

ANSI/AHRI Standard 365 (I-P)

2009 Standard for

Performance Rating of Commercial and Industrial Unitary Air-Conditioning Condensing Units



Approved by ANSI on 4 January 2011



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AHRI CERTIFICATION PROGRAM PROVISIONS

Scope of the Certification Program

The Certification Program includes Commercial and Industrial Unitary Air-Conditioning Condensing Units rated at or above 135,000 Btu/h but below 250,000 Btu/h at the AHRI Standard Rating Conditions (Cooling).

Certified Ratings

The following Certification Program ratings are verified by test:

1. Single Number Rating Cooling Capacity, Btu/h
2. Single Number Rating Energy Efficiency Ratio, EER, Btu/(W·h)
3. Integrated Energy Efficiency Ratio, IEER (effective January 1, 2010) or Integrated Part-Load Value, (IPLV) (effective through December 31, 2009)

Conformance to the requirements of the Maximum Operating Conditions Tests (Section 8) is also verified by test.

Note:

This standard supersedes ARI Standard 365-2002.
For SI ratings, see ANSI/AHRI Standard 366 (SI)-2009.

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PERFORMANCE RATING OF COMMERCIAL AND INDUSTRIAL UNITARY AIR-CONDITIONING CONDENSING UNITS

Section 1. Purpose

1.1 Purpose. The purpose of this standard is to establish for Commercial and Industrial Unitary Air-Conditioning Condensing Units: definitions; classifications; test requirements; rating requirements; minimum data requirements for Published Ratings; operating requirements; marking and nameplate data; and conformance conditions.

1.1.1 Intent. This standard is intended for the guidance of the industry, including manufacturers, engineers, installers, contractors and users.

1.1.2 Review and Amendment. This standard is subject to review and amendment as technology advances.

Section 2. Scope

2.1 Scope. This standard applies to factory-made Commercial and Industrial Unitary Air-Conditioning Condensing Units greater than or equal to 135,000 Btu/h as defined in Section 3.

2.1.1 Energy Source. This standard applies only to electrically-driven, mechanical compression-type condensing units.

2.2 Exclusions. This standard does not apply to the testing and rating of condensing units for refrigeration purposes, as defined in AHRI Standard 520.

Section 3. Definitions

All terms in this document shall follow the standard industry definitions in the current edition of ASHRAE *Terminology of Heating, Ventilation, Air-Conditioning and Refrigeration* unless otherwise defined in this section.

3.1 Bubble Point. Refrigerant liquid saturation temperature at a specified pressure.

3.2 Commercial and Industrial Unitary Air-Conditioning Condensing Unit. A factory-made assembly of refrigeration components designed to compress and liquefy a specific refrigerant. It consists of one or more refrigerant compressors, refrigerant condensers (air-cooled, evaporatively – cooled, and/or water-cooled), condenser fans and motors (where used) and factory-supplied accessories.

3.3 Cooling Capacity. The capacity in Btu/h obtained at specific conditions. It is equal to 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.

3.4 Dew Point. Refrigerant vapor saturation temperature at a specified pressure.

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

3.6 Integrated Energy Efficiency Rating (IEER). A single number part-load efficiency figure of merit calculated per the method described in this standard.

3.7 Integrated Part-Load Value (IPLV). A single number cooling part-load figure of merit calculated per the method described in Appendix C.

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

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

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

3.9 *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.

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

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

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

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

3.11 *Single Number Rating.* The Cooling Capacity and EER determined by the results of the tests at Rating Condition No. 1 for air-cooled and evaporatively-cooled condensing units and at Rating Condition No. 3 for water-cooled condensing units (Section 6).

Section 4. Classifications

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

Table 1. Classifications of Commercial and Industrial Air-Conditioning Condensing Units			
Designation	AHRI Type	Condenser Type	Arrangement
Remote Condensing Unit (RCU)	RCU-A	Air	COMP COND
	RCU-E	Evaporatively	
	RCU-W	Water	

Section 5. Test Requirements

5.1 *Test Requirements.* All Standard Ratings shall be verified by tests conducted in accordance with ANSI/ASHRAE Standard 23 and with the test methods and procedures as described in this standard.

5.1.1 An alternate method of verification may be by tests conducted in accordance with ANSI/ASHRAE Standard 37 provided that the suction dew point temperature and the return gas temperature are determined from the procedures in this standard.

Section 6. Rating Requirements

6.1 *Standard Ratings.* Published Ratings shall be obtained at one or more of the Standard Rating Conditions as shown in Table 2. Power input shall be the total power input to the compressor(s), fan(s), controls, and any other components included as part of the condensing unit.

Table 2. Standard Rating Conditions				
Air- and Evaporatively-Cooled Condensing Units				
Rating Condition	Air Temperature Entering and Surrounding Unit		Refrigerant Temperature Entering Condensing Unit ¹	
	Dry-Bulb, °F	Wet-Bulb ² , °F	Suction Dew Point, °F	Return Gas, °F
1 ³	95.0	75.0	45.0	60.0
2	80.0	67.0	45.0	60.0
Water-Cooled Condensing Units				
Rating Condition	Water Temperature Entering, °F	Water Temperature Leaving, °F	Suction Dew Point, °F	Return Gas, °F
3 ³	85.0	95.0	45.0	60.0
4	75.0	Same water flow rate as established above.	45.0	60.0
Notes:				
1) The liquid temperature and pressure leaving the condensing unit shall be reported by the manufacturer in its ratings.				
2) Required for evaporatively-cooled condensing units only.				
3) The Single Number Ratings are determined by the results of the tests at Rating Condition No. 1 or at Rating Condition No. 3.				

6.1.1 *Values of Standard Cooling Capacity Ratings.* These ratings shall be expressed only in terms of thousands of Btu/h in multiples of 2,000 Btu/h for units with Standard Ratings of 400,000 Btu/h and under. For units with Standard Ratings of over 400,000 Btu/h, the ratings shall be expressed in multiples of 5,000 Btu/h.

6.1.2 *Values of Standard Efficiency Ratings.* EER, in Btu/(W·h), and IEER shall be expressed in multiples of 0.1.

6.1.3 *Single Number Ratings.* The reported values shall be determined by the results obtained at Rating Condition No. 1 or at Rating Condition No. 3.

6.1.4 *Electrical Conditions.* Standard Rating tests shall be performed at the nameplate rated voltage(s) and frequency.

For condensing units with dual nameplate voltage ratings, Standard Rating tests shall be performed at both voltages, or at the lower of the two voltages, if only a single Standard Rating is to be published.

6.1.5 *Condenser Airflow Rate.* All Standard Ratings for condensing units shall be determined at the condenser airflow rate specified by the manufacturer where the fan drive is adjustable. Where the fan drive is direct-connected, Standard Ratings shall be determined at the condenser airflow rate established when the condensing unit is operated with all of the associated inlet louvers and any duct work and attachments considered by the manufacturer as normal installation practice. Once established, the airflow circulation rate of the condensing unit shall remain unchanged throughout all tests prescribed herein, except as altered by automatic controls.

6.2 Part-Load Rating. Integrated Part-Load Value (IPLV) is in effect until January 1, 2010. See Appendix C for the method and calculation of IPLV. Effective January 1, 2010, all units rated in accordance with this standard shall include an Integrated Energy Efficiency Ratio (IEER), even if they only have one stage of capacity control.

6.2.1 General. The IEER is intended to be a measure of merit for the part load performance of the unit. Each building may have different part load performance due to local occupancy schedules, building construction, building location and ventilation requirements. For specific building energy analysis an hour-by-hour analysis program should be used.

6.2.2 Integrated Energy Efficiency Ratio (IEER). For equipment covered by this standard, the IEER shall be calculated using tests, derived data, and the following formula.

$$\text{IEER} = 0.020 \cdot A + 0.617 \cdot B + 0.238 \cdot C + 0.125 \cdot D \quad 1$$

Where:

- A = EER at 100% capacity at design conditions
- B = EER at 75% capacity and reduced ambient (see Table 3)
- C = EER at 50% capacity and reduced ambient (see Table 3)
- D = EER at 25% capacity and reduced ambient (see Table 3)

The IEER rating requires that the unit efficiency be determined at 100%, 75%, 50% and 25% load at the conditions specified in Table 3. If the unit, due to its capacity control logic cannot be operated at the 75%, 50%, or 25% load points, then the 75%, 50%, or 25% performance should be determined by plotting the efficiency vs. the percent load and using straight line segments to connect the actual performance points and interpolation to determine the rating performance at 75%, 50% and 25%. For the interpolation, an actual capacity point equal to or less than the required rating point must be used to plot the curves. Extrapolation of the data is not allowed.

If the unit cannot be unloaded to the 75%, 50%, or 25% load, then the unit should be run at the minimum step of unloading at the condensing unit conditions defined for each of the rating load points and then adjust the efficiency for cyclic performance using the following equation.

$$\text{EER} = \frac{\text{LF} \cdot \text{Capacity}}{\text{LF} \cdot (\text{C}_D \cdot (\text{P}_C + \text{P}_{\text{CF}})) + \text{P}_{\text{CT}}} \quad 2$$

Where:

- Capacity = Measured capacity at the lowest machine unloading point operating at the desired part load rating condition (Btu/h)
- P_C = Compressor power at the lowest machine unloading point operating at the desired part load rating condition (Watts)
- P_{CD} = Condenser fan power, if applicable, at the minimum step of unloading at the desired part load rating condition (Watts)
- P_{CT} = Control circuit power and any auxiliary loads (Watts)
- C_D = Degradation coefficient to account for cycling of the compressor for capacity less than the minimum step of capacity. C_D should be determined using the following equation.

$$\text{C}_D = (-0.13 \cdot \text{LF}) + 1.13 \quad 3$$

Where:

LF = Fractional “on” time for last stage at the desired load point

$$\text{LF} = \frac{\left(\frac{\% \text{Load}}{100} \right) \cdot (\text{Full Load Unit Capacity})}{\text{Part Load Unit Capacity}} \quad 4$$

%Load = Standard rating point, i.e. 75%, 50%, 25%.

Table 3. IEER Part-Load Rating Conditions	
CONDITIONS	°F
Refrigerant Entering Condensing Unit (For All Units) Suction Mid Point Temperature ² Return Gas Temperature	45.0 60.0
Condenser (Air-Cooled) Entering Dry-Bulb Temperature and Dry-Bulb Temperature Surrounding Unit Condenser Airflow Rate (cfm)	For %Load > 44.4%, $\text{Outdoor Air Temperature (OAT)} = 0.54 \cdot \% \text{Load} + 41.0$ For % Load ≤ 44.4 %, OAT = 65.0 Note 1
Condenser (Water-Cooled) Condenser Entering Water Temperature (EWT) Condenser Water Flow Rate (gpm)	For %Load > 34.8%, $\text{EWT} = 0.460 \cdot \% \text{Load} + 39.0$ For %Load ≤ 34.8% EWT = 55.0 Full Load Flow
Condenser (Evaporatively-Cooled) Entering Wet-Bulb (EWB) Temperature	For %Load > 36.6%, $\text{EWB} = 0.35 \cdot \% \text{Load} + 40.0$ For %Load ≤ 36.6%, EWB = 52.8
NOTES: 1 Adjust condenser airflow as required by the unit controls for head pressure control. 2 For refrigerants with a glide, the mid-point saturated suction temperature is the average of the bubble point and dew point.	

6.2.3 Example calculations.

Example 1 – Condensing unit has proportional capacity control and capable of being run at the 75%, 50%, and 25% rating points.

The following data was obtained from actual unit measurements.

Stage	Ambient	Actual % Load	Saturated Suction	Capacity	Compr. (P _C)	Cond. Fan (P _{CF})	Control (P _{CT})	EER
	(°F)	(Capacity)	(°F)	Btu/h	W	W	W	Btu/(W·h)
4	95.0	100	45	481,866	43,535	2,100	100	10.54
3	81.5	75	45	361,397	28,731	2,100	100	11.68
2	68.0	50	45	240,933	17,791	2,100	100	12.05
1	65.0	25	45	120,464	9,491	2,100	100	10.30

$$\text{IEER} = (0.02 \cdot 10.54) + (0.617 \cdot 11.68) + (0.238 \cdot 12.05) + (0.125 \cdot 10.30) = 11.58$$

Example 2 – Condensing unit has a single stage of capacity.

The following data was obtained from actual unit measurements.

Stage	Ambient	Actual % Load	Saturated Suction	Capacity	Compr. (P _C)	Cond. Fan (P _{CF})	Control (P _{CT})	EER
	(°F)	(Capacity)	(°F)	Btu/h	W	W	W	Btu/(W·h)
1	95.0	100	45	481,866	43,535	2,100	100	10.54
1	81.5	98.8	45	476,245	38,877	2,100	100	11.59
1	68.0	100.3	45	483,502	35,261	2,100	100	12.91
1	65.0	98.7	45	475,813	35,475	2,100	100	12.63

The unit can not unload to the 75%, 50%, or 25% points so tests were run with the compressor on at the ambients specified for 75%, 50%, and 25%

Using this data you then can calculate the Load Factor (LF) and the C_D factors, then calculate the adjusted performance for the 75%, 50%, and 25% points, and calculate the IEER as shown in the following.

Stage	Ambient	Actual % Load	Capacity	Compr. (P _C)	Cond. Fan (P _{CF})	Control (P _{CT})	EER	C _D	LF
	(°F)	(Capacity)	Btu/h	W	W	W	Btu/(W·h)		
1	95.0	100.0	481,866	43,535	2,100	100	10.54		
1	81.5	98.8	476,245	38,877	2,100	100	11.59		
		75.0					11.23	1.031	0.759
1	68.0	100.3	483,502	35,261	2,100	100	12.91		
		50.0					12.09	1.065	0.498
1	65.0	98.7	475,813	35,475	2,100	100	12.63		
		25.0					11.43	1.097	0.253

The following is an example of the CD calculation for the 50% point.

$$LF = \frac{\left(\frac{50}{100}\right) \cdot 481,866}{483,502} = .498$$

$$C_D = (-0.13 \cdot 0.498) + 1.13 = 1.065$$

$$EER_{50\%} = \frac{0.498 \cdot 483,502}{0.498 \cdot [1.065 \cdot (35,261 + 2,100)] + 100}$$

Using these types of calculations for the 75%, 50%, and 25% points you can then calculate the IEER

$$IEER = (0.02 \cdot 10.54) + (0.617 \cdot 11.23) + (0.238 \cdot 12.09) + (0.125 \cdot 11.43) = 11.45$$

Example 3 – Condensing unit has 2 stages of capacity.

The following data was obtained from actual unit measurements.

Stage	Ambient	Actual % Load	Saturated Suction	Capacity	Compr. (P _C)	Cond. Fan (P _{CF})	Control (P _{CT})	EER
	(°F)	(Capacity)	(°F)	Btu/h	W	W	W	Btu/(W·h)
2	95.0	100	45	481,866	43,535	2,100	100	10.54
1	69.6	52.9	45.0	254,800	15,682	2,100	100	14.25
1	68.0	53.2	45.0	256,400	17,125	2,100	100	13.27
1	65.0	53.5	45.0	257,600	16,250	2,100	100	13.96

We can use the 52.9% point and 100% point to interpolate for the 75% point, but will have to calculate the C_D factor for the 50% and 25% points as shown in the following table.

Stage	Ambient	Actual % Load	Capacity	Compr. (P _C)	Cond. Fan (P _{CF})	Control (P _{CT})	EER	C _D	LF
	(°F)	(Capacity)	Btu/h	W	W	W	Btu/(W·h)		
2	95.0	100.0	481,866	43,535	2,100	100	10.54		
1	69.6	52.9	254,800	15,682	2,100	100	14.25		
		75.0					12.51		
1	68.0	53.2	256,400	17,125	2,100	100	13.27		
		50.0					13.16	1.008	0.940
1	65.0	53.5	257,600	16,250	2,100	100	13.96		
		25.0					12.99	1.069	0.468

Using the above calculations we can then calculate the IEER

$$IEER = (0.02 \cdot 10.54) + (0.617 \cdot 12.51) + (0.238 \cdot 13.16) + (0.125 \cdot 12.99) = 12.68$$

6.3 Tolerances. To comply with this standard, measured test results shall not be less than 95% of Published Ratings for Cooling Capacity and Energy Efficiency Ratio (EER). Results shall not be less than 90% of Published Ratings for IEER or IPLV.

Section 7. Minimum Data Requirements for Published Ratings

7.1 *Minimum Data Requirements for Published Ratings.* As a minimum, Published Ratings shall consist of the following information:

- a. Single Number Rating Cooling Capacity, Btu/h
- b. Single Number Rating Energy Efficiency Ratio, EER, Btu/(W·h)
- c. Integrated Energy Efficiency Ratio, IEER (effective 1 January 2010) or Integrated Part-Load Value (IPLV) (effective through December 31, 2009)

All claims to ratings within the scope of this standard shall include the statement “Rated in accordance with AHRI Standard 365 (I-P)”. All claims to ratings outside the scope of this standard shall include the statement “Outside the scope of AHRI Standard 365 (I-P)”. Wherever Application Ratings are published or printed, they shall include a statement of the conditions at which the ratings apply.

Section 8. Operating Requirements

8.1 *Operating Requirements.* To comply with this standard, any production Commercial and Industrial Unitary Air-Conditioning Condensing Unit shall meet the requirements detailed herein.

8.2 *Maximum Operating Conditions Test.* Commercial and Industrial Unitary Air-Conditioning Condensing Units shall be designed and produced to pass the following maximum operating conditions tests. For multi-capacity units, this test shall be conducted with the unit’s controls set for maximum capacity.

8.2.1 *Temperature Conditions.*

For all units:

Air temperature surrounding unit 115 °F dry-bulb (For units or portions thereof intended to be installed only indoors, this temperature may be reduced to 95.0 °F dry-bulb.)

Refrigerant Entering Condensing Unit

Suction Dew Point temperature..... 50.0 °F

Return gas temperature..... 65.0°F

For water-cooled units:

Water temperature entering condenser 90.0 °F

Water temperature leaving condenser 100 °F

For air-cooled units:

Outside air temperature. 115 °F dry-bulb (and 75.0 °F wet-bulb when condensate is rejected to the condenser air stream) at the standard condenser airflow rate specified and stated by the manufacturer.

For evaporatively-cooled units:

Outside air temperature 100.0 °F dry-bulb
80.0 °F wet-bulb

Make-up water temperature..... 90.0 °F

8.2.2 *Voltages.* Tests shall be conducted at the Range B minimum and maximum utilization voltages from AHRI Standard 110, Table 1, based on the unit's nameplate rated voltage(s). These voltages shall be supplied at the unit's service connection and at rated frequency. A lower minimum or a higher maximum voltage shall be used if listed on the nameplate.

8.2.3 *Procedure.*

8.2.3.1 The condensing unit shall be operated continuously for two hours at the temperature conditions and voltage(s) specified.

8.2.3.2 All power to the condensing unit shall be interrupted for a period sufficient to cause the compressor to stop (not to exceed five seconds) and then be restored.

8.2.4 *Requirements.*

8.2.4.1 During both tests, the condensing unit shall operate without failure of any of its parts.

8.2.4.2 The unit shall resume continuous operation within one hour of restoration of power and shall then operate continuously for one hour. Operation and resetting of safety devices prior to establishment of continuous operation is permitted.

8.2.4.3 Units with water-cooled condensers shall operate at maximum conditions with a water-pressure drop not to exceed 15.0 psi, measured across the unit.

8.3 *Tolerances.* The conditions for the tests outlined in Section 8.2 are average values subject to tolerances of ± 1.0 °F for air wet-bulb and dry-bulb temperatures, ± 0.5 °F for water temperatures, and $\pm 1.0\%$ of the readings for specified voltages.

Section 9. Marking and Nameplate Data

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

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

Section 10. Conformance Conditions

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

APPENDIX A. REFERENCES – NORMATIVE

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

A1.1 AHRI Standard 110-2002 (formerly ARI Standard 110-2002), *Air-Conditioning and Refrigerating Equipment Nameplate Voltages*, 2002, Air-Conditioning, Heating, and Refrigeration Institute, 2111 Wilson Blvd., Suite 500, Arlington, VA 22203, U.S.A.

A1.2 AHRI Standard 520-2004 (formerly ARI Standard 520-2004), *Positive Displacement Condensing Units*, 2004, Air-Conditioning, Heating, and Refrigeration Institute, 2111 Wilson Blvd., Suite 500, Arlington, VA 22203, U.S.A.

A1.3 ANSI/AHRI Standard 365-2002 (formerly ANSI/ARI Standard 365-2002), *Commercial and Industrial Unitary Air-Conditioning Condensing Units*, 2002, Air-Conditioning, Heating, and Refrigeration Institute, 2111 Wilson Blvd., Suite 500, Arlington, VA 22203, U.S.A.

A1.4 ANSI/ASHRAE Standard 23.1-2009, *Methods of Testing for Rating Positive Displacement Refrigerant Compressors and Condensing Units*, 2009, American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., 1791 Tullie Circle, N.E., Atlanta, GA 30329, U.S.A.

A1.5 ANSI/ASHRAE Standard 37-2009, *Methods of Testing for Rating Unitary Air-Conditioning and Heat Pump Equipment*, 2009, American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., 1791 Tullie Circle, N.E., Atlanta, GA 30329, U.S.A.

A1.6 ASHRAE *Terminology of Heating, Ventilation, Air-Conditioning and Refrigeration*, Second Edition, 1991, American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., 1791 Tullie Circle, N.E., Atlanta, GA 30329, U.S.A.

A1.7 IEC Standard 60038, *IEC Standard Voltages*, 2002, International Electrotechnical Commission, 3, rue de Varembe, P.O. Box 131, 1211 Geneva 20, Switzerland.

APPENDIX B. REFERENCES – INFORMATIVE

None.

APPENDIX C. METHOD AND EXAMPLE OF CALCULATING INTEGRATED PART-LOAD VALUES (IPLV) - NORMATIVE

C1 *Part-Load Rating.* Condensing units which are capable of capacity reduction shall be rated at 100% and at each step of capacity reduction provided by the condensing unit as published by the manufacturer. These rating points shall be used to calculate the IPLV.

C1.1 *Part-Load Rating Conditions.* Test conditions for part-load ratings shall be per 6.2.1 of ARI Standard 365-2002.

Capacity reduction means may be adjusted to obtain the specified step of unloading. No manual adjustment of condenser air quantities from those of the Standard Rating Conditions shall be made. However, automatic adjustment of condenser air quantities by condensing unit function is permissible.

C1.2 *Integrated Part-Load Value (IPLV).* For equipment covered by this standard, the IPLV shall be calculated as follows:

- a. Determine the net capacity and EER at the conditions specified in 6.2.1 of ARI Standard 365-2002.
- b. Determine the Part-Load Factor (PLF) from Figure C1, at each rating point.
- c. Use the following equation to calculate IPLV:

$$\begin{aligned} \text{IPLV} = & (\text{PLF}_1 - \text{PLF}_2) \left(\frac{\text{EER}_1 + \text{EER}_2}{2} \right) + (\text{PLF}_2 - \text{PLF}_3) \left(\frac{\text{EER}_2 + \text{EER}_3}{2} \right) \\ & + \dots + (\text{PLF}_{n-1} - \text{PLF}_n) \left(\frac{\text{EER}_{n-1} + \text{EER}_n}{2} \right) + (\text{PLF}_n) (\text{EER}_n) \dots \text{C1} \end{aligned}$$

Where:

PLF = Part-Load Factor determined from Figure C1

n = Total number of capacity steps

Subscript 1 = 100% capacity and EER at part-load rating conditions

Subscript 2, 3, etc. = Specific capacity and EER at part-load steps per C1.

C2 *Example Calculation.*

C2.1 This appendix shows example calculations for determining Integrated Part-Load Values (IPLV).

C2.2 This appendix is for equipment covered by this standard.

C2.3 Equation C1 expresses the IPLV general equation and definition of terms.

C3 *Calculation Example for a Four Capacity Step System.*

C3.1 *Unit Performance Data and Sample Calculation.*

C3.1.1 Assume equipment has four capacity steps as follows:

- 1 100% (full load)
- 2 75% of full load
- 3 50% of full load
- 4 25% of full load

C3.1.2 Obtain Part-Load Factors from Figure C1.

C3.1.3 Obtain EER at each capacity step per C1 of this standard.

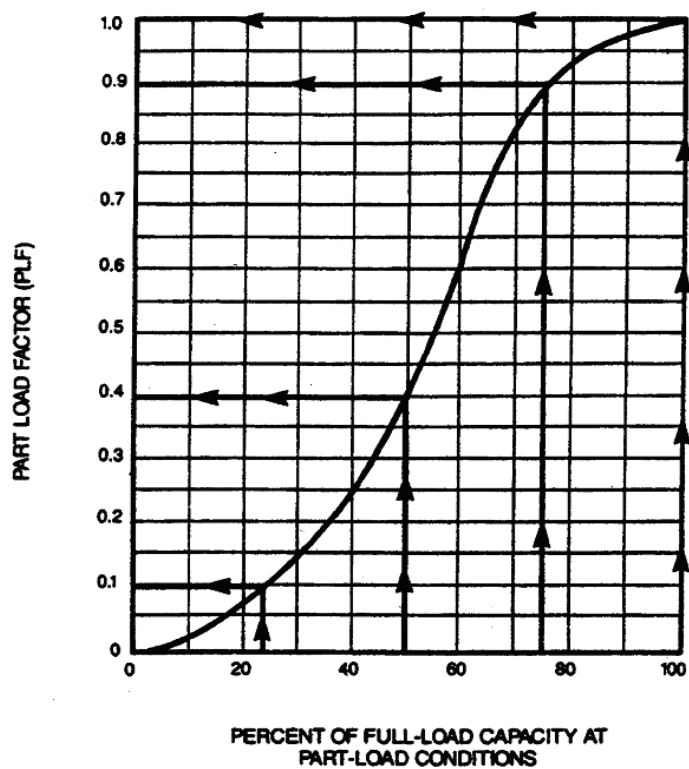
C3.1.4 Calculate IPLV using Equation C1:

$$\begin{aligned}n &= 4 \\ \text{PLF}_1 &= 1.0 & \text{EER}_1 &= 8.9 \\ \text{PLF}_2 &= 0.9 & \text{EER}_2 &= 7.7 \\ \text{PLF}_3 &= 0.4 & \text{EER}_3 &= 7.1 \\ \text{PLF}_4 &= 0.1 & \text{EER}_4 &= 5.0\end{aligned}$$

Enter the above values in Equation C1.

$$\begin{aligned}\text{IPLV} &= (1.0 - 0.9) \left(\frac{8.9 + 7.7}{2} \right) + (0.9 - 0.4) \left(\frac{7.7 + 7.1}{2} \right) + (0.4 - 0.1) \left(\frac{7.1 + 5.0}{2} \right) + 0.1 \times 5.0 \\ &= (0.1 \times 8.3) + (0.5 \times 7.4) + (0.3 \times 6.0) + 0.5 \\ &= 0.83 + 3.70 + 1.80 + 0.5 \\ \text{IPLV} &= 6.8 \text{ (rounded)}\end{aligned}$$

To further illustrate the calculation process, refer to the example in Table C1.



Note: The curve is based on following equation:

$$PLF = A0 + (A1 \times Q) + (A2 \times Q^2) + (A3 \times Q^3) + (A4 \times Q^4) + (A5 \times Q^5) + (A6 \times Q^6)$$

where: PLF = Part-Load Factor

Q = Percent of full-load capacity at part-load rating conditions.

$$A0 = -0.12773917 \times 10^{-6}$$

$$A1 = -0.27648713 \times 10^{-3}$$

$$A2 = 0.50672449 \times 10^{-3}$$

$$A3 = -0.25966636 \times 10^{-4}$$

$$A4 = 0.69875354 \times 10^{-6}$$

$$A5 = -0.76859712 \times 10^{-8}$$

$$A6 = 0.28918272 \times 10^{-10}$$

Figure C1. Part-Load Factor Example

Table C1. Example IPLV Calculation (I-P Units)

Capacity Step	% Full Load Cap. ²	PLF ³	Mfrs. Part-Load EER	Avg. Part-Load EER	PLF Diff.	Avg. EER x PLF Diff. =	Weighted Avg.
1	100%	1.0	8.9 ²		(1.0 - 0.9) = 0.1	8.3 x 0.1 =	0.83
2	75%	0.9	7.7	8.3		7.4 x 0.5 =	3.70
3	50%	0.4	7.1	7.4	(0.9 - 0.4) = 0.5	6.0 x 0.3 =	1.80
4	25%	0.1	5.0	6.0	(0.4 - 0.1) = 0.3	5.01 x 0.1 =	<u>0.50</u>
	0%	0.0		5.0 ¹ -----	(0.1 - 0.0) = 0.1	Single number IPLV	6.83 ⁴

NOTES:

¹ For the range between 0% capacity and the last capacity step, use EER of the last capacity step for the average EER.

² The 100% capacity and EER are to be determined at the part-load Rating Conditions.

³ Part-Load Factor from Figure C1.

⁴ Rounded to 6.8