

# ADDENDA

**ANSI/ASHRAE/IES Addenda m, ai, aj, au, az, bg, dn  
to ANSI/ASHRAE/IES Standard 90.1-2016**

# Energy Standard for Buildings Except Low-Rise Residential Buildings

See Informative Appendix H for ASHRAE, IES, and ANSI approval dates.

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*The track changes in this document show the changes made in addenda m, ai, aj, au, az, bg and dn.*

### 3.2 Definitions

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**commissioning:** a quality-focused process for enhancing the delivery of a project for verifying and documenting that the *building* and its *systems*, controls, and *building envelope* are planned, designed, installed, tested, and include plans for operation and maintenance to meet specified requirements.

**Commissioning Provider (CxP):** an entity who manages the *Commissioning Team* to implement *building commissioning*.

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**control:** to regulate the operation of *equipment*.

**Informative Note:** This definition is not applicable to the use of this word as a noun to describe a combination of *control devices* and software, used to achieve *control* of HVAC, lighting, or other equipment or *systems*.

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**functional performance testing (FPT):** a systematic process to verify that control and other elements of the *building* project are capable of and configured to operate or perform as required.

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**process application:** a manufacturing, industrial, or commercial procedure or activity where the primary purpose is other than conditioning *spaces* and maintaining comfort and amenities for the occupants of a *building*.

**process energy:** energy consumed in support of a ~~manufacturing, industrial, or commercial~~ *process application* other than conditioning *spaces* and maintaining comfort and amenities for the occupants of a *building*.

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**service water heating:** heating water for domestic or commercial purposes other than *space* heating and *process application* requirements.

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**system:** a combination of *equipment* and auxiliary devices (e.g., *controls*, accessories, interconnecting means, and *terminal* elements) by which *energy* is transformed so it performs a specific function, such as HVAC, *service water heating*, or lighting.

**Informative Note:** This definition is not applicable to the use of this word in *building envelope* contexts such as, but not limited to, “curtain wall system,” “drainage system,” “fenestration system,” “framing system,” “roof system,” and “shading system.”

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verification and testing provider (V&T provider): an entity who completes the activities needed to implement the building functional performance testing (FPT) activities or verify that elements of the building project meet stated requirements.

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#### **4.2.5 Verification, Testing and Commissioning-Reporting**

Building systems, controls, and the building envelope shall comply with Sections 4.2.5.1, 4.2.5.2, and 4.2.5.3.

~~Where reporting is required, the building official or other approved agencies shall report to the contractor their findings of conformance and nonconformance for correction.~~

#### **4.2.5.1 Nonconformance Building Systems Verification and Testing Requirements**

~~If the nonconforming work is found not to be corrected within a predetermined time as agreed upon by the contractor, the nonconforming work shall be reported in writing to the building official and design professional. At a time agreed on by the building official or other approved agencies, a final report shall be submitted to the building official and the contractor that outlines the inspection findings and documents the correction of nonconforming work.~~Verification or functional performance testing (FPT) to confirm compliance with required provisions of this standard shall be performed on building systems, controls, and the building envelope, as required by Sections 5.9.1, 6.9.1, 7.9.1, 8.9.1, 9.9.1, 10.9.1, 11.2(d), and G1.21(c). Where testing is required, but specific FPT procedures are not specified in this standard, testing shall use generally accepted engineering standards acceptable to the building official.

For alterations and additions, verification and testing shall be performed for new systems, and their interface and integration with existing building systems shall be verified or tested.

V&T providers shall be Owner's qualified employees, Commissioning Providers, design professionals, qualified designers, or qualified technicians experienced with verification or FPT of the designated systems. V&T providers shall not be individuals who performed design or installation of the systems or assemblies being verified or tested.

##### **4.2.5.1.1 Information on Building Permit Application**

The following information shall be included on the construction documents as part of the building permit application:

- a. For systems that are required to comply with Section 4.2.5.1, the construction documents shall identify V&T providers.
- b. V&T providers shall review the construction documents to verify that the relevant sensor locations, devices, and control sequences are properly specified; performance and testing criteria are included; and equipment to be tested is accessible for testing and maintenance.
- c. FPT and verification processes and system performance requirements shall be incorporated into the construction documents.

##### **4.2.5.1.2 FPT and Verification Documentation**

The completed verification and FPT documentation shall include the results of the FPT and verification, be provided to the Owner, and be retained with the project records. The V&T providers shall certify completion of required verification and FPT and include a plan for the completion of any deferred FPT, including climatic and

other conditions required for performance of the deferred tests. A copy of verification and FPT documentation shall be submitted to the *building official* if requested.

#### **4.2.5.2 Building Commissioning Requirements**

Commissioning shall be performed in accordance with this section and Sections 5.9.2, 6.9.2, 7.9.2, 8.9.2, 9.9.2, 10.9.2, 11.2(d), and G1.21(c). Commissioning shall use ANSI/ASHRAE/IES Standard 202 or other *generally accepted engineering standards* acceptable to the *building official*. FPT and verification requirements for *commissioning* are as stated in Section 4.2.5.1. Commissioning shall also document in sufficient detail compliance of the *building systems*, controls, and *building envelope* with required provisions of this standard. Commissioning requirements shall be incorporated into the *construction documents*.

The *Commissioning Provider* (CxP) shall have the necessary training, experience, and FPT equipment. The *Commissioning Team* shall include *V&T providers*. The CxP shall be (a) a *third-party entity* not associated with the *building project*, (b) *Owner's* qualified employees, or (c) an individual associated with the design firm or contractor but not directly associated with design or installation of the *building systems*, controls, or *building envelope* being commissioned.

##### **Exceptions to 4.2.5.2:**

1. *Buildings, additions, or alterations* with less than 10,000 ft<sup>2</sup> (930 m<sup>2</sup>) of *conditioned space* and combined heating, cooling, and *service water heating equipment* totaling less than 960,000 Btu/h (280 kW) in capacity.
2. *Buildings* or portions of *buildings* that use the Simplified Approach Option for *HVAC Systems* in Section 6.3.
3. *Dwelling units*.
4. Nonrefrigerated warehouses.

##### **4.2.5.2.1 Commissioning Activities Prior to Building Permit Issuance**

The following activities shall be completed prior to issuance of a *building permit*:

- a. A copy of the *Commissioning Plan* shall be submitted to the Owner. A copy of the *Commissioning Plan* shall be submitted with the *building permit application* if requested by the *building official*.
- b. A CxP shall be designated by the Owner to manage *commissioning* activities prior to completion of *construction documents*. The *construction documents* shall identify the CxP.
- c. The CxP shall submit the Design Review Report to the Owner.
- d. *Construction phase commissioning* requirements shall be incorporated into *construction documents*.

##### **4.2.5.2.2 Project Commissioning Documents**

Project *commissioning* documents shall comply with ANSI/ASHRAE/IES Standard 202 or other *generally accepted engineering standards* acceptable to the *building official*. The CxP shall certify completion of the required *Commissioning Process* and provide the following documents to the Owner and Design Teams:

- a. **Commissioning Plan.** Identify FPT or verification procedures for all systems to be verified, commissioned, or tested.
- b. **Design Review Report.** Detail compliance of the design with the Owner's Project Requirements (OPR) and provisions of this standard. This

Commissioning Design Review shall not be considered a design peer review or a code or regulatory review.

c. Preliminary Commissioning Report. The Preliminary Commissioning Report shall include the following:

1. Required performance of commissioned equipment, systems, and assemblies, and results of FPT and verification
2. Summary of compliance of the building and its components, assemblies, controls, and systems with required provisions of this standard
3. Issues and resolution logs, including itemization of deficiencies found during verification, testing, and commissioning that have not been corrected at the time of report preparation
4. Deferred tests that cannot be performed at the time of report preparation
5. Documentation of the training of operating personnel and building occupants on commissioned systems, and a plan for the completion of any deferred trainings not completed at the time of report preparation
6. A plan for the completion of commissioning and training, including climatic and other conditions required for performance of the deferred tests

d. Final Commissioning Report. The construction documents shall require the CxP to provide a final Commissioning Report to the Owner before completion of the contractor's general warranty period.

#### **4.2.5.3 Activities Prior to Building Occupancy**

Before issuance of a certificate of occupancy, the V&T providers or CxP shall complete the following activities:

a. Verification and FPT of the systems specified in Section 4.2.5.1.1 shall be completed and documented.

##### **Exception to 4.2.5.3(a):**

Systems for which operation is seasonally dependent, and which cannot be fully verified or tested at the time of occupancy, shall be functionally tested or commissioned when allowed for by postoccupancy operating conditions as determined by the CxP or V&T provider.

b. The Owner shall be provided with the verification and FPT documentation as provided for in Section 4.2.5.1.2, or a preliminary Commissioning Report as provided for in Section 4.2.5.2.2.

c. The Owner shall provide the building official with one of the following:

1. A letter of transmittal acknowledging that the building Owner or Owner's authorized agent has received and accepted all required verification documentation, FPT documentation, and required preliminary Commissioning Report
2. A copy of the reports listed in Section 4.2.5.3(b), if requested by the building official

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#### **5.2.1 Requirements for All Compliance Paths**

The building envelope shall comply with Section 5.1, "General"; Section 5.4, "Mandatory Provisions"; Section 5.7, "Submittals"; Section 5.8, "Product

Information and Installation Requirements”; and Section 5.9, “~~Inspection and Verification, Testing, Commissioning, and Inspection~~”;

## 5.2.2 Additional Requirements to Comply with Section 5

The *building envelope* shall comply with either:

- a. Section 5.5, “Prescriptive *Building Envelope* Compliance Path,” provided that the *fenestration area* does not exceed the maximum allowed by Section 5.5.4.2, or
- b. Section 5.6, “*Building Envelope* Trade-Off Compliance Path.”

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### 5.4.3.1.1 Whole Building Air Leakage

Whole-building pressurization testing shall be conducted in accordance with ASTM E779 or ASTM E1827 by an independent third party. The measured air leakage rate of the *building envelope* shall not exceed 0.40 cfm/ft<sup>2</sup> under a pressure differential of 0.3 in. of water, with this air leakage rate normalized by the sum of the above-grade and below-grade *building envelope* areas of the *conditioned* and *semiheated space*.

Where a *building* contains both *conditioned space* and *semiheated space* compliance shall be shown:

- a. separately for the *conditioned space* and for the *semiheated space*, with the air leakage rate for the *conditioned space* normalized by the *exterior building envelope* area of the *conditioned space* and the air leakage rate for the *semiheated space* normalized by the *semiexterior building envelope* area of the *semiheated space*; or
- b. for the *conditioned space* and for the *semiheated space* together, with the air leakage rate for the overall *space* normalized by the sum of the *exterior building envelope* area and the *semiexterior building envelope* area minus the *semiexterior building envelope* area that separates the *conditioned space* from the *semiheated space*.

Reporting shall be in compliance with Section 4.2.5.1.2.

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#### Exceptions to 5.4.3.1.1

1. For *buildings* having over 50,000 ft<sup>2</sup> of *gross conditioned floor area*, air leakage testing shall be permitted to be conducted on less than the whole *building*, provided the following portions of the *building* are tested and their measured air leakage is area-weighted by the surface areas of the *building envelope*:
  - a. The entire *floor* area of all *stories* that have any *spaces* directly under a *roof*.
  - b. The entire *floor* area of all *stories* that have a *building entrance* or loading dock.
  - c. Representative *above-grade wall* sections of the *building* totaling at least 25% of the *wall* area enclosing the remaining *conditioned space*; floor area tested per (a) and (b) shall not be included in the 25%.
2. Where the measured air leakage rate exceeds 0.40 cfm/ft<sup>2</sup> but does not exceed 0.60 cfm/ft<sup>2</sup>, a diagnostic evaluation, such as a smoke tracer or infrared imaging shall be conducted while the *building* is pressurized, and any leaks noted shall be sealed if such sealing can be made without destruction of *existing building* components. In addition, a visual inspection of the air barrier shall



be conducted, and any leaks noted shall be sealed if such sealing can be made without destruction of *existing building* components. An additional report identifying the corrective actions taken to seal leaks shall be submitted to the *code official* and the *building* owner and shall be deemed to satisfy the requirements of this section.

3. *Continuous air barrier* design and installation verification program in accordance with Section 5.9.2.21.

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### 5.7.3 Completion Requirements

#### 5.7.3.1 Record Documents

*Construction documents* shall require that, within 90 days after the date of *building envelope* acceptance, *record documents* be provided to the *building* owner or the designated representative of the *building* owner. *Record documents* shall include, as a minimum, those items listed in Section 5.7.2, and the following:

- a. A report complying with Section 4.2.5.1.2 providing the results of air leakage verification of the *building envelope* in accordance with Section 5.9.12. Insulation documentation in accordance with 5.8.1.11.

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## 5.9 ~~Inspection and Verification, Testing, Commissioning, and Inspection~~

### ~~5.9.1 Inspections~~

~~In addition to the requirements of Section 4.2.4, building envelope components and assemblies shall be inspected in accordance with Sections 5.9.1.1 through 5.9.1.4.~~

~~Informative Note: See Appendix E for commissioning references.~~

#### ~~5.9.1.1 Inspection of Fenestration and Door Requirements~~

~~Fenestration and doors shall be inspected to ensure compliance with the requirements of Sections 5.4.3.2, 5.8.2.1, 5.8.2.2, and 5.8.2.3. Where testing is required to demonstrate compliance with the air leakage requirements, it shall be conducted by an independent third party. Operation of the door and closer or operating mechanism shall be inspected for conformance with the manufacturer's instructions, and that the seals or gaskets are installed and in accordance with the manufacturer's instructions.~~

#### ~~5.9.1.2 Inspection of Loading Dock Weatherseals~~

~~Where there is a loading dock, weatherseals shall be inspected for proper installation and to ensure that the seals are in good condition.~~

#### ~~5.9.1.3 Inspection of Opaque Building Envelope Air Tightness Requirements~~

~~Opaque roof, above-grade walls and below-grade walls, and floors, shall be subject to the following inspections during construction:~~

- a. ~~Use of compliant materials and assemblies as indicated in Section 5.4.3.1.3.~~
- b. ~~Integration with adjoining fenestration and continuous air barrier elements.~~

#### ~~5.9.1.4 Fenestration Inspections~~

~~Fenestration shall be subject to the following inspections during construction:~~

- a. ~~Skylights size and location in relation to the designed primary sidelighted area and secondary lighted area below.~~

- b. ~~Roof monitor size and location in relation to the designed primary sidelighted area and secondary lighted area areas below.~~
- e. ~~Dynamic glazing compliance with SHGC and U-factor in accordance with Sections 5.5.4.4.1 and 5.5.4.4.2, and testing of the operation for conformance with the manufacturer's instructions.~~
- d. ~~Permanent fenestration projections installation and performance in accordance with Section 5.5.4.4.1 and the construction documents.~~

## 5.9.12. Verification and Testing

### 5.9.12.1 Building Envelope Performance Verification

The *energy* performance of the *building envelope* shall be verified in accordance with this section and Section [4.2.5.1](#).

### 5.9.12.2 Verification of the Design and Installation of the *Continuous Air Barrier*

A Verification of the design and installation of the *continuous air barrier* shall be determined in accordance with the following by an independent third party when using Exception 3 of Section 5.4.3.1.1:

1. design review shall be conducted to verify and document compliance with the requirements in Sections 5.4.3 and 5.8.3.2.
2. Periodic field inspection of the *continuous air barrier* materials and assemblies shall be conducted during *construction* while the *continuous air barrier* is still accessible for inspection and *repair* to verify and document compliance with the requirements of Sections [5.4.3.1.2](#) and 5.8.3.
3. Reporting shall ~~be in compliance~~ comply with Section [4.2.5.1.2](#).

## 5.9.2. Commissioning

The *energy* performance of the *building envelope* shall be *commissioned* in accordance with Section 4.2.5.2. Commissioning reporting shall comply with Section 4.2.5.2.2.

*Informative Note: See Appendix E for commissioning references.*

## 5.9.43 Inspections

In addition to the requirements of Section [4.2.4](#), *building envelope* components and assemblies shall be inspected in accordance with Sections ~~5.9.31.1~~ through ~~5.9.31.4~~.

### 5.9.43.1 Inspection of Fenestration and Door Requirements

*Fenestration* and *doors* shall be inspected to ~~ensure-verify~~ compliance with the requirements of Sections [5.4.3.2](#), [5.8.2.1](#), [5.8.2.2](#), and [5.8.2.3](#). Where testing is required to demonstrate compliance with the air leakage requirements, it shall be conducted by an independent third party. Operation of the *door* and closer or operating mechanism shall be inspected for conformance with the *manufacturer's* instructions, and that the seals or gaskets are installed and in accordance with the *manufacturer's* instructions.

### 5.9.43.2 Inspection of Loading Dock Weatherseals

Where there is a loading dock, weatherseals shall be inspected for proper installation and to ~~ensure-verify~~ that the seals are in good condition.

### 5.9.43.3 Inspection of Opaque Building Envelope Air Tightness Requirements

*Opaque roof, above-grade walls and below-grade walls, and floors, shall be subject to the following inspections during construction:*

- a. Use of compliant materials and assemblies as indicated in Section [5.4.3.1.3](#).
- b. Integration with adjoining *fenestration* and *continuous air barrier* elements.

#### 5.9.4.4 Fenestration Inspections

*Fenestration shall be subject to the following inspections during construction:*

- a. *Skylights* size and location in relation to the designed *primary sidelighted area* and *secondary sidelighted area* below.
- b. *Roof monitor* size and location in relation to the designed *primary sidelighted area* and *secondary sidelighted area* below.
- c. *Dynamic glazing* compliance with *SHGC* and *U-factor* in accordance with Sections [5.5.4.4.1](#) and [5.5.4.4.2](#), and testing of the operation for conformance with the *manufacturer's* instructions.
- d. Permanent *fenestration* projections installation and performance in accordance with Section [5.5.4.4.1](#) and the *construction documents*.

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### 6.5.1 Economizers

Each cooling *system* shall include either an *air economizer* or *fluid economizer* meeting the requirements of Sections [6.5.1.1](#) through [6.5.1.5](#).

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#### Exceptions to 6.5.1

Economizers are not required for the following *systems*:

1. Individual fan-cooling units with a supply capacity less than the minimum listed in Table [6.5.1-1](#)
2. Chilled-water cooling *systems* without a fan or that use induced airflow, where the total capacity of these *systems* is less than 1,000,000 Btu/h in Climate Zones 0, 1B, and 2 through 4; less than 1,400,000 Btu/h in Climate Zones 5 through 8; or any size in Climate Zone 1A.
3. *Systems* that include nonparticulate air treatment as required by Section 6.2.1 in Standard 62.1.
4. In hospitals and ambulatory surgery centers, where more than 75% of the air designed to be supplied by the *system* is to *spaces* that are required to be humidified above 35°F dew-point temperature to comply with applicable codes or accreditation standards; in all other *buildings*, where more than 25% of the air designed to be supplied by the *system* is to *spaces* that are designed to be humidified above 35°F dew-point temperature to satisfy *process application* needs. This exception does not apply to *computer rooms*.
5. *Systems* that include a condenser heat recovery *system* with a minimum capacity as defined in Section [6.5.6.2.2](#).
6. *Systems* that serve *residential spaces* where the *system* capacity is less than five times the requirement listed in Table [6.5.1-1](#).

7. *Systems* that serve *spaces* whose sensible cooling load at *design conditions*, excluding transmission and *infiltration* loads, is less than or equal to transmission and *infiltration* losses at an outdoor temperature of 60°F.
8. *Systems* expected to operate fewer than 20 hours per week.
9. Where the use of *outdoor air* for cooling will affect supermarket open refrigerated casework *systems*.
10. For comfort cooling where the cooling *efficiency* meets or exceeds the *efficiency* improvement requirements in Table [6.5.1-2](#).
11. *Systems* primarily serving *computer rooms* where
  - a. the total design cooling load of all *computer rooms* in the *building* is less than 3,000,000 Btu/h and the *building* in which they are located is not served by a centralized chilled water plant;
  - b. the room total design cooling load is less than 600,000 Btu/h and the *building* in which they are located is served by a centralized chilled water plant;
  - c. the local water authority does not allow cooling towers; or
  - d. less than 600,000 Btu/h of *computer-room* cooling *equipment* capacity is being added to an *existing building*.

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#### 6.5.2.1 Zone Controls

Zone *thermostatic controls* shall prevent

- a. *reheating*;
- b. *recooling*;
- c. mixing or simultaneously supplying air that has been previously mechanically heated and air that has been previously cooled, either by *mechanical cooling* or by economizer *systems*; and
- d. other simultaneous operation of heating and cooling *systems* to the same zone.

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##### Exceptions to 6.5.2.1

1. Zones for which the volume of air that is reheated, recooled, or mixed is less than the larger of the following:
  - a. Twenty percent of the zone design peak supply for *systems* with *DDC* and 30% for other *systems*.
  - b. The outdoor airflow rate required to meet the *ventilation* requirements of ASHRAE Standard 62.1 for the zone.
  - c. Any higher rate that can be demonstrated, to the satisfaction of the *authority having jurisdiction*, to reduce overall *system* annual *energy* use by offsetting *reheat/recool energy* losses through a reduction in *outdoor air* intake for the *system*.
  - d. The airflow rate required to comply with applicable codes or accreditation standards, such as pressure relationships or minimum air change rates.
2. Zones with *DDC* that comply with all of the following:

- a. The airflow rate in *dead band* between heating and cooling does not exceed the larger of the following:
    - ~~(1) Twenty percent of the zone design peak supply rate.~~
    - (1) The minimum primary outdoor airflow rate required to meet the Simplified Procedure ventilation requirements of ASHRAE Standard 62.1 for the zone and that is permitted to be the average airflow rate as allowed by ASHRAE Standard 62.1.
    - (2) Any higher rate that can be demonstrated, to the satisfaction of the *authority having jurisdiction*, to reduce overall *system annual energy* use by offsetting *reheat/recool energy* losses through a reduction in *outdoor air intake*.
    - (3) The airflow rate required to comply with applicable codes or accreditation standards, such as pressure relationships or minimum air change rates.
  - b. The airflow rate that is reheated, recooled, or mixed shall be less than 50% of the zone design peak supply rate.
  - c. The first stage of heating consists of modulating the zone supply air temperature *set point* up to a maximum *set point* while the airflow is maintained at the *dead band* flow rate.
  - d. The second stage of heating consists of modulating the airflow rate from the *dead band* flow rate up to the heating maximum flow rate.
3. Laboratory exhaust systems that comply with Section [6.5.7.3](#).
  4. Zones where at least 75% of the *energy for reheating* or for providing warm air in mixing systems is provided from *site-recovered energy* (including condenser heat) or *site-solar energy*.
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### 6.5.2.3 Dehumidification

Where humidity *controls* are provided, such *controls* shall prevent *reheating*, mixing of hot and cold airstreams, or other means of simultaneous heating and cooling of the same airstream.

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#### Exceptions to 6.5.2.3

1. The *system* is capable of and configured to reduce supply air volume to 50% or less of the design airflow rate or the minimum *outdoor air ventilation* rate specified in ASHRAE Standard 62.1 or other applicable federal, state, or local code or recognized standard, whichever is larger, before simultaneous heating and cooling takes place.
2. The individual fan cooling unit has a design cooling capacity of 65,000 Btu/h or less and is capable of and configured to unload to 50% capacity before simultaneous heating and cooling takes place.
3. The individual *mechanical cooling* unit has a design cooling capacity of 40,000 Btu/h or less. An individual *mechanical cooling* unit is a single *system* comprising a fan or fans and a cooling coil capable of providing *mechanical cooling*.
4. *Systems* serving *spaces* where specific humidity levels are required to satisfy *process application* needs, such as vivariums; museums; surgical suites; pharmacies; and *buildings* with refrigerating *systems*,

such as supermarkets, refrigerated warehouses, and ice arenas, and where the *building* includes *site-recovered energy* or *site-solar energy* that provide *energy* equal to at least 75% of the annual *energy* for *reheating* or for providing warm air in mixing *systems*. This exception does not apply to *computer rooms*.

5. At least 90% of the annual *energy* for *reheating* or for providing warm air in mixing *systems* is provided from *site-recovered energy* (including condenser heat) or *site-solar energy*.
  6. *Systems* where the heat added to the airstream is the result of the use of a desiccant *system*, and 75% of the heat added by the desiccant *system* is removed by a heat exchanger, either before or after the desiccant *system*, with *energy* recovery.
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#### 6.5.4.4 Chilled- and Hot-Water Temperature Reset Controls

Chilled- and hot-water *systems* with a *design capacity* exceeding 300,000 Btu/h supplying chilled or heated water to comfort conditioning *systems* shall include *controls* that *automatically reset* supply water temperatures by representative *building* loads (including return water temperature) or by *outdoor air* temperature. Where *DDC* is used to *control* valves, the *set point* shall be *reset* based on valve positions until one valve is nearly wide open or *set-point* limits of the *system equipment* or application have been reached.

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##### Exceptions to 6.5.4.4

1. Where chilled-water supply is already cold, such as chilled water supplied from a district cooling or thermal *energy* storage *system*, such that blending would be required to achieve the *reset* chilled-water supply temperature.
  2. Where a specific temperature is required for a *process application*.
  3. Water temperature *reset* is not required where valve position is used to comply with Section [6.5.4.2](#).
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#### Nontransient dwelling units

Each fan *system* serving spaces other than *nontransient dwelling units* shall have an *energy* recovery *system* when the design supply fan airflow rate exceeds the value listed in Tables 6.5.6.1.2-1 and 6.5.6.1.2-2, based on the climate zone and percentage of *outdoor air* at design airflow conditions. Table 6.5.6.1.2-1 shall be used for all *ventilation systems* that operate less than 8000 hours per year, and Table 6.5.6.1.2-2 shall be used for all *ventilation systems* that operate 8000 or more hours per year. For spaces other than *nontransient dwelling units*, *energy* recovery *systems* shall result in an *enthalpy* recovery ratio of at least 50%. The *energy* recovery *system* shall provide the required *enthalpy* recovery

*ratio* at both heating and cooling *design conditions*, unless one mode is not required for the climate zone by the exceptions below. Provision shall be made to bypass or *control* the *energy recovery system* to permit *air economizer* operation as required by Section [6.5.1.1](#)

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#### Exceptions to 6.5.6.1.2

1. Laboratory *systems* meeting Section [6.5.7.3](#).
  2. *Systems* serving *spaces* that are not cooled and that are heated to less than 60°F.
  3. [Heating energy recovery w](#)Where more than 60% of the *outdoor air heating energy* is provided from *site-recovered energy* or *site-solar energy*.
  4. *Enthalpy recovery ratio* requirements at heating design condition in Climate Zones 0, 1, and 2.
  5. *Enthalpy recovery ratio* requirements at cooling design condition in Climate Zones 3C, 4C, 5B, 5C, 6B, 7, and 8.
  6. Where the sum of the airflow rates exhausted and relieved within 20 ft of each other is less than 75% of the design outdoor airflow rate, excluding exhaust air that is
    - a. used for another *energy recovery system*,
    - b. not allowed by ASHRAE Standard 170 for use in *energy recovery systems* with leakage potential, or
    - c. of Class 4 as defined in ASHRAE Standard 62.1.
  7. [Heating energy recovery for s](#)*Systems* requiring dehumidification [during heating mode](#) that employ *energy recovery* in series with the cooling coil.
  8. *Systems* expected to operate less than 20 hours per week at the *outdoor air* percentage covered by Table 6.5.6.1.2-1.
  - 9 *Indoor pool dehumidifiers* meeting Section 6.5.6.4.
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#### **6.7.2.4 System Commissioning**

~~HVAC control systems shall be tested to ensure that control elements are calibrated, adjusted, and in proper working condition. For projects larger than 50,000 ft<sup>2</sup> conditioned area, except warehouses and semiheated spaces, detailed instructions for commissioning HVAC systems (see Informative Appendix E) shall be provided by the designer in plans and specifications.~~

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## **6.9 Verification, Testing, and Commissioning**

### **6.9.1 Verification and Testing**

~~HVAC control systems shall be tested in accordance with this section and provisions of Section 4.2.5.1. Testing shall verify to ensure that systems and control elements~~

are calibrated, adjusted, ~~and in proper working condition.~~ configured, and operating in accordance with applicable requirements of Sections 6.3, 6.4, and 6.5. Verification and FTP documentation shall comply with Section 4.2.5.1.2.

### **6.9.2 Commissioning**

~~The performance of the *mechanical systems* shall be commissioned in accordance with Section 4.2.5.2. For projects larger than 50,000 ft<sup>2</sup> conditioned area, except warehouses and semiheated spaces, d~~ Detailed instructions for commissioning HVAC systems (see Informative Appendix E) shall be provided by the designer in the construction documents plan and specifications. Commissioning reporting shall comply with Section 4.2.5.2.2.

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## **7.9 Verification, Testing, and Commissioning**

### **7.9.1 Verification and Testing**

Service hot-water *controls* shall be verified and tested in accordance with this section and provisions of Section 4.2.5.1. Testing shall verify that *systems* and *controls* are configured and operating in accordance with applicable requirements of

- a. *service water heating system temperature controls* (Sections 7.4.4.1 and 7.4.4.3),
- b. *a recirculation pump or heat trace controls* (Section 7.4.4.2), or
- c. *pool time switch controls* (Section 7.4.5.3).

Verification and FTP documentation shall comply with Section 4.2.5.1.2.

### **7.9.2 Commissioning**

The *energy* performance of the *service water heating systems* shall be *commissioned* in accordance with Section 4.2.5.2, and reporting shall comply with Section 4.2.5.2.2.

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## **8.9 Verification, Testing, and Commissioning**

### **8.9.1 Verification and Testing**

*Automatic receptacles controls* (Section 8.4.2) and *energy monitoring* (Section 8.4.3) shall be verified and tested in accordance with this section and provisions of Section 4.2.5.1. Testing shall verify that *control* elements are configured and operating in accordance with Sections 8.4.2 and 8.4.3. Verification and *FPT* documentation shall comply with Section 4.2.5.1.



### 8.9.2 Commissioning

The energy performance of the power systems shall be commissioned in accordance with Section 4.2.5.2, and reporting shall comply with Section 4.2.5.2.2.

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## **9.2 Compliance Paths**

Lighting systems and equipment shall comply with Section 9.2.1 and Section 9.2.2.

### **9.2.1 Requirements for All Compliance Paths**

Lighting systems and equipment shall comply with Section 9.1, "General"; Section 9.4, "Mandatory Provisions"; and Section 9.7, "Submittals".

Compliance with Section 9 shall be achieved by meeting all of the requirements of Section 9.1 ("General"), 9.4.3 (Functional Testing), Section 9.7 ("Submittals"), and either one of the following:

- a. Section 9.3, "Simplified Building Method"
- b. Section 9.4, ("Mandatory Provisions"), and the prescriptive requirements of either Section 9.5, ("Building Area Method")
- c. Section 9.4, "Mandatory Provisions," and Section 9.6, ("Space-by-Space Method"

The installed lighting power identified in accordance with Section 9.1.3 shall not exceed the lighting power allowance developed in accordance with Section 9.2.1(a), (b), or (c).

Trade-offs of lighting power allowance among portions of the building for which a different calculation method has been used for compliance are not permitted.

### **9.2.2 Additional Requirements to Comply with Section 9**

Lighting systems and equipment shall comply with:

- a. Section 9.5, "Building Area Method Compliance Path," or
- b. Section 9.6, "Alternative Compliance Path: Space-by-Space Method."

Projects using the Energy Cost Budget Method (see Section 11 of this standard) must comply with Section 9.4, the mandatory provisions of this section, as a portion of that compliance path.

9.2.3 Interior Lighting Power. Lighting systems and equipment shall comply with Section 9.1 "General"; Section 9.4, "Mandatory Provisions"; Section 9.7, "Submittals"; and the prescriptive requirements of either

- a. Section 9.5, "Building Area Method Compliance Path" or
- b. Section 9.6, "Alternative Compliance Path: Space-by-Space Method."

### **9.2.2 Prescriptive Requirements**

#### **9.2.2.1 Building Area Method**

This method for determining the interior lighting power allowance, described in Section 9.5, is a simplified approach for demonstrating compliance.

#### **9.2.2.2 Space-by-Space Method**

This method, described in Section 9.6, is an alternative approach that allows greater flexibility.

### **9.2.2.3 Interior Lighting Power**

The *interior lighting power allowance* for a *building* or a separately metered or permitted portion of a *building* shall be determined by either the [Simplified Building Method described in Section 9.3](#), the *Building Area Method* described in Section [9.5](#), or the *Space-by-Space Method* described in Section [9.6](#). ~~Trade-offs of interior lighting power allowance among portions of the building for which a different method of calculation has been used are not permitted. The installed interior lighting power identified in accordance with Section [9.1.3](#) shall not exceed the interior lighting power allowance developed in accordance with Section [9.3](#), [9.5](#) or [9.6](#).~~

~~**9.2.3.1 Simplified Building Method.** This method for determining the interior and exterior lighting power allowances and control requirements, described in [9.3](#), is a whole building approach for demonstrating compliance.~~

~~**9.2.3.2 Building Area Method.** This method for determining the interior lighting power allowance, described in Section [9.5](#), is a simplified approach for demonstrating compliance.~~

~~**9.2.3.3 Space-by-Space.** This method, described in Section [9.6](#), is an alternative approach that allows greater flexibility.~~

~~**9.2.3.4 Interior Lighting Power Allowance.** The *interior lighting power allowance* for a *building* or a separately metered or permitted portion of a *building* shall be determined by either the *Building Area Method*, described in Section [9.5](#), or the *Space-by-Space Method*, described in Section [9.6](#).~~

~~Trade-offs of interior lighting power allowance among portions of the building for which a different method of calculation has been used are not permitted. The installed interior lighting power identified in accordance with Section [9.1.3](#) shall not exceed the interior lighting power allowance developed in accordance with Section [9.5](#) or [9.6](#).~~

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#### ~~**Exception to 9.2.3.1s-9.2.2.3:**~~

~~When using the compliance methods in Section [9.5](#) or [9.6](#) only, lighting equipment and applications listed in Table 9.2.2.3 shall not be considered when determining the *interior lighting power allowance* developed in accordance with Section [9.5](#) or [9.6](#), nor shall the wattage for such lighting be included in the *installed interior lighting power* identified in accordance with Section [9.1.3](#). This exemption shall only apply when the lighting and controls are in compliance with the requirements of Table 9.2.2.3. Lighting controls noted in this table are the only required controls for this equipment and these applications.~~

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### **9.2.3.2 Exterior Lighting Power Allowance**

The exterior lighting power allowance for a building or a separately metered or permitted portion of a building shall be determined by

- a. Section 9.3.2, “Simplified Building Method of Calculating Exterior Lighting Power Allowance,” when using Section 9.3 to determine the lighting power allowance, or
- b. Section 9.4.2, “Exterior Building Lighting Power,” when using Section 9.5 or Section 9.6 to determine the interior lighting power allowance.

**(Not Used) 9.3 Simplified Building Method Compliance Path**

Informative note: the following text is from Section 9.3 of current Addendum Y to Standard 90.1-2013 and is modified here to include new building types.

This section contains the simplified building method options for Section 9.3.1 Office Buildings, Section 9.3.2 Retail Buildings and Section 9.3.3 School Buildings. The Simplified Building Method contains the requirements for interior lighting in Section 9.3.1 and exterior lighting in Section 9.3.2 and shall be allowed to be used where at least 80% of the floor area supports either office buildings, retail buildings, or school buildings. that building type. The Simplified Building Method shall be used for new buildings or tenants improvements of less than 25,000 ft<sup>2</sup> (2300 m<sup>2</sup>). Trade-offs are not allowed between interior and exterior wattage allowances shall be calculated and complied with separately.

**Exception to 9.3:**

Alterations involving only luminaire and lamp/ballast replacements shall be permitted to comply by reducing the installed power by a minimum of 35% for existing T12 systems, 20% for existing T8 or T5 systems, 45% for existing HID systems, and 75% for existing incandescent systems.

**9.3.1 Simplified Building Method of Calculating Interior Lighting Power Allowance Office buildings. Office**

For the building types listed below, bBuildings (new and alterations) shall comply with the lighting power densities allowance and control requirements of the 9.3.1 Tables 9.3.1-1-9.3.1.1-1 (interior spaces) and 9.3.1.1-2 (exterior spaces) when the Simplified Building Method for Office Buildings, Retail Buildings or School Buildings has been selected. Trade-offs are not allowed between interior and exterior wattage allowances.

Exception: Alterations involving only luminaire and lamp/ballast replacements shall be permitted to comply by reducing the installed power by a minimum of 35% for existing T12 systems, 20% for existing T8 or T5 systems, 45% for existing HID systems and 75% for existing incandescent systems.

**Table 9.3.1-1 Simplified Building Method for Office Buildings**

<u>Interior Space Type</u>	<u>Maximum Interior Lighting Power Allowance</u>	<u>Controls (All lights in the space shall be controlled.)</u>

<p>All <i>spaces</i> in office <i>buildings</i> other than parking garages, stairwells, and corridors.</p>		<p>All lighting shall be <i>automatically</i> controlled to turn off when the <i>building</i> is either unoccupied or scheduled to be unoccupied-not occupied.</p> <p>Exception: Lighting load not exceeding 0.02 W/ft<sup>2</sup> multiplied by the gross lighted area of the <i>building</i> shall be permitted to operate at all times.</p> <p>Each <i>space</i> shall have a <i>manual</i> control device that allows the occupant to reduce lighting power by a minimum of 50% and to turn the lighting off.</p>
<p>Office <i>spaces</i> less than or equal to 250 ft<sup>2</sup>, classrooms, conference rooms, meeting rooms, training rooms, storage rooms, and break rooms</p>	<p>0.750 W/ft<sup>2</sup></p>	<p>These <i>spaces</i> shall also be controlled by <i>manual-on-occupant sensors</i>.</p> <p>These <i>spaces</i> shall also be controlled by automatic continuous daylight dimming controls<sup>a</sup>.</p>
<p>Offices greater than 250 ft<sup>2</sup> and restrooms</p>		<p>These <i>spaces</i> shall also be controlled by <i>occupant sensors</i>.</p> <p>These <i>spaces</i> shall also be controlled by automatic continuous daylight dimming controls<sup>a</sup>.</p>
<p>Stairwells and corridors in office <i>buildings</i> and parking garages</p>		<p>These <i>spaces</i> shall also be controlled by <i>occupant sensors</i> that reduce the lighting power by a minimum of 50% when no activity is detected for not longer than 20 minutes, and shall be controlled to turn off when the <i>building</i> is either unoccupied or scheduled to be unoccupied.</p>
<p>Parking garages</p>	<p>0.20-0.173 W/ft<sup>2</sup></p>	<p>All lighting shall be <i>automatically</i> controlled to turn off during nonoperating hours. Lighting shall also be controlled by occupant sensors. <i>Control</i> shall reduce the power by a minimum of 50% when no activity is detected for not longer than 20 minutes. No device shall control more than 3600 ft<sup>2</sup>.</p>

<sup>a</sup>-When the input power of the general lights completely or partially within the primary daylight area is 150 watts or greater.

**Table 9.3.1-2 Simplified Building Method for Office Buildings**

<b>Exterior Area Type</b>	<b>Maximum Allowance<sup>b,c</sup></b>	<b>Controls (All exterior lighting shall be automatically shut off when sufficient daylight is available)</b>
<p>Base allowance</p>	<p>600 watts</p>	
<p>Facade Lighting and Special Feature Areas, Walkways, Plazas</p>	<p>0.15 W/ft<sup>2</sup></p>	<p>Luminaires shall be turned off or the power reduced by a minimum of 75% during non-operating hours.</p>

<u>Landscape</u>	<u>0.05 W/ft<sup>2</sup></u>	
<u>Entry Doors</u>	<u>20 W/linear foot</u>	
<u>Stairs and ramps</u>	<u>1.00 W/ft<sup>2</sup></u>	<u>No additional controls required</u>
<u>Parking Lots and Drives</u>	<u>0.08-0.06 W/ft<sup>2</sup></u>	<u>Luminaires mounted 25 feet or less above grade shall be controlled to reduce the power by at least 50% when no activity is detected for not longer than 15-20 minutes.</u>
<u>All other areas not listed</u>	<u>0.20 W/ft<sup>2</sup></u>	<u>Luminaires shall be turned off or the power reduced by a minimum of 75% during non-operating hours.</u>

<sup>b</sup> To calculate the Exterior allowance multiply the space or area square footage by the allowed W/ft<sup>2</sup> and sum the exterior allowances and the base allowance. Facade lighting shall be calculated separately by multiplying the facade area by the allowed W/ft<sup>2</sup>. Facade allowance shall not be traded with other exterior areas or between separate facade areas.

<sup>c</sup> For office buildings in Lighting Zone 4, as defined in Table 9.4.2.1, increase exterior allowances by 25%.

**9.3.2 Retail Buildings.** Retail buildings (new and alterations) shall comply with the lighting power densities and control requirements of Tables 9.3.2.1-1 (interior spaces) and 9.3.2.1-2 (exterior spaces) when the Simplified Building Method for Retail Buildings has been selected. Trade-offs are not allowed between interior and exterior wattage allowances.

**Exception:** Alterations involving only luminaire and lamp/ballast replacements shall be permitted to comply by reducing the installed power by a minimum of 35% for existing T12 systems, 20% for existing T8 or T5 systems, 45% for existing HID systems and 75% for existing incandescent systems.

**Table 9.3.21-21 Simplified Building Method for Retail Buildings**

<u>Interior Space Type</u>	<u>Maximum Allowance</u>	<u>Controls (All lights in the space shall be controlled.)</u>
<u>All spaces in retail buildings other than parking garages, stairwells, and corridors:</u>	<u>1.00-1.5 W/ft<sup>2</sup></u> <u>(12.4 W/m<sup>2</sup>)</u>	<u>All lighting shall be <i>automatically</i> controlled to turn off when the building is either unoccupied or scheduled to be unoccupied.</u>  <u>Exception: Lighting load not exceeding 0.02 W/ft<sup>2</sup> (0.22 W/m<sup>2</sup>) multiplied by the gross lighted area of the building shall be permitted to operate at all times.</u>  <u>Each space shall have a <i>manual control</i> device that allows the occupant to reduce lighting power by a minimum of 50% and to turn the lighting off.</u>
<u>Sales area</u>		<u>These spaces shall also be controlled</u>  <u>1. to reduce the <i>general lighting</i> power by a minimum of 75% during nonbusiness hours,</u> <u>2. to turn off all lighting other than <i>general lighting</i> during nonbusiness hours, and</u> <u>3. by <i>continuous daylight dimming controls</i><sup>a</sup> in spaces with <i>toplighting</i>.</u>

<p><u>Stock rooms, dressing/fitting rooms, locker rooms, and restrooms</u></p>		<p><u>These spaces shall also be controlled by:</u></p> <p>1. <u>auto-on or manual-on occupant sensors and continuous daylight dimming controls<sup>a</sup> in spaces with toplighting.</u></p>
<p><u>Office spaces, conference rooms, meeting rooms, training rooms, storage rooms, break rooms, and utility spaces</u></p>		<p><u>These spaces shall also be controlled by</u></p> <p>1. <u>manual-on occupant sensors and continuous daylight dimming controls<sup>a</sup> in spaces with toplighting.</u></p>
<p><u>Stairwells and corridors in retail buildings and parking garages</u></p>		<p><u>These spaces shall also be controlled by occupant sensors that reduce the lighting power by a minimum of 50% when no activity is detected for not longer than 20 minutes, and shall be controlled to turn off when the building is either unoccupied or scheduled to be unoccupied.</u></p>
<p><u>Parking garages</u></p>	<p><u>0.173 W/ft<sup>2</sup></u> <u>(1.8 W/m<sup>2</sup>)</u></p>	<p><u>All lighting shall be automatically controlled to turn off during nonoperating hours. Lighting shall also be controlled by occupant sensors. Control shall reduce the power by a minimum of 50% when no activity is detected for not longer than 20 minutes. No device shall control more than 3600 ft<sup>2</sup> (334 m<sup>2</sup>).</u></p>

<sup>a</sup> When the combined input power of the general lights completely or partially within the primary daylight areas is 150 W or greater.

**Table 9.3.1-3 Simplified Building Method for School Buildings**

<u>Interior Space Type</u>	<u>Maximum Interior Lighting Power Allowance</u>	<u>Controls (All lights in the space shall be controlled.)</u>
All spaces in school buildings other than parking garages, stairwells, and corridors		<p>All lighting shall be <i>automatically</i> controlled to turn off when the building is either unoccupied or scheduled to be unoccupied.</p> <p>Exception: Lighting load not exceeding 0.02 W/ft<sup>2</sup> multiplied by the gross lighted area of the building shall be permitted to operate at all times.</p> <p>Each space shall have a <i>manual control</i> device that allows the occupant to reduce lighting power by a minimum of 50% and to turn the lighting off.</p>
Sales area Classrooms, office spaces, conference rooms, meeting rooms, library, storage rooms, and break rooms	0.70 W/ft <sup>2</sup>	<p>These spaces shall also be controlled by:</p> <ul style="list-style-type: none"> <li>— to reduce the general lighting power by a minimum of 75% during non-business hours, and</li> <li>— to turn off all lighting other than general lighting during non-business hours, and</li> <li>by continuous daylight dimming controls<sup>a</sup> in spaces with top lighting <i>manual-on occupant sensors</i>.</li> </ul>
Stock rooms, dressing/fitting rooms, locker rooms, and restrooms Gymnasium and cafeterias		<p>These spaces shall also be controlled by:</p> <ul style="list-style-type: none"> <li>— <del>auto-on or manual-on occupant sensors, and</del></li> <li><del>continuous daylight dimming controls<sup>a</sup> in spaces with top lighting.</del></li> </ul>
Office spaces, conference rooms, meeting rooms, training rooms, storage rooms, break rooms, and utility spaces Restrooms		<p>These spaces shall also be controlled by:</p> <ul style="list-style-type: none"> <li>— <del>manual-on occupant sensors, and</del></li> <li><del>continuous daylight dimming controls<sup>a</sup> in spaces with top lighting.</del></li> </ul>
Stairwells and corridors in retail school buildings and parking garages		<p>These spaces shall also be controlled by <i>occupant sensors</i> that reduce the lighting power by a minimum of 50% when no activity is detected for not longer than 20 minutes, and shall be controlled to turn off when the building is either unoccupied or scheduled to be unoccupied.</p>
Parking garages	0.13 W/ft <sup>2</sup>	<p>All lighting shall be <i>automatically</i> controlled to turn off during garage nonoperating hours. Lighting shall also be</p>

		controlled by <i>occupant sensors</i> . Control shall reduce the power by a minimum of 50% when no activity is detected for not longer than 20 minutes. No device shall control more than 3600 ft <sup>2</sup> .
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<sup>a</sup> When the input power of the general lights completely or partially within the daylight area is 150 watts or greater.

### 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 Tables 9.3.2.

**Table 9.3.2-2 Simplified Building Method for Building Exterior Retail Buildings**

Exterior Area Type	Maximum Exterior Lighting Power Allowance <sup>ba, eb</sup>	Controls (All exterior lighting shall be automatically shut-off controlled by either a photocell or an astronomical time switch to shut off the lighting when daylight is available.) when sufficient daylight is available.)
Base allowance	6200 W	Luminaires shall be turned off or the power reduced by a minimum of 75% during nonoperating hours.
Facade lighting and special feature areas, walkways, and plazas	0.105 W/ft <sup>2</sup> (1.6 W/m <sup>2</sup> )	
Landscape	0.045 W/ft <sup>2</sup> (0.54 W/m <sup>2</sup> )	
Entry doors	1420 W/linear foot (66 W/m)	
Stairs and ramps	100.70 W/ft <sup>2</sup> (10.8 W/m <sup>2</sup> )	No additional controls required
Parking lots and drives	0.056 W/ft <sup>2</sup> (0.65 W/m <sup>2</sup> )	Luminaires mounted 25 ft (7.6 m) or less above grade shall be controlled to reduce the power by at least 50% when no activity is detected for not longer than 15 minutes.
All other areas not listed	0.20 W/ft <sup>2</sup> (2.2 W/m <sup>2</sup> )	Luminaires shall be turned off or the power reduced by a minimum of 75% during nonoperating hours.



<sup>ba</sup> To calculate the exterior allowance, multiply the space or area square footage by the allowed W/ft<sup>2</sup> and sum the exterior allowances and the base allowance. Façade lighting shall be calculated separately by multiplying the façade area by the allowed W/ft<sup>2</sup>. Façade allowance shall not be traded with other exterior areas or between separate facade areas.

<sup>eb</sup> For buildings in Lighting Zone 2, as defined in Table 9.4.2-1, decrease exterior allowances by 20%. For retail buildings in Lighting Zone 4, as defined in Table 9.4.2-1, increase exterior allowances by 25%.

**9.3.3 School buildings.** School buildings (new and alterations) shall comply with the lighting power densities and control requirements of Tables 9.3.3.1-1 (interior spaces) and 9.3.3.1-2 (exterior spaces) when the Simplified Building Method for School Buildings has been selected. Trade offs are not allowed between interior and exterior wattage allowances.

**Exception:** Alterations involving only luminaire and lamp/ballast replacements shall be permitted to comply by reducing the installed power by a minimum of 35% for existing T12 systems, 20% for existing T8 or T5 systems, 45% for existing HID systems and 75% for existing incandescent systems.

**Table 9.3.3-1 Simplified Building Method for School Buildings**

Interior Space Type	Maximum Allowance	Controls (All lights in the space shall be controlled)
<u>All spaces in school buildings other than parking garages.</u>	<u>0.75 W/ft<sup>2</sup></u> <u>(8.1 W/m<sup>2</sup>)</u>	<p><u>All lighting shall be automatically controlled to turn off when the building is either unoccupied or scheduled to be unoccupied.</u></p> <p><u>Exception: Lighting load not exceeding 0.02 W/ft<sup>2</sup> (0.22 W/m<sup>2</sup>) multiplied by the gross lighted area of the building shall be permitted to operate at all times.</u></p> <p><u>Each space shall have a manual control device that allows the occupant to reduce lighting power by a minimum of 50% and to turn the lighting off.</u></p>
<u>Classrooms, office spaces, conference rooms, meeting rooms, library, storage rooms, and break rooms</u>		<p><u>These spaces shall also be controlled by:</u></p> <ul style="list-style-type: none"> <li><u>— manual on-occupant sensors, and</u></li> <li><u>— continuous daylight dimming controls<sup>a</sup>.</u></li> </ul>
<u>Gymnasiums and cafeterias</u>		<p><u>These spaces shall also be controlled by:</u></p> <ul style="list-style-type: none"> <li><u>— occupant sensors, and</u></li> <li><u>— continuous daylight dimming controls<sup>a</sup>.</u></li> </ul>
<u>Restrooms</u>		<p><u>These spaces shall also be controlled by occupant sensors.</u></p>
<u>Stairwells and corridors</u>		<p><u>These spaces shall also be controlled by occupant sensors that reduce the lighting power by a minimum of 50%</u></p>

		<u>when no activity is detected for not longer than 20 minutes.</u>
<u>Parking Garages</u>	<u>0.17 W/ft<sup>2</sup></u> <u>(1.8 W/m<sup>2</sup>)</u>	<u>All lighting shall be automatically controlled to turn off during non-operating hours. Lighting shall also be controlled by occupant sensors. Control shall reduce the power by a minimum of 50% when no activity is detected for not longer than 20 minutes. No device shall control more than 3600 ft<sup>2</sup> (334 m<sup>2</sup>).</u>

<sup>a</sup>-When the input power of the general lights completely or partially within the primary daylight area is 150 watts or greater.

**Table 9.3.3-2 Simplified Building Method for School Buildings**

<u>Exterior Area Type</u>	<u>Maximum Allowance<sup>b,c</sup></u>	<u>Controls (All exterior lighting shall be automatically shut-off when sufficient daylight is available)</u>
<u>Base allowance</u>	<u>600 watts</u>	<u>Luminaires shall be turned off or the power reduced by a minimum of 75% during non-operating hours.</u>
<u>Facade Lighting and Special Feature Areas, Walkways, Plazas</u>	<u>0.15 W/ft<sup>2</sup></u> <u>(1.6 W/m<sup>2</sup>)</u>	
<u>Landscape</u>	<u>0.05 W/ft<sup>2</sup></u> <u>(0.54 W/m<sup>2</sup>)</u>	
<u>Entry Doors</u>	<u>20 W/linear foot</u> <u>(66 W/m)</u>	
<u>Stairs and ramps</u>	<u>1.00 W/ft<sup>2</sup></u> <u>(10.8 W/m<sup>2</sup>)</u>	<u>No additional controls required</u>
<u>Parking Lots and Drives</u>	<u>0.06 W/ft<sup>2</sup></u> <u>(0.65 W/m<sup>2</sup>)</u>	<u>Luminaires mounted 25 feet or less above grade shall be controlled to reduce the power by at least 50% when no activity is detected for not longer than 15 minutes.</u>
<u>All other areas not listed</u>	<u>0.20 W/ft<sup>2</sup></u> <u>(2.2 W/m<sup>2</sup>)</u>	<u>Luminaires shall be turned off or the power reduced by a minimum of 75% during non-operating hours.</u>

<sup>b</sup>-To calculate the Exterior allowance multiply the space or area square footage by the allowed W/ft<sup>2</sup> and sum the exterior allowances and the base allowance. Facade lighting shall be calculated separately by multiplying the facade area by the allowed W/ft<sup>2</sup>. Facade allowance shall not be traded with other exterior areas or between separate facade areas.

<sup>c</sup>-For school buildings in Lighting Zone 4, as defined in Table 9.4.2-1, increase exterior allowances by 25%.

## 9.3

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### 9.4.3 Functional Testing

~~Lighting control devices and control systems shall be tested to ensure that control hardware and software are calibrated, adjusted, programmed, and in proper working condition in accordance with the construction documents and manufacturer's installation instructions. When occupant occupancy sensors, time switches, programmable schedule controls, or photosensors are installed, at a minimum, the following procedures shall be performed:~~

- a. ~~Occupant Occupancy Sensors~~
  1. ~~Certify that the sensor has been located and aimed in accordance with manufacturer recommendations.~~
  2. ~~For projects with up to seven (7) occupancy sensorsoccupancy sensors, all occupancy sensorsoccupancy sensors shall be tested.~~
  3. ~~For projects with more than seven (7) occupancy sensorsoccupancy sensors, testing shall be done for each unique combination of sensor type and space geometry.~~
    - (a) ~~For each sensor to be tested, verify the following:~~
      - (1) ~~Status indicator (as applicable) operates correctly.~~
      - (2) ~~Controlled lights turn off or down to the permitted level within the required time.~~
      - (3) ~~For auto ON occupant occupancy sensors, the lights turn on to the permitted level when someone enters the space.~~
      - (4) ~~For manual ON sensors, the lights turn on only when manually activated.~~
      - (5) ~~The lights are not incorrectly turned on by movement in nearby areas or by HVAC operation.~~
- b. ~~Automatic Time Switches~~
  1. ~~Confirm that the automatic time switch control is programmed with appropriate weekday, weekend, and holiday (as applicable) schedules.~~
  2. ~~Document for the owner automatic time switch programming, including weekday, weekend, and holiday schedules, as well as all setup and preference program settings.~~
  3. ~~Verify that correct time and date are properly set in the time switch.~~
  4. ~~Verify that any battery backup (as applicable) is installed and energized.~~

5. ~~Verify that the override time limit is set to no more than two (2) hours.~~
6. ~~Simulate occupied condition. Verify and document the following:~~
  - (a) ~~All lights can be turned on and off by their respective area control switch.~~
  - (b) ~~The switch only operates lighting in the enclosed space in which the switch is located.~~
7. ~~Simulate unoccupied condition. Verify and document the following:~~
  - (a) ~~All nonexempt lighting turns off.~~
  - (b) ~~Manual override switch allows only the lights in the enclosed space where the override switch is located to turn on or remain on until the next scheduled shut off occurs.~~
- e. ~~Daylight Controls~~
  1. ~~All control devices (photocontrols) have been properly located, field calibrated, and set for appropriate set points and threshold light levels.~~
  2. ~~Daylight controlled lighting loads adjust to appropriate light levels in response to available daylight.~~
  3. ~~The location where calibration adjustments are made is readily accessible only to authorized personnel.~~

~~The individuals responsible for the functional testing shall not be directly involved in either the design or construction of the project and shall provide documentation certifying that the installed lighting controls meet or exceed all documented performance criteria.~~

#### ~~9.4.4~~ ~~9.4.3~~ Dwelling Units

~~Not less than 75% of the permanently installed lighting fixtures shall use lamps with an efficacy of at least 55 lm/W or have a total luminaire efficacy of at least 45 lm/W. No other provisions of Section 9 apply to dwelling units.~~

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## 9.9 Functional Testing Verification, Testing, and Commissioning

### 9.9.1 Verification and Testing

Lighting control devices and control systems shall be tested in accordance with this section and Section 4.2.5.1 to ensure-verify that control hardware and software are calibrated, adjusted, programmed, and in proper working condition in accordance with the construction documents and manufacturer's installation instructions. When occupancy sensors, time switches, programmable schedule controls, or photosensors are installed, at a minimum, the following procedures shall be performed:

- a. *Occupancy Sensors*
  1. Certify that the sensor has been located and aimed in accordance with manufacturer recommendations.

2. For projects with up to seven (7) *occupancy sensors*, all *occupancy sensors* shall be tested.
3. For projects with more than seven (7) *occupancy sensors*, testing shall be ~~done~~ performed for each unique combination of sensor type and *space* geometry.
  - (a) For each sensor to be tested, verify the following:
    - (1) Status indicator (as applicable) operates correctly.
    - (2) *Controlled* lights turn off or down to the permitted level within the required time.
    - (3) For auto-ON *occupancy sensors*, the lights turn on to the permitted level when someone enters the *space*.
    - (4) For *manual-ON* sensors, the lights turn on only when *manually* activated.
    - (5) The lights are not incorrectly turned on by movement in nearby areas or by HVAC operation.
  - b. *Automatic Time Switches*
    1. Confirm that the *automatic* time-switch *control* is programmed with ~~appropriate~~ weekday, weekend, and holiday (as applicable) schedules.
    2. Document for the owner *automatic* time-switch programming, including weekday, weekend, and holiday schedules, as well as all setup and preference program settings.
    3. Verify that correct time and date are properly set in the time switch.
    4. Verify that any battery backup (as applicable) is installed and energized.
    5. Verify that the override time limit is set to no more than two (2) hours.
    6. Simulate occupied condition. Verify and document the following:
      - (a) All lights can be turned on and off by their respective area *control* switch.
      - (b) The switch only operates lighting in the *enclosed space* in which the switch is located.
    7. Simulate unoccupied condition. Verify and document the following:
      - (a) All nonexempt lighting turns off.
      - (b) *Manual* override switch allows only the lights in the *enclosed space* where the override switch is located to turn on or remain on until the next scheduled shut off occurs.
  - c. *Daylight Controls*
    1. All *control devices* (photocontrols) have been properly located, ~~and~~ field-calibrated, ~~and set for appropriate to~~ set points and threshold light levels.

2. Daylight *controlled* lighting loads adjust ~~to~~ appropriate light levels in response to available daylight.
3. The location where calibration adjustments are made is *readily accessible* only to authorized personnel.

~~The individuals responsible for the functional testing shall not be directly involved in either the design or construction of the project. Verification and FTP documentation shall comply with Section 4.2.5.1.2, and shall provide documentation certifying that the installed lighting controls meet or exceed all documented performance criteria.~~

### **9.9.2 Commissioning**

The energy performance of the lighting systems shall be commissioned (see Informative Appendix E) in accordance with Section 4.2.5.2, and reporting shall comply with Section 4.2.5.2.2.

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## **10.9 Verification, Testing, and Commissioning**

### **10.9.1 Verification and Testing**

Service water pressure-booster system controls, elevator stand-by mode and whole-building energy monitoring shall be commissioned or verified and tested to verify that control elements and monitoring systems are configured and operating in accordance with Sections 10.4.2, 10.4.3.3, 10.4.5, and 4.2.5.2. FPT documentation shall comply with Section 4.2.5.1.2.

### **10.9.2 Commissioning**

The energy performance of the other equipment systems shall be commissioned in accordance with Section 4.2.5.2, and reporting shall comply with Section 4.2.5.2.2.

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The proposed building design shall comply with all of the following:

- a. Sections 5.2.1, 6.2.1, 7.2.1., 8.2.1, 9.2.1, and 10.2.1.
- b. A *design energy cost*, as calculated in Section 11.5, that does not exceed the *energy cost budget* as calculated by the *simulation program* described in Section 11.4.
- c. The *energy efficiency* level of installed components and systems that meets or exceeds the *efficiency* levels used to calculate the *design energy cost*.
- d. Verification, testing, and commissioning requirements of Section 4.2.5 shall be met.
- e. Proposed building systems, controls, or building envelope documented in Section 11.7(b) that do not have criteria in Sections 5 through 10 shall have verification or testing to document proper installation and operation in accordance with Section 4.2.5.

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 E2947-14	Standard Guide for Building Enclosure Commissioning, Section 9.4
5.9.1	ASTM E2947-14	Standard Guide for Building Enclosure Commissioning
5.9.1	ASTM E2813-12	Standard Practice for Building Enclosure Commissioning
6.4.1	CTI STD-201 OM (13) Operations Manual for Thermal Performance Certification of Evaporative Heat Rejection Equipment	Cooling Technology Institute
6.4.2	2013 ASHRAE Handbook—Fundamentals	ASHRAE
6.4.3.11	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
6.7.2.2	ASHRAE Guideline 4-2008 (RA2013)	Preparation of Operating and Maintenance Documentation for Building Systems
6.7.2.3.1	AABC 2002	Associated Air Balance Council, National Standards for Total System Balance
6.7.2.3.1	ASHRAE Standard 111-2008	Measurement, Testing, Adjusting and Balancing of Building HVAC Systems
<a href="#">6.7.2.46.9.2</a>	ASHRAE Standard 202-2013	Commissioning Process for Buildings and Systems
<a href="#">6.7.2.46.9.2</a>	ASHRAE Guideline 0-2013	The Commissioning Process
<a href="#">6.7.2.46.9.2</a>	ASHRAE Guideline 1.1-2007	HVAC&R Technical Requirements for the Commissioning Process
6.7.2.4	NEBB Procedural Standards—2013	Procedural Standards for Building Systems Commissioning
7.4.1 and 7.5	2011 ASHRAE Handbook—HVAC Applications	Chapter 49, Service Water Heating/ASHRAE
8.4.2.2	Lawrence Berkeley National Laboratory LBNL-2001075	Characterization and Survey of Automated Fault Detection and Diagnostic Tools
8.4.2.2	Institute for Building Efficiency	Fault Detection and Diagnostics – Enabling techno-commissioning to ease building operation and improve performance
8.4.2.2	ASHRAE	Methods for Fault Detection, Diagnostics, and Prognostics for Building Systems – A Review, Part I HVAC&R RESEARCH January 2005 VOLUME 11, NUMBER 1
8.4.2.2	ASHRAE	Methods for Fault Detection, Diagnostics, and Prognostics for Building Systems – A Review, Part I HVAC&R RESEARCH April 2005 VOLUME 11, NUMBER 2
8.4.2.2	US Department of Energy EERE; Better Buildings	Energy Management Information Systems (EMIS) Specification and Procurement Support Materials
9.6.1	IES RP-6 (2015)	Recommended Practice for Sports and Recreational Area Lighting
<a href="#">9.9.2</a>	<a href="#">IES Design Guide 29 – 2011</a>	<a href="#">The Commissioning Process Applied to Lighting and Control</a>



Systems

10.4.5	ISO 27327-1:209 (R2014) — Air curtain units — Part 1: Laboratory Methods of Testing for Aerodynamic Performance Rating	AMCA
10.4.5	ANSI/AMCA Standard 220-05 (R2012) Laboratory Methods of Testing Air Curtain Units for Aerodynamic Performance Rating	ISO
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
11.4.1	DOE-2	Support provided by Lawrence Berkeley National Laboratory at the referenced Web site
11.4.1	BLAST	University of Illinois
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 Metal Building U-Factor Equations	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	ASHRAE Transactions 116(1):10–017
A9.4.6 Metal Building U-Factor Equations	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	ASHRAE Transactions 116(1):10–018
A9.4.6 Metal Building U-Factor Equations	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	ASHRAE Transactions 116(1):10–019
A9.4.6 Metal Building U-Factor Equations	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.	ASHRAE Transactions 116(1):10–020
A9.4.6 Metal Building U-Factor Equations	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	ASHRAE Transactions 118(1):12–006
A9.4.6 Metal Building U-Factor Equations	Choudhary, M.K. 2016. A general approach for predicting the thermal performance of metal building fiberglass insulation assemblies	ASHRAE Transactions 122(1):16–014
G3.1 Building Performance Calculations	ISO 25745-2:2015	Energy performance of lifts, escalators and moving walks— Part 2: Energy calculation and classification for lifts (elevators)

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**G1.2.1 Mandatory Provisions**

The proposed *building* design shall comply with all of the following:

- a. Sections 5.2.1, 6.2.1, 7.2.1, 8.2.1, 9.2.1, and 10.2.1;
- and

1. Interior lighting power shall not exceed the *interior lighting power allowance* determined using either
  1. Table [G3.7](#) and the methodology described in Section [9.6.1](#), or
  2. Table [G3.8](#) and the methodology described in Section [9.5.1](#); and
- c. Energy efficiency levels of installed components and *systems* that meet or exceed the efficiency levels used to calculate the *proposed building performance*.
- d. Verification, testing, and commissioning requirements of Section 4.2.5 shall be met.
- e. Proposed building systems, controls, or building envelope documented in Section G1.3(c) that do not have criteria in Sections 5 through 10 shall have verification or testing to document proper installation and operation in accordance with Section 4.2.5.

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### 5. Building Envelope

- a. All components of the *building envelope* in the *proposed design* shall be modeled as shown on architectural drawings or as built for *existing building envelopes*.
- b. All uninsulated assemblies (e.g., projecting balconies, perimeter edges of intermediate *floor* slabs, concrete *floor* beams over parking garages, *roof* parapet) shall be separately modeled using either of the following techniques:
  - a. Separate model of each of these assemblies within the *energy* simulation model.
  - b. Adjust the *U-factor* of the assembly interrupted by thermal bridges in accordance with Appendix A10.

**Exceptions:** The following *building* elements shall be permitted to differ from architectural drawings:

1. Any other *building envelope* assembly that covers less than 5% of the total area of that assembly type (e.g., *exterior walls*) need not be separately described, provided that it is similar to an assembly being modeled. If not separately described, the area of a *building envelope* assembly shall be added to the area of an assembly of that same type with the same *orientation* and thermal properties.
2. Exterior surfaces whose azimuth *orientation* and tilt differ by less than 45 degrees and are otherwise the same may be described as either a single surface or by using multipliers.

Equivalent dimensions shall be assumed for each *building envelope* component type as in the *proposed design*; i.e., the total gross area of *walls* shall be the same in the *proposed design* and *baseline building design*. The same shall be true for the areas of *roofs*, *floors*, and *doors*, and the exposed perimeters of concrete slabs on *grade* shall also be the same in the *proposed design* and *baseline building design*. The following additional requirements shall apply to the modeling of the *baseline building design*:

- a. **Orientation.** The *baseline building performance* shall be generated by simulating the *building* with its actual *orientation* and again after rotating the entire *building* 90, 180, and 270 degrees, then averaging the results. The *building* shall be modeled so that it does not shade itself.

**Exceptions:**

1. If it can be demonstrated to the satisfaction of the *rating authority* that the *building orientation* is dictated by site considerations.
2. *Buildings* where the *vertical fenestration area* on each *orientation* varies by less than 5%.
- b. **Opaque Assemblies.** *Opaque* assemblies used for new *buildings*, *existing buildings*, or additions shall conform with assemblies detailed in [Appendix A](#) and shall match the appropriate assembly maximum *U-factors* in Tables [G3.4-1](#) through [G3.4-8](#):
  - *Roofs*—Insulation entirely above deck ([A2.2](#)).
  - *Above-grade walls*—Steel-framed ([A3.3](#)).
  - *Below-grade walls*—Concrete block ([A4](#)).
  - *Floors*—Steel-joist ([A5.3](#)).
  - *Slab-on-grade floors* shall match the *F-factor* for unheated slabs from the same tables ([A6](#)).

### 5. Building Envelope (contd.)

3. The exterior *roof* surface shall be modeled using the aged solar *reflectance* and thermal *emittance* determined in accordance with Section [5.5.3.1.1\(a\)](#). Where aged test data are unavailable, the *roof* surface may be modeled with a *reflectance* of 0.30 and a thermal *emittance* of 0.90.
4. *Manual fenestration* shading devices, such as blinds or shades, shall be modeled or not modeled the same as in the *baseline building design*. *Automatically*

- *Opaque door* types shall be of the same type of *construction* as the *proposed design* and conform to the *U-factor* requirements from the same tables ([A7](#)).
- c. **Vertical Fenestration Areas.** For *building* area types included in Table [G3.1.1-1](#), *vertical fenestration areas* for new *buildings* and additions shall equal that in Table [G3.1.1-1](#) based on the area of gross *above-grade walls* that separate *conditioned spaces* and *semiheated*

controlled *fenestration* shades or blinds shall be modeled. Permanent shading devices, such as fins, overhangs, and light shelves shall be modeled.

5. *Automatically controlled dynamic glazing* may be modeled. Manually controlled *dynamic glazing* shall use the average of the minimum and maximum *SHGC* and *VT*.

b. *Infiltration* shall be modeled using the same methodology, ~~air leakage rate~~, and adjustments for weather and *building* operation in both the *proposed design* and the *baseline building design*. These adjustments shall be made for each simulation time step and must account for but not be limited to weather conditions and *HVAC system* operation, including strategies that are intended to positively pressurize the *building*. The air leakage rate of the *building envelope* ( $I_{75Pa}$ ) at a fixed *building* pressure differential of 0.3 in. of water shall be 0.40.6 cfm/ft<sup>2</sup> for buildings providing verification in accordance with Section 5.9.2.2(a). The air leakage rate of the *building envelope* shall be converted to appropriate units for the *simulation program* using one of the methods in Section G3.1.1.4.

**Exceptions:** When whole-*building* air leakage testing, in accordance with Section 5.9.2.2(b) ASTM E779, is specified during design and completed after *construction*, the *proposed design* air leakage rate of the *building envelope* shall be as measured.

*spaces* from the exterior. Where a *building* has multiple *building* area types, each type shall use the values in the table. The *vertical fenestration* shall be distributed on each face of the *building* in the same proportion as in the *proposed design*. For *building* areas not shown in Table G3.1.1-1, *vertical fenestration areas* for new *buildings* and additions shall equal that in the *proposed design* or 40% of gross *above-grade wall* area, whichever is smaller, and shall be distributed on each face of the *building* in the same proportions in the *proposed design*. The *fenestration area* for an *existing building* shall equal the existing *fenestration area* prior to the proposed work and shall be distributed on each face of the *building* in the same proportions as the *existing building*.

d. **Vertical Fenestration Assemblies.** *Fenestration* for new *buildings*, *existing buildings*, and additions shall comply with the following:

- *Fenestration U-factors* shall match the appropriate requirements in Tables G3.4-1 through G3.4-8 for the applicable glazing percentage for  $U_{all}$ .
- *Fenestration SHGCs* shall match the appropriate requirements in Tables G3.4-1 through G3.4-8 using the value for  $SHGC_{all}$  for the applicable vertical glazing percentage.
- All *vertical fenestration* shall be assumed to be flush with the *exterior wall*, and no shading projections shall be modeled.
- *Manual window shading devices* such as blinds or shades are not required to be modeled.

e. **Skylights and Glazed Smoke Vents.** *Skylight* area shall be equal to that in the *proposed design* or 3%, whichever is smaller. If the *skylight* area of the *proposed design* is greater than 3%, baseline *skylight* area shall be decreased by an identical percentage in all *roof* components in which *skylights* are located to reach 3%. *Skylight orientation* and tilt shall be the same as in the *proposed design*. *Skylight U-factor* and *SHGC* properties shall match the appropriate requirements in Tables G3.4-1 through G3.4-8 using the value and the applicable *skylight* percentage.

f. **Roof Solar Reflectance and Thermal Emittance.** The exterior *roof* surfaces shall be modeled using a solar *reflectance* of 0.30 and a thermal *emittance* of 0.90.

g. **Roof Albedo.** All *roof* surfaces shall be modeled with a reflectivity of 0.30.

h. The air leakage rate of the building envelope ( $I_{75Pa}$ ) at a fixed building pressure differential of 0.3 in. of water (75 Pa) shall be 1.0 cfm/ft<sup>2</sup> (5.1 L/s-m<sup>2</sup>).

i. Where *linear thermal bridges* and *point thermal bridges* as identified in Section 5.5.5.1 through 5.5.5.5 are modeled in the *proposed design*, they shall be represented as modified *U-factors* by adjusting the *U-factor* in accordance with the default values in Appendix A10. If the proposed design does not have *linear thermal bridges* and *point thermal bridges*, as identified in Section 5.5.5.1 through 5.5.5.5, they shall not be modeled in the *budget building design*.

If the balcony length in the *proposed design* exceeds the maximum allowed by Section 5.5.5.2, Exception 2(c)(i), the area shall be reduced proportionally for each balcony until the limit set in Section 5.5.5.2, Exception 2(c)(i) is met.

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## 17. 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 Tables G3.10.1 and G3.10.2, the baseline building design shall be modeled as specified in Tables G3.10.1 and G3.10.2 using the actual equipment capacities. If the refrigeration equipment is not listed in Tables G3.10.1 and G3.10.2, the baseline building design shall be modeled the same as the proposed design.

This appendix is not part of this standard. It is merely informative and does not contain requirements necessary for conformance to the standard. It has not been processed according to the ANSI requirements for a standard and may contain material that has not been subject to public review or a consensus process. Unresolved objectors on informative material are not offered the right to appeal. at ASHRAE or ANSI.

## Informative Appendix H

ANSI/ASHRAE/IES Standard 90.1-2019 incorporates all addenda to ANSI/ASHRAE/IES Standard 90.1-2016. Table H-1 lists each addendum and describes the way in which the standard is affected by the change. It also lists the ASHRAE, IES, and ANSI approval dates for each addendum.

**Table H-1 Addenda to ANSI/ASHRAE/IES Standard 90.1-2016**

Addendum	Sections	Description of Changes <sup>a</sup>	ASHRAE Standard Committee Approval	ASHRAE BOD/Tech Council Approval	IES BOD Approval	ANSI Approval
bg (formerly addendum bg to 90.1-2013)	9.2, 9.3, Table 9.3	Adds a simplified building method for interior lighting in offices, schools, and retail buildings, and exterior lighting. This includes the addition of table 9.3.	1/12/2019	10/3/2019	12/14/2018	2/13/2019
dn (formerly addendum dn to 90.1-2013)	A9.4	Allows the use of the R-value of an airspace in enclosed cavities with or without insulation (Appendix A). Expands the R-value table in Appendix A (based on 2009 <i>ASHRAE Handbook—Fundamentals</i> , Chapter 26).	1/12/2019	1/16/2019	12/14/2018	1/17/2019
a	6.4.3.3.3, 6.3.3.4.2, 6.5.1.1.4	Changes term "ventilation air" to "outdoor air" in multiple locations. Revises tables and footnotes. Clarifies requirements for economizer return dampers.	1/20/2018	1/24/2018	1/8/2018	1/25/2018
b	5.5.3.1.1, 12	Updates reference to ANSI/CRRC S100 "Standard Test Methods for Determining Radiative Properties of Materials".	6/24/2017	6/24/2017	6/13/2017	6/29/2017
c	3.2	Adds rooftop monitors to definition of fixed and operable vertical fenestration.	6/24/2017	6/24/2017	6/13/2017	6/29/2017
d	Tables G3.1.1 \	Modifies text to make it consistent with other portions of Appendix G for projects undergoing phased permitting.	6/24/2017	6/24/2017	6/13/2017	6/29/2017
e	Table G3.1.11	Adds direction that SWH piping losses shall not be modeled.	6/24/2017	6/24/2017	6/13/2017	6/29/2017

f	G3.1.2.1	Modifies text to require that the capacity used for selecting the system efficiency represents that for the size of the actual zone instead of the size of the zones as combined into a single thermal block.	6/24/2017	6/24/2017	6/13/2017	6/29/2017
g	3.2, 6.3.2, 6.5.3.8	Provides definition of "occupied-standby mode" and adds new ventilation air requirements for zones served rooms in occupied-standby mode.	1/20/2018	1/24/2018	1/8/2018	1/25/2018
h	6.5.6.1	Clarifies that exhaust air energy recovery systems should be sized to meet both heating and cooling design conditions unless one mode is not exempted by existing exceptions.	1/20/2018	1/24/2018	1/8/2018	1/25/2018
j	6.4.3.8	Changes an exception related to demand control ventilation.	6/24/2017	6/24/2017	6/13/2017	6/29/2017
k	3.2, 6.4.3.3.5	Revises definition of "networked guest room control system" and aligns HVAC and lighting time-out periods for guest rooms.	6/23/2018	6/27/2018	5/30/2018	7/25/2018
l	Table G3.1.2.9	Adds requirements for fan break horsepower for two systems.	1/20/2018	1/24/2018	1/8/2018	1/25/2018
m	Table G3.1.5	Lowers baseline building performance air leakage and sets an air leakage value to be used in conjunction with the air-barrier verification path.	1/12/2019	1/16/19	12/14/2018	2/13/2019
n	3.2	Removes ten unused definitions and changes definition of "unitary cooling equipment" to "unitary air conditioners".	1/20/2018	1/24/2018	1/8/2018	1/25/2018
o	3.2, 4.2.2.3, 5.5, 5.7 through 11.7, G 1.3	Revises the submittals section of the envelope and power chapters for consistency across the standard.	6/23/2018	6/27/2018	5/30/2018	6/28/2018
p	Table 6.1.8 -14	Revises the rating conditions for indoor pool dehumidifiers.	1/20/2018	1/24/2018	1/8/2018	1/25/2018
q	5.4.3, 5.5, 5.8.3, 5.9.1	Clarifies and restructures air leakage requirements for the building envelope.	9/14/2018	10/10/2018	10/23/2018	12/7/2018
r	G3.1.2.6	Specifies air economizer control types for Appendix G.	1/20/2018	1/24/2018	1/8/2018	1/25/2018

s	4.2.1.1, 11.4.3.1, G2.4	Modifies the Performance Cost Index (PCI) equation to implement a 5% limitation on renewable energy usage and clarifies what types of renewable energy systems are eligible.	9/14/2018	10/10/2018	10/23/2018	12/7/2018
t	9.4.2, Table 9.4.2-2	Expands the exterior LPD application table to cover additional exterior spaces that are not currently in the exterior LPD table	6/22/2019	6/26/2019	6/10/2019	7/24/2019
v	6.5.6.3	Adds section 6.5.6.3 containing heat recovery requirements for space conditioning in acute inpatient hospitals.	6/22/2019	6/26/2019	6/10/2019	7/24/2019
x	4.1.1.2, 4.2.1.1, 4.2.1.2, 4.2.1.3	Clarifies compliance paths for new construction, additions, and alterations.	6/23/2018	6/27/2018	5/30/2018	6/28/2018
y	G3.1.2.2	Fixes duct sizing run parameters within the Appendix G.	6/22/2019	6/26/2019	6/10/2019	7/1/2019
z	G3.1.2.1, Table G3.5.1, Table G3.5.2	Modifies the formulas in Section 11 and G3.1.2.1 for removing fan energy from baseline packaged heating and cooling efficiency ratings to cap the system capacity equations in Section 11 to levels allowed in Section 6 and provide a fixed baseline efficiency rating for Appendix G.	9/14/2018	9/28/2018	10/23/2018	10/1/2018
ab	3.2	Modifies definition of "door", "entrance door", "fenestration", and "sectional garage door".	6/23/2018	6/27/2018	5/30/2018	6/28/2018
ac	3.1, 3.2	Clarifies use of defined terms to include the term with different tense or plurality.	6/23/2018	6/27/2018	5/30/2018	6/28/2018
ad	5.2 through 11.2	This addendum clarifies the requirements for showing compliance using the methods in Sections 5-10, or Section 11, or Appendix G.	6/23/2018	6/27/2018	5/30/2018	6/28/2018
ae	3.2, 6.4.3.6, G3.1.3.18	Clarify humidification and dehumidification control requirements.	6/23/2018	6/27/2018	5/30/2018	6/28/2018
ag	Table G3.1.12	Provides accounts for the inclusion of automatic receptacle controls in a proposed building design for spaces that are not required to have them.	6/23/2018	6/27/2018	5/30/2018	6/28/2018
ah	9.1.4	Updates the language and terminology of the lighting wattage section. Also adds a section specifically to address using DC power over Cat6 structured cable for connection of LED lighting to a remote power supply.	6/23/2018	6/27/2018	5/30/2018	6/28/2018
ai	3.2., 4.2.5, 5.2.9, 6.7.2.4, 9.4.3, 5.9 through 10.9, 11.2	Restructures commissioning and functional testing requirements in all sections of Standard 90.1 to require verification for smaller and simpler buildings and commissioning for larger and more complex buildings.	1/12/2019	1/16/2019	12/14/2018	2/13/2019

aj	3.2, 6.5.1, 6.5.2.3, 6.5.4.4	Adds a new definition "process application" and uses it throughout Standard in place of "process load".	1/12/2019	1/16/2019	12/14/2018	2/13/2019
ak	Table G3.1.5, Tables G3.4-1 through G3.4-8	Defines SHGC baseline for buildings in zones where there is no prescriptive maximum SHGC.	6/23/2018	6/27/2018	5/30/2018	6/28/2018
al	Table G3.1.3, Table G3.1.7	Clarifies the modeling rules within section G3.1.	6/22/2019	6/26/2019	6/10/19	7/1/2019
am	6.5.6.4	Adds an indoor pool dehumidifier energy recovery requirement in new section 6.5.6.4.	6/23/2018	6/27/2018	5/30/2018	6/28/2018
an	3.2; 10.4.7; Table 10.8-6; 12; Appendix E	Provides a new table (Table 10.8.6) of information about the new efficiency requirements for commercial and industrial clean water pumps to users of ASHRAE 90.1. It also provides new definitions that are needed to accompany the table. New section 10.4.7 was also added.	6/22/2019	6/26/2019	6/10/2019	7/24/2019
ao	3.2; 6.5.3.1.3; 12	Introduces the revised fan product efficiency requirement FEI and complements the fan power limitation in section 6.5.3.1.1.	6/22/2019	6/26/2019	6/10/2019	7/24/2019
ap	6.5.3.5	Revises supply air temperature reset controls.	9/14/2018	9/28/19	10/23/2018	10/1/2018
aq	9.1.1, 9.2.2.3, 9.4.1.1, 9.4.1.3, 9.4.4, 9.6.2	Clarifies lighting control requirements for applications not covered in Section 9.6.2.	9/14/2018	9/28/19	10/23/2018	10/1/2018
ar	Table G3.1.12, G3.1.2.9, Table G 3.5.5, Table G.3.5.6, Table G3.6, Table G3.9.1	Cleanup of motor requirements in Appendix G related to Addend di in Standard 90.1-2016.	9/14/2018	9/28/19	10/23/2018	10/1/2018
as	Appendix I	Adds an informative appendix specific to commissioning.	NA	NA	NA	NA
at	11.5.1; G1.2.2	Revises language for energy accounting at buildings that provide fuel or electricity to vehicles.	6/22/2019	6/26/2019	6/10/2019	7/24/2019
au	6.5.2.1	Eliminates the requirement that zones with DDC have air flow rates that are no more than 20% of the zone design peak flow rate.	1/12/2019	1/16/2019	12/14/2018	1/17/2019
aw	3.2; Tables 5.5-0 through 5.5-8, 5.8.2.5, 12	Revises the fenestration prescriptive criteria in Tables 5.5-0 through 5.5-8.	6/22/2019	6/26/2019	6/10/2019	7/24/2019



ay	3.2, 6.5.6	Provides separate requirements for nontransient dwelling unit exhaust air energy recovery.	6/22/2019	6/26/2019	6/10/2019	7/24/2019
az	Table G3.1.17	Revises the modeling methodology language to clarify the baseline and proposed designs for refrigeration equipment.	1/12/2019	1/16/2019	12/14/2018	1/17/2019
ba	Table G3.1.1 Table G3.1.11	Establishes a methodology for determining the baseline flow rates on projects where service water-heating is demonstrated to be reduced by water conservation measures that reduce the physical volume of service water required.	6/22/2019	6/26/2019	6/10/2019	7/1/2019
bb	Table 9.6.1	Revises the lighting power densities for the Space-by-Space method	6/22/2019	6/26/2019	6/10/2019	7/24/2019
bd	Table 6.8.1-16	Adds the minimum efficiency requirements of Heat Pump and Heat Reclaim Chiller Packages. <del>and</del>	6/22/2019	6/26/2019	6/10/2019	7/1/2019
be	6.4.1.1; Table 6.8.1-10 & 6.8.1-17	Revises the efficiency requirements for Computer Room air conditioners.	7/22/2019	8/15/2019	7/19/2019	8/19/2019
bf	5.4.3.4; 10.4.5	Establishes an alternative to the requirement for vestibules by use of an air curtain that meets specific requirements prescribed in the proposed language. Adds new section 10.4.5.	6/22/2019	6/26/2019	6/10/2019	7/24/2019
bh	Table 5.8.3.2	Corrects an omission related to nonswinging doors in Table 5.8.3.2	6/22/2019	6/26/2019	6/10/2019	7/1/2019
bi	11.4.2; 12; Appendix C; Appendix G	Updates the reference year for Standard 140 in Sections 11 and 12 as well as Appendix C and G.	6/22/2019	6/26/2019	6/10/2019	7/1/2019
bj	6.5.5.1	Adds tables to the list of products that are exempt from meeting the requirements of section 6.5.6 - Heat Rejection Equipment.	6/22/2019	6/26/2019	6/10/2019	7/1/2019
bk	3.2, 11.4.3.2, G2.4.2	Clarifies that such projects must model the same electricity generation system in the baseline and proposed design and is aligned with the interpretation IC 90.1- 2013-16 OF ANSI/ASHRAE/IES STANDARD 90.1- 2013 form January 21, 2018.	6/22/2019	6/26/2019	6/10/2019	7/1/2019
bl	Table 6.8.1-1	Revises Table 6.8.1-1 Electrically Operated Unitary Air Conditioners and Condensing Units—Minimum Efficiency Requirements.	6/22/2019	6/26/2019	6/10/2019	7/1/2019
bm	Table 6.8.1-2, 6.8.1-15	Revises Table 6.8.1-2 Electrically Operated Air Cooled Unitary Heat Pumps—Minimum Efficiency Requirements. Adds Table 6.8.1-15.	7/22/2019	8/15/2019	7/19/2019	8/19/2019

bn	3.2, Table 6.8.1-4, Table F3	Revises 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. Adds Table F-3.	7/22/2019	8/15/2019	7/19/2019	8/19/2019
bo	3; Table 6.8.1-5; Table F-4	Revises 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 and adds Table F-4 Residential Warm Air Furnaces – Minimum Efficiency Requirements for sale in the US (see 10 CFR Part 430).	6/26/2019	8/1/2019	7/19/2019	8/26/2019
bp	Table 6.8.1-6; Table F-5	Revises Table 6.8.1.6 – Gas and Oil-Fired Boilers – Minimum Efficiency Requirements and adds table F-5 - Residential Boiler Minimum Efficiency Requirements for applications in the US (Refer to 10 CFR 430).	7/22/2019	8/15/2019	7/19/2019	8/19/2019
bq	Table 6.8.1-7; 12	Revises Table 6.8.1-7 Performance Requirements for Heat Rejection Equipment—Minimum Efficiency Requirements.	6/22/2019	6/26/2019	6/10/2019	7/1/2019
br	Table 6.8.1-11	Revises the previous Tables 6.8.1-12 & 13 and combines them into one table - Table 6.8.1-131 Commercial Refrigerators, Commercial Freezers and Refrigeration—Minimum Efficiency Requirements.	7/22/2019	8/15/2019	7/19/2019	8/19/2019
bs	Table 7.8; F2; Table F-2	Revises Table 7.8 Performance Requirements for Water-Heating Equipment—Minimum Efficiency Requirements and Table F-2 Minimum Energy Efficiency Requirements for Water Heaters.	7/22/2019	8/15/2019	7/19/2019	8/19/2019
bt	Table 4.2.1.1	Revises Table 4.2.1.1 Building Performance Factor (BPF).	6/22/2019	6/26/2019	6/10/2019	7/1/2019
bu	Table G3.1.1-1, G3.1.1, G3.1.3, Table G3.4-1 through Table G3.4-8	Clarifies requirements in the Appendix G as they related to HVAC zones and baseline heating.	7/22/2019	8/15/2019	7/19/2019	8/19/2019
bv	6.2.1, 6.6.2, 8.2.1, 8.6.1	Clarifies that designers have the option to use ASHRAE Standard 90.4 requirements instead of ASHRAE 90.1 requirements in computer rooms that have an IT equipment load larger than 10 kW. Adds section 8.6.1.	7/22/2019	8/15/2019	7/19/2019	8/19/2019
bx	3.2, A6.1, A6.3	Adds heated slab F-factors for multiple combinations of under-slab and perimeter insulation in Appendix A. Adds Table A6.3.1-1&2.	6/22/2019	6/26/2019	6/10/2019	6/27/2019
bz	3.2; Appendix C1.4, C2, C3.1.2, C3.3,	Clarifies requirements of Appendix C as they pertain to informative outputs, the schedule of shades, energy costs, and updated references to Section 6.	6/22/2019	6/26/2019	6/10/2019	7/1/2019

C3.5.5.1,  
C3.5.8

ca	Table A3.2.3	Adds U-factors to Table A3.2.3 for use of continuous insulation on metal building walls with double layer cavity insulation.	6/22/2019	6/26/2019	6/10/2019	7/1/2019
cc	A9.4.6	Clarifies the limitations of the calculation procedures in A9.4.6.	6/22/2019	6/26/2019	6/10/2019	7/1/2019
ce	6.5.3.1.2	Makes revisions to provide energy savings potential by removing one of three criteria for fan motor selections, increasing the design options for load-matching variable-speed fan applications, accommodating new motor and drive technologies, and simplifying the motor selection criteria for fans.	6/22/2019	6/26/2019	6/10/2019	7/1/2019
cf	6.4.5	Adds vacuum insulating glazing to the list of options for reach-in doors in walk-in coolers and freezers.	7/22/2019	8/15/2019	7/19/2019	8/19/2019
cg	Table 9.5.1	Revises Table 9.5.1 Lighting Power Density Allowances Using the Building Area Method.	6/22/2019	6/26/2019	6/10/2019	7/1/2019
ch	3.2; 9.4.1.1 (e)	Clarifies daylighted area requirements as they relate to skylights and clarifies primary sidelighting requirements.	6/22/2019	6/26/2019	6/10/2019	6/27/2019
ci	Table 4.2.1.1	Further revises Table 4.2.1.1 Building Performance Factor (BPF).	6/22/2019	6/26/2019	6/10/2019	7/1/2019
cj	Table 11.5.1.6; Table G3.1.6; Table G3.7	Revises the energy cost budget method in reference to lighting.	6/22/2019	6/26/2019	6/10/2019	7/1/2019
cl	3.2; 11; Appendix G	Clarifies requirements throughout Section 11 to better align with Appendix G providing greater consistency between the two sections.	6/26/2019	8/1/2019	7/19/2019	8/26/2019
cm	6.5.2.1	Revises exceptions related to DDC enabled zones.	7/22/2019	8/15/2019	7/19/2019	8/19/2019
cn	6.4, 6.4.1.1, 6.4.5m; Tables 6.8.1-18, 19, & 20.	Cleans up outdated language regarding walk-in cooler and walk-in freezer requirements, and make the requirements consistent with current federal regulations that either already came into effect June 5, 2017 or will come into effect July 10, 2020. Adds new section 6.4.5m and Tables 6.8.1-18, 19, & 20.	6/22/2019	6/26/2019	6/10/2019	7/1/2019
co	12	Revises the normative references in Standard 90.1.	6/22/2019	6/26/2019	6/10/2019	7/1/2019
cq	3.2; 6.4.1.2, 6.5.3.1.3	Makes clarifications ensure that the maximum fan power input is properly reported for installations both inside and outside the United States. Adds sections 6.4.1.3 and 6.5.3.1.3.	7/22/2019	8/15/2019	7/19/2019	8/19/2019
cs	Appendix E	Revises the informative references of the Informative Appendix E.	NA	NA	NA	NA
ct	12	Updates the CTI normative reference in Standard 90.1.	7/22/2019	8/15/2019	7/19/2019	8/19/2019

cu	6.4.1.1, 6.4.1.5, Table 6.8.1-8	Revises requirements for liquid-to-liquid heat exchangers.	7/22/2019	8/15/2019	7/19/2019	8/19/2019
cv	9.4.1.2	Updates lighting control requirements for parking garages in section 9.4.1.2.	6/26/2019	8/1/2019	7/19/2019	8/26/2019
cw	9.4.1.1(e), 9.4.1.1(f)	Revises the daylight responsiveness requirements to continuous dimming.	6/26/2019	8/1/2019	7/19/2019	8/26/2019
cy	9.4.1(e)	Revises the sidelighting requirement exceptions.	7/22/2019	8/15/2019	7/19/2019	8/19/2019

#### NOTE

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a. \*These descriptions may not be complete and are provided for information only.

## **POLICY STATEMENT DEFINING ASHRAE'S CONCERN FOR THE ENVIRONMENTAL IMPACT OF ITS ACTIVITIES**

ASHRAE is concerned with the impact of its members' activities on both the indoor and outdoor environment. ASHRAE's members will strive to minimize any possible deleterious effect on the indoor and outdoor environment of the systems and components in their responsibility while maximizing the beneficial effects these systems provide, consistent with accepted Standards and the practical state of the art.

ASHRAE's short-range goal is to ensure that the systems and components within its scope do not impact the indoor and outdoor environment to a greater extent than specified by the Standards and Guidelines as established by itself and other responsible bodies.

As an ongoing goal, ASHRAE will, through its Standards Committee and extensive Technical Committee structure, continue to generate up-to-date Standards and Guidelines where appropriate and adopt, recommend, and promote those new and revised Standards developed by other responsible organizations.

Through its *Handbook*, appropriate chapters will contain up-to-date Standards and design considerations as the material is systematically revised.

ASHRAE will take the lead with respect to dissemination of environmental information of its primary interest and will seek out and disseminate information from other responsible organizations that is pertinent, as guides to updating Standards and Guidelines.

The effects of the design and selection of equipment and systems will be considered within the scope of the system's intended use and expected misuse. The disposal of hazardous materials, if any, will also be considered.

ASHRAE's primary concern for environmental impact will be at the site where equipment within ASHRAE's scope operates. However, energy source selection and the possible environmental impact due to the energy source and energy transportation will be considered where possible. Recommendations concerning energy source selection should be made by its members.

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### **About ASHRAE**

Founded in 1894, ASHRAE is a global professional society committed to serve humanity by advancing the arts and sciences of heating, ventilation, air conditioning, refrigeration, and their allied fields.

As an industry leader in research, standards writing, publishing, certification, and continuing education, ASHRAE and its members are dedicated to promoting a healthy and sustainable built environment for all, through strategic partnerships with organizations in the HVAC&R community and across related industries.

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### **IMPORTANT NOTICES ABOUT THIS STANDARD**

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