

STANDARD

ANSI/ASHRAE/IES Standard 90.1-2016
(Supersedes ANSI/ASHRAE/IES Standard 90.1-2013)
Includes ANSI/ASHRAE/IES addenda listed in Appendix H

Energy Standard for Buildings Except Low-Rise Residential Buildings (I-P Edition)

See Appendix H for approval dates by the ASHRAE Standards Committee, the ASHRAE Board of Directors, the IES Board of Directors, and the American National Standards Institute.

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NOTE

Approved addenda, errata, or interpretations for this standard can be downloaded free of charge from the ASHRAE website at www.ashrae.org/technology.

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Foreword

Standard 90.1 was first published originally in 1975, and revised editions followed in 1980, 1989, and 1999 following ANSI and ASHRAE periodic maintenance procedures. In this way, the standard was publicly reviewed and published in its entirety each time. As energy prices and technology began changing more rapidly, the ASHRAE Board of Directors voted in 1999 to place the standard on continuous maintenance, which permitted the standard to be updated several times each year through publication of approved addenda. As of the 2001 edition, the standard is now published in its entirety in the fall of every third year. This schedule allows the standard to be submitted for inclusion or reference in model building and energy codes. All approved addenda and errata are included in the new edition. This procedure allows users some certainty of the timing of publication.

The 2016 edition of the standard includes numerous energy-saving measures resulting from continuous maintenance proposals submitted by the public and from volunteers on the committee. The Project Committee welcomes suggestions for improvement, and users are encouraged to use the continuous maintenance proposal (CMP) form included in the back of this standard to submit recommended changes. The committee takes formal action on every CMP received.

More than 125 addenda to the 2013 edition of the standard were processed by the committee and approved by the ASHRAE and IES Boards of Directors and are incorporated into the 2016 edition. [Appendix H](#) gives brief descriptions and publication dates of these addenda. The 2016 edition also corrects all known typographical errors in the 2013 standard.

This new edition includes format changes to improve usability and readability:

- a. One-column format for easier reading*
- b. Exceptions separated, indented, and set apart with a smaller font size*
- c. Italicized defined terms*
- d. Changes to table formats to provide contrast between rows*

Additional structural changes include the following:

- a. A new Reference Standard Reproduction Annex 1 is provided at the end of the document. Section [5.1.4](#) now cites ASHRAE Standard 169 as the source for climatic data, and Annex 1 contains extracts of tables and figures from that standard for the reader's convenience.*
- b. Two new climate zones (0A/B) have been added to all prescriptive requirements tables.*

The most significant technical changes included are as follows:

- a. **Building Envelope***

- 1. Mandatory provisions include the addition of envelope verification in support of reduced air infiltration and increased requirements for air leakage of overhead coiling doors.*
- 2. Prescriptive requirements include increased stringency requirements for metal building roofs and walls, fenestration, and opaque doors. Requirements have been added for all assemblies for Climate Zone 0.*

3. *The clarity of the standard has been improved with regard to topics such as defining exterior walls, building orientation, fault assumptions for the effective R-value of air spaces, and calculation procedures for insulating metal building walls.*

b. Lighting

1. *Requirements for exterior and interior lighting power densities have been modified to reflect new lighting levels in the IES lighting handbook, which recognizes that LED technology is a common application in current lighting design and can provide additional energy savings.*
2. *Lighting control requirements have been modified to add additional controls in some space types and options to others to allow easier application of advanced controls.*

c. Mechanical

1. *Chilled-water plant metering. Large, electric-driven chilled-water plants are now required to be monitored for electric energy use and efficiency.*
2. *DOAS requirements. Dedicated outdoor air systems now include both efficiency and rating requirements for compliance.*
3. *Elevator efficiency. Requirements are introduced for designs to include both use category and efficiency class. While a minimum threshold is not listed, the first step is taken toward including minimum elevator efficiency requirement in a future standard.*
4. *Economizer diagnostics. The standard now requires that air-cooled DX cooling units with economizers have a monitoring system to determine that the air economizer is working properly.*

d. Energy Cost Budget (ECB) and Modeling. *Significant changes to the application of [Appendix G](#) are included as follows:*

1. *[Appendix G](#) now can be used as a path for compliance with the standard. Previously, [Appendix G](#) was used only to rate beyond-code performance of buildings. This new version of [Appendix G](#) can show compliance with the 2016 version of the standard in the following manner:*
 - (a) *The proposed design requires computation of a new metric, Performance Cost Index (PCI), and demonstration that it is less than that shown in Table [4.2.1.1](#), based on building type and climate zone.*
 - (b) *The baseline design is now fixed at a certain level of performance, the stringency or baseline of which is expected not to change with subsequent versions of the standard. In this way, a building of any era can be rated using the same method.*
2. *Other modifications to [Appendix G](#) include changes to elevator, motor, and refrigeration baselines; changes to the baseline for existing building projects; and changes to specific opaque assemblies for the baseline envelope model. Modeling rule changes were made to heat pump auxiliary heat, economizer shutoff, lighting controls, humidification systems, cooling towers, and the simulation of preheat coils.*

Standard 90.1 is a fluid document. As technology evolves, the project committee is continually considering new changes and proposing addenda for public review. When addenda are approved, notices are published on the ASHRAE and IES websites. Users are encouraged to sign up for the free ASHRAE and IES Internet listserv for this standard to receive notice of all public reviews and approved and published addenda and errata.

The Chair and Vice-Chairs extend grateful thanks to the committee volunteers, public review commenters, and all involved in the open, consensus-based process.

1 Purpose

1.1

To establish the minimum *energy efficiency* requirements of *buildings* other than *low-rise residential buildings* for

- a. design, *construction*, and a plan for operation and maintenance; and
- b. utilization of on-site, renewable *energy* resources.

2 Scope

2.1

This standard provides

- a. minimum *energy*-efficient requirements for the design and *construction*, and a plan for operation and maintenance of
 - 1. new *buildings* and their *systems*,
 - 2. new portions of *buildings* and their *systems*,
 - 3. new *systems* and *equipment* in *existing buildings*, and
 - 4. new *equipment* or *building systems* specifically identified in the standard that are part of industrial or manufacturing processesand
- b. criteria for determining compliance with these requirements.

2.2

The provisions of this standard do not apply to

- a. single-family houses, multifamily structures of three stories or fewer above *grade*, manufactured houses (mobile homes), and manufactured houses (modular) or
- b. *buildings* that use neither electricity nor *fossil fuel*.

2.3

Where specifically noted in this standard, certain other *buildings* or elements of *buildings* shall be exempt.

2.4

This standard shall not be used to circumvent any safety, health, or environmental requirements.

3 Definitions, Abbreviations, and Acronyms

3.1 General

Certain terms, abbreviations, and acronyms are defined in this section for the purposes of this standard. These definitions are applicable to all sections of this standard. Terms that are not defined shall have their ordinarily accepted meanings within the context in which they are used. Ordinarily accepted meanings shall be based on American standard English language usage as documented in an unabridged dictionary accepted by the *adopting authority*.

Informative Note

Throughout the standard, words that have definitions in this section are italicized.

3.2 Definitions

A

above-grade wall: see *wall*.

access hatch: see *door*.

addition: an extension or increase in *floor* area or height of a *building* outside of the *existing building envelope*.

adopting authority: the agency or agent that adopts this standard.

air economizer: see *economizer, air*.

air system balancing: see *balancing, air system*.

alteration: a replacement or addition to a *building* or its *systems* and *equipment*; routine maintenance, *repair*, and *service*, or a change in the *building's* use classification or category shall not constitute an *alteration*.

annual fuel utilization efficiency (AFUE): an *efficiency* descriptor of the ratio of annual output *energy* to annual input *energy* as developed in accordance with the requirements of U.S. Department of Energy (DOE) 10 CFR Part 430.

attic and other roofs: see *roof*.

authority having jurisdiction: the agency or agent responsible for enforcing this standard.

automatic: self-acting, operating by its own mechanism when actuated by some nonmanual influence, such as a change in current strength, pressure, temperature, or mechanical configuration.

automatic control device: a device capable of automatically turning loads off and on without *manual* intervention.

B

balancing, air system: adjusting airflow rates through air *distribution system* devices, such as fans and diffusers, by manually adjusting the position of dampers, splitter vanes, extractors, etc., or by using *automatic control devices*, such as constant-air-volume or variable-air-volume (*VAV*) boxes.

balancing, hydronic system: adjusting water flow rates through hydronic *distribution system* devices, such as pumps and coils, by manually adjusting the position valves or by using *automatic control devices*, such as *automatic flow control* valves.

ballast: a device used in conjunction with an electric-discharge *lamp* to cause the *lamp* to start and operate under the proper circuit conditions of voltage, current, wave form, electrode heat, etc.

baseline building design: a computer representation of a hypothetical design based on the proposed design. This representation is used as the basis for calculating the *baseline building performance* for rating above-standard design or when using the *performance rating method* as an alternative path for minimum standard compliance in accordance with Section [4.2.1.1](#).

baseline building performance: the annual *energy* cost for a *building* design intended for use as a baseline for rating above-standard design or when using the *performance rating method* as an alternative path for minimum standard compliance in accordance with Section [4.2.1.1](#).

below-grade wall: see *wall*.

boiler: a self-contained, low-pressure appliance for supplying steam or hot water.

modulating boiler: a *boiler* that is capable of more than a single firing rate in response to a varying temperature or heating load.

packaged boiler: a *boiler* that is shipped complete with heating *equipment*, mechanical draft *equipment*, and *automatic controls*, and that is usually shipped in one or more sections. A *packaged boiler* includes factory-built *boilers* manufactured as a unit or *system*, disassembled for shipment, and reassembled at the site.

boiler system: one or more *boilers* and their *piping* and *controls* that work together to supply steam or hot water to heat output devices remote from the *boiler*.

branch circuit: the circuit conductors between the final *overcurrent* device protecting the circuit and the outlets; the final wiring run to the load.

bubble point: the refrigerant liquid saturation temperature at a specified pressure.

budget building design: a computer representation of a hypothetical design based on the actual *proposed design*. This representation is used as the basis for calculating the *energy cost budget*.

building: any structure used or intended for supporting or sheltering any use or occupancy.

building entrance: any doorway, set of *doors*, revolving *door*, vestibule, or other form of portal that is ordinarily used to gain access to the *building* or to exit from the *building* by its users and occupants. This does not include *doors* solely used to directly enter mechanical, electrical, and other *building utility service equipment* rooms.

building envelope: the exterior plus the semiexterior portions of a *building*. For the purposes of determining *building envelope* requirements, the classifications are defined as follows:

exterior building envelope: the elements of a *building* that separate *conditioned spaces* from the exterior.

semiexterior building envelope: the elements of a *building* that separate *conditioned space* from *unconditioned space* or that enclose *semiheated spaces* through which thermal energy may be transferred to or from the exterior, to or from *unconditioned spaces*, or to or from *conditioned spaces*.

building envelope trade-off schedules and loads: the schedules and internal loads¹, by *building* area type, to be used in the *building envelope* trade-off option simulations described in [Appendix C](#).

building exit: any doorway, set of *doors*, or other form of portal that is ordinarily used only for emergency egress or convenience exit.

1. Schedules and internal loads by *building* area type are at <http://sspc901.ashraepcs.org/content.html>.

building grounds lighting: lighting provided through a *building's* electrical *service* for parking lot, site, roadway, pedestrian pathway, loading dock, or security applications.

building material: any element of the *building envelope*, other than air films and insulation, through which heat flows and that is included in the component *U-factor* calculations.

building official: the officer or other designated *authority having jurisdiction* charged with the administration and enforcement of this standard, or a duly authorized representative.

C

C-factor: see *thermal conductance*.

circuit breaker: a device designed to open and close a circuit by *nonautomatic* means and to open the circuit automatically at a predetermined *overcurrent* without damage to itself when properly applied within its rating.

class of construction: for the *building envelope*, a subcategory of *roof*, *above-grade wall*, *below-grade wall*, *floor*, *slab-on-grade floor*, *opaque door*, *vertical fenestration*, or *skylight*. (See *roof*, *wall*, *floor*, *slab-on-grade floor*, *door*, and *fenestration*.)

code official: see *building official*.

coefficient of performance (COP)—cooling: the ratio of the rate of heat removal to the rate of *energy* input, in consistent units, for a complete refrigerating *system* or some specific portion of that *system* under designated operating conditions.

coefficient of performance (COP), heat pump—heating: the ratio of the rate of heat delivered to the rate of *energy* input, in consistent units, for a complete heat pump *system*, including the compressor and, if applicable, auxiliary heat, under designated operating conditions.

computer room: a room whose primary function is to house *equipment* for the processing and storage of electronic data and that has a design electronic data *equipment* power density exceeding 20 W/ft² of conditioned *floor area*.

computer room energy: annual *energy* use of the data center, including all *IT equipment energy*, plus *energy* that supports the *IT equipment* and *computer room space*, calculated in accordance with industry-accepted standards defined as Total Annual *Energy* (see Informative [Appendix E](#)).

condensing unit: a factory-made assembly of refrigeration components designed to compress and liquefy a specific refrigerant. It consists of one or more refrigerant compressors, refrigerant condensers (air-cooled, evaporatively cooled, and/or water-cooled), condenser fans and motors (where used), and factory-supplied accessories.

conditioned floor area, gross: see *floor area, gross*.

conditioned space: see *space*.

conductance: see *thermal conductance*.

construction: the fabrication and erection of a new *building* or any addition to or *alteration* of an existing *building*.

construction documents: drawings and specifications used to construct a *building*, *building systems*, or portions thereof.

continuous air barrier: the combination of interconnected materials, assemblies, and sealed joints and components of the *building envelope* that minimize air leakage into or out of the *building envelope*.

continuous daylight dimming: method of *automatic lighting control* using daylight *photo-sensors*, where the lights are dimmed continuously, or using at least four preset levels with at least a five-second fade between levels, where the *control* turns the lights off when sufficient daylight is available.

continuous insulation (c.i.): insulation that is uncompressed and continuous across all structural members without thermal bridges other than fasteners and service openings. It is installed on the interior or exterior or is integral to any *opaque* surface of the *building envelope*.

control: to regulate the operation of *equipment*.

control device: a specialized device used to regulate the operation of *equipment*.

cooldown: reduction of *space* temperature down to occupied *set point* after a period of shut-down or setup.

cooled space: see *space, conditioned space*.

cooling degree-day, base (CDD): see *degree-day*.

cooling design temperature: the outdoor dry-bulb temperature equal to the temperature that is exceeded by 1% of the number of hours during a typical weather year.

cooling design wet-bulb temperature: the mean coincident outdoor wet-bulb temperature utilized in conjunction with the cooling design dry-bulb temperature, often used for the sizing of cooling *systems*.

critical circuit: the hydronic circuit that determines the minimum differential pressure that the pump must produce to satisfy the zone loads (e.g., the circuit with the most-open valve). The *critical circuit* is the one with the highest pressure drop required to satisfy its load. At part-load conditions, the *critical circuit* can change based on zone loads.

D

daylight area:

daylight area under roof monitors: the *daylight area under roof monitors* is the combined *daylight area* under each *roof monitor* within each *space*. The *daylight area* under each *roof monitor* is the product of

- a. the width of the *vertical fenestration* above the ceiling level plus, on each side, the smallest of
 1. 2 ft,
 2. the distance to any 5 ft or higher vertical obstruction, or
 3. the distance to the edge of any *primary sidelighted area*

and

- b. the smaller of the following horizontal distances inward from the bottom edge of the *vertical fenestration* (see Figure 3.2-1):
 1. The monitor sill height (MSH) (the vertical distance from the *floor* to the bottom edge of the monitor glazing).
 2. The distance to the nearest face of any *opaque* vertical obstruction, where any part of the obstruction is farther away than the difference between the height of the obstruction and the monitor sill height (MSH – OH).

daylight area under skylights: the *daylight area under skylights* is the combined *daylight area* under each *skylight* within a *space*. The *daylight area* under each *skylight* is bounded by the opening beneath the *skylight* and horizontally in each direction (see Figure 3.2-2), the smaller of

- a. 70% of the ceiling height ($0.7 \times CH$) or
- b. the distance to the nearest face of any *opaque* vertical obstruction, where any part of the obstruction is farther away than 70% of the distance between the top of the obstruction and the ceiling ($0.7 \times [CH - OH]$, where CH = the height of the ceiling at the lowest edge of the *skylight* and OH = the height to the top of the obstruction).

primary sidelighted area: the total *primary sidelighted area* is the combined *primary sidelighted area* within each *space*. Each *primary sidelighted area* is directly adjacent to *vertical fenestration* below the ceiling (see Figure 3.2-3).

- a. The *primary sidelighted area* width is the width of the *vertical fenestration* plus, on each side, the smaller of
 - 1. one half of the *vertical fenestration* head height (where head height is the distance from the *floor* to the top of the glazing) or
 - 2. the distance to any 5 ft or higher *opaque* vertical obstruction.
- b. The *primary sidelighted area* depth is the horizontal distance perpendicular to the *vertical fenestration*, which is the smaller of
 - 1. one *vertical fenestration* head height or
 - 2. the distance to any 5 ft or higher *opaque* vertical obstruction.

secondary sidelighted area: the total *secondary sidelighted area* is the combined *secondary sidelighted area* within a *space*. Each *secondary sidelighted area* is directly adjacent to a *primary sidelighted area* (see Figure 3.2-4):

- a. The *secondary sidelighted area* width is the width of the *vertical fenestration* plus, on each side, the smaller of
 - 1. one half of the *vertical fenestration* head height or
 - 2. the distance to any 5 ft or higher *opaque* vertical obstruction.
- b. The *secondary sidelighted area* depth is the horizontal distance perpendicular to the *vertical fenestration*, which begins at the edge of the *primary sidelighted area* depth and ends at the smaller of
 - 1. one *vertical fenestration* head height or
 - 2. the distance to any 5 ft or higher *opaque* vertical obstruction.

If the adjacent *primary sidelighted area* ends at a 5 ft or higher *opaque* vertical obstruction, there is no *secondary sidelighted area* beyond such obstruction.

daylighted area: the *floor* area substantially illuminated by daylight.

dead band: the range of values within which a sensed variable can vary without initiating a change in the controlled process.

decorative lighting: see *lighting, decorative*.

dedicated replacement air: see *makeup air*.

degree-day: the difference in temperature between the outdoor *mean temperature* over a twenty-four-hour period and a given base temperature. The classifications are defined as follows:

cooling degree-day base 50°F (CDD50): for any one day, when the *mean temperature* is more than 50°F, there are as many *degree-days* as degrees Fahrenheit temperature difference between the *mean temperature* for the day and 50°F. Annual *cooling degree-days* (CDDs) are the sum of the *degree-days* over a calendar year.

heating degree-day base 65°F (HDD65): for any one day, when the *mean temperature* is less than 65°F, there are as many *degree-days* as degrees Fahrenheit temperature difference between the *mean temperature* for the day and 65°F. Annual *heating degree-days* (HDDs) are the sum of the *degree-days* over a calendar year.

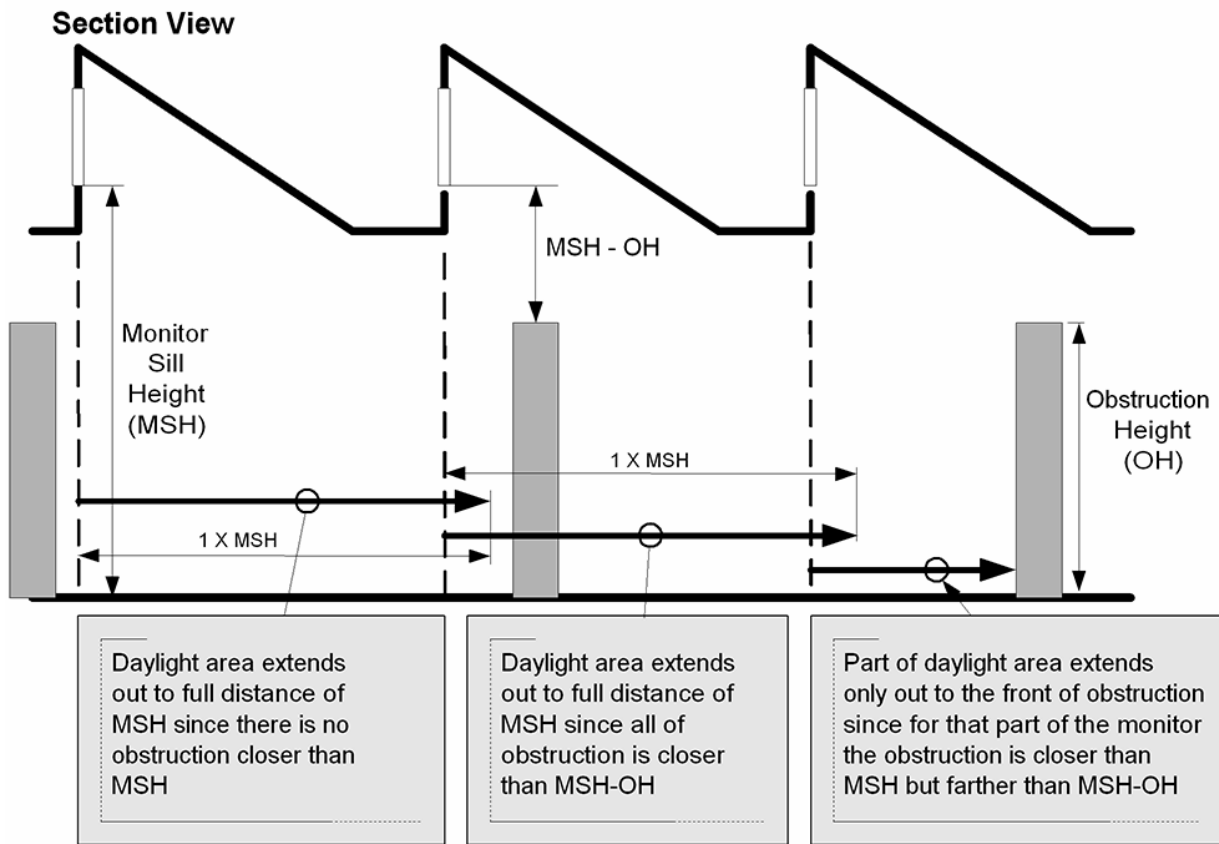
demand: the highest amount of power (average Btu/h over an interval) recorded for a *building* or facility in a selected time frame.

demand control ventilation (DCV): a *ventilation system* capability that provides for the *automatic* reduction of *outdoor air* intake below design rates when the actual occupancy of *spaces* served by the *system* is less than design occupancy.

design capacity: output capacity of a *system* or piece of *equipment* at *design conditions*.

design conditions: specified environmental conditions, such as temperature and light intensity, required to be produced and maintained by a *system* and under which the *system* must operate.

design energy cost: the annual *energy* cost calculated for a *proposed design*.



Plan View

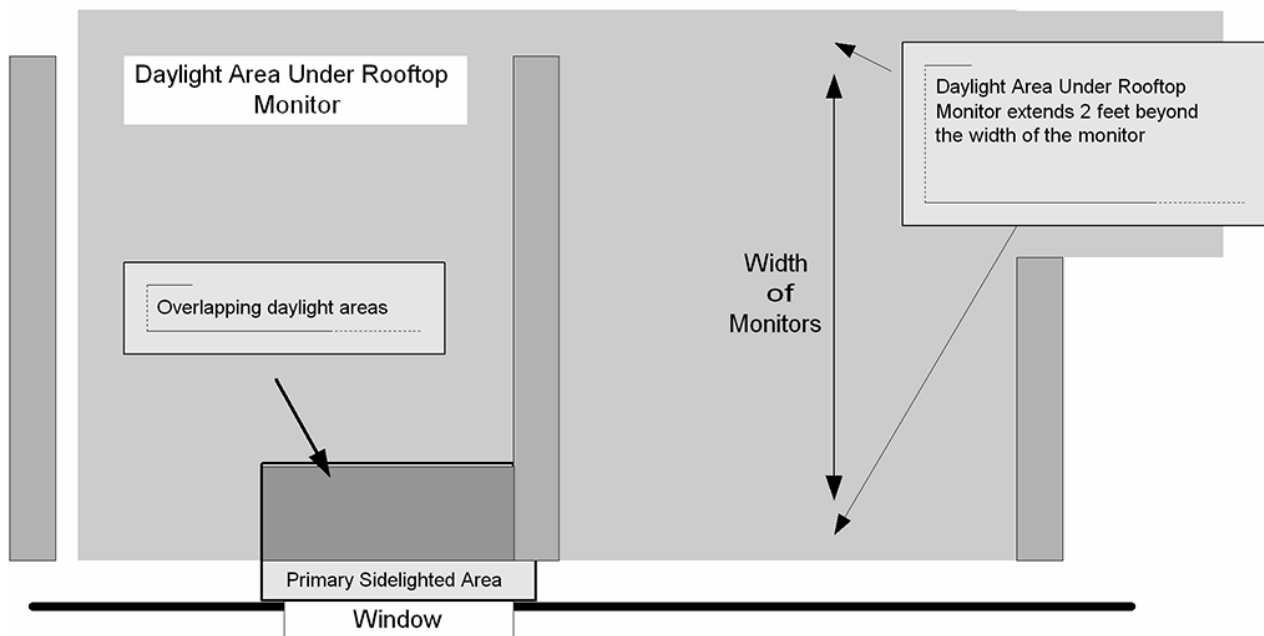


Figure 3.2-1 Computing the *daylight area under roof monitors*.

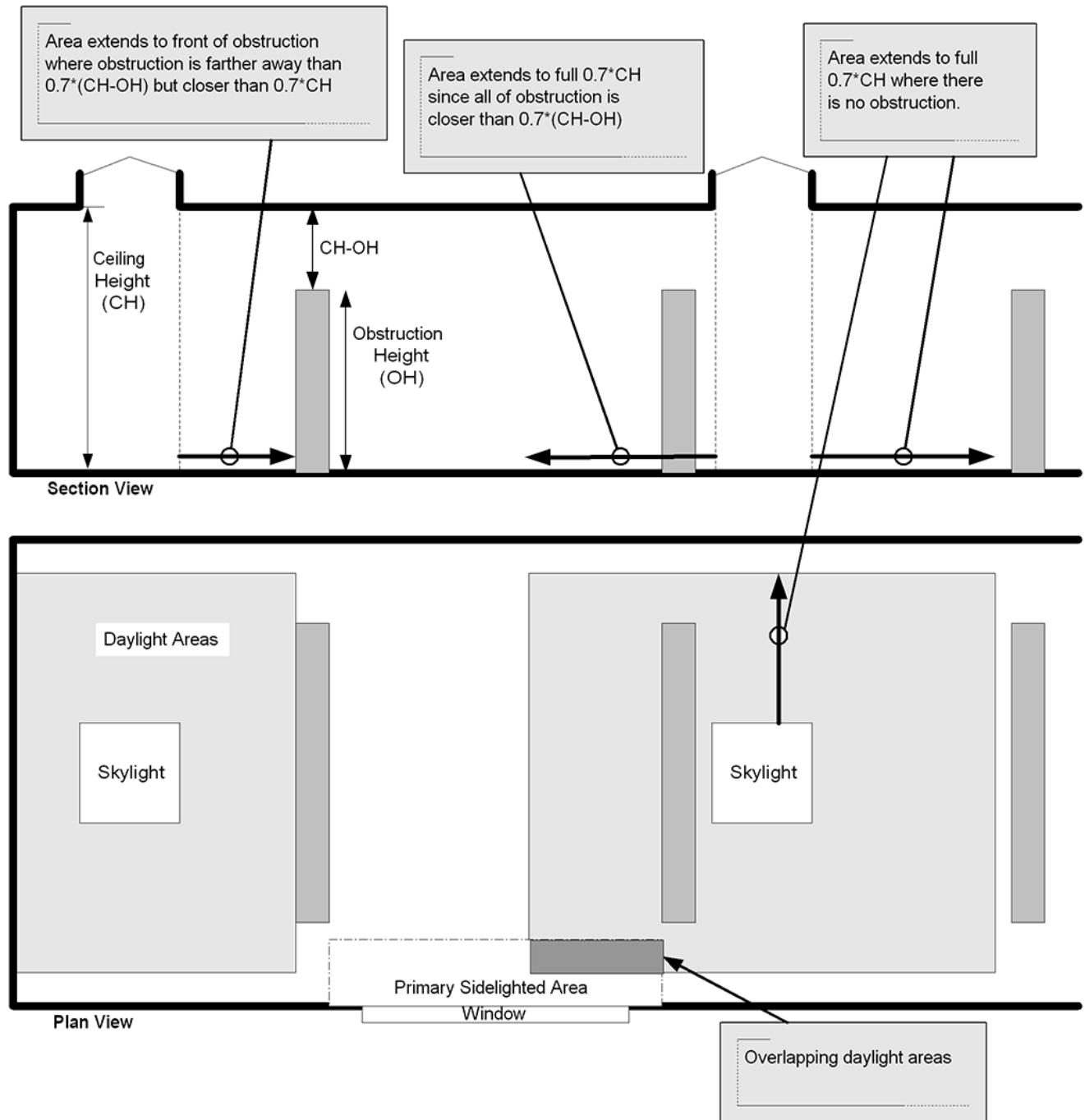


Figure 3.2-2 Computing the *daylight area under skylights*.

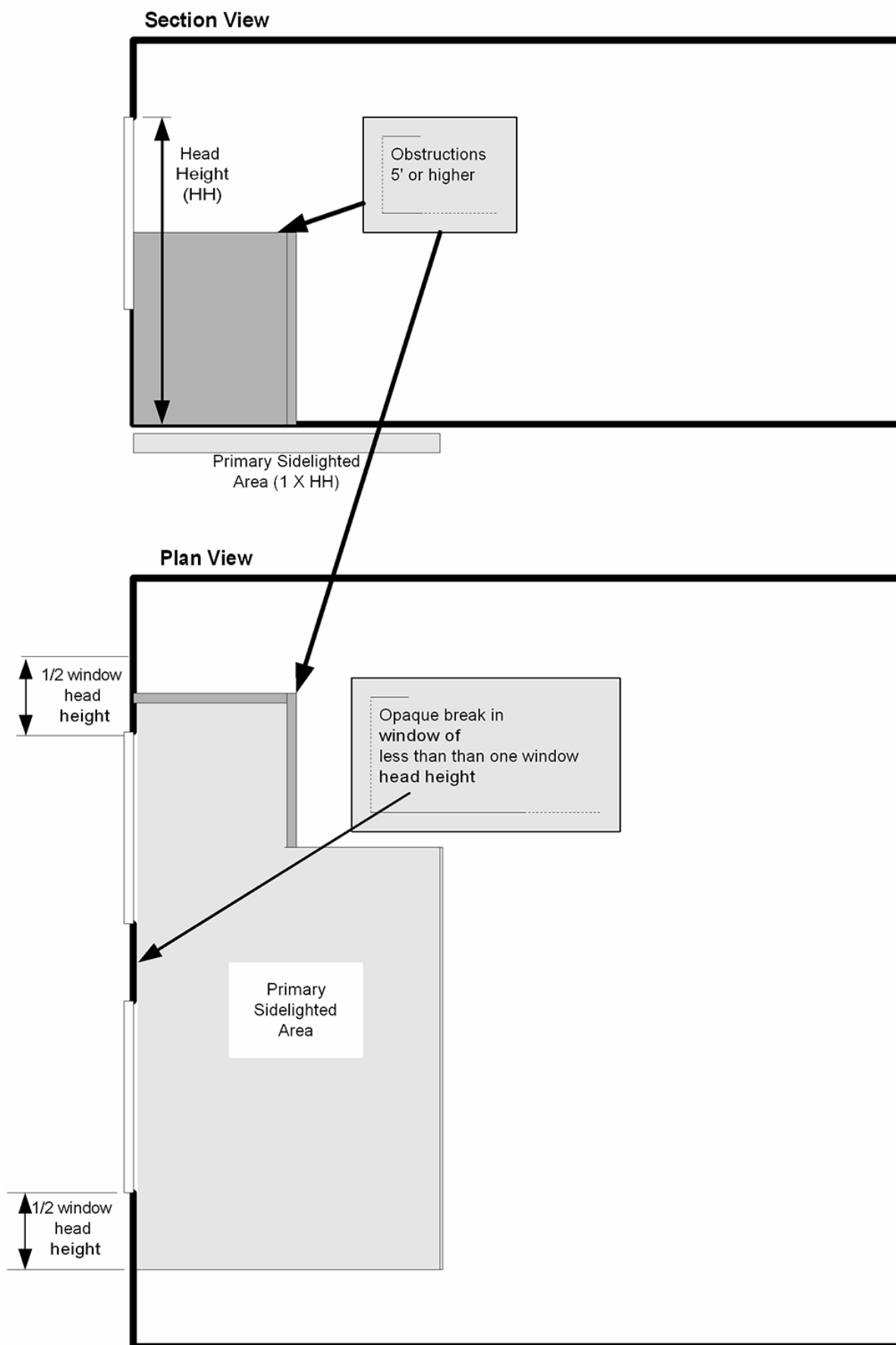


Figure 3.2-3 Computing the *primary sidelighted area*.

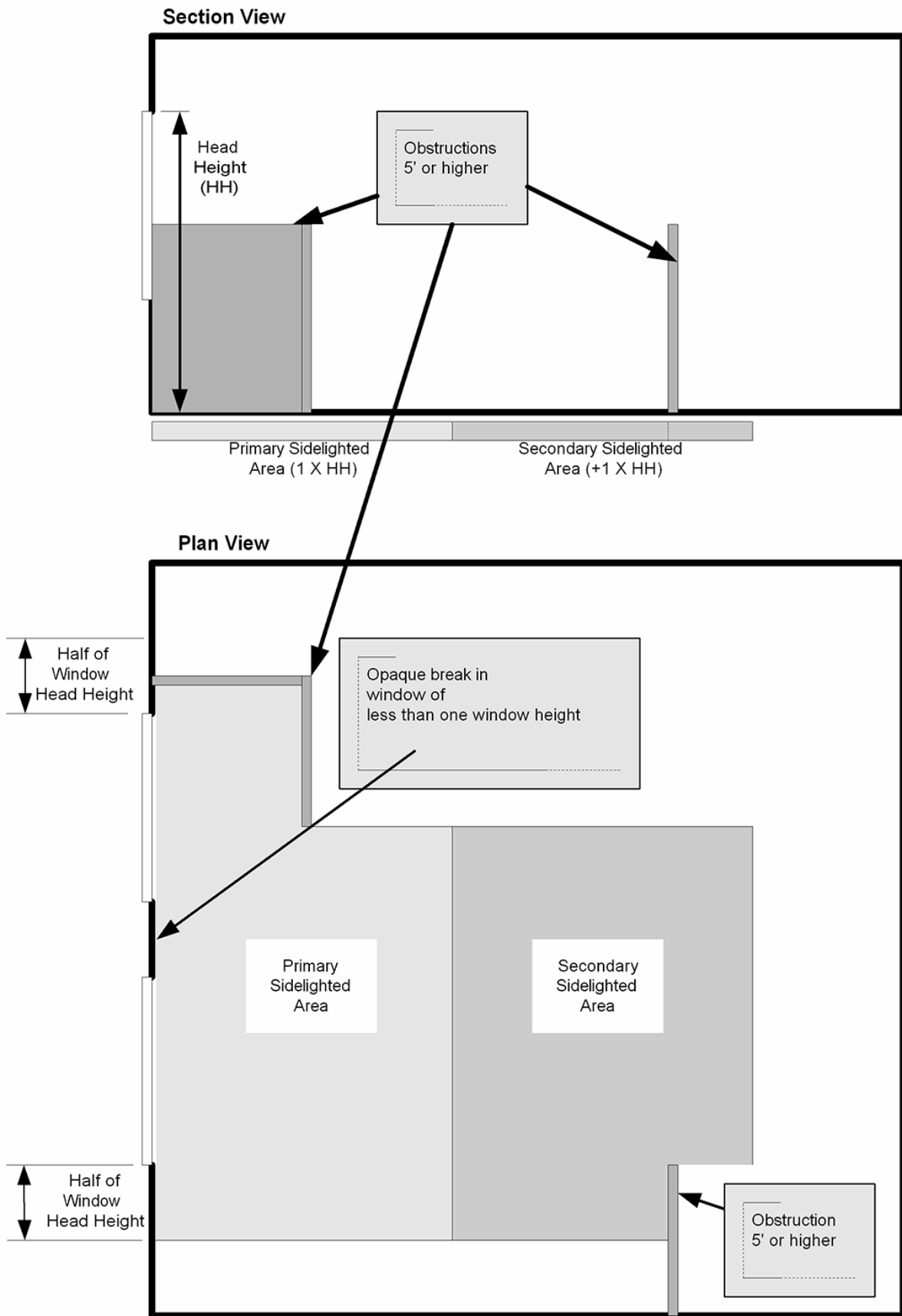


Figure 3.2-4 Computing the *secondary sidelighted area*.

design professional: an architect or engineer licensed to practice in accordance with applicable state licensing laws.

dimmer: a lighting *control device* that is capable of varying the light output and *energy* usage of light sources.

direct digital control (DDC): a type of *control* where controlled and monitored analog or binary data (e.g., temperature, contact closures) are converted to digital format for manipulation and calculations by a digital computer or microprocessor and then converted back to analog or binary form to *control* physical devices.

distribution system: conveying means, such as ducts, pipes, and wires, to bring substances or *energy* from a source to the point of use. The *distribution system* includes such auxiliary *equipment* as fans, pumps, and *transformers*.

door (access hatch): all *operable* opening areas (that are not *fenestration*) in the *building envelope*, including swinging and roll-up *doors*, fire *doors*, and *access hatches*. *Doors* that are more than one-half glass are considered *fenestration* (see *fenestration*). For the purposes of determining *building envelope* requirements, the classifications are defined as follows:

metal coiling door: an upward-acting, *nonswinging door* assembly consisting of interlocking horizontal slats or sheets that, upon opening the *door*, roll up around a horizontal barrel above the *door* opening.

nonswinging door: roll-up, metal coiling, sliding, and all other *doors* that are not *swinging doors*.

swinging door: all *operable opaque* panels with hinges on one side and *opaque revolving doors*.

door area: total area of the *door* measured using the rough opening and including the *door* slab and the frame. (See *fenestration area*.)

driver: a device designed to operate a solid-state (e.g., LED) light source.

ductwork: a *system* of ducts for distribution and extraction of air.

dwelling unit: a single unit providing complete independent living facilities for one or more persons, including permanent provisions for living, sleeping, eating, cooking, and sanitation.

DX-dedicated outdoor air system units (DX-DOAS units): a type of air-cooled, water-cooled, or water source factory assembled product that dehumidifies 100% *outdoor air* to a low dew point and includes *reheat* that is capable of controlling the supply dry-bulb temperature of the dehumidified air to the designed supply air temperature. This conditioned *outdoor air* is then delivered directly or indirectly to the *conditioned spaces*. It may precondition *outdoor air* by containing an enthalpy wheel, sensible wheel, desiccant wheel, plate heat exchanger, heat pipes, or other heat or mass transfer apparatus.

dynamic glazing: any glazing *system*/glazing infill that has the fully reversible ability to change its performance properties, including *U-factor*, *solar heat gain coefficient*, or *visible transmittance*. This includes, but is not limited to, shading *systems* between the glazing layers and chromogenic glazing.

E

economizer, air: a duct and damper arrangement and *automatic control system* that together allow a cooling *system* to supply *outdoor air* to reduce or eliminate the need for *mechanical cooling* during mild or cold weather.

economizer, fluid: a *system* by which the supply air of a cooling *system* is cooled indirectly with a fluid that is itself cooled by heat or mass transfer to the environment without the use of *mechanical cooling*. Examples of commonly used fluids are water, glycol mixtures, and refrigerants.

effective panel surface: see *thermally effective panel surface*.

efficacy (of a lamp): the ratio of the total luminous output of a *lamp* to the total power input to the *lamp*, typically expressed in lm/W.

efficiency: performance at specified rating conditions.

electric resistance: see *resistance, electric*.

emittance: the ratio of the radiant heat flux emitted by a specimen to that emitted by a black-body at the same temperature and under the same conditions.

enclosed space: a volume substantially surrounded by solid surfaces, such as *walls, floors, roofs*, and openable devices, such as *doors* and *operable* windows.

energy: the capacity for doing work. It takes a number of forms that may be transformed from one into another such as thermal (heat), mechanical (work), electrical, and chemical (Btu).

energy cost budget: the annual *energy* cost for the *budget building design* intended for use in determining minimum compliance with this standard.

energy efficiency ratio (EER): the ratio of net cooling capacity (Btu/h) to total rate of electric input in watts under designated operating conditions. (See *coefficient of performance [COP]—cooling*.)

energy factor (EF): a measure of *water heater* overall *efficiency*.

enthalpy recovery ratio: change in the enthalpy of the *outdoor air* supply divided by the difference between the *outdoor air* and entering exhaust air enthalpy, expressed as a percentage.

entrance door: see *fenestration*.

envelope performance factor: the trade-off value for the *building envelope* performance compliance option calculated using the procedures specified in Section 5.6. For the purposes of determining *building envelope* requirements, the classifications are defined as follows:

base envelope performance factor: the *building envelope performance factor* for the base design.

proposed envelope performance factor: the *building envelope performance factor* for the *proposed design*.

equipment: devices for comfort conditioning, electric power, lighting, transportation, or *service water heating*, including but not limited to furnaces, *boilers*, air conditioners, heat pumps, chillers, *water heaters*, *lamps*, *luminaires*, *ballasts*, elevators, escalators, or other devices or installations.

essential facility: those portions of a *building* serving one of the following functions:

- a. Hospitals and other health care facilities having surgery or emergency treatment facilities
- b. Fire, rescue, and police stations and emergency vehicle garages
- c. Designated earthquake, hurricane, or other emergency shelters
- d. Designated emergency preparedness, communication, and operation centers and other facilities required for emergency response
- e. Power-generating stations and other public utility facilities required as emergency backup facilities for other *essential facilities*
- f. Structures containing highly toxic materials where the quantity of the material exceeds the maximum allowable quantities
- g. Aviation *control* towers, air traffic *control* centers, and emergency aircraft hangars
- h. Buildings and other structures having critical national defense functions

evaporation design wet-bulb temperature: the outdoor wet-bulb temperature utilized in conjunction with the mean coincident dry-bulb temperature, often used for the sizing of evaporative *systems* such as cooling towers.

existing building: a *building* or portion thereof that was previously occupied or approved for occupancy by the *authority having jurisdiction*.

existing equipment: *equipment* previously installed in an *existing building*.

existing system: a *system* or *systems* previously installed in an *existing building*.

exterior building envelope: see *building envelope*.

exterior lighting power allowance: see *lighting power allowance, exterior*.

exterior wall: see *building envelope* and *wall*.

eye adaptation: the process by which the retina becomes accustomed to more or less light than it was exposed to during an immediately preceding period. It results in a change in the sensitivity to light.

F

F-factor: the perimeter heat loss factor for *slab-on-grade floors* (Btu/h·ft·°F).

façade area: area of the *façade*, including overhanging soffits, cornices, and protruding columns, measured in elevation in a vertical plane parallel to the plane of the face of the *building*. Nonhorizontal *roof* surfaces shall be included in the calculation of vertical *façade area* by measuring the area in a plane parallel to the surface.

fan brake horsepower (bhp): the horsepower delivered to the fan's shaft. Brake horsepower does not include the mechanical drive losses (belts, gears, etc.).

fan efficiency grade (FEG): the fan *efficiency* without consideration of drives, as defined in AMCA 205.

fan system brake horsepower (bhp): the sum of the *fan brake horsepower* of all fans that are required to operate at *fan system design conditions* to supply air from the heating or cooling source to the *conditioned spaces* and return it to the source or exhaust it to the outdoors.

fan system design conditions: operating conditions that can be expected to occur during normal *system* operation that result in the highest supply airflow rate to *conditioned spaces* served by the *system*, other than during *air economizer* operation.

fan system motor nameplate horsepower (hp): the sum of the motor *nameplate horsepower* of all fans that are required to operate at *design conditions* to supply air from the heating or cooling source to the *conditioned spaces* and return it to the source or exhaust it to the outdoors.

feeder conductors: the wires that connect the *service equipment* to the *branch circuit breaker* panels.

fenestration: all areas (including the frames) in the *building envelope* that let in light, including windows, plastic panels, clerestories, *roof monitors*, *skylights*, *doors* that are more than one-half glass, and glass block *walls*. (See *building envelope* and *door*.)

field-fabricated fenestration: *fenestration* whose frame is made at the *construction* site of materials that were not previously cut, or otherwise formed with the specific intention of being used to fabricate a *fenestration* product or exterior glazed *door*. *Field-fabricated fenestration* does not include site-built *fenestration* designed to be glazed or assembled in the field using specific factory-cut or otherwise factory-formed framing and glazing units, such as storefront *systems*, curtain *walls*, and atrium *roof systems*.

skylight: a *fenestration* surface having a slope of less than 60 degrees from the horizontal plane. Other *fenestration*, even if mounted on the *roof* of a *building*, is considered *vertical fenestration*.

vertical fenestration: all *fenestration* other than *skylights*. Trombe *wall* assemblies, where glazing is installed within 12 in. of a *mass wall*, are considered *walls*, not *fenestration*.

fenestration area: total area of the *fenestration* measured using the rough opening and including the glazing, sash, and frame. For *doors* where the glazed vision area is less than

50% of the *door area*, the *fenestration area* is the glazed vision area. For all other *doors*, the *fenestration area* is the *door area*. (See *door area*.)

fixed: see *vertical fenestration*.

fixture: the component of a *luminaire* that houses the *lamp* or *lamps* or positions the *lamp*, shields it from view, and distributes the light. The *fixture* also provides for connection to the power supply, which may require the use of a *ballast/driver*.

floor: that lower portion of the *building envelope*, including *opaque area* and *fenestration*, that has conditioned or *semiheated space* above and is horizontal or tilted at an angle of less than 60 degrees from horizontal but excluding *slab-on-grade floors*. For the purposes of determining *building envelope* requirements, the classifications are defined as follows:

mass floor: a *floor* with a *heat capacity* that exceeds (a) 7 Btu/ft²·°F or (b) 5 Btu/ft²·°F, provided that the *floor* has a material unit mass not greater than 120 lb/ft³.

steel-joint floor: a *floor* that (a) is not a *mass floor* and (b) has *steel joist* members supported by structural members.

wood-framed and other floors: all other *floor* types, including wood-joint floors.

(See *building envelope*, *fenestration*, *opaque*, and *slab-on-grade floor*).

floor area, gross: the sum of the *floor areas* of the *spaces* within the *building*, including basements, mezzanine and intermediate-floored tiers, and penthouses with a headroom height of 7.5 ft or greater. It is measured from the exterior faces of *walls* or from the center-line of *walls* separating buildings, but excluding covered walkways, open roofed-over areas, porches and similar *spaces*, pipe trenches, exterior terraces or steps, chimneys, *roof overhangs*, and similar features.

gross building envelope floor area: the *gross floor area* of the *building envelope*, but excluding *slab-on-grade floors*.

gross conditioned floor area: the *gross floor area* of conditioned *spaces*.

gross lighted floor area: the *gross floor area* of lighted *spaces*.

gross semiheated floor area: the *gross floor area* of *semiheated spaces*.

(See *building envelope*, *floor*, *slab-on-grade floor*, and *space*.)

flue damper: a device in the flue outlet or in the inlet of or upstream of the draft *control device* of an individual, automatically operated, *fossil-fuel*-fired appliance that is designed to automatically open the flue outlet during appliance operation and to automatically close the flue outlet when the appliance is in a standby condition.

fluid economizer: see *economizer*, *fluid*.

fuel: a material that may be used to produce heat or generate power by combustion.

fossil fuel: *fuel* derived from a hydrocarbon deposit, such as petroleum, coal, or natural gas derived from living matter of a previous geologic time.

G

general lighting: see *lighting*, *general*.

generally accepted engineering standard: a specification, rule, guide, or procedure in the field of engineering, or related thereto, recognized and accepted as authoritative.

grade: the finished ground level adjoining a *building* at all *walls*.

gross floor area: see *floor area*, *gross*.

gross lighted area (GLA): see *floor area*, *gross*.

gross roof area: see *roof area*, *gross*.

gross wall area: see *wall area*, *gross*.

growth media: an engineered formulation of inorganic and organic materials including but not limited to heat-expanded clays, slates, shales, aggregate, sand, perlite, vermiculite, and

organic material including but not limited to compost worm castings, coir, peat, and other organic material.

H

heat capacity (HC): the amount of heat necessary to raise the temperature of a given mass 1°F. Numerically, the *HC* per unit area of surface (Btu/ft²·°F) is the sum of the products of the mass per unit area of each individual material in the *roof*, *wall*, or *floor* surface multiplied by its individual specific heat.

heat trace: a heating *system* where the externally applied heat source follows (traces) the object to be heated (e.g., water *pipng*).

heated space: see *space*.

heating degree-day, base: see *degree-day*.

heating design temperature: the outdoor dry-bulb temperature equal to the temperature that is exceeded at least 99.6% of the number of hours during a typical weather year.

heating seasonal performance factor (HSPF): the total heating output of a heat pump during its normal annual usage period for heating (Btu) divided by the total electric *energy* input during the same period.

historic: a *building* or *space* that has been specifically designated historically significant by the *adopting authority* or is listed in The National Register of *Historic* Places or has been determined to be eligible for such listing by the U.S. Secretary of the Interior.

hot-water supply boiler: a *boiler* used to heat water for purposes other than *space* heating.

humidistat: an *automatic control device* used to maintain humidity at a *fixed* or adjustable *set point*.

HVAC system: the *equipment*, *distribution systems*, and *terminals* that provide, either collectively or individually, the processes of heating, ventilating, or air conditioning to a *building* or portion of a *building*.

HVAC zone: a *space* or group of *spaces* within a *building* with heating and cooling requirements that are sufficiently similar so that desired conditions (e.g., temperature) can be maintained throughout using a single sensor (e.g., *thermostat* or temperature sensor).

hydronic system balancing: see *balancing*, *hydronic system*.

I

IEC Design H motor: an electric motor that

- a. is an induction motor designed for use with three-phase power;
- b. contains a cage rotor;
- c. is capable of direct-on-line starting;
- d. has 4, 6, or 8 poles;
- e. is rated from 0.4 to 1600 *kW* at a frequency of 60 Hz; and
- f. conforms to Sections 8.1, 8.2, and 8.3 of IEC 60034-12, edition 2.1, requirements for starting torque, locked rotor apparent power, and starting.

IEC Design N motor: an electric motor that

- a. is an induction motor designed for use with three-phase power;
- b. contains a cage rotor;
- c. is capable of direct-on-line starting;
- d. has 2, 4, 6, or 8 poles;
- e. is rated from 0.4 to 1600 *kW* at a frequency of 60 Hz; and
- f. conforms to Sections 6.1, 6.2, and 6.3 of IEC 60034-12, edition 2.1, requirements for torque characteristics, locked rotor apparent power, and starting.

indirectly conditioned space: see *space*.

indoor pool dehumidifier: a type of air-cooled or water-cooled electrically operated vapor compression refrigeration *system*, factory assembled as a single package or split *system*, which includes an indoor cooling/dehumidifying coil, an air *reheat* coil, one or more compressors, and an air moving device. It may also include a refrigerant heat recovery unit, an auxiliary refrigerant condenser, an economizer, and an air-to-air heat recovery device. It shall provide the function of dehumidification, air circulation, and air *reheating* and may include the function of air-cooling, air-cleaning, *pool* water heating, and air-to-air heat recovery.

ineffective panel surface: see *thermally ineffective panel surface*.

infiltration: the uncontrolled inward air leakage through cracks and crevices in any *building* element and around windows and *doors* of a *building* caused by pressure differences across these elements due to factors such as wind, inside and outside temperature differences (stack effect), and imbalance between supply and exhaust air *systems*.

installed exterior lighting power: the power in watts of all site, landscape, and *building* lighting *systems* for exterior *luminaires*.

installed interior lighting power: the power in watts of all general, task, and furniture *lighting systems* for interior *luminaires*.

integrated energy efficiency ratio (IEER): a single-number figure of merit expressing cooling part-load *EER efficiency* for commercial unitary air-conditioning and heat pump *equipment* on the basis of weighted operation at various load capacities for the *equipment*.

integrated part-load value (IPLV): a single-number figure of merit based on part-load *EER*, COP, or *kW/kW* expressing part-load *efficiency* for air-conditioning and heat pump *equipment* on the basis of weighted operation at various load capacities for the *equipment*.

integrated seasonal coefficient of performance (ISCOP): a seasonal *efficiency* number that is a combined value based on the formula listed in AHRI Standard 920 of the two COP values for the heating season of a *DX-DOAS unit* water or air source heat pump, expressed in W/W.

integrated seasonal moisture removal efficiency (ISMRE): a seasonal *efficiency* number that is a combined value based on the formula listed in AHRI Standard 920 of the four dehumidification *moisture removal efficiency (MRE)* ratings required for *DX-DOAS units*, expressed in lb of moisture/kWh.

interior lighting power allowance: see *lighting power allowance*.

isolation devices: devices that isolate *HVAC zones* so that they can be operated independently of one another. *Isolation devices* include, but are not limited to, separate *systems*, isolation dampers, and *controls* providing shutoff at *terminal* boxes.

IT equipment energy: annual *energy* used for computer storage and network *equipment* along with supplemental *equipment* represented by the uninterruptible power supply (UPS) output calculated in accordance with industry-accepted standards (see Informative [Appendix E](#)).

J

joist, steel: any structural steel member of a *building* or structure made of hot-rolled or cold-rolled solid or open-web sections.

K

kilovolt-ampere (kVA): where the term *kilovolt-ampere* is used in this standard, it is the product of the line current (amperes) times the nominal *system* voltage (kilovolts) times 1.732 for three-phase currents. For single-phase applications, *kVA* is the product of the line current (amperes) times the nominal *system* voltage (kilovolts).

kilowatt (kW): the basic unit of electric power, equal to 1000 W.

L

labeled: *equipment* or materials to which a symbol or other identifying mark has been attached by the *manufacturer* indicating compliance with specified standards or performance in a specified manner.

lamp: a generic term for a man-made light source, often called a “bulb” or “tube.”

high-intensity discharge (HID) lamp: an electric discharge *lamp* in which light is produced when an electric arc is discharged through a vaporized metal such as mercury or sodium. Some *HID lamps* may also have a phosphor coating that contributes to the light produced or enhances the light color.

light-to-solar-gain ratio (LSG): the ratio of the center-of-glass *visible transmittance* to the center-of-glass *solar heat gain coefficient*.

lighting, decorative: lighting that is ornamental or installed for aesthetic effect. *Decorative lighting* shall not include *general lighting*.

lighting, general: lighting that provides a substantially uniform level of illumination throughout an area. *General lighting* shall not include *decorative lighting* or lighting that provides a dissimilar level of illumination to serve a specialized application or feature within such area.

lighting power allowance, exterior: the maximum lighting power in watts allowed for the exterior of a *building*.

lighting power allowance, interior: the maximum lighting power in watts allowed for the interior of a *building*.

lighting power density (LPD): the lighting power per unit area of a *building*, *space*, or outdoor area expressed in W/ft².

lighting system: a group of *luminaires* circuited or controlled to perform a specific function.

liner system (Ls): a continuous vapor barrier liner installed below the purlins and uninterrupted by framing members.

low-rise residential buildings: single-family houses, multifamily structures of three stories or fewer above *grade*, manufactured houses (mobile homes), and manufactured houses (modular).

luminaire: a complete lighting unit consisting of a *lamp* or *lamps* together with the housing designed to distribute the light, position and protect the *lamps*, and connect the *lamps* to the power supply.

M

makeup air (dedicated replacement air): *outdoor air* deliberately brought into the *building* from the outside and supplied to the vicinity of an exhaust hood to replace air, vapor, and contaminants being exhausted. *Makeup air* is generally filtered and fan-forced, and it may be heated or cooled depending on the requirements of the application. *Makeup air* may be delivered through outlets integral to the exhaust hood or through outlets in the same room.

manual (nonautomatic): requiring personal intervention for *control*. *Nonautomatic* does not necessarily imply a *manual* controller, only that personal intervention is necessary. (See *automatic*.)

manufacturer: the company engaged in the original production and assembly of products or *equipment* or a company that purchases such products and *equipment* manufactured in accordance with company specifications.

mass floor: see *floor*.

mass wall: see *wall*.

mean temperature: one-half the sum of the minimum daily temperature and maximum daily temperature.

mechanical cooling: reducing the temperature of a gas or liquid by using vapor compression, absorption, desiccant dehumidification combined with evaporative cooling, or another *energy*-driven thermodynamic cycle. Indirect or direct evaporative cooling alone is not considered *mechanical cooling*.

mechanical heating: raising the temperature of a gas or liquid by use of *fossil fuel* burners, *electric resistance* heaters, heat pumps, or other *systems* that require *energy* to operate.

metal building: a complete integrated set of mutually dependent components and assemblies that form a *building*, which consists of a steel-framed superstructure and metal skin.

metal building roof: see *roof*.

metal building wall: see *wall*.

metering: instruments that measure electric voltage, current, power, etc.

moisture removal efficiency (MRE): a ratio of the moisture removal capacity in lb of moisture/h to the power input values in *kW* at any given set of standard rating conditions expressed in lb of moisture/kWh.

motor power, rated: the rated output power from the motor.

multilevel occupancy sensor: an occupancy sensor having an *automatic* OFF function that turns off all the lights, and either an *automatic* or a manually controlled ON function capable of activating between 30% and 70% of the lighting power. After that event occurs, the device shall be capable of all of the following actions when manually called to do so by the occupant:

- a. Activating alternate sets of lights
- b. Activating 100% of the lighting power
- c. Deactivating all lights

multiscene control: a lighting *control device* or *system* that allows for two or more predefined lighting settings, in addition to all off, for two or more groups of *luminaires* to suit multiple activities in the *space*, and allows the *automatic* recall of those settings.

N

nameplate horsepower (hp): the nominal motor output power rating stamped on the motor nameplate.

nameplate rating: the design load operating conditions of a device as shown by the *manufacturer* on the nameplate or otherwise marked on the device.

NEMA Design A motor: a squirrel-cage motor that

- a. is designed to withstand full-voltage starting and developing locked-rotor torque as shown in NEMA MG 1, paragraph 12.38.1;
- b. has pull-up torque not less than the values shown in NEMA MG 1, paragraph 12.40.1;
- c. has breakdown torque not less than the values shown in NEMA MG 1, paragraph 12.39.1;
- d. has a locked-rotor current higher than the values shown in NEMA MG 1, paragraph 12.35.1, for 60 Hz, and NEMA MG 1, paragraph 12.35.2, for 50 Hz; and
- e. has a slip at rated load of less than 5% for motors with fewer than 10 poles.

NEMA Design B motor: a squirrel-cage motor that is

- a. designed to withstand full-voltage starting;
- b. develops locked-rotor, breakdown, and pull-up torques adequate for general application as specified in NEMA MG1, paragraphs 12.38, 12.39, and 12.40;
- c. draws locked-rotor current not to exceed the values shown in NEMA MG1, paragraph 12.35.1, for 60 Hz, and paragraph 12.35.2 for 50 Hz; and
- d. has a slip at rated load of less than 5% for motors with fewer than 10 poles.