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ADDENDA

ANSI/ASHRAE/IES Addendum bd to ANSI/ASHRAE/IES Standard 90.1-2019

Energy Standard for Buildings Except Low-Rise Residential Buildings

Approved by ASHRAE and the American National Standards Institute on May 31, 2022, and by the Illuminating Engineering Society on May 19, 2022.

This addendum was approved by a Standing Standard Project Committee (SSPC) for which the Standards Committee has established a documented program for regular publication of addenda or revisions, including procedures for timely, documented, consensus action on requests for change to any part of the standard. Instructions for how to submit a change can be found on the ASHRAE® website (https://www.ashrae.org/continuous-maintenance).

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FOREWORD

Background

Many projects that follow Section 11 and Normative Appendix G model chillers in the baseline and/or proposed design. For Section 11, the chillers in the budget design must minimally comply with the full- and part-load efficiency requirements in Section 6 for the appropriate chiller type and capacity. For Appendix G, the baseline chillers must be modeled with part- and full-load efficiencies specified in Table G3.5.3. For both Appendix G and Section 11, chillers in the proposed designs must be modeled with part- and full-load efficiency of the specified equipment.

Since part-load performance curves for the budget/baseline chillers are not prescribed, modelers often rely on software default performance curves. These default curves differ between the simulation programs and do not reflect the intended integrated part-load value (IPLV). A similar problem exists when modeling the proposed chillers. While the performance curves can be generated based on detailed information for the specified chiller obtained from the manufacturer, these equipment-specific curves are often not available during the preliminary analysis before chiller make and model are known. Software default curves are often used even after chillers are specified. Addendum bd addresses these issues by prescribing the performance curves for the baseline/budget chillers and providing default performance curves that may be modeled for the chillers in the proposed design if the actual equipment curves are not available.

Addendum Description

Addendum bd adds new Normative Appendix J, which contains two tables with sets of performance curves that aim to represent minimally compliant chiller performance for the budget and baseline building designs when using Section 11 or Normative Appendix G and for proposed building designs when specific equipment performance is not known. The sets of performance curves are provided for modeling inputs in I-P and SI units for both the I-P and SI versions of the standard. This is to accommodate inputs in software such as EnergyPlus, which uses inputs in SI, and DOE-2 which uses inputs in I-P. Both of these simulation programs could target requirements from either the I-P or SI version of the standard. Reference to the sets of performance curves was added to the minimum efficiency tables for both Section 11, which refers to Section 6, and Appendix G. Language was added in both Section 11 and Appendix G that requires users to use the curves if they are supported by the simulation program.

Information supporting the development of the curves including summary tables and charts are provided ***here****.*

Cost Effectiveness

Addendum bd impacts an optional performance path in the standard designed to provide increased flexibility and therefore was not subjected to cost-effectiveness analysis.

Note: In this addendum, changes to the current standard are indicated in the text by underlining (for additions) and ~~strikethrough~~ (for deletions) unless the instructions specifically mention some other means of indicating the changes.

Addendum bd to Standard 90.1-2019

Modify Section 11.5.2 and Table 11.5.1 shown (I-P only).

11.5.2 HVAC Systems. The *HVAC system* type and related performance parameters for the *budget building design* shall be determined from Figure 11.5.2, the *system* descriptions in Table 11.5.2-1 and accompanying notes, and the following rules:

a. **Budget *Building Systems* Not Listed.** Components and parameters not listed in Figure 11.5.2 and Table 11.5.2-2 or otherwise specifically addressed in this subsection shall be identical to those in the *proposed design*.

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Exception to 11.5.2(a): Where there are specific requirements in Sections 6.4 and 6.5, the component *efficiency* in the *budget building design* shall be adjusted to the lowest *efficiency* level allowed by the requirement for that component type.

b. **Minimum *Equipment Efficiency*.** All HVAC and service water-heating equipment in the budget building design shall be modeled at the minimum efficiency levels, both part load and full load, in accordance with Sections 6.4 and 7.4 based on the budget system type determined following Section 11.5.2(j) and capacity determined following Section 11.5.2(i). Chillers shall use Path A efficiencies as shown in Table 6.8.1-3~~.~~ and be modeled using the performance curves specified in Table J-1 and included in Normative Appendix J. When using performance curves from Appendix J, chiller minimum part-load ratio (ratio of load to available capacity at a given simulation time step) and minimum compressor unloading ratio (part-load ratio below which the chiller capacity cannot be reduced by unloading and chiller is false loaded) shall be equal to 0.25. *Simulation programs* that do not use performance curves are permitted to use an alternative simulation method that results in the same performance as the curves described in Normative Appendix J.

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Table 11.5.1 Modeling Requirements for Calculating *Design Energy Cost* and *Energy Cost Budget* (I-P only)

No.	*Proposed Design* (Column A) *Design Energy Cost* (DEC)	*Budget Building Design* (Column B) *Energy Cost Budget* (ECB)
[. . .]		
10.	*HVAC Systems*	
	The *HVAC system* type and all related performance parameters, such as *equipment* capacities and efficiencies, in the proposed design shall be determined as follows: a. Where a complete *HVAC system* exists, the model shall reflect the actual *system* type using actual component capacities and efficiencies. b. Where an *HVAC system* has been designed, the HVAC model shall be consistent with design documents. Mechanical *equipment* efficiencies shall be adjusted from actual *design conditions* to the standard rating conditions specified in Section 6.4.1 if required by the simulation model. Where *efficiency* ratings include supply fan energy, the *efficiency* rating shall be adjusted to remove the supply fan *energy* from the *efficiency* rating in the *budget building design*. The equations in Section 11.5.2 shall not be used in the *proposed design*. The *proposed design HVAC system* shall be modeled using *manufacturers*' full- and part-load data for the *HVAC system* without fan power. <u>**Exception to (a) and (b):** Where part-load performance of chillers in the *proposed design* is not available, and design temperature across the condenser is 10°F, the performance curves in Normative Appendix J for the appropriate chiller type and capacity, as referenced in Table J-1, shall be modeled for the specified chiller. When using performance curves from Appendix J, chiller minimum part-load ratio (ratio of load to available capacity at a given simulation time step) and minimum compressor unloading ratio (part-load ratio below which the chiller capacity cannot be reduced by unloading and chiller is false loaded) shall be equal to 0.25. *Simulation programs* that do not use performance curves are permitted to use an alternative simulation method that results in the same performance as the curves described in Normative Appendix J.</u> c. Where no heating *system* exists or no heating *system* has been specified, the heating *system* shall be modeled as *fossil fuel*. The *system* characteristics shall be identical to the *system* modeled in the *budget building design*. d. Where no cooling *system* exists or no cooling *system* has been specified, the cooling *system* shall be modeled as an air-cooled *single-zone system*, one unit per *thermal block*. The *system* characteristics shall be identical to the *system* modeled in the *budget building design*.	The *HVAC system* type and related performance parameters for the *budget building design* shall be determined from Figure 11.5.2, the *system* descriptions in Table 11.5.2-1 and accompanying notes, and in accord with rules specified in Section 11.5.2(a) through 11.5.2(k).
[. . .]		

[. . .]

Modify Normative Appendix G and Table G3.1 as shown (I-P only).

G3.1.2 General Baseline HVAC System Requirements. *HVAC* systems in the *baseline building* design shall conform with the general provisions in this section.

G3.1.2.1 Equipment Efficiencies. All HVAC *equipment* in the *baseline building design* shall be modeled at the minimum *efficiency* levels, both part load and full load, in accordance with Tables G3.5.1 through G3.5.6. Where multiple *HVAC zones* or *residential spaces* are combined into a single *thermal block* in accordance with Table G3.1, the efficiencies (for baseline HVAC System Types 1, 2, 3, 4, 9, and 10) taken from Tables G3.5.1, G3.5.2, G3.5.4, and G3.5.5 shall be based on the equipment capacity of the *thermal block* divided by the number of *HVAC zones* or *residential spaces*. HVAC System Types 5 or 6 efficiencies taken from Table G3.5.1 shall be based on the cooling equipment capacity of a single floor when grouping identical floors in accordance with Section G3.1.1(a)(4). Fan *energy* shall be modeled separately according to Section G3.1.2.9.

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$COP_{nfcooling}$ and $COP_{nfheating}$ are the packaged HVAC *equipment* cooling and heating *energy efficiency*, respectively, to be used in the *baseline building design*, which excludes supply fan power.

The sets of performance curves specified in Table J-2 should be used to represent part-load performance of chillers in the *baseline building design.* When using performance curves from Normative Appendix J, chiller minimum part-load ratio (ratio of load to available capacity at a given simulation time step) and minimum compressor unloading ratio (part-load ratio below which the chiller capacity cannot be reduced by unloading and chiller is false loaded) shall be equal to 0.25. *Simulation programs* that do not use performance curves are permitted to use an alternative simulation method that results in the same performance as the curves described in Normative Appendix J

[. . .]

Table G3.1 Modeling Requirements for Calculating Proposed and *Baseline Building Performance*

No. Proposed Building Performance	Baseline Building Performance
[. . .]	
10. *HVAC Systems*	
The *HVAC system* type and all related performance parameters in the *proposed design*, such as *equipment* capacities and efficiencies, shall be determined as follows: a. Where a complete *HVAC system* exists, the model shall reflect the actual *system* type using actual component capacities and efficiencies. a. Where an *HVAC system* has been designed and submitted with design documents, the HVAC model shall be consistent with design documents. Mechanical *equipment* efficiencies shall be adjusted from actual *design conditions* to the standard rating conditions specified in Section 6.4.1 if required by the simulation model. Where *efficiency* ratings include supply fan *energy*, the *efficiency* rating shall be adjusted to remove the supply fan *energy* from the *efficiency* rating in the *baseline building design*. The equations in Section G3.1.2.1 shall not be used in the *proposed design*. The *proposed design HVAC system* shall be modeled using *manufacturers*' full- and part-load data for the *HVAC system* without fan power. **Exception to (a) and (b):** Where part-load performance of chillers in the proposed design is not available, and design temperature across the condenser is 10°F, the performance curves in Normative Appendix J, as referenced in Table J-1, shall be modeled for the specified chiller. When using performance curves from Appendix J, chiller minimum part-load ratio (ratio of load to available capacity at a given simulation time step) and minimum compressor unloading ratio (part-load ratio below which the chiller capacity cannot be reduced by unloading and chiller is false loaded) shall be equal to 0.25. *Simulation programs* that do not use performance curves are permitted to use an alternative simulation method that results in the same performance as the curves described in Normative Appendix J. a. Where no heating *system* exists or no heating *system* has been submitted with design documents, the *system* type shall be the same *system* as modeled in the *baseline building design* and shall comply with but not exceed the requirements of Section 6. a. Where no cooling *system* exists or no cooling *system* has been submitted with design documents, the cooling *system* type shall be the same as modeled in the *baseline building design* and shall comply with the requirements of Section 6. **Exception:** *Spaces* using baseline *HVAC system* types 9 and 10.	The *HVAC systems* in the *baseline building design* shall be of the type and description specified in Section G3.1.1, shall meet the general *HVAC system* requirements specified in Section G3.1.2, and shall meet any *system*-specific requirements in Section G3.1.3 that are applicable to the baseline *HVAC system* types. If the *proposed design* includes humidification then the *baseline building design* shall use adiabatic humidification. **Exception:** If the proposed *building* humidification *system* complies with Section 6.5.2.4 then the *baseline building design* shall use nonadiabatic humidification. For *systems* serving *computer rooms*, the *baseline building design* shall not have *reheat* for the purpose of dehumidification. *Fossil fuel systems* shall be modeled using natural gas as their *fuel* source. **Exception:** For *fossil fuel systems* where natural gas is not available for the proposed *building* site as determined by the *rating authority*, the baseline *HVAC systems* shall be modeled using propane as their *fuel*.
[. . .]	

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Modify Table G3.5.3 as shown (I-P only).

Table G3.5.3 *Performance Rating Method* Water Chilling Packages—Minimum *Efficiency* Requirements

Equipment Type	Size Category	Subcategory or Rating Condition	Minimum *Efficiency*	Test Procedure
Water-cooled, electrically operated, positive displacement (rotary screw and scroll)	<150 tons	*kW*/ton	0.7903 FL 0.6763 *IPLV*.IP	AHRI 550/590
	≥150 tons and <300 tons		0.71~~8~~78 FL 0.62~~9~~80 *IPLV*.IP	
	≥300 tons		0.6395 FL 0.57~~2~~19 *IPLV*.IP	
Water-cooled, electrically operated, centrifugal	<150 tons	*kW*/ton	0.7034 FL 0.6~~70~~699 *IPLV*.IP	AHRI 550/590
	≥150 tons and <300 tons		0.63437 FL 0.5961 *IPLV*.IP	
	≥300 tons		0.5766 FL 0.5495 *IPLV*.IP	

Add new Normative Appendix J as shown (I-P only).

(This is a normative appendix and is part of this standard.)

NORMATIVE APPENDIX J
SETS OF PERFORMANCE CURVES

J1. GENERAL

J1.1 Description. This appendix provides sets of performance curves that shall be used to represent the part-load performance of chillers in the *budget building design* when using Section 11 and in the *baseline building design* when using Normative Appendix G. They are also permitted to be used for the *proposed building design* when specific chiller performance is not known.

Each set includes three curves: an energy-input-ratio modifier as a function of temperatures (EIR-f-T) and as a function of a chiller's part-load ratio (EIR-f-PLR), and a capacity modifier as a function of temperatures (CAP-f-T). These curves are intended to describe the part-load performance of a chiller when its operating capacity and power (not including cycling degradation) are calculated by the *simulation program* as follows:

Operating Capacity = Rated Capacity × CAP-f-T

Operating Power = Operating Capacity × EIR-f-T × EIR-f-PLR ×
Chiller Input Power at Rated Conditions/Chiller Capacity at Rated Conditions

Table J-3 provides the reference values for the curves. Tables J-4 and J-6 are to be used when the *simulation program* uses I-P units to evaluate the performance curves, and Tables J-5 and J-7 are to be used when the *simulation program* uses SI units to evaluate the performance curves.

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Table J-1 Sets of Chiller Performance Curves for Section 11

Equipment Type	Size Category	Set Path A	Set Path B
Air-cooled chillers	<150 tons	A	K
	≥150 tons	B	L
Liquid-cooled, electrically operated positive displacement	<75 tons	C	M
	≥75 tons and <150 tons	D	N
	≥150 tons and <300 tons	E	O
	≥300 tons and <600 tons	F	P
	≥600 tons	G	Q
Liquid-cooled, electrically operated centrifugal	<150 tons	H	R
	≥150 tons and <300 tons	H	S
	≥300 tons and <400 tons	I	T
	≥400 tons and <600 tons	J	U
	≥600 tons	J	U

Table J-2 Sets of Chiller Performance Curves for Normative Appendix G

Equipment Type	Size Category	Set
Water-cooled, electrically operated, positive displacement (rotary screw and scroll)	<150 tons	V
	≥150 tons and <300 tons	X
	≥300 tons	Y
Water-cooled, electrically operated, centrifugal	<150 tons	Z
	≥150 tons and <300 tons	AA
	≥300 tons	AB

Table J-3 Chiller Performance Curves References

Chiller Condenser Type	Output Variable[a]	Curve Type[b]	X[c]	Y[c]	Minimum/ Maximum Value for X (I-P °F)	Minimum/ Maximum Value for Y (I-P °F)	Rated Values for X/Y (I-P °F)	Minimum/ Maximum Value for X (SI °C)	Minimum/ Maximum Value for Y (SI °C)	Rated Values for X/Y (SI °C)
Air	EIR-f-T	T1	CHWT	OAT	39/60	55/125.6	44/95	4/16	12.8/52	7/35
Air	CAP-f-T	T1	CHWT	OAT	39/60	55/125.6	44/95	4/16	12.8/52	7/35
Air	EIR-f-PLR	T3	PLR		0/1		1	0/1	N/A	1
Water	EIR-f-T	T1	CHWT	ECT	39/60	55/104	44/85	4/16	12.8/40	7/30
Water	CAP-f-T	T1	CHWT	ECT	39/60	55/104	44/85	4/16	12.8/40	7/30
Water	EIR-f-PLR	T2	PLR		0/1		1	0/1	N/A	1

a. EIR-f-T is the energy input ratio modifier as a function of temperatures; CAP-f-T is the capacity modifier as a function of temperatures; and EIR-f-PLR is the energy input ratio modifier as a function of the chiller's part load ratio.

b. T1: Output = Coeff1 + Coeff2 × X + Coeff3 × X^2 + Coeff4 × Y + Coeff5 × Y^2 + Coeff6 × X × Y
T2: Output = Coeff1 + Coeff2 × X + Coeff3 × X^2
T3: Output = Coeff1 + Coeff2 × X + Coeff3 × X^2 + Coeff4 × X^3

c. CHWT : chilled-water temperature
OAT: outdoor-air dry-bulb temperature
ECT: entering condenser temperature
PLR: part-load ratio = load at a given simulation time step/available capacity at given simulation time step

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Table J-4 Chiller Performance Curves for Section 11 (Simulation Input Required in I-P Units)

Set	Description	Output Variable	Coeff 1	Coeff 2	Coeff 3	Coeff 4	Coeff 5	Coeff 6
A	Air-cooled <150 tons, 10.100 FL, 13.700 IPLV.IP Path A	EIR-f-T	1.777758	–0.038258	0.000431	–0.005368	0.000118	–0.000115
		CAP-f-T	–1.347697	0.070674	–0.000566	0.016793	–0.000104	–0.000076
		EIR-f-PLR	0.087789	0.185696	1.561411	–0.832304		
B	Air-cooled ≥150 tons, 10.100 FL, 14.00 IPLV.IP Path A	EIR-f-T	1.872341	–0.041886	0.000442	–0.006710	0.000123	–0.000086
		CAP-f-T	–1.153535	0.075066	–0.000622	0.009777	–0.000071	–0.000057
		EIR-f-PLR	0.118081	0.107477	1.570838	–0.794051		
C	Liquid-cooled positive displacement <75 tons 0.750 FL, 0.600 IPLV.IP Path A	EIR-f-T	2.001725	–0.044957	0.000484	–0.008296	0.000168	–0.000125
		CAP-f-T	–0.907598	0.073300	–0.000653	0.003700	–0.000054	0.000006
		EIR-f-PLR	0.243730	0.165972	0.586099			
D	Liquid-cooled positive displacement ≥75 and <150 tons 0.720 FL, 0.560 IPLV.IP Path A	EIR-f-T	1.679306	–0.041960	0.000456	–0.002081	0.000128	–0.000125
		CAP-f-T	–0.857791	0.074596	–0.000670	0.001523	–0.000042	0.000012
		EIR-f-PLR	0.208982	0.224001	0.561479			
E	Liquid-cooled positive displacement ≥150 and <300 tons 0.660 FL, 0.540 IPLV.IP Path A	EIR-f-T	1.136125	–0.034608	0.000401	0.008006	0.000058	–0.000131
		CAP-f-T	–0.424942	0.047087	–0.000458	0.006232	–0.000070	0.000058
		EIR-f-PLR	0.246644	0.184576	0.566463			
F	Liquid-cooled positive displacement ≥300 and <600 tons 0.610 FL, 0.520 IPLV.IP Path A	EIR-f-T	1.161349	–0.040557	0.000431	0.013567	0.000003	–0.000103
		CAP-f-T	0.012766	0.033086	–0.000350	0.004004	–0.000061	0.000083
		EIR-f-PLR	0.244926	0.218890	0.532972			
G	Liquid-cooled positive displacement ≥600 tons 0.560 FL, 0.500 IPLV.IP Path A	EIR-f-T	0.874461	–0.041390	0.000430	0.022262	–0.000058	–0.000097
		CAP-f-T	0.122304	0.024081	–0.000293	0.006302	–0.000081	0.000116
		EIR-f-PLR	0.264371	0.263302	0.471690			
H	Liquid-cooled centrifugal <150 tons 0.610 FL, 0.550 IPLV.IP Path A Liquid-cooled centrifugal ≥150 tons <300 tons 0.610 FL, 0.550 IPLV.IP Path A	EIR-f-T	0.474969	–0.036087	0.000223	0.030749	–0.000178	0.000094
		CAP-f-T	–0.454052	0.056252	–0.000669	0.000736	–0.000099	0.000249
		EIR-f-PLR	0.304206	0.073866	0.621457			
I	Liquid-cooled centrifugal ≥300 tons <400 tons 0.560 FL, 0.520 IPLV.IP Path A	EIR-f-T	0.596868	–0.022768	0.000131	0.023536	–0.000130	0.000024
		CAP-f-T	0.947009	0.032913	–0.000354	–0.020151	0.000062	0.000148
		EIR-f-PLR	0.276961	0.101749	0.621383			
J	Liquid-cooled centrifugal ≥400 tons <600 tons 0.560 FL, 0.500 IPLV.IP Path A Liquid-cooled centrifugal ≥600 tons 0.560 FL, 0.500 IPLV.IP Path A	EIR-f-T	0.551957	–0.036196	0.000300	0.028396	–0.000147	0.000029
		CAP-f-T	–0.702242	0.077132	–0.000785	–0.005637	–0.000033	0.000145
		EIR-f-PLR	0.290891	0.059366	0.649421			

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Table J-4 Chiller Performance Curves for Section 11 (Simulation Input Required in I-P Units) *(Continued)*

Set	Description	Output Variable	Coeff 1	Coeff 2	Coeff 3	Coeff 4	Coeff 5	Coeff 6
K	Air-cooled <150 tons, 9.700 FL, 15.800 IPLV.IP Path B	EIR-f-T	2.054048	–0.042406	0.000450	–0.009813	0.000140	–0.000093
		CAP-f-T	–1.325652	0.074160	–0.000607	0.013871	–0.000088	–0.000069
		EIR-f-PLR	0.036849	0.100792	1.614142	–0.748013		
L	Air-cooled ≥150 tons, 9.700 FL, 16.100 IPLV.IP Path B	EIR-f-T	1.673814	–0.041178	0.000429	–0.003424	0.000109	–0.000084
		CAP-f-T	–0.939345	0.074488	–0.000615	0.005127	–0.000048	–0.000048
		EIR-f-PLR	0.095711	0.009903	1.543396	–0.646737		
M	Liquid-cooled positive displacement <75 tons 0.780 FL, 0.500 IPLV.IP Path B	EIR-f-T	2.018167	–0.045111	0.000485	–0.008503	0.000168	–0.000124
		CAP-f-T	–0.913752	0.073361	–0.000654	0.003787	–0.000054	0.000006
		EIR-f-PLR	0.107200	0.182611	0.705182			
N	Liquid-cooled positive displacement ≥75 and <150 tons 0.750 FL, 0.490 IPLV.IP Path B	EIR-f-T	1.849951	–0.043409	0.000467	–0.005187	0.000146	–0.000123
		CAP-f-T	–0.840342	0.071938	–0.000641	0.002703	–0.000047	0.000007
		EIR-f-PLR	0.183811	–0.044417	0.855660			
O	Liquid-cooled positive displacement ≥150 and <300 tons 0.680 FL, 0.440 IPLV.IP Path B	EIR-f-T	1.020192	–0.030046	0.000363	0.008504	0.000053	–0.000135
		CAP-f-T	–0.451749	0.051393	–0.000490	0.004351	–0.000058	0.000050
		EIR-f-PLR	0.090936	0.207812	0.696735			
P	Liquid-cooled positive displacement ≥300 and <600 tons 0.625 FL, 0.410 IPLV.IP Path B	EIR-f-T	1.189071	–0.038585	0.000415	0.011574	0.000017	–0.000108
		CAP-f-T	–0.063852	0.038321	–0.000388	0.002935	–0.000054	0.000072
		EIR-f-PLR	0.103665	0.148024	0.744887			
Q	Liquid-cooled positive displacement ≥600 tons 0.585 FL, 0.380 IPLV.IP Path B	EIR-f-T	0.916144	–0.041541	0.000436	0.020987	–0.000047	–0.000100
		CAP-f-T	0.131880	0.023312	–0.000286	0.006699	–0.000084	0.000116
		EIR-f-PLR	0.061706	0.261711	0.677017			
R	Liquid-cooled centrifugal <150 tons 0.695 FL, 0.440 IPLV.IP Path B	EIR-f-T	0.860442	–0.036414	0.000317	0.022419	–0.000108	0.000001
		CAP-f-T	–0.062772	0.054642	–0.000550	–0.008072	0.000004	0.000101
		EIR-f-PLR	0.072183	0.108650	0.818174			
S	Liquid-cooled centrifugal ≥150 tons <300 tons 0.635 FL, 0.400 IPLV.IP Path B	EIR-f-T	0.582513	–0.033786	0.000227	0.027678	–0.000157	0.000067
		CAP-f-T	0.015941	0.049796	–0.000573	–0.007266	–0.000041	0.000219
		EIR-f-PLR	0.064979	0.151829	0.779131			
T	Liquid-cooled centrifugal ≥300 tons <400 tons 0.595 FL, 0.390 IPLV.IP Path B	EIR-f-T	0.634610	–0.033472	0.000260	0.026148	–0.000130	0.000015
		CAP-f-T	0.127596	0.046709	–0.000538	–0.006247	–0.000047	0.000195
		EIR-f-PLR	0.082812	0.152816	0.764822			
U	Liquid-cooled centrifugal ≥400 tons <600 tons 0.585 FL, 0.380 IPLV.IP Path B Liquid-cooled centrifugal ≥600 tons 0.585 FL, 0.380 IPLV.IP Path B	EIR-f-T	0.593414	–0.028948	0.000224	0.024197	–0.000126	0.000027
		CAP-f-T	–0.487422	0.071558	–0.000737	–0.006964	–0.000032	0.000158
		EIR-f-PLR	0.058583	0.205486	0.736345			

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Table J-5 Chiller Performance Curves for Section 11 (Simulation Input Required in SI Units)

Set	Description	Output Variable	Coeff 1	Coeff 2	Coeff 3	Coeff 4	Coeff 5	Coeff 6
A	Air-cooled <150 tons, 10.100 FL, 13.700 IPLV.IP Path A	EIR-f-T	0.825618	–0.025861	0.001396	–0.002728	0.000381	–0.000373
		CAP-f-T	0.686206	0.057562	–0.001835	0.013810	–0.000338	–0.000247
		EIR-f-PLR	0.087789	0.185696	1.561411	–0.832304		
B	Air-cooled ≥150 tons, 10.100 FL, 14.00 IPLV.IP Path A	EIR-f-T	0.807832	–0.029452	0.001431	–0.002832	0.000399	–0.000278
		CAP-f-T	0.794185	0.060199	–0.002016	0.006203	–0.000229	–0.000183
		EIR-f-PLR	0.118081	0.107477	1.570838	–0.794051		
C	Liquid-cooled positive displacement <75 tons 0.750 FL, 0.600 IPLV.IP Path A	EIR-f-T	0.836880	–0.032383	0.001568	–0.002806	0.000544	–0.000407
		CAP-f-T	0.838337	0.057024	–0.002117	0.000793	–0.000175	0.000020
		EIR-f-PLR	0.243730	0.165972	0.586099			
D	Liquid-cooled positive displacement ≥75 and <150 tons 0.720 FL, 0.560 IPLV.IP Path A	EIR-f-T	0.740920	–0.030144	0.001479	0.003850	0.000416	–0.000404
		CAP-f-T	0.861840	0.057837	–0.002170	–0.001391	–0.000136	0.000040
		EIR-f-PLR	0.208982	0.224001	0.561479			
E	Liquid-cooled positive displacement ≥150 and <300 tons 0.660 FL, 0.540 IPLV.IP Path A	EIR-f-T	0.620834	–0.023642	0.001300	0.013555	0.000189	–0.000425
		CAP-f-T	0.800066	0.035377	–0.001482	0.006462	–0.000227	0.000187
		EIR-f-PLR	0.246644	0.184576	0.566463			
F	Liquid-cooled positive displacement ≥300 and <600 tons 0.610 FL, 0.520 IPLV.IP Path A	EIR-f-T	0.636828	–0.029245	0.001397	0.018817	0.000008	–0.000332
		CAP-f-T	0.863175	0.023955	–0.001135	0.004955	–0.000197	0.000268
		EIR-f-PLR	0.244926	0.218890	0.532972			
G	Liquid-cooled positive displacement ≥600 tons 0.560 FL, 0.500 IPLV.IP Path A	EIR-f-T	0.544967	–0.030491	0.001395	0.027852	–0.000187	–0.000314
		CAP-f-T	0.830804	0.016310	–0.000949	0.008707	–0.000263	0.000377
		EIR-f-PLR	0.264371	0.263302	0.471690			
H	Liquid-cooled centrifugal <150 tons 0.610 FL, 0.550 IPLV.IP Path A Liquid-cooled centrifugal ≥150 tons <300 tons 0.610 FL, 0.550 IPLV.IP Path A	EIR-f-T	0.447243	–0.033785	0.000724	0.040274	–0.000577	0.000305
		CAP-f-T	0.837420	0.038528	–0.002167	0.004185	–0.000322	0.000806
		EIR-f-PLR	0.304206	0.073866	0.621457			
I	Liquid-cooled centrifugal ≥300 tons <400 tons 0.560 FL, 0.520 IPLV.IP Path A	EIR-f-T	0.647193	–0.024484	0.000426	0.028764	–0.000421	0.000077
		CAP-f-T	1.207878	0.026951	–0.001148	–0.020576	0.000202	0.000479
		EIR-f-PLR	0.276961	0.101749	0.621383			
J	Liquid-cooled centrifugal ≥400 tons <600 tons 0.560 FL, 0.500 IPLV.IP Path A Liquid-cooled centrifugal ≥600 tons 0.560 FL, 0.500 IPLV.IP Path A	EIR-f-T	0.489242	–0.028851	0.000973	0.035835	–0.000477	0.000096
		CAP-f-T	0.896806	0.056739	–0.002544	–0.005536	–0.000105	0.000470
		EIR-f-PLR	0.290891	0.059366	0.649421			

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Table J-5 Chiller Performance Curves for Section 11 (Simulation Input Required in SI Units)

Set	Description	Output Variable	Coeff 1	Coeff 2	Coeff 3	Coeff 4	Coeff 5	Coeff 6
K	Air-cooled <150 tons, 9.700 FL, 15.800 IPLV.IP Path B	EIR-f-T	0.891872	–0.029821	0.001459	–0.006929	0.000453	–0.000303
		CAP-f-T	0.709195	0.059566	–0.001968	0.010899	–0.000284	–0.000222
		EIR-f-PLR	0.036849	0.100792	1.614142	–0.748013		
L	Air-cooled ≥150 tons, 9.700 FL, 16.100 IPLV.IP Path B	EIR-f-T	0.711589	–0.029520	0.001390	0.001554	0.000353	–0.000272
		CAP-f-T	0.879844	0.060415	–0.001994	0.000937	–0.000156	–0.000155
		EIR-f-PLR	0.095711	0.009903	1.543396	–0.646737		
M	Liquid-cooled positive displacement <75 tons 0.780 FL, 0.500 IPLV.IP Path B	EIR-f-T	0.844064	–0.032504	0.001571	–0.003076	0.000545	–0.000402
		CAP-f-T	0.835803	0.057057	–0.002119	0.000903	–0.000176	0.000019
		EIR-f-PLR	0.107200	0.182611	0.705182			
N	Liquid-cooled positive displacement ≥75 and <150 tons 0.750 FL, 0.490 IPLV.IP Path B	EIR-f-T	0.797371	–0.031361	0.001514	0.000419	0.000473	–0.000398
		CAP-f-T	0.850710	0.056037	–0.002077	–0.000147	–0.000153	0.000023
		EIR-f-PLR	0.183811	–0.044417	0.855660			
O	Liquid-cooled positive displacement ≥150 and <300 tons 0.680 FL, 0.440 IPLV.IP Path B	EIR-f-T	0.617871	–0.020110	0.001175	0.013623	0.000172	–0.000439
		CAP-f-T	0.822519	0.038968	–0.001588	0.004048	–0.000188	0.000164
		EIR-f-PLR	0.090936	0.207812	0.696735			
P	Liquid-cooled positive displacement ≥300 and <600 tons 0.625 FL, 0.410 IPLV.IP Path B	EIR-f-T	0.656763	–0.027891	0.001343	0.016627	0.000056	–0.000348
		CAP-f-T	0.877218	0.028393	–0.001257	0.003217	–0.000174	0.000232
		EIR-f-PLR	0.103665	0.148024	0.744887			
Q	Liquid-cooled positive displacement ≥600 tons 0.585 FL, 0.380 IPLV.IP Path B	EIR-f-T	0.553694	–0.030347	0.001412	0.026568	–0.000153	–0.000325
		CAP-f-T	0.831828	0.015657	–0.000928	0.009067	–0.000272	0.000376
		EIR-f-PLR	0.061706	0.261711	0.677017			
R	Liquid-cooled centrifugal <150 tons 0.695 FL, 0.440 IPLV.IP Path B	EIR-f-T	0.627360	–0.028989	0.001027	0.027958	–0.000350	0.000002
		CAP-f-T	0.972517	0.040861	–0.001781	–0.008217	0.000013	0.000328
		EIR-f-PLR	0.072183	0.108650	0.818174			
S	Liquid-cooled centrifugal ≥150 tons <300 tons 0.635 FL, 0.400 IPLV.IP Path B	EIR-f-T	0.526475	–0.030843	0.000735	0.035532	–0.000510	0.000216
		CAP-f-T	0.971699	0.036192	–0.001858	–0.005224	–0.000134	0.000709
		EIR-f-PLR	0.064979	0.151829	0.779131			
T	Liquid-cooled centrifugal ≥300 tons <400 tons 0.595 FL, 0.390 IPLV.IP Path B	EIR-f-T	0.547810	–0.029470	0.000842	0.032888	–0.000423	0.000048
		CAP-f-T	1.023337	0.033378	–0.001742	–0.005438	–0.000153	0.000633
		EIR-f-PLR	0.082812	0.152816	0.764822			
U	Liquid-cooled centrifugal ≥400 tons <600 tons 0.585 FL, 0.380 IPLV.IP Path B Liquid-cooled centrifugal ≥600 tons 0.585 FL, 0.380 IPLV.IP Path B	EIR-f-T	0.569569	–0.024700	0.000727	0.030569	–0.000409	0.000087
		CAP-f-T	0.953580	0.053010	–0.002387	–0.007165	–0.000104	0.000510
		EIR-f-PLR	0.058583	0.205486	0.736345			

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Table J-6 Chiller Performance Curves for Normative Appendix G (Simulation Input Required in I-P Units)

Set	Description	Output Variable	Coeff 1	Coeff 2	Coeff 3	Coeff 4	Coeff 5	Coeff 6
V	Liquid-cooled positive displacement <150 tons 0.7903 FL, 0.6763 IPLV.IP	EIR–f–T	2.044998	–0.047515	0.000505	–0.008787	0.000175	–0.000120
		CAP–f–T	–0.981909	0.076674	–0.000687	0.003920	–0.000058	0.000006
		EIR–f–PLR	0.276037	0.253577	0.466353			
X	Liquid-cooled positive displacement ≥150 and <300 tons 0.7178 FL, 0.6280 IPLV.IP	EIR–f–T	1.037805	–0.024695	0.000329	0.003130	0.000102	–0.000159
		CAP–f–T	–0.683858	0.065283	–0.000602	0.002347	–0.000050	0.000036
		EIR–f–PLR	0.250801	0.345915	0.399138			
Y	Liquid-cooled positive displacement ≥300 tons 0.6395 FL, 0.5719 IPLV.IP	EIR–f–T	1.188945	–0.039426	0.000413	0.012888	0.000002	–0.000098
		CAP–f–T	–0.160681	0.044390	–0.000429	0.001024	–0.000035	0.000055
		EIR–f–PLR	0.320097	0.074356	0.602938			
Z	Liquid-cooled centrifugal <150 tons 0.7034 FL, 0.6699 IPLV.IP	EIR–f–T	0.857485	–0.036148	0.000314	0.022356	–0.000108	0.000001
		CAP–f–T	–0.061958	0.054739	–0.000550	–0.008177	0.000005	0.000101
		EIR–f–PLR	0.281669	0.202762	0.515409			
AA	Liquid-cooled centrifugal ≥150 and <300 tons 0.6337 FL, 0.5961 IPLV.IP	EIR–f–T	0.479847	–0.035964	0.000225	0.031377	–0.000183	0.000085
		CAP–f–T	–0.128081	0.050459	–0.000581	–0.004297	–0.000049	0.000200
		EIR–f–PLR	0.339494	0.049090	0.611582			
AB	Liquid-cooled centrifugal ≥300 tons 0.5766 FL, 0.5495 IPLV.IP	EIR–f–T	0.747210	–0.038874	0.000313	0.027638	–0.000133	–0.000008
		CAP–f–T	0.117208	0.042940	–0.000478	–0.003930	–0.000045	0.000155
		EIR–f–PLR	0.309752	0.153649	0.536462			

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Table J-7 Chiller Performance Curves for Normative Appendix G (Simulation Input Required in SI Units)

Set	Description	Output Variable	Coeff 1	Coeff 2	Coeff 3	Coeff 4	Coeff 5	Coeff 6
V	Liquid-cooled positive displacement <150 tons 0.7903 FL, 0.6763 IPLV.IP	EIR-f-T	0.817024	–0.034213	0.001638	–0.002590	0.000566	–0.000389
		CAP-f-T	0.840898	0.059263	–0.002225	0.000735	–0.000188	0.000020
		EIR-f-PLR	0.276037	0.253577	0.466353			
X	Liquid-cooled positive displacement ≥150 and <300 tons 0.7178 FL, 0.6280 IPLV.IP	EIR-f-T	0.627193	–0.015646	0.001067	0.008270	0.000331	–0.000515
		CAP-f-T	0.850133	0.050234	–0.001951	0.000606	–0.000161	0.000118
		EIR-f-PLR	0.250801	0.345915	0.399138			
Y	Liquid-cooled positive displacement ≥300 tons 0.6395 FL, 0.5719 IPLV.IP	EIR-f-T	0.664854	–0.029016	0.001339	0.017823	0.000008	–0.000318
		CAP-f-T	0.873130	0.033599	–0.001391	0.000961	–0.000114	0.000178
		EIR-f-PLR	0.320097	0.074356	0.602938			
Z	Liquid-cooled centrifugal <150 tons 0.7034 FL, 0.6699 IPLV.IP	EIR-f-T	0.628525	–0.028798	0.001019	0.027867	–0.000349	0.000002
		CAP-f-T	0.973310	0.040996	–0.001782	–0.008340	0.000016	0.000327
		EIR-f-PLR	0.281669	0.202762	0.515409			
AA	Liquid-cooled centrifugal ≥150 and <300 tons 0.6337 FL, 0.5961 IPLV.IP	EIR-f-T	0.464330	–0.033834	0.000731	0.040345	–0.000592	0.000277
		CAP-f-T	0.909633	0.035460	–0.001881	–0.001808	–0.000158	0.000648
		EIR-f-PLR	0.339494	0.049090	0.611582			
AB	Liquid-cooled centrifugal ≥300 tons 0.5766 FL, 0.5495 IPLV.IP	EIR-f-T	0.563967	–0.034331	0.001015	0.033941	–0.000432	–0.000025
		CAP-f-T	0.988289	0.031128	–0.001550	–0.003349	–0.000147	0.000503
		EIR-f-PLR	0.309752	0.153649	0.536462			

Modify Section 11.5.3 and Table 11.5.1 as shown (SI only).

11.5.2 HVAC Systems. The *HVAC system* type and related performance parameters for the *budget building design* shall be determined from Figure 11.5.2, the *system* descriptions in Table 11.5.2-1 and accompanying notes, and the following rules:

a. **Budget *Building Systems* Not Listed.** Components and parameters not listed in Figure 11.5.2 and Table 11.5.2-2 or otherwise specifically addressed in this subsection shall be identical to those in the *proposed design*.

Exception to 11.5.2(a): Where there are specific requirements in Sections 6.4 and 6.5, the component *efficiency* in the *budget building design* shall be adjusted to the lowest *efficiency* level allowed by the requirement for that component type.

b. **Minimum *Equipment Efficiency*.** All HVAC and service water-heating equipment in the budget building design shall be modeled at the minimum efficiency levels, both part load and full load, in accordance with Sections 6.4 and 7.4 based on the budget system type determined following Section 11.5.2(j) and capacity determined following Section 11.5.2(i). Chillers shall use Path A efficiencies as shown in Table 6.8.1-3~~.~~ and be modeled using the performance curves specified in Table J-1 and included in Normative Appendix J. When using performance curves from Appendix J, chiller minimum part-load ratio (ratio of load to available capacity at a given simulation time step) and minimum compressor unloading ratio (part-load ratio below which the chiller capacity cannot be reduced by unloading and chiller is false loaded) shall be equal to 0.25. *Simulation programs* that do not use performance curves are permitted to use an alternative simulation method that results in the same performance as the curves described in Normative Appendix J.

[. . .]

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Table 11.5.1 Modeling Requirements for Calculating *Design Energy Cost* and *Energy Cost Budget*

***Proposed Design* (Column A)** ***Design Energy Cost* (DEC)**	***Budget Building Design* (Column B)** ***Energy Cost Budget* (ECB)**
[. . .]	
10. *HVAC Systems*	
The *HVAC system* type and all related performance parameters, such as *equipment* capacities and efficiencies, in the *proposed design* shall be determined as follows: a. Where a complete *HVAC system* exists, the model shall reflect the actual *system* type using actual component capacities and efficiencies. b. Where an *HVAC system* has been designed, the HVAC model shall be consistent with design documents. Mechanical *equipment* efficiencies shall be adjusted from actual *design conditions* to the standard rating conditions specified in Section 6.4.1 if required by the simulation model. Where *efficiency* ratings include supply fan *energy*, the *efficiency* rating shall be adjusted to remove the supply fan *energy* from the *efficiency* rating in the *budget building design*. The equations in Section 11.5.2 shall not be used in the *proposed design*. The *proposed design HVAC system* shall be modeled using *manufacturers*' full- and part-load data for the *HVAC system* without fan power. **Exception to (a) and (b):** Where part-load performance of chillers in the proposed design is not available, and design temperature across the condenser is 5.56°C, the performance curves in Normative Appendix J for the appropriate chiller type and capacity, as referenced in Table J-1, shall be modeled for the specified chiller. When using performance curves from Appendix J, chiller minimum part-load ratio (ratio of load to available capacity at a given simulation time step) and minimum compressor unloading ratio (part-load ratio below which the chiller capacity cannot be reduced by unloading and chiller is false loaded) shall be equal to 0.25. *Simulation programs* that do not use performance curves are permitted to use an alternative simulation method that results in the same performance as the curves described in Normative Appendix J. c. Where no heating *system* exists or no heating *system* has been specified, the heating *system* shall be modeled as *fossil fuel*. The *system* characteristics shall be identical to the *system* modeled in the *budget building design*. d. Where no cooling *system* exists or no cooling *system* has been specified, the cooling *system* shall be modeled as an air-cooled *single-zone system*, one unit per *thermal block*. The *system* characteristics shall be identical to the *system* modeled in the *budget building design*.	The *HVAC system* type and related performance parameters for the *budget building design* shall be determined from Figure 11.5.2, the *system* descriptions in Table 11.5.2-1 and accompanying notes, and in accord with rules specified in Section 11.5.2(a) through 11.5.2(k).
[. . .]	

Modify Normative Appendix G and Table G3.1 as shown (SI only).

G3.1.2 General Baseline HVAC System Requirements. *HVAC* systems in the *baseline building design* shall conform with the general provisions in this section.

G3.1.2.1 Equipment Efficiencies. All HVAC *equipment* in the *baseline building design* shall be modeled at the minimum *efficiency* levels, both part load and full load, in accordance with Tables G3.5.1 through G3.5.6. Where multiple *HVAC zones* or *residential spaces* are combined into a single *thermal block* in accordance with Table G3.1, the efficiencies (for baseline HVAC System Types 1, 2, 3, 4, 9, and 10) taken from Tables G3.5.1, G3.5.2, G3.5.4, and G3.5.5 shall be based on the equipment capacity of the *thermal block* divided by the number of *HVAC zones* or *residential spaces*. HVAC System Types 5 or 6 efficiencies taken from Table G3.5.1 shall be based on the cooling equipment capacity of a single floor when grouping identical floors in accordance with Section G3.1.1(a)(4). Fan *energy* shall be modeled separately according to Section G3.1.2.9.

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Table G3.1 Modeling Requirements for Calculating Proposed and *Baseline Building Performance*

No.	Proposed Building Performance	Baseline Building Performance
[. . .]		
10. *HVAC Systems*		
	The *HVAC system* type and all related performance parameters in the *proposed design*, such as *equipment* capacities and efficiencies, shall be determined as follows: a. Where a complete *HVAC system* exists, the model shall reflect the actual *system* type using actual component capacities and efficiencies. b. Where an *HVAC system* has been designed and submitted with design documents, the HVAC model shall be consistent with design documents. Mechanical *equipment* efficiencies shall be adjusted from actual *design conditions* to the standard rating conditions specified in Section 6.4.1 if required by the simulation model. Where *efficiency* ratings include supply fan *energy*, the *efficiency* rating shall be adjusted to remove the supply fan *energy* from the *efficiency* rating in the *baseline building design*. The equations in Section G3.1.2.1 shall not be used in the *proposed design*. The *proposed design HVAC system* shall be modeled using *manufacturers*' full- and part-load data for the *HVAC system* without fan power. **Exception to (a) and (b):** Where part-load performance of chillers in the proposed design is not available, and design temperature across the condenser is 5.56°C, the performance curves in Normative Appendix J, as referenced in Table J-1, shall be modeled for the specified chiller. When using performance curves from Appendix J, chiller minimum part-load ratio (ratio of load to available capacity at a given simulation time step) and minimum compressor unloading ratio (part-load ratio below which the chiller capacity cannot be reduced by unloading and chiller is false loaded) shall be equal to 0.25. *Simulation programs* that do not use performance curves are permitted to use an alternative simulation method that results in the same performance as the curves described in Normative Appendix J. c. Where no heating *system* exists or no heating *system* has been submitted with design documents, the *system* type shall be the same *system* as modeled in the *baseline building design* and shall comply with but not exceed the requirements of Section 6. d. Where no cooling *system* exists or no cooling *system* has been submitted with design documents, the cooling *system* type shall be the same as modeled in the *baseline building design* and shall comply with the requirements of Section 6. **Exception:** *Spaces* using baseline *HVAC system* types 9 and 10.	The *HVAC systems* in the *baseline building design* shall be of the type and description specified in Section G3.1.1.1, shall meet the general *HVAC system* requirements specified in Section G3.1.2, and shall meet any *system*-specific requirements in Section G3.1.3 that are applicable to the baseline *HVAC system* types. If the *proposed design* includes humidification then the *baseline building design* shall use adiabatic humidification. **Exception:** If the proposed *building* humidification *system* complies with Section 6.5.2.4 then the *baseline building design* shall use nonadiabatic humidification. For *systems* serving *computer rooms*, the *baseline building design* shall not have *reheat* for the purpose of dehumidification. *Fossil fuel systems* shall be modeled using natural gas as their *fuel* source. **Exception:** For *fossil fuel systems* where natural gas is not available for the proposed *building* site as determined by the *rating authority*, the baseline *HVAC systems* shall be modeled using propane as their *fuel*.
[. . .]		

$COP_{nfcooling}$ and $COP_{nfheating}$ are the packaged HVAC *equipment* cooling and heating *energy efficiency*, respectively, to be used in the *baseline building design*, which excludes supply fan power.

The sets of performance curves specified in Table J-2 should be used to represent part-load performance of chillers in the *baseline building design*. When using performance curves from Normative Appendix J, chiller minimum part-load ratio (ratio of load to available capacity at a given simulation time step) and minimum compressor unloading ratio (part-load ratio below which the chiller capacity cannot be reduced by unloading and chiller is false loaded) shall be equal to 0.25. *Simulation programs* that do not use performance curves are permitted to use an alternative simulation method that results in the same performance as the curves described in Normative Appendix J.

[. . .]

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Modify Table G3.5.3 as shown (SI only).

Table G3.5.3 *Performance Rating Method* Water Chilling Packages—Minimum *Efficiency* Requirements

***Equipment* Type**	**Size Category**	**Unit**	**Minimum *Efficiency***	**Test Procedure**
Water-cooled, electrically operated, positive displacement (rotary screw and scroll)	<528 *kW*	COP	4.45 *COP* 5.20 *IPLV*.SI	AHRI 550/590
	≥528 *kW* and <1055 *kW*		4.90 *COP* 5.60 *IPLV*.SI	
	≥1055 *kW*		5.50 *COP* 6.15 *IPLV*.SI	
Water-cooled, electrically operated, centrifugal	<528 *kW*	COP	5.00 *COP* 5.25 *IPLV*.SI	AHRI 550/590
	≥528 *kW* and <1055 *kW*		5.55 *COP* 5.90 *IPLV*.SI	
	≥1055 *kW*		6.10 *COP* 6.40 *IPLV*.SI	

Add new Normative Appendix J as shown (SI only).

(This is a normative appendix and is part of this standard.)

NORMATIVE APPENDIX J
SETS OF PERFORMANCE CURVES

J1. GENERAL

J1.1 Description. This appendix provides sets of performance curves that shall be used to represent the part-load performance of chillers in the *budget building design* when using Section 11 and in the *baseline building design* when using Normative Appendix G. They are also permitted to be used for the *proposed building design* when specific chiller performance is not known.

Each set includes three curves: an energy-input-ratio modifier as a function of temperatures (EIR-f-T) and as a function of a chiller's part-load ratio (EIR-f-PLR), and a capacity modifier as a function of temperatures (CAP-f-T). These curves are intended to describe the part-load performance of a chiller when its operating capacity and power (not including cycling degradation) are calculated by the *simulation program* as follows:

Operating Capacity = Rated Capacity × CAP-f-T

Operating Power = Operating Capacity × EIR-f-T × EIR-f-PLR ×
Chiller Input Power at Rated Conditions/Chiller Capacity at Rated Conditions

Table J-3 provides the reference values for the curves. Tables J-4 and J-6 are to be used when the *simulation program* uses I-P units to evaluate the performance curves, and Tables J-5 and J-7 are to be used when the *simulation program* uses SI units to evaluate the performance curves.

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Table J-1 Sets of Chiller Performance Curves for Section 11

***Equipment* Type**	**Size Category**	**Path A**	**Path B**
Air-cooled chillers	<528 kW	A	K
	≥150 tons	B	L
Liquid-cooled, electrically operated positive displacement	<264 kW	C	M
	≥75 tons and <150 tons	D	N
	≥264 kW and <528 kW	E	O
	≥300 tons and <600 tons	F	P
	≥528 kW and <1055 kW	G	Q
Liquid-cooled, electrically operated centrifugal	<150 tons	H	R
	≥1055 kW and <2110 kW	H	S
	≥300 tons and <400 tons	I	T
	≥2100 kW	J	U
	≥600 tons	J	U

Table J-2 Sets of Chiller Performance Curves for Normative Appendix G

***Equipment* Type**	**Size Category**	
Water-cooled, electrically operated, positive displacement (rotary screw and scroll)	<528 kW	V
	≥528 kW and <1055 kW	X
	≥1055 kW	Y
Water-cooled, electrically operated, centrifugal	<528 kW	Z
	≥528 kW and <1055 kW	AA
	≥1055 kW	AB

Table J-3 Chiller Performance Curves References

Chiller Condenser Type	**Output Variable**[a]	**Curve Type**[b]	***X***[c]	***Y***[c]	**Minimum/ Maximum Value for *X* (I-P °F)**	**Minimum/ Maximum Value for *Y* (I-P °F)**	**Rated Values for *X*/*Y* (I-P °F)**	**Minimum/ Maximum Value for *X* (SI °C)**	**Minimum/ Maximum Value for *Y* (SI °C)**	**Rated Values for *X*/*Y* (SI °C)**
Air	EIR-f-T	T1	CHWT	OAT	39/60	55/125.6	44/95	4/16	12.8/52	7/35
Air	CAP-f-T	T1	CHWT	OAT	39/60	55/125.6	44/95	4/16	12.8/52	7/35
Air	EIR-f-PLR	T3	PLR		0/1		1	0/1	N/A	1
Water	EIR-f-T	T1	CHWT	ECT	39/60	55/104	44/85	4/16	12.8/40	7/30
Water	CAP-f-T	T1	CHWT	ECT	39/60	55/104	44/85	4/16	12.8/40	7/30
Water	EIR-f-PLR	T2	PLR		0/1		1	0/1	N/A	1

a. EIR-f-T is the energy input ratio modifier as a function of temperatures, CAP-f-T is the capacity modifier as a function of temperatures, and EIR-f-PLR is the energy input ratio modifier as a function of the chiller's part load ratio.

b. T1: Output = Coeff1 + Coeff2 × X + Coeff3 × X^2 + Coeff4 × Y + Coeff5 × Y^2 + Coeff6 × X × Y
T2: Output = Coeff1 + Coeff2 × X + Coeff3 × X^2
T3: Output = Coeff1 + Coeff2 × X + Coeff3 × X^2 + Coeff4 × X^3

c. CHWT: chilled-water temperature
OAT: outdoor-air dry-bulb temperature
ECT: entering condenser temperature
PLR: part-load ratio = load at a given simulation time step/available capacity at given simulation time step

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Table J-4 Chiller Performance Curves for Section 11 (Simulation Input Required in I-P Units)

Set	Description	Output Variable	Coeff 1	Coeff 2	Coeff 3	Coeff 4	Coeff 5	Coeff 6
A	Air-cooled <528 kW, 2.985 FL, 4.048 IPLV.SI Path A	EIR-f-T	1.777758	–0.038258	0.000431	–0.005368	0.000118	–0.000115
		CAP-f-T	–1.347697	0.070674	–0.000566	0.016793	–0.000104	–0.000076
		EIR-f-PLR	0.087789	0.185696	1.561411	–0.832304		
B	Air-cooled ≥528 kW, 2.985 FL, 4.137 IPLV.SI Path A	EIR-f-T	1.872341	–0.041886	0.000442	–0.006710	0.000123	–0.000086
		CAP-f-T	–1.153535	0.075066	–0.000622	0.009777	–0.000071	–0.000057
		EIR-f-PLR	0.118081	0.107477	1.570838	–0.794051		
C	Liquid-cooled positive displacement <264 kW 4.694 FL, 5.867 IPLV.SI Path A	EIR-f-T	2.001725	–0.044957	0.000484	–0.008296	0.000168	–0.000125
		CAP-f-T	–0.907598	0.073300	–0.000653	0.003700	–0.000054	0.000006
		EIR-f-PLR	0.243730	0.165972	0.586099			
D	Liquid-cooled positive displacement ≥264 and <528 kW 4.889 FL, 6.286 IPLV.SI Path A	EIR-f-T	1.679306	–0.041960	0.000456	–0.002081	0.000128	–0.000125
		CAP-f-T	–0.857791	0.074596	–0.000670	0.001523	–0.000042	0.000012
		EIR-f-PLR	0.208982	0.224001	0.561479			
E	Liquid-cooled positive displacement ≥528 and <1055 kW 5.334 FL, 6.519 IPLV.SI Path A	EIR-f-T	1.136125	–0.034608	0.000401	0.008006	0.000058	–0.000131
		CAP-f-T	–0.424942	0.047087	–0.000458	0.006232	–0.000070	0.000058
		EIR-f-PLR	0.246644	0.184576	0.566463			
F	Liquid-cooled positive displacement ≥1055 and <2110 kW 5.771 FL, 6.770 IPLV.SI Path A	EIR-f-T	1.161349	–0.040557	0.000431	0.013567	0.000003	–0.000103
		CAP-f-T	0.012766	0.033086	–0.000350	0.004004	–0.000061	0.000083
		EIR-f-PLR	0.244926	0.218890	0.532972			
G	Liquid-cooled positive displacement ≥2100 kW 6.286 FL, 7.041 IPLV.SI Path A	EIR-f-T	0.874461	–0.041390	0.000430	0.022262	–0.000058	–0.000097
		CAP-f-T	0.122304	0.024081	–0.000293	0.006302	–0.000081	0.000116
		EIR-f-PLR	0.264371	0.263302	0.471690			
H	Liquid-cooled centrifugal <528 kW 5.771 FL, 6.401 IPLV.SI Path A	EIR-f-T	0.474969	–0.036087	0.000223	0.030749	–0.000178	0.000094
		CAP-f-T	–0.454052	0.056252	–0.000669	0.000736	–0.000099	0.000249
	Liquid-cooled centrifugal ≥528 kW <1055 kW 5.771 FL, 6.401 IPLV.SI Path A	EIR-f-PLR	0.304206	0.073866	0.621457			
I	Liquid-cooled centrifugal ≥1055 kW <1407 kW 6.286 FL, 6.770 IPLV.SI Path A	EIR-f-T	0.596868	–0.022768	0.000131	0.023536	–0.000130	0.000024
		CAP-f-T	0.947009	0.032913	–0.000354	–0.020151	0.000062	0.000148
		EIR-f-PLR	0.276961	0.101749	0.621383			
J	Liquid-cooled centrifugal ≥1407 kW <2110 kW 6.286 FL, 7.041 IPLV.SI Path A	EIR-f-T	0.551957	–0.036196	0.000300	0.028396	–0.000147	0.000029
		CAP-f-T	–0.702242	0.077132	–0.000785	–0.005637	–0.000033	0.000145
	Liquid-cooled centrifugal ≥2110 kW 6.286 FL, 7.041 IPLV.SI Path A	EIR-f-PLR	0.290891	0.059366	0.649421			
K	Air-cooled <528 kW, 2.966 FL, 4.669 IPLV.SI Path B	EIR-f-T	2.054048	–0.042406	0.000450	–0.009813	0.000140	–0.000093
		CAP-f-T	–1.325652	0.074160	–0.000607	0.013871	–0.000088	–0.000069
		EIR-f-PLR	0.036849	0.100792	1.614142	–0.748013		

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Table J-4 Chiller Performance Curves for Section 11 (Simulation Input Required in I-P Units) *(Continued)*

Set	Description	Output Variable	Coeff 1	Coeff 2	Coeff 3	Coeff 4	Coeff 5	Coeff 6
L	Air-cooled ≥528 kW, 2.866 FL, 4.758 IPLV.SI Path B	EIR-f-T	1.673814	–0.041178	0.000429	–0.003424	0.000109	–0.000084
		CAP-f-T	–0.939345	0.074488	–0.000615	0.005127	–0.000048	–0.000048
		EIR-f-PLR	0.095711	0.009903	1.543396	–0.646737		
M	Liquid-cooled positive displacement <264 kW 4.513 FL, 7.041 IPLV.SI Path B	EIR-f-T	2.018167	–0.045111	0.000485	–0.008503	0.000168	–0.000124
		CAP-f-T	–0.913752	0.073361	–0.000654	0.003787	–0.000054	0.000006
		EIR-f-PLR	0.107200	0.182611	0.705182			
N	Liquid-cooled positive displacement ≥264 and <528 kW 4.694 FL, 7.184 IPLV.SI Path B	EIR-f-T	1.849951	–0.043409	0.000467	–0.005187	0.000146	–0.000123
		CAP-f-T	–0.840342	0.071938	–0.000641	0.002703	–0.000047	0.000007
		EIR-f-PLR	0.183811	–0.044417	0.855660			
O	Liquid-cooled positive displacement ≥528 and <1055 kW 5.177 FL, 8.001 IPLV.SI Path B	EIR-f-T	1.020192	–0.030046	0.000363	0.008504	0.000053	–0.000135
		CAP-f-T	–0.451749	0.051393	–0.000490	0.004351	–0.000058	0.000050
		EIR-f-PLR	0.090936	0.207812	0.696735			
P	Liquid-cooled positive displacement ≥1055 and <2110 kW 5.633 FL, 8.586 IPLV.SI Path B	EIR-f-T	1.189071	–0.038585	0.000415	0.011574	0.000017	–0.000108
		CAP-f-T	–0.063852	0.038321	–0.000388	0.002935	–0.000054	0.000072
		EIR-f-PLR	0.103665	0.148024	0.744887			
Q	Liquid-cooled positive displacement ≥2100 kW 6.018 FL, 9.264 IPLV.SI Path B	EIR-f-T	0.916144	–0.041541	0.000436	0.020987	–0.000047	–0.000100
		CAP-f-T	0.131880	0.023312	–0.000286	0.006699	–0.000084	0.000116
		EIR-f-PLR	0.061706	0.261711	0.677017			
R	Liquid-cooled centrifugal <528 kW 5.065 FL, 8.001 IPLV.SI Path B	EIR-f-T	0.860442	–0.036414	0.000317	0.022419	–0.000108	0.000001
		CAP-f-T	–0.062772	0.054642	–0.000550	–0.008072	0.000004	0.000101
		EIR-f-PLR	0.072183	0.108650	0.818174			
S	Liquid-cooled centrifugal ≥528 kW <1055 kW 5.544 FL, 8.801 IPLV.SI Path B	EIR-f-T	0.582513	–0.033786	0.000227	0.027678	–0.000157	0.000067
		CAP-f-T	0.015941	0.049796	–0.000573	–0.007266	–0.000041	0.000219
		EIR-f-PLR	0.064979	0.151829	0.779131			
T	Liquid-cooled centrifugal ≥1055 kW <1407 kW 5.917 FL, 9.027 IPLV.SI Path B	EIR-f-T	0.634610	–0.033472	0.000260	0.026148	–0.000130	0.000015
		CAP-f-T	0.127596	0.046709	–0.000538	–0.006247	–0.000047	0.000195
		EIR-f-PLR	0.082812	0.152816	0.764822			
U	Liquid-cooled centrifugal ≥1407 kW <2110 kW 6.018 FL, 9.264 IPLV.SI Path B	EIR-f-T	0.593414	–0.028948	0.000224	0.024197	–0.000126	0.000027
		CAP-f-T	–0.487422	0.071558	–0.000737	–0.006964	–0.000032	0.000158
	Liquid-cooled centrifugal ≥2110 kW 6.018 FL, 9.264 IPLV.SI Path B	EIR-f-PLR	0.058583	0.205486	0.736345			

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Table J-5 Chiller Performance Curves for Section 11 (Simulation Input Required in SI Units)

Set	Description	Output Variable	Coeff 1	Coeff 2	Coeff 3	Coeff 4	Coeff 5	Coeff 6
A	Air-cooled <528 kW, 2.985 FL, 4.048 IPLV.SI Path A	EIR-f-T	0.825618	–0.025861	0.001396	–0.002728	0.000381	–0.000373
		CAP-f-T	0.686206	0.057562	–0.001835	0.013810	–0.000338	–0.000247
		EIR-f-PLR	0.087789	0.185696	1.561411	–0.832304		
B	Air-cooled ≥528 kW, 2.985 FL, 4.137 IPLV.SI Path A	EIR-f-T	0.807832	–0.029452	0.001431	–0.002832	0.000399	–0.000278
		CAP-f-T	0.794185	0.060199	–0.002016	0.006203	–0.000229	–0.000183
		EIR-f-PLR	0.118081	0.107477	1.570838	–0.794051		
C	Liquid-cooled positive displacement <264 kW 4.694 FL, 5.867 IPLV.SI Path A	EIR-f-T	0.836880	–0.032383	0.001568	–0.002806	0.000544	–0.000407
		CAP-f-T	0.838337	0.057024	–0.002117	0.000793	–0.000175	0.000020
		EIR-f-PLR	0.243730	0.165972	0.586099			
D	Liquid-cooled positive displacement ≥264 and <528 kW 4.889 FL, 6.286 IPLV.SI Path A	EIR-f-T	0.740920	–0.030144	0.001479	0.003850	0.000416	–0.000404
		CAP-f-T	0.861840	0.057837	–0.002170	–0.001391	–0.000136	0.000040
		EIR-f-PLR	0.208982	0.224001	0.561479			
E	Liquid-cooled positive displacement ≥528 and <1055 kW 5.334 FL, 6.519 IPLV.SI Path A	EIR-f-T	0.620834	–0.023642	0.001300	0.013555	0.000189	–0.000425
		CAP-f-T	0.800066	0.035377	–0.001482	0.006462	–0.000227	0.000187
		EIR-f-PLR	0.246644	0.184576	0.566463			
F	Liquid-cooled positive displacement ≥1055 and <2110 kW 5.771 FL, 6.770 IPLV.SI Path A	EIR-f-T	0.636828	–0.029245	0.001397	0.018817	0.000008	–0.000332
		CAP-f-T	0.863175	0.023955	–0.001135	0.004955	–0.000197	0.000268
		EIR-f-PLR	0.244926	0.218890	0.532972			
G	Liquid-cooled positive displacement ≥2100 kW 6.286 FL, 7.041 IPLV.SI Path A	EIR-f-T	0.544967	–0.030491	0.001395	0.027852	–0.000187	–0.000314
		CAP-f-T	0.830804	0.016310	–0.000949	0.008707	–0.000263	0.000377
		EIR-f-PLR	0.264371	0.263302	0.471690			
H	Liquid-cooled centrifugal <528 kW 5.771 FL, 6.401 IPLV.SI Path A Liquid-cooled centrifugal ≥528 kW <1055 kW 5.771 FL, 6.401 IPLV.SI Path A	EIR-f-T	0.447243	–0.033785	0.000724	0.040274	–0.000577	0.000305
		CAP-f-T	0.837420	0.038528	–0.002167	0.004185	–0.000322	0.000806
		EIR-f-PLR	0.304206	0.073866	0.621457			
I	Liquid-cooled centrifugal ≥1055 kW <1407 kW 6.286 FL, 6.770 IPLV.SI Path A	EIR-f-T	0.647193	–0.024484	0.000426	0.028764	–0.000421	0.000077
		CAP-f-T	1.207878	0.026951	–0.001148	–0.020576	0.000202	0.000479
		EIR-f-PLR	0.276961	0.101749	0.621383			
J	Liquid-cooled centrifugal ≥2110 kW 6.286 FL, 7.041 IPLV.SI Path A	EIR-f-T	0.489242	–0.028851	0.000973	0.035835	–0.000477	0.000096
		CAP-f-T	0.896806	0.056739	–0.002544	–0.005536	–0.000105	0.000470
		EIR-f-PLR	0.290891	0.059366	0.649421			
K	Air-cooled <528 kW, 2.966 FL, 4.669 IPLV.SI Path B	EIR-f-T	0.891872	–0.029821	0.001459	–0.006929	0.000453	–0.000303
		CAP-f-T	0.709195	0.059566	–0.001968	0.010899	–0.000284	–0.000222
		EIR-f-PLR	0.036849	0.100792	1.614142	–0.748013		
L	Air-cooled ≥528 kW, 2.866 FL, 4.758 IPLV.SI Path B	EIR-f-T	0.711589	–0.029520	0.001390	0.001554	0.000353	–0.000272
		CAP-f-T	0.879844	0.060415	–0.001994	0.000937	–0.000156	–0.000155
		EIR-f-PLR	0.095711	0.009903	1.543396	–0.646737		

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Table J-5 Chiller Performance Curves for Section 11 (Simulation Input Required in SI Units)

Set	Description	Output Variable	Coeff 1	Coeff 2	Coeff 3	Coeff 4	Coeff 5	Coeff 6
M	Liquid-cooled positive displacement <264 kW 4.513 FL, 7.041 IPLV.SI Path B	EIR-f-T	0.844064	–0.032504	0.001571	–0.003076	0.000545	–0.000402
		CAP-f-T	0.835803	0.057057	–0.002119	0.000903	–0.000176	0.000019
		EIR-f-PLR	0.107200	0.182611	0.705182			
N	Liquid-cooled positive displacement ≥264 and <528 kW 4.694 FL, 7.184 IPLV.SI Path B	EIR-f-T	0.797371	–0.031361	0.001514	0.000419	0.000473	–0.000398
		CAP-f-T	0.850710	0.056037	–0.002077	–0.000147	–0.000153	0.000023
		EIR-f-PLR	0.183811	–0.044417	0.855660			
O	Liquid-cooled positive displacement ≥528 and <1055 kW 5.177 FL, 8.001 IPLV.SI Path B	EIR-f-T	0.617871	–0.020110	0.001175	0.013623	0.000172	–0.000439
		CAP-f-T	0.822519	0.038968	–0.001588	0.004048	–0.000188	0.000164
		EIR-f-PLR	0.090936	0.207812	0.696735			
P	Liquid-cooled positive displacement ≥1055 and <2110 kW 5.633 FL, 8.586 IPLV.SI Path B	EIR-f-T	0.656763	–0.027891	0.001343	0.016627	0.000056	–0.000348
		CAP-f-T	0.877218	0.028393	–0.001257	0.003217	–0.000174	0.000232
		EIR-f-PLR	0.103665	0.148024	0.744887			
Q	Liquid-cooled positive displacement ≥2100 kW 6.018 FL, 9.264 IPLV.SI Path B	EIR-f-T	0.553694	–0.030347	0.001412	0.026568	–0.000153	–0.000325
		CAP-f-T	0.831828	0.015657	–0.000928	0.009067	–0.000272	0.000376
		EIR-f-PLR	0.061706	0.261711	0.677017			
R	Liquid-cooled centrifugal <528 kW 5.065 FL, 8.001 IPLV.SI Path B	EIR-f-T	0.627360	–0.028989	0.001027	0.027958	–0.000350	0.000002
		CAP-f-T	0.972517	0.040861	–0.001781	–0.008217	0.000013	0.000328
		EIR-f-PLR	0.072183	0.108650	0.818174			
S	Liquid-cooled centrifugal ≥528 kW <1055 kW 5.544 FL, 8.801 IPLV.SI Path B	EIR-f-T	0.526475	–0.030843	0.000735	0.035532	–0.000510	0.000216
		CAP-f-T	0.971699	0.036192	–0.001858	–0.005224	–0.000134	0.000709
		EIR-f-PLR	0.064979	0.151829	0.779131			
T	Liquid-cooled centrifugal ≥1055 kW <1407 kW 5.917 FL, 9.027 IPLV.SI Path B	EIR-f-T	0.547810	–0.029470	0.000842	0.032888	–0.000423	0.000048
		CAP-f-T	1.023337	0.033378	–0.001742	–0.005438	–0.000153	0.000633
		EIR-f-PLR	0.082812	0.152816	0.764822			
U	Liquid-cooled centrifugal ≥1407 kW <2110 kW 6.018 FL, 9.264 IPLV.SI Path B Liquid-cooled centrifugal ≥2110 kW 6.018 FL, 9.264 IPLV.SI Path B	EIR-f-T	0.569569	–0.024700	0.000727	0.030569	–0.000409	0.000087
		CAP-f-T	0.953580	0.053010	–0.002387	–0.007165	–0.000104	0.000510
		EIR-f-PLR	0.058583	0.205486	0.736345			

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Table J-6 Chiller Performance Curves for Normative Appendix G (Simulation Input Required in I-P Units)

Set	Description	Output Variable	Coeff 1	Coeff 2	Coeff 3	Coeff 4	Coeff 5	Coeff 6
V	Liquid-cooled positive displacement <528 kW 4.45 FL, 5.20 IPLV.SI	EIR-f-T	2.044998	–0.047515	0.000505	–0.008787	0.000175	–0.000120
		CAP-f-T	–0.981909	0.076674	–0.000687	0.003920	–0.000058	0.000006
		EIR-f-PLR	0.276037	0.253577	0.466353			
X	Liquid-cooled positive displacement ≥528 and <1055 kW 4.90 FL, 5.60 IPLV.SI	EIR-f-T	1.037805	–0.024695	0.000329	0.003130	0.000102	–0.000159
		CAP-f-T	–0.683858	0.065283	–0.000602	0.002347	–0.000050	0.000036
		EIR-f-PLR	0.250801	0.345915	0.399138			
Y	Liquid-cooled positive displacement ≥1055 kW 5.50 FL, 6.15 IPLV.SI	EIR-f-T	1.188945	–0.039426	0.000413	0.012888	0.000002	–0.000098
		CAP-f-T	–0.160681	0.044390	–0.000429	0.001024	–0.000035	0.000055
		EIR-f-PLR	0.320097	0.074356	0.602938			
Z	Liquid-cooled centrifugal <528 kW 5.00 FL, 5.25 IPLV.SI	EIR-f-T	0.857485	–0.036148	0.000314	0.022356	–0.000108	0.000001
		CAP-f-T	–0.061958	0.054739	–0.000550	–0.008177	0.000005	0.000101
		EIR-f-PLR	0.281669	0.202762	0.515409			
AA	Liquid-cooled centrifugal ≥528 and <1055 kW 5.55 FL, 5.90 IPLV.SI	EIR-f-T	0.479847	–0.035964	0.000225	0.031377	–0.000183	0.000085
		CAP-f-T	–0.128081	0.050459	–0.000581	–0.004297	–0.000049	0.000200
		EIR-f-PLR	0.339494	0.049090	0.611582			
AB	Liquid-cooled centrifugal ≥1055 kW 6.10 FL, 6.40 IPLV.SI	EIR-f-T	0.747210	–0.038874	0.000313	0.027638	–0.000133	–0.000008
		CAP-f-T	0.117208	0.042940	–0.000478	–0.003930	–0.000045	0.000155
		EIR-f-PLR	0.309752	0.153649	0.536462			

Table J-7 Chiller Performance Curves for Normative Appendix G (Simulation Input Required in SI Units)

Set	Description	Output Variable	Coeff 1	Coeff 2	Coeff 3	Coeff 4	Coeff 5	Coeff 6
V	Liquid-cooled positive displacement <528 kW 4.45 FL, 5.20 IPLV.SI	EIR-f-T	0.817024	–0.034213	0.001638	–0.002590	0.000566	–0.000389
		CAP-f-T	0.840898	0.059263	–0.002225	0.000735	–0.000188	0.000020
		EIR-f-PLR	0.276037	0.253577	0.466353			
X	Liquid-cooled positive displacement ≥528 and <1055 kW 4.90 FL, 5.60 IPLV.SI	EIR-f-T	0.627193	–0.015646	0.001067	0.008270	0.000331	–0.000515
		CAP-f-T	0.850133	0.050234	–0.001951	0.000606	–0.000161	0.000118
		EIR-f-PLR	0.250801	0.345915	0.399138			
Y	Liquid-cooled positive displacement ≥1055 kW 5.50 FL, 6.15 IPLV.SI	EIR-f-T	0.664854	–0.029016	0.001339	0.017823	0.000008	–0.000318
		CAP-f-T	0.873130	0.033599	–0.001391	0.000961	–0.000114	0.000178
		EIR-f-PLR	0.320097	0.074356	0.602938			
Z	Liquid-cooled centrifugal <528 kW 5.00 FL, 5.25 IPLV.SI	EIR-f-T	0.628525	–0.028798	0.001019	0.027867	–0.000349	0.000002
		CAP-f-T	0.973310	0.040996	–0.001782	–0.008340	0.000016	0.000327
		EIR-f-PLR	0.281669	0.202762	0.515409			
AA	Liquid-cooled centrifugal ≥528 and <1055 kW 5.55 FL, 5.90 IPLV.SI	EIR-f-T	0.464330	–0.033834	0.000731	0.040345	–0.000592	0.000277
		CAP-f-T	0.909633	0.035460	–0.001881	–0.001808	–0.000158	0.000648
		EIR-f-PLR	0.339494	0.049090	0.611582			
AB	Liquid-cooled centrifugal ≥1055 kW 6.10 FL, 6.40 IPLV.SI	EIR-f-T	0.563967	–0.034331	0.001015	0.033941	–0.000432	–0.000025
		CAP-f-T	0.988289	0.031128	–0.001550	–0.003349	–0.000147	0.000503
		EIR-f-PLR	0.309752	0.153649	0.536462			

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