27, as appropriate, and where

$$\Gamma_{ON} = \int_{\theta_3}^{\theta_4} [t_{a2}(\theta) - t_{a1}(\theta)] d\theta \qquad 11.54$$

$$\dot{q}_{def,x} = \frac{q_{def,x}}{\theta_4 - \theta_3} \qquad 11.55$$

11.1.14 *Heating Frost Accumulation Energy and Power.* The energy, $\boldsymbol{E_{def,x}}$, and power, $\boldsymbol{P_{def,x}}$, used during defrost tests shall be as measured during test, adjusted as follows, using Equation 11.56 for Blower Coil Systems or using Equation 11.57 for Coil-only Systems.

$$E_{def,x} = E_{m,x} \qquad 11.56$$

$$E_{def,x} = E_{m,x} + Ec_{adj,x} \qquad 11.57$$

Where:

For Non-mobile home, Non-Space Constrained Systems:

$$Ec_{adj,x} = \frac{DFPC_C}{1000} \cdot \dot{Q}_s \cdot [\theta_4 - \theta_3] \qquad 11.58$$

For Mobile home, Space Constrained Systems:

$$Ec_{adj,x} = \frac{DFPC_{MHSC}}{1000} \cdot \dot{Q}_s \cdot [\theta_4 - \theta_3] \qquad 11.59$$

$$P_{def,x} = \frac{E_{def,x}}{\theta_4 - \theta_3} + P_{adj} \qquad 11.60$$

Where P_{adj} only applies for Constant-volume AMS per Section 6.1.5.1.3.

11.1.15 *Heating Frost Accumulation Efficiency, COP2.*

$$COP2_{def,x} = \frac{\dot{q}_{def,x}}{3.412 \cdot P_{def,x}} \qquad 11.61$$

11.2 *Seasonal Efficiency Calculations.* Seasonal efficiency descriptors, SEER2, HSPF2, shall be calculated per the equations in this section, using the results from the individual test calculations from Section 11.1. Throughout the seasonal efficiency calculations wherever the values 95, 87, 82, 67, 62, 47, 35, 17, and 5°F are used, they are derived from the outdoor dry-bulb temperatures, °F, at test conditions A, E, B, F, H0, H1, H2, H3, and H4 respectively.

11.2.1 *SEER2.*

11.2.1.1 *Single Stage System and Variable capacity Certified, Single-Stage System.* SEER2 for a Single Stage System including Variable capacity Certified, Single-Stage System shall be calculated as follows.

$$SEER2 = PLF(0.5) \cdot EER2_{B,Full} \qquad 11.62$$

Where:

$$\text{PLF}\ (0.5) = 1 - 0.5 \cdot C_D^{c,Full} \qquad 11.63$$

$$C_D^{c,Full} = \frac{\left\{1 - \frac{EER_{D,Full}}{EER_{C,Full}}\right\}}{1 - CLF^{cyc,Full}} \qquad 11.64$$

$$CLF^{cyc,Full} = \frac{q'_{cyc,D,Full}}{\left(\dot{q}_{C,Full} \cdot \theta_{cyc}\right)} \qquad 11.65$$

If the optional Tests C and D (refer to Table 7) are not performed, or the calculated result for $C_D^{c,Full}$ is greater than the default value of Section 6.1.3.1, the default value shall be used. See Figure 2 for a graphical representation of SEER2.

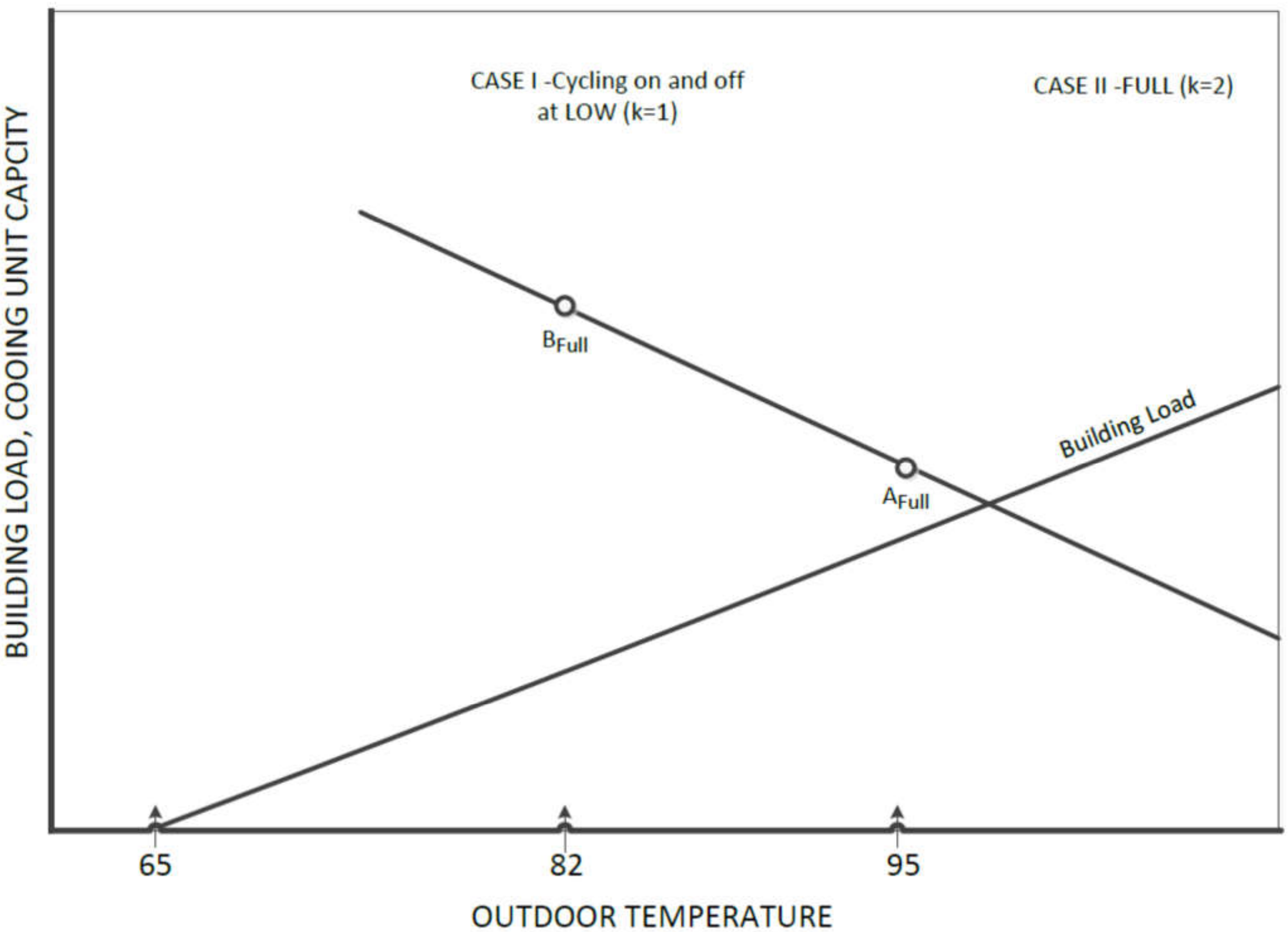

Figure 2. Schematic of a Single-speed System and Variable Capacity Certified, Single-Capacity System Operation in the Cooling Mode (See Tables 8 and 9 for Temperature References)

11.2.1.1.1 *Additional Steps for Calculating the SEER2 for MIB*

For MIB matched with one (1) Single Stage Air Conditioner or Heat Pump, SEER2 shall be calculated per Section 11.2.1.2.

11.2.1.2 Two-stage System and Variable capacity Certified, Two-Stage Capacity System. SEER2 for a Two-stage System, including MIB, and Variable capacity Certified, Two-Stage Capacity System shall be calculated as follows.

$$SEER2 = \frac{\sum_{j=1}^{8} q(t_j)}{\sum_{j=1}^{8} E(t_j)} \qquad 11.66$$

The quantities $q(t_j)$ 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 shall be realized from Table 15. 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 Full Stage capacity, either Section 11.2.1.2.2 or Section 11.2.1.2.3 is used, depending on the operating characteristics of the system.

Table 15. Fractional Bin Hours to Be Used in Calculation of SEER2

Bin Number (j)	Bin Temperature (t_j), °F	Fractional Bin Hours (n_j)
1	67	0.214
2	72	0.231
3	77	0.216
4	82	0.161
5	87	0.104
6	92	0.052
7	97	0.018
8	102	0.004

When the building load is greater than the unit capacity use Section 11.2.1.2.4. Geographical map showing cooling load hours is shown in Figure 3. See Figure 4 for a graphical representation. See Tables 8 and 9 for temperature references.

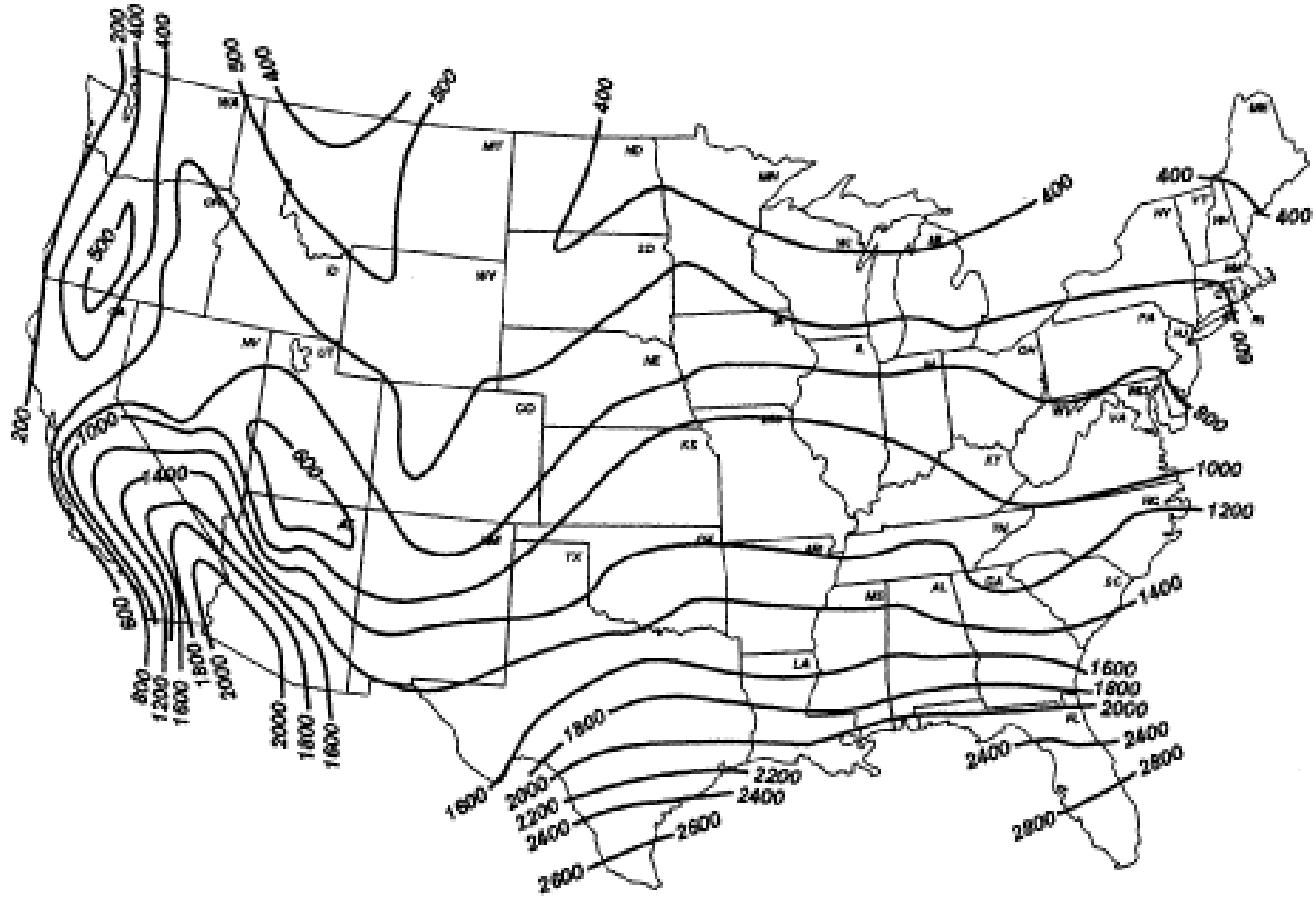

Figure 3. Cooling Load Hours (CLH_A) for the Contiguous United States

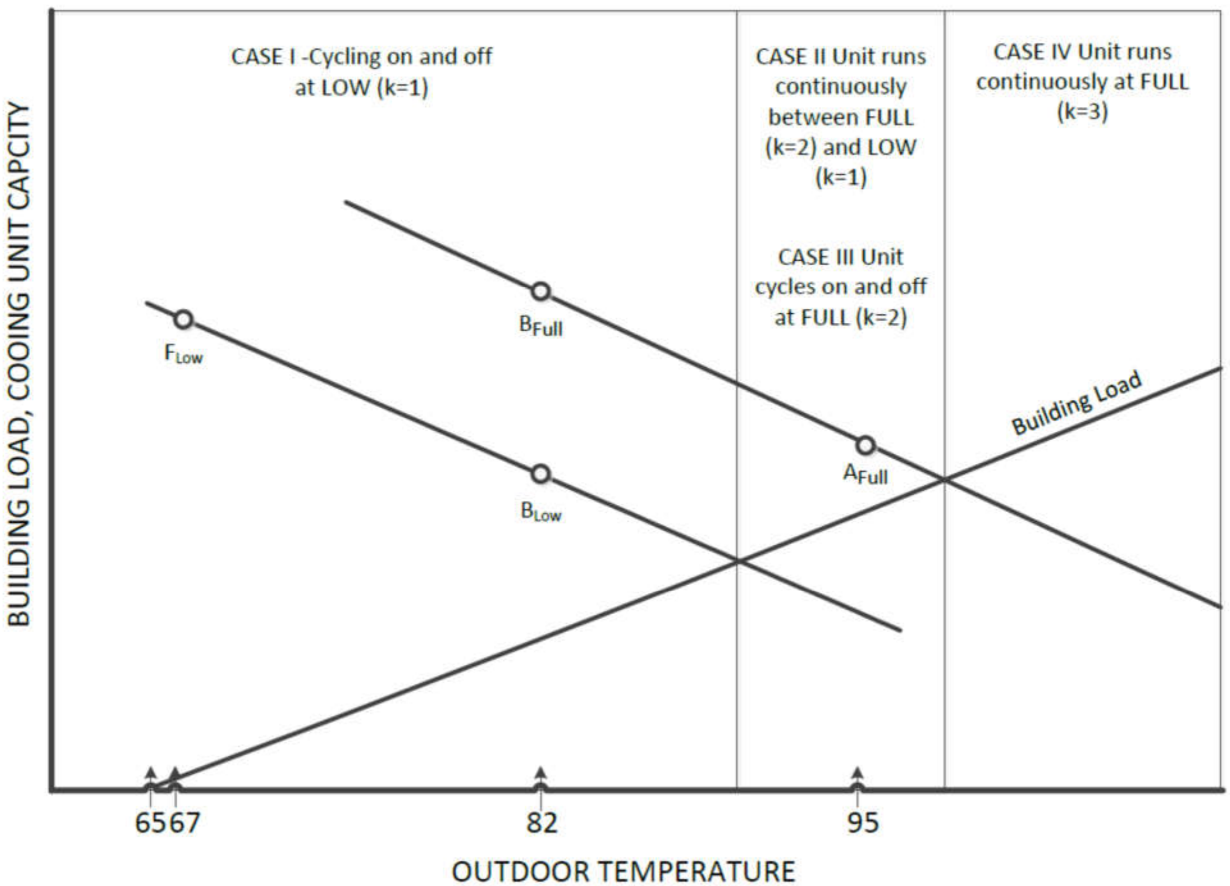

Figure 4. Schematic of a Two-speed System and Variable Capacity Certified, Two-Capacity System Operation in the Cooling Mode

The estimated building load for each bin temperature shall be calculated using Equation 11.67.

$$BL(t_j) = \left(\frac{t_j - 65}{95 - 65}\right) \cdot \left(\frac{\dot{q}_{A,Full}}{SF}\right) \cdot V \qquad 11.67$$

Where:

$$SF = 1.1 \qquad 11.68$$

V = 0.93 for Variable capacity Heat Pumps, otherwise V = 1.0.

The calculated Low Stage system capacity at each bin temperature shall be calculated by Equation 11.69.

$$\dot{q}_{Low}(t_j) = \dot{q}_{F,Low} + \left\{\frac{\dot{q}_{B,Low} - \dot{q}_{F,Low}}{82 - 67}\right\} \cdot (t_j - 67) \qquad 11.69$$

The calculated Low Stage power consumption at each bin temperature shall be calculated by Equation 11.70.

$$P_{Low}(t_j) = P_{F,Low} + \left\{\frac{P_{B,Low} - P_{F,Low}}{82 - 67}\right\} \cdot (t_j - 67) \qquad 11.70$$

The calculated Full Stage system capacity at each bin temperature shall be calculated by Equation 11.71.

$$\dot{q}_{Full}(t_j) = \dot{q}_{B,Full} + \left\{\frac{\dot{q}_{A,Full} - \dot{q}_{B,Full}}{95 - 82}\right\} \cdot (t_j - 82) \qquad 11.71$$

The calculated Full Stage power consumption at each bin temperature shall be calculated by Equation 11.72.

$$P_{Full}(t_j) = P_{B,Full} + \left\{\frac{P_{A,Full} - P_{B,Full}}{95-82}\right\} \cdot (t_j - 82) \tag{11.72}$$

11.2.1.2.1 *Case I. Building load is no greater than unit capacity at low speed, $BL(t_j) \leq \dot{q}_{Low}(t_j)$.* Calculate total bin capacity by using Equation 11.73 and total bin energy by using Equation 11.74.

$$q(t_j) = CLF^{Low}(t_j) \cdot \dot{q}_{Low}(t_j) \cdot n_j \tag{11.73}$$

$$E(t_j) = \frac{CLF^{Low}(t_j) \cdot P_{Low}(t_j) \cdot n_j}{PLF^{Low}(t_j)} \tag{11.74}$$

Where:

$$CLF^{Low}(t_j) = \frac{BL(t_j)}{\dot{q}_{Low}(t_j)} \tag{11.75}$$

$$PLF^{Low}(t_j) = 1 - C_D^{c,Low} \cdot \left[1 - CLF^{Low}(t_j)\right] \tag{11.76}$$

$$C_D^{c,Low} = \frac{\left\{1 - \frac{EER_{D,Low}}{EER_{C,Low}}\right\}}{1 - CLF^{cyc,Low}} \tag{11.77}$$

Where:

$$CLF^{cyc,Low} = \frac{q_{cyc,D,Low}}{(\dot{q}_{C,Low} \cdot \theta_{cyc})} \tag{11.78}$$

If the optional Tests C and D (refer to Table 7) 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 Full Stage capacity, $\dot{q}_{Low}(t_j) \leq BL(t_j) < \dot{q}_{Full}(t_j)$ and the unit cycles between Low Stage operation and Full Stage operation*. Calculate total bin capacity by using Equation 11.79 and total bin energy by using Equation 11.80.

$$q(t_j) = [CLF^{Low} \cdot \dot{q}_{Low}(t_j) + CLF^{Full} \cdot \dot{q}_{Full}(t_j)] \cdot n_j \tag{11.79}$$

$$E(t_j) = [CLF^{Low} \cdot P_{Low}(t_j) + CLF^{Full} \cdot P_{Full}(t_j)] \cdot n_j \tag{11.80}$$

Where:

$$CLF^{Low} = \frac{\dot{q}_{Full}(t_j) - BL(t_j)}{\dot{q}_{Full}(t_j) - \dot{q}_{Low}(t_j)} \tag{11.81}$$

$$CLF^{Full} = 1 - CLF^{Low} \tag{11.82}$$

11.2.1.2.3 *Case III. Building load is greater than the Low Stage capacity, but less than the Full Stage capacity, $\dot{q}_{Low}(t_j) \leq BL(t_j) < \dot{q}_{Full}(t_j)$ and the unit cycles between off and Full Stage operation*. Calculate total bin capacity by using Equation 11.83 and total bin energy by using Equation 11.84.

$$q(t_j) = CLF^{Full} \cdot \dot{q}_{Full}(t_j) \cdot n_j \quad 11.83$$

$$E(t_j) = \frac{CLF^{Full} \cdot P_{Full}(t_j) \cdot n_j}{PLF^{Full}} \quad 11.84$$

Where:

$$CLF^{Full} = \frac{BL(t_j)}{\dot{q}_{Full}(t_j)} \quad 11.85$$

$$PLF^{Full} = 1 - C_D^{c,Full} \cdot [1 - CLF^{Full}] \quad 11.86$$

If the optional C_{Full} and D_{Full} Tests (see Table 7) are not conducted, set $C_D^{c,Full}$ equal to the lower of a) the $C_D^{c,Low}$ value calculated as per Equation 11.77; or b) the default value identified in Section 6.1.3.1. If this optional test is conducted, set $C_D^{c,Full}$ to the value calculated as per Equation 11.87.

$$C_D^{c,Full} = \frac{\left\{1 - \frac{EER_{D,Full}}{EER_{C,Full}}\right\}}{1 - CLF^{cyc,Full}} \quad 11.87$$

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*, $BL(t_j) \geq \dot{q}_{Full}(t_j)$. Calculate total bin capacity by using Equation 11.88 and total bin energy by using Equation 11.89.

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

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

11.2.1.3 *Variable capacity System.* SEER2 for a Variable capacity System shall be calculated using Equation 11.66 where the quantities $q(t_j)$ 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 capacity System as defined in this section. Bin temperatures and bin hours shall be realized from Table 15. When the building load is less than or equal to 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 5 for a graphical representation.

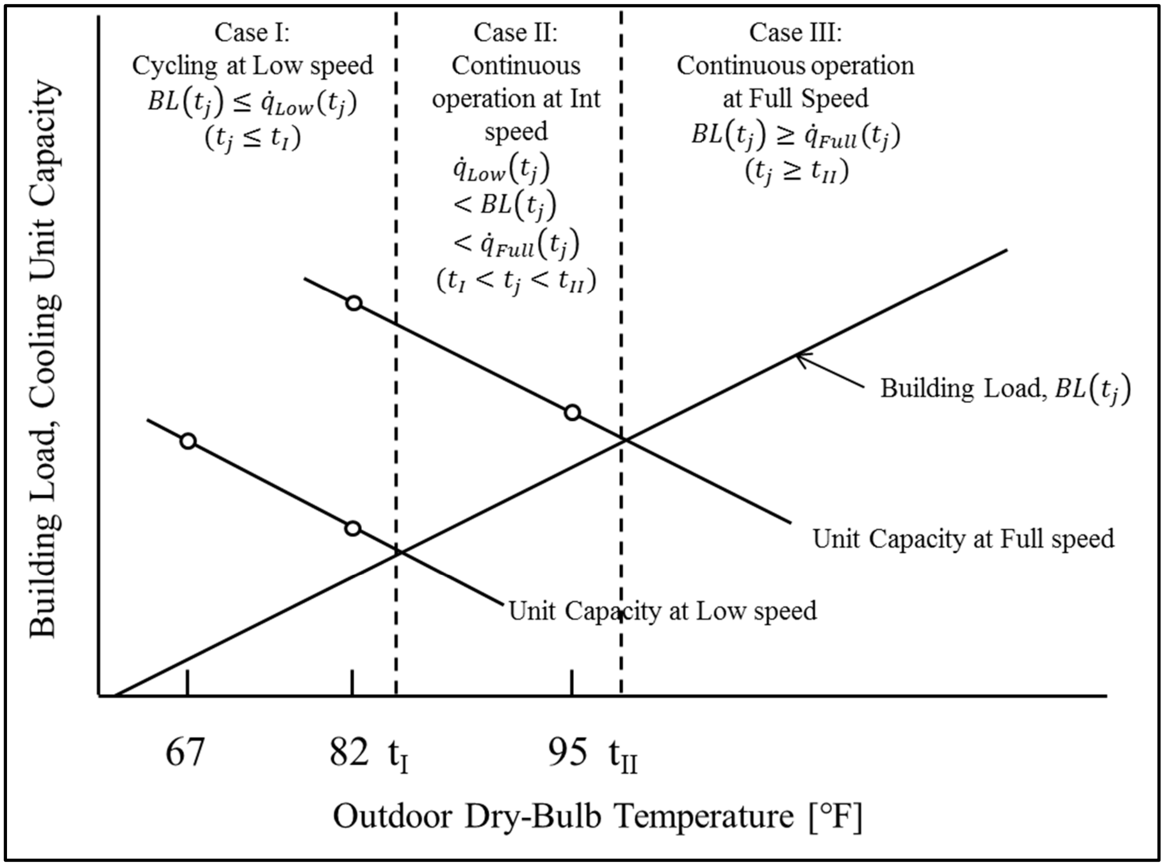

Figure 5. Schematic of a Variable capacity System Operation in the Cooling Mode

For each bin temperature, the building load, $BL(t_j)$, shall be calculated per Equation 11.67.

The calculated steady state capacity and power consumption at the Full Compressor Speed for each bin temperature shall be calculated per Equations 11.71 and 11.72.

The calculated steady state capacity and power consumption at the Low Compressor Speed for each bin temperature shall be calculated as follows.

$$\dot{q}_{Low}(t_j) = \dot{q}_{F,Low} + \left[\dot{q}_{B,Low} - \dot{q}_{F,Low}\right] \cdot \left[\frac{t_j - 67}{82 - 67}\right] \quad 11.90$$

$$P_{Low}(t_j) = P_{F,Low} + \left[P_{B,Low} - P_{F,Low}\right] \cdot \left[\frac{t_j - 67}{82 - 67}\right] \quad 11.91$$

The Total Cooling Capacity and energy at an intermediate speed for each bin temperature shall be calculated as follows, for individual bin calculation (see Section 11.2.1.3.2).

$$\dot{q}_{Int-Bin}(t_j) = BL(t_j) \quad 11.92$$

$$E_{Int-Bin}(t_j) = \frac{\dot{q}_{Int-Bin}(t_j)}{EER_{Int-Bin}(t_j)} \cdot n_j \quad 11.93$$

Intermediate steady state capacity for each bin temperature, $\dot{q}_{Int}(t_j)$, shall be calculated as follows, for intermediate compressor speed capacity, power and efficiency (Equations 11.94 to 11.99).

$$\dot{q}_{Int}(t_j) = \dot{q}_{E,Int} + M_{Cq}[t_j - 87] \quad 11.94$$

Where:

$$M_{Cq} = \frac{\dot{q}_{B,Low} - \dot{q}_{F,Low}}{82-67} \cdot (1 - N_{Cq}) + \frac{\dot{q}_{A,Full} - \dot{q}_{B,Full}}{95-82} \cdot N_{Cq} \quad 11.95$$

$$N_{Cq} = \frac{\dot{q}_{E,Int} - \dot{q}_{Low}(87)}{\dot{q}_{Full}(87) - \dot{q}_{Low}(87)} \quad 11.96$$

$\dot{q}_{Low}(87)$ shall be calculated per Equation 11.90.

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

Intermediate steady state power for each bin temperature, $P_{Int-Bin}(t_j)$, shall be calculated as follows.

$$P_{Int}(t_j) = P_{E,Int} + M_{CE}[t_j - 87] \quad 11.97$$

Where:

$$M_{CE} = \frac{P_{B,Low} - P_{F,Low}}{82-67} \cdot (1 - N_{CE}) + \frac{P_{A,Full} - P_{B,Full}}{95-82} \cdot N_{CE} \quad 11.98$$

$$N_{CE} = \frac{P_{E,Int} - P_{Low}(87)}{P_{Full}(87) - P_{Low}(87)} \quad 11.99$$

$P_{Low}(87)$ shall be calculated per Equation 11.91.

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

11.2.1.3.1 *Case I – Building load is no greater than unit capacity at low speed,* $BL(t_j) \leq \dot{q}_{Low}(t_j)$, where $(t_j \leq t_I)$. Equations from Section 11.2.1.2.1 shall be used to calculate capacity and power consumption for each bin temperature using Equations 11.73 and 11.74 for the calculated system capacity and power consumption at the Low Compressor Speed for each bin temperature and calculate $C_D^{c,Low}$ per Equation 11.100.

$$C_D^{c,Low} = \frac{\left\{1 - \frac{EER_{I,Low}}{EER_{G,Low}}\right\}}{1 - CLF^{cyc,Low}} \quad 11.100$$

Use Equation 11.78 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 7) 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,* $\dot{q}_{Low}(t_j) < BL(t_j) < \dot{q}_{Full}(t_j)$, where $(t_I < t_j < t_{II})$. Use Equations 11.92 and 11.93 to calculate the and energy calculations for each bin.

Intermediate efficiency, $EER_{Int-Bin}(t_j)$, shall be calculated as follows.

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

$$EER_{Int-Bin}(t_j) = EER_{Low}(t_j) + \frac{EER_{Int}(t_j) - EER_{Low}(t_j)}{\dot{q}_{Int}(t_j) - \dot{q}_{Low}(t_j)} \cdot (BL(t_j) - \dot{q}_{Low}(t_j)) \qquad 11.101$$

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

$$EER_{Int-Bin}(t_j) = EER_{Int}(t_j) + \frac{EER_{Full}(t_j) - EER_{Int}(t_j)}{\dot{q}_{Full}(t_j) - \dot{q}_{Int}(t_j)} \cdot (BL(t_j) - \dot{q}_{Int}(t_j)) \qquad 11.102$$

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 and electrical power consumption $P_{Low}(t_j)$ calculated using Equation 11.91;

$EER_{Int}(t_j)$ 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 11.94 and electrical power consumption $P_{Int}(t_j)$ calculated using Equation 11.97;

$EER_{Full}(t_j)$ 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 11.71 and electrical power consumption $P_{Full}(t_j)$ calculated using Equation 11.72.

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

11.2.2 ***HSPF2.***

11.2.2.1 *Single Stage System and Variable capacity Certified, Single Stage System*. HSPF2 for a Single Stage System and Variable capacity Certified, Single Stage System shall be calculated using Equation 11.103, except as described below, substituting $\dot{q}_x^{calc}$ for $\dot{q}_x$ and P_x^{calc} for P_x.

$$HSPF2 = \frac{\sum_{j=1}^{18} n_j BL(t_j)}{\sum_{j=1}^{18} E(t_j) + \sum_{j=1}^{18} RH(t_j)} \cdot F_{def} \qquad 11.103$$

Where:

$$BL(t_j) = \left\{\frac{t_{zl} - t_j}{t_{zl} - 5}\right\} \cdot C_x \cdot \dot{q}_{AFull} \qquad 11.104$$

where,

t_j = the outdoor bin temperature, °F

t_{zl} = the zero-load temperature, °F, which varies by climate region according to Table 16

C_x = the slope (adjustment) factor, which varies by climate region according to Table 16, where C_x equals C_{vc} for variable capacity equipment and C_x equals C for all other equipment types

$\dot{q}_{AFull}$ = the cooling capacity at 95°F determined from the A_{Full} test, Btu/h

For heating-only heat pump units, replace $\dot{q}_{AFull}$ with $\dot{q}_{HFull}$

$\dot{q}_{H1,Full}$ = the heating capacity at 47°F determined from the $H1_{Nom}$ test for variable capacity systems and from the $H1_{Full}$ test for other systems, Btu/h.

Distribution of fractional heating hours per Temperature Bin, n_j, for each bin, j, shall be obtained from Table 16.

Table 16. Distribution of Fractional Heating Hours in Temperature Bins, Heating Load Hours, and Outdoor Design Temperature for Different Climatic Regions

Region Number		**I**	**II**	**III**	**IV**	**V**	***VI**
Heating Load Hours, HLH		493	857	1247	1701	2202	1842
Outdoor Design Temperature, T_{OD}		37	27	17	5	−10	30
Heating Load Line Equation Slope Factor, C		1.10	1.06	1.30	1.15	1.16	1.11
Variable Capacity Slope Factor, C_{vc}		1.03	0.99	1.21	1.07	1.08	1.03
Zero-Load Temperature, T_{zl}		58	57	56	55	55	57
j t_j (°F)	t_j (°F)	Fractional Bin Hours, n_j/N					
1	62	0	0	0	0	0	0
2	57	.239	0	0	0	0	0
3	52	.194	.163	.138	.103	.086	.215
4	47	.129	.143	.137	.093	.076	.204
5	42	.081	.112	.135	.100	.078	.141
6	37	.041	.088	.118	.109	.087	.076
7	32	.019	.056	.092	.126	.102	.034
8	27	.005	.024	.047	.087	.094	.008
9	22	.001	.008	.021	.055	.074	.003
10	17	0	.002	.009	.036	.055	0
11	12	0	0	.005	.026	.047	0
12	7	0	0	.002	.013	.038	0
13	2	0	0	.001	.006	.029	0
14	-3	0	0	0	.002	.018	0
15	-8	0	0	0	.001	.010	0
16	-13	0	0	0	0	.005	0
17	-18	0	0	0	0	.002	0
18	-23	0	0	0	0	.001	0

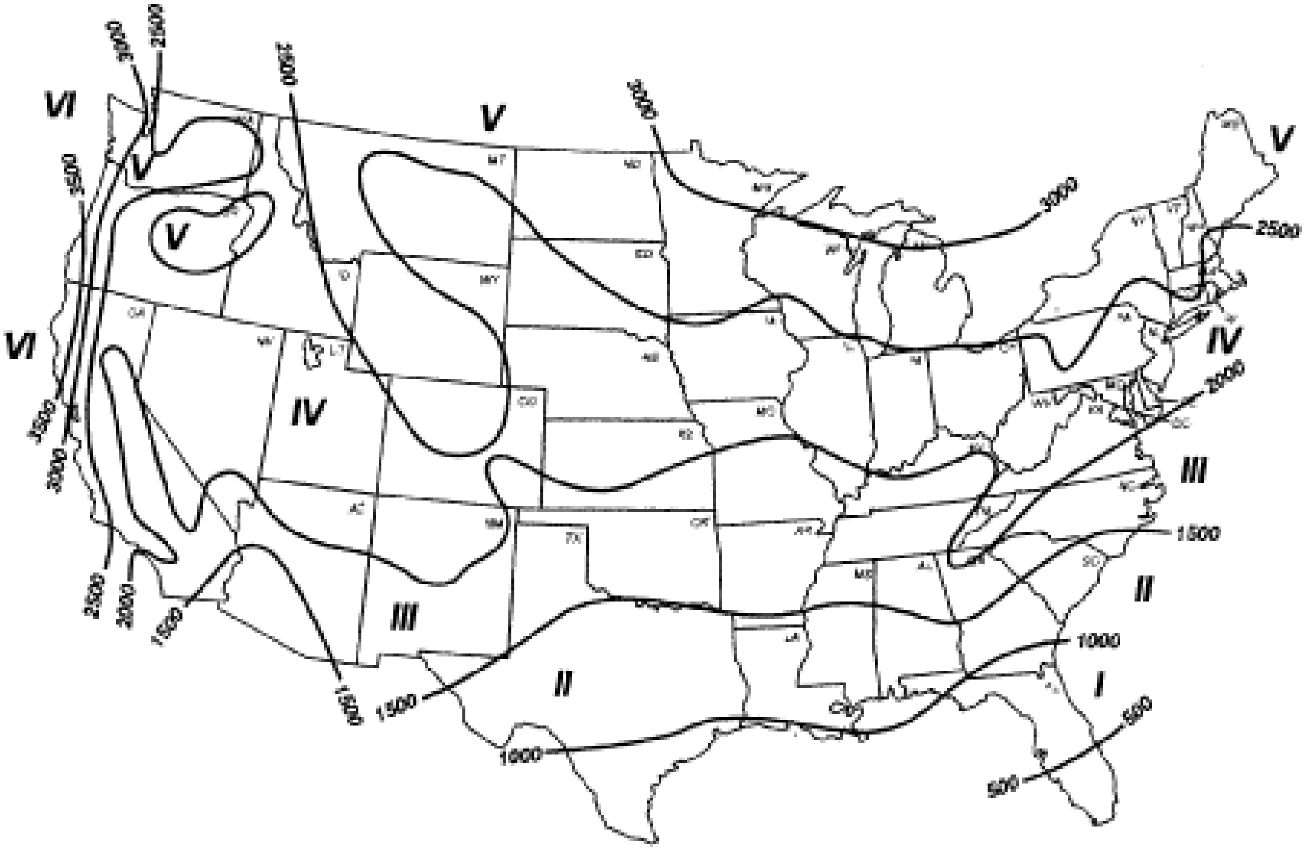

Figure 6. Heating Load Hours (HLH_A) for the Contiguous United States

For systems with Demand-defrost Control System

$$F_{def} = 1 + 0.03(1 - \frac{T_{test} - 90}{T_{max} - 90}) \quad 11.105$$

For other systems

$$F_{def} = 1 \quad 11.106$$

Where:

T_{test} = Time between defrost terminations in minutes, or ninety, whichever is greater

T_{max} = Maximum time between defrosts allowed by controls in minutes, or 720, whichever is smaller

11.2.2.1.1 *Single Stage System with Either a Fixed-Speed Indoor Blower or a Constant-Air-Volume-Rate Indoor Blower, or a Single-Speed Coil-Only System Heat Pump*

$HLF^{Full}(t_j)$ shall be calculated depending upon the cases below.

For $\dot{q}_{Full}(t_j) > BL(t_j)$

$$HLF^{Full}(t_j) = \frac{BL(t_j)}{\dot{q}_{Full}(t_j)} \quad 11.107$$

For $\dot{q}_{Full}(t_j) \leq BL(t_j)$

$$HLF^{Full}(t_j) = 1 \qquad 11.108$$

$\dot{q}_{Full}(t_j)$ shall be calculated depending upon the cases below

If neither the $H4_{boost}$ test nor the $H4_{full}$ test is conducted calculate $\dot{q}_{Full}(t_j)$ as

For $t_j \geq t_{OBO}$ or $t_j \leq 17$

$$\dot{q}_{Full}(t_j) = \dot{q}_{H3,Full} + [\dot{q}_{H1,Full} - \dot{q}_{H3,Full}] \cdot \frac{[t_j - 17]}{47 - 17} \qquad 11.109$$

For $17 < t_j < t_{OBO}$

$$\dot{q}_{Full}(t_j) = \dot{q}_{H3,Full} + [\dot{q}_{H2,Full} - \dot{q}_{H3,Full}] \cdot \frac{[t_j - 17]}{35 - 17} \qquad 11.110$$

Where the temperature at which frosting influence on full stage performance begins, t_{OBO}, is defined as:

$$t_{OBO} = 45 \qquad 11.111$$

If either the $H4_{boost}$ or $H4_{full}$ test is conducted calculate $\dot{q}_{Full}(t_j)$ as

For $t_j \geq t_{OBO}$

$$\dot{q}_{Full}(t_j) = \dot{q}_{H3,Full} + [\dot{q}_{H1,Full} - \dot{q}_{H3,Full}] \cdot \frac{[t_j - 17]}{47 - 17} \qquad 11.112$$

For $17 \leq t_j < t_{OBO}$

$$\dot{q}_{Full}(t_j) = \dot{q}_{H3,Full} + [\dot{q}_{H2,Full} - \dot{q}_{H3,Full}] \cdot \frac{[t_j - 17]}{35 - 17} \qquad 11.113$$

For $t_j < 17$

$$\dot{q}_{Full}(t_j) = \dot{q}_{H4,Full} + [\dot{q}_{H3,Full} - \dot{q}_{H4,Full}] \cdot \frac{[t_j - 5]}{17 - 5} \qquad 11.114$$

Where $\dot{q}_{H4,Full}$ is determined from $H4_{Full}$ Test, and $H4_{Boost}$ test for Triple-capacity systems (substituting $\dot{q}_{H4,Full}$ with $\dot{q}_{H4,Boost}$).

$P_{Full}(t_j)$ shall be calculated depending upon the cases below

If neither the $H4_{Boost}$ test nor the $H4_{Full}$ test is conducted calculate $P(t_j)$ as

For $t_j \geq t_{OBO}$ or $t_j \leq 17$

$$P_{Full}(t_j) = P_{H3,Full} + [P_{H1,Full} - P_{H3,Full}] \cdot \frac{[t_j - 17]}{47 - 17} \qquad 11.115$$

For $17 < t_j < t_{OBO}$

$$P_{Full}(t_j) = P_{H3,Full} + \left[P_{H2,Full} - P_{H3,Full}\right] \cdot \frac{[t_j - 17]}{35-17} \quad 11.116$$

If either the H4Boost or the H4Full test is conducted calculate $P(t_j)$ as

For $t_j \geq t_{OBO}$

$$P_{Full}(t_j) = P_{H3,Full} + \left[P_{H1,Full} - P_{H3,Full}\right] \cdot \frac{[t_j - 17]}{47-17} \quad 11.117$$

For $17 \leq t_j < t_{OBO}$

$$P_{Full}(t_j) = P_{H3,Full} + \left[P_{H2,Full} - P_{H3,Full}\right] \cdot \frac{[t_j - 17]}{35-17} \quad 11.118$$

For $t_j < 17$

$$P_{Full}(t_j) = P_{H4,Full} + \left[P_{H3,Full} - P_{H4,Full}\right] \cdot \frac{[t_j - 5]}{17-5} \quad 11.119$$

Where $P_{H4,Full}$ is determined from H4Full test, and H4Boost test for Triple-capacity, Northern Heat Pump (substituting $P_{H4,Full}$ with $P_{H4,Boost}$).

Evaluate the following quantities as

$$E(t_j) = \frac{HLF^{Full}(t_j)\delta^{Full}(t_j)\, P_{Full}(t_j)}{PLF^{Full}(t_j)} \cdot n_j \quad 11.120$$

$$RH(t_j) = \frac{[BL(t_j) - \dot{q}_{Full}(t_j)HLF^{Full}(t_j)\delta^{Full}(t_j)]}{3.412} \cdot n_j \quad 11.121$$

Where,

$$PLF^{Full}(t_j) = 1 - C_D^{h,Full}[1 - HLF^{Full}(t_j)] \quad 11.122$$

$$C_D^{h,Full} = \frac{\left\{1 - \frac{COP_{H1C,Full}}{COP_{cyc,H1,Full}}\right\}}{1 - HLF^{Cyc,Full}} \quad 11.123$$

$$HLF^{Cyc,Full} = \frac{q'_{H1C,Full}}{(\dot{q}'_{H1,Full} \cdot \theta_{cyc})} \quad 11.124$$

If the optional Cyclic Test H1CFull (refer to Table 7) is not performed, or the calculated result for $C_D^{h,Full}$ is greater than the default value of Section 6.1.3.2, the default value shall be used.

$\delta^{Full}(t_j)$ shall be calculated depending upon the cases below

For $t_j \leq t_{OFF}\ or\ \frac{\dot{q}_{Full}(t_j)}{3.412 \cdot P_{Full}(t_j)} < 1$

$$\delta^{Full}(t_j) = 0 \quad 11.125$$

For $t_{OFF} < t_j \leq t_{ON}$

$$\delta^{Full}(t_j) = 0.5 \quad 11.126$$

For $t_j > t_{ON}$

$$\delta^{Full}(t_j) = 1 \quad 11.127$$

The outdoor temperature below which the compressor ceases to operate, t_{OFF}, is Specified by the manufacturer, as is the outdoor temperature at which the compressor reinitiates operation, t_{ON}. If the controls of the unit prohibit compressor operation based on outdoor temperature, the manufacturer shall have Specified in product literature t_{OFF} and t_{ON} values. Values of t_{OFF} and t_{ON} shall be consistent with the operation observed during Appendix J testing .

11.2.2.1.2 *Additional Steps for Calculating the HSPF2 of a Heat Pump Having a Single-Speed Compressor and a Variable-Speed, Variable-Air-Volume-Rate Indoor Blower*

$HLF^{VAV}(t_j)$ shall be calculated depending upon the cases using Equation 11.107 and 11.108 (Section 11.2.2.1.1) substituting $HLF^{Full}(t_j)$ and $\dot{q}_{Full}(t_j)$ with $HLF^{VAV}(t_j)$ and $\dot{q}_{VAV}(t_j)$ respectively, and evaluate the following quantities as

$$E(t_j) = \frac{HLF^{VAV}(t_j)\delta^{VAV}(t_j)P_{VAV}(t_j)}{PLF^{Low}(t_j)} \cdot n_j \quad 11.128$$

$$RH(t_j) = \frac{[BL(t_j) - \dot{q}^{VAV}(t_j)HLF^{VAV}(t_j)\delta^{VAV}(t_j)]}{3.412} \cdot n_j \quad 11.129$$

Where,

$$PLF^{Low}(t_j) = 1 - C_D^{h,Low}[1 - HLF^{Low}(t_j)] \quad 11.130$$

$$C_D^{h,Low} = \frac{\left\{1 - \frac{COP_{H1C,Low}}{COP_{cyc,H1,Low}}\right\}}{1 - HLF^{Cyc,Low}} \quad 11.131$$

$$HLF^{Cyc,Low} = \frac{q'_{H1C,Low}}{(\dot{q}'_{H1,Low} \cdot \theta_{cyc})} \quad 11.132$$

If the optional Cyclic Test $H1C_{Low}$ (refer to Table 7) is not performed, or the calculated result for $C_D^{h,Low}$ is greater than the default value of Section 6.1.3.2, the default value shall be used.

$\delta^{VAV}(t_j)$ shall be calculated depending upon the cases below.

For $t_j \leq t_{OFF}$ or $\frac{\dot{q}_{VAV}(t_j)}{3.412 \cdot P_{VAV}(t_j)} < 1$

$$\delta^{VAV}(t_j) = 0 \quad 11.133$$

For $t_{OFF} < t_j \leq t_{ON}$

$$\delta^{VAV}(t_j) = 0.5 \quad 11.134$$

For $t_j > t_{ON}$

$$\delta^{VAV}(t_j) = 1 \qquad 11.135$$

$\dot{q}_{VAV}(t_j)$ and $P_{VAV}(t_j)$ shall be calculated using the following equations.

$$\dot{q}_{VAV}(t_j) = \dot{q}_{h,Low}(t_j) + \frac{[\dot{q}_{h,Full}(t_j) - \dot{q}_{h,Low}(t_j)]}{[FP_{h,Full} - FP_{h,Low}]} \cdot [FP_h(t_j) - FP_{h,Low}] \qquad 11.136$$

$$P_{VAV}(t_j) = P_{h,Low}(t_j) + \frac{[P_{h,Full}(t_j) - P_{h,Low}(t_j)]}{[FP_{h,Full} - FP_{h,Low}]} \cdot [FP_h(t_j) - FP_{h,Low}] \qquad 11.137$$

For units where indoor blower speed is the primary control variable, FP_{Low} denotes the fan speed used during the required $H1_{Low}$ and $H3_{Low}$ tests, FP_{Full} denotes the fan speed used during the required $H1_{Full}$, $H2_{Full}$, and $H3_{Full}$ tests, and $FP_h(t_j)$ denotes the fan speed used by the unit when the outdoor temperature equals t_j. For units where indoor airflow is the primary control variable, the three FPs are similarly defined only now being expressed in terms of airflows rather than fan speeds.

$\dot{q}_{Low}(t_j)$ and $P_{Low}(t_j)$ shall be calculated as identified in Section 11.2.2.1.1, and $\dot{q}_{Low}(t_j)$ and $P_{Low}(t_j)$ shall be calculated depending upon the cases below.

For $t_j \geq t_{OBO}$ or $t_j \leq 17$

$$\dot{q}_{Low}(t_j) = \dot{q}_{H3,Low} + [\dot{q}_{H1,Low} - \dot{q}_{H3,Low}] \cdot \frac{t_j - 17}{47 - 17} \qquad 11.138$$

For $17 < t_j < t_{OBO}$

$$\dot{q}_{Low}(t_j) = \dot{q}_{H3,Low} + [\dot{q}_{H2,Low} - \dot{q}_{H3,Low}] \cdot \frac{t_j - 17}{35 - 17} \qquad 11.139$$

The calculated low stage system power consumption rate at each bin temperature shall be calculated depending upon the cases below.

For $t_j \geq t_{OBO}$ or $t_j \leq 17$

$$P_{Low}(t_j) = P_{H3,Low} + [P_{H1,Low} - P_{H3,Low}] \cdot \frac{t_j - 17}{47 - 17} \qquad 11.140$$

For $17 < t_j < t_{OBO}$

$$P_{Low}(t_j) = P_{H3,Low} + [P_{H2,Low} - P_{H3,Low}] \cdot \frac{t_j - 17}{35 - 17} \qquad 11.141$$

Determine $\dot{q}_{H1,Low}$ and $P_{H1,Low}$ from the $H1_{Low}$ test. Determine $\dot{q}_{H2,Low}$ and $P_{H2,Low}$ from the $H2_{Low}$ test or as identified below if not conducted; Determine $\dot{q}_{H3,Low}$ and $P_{H3,Low}$ from the $H3_{Low}$ test.

$$\dot{q}_{H2,Low} = QR_{H2,Full} \cdot \{\dot{q}_{H3,Low} + 0.6 \cdot [\dot{q}_{H1,Low} - \dot{q}_{H3,Low}]\} \qquad 11.142$$

$$P_{H2,Low} = PR_{H2,Full} \cdot \{P_{H3,Low} + 0.6 \cdot [P_{H1,Low} - P_{H3,Low}]\} \qquad 11.143$$

$QR_{H2,Full}$ and $PR_{H2,Full}$ shall be calculated using the following equations.

$$QR_{H2,Full} = \frac{\dot{q}_{H2,Full}}{\dot{q}_{H3,Full} + 0.6 \cdot [\dot{q}_{H1,Full} - \dot{q}_{H3,Full}]} \qquad 11.144$$

$$PR_{H2,Full} = \frac{P_{H2,Full}}{P_{H3,Full}+0.6\cdot[P_{H1,Full}-P_{H3,Full}]} \quad 11.145$$

11.2.2.1.3 *Additional Steps for Calculating the HSPF2 for MIB*

For MIB matched with one (1) Single Stage Air Conditioner or Heat Pump, HSPF2 shall be calculated per Section 11.2.2.2.

Figure 7 shows a graphical representation of the operation of a Single-speed Heat Pump.

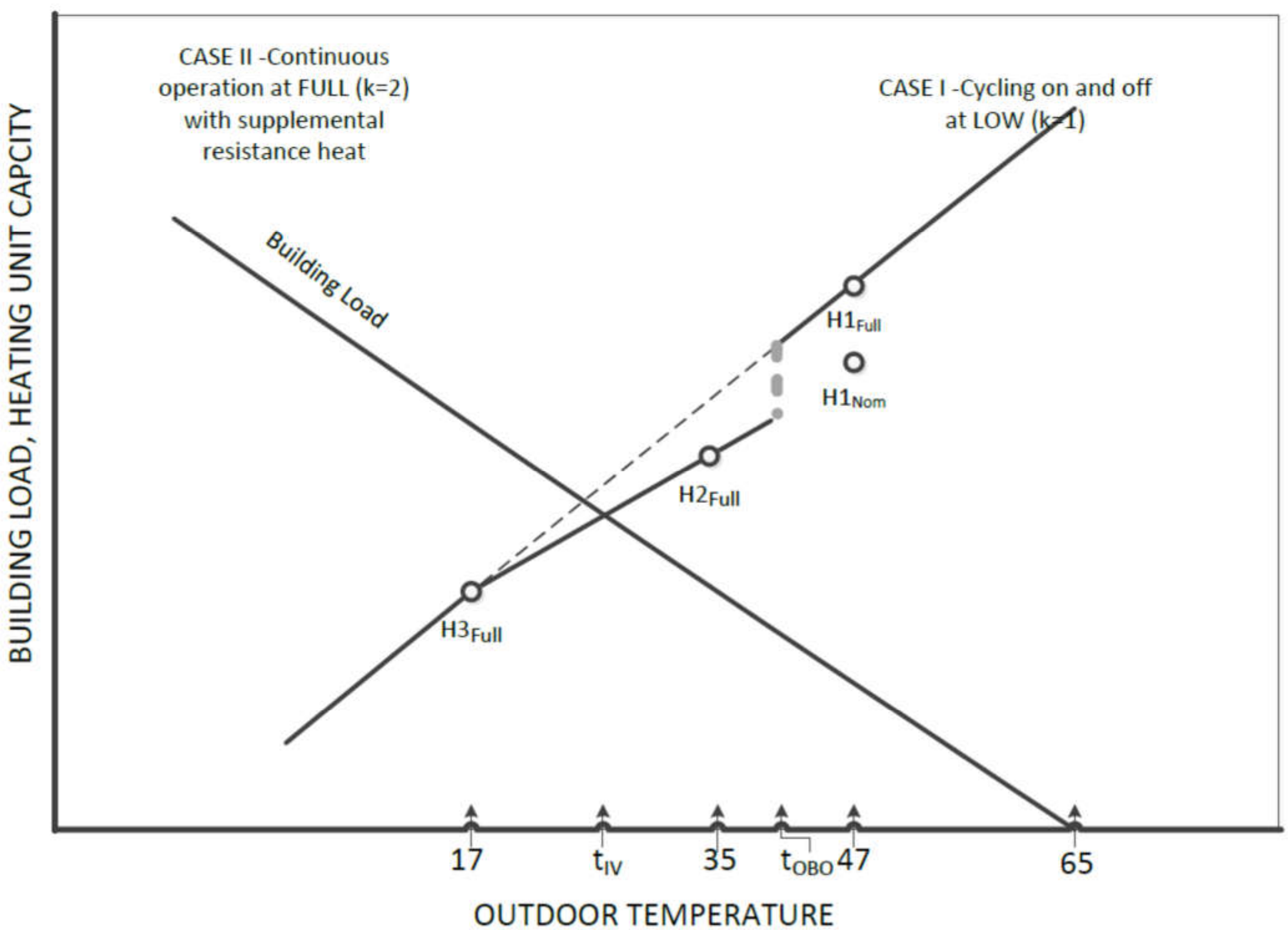

Figure 7. Schematic of a Single-speed Heat Pump Operation in Heating Mode

11.2.2.2 *Two-stage System* . HSPF2 for a Two-stage System, including MIB, shall be calculated using Equation 11.103 (Section 11.2.2.1), with the exception that the bin power consumption, $E(t_j)$, is calculated based on the cases defined below. See Figure 8 for a graphical representation.

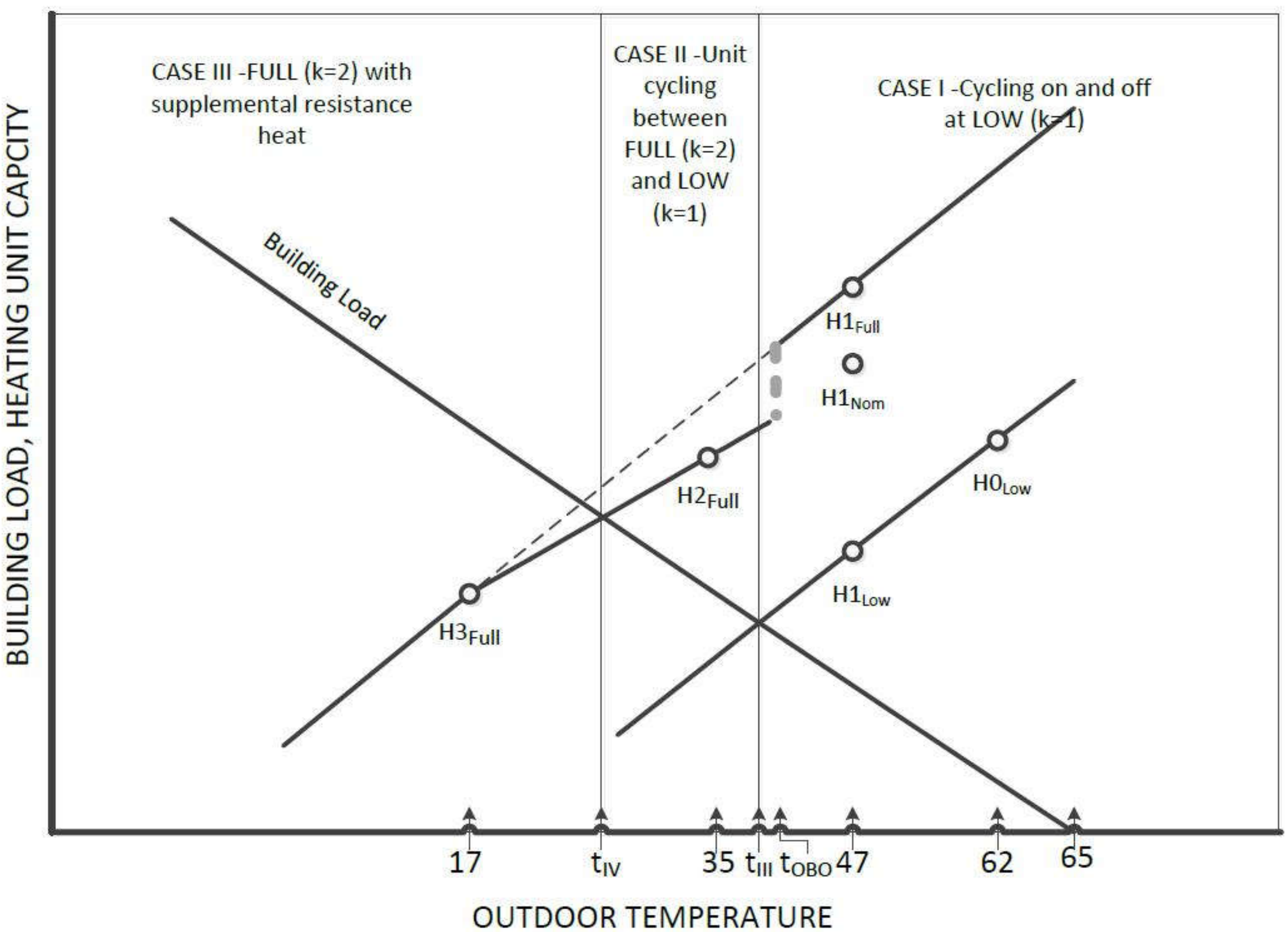

Figure 8. Schematic of a Two-speed Heat Pump Operation in Heating Mode

For two speed heat pumps, the temperature at which frosting influence on Low Stage performance begins, t_{OB}, is defined as:

$$t_{OB} = 40 \quad 11.146$$

The calculated Low Stage system capacity at each bin temperature shall be calculated depending upon the cases below.

For $t_j \geq t_{OB}$

$$\dot{q}_{Low}(t_j) = \dot{q}_{H1,Low} + [\dot{q}_{H0,Low} - \dot{q}_{H1,Low}] \cdot \frac{t_j - 47}{62 - 47} \quad 11.147$$

For $17 < t_j < t_{OB}$

$$\dot{q}_{Low}(t_j) = \dot{q}_{H3,Low} + [\dot{q}_{H2,Low} - \dot{q}_{H3,Low}] \cdot \frac{t_j - 17}{35 - 17} \quad 11.148$$

For $t_j \leq 17$

$$\dot{q}_{Low}(t_j) = \dot{q}_{H3,Low} + [\dot{q}_{H1,Low} - \dot{q}_{H3,Low}] \cdot \frac{t_j - 17}{47 - 17} \qquad 11.149$$

The calculated Low Stage system power consumption rate at each bin temperature shall be calculated depending upon the cases below.

For $t_j \geq t_{OB}$

$$P_{Low}(t_j) = P_{H1,Low} + [P_{H0,Low} - P_{H1,Low}] \cdot \frac{t_j - 47}{62 - 47} \qquad 11.150$$

For $17 < t_j < t_{OB}$

$$P_{Low}(t_j) = P_{H3,Low} + [P_{H2,Low} - P_{H3,Low}] \cdot \frac{t_j - 17}{35 - 17} \qquad 11.151$$

For $t_j \leq 17$

$$P_{Low}(t_j) = P_{H3,Low} + [P_{H1,Low} - P_{H3,Low}] \cdot \frac{t_j - 17}{47 - 17} \qquad 11.152$$

The calculated full stage system capacity at each bin temperature shall be calculated depending upon the cases per Equations 11.109 and 11.110 when optional $H4_{Full}$ test is not conducted, and using Equations 11.112, 11.113, and 11.114 (Section 11.2.2.1.1) when the optional $H4_{Full}$ test is conducted.

11.2.2.2.1 *Case I. Building load is not greater than Low Stage capacity,* $BL(t_j) \leq \dot{q}_{Low}(t_j)$. Calculate total bin energy by using Equation 11.153.

$$E(t_j) = \frac{P_{Low}(t_j) \cdot HLF^{Low}(t_j) \delta^{Low}(t_j) n_j}{PLF^{Low}(t_j)} \qquad 11.153$$

$$RH(t_j) = \frac{BL(t_j)[1 - \delta^{Low}(t_j)]}{3.412} \cdot n_j \qquad 11.154$$

$$HLF^{Low}(t_j) = \frac{BL(t_j)}{\dot{q}_{Low}(t_j)} \qquad 11.155$$

$$PLF^{Low}(t_j) = 1 - C_D^{h,Low}[1 - HLF^{Low}(t_j)] \qquad 11.156$$

Where:

$$C_D^{h,Low} = \frac{\left\{1 - \frac{COP_{H1C,Low}}{COP_{cyc,H1,Low}}\right\}}{1 - HLF^{Cyc,Low}} \qquad 11.157$$

$$HLF^{Cyc,Low} = \frac{q'_{H1C,Low}}{\left(\dot{q}'_{H1,Low} \cdot \theta_{cyc}\right)} \qquad 11.158$$

$\delta^{Low}(t_j)$ shall be calculated depending upon the cases below.

For $t_j \leq t_{OFF}$ or $\frac{\dot{q}_{Low}(t_j)}{3.412 \cdot P_{Low}(t_j)} < 1$

$$\delta^{Low}(t_j) = 0 \quad 11.159$$

For $t_{OFF} < t_j \le t_{ON}$

$$\delta^{Low}(t_j) = 0.5 \quad 11.160$$

For $t_j > t_{ON}$

$$\delta^{Low}(t_j) = 1 \quad 11.161$$

Use calculations from Section 11.2.2.2.3 for any bin where the heat pump locks out low capacity operation at low outdoor temperatures and t_j is below this lockout threshold temperature.

11.2.2.2.2 *Case II. Building load is greater than the Low Stage capacity, but less than the Full Stage capacity,* $\dot{q}_{Low}(t_j) < BL(t_j) < \dot{q}_{Full}(t_j)$ *and the unit cycles between Low Stage operation and Full Stage operation*. Calculate total bin energy by using Equation 11.162. $RH(t_j)$ is calculated using Equation 11.154.

$$E(t_j) = [P_{Low}(t_j)HLF^{Low}(t_j) + P_{Full}(t_j)HLF^{Full}(t_j)] \cdot \delta^{Low}(t_j)n_j \quad 11.162$$

$$HLF^{Low}(t_j) = \frac{\dot{q}_{Full}(t_j) - BL(t_j)}{\dot{q}_{Full}(t_j) - \dot{q}_{Low}(t_j)} \quad 11.163$$

$$HLF^{Full}(t_j) = 1 - HLF^{Low}(t_j) \quad 11.164$$

$\delta^{Low}(t_j)$ shall be calculated per Equations 11.159, 11.160 and 11.161.

11.2.2.2.3 *Case III. Building load is greater than the Low Stage capacity, but less than the Full Stage capacity,* $\dot{q}_{Low}(t_j) < BL(t_j) < \dot{q}_{Full}(t_j)$ *and the unit cycles between off and Full Stage operation*. Calculate total bin energy by using Equation 11.165. $RH(t_j)$ is calculated using Equation 11.154.

$$E(t_j) = \frac{P_{Full}(t_j) \cdot HLF^{Full}(t_j) \cdot \delta^{Full}(t_j) \cdot n_j}{PLF^{Full}(t_j)} \quad 11.165$$

$$HLF^{Full}(t_j) = \frac{BL(t_j)}{\dot{q}_{Full}(t_j)} \quad 11.166$$

$$PLF^{Full}(t_j) = 1 - C_D^{h,Full}[1 - HLF^{Full}(t_j)] \quad 11.167$$

δ^{Full} shall be calculated per Equations 11.125, 11.126 and 11.127 (Section 11.2.2.1.1). If the optional $H1C_{Full}$ Test (see Table 7) is not conducted, set $C_D^{h,Full}$ equal to the default value identified in Section 6.1.3.2. If this optional test is conducted, set $C_D^{h,Full}$ to the lower of a) the $C_D^{h,Full}$ value calculated as per Section 6.1.3.2; or b) the Section 6.1.3.2 default value for $C_D^{h,Full}$.

11.2.2.2.4 *When the building load is not less than the unit capacity*, $BL(t_j) \ge \dot{q}_{Full}(t_j)$. Calculate total bin capacity by using Equation 11.88 and total bin energy by using Equation 11.168.

$$E(t_j) = P_{Full}(t_j) \cdot HLF^{Full}(t_j) \cdot \delta^{Full}(t_j) \cdot n_j \quad 11.168$$

$$RH(t_j) = \frac{[BL(t_j) - \dot{q}_{Full}(t_j) \cdot HLF^{Full}(t_j) \cdot \delta^{Full}(t_j)]}{3.412} \cdot n_j \quad 11.169$$

$$HLF_{Full}(t_j) = 1.0 \quad 11.170$$

δ^{Full} shall be calculated per Equations 11.125, 11.126 and 11.127 (Section 11.2.2.1.1).

11.2.2.3 *Variable capacity certified, Two-stage System*. HSPF2 for a Variable capacity certified, Two-stage System shall be calculated using Equation 11.103 (Section 11.2.2.1), with the bin power consumption, $E(t_j)$, calculated based on the cases defined in sections 11.2.2.2.1 to 11.2.2.2.4 and the values of $\dot{q}_{Full}(tj)$, $\dot{q}_{low}(tj)$, $P_{full}(tj)$, and $P_{low}(tj)$ are determined as described in sections 11.2.2.3.1 to 11.2.2.3.3 below.

11.2.2.3.1 *Minimum Compressor Speed.* Use these instructions regardless of whether the system is minimum-speed-limiting or not.

The calculated Low Stage system capacity, $\dot{q}_{low}(t_j)$, and calculated Low Stage system power consumption rate, $P_{low}(t_j)$, at each bin temperature shall be calculated depending upon the cases below.

For $t_j \geq 47$

$$\dot{q}_{low}(t_j) = \dot{q}_{H1,Low} + [\frac{\dot{q}_{H0,Low} - \dot{q}_{H1,low}}{62-47}] * (t_j - 47) \quad 11.171$$

$$P_{low}(t_j) = P_{H1,Low} + \left[\frac{P_{H0,Low} - P_{H1.low}}{62-47}\right] * (t_j - 47) \quad 11.172$$

For $35 \leq t_j < 47$

$$\dot{q}_{low}(t_j) = \dot{q}_{H2,low} + \frac{[\dot{q}_{H1,low} - \dot{q}_{H2,low}] * (T_j - 35)}{47-35} \quad 11.173$$

$$P_{low}(t_j) = P_{H2,low} + \frac{[P_{H1,low} - P_{H2,low}] * (T_j - 35)}{47-35} \quad 11.174$$

For $17 \leq t_j < 35$

$$\dot{q}_{low}(t_j) = \dot{q}_{H3,low} + \frac{[\dot{q}_{H2,low} - \dot{q}_{H3,low}] * (T_j - 17)}{35-17} \quad 11.175$$

$$P_{low}(t_j) = P_{H3,low} + \frac{[P_{H2,low} - P_{H3,low}] * (T_j - 17)}{35-17} \quad 11.176$$

For $t_j < 17$

$$\dot{q}_{low}(t_j) = \dot{q}_{full}(T_j) * (\dot{q}_{H3,low} / \dot{q}_{H3,full}) \quad 11.177$$

$$P_{low}(t_j) = P_{full}(T_j) * (P_{H3,low} / P_{H3,full}) \quad 11.178$$

11.2.2.3.2 *Intermediate Compressor Speed.* For Variable capacity, Two-Stage Systems, there is no intermediate speed.

11.2.2.3.3 *Full Compressor Speed.* Calculate capacity $\dot{q}_{full}(tj)$ and power $P_{full}(tj)$ as described in section 11.2.2.4.3.

11.2.2.4 *Variable capacity System*. HSPF2 for a Variable capacity System shall be calculated using Equation 11.103, except as noted below, substituting $\dot{q}_x^{calc}$ for $\dot{q}_x$ and P_x^{calc} for P_x. See Figure 9 for a graphical representation.

If the $H1_{Full}$ test is conducted, set the capacity and power used for calculation of HSPF2 to be per Equations 11.179 and 11.180.

$$\dot{q}_{H1,Full}^{calc} = \dot{q}_{H1,Full} \quad 11.179$$

$$P_{H1,Full}^{calc} = P_{H1,Full} \quad 11.180$$

If the $H1_{Nom}$ test is conducted using the same compressor speed and the same airflow as the $H3_{Full}$ test, set the capacity and power used for calculation of HSPF2 to be per Equations 11.181 and 11.182.

$$\dot{q}_{H1,Full}^{calc} = \dot{q}_{H1,Nom} \quad 11.181$$

$$P_{H1,Full}^{calc} = P_{H1,Nom} \quad 11.182$$

If no H1 test is conducted at the same compressor speed as the $H3_{Full}$ test, set the capacity and power used for calculation of HSPF2 to be per equations 11.183 and 11.184.

$$\dot{q}_{H1,Full}^{calc} = \dot{q}_{H3,Full} \cdot (1 + 30 \cdot CSF) \quad 11.183$$

$$P_{H1,Full}^{calc} = P_{H3,Full} \cdot (1 + 30 \cdot PSF) \quad 11.184$$

Where:

CSF = 0.0204/°F, capacity slope factor for Split Systems
CSF = 0.0262/°F, capacity slope factor for Single Package Units
PSF = 0.00455/°F, power slope factor for all products

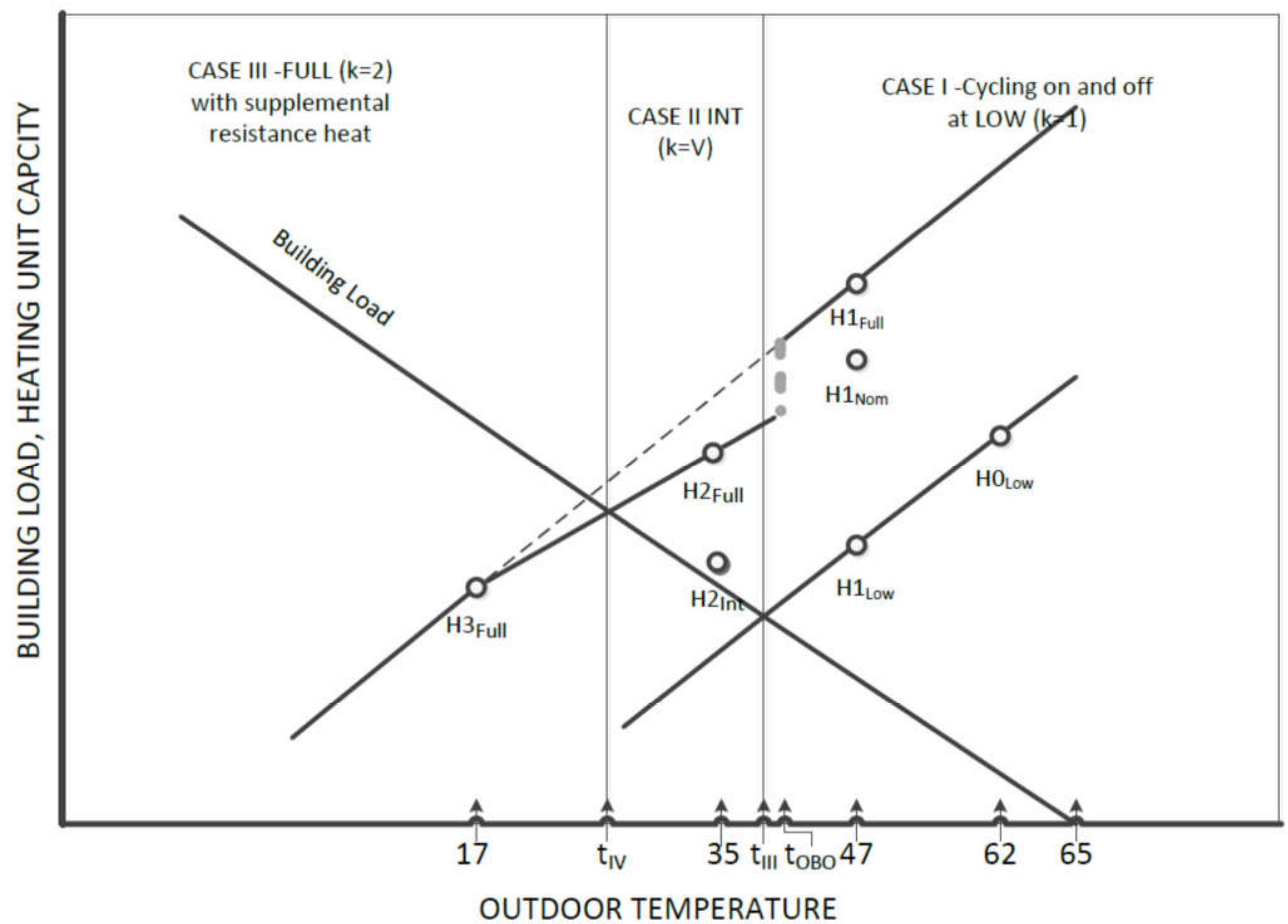

Figure 9. Schematic of a Variable capacity Heat Pump Operation in Heating Mode

11.2.2.4.1 *Case I. Building Load is no greater than the capacity of the unit at the Low Compressor Speed,* $\dot{q}_{Low}(t_j) \geq BL(t_j)$. For heat pumps that are not Minimum-speed-limiting Variable-speed Heat Pumps, calculate $E(t_j)$ per Equation 11.153 and $RH(t_j)$ per Equation 11.154. Calculate bin capacity and bin energy rate at Low Compressor Speed by using Equations 11.185 and 11.186.

$$\dot{q}_{Low}(t_j) = \dot{q}_{H1,Low} + [\dot{q}_{H0,Low} - \dot{q}_{H1,Low}] \cdot \frac{t_j - 47}{62 - 47} \quad 11.185$$

$$P_{Low}(t_j) = P_{H1,Low} + [P_{H0,Low} - P_{H1,Low}] \cdot \frac{t_j - 47}{62 - 47} \quad 11.186$$

For Minimum-speed-limiting variable-speed heat pumps, calculate bin capacity and bin energy rate at Low Compressor Speed by using Equations 11.187 to 11.192.

For $t_j \geq 47$

$$\dot{q}_{Low}(t_j) = \dot{q}_{H1,Low} + [\dot{q}_{H0,Low} - \dot{q}_{H1,Low}] \cdot \frac{t_j - 47}{62 - 47} \quad 11.187$$

For $35 \leq t_j < 47$

$$\dot{q}_{Low}(t_j) = \dot{q}_{H2,Int} + [\dot{q}_{H1,Low} - \dot{q}_{H2,Int}] \cdot \frac{t_j - 35}{47 - 35} \quad 11.188$$

For $t_j < 35$

$$\dot{q}_{Low}(t_j) = \dot{q}_{H,Int}(t_j) \quad 11.189$$

For $t_j \geq 47$

$$P_{Low}(t_j) = P_{H1,Low} + [P_{H0,Low} - P_{H1,Low}] \cdot \frac{t_j - 47}{62 - 47} \quad 11.190$$

For $35 \leq t_j < 47$

$$P_{Low}(t_j) = P_{H2,int} + [P_{H1,Low} - P_{H2,int}] \cdot \frac{t_j - 35}{47 - 35} \quad 11.191$$

For $t_j < 35$

$$P_{Low}(t_j) = P_{H,int}(t_j) \quad 11.192$$

11.2.2.4.2 *Case II. Building load can be matched by modulating the compressor speed between low speed and full speed,* $\dot{q}_{Low}(t_j) < BL(t_j) < \dot{q}_{Full}(t_j)$. Calculate total bin capacity by using Equation 11.193 and the total bin energy by using Equation 11.194.

$$\dot{q}(t_j) = \dot{q}_{Int-Bin}(t_j) \cdot n_j = BL(t_j) \cdot n_j \quad 11.193$$

$$E(t_j) = P_{Int-Bin}(t_j) \cdot \delta^{Int-Bin}(t_j) \cdot n_j = \frac{\dot{q}_{Int-Bin}(t_j)}{3.412 \cdot COP_{Int-Bin}(t_j)} \cdot \delta^{Int-Bin}(t_j) \cdot n_j \quad 11.194$$

Where for $\dot{q}_{Low}(t_j) < BL(t_j) < \dot{q}_{Int}(t_j)$

$$COP_{Int-Bin}(t_j) = COP_{Low}(t_j) + \frac{COP_{Int}(t_j) - COP_{Low}(t_j)}{\dot{q}_{Int}(t_j) - \dot{q}_{Low}(t_j)} \cdot \left(BL(t_j) - \dot{q}_{Low}(t_j)\right) \quad 11.195$$

and for $\dot{q}_{Int}(t_j) < BL(t_j) < \dot{q}_{Full}(t_j)$

$$COP_{Int-Bin}(t_j) = COP_{Int}(t_j) + \frac{COP_{Full}(t_j) - COP_{Int}(t_j)}{\dot{q}_{Full}(t_j) - \dot{q}_{Int}(t_j)} \cdot \left(BL(t_j) - \dot{q}_{Int}(t_j)\right) \quad 11.196$$

Where $COP_{Low}(t_j)$ is calculated based on $\dot{q}_{Low}(t_j)$ from Equation 11.185 and $P_{Low}(t_j)$ from Equation 11.186, $COP_{Int}(t_j)$ is calculated based on $\dot{q}_{Int}(t_j)$ from Equation 11.197 and $P_{Int}(t_j)$ from Equation 11.200 and $COP_{Full}(t_j)$ is calculated based on $q_{Full}(t_j)$ from Equations 11.207 or 11.209 and $P_{Full}(t_j)$ from Equations 11.208 or 11.210.

The capacity of the unit at temperature t_j at Intermediate Compressor Speed, shall be calculated as follows.

$$\dot{q}_{Int}(t_j) = \dot{q}_{H2,Int} + M_{Hq}[t_j - 35] \quad 11.197$$

Where,

$$M_{Hq} = \frac{\dot{q}_{H0,Low} - \dot{q}_{H1,Low}}{62-47} \cdot (1 - N_{Hq}) + \frac{\dot{q}_{H2,Full} - \dot{q}_{H3,Full}}{35-17} \cdot N_{Hq} \qquad 11.198$$

$$N_{Hq} = \frac{\dot{q}_{H2,Int} - \dot{q}_{Low}(35)}{\dot{q}_{H2,Full} - \dot{q}_{Low}(35)} \qquad 11.199$$

Where,

$\dot{q}_{Low}(35)$ shall be calculated per Equation 11.185 (Section 11.2.2.3.1).

Calculate $\dot{q}_{H2Full}$ using Equation 11.42 (Section 11.1.7.1) if the optional test is not run.

The electrical power of the unit $P_{Int}(t_j)$ at temperature t_j at Intermediate Compressor Speed, shall be calculated as follows.

$$P_{Int}(t_j) = P_{H2,Int} + M_{HE}[t_j - 35] \qquad 11.200$$

Where:

$$M_{HE} = \frac{P_{H0,Low} - P_{H1,Low}}{62-47} \cdot (1 - N_{HE}) + \frac{P_{H2,Full} - P_{H3,Full}}{35-17} \cdot N_{HE} \qquad 11.201$$

$$N_{HE} = \frac{P_{H2,Int} - P_{Low(35)}}{P_{H2,Full} - P_{Low}(35)} \qquad 11.202$$

Where,

$P_{Low}(35)$ shall be calculated per Equation 11.186.

Calculate $P_{H2,Full}$ using Equation 11.48 if the optional test is not run.

Evaluate $RH(t_j)$ as follows.

$$RH(t_j) = \frac{BL(t_j) \cdot [1 - \delta^{Int}(t_j)]}{3.412} \cdot n_j \qquad 11.203$$

$\delta^{Int-Bin}(t_j)$ shall be calculated depending upon the cases below.

For $t_j \leq t_{OFF}$ or $COP_{Int-Bin}(t_j) < 1$

$$\delta^{Int-Bin}(t_j) = 0 \qquad 11.204$$

For $t_{OFF} < t_j \leq t_{ON}$

$$\delta^{Int-Bin}(t_j) = 0.5 \qquad 11.205$$

For $t_j > t_{ON}$

$$\delta^{Int-Bin}(t_j) = 1 \qquad 11.206$$

11.2.2.4.3 *Case III. Building Load is no less than the capacity of the unit at the Full Compressor Speed, $\dot{q}_{Full}(t_j) \leq BL(t_j)$.* $E(t_j)$ shall be calculated using Equation 11.168, with

Equations 11.208 or 11.210 used to determine the bin power consumption rate when operating at Full Compressor Speed. $RH(t_j)$ shall be calculated using Equation 11.169, with Equations 11.207 or 11.209 used to determine the bin capacity when operating at Full Compressor Speed when the H4$_{Full}$ test is not conducted. . t_{OBO} shall be defined per Equation 11.111.

For $t_j \geq t_{OBO}$

$$\dot{q}_{Full}(t_j) = [\dot{q}_{H3,Full} + [\dot{q}^{calc}_{H1,Full} - \dot{q}_{H3,Full}] \cdot \frac{t_j - 17}{47-17}] \cdot \left(\frac{\dot{q}_{H1Nom}}{\dot{q}^{calc}_{H1,Full}}\right) \tag{11.207}$$

$$P_{Full}(t_j) = [P_{H3,Full} + [P^{calc}_{H1,Full} - P_{H3,Full}] \cdot \frac{t_j - 17}{47-17}] . \left(\frac{P_{H1Nom}}{\dot{P}^{calc}_{H1,Full}}\right) \tag{11.208}$$

For $t_j \leq 17$

$$\dot{q}_{Full}(t_j) = \dot{q}_{H3,Full} + [\dot{q}^{calc}_{H1,Full} - \dot{q}_{H3,Full}] \cdot \frac{t_j - 17}{47-17} \tag{11.209}$$

$$P_{Full}(t_j) = P_{H3,Full} + [P^{calc}_{H1,Full} - P_{H3,Full}] \cdot \frac{t_j - 17}{47-17} \tag{11.210}$$

For $17 < t_j < t_{OBO}$

$$\dot{q}_{Full}(t_j) = \dot{q}_{H3,Full} + [\dot{q}_{H2,Full} - \dot{q}_{H3,Full}] \cdot \frac{t_j - 17}{35-17} \tag{11.211}$$

$$P_{Full}(t_j) = P_{H3,Full} + [P_{H2,Full} - P_{H3,Full}] \cdot \frac{t_j - 17}{35-17} \tag{11.212}$$

When the H4$_{Full}$ test is conducted, determine the bin capacity and power consumption rate when operating at Full Compressor Speed using the following equations.

For $t_j \geq 17$, evaluate the bin capacity and bin energy when operating at full compressor speed using equations 11.207, 11.208, 11.211, and 11.212.

For $5 < t_j < 17$

$$\dot{q}_{Full}(t_j) = \dot{q}_{H4,Full} + [\dot{q}_{H3,Full} - \dot{q}_{H4,Full}] \cdot \frac{[t_j - 5]}{17-5} \tag{11.213}$$

$$P_{Full}(t_j) = P_{H4,Full} + [P_{H3,Full} - P_{H4,Full}] \cdot \frac{[t_j - 5]}{17-5} \tag{11.214}$$

For $t_j \leq 5$

$$\dot{q}_{Full}(t_j) = \dot{q}_{H4,Full} + [\dot{q}^{calc}_{H1,Full} - \dot{q}_{H3,Full}] \cdot \frac{[t_j - 5]}{47-17} \tag{11.215}$$

$$P_{Full}(t_j) = P_{H4,Full} + [P^{calc}_{H1,Full} - P_{H3,Full}] \cdot \frac{[t_j - 5]}{47-17} \tag{11.216}$$

11.2.2.5 *Heat Comfort Controller*. Heat pumps having a Heat Comfort Controller, the equations under Section 11.2.2.1-11.2.2.3 shall be used with the additions described in this Section 11.2.2.4.

11.2.2.5.1 *Additional Steps for Calculating the HSPF2 of a Heat Pump having a Single-Speed Compressor or Variable capacity certified, Single-stage System that was Tested with a Fixed-Speed Indoor Fan Installed, a Constant-Air-Volume-Rate Indoor Fan Installed, or with No Indoor Fan Installed*. Calculate the space heating capacity and electrical power of the heat pump without the Heat Comfort Controller being active as identified in Section 11.2.2.1 for each outdoor bin temperature, t_j, that is listed in Table 16. Denote these capacities and electrical powers by using the subscript "hp" instead of "h." Calculate the mass flow rate (expressed in pounds-mass of dry air per hour) and the specific heat of the indoor air (expressed in Btu/lbm_{da} • °F) from the results of the H1 Test using:

$$\dot{m}_{da} = 60\ \dot{Q}_s \cdot \rho_{da} = \frac{60 \cdot \dot{Q}_{mi}}{v'_n \cdot [1+W_n]} = \frac{60 \cdot \dot{Q}_{mi}}{v_n} \quad 11.217$$

Where

$\rho_{da} = 0.075 \frac{lbm_{da}}{ft^3}$ and 60 is a conversion from minutes to hours.

$$C_{p,da} = 0.24 + 0.444 \cdot W_n \quad 11.218$$

For each outdoor bin temperature listed in Table 16, calculate the nominal temperature of the air leaving the heat pump condenser coil using,

$$T_o(t_j) = 70°\text{F} + \frac{\dot{q}_{hp}(t_j)}{\dot{m}_{da} \cdot C_{p,da}} \quad 11.219$$

Calculate the HSPF2 using the equations found in Section 11.2.2.1 with the exception of the bin calculations shown below substituting $\dot{q}_{CC}(t_j)$ for $\dot{q}(t_j)$ and $P_{CC}(t_j)$ for $P(t_j)$.

For $T_o(t_j) \geq T_{CC}$ (The maximum supply temperature determined according to Section 6.1.7), calculate $\dot{q}_{CC}(t_j)$ and $P_{CC}(t_j)$ using Section 11.2.2.1.

Note: Even though $T_o(t_j) \geq T_{CC}$, resistance heating can be required; evaluate $RH(t_j)$ for all bins using the equation in Section 11.2.2.1.

For $T_o(t_j) < T_{CC}$, calculate $\dot{q}_{CC}(t_j)$ and $P_{CC}(t_j)$ using Equations 11.220 and 11.221.

$$\dot{q}_{CC}(t_j) = \dot{q}_{hp}(t_j) + \dot{m}_{da} C_{p,da} [T_{CC} - T_o(t_j)] \quad 11.220$$

$$P_{CC}(t_j) = P_{hp}(t_j) + \frac{\dot{m}_{da} \cdot C_{p,da} \cdot [T_{CC} - T_o(t_j)]}{3.412} \quad 11.221$$

Note: Even though $T_o(t_j) < T_{CC}$, additional resistance heating may be required; evaluate $RH(t_j)$ for all bins using the equation in Section 11.2.2.1.

11.2.2.5.2 *Additional Steps for Calculating the HSPF2 of a Heat Pump Having a Two-capacity Compressor or Variable capacity certified, Two-stage System.* Calculate the space heating capacity and electrical power of the heat pump without the Heat Comfort Controller being active as identified in Section 11.2.2.2 for both high and low capacity and at each outdoor bin temperature, t_j, that is listed in Table 16. Denote these capacities and electrical powers by using the subscript "hp" instead of "h." For the low capacity case, calculate the mass flow rate (expressed in pounds-mass of dry air per hour) and the specific heat of the indoor air (expressed in Btu/lbm$_{da}$ · °F) from the results of the H1$_{Low}$ Test using:

$$\dot{m}_{da,Low} = 60 \cdot \dot{Q}_s \rho_{da} = \frac{60 \cdot \dot{Q}_{mi}}{v'_n \cdot [1+W_n]} = \frac{60 \cdot \dot{Q}_{mi}}{v_n} \quad 11.222$$

$$C_{p,da,Low} = 0.24 + 0.444 \cdot W_n \quad 11.223$$

For each outdoor bin temperature listed in Table 16, calculate the nominal temperature of the air leaving the heat pump condenser coil when operating at low capacity using,

$$T_{o,Low}(t_j) = 70°\text{F} + \frac{\dot{q}_{hp,Low}(t_j)}{\dot{m}_{da,Low} \cdot C_{p,da,Low}} \quad 11.224$$

Repeat the above calculations to determine the mass flow rate ($m_{da,\ Full}$) and the specific heat of the indoor air ($C_{p,da,Full}$) when operating at high capacity by using the results of the H1$_{Full}$ Test. For each outdoor bin temperature listed in Table 16, calculate the nominal temperature of the air leaving the heat pump condenser coil when operating at high capacity using,

$$T_{o,Full}(t_j) = 70°\text{F} + \frac{\dot{q}_{hp,Full}(t_j)}{\dot{m}_{da,Full} \cdot C_{p,da,Full}} \quad 11.225$$

Evaluate $E(t_j)$, $RH(t_j)$, $HLF^{Low}(t_j)$, $HLF^{Full}(t_j)$, $PLF^{Low}(t_j)$, $PLF^{Full}(t_j)$, and $\delta^{Low}(t_j)$ or $\delta^{Full}(t_j)$ as identified in Sections 11.2.2.2.1, 11.2.2.2.2, 11.2.2.2.3, 11.2.2.2.4, whichever applies, for each Temperature Bin. To evaluate these quantities, use the low-capacity space heating capacity and the low-capacity electrical power from Case 1 or Case 2, whichever applies; use the high-capacity space heating capacity and the high-capacity electrical power from Case 3 or Case 4, whichever applies.

For $T_{o,Low}(t_j) \geq T_{CC}$ (The maximum supply temperature determined according to Section 6.1.7), calculate $\dot{q}_{h,Low}(t_j)$ and $P_{h,Low}(t_j)$ using Section 11.2.2.2 (*i.e.,* $\dot{q}_{h,Low}(t_j) = \dot{q}_{hp,Low}(t_j)$ and $P_{h,Low}(t_j) = P_{hp,Low}(t_j)$).

Note: Even though $T_{o,Low}(t_j) \geq T_{CC}$, resistance heating can be required; evaluate $RH(t_j)$ for all bins.

For $T_{o,Low}(t_j) < T_{CC}$, calculate $\dot{q}_{h,Low}(t_j)$ and $\dot{P}_{h,Low}(t_j)$ using Equations 11.226 and 11.227.

$$\dot{q}_{h,Low}(t_j) = \dot{q}_{hp,Low}(t_j) + \dot{q}_{CC,Low}(t_j) \quad 11.226$$

$$P_{h,Low}(t_j) = P_{hp,Low}(t_j) + P_{CC,Low}(t_j) \quad 11.227$$

Where:

$$\dot{q}_{CC,Low}(t_j) = \dot{m}_{da,Low} \cdot C_{p,da,Low} \cdot [T_{CC} - T_{o,Low}(t_j)] \quad 11.228$$

$$P_{CC,Low}(t_j) = \frac{\dot{q}_{CC,Low}(t_j)}{3.412} \quad 11.229$$

Note: Even though $T_{o,Low}(t_j) < T_{CC}$, additional resistance heating may be required; evaluate $RH(t_j)$ for all bins.

For $T_{o,Full}(t_j) \geq T_{CC}$, calculate $\dot{q}_{h,Full}(t_j)$ and $P_{h,Full}(t_j)$ using Section 11.2.2.2 (*i.e.,* $\dot{q}_{h,Full}(t_j) = \dot{q}_{hp,Full}(t_j)$ and $P_{h,Full}(t_j) = P_{hp,Full}(t_j)$).

Note: Even though $T_{o,Full}(t_j) \geq T_{CC}$, resistance heating may be required; evaluate $RH(t_j)$ for all bins.

For $T_{o,Full}(t_j) < T_{CC}$, calculate $\dot{q}_{h,Full}(t_j)$ and $P_{h,Full}(t_j)$ using Equations 11.230 and 11.231.

$$\dot{q}_{h,Full}(t_j) = \dot{q}_{hp,Full}(t_j) + \dot{q}_{CC,Full}(t_j) \quad 11.230$$

$$P_{h,Full}(t_j) = P_{hp,Full}(t_j) + P_{CC,Full}(t_j) \quad 11.231$$

Where:

$$\dot{q}_{CC,Full}(t_j) = \dot{m}_{da,Full} \cdot C_{p,da,Full} \cdot [T_{CC} - T_{o,Full}(t_j)] \quad 11.232$$

$$P_{CC,Full}(t_j) = \frac{\dot{q}_{CC,Full}(t_j)}{3.412} \quad 11.233$$

Note: Even though $T_{o,Full}(t_j) < T_{CC}$, additional resistance heating may be required; evaluate $RH(t_j)$ for all bins.

11.2.2.5.3 *Additional Steps for Calculating the HSPF2 of a Heat Pump Having a Variable capacity Compressor.* Calculate the space heating capacity and electrical power of the heat pump without the Heat Comfort Controller being active as identified in Section 11.2.2.4 for high, intermediate, and low capacity and at each outdoor bin temperature, t_j, that is listed in Table 16. Denote these capacities and electrical powers by using the subscript "hp" instead of "h." For the intermediate capacity case, calculate the mass flow rate (expressed in pounds-mass of dry air per hour) and the specific heat of the indoor air (expressed in Btu/lbm$_{da}$ · °F) from the results of the H2$_{Int}$ Test (Heat portion) using:

$$\dot{m}_{da,int} = 60 \cdot \dot{Q}_s \rho_{da} = \frac{60 \cdot \dot{Q}_{mi}}{v'_n \cdot [1+W_n]} = \frac{60 \cdot \dot{Q}_{mi}}{v_n} \quad 11.2xx$$

$$C_{p,da,int} = 0.24 + 0.444 \cdot W_n \quad 11.2xx$$

For each outdoor bin temperature listed in Table 16, calculate the nominal temperature of the air leaving the heat pump condenser coil when operating at intermediate capacity using,

$$T_{o,int}(t_j) = 70°\text{F} + \frac{\dot{q}_{hp,int}(t_j)}{\dot{m}_{da,int} \cdot C_{p,da,int}} \quad 11.2xx$$

Repeat the above calculations to determine the mass flow rate ($m_{da,low}$) and the specific heat of the indoor air ($C_{p,da,low}$) when operating at low capacity by using the results of the H1$_{Low}$ Test. For each outdoor bin temperature listed in Table 16, calculate the nominal temperature of the air leaving the heat pump condenser coil when operating at low capacity using,

$$T_{o,low}(t_j) = 70°\text{F} + \frac{\dot{q}_{hp,low}(t_j)}{\dot{m}_{da,low} \cdot C_{p,da,low}} \quad 11.2xx$$

Again repeat the above calculations to determine the mass flow rate ($m_{da,\ Full}$) and the specific heat of the indoor air ($C_{p,da,Full}$) when operating at high capacity by using the results of the H3$_{Full}$ Test. For each outdoor bin temperature listed in Table 16, calculate the nominal temperature of the air leaving the heat pump condenser coil when operating at high capacity using,

$$T_{o,Full}(t_j) = 70°\text{F} + \frac{\dot{q}_{hp,Full}(t_j)}{\dot{m}_{da,Full} \cdot C_{p,da,Full}} \quad 11.2xx$$

Evaluate E(t_j), RH(t_j), $HLF^{Low}(t_j)$, $HLF^{Full}(t_j)$, $PLF^{Low}(t_j)$, $PLF^{Full}(t_j)$, $COP_{Int\text{-}Bin}(t_j)$, and $\delta^{Low}(t_j)$, $\delta^{Int\text{-}Bin}(t_j)$ or $\delta^{Full}(t_j)$ as identified in Sections 11.2.2.4.1, 11.2.2.4.2, 11.2.2.4.3, whichever applies, for each Temperature Bin. To evaluate these quantities, use the low-capacity space heating capacity and the low-capacity electrical power from Case 1; use the intermediate-capacity space heating capacity and the intermediate-capacity electrical power from Case 2; and use the high-capacity space heating capacity and the high-capacity electrical power from Case 3.

For $T_{o,Low}(t_j) \geq T_{CC}$ (The maximum supply temperature determined according to Section 6.1.7), calculate $\dot{q}_{h,Low}(t_j)$ and $P_{h,Low}(t_j)$ using Section 11.2.2.4 (*i.e.,* $\dot{q}_{h,Low}(t_j) = \dot{q}_{hp,Low}(t_j)$ and $P_{h,Low}(t_j) = P_{hp,Low}(t_j)$). Note: Even though $T_{o,Low}(t_j) \geq T_{CC}$, resistance heating may be required; evaluate $RH(t_j)$ for all bins.

For $T_{o,Low}(t_j) < T_{CC}$, calculate $\dot{q}_{h,Low}(t_j)$ and $\dot{P}_{h,Low}(t_j)$ using Equations 11.2xx and 11.2xx.

$$\dot{q}_{h,Low}(t_j) = \dot{q}_{hp,Low}(t_j) + \dot{q}_{CC,Low}(t_j) \quad 11.2xx$$

$$P_{h,Low}(t_j) = P_{hp,Low}(t_j) + P_{CC,Low}(t_j) \quad 11.2xx$$

Where:

$$\dot{q}_{CC,Low}(t_j) = \dot{m}_{da,Low} \cdot C_{p,da,Low} \cdot [T_{CC} - T_{o,Low}(t_j)] \quad 11.2xx$$

$$P_{CC,Low}(t_j) = \frac{\dot{q}_{CC,Low}(t_j)}{3.412} \quad 11.2xx$$

Note: Even though $T_{o,Low}(t_j) < T_{CC}$, additional resistance heating can be required; evaluate $RH(t_j)$ for all bins.

For $T_{o,Full}(t_j) \geq T_{CC}$, calculate $\dot{q}_{h,Full}(t_j)$ and $P_{h,Full}(t_j)$ using Section 11.2.2.4 (*i.e.,* $\dot{q}_{h,Full}(t_j) = \dot{q}_{hp,Full}(t_j)$ and $P_{h,Full}(t_j) = P_{hp,Full}(t_j)$). Note: Even though $T_{o,Full}(t_j) \geq T_{CC}$, resistance heating may be required; evaluate $RH(t_j)$ for all bins.

For $T_{o,Full}(t_j) < T_{CC}$, calculate $\dot{q}_{h,Full}(t_j)$ and $P_{h,Full}(t_j)$ using Equations 11.2xx and 11.2xx.

$$\dot{q}_{h,Full}(t_j) = \dot{q}_{hp,Full}(t_j) + \dot{q}_{CC,Full}(t_j) \quad 11.2xx$$

$$P_{h,Full}(t_j) = P_{hp,Full}(t_j) + P_{CC,Full}(t_j) \quad 11.2xx$$

Where:

$$\dot{q}_{CC,Full}(t_j) = \dot{m}_{da,Full} \cdot C_{p,da,Full} \cdot [T_{CC} - T_{o,Full}(t_j)] \quad 11.2xx$$

$$P_{CC,Full}(t_j) = \frac{\dot{q}_{CC,Full}(t_j)}{3.412} \quad 11.2xx$$

Note: Even though $T_{o,Full}(t_j) < T_{CC}$, additional resistance heating can be required; evaluate $RH(t_j)$ for all bins.

For $T_{o,int}(t_j) \geq T_{CC}$, calculate $\dot{q}_{h,int}(t_j)$ and $P_{h,int}(t_j)$ using Section 11.2.2.4 (*i.e.,* $\dot{q}_{h,int}(t_j) = \dot{q}_{hp,int}(t_j)$ and $P_{h,int}(t_j) = P_{hp,int}(t_j)$). Note: Even though $T_{o,int}(t_j) \geq T_{CC}$, resistance heating may be required; evaluate $RH(t_j)$ for all bins.

For $T_{o,int}(t_j) < T_{CC}$, calculate $\dot{q}_{h,int}(t_j)$ and $P_{h,int}(t_j)$ using Equations 11.2xx and 11.2xx.

$$\dot{q}_{h,int}(t_j) = \dot{q}_{hp,int}(t_j) + \dot{q}_{CC,int}(t_j) \qquad 11.2xx$$

$$P_{h,int}(t_j) = P_{hp,int}(t_j) + P_{CC,int}(t_j) \qquad 11.2xx$$

Where:

$$\dot{q}_{CC,int}(t_j) = \dot{m}_{da,int} \cdot C_{p,da,int} \cdot [T_{CC} - T_{o,int}(t_j)] \qquad 11.2xx$$

$$P_{CC,int}(t_j) = \frac{\dot{q}_{CC,int}(t_j)}{3.412} \qquad 11.2xx$$

Note: Even though $T_{o,int}(t_j) < T_{CC}$, additional resistance heating can be required; evaluate $RH(t_j)$ for all bins.

11.2.2.6 *Additional Steps for Calculating the HSPF2 of a Heat Pump Having a Triple-Capacity Compressor*

The only triple-capacity heat pumps covered are triple-capacity, northern heat pumps. For such heat pumps, the calculation of the Equation 11.103 (Section 11.2.2.1), except as noted below, $E(t_j)$ *and* $RH(t_j)$ differ depending on whether the heat pump would cycle on and off at low capacity (Section 11.2.2.5.1), cycle on and off at high capacity (Section 11.2.2.5.2), cycle on and off at booster capacity (Section 11.2.2.5.3), cycle between low and high capacity (Section 11.2.2.5.4), cycle between high and booster capacity (Section 11.2.2.5.5), operate continuously at low capacity (Section 11.2.2.5.6), operate continuously at high capacity (Section 11.2.2.5.7), operate continuously at booster capacity (Section 11.2.2.5.8), or heat solely using resistance heating (Section 11.2.2.5.8) in responding to the building load. As an informative example, data may be submitted in this manner: At the low compressor capacity, the outdoor temperature range of operation is 40°F ≤ t_j ≤ 65°F; At the high compressor capacity, the outdoor temperature range of operation is 20°F ≤ t_j ≤ 50°F; At the booster compressor capacity, the outdoor temperature range of operation is −20°F ≤ t_j ≤ 30°F.

Evaluate the space heating capacity and electrical power consumption of the heat pump ($\dot{q}_{Low}(t_j)$ and $P_{Low}(t_j)$) when operating at low compressor capacity and outdoor temperature t_j using the equations given in Section 11.2.2.2. In evaluating the Section 11.2.2.2 equations, Determine $\dot{q}_{H0,Low}$ and $P_{H0,Low}$ from the $H0_{Low}$ test, $\dot{q}_{H1,Low}$ and $P_{H1,Low}$ from the $H1_{Low}$ test, and $\dot{q}_{H1,Full}$ and $P_{H1,Full}$ from the $H1_{Full}$ test. If the $H3_{Low}$ test is conducted, calculate $\dot{q}_{H3,Low}$ and $P_{H3,Low}$ and determine $\dot{q}_{H2,Low}$ and $P_{H2,Low}$ as identified below:

$$\dot{q}_{H2,Low} = 0.9 \cdot \{\dot{q}_{H3,Low} + 0.6 \cdot [\dot{q}_{H1,Low} - \dot{q}_{H3,Low}]\} \qquad 11.228$$

$$P_{H2,Low} = 0.985 \cdot \{P_{H3,Low} + 0.6 \cdot [P_{H1,Low} - P_{H3,Low}]\} \qquad 11.229$$

Evaluate the space heating capacity and electrical power consumption ($\dot{q}_{Full}(t_j)$ and $P_{Full}(t_j)$) of the heat pump when operating at high compressor capacity and outdoor temperature t_j using the equations given in Section 11.2.2.1.1. Determine $\dot{q}_{H0,Low}$ and $P_{H0,Low}$ from the $H0_{Low}$ test, $\dot{q}_{H1,Low}$ and $P_{H1,Low}$ from the $H1_{Low}$ test, and $\dot{q}_{H1,Full}$ and $P_{H1,Full}$ from the $H1_{Full}$ test. Determine the equation input for $\dot{q}_{H2,Full}$ and $P_{H2,Full}$ from the $H2_{Full,}$ test. Also, determine $\dot{q}_{H3,Full}$ and $P_{H3,Full}$ from the $H3_{Full}$ test.

Evaluate the space heating capacity and electrical power consumption of the heat pump when operating at booster compressor capacity and outdoor temperature t_j using

For $17 < t_j \le t_{OBO}$

$$\dot{q}_{Boost}(t_j) = \dot{q}_{H3,Boost} + [\dot{q}_{H2,Boost} - \dot{q}_{H3,Boost}] \cdot \frac{t_j - 17}{35 - 17} \quad 11.230$$

$$P_{Boost}(t_j) = P_{H3,Boost} + [P_{H2,Boost} - P_{H3,Boost}] \cdot \frac{t_j - 17}{35 - 17} \quad 11.231$$

For $t_j \le 17$

$$\dot{q}_{Boost}(t_j) = \dot{q}_{H4,Boost} + [\dot{q}_{H3,Boost} - \dot{q}_{H4,Boost}] \cdot \frac{t_j - 5}{17 - 5} \quad 11.232$$

$$P_{Boost}(t_j) = P_{H4,Boost} + [P_{H3,Boost} - P_{H4,Boost}] \cdot \frac{t_j - 5}{17 - 5} \quad 11.233$$

Determine $\dot{q}_{H3,Boost}$ and $P_{H3,Boost}$ from the $H3_{Boost}$ test and determine $\dot{q}_{H4,Boost}$ and $P_{H4,Boost}$ from the $H4_{Boost}$ test. Determine the equation input for $\dot{q}_{H2,Boost}$ and $P_{H2,Boost}$ from an optional $H2_{Boost}$ test. If this optional test is not conducted, using the following equations:

$$\dot{q}_{H2,Boost} = QR_{H2,Full} \cdot \{\dot{q}_{H3,Boost} + 1.20 \cdot [\dot{q}_{H3,Boost} - \dot{q}_{H4,Boost}]\} \quad 11.234$$

$$P_{H2,Boost} = PR_{H2,Full} \cdot \{P_{H3,Boost} + 1.20 \cdot [P_{H3,Boost} - P_{H4,Boost}]\} \quad 11.235$$

Where,

$$QR_{H2,Full} = \frac{\dot{q}_{H2,Full}}{\dot{q}_{H3,Full} + 0.6 \cdot [\dot{q}_{H1,Full} - \dot{q}_{H3,Full}]} \quad 11.236$$

$$PR_{H2,Full} = \frac{P_{H2,Full}}{P_{H3,Full} + 0.6 \cdot [P_{H1,Full} - P_{H3,Full}]} \quad 11.237$$

11.2.2.6.1 *Case I. Steady-State Space Heating Capacity When Operating at Low Compressor Capacity Is Greater Than or Equal to the Building Heating Load at Temperature t_j, $\dot{q}_{Low}(t_j) \ge BL(t_j)$., and the Heat Pump Permits Low Compressor Capacity at t_j.*

Evaluate the Quantities $E(t_j)$ and $RH(t_j)$ using Equations. 11.153 and 11.154, respectively. Determine the equation inputs $P_{Low}(t_j) \cdot PLF^{Low}(t_j)$ and $\delta^{Low}(t_j)$ as identified in Section 11.2.2.2.1. In calculating the part load factor, $PLF^{Low}(t_j)$, use the low-capacity cyclic-degradation coefficient $C_D^{h,Low}$ determined as below:

Conduct the optional high temperature cyclic test ($H1C_{Low}$) to determine the heating mode cyclic-degradation coefficient, $C_D^{h,Low}$. A default value for $C_D^{h,Low}$ of 0.25 can be used in lieu of conducting the cyclic. If a triple-capacity heat pump locks out low capacity operation at lower outdoor temperatures, conduct the high temperature cyclic test ($H1C_{Full}$) to determine the high capacity heating mode cyclic-degradation coefficient, $C_D^{h,Full}$. The default $C_D^{h,Full}$ is the same value as determined or assigned for the low-capacity cyclic-degradation coefficient, $C_D^{h,Low}$. Finally, if a triple-capacity heat pump locks out both low and high capacity operation at the lowest outdoor temperatures, conduct the low temperature cyclic test ($H3C_{Boost}$) to determine the booster-capacity heating mode cyclic-degradation coefficient, $C_D^{h,Boost}$. The default $C_D^{h,Boost}$ is the same value as determined or assigned for the high capacity cyclic-degradation coefficient, $C_D^{h,Full}$.

11.2.2.6.2 *Case II. Heat Pump Only Operates at Full Compressor Capacity at Temperature t_j and Its Capacity Is Greater Than or Equal to the Building Heating Load, $BL(t_j) < \dot{q}_{Full}(t_j)$.*

Evaluate the Quantities $E(t_j)$ and $RH(t_j)$ as identified in Section 11.2.2.2.3. Determine the equation inputs $P_{Full}(t_j) \cdot PLF^{Full}(t_j)$ and $\delta^{Full}(t_j)$ as identified in Section 11.2.2.2.3. In calculating the part load factor, $PLF^{Full}(t_j)$, use the high-capacity cyclic-degradation coefficient, $C_D^{h,Full}$, determined in accordance with Section 11.2.2.5.1.

11.2.2.6.3 *Case III. Heat Pump Only Operates at Booster Compressor Capacity at Temperature t_j and its Capacity Is Greater Than or Equal to the Building Heating Load, $BL(t_j) \leq \dot{q}_{Boost}(t_j)$.*

Calculate $RH(t_j)$ using Equation 11.154 and evaluate $E(t_j)$ using

$$E(t_j) = \frac{P_{Boost}(t_j) \cdot HLF^{Boost}(t_j) \cdot \delta^{Boost}(t_j) n_j}{PLF^{Boost}(t_j)} \qquad 11.238$$

Where,

$$HLF^{Boost}(t_j) = \frac{BL(t_j)}{\dot{q}_{Boost}(t_j)} \qquad 11.239$$

$$PLF^{Boost}(t_j) = 1 - C_D^{h,Boost}[1 - HLF^{Boost}(t_j)] \qquad 11.240$$

Use the booster-capacity cyclic-degradation coefficient, $C_D^{h,Boost}$ determined in accordance with Section 11.2.2.5.1.

Determine the low temperature cut-out factor, $\delta^{Boost}(t_j)$, depending the cases below.

For $t_j \leq t_{OFF}$ or $\frac{\dot{q}_{Boost}(t_j)}{3.412 \cdot P_{Boost}(t_j)} < 1$

$$\delta^{Boost}(t_j) = 0 \qquad 11.241$$

For $t_{OFF} < t_j \leq t_{ON}$

$$\delta^{Boost}(t_j) = 0.5 \qquad 11.242$$

For $t_j > t_{ON}$

$$\delta^{Boost}(t_j) = 1 \qquad 11.243$$

11.2.2.6.4 *Case IV. Heat Pump Alternates Between Full and Low Compressor Capacity To Satisfy the Building Heating Load at a Temperature t_j, $\dot{q}_{Low}(t_j) < BL(t_j) < \dot{q}_{Full}(t_j)$.*

Evaluate the following quantities $E(t_j)$ and $RH(t_j)$ as identified in Section 11.2.2.2.2. Determine the equation inputs $HLF^{Low}(t_j), HLF^{Full}(t_j)$, and $\delta^{Low}(t_j)$ as identified in Section 11.2.2.2.2.

11.2.2.6.5 *Case V. Heat Pump Alternates Between Full and Booster Compressor Capacity To Satisfy the Building Heating Load at a Temperature t_j, $\dot{q}_{Full}(t_j) < BL(t_j) < \dot{q}_{Boost}(t_j)$.*

Calculate $RH(t_j)$ using Equation 11.154 and evaluate $E(t_j)$ using

$$E(t_j) = [P_{Full}(t_j)HLF^{Full}(t_j) + P_{Boost}(t_j)HLF^{Boost}(t_j)] \cdot \delta^{Boost}(t_j)n_j \quad 11.244$$

$$HLF^{Full}(t_j) = \frac{\dot{q}_{Boost}(t_j) - BL(t_j)}{\dot{q}_{Boost}(t_j) - \dot{q}_{Full}(t_j)} \quad 11.245$$

Where $HLF^{boost}(t_j) = 1 - HLF^{Full}(t_j)$. Determine the low temperature cut-out factor, $\delta^{Boost}(t_j)$ using the equation given in Section 11.2.2.5.3.

11.2.2.6.6 *Case VI. Heat Pump Only Operates at Low Compressor Capacity at Temperature t_j and Its Capacity Is Less Than the Building Heating Load, $BL(t_j) > \dot{q}_{Low}(t_j)$.*

$$E(t_j) = P_{Low}(t_j) \cdot \delta^{Low}(t_j) \cdot n_j \quad 11.246$$

$$RH(t_j) = \frac{BL(t_j) - \dot{q}_{Low}(t_j) \cdot \delta^{Low}(t_j)}{3.412} \cdot n_j \quad 11.247$$

where the low temperature cut-out factor, $\delta^{Low}(t_j)$ as identified in Section 11.2.2.2.1.

11.2.2.6.7 *Case VII. Heat Pump Only Operates at Full Compressor Capacity at Temperature t_j and Its Capacity Is Less Than the Building Heating Load, $BL(t_j) > \dot{q}_{Full}(t_j)$.*

Evaluate the quantities $E(t_j)$ *and* $RH(t_j)$ as identified in Section 11.2.2.2.4. Calculate $\delta^{Full}(t_j)$ using the equation given in Section 11.2.2.2.4.

11.2.2.6.8 *Case VIII. Heat Pump Only Operates at Booster Compressor Capacity at Temperature t_j and Its Capacity Is Less Than the Building Heating Load, $BL(t_j) > \dot{q}_{Boost}(t_j)$ or the System Converts To Using Only Resistance Heating.*

$$E(t_j) = P_{Boost}(t_j) \cdot \delta^{Boost}(t_j) \cdot n_j \quad 11.248$$

$$RH(t_j) = \frac{[BL(t_j) - \dot{q}_{Boost}(t_j) \cdot \delta^{Boost}(t_j)]}{3.412} \cdot n_j \quad 11.249$$

where $\delta^{Boost}(t_j)$ is calculated as identified in Section 11.2.2.5.3 if the heat pump is operating at its booster compressor capacity. If the heat pump system converts to using only resistance heating at outdoor temperature t_j, set $\delta^{Boost}(t_j)$ equal to zero.

11.3 *Off-mode Power Calculations.* For central air-conditioners and heat pumps, Off-mode Power Consumption ($P_{W,Off}$) shall be tested per Appendix G and calculated as follows.

11.3.1 *Cooling Capacity Less Than 36,000 Btu/h.*

$$P_{W,Off} = \frac{P1 + P2}{2} \quad 11.250$$

11.3.2 *Cooling Capacity Great Than or Equal to 36,000 Btu/h.* Calculate the capacity scaling factor (F_{scale}) where $\dot{\boldsymbol{q}}_{\boldsymbol{A,Full}}$ is the total cooling capacity at the A_{Full} test conditions.

$$F_{scale} = \frac{\dot{q}_{A,Full}}{36000} \quad 11.251$$

Determine the off-mode represented value, $P_{W,Off}$ with the following equation, rounding to the nearest watt.

$$P_{W,Off} = \frac{P1+P2}{2 \cdot F_{scale}} \qquad 11.252$$

Section 12. Symbols, Subscripts and Superscripts

12.1 *Symbols,*

$AFUE$	Furnace rated efficiency (Annual Fuel Utilization Efficiency)
$AFUE_H$	Annual Fuel Utilization Efficiency for Dual Energy Systems ('dual fuel' or 'hybrid')
BE	Furnace blower power draw at mid-rise, high-stage from the furnace submittal
$BL(t_j)$	Building load at bin temperature t_j, Btu/h
$COP2_x$	Coefficient of performance for test x
$COP2_{cyc,x}$	Coefficient of performance during cyclic
$COP2_{def,x}$	Coefficient of performance during defrost
$COP2(y)$	Coefficient of performance for bin y
$COP2_x(y)$	Coefficient of performance at condition x, for bin y, where x equals "cyc," "Full," "Int" or "Low"
COP_{peak}	Coefficient of performance at peak load at 5F
c_{pa}	Specific heat of air, Btu/lbm$_{da}$·°F
c_{pa2}	Specific heat of air leaving the indoor side, Btu/lbm$_{da}$·°F
c_{pa4}	Specific heat of air leaving the outdoor side, Btu/lbm$_{da}$·°F
$c_{p,da,x}$	Specific heat of dry air for condition x, Btu/lbm$_{da}$·°F
C_D	The Degradation Coefficient to account for cycling of the compressor for capacity less than the minimum step of capacity
C_D^c	Cooling Degradation Coefficient, applies to both "Full" and "Low"
$C_D^{c,x}$	Cooling Degradation Coefficient, where x equals "Full" or "Low"
C_D^h	Heating Degradation Coefficient, applies to both "Full" and "Low"
$C_D^{h,x}$	Heating Degradation Coefficient, where x equals "Full" or "Low"
C_{vc}	Heating Load Line equation slope factor for variable capacity product
CLF^x	Cooling load factor for condition x, where x equals "cyc," "Full" or "Low"
CLH_A	Cooling load hours, actual
$DFPC_C$	Default fan power coefficient (watts) for non-mobile-home and non-space-constrained systems
$DFPC_{MHSC}$	Default fan power coefficient (watts) for mobile-home and space-constrained systems
$E_x(t_j)$	Total bin energy for test x, W·h, where x is blank, "Full" or "Low"
$E_{def,x}$	Total electrical energy used by the system during defrost test x, W·h
$E_{fan,x}$	Electrical energy used by the indoor fan for test x, W·h
$E_{furn}(t_j)$	Electrical power consumption of the furnace blower at temperature, t_j
$E_{m,x}$	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 adjustment calculated for Cyclic or defrost Test x, W·h
$EER2_x$	Energy efficiency ratio for test x, Btu/W·h
$EER2_x(y)$	Energy efficiency ratio for condition x, at y, where y can be t_j, t_I, t_{II}, etc., Btu/W·h
ESP_1	Lowest ESP where the unit is run with stability, in H_2O
ESP_2	Higher measured ESP, in H_2O
ESP_{FL}	ESP at full load airflow, in H_2O, as identified in Table 10
ESP_{min}	Target or minimum ESP, in H_2O
ESP_{PL}	ESP at part load airflow, in H_2O
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.
%FLAVR	% of full-load airflow
FR	Furnace Ratio, which is a ratio of furnace nominal capacity to heat pump nominal capacity
F_{CD}	Cyclic correction factor
F_{CD}^*	Cyclic correction factor applied to the grid or thermopile measurement during the Cyclic Test
F_{def}	Demand-defrost enhancement factor
F_{scale}	Capacity scaling factor
$GH(t_j)$	Gas power consumption of the furnace at temperature t_j, W·h
h_{a1}	Enthalpy, air entering indoor side, Btu/lbm$_{da}$
h_{a2}	Enthalpy, air leaving indoor side, Btu/lbm$_{da}$
h_{a3}	Enthalpy, air entering outdoor side, Btu/lbm$_{da}$

h_{a4}	Enthalpy, air leaving outdoor side, Btu/lbm_{da}
h_{r1}	Enthalpy, vapor refrigerant indoor side, Btu/lbm
h_{r2}	Enthalpy, liquid refrigerant indoor side, Btu/lbm
HB_x	Heat balance for test *x*
HLF	Heating load factor
$HLF^x(t_j)$	Heat pump heating load factor at condition *x* at Temperature Bin *j*
HLH_A	Heating load hours, actual
$HSPF2$	Heating Seasonal Performance Factor, HSPF2
LCL	Lower 90% confidence limit
L_f	Indoor coil fin length in inches, also height of the coil transverse to the tubes
LF	Fractional ON time for last stage at the desired load point
M_{CE}	Energy adjustment factor in cooling mode
M_{HE}	Energy adjustment factor in heating mode
M_{Cq}	Capacity adjustment factor in cooling mode
M_{Hq}	Capacity adjustment factor in heating mode
M_t	Refrigerant charge
$\dot{m}_{da,x}$	Mass flow of dry air for condition *x*, lb_m/h where *x* is blank, "Full" or "Low"
$\dot{m}_{ref,x}$	Mass flow of refrigerant-oil mixture for condition *x*, lb_m/h
n	Number of systems tested, number of bins
n_c	Number of compressors
n_s	Number of single stage compressors
n_v	Number of Variable capacity Compressors
n_j	Fractional bin hours in the jth Temperature Bin
N_{CE}	Energy adjustment factor in cooling mode
N_f	Number of fins
N_{HE}	Energy adjustment factor in heating mode
N_{Cq}	Capacity adjustment factor in cooling mode
N_{Hq}	Capacity adjustment factor in heating mode
$NGIFS$	Normalized gross indoor fin surface
$P1$	Off-mode power in Shoulder Season, per compressor, W
$P1_x$	Off-mode power in Shoulder Season, total, W
$P2$	Off-mode power in Heating Season, per compressor, W
$P2_x$	Off-mode power in Heating Season, total, W
P_x	Low voltage power, W
PLF^x	Part Load Factor for condition *x*, where *x* is blank, "Full" or "Low"
$PLF(0.5)$	Part Load Factor for SEER2
$PLF^x(t_j)$	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_C	Compressor power at the lowest machine unloading point operating at the desired part load rating condition, W
$P_{C,x}$	Compressor power during test *x*, W
$P_{CC}(t_j)$	Power for Heat Comfort Controller at bin temperature t_j, W
P_{CT}	Control circuit power and any auxiliary loads, W
$P_{def,x}$	Power used during defrost test *x*, W
$P_{fan,1}$	Measured power input of the indoor fan at ESP 1, W
$P_{fan,2}$	Measured power input of the indoor fan at ESP 2, W
$P_{fan,x}$	Fan power during test *x*, W
P_{IF}	Indoor fan motor power at the fan speed for the minimum step of capacity, W
$P_{m,x}$	System power measured during test *x*, W
$P_{tot,x}$	Total power for test *x*, W
$P_{W,Off}$	Off-mode power, W
P_x	When used with off-mode testing P_x is low voltage power, otherwise, power for test x
$P_x(y)$	Power at condition *x, W,* at temperature *y*, where *x* is blank, "Full," "Int" or "Low" and *y* is any Temperature Bin
$Ps_{adj,x}$	Power adjustment for steady state test *x*, W
q_x	Capacity, Btu
$\dot{q}_{A,Full}$	Rated full load Net Capacity, Btu/h

$\dot{q}_{CC}(t_j)$	Total bin capacity for Heat Comfort Controller, Btu/h
$\dot{q}_x$	Indoor capacity for test x before any duct or blower adjustments, Btu/h
$\dot{q}_{i,x}$	Part load Net Capacity, Btu/h
$q_x(t_j)$	Total bin capacity for speed x, Btu, where x is blank, "Full" or "Low"
$\dot{q}_x(t_j)$	Total bin capacity for condition x, Btu/h, where x is blank, "Full" or "Low"
$q_{def,x}$	Heating capacity during defrost test x, Btu
$\dot{q}_{def,x}$	Heating capacity during defrost test x, Btu/h
$\dot{q}_{duct,ci}$	Indoor duct loss rate in cooling, Btu/h
$\dot{q}_{duct,hi}$	Indoor duct loss rate in heating, Btu/h
$\dot{q}_{furnace}$	Nominal furnace input rating, Btu/h
$\dot{q}_{ref,x}$	Ttal capacity as measured by the refrigerant enthalpy method, Btu/h
$\dot{q}s_{adj,x}$	Capacity adjustment for indoor motor heat during Steady State Test x, Btu/h
$\dot{q}_{Low}$	Low Stage capacity, Btu/h
$\dot{q}_{tci,x}$	Total cooling capacity for test x, indoor side data, Btu/h
$\dot{q}_{tco,x}$	Total cooling capacity for test x, outdoor side data, Btu/h
$\dot{q}_{thi,x}$	Total Heating Capacity for test x – indoor side, Btu/h
$\dot{q}_{tho,x}$	Total Heating Capacity for test x– outdoor side, Btu/h
$q'_{cyc,x}$	Cooling or Heating Cyclic Net Total Capacity for Test x, Btu
$\dot{q}_{adj}$	Capacity adjustment, Btu/h
$qc_{adj,x}$	Capacity adjustment for indoor motor heat during Cyclic or defrost Test x, Btu
$\dot{Q}_C(95)$:	Total cooling capacity of the A or A_2 test conditions, Btu/h
$\dot{Q}_{A,Full}$	Cooling full airflow, scfm
$\dot{Q}_{Full}$	Cooling full airflow as measured after setting and/or the adjustment as described in Section 6.1.5.2, scfm
$\dot{Q}$	Net Capacity at the lowest machine unloading point operating at the desired part load rating condition, Btu/h
$\dot{Q}_{H1,Full}$:	Heating full airflow, cfm
$\dot{Q}_i$	Airflow for test I, scfm
$\dot{Q}_{i,x}$	Airflow for test I, scfm
$\dot{Q}_{max}$	Maximum measured airflow value, cfm
$\dot{Q}_{mi}$	Average airflow, indoor, measured, cfm
$\dot{Q}_{mo}$	Airflow, outdoor, measured, cfm
$\dot{Q}_{mx}$	Airflow of air mixture, cfm
$\dot{Q}_{min}$	Minimum measured airflow value, cfm
$\dot{Q}_s$	Standard airflow, indoor, scfm
Q_{var}	Airflow variance, percent
$RAT(t)$	Return Air Temperature, the current indoor dry-bulb temperature setpoint for the indoor room reconditioning system, °F
$RAT(t + \Delta t)$	The updated target indoor dry-bulb temperature setpoint for the indoor room reconditioning system, °F
$RH(t_j)$	Supplementary resistance heat at temperature (t_j), W·h
RTD	Resistance Temperature Detector
s	Standard deviation
$scfm_{FL}$	Standard Supply Airflow at full load rating conditions, scfm
$scfm_{PL}$	Standard Supply Airflow at part load rating conditions, scfm
$SEER2$	Seasonal energy efficiency ratio, Btu/W·h
SF	Sizing factor, by convention
t_{90}	t statistic for a 90% one-tailed confidence interval with sample size n
t_{a0}	Temperature, outdoor ambient, dry-bulb, °F
t_{a1}	Temperature, air entering indoor side, dry-bulb, °F
$t_{a1}(\theta)$	Dry-bulb temperature of air entering the indoor coil at elapsed time τ, °F; only recorded when indoor airflow is occurring
t_{a12}	Temperature, air entering outdoor side, dry-bulb, °F
t_{a2}	Temperature, air leaving indoor side, dry-bulb, °F
$t_{a2}(\theta)$	Dry-bulb temperature of air leaving the indoor coil at elapsed time τ, °F; only recorded when indoor Airflow is occurring

t_{a3}	Temperature, air entering outdoor side, dry-bulb, °F
t_{a4}	Temperature, air leaving outdoor side, dry-bulb, °F
t_j	Bin reference temperature, °F
t_{OB}	The temperature at which frosting influence on low stage performance begins, 40°F; applicable to the HSPF2 calculations for Two-stage Systems.
t_{OBO}	The temperature at which frosting influence on full stage performance begins, 45°F; applicable to the HSPF2 calculations for Single-stage and Variable capacity Systems.
t_{OD}	Outdoor design temperature, °F
t_{OFF}	The outdoor temperature at which the compressor is automatically stopped. If the compressor is not automatically controlled, t_j is considered greater than what might be t_{OFF} and t_{ON}, °F
t_{ON}	The outdoor temperature at which the compressor is automatically turned ON (if applicable) if designed for low-temperature automatic shutoff, °F
T_{ID}	Indoor design dry bulb temperature specified as the test unit thermostat setting for controls verification procedure, 80°F for cooling tests and 70°F for heating tests
T_{max}	Maximum time between defrosts allowed by controls in minutes, or 720, which ever is smaller, minutes
T_{test}	Time between defrost terminations in minutes, or ninety, whichever is greater, minutes
T_{cc}	Maximum supply temperature allowed by the comfort controller, °F
$T_{o,x}(t_j)$	Nominal temperature of air leaving the heat pump coil for condition *x*, °F
t_{vc}	Temperature at which $\dot{q}_{Int}(t) = BL(t)$:, °F
t_{vh}	Temperature at which building load is equal to the capacity when the unit is defrosting, °F
$UA_{ID,ro}$	Product of the overall heat transfer coefficient and surface area for the indoor coil return duct that is located in the outdoor test room, Btu/h·°F
$UA_{ID,si}$	Product of the overall heat transfer coefficient and surface area for the indoor coil supply duct that is located in the indoor test room, Btu/h·°F
$UA_{ID,so}$	Product of the overall heat transfer coefficient and surface area for the indoor coil supply duct that is located in the outdoor test room, Btu/h·°F
UCL	Upper 90% confidence limit
v_n	Specific volume of air at dry- and wet-bulb temperature conditions existing at nozzle but at standard barometric pressure, ft^3/lb of dry air
v'_n	Specific volume of air at the nozzle, ft^3/lbm of air-water vapor mixture
V_i	Internal volume of pressure measurement system (pressure lines, fittings, gauges and/or transducers) at location *I*, in^3
W_1	Water vapor content ratio, air entering indoor side, kg water vapor per kg of dry air, lbm_{wv}/lbm_{da}
W_2	Water vapor content ratio, air leaving indoor side, kg water vapor per kg of dry air, lbm_{wv}/lbm_{da}
W_4	Water vapor content ratio, air entering outdoor side, kg water vapor per kg of dry air, lbm_{wv}/lbm_{da}
W_f	Indoor coil fin width in inches, also depth of the coil.
W_n	Water vapor content ratio at the nozzle, lbm_{WV}/lbm_{da}
x	Mass ratio, refrigerant to refrigerant/oil mixture
$\bar{x}$	Test sample mean
x_i	Test result value for test sample i

12.2 *Greek Symbols.*

Γ	The integrated (with respect to elapsed time) air temperature difference across the indoor coil, °F·h
Γ_{ON}	The integrated air temperature difference across the indoor coil during the defrost cycle, °F·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
θ_3	Time at the initial defrost termination, h
θ_4	Time at the successive defrost termination, h
$\delta^x(t_j)$	Heat pump low-temperature cutout factor, where *x* is "Boost", "Full," "Int-Bin" or "Low"
ρ_{da}	Density of dry air, lb_m/ft^3
$\Delta\theta_{FR}$	Elapsed time from defrost termination to defrost termination, hr
ΔP_{st_i}	Target minimum ESP for test *I*, in H_2O

$\Delta P_{st_{A,Full}}$	Minimum ESP target from A_{Full} test (Table 10), in H_2O
$\Delta P_{st_{Full}}$	Minimum ESP target for test A or A_{Full} (Table 10), in H_2O
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 91his91os 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
CE	Cooling mode, energy
Cq	*C*ooling mode, capacity
cyc	Cyclic
def	Defrost
duct-ci	Indoor duct loss during cooling
duct-hi	Indoor duct loss during heating
Full	Operation/compressor speed at full load test
HE	Heating mode, energy
Hq	Heating mode, capacity
hp	Performance provided by heat pump
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
max	Maximum
mi	Measured indoor
min	Minimum
mo	Measured outdoor
ref	Refrigerant
r1	Refrigerant vapor side of Indoor Unit
r2	Refrigerant liquid side of Indoor Unit
s	Standard
tci	Total cooling indoor
tco	Total cooling outdoor
test	Test
thi	Total heating indoor
tho	Total heating outdoor
tot	Total
Var	Variance
x	Variable for an individual test, measurement, or compressor set point. For example, *x* can be A_{Full}, B_{Low}, $H0_{Low}$, etc.

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, USA.

A1.2 AHRI Standard 1230-2021, *Performance Rating of Variable Refrigerant Flow (VRF) Multi-Split Air-Conditioning and Heat Pump Equipment*, 2021, Air-Conditioning, Heating, and Refrigeration Institute, 2311 Wilson Boulevard, Suite 400, Arlington, VA 22201, USA.

A1.3 ANSI/AHRI/CSA Standard 310/380-2017, *Standard for Packaged Terminal Air-Conditioners and Heat Pumps (CSA.C744-14)*, 2017, Air-Conditioning, Heating, and Refrigeration Institute, 2311 Wilson Boulevard, Suite 400, Arlington, VA 22201, USA.

A1.4 AHRI Standard 340/360-2022, *Performance Rating of Commercial and Industrial Unitary Air-Conditioning and Heat Pump Equipment*, 2022, Air-Conditioning, Heating, and Refrigeration Institute, 2311 Wilson Boulevard, Suite 400, Arlington, VA 22201, USA.

A1.6 ANSI/AHRI Standard 390-2021, *Performance Rating of Single Package Vertical Air-Conditioners and Heat Pumps*, 2021, Air-Conditioning, Heating, and Refrigeration Institute, 2311 Wilson Boulevard, Suite 400, Arlington, VA 22201, USA.

A1.7 ANSI/ASHRAE Standard 116-2010 (RA2015), *Methods of Testing for Rating Seasonal Efficiency of Unitary Air Conditioners and Heat Pumps*, 2015, ASHRAE, 80 Technology Parkway NW, Peachtree Corners, GA 30092, USA.

A1.8 ANSI/ASHRAE Standard 37-2009 (RA2019), *Methods of Testing for Rating Electrically Driven Unitary Air-Conditioning and Heat Pump Equipment*, 2019, ASHRAE, 80 Technology Parkway NW, Peachtree Corners, GA 30092, USA.

A1.9 ANSI/ASHRAE Standard 41.1-2020, *Standard Method for Temperature Measurement*, 2020, ASHRAE, 80 Technology Parkway NW, Peachtree Corners, GA 30092, USA.

A1.10 ANSI/ASHRAE Standard 41.2-2022, *Standard Methods for Laboratory Airflow Measurement*, 2022, ASHRAE, 80 Technology Parkway NW, Peachtree Corners, GA 30092, USA.

A1.11 ANSI/ASHRAE Standard 41.4-2015, *Standard Method for Measuring the Proportion of Lubricant in Liquid Refrigerant*, 2013, ASHRAE, 80 Technology Parkway NW, Peachtree Corners, GA 30092, USA.

A1.12 ANSI/ASHRAE Standard 41.6-2021, Standard Method for Humidity Measurement, 2021, ASHRAE, 80 Technology Parkway NW, Peachtree Corners, GA 30092, USA.

A1.13 ANSI/ASHRAE Standard 41.9-2021, *Standard Methods for Volatile-Refrigerant Mass Flow Measurements Using Calorimeters*, 2021, ASHRAE, 80 Technology Parkway NW, Peachtree Corners, GA 30092, USA.

A1.14 ASHRAE Handbook Fundamentals – 2021, *Fundamentals*, 2021, ASHRAE, 80 Technology Parkway NW, Peachtree Corners, GA 30092, USA.

A1.15 ASHRAE Terminology, ASHRAE, Accessed October 24, 2023. https://www.ashrae.org/resources--publications/free-resources/ashrae-terminology.

A1.16 ASTM Standard B117-2019, *Standard Practice for Operating Salt Spray (Fog) Apparatus*, 2019, American Society for Testing and Materials, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA, 19428-2959, USA.

A1.17 ASTM Standard G85-2019, *Standard Practice for Modified Salt Spray (Fog) Testing*, 2019, American Society for Testing and Materials, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA, 19428-2959, USA.

A1.18 IEC Standard 60038, *IEC Standard Voltages*, 2009, International Electrotechnical Commission, 3, rue de Varembe, P.O. Box 131, 1211 Geneva 20, Switzerland.

A1.19 ISO/ANSI/ AHRI/ASHRAE 13256-1, *Water-source heat pumps – Testing and rating for performance – Part 1: Water-to-air and Brine-to-air heat pumps,* 2012, International Organization for Standardization, Case Postale 56, CH-1211, Geneva 21 Switzerland.

A1.20 ISO/ANSI/ AHRI/ASHRAE 13256-2, *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.

A1.21 ISO/IEC 17025-2017, *Testing and calibration laboratories,* 2017, International Organization for Standardization, Case Postale 56, CH-1211, Geneva 21 Switzerland.

A1.22 NIST Standard Reference Database 23, *Reference Fluid Thermodynamic and Transport Properties – REFPROP Version 9.1*, 2013, National Institute of Standards and Technology, 100 Bureau Drive, Gaithersburg, MD 20899.

A1.23 Title 10, *Code of Federal Regulations (CFR),* Part 429 and 430, last modified October 19, 2023, www.ecfr.gov.

A1.24 UL Standard 555, *Standard for Fire Dampers,* 2006, Underwriters Laboratories, Inc., 333 Pfingsten Road, Northbrook, IL, USA.

A1.25 UL Standard 555S, *Standard for Smoke Dampers,* 2014, Underwriters Laboratories, Inc., 333 Pfingsten Road, Northbrook, IL, USA.

APPENDIX B. REFERENCES – INFORMATIVE

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

None.

APPENDIX C. SECONDARY CAPACITY CHECK REQUIREMENTS – NORMATIVE

C1 *Purpose.* The purpose of this appendix is to state 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.

C3 *Definitions.*

C3.1 *Code Tester.* A nozzle airflow measuring apparatus as defined by ASHRAE 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, Btu/h
C4.2 q_{tir} = Total capacity, indoor, refrigerant, Btu/h
C4.3 q_{toa} = Total capacity, outdoor, air, Btu/h
C4.4 For Coil-only Systems, total capacity as defined in C4.1, C4.2 and C4.3 shall be Gross Capacity.
C4.5 For applications having a blower motor, total capacity as defined in C4.1, C4.2 and C4.3 shall be defined as Net Capacity.
C4.6 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 ASHRAE 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, except for H3 or any inverter at other than full speed which is exempt from this requirement if:

C5.1.2.1 The absolute values of HB for Tests B_{Full} and $H1_{Full}$ are 3.0% or less, and
C5.1.2.2 The subcooling leaving the Indoor Unit is less than 3.0°F.

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, except for H3 which is exempt from this requirement if the absolute values of HB for all other tests are 6.0% or less.

C5.3 The first Steady State Test in each mode (cooling and/or heating) 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 ASHRAE 37 Section 7.5.3 and ASHRAE 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 5°F superheat, as long as appropriate adjustments are made per Section C6.4.3.1.

C6.1.2 Taken within 12 in 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 ten tube diameters upstream or downstream of any bends that are greater than 30 degrees nor within ten 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 ASHRAE 41.1.

C6.2.2 The preferred method of refrigerant temperature measurements is resistance temperature devices (RTDs) per ASHRAE 41.1 Section 7.4. If used, RTDs shall be installed with tubing arrangement such that pressure drops due to application do not exceed 0.5 psi.

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 0.75°F 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 3 in of each other, with one TC at the ten o'clock position and one TC at the two 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 ASHRAE 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 ASHRAE 41.1 Section 5.5.2 with insulation having an R-value of at least 3.1 that extends along the tube for at least 6 in 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 ASHRAE 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 ASHRAE 37 Section 7.5.2.3, referencing ASHRAE 41.4.

C6.3.3 Mass flow rates shall be measured by equipment meeting ASHRAE 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, ft^3, times the liquid density of the refrigerant, lbm/ft^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 ASHRAE 37 Section 7.5.4 for cooling mode and Section 7.5.5 for heating mode.

C6.4.3.1 If vapor refrigerant at the indoor coil pressure tap is not superheated by at least 5°F, or the liquid refrigerant at the indoor coil pressure tap is not sub-cooled by at least 3°F, then refrigerant properties at the Outdoor Unit may be substituted, as long as refrigerant side capacity is adjusted by line loss calculations per ASHRAE 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 one foot. The adjustment is optional for elevation differences less than one foot.

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 ASHRAE 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 ASHRAE 41.2.

C7.2 *Temperature Measurement Requirements*.

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

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

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

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 ASHRAE 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.

Determine the average barometric pressure during each test. Use an instrument that meets the requirements specified in section 5.2 of ASHRAE 37.

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 ASHRAE 37, Section 6.2.

C7.4.2 Any code tester used shall have completed Section 5.1 of the LEAP.

C7.4.2.1 Any correction factors used from the LEAP evaluation process shall be recorded on the final test report.

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 6 in 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 6 in minimum is not required.
C7.5.1.2 For units that have air outlets next to the ground, the 6 in 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 two feet 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 6 in 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 as either cooling mode or heating mode, with additional modes in either cooling mode or heating mode in which the outdoor airflow rate changes. The most common operational modes are:

C7.6.1.1 For Single Stage Systems with single speed outdoor fan:

C7.6.1.1.1 Cooling mode
C7.6.1.1.2 Heating mode

C7.6.1.2 For Two Stage product with two speed outdoor fan:

C7.6.1.2.1 Cooling mode Full Stage
C7.6.1.2.2 Cooling mode Low Stage
C7.6.1.2.3 Heating mode Full Stage
C7.6.1.2.4 Heating mode Low Stage

C7.6.1.3 For variable capacity product, each individual test per Table 7 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 SectionC7.6.1, 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 Section 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 ASHRAE 37 Section 7.3.3.3 for cooling mode and ASHRAE 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. All steady state requirements per Section 5 and Section 6 shall be met. During this CD test the following requirements shall be met:

C7.6.4.1 The average inlet indoor DB temperature shall be within 0.25°F of the FA test.

C7.6.4.2 The average inlet indoor WB temperature shall be within 0.15°F of the FA test, except for split-system heating mode tests.

C7.6.4.3 The average inlet outdoor DB temperature shall be within 0.25°F of the FA test.

C7.6.4.4 The average inlet outdoor WB temperature shall be within 0.15°F of the FA test., except for split-system cooling mode tests.

C7.6.4.5 Any one or more of the following

C7.6.4.5.1 Fan motor current shall be within 3.0% of the value measured in Section C7.6.2.1.

C7.6.4.5.2 Fan motor speed shall be within 5 rpm of the value measured in D7.6.2.1.

C7.6.4.5.3 Fan motor power shall be within 3.0% of the value measured in C7.6.2.1.

C7.6.4.8 Any one or more of the following

C7.6.4.8.1 Refrigerant high side pressures of the CD test measured per Section C7.6.1.3 shall be within 0.5°F saturation temperatures of the FA test for all refrigerants.

C7.6.4.8.2 Refrigerant low side pressures of the CD test measured per Section C7.6.1.3 shall be within 0.3°F saturation temperatures of the FA test for all refrigerants.

C7.6.4. 8.3 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 0.1 psig).

C7.6.4. 8.4 Refrigerant tube temperatures measured per Section C7.6.2.3 shall be within 0.5°F of the FA test.

C7.6.4.92 Measured q_{tia} shall be within 2.0% of the FA test.

C7.6.4.10 Absolute value of HB shall be 6.0% or less.

C7.6.4.11 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 0.01 in H_2O. 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. ASHRAE 37 CLARIFICATIONS/EXCEPTIONS – NORMATIVE

The following sections are clarifications and exceptions to ASHRAE 37.

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

Add the following section: "*Water vapor content measurement.* As identified in ASHRAE 41.1, the temperature sensor (wick removed) shall be accurate to within 0.2°F. If used, apply dew point hygrometers as identified in Sections 5 and 8 of ASHRAE 41.6. The dew point hygrometers shall be accurate to within 0.4°F when operated at conditions that result in the evaluation of dew points above 35°F, or if used, a relative humidity (RH) meter shall be accurate to within 0.7% RH (both at the (80/67°F test conditions). 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 ASHRAE 37: "When testing air conditioners and heat pumps having a Variable capacity Compressor, an induction watt/watt hour meter shall not be used."

D3 Section 6.1.2 of ASHRAE 37 shall be modified by replacing the last sentence with the following, "Maintain the dry-bulb temperature within the test room within 5.0°F of the required dry-bulb temperature test condition for the air entering the Indoor Unit. Dew point shall be within 2°F of the required inlet conditions."

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

D4.1 Add the following section: "*Airflow Measuring Apparatus.* Refer Figure 14 of ASHRAE 41.2 (RA 92) for guidance on placing the static pressure taps and positioning the diffusion baffle (settling means) relative to the chamber inlet." When measuring the static pressure difference across nozzles and/or velocity pressure at nozzle throats using electronic pressure transducers and a data acquisition system, if high frequency fluctuations cause measurement variations to exceed the test tolerance limits identified in Table 2b, dampen the measurement system such that the time constant associated with response to a step change in measurement (time for the response to change 63% of the way from the initial output to the final output) is no longer than five seconds.

D4.2 Make the following modification in Table 2b: Replace Test Operating Tolerance on "Nozzle pressure drop (% of reading)" with "Standard Cubic Feet per Minute (SCFM)", with a value of 3% for both cooling and non-frosting tests.

D5 Section 6.4.2.2 of ASHRAE 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, 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." Except for ceiling cassettes, never use an inlet plenum when testing a non-ducted unit. If an inlet plenum is used for ceiling cassettes, the inlet plenum shall have a cross-sectional area at least 2 times the area of the ceiling cassette(s) combined inlet. Air velocities calculated as measured volume flow divided by duct or plenum cross-sectional area shall not exceed 250 ft/min inside the plenum.

D5.2 Attach a plenum to the outlet of the indoor coil.

Note: For some packaged systems, the indoor coil may be located in the outdoor test room.

For Multi-split systems or MIB systems, attach a plenum to each indoor coil or indoor blower outlet. In order to reduce the number of required airflow measurement apparatuses, each such apparatus may serve multiple outlet plenums connected to a single common duct leading to the apparatus. More than one indoor test room may be used, which may use one or more common ducts leading to one or more airflow measurement apparatuses within each test room that contains multiple indoor coils. At the plane where each plenum enters a common duct, install an adjustable airflow damper and use it to equalize the static pressure in each plenum. The outlet air temperature grid(s) and airflow measuring apparatus shall be located downstream of the inlet(s) to the common duct(s). For multiple-circuit (or multi-circuit) systems for which each indoor coil outlet is measured separately and its outlet plenum is not connected to a common duct connecting multiple outlet plenums, install the outlet air temperature grid and airflow measuring apparatus at each outlet plenum.

D6 Section 6.4.3 of ASHRAE 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 Airflow 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 Airflow, scfm	Maximum Diameter[1] of Outlet Plenum, in
≤ 500	6
501 to 700	7
701 to 900	8
901 to 1100	9
1101 to 1400	10
1401 to 1750	11

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.

DX Add the following (Section DX.1 of this Standard) to make a new Section 6.4.5 of ASHRAE 37 entitled: "*Inlet Duct for Ducted Indoor Units for Space-Constrained Test Rooms.*"

DX.1 For ducted indoor units for which space within the test room does not permit the full inlet duct connection per sections 6.4.1, 6.4.2, 6.4.3, or 6.4.4 of ASHRAE 37, an abbreviated inlet duct can be installed. The inlet duct shall have cross-sectional dimensions equal to those of the equipment and a minimum length of 15.2 cm (6.0 inches). Four static pressure taps shall be in the center of each face, with a tolerance for location parallel to air flow of ± 10% of duct length and tolerance for location perpendicular to air flow of ± 10% of corresponding duct face width perpendicular to air flow. This inlet duct shall be connected directly to the inlet of the unit.

DY Add the following (Section DY.1 of this Standard) to make a new Section 6.4.6 of ASHRAE 37 entitled: "*Outlet Duct for Ducted Indoor Units for Space-Constrained Test Rooms.*"

DY.1 For ducted indoor units for which space within the test room does not permit the full outlet plenum connection per sections 6.4.1, 6.4.2, 6.4.3, or 6.4.4 of ASHRAE 37-2009, an alternative outlet duct connection can be installed. A square elbow with turning vanes shall be attached to the outlet of the discharge side of the equipment (see Figure D.1). The orientation of the elbow shall be such that the discharge of the elbow is perpendicular to the blower shaft and the bend from inlet to outlet of the elbow follows the direction of rotation of the blower. The duct connected to the outlet of the elbow shall have cross-sectional dimensions equal to the dimensions of the indoor unit outlet. The length of the duct connected to the outlet of the elbow and distance between the elbow outlet plane and external static pressure measurement plane shall be as shown for a unit discharge duct in ASHRAE 37 Figures 7a, 7b, and 7c for an indoor unit with a fan downstream of the indoor coil, and as shown for a unit discharge duct in ASHRAE 37 Figure 8 for an indoor unit with a fan upstream of the indoor coil or without a fan. The outlet duct downstream of the elbow shall discharge into the mixer (if used) prior to the air sampling section upstream of the airflow measurement device.

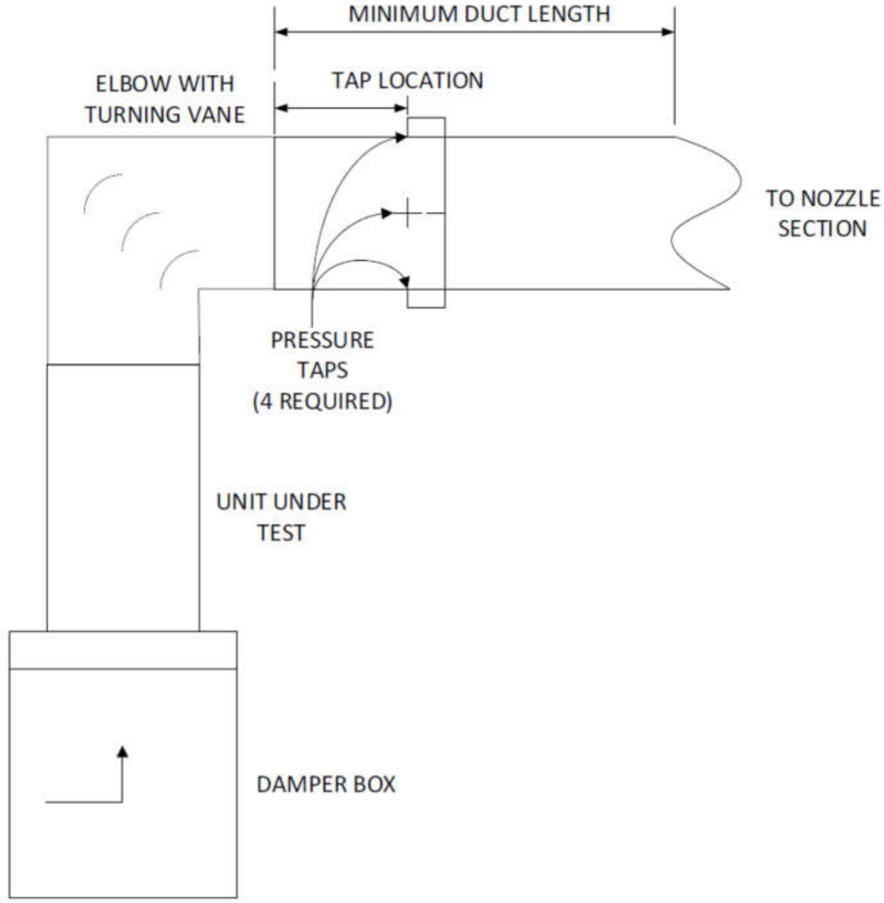

Figure D.1 Example Outlet Duct Elbow Arrangement

DZ Add the following (Section DZ.1 of this Standard) to make a new Section 6.4.7 of ASHRAE 37 entitled: "*Outlet Duct for Ducted Indoor Units with Fans and Multiple Outlets or Systems with Multiple Indoor Units.*"

DZ.1 Groups of indoor units tested with a single outdoor unit may be installed in separate indoor test rooms. All of the indoor units in each separate indoor test room shall discharge into a single common duct section, following the requirements of section 6.4.3 of ASHRAE 37

DXX Add the following (Sections DXX.1 to DXX.6 of this Standard) to make a new Section 6.4.8, with subsections, of ASHRAE 37 entitled: "*Outlet Plenum, Non-ducted Units.*"

DXX.1 For non-ducted units, a plenum (enlarged duct box) shall be installed at the air outlet of the indoor unit(s). The plenum must have a cross-sectional area at least 2 times the area of the indoor unit(s) combined outlet area or such that air velocity calculated as measured volume flow divided by plenum cross-sectional area shall not exceed 1.27 m/s (250 ft/min) inside the plenum, whichever is larger. For all outlets, the plenum must extend for a distance of at least 3.5 times the square root of the cross-sectional area of the indoor unit(s) combined outlet area prior to any duct transitions, elbows, or Air Sampling Trees used for air condition measurement. See Figure D.2.

DXX.2 If used, exit elbows connected to the end of the plenum shall have a centerline radius equal to at least 1.5 times the elbow duct width in the radial direction or have turning vanes. Air velocities calculated as measured volume flow divided by duct cross-sectional area shall not exceed 2.54 m/s (500 ft/min) in the connecting duct at its connection to the plenum.

DXX.3 Manifolded static pressure taps shall be installed in the plenum in at least four locations spaced uniformly around the plenum. The distance from the outlet(s) of the indoor unit(s) to the static pressure tap plane shall be at least 2.8 times the square root of the cross-sectional area of the area of the combined outlet area(s).

DXX.4 The plenum shall be constructed such that the discharge air leaving the indoor unit does not impinge on the plenum wall, taking into consideration the discharge air throw angle.

DXX.5 Air Sampling Trees used for temperature measurement shall be placed at or downstream of the plenum exit, or in the common duct for multiple indoor unit(s).

DXX.6 External static pressure measurement shall be as defined in section 6.5 of ASHRAE 37.

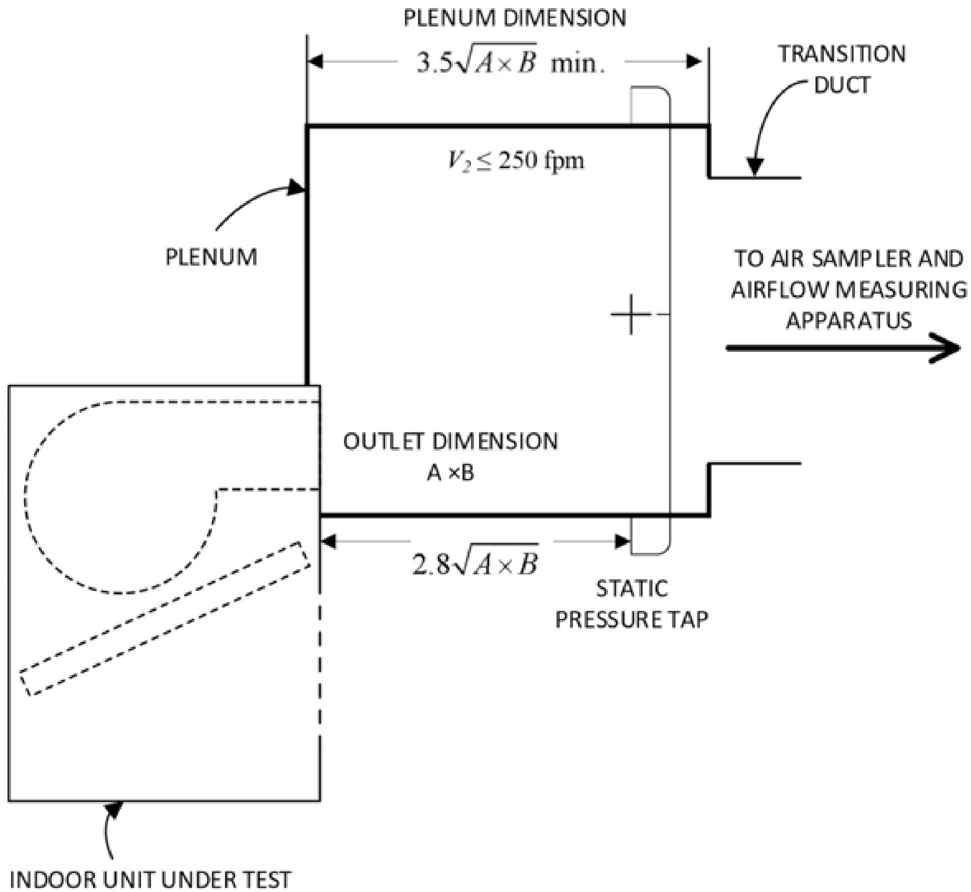

Figure D.2 Example Outlet Plenum Box Arrangement for a Ductless Indoor Unit

DYY Add the following (Sections DYY.1 to DYY.6 of this Standard) to make a new Section 6.7, with subsections, of ASHRAE 37 entitled: "*Damper Box or Airflow Prevention Device (Optional).*"

DYY.1 Use an inlet and outlet air damper box or Airflow Prevention Device when testing Ducted Systems if conducting Cyclic Tests or for conducting defrost tests for heat pumps (both ducted and non-ducted) that cycle off the indoor fan during Defrost Cycles if no other means exists for preventing natural or forced convection through the Indoor Unit when the indoor fan is off. The damper box shall be insulated to a nominal overall resistance (R-value) of at least $3.35 m^2 \cdot K/W$ ($19\ h \cdot ft^2 \cdot °F/Btu$).

DYY.2 If using a damper box, install it immediately upstream of the required inlet plenum. The cross-sectional dimensions of the damper box shall be equal to or greater than the dimensions of the indoor unit inlet. If needed, use an adaptor plate with a short transition duct section to connect the damper box with the unit's inlet plenum.

DYY.3 The dampers shall be capable of being completely opened or completely closed within a period not to exceed 10 seconds for each action. Dampers shall achieve a positive seal within 10 seconds. Airflow through the equipment being tested shall stop within 10 seconds after the airflow measuring device fan is de-energized. The differential pressure (ΔP) at the nozzle shall be within 2% of steady state ΔP within 15 seconds from the time the air-measuring device fan is re-energized.

DYY.4 If using an 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. 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 1% of the lowest measured airflow or 566 l/min (20 cfm) whichever is greater when a negative pressure of 0.248 kPa (1.0 in. of water) is maintained at the outlet of the outlet air damper.

DYY.5 As an alternate to an actuated inlet damper, a cold trap, consisting of an upturned duct can be used. An inlet upturned duct is a length of ductwork installed upstream of the indoor unit under test to prevent natural convection transfer out of the duct during the compressor OFF period. If an inlet upturned duct is used, install minimum 4 temperature sensors at the inlet opening of the indoor upturned duct evenly spaced across the inlet area. The average temperature at this location, measured during the compressor OFF period of the cyclic test, shall not drop more than 0.56°C (1°F) below the ON period average temperature at this location.

D7 Section 6.5 of ASHRAE 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 Do the following to test the set-up on the outlet side of the indoor coil:

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 make 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 19 $hr \cdot ft^2 \cdot °F/Btu$.

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:

    - Downstream of the air sampling device;
    - Upstream of the outlet air damper box, if installed;
    - Upstream of the airflow measuring apparatus.

D7.2.2 *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 0.5 in of water higher than the surrounding test room ambient. Instead of installing a separate damper, use the outlet air damper box if it has 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 0.5 in of water column."

D8 **S**ection 6.6.1 of ASHRAE 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 19 $hr \cdot ft^2 \cdot °F/Btu$."

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 210/240 shows the options allowed for the manifold configuration. See Figures 7a, 7b, 7c, and 8 (of ASHRAE 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."

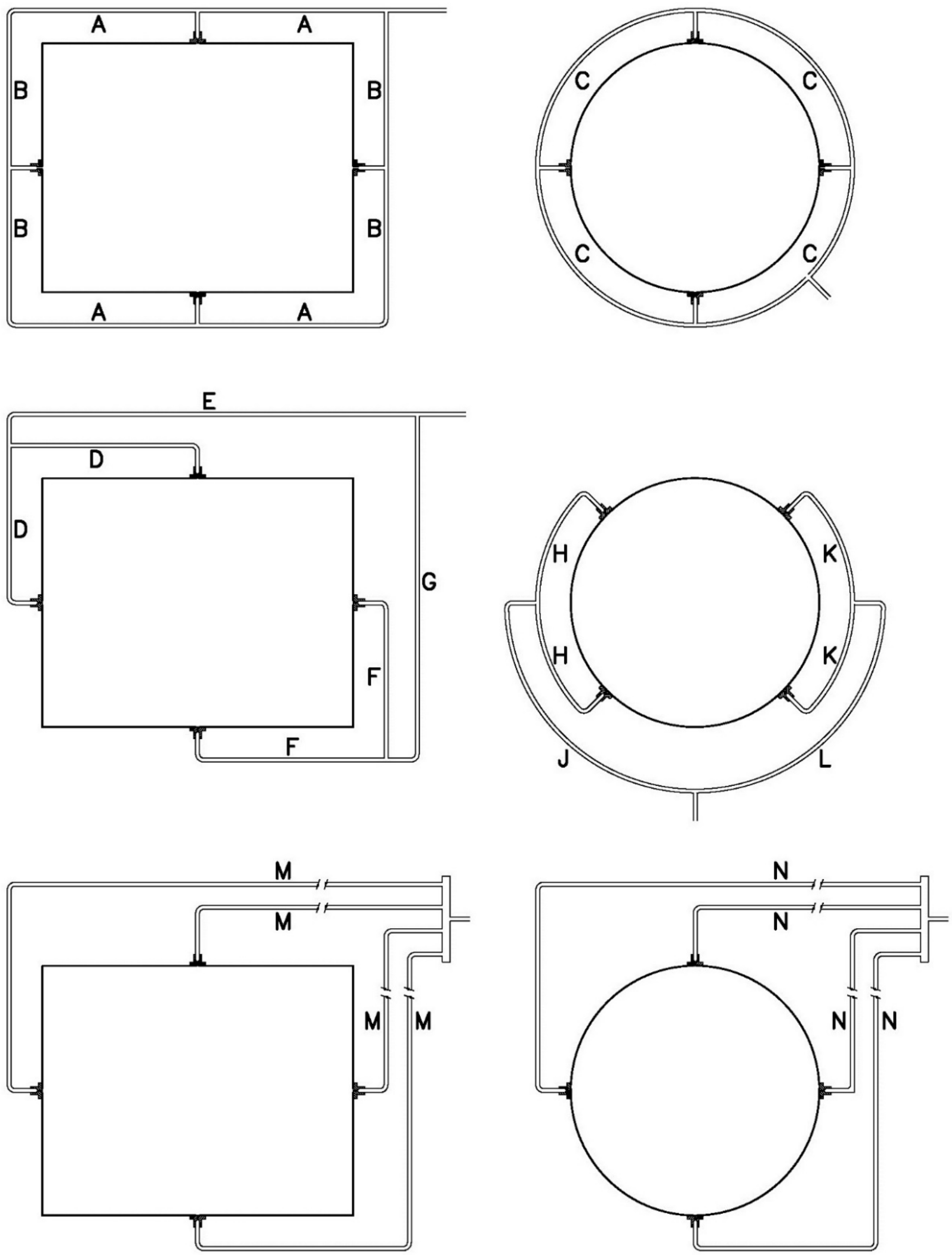

Figure D1. Configurations for Manifolding the Static Pressure Taps

D9 Append the following sentence to the end of Section 7.5.2.1 of ASHRAE 37: "Refrigerant flow measurement device(s) shall be either elevated at least two feet from the test chamber floor or placed upon insulating material having a total thermal resistance (R-value) of at least 12 hr·ft^2· °F/Btu. And extending at least one foot laterally beyond each side of the device(s)' exposed surfaces."

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

D10.1 *Test Operating Procedures for Variable capacity Products.*

D.10.1.1 S*pecial 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 parameters for indoor coil operation during the part load test shall be Specified by the manufacturer. For variable-speed systems, the manufacturer must designate in the certification report at least one indoor unit that is not providing heating or cooling 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 ASHRAE 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 ASHRAE 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, including during defrost cycles."

D11.2.2 Add the following sentence: "For Uncased Coils enclosure, create an enclosure adequate for structural requirements, such as sheet metal, ductboard, etc., having an insulated thermal resistance ("R" value) between 4 and 6 h·ft^2·°F/Btu. Size the enclosure and seal between the coil and/or drainage pan and the interior of the enclosure as Specified in installation instructions shipped with the unit. Also seal between the plenum and inlet and outlet ducts. For Cased Coils, no extra insulating or sealing is allowed."

D11.4 Section 8.2.4 of ASHRAE 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 4 to 6 hr·ft^2·°F/Btu."

D11.5 Replace Section 8.2.5 of ASHRAE 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 30 ounces per ton of Specifiedcooling 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."

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

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

Where

V_i = Internal volume of pressure measurement system (pressure lines, fittings, gauges and/or transducers) at location I, in^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.

P = the density associated with liquid refrigerant at 100 °F bubble point conditions (ounces per cubic inch)

Table D1. Pressure Measurement Location

Location	*i*
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 0.1 in^3 internal volume for each pressure transducer, and 0.2 in^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 D1 of AHRI 210/240) shall be no more than 1 in^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 ASHRAE 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 ASHRAE 37. "In the case of Non-ducted Systems having multiple indoor coils, locate a grid approximately 6 in 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 ASHRAE 37 entitled: "*Air Sampling Requirements.*"

D13.1 *Purpose.* The purpose of his 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 D4.4 for design requirements.

D13.2.2.2 *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 water vapor content. See Section D4.5 for design requirements.

D13.2.2.3 *Dew-point Hygrometer*. An instrument used to determine the water vapor content of air by detecting visible condensation of moisture on a cooled surface.

D13.3 *General Requirements.* Temperature measurements shall be made in accordance with ASHRAE 41.1. Where there are differences between this document and ASHRAE 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 2.0°F 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 210/240. 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 six holes per square foot of area to be sampled
D13.4.2 Sampler branch tube pitch (spacing) of 6 ± 3 in
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 2.5 ft/s as determined by evaluating the sum of the open area of the holes as compared to the flow area in the Aspirating Psychrometer.

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.

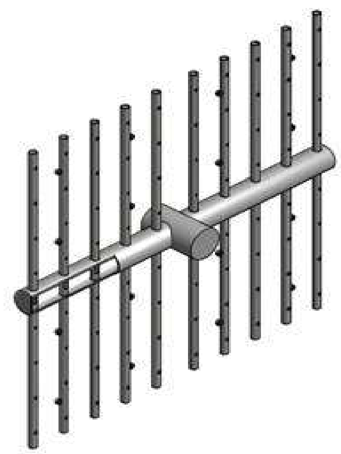

Figure D2. Typical Air Sampling Tree

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 ASHRAE 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 6-24 in 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 4 to 6 $h \cdot ft^2$ °F/Btu.

D13.5 *Psychrometer.* The Aspirating Psychrometer consists of a flow section and utilizes 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 water vapor content (RTD with wetted sock, chilled mirror hygrometer, or relative water vapor content sensor). In most typical applications, there are typically two sets of measurements for temperature and water vapor content, 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 of AHRI 210/240.

The psychrometer shall be made from suitable material which may be plastic (such as polycarbonate), aluminum or other metallic materials. Outside diameters are typically 4 in but may be as small as 2 in or as large as 6 in. 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 1000 ± 200 ft/min. For all other psychrometers, velocity shall be as stated by the sensor manufacturer.

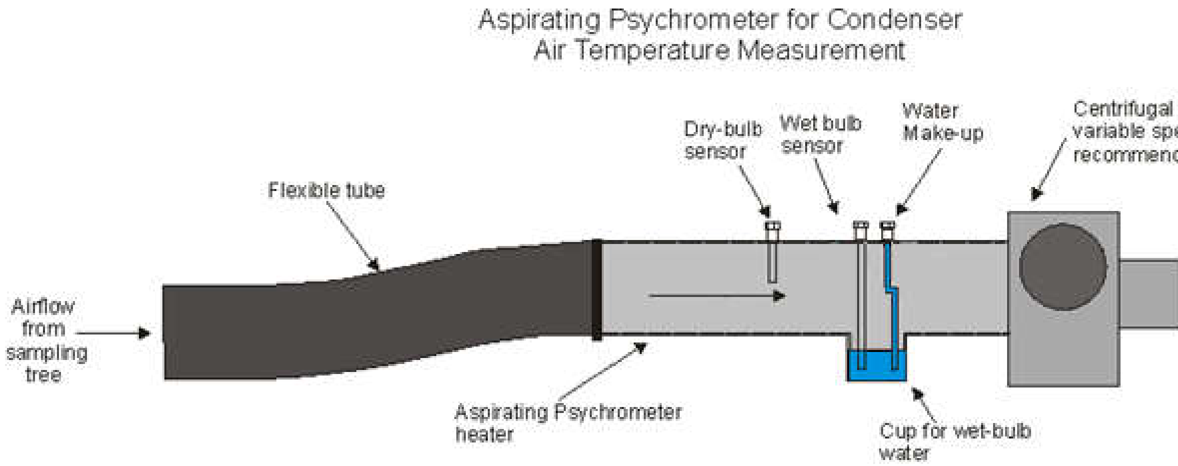

Figure D3. Aspirating Psychrometer

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 19 $h \cdot ft^2 \cdot F/Btu$ 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 ASHRAE 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 of this Standard].

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 6 to 24 in 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 square foot of inlet face area, whichever is less. This grid shall be constructed and used as per Section 5.3 of ASHRAE 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 2.0 ˚F."

The Air Sampler Trees shall be located at the geometric center of each side; either horizontal or vertical orientation of the branches is acceptable.

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.

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. Any fan used to enhance test room air mixing shall not cause air velocities in the vicinity of the test unit to exceed 500 feet per minute.

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). Holes can be blocked to reduce the region of coverage of the intake holes both in the direction of the trunk axis or perpendicular to the trunk axis. For intake hole region reduction in the direction of the trunk axis, block holes of one or more adjacent pairs of branches (the branches of a pair connect opposite each other at the same trunk location) at either the outlet end or the closed end of the trunk. For intake hole region reduction perpendicular to the trunk axis, block off the same number of holes on each branch on both sides of the trunk. Each outdoor coil side shall have one Air Sampler Tree.

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 19 h·ft2·F/Btu 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. No part of the air sampling device or the tubing conducting the sampled air to the sensors may be within two inches of the test chamber floor.

Take pairs of measurements (e.g. dry bulb temperature and wet bulb temperature) used to determine water vapor content of sampled air in the same location.

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.

D14.3 Monitoring and Adjustment for Air Sampling Device Conduit Temperature Change and Pressure Drop. If dry-bulb temperature is measured at a distance from the Air Sampling Tree exits, determine average conduit temperature change as the difference in temperature between the dry-bulb temperature and the average of thermopiles or thermocouple measurements of all Air Sampling Trees collecting air that is measured by the remote dry-bulb temperature sensor. If this difference is greater than 0.5°F, measure dry-bulb temperature at the exit of each Air Sampling Tree (as described in Section D13.4 of this appendix), and use these additional sensors to determine average entering air dry-bulb temperature.
Measure gauge pressure at the sensor location of any instrument measuring water vapor content. If the pressure differs from room pressure by more than 2 in H_2O, use this gauge pressure measurement to adjust the atmospheric pressure used to calculate the water vapor content ratio (in units of pounds of moisture per pound of dry air) at the measurement location.

If either the 0.5°F temperature difference threshold or the 2 in H_2O pressure difference threshold are exceeded, use a two-step process to calculate adjusted air properties (e.g., wet-bulb temperature or enthalpy) for the one or more affected Air Sampling Devices. First, calculate the moisture level (pounds water vapor per pound dry air) at the water vapor content measurement location(s) using either the Aspirating Psychrometer dry-bulb and wet-bulb temperature measurements or the Dew-point Hygrometer measurement, using for either approach the adjusted pressure, if it differs from the room atmospheric pressure by 2 in H_2O or more. Then calculate the air properties for the Air Sampling Tree location based on the moisture level, the room atmospheric pressure, and the dry-bulb temperature at the Air Sampling Tree location. If the Air Sampling Device fan serves more than one Air Sampling Tree, and the 0.5°F threshold was exceeded, the dry-bulb temperature used in this calculation shall be the average of the Air Sampling Tree exit measurements. Also, for multiple Air Sampling Trees, if water vapor content was measured using multiple Dew-point

Hygrometers, the moisture level used in this calculation shall be the average of the calculated moisture levels calculated in the first step.

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

D15.1 Section 8.7 of ASHRAE 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 ASHRAE 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 thirty minutes before test data are reported." Use the exhaust fan of the airflow measuring apparatus and, if installed, the indoor blower of the test unit to obtain and then maintain the indoor airflow and/or external static pressure specified for the particular test.

D16 Section 8.8 of ASHRAE 37 shall have the following changes:

D16.1 Section 8.8.1 of ASHRAE 37 shall have the following corrections and clarifications made for demand defrost systems. Add the following section: "*Defrost Control Settings.* Heat pump defrost controls shall be left at the factory settings unless otherwise Specified by the Installation Instructions. For demand defrost systems, if Specified by the manufacturer, a control board reset shall be allowed just prior to the defrost test."

D16.2 Sections 8.8.2.3 and 8.8.3.4 of ASHRAE 37 shall be modified by replacing "one hour" with "thirty-minutes." This requirement is waived when the heating test is at a frosting condition.

D17 Section 10.1 of ASHRAE 37 shall have the following changes:

D17.1 Insert Section 10.1.2.1 to ASHRAE 37: 10.1.2.1 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 ASHRAE 37 (except, if testing a Coil-only System, do not make the after-test fan heat adjustments).

D18 Tables 2a and 2b of ASHRAE 37 shall have the following data added:

D18.1 2.0% Electrical voltage Test Operating Tolerance.
D18.2 1.5% Electrical voltage Test Condition Tolerance.

APPENDIX E. ASHRAE 116-CLARIFICATIONS/EXCEPTIONS – NORMATIVE

E1 *Definitions.*

E1.1 Add the following definitions to ASHRAE 116:

E1.1.1 *Damper Box*. A short section of insulated duct having a means to block airflow during the off cycle of the Cyclic Test.

E1.1.2 *Defrost Cycle.* The period from Defrost Initiation to Defrost Termination.

E1.1.3 *Defrost Initiation.* The moment the controls of the heat pump first alter its normal heating operation in order to eliminate possible accumulations of frost on the Outdoor Coil.

E1.1.4 *Defrost Termination.* The moment the controls of the heat pump actuate the first change in converting from defrost operation to normal heating operation.

E1.1.5 *Dry-Coil Test.* Cooling mode test where the wet-bulb temperature of the air supplied to the indoor coil is maintained low enough that no condensate forms on the evaporator coil.

E2 Section 5.1.4 of ASHRAE 116 shall be modified as follows: "It is required that the same instrumentation be used for making both steady-state and non-steady (cyclic) test measurements".

E3 Section 5.4 of ASHRAE 116 shall have the following clarifications made for the electrical instruments section:

E3.1 Section 5.4.1 of ASHRAE 116 shall be clarified by adding the following: "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."

E3.2 Section 5.4.2 of ASHRAE 116 shall be clarified with the following: "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 fifteen seconds after beginning an OFF cycle. Activate the scale or meter having the higher power rating active within fifteen seconds prior to beginning an ON cycle. When testing air-conditioners and heat pumps having a Variable capacity Compressor, do not use an induction watt/watt-hour meter."

E3.3 Append the following sentence to Section 5.4.2 of ASHRAE 116: "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%."

E4 The second and third sentences of Section 6.1.1 of ASHRAE 116 shall be modified to say: "The dampers shall be capable of being completely opened or completely closed within a time period not to exceed five seconds for each action.

Airflow through the equipment being tested should stop within five seconds after the airflow measuring device is de-energized."

E5 Add the following sentences to Section 6.1.1 of ASHRAE 116:

E5.1 "The arrangement and size(s) of the components may be altered to meet the physical requirements of the unit to be tested."

E5.2 "Use an inlet and outlet air Damper Box or Airflow Prevention Device when testing Ducted Systems if conducting one or both of the Cyclic Tests. Otherwise, install an outlet air Damper Box or Airflow Prevention Device when testing heat pumps, both ducted and non-ducted, that cycle off the indoor fan during Defrost Cycles if no other means is available for preventing natural or forced convection through the Indoor Unit when the indoor fan is off."

E5.3 "Inlet damper(s) or Airflow Prevention Device(s) shall not be used on Non-ducted systems."

E5.4 "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."

E5.5 "Install the Damper Box immediately upstream of the inlet plenum. The cross-sectional dimensions of the Damper Box shall be equal to or greater than the dimensions of the indoor unit inlet. If needed, use an adaptor plate or a short transition duct section to connect the Damper Box with the unit's inlet plenum."

E5.6 "If using an 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. 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 20 cfm when a negative pressure of 1.0 in H_2O is maintained at the outlet of the outlet air damper."

"For an inlet damper box, locate the grid of entering air dry-bulb temperature sensors, if used, and the air sampling device, or the sensor used to measure the water vapor content of the inlet air, at a location immediately upstream of the damper box inlet. For an inlet upturned duct, locate the grid of entering air dry-bulb temperature sensors, if used, and the air sampling device, or the sensor used to measure the water vapor content of the inlet air, at a location at least one foot downstream from the beginning of the insulated portion of the duct but before the static pressure measurement."

E5.7 Add the following new paragraph to Section 6.1.1 of ASHRAE 116: "Airflow Prevention Device Requirements: 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 19 $h \cdot ft^2 \cdot °F/Btu$."

E6 The third and fourth sentences of Section 6.1.2 of ASHRAE 116 shall be replaced with the following: "For at least one cooling mode test and one heating mode test per calibration period not to exceed 1 year (or anytime a change is made to the measuring system), monitor the temperature distribution of the air leaving the indoor coil using the grid of individual sensors. For this thirty-minute data collection interval used to determine capacity, the maximum difference among the outlet dry-bulb temperatures from any data sampling shall not exceed 1.5°F."

E7 Add the following new Section 6.1.6 to Section 6.1 of ASHRAE 116 "6.1.6 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, C_D."

E8 Section 6.3 of ASHRAE 116 shall be replaced entirely with the following: "Inside the indoor and outdoor psychrometric rooms, use artificial loads during Cyclic Tests and frost accumulation tests, if needed, to produce stabilized room air temperatures. For the outdoor pyschrometric 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."

E9 *Thermal Mass Correction*. Replace Section 7.4.3.4.5 (a) of ASHRAE 116 with the following: "Thermal mass shall be calculated using the method identified in Section C5.2 of AHRI 210/240 Appendix C."

E10 *Test procedures for Frost Accumulation heating mode tests ($H2_{Full}$, $H2_{Int}$, and $H2_{Low}$).* Replace Section 8.2.2 of ASHRAE 116 and its subsections in their entirety with the following:

E10.1 For heat pumps containing defrost controls which cause Defrost Initiation at intervals less than one hour, the preliminary test period starts at the termination of an automatic Defrost Cycle and ends at the termination of the next occurring automatic Defrost Cycle. For heat pumps containing defrost controls which cause Defrost Initiation at intervals exceeding one hour, the preliminary test period shall consist of a heating interval lasting at least one hour followed by a Defrost Cycle that is either manually or automatically initiated. In all cases, the heat pump's own controls shall govern when a Defrost Cycle terminates.

E10.2 The official test period begins when the preliminary test period ends, at Defrost Termination. The official test period ends at the next automatically occurring Defrost Termination.

E10.2.1 When testing a heat pump that uses a Time Adaptive Defrost Control System, however, manually initiate the Defrost Cycle that ends the official test period at the instant indicated by instructions provided by the manufacturer. If the heat pump has not undergone a defrost after six hours, immediately conclude the test and use the results from the full six-hour period to calculate the average space heating capacity and average electrical power consumption.

E10.2.2 For heat pumps that turn the indoor fan off during the Defrost Cycle, airflow shall be stopped through the indoor coil by blocking the outlet and inlet plenum whenever the heat pump's controls cycle off the indoor fan. If it is installed, use the outlet Damper Box described in Section 6.1.1 of ASHRAE 116 to affect the blocked outlet duct. If it is installed, use the inlet Damper Box described in Section 6.1.1 of ASHRAE 116 to affect the blocked inlet plenum.

E10.2.3 For the purpose of determining defrost operation sequence, the first action of Defrost Termination and Defrost Initiation shall be Specified by the manufacturer and be made available to the laboratory.

E10.3 To constitute a valid Frost Accumulation test, the test tolerances identified in ASHRAE 116 Table 3C shall be satisfied during both the preliminary and official test periods. As noted in ASHRAE 116 Table 3C, Test Operating Tolerances are stated for two sub-intervals: (1) When heating, except for the first ten minutes after the termination of a Defrost Cycle (Sub-interval H, as described in ASHRAE 116Table 3C) and (2) when defrosting, plus these same first ten minutes after Defrost Termination (Sub-interval D, as described in ASHRAE 116 Table 3C). Evaluate compliance with ASHRAE 116 Table 3C Test Condition Tolerances and the Test Operating Tolerances using the averages from measurements recorded only during Sub-interval H. Continuously record the dry-bulb temperature of the air entering the indoor coil, and the dry-bulb temperature and water vapor content of the air entering the Outdoor Coil. Sample the remaining parameters listed in ASHRAE 116 Table 3C at equal intervals that span five minutes or less. Note that the ten minutes identified here shall replace the five minutes identified in ASHRAE 116 Table 3C footnote (1).

E10.4 For the official test period, collect and use the following data to calculate average space heating capacity and electrical power. During heating and defrosting intervals when the controls of the heat pump have the indoor fan on, continuously record the dry-bulb temperature of the air entering (as noted above) and leaving the indoor coil. If using a thermopile, continuously record the difference between the leaving and entering dry-bulb temperatures during the interval(s) that airflows through the indoor coil. For heat pumps tested without an indoor fan installed, determine the corresponding cumulative time (in hours) of indoor coil airflow, $\Delta\tau_a$. Sample measurements used in calculating the airflow (refer to Section 7.7.2.1 and Section 7.7.2.2 of ASHRAE 37) at equal intervals that span ten seconds or less. Record the electrical energy consumed, expressed in watt-hours, from Defrost Termination to Defrost Termination, $e_{DEF}^k(35)$, as well as the corresponding elapsed time in hours, $\Delta\tau_{FR}$.

E10.5 For heat pumps having a constant-air-volume-rate indoor fan and if the average of the external static pressures measured during sub-Interval H exceeds the minimum (or targeted) ESP (ΔP_{min}) by 0.03 in H_2O or more, follow the procedures in AHRI 210/240 Section 6.1.5.1.3.

E11 *Test procedures for the optional cyclic dry-coil cooling-mode tests (D_{Full}, D_{Low}, and I_{Low}).* Add the following sentences immediately following the title of Section 8.2.4 of ASHRAE 116: "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. Always revert to testing with the indoor blower disabled if cyclic testing with the fan enabled is unsuccessful."

E11.1 Add the following as new Section 8.2.4.3 to ASHRAE 116: "For Blower Coil Systems or Coil-only Systems Specified 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."

E11.2 Add the following as new Section 8.2.4.4 to ASHRAE 116: "Inside the psychrometric test rooms (both indoor and outdoor), use artificial loads during Cyclic Tests and frost accumulation tests, if needed, to produce stabilized room air temperatures. For the outdoor room, select an electric resistance heater(s) having a heating capacity that is approximately equal to the heat rejection capacity of the Outdoor Unit. For the indoor room, select a heater(s) having a capacity that is close to the Sensible Cooling Capacity of the Indoor Unit. In the indoor room, cycle the heater ON when the Indoor Unit is ON and cycle the heater OFF when the Indoor Unit is OFF. In the outdoor room, cycle the heater ON when the Outdoor Unit is OFF and cycle the heater OFF when the Outdoor Unit is ON.

E11.3 Add the following as new Section 8.2.4.5 to ASHRAE 116: "Inside the psychrometric test rooms (both indoor and outdoor), use artificial loads during Cyclic Tests and frost accumulation tests, if needed, to produce stabilized room air temperatures. For the outdoor room, select an electric resistance heater(s) having a heating capacity that is approximately equal to the heat rejection capacity of the Outdoor Unit. For the indoor room, select a heater(s) having a capacity that is close to the Sensible Cooling Capacity of the Indoor Unit. In the indoor room, cycle the heater ON when the Indoor Unit is ON and cycle the heater OFF when the Indoor Unit is OFF. In the outdoor room, cycle the heater ON when the Outdoor Unit is OFF and cycle the heater OFF when the Outdoor Unit is ON.

E11.4 Add the following as new Section 8.2.4.6 to ASHRAE 116: "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:

E11.4.1 The test unit automatically cycles off;
E11.4.2 Its blower motor reverses; or
E11.4.3 The unit operates for more than thirty seconds at an ESP that is equal to or greater than 0.1 in H_2O 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 stated 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."

E11.5 Add the following as new Section 8.2.4.7 to ASHRAE 116: "With regard to the Table 3b of ASHRAE 116 parameters, 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 two minutes during periods when air flows through the coil. Record ESP and the airflow 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 fifteen seconds after flow initiation.) For units having a variable-speed indoor blower that ramps, the tolerances listed for the external resistance to airflow apply from thirty seconds after achieving full speed until ramp down begins. Sample the electrical voltage at least every ten seconds beginning thirty seconds after compressor start-up. Continue until the compressor, the outdoor fan, and the indoor fan (if it is installed and operating) cycle off."

E11.6 Add the following as new Section 8.2.4.8 to ASHRAE 116: **"**For Ducted Systems, continuously record the dry-bulb temperature of the air entering (as noted in Section 8.2.4.7) and 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."

E11.7 Add the following as new Section 8.2.4.9 to ASHRAE 116: **"**Integrate each complete cycle as follows:

E11.7.1 For Blower Coil Systems tested with an indoor fan installed and operating or Coil-only Systems Specified with an indoor fan time delay, integrate electrical power from indoor fan OFF to indoor fan OFF.

E11.7.2 For all other Ducted Systems and for Non-ducted Systems, integrate electrical power from compressor OFF to compressor OFF.

E11.7.3 Capacity integration of all systems is from indoor fan ON to indoor fan OFF."

E11.8 Add the following as new Section 8.2.4.10 to ASHRAE 116: **"***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 Specified based on using a fan time delay, the indoor coil airflow shall be controlled according to the "OFF" delay listed by the manufacturer in the report . 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 (see ASHRAE 116 Section 6.1.1) during the OFF period.

The following algorithm shall be used to calculate $Ec_{adj,x}$ and $qc_{adj,x}$ in lieu of Equations 11.30 and 11.25, at the manufacturer's discretion, if the indoor fan ramps its speed when cycling.

E11.8.1 Measure the electrical power consumed by the Constant-volume AMS or Constant-torque AMS at a minimum of three operating conditions: at the speed/airflow/ESP 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 ESP are the same as required for the Steady State Test.

E11.8.2 For each case, determine the indoor fan power from the average of measurements made over a minimum of five minutes.

E11.8.3 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 forty-five seconds, use a forty-five-second ramp interval nonetheless when estimating the fan energy."

E11.9 Add the following as new Section 8.2.4.11 to ASHRAE 116: **"***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 three minutes prior to compressor cut-on and end three minutes after compressor cutoff. Subtract the electrical energy used by the indoor fan during the three minutes prior to compressor cut-on from the integrated electrical energy. Add the electrical energy used by the indoor fan during the three 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 in Section 8.2.4.9 (Section E11.7 of AHRI 210/240) for Blower Coil Systems with Constant-volume AMS or Constant-torque AMS which has the blower disabled for Cyclic Test."

E11.10 If an upturned duct is used, measure the dry-bulb temperature at the inlet of the device at least once every minute and ensure that its Test Operating Tolerance is within 1.0°F for each compressor OFF period.

E11.11 Prior to recording data during the steady-state dry coil test, operate the unit at least one hour after achieving dry coil conditions. Drain the drain pan and plug the drain opening.

Thereafter, the drain pan should remain completely dry.

E11.11 After completing the steady-state dry-coil test, remove the outdoor air enthalpy method test apparatus, if connected, and begin manual OFF/ON cycling of the unit's compressor.

The test set-up should otherwise be identical to the set-up used during the steady-state dry coil test.

E12 *Heating Cyclic Test Modification.* Append the following to Section 9.2.4 of ASHRAE 116:

E12.1 "*Test procedures for the optional cyclic heating mode tests ($H0C_{Low}$, $H1C_{Full}$, and $H1C_{Low}$).* If optional Cyclic Tests are conducted, they shall follow immediately after the Steady-state Test that requires the same test conditions."

E12.2 "If a heat pump Defrost Cycle is manually or automatically initiated immediately prior to or during the OFF/ON cycling, operate the heat pump continuously until ten minutes after Defrost Termination. After the ten-minute interval, begin cycling the heat pump immediately or delay until the required test conditions have been re-established. Prevent defrosts after beginning the cycling process (contact the manufacturer for the procedure on how to prevent defrost). For heat pumps that cycle off the indoor fan during a Defrost Cycle, do not restrict the air movement through the indoor coil while the fan is off. Resume the OFF/ON cycling while conducting a minimum of two complete compressor OFF/ON cycles before determining capacity and energy consumption."

E13 Make the following corrections to ASHRAE 116:

E13.1 Change 43500 to 43400 in Table A-2.

E13.2 Change "Two-Speed" in the title of Table A-5 to "Variable –Speed".

E13.3 Table A-8 shall be revised as per below. The revised data then provides a match for the example calculations in Table A-8.

Table A-8 Corrected

	k=1	k=2
q(62)	42000	*
q(47)	30000	65000
q(35)	22000	50000
q(17)	17000	42000
E(62)	3077	*
E(47)	2930	7054
E(35)	2865	6370
E(17)	2491	5128
Cd	0.2	**

E13.4 The equation for intermediate speed capacity (k=i) on page 25 begins $qss^{k=1}(t) = qss^{k=1}(t_{a14})$ +. This should be $qss^{k=i}(t) = qss^{k=i}(t_{a12})$ +.

E13.5 On page 25 is the statement "Once the equation for $qss^{k=1}(t)$ has been determined, the temperature at which $qss^{k=1}$ (t) = BL(t) can be found. This temperature, designated as t_{vc}, shall be calculated by the following equation:" - the 1's should be i's.

E13.6 The equation for t_{vc} on page 25 begins $33 \cdot qss^{k=i}$ (t_{a14}). Table 8b then lists t_{a14} as a minimum speed point at 67F. t_{a12} is the intermediate speed point, which is the data used in the example calculations of page 41 - the equation for t_{vc} on page 25 should begin $33 \cdot qss^{k=i}$ (t_{a12}).

E13.7 In total, there are fifteen references to ta14 on page 25 that should be t_{a12}.

E13.8 Based on Equation $Ess^{k=i}(t_{vc}) = Ess^{k=i}(t_{a14}) + Me(t_{vc}-t_{a14})$ on page 25 (bottom left) - the equation on page 39 (bottom right) which reads $Ess^{k=i}$ (86.88) = 1450-8.556 · (86.88-87.0) should read Ess $^{k=i}$ (86.88) = 1450+8.556 · (86.88-87.0) then the next line will change from $EER2ss^{k=i}(86.88)$ = 1451.0 watts to $EER2ss^{k=i}(86.88)$ = 1449.0 watts.

E13.9 The coefficient at the top of page 40 is calculated as "= - 29.950" the result should be "= -21.950".

E13.10 The example calculations on page 44 for temperature t_{IV} use E4 in the equation, which agrees with the sentence on page 32 above the equation for t_{IV} that indicates use E3 in the calculation if the calculated value for t_{IV} is greater than t_{a12} (17F) - the sentence on page 32, and on page 44 below the equation for t_{IV} should read "..if LESS than..".

E13.11 Table A-11 gives the regional outdoor design temperature for region IV as 10°F - this temperature should be 5°F, the same as listed in Table 14.

E13.12 ASHRAE 116 applies the demand defrost credit to the entire heating load, which includes any auxiliary heat. The credit shall only apply to the heat pump capacity.

E14 Inlet plenum may include a damper section or Airflow Prevention Device.

E14.1 The inlet and outlet damper leakage rate shall not exceed a combined 20 cfm when a negative pressure of 1.0 in H_2O is maintained at the plenum's inlet.

E14.2 The outlet plenum, minimum of nine individual temperature sensors, shall not exceed a difference of 1.5°F during the ON cycle. Use of mixers and/or perforated screen shall be used to meet this requirement.

E15 *Electrical Voltage, Power and Energy Measurement*.

E15.1 The supply voltage at the terminals on the test unit, using a voltage meter that provides a reading that is accurate to within ±1.0% of the measured quantity shall be used. During the ON and OFF cycle the voltage total observed range, excluding the thirty seconds after compressor startup and shutdown, shall not exceed 2.0% and the set-point average error shall not exceed 1.5%.

E15.2 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 fifteen seconds of the start of the OFF cycle and switched within fifteen seconds prior to the start of the ON cycle.

E16 *Grid Differential Temperature*.

E16.1 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. When sample rates are less than one minute apart, formula E1 shall be used to integrate results. When sample values are one minute apart from all sensors, formula E2 shall be used. Determine the value of F_{CD}.

$$F_{CD} = \int_0^6 \frac{\Delta t_{RTD}}{\Delta t_{TC}} \qquad \text{E1}$$

$$F_{CD} = \frac{1}{7}\sum_{i-6}^{i} \frac{\Delta t_{RTD}}{\Delta t_{TC}} \qquad \text{E2}$$

Δt_{RTD} shall be the 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} 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.

E16.2 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.

E16.3 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.

E17 *Cycle Stability Requirements*. Conduct three complete compressor OFF/ON cycles with the Test Operating Tolerances and Test Condition Tolerances given in ASHRAE 37 Table 2b satisfied. Calculate the degradation coefficient C_D for each complete cycle. 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.

E18 *Oil Recovery.* The Oil Recovery Mode shall be activated during testing. If Oil Recovery prevents a Steady-state test use the transient test procedure as described in Section 8.8.3 (except Section 8.8.3.3) of ASHRAE 37, with the revisions in the following section:

E18.1 For tests that cannot reach Steady-state because of Oil Recovery, Section 8.8.3 (except Section 8.8.3.3) of ASHRAE 37 shall be modified by replacing all mentions of "defrost" with "Oil Recovery", replacing all mentions of "Heat Pump" with "system" and replacing all mentions of "heating" with "conditioning". The test tolerances identified in Table 2 of ASHRAE 37for "heat portion" under "heat with frost" must be satisfied when conducting the tests. The test tolerance parameters included in Table 2 of ASHRAE 37- must be sampled throughout the preconditioning and data collection period. For the purpose of evaluating compliance with the stated test tolerances, the dry-bulb temperature of the air entering the indoor-side and the outdoor-side, and the water vapor content of the air entering the outdoor-side must be sampled at least every minute. All other parameters must be sampled at equal intervals that span five minutes or less.

E18.2 For tests for which the Oil Recovery occurs more frequently than every hour, the test period shall consist of two successive test period intervals comprising of a whole number of oil recovery cycles and a minimum of thirty minutes each, and both integrated capacity and integrated total power shall be within 2 percent of each other.

E19 *SCFM Tolerance.* Section 6.1.1 of ASHRAE 116shall have the following modification made:

E19.1 Replace the last sentence "The air pressure difference (Δ P) at the nozzle shall be within 2% of steady Δ P within fifteen seconds from the time the air-measuring device is recognized" with

"The SCFM should be within 2 percent of the value from the steady-state dry coil test within fifteen seconds after airflow initiation. For units having a variable-speed indoor blower that ramps when cycling on and/or off, use the exhaust fan of the airflow measuring apparatus to impose a step response that begins at the initiation of ramp up and ends at the termination of ramp down".

APPENDIX F. UNIT CONFIGURATION FOR STANDARD EFFICIENCY DETERMINATION - NORMATIVE

Scope. This appendix only applies to Split Systems with 3-phase Outdoor Units or 3-phase Single Package Units. This appendix shall not be applied to Small-duct High-velocity Systems.

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

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

F1.1 *Basic Model.* Basic Model means all units manufactured by one manufacturer within a single equipment class, having the same or comparably performing compressor(s), heat exchangers, and air moving system(s) that have a common "nominal" Cooling Capacity.

F.1.2 All components indicated in the following list shall be present and installed for all testing for each indoor unit and outdoor unit, as applicable, and shall be the components distributed in commerce with the model. Individual models that contain/use (different or alternate) versions of the same component shall either be represented separately as a unique Basic Model or Specified within the same Basic Model based on testing of the least efficient configuration.

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

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

- Reverse cycle heat pump functionality
- Gas furnace
- Electric resistance
- Steam and hydronic coils (if not optional per Section F2.10)

F2 *Optional System Features*. The following features are optional during testing. Individual models with these features may be represented separately as a unique Basic Model or Specified within the same Basic Model as otherwise identical individual models without the feature pursuant to the definition of "Basic Model".

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

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

F2.1 *UV Lights*. A lighting fixture and lamp mounted so that it shines light on the indoor coil, that emits ultraviolet light to inhibit growth of organisms on the indoor coil surfaces, the condensate drip pan, and/or other locations within the equipment. UV lights shall be turned off for testing.

F2.2 *High-Effectiveness Indoor Air Filtration*. Indoor air filters with greater air filtration effectiveness than the Standard Filter. Remove the non-Standard Filter and the test systems with external minimum static pressure adjustment per note 1 of Table 10.

F2.3 *Air Economizers*. An automatic system that enables a cooling system to supply and use outdoor air to reduce or eliminate the need for mechanical cooling during mild or cold weather. They provide significant energy efficiency improvements on an annualized basis, but are also a function of regional ambient conditions and are not considered in the EER2, SEER2, or HSPF2 metrics. If an air economizer is installed during the test, it shall be in the 100 % return position with outside air dampers closed and sealed using tape or equivalent means to block any leakage.

F2.4 *Fresh Air Dampers*. An assembly with dampers and means to set the damper position in a closed and one open position to allow air to be drawn into the equipment when the indoor fan is operating. If fresh air dampers are installed during the test, test with the fresh air dampers closed and sealed using tape or equivalent means to block any leakage.

F2.5 *Barometric Relief Dampers*. An assembly with dampers and means to automatically set the damper position in a closed position and one or more open positions to allow venting directly to the outside a portion of the building air that is returning to the unit, rather than allowing it to recirculate to the indoor coil and back to the building. If barometric relief dampers are installed during the test, test with the barometric relief dampers closed and sealed using tape or equivalent means to block any leakage.

F2.6 *Ventilation Energy Recovery System (VERS)*. An assembly that pre-conditions outdoor air entering equipment through direct or indirect thermal and/or moisture exchange with the unit's exhaust air, which is defined as the building air being exhausted to the outside from the equipment. If a VERS is installed during the test, test with the outside air and exhaust air dampers closed and sealed using tape or equivalent means to block any leakage.

F2.6.1 *Process Heat recovery / Reclaim Coils / Thermal Storage.* A heat exchanger located inside the unit that conditions the equipment's Supply Air using energy transferred from an external source using a vapor, gas, or liquid. If such a feature is present for testing, it shall be disconnected from its heat source.

F2.7 *Indirect/Direct Evaporative Cooling of Ventilation Air.* Water is used indirectly or directly to cool ventilation air. In a direct system the water is introduced directly into the ventilation air and in an indirect system the water is evaporated in secondary air stream and the heat is removed through a heat exchanger. If an indirect/direct evaporative cooler is present for testing, operate disconnected from a water supply, i.e. without active evaporative cooling of ventilation air.

F2.8 *Evaporative Pre-cooling of Condenser Intake Air.* Water is evaporated into the air entering the air-cooled condenser to lower the dry-bulb temperature and thereby increase efficiency of the refrigeration cycle. If an evaporative pre-cooler is present for testing, operate disconnected from a water supply, i.e. without active evaporative cooling.

F2.9 *Desiccant Dehumidification Components*. An assembly that reduces the moisture content of the Supply Air through moisture transfer with solid or liquid desiccants. If such a feature is present for testing, it shall be deactivated.

F2.10 *Steam/Hydronic Heat Coils*. Coils used to provide supplemental heating. Steam/hydronic heat coils are an optional system feature only if all otherwise identical individual models without the steam/hydronic heat coils that are part of the same Basic Model have another form of primary heating other than reverse cycle heating (e.g. electric resistance heating or gas heating). If all individual models of the Basic Model have either steam or hydronic heat coils and no other form of heat, test with steam/hydronic heat coils in place but providing no heat.

F2.11 *Refrigerant Reheat Coils*. A heat exchanger located downstream of the indoor coil that heats the Supply Air during cooling operation using high pressure refrigerant in order to increase the ratio of moisture removal to Cooling Capacity provided by the equipment. If this feature is present for testing, it shall be de-activated so as to provide the minimum (none if possible) reheat achievable by the system controls.

F2.12 *Powered Exhaust/Powered Return Air Fans*. A Powered Exhaust Fan is a fan that transfers directly to the outside a portion of the building air that is returning to the unit, rather than allowing it to recirculate to the indoor coil and back to the building. A Powered Return Fan is a fan that draws building air into the equipment. If a powered exhaust or return fan is present for testing, it shall be set up as indicated by the supplemental testing instructions (STI).

F2.13 *Coated Coils*. An indoor coil or outdoor coil whose entire surface, including the entire surface of both fins and tubes, is covered with a thin continuous non-porous coating to reduce corrosion. Corrosion durability of these coil coatings shall be confirmed through testing per ASTM B117 or the ASTM G85 salt spray test to a minimum of 500 hours or more. If an otherwise identical model (within the Basic Model) without the coated coil is not distributed in commerce, conduct tests with the coated coil present.

F2.14 *Power Correction Capacitors*. A capacitor that increases the power factor measured at the line connection to the equipment. Power correction capacitors shall be removed for testing.

F2.15 *Hail Guards*. A grille or similar structure mounted to the outside of the unit covering the outdoor coil to protect the coil from hail, flying debris and damage from large objects. Hail guards shall be removed for testing.

F2.18 *Non-Standard Ducted Condenser Fans*. A higher-static condenser fan/motor assembly designed for external ducting of condenser air that provides greater pressure rise and has a higher rated motor horsepower than the condenser fan provided as a standard component with the equipment. If a non-standard ducted condenser fan is installed for the test, operate the non-standard ducted condenser fan at zero ESP (either without ducts connected, or, if using the outdoor air enthalpy method, with ESP set to zero). Non-standard ducted condenser fans are not considered an optional feature for Double-duct Systems.

F2.19 *Sound Traps/Sound Attenuators*. An assembly of structures through which the Supply Air passes before leaving the equipment or through which the return air from the building passes immediately after entering the equipment for which the sound insertion loss is at least 6 dB for the 125 Hz octave band frequency range. If an otherwise identical model (within the Basic Model) without the sound traps/sound attenuators is not distributed in commerce, conduct tests with the sound traps/sound attenuators present.

F2.20 *Fire/Smoke/Isolation Dampers*. A damper assembly including means to open and close the damper mounted at the supply or return duct opening of the equipment. Such a damper may be rated by an appropriate test laboratory according to the appropriate safety standard, such as UL 555 or UL 555S. If a fire/smoke/isolation damper is present for testing, set the damper in the fully open position.

F2.21 *Hot Gas Bypass*. A method for adjusting Cooling Capacity that diverts a portion of the high pressure, hot gas refrigerant from the outdoor coil and delivers it to the low pressure portion of the refrigerant system. If hot gas bypass is present for testing, set the hot gas bypass as indicated in manufacturer's supplemental testing instructions.

F3 *Non-Standard Indoor Fan Motors*. The standard indoor fan motor is the motor Specified by the manufacturer for testing and shall be distributed in commerce as part of a particular model. A non-standard motor is an indoor fan motor that is not the standard indoor fan motor and that is distributed in commerce as part of an individual model within the same Basic Model. The minimum allowable efficiency of any non-standard indoor fan motor shall be related to the efficiency of the standard motor as identified in Section G.3.1. If the standard indoor fan motor can vary fan speed through control system adjustment of motor speed, all non-standard indoor fan motors shall also allow speed control (including with the use of VFD).

F3.1 *Determination of Motor Efficiency for Non-standard Indoor Fan Motors.*

F3.1.1 Standard and non-standard indoor fan motor efficiencies shall be based on the test procedures indicated in Table F1.

F3.1.2 Reference motor efficiencies shall be determined for the standard and non-standard indoor fan motor as indicated in Table F1.

F3.1.3 Non-standard motor efficiency shall meet the criterion in equation F1.

$$\eta_{non-standard} \geq \frac{\eta_{standard}-\eta_{reference\ standard}}{1-\eta_{reference\ standard}} \cdot \left(1-\eta_{reference\ non-standard}\right)+\eta_{reference\ non-standard} \qquad \text{F1}$$

Where:

$\eta_{standard}$ = the tested efficiency of the standard indoor fan motor

$\eta_{non-standard}$ = the tested efficiency of the non-standard indoor fan motor
$\eta_{reference\ standard}$ = the reference efficiency from Table F1 for the standard indoor fan motor
$\eta_{reference\ non-standard}$ = the reference efficiency from Table F1 for the non-standard indoor fan motor

Table F1. Test Procedures and Reference Motor Efficiency

Motor – Standard or Non-standard	Test Procedure	Reference Motor Efficiency[2]
Single Phase ≤ 2 hp	10 CFR 431.444	Federal standard levels for capacitor-start capacitor-run and capacitor-start induction run, 4 pole, open motors at 10 CFR 446
Single Phase > 2 hp and ≤ 3 hp	10 CFR 431.444	Federal standard levels for polyphase, 4 pole, open motors at 10 CFR 431.446.
Single Phase > 3hp	10 CFR 431.444	Federal standard levels for 4 pole, open motors at 10 CFR 431.25(h).
Polyphase ≤ 3 hp For cases in which the standard and/or non-standard indoor fan motor is <1 hp	10 CFR 431.444	Federal standard levels for polyphase, 4 pole, open motors at 10 CFR 431.446.
Polyphase ≤ 3 hp For cases in which both the standard and non-standard indoor fan motor are ≥ 1 hp	10 CFR 431.444 Appendix B to Subpart B of 10 CFR 431	For standard and/or non-standard 2-digit frame size motors (except 56-frame enclosed ≥ 1 HP) ≤3 HP: Federal standard levels for polyphase, 4 pole open motors at 10 CFR 431.446 For all other standard and/or non-standard motors ≤3 HP: Federal standard levels for 4 pole, open motors at 10 CFR 431.25(h).
Polyphase > 3 hp	Appendix B to Subpart B of 10 CFR 431	Federal standard levels for 4 pole, open motors at 10 CFR 431.25(h).
BLDC[3] motor or ECM[4] ≥ 1 hp	CSA 747-09[5]	Federal standard levels for 4 pole, open motors at 10 CFR 431.25(h).
BLDC motor or ECM < 1 hp	CSA 747-09[5]	Use Table F2.

Notes:

1. Air-over motors shall be tested to the applicable test procedure based on the motor's phase count and horsepower, except that the NEMA MG1-2016, Supplement 2017 procedure for air-over motor temperature stabilization shall be used rather than the temperature stabilization procedure stated in the applicable test procedure based on the motor's phase count and horsepower. The NEMA MG1-2016, Supplement 2017 procedure for air-over motor temperature stabilization offers three options – the same option shall be used by the manufacturer for both the standard and non-standard motor.
2. For standard or non-standard motors with horsepower ratings between values given in the references, use the steps at 10 CFR 431.446(b) to determine the applicable reference motor efficiency (i.e., use the efficiency of the next higher reference horsepower for a motor with a horsepower rating at or above the midpoint between two consecutive standard horsepower ratings or the efficiency of the next lower reference horsepower for a motor with a horsepower rating below the midpoint between two consecutive standard horsepower ratings.
3. Brushless DC (BLDC) permanent magnet motor.
4. Electronically commutated motor.
5. BLDC motors and ECMs shall be tested and rated for efficiency at full speed and full rated load. CSA 747-09 may be applied to motors ≥ 1 hp.

Table F2. BLDC Motor and ECM – Fractional hp – Reference Efficiencies

Motor hp	Reference Motor Efficiency[1,2]
0.25	78.0
0.33	80.0

0.50	82.5
0.75	84.0

1. For standard or non-standard motors with horsepower ratings between values given in Table F2, use the steps at 10 CFR 431.446(b) to determine the applicable reference motor efficiency (i.e., use the efficiency of the next higher reference horsepower for a motor with a horsepower rating at or above the midpoint between two consecutive standard horsepower ratings or the efficiency of the next lower reference horsepower for a motor with a horsepower rating below the midpoint between two consecutive standard horsepower ratings).
2. For BLDC motors and ECMs > 0.75 and < 1 hp, use Table F2 for motors < 0.875 hp, and use Federal standard levels for 1 hp, 4 pole, open motors at 10 CFR 431.25(h) for motors ≥ 0.875 hp.

APPENDIX G. OFF-MODE TESTING - NORMATIVE

G1 *Laboratory Testing to Determine Off-mode Average Power Ratings.*

Voltage tolerances: As a percentage of reading, Test Operating Tolerance shall be 2.0% and test condition tolerance shall be 1.5%.

Power Measurement Tolerance: Power measurements shall utilize equipment accurate to within 1% or 0.5W whichever is greater.

Conduct one of the following tests: If the central air-conditioner or heat pump lacks a compressor Crankcase Heater, perform the test in Section G1.1 of this appendix; if the central air-conditioner or heat pump has a compressor Crankcase Heater that lacks controls and is not self-regulating, perform the test in Section G1.1 of this appendix; if the central air-conditioner or heat pump has a Crankcase Heater with a fixed power input controlled with a thermostat that measures ambient temperature and whose sensing element temperature is not affected by the heater, perform the test in Section G1.1 of this appendix; if the central air-conditioner or heat pump has a compressor Crankcase Heater equipped with self-regulating control or with controls for which the sensing element temperature is affected by the heater, perform the test in Section G1.2 of this appendix.

G1.1 This test determines the off-mode average power rating for central air-conditioners and heat pumps that lack a compressor Crankcase Heater, or have a compressor crankcase heating system that can be tested without control of ambient temperature during the test. This test has no ambient condition requirements.

G1.1.1 *Test Sample Set-up and Power Measurement.* For Coil-only Systems, provide a furnace or Modular Blower that is compatible with the system to serve as an interface with the thermostat (if used for the test) and to provide low-voltage control circuit power. Make all control circuit connections between the furnace (or Modular Blower) and the Outdoor Unit as Specified by the Installation Instructions. Measure power supplied to both the furnace or Modular Blower and power supplied to the Outdoor Unit. Alternatively, provide a compatible transformer to supply low-voltage control circuit power, as described in Section G1.4 of this Appendix. Measure transformer power, either supplied to the primary winding or supplied by the secondary winding of the transformer, and power supplied to the Outdoor Unit. For blower coil and single-package systems, make all control circuit connections between components as Specified by the Installation Instructions, and provide power and measure power supplied to all system components.

G1.1.2 *Configure Controls*. Configure the controls of the central air-conditioner or heat pump so that it operates as if connected to a building thermostat that is set to the OFF position. Use a compatible building thermostat if necessary to achieve this configuration. For a thermostat-controlled Crankcase Heater with a fixed power input, bypass the Crankcase Heater thermostat if necessary to energize the heater.

G1.1.3 *Measure $P2_x$*. If the unit has a Crankcase Heater time delay, make sure that time delay function is disabled or wait until delay time has passed. Determine the average power from non-zero value data measured over a five-minute interval of the non-operating central air-conditioner or heat pump and designate the average power as $P2_x$, the heating season total off-mode power.

G1.1.4 *Measure P_x.* For Coil-only Systems and for Blower Coil Systems for which a furnace or a Modular Blower is the designated air mover: Disconnect all low- voltage wiring for the outdoor components and outdoor controls from the low-voltage transformer. Determine the average power from non-zero value data measured over a five-minute interval of the power supplied to the (remaining) low-voltage components of the central air-conditioner or heat pump, or low- voltage power, P_x. This power measurement does not include line power supplied to the Outdoor Unit. It is the line power supplied to the air mover, or, if a compatible transformer is used instead of an air mover, it is the line power supplied to the transformer primary coil. If a compatible transformer is used instead of an air mover and power output of the low-voltage secondary circuit is measured, P_x is zero.

G1.1.5 *Calculate P2*. Set the number of compressors (n_c) equal to the unit's number of single-stage compressors (n_s) plus 1.75 times the unit's number of compressors that are not single-stage (n_v).

$$n_c = n_s + (1.75 \cdot n_v) \qquad \text{G1}$$

For Single Package Units and Blower Coil Systems for which the designated air mover is not a furnace or

Modular Blower, divide the heating season total off-mode power ($P2_x$) by the number of compressors (n_c) to calculate $P2$, the heating season per- compressor off-mode power. Round $P2$ to the nearest watt. The expression for calculating $P2$ is as follows:

$$P2 = \frac{P2_x}{n_c} \qquad \text{G2}$$

For Coil Only Systems and Blower Coil Systems for which a furnace or a Modular Blower is the designated air mover, subtract the low-voltage power (P_x) from the heating season total off-mode power ($P2_x$) and divide by the number of compressors (n_c) to calculate $P2$, the heating season per- compressor off-mode power. Round $P2$ to the nearest watt. The expression for calculating $P2$ is as follows:

$$P2 = \frac{P2_x - P_x}{n_c} \qquad \text{G3}$$

G1.1.6 Shoulder Season per-compressor off-mode power, $P1$: If the system does not have a Crankcase Heater, has a Crankcase Heater without controls that is not self-regulating, or has a value for the Crankcase Heater turn-on temperature (as specified in the DOE Compliance Certification Database) that is higher than 71°F, then $P1$ is equal to $P2$.

Otherwise, de-energize the Crankcase Heater (by removing the thermostat bypass or otherwise disconnecting only the power supply to the Crankcase Heater) and repeat the measurement as described in Section G1.1.3 of this appendix. Designate the measured average power as $P1_x$, the Shoulder Season total off-mode power.

Determine the number of compressors (n_c) as described in Section G1.1.5 of this appendix

For Single Package Units and Blower Coil Systems for which the designated air mover is not a furnace or Modular Blower, divide the Shoulder Season total off-mode power ($P1_x$) by the number of compressors (n_c) to calculate $P1$, the Shoulder Season per- compressor off-mode power. Round $P1$ to the nearest watt. The expression for calculating $P1$ is as follows:

$$P1 = \frac{P1_x}{n_c} \qquad \text{G4}$$

For Coil-only Systems and Blower Coil Systems for which a furnace or a Modular Blower is the designated air mover, subtract the low-voltage power (P_x) from the Shoulder Season total off-mode power ($P1_x$) and divide by the number of compressors (n_c) to calculate $P1$, the Shoulder Season per- compressor off-mode power. Round $P1$ to the nearest watt. The expression for calculating $P1$ is as follows:

$$P1 = \frac{P1_x - P_x}{n_c} \qquad \text{G5}$$

G1.2 This test determines the off-mode average power rating for central air-conditioners and heat pumps for which ambient temperature can affect the measurement of Crankcase Heater power.

G1.2.1 *Test Sample Set-up and Power Measurement*. Set up the test and measurement as described in Section G1.1.1 of this appendix.

G1.2.2 *Configure Controls*. Position a temperature sensor to measure the outdoor dry-bulb temperature in the air between 2 and 6 in from the Crankcase Heater control temperature sensor or, if no such temperature sensor exists, position it in the air between 2 and 6 in from the Crankcase Heater. Utilize the temperature measurements from this sensor for this portion of the test procedure. Configure the controls of the central air-conditioner or heat pump so that it operates as if connected to a building thermostat that is set to the OFF position. Use a compatible building thermostat if necessary to achieve this configuration.

Conduct the test after completion of the B_{Full} or B_{Low} test. Alternatively, start the test when the outdoor dry-bulb temperature is at 82°F and the temperature of the compressor shell (or temperature of each compressor's shell if there is more than one compressor) is at least 81°F. Then adjust the outdoor temperature at a rate of change of no more than 20°F per hour and achieve an outdoor dry-bulb temperature of 72°F. Maintain this temperature within ±2°F while making the power measurement, as described in Section G1.2.3 of this appendix.

G1.2.3 *Measure $P1_x$.* If the unit has a Crankcase Heater time delay, make sure that time delay function is disabled or wait until delay time has passed. Determine the average power from non-zero value data measured over a five-minute interval of the non-operating central air-conditioner or heat pump and designate the average power as $P1_x$, the Shoulder Season total off-mode power. For units with Crankcase Heater which operate during this part of the test and whose controls cycle or vary Crankcase Heater power over time, the test period shall consist of three complete Crankcase Heater cycles or eighteen hours, whichever comes first. Designate the average power over the test period as $P1_x$, the Shoulder Season total off-mode power.

G1.2.4 *Reduce Outdoor Temperature.* Approach the target outdoor dry-bulb temperature by adjusting the outdoor temperature at a rate of change of no more than 20°F per hour. This target temperature is five degrees Fahrenheit less than the temperature Specified by the OUM at which the Crankcase Heater turns on. Maintain the target temperature within ±2°F while making the power measurement, as described in Section G1.2.5 of this appendix.

G1.2.5 *Measure $P2_x$.* If the unit has a Crankcase Heater time delay, make sure that time delay function is disabled or wait until delay time has passed. Determine the average non-zero power of the non-operating central air-conditioner or heat pump over a five-minute interval and designate it as $P2_x$, the heating season total off-mode power. For units with Crankcase Heater whose controls cycle or vary Crankcase Heater power over time, the test period shall consist of three complete Crankcase Heater cycles or eighteen hours, whichever comes first. Designate the average power over the test period as $P2_x$, the heating season total off-mode power.

G1.2.6 *Measure P_x.* For Coil-only Systems and for Blower Coil Systems for which a furnace or Modular Blower is the designated air mover: Disconnect all low- voltage wiring for the outdoor components and outdoor controls from the low-voltage transformer. Determine the average power from non-zero value data measured over a five-minute interval of the power supplied to the (remaining) low-voltage components of the central air-conditioner or heat pump, or low- voltage power, P_x. This power measurement does not include line power supplied to the Outdoor Unit. It is the line power supplied to the air mover, or, if a compatible transformer is used instead of an air mover, it is the line power supplied to the transformer primary coil. If a compatible transformer is used instead of an air mover and power output of the low-voltage secondary circuit is measured, P_x is zero.

G1.2.7 *Calculate P1.* Set the number of compressors (n_c) equal to the unit's number of single-stage compressors (n_s) plus 1.75 times the unit's number of compressors that are not single-stage (n_v).

For Single Package Units and Blower Coil Systems for which the air mover is not a furnace or Modular Blower, divide the Shoulder Season total off-mode power ($P1_x$) by the number of compressors (n_c) to calculate $P1$, the Shoulder Season per-compressor off-mode power. Round to the nearest watt. The expression for calculating $P1$ is as follows:

$$P1 = \frac{P1_x}{n_c} \qquad \text{G6}$$

For Coil-only Systems and Blower Coil Systems for which a furnace or a Modular Blower is the designated air mover, subtract the low-voltage power (P_x) from the Shoulder Season total off-mode power ($P1_x$) and divide by the number of compressors (n_c) to calculate P1, the Shoulder Season per- compressor off-mode power. Round to the nearest watt. The expression for calculating $P1$ is as follows:

$$P1 = \frac{P1_x - P_x}{n_c} \qquad \text{G7}$$

G1.2.8 *Calculate P2.* Determine the number of compressors (n_c) as described in Section G1.2.7 of this appendix.

For Single Package Units and Blower Coil Systems for which the air mover is not a furnace, divide the heating season total off-mode power ($P2_x$) by the number of compressors (n_c) to calculate $P2$, the heating season per-compressor off-mode power. Round to the nearest watt. The expression for calculating $P2$ is as follows:

$$P2 = \frac{P2_x}{n_c} \qquad \text{G8}$$

For Coil-only Systems and Blower Coil Systems for which a furnace or a Modular Blower is the designated air mover, subtract the low-voltage power (P_x) from the heating season total off-mode power ($P2_x$) and divide by the number of compressors (n_c) to calculate $P2$, the heating season per- compressor off-mode power. Round to the nearest watt. The expression for calculating $P2$ is as follows:

$$P2 = \frac{P2_x - P_x}{n_c} \quad \text{G9}$$

G1.3 When testing a Coil-only System, install a toroidal-type transformer to power the system's low-voltage components, complying with any additional requirements for the transformer mentioned in the Installation Instructions included with the unit by the OUM. If the Installation Instructions do not provide specifications for the transformer, use a transformer having the following features:

G1.3.1 A nominal volt-amp rating such that the transformer is loaded between 25% and 90% of this rating for the highest level of power measured during the off-mode test;

G1.3.2 Designed to operate with a primary input of 230 V, single phase, 60 Hz; and

G1.3.3 That provides an output voltage that is within the stated range for each low-voltage component. Include the power consumption of the components connected to the transformer as part of the total system power consumption during the off-mode tests; do not include the power consumed by the transformer when no load is connected to it.

APPENDIX H. VERIFICATION TESTING - NORMATIVE

To comply with this standard, single sample production verification tests shall meet the Specified Standard Rating performance metrics shown in Table H1 with the listed acceptance criteria.

Table H1. Acceptance Criteria

Performance Metric	Acceptance Criteria
Cooling Metrics	
Capacity[1]	≥ 95%
SEER2	≥ 95%
$EER2_{A,Full}$	≥ 95%
Heating Metrics	
Capacity[2]	≥ 95%
HSPF2	≥ 95%

Notes:
1. Cooling capacity at A_{Full} conditions
2. Heating capacity at $H1_{Full}$ or $H1_{Nom}$ conditions, as appropriate.

APPENDIX I. CONTROLS VERIFICATION PROCEDURE - NORMATIVE

I1 *Purpose.* This Controls Verification Procedure for air conditioners and heat pumps with *variable capacity compressors* validates whether override of modulating components in regulatory tests is consistent with native control operation. This procedure verifies and characterizes the following:

- Compliance with the *variable capacity compressor system* definition.
- Consistency of operation using *native control* algorithms when controlling to maintain the indoor room dry bulb temperature, with the system operation using fixed speed/position settings for the compressor speed and indoor air flow used in the regulatory test.

I2 *Scope*. This method is applicable to *unitary air-conditioners* or *unitary heat pumps* certifiedas *variable capacity compressor system*, as defined in 3.2.78.

I3 *Setup.* Setup the system in accordance with section 5, section 6, appendix D, and appendix E unless otherwise specified in this appendix. Include thermocouple grids on the indoor air inlet and outlet or a thermopile set up to measure outlet-vs.-inlet indoor air temperature difference for transient test dry bulb temperature measurement. The data reporting and time step (Δt) interval for equations I1-I9 shall be ten seconds or less unless otherwise modified by this appendix.

I3.1 *Control Device*. For systems certified and marketed for use with only a proprietary control device (i.e., thermostat or remote controller), this control device shall be installed for testing using *native control*. Otherwise, the laboratory shall simulate a generic thermostat by connecting the low voltage control wires through the laboratory supplied relays per the *installation instructions* and simulating the thermostat as described Table I1.

I3.1.1 The simulated thermostat operation shall engage the first stage of cooling or heating when the entering indoor dry-bulb temperature is either, (a) greater than or equal to (cooling mode) 0.5°F of T_{ID} or (b) less than or equal to (heating mode) 0.5°F of $T_{ID.}$ The simulated thermostat operation shall engage the second stage when the entering dry-bulb temperature is either, (a) greater than or equal to (cooling mode) 1.5°F of $T_{ID,}$ or (b) less than or equal to (heating mode) 1.5°F of $T_{ID.}$ The simulated thermostat operation shall dis-engage the second stage when the entering indoor dry-bulb temperature is either, (a) less than or equal to (cooling mode) 0°F of T_{ID} or (b) greater than or equal to (heating mode) 0°F of $T_{ID.}$ The simulated thermostat operation shall dis-engage the first stage when the entering indoor dry-bulb temperature is either, (a) less than or equal to (cooling mode) 0.5°F of T_{ID} or (b) greater than or equal to (heating mode) 0.5°F of $T_{ID.}$

Table I1 – Simulated Thermostat Operation

Temperature difference (entering indoor temperature minus setpoint temperature), ºF	Cooling Mode	Heating Mode
<= -0.5	Off	First Stage On
<= -1.5	Off	Second Stage On
>= 0	Off	Second Stage Off
>= 0.5	Off	First Stage Off
>= 0.5	First Stage On	Off
>= 1.5	Second Stage On	Off
<=0	Second Stage Off	Off
<= -0.5	First Stage Off	Off

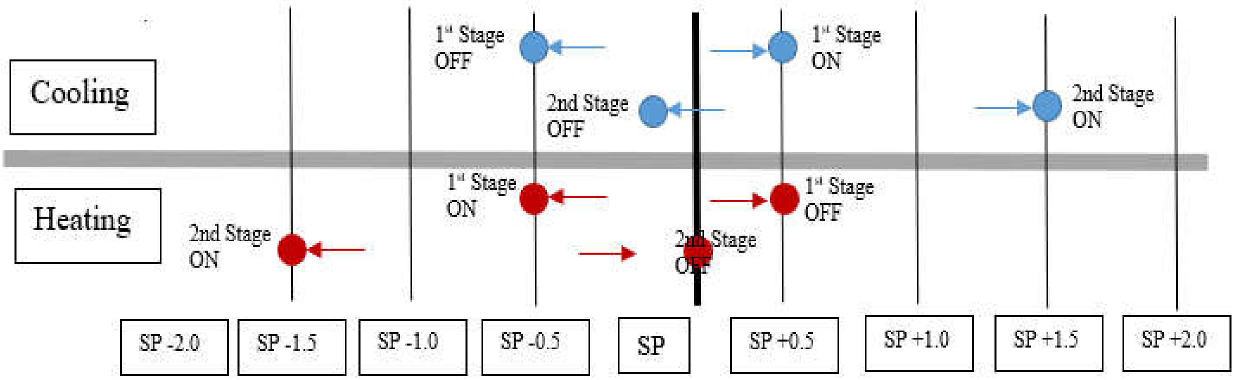

Figure I1 (Informative)

I3.1.2 *Control Device Installation***.** Install the Control Device on a flat surface (i.e. wood or insulation) extending twelve inches from the nearest edge on all sides. The Control Device must be located outside of the return air duct opening and within twelve inches of the mid-point of the nearest edge of the return air duct opening.

I3.1.3 *Thermocouple Installation***.** A thermocouple located within two inches of the inlet of the Control Device temperature sensor location shall be installed. When a remote return air thermistor is used to control the system, a second thermocouple shall be installed within two inches of remote thermistor. If both thermocouples are installed, they shall agree within 1°F of each other. Each thermocouple shall also agree with the air entering dry-bulb sensor within 1°F.

Informative note: To ensure that heat from the control device does not affect the thermocouple reading, the thermocouple should be placed upstream of the control device.

I3.1.4 *Uniformity*. It shall be permissible for mixing fans to be used to ensure temperature uniformity. Mixing fans, if used, shall not be directed at the Control Device. Air velocity as measured two inches away from the air inlet of the control device shall not exceed 50 fpm. Baffles or a perforated plate box shall be permitted to be used to reduce control device air velocity to this limit. Alternatively, a separate thermostat temperature control chamber shall be permitted to be used provided it complies with the temperature and air velocity tolerances listed in this paragraph.

I3.1.5. *Temperature Offset*. When instructed by the *installation instructions*, calibration or adjustment for control device temperature offsets shall be permitted such that displayed temperature on the control device corresponds to the thermocouple within the lowest allowable increment for the full-load interval (outdoor ambient temperatures of 95°F for cooling tests, and 17°F or 5°F for the heating tests). If there are no means for calibration or adjustments for control device temperature offset, adjust the control device setpoint by the difference between the displayed return/ambient indoor air temperature on the control device and the thermocouple(s) specified in this section.

I3.2 *Required control system accessories*. For systems shipped with a remote or in-duct temperature sensor, the sensor shall be installed according to the *installation instructions*.

I3.3 *Control setting*. Control settings shall be identical to those used in the regulatory test except that modulating component overrides are not allowed. The available control settings shall be determined from the MII. Cooling mode shall be selected for the cooling test CVP and heating mode shall be selected for heating test CVP. Auto changeover and troubleshooting /Refrigerant charge settings shall not be used. Set heat pump defrost controls per section 5.1.5. For systems having different Specified airflow control settings for full-speed, intermediate, or low-speed, set the indoor blower operation to automatic. For systems with optional settings (e.g., dehumidification, dry cooling or eco/energy save functions), these settings shall be set to default according to the MII or the "as-shipped settings" if the MII doesn't specify. In the event these optional control settings do not allow the system to operate continuously (e.g., occupancy sensor), the settings shall be modified as minimally as possible to complete the test.

Normative note: Care should be taken when selecting airflow nozzle combinations to minimize disruptions to the test.

In cases where airflow nozzle changes are required, they must occur during the transition period and the transition period shall not end fifteen minutes of a nozzle change.

I3.4 *Power measurements for digital compressor(s)*. Systems with digital compressor(s) require an integrating watt-hour measuring instrument per section 5.1.2.3. Watt-hour measurements shall be recorded at equal intervals, not to exceed one minute. Time integrated watt measurements shall be recorded every five minutes.

I4 *Test Procedure*. For each operating mode (cooling and/or heating), three tests, including the full, intermediate and minimum capacities, shall be conducted in series with intervening transition periods, using the *virtual load* (VL) approach.

I4.1 *Procedure and calculations for cooling tests*.

I4.1.1 *Full Load Interval*. Indoor return air conditions shall be controlled based on equations I1 through I6, outdoor entering dry-bulb temperature shall be set at 95.0°F, RAT(t) shall initially be set at 80.0°F, and indoor wet-bulb temperature shall initially be set at 67.0°F. Allow the system to operate to attain the tolerances specified in I5.1. Once tolerances from I5.1 are maintained for sixty minutes, the full load interval shall be considered complete. If all tolerances from I5.1 are not attained but the electrical voltage and entering outdoor dry-bulb temperature have maintained tolerances for four hours, starting from when the indoor and outdoor conditions cross the initial setpoints, the Full Load Interval is complete.

I4.1.2 *Transition Period One*. Immediately following the completion of the Full Load Interval, begin Transition Period One by updating the VL using equations I1 through I6 (do not reset T_{ID}) and simultaneously reducing the entering outdoor air dry-bulb temperature at a rate of not more than 1.0°F every fifteen minutes. Maintain tolerances specified in I5.2. Once the outdoor entering dry bulb temperature has ramped down to a point between 80.0ºF and 85.0ºF as determined by the test plan, Transition Period One is complete. If the tolerances in I5.2 are not maintained throughout the transition period, the transition period shall be repeated, re-starting from an outdoor entering dry-bulb temperature of 95.0°F.

I4.1.3 *Intermediate Load Interval*. Immediately following the completion of Transition Period One, continue to follow equations I1 through I6, and allow the system to operate for a period of at least sixty minutes after tolerances specified in I5.1 have been attained. Once tolerances from I5.1 are attained for sixty minutes, the Intermediate Load Interval shall be considered complete. If all tolerances from I5.1 are not attained but the electrical voltage and entering outdoor dry-bulb temperature have maintained tolerances for four hours, starting from when the tolerances in I5.1 are first attained, the Intermediate Load Interval is complete.

Informative Note: The target temperature for the Intermediate load interval can be any value between 80.0ºF and 85.0ºF designated by the test specifier. The range is provided to ensure that the *variable capacity compressor system* is designed to operate as expected regardless of the outdoor temperature.

I4.1.4 *Transition Period Two*. Immediately following the completion of the Intermediate Load Interval, begin transition period two by updating the VL using equations I1 through I6 (do not reset T_{ID}) and simultaneously reducing the entering outdoor air dry-bulb temperature at a rate of 1.0°F every fifteen minutes. Maintain tolerances specified in I5.2. Once the outdoor entering dry bulb temperature has ramped down to 67.0°F, Transition Period Two is complete. If the tolerances in I5.2 are not maintained throughout the transition period, the transition period shall be repeated, re-starting from the same entering dry-bulb temperature used during the Intermediate Load Interval.

I4.1.5 *Minimum Load Interval*. Immediately following the completion of Transition Period Two, continue to follow equations I1 through I6, and allow the system to operate for a period of at least sixty minutes after tolerances specified in I5.1 have been attained. Once the tolerances from I5.1 are attained for sixty minutes, the Minimum Load Interval shall be considered complete. If all tolerances from I5.1 are not attained but the electrical voltage and entering outdoor dry-bulb temperature have maintained tolerances for four hours, starting from when the tolerances in I5.1 are first attained, the Minimum Load Interval is complete.

Informative Note. The graph belowshows the outdoor room condition ramp down rate for the aforementioned series of cooling intervals, including intervals with outdoor dry bulb temperatures of 95°F, 80-85°F and 67°F and transition periods.

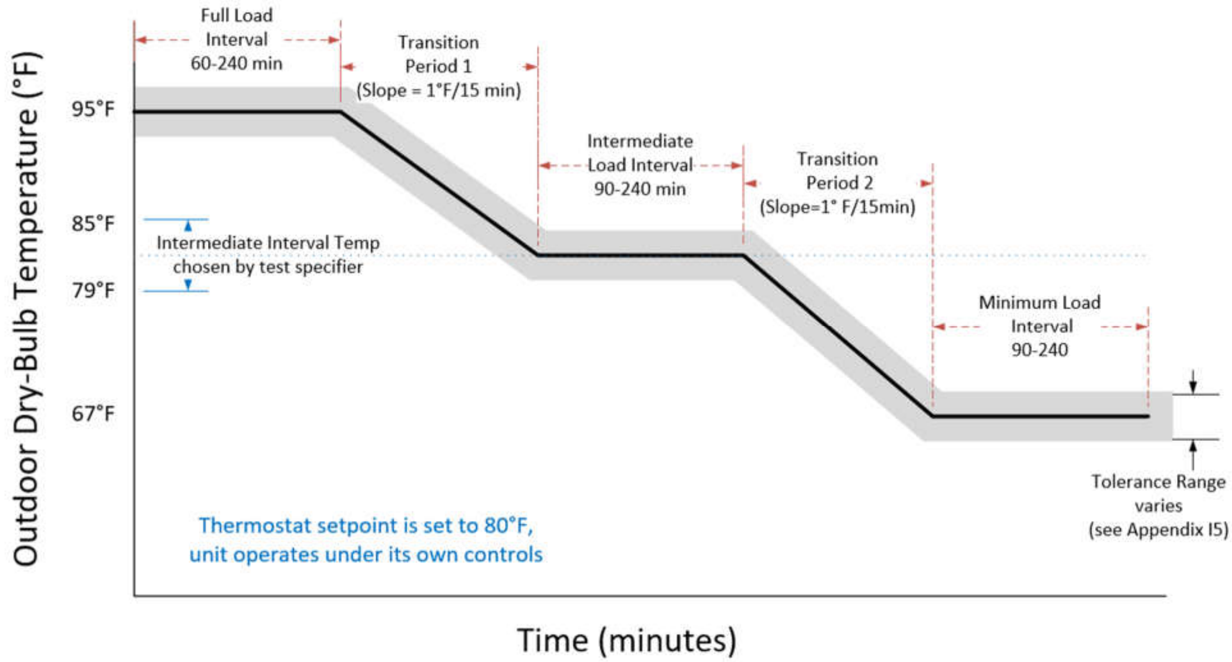

Figure I2 (Informative). Graphical representation of CVP

I4.1.6 *Cooling virtual sensible loads*. For the system under test, the sensible cooling portion of the VL, $VLs(T_j)$ (in Btu/hr), shall be simulated in the indoor room as defined by Equation I1:

$$VLs(T_j) = VLs(95) - \left[\frac{VLs(95) - VLs(67)}{95 - 67}\right] * (95 - Tj) \qquad \text{Equation I1}$$

Where:

$$VL_s(95) = SHR_{A,full} * \dot{Q}_{A,full} * 0.97 \qquad \text{Equation I2}$$

$$VL_s(67) = SHR_{F,low} * \dot{Q}_{F,low} * 1.03 \qquad \text{Equation I3}$$

$SHR_{A,full}$ = the target sensible heat ratio determined from the A_{full} regulatory test
$SHR_{F,low}$ = the target sensible heat ratio determined from the F_{low} regulatory test
$\dot{Q}_{A,full}$ = the Specified full load total cooling capacity at an outdoor ambient dry-bulb temperature of 95°F (in Btu/hr) as determined in the A_{full} regulatory test
$\dot{Q}_{F,low}$ = the Specifiedfull load total cooling capacity at an outdoor ambient dry-bulb temperature of 67°F (in Btu/hr) as determined in the F_{low} regulatory test

T_j = target outdoor ambient dry-bulb temperature for each interval

The updated target indoor dry-bulb temperature setpoint for the indoor room reconditioning system, $RAT(t + \Delta t)$, shall be updated based on the following equation:

If $RAT(t + \Delta t) < 83°F$ $\qquad RAT(t + \Delta t) = RAT(t) + \frac{\Delta t[VLs(T_J) - \dot{Q_S}]}{C}$; $\qquad$ Equation I4

Else $\qquad RAT(t + \Delta t) = 83$ $\qquad$ Equation I5

Where,
RAT(t) = the current indoor dry-bulb temperature setpoint for the indoor room reconditioning system
$\dot{Q}_S$ = the net sensible cooling capacity provided by the unit under test in the current time step, as determined by air-side measurements (see note below)
Δt = the time interval for updating the indoor room reconditioning system controller setpoint, in h
C = the simulated thermal capacitance of the building interior, in units of Btu/°F, given by

$$C = \frac{SHR_{A,full} * \dot{Q}_c(95)}{24} \qquad \text{Equation I6}$$

Airside temperature measurements shall be made using an RTD if steady-state or a thermocouple grid/thermopile if transient. If using the thermocouple grid/thermopile, use the F_{CD} value as evaluated per section E16.1.

I4.1.8 *Cooling Moisture Content*. Indoor return air wet bulb temperature shall be maintained at 67.0°F during all cooling tests.

I4.2 *Procedure and calculations for heating tests.*

I4.2.1 *CCHP Full Load Interval (Only for Heat Pumps that conduct the $H4_{full}$ test)*. If the system under test has not conducted the $H4_{full}$ test , skip ahead to Full Load Interval, Section I4.2.3. Follow equations I7 through I13 and set the outdoor entering dry-bulb temperature at 5.0°F. Allow the system to operate for a period of at least sixty minutes after tolerances specified in I5.1 have been attained. Once the tolerances from I5.1 are attained for sixty minutes, the full load interval shall be considered complete. If all tolerances from I5.1 are not attained but the electrical voltage and entering outdoor dry-bulb temperature have maintained tolerances for four hours, starting from when the indoor and outdoor conditions cross the starting setpoints, the full load interval is complete.

I4.2.2 *CCHP Transition Period (Only for Heat Pumps that conduct the $H4_{full}$ test).* If the system under test has not conducted the $H4_{full}$ test, skip ahead to Full Load Interval, Section I4.2.3. Immediately following the completion of the CCHP Full Load Interval, begin CCHP Transition Period by updating the VL using equations I7 through I13 (do not reset T_{ID}), and simultaneously increase the entering outdoor air dry-bulb temperature at a rate of 1°F every fifteen minutes. Maintain tolerances specified in I5.2. Once the outdoor entering dry bulb temperature has ramped up to 17.0°F, the CCHP Transition Period shall be considered complete. If the tolerances in I5.2 are not maintained throughout the transition period, the transition period shall be repeated, re-starting from an outdoor entering dry-bulb temperature of 5.0°F.

I4.2.3 *Full Load Interval*. Follow equations I7 through I13 and set the outdoor entering dry-bulb temperature at 17.0ºF. Allow the system to operate for a period of at least sixty minutes after tolerances in I5.1 have been attained. Once the tolerances from I5.1 are attained for sixty minutes, the full load interval is complete. If all tolerances from I5.1 are not attained and the electrical voltage and entering outdoor dry-bulb temperature have maintained tolerances for four hours, starting from when the indoor and outdoor conditions cross the starting setpoints, the Full Load Interval is complete.

I4.2.4 *Transition Period One*. Immediately following the completion of the Full Load Interval, begin Transition Period One by updating the VL using equations I7 through I13 (do not reset T_{ID}) and increasing the entering outdoor air dry-bulb temperature at a rate of 1°F every fifteen minutes. Maintain tolerances specified in I5.2. Once the outdoor entering dry bulb temperature has ramped up to between 27.0 to 32.0°F, Transition Period One is complete. If the tolerances in I5.2 are not maintained throughout the transition period, the transition period shall be repeated, re-starting from an outdoor entering dry-bulb temperature of 17.0°F.

I4.2.5 *Intermediate Load Interval*. Immediately following the completion of Transition Period One, continue to follow equations I7 through I13, and allow the system to operate for a period of at least sixty minutes after tolerances in I5.1 have been attained. Once the tolerances from I5.1 are attained for sixty minutes, the intermediate load interval shall be considered complete. If all tolerances from I5.1 are not attained, but the electrical voltage and entering outdoor dry-bulb temperature have maintained tolerances for four hours, starting from when the indoor and outdoor conditions cross the starting setpoints, the Intermediate Load Interval shall be considered complete.

Informative Note: The target temperature for the intermediate load interval can be any value between 27.0ºF and 32.0ºF, designated by the test specifier. The range is provided to ensure that the *variable capacity compressor* *system* is designed to operate as expected regardless of the outdoor temperature.

I4.2.6 *Transition Period Two*. Immediately following the completion of the Intermediate Load Interval, begin Transition Period Two by updating the VL using equations I7 through I13 (do not reset T_{ID}) and increasing the entering outdoor air dry-bulb temperature at a rate of 1°F every fifteen minutes. Maintain tolerances specified in I5.2. Once the outdoor entering dry bulb temperature has ramped up to 47.0°F, Transition Period Two shall be considered complete. If the tolerances in I5.2 are not maintained throughout the transition period, the transition period shall be repeated, re-starting from the outdoor entering dry-bulb temperature used for the intermediate load interval.

I4.2.7 *Minimum Load Interval*. Immediately following the completion of Transition Period Two, continue to follow equations I7 through I12, and allow the system to operate for a period of at least sixty minutes after tolerances specified in I5.1 have been attained. Once the tolerances from I5.1 are attained for sixty minutes, the Minimum Load Interval shall be considered complete. If all tolerances from I5.1 are not attained, but the electrical voltage and entering outdoor dry-bulb temperature have maintained tolerances for four hours, starting from when the indoor and outdoor conditions cross the starting setpoints, the Minimum Load Interval shall be considered complete.

Figure I2 represents how the outdoor room conditions are ramped up for the series of heating tests.

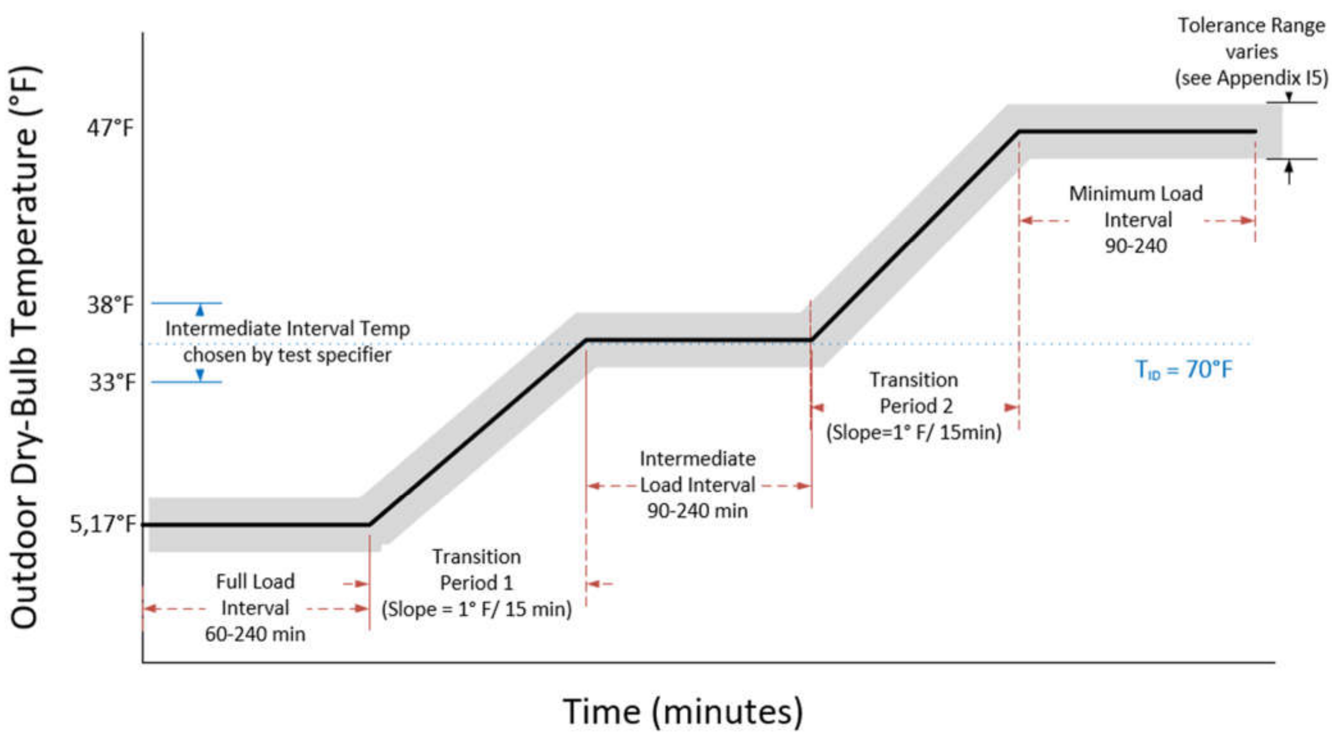

Figure I2. Informative Graphical Representation of Heating CVP

I4.2.8 *Heating load simulation*. For the system under test, the heating VL at each time step shall be determined using the following equation

The heating VL, $VL(T_j)$ (in Btu/hr), to be simulated in the indoor room shall be defined by the following equations:

For $5 < T_j < 17$ $$VL(T_j) = VL(5) + \left[\frac{VL(17) - VL(5)}{17 - 5}\right] * (T_j - 5)$$ Equation I2

For $17 \leq T_j < 47$ $$VL(T_j) = VL(47) + \left[\frac{VL(17) - VL(47)}{47 - 17}\right] * (47 - T_j)$$ Equation I8

Where:

$VL(5) \quad = \dot{Q}_h(5) * 0.97$ Equation I9

$VL(17) \quad = \dot{Q}_h(17) * 0.97$ Equation I10

$VL(47) \quad = \dot{Q}_h(47) * 1.03$ Equation I11

$\dot{Q}_h(17)$ = the measured total heating capacity of the heat pump during the $H3_{Full}$ test, Btu/h
$\dot{Q}_h(47)$ = the measured total heating capacity of the heat pump during the $H1_{low}$ test, Btu/h
T_j = outdoor ambient dry-bulb temperature for each interval, °F

The target indoor dry-bulb temperature setpoint for the indoor room reconditioning system, $RAT(t + \Delta t)$, shall be updated based on the Equation I12:

If $RAT(t + \Delta t) > 67°F$ $\quad RAT(t + \Delta t) = RAT(t) - \frac{\Delta t[VL(T_J) - \dot{Q}_h]}{C}$;

Equation I12

Else $\quad RAT(t + \Delta t) = 67$

Where,
RAT(t) = the current indoor dry-bulb temperature setpoint for the indoor room reconditioning system, °F
$\dot{Q}_h$ = the net heating capacity provided by the unit under test in the current time step, as determined by air-side measurements, Btu/h
Δt = the time interval for updating the indoor room reconditioning system controller setpoint, h
C = the simulated thermal capacitance of the building interior, Btu/°F, as determined by Equation I13

$$C = \frac{SHR_{A,full} * \dot{Q}_c(95)}{24}$$ Equation I13

I4.3 *Evaluation of CVP results.*

I4.3.1 *Variable Capacity Determination*. To determine compliance with the *variable capacity compressor system* definition, the intermediate load interval(s) shall be evaluated, using the data collected in test duration as specified in Section I4.3.1.1 to Section I4.3.1.3 , excluding the preliminary thirty minutes equilibrium data. If the standard deviation of the system power does not exceed 20% of the mean system power, the system shall be classified as *variable capacity compressor system*. For digital compressors, the five-minute time integrated watt measurements shall be used in this evaluation.

I4.3.1.1 If the system operates within the specified tolerances in Section I5.1 for sixty minutes, evaluate the compressor power (or outdoor unit power) requirement in Section I4.3.1 during that period.

I4.3.1.2 If the system reaches the four-hour time limit without maintaining the tolerances specified in Section I5.1 for a sixty-minute period, but two successive test period intervals are identified, each a minimum of thirty minutes, and each comprised of a whole number of compressor cycles (or during which the compressor does not cycle off) where both average capacity and average total power for the two periods are within 2% of each other, evaluate the compressor power (or outdoor unit power) requirement in Section I4.3.1 during those two test time periods.

I4.3.1.3. If the system reaches the four-hour time limit without maintaining the tolerances specified in Section I5.1 for a sixty-minute period and the acceptance criteria for two successive test period intervals in accordance with Section I4.3.1.2 are not met, evaluate the compressor power (or outdoor unit power) requirement in Section I4.3.1 over the final 120 minutes of the intermediate load interval.

I4.3.1.4 If a system does not comply with the compressor power (or outdoor unit power) requirement in Section I4.3.1 in either cooling or heating mode and it cycles between off and a single stage or capacity level (+/- 15%), the system shall be classified as Variable Capacity Certified, Single-Capacity System for both heating and cooling mode. Section I4.3.1.5 shall not apply.

I4.3.1.5 If a system does not comply with the compressor power (or outdoor unit power) requirement in I4.3.1 in either cooling or heating mode and it cycles between more than one stage or capacity level (+/-15%), the system shall be classified as Variable Capacity Certified, Two-Capacity System for both heating and cooling mode.

I5 *Test Condition and Test Operating Tolerances*. Test condition tolerances and test operating tolerances for the CVP shall comply with Table 2b of ASHRAE 37 and appendix E of this standard, except as modified in this section.

I5.1 For the Full, Intermediate and Minimum virtual load test intervals, the specified target indoor entering conditions (RAT(t) and w(t)) vary based on the equations in Section I4.1.7 of this appendix. The allowed deviation for indoor entering conditions shall be based on comparison to these targets rather than the setpoints used for control of the unit under test (i.e., fixed 80.0°F dry-bulb temperature and 67.0°F wet-bulb temperature (cooling) or 70.0°F dry-bulb temperature (heating)). The maximum allowed deviation between instantaneous measurements of RAT(t) and entering indoor dry-bulb shall be 1.0°F. The maximum allowed deviation for the indoor entering wet-bulb shall be 1.0°F.

I5.1.1 The test operating tolerance for nozzle pressure drop shall be 8% of reading.

I5.1.2 The test operating tolerance for indoor leaving dry-bulb shall be increased from 2.0°F to 4.0°F.

I5.1.3 The test operating tolerance for indoor leaving wet-bulb shall be increased from 1.0°F to 2.0°F.

I5.1.4 Outdoor wet bulb shall be maintained sufficiently low such that frost does not accumulate on the outdoor coil.

I5.1.5 The efficiency (EER or COP) shall not vary by more than 5%.

I5.2 For the transition periods, do not reset T_{ID}. The maximum allowed deviation between instantaneous measurements of RAT(t),entering indoor dry-bulb and indoor entering wet-bulb shall remain 1.0°F.

I5.2.1 The tolerance for the ramp down rate of outdoor entering dry-bulb temperature is five minutes for the 1.0°F per fifteen minutes ramp rate.

I5.2.2 Electrical voltage tolerances shall be maintained per section D18 of this standard.

I5.2.3 All other operating and condition tolerances shall be omitted.

APPENDIX J. DETERMINATION OF CUT-IN AND CUT-OUT TEMPERATURES - NORMATIVE

J1 *Purpose.* The purpose of this test is to confirm the Specified values $T_{OFF,C}$ and $T_{ON,C}$.

J2 Scope*.* This method is applicable to all Unitary-Air Source Heat Pumps, as defined in Section 3.1.74.

J3 *System Setup.*

Note: The system setup in the test laboratory should be as per Section 5, Section 6 and Appendix D, unless otherwise modified by the sections below.

J4 *Test Facility Requirements.* Test Facilities shall meet the requirements below in order to run the respective Cut-In and Cut-Out Tests.

J4.1 *Cut-Out Test.* In order to conduct the Cut-out Test, the Test Facility must be able to reach -22°F or a temperature that will cause the compressor to cut out (measured as described in Section J5.1 as the outdoor coil air inlet temperature), whichever is higher.

J4.2 *Cut-In Test.* In order to conduct the Cut-In Test, the Test Facility must be able to reach -22°F, or a temperature that will cause the compressor to cut out (measured as described in Section J5.1 as the outdoor coil air inlet temperature), whichever is higher.

J5 *Test Instructions.*

J5.1 *Pre-test.* For this test, capacity does not need to be measured. Measure a parameter that provides positive indication that the Heat Pump is operating in heating mode (e.g., power or discharge pressure). Also monitor the temperature of air entering the outdoor coil using one or more air samplers or parallel thermocouple grid(s) on each side of the Heat Pump that has air inlets. An additional thermocouple shall monitor the temperature at a location within two inches of the unit under test outdoor ambient sensor. Record measurements at a time interval of one-minute or shorter. The temperature of air entering the outdoor coil shall be used for determining outdoor temperature in the subsequent sections.

Informative Note: Unless the unit under test outdoor ambient sensor is located downstream of the outdoor coil, the test laboratory shall make reasonable efforts to align the unit under test outdoor ambient sensor thermocouple reading with the air entering outdoor coil temperature reading. This may include insulating vapor line service ports, locating the test unit in a position where the sensor receives adequately mixed and uniform air, and installation of additional mixing fans provided that the mixing fans do not violate the requirements of Section 8.1.2 ASHRAE 37 (air velocities in the vicinity of the equipment under test do not exceed 2.5 m/s or 500 fpm).

J5.2 *Cut-out Temperature*. Reduce outdoor temperature to a level that is 3ºF warmer than the Specified cut-out temperature for the heat pump. Pause outdoor chamber temperature reduction for not less than three minutes to allow conditions to stabilize. Continue reducing outdoor temperature in steps or continuously at an average rate of no faster than 1ºF every five minutes. The test ends when one of the following conditions is met:

J5.2.1 Test Facility has not reached $T_{OFF,C}$, but the compressor stops running.

J5.2.1.1 Record the average outdoor coil air inlet temperature when the compressor operation stopped as the tested $T_{OFF,T}$.

J5.2.1.2 Proceed to the Cut-In test.

J5.2.2 Test Facility reaches $T_{OFF,C}$ and compressor stops running at $T_{OFF,C}$.

J5.2.2.1 Record $T_{OFF,T}$ as equal to $T_{OFF,C}$.

J5.2.2.2 Proceed to the Cut-In test.

J5.2.3 Test Facility reaches $T_{OFF,C}$, but the compressor continues to run.

J5.2.3.1 Record $T_{OFF,T}$ as equal to $T_{OFF,C}$.

J5.2.3.2 Proceed to the Transition.

J5.2.4 Test Facility reaches -22°F and has not reached $T_{OFF,C}$ and the compressor continues to run.

J5.2.4.1 Record $T_{OFF,T}$ as equal to $T_{OFF,C}$.

J5.2.4.2 Continue on to the Manual Power Cycle

J5.3 *Transition.* Continue to reduce outdoor temperature at an average rate no faster than 1°F every five minutes. Transition ends when one of the following conditions is met:

J5.3.1 Test facility reaches a temperature that causes the compressor to stop. Proceed to the Cut-In test.

J5.3.2 Test facility reaches -22°F and the compressor continues to run. Proceed to the Manual Power Cycle.

J5.4 *Manual Power Cycle.* For systems where the Cut-out Temperature test ends by Section J5.2.4 or where the Transition ends by Section J5.3.2, remove the heating demand and manually cycle power. Allow the system to remain off for not less than three minutes. Then proceed to the Cut-In Temperature test.

J5.5 *Cut-in Temperature*. Begin this test by proceeding directly from the Cut-Out test, Transition, or from the Manual Power Cycle, as appropriate. Continue recording data.

J5.5.1 Following cut-out or manual power cycle, remove the heating demand if not already removed during the manual power cycle, then restart and wait for ten minutes. Then reapply the heating demand.

J5.5.1.1 If the compressor starts immediately, the test is complete. Record $T_{ON,T}$ as equal to $T_{OFF,C}$ if the outdoor coil air inlet temperature at the end of the test is lower than $T_{ON,C}$ or if the test facility had reached -22 °F during the Cut-out test or Transition. Otherwise record $T_{ON,T}$ as equal to the outdoor coil air inlet temperature at the end of the test.

J5.5.2 Then, reverse the temperature ramp and increase outdoor temperature 1 ºF every five minutes. Continue the test until five minutes after the compressor operation restarts. Set $T_{ON,T}$ equal to $T_{ON,C}$ if the outdoor coil air inlet temperature when compressor operation restarts is lower than $T_{ON,C}$. Otherwise set $T_{ON,T}$ equal to the outdoor coil air inlet temperature when compressor operation restarts

APPENDIX K. PEAK LOAD COEFFICIENT OF PERFORMANCE – NORMATIVE

K1 *Purpose.* Peak Load Coefficient of Performance (COP_{Peak}) represents the total energy consumed when meeting the building load at 5°F as calculated using Equation 11.104, including both the heat pump and supplemental heat. COP_{Peak} is distinct from COP at the H4 test condition because it accounts for the additional heat required to meet the building load at that condition.

K2 *Scope.* All *unitary heat pumps* meeting the scope of this standard can make optional representations of COP_{Peak}, whether or not they are cold climate heat pumps. Representations of COP_{Peak} must be made in accordance with this appendix. *Variable capacity compressor systems* for which representations of COP_{Peak} are reported shall have conducted either the $H1_{Full}$ and/or the $H4_{Full}$ tests.

K3 *Calculation.* COP_{Peak} (W/W) shall be calculated as follows:

$$COP_{Peak} = \frac{BL(5)}{3.412 \cdot P_{Full}(5) + \left[BL(5) - \dot{q}_{Full}(5)\right]}$$

Where:

BL(5) is evaluated using Equation 11.104 with t_j = 5°F, Btu/h

$P_{Full}(5)$ is the electrical power consumption of the heat pump during the $H4_{Full}$ test, if tested, or evaluated using Equation 11.115, if the $H4_{Full}$ test is not conducted, W.

$\dot{q}_{Full}(5)$ is the space heating capacity of the heat pump during the $H4_{Full}$ test, if tested, or evaluated using Equation 11.109, if the $H4_{Full}$ test is not conducted, Btu/h.

APPENDIX L. DUAL FUEL SYSTEM SEASONAL EFFICIENCY METRICS – NORMATIVE

L1 *Purpose.* Dual Fuel Systems (also known as ‘dual energy’ or ‘hybrid’ systems) do not have a combined seasonal efficiency metric that captures the effect of heating with the combination of an electric air-source heat pump and gas furnace. This calculation procedure provides a means of representing the seasonal site efficiency of such systems and thus enable comparison of various combinations of equipment. The procedure leverages existing test data and metrics already available to OEMs of such combined equipment (i.e. no additional testing is required for this calculation).

L2 *Scope.* This calculation method is applicable to unitary air-source heat pumps combined with a gas furnace and indoor coil.

X.X.X ((RCT 8/30 – to be moved to appendix)) *Dual Fuel Heat Pump* A central air conditioning heat pump consisting of (a) a rated combination of outdoor heat pump unit, of any type covered within this standard, (b) an indoor coil and (c) a furnace certified to DOE as an air mover and backup heat source.

L3 *Calculation.* DFUE shall be calculated as follows:

$$DFUE = \frac{TQ_{Furn}+TQ_{HP}}{(TGE_{Furnace}+TBE_{Furnace}+TE_{HP})\cdot 3.412}\cdot F_{def} \quad \text{L1}$$

Where:

DFUE is a seasonal efficiency metric: Dual Fuel Utilization Efficiency

To calculate these values, the procedures defined in Section 11.2.2 for HSPF2 are followed for the various types of heat pumps with the following changes and additions.

The building load shall be calculated using Equations L2 and L3 in place of Equation 11.104.

$$BL(t_j) = \left\{\frac{t_{zl}-t_j}{t_{zl}-t_{OD}}\right\}\cdot \dot{q}_{Furnace} * AFUE * OF \quad \text{L2}$$

$$OF = \frac{1}{1.3} \quad \text{L3}$$

Where:

$\dot{q}_{Furnace}$ = Nominal furnace input rating (Btu/h)

AFUE = Furnace rated efficiency (Annual Fuel Utilization Efficiency)

OF = Oversize Factor (assumes a 130% furnace oversizing for the design temperature)

Replace the cases for $\delta^{Full}(t_j)$ and equations 11.125, 11.126 and 11.127 with the following:

For $t_j \le t_{OFF}$ or $\frac{\dot{q}_{Full}(t_j)}{3.412\cdot P_{Full}(t_j)} < 1$ or $\dot{q}_{Full}(t_j) < BL(t_j)$

$$\delta^{Full}(t_j) = 0 \quad \text{L4}$$

For $t_{OFF} < t_j \le t_{ON}$

$$\delta^{Full}(t_j) = 0.5 \qquad \text{L5}$$

For $t_j > t_{ON}$ *and* $\dot{q}_{Full}(t_j) \geq BL(t_j)$

$$\delta^{Full}(t_j) = 1 \qquad \text{L6}$$

For the systems defined in Section 11.2.2.1.2, replace the cases for $\delta^{VAV}(t_j)$ and Equations 11.133, 11.134 and 11.135 with the following:

For $t_j \leq t_{OFF}$ *or* $\frac{\dot{q}_{VAV}(t_j)}{3.412 \cdot P_{VAV}(t_j)} < 1$ *or* $\dot{q}_{Full}(t_j) < BL(t_j)$

$$\delta^{VAV}(t_j) = 0 \qquad \text{L7}$$

For $t_{OFF} < t_j \leq t_{ON}$

$$\delta^{VAV}(t_j) = 0.5 \qquad \text{L8}$$

For $t_j > t_{ON}$ *and* $\dot{q}_{Full}(t_j) \geq BL(t_j)$

$$\delta^{VAV}(t_j) = 1 \qquad \text{L9}$$

For all types of heat pump system, calculate the following terms using the bin calculation procedure.

$$TQ_{Furn} = 0.001 \cdot HSH \cdot \sum_{j=1}^{18} \dot{q}_{Furn}(t_j) \cdot n_j \qquad \text{L10}$$

$$TQ_{HP} = 0.001 \cdot HSH \cdot \sum_{j=1}^{18} \dot{q}_{HP}(t_j) \cdot n_j \qquad \text{L11}$$

$$TGE_{Furn} = 0.001 \cdot HSH \cdot \sum_{j=1}^{18} GH(t_j) \qquad \text{L12}$$

$$TBE_{Furn} = 0.001 \cdot HSH \cdot \sum_{j=1}^{18} P_{Furn}(t_j) \cdot n_j \qquad \text{L13}$$

$$TE_{HP} = 0.001 \cdot HSH \cdot \sum_{j=1}^{18} E(t_j) \qquad \text{L14}$$

Where:

TQ_{Furn} = Total seasonal heat energy delivered by the furnace (kBtu)

TQ_{HP} = Total seasonal heat energy delivered by the heat pump (kBtu)

TGE_{Furn} = Total seasonal gas energy consumed by the furnace (kWh)

TBE_{Furn} = Total seasonal electrical energy consumed by the furnace during furnace operating hours (kWh)

TE_{HP} = Total seasonal electrical energy consumed by the heat pump (kWh)

HSH equals the heating season hours, which are the hours during which any amount of space heating is required. For Region IV, HSH = 5643 hours, For Region V, HSH = 6956 hours.

Use the following equations and cases to calculate the parameters for these bin calculations:

$$GH(t_j) = \frac{RH(t_j)}{AFUE} \quad \text{L15}$$

For $\dot{q}_{Full}(t_j) < BL(t_j)$

$$\dot{q}_{Furn}(t_j) = BL(t_j) \quad \text{L16}$$

$$\dot{q}_{HP}(t_j) = 0 \quad \text{L17}$$

$$P_{Furn}(t_j) = PE + BE \quad \text{L18}$$

For $\dot{q}_{Full}(t_j) \geq BL(t_j)$

$$\dot{q}_{Furn}(t_j) = 0 \quad \text{L19}$$

$$\dot{q}_{HP}(t_j) = BL(t_j) \quad \text{L20}$$

$$P_{Furn}(t_j) = 0 \quad \text{L21}$$

Where,

$GH(t_j)$ = Gas energy consumption of the furnace at temperature t_j (W * fractional hours)

$P_{Furn}(t_j)$ = Electrical energy consumption of the furnace blower at temperature t_j (W)

PE = Furnace Pilot Ignition Energy from the furnace submittal; this is the power the furnace draws prior to indoor blower energizing. (W)

BE = Furnace blower power draw at mid-rise, high-stage from the furnace submittal. (W)

RH = Parameter defined by equations 11.121, 11.129, 11.154, 11.169, 11.195, 11.243, 11.245 depending on the type of system. (W * fractional hours)

L4 *Procedure for heat pumps with coil-only combinations.*

If a heat pump is Specified with a coil-only combination, this procedure can be used to calculate the DFUE (and other metrics) with the following default values.

$$AFUE = 90\% \quad \text{L22}$$

$$\dot{q}_{Furnace} = FR \cdot \dot{q}_{AFull} \quad \text{L23}$$

Perform calculations for three cases to represent a range of possible furnace matches with the heat pump:

Case 1,

$FR = 1.5$ L24

Case 2,

$FR = 2.0$ L25

Case 3,

$FR = 2.5$ L26

$BE = P_{fan,x}$ L27

$PE = 71$ L28

Where:

FR = Furnace Ratio, which is a typical ratio of furnace nominal capacity to heat pump nominal capacity.

$\dot{q}_{AFull}$ is the heat pump's Specified full load Net Capacity (Btu/h)

$P_{fan,x}$ is the default fan power (W) as defined by equation 11.11 or 11.12.

For field application of these values, the following rules shall apply:

Calculate the furnace ratio (FR) based on the existing furnace nominal input and the new Specified heat pump's capacity ($\dot{q}_{AFull}$).

Use the published FR value results that are equal to or greater than for the system.

e.g. If the calculated field FR is 1.67, then use the values published for a FR of 2.0.

In the cases of applications with a calculated FR greater than 2.5, use the values published for a FR of 2.5.

L5 *Data reporting*

For Region IV and Region V, report the following results: DFUE, TQ_{Furn}, TQ_{HP}, $TGE_{Furnace}$, $TBE_{Furnace}$, and TE_{HP}.

For coil-only systems, report those same values for the three cases in L4. The parameter name shall be differentiated by appending the FR to the name.

e.g. DFUE-1.5, DFUE-2.0, DFUE-2.5