ERRATA SHEET FOR
ANSI/ASHRAE/IES STANDARD 90.1-2019 (SI Edition)
Energy Standard for Buildings Except Low-Rise Residential Buildings

March 17, 2025

The corrections listed in this errata sheet apply to ANSI/ASHRAE/IES Standard 90.1-2019, SI Edition. The first printing is identified on the outside back cover of the standard as "Product code: 86272 1/20". Shaded items have been added since the previously published errata sheet dated February 15, 2024 was distributed.

NOTICE: ASHRAE now has a list server for Standing Standards Project Committee 90.1 (SSPC 90.1). Interested parties can now subscribe and unsubscribe to the list server and be automatically notified via e-mail when activities and information related to the Standard and the User's Manual is available. To sign up for the list server please visit **Project Committee List Servers for Standard** on the Technology / Standards section of the ASHRAE website at https://www.ashrae.org/technical-resources/standards-and-guidelines/project-committee-list-servers.

Page(s)	Erratum
11	**3.2 Definitions.** In Section 3 add the following definition which was inadvertently removed when the 2019 edition was published. *(Note: Additions are shown in underline.)* ***computer room energy***: annual energy use of the data center, including all IT equipment energy, plus energy that supports the IT equipment and computer room space, calculated in accordance with industry-accepted standards defined as Total Annual Energy (see Informative Appendix E).
18	**Figure 3.2-5 Computing the *secondary sidelighting area.*** Replace Figure 3.2-5 with the attached.
75	**5.8.1.2 Manufacturer's Installation Instructions.** In Exception 2 to Section 5.8.1.2 change the reference to Table A9.4.5 to Table A9.4.6 as shown below. *(Note: Additions are shown in underline and deletions are shown in ~~strikethrough~~.)* **Exceptions to 5.8.1.2** 1. The R-value of compressed cavity insulation is determined in accordance with Table A9.4.3. 2. Where metal building roof or wall insulation is compressed between the steel structure and the metal roof or wall panels, the overall assembly *U-factor* is determined in accordance with Section A2.3, Section A3.2, or Section ~~A9.4.5~~A9.4.6.
78	**Table 5.8.3.1 Maximum Air Leakage for Materials and Assemblies.** Change the table heading in column two of Table 5.8.3.1 from "**Maximum Air Leakage, L/s?m²'** to "**Maximum Air Leakage, L/s·m²**".
86	**6.4.1.3 Ceiling Fans.** Add the following informative note immediately following Section 6.4.1.3. *(Note: Additions are shown in underline.)*

6.4.1.3 Ceiling Fans

Large-diameter ceiling fans shall be rated in accordance with 10 CFR 430 Appendix U or AMCA 230. The following data shall be provided:

a. Blade span (blade tip diameter)

b. Rated airflow and power consumption at the maximum speed

***Informative Note*: See Informative Appendix F for the U.S. Department of Energy requirements for US applications.**

91 **6.4.3.4.3 Damper Leakage.** Revise Section 6.4.3.4.3 as shown below.
(Note: Additions are shown in underline and deletions are shown in ~~strikethrough~~.)

6.4.3.4.3 Damper Leakage

Where *outdoor air* supply and exhaust/relief dampers are required by Section 6.4.3.4~~6.4.3.4.1~~, they shall have a maximum leakage rate as indicated in Table 6.4.3.4.3.

100 **Table 6.5.1.1.3 High-Limit Shutoff Control Settings for Air Economizers.** Revise Table 6.5.1.1.3 as shown in the attached.

113 **6.5.4.8 Buildings with High-Capacity Space-Heating Gas Boiler Systems.** Delete Section 6.5.4.8 in its entirety as shown below. Note that this material was inadvertently included in the published standard, the material is included in an addendum that is expected to be published to the 2019 edition at a later date.
(Note: Deletions are shown in ~~strikethrough~~.)

~~**6.5.4.8 Buildings with High-Capacity Space-Heating Gas Boiler Systems**~~

~~New buildings with gas hot-water *boiler systems* for space heating with a total *system* input of at least 290 kW but not more than 2900 kW shall comply with Sections 6.5.4.8.1 and 6.5.4.8.2.~~

~~**Exceptions to 6.5.4.8**~~

~~1. Where 25% of the annual space heating requirement is provided by on-site renewable energy, *site-recovered energy*, or heat recovery chillers.~~
~~2. *Space heating boilers* installed in individual dwelling units.~~
~~3. Where 50% or more of the design heating load is served using perimeter convective heating, radiant ceiling panels, or both.~~
~~4. Individual gas boilers with input capacity less than 87 kW shall not be included in the calculations of the total system input or total system efficiency.~~

~~**6.5.4.8.1 Boiler Efficiency**~~

~~Gas hot-water *boilers* shall have a minimum thermal *efficiency* (*Et*) of 90% when rated in accordance with the test procedures in Table 6.8.1-6. Systems with multiple boilers are allowed to meet this requirement if the space-heating input provided by equipment with thermal *efficiency* (*Et*) above and below 90% provides an input capacity-weighted average thermal *efficiency* of at least 90%. For boilers rated only for combustion *efficiency*, the calculation for the input capacity-weighted average thermal *efficiency* shall use the combustion *efficiency* value.~~

~~**6.5.4.8.2 Hot-Water Distribution System Design**~~

~~The hot-water distribution system shall be designed to meet all of the following:~~

~~a. Coils and other heat exchangers shall be selected so that at design conditions the hot-water return temperature entering the *boilers* is 49°C or less.~~
~~b. Under all operating conditions, the water temperature entering the boiler is 49°C or less, or the flow rate of supply hot water that recirculates directly into the return system, such as by three-way valves or minimum flow bypass controls, shall be no greater than 20% of the design flow of the operating boilers.~~

116 **Table 6.5.6.1.2-2 Exhaust Air Energy Recovery Requirements for Ventilation Systems Operating Greater than or Equal to 8000 Hours per Year.** Change "≥35" to "≥66" in Table 6.5.6.1.2-2 as shown below.
(Note: Additions are shown in underline and deletions are shown in strikethrough.)

Table 6.5.6.1.2-2 Exhaust Air *Energy* Recovery Requirements for *Ventilation Systems* Operating Greater than or Equal to 8000 Hours per Year

Climate Zone	% *Outdoor Air* at Full Design Airflow Rate							
	≥10% and <20%	≥20% and <30%	≥30% and <40%	≥40% and <50%	≥50% and <60%	≥60% and <70%	≥70% and <80%	≥80%
	Design Supply Fan Airflow Rate, L/s							
3C	NR	NR	NR	NR	NR	NR	NR	NR
0B, 1B, 2B, 3B, 4C, 5C	NR	≥9203	≥4248	≥2360	≥1888	≥1416	≥708	≥60
0A, 1A, 2A, 3A, 4B, 5B	≥1180	≥944	≥472	≥236	≥66~~35~~	≥60	≥50	≥40
4A, 5A, 6A, 6B, 7, 8	≥100	≥65	≥50	≥40	≥35	≥30	≥25	≥20

NR—Not required

130 **Table 6.8.1-4 Electrically Operated *Packaged Terminal Air Conditioners*, *Packaged Terminal Heat Pumps*, *Single-Package Vertical Air Conditioners*, *Single-Package Vertical Heat Pumps*, *Room Air Conditioners*, and Room Air-Conditioner Heat Pumps—Minimum *Efficiency* Requirements.** Revise Table 6.8.1-4 as shown below.
(Note: Additions are shown in underline and deletions are shown in ~~strikethrough~~.)

Equipment Type
PTAC (cooling mode) standard size
PTAC (cooling mode) nonstandard size-~~a~~b

132 **Table 6.8.1-5 Warm-Air Furnaces and Combination Warm-Air Furnaces/Air-Conditioning Units, Warm-Air Duct Furnaces, and Unit Heaters—Minimum *Efficiency* Requirements.** Revise Footnotes b and g in Table 6.8.1-5 as shown below.
(Note: Additions are shown in underline and deletions are shown in ~~strikethrough~~.)

a. Section 12 contains a complete specification of the referenced test procedure, including the referenced year version of the test procedure.

b. Combination units (i.e, furnaces contained within the same cabinet as an air conditioner) not covered by 10 CFR 430 (i.e., three-phase power or with cooling capacity greater than or equal to 19 *kW*) may comply with either rating. All other units ~~greater~~less than 66 *kW* sold in the U.S. must meet the *AFUE* standards for consumer products and test using USDOE's *AFUE* test procedure at 10 CFR 430, Subpart B, Appendix N.

c. Compliance of multiple firing rate units shall be at the maximum firing rate.

d. *Et* = thermal *efficiency*. Units must also include an interrupted or intermittent ignition device (IID), have jacket losses not exceeding 0.75 percent of the input rating, and have either power venting or a *flue damper*. A *vent damper* is an acceptable alternative to a *flue damper* for those furnaces where combustion air is drawn from the *conditioned space*.

e. *Ec = combustion efficiency* (100 percent less flue losses). See test procedure for detailed discussion.

f. Units must also include an interrupted or intermittent ignition device (IID) and have either power venting or an automatic flue damper.

g. For U.S. applications of federal covered <66 *kW* products, see Informative Appendix F, Table F-4.

134 **Table 6.8.1-7 Performance Requirements for Heat Rejection *Equipment*—Minimum *Efficiency* Requirements.** In Table 6.8.1-7 for Equipment Type "Propeller or axial fan dry coolers (air-cooled fluid coolers)" change "35.0°C entering wb" to "35.0°F entering db".

144 **Table 6.8.1-15 Electrically Operated Water Source Heat Pumps—Minimum *Efficiency* Requirements.** Add Footnote b of Table 6.8.1-15 as shown below.
(Note: Additions are shown in underline.)

Table 6.8.1-15 Electrically Operated Water Source Heat Pumps—Minimum *Efficiency* Requirements[b]

a. Section 12 contains a complete specification of the referenced test procedure, including the referenced year version of the test procedure.
b. Single-phase, U.S. air-cooled heat pumps <19 *kW* are regulated as consumer products by 10 CFR 430. *SCOPC*, *SCOP2C*, *SCOPH* and *SCOP2H* values for single-phase products are set by the USDOE.
Informative Note: See Informative Appendix F for the USDOE minimum.

145-146 **Table 6.8.1-16 Heat-Pump and Heat Recovery Chiller Packages—Minimum *Efficiency* Requirements.** Revise Table 6.8.1-16 by replacing all the highlighted (in yellow) "≤" with "≥" shown in the attached.

145 **Table 6.8.1-16 Heat-Pump and Heat Recovery Chiller Packages—Minimum *Efficiency* Requirements.** Revise Table 6.8.1-16 as shown in the attached.
(Note: Additions are shown in underline and deletions are shown in ~~strikethrough~~.)

145/146 **Table 6.8.1-16 Heat-Pump and Heat Recovery Chiller Packages—Minimum *Efficiency***

Requirements. Revise the footnote listed in the heading as shown below.
(Note: Additions are shown in underline and deletions are shown in ~~strikethrough~~.)

Table 6.8.1-16 Heat-Pump and Heat Recovery Chiller Packages—Minimum *Efficiency* Requirements

Equipment Type	Size Category (kW)	Cooling Only Operation Cooling Efficiency[~~a~~b] (Air Source COP FL/IPLV-W/W) Water Source COP FL/IPLV-(W/W) Path A	Path B

...

a. Cooling-only rating conditions are standard rating conditions defined in AHRI 551/591, Table 1.

b. Heating full-load rating conditions are at rating conditions defined in AHRI 551/591, Table 1.

147/148 **Table 6.8.9-17 Ceiling-Mounted Computer-Room Air Conditioners—Minimum *Efficiency* Requirements.** Change Table 6.8.9-17 to Table 6.8.1-17.

152 **7.4.3 Service Hot-Water Piping Insulation.** In the first sentence of Section 7.4.3 change "Table 6.8.1-3" to "Table 6.8.3-1" as shown below.
(Note: Additions are shown in underline and deletions are shown in ~~strikethrough~~.)

7.4.3 Service Hot-Water Piping Insulation
The following *piping* shall be insulated to levels shown in Section 6, ~~Table 6.8.1-3~~ Table 6.8.3-1:

[…]

155 **Table 7.8 Performance Requirements for Water-Heating *Equipment*—Minimum *Efficiency* Requirements.** In Table 7.8 for Electric storage *water heaters* and Electric instantaneous *water heaters* delete footnote "e" as shown below.
(Note: Deletions are shown in ~~strikethrough~~.)

Electric storage *water heaters*	≤12 *kW* [~~e~~]
	>12 *kW* [~~e~~]
Electric instantaneous *water heaters*	≤12 kW [~~e~~]
	>12 *kW* and ≤58.6 *kW* [c]
	≥58.6 *kW* [c]

155/156 **Table 7.8 Performance Requirements for Water-Heating *Equipment*—Minimum *Efficiency* Requirements.** Revise Table 7.8 as shown below.
(Note: Additions are shown in underline and deletions are shown in ~~strikethrough~~.)

Equipment Type	Size Category (Input)	Subcategory or Rating Condition	Performance Required [a]	Test Procedu
Electric table-top *water heaters*	≤12 *kW*	≥76 L and ≤450 L <309.75 W/L	For applications outside U.S., see footnote (h). For U.S. applications, see footnote (g).	10 CFR 4 Appendi
Electric storage *water heaters*	≤12 *kW* [e]	≥208 L and ≤309.75 W/L	For applications outside U.S., see footnote (h). For U.S. applications, see footnote (g).	10 CFR 4 Appendi
		>208 L and <454 L	For applications outside U.S., see footnote (h). For U.S. applications, see footnote (g).	10 CFR 4 Appendi
	>12 *kW* [e]	<309.75 W/L	SL ≤ 0.3 + 27/V_m %/h	10 CFR 4
Electric instantaneous *water heaters*	≤12 kW [e]	≥309.75 W/L <7.6 L	For applications outside US, see footnote (h). For US applications, see footnote (g).	10 CFR 4 Appendi
	>12 *kW* and ≤58.6 *kW* [c]	≥309.75 W/L ≤7.6 L ≤8.2°C	Very Small DP: UEF = 0.80 Low DP: UEF = 0.80 Medium DP: UEF = 0.80 High DP: UEF = 0.80	10 CFR 4 Appendi
	>≤58.6 *kW* [c]	≥309.75 W/L <38 L	No requirement	10 CFR 4
		≥309.75 W/L ≥38 L	No requirement	10 CFR 4

Equipment Type	Size Category (Input)
Oil storage *water heaters*	≤30.8 *kW*
	>≥30.8 *kW* and ≤41 *kW* [e]
	>41 *kW* [e]

165 **9.3.2 Simplified Building Method of Calculating *Exterior Lighting Power Allowance.*** In Section 9.3.2 change "Tables 9.3.1-1, 9.3.1.-2, and 9.3.1.-3" to "Table 9.3.2" as shown below.
(Note: Additions are shown in underline and deletions are shown in ~~strikethrough~~.)

9.3.2 Simplified Building Method of Calculating *Exterior Lighting Power Allowance*
For all *building* types listed in Section 9.3, exterior areas (new and *alterations*) shall comply with the *lighting power allowance* and *control* requirements of Table 9.3.2 ~~Tables 9.3.1-1, 9.3.1-2,~~

~~and 9.3.1.3~~.

197 **11.2 Compliance.** In Section 11.2(e) change the reference to "Section 11.7(b)" to "Section 11.7.2(d)".

203 **11.7.2 Permit Application Documentation.** Revise Section 11.7.2 to correctly show the defined terms in italics.
(Note: Additions are shown in underline and deletions are shown in ~~strikethrough~~.)

11.7.2 Permit Application Documentation

Compliance shall be documented and submitted to the *building official*. The information submitted shall include the following:

a. The *energy cost budget* for the *budget building design* and the *design energy cost* for the *proposed design*.

b. The ~~simulation program~~*simulation program* used and the version of the~~ simulation program~~*simulation program*.

c. An overview of the project that includes the number of stories (above and below grade), the typical ~~floor~~*floor* size, the uses in the ~~building~~*building* (e.g., office, cafeteria, retail, parking, etc.), the gross area of each use, and whether each use is ~~conditioned~~*conditioned*.

d. A list of the *energy*-related features that are included in the design and on which compliance with the provisions of Section 11 is based. This list shall document all *energy* features that differ between the models used in the *energy cost budget* and the *design energy cost* calculations.

e. A list showing compliance for the ~~proposed design~~*proposed design* with all the requirements of Sections 5.4, 6.4, 7.4, 8.4, 9.4, and 10.4 (mandatory provisions).

f. ~~Building~~*Building* elevations and ~~floor~~*floor* plans.

g. A diagram showing the ~~thermal blocks~~*thermal blocks* used in the computer simulation.

h. An explanation of any significant modeling assumptions.

i. Backup calculations and material to support data inputs (e.g., ~~U-factors~~ *U-factors* for ~~building envelope~~*building envelope* assemblies, NFRC ratings for ~~fenestration~~*fenestration*, end uses identified in Table 11.5.1, "1. Design Model," paragraph [a]).

j. The input and output reports from the *simulation program*, including a breakdown of e*nergy* usage by at least the following components: lights, internal *equipment* loads, *service water-heating equipment*, *space*-heating *equipment*, *space* cooling and heat- rejection *equipment*, fans, and other HVAC *equipment* (such as pumps). The output reports shall also show the amount of time any loads are not met by the *HVACsystem* for both the *proposed design* and *budget building design*.

k. ~~Purchased energy rates~~*Purchased energy rates* used in the simulations.

l. An explanation of any error messages noted in the *simulation program* output.

m. For any exceptional calculation methods employed, document the predicted ~~energy~~*energy* savings by ~~energy~~*energy* type, the ~~energy~~*energy* cost savings, a narrative explaining the exceptional calculation method performed, and theoretical or empirical information supporting the accuracy of the method.

206 **Table 11.5.1 Modeling Requirements for Calculating Design Energy Cost and Energy Cost Budget.** Revise item 6.g.1 as shown below.
(Note: Additions are shown in underline and deletions are shown in ~~strikethrough~~.)

6. Lighting
…
g. *Automatic* lighting *controls* included in the *proposed design* but not required by Section 9.4.1 shall be modeled using the following methods for each luminaire under control:
1. *Manual*-ON or partial-auto-ON occupancy sensors shall be modeled by reducing the lighting schedule each hour by the occupancy sensor reduction factors in Table G3.7 for the applicable *space* type multiplied by 1.25~~0.25~~.

209 **Table 11.5.1 Modeling Requirements for Calculating *Design Energy Cost* and *Energy Cost Budget (Continued).*** Revise Section 13 of Table 11.5.1 as shown in the attached.
(Note: Additions are shown in underline and deletions are shown in ~~strikethrough~~.)

214 **12 Normative References.** Addendum bv to Standard 90.1-2016 added a reference to ASHRAE Standard 90.4-2016 (with Addenda a and b) but that reference was inadvertently left out of Section 12. Add the following reference to Section 12 as shown below.
(Note: Additions are shown in underline.)

12 Normative References

ASHRAE
1791 Tullie Circle, NE, Atlanta, GA 30329

ANSI/ASHRAE Standard 90.4-2016 (with Addenda a and b) Energy Standard for Data Centers

220 **A2.3.3 U-Factors for Metal Building Roofs.** Revise Section A2.3.3 to change Table A2.2.3 to Table A2.3.3 in two places as shown below.
(Note: Additions are shown in underline and deletions are shown in ~~strikethrough~~.)

A2.3.3 U-Factors for Metal Building Roofs
U-factors for *metal building roofs* shall be taken from Table A2.3.3 ~~A2.2.3~~ or determined in accordance with Section A9.2, provided the average purlin spacing for *systems* with compressed insulation is at least 52 in. *U-factors* for *metal building roof* assemblies with average purlin spacing less than 52 in. shall be determined in accordance with Section A9.2. *U-factors* in Table A2.3.3 ~~A2.2.3~~ shall not be used where the insulation is substantially compressed by the bracing between the purlins.

260 **Equations A9.4-2.** In Equation A9.4-2 replace "A = 0.00258168" with "A = 0.0258168".

265 **Equations A9.4-22.** In Equation A9.4-22 replace "A = 0.00258168" with "A = 0.0258168".

271 **Table 9.4.2-1 Values for Cavity Air Spaces[a].** Change the title of Table 9.4.2-1 to "**R-Values for Cavity Air Spaces[a]**".

287 **Informative Appendix E Informative References.** Update the references as shown below. See also the revised table from Informative Appendix E attached with changes shown in red text.
(Note: Additions are shown in underline and deletions are shown in ~~strikethrough~~.)

~~**LBNL Characterization and Survey of**~~
~~**Automated Fault Detection and Diagnostics Tools**~~
~~Lawrence Berkeley National Laboratory Building Technology and~~
~~Urban Systems Division Energy Technologies Area~~
~~MS 90R3111~~
~~1 Cyclotron Road~~
~~Berkeley, CA 94720 USA~~

~~**Office of Energy Efficiency and Renewable Energy (EERE)**~~
~~US Department of Energy~~
~~Better buildings~~
~~Forrestal Building~~
~~1000 Independence Avenue, SW~~
~~Washington, DC 20585~~
~~betterbuildingssolutioncenter.enmmergy.gov/alliance~~

MICA
Midwest Insulation Contractors Association
16712 Elm Circle
Omaha, NE 68130
www.micainsulation.org

IWEC2 Data
ASHRAE
1791 Tullie Circle, NE
Atlanta, GA 30329-2305
(T) 404-636-8400
(F) 404-321-5478
http://www.techstreet.com/ashrae
(Direct link: http://www.techstreet.com/ashrae/products/1876209)

NEBB
National Environmental Balancing Bureau
8575 Grovemont Circle
Gaithersburg, MD 20877
www.nebb.org

SMACNA
Sheet Metal & Air Conditioning Contractors'
National Association
4201 Lafayette Center Drive
Chantilly, VA 20151
info@smacna.org
www.smacna.org

TMY3 Data
National Renewable Energy Laboratory
NREL/RReDC
Attn: Pamela Gray-Hann
1617 Cole Blvd., MS-1612

Golden, Colorado, USA 80401
http://rredc.nrel.gov/solar/old_data/nsrdb/1991-2005/tmy3

291 **Informative Appendix F U.S. Department of Energy Minimum Energy Efficiency Requirements.** Revise Informative Appendix F as shown below.
(Note: Additions are shown in underline and deletions are shown in ~~strikethrough~~.)

Informative Appendix F
U.S. Department of Energy Minimum Energy Efficiency Requirements, Test Procedures, and Definitions

In the United States, the U.S. Department of Energy establishes *efficiency* standards for products that it defines as "residential covered products." Since these products are used in buildings covered by this standard, ~~the~~ DOE *efficiency* requirements are shown here for convenience. All DOE *efficiency* requirements for residential products are found in the U.S. *Code of Federal Regulations*, 10 CFR ~~Part 430 Subpart C, Section~~ 430.32.

DOE also establishes definitions and test procedures for covered products. These are found in 10 CFR 430.2 and 10 CFR 430.23, respectively.

[…]

F3 DOE Test Procedure and Definitions for Ceiling Fans
DOE definitions for ceiling fans are found in 10 CFR 430.2 and 10 CFR part 430, subpart B, appendix U. On or after January 23, 2017, manufacturers of ceiling fans must make any representations with respect to energy use or efficiency in accordance with the test procedure in 10 CFR part 430, subpart B, appendix U. DOE also specifies, in 10 CFR 430.32, design requirements for ceiling fans, and for ceiling fans manufactured on or after January 21, 2020, minimum efficiency requirements.

305 **Table G3.1 Modeling Requirements for Calculating Proposed and *Baseline Building Performance.*** Revise Table G3.1, No. 6 Lighting, item g, as shown in the attached.
(Note: Additions are shown in underline and deletions are shown in ~~strikethrough~~.)

311 **G3.1.1.4 Modeling Building Envelope Infiltration.** Revise Section G3.1.1.4 as follows.
(Note: Additions are shown in underline and deletions are shown in ~~strikethrough~~.)

S = total area of the *building envelope* (m^2), including the lowest floor ~~*floor*~~, any *below-grade walls* or *above-grade walls*, and *roof* (including *vertical fenestration* and *skylights*)

312 **G3.1.2.1 Equipment Efficiencies.** In Section G3.1.2.1 add the last sentence as shown below. The text was added by Addendum z to 90.1-2016 but was inadvertently omitted from 90.1-2019.
(Note: Additions are shown in underline.)

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.
[…]

331 **Table G3.5.4 *Performance Rating Method* Electrically Operated *Packaged Terminal Air Conditioners*, *Packaged Terminal Heat Pumps* (efficiency ratings excluding supply fan power).** Deleting the superscript "a" in Minimum *Efficiency* in Table G3.5.4.

Table 6.5.1.1.3 High-Limit Shutoff *Control* Settings for *Air Economizers*[b]

Control Type	Allowed Only in Climate Zone at Listed *Set Point*	Required High-Limit *Set Points* (Economizer Off when):	
		Equation	Description
Fixed dry-bulb temperature	0B, 1B, 2B, 3B, 3C, 4B, 4C, 5B, 5C, 6B, 7, 8	T_{OA} > 24°C	*Outdoor air* temperature exceeds 24°C
	5A, 6A	T_{OA} > 21°C	*Outdoor air* temperature exceeds 21°C
	0A, 1A, 2A, 3A, 4A,	T_{OA} > 18°C	*Outdoor air* temperature exceeds 18°C
Differential dry-bulb temperature	0B, 1B, 2B, 3B, 3C, 4B, 4C, 5A, 5B, 5C, 6A, 6B, 7, 8	$T_{OA} > T_{RA}$	*Outdoor air* temperature exceeds return air temperature
Fixed enthalpy with *fixed* dry-bulb temperature	All	h_{OA} > 65.1 ~~47~~ kJ/kg[a] or T_{OA} > 24°C	*Outdoor air* enthalpy exceeds 65.1 ~~47~~ kJ/kg[a] of dry air[a] or *outdoor air* temperature exceeds 24°C
Differential enthalpy with *fixed* dry-bulb temperature	All	$h_{OA} > h_{RA}$ or T_{OA} > 24°C	*Outdoor air* enthalpy exceeds return air enthalpy or *outdoor air* temperature exceeds 24°C

a. At altitudes substantially different than sea level, the *fixed* enthalpy limit shall be set to the enthalpy value at 24°C and 50% rh. As an example, at approximately 1830 m elevation, the *fixed* enthalpy limit is approximately 71.4 ~~53.5~~ kJ/kg.

b. Devices with selectable rather than adjustable *set points* shall be capable of being set to within 1.1°C and 3.4kJ/kg of the *set point* listed.

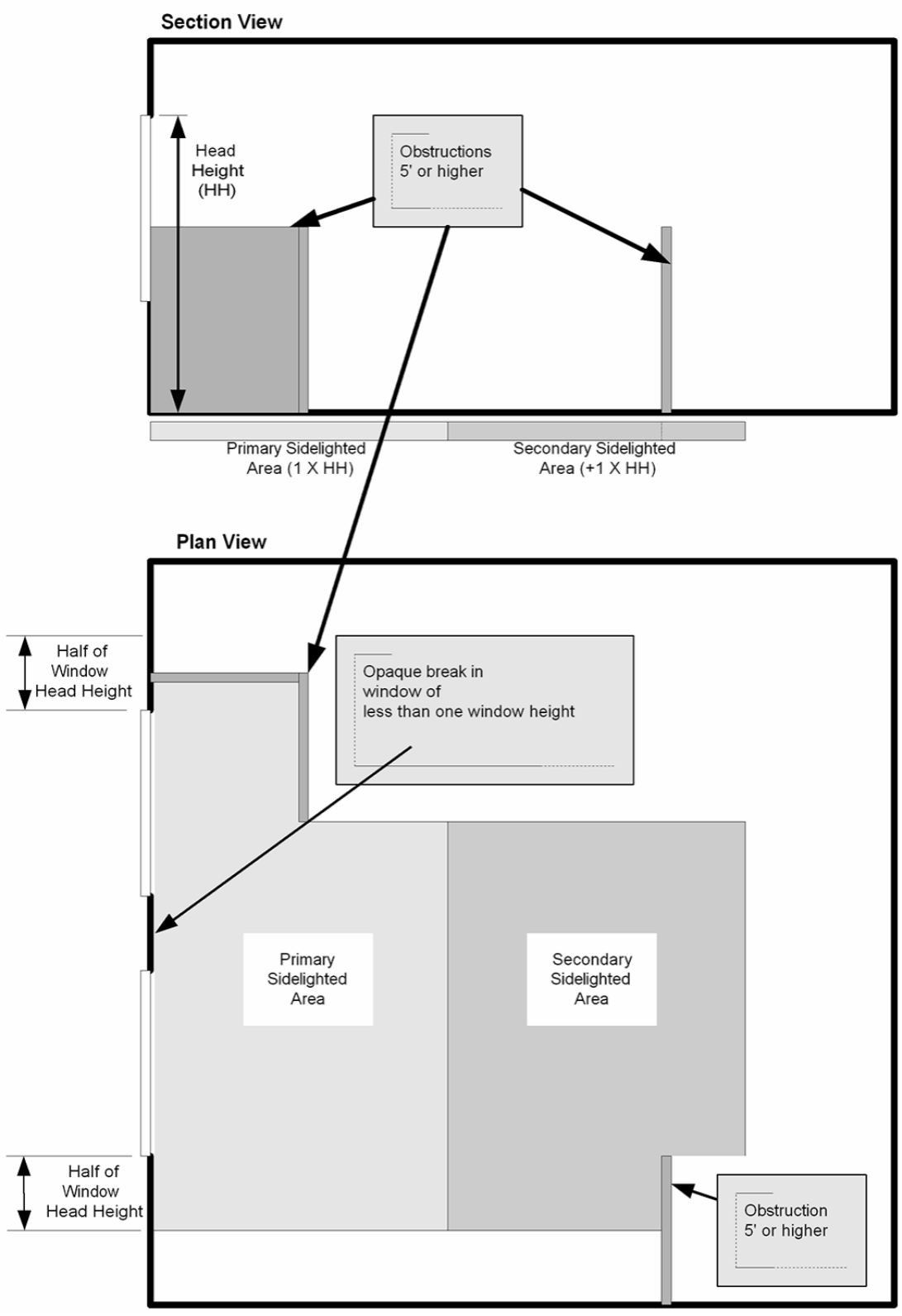

Figure 3.2-5 Computing the *secondary sidelighted area*.

Table 6.8.1-16 Heat-Pump and Heat Recovery Chiller Packages—Minimum *Efficiency* Requirements

Equipment Type	Size Category, kW	Cooling only Operation Cooling Efficiency[b] (Air Source COP FL/IPLV-W/W) Water Source COP (FL/IPLV), W/W		Heating Operation									Test Procedure
				Heating Source Conditions (entering/ leaving water) or OAT (db/wb), °C	Heat-Pump Heating Full-Load Efficiency (COP_H)[b], W/W				Heat Recovery Chiller Full-Load Efficiency (COP_{HR})[b,c], W/W Simultaneous Cooling and Heating Full-Load Efficiency (COP_{SHC})[b], W/W				
					Leaving Heating Water Temperature				Leaving Heating Water Temperature				
					Low	Medium	High	Boost	Low	Medium	High	Boost	
		Path A	Path B		40°C	50°C	60°C	60°C	40°C	50°C	60°C	60°C	
Air Source	All sizes	≥2.836 FL ≥3.846 IPLV.SI	≥2.723 FL ≥4.436 IPLV.SI	8.0 db[d] 6.0 wb	≥3.250	≥2.720	≥3.330	NA	NA	NA	NA	NA	AHRI 551/591
		≥2.836 FL ≥3.930 IPLV.SI	≥2.723 FL ≥4.520 IPLV.SI	–8.0 db[d] –9.0 wb	≥2.250	≥1.920	≥1.640	NA	NA	NA	NA	NA	
Water Source electrically operated positive displacement	< 264	≤4.659 FL ≤5.574 IPLV.SI	≤4.287 FL ≤6.689 IPLV.SI	12/7[e]	≥4.760	≥3.610	≥2.660	NA	≥8.550	≥6.290	≥4.390	NA	AHRI 551/591
				24/19[e]	NA	NA	NA	≥3.530	NA	NA	NA	6.100	
	≥264 and <528	≤4.645 FL ≤5.972 IPLV.SI	≤4.459 FL ≤6.825 IPLV.SI	12/7[e]	≥4.760	≥3.610	≥2.660	NA	≥8.550	≥6.290	≥4.390	NA	
				24/19[e]	NA	NA	NA	≥3.530	NA	NA	NA	6.100	
	≥528 and <1055	≤5.067 FL ≤6.193 IPLV.SI	≤4.918 FL ≤7.601 IPLV.SI	12/7[e]	≥4.760	≥3.610	≥2.660	NA	≥8.550	≥6.290	≥4.390	NA	
				24/19[e]	NA	NA	NA	≥3.530	NA	NA	NA	6.100	
	≥1055 and <2110	≤5.482 FL ≤6.432 IPLV.SI	≤5.351 FL ≤8.157 IPLV.SI	12/7[e]	≥5.060	≥3.880	≥2.950	NA	≥9.140	≥6.850	≥4.960	NA	
				24/19[e]	NA	NA	NA	≥3.870	NA	NA	NA	6.800	
	≥2110	≤5.072 FL ≤6.689 IPLV.SI	≤5.717 FL ≤8.801 IPLV.SI	12/7[e]	≥5.060	≥3.880	≥2.950	NA	≥9.140	≥6.850	≥4.960	NA	
				24/19[e]	NA	NA	NA	≥3.870	NA	NA	NA	6.800	

a. Cooling-only rating conditions are standard rating conditions defined in AHRI 551/591, Table 1.
b. Heating full-load rating conditions are at rating conditions defined in AHRI 551/591, Table 1.
c. For water-cooled heat recovery chillers that have capabilities for heat rejection to a heat recovery condenser and a tower condenser, the COP_{HR} applies to operation at full load with 100% heat recovery. Units that only have capabilities for partial heat recovery shall meet the requirements of Table 6.8.1-3 .
d. Outdoor air entering dry-bulb (db) temperature and wet-bulb (wb) temperature.
e. Source-water entering and leaving water temperature.

Table 6.8.1-16 Heat-Pump and Heat Recovery Chiller Packages—Minimum *Efficiency* Requirements *(Continued)*

Equipment Type	Size Category, kW	Cooling only Operation Cooling Efficiency[b] (Air Source COP FL/IPLV-W/W) Water Source COP (FL/IPLV), W/W		Heating Operation									Test Procedure
				Heating Source Conditions (entering/ leaving water) or OAT (db/wb), °C	Heat-Pump Heating Full-Load Efficiency (COP_H)[b], W/W				Heat Recovery Chiller Full-Load Efficiency (COP_{HR})[b,c], W/W Simultaneous Cooling and Heating Full-Load Efficiency (COP_{SHC})[b], W/W				
					Leaving Heating Water Temperature				Leaving Heating Water Temperature				
					Low	Medium	High	Boost	Low	Medium	High	Boost	
		Path A	Path B		40°C	50°C	60°C	60°C	40°C	50°C	60°C	60°C	
Water source electrically operated centrifugal	<264	≤5.482 FL ≤6.081 IPLV.SI	≤4.812 FL ≤7.601 IPLV.SI	12/7[e]	≥4.760	≥3.610	≥2.660	NA	≥8.550	≥6.290	≥4.390	NA	AHRI 551/591
				24/19[e]	NA	NA	NA	≥3.530	NA	NA	NA	≥6.100	
	≥264 and <528	≤5.482 FL ≤6.081 IPLV.SI	≤5.267 FL ≤6.361 IPLV.SI	12/7[e]	≥4.760	≥3.610	≥2.660	NA	≥8.550	≥6.290	≥4.390	NA	
				24/19[e]	NA	NA	NA	≥3.530	NA	NA	NA	≥6.100	
	≥528 and <1055	≤5.972 FL ≤6.432 IPLV.SI	≤5.621 FL ≤8.567 IPLV.SI	12/7[e]	≥4.760	≥3.610	≥2.660	NA	≥8.550	≥6.290	≥4.390	NA	
				24/19[e]	NA	NA	NA	≥3.530	NA	NA	NA	≥6.100	
	≥1055 and <2110	≤5.972 FL ≤6.689 IPLV.SI	≤5.717 FL ≤8.801 IPLV.SI	12/7[e]	≥5.060	≥3.880	≥2.950	NA	≥9.140	≥6.850	≥4.960	NA	
				24/19[e]	NA	NA	NA	≥3.870	NA	NA	NA	≥6.800	
	≥2110	≤5.972 FL ≤6.689 IPLV.SI	≤5.717 FL ≤8.801 IPLV.SI	12/7[e]	≥5.060	≥3.880	≥2.950	NA	≥9.140	≥6.850	≥4.960	NA	
				24/19[e]	NA	NA	NA	≥3.870	NA	NA	NA	≥6.800	

a. Cooling-only rating conditions are standard rating conditions defined in AHRI 551/591, Table 1.
b. Heating full-load rating conditions are at rating conditions defined in AHRI 551/591, Table 1.
c. For water-cooled heat recovery chillers that have capabilities for heat rejection to a heat recovery condenser and a tower condenser, the COP_{HR} applies to operation at full load with 100% heat recovery. Units that only have capabilities for partial heat recovery shall meet the requirements of Table 6.8.1-3 .
d. Outdoor air entering dry-bulb (db) temperature and wet-bulb (wb) temperature.
e. Source-water entering and leaving water temperature.

Table 6.8.1-16 Heat-Pump and Heat Recovery Chiller Packages—Minimum *Efficiency* Requirements

Heating Operation								
Heating Source Conditions (entering/ leaving water) or OAT (db/wb), °C	Heat-Pump Heating Full-Load Efficiency (COP_H)[b], W/W				Heat Recovery Chiller Full-Load Efficiency (COP_{HR})[b,c], W/W Simultaneous Cooling and Heating Full-Load Efficiency (COP_{SHC})[b], W/W			
	Leaving Heating Water Temperature				Leaving Heating Water Temperature			
	Low	Medium	High	Boost	Low	Medium	High	Boost
	40°C	50°C	60°C	60°C	40°C	50°C	60°C	60°C
8.0 db[d] 6.0 wb	≥3.250	≥2.720	≥3.330	NA	NA	NA	NA	NA
–8.0 db[d] –9.0 wb	≥2.250	≥1.920	≥1.640	NA	NA	NA	NA	NA
12/7[e]	≥4.760	≥3.610	≥2.660	NA	≥8.550	≥6.290	≥4.390	NA
24/19[e]	NA	NA	NA	≥3.530	NA	NA	NA	≥6.100
12/7[e]	≥4.760	≥3.610	≥2.660	NA	≥8.550	≥6.290	≥4.390	NA
24/19[e]	NA	NA	NA	≥3.530	NA	NA	NA	≥6.100
12/7[e]	≥4.760	≥3.610	≥2.660	NA	≥8.550	≥6.290	≥4.390	NA
24/19[e]	NA	NA	NA	≥3.530	NA	NA	NA	≥6.100
12/7[e]	≥5.060	≥3.880	≥2.950	NA	≥9.140	≥6.850	≥4.960	NA
24/19[e]	NA	NA	NA	≥3.870	NA	NA	NA	≥6.800
12/7[e]	≥5.060	≥3.880	≥2.950	NA	≥9.140	≥6.850	≥4.960	NA
24/19[e]	NA	NA	NA	≥3.870	NA	NA	NA	≥6.800

Table 11.5.1 Modeling Requirements for Calculating *Design Energy Cost* and *Energy Cost Budget (Continued).*

13. Refrigeration	
Where refrigeration equipment in the proposed design is rated in accordance with AHRI 1200, the rated energy use shall be modeled. Otherwise, the proposed design shall be modeled using the actual equipment capacities and efficiencies.	Where refrigeration equipment is specified in the proposed design and listed in Table 6.8.1~~-13~~ 11 the budget building design shall be modeled as specified in 6.8.1~~-13~~ 11using the actual equipment capacities. If the refrigeration equipment is not listed in Table 6.8.1~~-13~~ 11 the budget building design shall be modeled the same as the proposed design.

Informative Appendix E Informative References

Subsection No.	Reference	Title/Source
5.7.3.2	NIBS Guideline 3-2012	Building Enclosure Commissioning Process BECx, Annex O
5.7.3.2	ASTM E2947-16a	Standard Guide for Building Enclosure Commissioning, Section 9.4
5.9.1, H1	ASTM E2947-16a	Standard Guide for Building Enclosure Commissioning
5.9.1, H1	ASTM E2813-18	Standard Practice for Building Enclosure Commissioning
6.4.1	CTI STD-201 OM (17)	Operations Manual for Thermal Performance Certification of Evaporative Heat Rejection Equipment Cooling Technology Institute
6.4.2	2017 ASHRAE Handbook—Fundamentals	ASHRAE
6.4.3.1	ASHRAE Guideline 22-2012	Instrumentation for Monitoring Central Chilled-Water Plant Efficiency
6.4.4.1.1	MICA Insulation Standards—7th Edition	National Commercial and Industrial Insulation Standards
6.4.4.2.1	SMACNA Duct Construction Standards—2005	HVAC Duct Construction Standards, Metal and Flexible
6.4.4.2.2	SMACNA Duct Leakage Test Procedures—2012	HVAC Air Duct Leakage Test Manual Sections 3,5, and 6
6.7.3.3.1	ASHRAE Guideline 4-2019	Preparation of Operating and Maintenance Documentation for HVAC&R Systems
6.7.3.3.1	AABC 2002	Associated Air Balance Council, National Standards for Total System Balance
6.7.3.3.1	ASHRAE Standard 111-2008	Measurement, Testing, Adjusting and Balancing of Building HVAC Systems
6.9.2, H1	ASHRAE Standard 202-2018	Commissioning Process for Buildings and Systems
6.9.2, H1	ASHRAE Guideline 0-2013	The Commissioning Process
6.9.2, H1	ASHRAE Guideline 1.1-2007	HVAC&R Technical Requirements for the Commissioning Process
6.9.2, H1	NEBB Procedural Standards—2014	Procedural Standards for Building Systems Commissioning
7.4.1, 7.5	2011 ASHRAE Handbook—HVAC Applications	Chapter 49, Service Water Heating/ASHRAE
~~8.4.2~~	~~LBNL-2001075~~	~~Characterization and Survey of Automated Fault Detection and Diagnostic Tools~~
~~8.4.2~~	~~Fault Detection and Diagnostics – Enabling techno-commissioning to ease building operation and improve performance (Institute for Building Efficiency)~~	
~~8.4.2~~	~~HVAC&R RESEARCH, January 2005 Volume 11, Number 1 (ASHRAE)~~	~~Methods for Fault Detection, Diagnostics, and Prognostics for Building Systems – A Review, Part I~~
~~8.4.2~~	~~HVAC&R Research, April 2005, Volume 11, Number 2 (ASHRAE)~~	~~Methods for Fault Detection, Diagnostics, and Prognostics for Building Systems – A Review, Part I~~
~~8.4.2~~	~~US Department of Energy EERE; Better Buildings~~	~~Energy Management Information Systems (EMIS) Specification and Procurement Support Materials~~
9.6.1	IES RP-6-15	Recommended Practice for Sports and Recreational Area Lighting
9.9.2	IES Design Guide 29 – 2011	The Commissioning Process Applied to Lighting and Control Systems

Subsection No.	Reference	Title/Source
10.4.3.4	ISO 25745-2:2015	Energy performance of lifts, escalators and moving walks – Paret2: Energy calculation and classification for lifts (elevators)
10.4.5	ISO 27327-1:209 (R2014)	Air curtain units — Part 1: Laboratory Methods of Testing for Aerodynamic Performance Rating
10.4.5	ANSI/AMCA Standard 220-05 (R2012)	Laboratory Methods of Testing Air Curtain Units for Aerodynamic Performance Rating
10.4.7	ANSI/HI 1.1-1.2-2014	Rotodynamic Centrifugal Pumps for Nomenclature and Definitions
10.4.7	ANSI/HI 2.1-2.2-2014	Rotodynamic Vertical Pumps or Radial, Mixed, and Axial Flow Types for Nomenclature and Definitions
11.4.2	CWEC	Canadian Weather for Energy Calculations
11.4.2	IWEC2	International Weather for Energy Calculations, Generation 2
11.4.2	TMY3	Typical Meteorological Year, Generation 3
A9.4.6	ASHRAE Transactions 116(1):10–017	Choudhary, M.K., C. Kasprzak, R.H. Larson, and R. Venuturumilli. 2010. ASHRAE Standard 90.1 metal building U-factors—Part 1: Mathematical modeling and validation by calibrated hot box measurements
A9.4.6	ASHRAE Transactions 116(1):10–018	Choudhary, M.K., and C.P. Kasprzak. 2010. ASHRAE Standard 90.1 Metal building U-factors—Part 2: A system based approach for predicting the thermal performance of single layer fiberglass batt insulation assemblies
A9.4.6	ASHRAE Transactions 116(1):10–019	McBride, M.F., and P.M. Gavin. 2010. ASHRAE Standard 90.1 metal building U-factors—Part 3: Equations for double layers of fiberglass batt insulation in roof and wall assemblies
A9.4.6	ASHRAE Transactions 116(1):10–020	Christianson, L. 2010. ASHRAE Standard 90.1 metal building U-factors—Part 4: Metal building U-factors for walls and roof based on experimental measurements.
A9.4.6	ASHRAE Transactions 118(1):12–006	Choudhary, M.K., C.P. Kasprzak, D.E. Musick, M.J. Henry, and N.D. Fast. 2012. ASHRAE Standard 90.1 metal building U-factors—Part 5: Mathematical modeling of wall assemblies and validation by calibrated hot box measurements
A9.4.6	ASHRAE Transactions 122(1):16–014	Choudhary, M.K 2016. A general approach for predicting the thermal performance of metal building fiberglass insulation assemblies
H1	ISO/IEC 17024:2012	Community Assessment – General requirements for bodies operating certification of persons

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

No.	Proposed Building Performance	*Baseline Building Performance*
6. Lighting (continued)		
	[…] g. For lighting *controls*, at a minimum, the proposed design shall contain the mandatory *automatic* lighting *controls* specified in Section 9.4.1 (e.g., *automatic* daylight responsive *controls*, *occupancy sensors*, programmable *controls*, etc.). These *controls* shall be modeled in accordance with (~~g~~ h) and (~~h~~ i). […]	