

ANSI/AHRI Standard 390

2003 Standard for

**Performance Rating of
Single Package
Vertical Air-Conditioners
And Heat Pumps**



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Note:

This standard supersedes ARI 390-2001.

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

Section 1. Purpose

1.1 Purpose. The purpose of this standard is to establish, for Single Package Vertical Air-Conditioners and Heat Pumps: definitions; classifications; test requirements; rating requirements; minimum data requirements for Published Ratings; operating requirements; marking and nameplate data; and conformance conditions.

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

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

Section 2. Scope

2.1 Scope. This standard applies to factory-assembled commercial or industrial Single Package Vertical Air-Conditioner and Heat Pump equipment as defined in Section 3.

2.1.1 Applicability. AHRI Standard 210/240 (formerly ARI Standard 210/240) and AHRI Standard 340/360 (formerly ARI Standard 340/360) shall not apply to commercial or industrial equipment covered by this Standard.

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

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

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 Coefficient of Performance (COP). A ratio of Cooling/Heating Capacity in watts [W] to the power input values in watts [W] at any given set of Rating Conditions expressed in watts/watt [W/W]. For heating *COP*, supplementary resistance heat shall be excluded.

3.1.1 Standard Coefficient of Performance. A ratio of the capacity to power input value obtained at Standard Rating Conditions.

3.2 Cooling Capacity. The capacity associated with the change in air enthalpy which includes both the Latent and Sensible Capacities expressed in Btu/h [W].

3.2.1 Latent Capacity. Capacity associated with a change in humidity ratio.

3.2.2 Sensible Capacity. Capacity associated with a change in dry-bulb temperature.

3.3 Defrost Range. Ambient conditions such that a heat pump operating in the heating mode will develop frost on the outdoor coil to the extent that temperature ranges/tolerances specified in Table 4 of ANSI/ASHRAE Standard 37 will be exceeded.

3.4 *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).

3.4.1 *Standard Energy Efficiency Ratio*. A ratio of the capacity to power input value obtained at Standard Rating Conditions.

3.5 *Heating Capacity*. The capacity associated with the change in dry-bulb temperature expressed in Btu/h [W].

3.6 *Integrated Part-Load Value (IPLV)*. A single number part-load efficiency figure of merit calculated per the method described in this standard.

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. 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.

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

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

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

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

3.10 *Single Package Vertical Air-Conditioner (SPVAC)*. A type of air-cooled small or large commercial package air conditioning and heating equipment; factory assembled as a single package having its major components arranged vertically, which is an enclosed combination of cooling and optional heating components. This equipment is intended for exterior mounting on, adjacent interior to, or through, an outside wall; and is powered by single or three phase current. It may contain separate indoor grille(s), outdoor louvers, various ventilation options, indoor free air discharge, ductwork, wall plenum or sleeve. Heating components may include electrical resistance, steam, hot water, gas or no heat, but may not include reverse cycle refrigeration as a heating means.

3.10.1 *SPVAC Functions*. SPVAC, either alone or in combination with a heating plant, shall provide air-circulation, air-cleaning, cooling with controlled temperature and dehumidification, and may optionally include the function of heating and possible humidifying and ventilation.

3.11 *Single Package Vertical Heat Pump (SPVHP)*. A SPVAC that utilizes reverse cycle refrigeration as its primary heat source, with secondary supplemental heating by means of electrical resistance, steam, hot water or gas.

3.12 *Standard Air*. Air weighing 0.075 lb/ft³ [1.2 kg/m³] which approximates dry air at 70°F [21°C] and at a barometric pressure of 29.92 in Hg [101.3 kPa].

Section 4. Classifications

Equipment covered within the scope of this standard shall be classified as shown in Tables 1 and 2.

Section 5. Test Requirements

5.1 Test Requirements. All Standard Ratings shall be established at the Standard Rating Conditions specified in 5.2 and shall be verified by tests conducted in accordance with ANSI/ASHRAE Standard 37.

5.2 Standard Rating Tests. Table 3 indicates the tests and test conditions which are required to determine values of standard capacity ratings and energy efficiency.

5.2.1 Electrical Conditions. Nameplate voltages are shown in Table 1 of AHRI Standard 110 (formerly ARI Standard 110). Standard Rating Tests shall be performed at the nameplate rated voltage and frequency unless otherwise specified in this standard.

For equipment which is rated with 208/230 dual nameplate voltages and less than 65,000 Btu/h [19 000 W] cooling, 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 voltage if only a single Standard Rating is to be published.

5.2.2 Indoor-Side Airflow Rate. A Standard Rating shall be determined at an indoor-side airflow rate as outlined below. Airflow rates shall be expressed in cfm [m^3/s] of Standard Air.

- a. Ducted equipment shall be tested at the airflow rate delivered when operating against the minimum external static pressure specified in Table 4 or at a lower airflow rate if so specified by the manufacturer.

Non-filtered ducted equipment shall be tested at the airflow rate delivered when operating against the minimum external static pressure specified in Table 4 with an additional 0.08 in H₂O [19.9 Pa] of external static pressure.

Table 1. Classification of Single Package Vertical Air-Conditioner

Types of SPVAC Equipment			
Designation	AHRI Type†	Heat Rejection	Arrangement
Single Package	SPV-A	Air	FAN COMP
			EVAP COND
† A suffix of "-O" indicates equipment not intended for use with field-installed duct systems (See 5.2).			

Table 2. Classification of Single Package Vertical Heat Pump

Types of SPVHP Equipment		
Designation	AHRI Type†	Arrangement
	Heating and Cooling	
Single Package	HSPV-A	FAN COMP
		INDOOR OUTDOOR COIL COIL
† A suffix of "-O" indicates equipment not intended for use with field-installed duct systems (See 5.2).		

Table 3. Conditions for Standard Rating Tests and Operating Requirements

Test		Indoor Side		Outdoor Side	
		Air Entering		Air Entering	
		Dry-Bulb °F [°C]	Wet-Bulb °F [°C]	Dry-Bulb °F [°C]	Wet-Bulb °F [°C]
COOLING	Standard Rating Conditions, Cooling ¹	80.0 [26.7]	67.0 [19.4]	95.0 [35.0]	75.0 ⁴ [23.9]
	Low Temperature Operation, Cooling	67.0 [19.4]	57.0 [13.9]	67.0 [19.4]	57.0 ⁴ [13.9]
	Maximum High Temperature Operation	80.0 [26.7]	67.0 [19.4]	115.0 [46.1]	75.0 ⁴ [23.9]
	Insulation Effectiveness	80.0 [26.7]	75.0 [23.9]	80.0 [26.7]	75.0 ⁴ [23.9]
	Condensate Disposal	80.0 [26.7]	75.0 [23.9]	80.0 [26.7]	75.0 ⁴ [23.9]
HEATING	Part-Load Conditions ³	80.0 [26.7]	67.0 [19.4]	80.0 [26.7]	67.0 ⁴ [19.4]
	Standard Rating Conditions, High-Temperature Heat Pump, Heating	70.0 [21.1]	60.0 [15.6] (max)	47.0 [8.3]	43.0 [6.1]
	Standard Rating Conditions, Low-Temperature Heat Pump, Heating ²	70.0 [21.1]	60.0 [15.6] (max)	17.0 [-8.3]	15.0 [-9.4]
	Maximum High-Temperature Operation	80.0 [26.7]	- -	75.0 [23.9]	65.0 [18.3]
	Part-Load Conditions ³	70.0 [21.1]	60.0 [15.6] (max)	62.0 [16.7]	56.5 [13.6]

NOTES:

- 1 Same conditions used for voltage tolerance tests.
- 2 Only required if the manufacturer's Published Rating includes low-temperature specification.
- 3 For multiple compressor units or units with compressor capacity modulation.
- 4 Required when condensate is rejected to the condenser air stream.

Table 4. External Static Pressure

Capacity Ratings ¹		Minimum External Static Pressure	
MBtu/h	kW	in H2O	Pa
~28	~8.2	0.10	25
>28and~42	>8.2 and 12.4	0.15	37
>42and~70	>12.4and~20.5	0.20	50
>70 and ~ 105	>20.5 and ~ 30.8	0.25	62
> 105 and ~ 134	> 30.8 and ~ 39.3	0.30	75
>134and~210	>39.3and~61.5	0.35	87
>210and~280	>61.5and~82.1	0.40	100
>280and~350	>82.1 and~ 102.6	0.45	112
>350and~400	>102.6and~117.2	0.55	137
>400and~500	>117.2and~146.5	0.65	162
> 500	> 146.5	0.75	187

¹Cooling Capacity for units with cooling function.

- b. Non-ducted equipment shall be tested at the airflow rates obtained at zero external static pressure. All power consumed by the fan(s) shall be included in the power input to the unit.
- c. The manufacturer shall specify a single airflow rate for all tests required in this part of the standard unless the equipment provides automatic adjustment of airflow rate. A separate control signal output for each step of airflow rate shall be considered as an automatic adjustment.

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

5.2.4 Part-Load Rating Conditions. The conditions of test for part-load ratings shall be per Table 3.

The capacity reduction means may be adjusted to obtain the specified step of unloading. No manual adjustment of indoor and outdoor airflow rates from those of the Standard Rating Conditions shall be made. However, automatic adjustment of airflow rates by system function is permissible.

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

Section 6. Rating Requirements

6.1 Rating Requirements. Standard Ratings shall be expressed in Cooling Capacity or Heating Capacity. Power input ratings shall be expressed in increments or multiples of 5 W. Airflow rates shall be expressed in increments of 10 cfm [5 m³/s].

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

6.1.2 Values of Energy Efficiency Ratio (EER). Standard measure of Energy Efficiency Ratio, whenever published, shall be expressed in multiples of the nearest 0.05 Btu/W h for EER. Coefficient of Performance (COP) for heating or cooling, whenever published, shall be expressed in multiples of the nearest 0.02.

Capacity Ratings*		Multiples	
MBtu/h	kW	Btu/h	W
<20	<5.9	100	30
≥ 20 and < 38	≥ 5.9 and < 11	200	60
>38and<65	>11and<19	500	150
~65and<135	~19and<39.6	1000	300
~135and<400	~39.6and<117.0	2000	600
~400	~117.0	5000	1500
* Cooling Capacity for units with cooling function, high temperature Heating Capacity for heating-only units.			

6.2 Part-Load Rating. Systems which are capable of capacity reduction shall be rated at 100% and at each step of capacity reduction provided by the refrigeration system(s) as published by the manufacturer. These rating points shall be used to calculate the IPLV (see 6.2.1).

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

- a. Determine the capacity and *EER* at the conditions specified in 5.2.
- b. Determine the part-load factor (PLF) from Figure 1 at each rating point (see example Appendix C).
- c. Use the following equation to calculate *IPLV*:

$$\begin{aligned}
 IPLV = & (PLF_1 - PLF_2) \times \frac{(EER_1 + EER_2)}{2} \\
 & + (PLF_2 - PLF_3) \times \frac{(EER_2 + EER_3)}{2} \\
 & + (PLF_{n-1} - PLF_n) \times \frac{(EER_{n-1} + EER_n)}{2} \\
 & + (PLF_n) \times (EER_n)
 \end{aligned}$$

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 6.2 of this standard

6.3 *Application Ratings*. Ratings at conditions other than those specified in 5.2 and 5.2.4 may be published as Application Ratings, and shall be based on data determined by the methods prescribed in 5.1. Application Ratings in the Defrost Region shall include Heating Capacity and *COP* based upon a complete defrost cycle (from defrost termination to defrost termination).

6.4 *Tolerances*. To comply with this standard, measured test results shall not be less than 95% of the Published Rating for performance ratios and capacities.

Section 7. Minimum Data Requirements for Published Ratings

7.1 *Minimum Data Requirements for Published Ratings*. Published Ratings shall include all Standard Ratings. All claims to ratings within the scope of this standard shall include the verbiage "Rated in accordance with AHRI Standard 390 (formerly ARI Standard 390)". All claims to ratings outside the scope of this standard shall include the verbiage "Outside the scope of AHRI Standard 390 (formerly ARI Standard 390)". Wherever Application Ratings are published or printed, they shall include a statement of the conditions at which the ratings apply.

7.1.1 *Capacity Designations*. Capacities used in published specifications, literature or advertising, controlled by the manufacturer, for equipment rated under this standard, shall be expressed in Btu/h [W] at the Standard Rating Conditions specified in 5.2 and Part-Load Rating Conditions specified in 5.2.4 and expressed in terms described in 6.1.1 and 6.1.2.

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

- a. Sensible Capacity/total capacity ratio and total capacity
- b. Latent Capacity and total capacity
- c. Sensible Capacity and total capacity

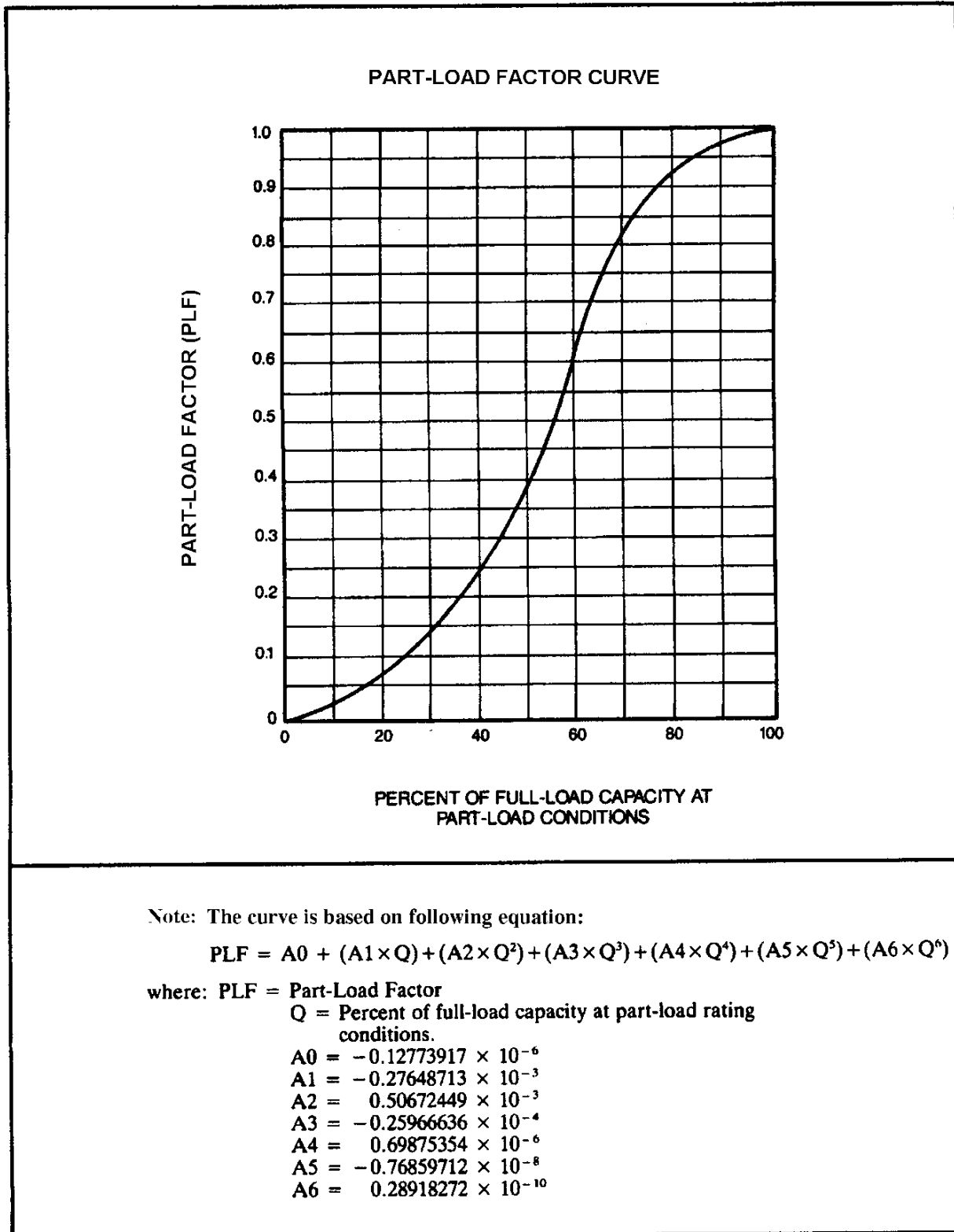


Figure 1. Part-Load Curve

Section 8. Operating Requirements

8.1 *Operating Requirements.* To comply with this standard, any production unit shall meet the requirements detailed herein.

8.2 *Maximum High-Temperature Operation Test.* SPVAC/SPVHP equipment shall pass the appropriate high-temperature operation tests required with an indoor-side air flow rate as determined under 5.2.2 and an outdoor-side airflow rate as determined under 5.2.3.

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

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

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

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

8.3 *Voltage Tolerance Test.* SPVAC/SPVHP equipment shall pass the following voltage tolerance test with an indoor-side coil air-flow rate as determined under 5.2.2 and an outdoor-side air-flow rate as determined under 5.2.3.

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

8.3.2 *Voltages.*

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

8.3.2.2 The power supplied to single phase equipment shall be adjusted just prior to the shut-down period (see 8.3.3.2) so that the resulting voltage at the unit's service connection is 86% of nameplate rated voltage when the compressor motor is in locked-rotor. (For 200V or 208V nameplate rated equipment, the restart voltage shall be set at 180V when the compressor motor is in locked-rotor).

Open circuit voltage for three-phase equipment shall not be greater than 90% of nameplate rated voltage.

8.3.2.3 Within one minute after the equipment has resumed continuous operation (see 8.3.4.3), the voltage shall be restored to the values specified in 8.3.2.1.

8.3.3 *Procedure.*

8.3.3.1 The equipment shall be operated for one hour at the temperature conditions and voltage(s) specified.

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

8.3.4 *Requirements.*

8.3.4.1 During both tests, the equipment shall operate without failure of any of its parts.

8.3.4.2 The equipment shall operate continuously without interruption for the one hour period preceding the power interruption.

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

8.4 *Low-Temperature Operation Test (Cooling).* SPVAC/SPVHP equipment shall pass the following low-temperature operation test when operating with initial airflow rates as determined in 5.2.2 and 5.2.3 and with controls, fans, dampers, and grilles set to produce the maximum tendency to frost or ice the evaporator, provided such settings are not contrary to the manufacturer's instructions to the user.

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

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

8.4.3 *Requirements.*

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

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

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

8.5 *Insulation Effectiveness Test (Cooling).* SPVAC/SPVHP equipment shall pass the following insulation effectiveness test when operating with airflow rates as determined in 5.2.2 and 5.2.3 with controls, fans, dampers, and grilles set to produce the maximum tendency to sweat, provided such settings are not contrary to the manufacturer's instructions to the user.

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

8.5.2 *Procedure.* After establishment of the specified temperature conditions, the unit shall be operated continuously for a period of four hours.

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

8.6 *Condensate Disposal Test (Cooling).* SPVAC/SPVHP equipment which rejects condensate to the condenser air shall pass the following condensate disposal test when operating with airflow rates as determined in 5.2.2 and 5.2.3. Controls, fans, dampers, and grilles shall be set to produce condensate at the maximum rate, provided such settings are not contrary to the manufacturer's instructions to the user.

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

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

8.6.2 *Procedure.* After establishment of the specified temperature conditions, the equipment shall be started with its condensate collection pan filled to the overflowing point and shall be operated continuously for four hours after the condensate level has reached equilibrium.

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

8.7 *Tolerances.* The conditions for the tests outlined in Section 8 are average values subject to tolerances of $\pm 1.0^{\circ}\text{F}$ [$\pm 0.6^{\circ}\text{C}$] for air wet-bulb and dry-bulb temperatures, and $\pm 1.0\%$ of the reading for voltages.

Section 9. Marking and Nameplate Data

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

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

Section 10. Conformance Conditions

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

APPENDIX A. REFERENCES – NORMATIVE

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

A1.1 ANSI/ASHRAE Standard 37-1988, *Methods of Testing for Rating Unitary Air-Conditioning and Heat Pump Equipment*, 1988, American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc., 1791 Tullie Circle N.E., Atlanta, GA 30329, U.S.A.

A1.2 AHRI Standard 110-2002 (formerly AHRI Standard 110-2002), *Air-Conditioning and Refrigerating Equipment Nameplate Voltages*, Air-Conditioning, Heating and Refrigeration Institute, 2002, 2111 Wilson Boulevard, Suite 500, Arlington, VA 22201, U.S.A.

A1.3 AHRI Standard 210/240-2003 (formerly ARI Standard 210/240-2003), *Unitary Air-Conditioning and Air-Source Heat Pump Equipment*, Air-Conditioning, Heating, and Refrigeration Institute, 2002, 2111 Wilson Boulevard, Suite 500, Arlington, VA 22201, U.S.A.

A1.4 AHRI Standard 340/360-2000 (formerly ARI Standard 340/360-2000), *Commercial and Industrial Unitary Air-Conditioning and Heat Pump Equipment*, Air-Conditioning, Heating, and Refrigeration Institute, 2002, 2111 Wilson Boulevard, Suite 500, Arlington, VA 22201, U.S.A.

A1.5 *ASHRAE Terminology of Heating, Ventilation, Air Conditioning & Refrigeration*, Second Edition, 1991, American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc., 1791 Tullie Circle NE, Atlanta, GA 30329, U.S.A.

A1.6 IEC Standard Publication 60038, *IEC Standard Voltages*, 1983, International Electrotechnical Commission, 3, rue de Varembe, P.O. Box 131, 1211 Geneva 20, Switzerland.

APPENDIX B. REFERENCES – INFORMATIVE

None.

APPENDIX C. INTEGRATED PART-LOAD VALUE (IPLV) CALCULATION EXAMPLE – NORMATIVE

C1 Purpose and Scope.

C1.1 Purpose. This appendix shows example calculations for determining Integrated Part-Load Values (IPLV).

C1.2 Scope. This appendix is for equipment covered by this standard.

C2 General Equation and Definitions of Terms.

$$\begin{aligned} IPLV = & (PLF_1 - PLF_2) \times \frac{(EER_1 + EER_2)}{2} \\ & + (PLF_2 - PLF_3) \times \frac{(EER_2 + EER_3)}{2} \\ & + (PLF_{n-1} - PLF_n) \times \frac{(EER_{n-1} + EER_n)}{2} \\ & + (PLF_n) \times (EER_n) \end{aligned}$$

C1

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 6.2 of this standard

C3 Calculation Example for a Four Capacity Step System.

C3.1 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 |

C3.2 Obtain Part-Load Factors from Figure C1.

C3.3 Obtain EER at each capacity step per 6.2 of this standard.

C3.4 Calculate IPLV using the general equation with:

n = 4	
PLF ₁ = 1.0	EER ₁ = 8.9
PLF ₂ = 0.9	EER ₂ = 7.7
PLF ₃ = 0.4	EER ₃ = 7.1
PLF ₄ = 0.1	EER ₄ = 5.0

Enter the above values in Equation C1:

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

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

I-P Units

Using information from C3:

Table C1. Example IPLV Calculation							
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	= 8.3	(1.0 - 0.9) = 0.1	8.3 x 0.1 =	0.83
2	75%	0.9	7.7	= 7.4	(0.9 - 0.4) = 0.5	7.4 x 0.5 =	3.70
3	50%	0.4	7.1	= 6.0	(0.4 - 0.1) = 0.3	6.0 x 0.3 =	1.80
4	25%	0.1	5.0	= 5.0 ¹	(0.1 - 0.0) = 0.1	5.0 ¹ x 0.1 =	<u>0.50</u>
	0%	0.0		-----	(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 Btu/(W·h).

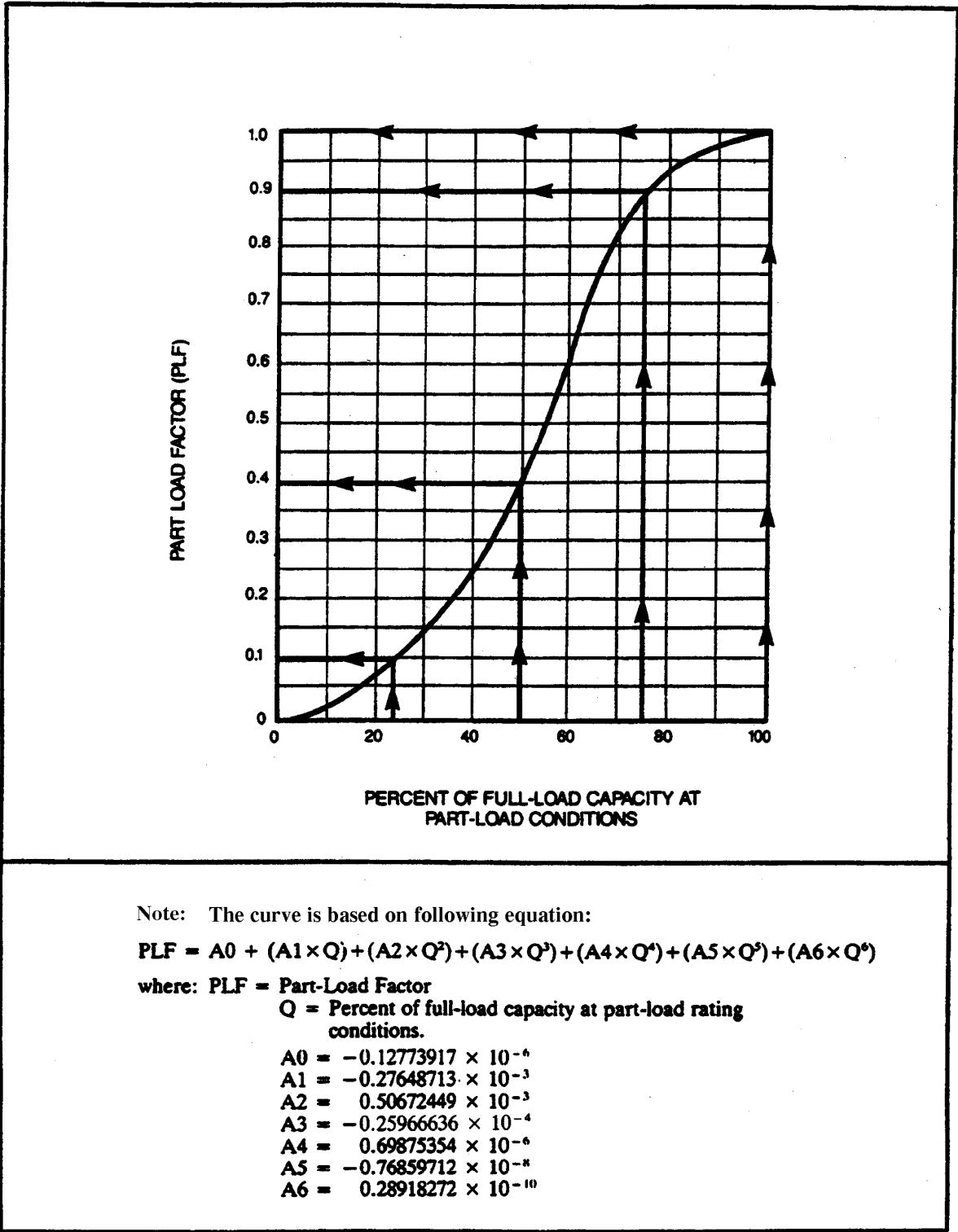


Figure C1. Part -Load Factor Example