2020 Standard for Performance Rating of Walk-in Coolers and Freezers

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Note:

This standard supersedes ANSI/AHRI Standard 1250 (I-P)-2014.

Price $10.00 (Members) $20.00 (Non-Members)
Printed in U. S.A.

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PERFORMANCE RATING OF WALK-IN COOLERS AND FREEZERS

Section 1. Purpose

1.1 *Purpose.* The purpose of this standard is to establish, for walk-in coolers and freezers: definitions; test requirements; rating requirements; minimum data requirements for Published Ratings; operating requirements; marking and nameplate data and conformance conditions.

1.1.1 *Intent*. This standard is intended for the guidance of the industry, including manufacturers, designers, 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 mechanical refrigeration equipment consisting of an integrated single package refrigeration unit, or separate unit cooler and condensing unit sections, where the condensing section can be located either outdoor or indoor. Controls may be integral, or can be provided by a separate party as long as performance is tested and certified with the listed mechanical equipment accordingly.

2.2 *Exclusions*. This standard does not apply to:

2.2.1 Enclosures used for telecommunications switch gear or other equipment requiring cooling
2.2.2 Enclosures designed for medical, scientific or research purposes
2.2.3 Performance testing and efficiency characterization of large parallel rack Refrigeration Systems (condensing unit)
2.2.4 Performance testing and efficiency characterization of Walk-in Cooler and Walk-in Freezer refrigeration systems with liquid cooled condensing units
2.2.5 Performance testing and efficiency characterization of Walk-in Cooler and Walk-in Freezer refrigeration systems using Carbon dioxide, glycol, or ammonia.

Section 3. Definitions

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

3.1 *Adaptive Defrost.* A defrost control system that reduces defrost cycle frequency by initiating defrost cycles or adjusting the number of defrost cycles per day in response to operating conditions (e.g., moisture levels in the refrigerated space, coil frost load) rather than initiating defrost cycles strictly based on compressor run time or clock time.

3.2 *Annual Walk-in Energy Factor (AWEF).* A ratio of the total heat, not including the heat generated by the operation of refrigeration systems, removed, in Btu, from a walk-in box during one-year period of usage for refrigeration to the total energy input of refrigeration systems, in watt-hours, during the same period.

3.3 *Dedicated Condensing Unit.* A specific combination of Refrigeration System components for a given refrigerant, consisting of an assembly that

(1) Includes one or more electric motor driven positive displacement compressors, condensers, and accessories as provided by the manufacturer; and
(2) Is designed to serve one refrigerated load.

3.4 *Energy Efficiency Ratio (EER).* A ratio of the Refrigeration Capacity in Btu/h to the power input values in watts at any given set of Rating Conditions expressed in Btu/W·h.

3.5 *Off-cycle.* The operating state of a system when it is not in refrigeration mode. This does not include transient conditions such as pump-down. Typical items running during the Off-cycle include controls or crankcase heaters.

3.6 *On-cycle.* The operating state of a system when it is in refrigeration mode. This is a Steady-state condition and does not include transient conditions such as start-up or pull down. Typical items running during the On-cycle include evaporator fans, condenser fans, compressor, and any controls.

3.7 *Published Rating.* A statement of the assigned values of those performance characteristics, under stated rating conditions, by which a unit may be chosen to fit its application. These values apply to all units of like nominal size and type (identification) produced by the same manufacturer. The term Published Rating includes the rating of all performance characteristics shown on the unit or published in specifications, advertising or other literature controlled by the manufacturer, at stated Rating Conditions.

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

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

3.8 *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

3.8.1 *Standard Ratings Conditions.* Rating conditions used as the basis of comparison for performance characteristics.

3.9 *Refrigeration Capacity.* The capacity associated with the increase in total enthalpy between the liquid refrigerant entering the expansion valve and superheated return gas multiplied by the mass flow rate of the refrigerant.

3.9.1 *Gross Refrigeration Capacity.* The heat absorbed by the refrigerant, Btu/h. This is the sum of the Net Refrigeration Capacity and the heat equivalent of the energy required to operate the Unit Cooler. This includes both sensible and latent cooling.

3.9.2 *Net Refrigeration Capacity.* The refrigeration capacity available for space and product cooling, Btu/h. It is equal to the Gross Refrigeration Capacity less the heat equivalent of energy required to operate the Unit Cooler (e.g.: evaporator fans, defrost cycle)

3.10 *Refrigeration System.* The mechanism (including all controls and other components integral to the system's operation) used to create the refrigerated environment in the interior of a walk-in cooler or walk-in freezer, consisting of a Dedicated Condensing Unit or a Unit Cooler.

3.10.1 *Matched Refrigeration System (Matched-pair).* A combination of a Dedicated Condensing Unit and one or more Unit Coolers specified by the Dedicated Condensing Unit manufacturer which are all distributed in commerce together. Single-Packaged Dedicated Systems are a subset of Matched Refrigeration Systems.

3.10.2 *Single-packaged Refrigeration System (Single-packaged).* A Matched Refrigeration System that is a Single-packaged assembly that includes one or more compressors, a condenser, a means for forced circulation of refrigerated air, and elements by which heat is transferred from air to refrigerant, without any element external to the system imposing resistance to flow of the refrigerated air.

3.11 *Saturation Temperature.* Refrigerant temperature at the Unit Cooler inlet or outlet determined either by measuring the temperature at the outlet of the two-phase refrigerant flow, for a Liquid Overfeed Unit Cooler, or by measuring refrigerant pressure and determining the corresponding temperature from reference thermodynamic tables or equations for the refrigerant, expressed in ºF. For zeotropic refrigerants, the corresponding temperature to a measured pressure is the refrigerant Dew Point or bubble point accordingly.

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

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

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

3.13 *Steady-state.* An operating state of a system, including its surroundings, in which the extent of change with time is within the required limits within this standard.

3.14 *Test Reading.* The recording of one full set of the test measurements required to assess the performance of the test unit. The reading of a specific test instrument at a specific point in time. The test measurement may be averaged with other measurements of the same parameter at the same time to determine a Test Reading or averaged over the duration of the test to determine the value for the test run.

3.15 *Total Walk-in System Heat Load.* Total heat load to the walk-in system including Walk-in Box Load and the heat load to the box contributed by the operation of the Refrigeration System.

3.15.1 *Walk-in System High Load* ($\dot{WLH}$). Total Walk-in System Heat Load during a High Load Period.
3.15.2 *Walk-in System Low Load* ($\dot{WLL}$). Total Walk-in System Heat Load during a Low Load Period.

3.16 *Unit Cooler.* A forced-circulation free-delivery assembly, including means for forced air circulation and elements by which heat is transferred from air to refrigerant without any element external to the cooler imposing air resistance. These may also be referred to as Air Coolers, Cooling Units, Air Units or Evaporators.

3.17 *Walk-in Box Load.* Heat load to the walk-in box resulting from conduction, infiltration and internal heat gains from equipment that is not related to the refrigeration system, such as lights and anti-sweat heaters, etc.

3.17.1 *High Box Load* ($\dot{BLH}$). Walk-in Box Load during a High Load Period.
3.17.2 *Low Box Load* ($\dot{BLL}$). Walk-in Box Load during a Low Load Period.

3.18 *Walk-in Cooler (Refrigerator) and Walk-in Freezer (Freezer).* An enclosed storage space refrigerated to temperatures, respectively, above, and at or below 32 °F that can be walked into, and has a total chilled storage area of less than 3,000 ft^2. Also referred to as WICF.

3.19 *WICF Load Factor.* A ratio of the Total Walk-in System Heat Load to the Steady-state Net Refrigeration Capacity.

3.20 *WICF Load Period.* A twenty-four-hour day.

3.20.1 *WICF High Load Period.* The period of the day corresponding to frequent door openings, product loading events, and other design Load Factors. For the purposes of this standard, this period shall be 8 continuous hours.

3.20.2 *WICF Low Load Period.* The period of the day other than the High Load Period. For the purposes of this standard, this period shall be the remaining 16 continuous hours of the total Load Period.

Section 4. Instrumentation Accuracy and Test Tolerances

4.1 *Instruments Accuracy.* All measuring instruments shall be selected to meet or exceed the accuracy criteria listed in Table 1 for each type of measurement. Precision instruments and automated electronic data acquisition equipment shall be used to measure and record temperature, pressure and refrigerant flow rate test parameters. All measuring instruments and instrument systems (e.g., data acquisition coupled to temperature, pressure, or flow sensors) shall be calibrated by comparison to primary or secondary standards with calibrations traceable to National Institute of Standards and Technology (NIST) measurements, other recognized national laboratories, or derived from accepted values of natural physical constants. All test instruments shall be calibrated annually, whenever damaged, or when the accuracy is called into question.

Table 1. Instrumentation Accuracy	
Measurement	Minimum Accuracy
Temperature, Air Entering/Leaving , °F	± 0.25
Temperature, Refrigerant Liquid/Vapor at Unit Cooler In/Out, °F	± 0.5
Temperature, Others, °F	± 1
Air Relative Humidity, %	± 3
Refrigerant Pressure, psi	Pressure corresponding to ± 0.2 °F of Saturation Temperature
Air Pressure, in Hg	±0.05
Refrigerant Flow	1 % of reading
Liquid Flow	1 % of reading
Electrical, Motor kilowatts/amperes/voltage	1 % of reading
Electrical, Auxiliary kilowatt input (e.g. heater)	
Speed, Motor / fan shaft	1 % of reading
Brine Specific Gravity	1 % of reading
Time, Hours / minutes / seconds	0.5 % of time interval

4.2 *Test Operating and Test Condition Tolerances.* Unless otherwise specified, all Steady-state temperature, pressure, mass flow, electrical voltage, and electrical frequency measurements, shall be made in accordance with Table 2 or Table 3, as appropriate.

4.2.1 *Provisions for Unit Coolers Tested Alone.* If the test operating or test condition tolerances specified in Table 3 cannot be achieved due to factory supplied expansion device and/or liquid solenoid, those components may be removed from the refrigerant flow circuit. However, the removed components shall remain energized and included in the measurement of energy consumption.

Table 2. Test Operating and Test Condition Tolerances for Matched-pairs and Dedicated Condensing Units Tested Alone Steady-state Test

Measurement	Location	Test Operating Tolerance [1]	Test Condition Tolerance [2]
Indoor dry-bulb, °F	Entering temperature[6]	± 4.0	± 0.5
Indoor wet-bulb, °F	Entering temperature[6]	± 4.0	± 0.5
Outdoor dry-bulb, °F	Entering temperature[6]	± 4.0	± 1.0
Outdoor wet-bulb[3], °F	Entering temperature[6]	± 2.0	± 1.0
Electrical voltage, % of reading[4]	All	± 2.0	± 1.0
Electrical Frequency, % of reading	All	± 1.0	± 1.0
Refrigerant Mass Flow Rate	All	Greater of: 3 lb/h or 2% of reading	-
Pressure[5], % of reading	Suction	2%	1%

Notes:
1. Test operating tolerance is the maximum permissible range of any measurement. When expressed as a percentage, the maximum allowable variation is the specified percentage of the average value.
2. Test condition tolerance is the maximum permissible variation of the average value of the measurement from the specified test condition.
3. Outdoor wet bulb temperature tolerance applies only to units with evaporative cooling and Single-packaged Systems.
4. For three-phase power, voltage imbalance shall be no more than 2 % from phase to phase.
5. Suction pressure tolerances apply to only Dedicated Condensing Units tested alone.
6. Measured at air entering location, as specified in Section C3.1 of Appendix C.

Table 3. Test Operating and Test Condition Tolerances for Unit Coolers Tested Alone Steady-state Test

Measurement	Location	Test Operating Tolerance [1]	Test Condition Tolerance [2]
Indoor dry-bulb, °F	Entering temperature[3]	± 1.0	± 0.5
Indoor wet-bulb, °F	Entering temperature[3]	± 1.0	± 0.5
Air dry-bulb temperature difference, °F	Entering temperature[3]	± 0.5	-
Refrigerant Mass Flow Rate	All	Greater of: 3 lb/h or 2% of reading	-
Inlet Saturation Temperature, °F	Entering temperature	± 5.0	± 2.5
Inlet Subcooling, °F	Entering temperature	± 5.0	± 2.0
Outlet Saturation Temperature, °F	Leaving temperature	± 1.0	± 0.5
Outlet Superheat, °F	Leaving temperature	± 1.5	± 1.0
Electrical voltage, % of reading[4]	All	± 2.0	± 1.0
Electrical Frequency, % of reading	All	± 1.0	± 1.0

Notes:
1. Test operating tolerance is the maximum permissible range of any measurement. When expressed as a percentage, the maximum allowable variation is the specified percentage of the average value.
2. Test condition tolerance is the maximum permissible variation of the average value of the measurement from the specified test condition.
3. Measured at air entering location, as specified in Section C3.1 of Appendix C.
4. For three-phase power, voltage imbalance shall be no more than 2% from phase to phase.

Section 5. Testing and Rating Requirements

5.1 *Method of Test.* The method of test for walk-in cooler and freezer systems that have matched Unit Coolers and Dedicated Condensing Units, and the procedures of testing Dedicated Condensing Units and Unit Coolers individually are described in Appendix C of this standard.

5.2 *Standard Ratings.*

5.2.1 *Standard Rating Conditions.* Standard rating conditions for medium and low temperature Matched Refrigeration Systems (Matched-pairs), Unit Coolers tested alone, and Dedicated Condensing Units tested alone are established in Tables 4 through 17. The unit under test shall use the table that corresponds to the unit's configuration. All testing shall be performed at the nameplate rated voltage(s) and frequency. For equipment which is rated with 208-230 V 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.

5.2.2 *Measured Values.* Each unit under test shall have all values listed in the "Test Objective" column of the table determined using the appropriate test methods established in Appendix C.

5.2.3 *Published Standard Ratings.*

5.2.3.1 *Annual Walk-in Energy Factor (AWEF)* shall be calculated for each unit under test, according to Section 7 of this standard

5.2.3.2 *Net Refrigeration Capacity* shall be determined for each Steady-state condition listed in the applicable Standards Ratings Conditions table (see Tables 4 through 17). Net Refrigeration Capacity is calculated in Section 7 for Dedicated Condensing Units tested alone and is measured directly as dictated in Appendix C for Matched-pairs and Unit Coolers tested alone.

5.3 *Application Ratings.*

5.3.1 *Application Rating Conditions* are any operating conditions other than those established in Tables 4 through 17.

5.3.2 *Measured Values.* Each unit under test shall determine all measured values e.g., on-cycle power, off-cycle power, net or gross refrigeration capacity, and defrost cycle power (if applicable)) using the appropriate test methods established in Appendix C.

5.3.3 *Published Application Ratings.* One or more of the following shall be published for an Application Rating point.

5.3.3.1 *Net Refrigeration Capacity* shall be determined for each application rating condition. Net Refrigeration Capacity is calculated in Section 7 for Dedicated Condensing Units tested alone and is measured directly as dictated in Appendix C for Matched-pairs and Unit Coolers tested alone.

5.3.3.2 *Energy Efficiency Ratio (EER)* shall be calculated for each Steady-state application rating condition, for Matched-pair, Single-packaged, and Dedicated Condensing Units tested alone. EER is calculated as the Net Refrigeration Capacity (in Btu/h) to the system steady-state power consumption ($\dot{E}_{ss}$) (in watts). The system Steady-state power consumption includes power consumptions of compressor(s), both condenser and evaporator fans, and any other components that consume power during the Steady-state On-cycle test. EER is expressed in Btu/W·h.

5.3.3.3 *Application Rating Conditions* shall be reported when Net Refrigeration Capacity and/or EER is published. Specifically, all ambient and/or refrigerant condition categories listed in the operating condition tables (Tables 4 through 17), shall be published, for the specific application rating condition.

5.4 *Acceptance Criteria.* To comply with this standard, measured test results shall not be less than 95% of Published Ratings for Capacity, AWEF and EER.

Table 4. Standard Rating Conditions for Fixed Capacity Refrigerator Matched-pair, Dedicated Condensing Unit Located Indoor

Test Title	Unit Cooler Air Entering Dry-bulb, ˚F	Unit Cooler Air Entering Relative Humidity, %	Condenser Air Entering Dry-bulb, ˚F	Condenser Air Entering Wet-bulb[1], ˚F	Compressor Operating Mode	Test Objective
Refrigeration Capacity, Ambient Condition A	35	<50	90	75^1, 65^2	Compressor On	Determine Net Refrigeration Capacity of Unit Cooler, $\dot{q}_{ss}$ and input power, $\dot{E}_{ss}$
Off-cycle Power	35	<50	90	-	Compressor Off	Measure total input wattage during compressor off cycle, ($\dot{E}_{cu,off} + \dot{EF}_{comp,off}$)

Note:
1. Required only for evaporative Dedicated Condensing Units.
2. Maximum allowable value for Single-packaged Systems that do not use evaporative Dedicated Condensing Units, where all or part of the equipment is located in the outdoor room.

Table 5. Standard Rating Conditions for Fixed Capacity Refrigerator Matched-pair, Dedicated Condensing Unit Located Outdoor

Test Title	Unit Cooler Air Entering Dry-bulb, ˚F	Unit Cooler Air Entering Relative Humidity, %	Condenser Air Entering Dry-bulb, ˚F	Condenser Air Entering Wet-bulb, ˚F	Compressor Operating Mode	Test Objective
Refrigeration Capacity, Ambient Condition A	35	<50	95	75[1], 68[2]	Compressor On	Determine Net Refrigeration Capacity of Unit Cooler, $\dot{q}_{ss,A}$ and input power, $\dot{E}_{ss,A}$ at high temperature condition
Off-cycle Power, Ambient Condition A	35	<50	95	75[1], 68[2]	Compressor Off	Measure total input wattage during compressor Off-cycle, $(\dot{E}_{cu,off} + \dot{EF}_{comp,off})$
Refrigeration Capacity, Ambient Condition B	35	<50	59	54[1], 46[2]	Compressor On	Determine Net Refrigeration Capacity, $\dot{q}_{ss,B}$, of Unit Cooler and system input power, $\dot{E}_{ss,B}$
Off-cycle Power, Ambient Condition B	35	<50	59	54[1], 46[2]	Compressor Off	Measure total input wattage during compressor Off-cycle, $(\dot{E}_{cu,off} + \dot{EF}_{comp,off})$
Refrigeration Capacity, Ambient Condition C	35	<50	35	34[1], 29[2]	Compressor On	Determine Net Refrigeration Capacity,$\dot{q}_{ss,C}$, of Unit Cooler and system input power, $\dot{E}_{ss,C}$
Off-cycle Power, Ambient Condition C	35	<50	35	34[1], 29[2]	Compressor Off	Measure total input wattage during compressor Off-cycle, $(\dot{E}_{cu,off} + \dot{EF}_{comp,off})$

Note:

1. Required only for evaporative Dedicated Condensing Units.
2. Maximum allowable value for Single-packaged Systems that do not use evaporative Dedicated Condensing Units, where all or part of the equipment is located in the outdoor room.

Table 6. Standard Rating Conditions for Two Capacity Refrigerator Matched-pair, Dedicated Condensing Unit Located Outdoor

Test Title	Unit Cooler Air Entering Dry-bulb, ˚F	Unit Cooler Air Entering Relative Humidity, %	Condenser Air Entering Dry-bulb, ˚F	Condenser Air Entering Wet-bulb, ˚F	Compressor Operating Mode	Test Objective
Refrigeration Capacity, Ambient Condition A Low Speed	35	<50	95	75[1], 68[2]	Minimum Capacity	Determine Net Refrigeration Capacity of Unit Cooler, $\dot{q}_{ss,A}^{k=1}$, and input power, $\dot{E}_{ss,A}^{k=1}$
Refrigeration Capacity, Ambient Condition A High Speed	35	<50	95	75[1], 68[2]	Maximum Capacity	Determine Net Refrigeration Capacity of Unit Cooler, $\dot{q}_{ss,A}^{k=2}$ and input power, $\dot{E}_{ss,A}^{k=2}$
Off-cycle Power, Ambient Condition A	35	<50	95	75[1], 68[2]	Compressor Off	Measure total input wattage during compressor Off-cycle, $(\dot{E}_{cu,off} + \dot{E}F_{comp,off})$
Refrigeration Capacity, Ambient Condition B Low Speed	35	<50	59	54[1], 46[2]	Minimum Capacity	Determine Net Refrigeration Capacity of Unit Cooler, $\dot{q}_{ss,B}^{k=1}$, and system input power, $\dot{E}_{ss,B}^{k=1}$
Refrigeration Capacity, Ambient Condition B High Speed	35	<50	59	54[1], 46[2]	Maximum Capacity	Determine Net Refrigeration Capacity of Unit Cooler, $\dot{q}_{ss,B}^{k=2}$, and system input power, $E_{ss,B}^{k=2}$
Off-cycle Power, Ambient Condition B	35	<50	59	54[1], 46[2]	Compressor Off	Measure total input wattage during compressor Off-cycle, $(\dot{E}_{cu,off} + \dot{E}F_{comp,off})$
Refrigeration Capacity, Ambient Condition C Low Speed	35	<50	35	34[1], 29[2]	Minimum Capacity	Determine Net Refrigeration Capacity of Unit Cooler, $\dot{q}_{ss,C}^{k=1}$, and system input power, $\dot{E}_{ss,C}^{k=1}$

Table 6. Standard Rating Conditions for Two Capacity Refrigerator Matched-pair, Dedicated Condensing Unit Located Outdoor (continued)

Refrigeration Capacity, Ambient Condition C High Speed	35	<50	35	34[1], 29[2]	Maximum Capacity	Determine Net Refrigeration Capacity of Unit Cooler, $\dot{q}_{ss,C}^{k=2}$, and system input power, $\dot{E}_{ss,C}^{k=2}$
Off-cycle Power, Ambient Condition C	35	<50	35	34[1], 29[2]	Compressor Off	Measure total input wattage during compressor Off-cycle, $(\dot{E}_{cu,off} + \dot{EF}_{comp,off})$

Note:

1. Required only for evaporative Dedicated Condensing Units.
2. Maximum allowable value for Single-packaged Systems that do not use evaporative Dedicated Condensing Units, where all or part of the equipment is located in the outdoor room.

Table 7. Standard Rating Conditions for Variable Capacity Refrigerator Matched-pair, Dedicated Condensing Unit Located Outdoor

Test Title	Unit Cooler Air Entering Dry-bulb, ˚F	Unit Cooler Air Entering Relative Humidity, %	Condenser Air Entering Dry-bulb, ˚F	Condenser Air Entering Wet-bulb, ˚F	Compressor Operating Mode	Test Objective
Refrigeration Capacity, Ambient Condition A Low Speed	35	<50	95	75[1], 68[2]	Minimum Capacity, k=1	Determine Net Refrigeration Capacity of Unit Cooler, $\dot{q}_{ss,A}^{k=1}$, and system input power, $\dot{E}_{ss,A}^{k=1}$
Refrigeration Capacity, Ambient Condition A Variable Speed	35	<50	95	75[1], 68[2]	Intermediate Capacity[3], k=i	Determine Net Refrigeration Capacity of Unit Cooler, $\dot{q}_{ss,A}^{k=i}$, and system input power, $\dot{E}_{ss,A}^{k=i}$
Refrigeration Capacity, Ambient Condition A High Speed	35	<50	95	75[1], 68[2]	Maximum Capacity, k=2	Determine Net Refrigeration Capacity of Unit Cooler, $\dot{q}_{ss,A}^{k=2}$ and system input power, $\dot{E}_{ss,A}^{k=2}$
Off-cycle Power, Ambient Condition A	35	<50	95	75[1], 68[2]	Compressor Off	Measure total input wattage during compressor Off-cycle, $(\dot{E}_{cu,off} + \dot{EF}_{comp,off})$

Table 7. Standard Rating Conditions for Variable Capacity Refrigerator Matched-pair, Dedicated Condensing Unit Located Outdoor (continued)

Refrigeration Capacity, Ambient Condition B Low Speed	35	<50	59	54[1], 46[2]	Minimum Capacity, k=1	Determine Net Refrigeration Capacity of Unit Cooler, $\dot{q}_{ss,B}^{k=1}$, and system input power, $\dot{E}_{ss,B}^{k=1}$
Refrigeration Capacity, Ambient Condition B Variable Speed	35	<50	59	54[1], 46[2]	Intermediate Capacity[3] k=i	Determine Net Refrigeration Capacity of Unit Cooler, $\dot{q}_{ss,B}^{k=i}$, and system input power, $\dot{E}_{ss,B}^{k=i}$
Refrigeration Capacity, Ambient Condition B High Speed	35	<50	59	54[1], 46[2]	Maximum Capacity, k=2	Determine Net Refrigeration Capacity of Unit Cooler, $\dot{q}_{ss,B}^{k=2}$ and system input power, $\dot{E}_{ss,B}^{k=2}$
Off-cycle Power, Ambient Condition B	35	<50	59	54[1], 46[2]	Compressor Off	Measure total input wattage during compressor Off-cycle, ($\dot{E}_{cu,off}$ + $\dot{E}F_{comp,off}$)
Refrigeration Capacity, Ambient Condition C Low Speed	35	<50	35	34[1], 29[2]	Minimum Capacity, k=1	Determine Net Refrigeration Capacity of Unit Cooler, $\dot{q}_{ss,C}^{k=1}$, and system input power, $\dot{E}_{ss,C}^{k=1}$, at cold condition and minimum compressor capacity
Refrigeration Capacity, Ambient Condition C Variable Speed	35	<50	35	34[1], 29[2]	Intermediate Capacity[3], k=i	Determine Net Refrigeration Capacity of Unit Cooler $\dot{q}_{ss,C}^{k=i}$, and system input power, $\dot{E}_{ss,C}^{k=i}$, at cold condition and intermediate compressor capacity
Refrigeration Capacity, Ambient Condition C High Speed	35	<50	35	34[1], 29[2]	Maximum Capacity, k=2	Determine Net Refrigeration Capacity of Unit Cooler, $\dot{q}_{ss,C}^{k=2}$ and system input power, $\dot{E}_{ss,C}^{k=2}$, at cold condition and maximum compressor capacity
Off-cycle Power, Ambient Condition C	35	<50	35	34[1], 29[2]	Compressor Off	Measure total input wattage during compressor Off-cycle, ($\dot{E}_{cu,off}$ + $\dot{E}F_{comp,off}$)

Notes:

1. Required only for evaporative Dedicated Condensing Units.
2. Maximum allowable value for Single-packaged Systems that do not use evaporative Dedicated Condensing Units, where all or part of the equipment is located in the outdoor room.
3. For the intermediate capacity test, the compressor capacity shall be set to an additional capacity stage that is closest to the average of the minimum and maximum capacity.

Table 8. Standard Rating Conditions for Fixed Capacity Freezer Matched-pair, Dedicated Condensing Unit Located Indoor						
Test Title	Unit Cooler Air Entering Dry-bulb, ˚F	Unit Cooler Air Entering Relative Humidity, %	Condenser Air Entering Dry-bulb, ˚F	Condenser Air Entering Wet-bulb, ˚F	Compressor Operating Mode	Test Objective
Refrigeration Capacity, Ambient Condition A	-10	<50	90	75^1, 65^2	Compressor On	Determine Net Refrigeration Capacity of Unit Cooler, $\dot{q}_{ss,A}$ and system input power, $\dot{E}_{ss,A}$
Off-cycle Power	-10	<50	90	75^1, 65^2	Compressor Off	Measure total input wattage during compressor Off-cycle, $(\dot{E}_{cu,off} + \dot{EF}_{comp,off})$
Defrost	-10	<50			System Dependent	Test according to Appendix C Section C10, $\dot{DF}$, $\dot{Q}_{DF}$.

Note:
1. Required only for evaporative Dedicated Condensing Units.
2. Maximum allowable value for Single-packaged Systems that do not use evaporative Dedicated Condensing Units, where all or part of the equipment is located in the outdoor room.

Table 9. Standard Rating Conditions for Fixed Capacity Freezer Matched-pair, Dedicated Condensing Unit Located Outdoor						
Test Title	Unit Cooler Air Entering Dry-bulb, ˚F	Unit Cooler Air Entering Relative Humidity, %	Condenser Air Entering Dry-bulb, ˚F	Condenser Air Entering Wet-bulb, ˚F	Compressor Operating Mode	Test Objective
Refrigeration Capacity, Ambient Condition A	-10	<50	95	75^1, 68^2	Compressor On	Determine Net Refrigeration Capacity of Unit Cooler, $\dot{q}_{ss,A}$ and system input power, $\dot{E}_{ss,A}$
Off-cycle Power, Ambient Condition A	-10	<50	95	75^1, 68^2	Compressor Off	Measure total input wattage during compressor Off-cycle, $(\dot{E}_{cu,off} + \dot{EF}_{comp,off})$
Refrigeration Capacity, Ambient Condition B	-10	<50	59	54^1, 46^2	Compressor On	Determine Net Refrigeration Capacity of Unit Cooler, $\dot{q}_{ss,B}$, and system input power, $\dot{E}_{ss,B}$, at moderate condition
Off-cycle Power, Ambient Condition B	-10	<50	59	54^1, 46^2	Compressor Off	Measure total input wattage during compressor Off-cycle, $(\dot{E}_{cu,off} + \dot{EF}_{comp,off})$

Table 9. Standard Rating Conditions for Fixed Capacity Freezer Matched-pair, Dedicated Condensing Unit Located Outdoor (continued)

Refrigeration Capacity, Ambient Condition C	-10	<50	35	34^1, 29^2	Compressor On	Determine Net Refrigeration Capacity of Unit Cooler, $\dot{q}_{ss,C}$, and system input power, $\dot{E}_{ss,C}$, at cold condition
Off-cycle Power, Ambient Condition C	-10	<50	35	34^1, 29^2	Compressor Off	Measure total input wattage during compressor Off-cycle, $(\dot{E}_{cu,off} + \dot{E}F_{comp,off})$
Defrost	-10	<50			System Dependent	Test according to Appendix C Section C10, $\dot{DF}$, $\dot{Q}_{DF}$.

Note:

1. Required only for evaporative Dedicated Condensing Units.
2. Maximum allowable value for Single-packaged Systems that do not use evaporative Dedicated Condensing Units, where all or part of the equipment is located in the outdoor room.

Table 10. Standard Rating Conditions for Two Capacity Freezer Matched-pair, Dedicated Condensing Unit Located Outdoor

Test Title	Unit Cooler Air Entering Dry-bulb, ˚F	Unit Cooler Air Entering Relative Humidity, %	Condenser Air Entering Dry-bulb, ˚F	Condenser Air Entering Wet-bulb, ˚F	Compressor Operating Mode	Test Objective
Refrigeration Capacity, Ambient Condition A Low Speed	-10	<50	95	75^1, 68^2	Minimum Capacity, k=1	Determine Net Refrigeration Capacity of Unit Cooler, $\dot{q}_{ss,A}^{k=1}$, and input power, $\dot{E}_{ss,A}^{k=1}$
Refrigeration Capacity, Ambient Condition A High Speed	-10	<50	95	75^1, 68^2	Maximum Capacity, k=2	Determine Net Refrigeration Capacity of Unit Cooler, $\dot{q}_{ss,A}^{k=2}$ and input power, $\dot{E}_{ss,A}^{k=2}$
Off-cycle Power, Ambient Condition A	-10	<50	95	75^1, 68^2	Compressor Off	Measure total input wattage during compressor Off-cycle, $(\dot{E}_{cu,off} + \dot{E}F_{comp,off})$

Table 10. Standard Rating Conditions for Two Capacity Freezer Matched-pair, Dedicated Condensing Unit Located Outdoor (continued)

Refrigeration Capacity, Ambient Condition B Low Speed	-10	<50	59	54[1], 46[2]	Minimum Capacity, k=1	Determine Net Refrigeration Capacity of Unit Cooler, $\dot{q}_{ss,B}^{k=1}$, and system input power, $\dot{E}_{ss,B}^{k=1}$
Refrigeration Capacity, Ambient Condition B High Speed	-10	<50	59	54[1], 46[2]	Maximum Capacity, k=2	Determine Net Refrigeration Capacity of Unit Cooler, $\dot{q}_{ss,B}^{k=2}$, and system input power, $E_{ss,B}^{k=2}$
Off-cycle Power, Ambient Condition B	-10	<50	59	54[1], 46[2]	Compressor Off	Measure total input wattage during compressor Off-cycle, $(\dot{E}_{cu,off} + \dot{EF}_{comp,off})$
Refrigeration Capacity, Ambient Condition C Low Speed	-10	<50	35	34[1], 29[2]	Minimum Capacity, k=1	Determine Net Refrigeration Capacity of Unit Cooler, $\dot{q}_{ss,C}^{k=1}$, and system input power, $\dot{E}_{ss,C}^{k=1}$
Refrigeration Capacity, Ambient Condition C High Speed	-10	<50	35	34[1], 29[2]	Maximum Capacity, k=2	Determine Net Refrigeration Capacity of Unit Cooler, $\dot{q}_{ss,C}^{k=2}$, and system input power, $\dot{E}_{ss,C}^{k=2}$
Off-cycle Power, Ambient Condition C	-10	<50	35	34[1], 29[2]	Compressor Off	Measure total input wattage during compressor Off-cycle, $(\dot{E}_{cu,off} + \dot{EF}_{comp,off})$
Defrost	-10	<50			System Dependent	Test according to Appendix C Section C10, $\dot{DF}$, $\dot{Q}_{DF}$.

Note:

1. Required only for evaporative Dedicated Condensing Units.
2. Maximum allowable value for Single-packaged Systems that do not use evaporative Dedicated Condensing Units, where all or part of the equipment is located in the outdoor room.

Table 11. Standard Rating Conditions for Variable Capacity Freezer Matched-pair, Dedicated Condensing Unit Located Outdoor

Test Title	Unit Cooler Air Entering Dry-bulb, ˚F	Unit Cooler Air Entering Relative Humidity, %	Condenser Air Entering Dry-bulb, ˚F	Condenser Air Entering Wet-bulb, ˚F	Compressor Operating Mode	Test Objective
Refrigeration Capacity, Ambient Condition A Low Speed	-10	<50	95	75[1], 68[2]	Minimum Capacity, k=1	Determine Net Refrigeration Capacity of Unit Cooler, $\dot{q}_{ss,A}^{k=1}$, and system input power, $\dot{E}_{ss,A}^{k=1}$
Refrigeration Capacity, Ambient Condition A Variable Speed	-10	<50	95	75[1], 68[2]	Intermediate Capacity[3], k=i	Determine Net Refrigeration Capacity of Unit Cooler, $\dot{q}_{ss,A}^{k=i}$, and system input power, $\dot{E}_{ss,A}^{k=i}$,
Refrigeration Capacity, Ambient Condition A High Speed	-10	<50	95	75[1], 68[2]	Maximum Capacity, k=2	Determine Net Refrigeration Capacity of Unit Cooler, $\dot{q}_{ss,A}^{k=2}$ and system input power, $\dot{E}_{ss,A}^{k=2}$
Off-cycle Power, Ambient Condition A	-10	<50	95	75[1], 68[2]	Compressor Off	Measure total input wattage during compressor Off-cycle, ($\dot{E}_{cu,off}$ + $\dot{E}F_{comp,off}$)
Refrigeration Capacity, Ambient Condition B Low Speed	-10	<50	59	54[1], 46[2]	Minimum Capacity, k=1	Determine Net Refrigeration Capacity of Unit Cooler, $\dot{q}_{ss,B}^{k=1}$, and system input power, $\dot{E}_{ss,B}^{k=1}$
Refrigeration Capacity, Ambient Condition B Variable Speed	-10	<50	59	54[1], 46[2]	Intermediate Capacity[3], k=i	Determine Net Refrigeration Capacity of Unit Cooler, $\dot{q}_{ss,B}^{k=i}$, and system input power, $\dot{E}_{ss,B}^{k=i}$
Refrigeration Capacity, Ambient Condition B High Speed	-10	<50	59	54[1], 46[2]	Maximum Capacity, k=2	Determine Net Refrigeration Capacity of Unit Cooler, $\dot{q}_{ss,B}^{k=2}$ and system input power, $\dot{E}_{ss,B}^{k=2}$

Table 11. Standard Rating Conditions for Variable Capacity Freezer Matched-pair, Dedicated Condensing Unit Located Outdoor (continued)

Off-cycle Power, Ambient Condition B	-10	<50	59	54^1, 46^2	Compressor Off	Measure total input wattage during compressor Off-cycle, ($\dot{E}_{cu,off}$ + $\dot{EF}_{comp,off}$)
Refrigeration Capacity, Ambient Condition C Low Speed	-10	<50	35	34^1, 29^2	Minimum Capacity, k=1	Determine Net Refrigeration Capacity of Unit Cooler, $\dot{q}_{ss,C}^{k=1}$, and system input power, $\dot{E}_{ss,C}^{k=1}$
Refrigeration Capacity, Ambient Condition C Variable Speed	-10	<50	35	34^1, 29^2	Intermediate Capacity^3, k=i	Determine Net Refrigeration Capacity of Unit Cooler $\dot{q}_{ss,C}^{k=i}$, and system input power, $\dot{E}_{ss,C}^{k=1}$
Refrigeration Capacity, Ambient Condition C High Speed	-10	<50	35	34^1, 29^2	Maximum Capacity, k=2	Determine Net Refrigeration Capacity of Unit Cooler, $\dot{q}_{ss,C}^{k=2}$ and system input power, $\dot{E}_{ss,C}^{k=1}$
Off-cycle Power, Ambient Condition C	-10	<50	35	34^1, 29^2	Compressor Off	Measure total input wattage during compressor Off-cycle, ($\dot{E}_{cu,off}$ + $\dot{EF}_{comp,off}$)
Defrost	-10	<50			System Dependent	Test according to Appendix C Section C10, $\dot{DF}$, $\dot{Q}_{DF}$.

Notes:

1. Required only for evaporative Dedicated Condensing Units.
2. Maximum allowable value for Single-packaged Systems that do not use evaporative Dedicated Condensing Units, where all or part of the equipment is located in the outdoor room.
3. For the intermediate capacity test, the compressor capacity shall be set to an additional capacity stage that is closest to the average of the minimum and maximum capacity.

Table 12. Standard Rating Conditions for Fixed Capacity Refrigerator Dedicated Condensing Unit, Dedicated Condensing Unit Located Indoor[1]

Test Title	Suction Dew Point, ˚F	Return Gas[2], ˚F	Condenser Air Entering Dry-bulb, ˚F	Condenser Air Entering Wet-bulb[3], ˚F	Compressor Operating Mode	Test Objective
Refrigeration Capacity, Ambient Condition A	23	41	90	75	Compressor On	Determine Gross Refrigeration Capacity, $\dot{Q}_{gross,i}$, and input power, $\dot{E}_{CU,on}$, of Dedicated Condensing Unit
Off-cycle Power	-	-	90	75	Compressor Off	Measure total input wattage during compressor Off-cycle, ($\dot{E}_{cu,off}$)

Notes:
1. Subcooling shall be set according to equipment specification and reported as part of standard rating.
2. Measured at the Dedicated Condensing Unit inlet location.
3. Required only for evaporative Dedicated Condensing Units.

Table 13. Standard Rating Conditions for Fixed Capacity Refrigerator Dedicated Condensing Unit, Dedicated Condensing Unit Located Outdoor[1]

Test Title	Suction Dew Point, ˚F	Return Gas[2], ˚F	Condenser Air Entering Dry-bulb, ˚F	Condenser Air Entering Wet-bulb[3], ˚F	Compressor Operating Mode	Test Objective
Refrigeration Capacity, Ambient Condition A	23	41	95	75	Compressor On	Determine Gross Refrigeration Capacity, $\dot{Q}_{gross,A}$, and input power, $\dot{E}_{CU,on,A}$, of Dedicated Condensing Unit
Off-cycle Power, Ambient Condition A	-	-	95	75	Compressor Off	Measure total input wattage during compressor Off-cycle, ($\dot{E}_{cu,off}$)
Refrigeration Capacity Ambient Condition B	23	41	59	54	Compressor On	Determine Gross Refrigeration Capacity, $\dot{Q}_{gross,B}$, and input power, $\dot{E}_{CU,on,B}$, of Dedicated Condensing Unit
Off-cycle Power, Ambient Condition B	-	-	59	54	Compressor off	Measure total input wattage during compressor Off-cycle, ($\dot{E}_{cu,off}$)
Refrigeration Capacity Ambient Condition C	23	41	35	34	Compressor On	Determine Gross Refrigeration Capacity, $\dot{Q}_{gross,C}$, and input power, $\dot{E}_{CU,on,C}$, of Dedicated Condensing Unit
Off-cycle Power, Ambient Condition C	-	-	35	34	Compressor off	Measure total input wattage during compressor Off-cycle, ($\dot{E}_{cu,off}$)

Table 13. Standard Rating Conditions for Fixed Capacity Refrigerator Dedicated Condensing Unit, Dedicated Condensing Unit Located Outdoor[1] (continued)

Notes:

1. Subcooling shall be set according to equipment specification and reported as part of standard rating.
2. Measured at the Dedicated Condensing Unit inlet location.
3. Required only for evaporative Dedicated Condensing Units.

Table 14. Standard Rating Conditions for Fixed Capacity Freezer Dedicated Condensing Unit, Dedicated Condensing Unit Located Indoor[1]

Test Title	Suction Dew Point, ˚F	Return Gas^2, ˚F	Condenser Air Entering Dry-bulb , ˚F	Condenser Air Entering Wet-bulb^3, ˚F	Compressor Operating Mode	Test Objective
Refrigeration Capacity, Ambient Condition A	-22	5	90	75	Compressor On	Determine Gross Refrigeration Capacity, $\dot{Q}_{gross,i}$, and input power, $\dot{E}_{CU,on}$, of Dedicated Condensing Unit
Off-cycle Power	-	-	90	75	Compressor Off	Measure total input wattage during compressor Off-cycle, ($\dot{E}_{cu,off}$)

Notes:

1. Subcooling shall be set according to equipment specification and reported as part of standard rating.
2. Measured at the Dedicated Condensing Unit inlet location.
3. Required only for evaporative Dedicated Condensing Units.

Table 15. Standard Rating Conditions for Fixed Capacity Freezer Dedicated Condensing Unit, Dedicated Condensing Unit Located Outdoor[1]

Test Title	Suction Dew Point, ˚F	Suction Gas^2, ˚F	Condenser Air Entering Dry-bulb, ˚F	Condenser Air Entering Wet-bulb^3, ˚F	Compressor Operating Mode	Test Objective
Refrigeration Capacity, Ambient Condition A	-22	5	95	75	Compressor On	Determine Gross Refrigeration Capacity, $\dot{Q}_{gross,A}$, and input power, $\dot{E}_{CU,on,A}$, of Dedicated Condensing Unit
Off-cycle Power, Ambient Condition A	-	-	95	75	Compressor Off	Measure total input wattage during compressor Off-cycle, ($\dot{E}_{cu,off}$)
Refrigeration Capacity, Ambient Condition B	-22	5	59	54	Compressor On	Determine Gross Refrigeration Capacity, $\dot{Q}_{gross,B}$, and input power, $\dot{E}_{CU,on,B}$, of Dedicated Condensing Unit
Off-cycle Power, Ambient Condition B	-	-	59	54	Compressor Off	Measure total input wattage during compressor Off-cycle, ($\dot{E}_{cu,off}$)
Refrigeration Capacity, Ambient Condition C	-22	5	35	34	Compressor On	Determine Gross Refrigeration Capacity, $\dot{Q}_{gross,C}$, and input power, $\dot{E}_{CU,on,C}$, of Dedicated Condensing Unit
Off-cycle Power, Ambient Condition C	-	-	35	34	Compressor Off	Measure total input wattage during compressor Off-cycle, ($\dot{E}_{cu,off}$)

Table 15. Standard Rating Conditions for Fixed Capacity Freezer Dedicated Condensing Unit, Dedicated Condensing Unit Located Outdoor[1]

Notes:
1. Subcooling shall be set according to equipment specification and reported as part of standard rating.
2. Measured at the Dedicated Condensing Unit inlet location.
3. Required only for evaporative Dedicated Condensing Units

Table 16. Standard Rating Conditions for Refrigerator Unit Cooler[1]

Test Title	Unit Cooler Air Entering Dry-bulb, ˚F	Unit Cooler Air Entering Relative Humidity, %	Suction Dew Point Temp[2], ˚F	Liquid Inlet Bubble Point Temperature, ˚F	Liquid Inlet Subcooling, ˚F	Compressor Operating Mode	Test Objective
Off-cycle Fan Power	35	<50	-	-	-	Compressor Off	Measure fan input power during compressor off cycle, $\dot{EF}_{comp,off}$
Refrigeration Capacity, Ambient Condition A	35	<50	25	105	9	Compressor On	Determine Net Refrigeration Capacity of Unit Cooler, $\dot{q}_{mix,rack}$

Note:
1. Superheat shall be set according to equipment specification in equipment or installation manual, if no superheat specification is given a default superheat value of 6.5 °F shall be used. The superheat setting used in the test shall be reported as part of standard rating.
2. Suction Dew Point shall be measured at the Unit Cooler Exit conditions

Table 17. Standard Rating Conditions for Freezer Unit Cooler[1]

Test Title	Unit Cooler Air Entering Dry-bulb, ˚F	Unit Cooler Air Entering Relative Humidity, %	Suction Dew Point Temp[2], ˚F	Liquid Inlet Bubble Point Temperature ˚F	Liquid Inlet Subcooling, ˚F	Compressor Operating Mode	Test Objective
Off-cycle Fan Power	-10	<50	-	-	-	Compressor Off	Measure fan input wattage during compressor off cycle, $\dot{EF}_{comp,off}$
Refrigeration Capacity, Ambient Condition A	-10	<50	-20	105	9	Compressor On	Determine Net Refrigeration Capacity of Unit Cooler, $\dot{q}_{mix,rack}$
Defrost	-10	<50	-	-	-	Compressor Off	Test according to Appendix C Section C10, $\dot{DF}$, $\dot{Q}_{DF}$.

Note:
1. Superheat shall be set according to equipment specification in equipment or installation manual, if no superheat specification is given a default superheat value of 6.5 °F shall be used. The superheat setting used in the test shall be reported as part of standard rating.
2. Suction Dew Point shall be measured at the Unit Cooler Exit conditions

Section 6. Calculation for Walk-in Box Load

6.1 *General Description.* The Walk-in Box Load is comprised of a High Load Period ($B\dot{L}H$) of the day corresponding to frequent door openings, product loading events, and other design Load Factors, and a Low Load Period of the day ($B\dot{L}L$) corresponding to the minimum load resulting from conduction, internal heat gains from equipment that is not related to the Refrigeration System, and infiltration when the door is closed. Both the $B\dot{L}H$ and $B\dot{L}L$ are defined as a linear relationship with outdoor ambient temperature. This relationship accounts for the influence of outdoor ambient on the conduction and infiltration loads for a "typical" walk-in box. The High Load Period for $B\dot{L}H$ is 8 hours per day or 1/3 of the operating hours, and the Low Load Period for $B\dot{L}L$ is 16 hours per day or 2/3 of the operating hours.

Note: The $B\dot{L}H$ and $B\dot{L}L$ equations established in this section are subsequently used in Section 7 as a part of the Annual Walk-in Energy Factor (AWEF) calculations.

6.2 *WICF Load Equations*

6.2.1 *Indoor Cooler and Freezer Dedicated Condensing Unit or Matched-pair.* The walk-in box and the Dedicated Condensing Unit are both located within a conditioned space. The Walk-in Box Load during a High Load Period is calculated using Equation 1.

$$\mathrm{B\dot{L}H} = \begin{Bmatrix} 0.7 \cdot \dot{q}_{ss,ID} & \text{for coolers} \\ 0.8 \cdot \dot{q}_{ss,ID} & \text{for freezers} \end{Bmatrix} \qquad 1$$

In which, the High Box Load equals 70% of the Refrigeration System Steady-state net capacity at the design point of 90˚F for coolers and 80% of this capacity for freezers. The Net Refrigeration Capacity shall be measured directly from the test, per the procedure defined in the Section 4 of this standard for coolers and Section 5 for freezers.

For coolers, the Walk-in Box Load during a Low Load Period equals 10% of the Refrigeration System Steady-state net capacity at the design point of 90˚F; for freezers, it equals 40% of this capacity. The Low Box Load can therefore be calculated using Equation 2.

$$\mathrm{B\dot{L}L} = \begin{Bmatrix} 0.1 \cdot \dot{q}_{ss,ID} & \text{for coolers} \\ 0.4 \cdot \dot{q}_{ss,ID} & \text{for freezers} \end{Bmatrix} \qquad 2$$

Note: $B\dot{L}H$ and $B\dot{L}L$ in Equations 1 and 2 are the Walk-in Box Loads during High and Low Load Periods for a refrigerator or freezer indoor Dedicated Condensing Unit. Section 6.2.2 calculates $B\dot{L}H$ and $B\dot{L}L$ for a refrigerator or freezer outdoor Dedicated Condensing Unit.

6.2.2 *Outdoor Cooler and Freezer Dedicated Condensing Unit.* The Walk-in Box Load at different bin temperatures (t_j) during High and Low Load Periods are calculated in Equations 3 and 4.

$$\mathrm{B\dot{L}H}(t_j) = \begin{Bmatrix} 0.65 \cdot \dot{q}_{ss,A} + 0.05 \cdot \dfrac{\dot{q}_{ss,A} \cdot (t_j - 35)}{60} & \text{for coolers} \\ 0.55 \cdot \dot{q}_{ss,A} + 0.25 \cdot \dfrac{\dot{q}_{ss,A} \cdot (t_j + 10)}{105} & \text{for freezers} \end{Bmatrix} \qquad 3$$

$$\mathrm{B\dot{L}L}(t_j) = \begin{Bmatrix} 0.03 \cdot \dot{q}_{ss,A} + 0.07 \cdot \dfrac{\dot{q}_{ss,A} \cdot (t_j - 35)}{60} & \text{for coolers} \\ 0.15 \cdot \dot{q}_{ss,A} + 0.25 \cdot \dfrac{\dot{q}_{ss,A} \cdot (t_j + 10)}{105} & \text{for freezers} \end{Bmatrix} \qquad 4$$

Section 7. Calculation for Annual Walk-in Energy Factor (AWEF)

7.1 *General Description.* This section contains methods to calculate AWEF, based on performance data obtained from testing at the Standard Rating Conditions defined in Section 5, for the following walk-in configurations:

7.1.1 Matched-pairs and single-package systems with single capacity compressor and outdoor Dedicated Condensing Unit (Section 7.4)

7.1.2 Matched-pairs and single-package systems with two-capacity compressor and outdoor Dedicated Condensing Unit (Section 7.5)

7.1.3 Matched-pairs and single-package systems with variable capacity compressor and outdoor Dedicated Condensing Unit (Section 7.6)

7.1.4 Matched-pairs and single-package systems with single capacity compressor and indoor Dedicated Condensing Unit (Section 7.7)

7.1.5 Unit Coolers tested alone (Section 7.8)

7.1.6 Fixed capacity Dedicated Condensing Units tested alone (Section 7.9)

For systems with outdoor Dedicated Condensing Units, the AWEF is calculated by weighting system performance at individual bins temperature by bin hours (i.e., the number of hours for a given temperature occurs over the year), as defined in Appendix D. For systems with indoor Dedicated Condensing Units, the AWEF is calculated based on tested system capacity and power at a single ambient condition. For Unit Coolers tested alone, AWEF is calculated using an EER lookup table, where EER is selected based on suction dew point temperature.

7.2 The Total Walk-in System Heat Load includes the Walk-in Box Load ($B\dot{L}H$ and $B\dot{L}L$), defined in Section 6, and the heat load contributed by the operation of the Refrigeration System (i.e., evaporator fan power and defrost cycle). The Total Walk-in System Heat Load is also comprised of a High Load Period ($W\dot{L}H$) and a Low Load Period ($W\dot{L}L$), corresponding to the Walk-in Box Loads $B\dot{L}H$ and $B\dot{L}L$. The Refrigeration System operates 8 hours (or 1/3 of operating hours) under High Load Period, and 16 hours (or 2/3 of operating time) during Low Load Period as defined in Section 6.1.

7.3 Load Factor is defined as the ratio of the Total Walk-in System Heat Load to the system Net Refrigeration Capacity. The Load Factors during High and Low Load Periods at each bin temperature can be calculated using Equations 5 and 6.

$$\mathrm{LFH}(t_j) = \frac{\mathrm{W\dot{L}H}(t_j)}{\dot{q}_{ss}(t_j)} \tag{5}$$

$$\mathrm{LFL}(t_j) = \frac{\mathrm{W\dot{L}L}(t_j)}{\dot{q}_{ss}(t_j)} \tag{6}$$

7.4 *Calculation of AWEF for Matched-pairs and Single-package Systems with Single Capacity Compressor and Outdoor Dedicated Condensing Unit.*

7.4.1 The operation of units with single capacity compressors is illustrated in Figure 1. The Total Walk-in System Heat Loads at each bin temperature during High and Low Load Periods for the walk-in unit with single capacity compressor are calculated by the following equations. The terms of defrost cycle power contributing to the box load, $\dot{Q}_{DF}$, and to the system power consumption, $\dot{DF}$, in these equations shall only be applied to the walk-in freezer systems, and shall be set to zero during the calculation for the walk-in refrigerator systems.

$$\mathrm{W\dot{L}H}\,(t_j) = \mathrm{B\dot{L}H}(t_j) + 3.412 \cdot \mathrm{\dot{E}F}_{comp,off} \cdot \left(1 - \mathrm{LFH}(t_j)\right) + \dot{Q}_{DF} \tag{7}$$

$$\mathrm{W\dot{L}L}(t_j) = \mathrm{B\dot{L}L}(t_j) + 3.412 \cdot \mathrm{\dot{E}F}_{comp,off} \cdot \left(1 - \mathrm{LFL}(t_j)\right) + \dot{Q}_{DF} \tag{8}$$

Substituting Equation 5 into Equation 7 and solving for LFH(t_j) using Equation 9.

$$LFH(t_j) = \frac{W\dot{L}H(t_j)}{\dot{q}_{ss}(t_j)} = \frac{B\dot{L}H(t_j) + 3.412\cdot E\dot{F}_{comp,off} + \dot{Q}_{DF}}{\dot{q}_{ss}(t_j) + 3.412\cdot E\dot{F}_{comp,off}} \qquad 9$$

Substituting Equation 6 into Equation 8 and solving for LFL(t_j) using Equation 10.

$$LFL(t_j) = \frac{W\dot{L}L(t_j)}{\dot{q}_{ss}(t_j)} = \frac{B\dot{L}L(t_j) + 3.412\cdot E\dot{F}_{comp,off} + \dot{Q}_{DF}}{\dot{q}_{ss}(t_j) + 3.412\cdot E\dot{F}_{comp,off}} \qquad 10$$

The Annual Walk-in Energy Factor, AWEF, is determined using Equation 11.

$$AWEF = \sum_{j=1}^{n} BL(t_j) / \sum_{j=1}^{n} E(t_j) \qquad 11$$

The term $BL(t_j)$ and E(t_j), summed over the temperature bins found in Appendix D, are evaluated at each temperature bin, and calculated using Equations 12 and 13.

$$BL(t_j) = \left[0.33 \cdot B\dot{L}H(t_j) + 0.67 \cdot B\dot{L}L(t_j)\right] \cdot n_j \qquad 12$$

$$E(t_j) = \left\{ \begin{array}{c} 0.33\cdot \left[\dot{E}_{ss}(t_j) \cdot LFH(t_j) + (\dot{E}_{CU,off} + E\dot{F}_{comp,off}) \cdot \left(1 - LFH(t_j)\right)\right] + 0.67 \cdot \\ \left[\dot{E}_{ss}(t_j) \cdot LFL(t_j) + (\dot{E}_{CU,off} + E\dot{F}_{comp,off}) \cdot \left(1 - LFL(t_j)\right)\right] + D\dot{F} \end{array} \right\} \cdot n_j \qquad 13$$

In the calculation above, the Refrigeration System operates 8 hours or 1/3 of operating hours under High Load Period, and 16 hours or 2/3 of operating time during Low Load Period as in Section 7.2.

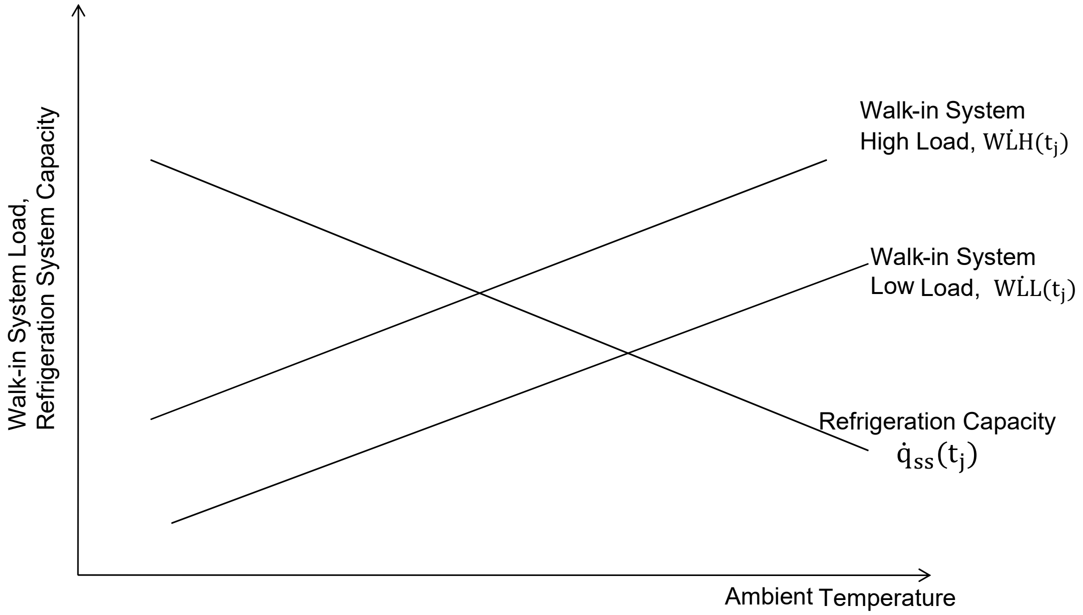

Figure 1. Schematic of the Operation for Units with Single Capacity Compressor

7.4.2 The system Steady-state Net Refrigeration Capacity and power consumption at a specific temperature bin shall use the measured values directly from the Steady-state tests if the bin temperature coincides with the designated rating conditions.

When a bin temperature does not coincide with the designated rating condition, the system Steady-state Net Refrigeration Capacity and power consumption at a specific temperature bin are interpolated using Equations 14 - 17:

If $t_j \leq 59$ ˚F

$$\dot{q}_{ss}(t_j) = \dot{q}_{ss,C} + \frac{(\dot{q}_{ss,B} - \dot{q}_{ss,C})}{(t_B - t_C)}(t_j - t_C) \quad 14$$

$$\dot{E}_{ss}(t_j) = \dot{E}_{ss,C} + \frac{(\dot{E}_{ss,B} - \dot{E}_{ss,C})}{(t_B - t_c)}(t_j - t_C) \quad 15$$

If $t_j > 59$ ˚F

$$\dot{q}_{ss}(t_j) = \dot{q}_{ss,B} + \frac{(\dot{q}_{ss,A} - \dot{q}_{ss,B})}{t_A - t_B}(t_j - t_B) \quad 16$$

$$\dot{E}_{ss}(t_j) = \dot{E}_{ss,B} + \frac{(\dot{E}_{ss,A} - \dot{E}_{ss,B})}{t_A - t_B}(t_j - t_B) \quad 17$$

7.5 *Calculation of AWEF for Matched-Pairs and Single-package Systems with Two-Capacity Compressor and Outdoor Dedicated Condensing Unit.*

7.5.1 Two-capacity compressor means a walk-in unit that has one of the following:

7.5.1.1 A two-speed compressor
7.5.1.2 Two compressors where only one compressor ever operates at a time
7.5.1.3 Two compressors where one compressor (Compressor #1) operates at low loads and both compressors (Compressors #1 and #2) operate at high loads but Compressor #2 never operates alone
7.5.1.4 A compressor that is capable of cylinder or scroll unloading

7.5.2 For such systems, low capacity means:

7.5.2.1 Operating at low compressor speed
7.5.2.2 Operating the lower capacity compressor
7.5.2.3 Operating Compressor #1
7.5.2.4 Operating with the compressor unloaded (*e.g.*, operating one piston of a two-piston reciprocating compressor, using a fixed fractional volume of the full scroll, etc.)

7.5.3 For such systems, high capacity means:

7.5.3.1 Operating at high compressor speed
7.5.3.2 Operating the higher capacity compressor
7.5.3.3 Operating Compressors #1 and #2
7.5.3.4 Operating with the compressor loaded (*e.g.*, operating both pistons of a two-piston reciprocating compressor, using the full volume of the scroll)

The unit shall be tested at the designated test conditions for both high and low capacities to evaluate the Steady-state capacities and power consumptions.

7.5.4 For two-capacity compressor units, the Annual Walk-in Energy Factor, AWEF, is calculated by

$$\text{AWEF} = \sum_{j=1}^{n} \text{BL}(t_j) \, / \sum_{j=1}^{n} \text{E}(t_j) \quad 18$$

The term $\text{BL}(t_j)$ and $\text{E}(t_j)$, summed over temperature bins, are evaluated at each temperature bin according to four possible cases shown in Figure 2 and described as follows. These four cases can be identified in terms of three outdoor temperatures, t_{IH}, t_{IL} and t_{IIH}, which are also shown in Figure 2. The outdoor temperature t_{IH} is the temperature at which the Total Walk-in System Heat Load equals system net capacity when the compressor operates at low capacity (k = 1) during the High Load Period. The outdoor temperature t_{IL} is the temperature at which the Total Walk-in System Heat Load equals system net capacity when the compressor operates at low capacity (k = 1) during the Low Load Period. The outdoor temperature t_{IIH} is the temperature at which the Total Walk-in System Heat Load equals system net capacity when the compressor operates at high capacity (k = 2) during the High Load Period.

The system Steady-state Net Refrigeration Capacity and power consumption at a specific temperature bin shall use the measured values directly from the Steady-state tests if the bin temperature coincides with the designated rating conditions, otherwise use the following equations to calculate the net capacities and the power consumptions for low capacity operation. For low capacity operation k = 1 and for high capacity operation, k = 2.

If $t_j \leq 59$ ˚F

$$\dot{q}^{k}_{ss}(t_j) = \dot{q}^{k}_{ss,C} + \frac{(\dot{q}^{k}_{ss,B} - \dot{q}^{k}_{ss,C})}{t_B - t_C}\,(t_j - t_C) \tag{19}$$

$$\dot{E}^{k}_{ss}(t_j) = \dot{E}^{k}_{ss,C} + \frac{(\dot{E}^{k}_{ss,B} - \dot{E}^{k}_{ss,C})}{(t_B - t_C)} \cdot (t_j - t_C) \tag{20}$$

If $t_j > 59$ ˚F

$$\dot{q}^{k}_{ss}(t_j) = \dot{q}^{k}_{ss,B} + \frac{(\dot{q}^{k}_{ss,A} - \dot{q}^{k}_{ss,B})}{(t_A - t_B)} \cdot (t_j - t_B) \tag{21}$$

$$\dot{E}^{k}_{ss}(t_j) = \dot{E}^{k}_{ss,B} + \frac{(\dot{E}^{k}_{ss,A} - \dot{E}^{k}_{ss,B})}{(t_A - t_B)} \cdot (t_j - t_B) \tag{22}$$

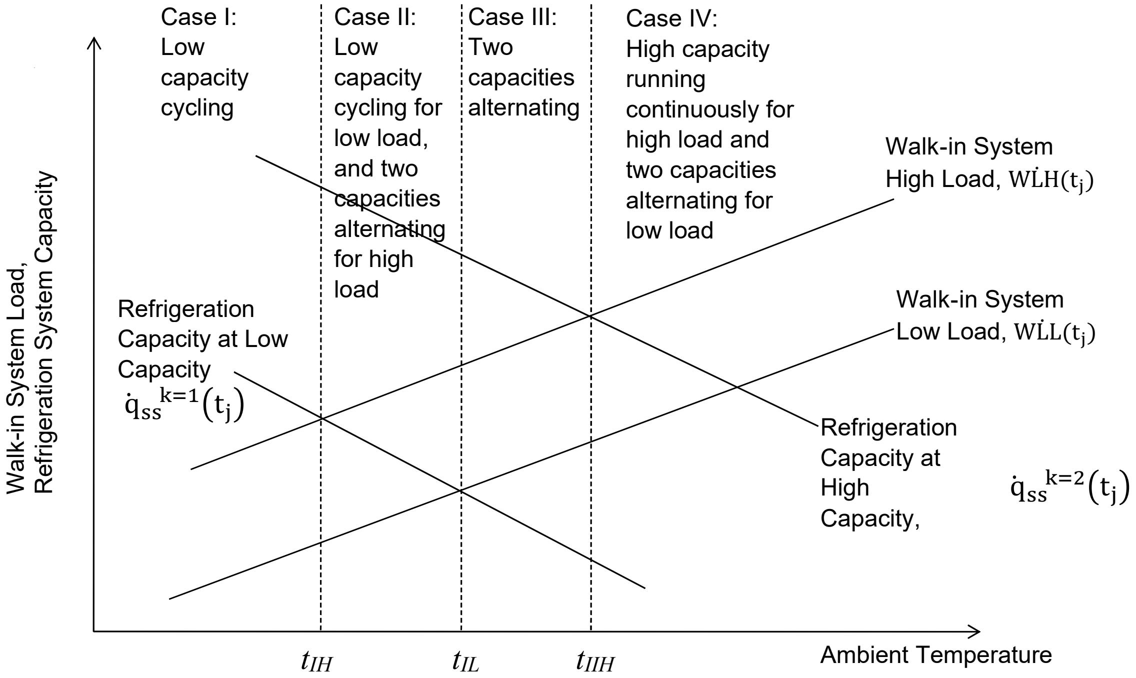

Figure 2. Schematic of the Various Modes of Operation for Units with Two Capacity Compressors

7.5.4.1 *Case I. Low Capacity Cycling During Both Low and High Load Periods ($t_j < t_{IH}$).* Units operate only at low compressor capacity, and cycle on and off to meet the Total Walk-in System Heat Load during both low and High Load Periods. In this case, units operate identically to single capacity units. The calculation of terms $BL(t_j)$ and $E(t_j)$ shall follow the single capacity compressor procedure described in Section 7.4.

7.5.4.2 *Case II. Low Capacity Cycling During Low Load Period and Two Capacities Alternating During High Load Period ($t_{IH} < t_j < t_{IL}$).* During a Low Load Period, units operate at low compressor capacity, and cycle on and off to meet the total walk-in system load. During a High Load Period, units alternate between high (k = 2) and low (k = 1) compressor capacities to satisfy the Total Walk-in System Heat Load at temperature t_j. In such a case, the compressor operates continuously during High Load Period. The terms of defrost cycle power contributing to the box load, $\dot{Q}_{DF}$, and to the system power consumption, $D\dot{F}$, in these equations shall only be applied to the walk-in freezer systems, and shall be set to zero during the calculation for the walk-in refrigerator systems.

$$W\dot{L}H(t_j) = B\dot{L}H(t_j) + \dot{Q}_{DF} \tag{23}$$

$$W\dot{L}L(t_j) = B\dot{L}L(t_j) + 3.412 \cdot E\dot{F}_{comp,off}\left(1 - LFL^{\,k=1}(t_j)\right) + \dot{Q}_{DF} \tag{24}$$

$$LFH^{k=1}(t_j) = \frac{\dot{q}_{ss}{}^{k=2}(t_j) - W\dot{L}H(t_j)}{\dot{q}_{ss}{}^{k=2}(t_j) - \dot{q}_{ss}{}^{k=1}(t_j)} \tag{25}$$

$$LFH^{\,k=2}(t_j) = 1 - LFH^{\,k=1}(t_j) \tag{26}$$

$$LFL^{k=1}(t_j) = \frac{W\dot{L}L(t_j)}{\dot{q}_{ss}{}^{k=1}(t_j)} = \frac{B\dot{L}L(t_j) + 3.412 \cdot E\dot{F}_{comp,off} + \dot{Q}_{DF}}{\dot{q}_{ss}{}^{k=1}(t_j) + 3.412 \cdot E\dot{F}_{comp,off}} \tag{27}$$

$$BL(t_j) = \left[0.33 \cdot B\dot{L}H(t_j) + 0.67 \cdot B\dot{L}L(t_j)\right] \cdot n_j \tag{28}$$

$$E(t_j) = \left\{\begin{matrix} 0.33 \cdot \left(\dot{E}_{ss}{}^{k=2}(t_j) \cdot LFH^{k=2}(t_j) + \dot{E}_{ss}{}^{k=1} \cdot LFH^{k=1}(t_j)\right) + 0.67 \cdot \\ \left[\dot{E}_{ss}{}^{k=1}(t_j) \cdot LFL^{k=1}(t_j) + \left(\dot{E}_{CU,off} + E\dot{F}_{comp,off}\right)\left(1 - LFL^{k=1}(t_j)\right)\right] + D\dot{F} \end{matrix}\right\} \cdot n_j \tag{29}$$

7.5.4.3 *Case III. Two Capacities Alternating During Both Low and High Load Periods* ($t_{IL}<t_j<t_{IIH}$). Units alternate between high (k = 2) and low (k = 1) compressor capacities to satisfy the total walk-in system load at temperature t_j. In such a case, the compressor operates continuously. The terms of defrost cycle power contributing to the box load, $\dot{Q}_{DF}$, and to the system power consumption, $D\dot{F}$, in these equations shall only be applied to the walk-in freezer systems, and shall be set to zero during the calculation for the walk-in refrigerator systems.

$$W\dot{L}H(t_j) = B\dot{L}H(t_j) + \dot{Q}_{DF} \tag{30}$$

$$W\dot{L}L(t_j) = B\dot{L}L(t_j) + \dot{Q}_{DF} \tag{31}$$

$$LFH^{k=1}(t_j) = \frac{\dot{q}_{ss}{}^{k=2}(t_j) - W\dot{L}H(t_j)}{\dot{q}_{ss}{}^{k=2}(t_j) - \dot{q}_{ss}{}^{k=1}(t_j)} \tag{32}$$

$$LFH^{\,k=2}(t_j) = 1 - LFH^{\,k=1}(t_j) \tag{33}$$

$$LFL^{k=1}(t_j) = \frac{\dot{q}_{ss}{}^{k=2}(t_j) - W\dot{L}L(t_j)}{\dot{q}_{ss}{}^{k=2}(t_j) - \dot{q}_{ss}{}^{k=1}(t_j)} \tag{34}$$

$$LFL^{\,k=2}(t_j) = 1 - LFL^{\,k=1}(t_j) \tag{35}$$

$$BL(t_j) = \left[0.33 \cdot B\dot{L}H(t_j) + 0.67 \cdot B\dot{L}L(t_j)\right] \cdot n_j \tag{36}$$

$$\begin{aligned} E(t_j) = [0.33 \cdot &\left(\dot{E}_{ss}{}^{k=2}(t_j) \cdot LFH^{k=2}(t_j) + \dot{E}_{ss}{}^{k=1}(t_j) \cdot LFH^{k=1}(t_j)\right) + \\ 0.67 \cdot &\left(\dot{E}_{ss}{}^{k=2}(t_j) \cdot LFL^{k=2}(t_j) + \dot{E}_{ss}{}^{k=1}(t_j) \cdot LFL^{k=1}(t_j)\right) + D\dot{F}] \cdot n_j \end{aligned} \tag{37}$$

7.5.4.4 *Case IV. High Capacity Running Continuously During High Load Period and Two Capacities Alternating During Low Load Period ($t_{IIH}<t_j$).* During a Low Load Period, units alternate between high (k = 2) and low (k = 1) compressor capacities to satisfy the total walk-in system load at temperature t_j. During a High Load Period, units operate at high (k = 2) compressor capacity continuously. The terms of defrost cycle power contributing to the box load, $\dot{Q}_{DF}$, and to the system power consumption, $\mathrm{D\dot{F}}$, in these equations shall only be applied to the walk-in freezer systems, and shall be set to zero during the calculation for the walk-in refrigerator systems.

$$\mathrm{W\dot{L}H}(t_j) = \mathrm{B\dot{L}H}(t_j) + \dot{Q}_{DF} \qquad 38$$

$$\mathrm{W\dot{L}L}(t_j) = \mathrm{B\dot{L}L}(t_j) + \dot{Q}_{DF} \qquad 39$$

$$\mathrm{LFH}^{\,k=2}(t_j) = 1 \qquad 40$$

$$\mathrm{LFL}^{k=1}(t_j) = \frac{\dot{q}_{ss}{}^{k=2}(t_j) - \mathrm{W\dot{L}L}(t_j)}{\dot{q}_{ss}{}^{k=2}(t_j) - \dot{q}_{ss}{}^{k=1}(t_j)} \qquad 41$$

$$\mathrm{LFL}^{\,k=2}(t_j) = 1 - \mathrm{LFL}^{\,k=1}(t_j) \qquad 42$$

$$\mathrm{BL}(t_j) = \left[0.33 \cdot \mathrm{B\dot{L}H}(t_j) + 0.67 \cdot \mathrm{B\dot{L}L}(t_j)\right] \cdot n_j \qquad 43$$

$$E(t_j) = \begin{bmatrix} 0.33 \cdot \dot{E}_{ss}{}^{k=2}(t_j) \cdot \mathrm{LFH}^{k=2}(t_j) + 0.67 \cdot \\ \left(\dot{E}_{ss}{}^{k=2}(t_j) \cdot \mathrm{LFL}^{k=2}(t_j) + \dot{E}_{ss}{}^{k=1}(t_j) \cdot \mathrm{LFL}^{k=1}(t_j)\right) + \mathrm{D\dot{F}} \end{bmatrix} \cdot n_j \qquad 44$$

7.6 *Calculation of AWEF for Matched-Pairs and Single-package Systems with Variable Capacity Compressor and Outdoor Dedicated Condensing Unit.*

7.6.1 The Annual Walk-in Energy Factor, AWEF, for the walk-in units with variable capacity compressors is determined using Equation 45.

$$\mathrm{AWEF} = \sum_{j=1}^{n} \mathrm{BL}(t_j) \Big/ \sum_{j=1}^{n} E(t_j) \qquad 45$$

The term $\mathrm{BL}(t_j)$ and $E(t_j)$, summed over temperature bins, are evaluated at each temperature bin according to four possible cases shown in Figure 3 and described as follows. These four cases can be identified in terms of three outdoor temperatures, t_{IH}, t_{IL} and t_{IIH}, which are also shown in Figure 3. The outdoor temperature t_{IH} is the temperature at which the Total Walk-in System Heat Load equals system net capacity when the compressor operates at its minimum capacity (k = 1) during the High Load Period. The outdoor temperature t_{IL} is the temperature at which the Total Walk-in System Heat Load equals system net capacity when the compressor operates at its minimum capacity (k = 1) during the Low Load Period. The outdoor temperature t_{IIH} is the temperature at which the Total Walk-in System Heat Load equals system net capacity when the compressor operates at its maximum capacity (k = 2) during the High Load Period.

The system Steady-state Net Refrigeration Capacity and power consumption at a specific temperature bin shall use the measured values directly from the Steady-state tests if the bin temperature coincides with the designated rating conditions, otherwise use the following equations to calculate the net capacities and the power consumptions for minimum capacity operation. For intermediate and maximum capacities operation, use the same equations, but replace the superscript k = 1 by k = i and k = 2, respectively.

If $t_j \leq 59$ °F

$$\dot{q}_{ss}^{k}(t_j) = \dot{q}_{ss,C}^{k} + \frac{\left(\dot{q}_{ss,B}^{k} - \dot{q}_{ss,C}^{k}\right)}{t_B - t_C}(t_j - t_C) \qquad 46$$

$$\dot{E}_{ss}^{k}(t_j) = \dot{E}_{ss,C}^{k} + \frac{\left(\dot{E}_{ss,B}^{k} - \dot{E}_{ss,C}^{k}\right)}{t_B - t_C}\left(t_j - t_C\right) \qquad 47$$

If t_j>59 ˚F

$$\dot{q}^{k}_{ss}(t_j) = \dot{q}^{k}_{ss,B} + \frac{\left(\dot{q}^{k}_{ss,A} - \dot{q}^{k}_{ss,B}\right)}{(t_A - t_B)} \cdot (t_j - t_B) \tag{48}$$

$$\dot{E}^{k}_{ss}(t_j) = \dot{E}^{k}_{ss,B} + \frac{\left(\dot{E}^{k}_{ss,A} - \dot{E}^{k}_{ss,B}\right)}{(t_A - t_B)} \cdot (t_j - t_B) \tag{49}$$

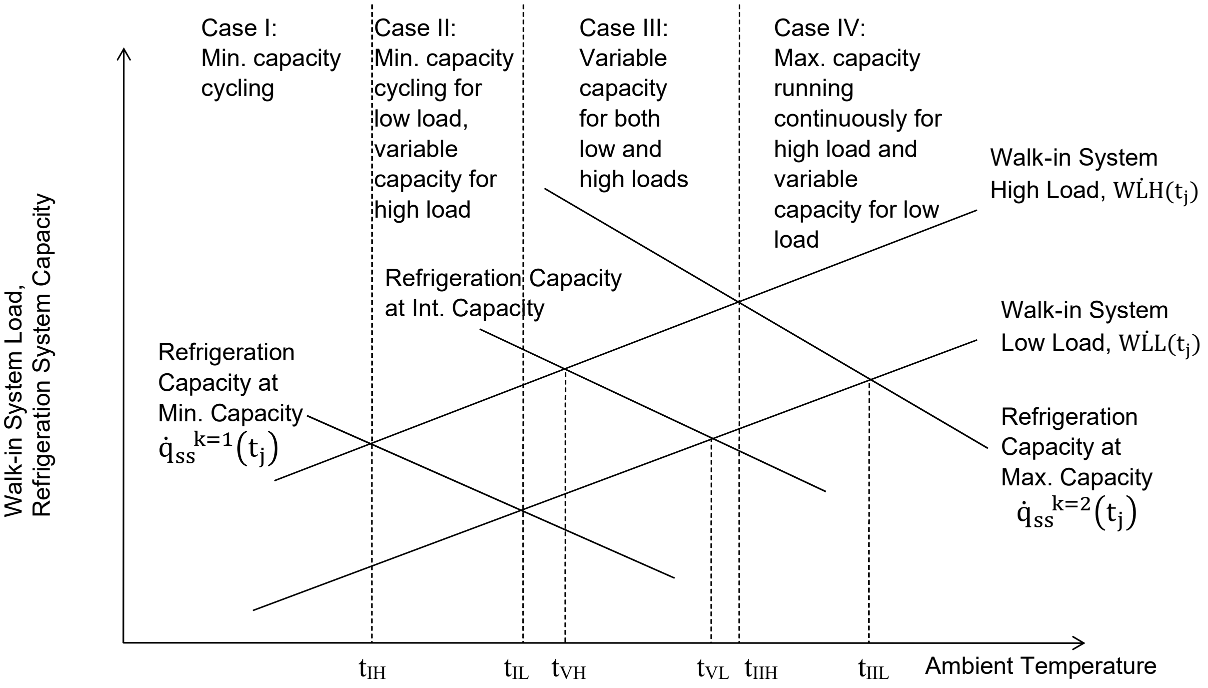

Figure 3. Schematic of the Various Modes of Operation for Units with Variable Capacity Compressors

7.6.1.1 *Case I. Minimum Capacity Cycling During Both Low and High Load Periods ($t_j < t_{IH}$).* Units operate at the minimum capacity, and cycle on and off to meet the total walk-in system load during both Low and High Load Periods. The terms of defrost cycle power contributing to the box load, $\dot{Q}_{DF}$, and to the system power consumption, $\dot{DF}$, in these equations shall only be applied to the walk-in freezer systems, and shall be set to zero during the calculation for the walk-in refrigerator systems.

$$\dot{WLH}(t_j) = \dot{BLH}(t_j) + 3.412 \cdot \dot{EF}_{comp,off}\left(1 - LFH(t_j)\right) + \dot{Q}_{DF} \tag{50}$$

$$\dot{WLL}(t_j) = \dot{BLL}(t_j) + 3.412 \cdot \dot{EF}_{comp,off}\left(1 - LFL(t_j)\right) + \dot{Q}_{DF} \tag{51}$$

$$LFH(t_j) = \frac{\dot{WLH}(t_j)}{\dot{q}_{ss}{}^{k=1}(t_j)} = \frac{\dot{BLH}(t_j) + 3.412 \cdot \dot{EF}_{comp,off} + \dot{Q}_{DF}}{\dot{q}_{ss}{}^{k=1}(t_j) + 3.412 \cdot \dot{EF}_{comp,off}} \tag{52}$$

$$LFL(t_j) = \frac{\dot{WLL}(t_j)}{\dot{q}_{ss}{}^{k=1}(t_j)} = \frac{\dot{BLL}(t_j) + 3.412 \cdot \dot{EF}_{comp,off} + \dot{Q}_{DF}}{\dot{q}_{ss}{}^{k=1}(t_j) + 3.412 \cdot \dot{EF}_{comp,off}} \tag{53}$$

$$BL(t_j) = \left[0.33 \cdot \dot{BLH}(t_j) + 0.67 \cdot \dot{BLL}(t_j)\right] \cdot n_j \tag{54}$$

$$E(t_j) = \left\{ \begin{matrix} 0.33 \cdot \left[\dot{E}_{ss}{}^{k=1}(t_j) \cdot LFH(t_j) + \left(\dot{E}_{CU,off} + E\dot{F}_{comp,off}\right)\left(1 - LFH(t_j)\right)\right] + 0.67 \cdot \\ \left[\dot{E}_{ss}{}^{k=1}(t_j) \cdot LFL(t_j) + \left(\dot{E}_{CU,off} + E\dot{F}_{comp,off}\right)\left(1 - LFL(t_j)\right)\right] + D\dot{F} \end{matrix} \right\} \cdot n_j \qquad 55$$

7.6.1.2 *Case II. Minimum Capacity Cycling During Low Load Period and Variable Capacity Operating Continuously During High Load Period ($t_{IH}<t_j<t_{IL}$).* During a Low Load Period, units operate at minimum capacity, and cycle on and off to meet the total walk-in system load. During a High Load Period, units operate at variable capacity (k = v). In such a case, the compressor varies the capacity between its minimum and maximum capacities, and continuously operates to match the total walk-in system load at temperature t_j. The terms of defrost cycle power contributing to the box load, $\dot{Q}_{DF}$, and to the system power consumption, $D\dot{F}$, in these equations shall only be applied to the walk-in freezer systems, and shall be set to zero during the calculation for the walk-in refrigerator systems.

$$W\dot{L}L(t_j) = B\dot{L}L(t_j) + 3.412 \cdot \dot{E}F_{comp,off}\left(1 - LFL^{k=1}(t_j)\right) + \dot{Q}_{DF} \qquad 56$$

$$W\dot{L}H(t_j) = B\dot{L}H(t_j) + \dot{Q}_{DF} \qquad 57$$

$$LFL^{k=1}(t_j) = \frac{B\dot{L}L(t_j) + 3.412 \cdot E\dot{F}_{comp,off} + \dot{Q}_{DF}}{\dot{q}_{ss}{}^{k=1}(t_j) + 3.412 \cdot E\dot{F}_{comp,off}} \qquad 58$$

$$\dot{q}_{SS,H}{}^{k=v}(t_j) = W\dot{L}H(t_j) \qquad 59$$

$$\dot{E}_{SS,H}{}^{k=v}(t_j) = \frac{\dot{q}_{SS,H}{}^{k=v}(t_j)}{EER_{SS,H}{}^{k=v}(t_j)} \qquad 60$$

$$EER_{SS,H}{}^{k=v}(t_j) = a + b \cdot t_j + c \cdot t_j{}^2 \qquad 61$$

Where:

To determine the coefficients a, b and c, it is required to evaluate the unit EER at three different compressor capacities: the minimum capacity (k = 1), the maximum capacity (k = 2), and the capacity (k = i) at which the intermediate-capacity test was conducted. The following is a procedure for evaluation of the coefficients a, b and c.

$$a = EER_{SS}{}^{k=2}(t_{IIH}) - b \cdot t_{IIH} - c \cdot t_{IIH}{}^2 \qquad 62$$

$$b = \frac{EER_{SS}{}^{k=1}(t_{IH}) - EER_{SS}{}^{k=2}(t_{IIH}) - d \cdot [EER_{SS}{}^{k=1}(t_{IH}) - EER_{SS}{}^{k=i}(t_{VH})]}{t_{IH} - t_{IIH} - d \cdot [t_{IH} - t_{VH}]} \qquad 63$$

$$c = \frac{EER_{SS}{}^{k=1}(t_{IH}) - EER_{SS}{}^{k=2}(t_{IIH}) - b \cdot (t_{IH} - t_{IIH})}{t_{IH}{}^2 - t_{IIH}{}^2} \qquad 64$$

$$d = \frac{t_{IIH}{}^2 - t_{IH}{}^2}{t_{VH}{}^2 - t_{IH}{}^2} \qquad 65$$

Where:

$$EER_{ss}^{k=1}(t_{IH}) = \frac{\dot{q}_{ss}^{k=1}(t_{IH})}{\dot{E}_{ss}^{k=1}(t_{IH})} \qquad 66$$

$$EER_{ss}^{k=2}(t_{IIH}) = \frac{\dot{q}_{ss}^{k=2}(t_{IIH})}{\dot{E}_{ss}^{k=2}(t_{IIH})} \qquad 67$$

$$\mathrm{EER}_{\mathrm{ss}}^{\mathrm{k=i}}(\mathrm{t}_{\mathrm{VH}}) = \frac{\dot{\mathrm{q}}_{\mathrm{ss}}^{\mathrm{k=i}}(\mathrm{t}_{\mathrm{VH}})}{\dot{\mathrm{E}}_{\mathrm{ss}}^{\mathrm{k=i}}(\mathrm{t}_{\mathrm{VH}})} \quad 68$$

The outdoor temperature t_{VH} is the temperature at which the Total Walk-in System Heat Load equals system net capacity when the compressor operates at its intermediate capacity (k = i) during the High Load Period.

$$\mathrm{BL}(\mathrm{t}_{\mathrm{j}}) = \left[0.33 \cdot \mathrm{B\dot{L}H}(\mathrm{t}_{\mathrm{j}}) + 0.67 \cdot \mathrm{B\dot{L}L}(\mathrm{t}_{\mathrm{j}})\right] \cdot \mathrm{n}_{\mathrm{j}} \quad 69$$

$$\mathrm{E}(\mathrm{t}_{\mathrm{j}}) = \Big\{0.33 \cdot \dot{\mathrm{E}}_{\mathrm{SS,H}}{}^{\mathrm{k=v}}(\mathrm{t}_{\mathrm{j}}) + 0.67 \cdot [\dot{\mathrm{E}}_{\mathrm{SS}}{}^{\mathrm{k=1}}(\mathrm{t}_{\mathrm{j}}) \cdot \mathrm{LFL}^{\mathrm{k=1}}(\mathrm{t}_{\mathrm{j}}) + \left(\dot{\mathrm{E}}_{\mathrm{CU,off}} + \mathrm{E\dot{F}}_{\mathrm{comp,off}}\right)\left(1 - \mathrm{LFL}^{\mathrm{k=1}}(\mathrm{t}_{\mathrm{j}})\right)\Big] + \mathrm{\dot{D}F}\Big\} \cdot \mathrm{n}_{\mathrm{j}} \quad 70$$

7.6.1.3 *Case III. Variable Capacity Running Continuously During Both Low and High Load Periods* **($t_{IL} < t_j < t_{IIH}$).** Units operate at variable compressor capacities (k = v) during both Low and High Load Periods. The compressor varies the capacity between its minimum and maximum capacities, and continuously operate to match the total walk-in system load at temperature t_{j}. The terms of defrost cycle power contributing to the box load, $\dot{\mathrm{Q}}_{\mathrm{DF}}$, and to the system power consumption, $\mathrm{\dot{D}F}$, in these equations shall only be applied to the walk-in freezer systems, and shall be set to zero during the calculation for the walk-in refrigerator systems.

$$\mathrm{W\dot{L}H}(\mathrm{t}_{\mathrm{j}}) = \mathrm{B\dot{L}H}(\mathrm{t}_{\mathrm{j}}) + \dot{\mathrm{Q}}_{\mathrm{DF}} \quad 71$$

$$\mathrm{W\dot{L}L}(\mathrm{t}_{\mathrm{j}}) = \mathrm{B\dot{L}L}(\mathrm{t}_{\mathrm{j}}) + \dot{\mathrm{Q}}_{\mathrm{DF}} \quad 72$$

$$\dot{\mathrm{q}}_{\mathrm{SS,H}}{}^{\mathrm{k=v}}(\mathrm{t}_{\mathrm{j}}) = \mathrm{W\dot{L}H}(\mathrm{t}_{\mathrm{j}}) \quad 73$$

$$\dot{\mathrm{q}}_{\mathrm{SS,L}}{}^{\mathrm{k=v}}(\mathrm{t}_{\mathrm{j}}) = \mathrm{W\dot{L}L}(\mathrm{t}_{\mathrm{j}}) \quad 74$$

$$\dot{\mathrm{E}}_{\mathrm{SS,H}}{}^{\mathrm{k=v}}(\mathrm{t}_{\mathrm{j}}) = \frac{\dot{\mathrm{q}}_{\mathrm{SS,H}}{}^{\mathrm{k=v}}(\mathrm{t}_{\mathrm{j}})}{\mathrm{EER}_{\mathrm{SS,H}}{}^{\mathrm{k=v}}(\mathrm{t}_{\mathrm{j}})} \quad 75$$

$$\dot{\mathrm{E}}_{\mathrm{SS,L}}{}^{\mathrm{k=v}}(\mathrm{t}_{\mathrm{j}}) = \frac{\dot{\mathrm{q}}_{\mathrm{SS,L}}{}^{\mathrm{k=v}}(\mathrm{t}_{\mathrm{j}})}{\mathrm{EER}_{\mathrm{SS,L}}{}^{\mathrm{k=v}}(\mathrm{t}_{\mathrm{j}})} \quad 76$$

$$\mathrm{EER}_{\mathrm{SS,L}}{}^{\mathrm{k=v}}(\mathrm{t}_{\mathrm{j}}) = \mathrm{a} + \mathrm{b} \cdot \mathrm{t}_{\mathrm{j}} + \mathrm{c} \cdot \mathrm{t}_{\mathrm{j}}{}^{2} \quad 77$$

Where:

$$\mathrm{a} = \mathrm{EER}_{\mathrm{SS}}{}^{\mathrm{k=2}}(\mathrm{t}_{\mathrm{IIL}}) - \mathrm{b} \cdot \mathrm{t}_{\mathrm{IIL}} - \mathrm{c} \cdot \mathrm{t}_{\mathrm{IIL}}{}^{2} \quad 78$$

$$\mathrm{b} = \frac{\mathrm{EER}_{\mathrm{SS}}{}^{\mathrm{k=1}}(\mathrm{t}_{\mathrm{IL}}) - \mathrm{EER}_{\mathrm{SS}}{}^{\mathrm{k=2}}(\mathrm{t}_{\mathrm{IIL}}) - \mathrm{d} \cdot [\mathrm{EER}_{\mathrm{SS}}{}^{\mathrm{k=1}}(\mathrm{t}_{\mathrm{IL}}) - \mathrm{EER}_{\mathrm{SS}}{}^{\mathrm{k=i}}(\mathrm{t}_{\mathrm{VL}})]}{\mathrm{t}_{\mathrm{IL}} - \mathrm{t}_{\mathrm{IIL}} - \mathrm{d} \cdot [\mathrm{t}_{\mathrm{IL}} - \mathrm{t}_{\mathrm{VL}}]} \quad 79$$

$$\mathrm{c} = \frac{\mathrm{EER}_{\mathrm{SS}}{}^{\mathrm{k=1}}(\mathrm{t}_{\mathrm{IL}}) - \mathrm{EER}_{\mathrm{SS}}{}^{\mathrm{k=2}}(\mathrm{t}_{\mathrm{IIL}}) - \mathrm{b} \cdot [(\mathrm{t}_{\mathrm{IL}}) - (\mathrm{t}_{\mathrm{IIL}})]}{\mathrm{t}_{\mathrm{IL}}{}^{2} - \mathrm{t}_{\mathrm{IIL}}{}^{2}} \quad 80$$

$$\mathrm{d} = \frac{\mathrm{t}_{\mathrm{IIL}}{}^{2} - \mathrm{t}_{\mathrm{IL}}{}^{2}}{\mathrm{t}_{\mathrm{VL}}{}^{2} - \mathrm{t}_{\mathrm{IL}}{}^{2}} \quad 81$$

Where:

$$\mathrm{EER}_{\mathrm{ss}}^{\mathrm{k=1}}(\mathrm{t}_{\mathrm{IL}}) = \frac{\dot{\mathrm{q}}_{\mathrm{ss}}^{\mathrm{k=1}}(\mathrm{t}_{\mathrm{IL}})}{\dot{\mathrm{E}}_{\mathrm{ss}}^{\mathrm{k=1}}(\mathrm{t}_{\mathrm{IL}})} \quad 82$$

$$\mathrm{EER}_{ss}^{k=2}(t_{IIL}) = \frac{\dot{q}_{ss}^{k=2}(t_{IIL})}{\dot{E}_{ss}^{k=2}(t_{IIL})} \tag{83}$$

$$\mathrm{EER}_{ss}^{k=i}(t_{VL}) = \frac{\dot{q}_{ss}^{k=i}(t_{VL})}{\dot{E}_{ss}^{k=i}(t_{VL})} \tag{84}$$

The outdoor temperature t_{VL} is the temperature at which the Total Walk-in System Heat Load equals system net capacity when the compressor operates at its intermediate capacity (k = i) during the Low Load Period.

$$\mathrm{BL}(t_j) = \left[0.33 \cdot \mathrm{B\dot{L}H}(t_j) + 0.67 \cdot \mathrm{B\dot{L}L}(t_j)\right] \cdot n_j \tag{85}$$

$$\mathrm{E}(t_j) = \left[0.33 \cdot \dot{E}_{SS,H}{}^{k=v}(t_j) + 0.67 \cdot \dot{E}_{SS,L}{}^{k=v}(t_j) + \mathrm{D\dot{F}}\right] \cdot n_j \tag{86}$$

7.6.1.4 *Case IV. High Capacity Running Continuously During High Load Period and Intermediate Capacity Running Continuously During Low Load Period ($t_{IIH}<t_j$).* During a Low Load Period, units operate at variable compressor capacities (k = v). The compressor varies the capacity between its minimum and maximum capacities, and continuously operate to match the total walk-in system load at temperature t_j. During a High Load Period, units operate at maximum (k = 2) compressor capacity continuously. The terms of defrost cycle power contributing to the box load, $\dot{Q}_{DF}$, and to the system power consumption, $\mathrm{D\dot{F}}$, in these equations shall only be applied to the walk-in freezer systems, and shall be set to zero during the calculation for the walk-in refrigerator systems.

$$\mathrm{W\dot{L}H}(t_j) = \mathrm{B\dot{L}H}(t_j) + \dot{Q}_{DF} \tag{87}$$

$$\mathrm{W\dot{L}L}(t_j) = \mathrm{B\dot{L}L}(t_j) + \dot{Q}_{DF} \tag{88}$$

$$\mathrm{BL}(t_j) = \left[0.33 \cdot \mathrm{B\dot{L}H}(t_j) + 0.67 \cdot \mathrm{B\dot{L}L}(t_j)\right] \cdot n_j \tag{89}$$

$$\mathrm{E}(t_j) = \left[0.33 \cdot \dot{E}_{SS}{}^{k=2}(t_j) + 0.67 \cdot \dot{E}_{SS,L}{}^{k=v}(t_j) + \mathrm{D\dot{F}}\right] \cdot n_j \tag{90}$$

7.7 *Calculation of AWEF for Matched-Pairs and Single-package Systems with Single Capacity Compressor and Indoor Dedicated Condensing Unit.* In such a case, the walk-in system load and the Refrigeration System performance are independent to the outdoor ambient conditions. The AWEF is calculated by the following equations. The terms of defrost cycle power contributing to the box load, $\dot{Q}_{DF}$, and to the system power consumption, $\mathrm{D\dot{F}}$, in these equations shall only be applied to the walk-in freezer systems, and shall be set to zero during the calculation for the walk-in refrigerator systems.

$$\mathrm{W\dot{L}H} = \mathrm{B\dot{L}H} + 3.412 \cdot \mathrm{E\dot{F}}_{comp,off} \cdot (1 - \mathrm{LFH}) + \dot{Q}_{DF} \tag{91}$$

$$\mathrm{W\dot{L}L} = \mathrm{B\dot{L}L} + 3.412 \cdot \mathrm{E\dot{F}}_{comp,off} \cdot (1 - \mathrm{LFL}) + \dot{Q}_{DF} \tag{92}$$

Where $\mathrm{B\dot{L}H}$ and $\mathrm{B\dot{L}L}$ for refrigerator and freezer systems are defined in Section 6.2.1 of this standard; and the Load Factors (LFH and LFL) are calculated using Equations 93 and 94.

$$\mathrm{LFH} = \frac{\mathrm{W\dot{L}H}}{\dot{q}_{SS,ID}} = \frac{\mathrm{B\dot{L}H} + 3.412 \cdot \mathrm{E\dot{F}}_{comp,off} + \dot{Q}_{DF}}{\dot{q}_{SS,ID} + 3.412 \cdot \mathrm{E\dot{F}}_{comp,off}} \tag{93}$$

$$\mathrm{LFL} = \frac{\mathrm{W\dot{L}L}}{\dot{q}_{SS,ID}} = \frac{\mathrm{B\dot{L}L} + 3.412 \cdot \mathrm{E\dot{F}}_{comp,off} + \dot{Q}_{DF}}{\dot{q}_{SS,ID} + 3.412 \cdot \mathrm{E\dot{F}}_{comp,off}} \tag{94}$$

The Annual Walk-in Energy Factor, AWEF, is determined using Equation 95.

$$\mathrm{AWEF} = \frac{0.33 \cdot \mathrm{B\dot{L}H} + 0.67 \cdot \mathrm{B\dot{L}L}}{0.33 \cdot \left[\dot{E}_{SS,ID} \cdot \mathrm{LFH} + \left(\dot{E}_{CU,off} + \mathrm{E\dot{F}}_{comp,off}\right) \cdot (1 - \mathrm{LFH})\right] + 0.67 \cdot \left[\dot{E}_{SS,ID} \cdot \mathrm{LFL} + \left(\dot{E}_{CU,off} + \mathrm{E\dot{F}}_{comp,off}\right) \cdot (1 - \mathrm{LFL})\right] + \mathrm{D\dot{F}}} \tag{95}$$

7.8 *Calculation of AWEF for Walk-in Unit Cooler Tested Alone.*

7.8.1 The following table (Table 18) based on ANSI/AHRI Standard 1200 defines the power required by the rack system to handle the walk-in Unit Cooler load:

7.8.1.1 For Unit Coolers with or without hot gas defrost capability, the suction dew point value for a refrigerator application shall be 23˚F and for a freezer application it shall be -22˚F.

Table 18. EER for Walk-in Refrigerator and Freezer Unit Coolers Tested Alone

Medium Temperature		Low Temperature	
Suction Dew Point ºF	EER	Suction Dew Point ºF	EER
0.0	9.25	-36.0	5.48
1.0	9.37	-35.0	5.56
2.0	9.50	-34.0	5.64
3.0	9.63	-33.0	5.73
4.0	9.76	-32.0	5.81
5.0	9.87	-31.0	5.90
6.0	10.03	-30.0	5.98
7.0	10.19	-29.0	6.06
8.0	10.36	-28.0	6.15
9.0	10.52	-27.0	6.24
10.0	10.69	-26.0	6.33
11.0	10.87	-25.0	6.41
12.0	11.05	-24.0	6.50
13.0	11.22	-23.0	6.60
14.0	11.40	-22.0	6.70
15.0	11.58	-21.0	6.78
16.0	11.79	-20.0	6.88
17.0	11.99	-19.0	6.98
18.0	12.19	-18.0	7.08
19.0	12.39	-17.0	7.19
20.0	12.59	-16.0	7.29
21.0	12.85	-15.0	7.39
22.0	13.04	-14.0	7.49
23.0	13.27	-13.0	7.60
24.0	13.49	-12.0	7.70
25.0	13.72	-11.0	7.81
26.0	13.95	-10.0	7.92
27.0	14.18	-9.0	8.03
28.0	14.47	-8.0	8.14
29.0	14.73	-7.0	8.25
30.0	14.98	-6.0	8.36
31.0	15.27	-5.0	8.48
32.0	15.56	-4.0	8.59
33.0	15.84	-3.0	8.71
34.0	16.13	-2.0	8.83
35.0	16.42	-1.0	8.95

Notes:
1. EER values at Medium and Low Temperature Applications are based on a typical reciprocating compressor.
2. Linear interpolation shall be used to calculate EER values for temperatures not shown in Table 18.

7.8.2 *Unit Cooler Tested Alone with Fixed Evaporator Fan Speed.*

7.8.2.1 The net capacity, $\dot{q}_{mix,evap}$ is determined from the test data for the Unit Cooler at the 25 ˚F suction dew point (at the Unit Cooler exit) for a refrigerator and the -20 ˚F suction dew point (at the Unit Cooler exit) for a freezer. The power consumption of the system is calculated by:

$$\dot{E}_{mix,rack} = \frac{\dot{q}_{mix,evap} + 3.412 \cdot \dot{EF}_{comp,on}}{EER_{UC}} + \dot{EF}_{comp,on} \qquad 96$$

Where:

EER_{UC} = Energy Efficiency Ratio at suction dew point, for use in Unit Cooler calculation, Btu/W·h. Value is found from Table 18.

7.8.2.2 The AWEF of the system is calculated by the following equations. The terms of defrost cycle power contributing to the box load, $\dot{Q}_{DF}$, and to the system power consumption, $D\dot{F}$, in these equations shall only be applied to the walk-in freezer systems, and shall be set to zero during the calculation for the walk-in refrigerator systems.

$$W\dot{L}H = B\dot{L}H + 3.412 \cdot \dot{EF}_{comp,off}\,(1 - LFH) + \dot{Q}_{DF} \qquad 97$$

$$W\dot{L}L = B\dot{L}L + 3.412 \cdot \dot{EF}_{comp,off}\,(1 - LFL) + \dot{Q}_{DF} \qquad 98$$

Where $B\dot{L}H$ and $B\dot{L}L$ for refrigerator and freezer systems are defined in Section 6.2.1 of this standard; for the equations provided in these sections $\dot{q}_{mix,evap}$ shall be used in place of $\dot{q}_{ss,ID}$. Load Factors (LFH and LFL) are calculated as follows.

$$LFH = \frac{W\dot{L}H}{\dot{q}_{mix,evap}} = \frac{B\dot{L}H + 3.412 \cdot \dot{EF}_{comp,off} + \dot{Q}_{DF}}{\dot{q}_{mix,evap} + 3.412 \cdot \dot{EF}_{comp,off}} \qquad 99$$

$$LFL = \frac{W\dot{L}L}{\dot{q}_{mix,evap}} = \frac{B\dot{L}L + 3.412 \cdot \dot{EF}_{comp,off} + \dot{Q}_{DF}}{\dot{q}_{mix,evap} + 3.412 \cdot \dot{EF}_{comp,off}} \qquad 100$$

The Annual Walk-in Energy Factor, AWEF, is determined by

$$AWEF = \frac{0.33 \cdot B\dot{L}H + 0.67 \cdot B\dot{L}L}{0.33 \cdot [\dot{E}_{mix,rack} \cdot LFH + \dot{EF}_{comp,off}(1 - LFH)] + 0.67 \cdot [\dot{E}_{mix,rack} \cdot LFL + \dot{EF}_{comp,off}(1 - LFL)] + D\dot{F}} \qquad 101$$

7.8.3 *Unit Cooler Tested Alone with Variable Speed Evaporator Fans*. For Unit Coolers with variable speed evaporator fans that modulate fan speed in response to load, the fan shall be operated under its minimum, maximum and intermediate speed that equals to the average of the maximum and minimum speeds, respectively during the Unit Cooler test. These Unit Coolers are designed for use with variable capacity refrigerant systems.

7.8.3.1 The evaporator net capacities, fan operating speed and the fan power consumptions under the three fan speeds shall be determined from the test data for the Unit Cooler at the 25˚F suction dew point for a refrigerator and the -20˚F suction dew point for a freezer, and correlated using Equations 102 and 103.

$$s(\dot{q}_{mix,evap}) = k_7 + k_8 \cdot \dot{q}_{mix,evap} + k_9 \cdot \dot{q}^2_{mix,evap} \qquad 102$$

$$\dot{EF}_{comp,on}(s) = k_{10} + k_{11} \cdot s + k_{12} \cdot s^2 \qquad 103$$

7.8.3.2 The total walk-in system load during High and Low Load Periods can be calculated by

$$W\dot{L}H = B\dot{L}H + \dot{Q}_{DF} \qquad 104$$

when $W\dot{L}L < \dot{q}_{mix,evap,min}$

$$\dot{W}LL = \dot{B}LL + 3.412 \cdot \dot{E}F_{\text{comp,off}} \cdot (1\text{- LFL}) + \dot{Q}_{DF} \qquad 105$$

when $\dot{W}LL \geq \dot{q}_{\text{mix,evap,min}}$

$$\dot{W}LL = \dot{B}LL + \dot{Q}_{DF} \qquad 106$$

Where $\dot{B}LH$ and $\dot{B}LL$ for refrigerator and freezer systems are defined in Section 6.2.1 of this standard; for the equations provided in these sections $\dot{q}_{\text{mix,evap,max}}$ shall be used in place of $\dot{q}_{\text{ss,ID}}$. Load Factor during Low Load Period is calculated using Equation 107.

$$LFL = \frac{\dot{W}LL}{\dot{q}_{\text{mix,evap,min}}} = \frac{\dot{B}LL + 3.412 \cdot \dot{E}F_{\text{comp,off}} + \dot{Q}_{DF}}{\dot{q}_{\text{mix,evap,min}} + 3.412 \cdot \dot{E}F_{\text{comp,off}}} \qquad 107$$

The terms of defrost cycle power contributing to the box load, $\dot{Q}_{DF}$, in these equations shall only be applied to the walk-in freezer systems, and shall be set to zero during the calculation for the walk-in refrigerator systems.

7.8.3.3 The power consumption of the system during the High and Low Load Periods are calculated using Equation 108.

$$\dot{E}_{\text{mix,rack, H}} = \frac{\dot{W}LH + 3.412 \cdot \dot{E}F_{\text{comp,on}}(s_H)}{EER_{UC}} + \dot{E}F_{\text{comp,on}}(s_H) \qquad 108$$

Where, the evaporator fan speed during the High Load Period, s_H, results in a coil capacity which matches $\dot{W}LH$, the combined box and defrost cycle load during the High Load Period.

when $\dot{W}LL \geq \dot{q}_{\text{mix,evap,min}}$

$$\dot{E}_{\text{mix,rack, L}} = \frac{\dot{W}LL + 3.412 \cdot \dot{E}F_{\text{comp,on}}(s_L)}{EER_{UC}} + \dot{E}F_{\text{comp,on}}(s_L) \qquad 109$$

Where, the evaporator fan speed during the Low Load Period, s_L, results in a coil capacity at that speed, which matches $\dot{W}LL$, the combined box and defrost cycle load during the Low Load Period.

when $\dot{W}LL < \dot{q}_{\text{mix,evap,min}}$

$$\dot{E}_{\text{mix,rack, L}} = \frac{\dot{q}_{\text{mix,evap,min}} + 3.412 \cdot \dot{E}F_{\text{comp,on}}(s_{\min})}{EER_{UC}} + \dot{E}F_{\text{comp,on}}(s_{\min}) \qquad 110$$

Where, fan speed during the Low Load Period, matches the minimum tested fan speed, $s_{\min}$, because at the minimum fan speed the coil capacity exceeds $\dot{W}LL$, the combined box and defrost cycle load during the Low Load Period.

In the above equations, EER_{UC} can be determined from Table 18; $s_{\min}$ is the minimum operating speed of the evaporator fan; s_H and s_L are fan operating speeds under the High and Low Load Periods, respectively, and determined by

$$s_H = k_7 + k_8 \cdot \dot{W}LH + k_9 \cdot \dot{W}LH^2 \qquad 111$$

$$s_L = k_7 + k_8 \cdot \dot{W}LL + k_9 \cdot \dot{W}LL^2 \qquad 112$$

7.8.3.4 The system Annual Walk-in Energy Factor, AWEF, is determined by the following equations.

If $\dot{W}LL \geq \dot{q}_{\text{mix,evap,min}}$, then

$$AWEF = \frac{0.33 \cdot \dot{B}LH + 0.67 \cdot \dot{B}LL}{0.33 \cdot \dot{E}_{\text{mix,rack, H}} + 0.67 \cdot \dot{E}_{\text{mix,rack, L}} + \dot{D}F} \qquad 113$$

If $\dot{W}LL < \dot{q}_{mix,evap,min}$, then

$$AWEF = \frac{0.33 \cdot B\dot{L}H + 0.67 \cdot B\dot{L}L}{0.33 \cdot \dot{E}_{mix,rack,H} + 0.67 \cdot \left[\dot{E}_{mix,rack,L} \cdot LFL + \dot{E}F_{comp,off}(1\text{-} LFL)\right] + \dot{D}F} \quad 114$$

The terms of defrost cycle power contributing to the system power consumption, $\dot{D}F$, in the above equations shall only be applied to the walk-in freezer systems, and shall be set to zero during the calculation for the walk-in refrigerator systems.

7.9 *Calculation of AWEF for Dedicated Condensing Units Tested Alone.*

7.9.1 *Refrigerator Indoor Dedicated Condensing Units Tested Alone*. The Dedicated Condensing Unit shall be tested at the ambient condition A in Table 12. Electrical energy consumption by the Dedicated Condensing Unit shall be measured during On-cycle periods $\dot{E}_{CU,\ on}$ and during Off-cycle periods, $\dot{E}_{CU,\ off}$. The Steady-state gross capacity, $\dot{Q}_{gross}$ shall also be measured during the On-cycle. Note: See Equations 131 and 132 for simplified AWEF calculation.

7.9.1.1 When the Dedicated Condensing Unit is on, its Steady-state gross capacity, $\dot{Q}_{gross}$, is reduced by the heat content of On-cycle evaporator fan power, $\dot{E}F_{comp,on}$, to yield its net capacity, $\dot{q}_{ss}$. $\dot{E}F_{comp,on}$ is calculated as a function of $\dot{Q}_{gross}$, which is defined in 7.9.1.3.

$$\dot{q}_{ss,ID} = \dot{Q}_{gross,ID} - 3.412 \cdot \dot{E}F_{comp,on} \quad 115$$

7.9.1.2 The Total Walk-in System Heat Load at High Load Periods and Low Load Periods, $W\dot{L}H$ and $W\dot{L}L$ respectively, includes the walk-in box heat load and the heat load from the fan energy when the Dedicated Condensing Unit compressor is off. This in turn can be used to calculate the fraction of time that the compressor is on during High Load and Low Load Periods, LFH and LFL respectively.

$$W\dot{L}H = B\dot{L}H + 3.412 \cdot \dot{E}F_{comp,off} \cdot (1\text{-}LFH) \quad 116$$

$$W\dot{L}L = B\dot{L}L + 3.412 \cdot \dot{E}F_{comp,off} \cdot (1\text{-}LFL) \quad 117$$

Where $B\dot{L}H$ and $B\dot{L}L$ are defined by Equations 1 and 2 in Section 6 and $\dot{E}F_{comp,off}$ is assumed to consume 20% of the energy as $\dot{E}F_{comp,on}$;

$$\dot{E}F_{comp,off} = 0.2 \cdot \dot{E}F_{comp,on} \quad 118$$

The Load Factor LFH is calculated as follows:

$$LFH = \frac{W\dot{L}H}{\dot{q}_{ss,ID}} \quad 119$$

Substituting for $W\dot{L}H$ using Equation 116

$$LFH= \frac{B\dot{L}H + 3.412 \cdot \dot{E}F_{comp,off}}{\dot{q}_{ss,ID} + 3.412 \cdot \dot{E}F_{comp,off}} \quad 120$$

Substituting for $B\dot{L}H$ using Equation 1 and $\dot{E}F_{comp,off}$ using Equation 118

$$LFH = \frac{(0.7 \cdot \dot{q}_{ss,ID}) + 3.412 \cdot (0.2 \cdot \dot{E}Fcomp,on)}{\dot{q}_{ss,ID} + 3.412 \cdot (0.2 \cdot \dot{E}Fcomp,on)} \quad 121$$

Substituting for $\dot{q}_{ss,ID}$ using Equation 115 and reducing

$$LFH= \frac{0.7 \cdot (\dot{Q}_{gross,ID} - 3.412 \cdot \dot{E}Fcomp,on\,) + 3.412 \cdot (0.2 \cdot \dot{E}Fcomp,on)}{(\dot{Q}_{gross,ID} - 3.412 \cdot \dot{E}Fcomp,on\,) + 3.412 \cdot (0.2 \cdot \dot{E}Fcomp,on)} = \frac{0.7 \cdot \dot{Q}_{gross,ID} - 1.706 \cdot \dot{E}Fcomp,on}{\dot{Q}_{gross,ID} - 2.7296 \cdot \dot{E}Fcomp,on} \quad 122$$

The Load Factor LFL is calculated as follows:

$$\mathrm{LFL} = \frac{\mathrm{W\dot{L}L}}{\dot{q}_{\mathrm{ss,ID}}} \tag{123}$$

Substituting for $\mathrm{W\dot{L}L}$ using Equation 117

$$\mathrm{LFL} = \frac{\mathrm{B\dot{L}L} + 3.412 \cdot \dot{E}F_{\mathrm{comp,off}}}{\dot{q}_{\mathrm{ss,ID}} + 3.412 \cdot \dot{E}F_{\mathrm{comp,off}}} \tag{124}$$

Substituting for $\mathrm{B\dot{L}L}$ using Equation 2 and $\dot{E}F_{\mathrm{comp,off}}$ using Equation 118

$$\mathrm{LFL} = \frac{\left(0.1 \cdot \dot{q}_{\mathrm{ss,ID}}\right) + 3.412 \cdot 0.2 \cdot \left(\dot{E}F_{\mathrm{comp,on}}\right)}{\dot{q}_{\mathrm{ss,ID}} + 3.412 \cdot 0.2 \cdot \left(\dot{E}F_{\mathrm{comp,on}}\right)} \tag{125}$$

Substituting for $\dot{q}_{ss,ID}$ using Equation 115 and reducing

$$\mathrm{LFL} = \frac{0.1 \cdot \left(\dot{Q}_{\mathrm{gross,ID}} - 3.412 \cdot \dot{E}F\mathrm{comp,on}\right) + 3.412 \cdot \left(0.2 \cdot \dot{E}F\mathrm{comp,on}\right)}{\left(\dot{Q}_{\mathrm{gross,ID}} - 3.412 \cdot \dot{E}F\mathrm{comp,on}\right) + 3.412 \cdot \left(0.2 \cdot \dot{E}F\mathrm{comp,on}\right)} = \frac{0.1 \cdot \dot{Q}_{\mathrm{gross,ID}} + 0.3412 \cdot \dot{E}F\mathrm{comp,on}}{\dot{Q}_{\mathrm{gross,ID}} - 2.7296 \cdot \dot{E}F\mathrm{comp,on}} \tag{126}$$

7.9.1.3 The Annual Walk-in Energy Factor, AWEF, is determined by a calculation that is a function of three measurements: Steady-state gross capacity, $Q_{\mathrm{gross,ID}}$, Steady-state electrical consumption by the Dedicated Condensing Unit measured during On-cycle periods $E_{\mathrm{CU,\ on}}$, and electrical consumption by the Dedicated Condensing Unit during Off-cycle periods, $E_{\mathrm{CU,\ off}}$.

$$\mathrm{AWEF} = \frac{0.33 \cdot \mathrm{B\dot{L}H} + 0.67 \cdot \mathrm{B\dot{L}L}}{\begin{gathered}0.33 \cdot \left[\left(\dot{E}_{\mathrm{CU,on}} + \dot{E}F_{\mathrm{comp,on}}\right) \cdot \mathrm{LFH} + \left(\dot{E}_{\mathrm{CU,off}} + \dot{E}F_{\mathrm{comp,off}}\right) \cdot (1\text{-}\mathrm{LFH})\right] + \\ 0.67 \cdot \left[\left(\dot{E}_{\mathrm{CU,on}} + \dot{E}F_{\mathrm{comp,on}}\right) \cdot \mathrm{LFL} + \left(\dot{E}_{\mathrm{CU,off}} + \dot{E}F_{\mathrm{comp,off}}\right) \cdot (1\text{-}\mathrm{LFL})\right]\end{gathered}} \tag{127}$$

Substituting for $\mathrm{B\dot{L}H}$ and $\mathrm{B\dot{L}L}$, using Equations 1 and 2:

$$\mathrm{AWEF} = \frac{0.33 \cdot \left(0.7 \cdot \dot{q}_{\mathrm{ss,ID}}\right) + 0.67 \cdot \left(0.1 \cdot \dot{q}_{\mathrm{ss,ID}}\right)}{\begin{gathered}0.33 \cdot \left[\left(\dot{E}_{\mathrm{CU,on}} + \dot{E}F_{\mathrm{comp,on}}\right) \cdot \mathrm{LFH} + \left(\dot{E}_{\mathrm{CU,off}} + \dot{E}F_{\mathrm{comp,off}}\right) \cdot (1\text{-}\mathrm{LFH})\right] + \\ 0.67 \cdot \left[\left(\dot{E}_{\mathrm{CU,on}} + \dot{E}F_{\mathrm{comp,on}}\right) \cdot \mathrm{LFL} + \left(\dot{E}_{\mathrm{CU,off}} + \dot{E}F_{\mathrm{comp,off}}\right) \cdot (1\text{-}\mathrm{LFL})\right]\end{gathered}} \tag{128}$$

Substituting for $\dot{q}_{ss,ID}$, $\dot{E}F_{\mathrm{comp,off}}$, LFH, and LFL:

$$\mathrm{AWEF} = \frac{0.33 \cdot \left(0.7 \cdot \left(\dot{Q}_{\mathrm{gross,ID}} - 3.412 \cdot \dot{E}F_{\mathrm{comp,on}}\right)\right) + 0.67 \cdot \left(0.1 \cdot \left(\dot{Q}_{\mathrm{gross,ID}} - 3.412 \cdot \dot{E}F_{\mathrm{comp,on}}\right)\right)}{\begin{gathered}0.33 \cdot \left[\left(\dot{E}_{\mathrm{CU,on}} + \dot{E}F_{\mathrm{comp,on}}\right) \cdot \left(\frac{0.7 \cdot \dot{Q}_{\mathrm{gross,ID}} - 1.706 \cdot \dot{E}F_{\mathrm{comp,on}}}{\dot{Q}_{\mathrm{gross,ID}} - 2.730 \cdot \dot{E}F_{\mathrm{comp,on}}}\right) + \left(\dot{E}_{\mathrm{CU,off}} + \left(0.2 \cdot \dot{E}F_{\mathrm{comp,on}}\right)\right) \cdot \left(1\text{-}\left(\frac{0.7 \cdot \dot{Q}_{\mathrm{gross,ID}} - 1.706 \cdot \dot{E}F_{\mathrm{comp,on}}}{\dot{Q}_{\mathrm{gross,ID}} - 2.730 \cdot \dot{E}F_{\mathrm{comp,on}}}\right)\right)\right] + \\ 0.67 \cdot \left[\left(\dot{E}_{\mathrm{CU,on}} + \dot{E}F_{\mathrm{comp,on}}\right) \cdot \left(\frac{0.1 \cdot \dot{Q}_{\mathrm{gross,ID}} + .3412 \cdot \dot{E}F_{\mathrm{comp,on}}}{\dot{Q}_{\mathrm{gross,ID}} - 2.730 \cdot \dot{E}F_{\mathrm{comp,on}}}\right) + \left(\dot{E}_{\mathrm{CU,off}} + \left(0.2 \cdot \dot{E}F_{\mathrm{comp,on}}\right)\right) \cdot \left(1\text{-}\left(\frac{0.1 \cdot \dot{Q}_{\mathrm{gross,ID}} + .3412 \cdot \dot{E}F_{\mathrm{comp,on}}}{\dot{Q}_{\mathrm{gross,ID}} - 2.730 \cdot \dot{E}F_{\mathrm{comp,on}}}\right)\right)\right]\end{gathered}} \tag{129}$$

The reference evaporator has an On-cycle evaporator fan power, in Watts, as a function of Dedicated Condensing Unit gross capacity:

$$\dot{E}F_{\mathrm{comp,on}} = \begin{cases} 0.0112 \cdot \dot{Q}_{\mathrm{gross,ID}}; & \text{for } \dot{Q}_{\mathrm{gross,ID}} \leq 50{,}000\ \mathrm{Btu/h} \\ 0.0161 \cdot \dot{Q}_{\mathrm{gross,ID}} - 246.2; & \text{for } \dot{Q}_{\mathrm{gross,ID}} > 50{,}000\ \mathrm{Btu/h} \end{cases} \tag{130}$$

Substituting Equation 130 into Equation 129 and simplifying results in following two AWEF Equations:

For $\dot{Q}_{\mathrm{gross,ID}} \leq 50{,}000\ \mathrm{Btu/h}$:

$$\mathrm{AWEF} = \frac{0.2866 \cdot \dot{Q}_{\mathrm{gross,ID}}}{\begin{gathered}0.33 \cdot \left[\left(\dot{E}_{\mathrm{CU,on}} + (0.0112 \cdot \dot{Q}_{\mathrm{gross,ID}}\right) \cdot (0.7023) + \left(\dot{E}_{\mathrm{CU,off}} + 0.00224 \cdot \dot{Q}_{\mathrm{gross,ID}}\right) \cdot \left(1\text{-}(0.7023)\right)\right] + \\ 0.67 \cdot \left[\left(\dot{E}_{\mathrm{CU,on}} + 0.0112 \cdot \dot{Q}_{\mathrm{gross,ID}}\right) \cdot (0.10710) + \left(\dot{E}_{\mathrm{CU,off}} + 0.00224 \cdot \dot{Q}_{\mathrm{gross,ID}}\right) \cdot \left(1\text{-}(0.1071)\right)\right]\end{gathered}}$$

$$= \frac{0.2866 \cdot \dot{Q}_{gross,ID}}{0.00496 \cdot \dot{Q}_{gross,ID} + 0.3035 \cdot \dot{E}_{CU,on} + 0.6964 \cdot \dot{E}_{CU,off}} \qquad 131$$

For $\dot{Q}_{gross,ID} > 50{,}000$ Btu/h:

$$\text{AWEF} = \frac{0.33 \cdot \left(0.7 \cdot \left(\dot{Q}_{gross,ID} - 3.412 \cdot \left(0.0161 \cdot \dot{Q}_{gross,ID} - 246.2\right)\right)\right) + 0.67 \cdot \left(0.1 \cdot \left(\dot{Q}_{gross,ID} - 3.412 \cdot \left(0.0161 \cdot \dot{Q}_{gross,ID} - 246.2\right)\right)\right)}{\begin{array}{l} 0.33 \cdot \left[\left(\dot{E}_{CU,on} + (0.0161 \cdot \dot{Q}_{gross,ID} - 246.2) \cdot \left(\frac{0.6725 \cdot \dot{Q}_{gross,ID} + 420.017}{0.9561 \cdot \dot{Q}_{gross,ID} + 672.126}\right) + \left(\dot{E}_{CU,off} + \left(0.00322 \cdot \dot{Q}_{gross,ID} - 49.24\right)\right) \cdot \left(1 - \left(\frac{0.6725 \cdot \dot{Q}_{gross,ID} + 420.017}{0.9561 \cdot \dot{Q}_{gross,ID} + 672.126}\right)\right)\right]\right. + \\ 0.67 \cdot \left[\left(\dot{E}_{CU,on} + (0.0161 \cdot \dot{Q}_{gross,ID} - 246.2) \cdot \left(\frac{0.10549 \cdot \dot{Q}_{gross,ID} - 84.003}{0.9561 \cdot \dot{Q}_{gross,ID} + 672.028}\right) + \left(\dot{E}_{CU,off} + \left(0.00322 \cdot \dot{Q}_{gross,ID} - 49.24\right)\right) \cdot \left(1 - \left(\frac{0.10549 \cdot \dot{Q}_{gross,ID} - 84.003}{0.9561 \cdot \dot{Q}_{gross,ID} + 672.028}\right)\right)\right)\right] \end{array}} \qquad 132$$

7.9.2 *Refrigerator Outdoor Dedicated Condensing Units Tested Alone*. The Dedicated Condensing Unit shall be tested at the ambient condition A, B, and C in Table 13. Electrical energy consumption by the Dedicated Condensing Unit shall be measured at the three ambient outdoor temperature conditions listed in Table 13 during On-cycle periods $\dot{E}_{CU,on}(t_X)$, and during Off-cycle periods, $E_{CU,off}(t_X)$ (where X = ambient condition A, B, or C). The Steady-state gross capacity, $\dot{Q}_{gross}(t_X)$, shall also be measured at the three ambient outdoor temperature conditions listed in Table 13 during On-cycle periods. Note: See Equations 154 and 155 for simplified AWEF calculation.

7.9.2.1 When the Dedicated Condensing Unit is on, its Steady-state gross capacity, $\dot{Q}_{gross}(t_j)$, is reduced by the heat content of On-cycle evaporator fan power, $\dot{EF}_{comp,on}$, to yield its Steady-state net capacity, $\dot{q}_{ss}(t_j)$. $\dot{EF}_{comp,on}$ is calculated as a function of $\dot{Q}_{gross}(t_j)$, which is defined in Section 7.9.2.3.

$$\dot{q}_{ss}(t_j) = \dot{Q}_{gross}(t_j) - 3.412 \cdot \dot{EF}_{comp,on} \qquad 133$$

The steady state net capacity at 95°F, is used to calculate the Walk-in Box Load and is calculated as:

$$\dot{q}_{ss,A} = \dot{Q}_{gross,A} - 3.412 \cdot \dot{EF}_{comp,on} \qquad 134$$

7.9.2.2 The Total Walk-in System Heat Load at High Load Periods and Low Load Periods, $\dot{WLH}$ and $\dot{WLL}$ respectively, includes the box heat load and the heat load from the fan energy when the Dedicated Condensing Unit compressor is off. This in turn can be used to calculate the fraction of time that the compressor is on during High Load and Low Load Periods, LFH and LFL respectively.

$$\dot{WLH}\left(t_j\right) = \dot{BLH}\left(t_j\right) + 3.412 \cdot \dot{EF}_{comp,off}\left(1 - LFH\left(t_j\right)\right) \qquad 135$$

$$\dot{WLL}\left(t_j\right) = \dot{BLL}\left(t_j\right) + 3.412 \cdot \dot{EF}_{comp,off}\left(1 - LFL\left(t_j\right)\right) \qquad 136$$

Where:

Where $\dot{BLH}$ and $\dot{BLL}$ are defined by Equations 3 and 4 in Section 6 and $\dot{EF}_{comp,off}$ is assumed to consume 20% of the energy as $\dot{EF}_{comp,on}$;

$$\dot{EF}_{comp,off} = 0.2 \cdot \dot{EF}_{comp,on} \qquad 137$$

The Load Factor LFH is calculated as follows:

$$LFH\left(t_j\right) = \frac{\dot{WLH}\left(t_j\right)}{\dot{q}_{ss}\left(t_j\right)} \qquad 138$$

Substituting for $\dot{WLH}$ using Equation 135

$$\mathrm{LFH}\left(t_j\right)= \frac{\dot{\mathrm{BLH}}\left(t_j\right) + 3.412 \cdot \dot{\mathrm{EF}}_{\mathrm{comp,off}}}{\dot{q}_{ss}\left(t_j\right) + 3.412 \cdot \dot{\mathrm{EF}}_{\mathrm{comp,off}}} \tag{139}$$

Substituting for $\dot{\mathrm{BLH}}$ using Equation 3 and $\dot{EF}_{\mathrm{comp,off}}$ using Equation 137

$$\mathrm{LFH}\left(t_j\right) = \frac{\left(0.65 \cdot \dot{q}_{ss,A} + 0.05 \cdot \frac{\dot{q}_{ss,A} \cdot \left(t_j - 35\right)}{60}\right) + 3.412 \cdot \left(0.2 \cdot \dot{\mathrm{EF}}_{\mathrm{comp,on}}\right)}{\dot{q}_{ss}\left(t_j\right) + 3.412 \cdot \left(0.2 \cdot \dot{\mathrm{EF}}_{\mathrm{comp,on}}\right)} \tag{140}$$

Substituting for $\dot{q}_{ss}(t_j)$, $\dot{q}_{ss,A}$, using Equation 133 and 134, respectively, and reducing

$$\mathrm{LFH}\left(t_j\right) = \frac{\left[0.65 \cdot \left(\dot{Q}_{\mathrm{gross,A}} - 3.412 \cdot \dot{\mathrm{EF}}_{\mathrm{comp,on}}\right) + 0.05 \cdot \frac{\left(\dot{Q}_{\mathrm{gross,A}} - 3.412 \cdot \dot{\mathrm{EF}}_{\mathrm{comp,on}}\right) \cdot \left(t_j - 35\right)}{60}\right] + 3.412 \left(0.2 \cdot \dot{\mathrm{EF}}_{\mathrm{comp,on}}\right)}{\left(\dot{Q}_{\mathrm{gross}}\left(t_j\right) - 3.412 \cdot \dot{\mathrm{EF}}_{\mathrm{comp,on}}\right) + 3.412 \cdot \left(0.2 \cdot \dot{\mathrm{EF}}_{\mathrm{comp,on}}\right)} \tag{141}$$

Reducing Equation 141

$$\mathrm{LFH}\left(t_j\right) = \frac{-1.4358 \cdot \dot{\mathrm{EF}}_{\mathrm{comp,on}} - 0.00284 \cdot \dot{\mathrm{EF}}_{\mathrm{comp,on}} \cdot t_j + 0.6208 \cdot \dot{Q}_{\mathrm{gross,A}} + 0.00083 \cdot \dot{Q}_{\mathrm{gross,A}} \cdot t_j}{\dot{Q}_{\mathrm{gross}}\left(t_j\right) - 2.7296 \cdot \dot{\mathrm{EF}}_{\mathrm{comp,on}}} \tag{142}$$

The Load Factor LFL is calculated as follows:

$$\mathrm{LFL}\left(t_j\right) = \frac{\dot{\mathrm{WLL}}(t_j)}{\dot{q}_{ss}(t_j)} \tag{143}$$

Substituting for $\dot{\mathrm{WLL}}$ using Equation 136

$$\mathrm{LFL}\left(t_j\right) = \frac{\dot{\mathrm{BLL}}\left(t_j\right) + 3.412 \cdot \dot{\mathrm{EF}}_{\mathrm{comp,off}}}{\dot{q}_{ss}\left(t_j\right) + 3.412 \cdot \dot{\mathrm{EF}}_{\mathrm{comp,off}}} \tag{144}$$

Substituting for $\dot{\mathrm{BLL}}$ using Equation 4 and $\dot{EF}_{\mathrm{comp,off}}$ using Equation 137

$$\mathrm{LFL}\left(t_j\right) = \frac{\left(0.03 \cdot \dot{q}_{ss,A} + 0.07 \cdot \frac{\dot{q}_{ss,A} \cdot \left(t_j - 35\right)}{60}\right) + 3.412 \cdot \left(0.2 \cdot \dot{\mathrm{EF}}_{\mathrm{comp,on}}\right)}{\dot{q}_{ss}\left(t_j\right) + 3.412 \cdot \left(0.2 \cdot \dot{\mathrm{EF}}_{\mathrm{comp,on}}\right)} \tag{145}$$

Substituting for $\dot{q}_{ss}(t_j)$, $\dot{q}_{ss,A}$ using Equation 133 and 134, respectively, and reducing

$$\mathrm{LFL}\left(t_j\right) = \frac{\left[0.03 \cdot \left(\dot{Q}_{\mathrm{gross,A}} - 3.412 \cdot \dot{\mathrm{EF}}_{\mathrm{comp,on}}\right) + 0.07 \cdot \frac{\left(\dot{Q}_{\mathrm{gross,A}} - 3.412 \cdot \dot{\mathrm{EF}}_{\mathrm{comp,on}}\right) \cdot \left(t_j - 35\right)}{60}\right] + (3.412) \cdot \left(0.2 \cdot \dot{\mathrm{EF}}_{\mathrm{comp,on}}\right)}{\left(\dot{Q}_{\mathrm{gross}}\left(t_j\right) - 3.412 \cdot \dot{\mathrm{EF}}_{\mathrm{comp,on}}\right) + (3.412) \cdot \left(0.2 \cdot \dot{\mathrm{EF}}_{\mathrm{comp,on}}\right)} \tag{146}$$

Reducing Equation 146

$$\mathrm{LFL}\left(t_j\right) = \frac{0.71936 \cdot \dot{\mathrm{EF}}_{\mathrm{comp,on}} - 0.00398 \cdot \dot{\mathrm{EF}}_{\mathrm{comp,on}} \cdot t_j - 0.01083 \cdot \dot{Q}_{\mathrm{gross,A}} + 0.00117 \cdot \dot{Q}_{\mathrm{gross,A}} \cdot t_j}{\dot{Q}_{\mathrm{gross}}\left(t_j\right) - 2.7296 \cdot \dot{\mathrm{EF}}_{\mathrm{comp,on}}} \tag{147}$$

Where:

If $t_j \leq 59$ °F

$$\dot{Q}_{gross}(t_j) = \dot{Q}_{gross,C} + \frac{(\dot{Q}_{gross,B} - \dot{Q}_{gross,C})}{t_B - t_C}(t_j - t_C) \qquad 148$$

If $t_j > 59°F$

$$\dot{Q}_{gross}(t_j) = \dot{Q}_{gross,B} + \frac{(\dot{Q}_{gross,A} - \dot{Q}_{gross,B})}{t_A - t_B}(t_j - t_B) \qquad 149$$

7.9.2.3 The Annual Walk-in Energy Factor, AWEF, is determined by a calculation that is a function of three measurements: Steady-state gross capacity, $\dot{Q}_{gross}(t_j)$, Steady-state electrical consumption by the Dedicated Condensing Unit measured during On-cycle periods $\dot{E}_{CU,\ on}$, and electrical consumption by the Dedicated Condensing Unit during Off-cycle periods, $E_{CU,\ off}$. These calculations are weighted by the number of bin hours, n_j, from Table D1 in Appendix D, for each of the 20 bin temperatures, t_j, in Table D1.

$$AWEF = \frac{\sum_{j=1}^{n}[0.33\cdot B\dot{L}H(t_j) + 0.67\cdot B\dot{L}L(t_j)]\cdot n_j}{\sum_{j=1}^{n}\begin{bmatrix}0.33\cdot[(\dot{E}_{CU,on}(t_j) + \dot{EF}_{comp,on})\cdot LFH(t_j) + (\dot{E}_{CU,off}(t_j)+\dot{EF}_{comp,off})\cdot(1 - LFH(t_j))] + \\ 0.67\cdot[(\dot{E}_{CU,on}\ (t_j)+ \dot{EF}_{comp,on})\cdot LFL(t_j)\ + (\dot{E}_{CU,off}(t_j)+\dot{EF}_{comp,off})\cdot(1 - LFL(t_j))]\end{bmatrix}\cdot n_j} \qquad 150$$

Substituting for $B\dot{L}H$ and $B\dot{L}L$:

$$AWEF = \frac{\sum_{j=1}^{20}\left\{0.33\cdot\left(0.65\cdot\dot{q}_{ss,A} + 0.05\cdot\frac{\dot{q}_{ss,A}\cdot(t_j-35)}{60}\right)+0.67\cdot\left(0.03\cdot\dot{q}_{ss,A} + 0.07\cdot\frac{\dot{q}_{ss,A}\cdot(t_j-35)}{60}\right)\right\}\cdot n_j}{\sum_{j=1}^{n}\begin{bmatrix}0.33\cdot[(\dot{E}_{CU,on} + \dot{EF}_{comp,on})\cdot LFH(t_j) + (\dot{E}_{CU,off}+\dot{EF}_{comp,off})\cdot(1 - LFH(t_j))] + \\ 0.67\cdot[(\dot{E}_{CU,on} + \dot{EF}_{comp,on})\cdot LFL(t_j)\ + (\dot{E}_{CU,off}+\dot{EF}_{comp,off})\cdot(1 - LFL(t_j))]\end{bmatrix}\cdot n_j} \qquad 151$$

Substituting for $\dot{q}_{ss,A}$ and $\dot{EF}_{comp,off}$

$$AWEF = \frac{\sum_{j=1}^{20}\left\{0.33\cdot\left(0.65\cdot(\dot{Q}_{gross,A} - 3.412\cdot\dot{EF}_{comp,on})+0.05\cdot\frac{(\dot{Q}_{gross,A} - 3.412\cdot\dot{EF}_{comp,on})\cdot(t_j-35)}{60}\right)+0.67\cdot\left(0.03\cdot(\dot{Q}_{gross,A} - 3.412\cdot\dot{EF}_{comp,on})+ 0.07\cdot\frac{(\dot{Q}_{gross,A} - 3.412\cdot\dot{EF}_{comp,on})\cdot(t_j-35)}{60}\right)\right\}\cdot n_j}{\sum_{j=1}^{n}\begin{bmatrix}0.33\cdot[(\dot{E}_{CU,on} + \dot{EF}_{comp,on})\cdot LFH(t_j) + (\dot{E}_{CU,off}+(0.2\cdot\dot{EF}_{comp,on}))\cdot(1 - LFH(t_j))] + \\ 0.67\cdot[(\dot{E}_{CU,on} + \dot{EF}_{comp,on})\cdot LFL(t_j)\ + (\dot{E}_{CU,off}+(0.2\cdot\dot{EF}_{comp,on}))\cdot(1 - LFL(t_j))]\end{bmatrix}\cdot n_j} \qquad 152$$

The reference evaporator has an On-cycle evaporator fan power, in Watts, as a function of Dedicated Condensing Unit gross capacity:

$$\dot{EF}_{comp,on} = \begin{cases}0.0112\cdot\dot{Q}_{gross,A}; & \text{for } \dot{Q}_{gross,A} \leq 50{,}000\ \text{Btu/h} \\ 0.0161\cdot\dot{Q}_{gross,A} - 246.2; & \text{for } \dot{Q}_{gross,A} > 50{,}000\ \text{Btu/h}\end{cases} \qquad 153$$

Substituting Equation 153 into Equation 152 and simplifying results in following two AWEF Equations:

For $\dot{Q}_{gross,A} \leq 50{,}000$ Btu/h:

$$AWEF = \frac{\sum_{j=1}^{20}\left\{0.33\cdot\left(0.65\cdot(\dot{Q}_{gross,A} - 3.412\cdot(0.0112\cdot\dot{Q}_{gross,A}))+0.05\cdot\frac{(\dot{Q}_{gross,A} - 3.412\cdot(0.0112\cdot\dot{Q}_{gross,A}))\cdot(t_j-35)}{60}\right)+0.67\ \cdot\left(0.03\ (\dot{Q}_{gross,A} - 3.412\cdot(0.0112\cdot\dot{Q}_{gross,A}))+ 0.07\cdot\frac{(\dot{Q}_{gross,A} - 3.412\cdot(0.0112\cdot\dot{Q}_{gross,A}))\cdot(t_j-35)}{60}\right)\right\}\cdot n_j}{\sum_{j=1}^{n}\begin{bmatrix}0.33\cdot[(\dot{E}_{CU,on} + (0.0112\cdot\dot{Q}_{gross,A}))\cdot LFH(t_j) + (\dot{E}_{CU,off}+(0.2\cdot\dot{EF}_{comp,on}))\cdot(1 - LFH(t_j))] + \\ 0.67\cdot[(\dot{E}_{CU,on} + (0.0112\cdot\dot{Q}_{gross,A}))\cdot LFL(t_j)\ + (\dot{E}_{CU,off}+(0.2\cdot\dot{EF}_{comp,on}))\cdot(1 - LFL(t_j))]\end{bmatrix}\cdot n_j}$$

$$= \frac{\sum_{j=1}^{20}\{\ 0.001016\cdot\dot{Q}_{gross,A}\cdot t_j + 0.190065\cdot\dot{Q}_{gross,A}\}\cdot n_j}{\sum_{j=1}^{n}\begin{bmatrix}0.33\cdot[(\dot{E}_{CU,on} + (0.0112\cdot\dot{Q}_{gross,A}))\cdot LFH(t_j) + (\dot{E}_{CU,off}+(0.00224\cdot\dot{Q}_{gross,A}\ ))\cdot(1 - LFH(t_j))] + \\ 0.67\cdot[(\dot{E}_{CU,on} + (0.0112\cdot\dot{Q}_{gross,A}))\cdot LFL(t_j)\ + (\dot{E}_{CU,off}+(0.00224\cdot\dot{Q}_{gross,A}\ ))\cdot(1 - LFL(t_j))]\end{bmatrix}\cdot n_j} \qquad 154$$

For $\dot{Q}_{gross,A} > 50{,}000$ Btu/h:

$$\mathrm{AWEF} = \frac{\sum_{j=1}^{20}\left\{0.33\cdot\left(0.65\cdot(\dot{Q}_{gross,A}-3.412\cdot(0.0161\cdot\dot{Q}_{gross,A}-246.2))+0.05\cdot\frac{(\dot{Q}_{gross,A}-3.412\cdot(0.0161\cdot\dot{Q}_{gross,A}-246.2))\cdot(t_j-35)}{60}\right)+0.67\cdot\left(0.03\,(\dot{Q}_{gross,A}-3.412\cdot(0.0161\cdot\dot{Q}_{gross,A}-246.2))+0.07\cdot\frac{(\dot{Q}_{gross,A}-3.412\cdot(0.0161\cdot\dot{Q}_{gross,A}-246.2))\cdot(t_j-35)}{60}\right)\right\}\cdot n_j}{\sum_{j=1}^{n}\begin{bmatrix}0.33\cdot[(\dot{E}_{CU,on}+(0.0161\cdot\dot{Q}_{gross,A}-246.2))\cdot LFH(t_j)+(\dot{E}_{CU,off}+(0.2\cdot\dot{EF}_{comp,on}))\cdot(1-LFH(t_j))]+\\ 0.67\cdot[(\dot{E}_{CU,on}+(0.0161\cdot\dot{Q}_{gross,A}-246.2))\cdot LFL(t_j)+(\dot{E}_{CU,off}+(0.2\cdot\dot{EF}_{comp,on}))\cdot(1-LFL(t_j))]\end{bmatrix}\cdot n_j}$$

$$= \frac{\sum_{j=1}^{20}\{0.000998621\cdot\dot{Q}_{gross,A}\cdot t_j+0.18671\cdot\dot{Q}_{gross,A}+0.887636\cdot t_j+166.005\}\cdot n_j}{\sum_{j=1}^{n}\begin{bmatrix}0.33\cdot[(\dot{E}_{CU,on}+(0.0161\cdot\dot{Q}_{gross,A}-246.2))\cdot LFH(t_j)+(\dot{E}_{CU,off}+(0.00322\cdot\dot{Q}_{gross,A}-49.24))\cdot(1-LFH(t_j))]+\\ 0.67\cdot[(\dot{E}_{CU,on}+(0.0161\cdot\dot{Q}_{gross,A}-246.2))\cdot LFL(t_j)+(\dot{E}_{CU,off}+(0.00322\cdot\dot{Q}_{gross,A}-49.24))\cdot(1-LFL(t_j))]\end{bmatrix}\cdot n_j} \quad 155$$

Where:

If $t_j \leq 59°F$

$$\dot{E}_{CU,on}(t_j)=\dot{E}_{CU,on}(35°F)+\frac{(\dot{E}_{CU,on}(59°F)-\dot{E}_{CU,on}(35°F))}{59-35}\cdot(t_j-35) \quad 156$$

$$\dot{E}_{CU,off}(t_j)=\dot{E}_{CU,off}(35°F)+\frac{(\dot{E}_{CU,off}(59°F)-\dot{E}_{CU,off}(35°F))}{59-35}\cdot(t_j-35) \quad 157$$

If $t_j > 59°F$

$$\dot{E}_{CU,on}(t_j)=\dot{E}_{CU,on}(59°F)+\frac{(\dot{E}_{CU,on}(95°F)-\dot{E}_{CU,on}(59°F))}{95-59}\cdot(t_j-59) \quad 158$$

$$\dot{E}_{CU,off}(t_j)=\dot{E}_{CU,off}(59°F)+\frac{(\dot{E}_{CU,off}(95°F)-\dot{E}_{CU,off}(59°F))}{95-59}\cdot(t_j-59) \quad 159$$

7.9.3 *Freezer Indoor Dedicated Condensing Units Tested Alone*. The Dedicated Condensing Unit shall be tested at the ambient condition A in Table 14. Electrical energy consumption by the Dedicated Condensing Unit shall be measured during On-cycle periods $\dot{E}_{CU,\ on}$ and during Off-cycle periods, $\dot{E}_{CU,\ off}$. The Steady-state gross capacity, $\dot{Q}_{gross}$ shall also be measured during the On-cycle. Note: See Equations 175 and 176 for simplified AWEF calculation.

7.9.3.1 When the Dedicated Condensing Unit is on, its Steady-state gross capacity, $\dot{Q}_{gross}$, is reduced by the heat content of On-cycle evaporator fan power, $EF_{comp,on}$, to yield its net capacity, $\dot{q}_{ss}$. $\dot{EF}_{comp,on}$ is calculated as a function of $\dot{Q}_{gross}$, which is defined in Section 7.9.3.3.

$$\dot{q}_{ss,ID} = \dot{Q}_{gross,ID} - 3.412\cdot\dot{EF}_{Comp,on} \quad 160$$

7.9.3.2 Walk-in System High Load, $\dot{WLH}$, and Walk-in System Low Load, $\dot{WLL}$, include the box heat load and the heat load from the fan energy when the Dedicated Condensing Unit compressor is off. This in turn can be used to calculate the fraction of time that the compressor is on during High Load and Low Load Periods, LFH and LFL respectively.

$$\dot{WLH} = \dot{BLH} + 3.412\cdot\dot{EF}_{comp,off}\,(1\text{-}LFH) + \dot{Q}_{DF} \quad 161$$

$$\dot{WLL} = \dot{BLL} + 3.412\cdot\dot{EF}_{comp,off}\,(1\text{-}LFL) + \dot{Q}_{DF} \quad 162$$

Where $\dot{BLH}$ and $\dot{BLL}$ are defined by Equations 1 and 2 in Section 6, and $\dot{EF}_{comp,off}$ is assumed to consume 20% of the energy as $\dot{EF}_{comp,on}$, and $\dot{Q}_{DF}$ is calculated in Section C10 of this standard.

$$\dot{EF}_{comp,off}=0.2\cdot\dot{EF}_{comp,on} \quad 163$$

The Load Factors LFH is calculated as follows.

$$\mathrm{LFH} = \frac{\mathrm{W\dot{L}H}}{\dot{q}_{ss,ID}} \tag{164}$$

Substituting for $\mathrm{W\dot{L}H}$ using Equation 160 and $\mathrm{B\dot{L}H}$ using Equation 1 and $\dot{E}F_{\mathrm{comp,off}}$ using Equation 163

$$\mathrm{LFH} = \frac{\mathrm{B\dot{L}H} + 3.412 \cdot \dot{\mathrm{E}}\mathrm{F}_{\mathrm{comp,off}} + \dot{\mathrm{Q}}_{\mathrm{DF}}}{\dot{q}_{\mathrm{ss,ID}} + 3.412 \cdot \dot{\mathrm{E}}\mathrm{F}_{\mathrm{comp,off}}} = \frac{\left(0.8 \cdot \dot{q}_{\mathrm{ss,ID}}\right) + 3.412 \cdot \left(0.2 \cdot \dot{\mathrm{E}}\mathrm{F}_{\mathrm{comp,on}}\right) + \dot{\mathrm{Q}}_{\mathrm{DF}}}{\dot{q}_{\mathrm{ss,ID}} + 3.412 \cdot \left(0.2 \cdot \dot{\mathrm{E}}\mathrm{F}_{\mathrm{comp,on}}\right)} \tag{165}$$

Substituting for $\dot{q}_{ss,ID}$ using Equation 159 and reducing

$$\mathrm{LFH} = \frac{0.8 \cdot \left(\dot{\mathrm{Q}}_{\mathrm{gross,ID}} - 3.412 \cdot \dot{\mathrm{E}}\mathrm{F}_{\mathrm{comp,on}}\right) + 3.412 \cdot \left(0.2 \cdot \dot{\mathrm{E}}\mathrm{F}_{\mathrm{comp,on}}\right) + \dot{\mathrm{Q}}_{\mathrm{DF}}}{\left(\dot{\mathrm{Q}}_{\mathrm{gross,ID}} - 3.412 \cdot \dot{\mathrm{E}}\mathrm{F}_{\mathrm{comp,on}}\right) + 3.412 \cdot \left(0.2 \cdot \dot{\mathrm{E}}\mathrm{F}_{\mathrm{comp,on}}\right)} = \frac{0.8 \cdot \dot{\mathrm{Q}}_{\mathrm{gross,ID}} - 2.0472 \cdot \dot{\mathrm{E}}\mathrm{F}_{\mathrm{comp,on}} + \dot{\mathrm{Q}}_{\mathrm{DF}}}{\dot{\mathrm{Q}}_{\mathrm{gross,ID}} - 2.7296 \cdot \dot{\mathrm{E}}\mathrm{F}_{\mathrm{comp,on}}} \tag{166}$$

The Load Factor LFL is calculated as follows:

$$\mathrm{LFL} = \frac{\mathrm{W\dot{L}L}}{\dot{q}_{\mathrm{ss,ID}}} \tag{167}$$

Substituting for $\mathrm{W\dot{L}L}$ using Equation 162 and $\mathrm{B\dot{L}L}$ using Equation 1 and $\dot{\mathrm{E}}\mathrm{F}_{\mathrm{comp,off}}$ using Equation 163

$$\mathrm{LFL} = \frac{\mathrm{B\dot{L}L} + 3.412 \cdot \dot{\mathrm{E}}\mathrm{F}_{\mathrm{comp,off}} + \dot{\mathrm{Q}}_{\mathrm{DF}}}{\dot{q}_{\mathrm{ss,ID}} + 3.412 \cdot \dot{\mathrm{E}}\mathrm{F}_{\mathrm{comp,off}}} = \frac{\left(0.4 \cdot \dot{q}_{\mathrm{ss,ID}}\right) + 3.412 \cdot \left(0.2 \cdot \dot{\mathrm{E}}\mathrm{F}_{\mathrm{comp,on}}\right) + \dot{\mathrm{Q}}_{\mathrm{DF}}}{\dot{q}_{\mathrm{ss,ID}} + 3.412 \cdot \left(0.2 \cdot \dot{\mathrm{E}}\mathrm{F}_{\mathrm{comp,on}}\right)} \tag{168}$$

Substituting for $\dot{q}_{ss,ID}$ using Equation 160 and reducing

$$\mathrm{LFL} = \frac{0.4 \cdot \left(\dot{\mathrm{Q}}_{\mathrm{gross,ID}} - 3.412 \cdot \dot{\mathrm{E}}\mathrm{F}_{\mathrm{comp,on}}\right) + 3.412 \cdot \left(0.2 \cdot \dot{\mathrm{E}}\mathrm{F}_{\mathrm{comp,on}}\right) + \dot{\mathrm{Q}}_{\mathrm{DF}}}{\left(\dot{\mathrm{Q}}_{\mathrm{gross,ID}} - 3.412 \cdot \dot{\mathrm{E}}\mathrm{F}_{\mathrm{comp,on}}\right) + 3.412 \cdot \left(0.2 \cdot \dot{\mathrm{E}}\mathrm{F}_{\mathrm{comp,on}}\right)} = \frac{0.4 \cdot \dot{\mathrm{Q}}_{\mathrm{gross,ID}} - 0.6284 \cdot \dot{\mathrm{E}}\mathrm{F}_{\mathrm{comp,on}} + \dot{\mathrm{Q}}_{\mathrm{DF}}}{\dot{\mathrm{Q}}_{\mathrm{gross,ID}} - 2.7296 \cdot \dot{\mathrm{E}}\mathrm{F}_{\mathrm{comp,on}}} \tag{169}$$

7.9.3.3 The Annual Walk-in Energy Factor, AWEF, is determined by a calculation that is a function of four measurements: Steady-state gross capacity, $\dot{Q}_{gross,ID}$, Steady-state electrical consumption by the Dedicated Condensing Unit measured during On-cycle periods $\dot{E}_{\mathrm{CU,\ on}}$, electrical consumption by the Dedicated Condensing Unit during Off-cycle periods, $\dot{E}_{\mathrm{CU,\ off}}$, and the hourly defrost cycle energy, $\mathrm{\dot{D}F}$. $\mathrm{\dot{D}F}$ is calculated in Section C10 of this standard.

$$\mathrm{AWEF} = \frac{0.33 \cdot \mathrm{B\dot{L}H} + 0.67 \cdot \mathrm{B\dot{L}L}}{\begin{array}{c} 0.33 \cdot \left[\left(\dot{\mathrm{E}}_{\mathrm{CU,on}} + \dot{\mathrm{E}}\mathrm{F}_{\mathrm{comp,on}}\right) \cdot \mathrm{LFH} + \left(\dot{\mathrm{E}}_{\mathrm{CU,off}} + \dot{\mathrm{E}}\mathrm{F}_{\mathrm{comp,off}}\right) \cdot (1\text{-}\mathrm{LFH})\right] + \\ 0.67 \cdot \left[\left(\dot{\mathrm{E}}_{\mathrm{CU,on}} + \dot{\mathrm{E}}\mathrm{F}_{\mathrm{comp,on}}\right) \cdot \mathrm{LFL} + \left(\dot{\mathrm{E}}_{\mathrm{CU,off}} + \dot{\mathrm{E}}\mathrm{F}_{\mathrm{comp,off}}\right) \cdot (1\text{-}\mathrm{LFL})\right] + \mathrm{\dot{D}F} \end{array}} \tag{170}$$

Substituting for $\mathrm{B\dot{L}H}$ and $\mathrm{B\dot{L}L}$:

$$\mathrm{AWEF} = \frac{0.33 \cdot \left(0.8 \cdot \dot{q}_{\mathrm{ss,ID}}\right) + 0.67 \cdot \left(0.4 \cdot \dot{q}_{\mathrm{ss,ID}}\right)}{\begin{array}{c} 0.33 \cdot \left[\left(\dot{\mathrm{E}}_{\mathrm{CU,on}} + \dot{\mathrm{E}}\mathrm{F}_{\mathrm{comp,on}}\right) \cdot \mathrm{LFH} + \left(\dot{\mathrm{E}}_{\mathrm{CU,off}} + \dot{\mathrm{E}}\mathrm{F}_{\mathrm{comp,off}}\right) \cdot (1\text{-}\mathrm{LFH})\right] + \\ 0.67 \cdot \left[\left(\dot{\mathrm{E}}_{\mathrm{CU,on}} + \dot{\mathrm{E}}\mathrm{F}_{\mathrm{comp,on}}\right) \cdot \mathrm{LFL} + \left(\dot{\mathrm{E}}_{\mathrm{CU,off}} + \dot{\mathrm{E}}\mathrm{F}_{\mathrm{comp,off}}\right) \cdot (1\text{-}\mathrm{LFL})\right] + \mathrm{\dot{D}F} \end{array}} \tag{171}$$

Substituting for $\dot{q}_{\mathrm{ss,ID}}$, $\dot{\mathrm{E}}\mathrm{F}_{\mathrm{comp,off}}$, LFH, and LFL:

$$\mathrm{AWEF} = \frac{0.33 \cdot \left(0.8 \cdot \left(\dot{Q}_{gross,ID} - 3.412 \cdot \dot{EF}_{comp,on}\right)\right) + 0.67 \cdot \left(0.4 \cdot \left(\dot{Q}_{gross,ID} - 3.412 \cdot \dot{EF}_{comp,on}\right)\right)}{\begin{gathered}0.33 \cdot \left[\left(\dot{E}_{CU,on} + \dot{EF}_{comp,on}\right) \cdot \left(\frac{0.8 \cdot \dot{Q}_{gross,ID} - 2.0472 \cdot \dot{EF}_{comp,on} + \dot{Q}_{DF}}{\dot{Q}_{gross,ID} - 2.7296 \cdot \dot{EF}_{comp,on}}\right) + \left(\dot{E}_{CU,off} + \left(0.2 \cdot \dot{EF}_{comp,on}\right)\right) \cdot \left(1 - \left(\frac{0.8 \cdot \dot{Q}_{gross,ID} - 2.0472 \cdot \dot{EF}_{comp,on} + \dot{Q}_{DF}}{\dot{Q}_{gross,ID} - 2.7296 \cdot \dot{EF}_{comp,on}}\right)\right)\right] + \\ 0.67 \cdot \left[\left(\dot{E}_{CU,on} + \dot{EF}_{comp,on}\right) \cdot \left(\frac{0.4 \cdot \dot{Q}_{gross,ID} - 0.6284 \cdot \dot{EF}_{comp,on} + \dot{Q}_{DF}}{\dot{Q}_{gross,ID} - 2.7296 \cdot \dot{EF}_{comp,on}}\right) + \left(\dot{E}_{CU,off} + \left(0.2 \cdot \dot{EF}_{comp,on}\right)\right) \cdot \left(1 - \left(\frac{0.4 \cdot \dot{Q}_{gross,ID} - 0.6284 \cdot \dot{EF}_{comp,on} + \dot{Q}_{DF}}{\dot{Q}_{gross,ID} - 2.7296 \cdot \dot{EF}_{comp,on}}\right)\right)\right] + \dot{DF}\end{gathered}} \qquad 172$$

The reference evaporator has an On-cycle evaporator fan power, in Watts, as a function of Dedicated Condensing Unit gross capacity:

$$\dot{EF}_{comp,on} = \begin{cases} 0.0162 \cdot \dot{Q}_{gross,ID}; & \text{for } \dot{Q}_{gross,ID} \leq 50{,}000 \text{ Btu/h} \\ 0.0216 \cdot \dot{Q}_{gross,ID} - 269.9; & \text{for } \dot{Q}_{gross,ID} > 50{,}000 \text{ Btu/h} \end{cases} \qquad 173$$

Substituting Equations 173 into Equation 172 and simplifying results in following two AWEF Equations:

For $\dot{Q}_{gross,ID} \leq 50{,}000$ Btu/h:

$$\mathrm{AWEF} = \frac{0.502594 \cdot \dot{Q}_{gross,ID}}{\begin{gathered}0.33 \cdot \left[\left(\dot{E}_{CU,on} + \left(0.0162 \cdot \dot{Q}_{gross,ID}\right)\right) \cdot \left(\frac{0.7668 \cdot \dot{Q}_{gross,ID} + \dot{Q}_{DF}}{0.9558 \cdot \dot{Q}_{gross,ID}}\right) + \left(\dot{E}_{CU,off} + \left(0.2 \cdot \left(0.0162 \cdot \dot{Q}_{gross,ID}\right)\right)\right) \cdot \left(1 - \left(\frac{0.7668 \cdot \dot{Q}_{gross,ID} + \dot{Q}_{DF}}{0.9558 \cdot \dot{Q}_{gross,ID}}\right)\right)\right] + \\ 0.67 \cdot \left[\left(\dot{E}_{CU,on} + \left(0.0162 \cdot \dot{Q}_{gross,ID}\right)\right) \cdot \left(\frac{0.3898 \cdot \dot{Q}_{gross,ID} + \dot{Q}_{DF}}{0.9558 \cdot \dot{Q}_{gross,ID}}\right) + \left(\dot{E}_{CU,off} + \left(0.2 \cdot \left(0.0162 \cdot \dot{Q}_{gross,ID}\right)\right)\right) \cdot \left(1 - \left(\frac{0.3898 \cdot \dot{Q}_{gross,ID} + \dot{Q}_{DF}}{0.9558 \cdot \dot{Q}_{gross,ID}}\right)\right)\right] + \dot{DF}\end{gathered}} \qquad 174$$

For $\dot{Q}_{gross,ID} > 50{,}000$ Btu/h:

$$\mathrm{AWEF} = \frac{0.492792 \cdot \dot{Q}_{gross,ID} + 489.918}{\begin{gathered}0.33 \cdot \left[\left(\dot{E}_{CU,on} + \left(0.0216 \cdot \dot{Q}_{gross,ID} - 269.9\right)\right) \cdot \left(\frac{0.8 \cdot \dot{Q}_{gross,ID} - 2.0472 \cdot \dot{EF}_{comp,on} + \dot{Q}_{DF}}{\dot{Q}_{gross,ID} - 2.7296 \cdot \dot{EF}_{comp,on}}\right) + \left(\dot{E}_{CU,off} + \left(0.00432 \cdot \dot{Q}_{gross,ID} - 53.98\right)\right) \cdot \left(1 - \left(\frac{0.8 \cdot \dot{Q}_{gross,ID} - 2.0472 \cdot \dot{EF}_{comp,on} + \dot{Q}_{DF}}{\dot{Q}_{gross,ID} - 2.7296 \cdot \dot{EF}_{comp,on}}\right)\right)\right] + \\ 0.67 \cdot \left[\left(\dot{E}_{CU,on} + \left(0.0216 \cdot \dot{Q}_{gross,ID} - 269.9\right)\right) \cdot \left(\frac{0.4 \cdot \dot{Q}_{gross,ID} - 0.6284 \cdot \dot{EF}_{comp,on} + \dot{Q}_{DF}}{\dot{Q}_{gross,ID} - 2.7296 \cdot \dot{EF}_{comp,on}}\right) + \left(\dot{E}_{CU,off} + \left(0.00432 \cdot \dot{Q}_{gross,ID} - 53.98\right)\right) \cdot \left(1 - \left(\frac{0.4 \cdot \dot{Q}_{gross,ID} - 0.6284 \cdot \dot{EF}_{comp,on} + \dot{Q}_{DF}}{\dot{Q}_{gross,ID} - 2.7296 \cdot \dot{EF}_{comp,on}}\right)\right)\right] + \dot{DF}\end{gathered}} \qquad 175$$

7.9.4 *Freezer Outdoor Dedicated Condensing Units Tested Alone*. The Dedicated Condensing Unit shall be tested at ambient condition A, B, and C in Table 15. Electrical energy consumption by the Dedicated Condensing Unit shall be measured at the three ambient outdoor temperature conditions listed in Table 15 during On-cycle periods $\dot{E}_{CU,on}(t_X)$, and during Off-cycle periods, $\dot{E}_{CU,off}(t_X)$ (where X = ambient condition A, B, or C). The Steady-state gross capacity, $\dot{Q}_{gross}(t_X)$, shall also be measured at the three ambient outdoor temperature conditions listed in Table 15 during On-cycle periods. Note: See Equations 197 and 198 for simplified AWEF calculation.

7.9.4.1 When the Dedicated Condensing Unit is on, its Steady-state gross capacity $\dot{Q}_{gross}(t_j)$, is reduced by the heat content of On-cycle evaporator fan power, $\dot{EF}_{\mathrm{comp,on}}$, to yield its Steady-state net capacity, $\dot{q}_{\mathrm{ss}}(t_j)$. $\dot{EF}_{\mathrm{comp,on}}$ is calculated as a function of $\dot{Q}_{gross}$, which is defined in Section 7.9.4.3.

The reference evaporator has an On-cycle evaporator fan power, in Watts, as a function of Dedicated Condensing Unit gross capacity:

$$\dot{q}_{ss(t_j)} = \dot{Q}_{gross}(t_j) - 3.412 \cdot \dot{EF}_{comp,on} \qquad 176$$

The steady state net capacity at 95 °F, is used to calculate the Walk-in Box Load and can be simplified as:

$$\dot{q}_{ss(95)} = \dot{Q}_{gross,\,A} - 3.412 \cdot E\dot{F}_{comp,on} \tag{177}$$

7.9.4.2 The Total Walk-in System Heat Load at High Load Periods and Low Load Periods, $W\dot{L}H$ and $W\dot{L}L$ respectively, includes the box heat load and the heat load from the fan energy when the Dedicated Condensing Unit compressor is off. This in turn can be used to calculate the fraction of time that the compressor is on during High Load and Low Load Periods, LFH and LFL respectively.

$$W\dot{L}H\left(t_j\right) = B\dot{L}H\left(t_j\right) + 3.412 \cdot E\dot{F}_{comp,off}\left(1\text{-}LFH\left(t_j\right)\right) + \dot{Q}_{DF} \tag{178}$$

$$W\dot{L}L\left(t_j\right) = B\dot{L}L\left(t_j\right) + 3.412 \cdot E\dot{F}_{comp,off}\left(1\text{-}LFL\left(t_j\right)\right) + \dot{Q}_{DF} \tag{179}$$

Where $B\dot{L}H\left(t_j\right)$ and $B\dot{L}L\left(t_j\right)$ are defined by Equations 3 and 4 in Section 6 and $E\dot{F}_{comp,off}$ is assumed to consume 20% of the energy as $E\dot{F}_{comp,on}$, and $\dot{Q}_{DF}$ is calculated in Section C10 of this standard

$$E\dot{F}_{comp,off} = 0.2 \cdot E\dot{F}_{comp,on} \tag{180}$$

The Load Factors LFH calculated as follows:

$$LFH\left(t_j\right) = \frac{W\dot{L}H\left(t_j\right)}{\dot{q}_{ss}\left(t_j\right)} \tag{181}$$

Substituting for $W\dot{L}H$ using Equation 178

$$LFH\left(t_j\right) = \frac{B\dot{L}H\left(t_j\right) + 3.412 \cdot E\dot{F}_{comp,off} + \dot{Q}_{DF}}{\dot{q}_{ss}\left(t_j\right) + 3.412 \cdot E\dot{F}_{comp,off}} \tag{182}$$

Substituting for $B\dot{L}H$ using Equation 3 and $E\dot{F}_{comp,off}$ using Equation 180

$$LFH\left(t_j\right) = \frac{\left(0.55 \cdot \dot{q}_{ss,A} + 0.25 \cdot \frac{\dot{q}_{ss,A} \cdot \left(t_j+10\right)}{105}\right) + 3.412 \cdot \left(0.2 \cdot E\dot{F}_{comp,on}\right) + \dot{Q}_{DF}}{\dot{q}_{ss}\left(t_j\right) + 3.412 \cdot \left(0.2 \cdot E\dot{F}_{comp,on}\right)} \tag{183}$$

Substituting for $\dot{q}_{ss}(t_j), \dot{q}_{ss,A}$ using Equation 176 and 177, respectively, and reducing

$$LFH\left(t_j\right) = \frac{\left[0.55 \cdot \left(\dot{Q}_{gross,A} - 3.412 \cdot E\dot{F}_{comp,on}\right) + 0.25 \cdot \frac{\left(\dot{Q}_{gross,A} - 3.412 \cdot E\dot{F}_{comp,on}\right) \cdot \left(t_j + 10\right)}{105}\right] + 3.412 \cdot \left(0.2 \cdot E\dot{F}_{comp,on}\right) + \dot{Q}_{DF}}{\left(\dot{Q}_{gross}\left(t_j\right) - 3.412 \cdot E\dot{F}_{comp,on}\right) + 3.412 \cdot \left(0.2 \cdot EF_{comp,on}\right)} \tag{184}$$

Reducing Equation 184

$$LFH\left(t_j\right) = \frac{-1.2754 \cdot E\dot{F}_{comp,on} - 0.00812 \cdot E\dot{F}_{comp,on} \cdot t_j + 0.5738 \cdot \dot{Q}_{gross,A} + 0.00238 \cdot \dot{Q}_{gross,A} \cdot t_j + \dot{Q}_{DF}}{\dot{Q}_{gross}\left(t_j\right) - 2.7296 \cdot E\dot{F}_{comp,on}} \tag{185}$$

The Load Factor LFL is calculated as follows:

$$LFL\left(t_j\right) = \frac{W\dot{L}L\left(t_j\right)}{\dot{q}_{ss}\left(t_j\right)} \tag{186}$$

Substituting for $W\dot{L}L$ using Equation 179

$$LFL\left(t_j\right) = \frac{B\dot{L}L\left(t_j\right) + 3.412 \cdot E\dot{F}_{comp,off} + \dot{Q}_{DF}}{\dot{q}_{ss}\left(t_j\right) + 3.412 \cdot E\dot{F}_{comp,off}} \tag{187}$$

Substituting for $B\dot{L}L$ using Equation 4 and $E\dot{F}_{comp,off}$ using Equation 180

$$\mathrm{LFL}(t_j) = \frac{\left(0.15 \cdot \dot{q}_{ss,A} + 0.25 \cdot \frac{\dot{q}_{ss,A} \cdot (t_j+10)}{105}\right) + 3.412 \cdot (0.2 \cdot \dot{EF}_{comp,on}) + \dot{Q}_{DF}}{\dot{q}_{ss}(t_j) + 3.412 \cdot (0.2 \cdot \dot{EF}_{comp,on})} \tag{188}$$

Substituting for $\dot{q}_{ss}(t_j), \dot{q}_{ss,A}$ using Equations 176 and 177, respectively, and reducing

$$\mathrm{LFL}(t_j) = \frac{\left[0.15 \cdot (\dot{Q}_{gross,A} - 3.412 \cdot \dot{EF}_{comp,on}) + 0.25 \cdot \frac{(\dot{Q}_{gross,A} - 3.412 \cdot \dot{EF}_{comp,on}) \cdot (t_j + 10)}{105}\right] + (3.412) \cdot (0.2 \cdot \dot{EF}_{comp,on}) + \dot{Q}_{DF}}{(\dot{Q}_{gross}(t_j) - 3.412 \cdot \dot{EF}_{comp,on}) + (3.412) \cdot (0.2 \cdot \dot{EF}_{comp,on})} \tag{189}$$

Reducing Equation 189

$$\mathrm{LFL}(t_j) = \frac{0.08936 \cdot \dot{EF}_{comp,on} - 0.00812 \cdot \dot{EF}_{comp,on} \cdot t_j + 0.17381 \cdot \dot{Q}_{gross,A} + 0.00238 \cdot \dot{Q}_{gross,A} \cdot t_j + \dot{Q}_{DF}}{\dot{Q}_{gross}(t_j) - 2.7296 \cdot \dot{EF}_{comp,on}} \tag{190}$$

Where $\dot{Q}_{gross}(t_j)$ is calculated from the measured Dedicated Condensing Unit gross capacity at the ambient test conditions of 35 °F, 59 °F and 95 °F as follows.

If $t_j \leq 59°F$

$$\dot{Q}_{gross}(t_j) = \dot{Q}_{gross,C} + \frac{(\dot{Q}_{gross,B} - \dot{Q}_{gross,C})}{t_B - t_C} \cdot (t_j - t_C) \tag{191}$$

If $t_j > 59°F$

$$\dot{Q}_{gross}(t_j) = \dot{Q}_{gross,B} + \frac{(\dot{Q}_{gross,A} - \dot{Q}_{gross,B})}{t_A - t_B} \cdot (t_j - t_B) \tag{192}$$

7.9.4.3 The Annual Walk-in Energy Factor, AWEF, is determined by a calculation that is a function of: Steady-state gross capacity, $\dot{Q}_{gross}(t_j)$, Steady-state electrical consumption by the Dedicated Condensing Unit measured during On-cycle periods $\dot{E}_{CU,\ on}$, electrical consumption by the Dedicated Condensing Unit during Off-cycle periods, $\dot{E}_{CU,\ off}$, and the hourly defrost cycle energy, $\dot{DF}$. $\dot{DF}$ is calculated in Section C10 of this standard. $\dot{Q}_{gross}(t_j)$, $\dot{E}_{CU,\ on}$, and $\dot{E}_{CU,\ off}$ are measured values. These calculations are weighted by the number of bin hours, n_j, from Table D1 in Appendix D, for each of the 20 bin temperatures, t_j, in table D1.

$$\mathrm{AWEF} = \frac{\sum_{j=1}^{20}[0.33 \cdot B\dot{L}H(t_j) + 0.67 \cdot B\dot{L}L(t_j)] \cdot n_j}{\sum_{j=1}^{20}\left[\begin{array}{c} 0.33 \cdot \left[(\dot{E}_{CU,on} + \dot{EF}_{comp,on}) \cdot \mathrm{LFH}(t_j) + (\dot{E}_{CU,off} + \dot{EF}_{comp,off}) \cdot (1 - \mathrm{LFH}(t_j))\right] + \\ 0.67 \cdot \left[(\dot{E}_{CU,on} + \dot{EF}_{comp,on}) \cdot \mathrm{LFL}(t_j) + (\dot{E}_{CU,off} + \dot{EF}_{comp,off}) \cdot (1 - \mathrm{LFL}(t_j))\right] + \dot{DF} \end{array}\right] \cdot n_j} \tag{193}$$

Substituting for $B\dot{L}H$ and $B\dot{L}L$:

$$\mathrm{AWEF} = \frac{\sum_{j=1}^{20}\left\{0.33 \cdot \left(0.55 \cdot \dot{q}_{ss,A} + 0.25 \cdot \frac{\dot{q}_{ss,A} \cdot (t_j + 10)}{105}\right) + 0.67 \cdot \left(0.15 \cdot \dot{q}_{ss,A} + 0.25 \cdot \frac{\dot{q}_{ss,A} \cdot (t_j + 10)}{105}\right)\right\} \cdot n_j}{\sum_{j=1}^{20}\left[\begin{array}{c} 0.33 \cdot \left[(\dot{E}_{CU,on} + \dot{EF}_{comp,on}) \cdot \mathrm{LFH}(t_j) + (\dot{E}_{CU,off} + \dot{EF}_{comp,off}) \cdot (1 - \mathrm{LFH}(t_j))\right] + \\ 0.67 \cdot \left[(\dot{E}_{CU,on} + \dot{EF}_{comp,on}) \cdot \mathrm{LFL}(t_j) + (\dot{E}_{CU,off} + \dot{EF}_{comp,off}) \cdot (1 - \mathrm{LFL}(t_j))\right] + \dot{DF} \end{array}\right] \cdot n_j} \tag{194}$$

Substituting for $\dot{q}_{ss,A}$, and $\dot{EF}_{comp,off}$:

$$\mathrm{AWEF} = \frac{\sum_{j=1}^{20}\left\{0.33 \cdot \left(0.55 \cdot (\dot{Q}_{gross,A} - 3.412 \cdot \dot{EF}_{comp,on}) + 0.25 \cdot \frac{(\dot{Q}_{gross,A} - 3.412 \cdot \dot{EF}_{comp,on}) \cdot (t_j+10)}{105}\right) + 0.67 \cdot \left(0.15 \cdot (\dot{Q}_{gross,A} - 3.412 \cdot \dot{EF}_{comp,on}) + 0.25 \cdot \frac{(\dot{Q}_{gross,A} - 3.412 \cdot \dot{EF}_{comp,on}) \cdot (t_j+10)}{105}\right)\right\} \cdot n_j}{\sum_{j=1}^{20}\left[\begin{array}{c} 0.33 \cdot \left[(\dot{E}_{CU,on} + \dot{EF}_{comp,on}) \cdot \mathrm{LFH}(t_j) + (\dot{E}_{CU,off} + (0.2 \cdot \dot{EF}_{comp,on})) \cdot (1 - \mathrm{LFH}(t_j))\right] + \\ 0.67 \cdot \left[(\dot{E}_{CU,on} + \dot{EF}_{comp,on}) \cdot \mathrm{LFL}(t_j) + (\dot{E}_{CU,off} + (0.2 \cdot \dot{EF}_{comp,on})) \cdot (1 - \mathrm{LFL}(t_j))\right] + \dot{DF} \end{array}\right] \cdot n_j} \tag{195}$$

The reference evaporator has an On-cycle evaporator fan power, in Watts, as a function of Dedicated Condensing Unit gross capacity:

$$\dot{EF}_{comp,on}=\begin{cases}0.0162\cdot\dot{Q}_{gross,A}; & \text{for } \dot{Q}_{gross,A}\le 50{,}000\ \text{Btu/h}\\ 0.0216\cdot\dot{Q}_{gross,A}-269.9; & \text{for } \dot{Q}_{gross,A}>50{,}000\ \text{Btu/h}\end{cases} \tag{196}$$

Substituting Equations 196 into Equation 195 and simplifying results in following two AWEF Equations:

For $\dot{Q}_{gross,A}\le 50{,}000$ Btu/h:

$$AWEF=\frac{\sum_{j=1}^{20}\left\{0.33\cdot\left(0.55\cdot\left(\dot{Q}_{gross,A}-3.412\cdot\left(0.0162\cdot\dot{Q}_{gross,A}\right)\right)+0.25\cdot\frac{\left(\dot{Q}_{gross,A}-3.412\cdot\left(0.0162\cdot\dot{Q}_{gross,A}\right)\right)\cdot\left(t_j+10\right)}{105}\right)+0.67\cdot\left(0.15\cdot\left(\dot{Q}_{gross,A}-3.412\cdot\left(0.0162\cdot\dot{Q}_{gross,A}\right)\right)+0.25\cdot\frac{\left(\dot{Q}_{gross,A}-3.412\cdot\left(0.0162\cdot\dot{Q}_{gross,A}\right)\right)\cdot\left(t_j+10\right)}{105}\right)\right\}\cdot n_j}{\sum_{j=1}^{20}\begin{bmatrix}0.33\cdot\left[\left(\dot{E}_{CU,on}+\left(0.0162\cdot\dot{Q}_{gross,A}\right)\right)\cdot LFH(t_j)+\left(\dot{E}_{CU,off}+\left(0.2\cdot\left(0.0162\cdot\dot{Q}_{gross,A}\right)\right)\right)\cdot\left(1-LFH(t_j)\right)\right]+\\0.67\cdot\left[\left(\dot{E}_{CU,on}+\left(0.0162\cdot\dot{Q}_{gross,A}\right)\right)\cdot LFL(t_j)+\left(\dot{E}_{CU,off}+\left(0.2\cdot\left(0.0162\cdot\dot{Q}_{gross,A}\right)\right)\right)\cdot\left(1-LFL(t_j)\right)\right]+\dot{DF}\end{bmatrix}\cdot n_j} \tag{197}$$

Further reducing the numerator from Equation 197 and substituting for $\dot{EF}_{comp,off}$ using Equation 180

$$AWEF=\frac{\sum_{j=1}^{20}\left\{0.00224935\cdot\dot{Q}_{gross,A}\cdot t_j+0.288124\cdot\dot{Q}_{gross,A}\right\}\cdot n_j}{\sum_{j=1}^{20}\begin{bmatrix}0.33\cdot\left[\left(\dot{E}_{CU,on}+\left(0.0162\cdot\dot{Q}_{gross,A}\right)\right)\cdot LFH(t_j)+\left(\dot{E}_{CU,off}+\left(0.00324\cdot\dot{Q}_{gross,A}\right)\right)\cdot\left(1-LFH(t_j)\right)\right]+\\0.67\cdot\left[\left(\dot{E}_{CU,on}+\left(0.0162\cdot\dot{Q}_{gross,A}\right)\right)\cdot LFL(t_j)+\left(\dot{E}_{CU,off}+\left(0.00324\cdot\dot{Q}_{gross,A}\right)\right)\cdot\left(1-LFL(t_j)\right)\right]+\dot{DF}\end{bmatrix}\cdot n_j} \tag{198}$$

For $\dot{Q}_{gross,A}>50{,}000$ Btu/h:

$$AWEF=\frac{\sum_{j=1}^{20}\left\{\begin{matrix}0.33\cdot\left(0.55\cdot\left(\dot{Q}_{gross,A}-3.412\cdot\left(0.0216\cdot\dot{Q}_{gross,A}-269.9\right)\right)+0.25\cdot\frac{\left(\dot{Q}_{gross,A}-3.412\cdot\left(0.0216\cdot\dot{Q}_{gross,A}-269.9\right)\right)\cdot\left(t_j+10\right)}{105}\right)\\+0.67\cdot\left(0.15\cdot\left(\dot{Q}_{gross,A}-3.412\cdot\left(0.0216\cdot\dot{Q}_{gross,A}-269.9\right)\right)+0.25\cdot\frac{\left(\dot{Q}_{gross,A}-3.412\cdot\left(0.0216\cdot\dot{Q}_{gross,A}-269.9\right)\right)\cdot\left(t_j+10\right)}{105}\right)\end{matrix}\right\}\cdot n_j}{\sum_{j=1}^{20}\begin{bmatrix}0.33\cdot\left[\left(\dot{E}_{CU,on}+\left(0.0216\cdot\dot{Q}_{gross,A}-269.9\right)\right)\cdot LFH(t_j)+\left(\dot{E}_{CU,off}+0.2\cdot\left(0.0216\cdot\dot{Q}_{gross,A}-269.9\right)\right)\cdot\left(1-LFH(t_j)\right)\right]+\\0.67\cdot\left[\left(\dot{E}_{CU,on}+\left(0.0216\cdot\dot{Q}_{gross,A}-269.9\right)\right)\cdot LFL(t_j)+\left(\dot{E}_{CU,off}+0.2\cdot\left(0.0216\cdot\dot{Q}_{gross,A}-269.9\right)\right)\cdot\left(1-LFL(t_j)\right)\right]+\dot{DF}\end{bmatrix}\cdot n_j} \tag{199}$$

Further reducing the numerator from Equation 199 and substituting for $\dot{EF}_{comp,off}$ using Equation 180

$$AWEF=\frac{\sum_{j=1}^{20}\left\{0.00220548\cdot\dot{Q}_{gross,A}\cdot t_j+0.283272\cdot\dot{Q}_{gross,A}+2.19265\cdot t_j+281.62\right\}\cdot n_j}{\sum_{j=1}^{20}\begin{bmatrix}0.33\cdot\left[\left(\dot{E}_{CU,on}+\left(0.0216\cdot\dot{Q}_{gross,A}-269.9\right)\right)\cdot LFH(t_j)+\left(\dot{E}_{CU,off}+\left(0.00432\cdot\dot{Q}_{gross,A}-53.98\right)\right)\cdot\left(1-LFH(t_j)\right)\right]+\\0.67\cdot\left[\left(\dot{E}_{CU,on}+\left(0.0216\cdot\dot{Q}_{gross,A}-269.9\right)\right)\cdot LFL(t_j)+\left(\dot{E}_{CU,off}+\left(0.00432\cdot\dot{Q}_{gross,A}-53.98\right)\right)\cdot\left(1-LFL(t_j)\right)\right]+\dot{DF}\end{bmatrix}\cdot n_j} \tag{200}$$

Where $\dot{E}_{CU,on}(t_j)$ and $\dot{E}_{CU,off}(t_j)$ is calculated from the measured Dedicated Condensing Unit gross capacity at the ambient test conditions of 35 °F, 59 °F and 95 °F as follows.

If $t_j\le 59°F$

$$\dot{E}_{CU,on}(t_j)=\dot{E}_{CU,on,C}+\frac{\left(\dot{E}_{CU,on,B}-\dot{E}_{CU,on,C}\right)}{t_B-35}\left(t_j-t_C\right) \tag{201}$$

$$\dot{E}_{CU,off}(t_j)=\dot{E}_{CU,off,C}+\frac{\left(\dot{E}_{CU,off,B}-\dot{E}_{CU,off,C}\right)}{t_B-t_C}\left(t_j-t_C\right) \tag{202}$$

If $t_j>59°F$

$$\dot{E}_{CU,on}(t_j)=\dot{E}_{CU,on,B}+\frac{\left(\dot{E}_{CU,on,A}-\dot{E}_{CU,on,B}\right)}{t_A-t_B}\left(t_j-t_B\right) \tag{203}$$

$$\dot{E}_{CU,off}(t_j)=\dot{E}_{CU,off,B}+\frac{\left(\dot{E}_{CU,off,A}-\dot{E}_{CU,off,B}\right)}{t_A-t_B}\left(t_j-t_B\right) \tag{204}$$

Section 8. Symbols and Subscripts

8.1 *Symbols.* The symbols used in this standard are as follows:

AWEF:	Annual Walk-in Energy Factor, Btu/W·h
$BL(t_j)$:	Heat removed from walk-in box that does not include the heat generated by the operation of refrigeration systems, W·h
$\dot{BLH}(t_j)$:	Non-equipment related Walk-in Box Load during High Load Period, Btu/h
$\dot{BLL}(t_j)$:	Non-equipment related Walk-in Box Load during Low Load Period, Btu/h
DF:	Daily average defrost cycle energy required for the Refrigeration System, W·h
DF_f:	Energy input for a defrost cycle for frost coil condition, W·h
DF_d:	Energy input for a defrost cycle for dry coil condition, W·h
$DF_{d,avg}$	Average energy input from multiple hot gas defrost cycles at dry coil condition, W·h
$DF_{d,lower}$	Lower hot gas defrost cycle energy limit, W·h
$DF_{d,upper}$	Upper hot gas defrost cycle energy limit, W·h
$\dot{DF}$:	Defrost cycle power consumption, W
EER:	Energy Efficiency Ratio, Btu/W·h
EER_{UC}:	Energy Efficiency Ratio at suction dew point, for use in Unit Cooler calculation, Btu/W·h. Value is found from Table 18.
$E(t_j)$:	System energy consumption at t_j , W·h
$\dot{E}_c$:	Total power consumption of the heater and auxiliary equipment of the calibrated box, W
$\dot{E}_{cu,on}$:	Power consumption of the Dedicated Condensing Unit during compressor on period, W
$\dot{E}_{cu,off}$:	Power consumption of the Dedicated Condensing Unit during compressor off period, W
$\dot{E}_{mix,rack}$:	Power consumption of the rack system for mix-match system, W
$\dot{E}_{mix,rack,H}$:	Power consumption of the rack system for mix-match system during a High Load Period, W
$\dot{E}_{mix,rack,L}$:	Power consumption of the rack system for mix-match system during a Low Load Period, W
$\dot{E}_{ss}(t_j)$:	System Steady-state power consumption at t_j, including power consumptions of compressor(s), both condenser and evaporator fans, and any other components that consume power during the Steady-state On-cycle test, W
$\dot{E}^k_{ss,X}$:	System Steady-state power consumption at Tests A, B, C, or ID (X = A, B, C or ID) where k = 1,2 or i for Minimum Capacity, Maximum Capacity or Intermediate Capacity (See Section 5). No superscript designates a single capacity system. System stead-state power consumption includes power consumptions of compressor(s), both condenser and evaporator fans, and any other components that consume power during the Steady-state On-cycle test, W
$\dot{EF}_{comp,off}$:	Power consumption of the Unit Cooler during compressor off period, W
$\dot{EF}_{comp,on}$:	Power consumption of the Unit Cooler during compressor on period, W
FS:	Fan speed (s), rpm
h_{0x}:	Enthalpy of subcooled refrigerant liquid entering the expansion device when using DX - Dual Instrumentation Method, two independent measurements taken (x = a or b), Btu/lb
h_{2x}:	Enthalpy of superheated refrigerant vapor leaving the unit cooler when using DX - Dual Instrumentation Method, two independent measurements taken (x = a or b), Btu/lb
h_{in}:	Enthalpy of subcooled refrigerant liquid entering the expansion device when using DX -Calibrated Box Method, Btu/lb
h_{out} :	Enthalpy at of superheated refrigerant vapor leaving the unit cooler when using DX -Calibrated Box Method, Btu/lb
i:	Intermediate compressor capacity case in which the compressor was tested at the designated testing condition.
j:	Bin number
k:	Case number, (1: low capacity or minimum capacity; 2: high capacity or maximum capacity; i: intermediate capacity; v: variable capacity)
k_7~k_{12}:	Coefficients derived from evaporator coil test points
K_{cb}:	Heat leakage coefficient of calibrated box, Btu/h·˚F

$\mathrm{LFH}(t_j)$:	Load Factor during High Load Period
$\mathrm{LFL}(t_j)$:	Load Factor during Low Load Period
$\dot{m}_{ref}$:	Refrigerant mass flow rate, lb/h
$\dot{m}_{ref,1}$:	Refrigerant mass flow rate measured at subcooled refrigerant liquid line (1st independent measurement), lb/h
$\dot{m}_{ref,2}$:	Refrigerant mass flow rate measured at subcooled or superheated refrigerant vapor line (2nd independent measurement), lb/h
M1:	Mass flow meter 1
M2:	Mass flow meter 2
M2ALT:	Mass flow meter in alternate M2 location.
n:	Number of bins
n_j:	Bin hours, hr
N:	Number of motors
N_{DF}:	Number of defrost cycles per day
P_0:	Pressure of subcooled refrigerant liquid entering the expansion valve when using DX -Calibrated Box Method, psi
P_{0x}:	Pressure of subcooled refrigerant liquid entering the expansion valve when using DX - Dual Instrumentation Method, two independent measurements taken (x = a or b), psi
P_2:	Pressure of superheated refrigerant vapor leaving the Unit Cooler when using DX -Calibrated Box Method, psi
P_{2x}:	Pressure of superheated refrigerant vapor leaving the Unit Cooler when using DX - Dual Instrumentation Method, two independent measurements taken (x = a or b), psi
P_b:	Barometric pressure, Hg
P_{pan}:	Rated pan heater wattage, W
$\dot{q}_{ss}$:	Net Refrigeration Capacity, Btu
$\dot{q}_{ss}(t_j)$:	System Steady-state Net Refrigeration Capacity at t_j, Btu/h
$\dot{q}^{k}_{ss,X}$:	System Steady-state Net Refrigeration Capacity at Tests A, B, C or ID (X = A, B, C or ID) where k = 1, 2 or i for Minimum Capacity, Maximum Capacity or Intermediate Capacity (See Section 5). No superscript designates a single capacity system.
$\dot{q}_{mix,cd}$:	Dedicated Condensing Unit capacity for mix-match system, Btu/h
$\dot{q}_{mix,evap}$:	Evaporator coil net capacity for mix-match system, Btu/h
$\dot{q}_{mix,evap,max}$:	Net coil capacity at the maximum fan speed test point, Btu/h
$\dot{q}_{mix,evap,min}$:	Net coil capacity at the minimum fan speed test point, Btu/h
$\dot{q}_{mix,rack}$	Rack coil net capacity for mix-matched system, Btu/h
$\dot{Q}_{air}$:	Air-side Gross Refrigeration Capacity, Btu/h
$\dot{Q}_{DF}$:	Defrost heat contributed to the box load, Btu/h
$\dot{Q}_{DF,coil}$:	Coil defrost heat contributed to the box load, Btu/h
$\dot{Q}_{DF,pan}$:	Pan defrost heat contributed to the box load, Btu/h
$\dot{Q}_{gross}$:	Gross Refrigeration Capacity, Btu/h
$\dot{Q}_{gross,X}$:	Gross Refrigeration Capacity at Tests A, B, C or ID (X = A, B, C or ID)
$\dot{Q}_{net,primary}$:	Net Refrigeration Capacity for single-package units, as measured using the selected primary method, Btu/h
$\dot{Q}_{net,secondary}$:	Net Refrigeration Capacity for single-package units, as measured using the selected secondary method, Btu/h
$\dot{Q}_t$:	Gross total Refrigeration Capacity, Btu/h
$\dot{Q}_{ref}$:	Refrigerant-side gross capacity, Btu/h
$\dot{Q}_{ref,1}$:	Refrigerant-side gross capacity calculated based on the first independent measurement, Btu/h
$\dot{Q}_{ref,2}$:	Refrigerant-side gross capacity calculated based on the second independent measurement, Btu/h
s:	Evaporator fan speed, rpm
s_H:	Evaporator fan speed resulting in a coil capacity which matches walk-in system load during a High Load Period, rpm
s_L:	Evaporator fan speed resulting in a coil capacity which matches walk-in system load during a Low Load Period, rpm
s_{min}:	Minimum evaporator fan speed, rpm

t_0:	Temperature of subcooled refrigerant liquid entering the expansion device when using DX - Calibrated Box Method, ˚F
t_{0x}:	Temperature of subcooled refrigerant liquid entering the expansion device when using DX - Dual Instrumentation Method, two independent measurements taken (x = a or b), ˚F
t_{0sx}:	Liquid Saturation Temperature of subcooled refrigerant liquid entering the expansion device when using DX - Dual Instrumentation Method, two independent measurements taken (x = a or b), ˚F
t_{0scx}:	Liquid subcooling temperature of subcooled refrigerant liquid entering the expansion device when using DX - Dual Instrumentation Method, two independent measurements taken (x = a or b), ˚F
t_2:	Temperature of superheated refrigerant vapor leaving the Unit Cooler when using DX - Calibrated Box Method, ˚F
t_{2x}:	Temperature of superheated refrigerant vapor leaving the Unit Cooler when using DX - Dual Instrumentation Method, two independent measurements taken (x = a or b), ˚F
t_{2s}:	Vapor Saturation Temperature of superheated refrigerant vapor leaving the Unit Cooler when using DX - Calibrated Box Method, ˚F
t_{2sx}:	Vapor Saturation Temperature of refrigerant vapor leaving the Unit Cooler when using DX - Dual Instrumentation Method, two independent measurements taken (x = a or b), ˚F
t_{2shx}:	Vapor superheat temperature of refrigerant vapor leaving the Unit Cooler when using DX - Dual Instrumentation Method, two independent measurements taken (x = a or b), ˚F
T_{cb}:	Average dry-bulb temperature of the air within the calibrated box, ˚F
T_{en}:	Average dry-bulb temperature of the air within the temperature controlled enclosure, ˚F
T_{evap}:	Evaporating temperature, °F
T_{db}:	Dry-bulb temperature of air at inlet, ˚F
T_{DF}:	Defrost cycle duration, h
$T_{DF,avg}$	Average defrost cycle duration, h
T_{dp}:	Dew point temperature of air at inlet, ˚F
T_{wb}:	Wet-bulb temperature of air at inlet, ˚F
T_w:	Temperature of the drained water from defrost cycle, ˚F
t_j:	Bin temperature, ˚F
t_A:	Test A condenser air temperature, 95˚F
t_B:	Test B condenser air temperature, 59˚F
t_C:	Test C condenser air temperature, 35˚F
t_{IH}:	The outdoor temperature at which the Total Walk-in System Heat Load equals system net capacity when the compressor operates at low or minimum capacity (k = 1) during the High Load Period, ˚F
t_{IIH}:	The outdoor temperature at which the Total Walk-in System Heat Load equals system net capacity when the compressor operates at high or maximum capacity (k = 2) during the High Load Period, ˚F
t_{IL}:	The outdoor temperature at which the Total Walk-in System Heat Load equals system net capacity when the compressor operates at low or minimum capacity (k = 1) during the Low Load Period, ˚F
t_{IIL}:	The outdoor temperature at which the Total Walk-in System Heat Load equals system net capacity when the compressor operates at high or maximum capacity (k = 2) during the Low Load Period, ˚F
t_{VH}:	The outdoor temperature at which the unit, when operating at the intermediate capacity that is tested under the designated condition, provides a Refrigeration Capacity that is equal to the Total Walk-in System Heat Load during High Load Period, ˚F
t_{VL}:	The outdoor temperature at which the unit, when operating at the intermediate capacity that is tested under the designated condition, provides a Refrigeration Capacity that is equal to the Total Walk-in System Heat Load during Low Load Period, ˚F
TD_{CF}:	Temperature difference correction factor ˚F
TD_{rated}:	Rated temperature difference between the dry-bulb temperature of the air entering the unit cooler and the refrigerant saturation temperature at the unit cooler outlet, ˚F
TD_{test}:	Tested temperature difference between the dry-bulb temperature of the air entering the unit cooler and the refrigerant saturation temperature at the unit cooler outlet, ˚F
V:	Voltage of each phase, V
$W\dot{L}H(t_j)$:	Total Walk-in System Heat Load during High Load Period, Btu/h
$W\dot{L}L(t_j)$:	Total Walk-in System Heat Load during Low Load Period, Btu/h

8.2 *Subscripts.* The symbols used in this standard are as follows:

A:	Test A at 95 ºF

B: Test B at 59 °F
C: Test C at 35 °F
H: High load period
ID: Indoor unit at 90 °F
in: Inlet
L: Low load period
out: Outlet
ss: Steady-state
v: Variable compressor capacity case in which the compressor was operated at any capacity between the max and min capacities.

Section 9. Minimum Data Requirements for Published Ratings

9.1 *Minimum Data Requirements for Published Ratings.* As a minimum, Published Ratings shall include AWEF at the standard rating condition. Publication of Net Refrigeration Capacity is optional. All claims to ratings within the scope of this standard shall include the statement “Rated in accordance with ANSI/CAN/AHRI Standard 1250”. All claims to ratings outside the scope of this standard shall include the statement “Outside the scope of ANSI/CAN/AHRI Standard 1250”. Wherever Application Ratings are published or printed, they shall include a statement of the conditions at which the ratings apply.

Section 10. Marking and Nameplate Data

10.1 *Marking and Nameplate Data.* As a minimum, the manufacturer name or trade-name; model number; refrigerant(s); current, A; voltage, V; frequency, Hz; and phase shall be shown in a conspicuous place on the unit.

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

Section 11. Conformance Conditions

11.1 *Conformance.* While conformance with this standard is voluntary, conformance shall not be claimed or implied for products or equipment within the standard’s Purpose (Section 1) and Scope (Section 2) unless such product claims meet all of the requirements of the standard and all of the testing and rating requirements are measured and reported in complete compliance with the standard. Any product that has not met all the requirements of the standard shall not reference, state, or acknowledge the standard in any written, oral, or electronic communication.

APPENDIX A. REFERENCES – NORMATIVE

A1. Listed here are all standards, handbooks, and other publications essential to the formation and implementation of the standard. All references in this appendix are considered as part of 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 Blvd., Suite 400, Arlington, VA 22201, U.S.A.

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

A1.3 ANSI/AHRI Standard 1200 (I-P)-2013, Performance *Rating of Commercial Refrigerated Display Merchandisers and Storage Cabinets,* 2010, Air-Conditioning, Heating and Refrigeration Institute, 2311 Wilson Boulevard, Suite 400, Arlington, VA 22201, U.S.A.

A1.4 ANSI/ASHRAE Standard 16-2016, *Method of Testing for Rating Room Air Conditioners and Packaged Terminal Air Conditioners,* 2010*,* ASHRAE, 1791 Tullie Circle N.E., Atlanta, GA 30329, U.S.A.

A1.5 ANSI/ASHRAE 23.1-2010, *Methods of Testing for Rating Positive Displacement Refrigerant Compressors and Dedicated Condensing Units That Operate at Subcritical Temperatures,* 2010, ASHRAE, 1791 Tullie Circle N.E., Atlanta, GA 30329, U.S.A.

A1.6 ANSI/ASHRAE Standard 37-2009, *Methods of Testing for Rating Electrically Driven Unitary Air-Conditioning and Heat Pump Equipment,* 2009, ASHRAE, 1791 Tullie Circle, N.E., Atlanta, GA 30329, U.S.A.

A1.7 ANSI/ASHRAE Standard 41.1-2013, *Standard Method for Temperature Measurement*, 2013, ASHRAE, 1791 Tullie Circle, N.E., Atlanta, GA 30329, U.S.A.

A1.8 ANSI/ASHRAE Standard 41.10-2013, *Standard Methods for Volatile-Refrigerant Mass Flow Measurements Using Flowmeters,* 2013, ASHRAE, 1791 Tullie Circle, N.E., Atlanta, GA 30329, U.S.A.

A1.9 ANSI/ASHRAE Standard 41.3-2014, *Standard Method for Pressure Measurement*, 2014, ASHRAE, 1791 Tullie Circle, N.E., Atlanta, GA 30329, U.S.A.

A1.10 ANSI/ASHRAE Standard 41.6-2014, *Standard Method for Humidity Measurement,* 2014, ASHRAE, 1791 Tullie Circle, N.E., Atlanta, GA 30329, U.S.A.

A1.11 ASHRAE Handbook, *Fundamentals*, 2017, ASHRAE, 1791 Tullie Circle N.E., Atlanta, GA 30329, U.S.A.

A1.12 *ASHRAE Terminology,* https://www.ashrae.org/resources--publications/free-resources/ashrae-terminology, 201X, ASHRAE, 1791 Tullie Circle, N.E., Atlanta, GA 30329, U.S.A.

A1.13 REFPROP Reference Fluid Thermodynamic and Transport Properties *NIST Standard Reference Database 23 Version 9.1*, 2013, U.S. Department of Commerce, Technology Administration, National Institute of Standards and Technology, Standard Reference Data Program, Gaithersburg, Maryland 20899, U.S.A.

A1.14 TYM3 Weather Data for Kansas City, Missouri, *National Solar Radiation Database*, http://rredc.nrel.gov/solar/old_data/nsrdb/1991-2005/tmy3/by_state_and_city.html#O.

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. METHODS OF TESTING WALK-IN COOLER AND FREEZER SYSTEMS – NORMATIVE

C1 *Purpose*. The purpose of this appendix is to provide a method of testing for Matched-pair, Single-packaged walk-in Refrigeration Systems, as well as unit coolers and Dedicated Condensing Units tested alone.

C2 *Scope*. These methods of testing apply to walk-in cooler and freezer systems that have either matched or tested alone, factory-made, forced circulation, free-delivery Unit Coolers and factory-made electric motor driven, single and variable capacity Positive Displacement Dedicated Condensing Units

C2.1 *Exclusions.* These methods of testing do not apply to:

C2.1.1 Air-conditioning units used primarily for comfort cooling for which testing methods are given in other standards.
C2.1.2 Unit Coolers installed in or connected to ductwork
C2.1.3 Parallel rack refrigeration systems
C2.1.4 Field testing of Unit Coolers

C3 *Measurements.* All the measurements associated with the test shall be in accordance with ANSI/CAN/AHRI Standard 1250 Table 1 for required instrumentation accuracy. All requirements described in this section are applicable to Steady-state and Off-cycle tests, unless otherwise specified.

C3.1 *Temperature Measurements.*

C3.1.1 Temperature measurements shall be made in accordance with ANSI/ASHRAE Standard 41.1.

C3.1.2 Air wet-bulb and dry-bulb temperatures entering the Unit Cooler shall be measured based on the airflow area at the point of measurement. One measuring station is required for each 2.0 ft^2 of the first 10.0 ft^2 of airflow area and one additional measuring station is required for each 4.0 ft^2 of airflow area above 10.0 ft^2. A minimum of two stations shall be used and the number of measuring stations shall be rounded up to the next whole number.

C3.1.2.1 The airflow area shall be divided into the required number of equal area rectangles with aspect ratios no greater than 2 to 1. Additional measuring stations may be necessary to meet this requirement. The measuring stations shall be located at the geometric center of each rectangle.

C3.1.2.2 The maximum allowable deviation between any two air temperature measurement stations shall be 2.0 °F.

C3.1.2.3 If sampling tubes are used, each tube opening may be considered a temperature measuring station provided the openings are uniformly spaced along the tube, the airflow rates entering each port are relatively uniform (± 15%) and the arrangement of tubes complies with the location requirements of Section C3.1.3. Additionally, a one time temperature traverse shall be made over the measurement surface, prior to the test to assess the temperature variation and ensure it complies with the allowable deviation specified in Section C3.1.2.2 (Refer to ANSI/ASHRAE Standard 41.1 for more information and diagrams).

C3.1.3 Refrigerant temperatures entering and leaving the Unit Cooler shall be measured by sheathed temperature sensors immersed in flowing refrigerant or by a temperature measuring instrument placed in a thermometer well and inserted into the refrigerant stream. These wells shall be filled with non-solidifying, thermal conducting liquid or paste to ensure the temperature sensing instrument is exposed to a representative temperature.

C3.1.3.1 For Unit Coolers tested alone, the entering temperature of the refrigerant shall be measured within six pipe diameters upstream of the control device.

C3.1.3.2 For Matched-pairs (not including Single-packaged Systems), the entering temperature of the refrigerant shall be measured within the first six inches of refrigerant pipe entering the unit cooler conditioned space. The leaving temperature of the refrigerant shall be measured within the last six inches of refrigerant pipe leaving the unit cooler conditioned space.

C3.1.3.3 For Dedicated Condensing Units tested alone, the entering and leaving temperature of the refrigerant shall be measured per Section C4.1.3.1.

C3.2 *Pressure Measurements.* Connections for pressure measurements shall be smooth and flush within the pipe wall and shall be located not less than six pipe diameters downstream from fittings, bends, or obstructions. (Refer to ANSI/ASHRAE Standard 41.3 for more information and diagrams).

C3.3 *Refrigerant Properties Measurement*.

C3.3.1 With the equipment operating at the desired test conditions, the temperature and pressure of the refrigerant leaving the Unit Cooler, entering the expansion device, and entering and leaving the compressor shall be measured. For cases where the calibrated box method is also conducted, data used to calculate capacity according to the refrigerant enthalpy method and the calibrated box method shall be collected over the same intervals.

C3.3.2 On equipment not sensitive to refrigerant charge, pressure measuring instruments may be tapped into the refrigerant lines provided that they do not affect the total charge by more than 0.5%.

C3.3.3 On equipment sensitive to refrigerant charge, a preliminary test is required prior to connecting any pressure gauges or beginning the first official test. In preparation for this preliminary test, temperature sensors shall be attached to the equipment's evaporator and condenser coils. The sensors shall be located at points that are not affected by vapor superheat or liquid subcooling. Placement near the midpoint of the coil, at a return bend, is recommended. The preliminary test shall be conducted with the requirement that the temperatures of the on-coil sensors be included with the regularly recorded data. After the preliminary test is completed, the refrigerant shall be removed from the equipment, and the needed pressure gauges shall be installed. The equipment shall be evacuated and recharged with refrigerant. The test shall then be repeated. Once Steady-state operation is achieved, refrigerant shall be added or removed until, as compared to the average values from the preliminary test, the following conditions are achieved: (1) each on-coil temperature sensor indicates a reading that is within ±0.5 °F, (2) the temperatures of the refrigerant entering and leaving the compressor are within ±4 °F, and (3) the refrigerant temperature entering the expansion device is within ±1 °F. Once these conditions have been achieved over an interval of at least ten minutes, refrigerant charging equipment shall be removed and the first of the official tests shall be initiated.

C3.3.4 No instrumentation shall be removed, replaced, or otherwise disturbed during any portion of a complete capacity test.

C3.3.5 Temperatures and pressures of the refrigerant vapor entering and leaving the compressor shall be measured at approximately 10 inches from the compressor shell.

C3.4 *Refrigerant Flow Measurement.*

C3.4.1 Refrigerant flow meters shall be installed and the flow rate of Volatile Refrigerants shall be measured in accordance with ANSI/ASHRAE Standard 41.10.

C3.4.2 The refrigerant flow rate shall be measured with an integrating type flow meter connected in the liquid line upstream of the refrigerant control device. This meter shall be sized so that its pressure drop does not exceed the vapor pressure change that a 4 °F Saturation Temperature change would produce. Refrigerant flow meter is only allowed to be installed at the superheated vapor line as second independent measurement when the refrigerant enthalpy method is used. In such a case, refrigerant vapor must be superheated both upstream and downstream of the meter to ensure the vapor remains single phase.

C3.4.3 Flow meters shall be installed with at least ten pipe diameters upstream and five diameters downstream of the meter, in straight pipe free of valves and fittings, or in accordance with the manufacturer's instructions.

C3.4.4 A direct reading mass-flow-rate measuring device, such as a coriolis meter, is the preferred instrument for measuring the refrigerant flow rate. Other flow meters that demonstrate the capability to measure flow rate with the specified accuracy are also acceptable.

C3.4.5 Temperature and pressure measuring instruments and a sight glass shall be installed immediately downstream of the meter to determine if the refrigerant liquid is adequately subcooled. Subcooling of 3 °F and the absence of any vapor bubbles in the liquid are considered adequate. It is recommended that the meter be installed at the bottom of a vertical downward loop in the liquid line to take advantage of the static head of liquid thus provided.

C3.5 *Off-cycle Specific Requirements.*

C3.5.1 *Unit Cooler Power Measurement.* The following parameters, listed in Table C1 shall be measured and recorded during a compressor Off-cycle test.

Table C1. Unit Cooler Fan Power Measurements

Test Parameter	Test Parameter Description
$\dot{EF}_{comp,off}$, W	Total electrical power input to fan motor(s), pan heaters, and controls of Unit Cooler
FS, rpm	Fan speed (s)
N	Number of motors
P_b, in.Hg	Barometric pressure
T_{db}, °F	Dry-bulb temperature of air at inlet
T_{wb}, °F	Wet-bulb temperature of air at inlet
V, v	Voltage of each phase

C3.5.2 *Dedicated Condensing Unit Power Measurement.* The following parameters, listed in Table C2 shall be measured and recorded during a compressor-Off-cycle test.

Table C2. Dedicated Condensing Unit Power Measurements

Test Parameter	Test Parameter Description
$\dot{E}_{cu,off}$, W	Total electrical power input to Dedicated Condensing Unit
T_{db}, °F	Dry-bulb temperature of air at inlet
V, v	Voltage of each phase

C3.5.3 *Off-cycle Measurement Intervals.*

C3.5.3.1 For equipment under test that lacks controls for which ambient or refrigerant temperatures can affect the level or duration of power consumed during the Off-cycle test (e.g., a crankcase heater or fan cycling control), determine the average power in the Off-cycle, measured over a single 5-minute interval, immediately following the Steady-state test.

C3.5.3.2 For equipment under test that employs a qualifying fan cycling controller or employs controls for which ambient or refrigerant temperatures can affect the level or duration of power consumed, determine the integrated power in the Off-cycle measured over three consecutive 30 minute intervals. At the start of each Off-cycle interval, the compressor will turn on for six minutes, however, the integrated power will not include measurements from the compressor on period.

C3.5.3.2.1 If the integrated power values of all three intervals are within 2% of the average integrated power, then stability has been achieved and Off-cycle power is calculated as the average of the three integrated readings.

C3.5.3.2.2 If stability has not been achieved, conduct an additional three cycles. Utilize the same stability criteria for these three cycles. If after a total of six cycles stability has still not been achieved, calculate Off-cycle power as the maximum of the six integrated readings.

C3.5.4 *Off-cycle Operating Tolerances*. Except for the first 10 minutes after termination of the compressor on interval, operating tolerances for Off-cycle intervals shall comply with the values listed in Table 2.

C3.5.5 *Off-cycle Data Collection Rates*. For the Off-cycle Power Consumption test, minimum data collection rates shall be in accordance with Table C3.

C3.6 *Steady-state-Specific Requirements*.

C3.6.1 For the Steady-state Refrigeration Capacity and Power Consumption test, the room conditioning apparatus and the equipment under test shall be operated until Steady-state performance, consistent with the test tolerances specified in Table 2, is attained for at least 30 minutes at test conditions defined in Section 5.1. The unit under test shall maintain Steady-state operation throughout the entire recording period.

C3.6.2 For the Steady-state Refrigeration Capacity and Power Consumption test, measurement intervals shall be in accordance with Table C3.

Table C3. Minimum Data Collection Requirements[1]

Test Parameter	Steady-state		Off-cycle
	Minimum Data Collection Rate, Test Readings per Hour	Minimum Number of Test Readings per Test Run [3]	Minimum Data Collection Rate, Test Readings per Hour
Temperature	30	15	60
Pressure	30	15	NA
Refrigerant mass flow rate	30	15	NA
Test room barometric pressure	1	1	1
Fan speed(s)	1	1	1
Total electrical power input to Unit Cooler	3	2	60[4,5]
Total electrical power to Dedicated Condensing Unit	30	15	60[4,5]
Total electrical power input to heater and auxiliary equipment [2]	3	2	NA

Notes:
1. Once the system achieves Steady-state condition, data shall be recorded.
2. For calibrated box only (Method 2)
3. Duration of recording data shall be a minimum of 30 minutes
4. For Off-cycle tests conducted to Section C3.5.3.1, power is recorded at the specified interval only for the required 5 minutes.
5. For Off-cycle tests conducted to Section C3.5.3.2, power measurements are integrated and averaged over the recording interval with a sampling rate of no less than 1 second unless an integrating watt/hour meter is used.

C4 *Test Methods.*

C4.1 *Methods of Testing to Determine Steady-state Refrigeration Capacity and Power Consumption*.

C4.1.1 For matched-pairs (not including Single-packaged Systems) and Unit Coolers tested alone, calculate the appropriate Steady-state refrigeration capacity and power consumption values using one of the following methods.

C4.1.1.1 *Method 1, DX Dual Instrumentation (Refrigerant Enthalpy Method).* The Refrigeration Capacity shall be determined by measuring the enthalpy change and the mass flow rate of the refrigerant across the Unit Cooler using two independent measuring systems. See Section C7 of this appendix for complete details on this test method.

C4.1.1.2 *Method 2, DX Calibrated Box.* The Refrigeration Capacity shall be determined concurrently by measuring the enthalpy change and the mass flow rate of the refrigerant across the Unit Cooler and the heat input to the calibrated box. See Section C8 of this appendix for complete details on this test method.

C4.1.2 For Single-packaged Systems, use two methods listed in Table C4 this section to calculate the refrigeration capacity and power consumption. The method listed with a lower "Hierarchy Number" in Table C4 shall be considered the primary measurement and used to report capacity. See Section C9 of this appendix for complete details on each test method.

Table C4. Single-packaged Methods of Test and Hierarchy

Hierarchy Number	Method of Test	Allowable Use
1	Balanced Ambient Indoor Calorimeter	Primary
2	Balanced Ambient Outdoor Calorimeter	Primary or Secondary
3	Indoor Air Enthalpy	Primary or Secondary
4	Indoor Room Calorimeter	Primary or Secondary
5	Outdoor Room Calorimeter	Secondary
6	Outdoor Air Enthalpy	Secondary
7	Compressor Calibration	Secondary

C4.1.3 For Dedicated Condensing Units tested alone, calculate the appropriate Steady-state refrigeration capacity and power consumption values using the following method.

C4.1.3.1 *Method 1, DX Dual Instrumentation (Refrigerant Enthalpy Method).* The Refrigeration Capacity shall be determined as described in Section C7.5 based on measuring the mass flow rate of the refrigerant and refrigerant pressure and temperature at the inlet and outlet of the Dedicated Condensing Unit using two independent measuring systems. See Section C7 of this appendix for complete details on this test method.

C4.2 *Method of Testing to Determine Off-cycle Power Consumption.* Upon the completion of the Steady-state test, an Off-cycle power test shall be conducted. Specifically, upon the completion of the Steady-state test, the compressor(s) of the walk-in systems shall be turned off. Unit Coolers fan(s), pan heater, crank case heater, and control power consumption shall be measured in accordance with the requirements in Section C3.5. Qualifying evaporator fan controls may have a user adjustable method of destratifying air during the Off-cycle including but not limited to: adjustable fan speed control or periodic "stir cycles." If adjustable, controls shall be adjusted so that the greater of a 50% duty cycle or the manufacturer default is used for measuring Off-cycle fan energy. For variable speed controls, the greater of 50% fan speed or the manufacturer's default fan speed shall be used for measuring Off-cycle fan energy. When a cyclic control is used, at least three full "stir cycles" are measured. If the control is non-adjustable, the test is to be conducted at the as shipped setting.

C4.3 *Method of Testing and Calculation to Determine Defrost cycle Power Consumption and Load Contribution.* All walk-in freezer systems shall determine defrost cycle power consumption ($\dot{D}F$) and defrost cycle power consumption contributed to the box load ($\dot{Q}_{DF}$) according to the methods established in Section C10 of this Standard. Section C10 provides a two general methods for determining $\dot{DF}$ and $\dot{Q}_{DF}$: one for systems with hot gas defrost (with or without Adaptive Defrost) and one for systems with electric defrost (with or without Adaptive Defrost). Manufacturers may choose the appropriate method based on the configuration of their system.

C5 *Test Chambers Requirements.*

C5.1 For all system constructions (split systems, Single-packaged, Unit Cooler tested alone, and Dedicated Condensing Unit tested alone), the Unit Cooler under test may be used to aid in achieving the required test chamber ambient temperatures prior to beginning any Steady-state test. However, the unit under test must be free from frost before initiating any Steady-state testing.

C5.2 For Split Systems Unit Coolers tested alone, and Dedicated Condensing Units tested alone:

C5.2.1 The Unit Cooler and the Dedicated Condensing Unit shall be installed in separate environment chambers with sufficient size to avoid airflow restrictions or recirculation such that:

C5.2.1.1 No obstacle is positioned within a distance of $2\sqrt{AB}$ from the discharge of the Unit Cooler and the Dedicated Condensing Unit, where A and B are the air inlet dimensions, in, per fan section of the Unit Cooler and the Dedicated Condensing Unit.

C5.2.1.2 All other distances correspond to the minimum requirements of the installation instructions provided by the manufacturer.

C5.2.1.3 The minimum volume, ft^3, of the test chamber shall be 20 % of the airflow rate, ft^3/min, produced by the Unit Cooler together with all auxiliary air moving devices that operate simultaneously with the Unit Cooler.

C5.2.2 Both environmental chambers shall be equipped with essential air handling units and controllers to process and maintain the enclosed air to any required test conditions.

C5.3 For Single-package Systems, refer to the applicable methods of test for Single-package systems listed in Section C9 of this appendix

C6 *General Test Conditions and Data Recording.*

C6.1 Refer to the standard rating conditions for a particular application listed in Section 5 of this standard. Test acceptance criteria listed in Tables 2 and 3 in Section 4 of this standard apply to the Dual Instrumentation and Calibrated Box Methods. Single Package system test tolerances are listed in each applicable Method of Test outlined in Section C9.

C6.2 Data that need to be recorded during the test are listed in Table C5 (Appendix C).

Table C5. Data to be Recorded

	Units	Refrigerant Enthalpy Method	Calibrated Box Method
Date		×	×
Observer(s)		×	×
Barometric pressure	in Hg	×	×
Times		×	×
Power input to Dedicated Condensing Unit	W	×	×
Power input to Unit Cooler fan(s)	W	×	×
Applied Voltage to Dedicated Condensing Unit	V	×	×
Applied Voltage to Unit Cooler fan	V	×	×
Total electrical power input to heater and auxiliary equipment	W		×
Frequency	Hz	×	×
Fan speed(s) if adjustable	rpm	×	×
Air inlet relative humidity, rh		×	×
Average dry-bulb temperature of air within the calibrated box, T_{en}	˚F		×
Average dry-bulb temperature of air within the temperature controlled enclosure, T_{cb}	˚F		×
Dry-bulb temperatures of air entering Unit Cooler and Dedicated Condensing Unit, T_{db}	˚F	×	×
Wet-bulb temperatures of air entering Unit Cooler and evaporative Dedicated Condensing Unit, T_{wb}	˚F	×	×
Pressure of subcooled refrigerant liquid entering the expansion valve, P_{0a}	psi	×	×
Pressure of subcooled refrigerant liquid entering the expansion valve, P_{0b}	psi	×	
Pressure of superheated refrigerant vapor leaving the Unit Cooler, P_{2a}	psi	×	×
Pressure of superheated refrigerant vapor leaving the Unit Cooler, P_{2b}	psi	×	
Pressure of refrigerant vapor at compressor suction	psi	×	×
Temperature of subcooled refrigerant liquid entering the expansion device, t_{0a}	˚F	×	×
Temperature of subcooled refrigerant liquid entering the expansion, t_{0b}	˚F	×	
Temperature of superheated refrigerant vapor leaving the Unit Cooler, t_{2a}	˚F	×	×
Temperature of superheated refrigerant vapor leaving the Unit Cooler, t_{2b}	˚F	×	
Temperature of the subcooled refrigerant immediately after M1	˚F	×	×
Mass flow rate of subcooled refrigerant liquid through M1	lb/h	×	×
Temperature of the subcooled refrigerant immediately after M2	˚F	×	
Mass flow rate of subcooled refrigerant liquid through M2 or superheated refrigerant vapor through M2ALT	lb/h	×	

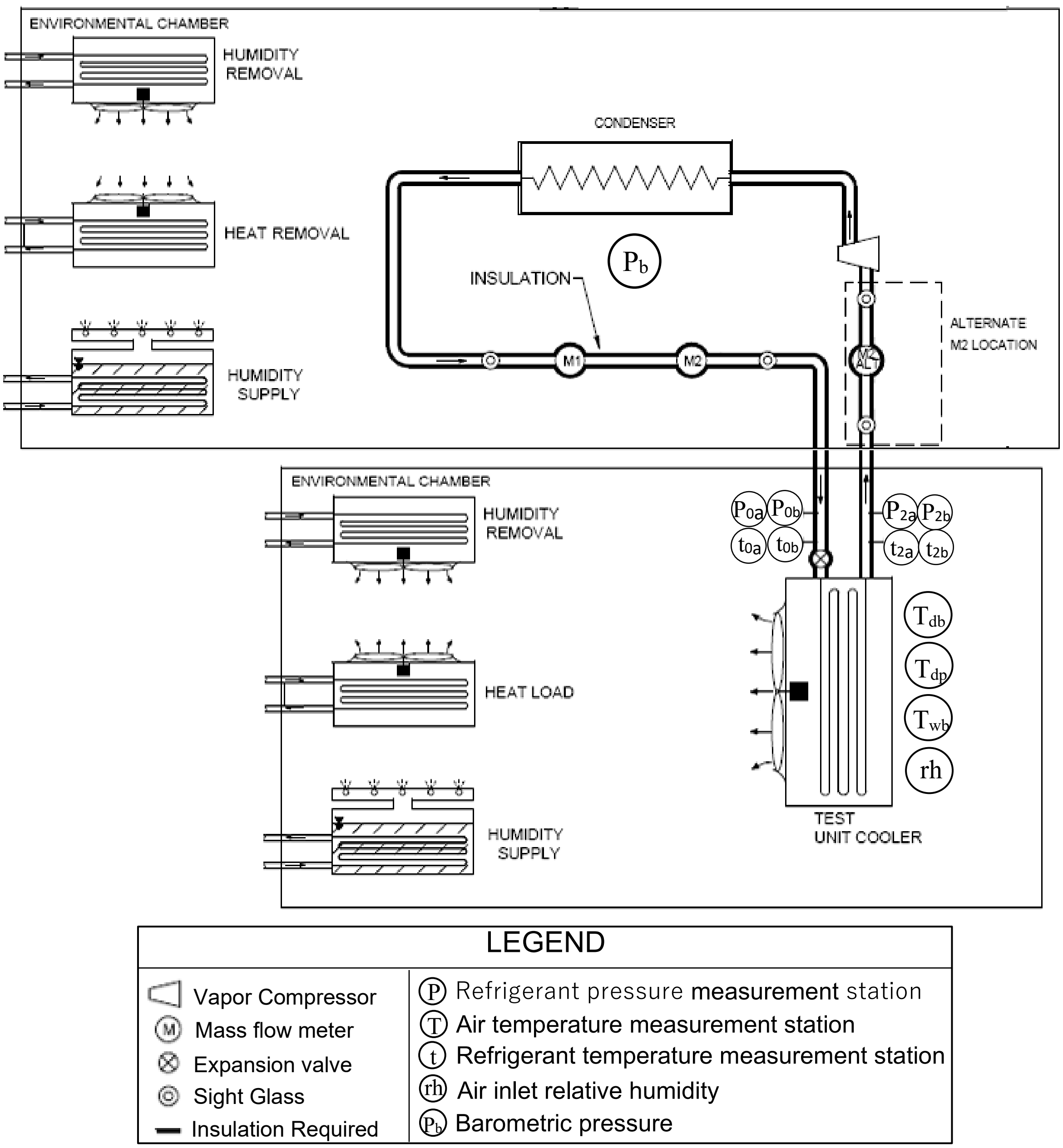

Figure C1. Method 1: DX - Dual Instrumentation for Matched-pairs and Unit Cooler Tested Alone

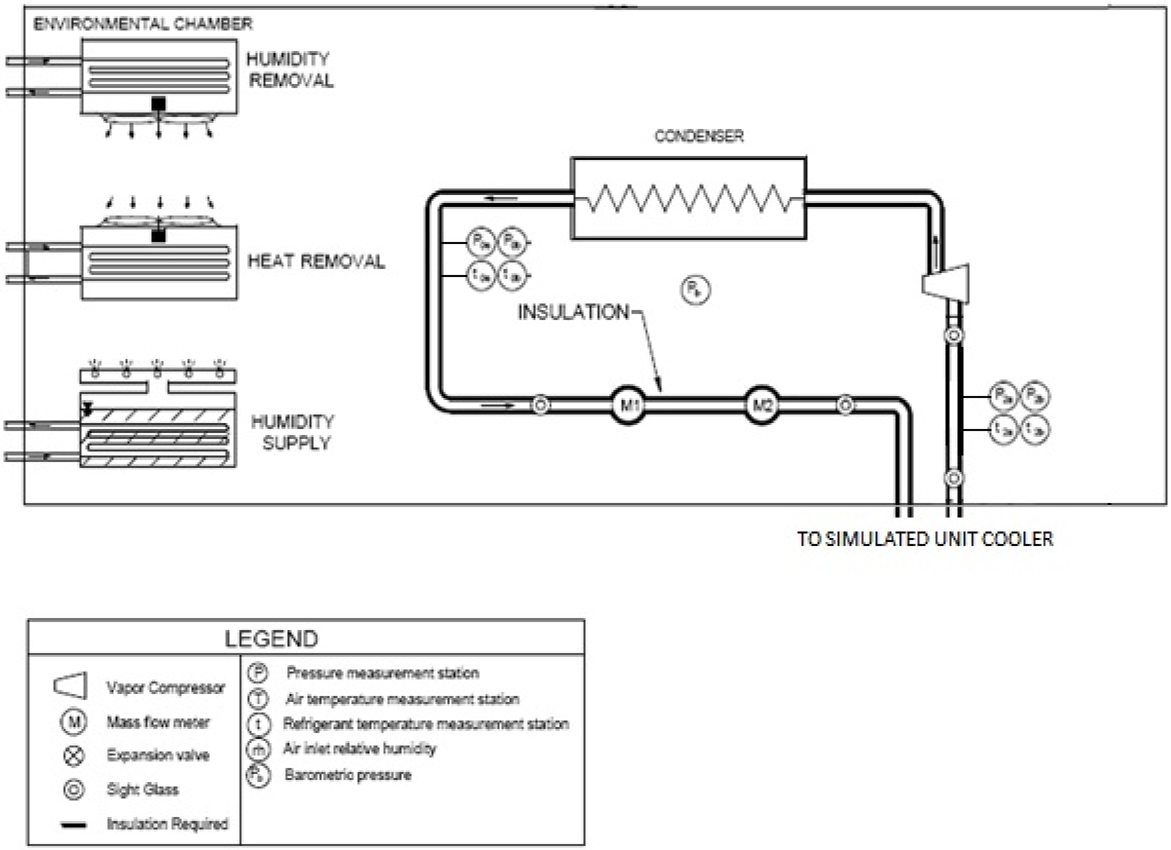

Figure C2. Method 1: DX - Dual Instrumentation for Dedicated Condensing Units Tested Alone

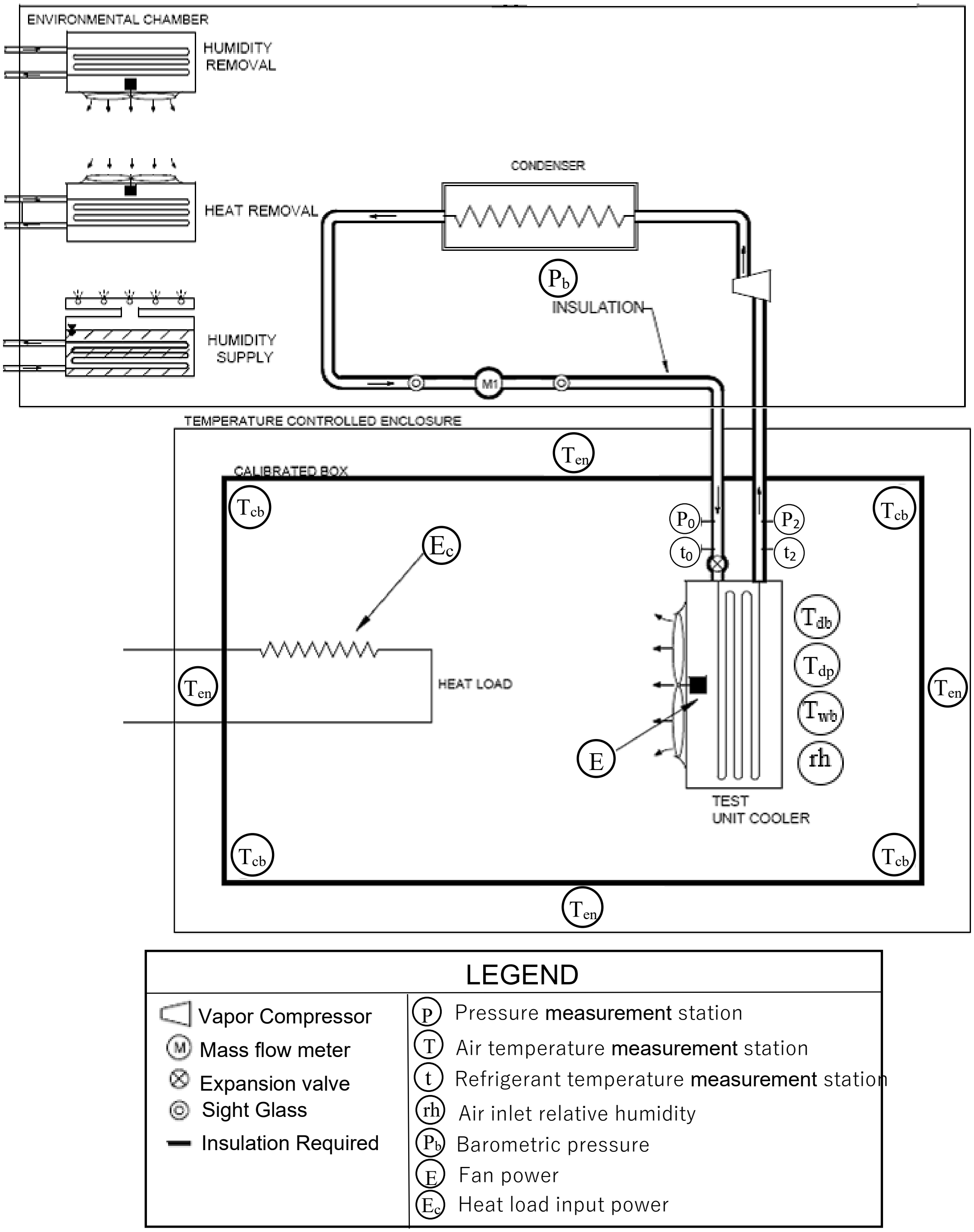

Figure C3. Method 2: DX – Calibrated Box

C7 *DX Dual Instrumentation Test Procedure (Method 1: Refrigerant Enthalpy Method).*

C7.1 *General Description.* In this method, capacity is determined from the refrigerant enthalpy change and flow rate. Enthalpy changes are determined from measurements of entering and leaving pressures and temperatures of the refrigerant, and the flow rate is determined by a suitable flow meter in the liquid line. For cases where calibrated box method is also conducted, data used to calculate capacity as described in the refrigerant enthalpy method and the calibrated box method shall be collected over the same intervals. This method may be used for tests of equipment in which the refrigerant charge is not critical and where normal installation procedures involve the field connection of refrigerant lines. This method shall not be used for tests in which the refrigerant liquid leaving the flow meter is subcooled less than 3 °F or for tests in which any instantaneous measurement of the superheat of the vapor leaving the evaporator coil is less than 5 °F. If supplementary cooling in the liquid line is artificially introduced to ensure enough subcooling, the added cooling capacity shall be measured and deducted from the Gross Refrigeration Capacity calculated in Section C7.5.2.

C7.2 *Measurements.* Refer to Section C3 for requirements of air-side and refrigerant-side measurements.

C7.3 *Test Setup and Procedure*. Refer to Sections C5 and C6 and Figures C1 and C2 for specific test setup. The Dedicated Condensing Unit and the Unit Cooler shall be connected by pipes with manufacturer' specified size. The pipe lines shall be insulated with a minimum total thermal resistance equivalent to ½" thick insulation having a flat-surface R-Value of 3.7 ft^2-°F-h/Btu per inch or greater. Flow meters need not be insulated but must not be in contact with the floor. The lengths of each of the connected liquid line and suction line shall be 25 feet ±3 in, not including the requisite flow meters. Of this length, no more than 15 feet shall be in the conditioned space. In the case that there are multiple branches of piping, the maximum length of piping applies to each branch individually as opposed to the total length of the piping.

C7.4 *Data to be Measured and Recorded.* Refer to Table C5 in Section C6.2 for the required data that need to measured and recorded.

C7.5 *Refrigeration Capacity Calculation.*

C7.5.1 Determine refrigerant Saturation Temperatures and enthalpy (h) for the appropriate refrigerant using respective temperature and pressure measured at each independent set of instrumentation (i.e., set "a" and set "b") and referencing ASHRAE Handbook Fundamentals or NIST REFPROP. The following terms are used in this calculation

t_{0sa} is the liquid Saturation Temperature evaluated for $P_{0a.}$
t_{0sb} is the liquid Saturation Temperature evaluated for $P_{0b.}$
t_{2sa} is the vapor Saturation Temperature evaluated for $P_{2a.}$
t_{2sb} is the vapor Saturation Temperature evaluated for $P_{2b.}$

C7.5.1.1 Calculate liquid subcooling (t_{0sca} and t_{0scb}) for each independent set of instrumentation.

$$t_{0sca} = t_{0sa} - t_{0a} \quad \text{C1}$$
$$t_{0scb} = t_{0sb} - t_{0b} \quad \text{C2}$$

C7.5.1.1.1 For Matched-pairs (not including Single-packaged Systems) and Unit Coolers tested alone, refrigerant temperature and pressure measurement instrumentation shall be located entering the expansion valve.

C7.5.1.1.2 For Dedicated Condensing Units tested alone, temperature and pressure measurement instrumentation shall be located leaving the Dedicated Condensing Unit. The liquid line shall be insulated from the exit of the Dedicated Condensing Unit to the temperature sensors.

C7.5.1.2 Calculate vapor superheat (t_{2sha} and t_{2shb}) for each independent set of instrumentation

$$t_{2sha} = t_{2a} - t_{2sa} \quad \text{C3}$$
$$t_{2shb} = t_{2b} - t_{2sb} \quad \text{C4}$$

C7.5.1.2.1 For Matched-pairs (not including Single-packaged Systems) and Unit Coolers tested alone, temperature and pressure measurement instrumentation shall be located leaving the Unit Cooler.

C7.5.1.3 For Unit Coolers tested alone, calculate temperature Difference Correction Factor (TD_{CF}) for each independent set of instrumentation

$$\mathrm{TD_{CF}} = \frac{\mathrm{TD_{rated}}}{\mathrm{TD_{test}}} \qquad \text{C5}$$

Where:

$$\mathrm{TD_{rated}} = 10\ °\mathrm{F} \qquad \text{C6}$$

$$\mathrm{TD_{test}} = \mathrm{T_{db}} - \mathrm{t_{2s}} \qquad \text{C7}$$

$$\mathrm{t_{2s}} = \frac{\mathrm{t_{2sa}} + \mathrm{t_{2sb}}}{2} \qquad \text{C8}$$

C7.5.1.4 For Match-pair and Dedicated Condensing Units tested alone, the temperature Difference Correction Factor ($\mathrm{TD_{CF}}$) equals 1:

$$\mathrm{TD_{CF}} = 1 \qquad \text{C9}$$

C7.5.2 The refrigerant-side gross capacities by independent measurement are calculated using Equations C10 and C11.

$$\dot{\mathrm{Q}}_{\mathrm{ref,1}} = \dot{\mathrm{m}}_{\mathrm{ref,1}} \cdot (\mathrm{h_{2a}} - \mathrm{h_{0a}}) \cdot (\mathrm{TD_{CF}}) \qquad \text{C10}$$

$$\dot{\mathrm{Q}}_{\mathrm{ref,2}} = \dot{\mathrm{m}}_{\mathrm{ref,2}} \cdot (\mathrm{h_{2b}} - \mathrm{h_{0b}}) \cdot (\mathrm{TD_{CF}}) \qquad \text{C11}$$

Where,
$\mathrm{h_{2a}}$ and $\mathrm{h_{2b}}$= enthalpy at pressure and temperature recorded at the exit of Unit Cooler (for matched pair test and Unit Cooler tested alone)
$\mathrm{h_{2a}}$ and $\mathrm{h_{2b}}$ = enthalpy for a pressure corresponding to dew point 2 °F higher than for the recorded pressure at the inlet of the Dedicated Condensing Unit, and assumed theoretical superheat of 6.5 ˚F (for Dedicated Condensing Unit tested alone)

C7.5.3 The Gross Refrigeration Capacity is calculated by

$$\dot{\mathrm{Q}}_{\mathrm{ref}} = \frac{\dot{\mathrm{Q}}_{\mathrm{ref,1}} + \dot{\mathrm{Q}}_{\mathrm{ref,2}}}{2} \qquad \text{C12}$$

C7.5.4 The Allowable Cooling Capacity heat balance is

$$-5\% \leq \frac{\dot{\mathrm{Q}}_{\mathrm{ref,1}} - \dot{\mathrm{Q}}_{\mathrm{ref,2}}}{\dot{\mathrm{Q}}_{\mathrm{ref}}} \cdot 100\% \leq 5\% \qquad \text{C13}$$

C7.5.5 The Net Refrigeration Capacity is calculated by

$$\dot{\mathrm{q}}_{\mathrm{ss}} = \dot{\mathrm{Q}}_{\mathrm{ref}} - 3.412 \cdot \dot{\mathrm{E}}\mathrm{F}_{\mathrm{comp,on}} \qquad \text{C14}$$

C8 *DX Calibrated Box Test Procedure (Method 2).*

C8.1 *Measurements.* Refer to Section C3 for requirements of air-side and refrigerant-side measurements.

C8.2 *Test Setup and Procedure.* Refer to Sections C5, C6 and Figure C3 for specific test setup. The Dedicated Condensing Unit and the Unit Cooler shall be connected by pipes with manufacturer' specified size. The pipe lines shall be insulated with a minimum total thermal resistance equivalent to ½" thick insulation having a flat-surface R-Value of 3.7 $\mathrm{ft^2 \cdot °F \cdot h/Btu}$ per inch or greater. Flow meters need not be insulated but must not be in contact with the floor. The lengths of each of the connected liquid line and suction line shall be 25 ft ±3 in, not including the requisite flow meters.

Of this length, no more than 15 ft shall be in the conditioned space. In the case that there are multiple branches of piping, the maximum length of piping applies to each branch individually as opposed to the total length of the piping.

C8.2.1 *Apparatus Setup for Calibrated Box Calibration and Test.*

C8.2.1.1 The calibrated box shall be installed in a temperature controlled enclosure in which the temperature can be maintained at a constant level.

C8.2.1.2 The temperature controlled enclosure shall be of a size that will provide clearances of not less than 18 in at all sides, top and bottom, except that clearance of any one surface may be reduced to not less than 5.5 in.

C8.2.1.3 In no case shall the heat leakage of the calibrated box exceed 30 % of the Gross Total Cooling Effect of the Unit Cooler under test. The ability to maintain a low temperature in the temperature controlled enclosure will reduce the heat leakage into the calibrated box and may extend its application range.

C8.2.1.4 Instruments for measuring the temperature around the outside of the calibrated box shall be located at the center of each wall, ceiling, and floor at a distance of 6 in from the calibrated box. Exception: in the case where a clearance around the outside of the calibrated box, as indicated above, is reduced to less than 18 in, the number of temperature measuring devices on the outside of that surface shall be increased to six, which shall be treated as a single temperature to be averaged with the temperature of each of the other five surfaces. When the clearance is reduced below 12 in. (one surface only), the temperature measuring instruments shall be located midway between the outer wall of the calibrated box and the adjacent wall. The six temperature measuring instruments shall be located at the center of six rectangular sections of equal area.

C8.2.1.5 Heating means inside the calibrated box shall be shielded or installed in a manner to avoid radiation to the Unit Cooler, the temperature measuring instruments, and to the walls of the box. The heating means shall be constructed to avoid stratification of temperature, and suitable means shall be provided for distributing the temperature uniformly.

C8.2.1.6 The average air dry-bulb temperature in the calibrated box during Unit Cooler tests and calibrated box heat leakage tests shall be the average of eight temperatures measured at the corners of the box at a distance of 2 in. to 4 in. from the walls. The instruments shall be shielded from any cold or warm surfaces except that they shall not be shielded from the adjacent walls of the box. The Unit Cooler under test shall be mounted such that the temperature instruments are not in the direct air stream from the discharge of the Unit Cooler.

C8.2.2 *Calibration of the Calibrated Box.* A calibration test shall be made for the maximum and the minimum forced air movements expected in the use of the calibrated box. The calibration heat leakage shall be plotted as a straight line function of these two air quantities and the curve shall be used as calibration for the box.

C8.2.2.1 The heat input shall be adjusted to maintain an average box temperature not less than 25.0 ºF above the test enclosure temperature.

C8.2.2.2 The average dry-bulb temperature inside the calibrated box shall not vary more than 1.0 ºF over the course of the calibration test.

C8.2.2.3 A calibration test shall be the average of eleven consecutive hourly readings when the box has reached a Steady-state temperature condition.

C8.2.2.4 The box temperature shall be the average of all readings after a Steady-state temperature condition has been reached.

C8.2.2.5 The calibrated box has reached a Steady-state temperature condition when:

C8.2.2.5.1 The average box temperature is not less than 25 ºF above the test enclosure temperature.

C8.2.2.5.2 Temperature variations do not exceed 5.0 ºF between temperature measuring stations.

C8.2.2.5.3 Temperatures do not vary by more than 2 ºF at any one temperature-measuring station.

C8.3 *Data to be Measured and Recorded.* Refer to Table C2 in Section C6.2 for the required data that need to measured and recorded.

C8.4 *Refrigeration Capacity Calculation.*

C8.4.1 The heat leakage coefficient of the calibrated box is calculated by

$$K_{cb} = \frac{3.412 \cdot \dot{E}_c}{T_{en} - T_{cb}} \qquad C15$$

C8.4.2 For each Dry Rating Condition, calculate the air-side Gross Total Refrigeration Capacity:

$$\dot{Q}_{air} = (K_{cb} \cdot (T_{en} - T_{cb}) + 3.412 \cdot (\dot{E}_c + \dot{EF}_{comp,on})) \cdot TD_{CF} \qquad C16$$

C8.4.3 For each Dry Rating Condition, calculate the refrigerant-side Gross Refrigeration Capacity ($\dot{Q}_{ref}$). Determine refrigerant Saturation Temperatures and enthalpy (h) for the appropriate refrigerant using temperature and pressure measured at each location and referencing ASHRAE Handbook Fundamentals or NIST REFPROP.

$$\dot{Q}_{ref} = \dot{m}_{ref} \cdot (h_{out} - h_{in}) \cdot (TD_{CF}) \qquad C17$$

C8.4.3.1 For Unit Coolers tested alone, calculate temperature Difference Correction Factor (TD_{CF}) for each independent set of instrumentation

$$TD_{CF} = \frac{TD_{rated}}{TD_{test}} \qquad C18$$

Where:

$$TD_{rated} = 10\ °F \qquad C19$$

$$TD_{test} = T_{db} - t_{2s} \qquad C20$$

And t_{2s} is the vapor Saturation Temperature evaluated at P_0

C8.4.3.2 For Matched-pair and Dedicated Condensing Units tested alone, the temperature Difference Correction Factor (TD_{CF}) equals 1:

$$TD_{CF} = 1 \qquad C21$$

C8.4.4 Calculate the Gross Total Refrigeration Capacity as:

$$\dot{Q}_t = \frac{\dot{Q}_{air} + \dot{Q}_{ref}}{2} \qquad C22$$

C8.4.5 The allowable Refrigeration Capacity heat balance is:

$$-5\% \leq \frac{\dot{Q}_{air} - \dot{Q}_{ref}}{\dot{Q}_t} \cdot 100\% \leq 5\% \qquad C23$$

C9 *Single-packaged Test Methods and Allowable Refrigeration Capacity Heat Balance.*

C9.1 *Single-packaged Test Methods*.

C9.1.1 *Indoor Air Enthalpy Method*. Determine Net Refrigeration Capacity of Unit Cooler and input power in accordance with ANSI/ASHRAE 37, Figure C4 of this standard, and the following modifications.

C9.1.1.1 Space conditioning capacity is determined by measuring airflow rate and the dry-bub temperature and water vapor content of the air that enters and leaves the coil. Air enthalpies shall be determined in accordance with ANSI/ASHRAE Standard 41.6. Entering air is to be sufficiently dry as to not produce frost on the Unit Cooler coil. Therefore, only sensible capacity measured by dry bulb change shall be used to calculate capacity.

C9.1.1.2 *Test Setup for Non-Ducted Unit Coolers.* A single outlet plenum box shall be constructed in a cubic arrangement. The length of the longest dimension of the Unit Cooler outlet shall be used to determine the dimension of the cube outlet plenum. Four static pressure taps shall be installed in the center of each face. A 6 in inlet plenum skirt shall be installed with four static pressure taps at each center face as well. Airflow shall be adjusted by the exhaust fan on the airflow plenum to achieve 0.00 in WC (± 0.02 in WC).

C9.1.2 *Outdoor Air Enthalpy Method.* Determine Net Refrigeration Capacity of Unit Cooler and input power in accordance with ANSI/ASHRAE Standard 37, Figure C4 of this standard, and the following modifications.

C9.1.2.1 Outdoor Air Enthalpy is only applicable on Dedicated Condensing Units for which the leaving air can be fully captured. Space conditioning capacity is determined by measuring airflow rate and the dry-bub temperature and water vapor content of the air that enters and leaves the coil. Air enthalpies shall be determined in accordance with ANSI/ASHRAE Standard 41.6. Line loss adjustments in Section 7.3.3.4 of ANSI/ASHRAE Standard 37 are not applicable to package units.

C9.1.3 *Compressor Calibration Method.* Determine Net Refrigeration Capacity of Unit Cooler and input power in accordance with ANSI/ASHRAE Standard 37 and the following modifications.

C9.1.3.1 Capacity is determined by utilizing refrigerant flow measured by prior or subsequent calibration of the same compressor under identical operating conditions (compressor suction and discharge temperature and pressures) to ANSI/ASHRAE Standard 23.1. Measured values for refrigerant temperature and pressures at the appropriate locations listed in Section 7.4 of ANSI/ASHRAE Standard 37 are required during the test.

C9.1.4 *Indoor Room Calorimeter Method.* Determine Net Refrigeration Capacity of Unit Cooler and input power in accordance with ANSI/ASHRAE Standard 16, Figure C5 of this standard.

C9.1.5 *Outdoor Room Calorimeter Method*. Determine Net Refrigeration Capacity of Unit Cooler and input power in accordance with ANSI/ASHRAE Standard 16, Figure C5 of this standard.

C9.1.6 *Balanced Ambient Room Calorimeter.* Determine Net Refrigeration Capacity of Unit Cooler and input power in accordance with ANSI/ASHRAE Standard 16 and Figure C6 of this standard.

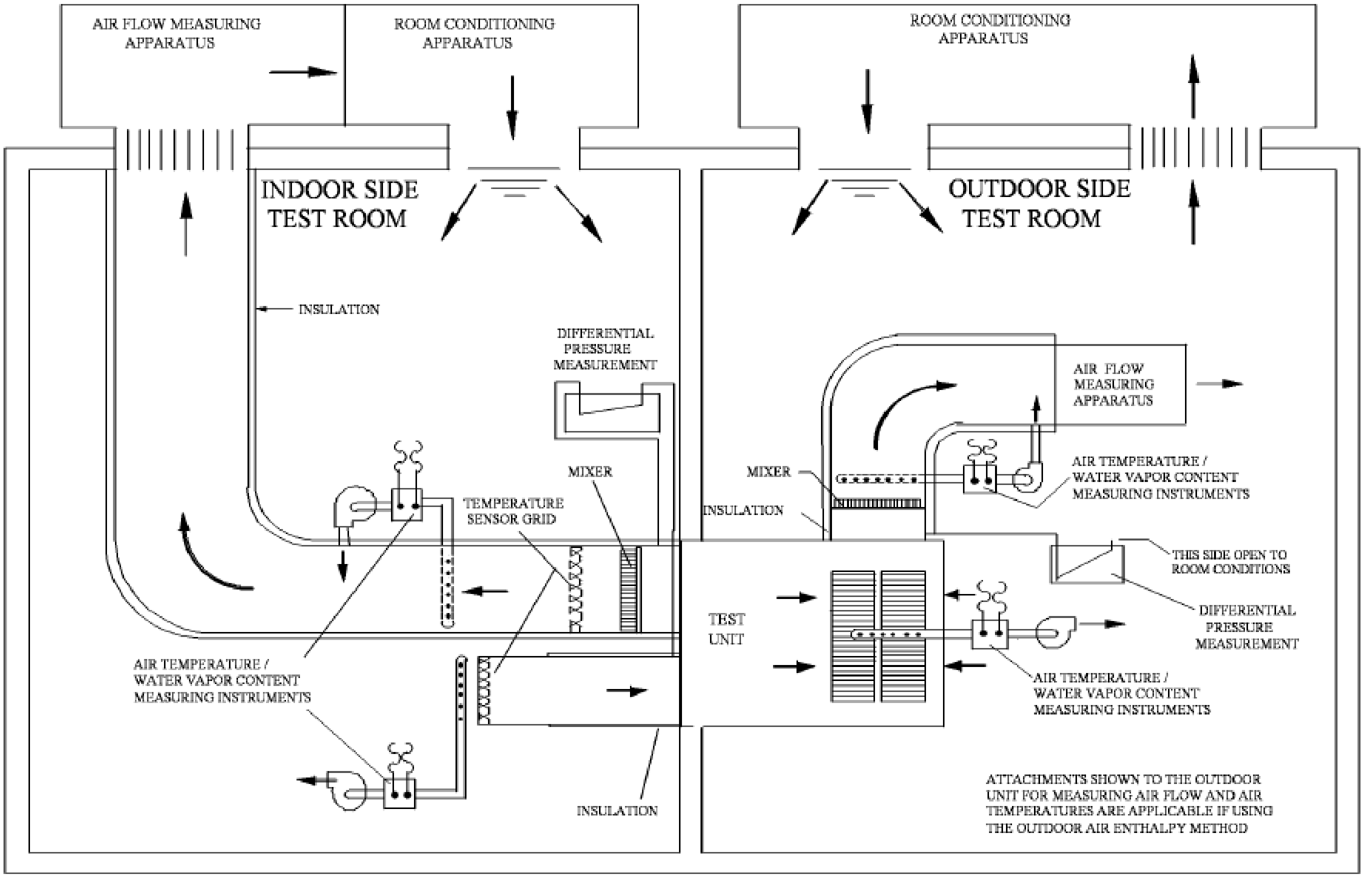

Figure C4. Air Enthalpy Method

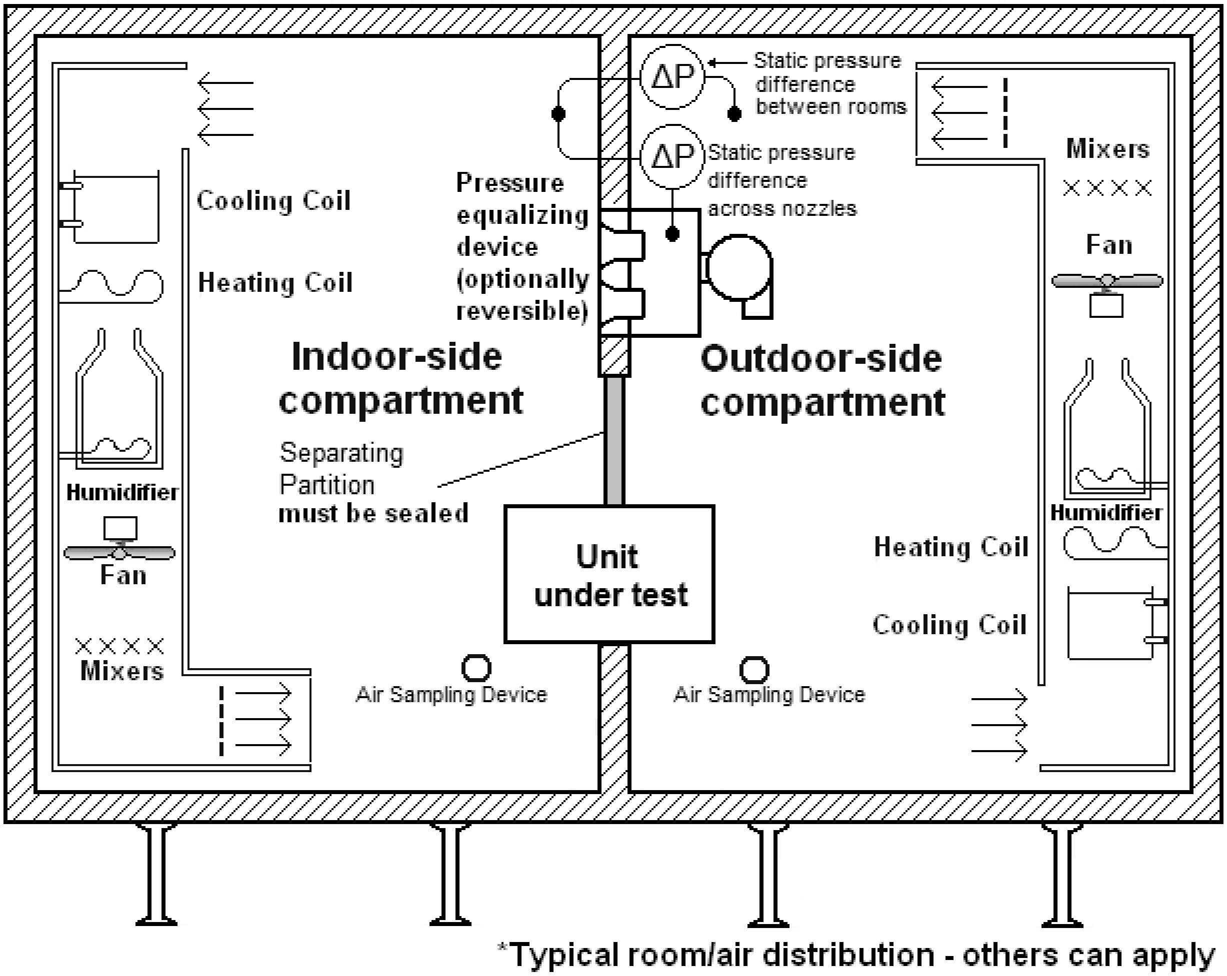

Figure C5. Room Calorimeter Method

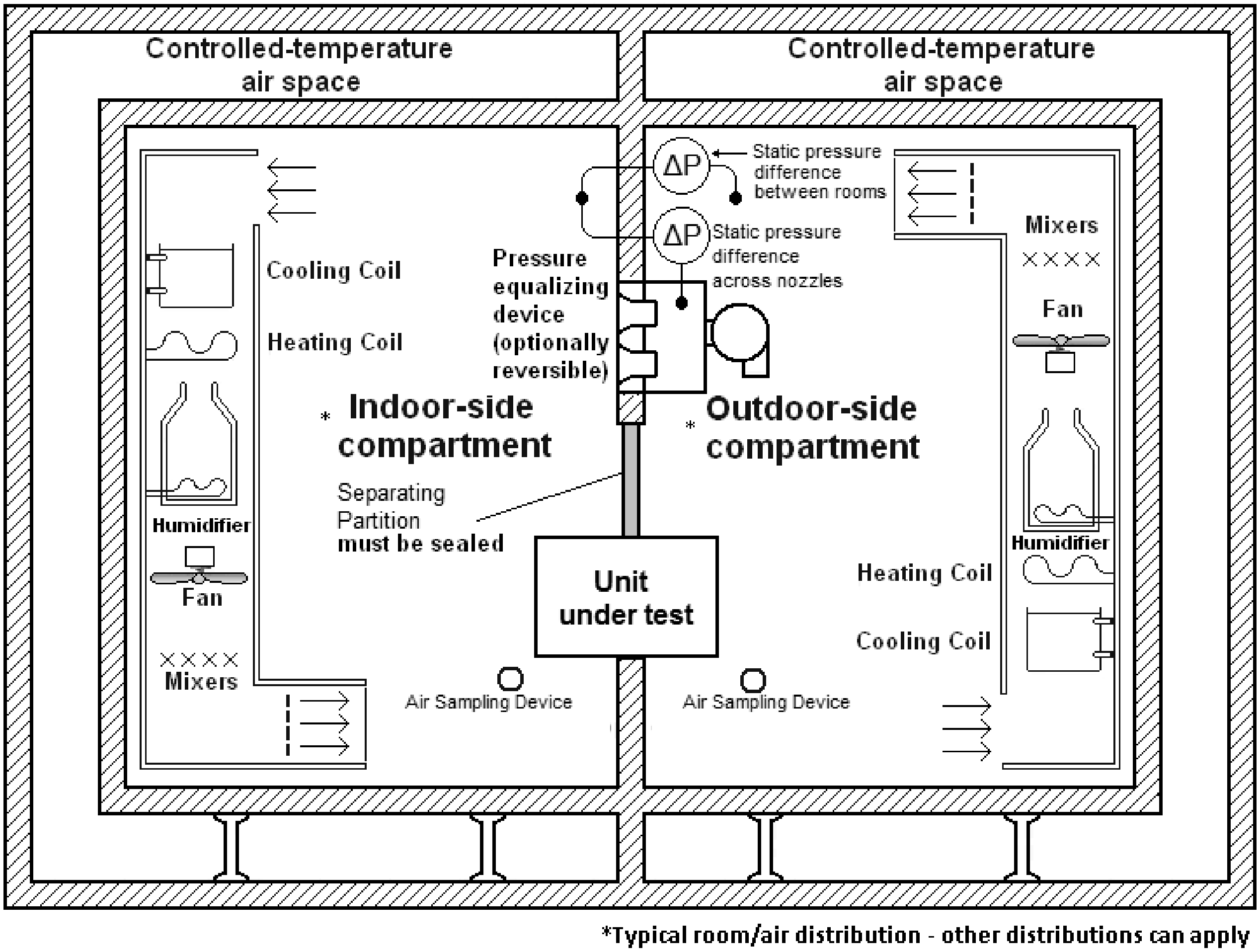

Figure C6. Balanced Ambient Calorimeter Method

C9.2 *Allowable Refrigeration Capacity Heat Balance.*

C9.2.1 Following the completion of the Steady-state capacity test, for each rating condition, the measured net capacities of the primary and secondary test methods must balance within 6%, per Equation C24

$$-6\% \leq \frac{\dot{Q}_{net,primary}-\dot{Q}_{net,secondary}}{\dot{Q}_{net,primary}} \cdot 100\% \leq 6\% \qquad \text{C24}$$

C9.2.2 If measured net capacities do not balance per Equation C24, investigate all potential test facility leaks and/or non-conformances. If no leaks or non-conformances are detected, proceed to Section C9.2.3. If any leaks or non-conformances are detected, remedy the concerns and rerun the Steady-state test at all applicable rating condition(s). If the measured net capacities balance per Equation C24, then the test is considered valid and capacity and power measurements from the primary method of the second test will be used. If the measured net capacities still do not balance per Equation C24, proceed to Section C9.2.3.

C9.2.3 To achieve a capacity heat balance, the test lab may modify the exterior of the unit under test to reduce leakage and surface losses. Specifically, the lab may add insulation to the outside surface of the Single-package system and/or tape and seal sheet metal edges to minimize outdoor ambient air intrusion to the Unit Cooler. After the unit is insulated, rerun the Steady-state test at all applicable rating condition(s). If the measured net capacities balance per Equation C24, then the lab facility and instrumentation are verified as complying with the applicable method of test. However, capacity, power, and all downstream calculations will be based on the results of the primary method from the first test, which occurred before the unit was altered. If the measured net capacities still do not balance per Equation C24, then the lab facility and instrumentation are considered non-compliant, must be remedied, and all prior tests for the unit under test are considered invalid.

C10 *Defrost Calculation and Test Methods.* This section is applicable to only low-temperature (i.e., freezer) Refrigeration Systems and contains two general methods for determining $\dot{DF}$ and $\dot{Q}_{DF}$: one for systems with hot gas defrost (with or without Adaptive Defrost) and one for systems with electric defrost (with or without Adaptive Defrost). Manufacturers choose the appropriate method based on the configuration of their system.

C10.1 *Refrigeration Systems with Hot Gas Defrost (with or without Adaptive Defrost).* The following subsection provide equations to calculate $\dot{DF}$ and $\dot{Q}_{DF}$ based on the configuration of the unit under test.

C10.1.1 *Method for Outdoor and Indoor Matched-pairs and Single-packaged Refrigeration Systems, and All Unit Coolers with Full Coil and Pan Hot Gas Defrost.*

C10.1.1.1 Calculate the defrost heat:

If $\dot{Q}_{gross} \leq 25{,}000\ \text{Btu/h}$:

$$\dot{Q}_{DF} = 0.195 \cdot \dot{Q}_{gross} \cdot \frac{N_{DF}}{24} \quad \text{C25}$$

If $\dot{Q}_{gross} > 25{,}000\ \text{Btu/h}$ and $\dot{Q}_{gross} \leq 70{,}000\ \text{Btu/h}$:

$$\dot{Q}_{DF} = \dot{Q}_{gross} \cdot \left[0.195 - \frac{0.049\left(\dot{Q}_{gross} - 25{,}000\right)}{45{,}000}\right] \cdot \frac{N_{DF}}{24} \quad \text{C26}$$

If $\dot{Q}_{gross} > 70{,}000\ \text{Btu/h}$:

$$\dot{Q}_{DF} = 0.146 \cdot \dot{Q}_{gross} \cdot \frac{N_{DF}}{24} \quad \text{C27}$$

Where,

$\dot{Q}_{gross}$ is calculated based on the tested configuration:

For *outdoor Matched-pair systems*:

$$\dot{Q}_{gross} = \dot{q}_{ss,A} + 3.412 \cdot \dot{EF}_{comp,on} \quad \text{C28}$$

For *indoor Matched-pair systems*:

$$\dot{Q}_{gross} = \dot{q}_{ss,ID} + 3.412 \cdot \dot{EF}_{comp,on} \quad \text{C29}$$

And for *Unit Coolers*:

$$\dot{Q}_{gross} = \dot{q}_{mix,rack} + 3.412 \cdot \dot{EF}_{comp,on} \quad \text{C30}$$

N_{DF} is defined based on the presence or absence of an adaptive defrost system:

For systems with Adaptive Defrost, $N_{DF} = 2.5$, and

For systems without Adaptive Defrost, $N_{DF} = 4.0$.

C10.1.1.2 Calculate the defrost cycle power consumption, in watts:

$$\dot{DF} = \frac{\frac{\dot{Q}_{DF}}{2.7}}{0.95 \times 3.412} \quad \text{C31}$$

C10.1.2 *Method for Outdoor and Indoor Matched-pairs and Single-packaged Refrigeration Systems, and all Unit Coolers with Hot Gas Defrost Coil and Electric Defrost Pan. This Method is also for all Dedicated Condensing Units tested alone with Hot Gas Defrost.*

C10.1.2.1 Calculate the defrost heat for the coil and the pan heater:

If $\dot{Q}_{gross} \leq 25{,}000\ \text{Btu/h}$:

$$\dot{Q}_{DF,coil} = 0.136 \cdot \dot{Q}_{gross} \cdot \frac{N_{DF}}{24} \quad \text{C32}$$

$$\dot{Q}_{DF,pan} = 0.034 \cdot \dot{Q}_{gross} \cdot \frac{N_{DF}}{24} \quad \text{C33}$$

If $\dot{Q}_{gross} > 25{,}000\ \text{Btu/h}$ and $\dot{Q}_{gross} \leq 70{,}000\ \text{Btu/h}$:

$$\dot{Q}_{DF,coil} = \dot{Q}_{gross} \cdot \left[0.136 - \frac{0.035\ \left(\dot{Q}_{gross} - 25{,}000\right)}{45{,}000}\right] \cdot \frac{N_{DF}}{24} \quad \text{C34}$$

$$\dot{Q}_{DF,pan} = \dot{Q}_{gross} \cdot \left[0.034 - \frac{0.019\,(\dot{Q}_{gross} - 25{,}000)}{45{,}000} \right] \cdot \frac{N_{DF}}{24} \qquad \text{C35}$$

If $\dot{Q}_{gross} > 70{,}000$ Btu/h:

$$\dot{Q}_{DF,coil} = 0.102 \cdot \dot{Q}_{gross} \cdot \frac{N_{DF}}{24} \qquad \text{C36}$$

$$\dot{Q}_{DF,pan} = 0.015 \cdot \dot{Q}_{gross} \cdot \frac{N_{DF}}{24} \qquad \text{C37}$$

Where,

$\dot{Q}_{gross}$ is determined based on the tested configuration:

For Dedicated Condensing Units tested alone, $\dot{Q}_{gross}$ is the measured gross capacity at condition A (per Section C4),

For outdoor Matched-pair systems:

$$\dot{Q}_{gross} = \dot{q}_{ss,A} + 3.412 \cdot \dot{EF}_{comp,on} \qquad \text{C38}$$

For indoor Matched-pair systems:

$$\dot{Q}_{gross} = \dot{q}_{ss,ID} + 3.412 \cdot \dot{EF}_{comp,on} \qquad \text{C39}$$

And for Unit Coolers:

$$\dot{Q}_{gross} = \dot{q}_{mix,rack} + 3.412 \cdot \dot{EF}_{comp,on} \qquad \text{C40}$$

N_{DF} is defined based on the presence or absence of an Adaptive Defrost system:

For systems *with* Adaptive Defrost, $N_{DF} = 2.5$, and

For systems *without* Adaptive Defrost, $N_{DF} = 4.0$.

C10.1.2.2 Calculate the defrost cycle power consumption, in W:

$$\dot{DF} = \frac{\left(\frac{\dot{Q}_{DF,coil}}{2.7} + \dot{Q}_{DF,pan} \right)}{0.95 \times 3.412} \qquad \text{C41}$$

C10.2 *Refrigeration Systems without Hot Gas Defrost (with or without Adaptive Defrost).* The following subsection provide equations to calculated $\dot{DF}$ and $\dot{Q}_{DF}$ based on the configuration of the unit under test.

C10.2.1 *Method for Outdoor and Indoor Matched-pairs and Single-packaged Refrigeration Systems, and all Unit Coolers with Electric Defrost.*

C10.2.1.1 *Test Rom Conditioning Equipment*. For the defrost portion of the test, test condition tolerances are not applicable. However, the indoor entering dry-bulb temperature would not be permitted to exceed the test operating tolerance of 4°F. Additionally, 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.

C10.2.1.2 *Instrumentation Accuracy, Stability Tolerances, and Test Requirements.* All provisions established in Sections 4 and C3.1 of this standard apply.

C10.2.1.3 *Operating conditions.* Operating conditions are defined in Tables 8, 9, 10, 11 and 17 Select the table and operating conditions that correspond to the configuration of the unit under test.

C10.2.1.4 *Minimum Data Collection Requirements.* Either power (in W) or energy (in W·h) shall be measured. Power measurements shall be made with a sampling rate of no less than 1 per second and shall be timestamped. Energy measurements shall be made with an integrating watt-hour meter with a sampling rate of no less than 1 per 15 seconds.

C10.2.1.5 *Test Method to Find the Dry Defrost Cycle Energy, DF_d.* Initiate an initial defrost cycle, either through manual override or by the automatic controls. Power measurements are not required during the initial defrost cycle. Following the termination of the initial defrost cycle, operate the Unit Cooler at the specified operating conditions until stability is reached. After stability is reached, initiate a second defrost cycle, either through manual override or by the automatic controls. Record either power or energy until 60 seconds after the second defrost cycle has terminated.

C10.2.1.5.1 If an integrating watt-hour meter is used, the dry coil defrost cycle energy input (DF_d) is the total energy consumed between the first and last readings within the second defrost cycle period.

C10.2.1.5.2 If a power meter is used, calculate the dry coil defrost cycle energy input (DF_d) by average all power readings taken during the second defrost cycle, and multiplying that value by the duration of the second defrost cycle.

C10.2.1.6 Calculate the frosted defrost cycle energy, DF_f, as follows:

$$DF_F = 1.05 \cdot DF_d \tag{C42}$$

C10.2.1.7 Calculate the daily average defrost cycle energy, DF, as follows:

$$DF = \frac{DF_d + DF_f}{2} \cdot N_{DF} \tag{C43}$$

Where,

N_{DF} is defined based on the presence or absence of an Adaptive Defrost system:
For systems with Adaptive Defrost, $N_{DF} = 2.5$, and
For systems without Adaptive Defrost, $N_{DF} = 4.0$.

C10.2.1.8 Calculate the defrost cycle power consumption, in watts, as the daily weighted-average defrost cycle energy divided by 24 hours:

$$\dot{DF} = \frac{DF}{24} \tag{C44}$$

C10.2.1.9 Calculate the defrost cycle power contributed to the box load ($\dot{Q}_{DF}$) as:

$$\dot{Q}_{DF} = 0.95 \cdot 3.412 \cdot \dot{DF} \tag{C45}$$

C10.2.2 *Method of Calculation for Dedicated Condensing Units Tested Alone with Electric Defrost*

C10.2.2.1 Calculate the defrost heat:
If $\dot{Q}_{gross} \leq 25{,}000\ \text{Btu/h}$:

$$\dot{Q}_{DF} = 0.195 \cdot \dot{Q}_{gross} \cdot \frac{N_{DF}}{24} \tag{C46}$$

If $\dot{Q}_{gross} > 25{,}000\ \text{Btu/h}$ and $\dot{Q}_{gross} \leq 70{,}000\ \text{Btu/h}$:

$$\dot{Q}_{DF} = \dot{Q}_{gross} \cdot \left[0.195 - \frac{0.049\ (\dot{Q}_{gross} - 25{,}000)}{45{,}000}\right] \cdot \frac{N_{DF}}{24} \tag{C47}$$

If $\dot{Q}_{gross} > 70{,}000\ \text{Btu/h}$:

$$\dot{Q}_{DF} = 0.146 \cdot \dot{Q}_{gross} \cdot \frac{N_{DF}}{24} \tag{C48}$$

Where,

$\dot{Q}_{gross}$ is the measured gross capacity at condition A (per Section C4) and

N_{DF} is defined based on the presence or absence of an adaptive defrost system:
For systems *with* Adaptive Defrost, $N_{DF} = 2.5$, and
For systems *without* Adaptive Defrost, $N_{DF} = 4.0$.

C10.2.2.2 Calculate the defrost cycle power consumption, in watts

$$\dot{DF} = \frac{\frac{\dot{Q}_{DF}}{1.0}}{0.95 \times 3.412} \quad \text{C49}$$

APPENDIX D. WEATHER DATA IN REGION IV – NORMATIVE

D1 The temperature bins and corresponding bin hours applied in the AWEF shall be based on the TMY-3 weather data of Kansans City, Missouri, which corresponds closely to the 'use cycle' climate parameters prescribed in other DOE appliance standards (10 CFR 430.23). The temperature and bin hours are listed in Table D1.

Table D1. Bin Temperatures and Corresponding Bin Hours for AWEF Calculation

Bin Number, j	Bin Temperature (t_j), ˚F	Bin hours (n_j), h
1	100.4	9
2	95	74
3	89.6	257
4	84.2	416
5	78.8	630
6	73.4	898
7	68	737
8	62.6	943
9	57.2	628
10	51.8	590
11	46.4	677
12	41	576
13	35.6	646
14	30.2	534
15	24.8	322
16	19.4	305
17	14	246
18	8.6	189
19	3.2	78
20	-2.2	5

APPENDIX E. ADAPTIVE DEFROST CHALLENGE TEST – INFORMATIVE

E1 *Purpose.* The purpose of this section is to provide a method to functionally validate defrost controllers. This section is not intended to quantify the adequacy or frequency of defrosts at a standard frost load condition.

E2 *Scope.* These methods of testing apply to only low-temperature (i.e., freezer) Refrigeration Systems which utilize an N_{DF} of 2.5 in the defrost calculations.

E3 *Matched-pair Adaptive Defrost Verification*. For a Matched-pair verification, the challenge test shall be conducted using the Matched-pair System. For a Unit Cooler, the manufacturer shall specify whether the challenge test will be conducted using a Dedicated Condensing Unit or using the test facility's variable-capacity condensing system. If the challenge test is to be conducted with a Dedicated Condensing Unit, the manufacturer shall designate one or more Dedicated Condensing Units to be used for the challenge test. For each of these Dedicated Condensing Units, the evaporator TD (air inlet dry bulb temperature minus effective dewpoint Saturation Temperature) during steady state dry-condition capacity testing shall be in the range 8 °F to 12 °F. The manufacturer shall specify an appropriate Adaptive Defrost controller. For a Dedicated Condensing Unit, the manufacturer shall designate one or more Unit Coolers to be used for the challenge test. For each of these Unit Coolers, the evaporator TD during steady state dry-condition capacity testing shall be in the range 8 °F to 12 °F. The manufacturer shall specify an appropriate Adaptive Defrost controller.

E4 *Test Setup, Installation and Conditions.* Install the challenge test system in the test lab as required per the manufacturer's installation instructions.

E4.1 The following quantities shall be measured: Refrigerant suction pressure and temperature (dual measurement not required); Inlet air sampling temperature, humidity, and barometric pressure; Absolute test time of system state change on initiation and termination of defrost. (e.g. electric defrost power, SOV/solenoid low voltage signal monitoring, Dedicated Condensing Unit power, etc).

E4.2 Unless otherwise specified, installation for the Adaptive Defrost Challenge Test should be consistent with ANSI/CAN/AHRI Standard 1250. Instrumentation that is installed for measurements as described above shall also be consistent with ANSI/CAN/AHRI Standard 1250.

E4.3 Install the Adaptive Defrost controller in accordance with Refrigeration System installation instructions.

E4.4 Install an inlet air guidance duct, as shown in Figure E1, to guide injected moisture to the Unit Cooler air inlet. For draw-though coils, the outlet of the duct shall be no smaller than the finned height and width of the Unit Cooler and shall ensure no portion of the finned inlet area is blocked. For blow-through coils, the inlet duct shall be sufficiently sized to cover all inlets to fans without disturbing normal flow patterns. The minimum approach angle to the inlet of the coil is 7°.

E4.5 Moisture will be provided by a mixture of steam and chamber air entering the inlet air guidance duct. Use a steam quantity equal to 0.5 lb/h (+/- 0.1 lb/hr) per 1,000 Btu/h Net Refrigeration Capacity. Use either the individual component net capacity or the challenge test system net capacity to calculate the moisture addition rate. During defrost, moisture injection shall be suspended. (Recommend jacketed injectors to prevent freezing)

E4.6 Test condition and test operating tolerances shall be as indicated in Table 2 of ANSI/CAN/AHRI Standard 1250 for Steady-state testing except during and for 60 minutes after termination of defrosts. For the moist coil portion of the test, stability criteria for entering wet-bulb, refrigerant mass flow rate and suction pressure may be ignored.

E4.7 The Unit Cooler Air Entering dry-bulb temperature shall be -10 °F. For Matched-pair and Dedicated Condensing Unit, the Condenser Air Entering dry-bulb temperature shall be 95 °F for Outdoor Dedicated Condensing Units and 90 °F for Indoor Dedicated Condensing Units.

E4.8 Unit Cooler tested without a designated Dedicated Condensing Unit. Adjust the test facility condensing system to maintain 10 °F evaporator TD. Use these test facility compressor control settings (compressors operating and compressor speeds) for the remainder of the test sequence requiring compressor operation, including both the dry and moist tests.

E5 *Adaptive Defrost Challenge Test Sequence.*

E5.1 *Dry Test*. Operate the challenge test system in dry conditions, including Unit Cooler Air Entering dry-bulb temperature of -10 °F and relative humidity less than 50%. For Single-packaged Systems, the Condenser Air entering relative humidity shall be less than 25%. If the Adaptive Defrost controller or refrigeration system installation instructions specifies a required run time before adaptation occurs, then operate the system in dry conditions for the specified time up to a maximum of 36 hours.

E5.1.1 Initiate a preliminary defrost to clear frost from the evaporator and continue operating the system. If 24 hours elapses after initiation of the first defrost without occurrence of an additional defrost, record 24 hours as the time between dry defrosts and move on to the moist test.

E5.1.2 If a second defrost occurs automatically before 24 hours elapses after initiation of the first defrost, continue operation and record the elapsed time between defrosts as interval A.

E5.1.3 If 24 hours elapses after initiation of the second defrost without occurrence of an additional defrost, record 24 hours as the time between dry defrosts and move on to the moist test.

E5.1.4 If a third defrost occurs automatically before 24 hours elapses after initiation of the second defrost, continue operation and record the elapsed time between defrost as interval B.

E5.1.5 If 24 hours elapses after initiation of the third defrost without occurrence of an additional defrost, record 24 hours as the time between dry defrosts and move on to the moist test.

E5.1.6 If a fourth defrost occurs automatically before 24 hours elapses after initiation of the third defrost, stop testing and record the elapsed time between defrosts as interval C.

E5.1.7 Evaluate the elapsed time rate of change from interval A to B and B to C. If the elapsed time increased by 20% or more in successive intervals and interval C is greater than 12 hours, record interval C as the time between dry defrosts and move to the moist test.

E5.1.8 If the elapsed time did not increase by 20% or more in successive intervals and both interval B and C are greater than 18 hours, record the average of interval B and C as the time between dry defrosts and proceed to the moist test.

E5.1.9 If the elapsed time did not increase by 20% or more in successive intervals and interval C is less than 12 hours, the challenge test is a failure.

E5.2 *Moist Test*. Initiate introduction of moisture, as described in Section E4.5, immediately following the final dry condition defrost termination. If the dry test terminated after 24 hours without defrost, initiate a manual defrost prior to moisture introduction. Monitor elapsed time from the start of the moist test and record the elapsed time at which each defrost initiation occurs.

E5.2.1 If a defrost initiation occurs within 6 hours elapsed time, the challenge test is complete and the result is success.

E5.2.2 If a defrost does not initiate within 6 hours, continue operation and moisture introduction through either a defrost initiation or until the elapsed time equals the time between dry defrosts. If the time between dry defrosts is reached with no defrost initiation, proceed to E5.2.6. If a defrost initiates after 6 hours and before the time between dry defrosts, continue operation and record the elapsed time as time between moist defrost interval D.

E5.2.3 Continue operation and monitor elapsed time from the termination of the initial moist defrost. If a defrost initiation occurs within 6 hours elapsed time, the challenge test is complete and the result is success.

E5.2.4 If a defrost does not initiate within 6 hours, continue operation and moisture introduction through either a defrost initiation or until the elapsed time equals the time between dry defrost. If the time between dry defrost is reached with no defrost initiation, proceed to E5.2.6. If a defrost initiates after 6 hours and before the time between dry defrost, stop the test and record the elapsed time as time between moist defrost interval E.

E5.2.5 Evaluate the elapsed time rate of change between interval D and E. If the elapsed time is decreasing by 20% or more in successive intervals or interval D and E are both less than 12 hours, record interval E as the time between moist defrosts. If the time between moist defrosts is less than half of the time between dry defrosts then the challenge test result is success. If the elapsed time is not decreasing by 20% or more in successive intervals or the time between moist defrost is not less than half of the time between dry defrosts, proceed to E5.2.6.

E5.2.6 Perform a visual inspection of the Unit Cooler to determine if it is sufficiently frosted by ensuring a layer of frost is blocking at least two thirds of the Unit Cooler coil inlet or outlet face. If so, the test is failure. Challenge test failure reports shall include a photograph of the frosted coil. If the Unit Cooler is not sufficiently frosted, the lab should rectify the setup to ensure moisture is reaching the Unit Cooler and repeat the adaptive challenge test.

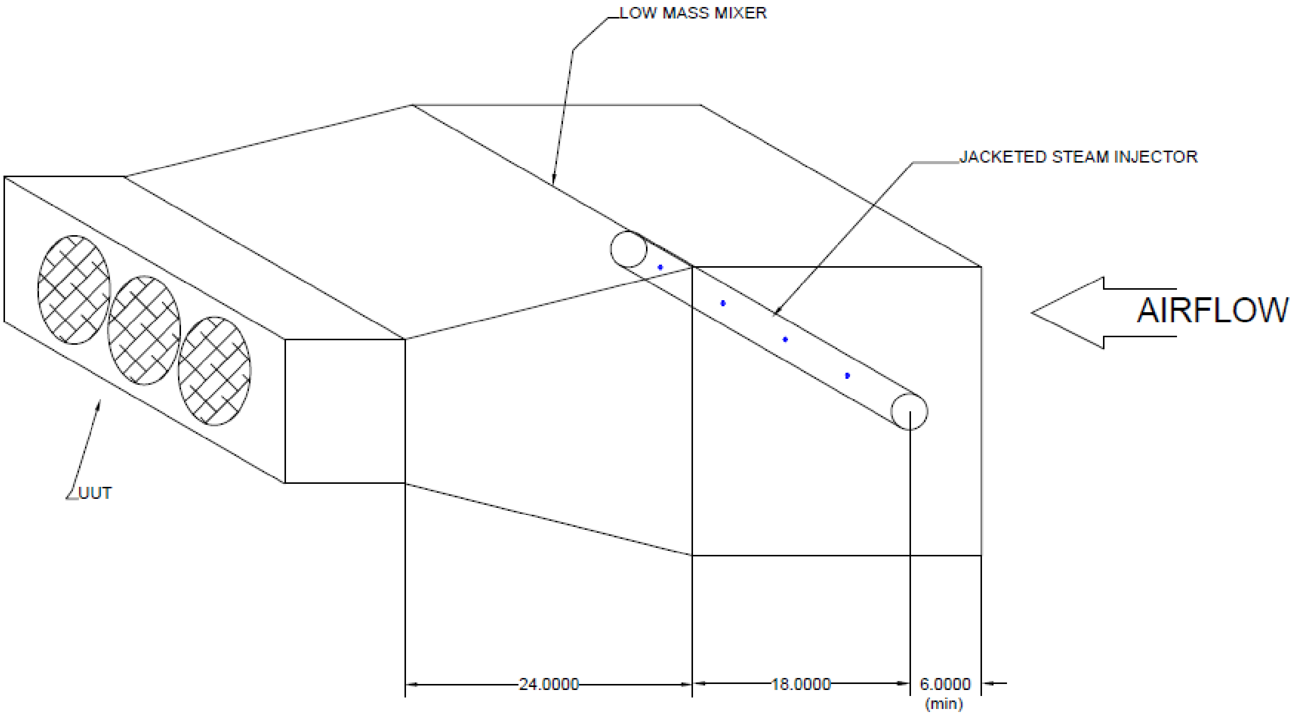

Figure E1. Inlet Air Guidance Duct

APPENDIX F. HOT GAS DEFROST CHALLENGE TEST – INFORMATIVE

F1 *Purpose.* The purpose of this section is to functionally validate the unit under test engages in a hot gas defrost cycle that is at least partially powered by the Dedicated Condensing Unit, rather than electric heat mounted to the Unit Cooler. This section is not intended to quantify the adequacy of hot gas defrosts at a standard frost load condition.

F2 *Scope*. These methods of testing apply to only low-temperature (i.e., freezer) refrigeration systems which utilize hot gas defrost to determine $\dot{DF}$ and $\dot{Q}_{DF}$.

F3 *Matched-pair Hot Gas Defrost Verification.* For a Matched-pair verification, the challenge test shall be conducted using the certified Matched-pair system.

For a Unit Cooler tested alone, the manufacturer shall specify whether the challenge test will be conducted using a hot gas capable Dedicated Condensing Unit or using the test facility's hot gas capable variable-capacity condensing system. For challenge tests conducted with a test facility hot gas capable variable-capacity condensing system, the evaporator TD must be 10 °F during steady state dry condition capacity test. If the challenge test is to be conducted with a Dedicated Condensing Unit, the manufacturer shall designate one or more Dedicated Condensing Units to be used for the challenge test at the time of certification. For each of these Dedicated Condensing Units, the evaporator TD (air inlet dry bulb temperature minus effective dewpoint Saturation Temperature) during steady state dry-condition capacity testing shall be in the range 8 °F to 12 °F.

For a Dedicated Condensing Unit tested alone, the manufacturer shall designate one or more Unit Coolers to be used for the challenge test at the time of certification. For each of these Unit Coolers, the evaporator TD during steady state dry-condition capacity testing shall be in the range 8 °F to 12 °F. The Unit Coolers may be full hot gas or hot gas with electric pan heat.

F4 *Test Setup, Installation and Conditions.* Install the challenge test system in the test lab as required per the manufacturer's installation instructions.

F4.1 The following quantities shall be measured: Refrigeration system capacity; Refrigerant suction and discharge pressure and temperature (dual measurement not required); Inlet air sampling temperature, humidity, and barometric pressure; total energy consumed during defrost cycle.

F4.2 Unless otherwise specified, installation for the hot gas defrost Challenge Test should be consistent with ANSI/CAN/AHRI 1250. Instrumentation that is installed for measurements as described above shall also be consistent with ANSI/CAN/AHRI Standard 1250.

F4.3 Install the coil temperature measurement thermocouples as shown in Figures F1a and F1b. Four thermocouples shall be attached to the Unit Cooler coil face in the center of each quadrant. Exact thermocouple locations are dependent on coil geometry. The individual thermocouples shall be measured and no thermocouple shall be below 40 °F at the defrost termination. For coils with effective surface height greater than or equal to half the effective surface width, thermocouples shall be arranged in two rows and two columns as shown in Figure F1a. For coils with effective surface height less than half the effective surface width, thermocouples shall be arranged in a single row at the center height as shown in Figure F1b.

F4.4 Test condition and test operating tolerances for the steady portion prior to each defrost shall be as indicated in Table 2 of ANSI/CAN/AHRI Standard 1250. An additional tolerance for saturated suction and discharge (if applicable) temperatures of ±0.5 °F shall also be included

F4.5 For the defrost portion of the test, test condition tolerances are not applicable. However, the indoor entering dry-bulb temperature would not be permitted to exceed the test operating tolerance of 4 °F. Additionally, any fan used to enhance test room air mixing shall not cause air velocities in the vicinity of the test unit to exceed 500 ft/min.

F4.6 The Unit Cooler Air Entering dry-bulb temperature shall be -10 °F. For Matched-pair and Dedicated Condensing Unit, the Condenser Air Entering dry-bulb temperature shall be 35 °F for Outdoor Dedicated Condensing Units and 90 °F for Indoor Dedicated Condensing Units.

F5 *Hot Gas Defrost Challenge Test Sequence*

F5.1 Operate the challenge test system in dry conditions at the dry bulb temperatures specified in Section F4.6 until steady state criteria outlined in Section C3.6 are attained. Record refrigeration system capacity, Saturation Temperatures and average power as cycle 1 steady state.

F5.2 Initiate a defrost and record the energy input and Unit Cooler coil temperatures through automatic defrost termination as cycle 1 defrost.

F5.3 Return to steady state cooling operation ensuring saturated suction and discharge (if applicable) temperatures are within tolerance before recording cycle 2 steady state data.

F5.4 Initiate a second defrost and record the energy input and Unit Cooler coil temperatures through automatic defrost termination as cycle 2 defrost.

F5.5 Return to steady state cooling operation ensuring saturated suction and discharge (if applicable) temperatures are within tolerance before recording cycle 3 steady state data.

F5.6 Initiate a third defrost and record the energy input and Unit Cooler coil temperatures through automatic defrost termination as cycle 3 defrost.

F6 *Hot Gas Defrost Challenge Test Acceptance Criteria.* The unit under test shall meet all applicable criteria.

F6.1 The Unit Cooler must exceed the minimum temperature threshold, specified in Section F4.3, for all three defrost cycles.

F6.2 The measured energy input and duration for each of the three hot gas defrost cycles shall be averaged to calculate the average dry hot gas defrost cycle energy ($\mathrm{DF_{d,avg}}$) and average defrost duration ($\mathrm{T_{DF,avg}}$). $\mathrm{DF_{d,avg}}$ shall meet all of the following requirements, as applicable:

F6.2.1 For all refrigeration system configurations (Matched-pair, Single-packaged, and Unit Coolers and Dedicated Condensing Units tested alone), the average hot gas defrost cycle energy ($\mathrm{DF_{d,avg}}$) shall be less than the upper defrost cycle energy limit ($\mathrm{DF_{d,upper}}$), which corresponds to the default electric defrost energy equations established in Section C10.

$$\mathrm{DF_{d,avg}} < \mathrm{DF_{d,upper}} \tag{F1}$$

Where $\mathrm{DF_{d,upper}}$ is defined as

$$\mathrm{DF_{d,upper}} = \begin{cases} \left(0.1315 \cdot \dot{Q}_{gross}\right); & \text{for } \dot{Q}_{gross,ID} \leq 50{,}000 \text{ Btu/h} \\ \left(0.2288 \cdot \dot{Q}_{gross} - 4865.1\right); & \text{for } \dot{Q}_{gross,ID} > 50{,}000 \text{ Btu/h} \end{cases} \tag{F2}$$

And $\dot{Q}_{gross}$ is the measured gross capacity at condition A (per Section C4)

F6.2.2 The average hot gas defrost cycle energy ($\mathrm{DF_{d,avg}}$) shall be greater than or equal to the lower defrost cycle energy limit ($\mathrm{DF_{d,lower}}$).

$$\mathrm{DF_{d,avg}} \geq \mathrm{DF_{d,lower}} \tag{F3}$$

Where $\mathrm{DF_{d,lower}}$ is defined in the following sections.

F6.2.2.1 For Matched-pair, Single-packaged, and Dedicated Condensing Units tested alone $\mathrm{DF_{d,lower}}$ is defined as 1/3 of the System Steady-state power consumption for an indoor system test or a Condition C outdoor system test (for variable- or multiple-capacity systems use the Maximum-Capacity power input):

$$DF_{d,lower} = \begin{cases} (1/3) \cdot T_{DF,avg} \cdot \dot{E}_{ss,ID}; & \text{For Indoor Dedicated Condensing Units} \\ (1/3) \cdot T_{DF,avg} \cdot \dot{E}_{ss,C}; & \text{For Outdoor Dedicated Condensing Units} \end{cases} \quad F4$$

F6.2.2.2 For Unit Coolers tested alone $DF_{d,lower}$ is defined as:

$$DF_{d,lower} = T_{DF,avg} \cdot (0.07 \cdot \dot{Q}_{gross} + 92) \quad F5$$

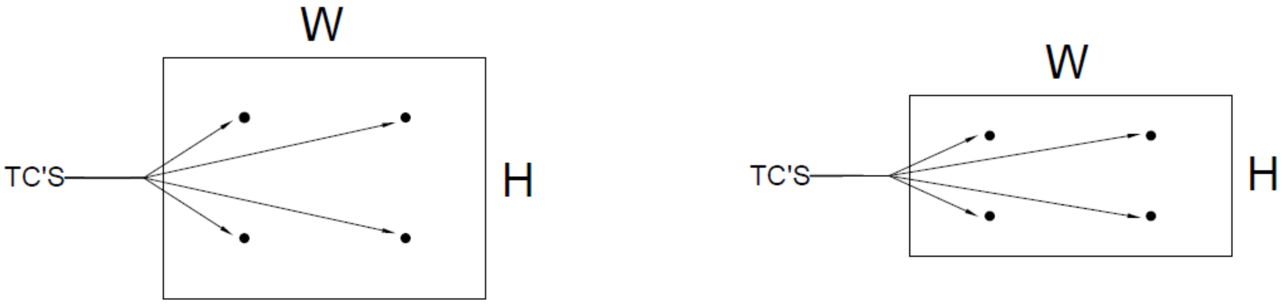

Figure F1a. Coil Temperature Measurement

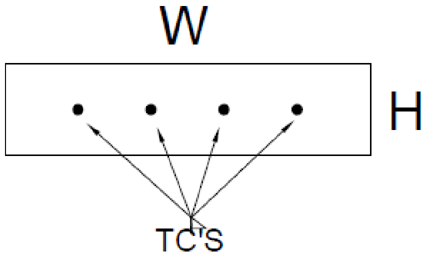

Figure F1b. Coil Temperature Measurement